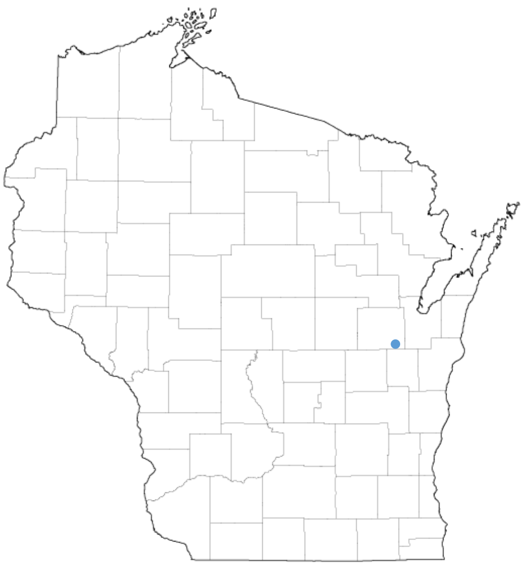

KAUKAUNA UTILITIES
Outagamie County, WI

# Kaukauna Utilities

# Water System Study

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# Kaukauna Utilities Water System Study 2024
# Executive Summary

Kaukauna Utilities serves the City of Kaukauna with drinking water. Kaukauna Utilities has an extensive water system with over 100 miles of water main, utilizing five wells with three iron removal plants and two water towers. Kaukauna Utilities provides service to approximately 7,000 customers. Residential usage accounts for most of the water demand.

Kaukauna Utilities is looking to investigate potential changes and upgrades to the water system in their effort to continue to provide water that meets or exceeds all federal and state regulatory standards while remaining safe, environmentally responsible, and cost-effective. The purpose of this water system study is to analyze existing and future water demands, supply, water storage, water quality, various water treatment options, and replacement options for the Main Filter Plant, including potential replacement of the plant at other site locations. The water study also explores future development areas for the water distribution system.

The following is a summary of the findings of the water system study.

## *Water Demand/Water Supply*

The water system study looked at the projected water demands for the next 20 years. It forecasted the future water demands will increase steadily at a rate of about 1.7% annually. The groundwater that supplies Kaukauna Utilities' system is projected to be a sustainable source of water for at least the next 20 years. The existing pumping and treatment equipment is projected to be adequate for at least the next 15 years. A new well should be reevaluated in approximately 15 years to ensure that Kaukauna Utilities can meet the future demand.

The water system study analyzed a couple of water supply options. One option evaluated was to move from groundwater to surface water. Changing the water source to surface water from the Green Bay Water Utility or surface water from the City of Appleton is not a cost-effective solution for delivering improved water quality to customers. The operational costs of using surface water are higher than treating water from groundwater sources in Kaukauna.

The reuse of water from the wastewater treatment plant was also evaluated as a water source for Kaukauna Utilities. It would involve extensive treatment prior to being distributed as drinking water. This source option should not be pursued because it is not cost-effective.

## *Water Storage*

Kaukauna currently meets the current capacity needs with the current underground storage reservoirs, but replacement is needed due to the condition of the tanks. The floors of the reservoirs are below the groundwater table and are subject to potential contaminants leaking into the tanks. This risk should be avoided by building new reservoirs above the groundwater table.

The water storage capacity is projected to be adequate for at least the next 20 years. No additional elevated storage tanks need to be considered during this time frame. It is estimated that the future development in the southeast corner of the study area, which will need a second pressure zone and an elevated storage tank, will occur after the 20-year study period of this report.

## *Water Quality*

The Wisconsin Department of Natural Resources (DNR) sets primary maximum contaminant levels for drinking water that pose a health risk and also sets secondary maximum contaminant levels for contaminants posing aesthetic and cosmetic objections in drinking water, such as taste, water hardness, and smell. Kaukauna Utilities currently uses a water treatment system consisting of a pressure filter tank and chemical addition to remove radium and iron. The treated water meets all DNR primary maximum contaminant levels and meets secondary maximum contaminant levels for iron. The treated water has levels of sulfate and total dissolved solids that exceed the DNR secondary maximum contaminant level, but the levels set by the DNR for these components of the water are guidelines and not mandated. Water hardness, which Kaukauna Utilities has identified as a potential area of improvement, is a component of total dissolved solids. Total dissolved solids and water hardness contribute to mineral buildup customers observe on water fixtures. Kaukauna Utilities' treated water is safe to drink and does not pose a health risk.

## *Main Filter Plant*

The pressure filter tank at the Main Filter Plant is over 60 years old and is at the end of its service life. The tank was temporarily patched seven years ago and will need to be replaced within the next three to five years. In addition, the Main Filter Plant Site is located in a floodplain. This does not comply with current DNR Administrative Code which requires first floor elevation of water facilities to be two feet above the 100-year floodplain.

Four Alternatives for the Main Filter Plant were studied to address the above issues. The capital and operation costs, customer impacts, and risks were evaluated for each alternative. The alternatives studied were:

- Alternative 1: No Changes
- Alternative 2: Replace Pressure Filter Tank at Current Location
- Alternative 3: Rebuild Water Treatment Plant Building and Reservoirs at Current Location
- Alternative 4: New Water Treatment Plant Building at New Site

Alternative 4 minimizes the most risk factors that were considered. Alternative 4 consists of building a new water treatment plant with reservoirs and a booster pump station at a new location outside the floodplain. The new Main Water Treatment Plant location would allow for the necessary building size for new treatment. This alternative would replace the equipment and structures identified in the water system study report as being past their useful life. Alternative 4 also allows the existing Main Filter Plant to continue producing water while the new water treatment plant is built.

## *Water Treatment Process Options*

The existing water treatment process involves chemical addition to remove radium and iron using a pressure filter tank. New treatment processes are being considered to also remove the water hardness from the treated water. Nine water treatment processes were considered as part of the water study. The five water treatment processes further evaluated are:

Water Treatment Option 1: Keep Existing Water Treatment Process
Water Treatment Option 2: Ion Exchange Treatment Process
Water Treatment Option 3: Reverse Osmosis or Nanofiltration Treatment Process
Water Treatment Option 4: Pellet Softening Treatment Process
Water Treatment Option 5: Change from Groundwater Source to Surface Water Source (Purchase Treated Water)

Treatment Option 3 meets Kaukauna Utilities' water treatment objectives best. It consists of nanofiltration or reverse osmosis water treatment process to lower or remove radium, iron, sulfate, water hardness, and total dissolved solids levels in the raw water. This treatment process would benefit customers by lowering water hardness to a predetermined range and allow them to save on water softening costs if they choose to eliminate their water softener.

## ***Water Distribution System***

Within the existing water distribution system, improvements such as water main looping and water main upsizing were considered. Kaukauna Utilities is anticipating residential growth to the southeast as well as industrial and residential growth to the north. The water distribution system was studied with a computer water model prepared in the Bentley WaterCAD software. The current water distribution system meets the minimum fire flow requirements established by the DNR of 500 gallons per minute (gpm) and 20 pounds per square inch (psi). This is the required amount of water flow and pressure needed to continuously fight a fire. The water distribution system also meets the minimum static system pressure established by the DNR of 35 psi for customers.

A potential improvement to the water distribution system includes upsizing the water main on Hillcrest Drive from the current 8 and 10-inch piping to 12-inch piping. This improvement would benefit the areas of low fire flow in the southeastern part of the existing water system and allow for higher fire flows in the future expansion to the southeast.

Additionally, Kaukauna Utilities can stay on one pressure zone until development to the southeast necessitates the addition of a second pressure zone. It is projected Kaukauna Utilities can add to the water system to the southeast, to an area east of County Road GG and south of Weiler Road, before needing to add another pressure zone. By staying with one pressure zone as long as possible, it would minimize maintenance labor and postpone adding dead ends in the water system until another pressure zone is needed. Once development reaches this area, a second pressure zone should be evaluated as well as the possible need for another elevated storage tank for the second pressure zone.

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## 1. Introduction

Kaukauna Utilities is located in the City of Kaukauna, WI, which is in Outagamie County in northeastern Wisconsin. A location map of the City of Kaukauna is shown in **Figure 1** included in **Appendix B.** The municipal water distribution system serves approximately 7,000 customers utilizing approximately 100 miles of water mains according to the 2022 Public Service Commission (PSC) Annual Report.

The water system study includes Kaukauna Utilities' existing water system as well as areas of future growth. The 100-year expansion for the City of Kaukauna was delineated with the water study limits. The water system study limits go as far east as Outagamie Road / County Line Road and as far north as County Road UU. The west and south boundary of the water study are that of the existing system—STH 55 and CTH KK. A map of the water study limits is shown in **Figure 2** included in **Appendix B.**

Kaukauna Utilities' water is sourced from five groundwater wells: Well 4, Well 5, Well 8, Well 9 and Well 10. Kaukauna Utilities has three water treatment plants. The water from Well 4, Well 5, and Well 10 is treated in the Main Filter Plant. The Main Filter Plant has two ground storage reservoirs with a total capacity of 579,000 gallons. The water from Well 8 and Well 9 is treated at a water treatment plant located at each well building. Kaukauna Utilities' distribution system also includes two water elevated storage tanks, also known as water towers, with a combined capacity of 1 million gallons.

Based on data from the 2022 PSC Annual Report, the average daily demand for Kaukauna Utilities was 1,300,445 gallons per day. The water demand is largely driven by residential usage which accounts for about 67% of water usage annually.

The purpose of this report is to provide Kaukauna Utilities with an evaluation of the water system, providing alternatives, analysis, and recommendations.

## 2. Water Study Need

This study represents Kaukauna Utilities' ongoing commitment to deliver safe and reliable drinking water. The study will help Kaukauna Utilities make informed decisions about potential changes and upgrades to the system. Some areas that have been identified by Kaukauna Utilities for potential enhancements are the Main Filter Plant and the water treatment process. The existing Main Filter Plant is located in the Fox River floodplain and does not comply with current Department of Natural Resources (DNR) code requirements. The Main Filter Plant treatment equipment, building structure, and reservoir structures are at the end of their lifespans. Additionally, Kaukauna Utilities is evaluating whether the water treatment process should include water hardness removal. This treatment process would involve updated water treatment equipment for all the wells.

Kaukauna Utilities also requested that the study evaluate improvements and expansions to the water distribution system. Improvements such as looping and pipe upsizing were considered within the existing water distribution system. Kaukauna Utilities is anticipating residential growth to the southeast and industrial and residential growth to the north. These water distribution system expansions were considered, with additional pressure zones when applicable.

## 3. Topography

The topography of Kaukauna includes a high east end. A river runs through the center of Kaukauna, which divides the water distribution system. The river area includes some development, which is at a lower elevation than the rest of Kaukauna. A topographic map is shown in **Figure 3** included in **Appendix B.**

## 4. Population Projections

Past population estimates and projected population figures for Kaukauna are shown in **Table 1**. The population estimates are from the U.S. Census Bureau which predicts the City's population will increase annually at a steady rate of 1.7%.

Table 1: Population Data for the City of Kaukauna

| 1990 Population | 2000 Population | 2010 Population | 2020 Population | *2025 Projection* | *2030 Projection* | *2035 Projection* | *2040 Projection* |
|---|---|---|---|---|---|---|---|
| 12,000 | 13,000 | 15,500 | 17,100 | 18,600 | 20,200 | 22,020 | 24,000 |

## 5. Design Period

The water main expansion area is for a 100-year design period. The remainder of the water study is a 20-year design period. The design period for the concrete structures, water treatment plant building, and water treatment plant equipment is 60 years.

## 6. Past Studies

McMahon Associates Incorporated prepared an Evaluation of Water Supply System in 2003. The report detailed the current system and made recommendations for improvements. The 2003 McMahon report is included in **Appendix L.**

## 7. Environmental Characteristics

### 7.1 Wetlands

The Wisconsin DNR Surface Water Data Viewer was used to show wetlands within the study area. Wetland areas occur throughout Kaukauna. They are generally located on the southeast side of Kaukauna in areas around the Fox River and Konkapot Creek. A Wetland Inventory Map from the Wisconsin DNR is shown in **Figure 4** included in **Appendix B**.

### 7.2 Floodplain

The Wisconsin DNR Surface Water Data Viewer and FEMA mapping was reviewed to determine the location of the existing 100-year floodplain within the study area. Floodplains are in Kaukauna around the Fox River, Konkapot Creek, and in the southeast portion of Kaukauna. The Main Filter Plant is located within the 100-year floodplain. Floodplain Mapping is shown in **Figures 5 and 6** in **Appendix B**.

# 8. Existing Water System

## 8.1 Water Supply Facilities

The water supply for Kaukauna Utilities is obtained entirely from groundwater wells. There are currently five wells in service. Wells 4, 5, and 10 are located south of the Fox River, which divides the City of Kaukauna. Wells 8 and 9 are located north of the Fox River. A map of Kaukauna Utilities' water facilities locations is shown in **Figure 7** in **Appendix B.** A schematic of the existing water system wells and treatment system is included in **Figure 8** in **Appendix B.** A Condition Report for existing water filter plants was prepared on October 23, 2023 to determine the deficiencies of the existing water filter plants, existing ground storage reservoirs, and main booster pump station. The Condition Report for Existing Water Filter Plants is included in **Appendix C**. The asset conditions are summarized in Figure 8.

### 8.1.1 Well 4

Well 4 is located at the Main Filter Plant site at 304 Elm Street. Well 4 consists of a 15.5-inch casing to a depth of 34 feet and a 12-inch casing extended to a depth of 120 feet. A 12-inch open hole was drilled from a depth of 120 feet to a total depth of 726 feet. A 10-inch liner was placed from the surface to a depth of 120 feet. The annular space between the 10-inch liner and the larger diameter casings was sealed with grout to a depth of 120 feet.

Well 4 has a submersible pump with a capacity of 600 gallons per minute (gpm) that was installed in 2024. This pump is driven by a variable frequency drive (VFD) and operates at 555 gpm. A variable frequency drive allows the well pump to operate at different speeds. The raw water from Well 4 is pumped to the Main Filter Plant which is adjacent to Well 4. There is no standby power for Well 4.

Well 4 is in a building connected to the Maintenance Facility Building and the Booster Pump Station Building. The Well 4 Building is in good condition.

The Well 4 Building is located just outside of the 100-year flood plain. The current Wisconsin DNR Administrative Code Chapter NR811.25(d) requires a floor elevation at least two feet above the regional flood elevation.

**It is recommended that the next time Well 4 is scheduled for a major renovation, a cost benefit analysis should be performed to determine if the first floor of the building should be raised two feet above the 100-year flood plain to meet the current Wisconsin DNR Administrative Code Chapter NR811.25(d). It is anticipated that the DNR may require Well 4 to be brought up to meet current code the next time Well 4 is scheduled for a major renovation.**

### 8.1.2 Well 5

Well 5 is located at 601 Pool Road southeast of the intersection of Dodge Street and Island Street. Well 5 was originally constructed in 1935 to a depth of 570 feet. In 1942, the well was extended to a depth of 733.5 feet and was then backfilled to a depth of 524 feet in 1947 to improve water quality. The well consists of a 16-inch grouted casing extended to a depth of 121 feet. A 15-inch open hole extends from the bottom of the casing to a depth of 350 feet, and a 12-inch open hole extends from a depth of 350 feet to a total depth of 524 feet.

The Well 5 building was constructed in 1975. Well 5 has a submersible pump with a capacity of 380 gpm that was installed in 2022. This pump is driven by variable frequency drive and operates at 315 gpm. Well 5 was most recently serviced in February 2022.  There is no standby power for Well 5. Both Well 5 and the Well 5 building are in good condition.

Sodium hypochlorite is added to the raw water at the Well 5 site to assist in disinfection prior to treatment at the Main Filter Plant. Well 5 water is conveyed through 2,100 feet of 8-inch diameter raw water transmission main to the Main Filter Plant.

**8.1.3 Well 10**

Well 10 is located on Tenth Street near Kenneth Avenue. Well 10 was originally constructed in 1945 as Well 6. Well 10 was originally constructed with a 10-inch casing grouted to a depth of 159 feet with a 10-inch open hole drilled to a depth of 568 feet. In 1995, the 10-inch open hole was extended to a depth of 841 feet and the well was renamed Well 10. In 2000, the well was filled to a depth of 660 feet to reduce radium and gross alpha levels. Radium levels were reduced as a result of filling the well.

Well 10 has a submersible pump with a capacity of 580 gpm that was installed in 2013. Well 10 was last serviced in 2013. The well is up for rehabilitation in 2024. There is no standby power for Well 10. Both Well 10 and the Well 10 building are in good condition.

Water from Well 10 is conveyed through 6,100 feet of 8-inch diameter raw water transmission line to the Main Filter Plant. Well 5 is also connected to this raw water transmission main.

**8.1.4 Main Filter Plant Site**

The existing Main Filter Plant site, originally developed in 1899, is located at 304 Elm Street. Water from Wells 4, 5, and 10 is treated and stored at the Main Filter Plant site.

*8.1.4.1 Main Filter Plant Building*

The Main Filter Plant building was last improved in 2022. Improvements included a new roof and new doors. The windows are original block windows. The Main Filter Plant building is currently in good condition. There is no standby power at this facility.

The floor elevation of the Main Filter Plant building is located below the 100-year floodplain elevation. The current Wisconsin DNR Administrative Code Chapter NR811.25(d) requires a floor elevation at least two feet above the regional flood elevation. The DNR may require the first floor of this building to be raised during the next major renovation to comply with current code.

A schematic of the Main Filter Plant treatment process is shown in **Figure 9** in **Appendix B.** The Main Filter Plant building includes one pressure filter tank and chemical feed systems. Manganese sulfate and potassium permanganate are added prior to filtration for oxidation and radionuclide removal. A pressure filter tank is used for iron, manganese, and radionuclide removal. Sodium hypochlorite is added following filtration for disinfection. An orthophosphate blend (50% ortho, 50% poly) is added following filtration for corrosion control. The finished drinking water is then stored in two ground storage reservoirs until it is pumped to the distribution system from the main booster pump station.

The pressure filter tank is over 60 years old and in poor condition. The pressure filter tank is made of steel and coated with paint on the inside and outside for corrosion protection. The pressure filter tank works using low pressure around 10-15 pounds per square inch. The pressure filter tank was leaking in 2016. Upon visual inspection of the interior of the pressure filter tank in 2016, the tank was failing due to pitting of the interior steel surface caused by corrosion. The tank was repaired in 2016 by installing a concrete liner inside the bottom half of the tank to prolong its useful life. This type of repair was possible due to the low working pressure of the tank and was estimated to extend the life of the tank another 10 years. The repair has been a good temporary solution because the pressure filter tank is still producing satisfactory water quality.

Metal thickness testing of the pressure filter tank wall was performed on September 28, 2023. The results of the metal thickness testing are documented in the Condition Report for Existing Water Filter Plants included in **Appendix C**. The results show that the 60-year-old pressure filter tank has severe pitting on the interior of the tank walls. This result is consistent with the visual inspection performed on the interior of the tank in 2016. The structural integrity of the tank is in poor condition. The pressure filter tank currently has signs of mineral buildup on its exterior in two locations which indicates the tank is leaking.

**It is recommended that the pressure filter tank be replaced within the next three to five years. The pressure filter tank at the Main Filter Plant is over 60 years old and is at the end of its service life. The tank was temporarily patched seven years ago. In addition, the Main Filter Plant Site is located in a floodplain. If major building renovations are performed, it is anticipated that the DNR may require the first floor of the Main Filter Plant Building to be raised two feet above the 100-year flood plain in accordance with Wisconsin DNR Administrative Code Chapter NR811.25(d).**

*8.1.4.2 Ground Storage Water Reservoirs*
The Main Filter Plant Site has two ground storage reservoirs for storing finished water. See Section 8.2 (Water Storage) of this report for a discussion of the reservoirs.

*8.1.4.3 Booster Pump Station Building*
The Booster Pump Station building is on the north side of the Main Filter Plant site. The exterior of the building is in poor condition due to the rusty metal roof and rusty metal siding. The interior of the building is in good condition.

The Booster Pump Station building houses three booster pumps. Two of the pumps were installed in 2019 and have a capacity of 1,200 gpm each. They operate regularly. These two booster pumps are in good condition.

The third pump was installed in 1967 and has a capacity of 2,000 gpm. It is for emergency backup use only in the event of a power failure. The third booster pump is operated by a right-angle drive liquid propane engine, which is not considered a good emergency backup pump. The third booster pump will only provide water to the distribution system until the two ground storage reservoirs are empty. The engine only runs one booster pump and will not run the wells or the filter plant.

**It is recommended that the third booster pump be replaced when emergency backup power is installed.**

### 8.1.5 Well 8

Well 8 is located at 311 Delanglade Street, which is at the southwest corner of the intersection of Blackwell Street and Delanglade Street. Well 8 was originally constructed in 1959 and was rehabilitated in 1995. The well has a 20-inch casing pipe to a depth of 73 feet and a 16-inch liner to a depth of 151 feet. The well has been grouted to 151 feet. Well 8 has a total depth of 700 feet.

Well 8 has a submersible pump with a capacity of 600 gpm that was installed in 2023. This pump is driven by a variable frequency drive and operates at 475 gpm. Well 8 was last serviced by Municipal Well Services in 2023. There is no standby power for Well 8. Well 8 is in excellent condition.

Well 8 water is treated on site at a water treatment plant inside the well house. The treatment at Well 8 includes manganese sulfate and potassium permanganate injection prior to filtration for oxidation and radionuclide removal. One pressure filter tank is used for iron, manganese, and radionuclides removal. Following filtration, sodium hypochlorite is added for disinfection and an orthophosphate blend (50% ortho, 50% poly) is added for corrosion control. The water is stored in a ground storage reservoir before being pumped to the distribution system.

The Well 8 Water Treatment Plant building and pressure filter tank are in excellent condition after the recent renovation. The pressure filter tank was completely replaced in 2018 due to corrosion in the tank wall and a failure in the internal filter media bed, underdrain, and diffuser. The pressure filter tank is made of steel and coated with paint on the inside and outside for corrosion protection. The pressure filter tank works using low pressure around 10-15 pounds per square inch but is at 53-65 pounds per square inch (distribution system pressure) during backwash cycles.

Metal thickness testing of the pressure filter tank wall was performed on September 28, 2023. The results of the metal thickness testing are documented in the Condition Report for Existing Water Filter Plants included in **Appendix C**. The results show that the 5-year-old pressure filter tank has no pitting on the interior of the tank walls. The structural integrity of the tank is in excellent condition. The pressure filter tank currently has no signs of mineral buildup on the exterior of the tank which indicates the tank is not leaking.

The ground storage reservoir, built in 1999, is 15,000 gallons and is in excellent condition. The booster pumps at Well 8 are in fair condition.

### 8.1.6 Well 9

Well 9 is in Riverside Park at 101 River Street on the west side of Kaukauna. Well 9 was originally constructed in 1974. The well consists of an 18-inch casing grouted to a depth of 239 feet. A 17.25-inch diameter open hole was originally extended to a depth of 806 feet. In 1989, the well was filled to a depth of 620 feet to improve the water quality and reduce radium levels. The well is chlorinated once a month to control iron bacteria. Well 9 was last serviced by Water Well Solutions in 2020. Well 9 is in good condition.

Well 9 site consists of two buildings: the Well House building and the Water Filter Plant building. The Well 9 Well House building, originally built in 1974, is in good condition. The Well House building houses a vertical turbine pump with a capacity of 1,300 gpm. Well 9 is the only well that Kaukauna Utilities is able to run during a power outage. Well 9 is equipped with a right-angle drive natural gas engine which was installed in 2015. The natural gas engine operates the well pump at 850 gpm which is 63% of the normal well pump capacity of 1,300 gpm.

Well 9 water is treated on site in a Water Filter Plant building located south of the Well House building. The filtration process includes injection of manganese sulfate and potassium permanganate for oxidation and radionuclide removal. The pressure filter tank is used for iron, manganese, and radionuclides removal. Sodium hypochlorite is added following filtration for disinfection. An orthophosphate blend (50% ortho, 50% poly) is added following filtration for corrosion control.

There are two horizontal pressure filter tanks inside the Well 9 Water Filter Plant building. The pressure filter tank was installed in 1990 and is made of steel and coated with paint on the inside and outside for corrosion protection. The pressure filter tank works using 75-82 pounds per square inch (distribution system pressure) all the time. All the inner piping has failed and was replaced in 2010 with PVC. The media was replaced in 2010. Media typically lasts 15 years.

Metal thickness testing of the pressure filter tank wall was performed on September 28, 2023. The results of the metal thickness testing are documented in the Condition Report for Existing Water Filter Plants included in **Appendix C**. The results show that the 33-year-old pressure filter tank has some pitting on the interior of the tank walls. The structural integrity of the tank is in good condition. The pressure filter tank currently has no signs of mineral buildup on the exterior of the tank, which indicates the tank is not leaking. It is anticipated that the pressure filter tank has about 20 more years of useful life. It should be evaluated at that time. An evaluation can also be done when the media in the tank is replaced.

Well 9 Filter Plant building has a standby generator to run during a power outage. The generator is sized to run only the building heaters, lights, and chemical pumps. Well 9 can produce treated water during a power outage using the natural gas engine driven well pump and the generator to run the chemical pumps. During a power outage, the well capacity is only 850 gpm due to the size of the natural gas engine.

**It is recommended that the media in the pressure filter tank be replaced in the next three to five years. The pressure filter tank can be reused for the next 20 years based on the findings in the Condition Report for Existing Water Filter Plants. In approximately 20 years, the pressure filter tank should be re-evaluated to determine its condition.**

**A study should be conducted to determine which components of the water system should be supplied with backup power pursuant to Wisconsin DNR Administrative Code Chapter NR 811.27: "all municipal pumping stations, pumphouses, and water treatment plants shall have a standby auxiliary power source unless the department determines that there is sufficient pumping capacity with existing auxiliary power located at other water system facilities to**

**provide at least an average day supply of water." The DNR has clarified that the backup power should, at a minimum, be able to provide average day demand. The study should include an analysis of which components need backup and whether the backup power can be phased into the water system or if all facilities should receive backup power at the same time. Water system components to be reviewed for a need for backup power should include all wells, pumping stations, and water treatment plants.**

**8.2 Water Storage**

Kaukauna Utilities has two elevated storage tanks in the water distribution system that have capacities of 500,000 gallons each. The Industrial Park Tower is located on the north side of the river and was constructed in 1974. The Ann Street Tower is located on the south side of the river and was constructed in 1999. Both elevated storage tanks have an overflow elevation of 865 feet. Both elevated storage tanks are in good condition.

The Main Filter Plant site contains two ground storage water reservoirs. Ground Storage Reservoir #1 is circular and was constructed in 1899. Ground Storage Reservoir #1 has a capacity of 284,000 gallons and is approximately 60 feet in diameter and 18 feet deep. The reservoir is in the floodplain. Ground Storage Reservoir #1 is in poor condition.

Ground Storage Reservoir #2 is rectangular and was constructed in 1940. Ground Storage Reservoir #2 has a capacity of 295,000 gallons and is approximately 13 feet deep. Ground Storage Reservoir #2 is in poor condition.

Reservoir #1 is located in the floodplain. Reservoir #2 is not located in the floodplain. The bottom floor of each reservoir is located below the 100-year floodplain and the groundwater table. The elevation of each reservoir violates the current Wisconsin DNR Administrative Code Chapter NR 811.63(1) because the floor of a reservoir is required to be a minimum of two feet above the 100-year floodplain and the groundwater table.

The current Wisconsin DNR Administrative Code Chapter NR811.63(4) states: "The department recommends that the lowest elevations of floors and sump floors of ground level reservoirs and standpipes should be placed at or above the normal ground surface. If the department allows the floor or sump to be below the normal ground surface, it shall be placed a minimum of two feet above the groundwater table." The bottoms of both ground storage reservoirs at the Main Filter Plant site are located below the groundwater table. This puts the reservoirs at a high risk of contamination leaking into the tanks.

It is anticipated that the DNR will require the reservoirs to comply with the current Wisconsin DNR Administrative Code at the time of major renovation or remove both reservoirs from service. The reservoirs have outlived their useful life.

The Well 8 site contains one ground storage reservoir. The ground storage reservoir is 15,000 gallons and was built in 1999. The ground storage reservoir is in excellent condition.

**The existing reservoirs at the Main Filter Plant site are located below the groundwater table and are subject to potential contaminants leaking into the tanks. This risk should be avoided by building the new reservoirs above the groundwater table and at least two feet above the**

**floodplain. Although grandfathered in, the elevation of each reservoir does not comply with current Wisconsin DNR Administrative Code NR 811.63 relating to reservoir placement with respect to floodplains and the groundwater table. A study should be performed to determine the most feasible location for the ground storage reservoirs.**

### 8.3 Water Distribution System

The water distribution system for Kaukauna Utilities consists of a single pressure zone. The water system includes PVC, ductile iron, and cast-iron pipes ranging in size from 4-16 inches. A breakdown of pipe sizes is shown in
**Table 2**.

Table 2: Water Distribution System Pipe Summary

| Size | Material | Linear Feet |
|---|---|---:|
| **4”** | Metal | 754 |
| **4”** | PVC | 642 |
| **6”** | Metal | 79,569 |
| **6”** | PVC | 25,195 |
| **8”** | Metal | 27,838 |
| **8”** | PVC | 209,887 |
| **10”** | Metal | 30,583 |
| **10”** | PVC | 19,103 |
| **12”** | Metal | 16,685 |
| **12”** | PVC | 117,093 |
| **16”** | Metal | 10,636 |
| **16”** | PVC | 1,100 |
| | **Total** | **539,085** |

The areas of the distribution system that are being served by 4-inch undersized water mains have access to hydrants fed on larger water mains.

Kaukauna Utilities has 6,695 utility-owned water service lines. Approximately 214 private lead water services and 351 public lead water services remain in the water distribution system as of May 1, 2024. Kaukauna Utilities is working to remove the private and public lead water service lines from the water distribution system. The City of Kaukauna has a lead service line replacement ordinance which requires owners to replace the private lead water service lines in conjunction with public water main and service reconstruction.

## 9. Water Demand

Kaukauna Utilities has an average daily pumping demand of 1,300,445 gallons based on data from the 2022 PSC Annual Report. This demand consists of about 67% residential demand. A summary of the water demand for Kaukauna Utilities is included in **Appendix D.**

The top ten water users in the system are listed in **Table 3**. These customers are not anticipated to leave the Kaukauna Utilities water system in the next 20 years.

Table 3: Top 10 Water Users

| | Customer | Annual Water Use (High Year) Gallons |
|---|---|---|
| 1 | Ahlstrom Munksjo | 2,321,585 |
| 2 | Bernatello's Pizza | 1,798,934 |
| 3 | St. Paul Elder Services | 769,335 |
| 4 | Aurora BayCare Medical Center | 617,261 |
| 5 | Kaukauna Utilities | 538,255 |
| 6 | Kaukauna Area School District | 495,493 |
| 7 | Griesbach Trucking | 427,892 |
| 8 | Albany International Corp | 168,114 |
| 9 | Best Wash Inc | 163,276 |
| 10 | City of Kaukauna | 147,300 |

Kaukauna Utilities should anticipate increased water demand over the next 20 years. This demand includes residential development to the southeast and industrial development to the north. The projections were calculated assuming a 0.5% annual increase in water demand, following discussions with Kaukauna Utilities. The water demand projections are shown in **Table 4** and **Figure 1.**

Table 4: Water Demand Projections

| Year | Total Water Demand (gal) | Average Day Demand (gal) | Maximum Day Demand (gal) |
|---|---|---|---|
| 2000 | 464,305,000 | 1,272,000 | 2,252,000 |
| 2001 | 484,189,000 | 1,327,000 | 1,961,000 |
| 2002 | 501,160,000 | 1,373,000 | 2,011,000 |
| 2003 | 536,283,000 | 1,470,000 | 2,204,000 |
| 2004 | 512,887,000 | 1,405,000 | 3,026,000 |
| 2005 | 534,648,000 | 1,465,000 | 2,336,000 |
| 2006 | 516,376,000 | 1,415,000 | 2,495,000 |
| 2007 | 510,719,000 | 1,399,000 | 2,261,000 |
| 2008 | 506,623,000 | 1,388,000 | 2,556,000 |
| 2009 | 471,048,000 | 1,291,000 | 2,135,000 |
| 2010 | 430,703,000 | 1,180,000 | 2,308,000 |
| 2011 | 444,951,000 | 1,219,000 | 2,022,000 |
| 2012 | 457,694,000 | 1,254,000 | 1,862,000 |
| 2013 | 444,685,000 | 1,218,000 | 1,929,000 |
| 2014 | 469,407,000 | 1,286,000 | 1,911,000 |
| 2015 | 435,258,500 | 1,192,000 | 2,057,000 |
| 2016 | 432,127,000 | 1,184,000 | 2,064,000 |
| 2017 | 432,714,000 | 1,186,000 | 2,288,000 |
| 2018 | 432,995,000 | 1,186,000 | 2,030,000 |
| 2019 | 416,569,000 | 1,141,000 | 2,192,000 |

| | | | |
|---|---|---|---|
| 2020 | 409,484,000 | 1,122,000 | 1,827,000 |
| 2021 | 422,636,000 | 1,158,000 | 1,922,000 |
| 2022 | 473,362,000 | 1,297,000 | 2,213,000 |
| 2025 | 480,499,000 | 1,316,000 | 2,317,000 |
| 2030 | 492,631,000 | 1,350,000 | 2,376,000 |
| 2035 | 505,071,000 | 1,384,000 | 2,435,000 |
| 2040 | 517,824,000 | 1,419,000 | 2,497,000 |
| 2045 | 530,900,000 | 1,455,000 | 2,560,000 |

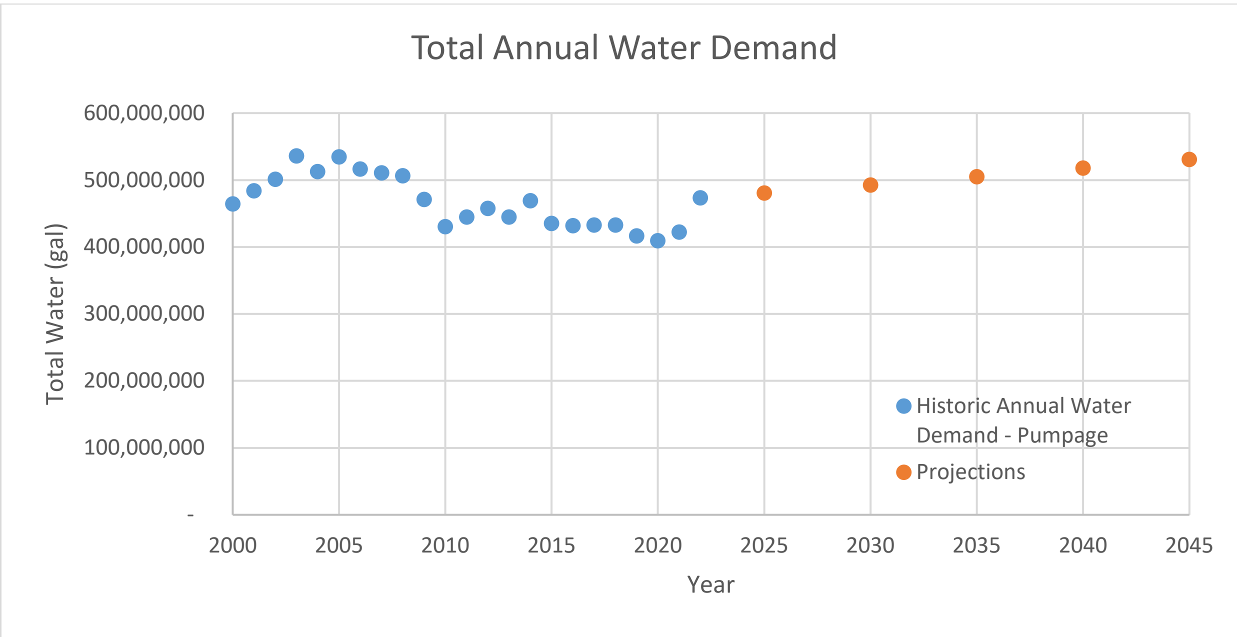


Figure 1: Annual Water Demand Projections

## 10. Water Supply System

### 10.1 Well Capacity

The existing water supply system consists of five municipal wells. The wells can supply a total of 3,225 gpm (4.6 million gallons per day (MGD)) if run concurrently. The well capacity is shown in **Table 5**.

Table 5: Well Capacity

| Well | Current DNR Approved Well Capacity (GPD) | Maximum DNR-Allowed Pumping Rate (gpm)* | Current Well Pumping Rate (gpm) | Proposed Well Capacity (gpm) |
|---|---|---|---|---|
| Well 4 | 864,000 | 600 | 555 | 600 |
| Well 5 | 360,000 | 250 | 315 | 500 |
| Well 8 | 756,000 | 525 | 475 | 525 |
| Well 9 | 1,872,000 | 1,300 | 1,300 | 1,300 |
| Well 10 | 756,000 | 525 | 580 | 580 |
| **Total Well Capacity** | 4,608,000 | | 3,225 | 3,505 |
| **Total Well Capacity Without Well 9** | 2,736,000 | | 1,925 | 2,205 |
| **Total Well Capacity Without Well 10** | 3,852,000 | | 2,745 | 2,925 |

*Calculated assuming a 24-hour pumping day.

The PSC uses Firm Well Capacity (FWC) to determine how the water supply system will perform under different demand conditions. Firm Well Capacity is the total capacity of the water supply system with the largest well out of service. In the case of Kaukauna Utilities, this would be Well 9, which operates at 1,300 gpm. This formula shows the total FWC of Kaukauna Utilities at 1,925 gpm (2.7 MGD pumping at 24 hours per day; 2.0 MGD pumping at 18 hours per day).

The PSC uses four equations to study a water supply system's ability to provide for different demand conditions. All equations use FWC for the water supplied during an event. Equations 3 and 4 also include storage in the water towers as a supply for the events considered. Equation 1 studies maximum day demand in gallons per minute. Equation 2 looks at average day demand in gallons per minute. Equation 3 includes a fire flow event on a day of maximum demand in gallons per minute. Equation 4 considers maximum hour demand in gallons per minute. These calculations are included in **Appendix D.** A summary of the water demand calculations, for both the current system and future demands for the year 2043 are included in **Table 6**. If the number is positive, then Kaukauna Utilities has excess capacity in that category. If the number is negative, the Utility is deficient in that category, which means Kaukauna Utilities could not supply water under that demand condition with the largest well out of service.

Table 6: Water Demand Calculations Summary

| Scenario | Equation 1 – Maximum Day (gpm) | Equation 2 – Average Day (gpm) | Equation 3 – Fire Flow on Maximum Day (gpm) | Equation 4 – Maximum Hour (gpm) |
|---|---|---|---|---|
| Current 2023 – FWC | 0 | 124 | 1,500 | 12,883 |
| **Future 2043 – FWC** | (422) | (75) | 1,078 | 11,997 |
| **Future – With Well 9** | 878 | 1,225 | | |

These calculations indicate that the system's storage and well capacity is currently sufficient to provide for maximum day demand, average day demand, a fire flow event, and maximum hour demand. The water storage and well capacity is also sufficient to provide average day, fire flow, and maximum hour demand for the projected demands in 2043. It is projected that the existing system will not be able to provide maximum day demand in the year 2043 with Well 9 out of service.

The above calculations for maximum day demand were made by using a pumping time of 18 hours per day. This 18-hour pumping time leads to the conclusion that Kaukauna Utilities cannot provide the water demand on the current or future maximum day with Well 9 out of service. One solution to this is to run the pumps for 24 hours during maximum day instead of 18 hours if Well 9 is out of service. Kaukauna Utilities' wells can handle a 24-hour pumping day in the short term (such as on the maximum day when Well 9 is out of service), but this is not a recommended long-term solution to meet average day demand. In the case of a 24-hour pumping day, the system spare capacity for the current maximum day demand increases from 0 gpm to 481 gpm. The future spare capacity for maximum day demand increases from -422 gpm to 165 gpm. The system can handle these maximum day and average day demands with Well 9 out of service but would need to extend the pumping duration.

Another solution to meet these demands is to add another well to the system. The FWC will change significantly if another well is drilled that has a capacity close to Well 9. The calculations require that the largest well is out of service. It is unlikely that planned maintenance would occur on Well 9 during the summer months when maximum day demand occurs. If the calculation is run with the second largest well out of service instead of the largest well out of service, the FWC increases from 1,925 gpm to 2,745 gpm.

A decision could be made by Kaukauna Utilities to become a wholesale water provider to smaller communities without wells. Kaukauna Utilities currently has adequate water supply to expand to small neighboring communities to meet the average day demand even with Well 9 out of service. Well 9 would need to be in service to meet the maximum day demand.

If Kaukauna Utilities joined water systems with Kimberly and Little Chute, as an example, the wells from Kimberly and Little Chute could be added to the water supply system if all the treatment processes were the same. Currently, Kimberly and Little Chute use ion exchange for water treatment. The advantage of joining water systems is when the FWC calculation is done, only one well out of all three communities needs to be considered not in service. Right now, each community needs to have one well out of service for the calculation. This joining of water systems increases redundancy in the water system. Another advantage of joining water systems would be increasing the efficiency in the water system, such as sampling and repairing water main breaks.

Currently, Kimberly and Little Chute outsource sampling and water main breaks to private companies.

**Based on the above discussion of well capacity, recommendations include the following:**

1. **Evaluate in ten years whether another well is needed by 2035 to meet future average day and maximum day demand with Well 9 out of service. The evaluation will further refine the average day and maximum day projections that will be utilized at that time.**
2. **Obtain DNR approval to increase the daily capacity of Well 5 from 360,000 gallons per day (250 gpm) to 720,000 gallons per day (500 gpm) within the next 10-15 years based on the current growth projections.**
3. **Increase the capacity of Well 4 and Well 8 by increasing the speed of the pumps using the variable frequency drive which will pump more water.**
4. **Consider and evaluate whether Kaukauna Utilities wants to become a wholesale water provider.**
    a. **If Kaukauna Utilities wants to proceed with becoming a wholesale water provider for a community that does not have any wells, perform a study to determine if a well is needed.**
    b. **If Kaukauna Utilities wants to proceed with becoming a wholesale provider for a community with wells and have those wells as a part of the water supply system, perform a feasibility study to determine how to integrate the systems.**

### 10.2 Aquifer and Pumping Information

More information on each well is included in **Table 7**. The well information came from Kaukauna Utilities and the DNR Groundwater Retrieval Network. The water elevations listed are from pumping records from June 2023.

Table 7: Well Information

| Well No. | Aquifer | Static Water Elevation (ft) | Pumping Water Elevation (ft) |
|---|---|---|---|
| **4** | Sandstone/ Limestone | 524 | 405 |
| **5** | St. Peter Sandstone | 524 | 490 |
| **10** | Sandstone/ Dolomite | 540 | 469 |
| **8** | Sandstone/ Dolomite | 531 | 398 |
| **9** | Sandstone/ Limestone | 531 | 432 |

Currently, Kaukauna Utilities does not have issues with its groundwater supply. The static water levels have been consistent over the years. **Figure 2** shows the average annual static water level at each Utility well. The level has generally increased in the past ten years, even with increased water demand. Wisconsin Rural Water Association was also consulted on the sustainability of the aquifers in Kaukauna, and they did not have concerns with the aquifer's ability to supply water to Kaukauna Utilities long-term.

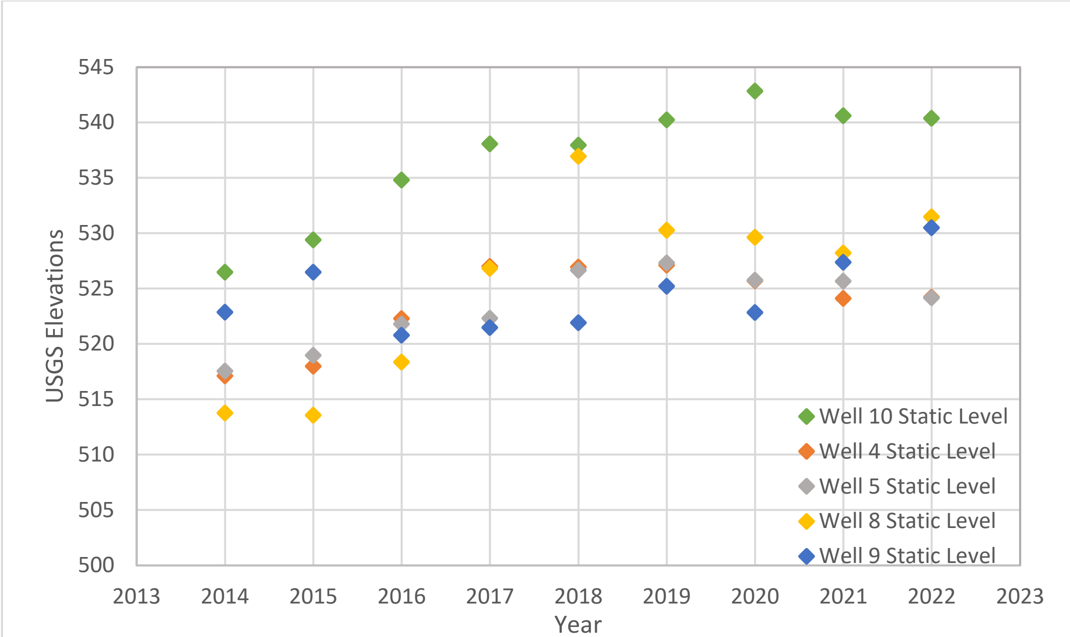


Figure 2: Annual Average Static Water Level at Kaukauna Utilities Wells

### 10.3 Surface Water

Kaukauna Utilities has an option to switch from groundwater to surface water as a source of water. This option has the benefit of eliminating the issue of radium and high water hardness associated with Kaukauna's groundwater. There are two communities nearby that are wholesale suppliers for surface water.

#### 10.3.1 Lake Michigan Surface Water – Green Bay Water Utility

The Green Bay Water Utility supplies water to Ashwaubenon, Hobart, the Town of Scott, and Wrightstown. The Green Bay Water Utility obtains water from Lake Michigan by Algoma. The water hardness of the water from Lake Michigan is 135-155 mg/L (8-9 grains per gallon).

The nearest water transmission main connection is located near the Village of Wrightstown. The pipeline is an 18-inch diameter pipeline that serves Wrightstown. The pipeline may have capacity to supply Kaukauna Utilities with surface water. The transmission main is approximately 4.5 miles from Kaukauna Utilities' water distribution system. Kaukauna Utilities would need to install a 4.5-mile pipeline to connect to the surface water transmission main near Wrightstown. A booster pump station may be required to pump water to Kaukauna.

This option also includes the annual cost of purchasing water from the Green Bay Water Utility. Currently, the wholesale water rate from the Green Bay Water Utility is $2.55 per 1,000 gallons. The wholesale water rate is the same for all their wholesale customers. A conveyance charge is also required to be paid to Wrightstown and Ashwaubenon for using their transmission mains. The conveyance rate for Ashwaubenon is $0.33 per 1,000 gallons. The estimated conveyance rate for Wrightstown is $0.50 per 1,000 gallons.

### 10.3.2 Lake Winnebago Surface Water – Appleton Water Department

The City of Appleton obtains surface water from Lake Winnebago. The nearest connection point is located approximately 2.5 miles southwest of the Kaukauna Utilities water system. The pipeline is a 12-inch diameter pipeline that serves Sherwood. The pipeline may have capacity to supply Kaukauna Utilities with surface water. Kaukauna Utilities would need to install a 2.5-mile pipeline to connect to the surface water transmission main. A booster pump station may be required to pump water to Kaukauna.

This option also includes the annual cost of purchasing water from the City of Appleton. Currently, the wholesale water rate from the City of Appleton is $4.39 per 1,000 gallons. The wholesale water rate varies to each of their wholesale customers. A fire protection charge and a meter charge would be charged to Kaukauna Utilities each quarter. These charges are based on each customer's specific situation. An estimated fire protection charge is $35,500 per quarter. The estimated meter charge is $700 per quarter.

### 10.3.3 Surface Water Risks

There is risk with purchasing water from another utility. Initially, there is only a single transmission main from the source water to the distribution system. There is a risk of transmission main failure. Kaukauna Utilities would have to decide if a backup system is going to be maintained in case of pipeline failure or other issues with the purchased water. If switching to surface water, it is recommended that the wells should be maintained as a backup system in case of emergency. The DNR does not require water treatment equipment to be maintained for emergency backup systems.

The water rates can be unpredictable when set outside of the utility. The water rates are set by the PSC. It also does not give Kaukauna Utilities any control over final water quality.

### 10.3.4 Surface Water Costs

The cost comparisons between the two surface water options are included in **Table 8** below. A detailed breakdown of this cost estimate is included in **Appendix A.**

Table 8: Surface Water Options Cost Breakdown

| Description | Capital Cost Estimate | Annual O+M Estimate | 20-Yr O+M Estimate | Capital + 20-Year O+M Estimate |
|---|---|---|---|---|
| **Surface Water from Appleton** | $6,570,000 | $ 2,280,000 | $45,500,000 | $52,100,000 |
| **Surface Water from Wrightstown** | $9,270,000 | $1,660,000 | $ 33,100,000 | $42,400,000 |

**Kaukauna Utilities should stay with groundwater since well capacity and aquifer capacity is projected to be sufficient for at least the next 20 years. If Kaukauna Utilities chooses to pursue the option of changing the source water to surface water, it is recommended that a further study be performed to determine specific connection points and hydraulics required for the**

**connection pipeline. The preliminary costs estimates should be refined in that study before a final decision is made to switch to surface water.**

### 10.4 Water Reuse

Water reuse is the capture and use of wastewater for beneficial use such as agricultural irrigation, industrial cooling, or potable water. Indirect potable reuse (IPR) uses an environmental buffer such as a lake, river, or aquifer before the water is treated at a drinking water treatment plant. Direct potable reuse (DPR) involves treatment and distribution of water without an environmental buffer. IPR is the more common water reuse method.

Water reuse has been an effective solution in areas with little access to fresh water. As early as 1962, Montebello Forebay in Los Angeles County, California started using IPR by recharging the aquifer with wastewater treatment plant effluent. In recent years, a lack of water in some communities has sped up the integration of water reuse into water systems. Wichita Falls, Texas experiences extreme drought conditions throughout the year. In 2018, Wichita Falls brought its IPR project into service, which discharges wastewater via a 17-mile pipeline to a lake. This water is then treated with Cloth Media Filtration and used for drinking water. Several water districts across California have also implemented water reuse. Orange County Water District employs a Groundwater Replenishment System. This process takes treated wastewater effluent from Orange County Sanitary and treats it with microfiltration, reverse osmosis, and ultraviolet light disinfection. The treated water is then pumped into injection wells and percolation basins. **Figure 3** is from the EPA and shows planned and construction reuse projects in the United States as of 2017.

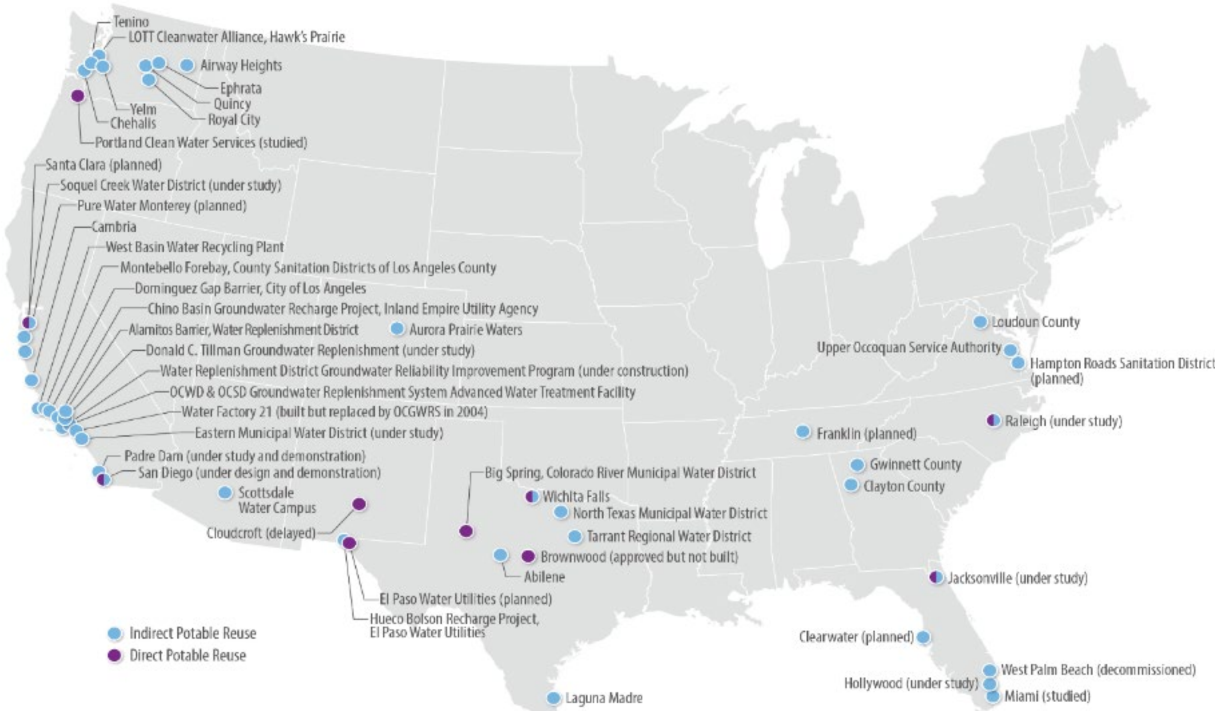


Figure 3: Water Reuse Programs in the U.S. 2017

**Reference:** U.S. Environmental Protection Agency and CDM Smith. 2017. Potable Reuse Compendium. Washington D.C.

Kaukauna Utilities has expressed an interest in investigating the feasibility of reusing wastewater treatment plant effluent from the Heart of the Valley Metropolitan Sewerage District (HVMSD) as a drinking water source. HVMSD receives wastewater from Kaukauna, Little Chute, Kimberly, Combined Locks, and the Darboy Sanitary District. The average daily flow to the plant is 5.5 MGD. The plant can treat flows up to 26 MGD.

HVMSD discharges effluent to the Fox River. The water reuse project for Kaukauna Utilities would involve rerouting some of the effluent water for drinking water treatment. HVMSD already provides 3 MGD to Fox Energy Center for power plant cooling. There would be sufficient effluent water to supply Kaukauna Utilities because the maximum day demand for Kaukauna Utilities is approximately 2 million gallons. The average day demand for Kaukauna Utilities is 1.3 million gallons.

There has been one case study in central Wisconsin on water reuse. The case study was the result of declining water levels and increasing water demand in the area. A pilot study was conducted with DNR approval involving the treatment of water in a stream down-river of the municipality’s wastewater treatment plant. The project did not result in water reuse in the area due to public disinterest and DNR involvement.

The DNR requires that community water be taken from the best available source. The best available source is determined through many characteristics including contaminant concentrations, seasonal variations, and treatment required. Determining the characteristics of the effluent water from HVMSD would require intensive testing. It is unlikely the effluent water would be determined to be of a higher quality than the current groundwater source for Kaukauna Utilities.

Even if the effluent water was determined to be the best available source, there would be high capital and operational costs associated with water reuse. The pilot study would be required to run throughout at least a full calendar year to determine how treatment efficiency would change seasonally. The whole treatment process would need to be more advanced than reverse osmosis treatment and would need to include multiple stages of disinfection. Lastly, because water reuse is new to municipalities in the state of Wisconsin, the DNR would require extensive testing throughout the life of the water reuse plant to ensure quality water is being delivered to Kaukauna Utilities’ customers. The PSC may not allow a water reuse project to advance if there are other, less costly options for safe drinking water.

Even with these hurdles, the largest barrier for water reuse in Kaukauna Utilities would be public perception. Each community that has implemented water reuse has faced the difficulty of public acceptance. To gain public acceptance, extensive information campaigns to educate the community would be necessary. This adds time and expense to a water reuse project.

**Kaukauna Utilities should stay with groundwater since well capacity and aquifer capacity is projected to be sufficient for at least the next 20 years. If Kaukauna Utilities chooses to pursue the option of changing to water reuse, it is recommended that a further study be performed to determine constituents in the HVMSD effluent water.**

## 11. Water Quality

### 11.1 Raw Water Quality

Full raw water quality results for all wells are included in **Appendix E.** Kaukauna Utilities currently treats raw water by removing iron and radium. Water hardness is also an issue in the water system. Currently, customers are responsible for softening their water. The raw water quality results are summarized in **Table 9**.

Table 9: Raw Water Quality Summary

| Well No. | Iron (mg/L) | Strontium (mg/L) | Sulfate (mg/L) | Hardness as CaCO3 (mg/L) | Total Dissolved Solids (mg/L) | Sample Date |
|---|---|---|---|---|---|---|
| **4** | 0.61 | 24 | 583 | 754 | 1,088 | 2/22/2023 |
| **5** | 0.81 | 21 | 607 | 778 | 1,173 | 2/22/2023 |
| **10** | 0.59 | 27 | 381 | 536 | 802 | 2/22/2023 |
| **8** | 0.55 | 20 | 441 | 565 | 862 | 2/22/2023 |
| **9** | 0.53 | 26 | 451 | 619 | 918 | 2/22/2023 |

The Utility tested the raw water for PFAS in February 2023. All five wells were found to have no detection of any PFAS compounds in the raw water.

### 11.2 Treated Water Quality

The water treatment plants (Main Filter Plant, Well, 8 and Well 9 treatment plants) are removing iron and radium to levels acceptable by Kaukauna Utilities. The drawback to the current treatment technique is the high cost of removing radium with chemical addition and the lack of water hardness removal. A summary of finished water quality results for the treated water is included in **Table 10. Appendix E** includes more finished water quality data from sample points around the distribution system.

Table 10: Finished Water Quality

| Testing Location | Total Chlorine (mg/L) | Iron (mg/L) | Sulfate (mg/L) | Hardness as CaCO3 (mg/L) | Sample Date |
|---|---|---|---|---|---|
| **Main Filter Plant** | --- | <0.02 | --- | 665 | 4/23/2021 |
| **Entry Point 8** | --- | <0.02 | --- | 585 | 4/23/2021 |
| **Entry Point 9** | --- | 0.02 | --- | 639 | 4/23/2021 |
| **Entry Point 8** | 1.71 | <0.06 | 430 | 618 | 10/20/2022 |
| **Entry Point 9** | 1.80 | <0.06 | 464 | 670 | 10/20/2022 |
| **Entry Point 400** | 1.83 | <0.06 | 528 | 727 | 10/20/2022 |
| **777 Island St** | 1.26 | 0.06 | 536 | 719 | 10/20/2022 |
| **2700 Northridge Dr** | 1.25 | <0.06 | 440 | 638 | 10/20/2022 |
| **406 10$^{th}$ St** | 1.30 | <0.06 | 456 | 677 | 10/20/2022 |
| **1701 CTY HWY CE** | 1.33 | <0.06 | 485 | 706 | 10/20/2022 |
| **Main Filter Plant** | --- | <0.06 | 548 | 563 | 1/17/2023 |

Note the finished water quality's hardness concentration is very similar to the raw water hardness. The pressure filter tanks do not remove water hardness.

The DNR requires chlorine in the distribution system to be greater than 0.01 mg/L, with a maximum residual chlorine level of 4 mg/L. The chlorine results show that Kaukauna Utilities is maintaining an acceptable level of chlorine in the distribution system.

The DNR sets secondary maximum contaminant levels for drinking water in NR 809.70. The secondary maximum contaminant levels are for inorganic chemicals that do not have health risks when exceeded and are only associated with cosmetic or aesthetic aspects of drinking water quality. There are no DNR violations when the maximum levels are exceeded. NR 809.70(1) states "Waters containing inorganic chemicals in quantities above the limits contained in this section are not hazardous to health but may be objectionable to an appreciable number of persons." The secondary standard for sulfate is 250 mg/L. Finished water sulfate level ranges from 430-548 mg/L. The secondary standard for total dissolved solids is 500 mg/L. Total dissolved solids level ranges from 802-1173 mg/L.

NR 809.71, Sampling and Analytical Requirements for Secondary Standards, states if the DNR receives complaints on aesthetic water quality, then the water supplier will be required to implement a monitoring program to determine compliance with the secondary standards.

Water supplied by Kaukauna Utility is completely safe to drink and does not pose a health risk.

### 11.2.1 Strontium

Strontium is not currently regulated by the DNR. It is a naturally occurring mineral found in groundwater. It does not pose a cancer risk to people but could have other health impacts. Because of this, the EPA has considered establishing a maximum contaminant level for strontium. The current level of strontium in Kaukauna Utilities' drinking water is higher than any level being considered for the maximum contaminant level by the EPA. The EPA has set a non-enforceable lifetime limit of 4 mg/L and a short-term limit of 25 mg/L. If the EPA pursues setting a maximum contaminant level for strontium in the future, the current levels in Kaukauna Utilities' drinking water would need to be addressed and treatment would need to be added for strontium removal.

### 11.2.2 Water Hardness

There is no secondary standard for water hardness directly, but water hardness and sulfate both contribute to total dissolved solids. The water in Kaukauna is extremely hard. The main components of water hardness are caused by calcium and magnesium. The groundwater in Kaukauna has a total water hardness level of $CaCO_3$ ranging from 563-778 mg/L (36-45 grains per gallon). Kaukauna Utilities encourages customers to use a total water hardness setting of 48 grains per gallon for their water softeners because the water softener should be set to 4 grains per gallon higher than the water hardness.

There is a wide range in the water hardness test results. Table 11 shows water hardness testing results from two different laboratories from 2021 – 2023. The main filter plant site shows a water hardness range of 665-838 mg/l. It is suspected that the large range of water hardness levels is not accurate as water hardness should not vary greatly at each site.

## Table 11 - Hardness Testing Results

| *Location* | | Main Filter Plant | | | | | Well 4 | | Well 5 | Well 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Laboratory* | | Carus | Carus | Carus | Carus | Carus | Carus | Badger | Badger | Carus | Badger |
| *Test Date* | | 4/23/2021 | 2/25/2022 | 2/25/2022 | 2/25/2022 | 2/25/2022 | 4/23/2021 | 2/22/2023 | 2/22/2023 | 4/23/2021 | 2/22/2023 |
| *Treated or Raw Water* | | Treated | Treated | Treated | Finished | Finished | Raw | Raw | Raw | Raw | Raw |
| Hardness as CaCO3 | mg/l | 665 | 792 | 838 | 827 | 810 | 783 | 754 | 778 | 548 | 536 |
| Calcium | mg/l | 231 | 278 | 295 | 287 | 281 | 280 | 271 | 279 | 182 | 178 |
| Magnesium | mg/l | 21 | 23 | 25 | 27 | 26 | 20 | 19 | 20 | 22 | 22 |

| *Location* | | Well 8 | | | | Well 9 | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Laboratory* | | Carus | Carus | Badger | Badger | Carus | Carus | Badger | Badger |
| *Test Date* | | 4/23/2021 | 4/23/2021 | 2/22/2023 | 10/20/2022 | 4/23/2021 | 4/23/2021 | 2/22/2023 | 10/20/2022 |
| *Treated or Raw Water* | | Raw | Finished | Raw | Finished | Raw | Finished | Raw | Finished |
| Hardness as CaCO3 | mg/l | 585 | 589 | 565 | 618 | 637 | 639 | 619 | 670 |
| Calcium | mg/l | 202 | 203 | 195 | 215 | 215 | 216 | 210 | 229 |
| Magnesium | mg/l | 19 | 19 | 19 | 19 | 23 | 24 | 23 | 23 |

Note: Carus testing  data on 2/25/2022 at Main Filter Plant is not considered accurate beause they are higher than any individual test result at Well 4, 5, or 10. The Main Filter Plant water hardness is the weighted average of the water from Wells 4, 5, and 10.

For example, the Main Filter Plant water hardness levels should be the same as a weighted average of the water hardness levels from Wells 4, 5, and 10. The Main Filter Plant water hardness level cannot be higher than any of the levels from the individual wells. But in February 2022, the Main Filter Plant water hardness was measured at 792-838 mg/L, which is higher than the water hardness measured individually at Wells 4, 5, or 10. This inconsistency in water hardness could be a result of different testing methods from different laboratories or from the testing being wrong that day. Strontium, orthophosphate, and polyphosphate interfere with the water hardness testing procedure.

## 12. Main Filter Plant Alternatives Analysis

Part of the Main Filter Plant site is located in the 100-year floodplain of the Fox River. As previously explained in Section 8.1.4 Main Filter Plant Site, the pressure filter tank in the Main Filter Plant building is in poor condition and is in need of replacement. There are four alternatives being considered for the Main Filter Plant.

### 12.1 Alternative 1: No Changes

This alternative includes not making any improvements to the Main Filter Plant or changing the location. The high risk associated with this alternative is having the Main Filter Plant fail and not being able to produce potable water. The high risk is associated with the pressure filter developing leaks that cannot be repaired so the tank cannot be placed back in service in a timely fashion. The Main Filter Plant produces potable water at 1,450 gpm. If the Main Filter Plant is removed from service, then Well 4, Well 5, and Well 10 would be out of service. The Main Filter Plant can be removed from service during low flow periods but should not be removed from service during high flow periods. If the Main Filter Plant was removed from service for several months during high flow periods, over-pumping of Well 8 and Well 9 would occur. The aquifer would not be able to recharge properly during that time.

This alternative is not recommended because the structures at the Main Filter Plant are past their useful life. The pressure filter tank was lined in 2016 as a temporary solution to extend the life of the filters by about ten years. The filters should be replaced to ensure the Main Filter Plant can function when the liner fails.

The ground storage reservoirs present a high risk of groundwater leaking into the reservoir. Groundwater can contain surface water contaminants that can cause widespread sickness to customers. The current process of chlorine addition minimizes the risk of these contaminants impacting customer health.

This alternative is not desirable because the Main Filter Plant is located within the 100-year floodplain of the Fox River. Wisconsin DNR Administrative Code Chapter NR811.25 (1) (d) states all water system related buildings must be constructed such that the floor elevation is at least two feet above the 100-year flood elevation. The Main Filter Plant currently does not meet this requirement but is grandfathered into the code.

In addition to the building itself being in the floodplain, the reservoirs on the Main Filter Plant site are in the 100-year floodplain. In Wisconsin DNR Administrative Code Chapter NR 811.63(1), it states that potable water storage facilities may not be located within a floodway and the lowest elevation of the bottom floor shall be a minimum of two feet above the regional 100-year flood elevation. The existing reservoirs are not in the floodway but are in the floodplain. The bottom floors of the reservoirs are below the 100-year floodplain and the groundwater table. The existing water reservoirs do not conform to the current Wisconsin DNR Administrative Code requirements, thus posing a larger risk of contaminants leaking into the ground storage reservoirs.

### 12.2 Alternative 2: Replace Pressure Filter Tank at Current Location

This alternative includes replacing just the pressure filter tank at the Main Filter Plant. This alternative is to be considered the bare minimum for improvements needed at the Main Filter Plant because the concrete liner in the steel pressure filter tank is anticipated to start leaking considerably in less than five years. There are currently signs of the pressure filter tank leaking. This alternative would involve reusing the existing building for the pressure filter tank. The work would need to be coordinated to remove the Main Filter Plant from service during the low flow months to install the new pressure filter tank. This raises the cost of this alternative to speed up the replacement process.

This alternative does not consider any other improvements at the Main Filter Plant site, such as the aged ground storage reservoirs. In addition, it does not move the Main Filter Plant out of the floodplain and therefore would not address the current Wisconsin DNR Administrative Code violations associated with their location in the floodplain discussed in Alternative 1. This alternative is not recommended for these reasons.

The preliminary cost estimate for replacing the pressure filter tank at the Main Filter Plant is included in **Table 14.**

### 12.3 Alternative 3: Rebuild Water Treatment Plant Building and Reservoirs at Current Location

This alternative includes a new pressure filter tank, reservoirs, booster pumps, suction and discharge piping, and a generator at the current Main Filter Plant location. This alternative includes demolition of existing reservoirs, booster pumps, and piping in the Booster Pump Station. This alternative includes reusing the Main Filter Plant Building.

This alternative was explored to determine if there would be any cost savings associated with staying on the same site for the Main Filter Plant. There are some limitations with staying at the current site. The Main Filter Plant must stay in operation during construction to supply average water demand during high flow periods. The water system cannot be supplied by just Well 8 and Well 9 during the entire construction period. The work would need to be coordinated to remove the Main Filter Plant from service during the low flow months to install the new pressure filter tank. This raises the cost of this alternative in order to speed the replacement process along.

The reservoir construction must be sequenced so that one reservoir is demolished, part of the new reservoir is built, then the other reservoir is demolished and the second part of the new reservoir can be built. This sequencing is necessary due to the need for the reservoir during construction, as well as the limited space on site. The current reservoir locations will have to be used for the future reservoir. These construction sequencing requirements will add to the cost of this alternative.

This alternative is beneficial because it would not involve rerouting the transmission main from Wells 4, 5, and 10 to a new location. There is currently an 8-inch transmission main that connects Well 4 (100 linear feet), Well 5 (2,100 linear feet), and Well 10 (6,100 linear feet) to the existing Main Filter Plant.

This alternative is also not desirable because the Main Filter Plant site would still be located in the floodplain. Keeping the Main Filter Plant in the floodplain does not comply with Wisconsin DNR Administrative Code, as discussed in Alternative 1.

The DNR may not allow this as an alternative unless the floor of the Main Filter Plant building was raised two feet above the 100-year floodplain during the installation process of the tank. A detailed predesign study would need to be performed to determine if the DNR would require alterations to the building and to determine the feasibility of the actual construction process and length of construction for the work. It is possible that the construction time frame would be too long to have the Main Filter Plant out of service.

If a different treatment process is selected, the Main Filter Plant building would require an addition. The preliminary cost estimates for rebuilding the Main Filter Plant at the current site are included in **Tables 14, 15, and 17.**

### 12.4 Alternative 4: New Water Treatment Plant Building at New Site

This alternative includes building a new Water Treatment Plant building including a new pressure filter tank, booster pumps, suction and discharge piping, ground storage reservoir, and a generator on a new site. This alternative includes demolition of the existing reservoirs, booster pumps, and the piping in the Booster Pump Station and removing the pressure filter tank from the Main Filter Plant building and repurposing the existing Main Filter Plant building to a storage facility.

Four proposed building sites for a new Water Treatment Plant building are being considered to relocate the Main Filter Plant outside the 100-year floodplain. A two-acre site is needed for the new Main Treatment Plant. The main drawbacks of this alternative are the high capital costs of new building construction and the cost of rerouting the raw water transmission main for Wells 4, 5, and 10 to a new site. All the sites being considered are along the raw water transmission main from Well 10 to the existing Main Filter Plant to minimize the raw water transmission main costs.

This alternative has the major benefit of moving the Main Filter Plant outside the floodplain. This would allow access and use of the water treatment plant and reservoirs during a 100-year flood event. The preliminary cost estimate for building the Main Filter Plant at a new site is included in **Tables 14, 15 and 17.**

Four sites were considered for a new Water Treatment Plant building location. A map of the proposed Water Treatment Plant sites is shown in **Figure 10** in **Appendix B.**

Proposed Site #1 is on Boyd Avenue, just south of the City pool at the current archery range site. This site is desirable due to its proximity to the existing raw water transmission main, and the property is currently owned by the City of Kaukauna. This site is also uphill from the river, fairly level, and out of the floodplain. The archery range is currently located on this site.

Proposed Site #2 is to the west of the Konkapot Creek Trail. This site is also near the existing raw water transmission main. This site is undesirable due to the steep topography in this area.

Proposed site #3 and #4 are in Horseshoe Park. These sites are beneficial because they are already located on City-owned property and are near the raw water transmission main. These sites are also outside the floodplain. Site #3 is north of the baseball field. This site is not desirable due to the steep slope. Site #4 is not desirable because it is the site of a former fill site, not suitable for building foundations.

### 12.5 Main Filter Plant Recommendations

The risks and benefits for each alternative for the Main Filter Plant are included in **Appendix G**.

**Alternative #4 - New Water Treatment Plant Building at New Site is the recommended alternative. The new Main Water Treatment Plant location would allow for the necessary building size for new treatment equipment and would comply with the DNR regulation of being outside the floodplain. This alternative would lower the risks associated with having the Main Filter Plant, reservoirs, and booster pump station in the floodplain and would replace the equipment and structures identified in the study report as being past their useful life. Alternative #4 also allows the existing Main Filter Plant to keep producing water while the new water treatment plant is being built.**

**Site #1, located on Boyd Street just south of the City pool at the current archery range site, is considered the most viable location for the proposed Water Treatment Plant building that was studied. Site #1 appears to be the most feasible of the properties studied since the property is already owned by the City, the property is relatively level, and the property is close to the raw water transmission main located at Well 5. We recommend that a predesign study be performed to refine the preliminary cost estimate for the alternative, exact site, and treatment option selected. This study should include working with the City on relocation of the archery range site.**

## 13. Water Treatment Analysis

The scope of the study includes an analysis of various water treatment processes to remove water hardness. The focus of the treatment options is removing water hardness to address customer concerns and provide cost savings to customers.

### 13.1 Surveys

A survey of Kaukauna Utilities' customers was conducted to gain a better understanding of how customers soften and use their water, and what customers would like to see in water improvements moving forward. There were 1,309 people that responded to the survey. It was found that 87% of respondents use a water softener to treat their water. The survey showed that 957 respondents use a water filter in their house or buy bottled water for drinking water instead of drinking water directly from the tap. Only 8% of respondents did not want to see improvements or changes to the water quality in Kaukauna. Of the respondents that gave a reason for their dissatisfaction with the water quality, hard water was the top reason for dissatisfaction. The survey questions and results are included in **Appendix H.**

A survey of plumbing contractors and salt suppliers in the Fox Valley area was conducted to investigate how much Kaukauna Utilities' customers spend on water softening and replacement appliances compared to other communities. Questions included the lifespan of different appliances in Kaukauna versus other communities, the cost of replacement water heaters, and the amount of salt customers use each month. The survey questions and results are included in **Appendix H.**

### 13.2 Water Softeners

Based on the Kaukauna Utilities customer survey, 1,131 people out of 1,304 people (87%) that answered the question chose to treat the water with a water softener. Water softeners use an ion exchange process to remove water hardness. Ion exchange water treatment is a common method used to remove water hardness from water by exchanging calcium and magnesium ions with sodium or potassium ions. Water softeners require salt to operate. While this ion exchange process is effective for moderately hard water, water softeners can face challenges when dealing with water that is extremely hard.

When the ion exchange resin comes in contact with extremely hard water, the resin gets exhausted quickly as it reaches its maximum capacity for exchanging ions. As a result, the resin needs frequent regeneration which uses more salt and water. The need for more frequent regeneration cycles adds to the operational costs and disrupts the continuous flow of treated water. It also requires larger ion exchange equipment to handle the higher volume of resin.

When using sodium as the exchange ion, the process adds sodium ions to the treated water. The extremely hard water will add a significant amount of sodium ions to the water. Sodium, when dissolved in water, forms sodium ions ($Na^+$), which are charged particles. These ions increase the water's overall conductivity, meaning the water becomes a better conductor of electricity.

Water heaters have metal components, such as heating elements and the tank itself. When high-conductivity water (water with high sodium content) surrounds these metal parts, it creates an environment that facilitates an electrochemical process known as electrolytic corrosion. This corrosion occurs when electric currents flow between different metal components through the conductive water resulting in the breakdown of the metal over time. The electrolytic corrosion eats away at the metal components of the downstream equipment leading to leaks, rust, and ultimately, failure.

Water heaters in Kaukauna have been estimated to fail every five to seven years based on information from the local plumbing contractors. Clothes washers, dish washers, and water fixtures are also ruined prematurely and need to be replaced sooner with corrosive water.

It is important to note that while sodium can contribute to increased conductivity and corrosion, other factors, such as the presence of other dissolved minerals and the pH of the water, can also play a role in the corrosion process.

### 13.3 Target Water Hardness

The recommended target water hardness level is between 70-120 mg/L (4-7 grains per gallon). There are factors that contribute to this recommended water hardness level.

Water hardness levels for communities surrounding Kaukauna were compared. The target water hardness level for Kaukauna is lower than the water hardness level in the surrounding communities. It is anticipated that by providing water at this hardness level, Kaukauna customers can remove or bypass their water softeners. Table 12 has the water hardness levels for surrounding communities.

Additionally, Kaukauna Utilities performed a taste test on six different bottled waters. Each person who participated in the taste test ranked their top choice of bottled water by flavor. The hardness level of each bottled water was also tested. The bottled water hardness ranged from 4-10 grains per gallon. It was found that taste was subjective and lower hardness does not always result in better tasting water. **Table 12** also includes the water hardness results from Kaukauna Utilities' taste test.

Table 12: Water Hardness Level Comparisons

| Water Source | Water Hardness Level (mg/L) | Water Hardness Level (grains per gallon) |
|---|---|---|
| City of Appleton | 138 | 8.0 |
| City of Green Bay | 157 | 9.1 |
| Village of Little Chute | 129 | 7.5 |
| Village of Kimberly | 95 | 5.5 |
| Village of Wrightstown | 157 | 9.1 |
| Core Bottled Water | 69 | 4 |
| Smart Water Bottled Water | 69 | 4 |
| Fiji Bottled Water | 138 | 8 |
| Ice Mountain Bottled Water | 172 | 10 |
| Nature's Touch Bottled Water | 103 | 6 |
| Aquafina Bottled Water | 69 | 4 |

Another resource when determining the target water hardness for Kaukauna Utilities was the UW-Madison Water System Excellence Project (WSEP) Wisconsin Water Utility Report Cards. The WSEP compiled publicly available and original data to "grade" municipal water on multiple subjects – Water Quality - Health, Water Quality - Aesthetics, Finance, Infrastructure & Operations, and Communications. The Water Quality - Aesthetic score incorporates water hardness into the grade. **Appendix F** includes more details into the WSEP Report Card grading.

The current average water hardness of Kaukauna Utilities' water is 665 mg/L (39 grains per gallon). This results in a water quality - aesthetics score of 63.6, which is a grade of D-. The water quality - aesthetic score for Kaukauna Utilities' water was calculated for different hardness levels if centralized softening was implemented. Kaukauna Utilities would receive a score between 94.4 - 96.8 with a finished water hardness between 70-120 mg/L (4-7 grains per gallon). This score is considered an "A", or excellent water quality, with respect to hardness. **Figure 4** illustrates how the quality - aesthetic score for Kaukauna Utilities changes with different target water hardness levels.

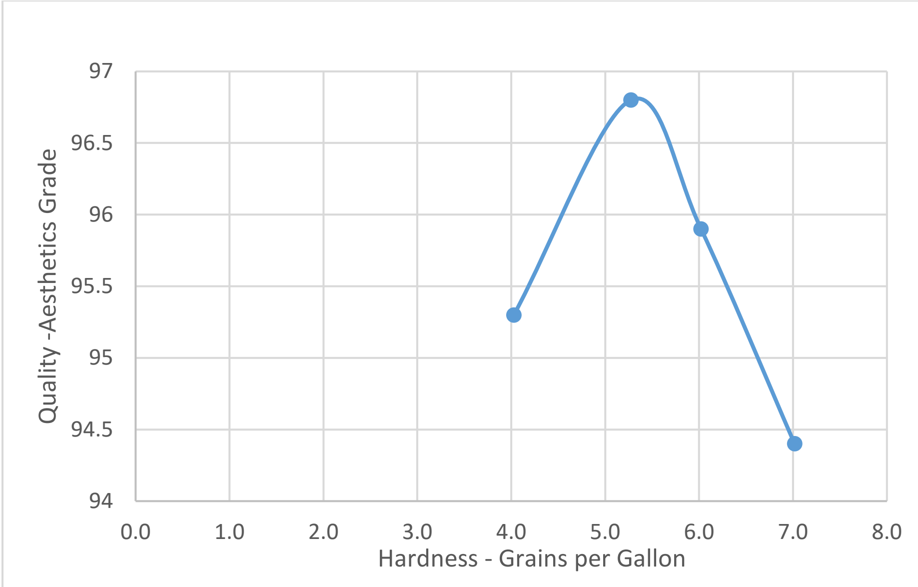


Figure 4: Kaukauna Water Quality - Aesthetics Score for Different Proposed Target Hardness Levels Using Reverse Osmosis Treatment

A case study with a similar change in water hardness occurred in Wrightstown when they switched from using groundwater as their source of water to purchasing surface water from Lake Michigan. When Wrightstown was using groundwater as the water source, the water hardness level was 540 mg/L (32 grains per gallon). By switching to surface water, the water hardness level is now 155 mg/L (9.1 grains per gallon). Wrightstown has estimated that 90% of residents no longer use water softeners. It is expected that a similar change in water softening by customers will occur if Kaukauna changes their target water hardness level to between 70-120 mg/L (4-7 grains per gallon).

**Appendix F** includes supplemental information on water hardness which contributed to the recommended target water hardness level for Kaukauna Utilities.

### 13.4 Customer Cost Savings for Water Hardness Reduction Performed by Utility

The survey results were compiled and extrapolated to find the cost savings if the customers receive water with a water hardness level between 70-120 mg/L (4-7 grains per gallon). It is assumed that if Kaukauna Utilities adds treatment for water hardness reduction, customers will remove their water softeners and save on costs associated with water softening and longer service life for water heaters and appliances. An explanation of calculations is included in **Appendix H.** It is anticipated that the average residential customers of Kaukauna Utilities will save approximately $720 per year. The potential total savings for all the customers is $4.8 million annually by receiving water that has water hardness reduced to a level between 70-120 mg/L (4-7 grains per gallon). This calculation is a conservative estimate for the items that could be quantified. See **Table 13.1 and 13.2.** There are far more benefits than those listed in the estimate such as the saving of faucets, valves, coffee makers, showers, toilets, swimming pools, and hot tubs. The reduced water hardness will also add life to plumbing fixtures.

# Table 13.1 - Estimated Annual Water Softening Costs for Residential Customers with 3/4" Meter

Kaukauna Utilities
Estimate Annual Costs Savings for Customers with 3/4" Meter if Hardness Reduction Treatment is Implemented
April 4, 2024

| *Percentage of Customers to Which Costs Apply* | *75%* | *15%* | *10%* |
|---|---|---|---|
| **Residential Customer Costs with Current Treatment - Iron and Radium Filtration** | | | |
| Salt Usage Costs - Materials Only[1] | \$ 180 - \$ 240 | \$ 180 - \$ 240 | |
| Labor Costs for Salt | \$ - - \$ - | \$ - - \$ - | |
| Water Softener Regeneration Water Costs | \$ 95 - \$ 135 | \$ 95 - \$ 135 | |
| Water Softener Replacement Costs | \$ 80 - \$ 120 | \$ 80 - \$ 120 | |
| Water Heater Replacement Costs[2] | \$ 125 - \$ 175 | \$ 125 - \$ 175 | \$ 125 - \$ 175 |
| Appliance Replacement Costs[2] | \$ 225 - \$ 275 | \$ 225 - \$ 275 | \$ 225 - \$ 275 |
| Bottled/ Home Filter Water Costs[1] | \$ 220 - \$ 260 | | |
| Total Annual Costs | \$ 925 - \$ 1,205 | \$ 705 - \$ 945 | \$ 350 - \$ 450 |
| **Average Annual Costs with Current Treatment** | **\$ 1,065** | **\$ 825** | **\$ 400** |
| **Residental Customer Costs with Adding Hardness Reduction Treatment** | | | |
| Water Heater Replacement Costs[2] | \$ 80 - \$ 100 | \$ 80 - \$ 100 | \$ 80 - \$ 100 |
| Appliance Replacement Costs[2] | \$ 125 - \$ 175 | \$ 125 - \$ 175 | \$ 125 - \$ 175 |
| Total Annual Costs | \$ 205 - \$ 275 | \$ 205 - \$ 275 | \$ 205 - \$ 275 |
| **Average Annual Costs with Hardness Reduction Treatment** | **\$ 240** | **\$ 240** | **\$ 240** |
| **Summary** | | | |
| Average Annual Costs with Current Treatment | \$ 1,065 | \$ 825 | \$ 400 |
| Average Annual Costs with Hardness Reduction Treatment | \$ 240 | \$ 240 | \$ 240 |
| **Annual Cost Savings for Residential Customers** | **\$ 825** | **\$ 585** | **\$ 160** |
| Total Number of Residental Customers with 3/4" Meter | 4,856 | 971 | 647 |
| | | | |
| **Estimated Total Annual Residential Customer Cost Savings** | **\$ 4,006,000** | **\$ 568,000** | **\$ 104,000** |
| **Potential Total Annual Customer Cost Savings** | | | **\$ 4,678,000** |
| **Estimated Weighted Average Annual Cost Saving for Residential Customers** | | | **\$ 723** |

[1]Costs from Kaukauna Customer Cost Survey

[2]Costs from Plumber and Softening Company Surveys

# Table 13.2 - Estimated Annual Water Softening Costs for Customers

Kaukauna Utilities
Estimate Annual Costs Savings for Customers if Hardness Reduction Treatment is Implemented
April 4, 2024

| | Residential Water Service | | Commerical & Industrial Water Service | | Residential, Commercial, & Industrial Water Service | | | |
|---|---|---|---|---|---|---|---|---|
| *Meter Size* | *0.75 Inch* | *1.0 Inch* | *0.75 Inch* | *1.0 Inch* | *1.5 Inch* | *2.0 Inch* | *3.0 Inch* | *4.0 Inch* |
| **Customer Costs with Current Treatment - Iron and Radium Filtration** | | | | | | | | |
| Salt Usage Costs - Materials Only | See Table 13.1 | $ 325 - $ 400 | $ 180 - $ 240 | $ 325 - $ 400 | $ 790 - $ 890 | $ 1,400 - $ 1,600 | $ 3,100 - $ 3,500 | $ 5,000 - $ 12,000 |
| Labor Costs for Salt | | $ - - $ - | $ 240 - $ 300 | $ 320 - $ 380 | $ 450 - $ 550 | $ 700 - $ 900 | $ 1,200 - $ 1,600 | $ 2,000 - $ 6,000 |
| Water Softener Regeneration Water Costs | | $ 180 - $ 220 | $ 95 - $ 135 | $ 180 - $ 220 | $ 430 - $ 490 | $ 720 - $ 920 | $ 1,600 - $ 2,000 | $ 2,500 - $ 4,500 |
| Water Softener Replacement Costs | | $ 125 - $ 200 | $ 80 - $ 120 | $ 125 - $ 200 | $ 350 - $ 450 | $ 600 - $ 800 | $ 1,400 - $ 1,800 | $ 4,000 - $ 28,000 |
| Water Heater Replacement Costs | | $ 240 - $ 290 | $ 125 - $ 175 | $ 240 - $ 290 | $ 550 - $ 650 | $ 900 - $ 1,100 | $ 2,200 - $ 2,600 | $ 3,000 - $ 8,000 |
| Appliance Replacement Costs | | $ 225 - $ 275 | - | - | - | - | - | - |
| Total Annual Costs | | $ 1,095 - $ 1,385 | $ 720 - $ 970 | $ 1,190 - $ 1,490 | $ 2,570 - $ 3,030 | $ 4,320 - $ 5,320 | $ 9,500 - $ 11,500 | $ 16,500 - $ 58,500 |
| **Average Annual Costs with Current Treatment** | | **$ 1,240** | **$ 845** | **$ 1,340** | **$ 2,800** | **$ 4,820** | **$ 10,500** | **$ 37,500** |
| **Customer Costs with Adding Hardness Reduction Treatment** | | | | | | | | |
| Water Heater Replacement Costs | See Table 13.1 | $ 140 - $ 180 | $ 80 - $ 100 | $ 140 - $ 180 | $ 330 - $ 390 | $ 600 - $ 680 | $ 1,200 - $ 1,800 | $ 2,300 - $ 2,800 |
| Appliance Replacement Costs | | $ 125 - $ 175 | - | - | - | - | - | - |
| Total Annual Costs | | $ 265 - $ 355 | $ 80 - $ 100 | $ 140 - $ 180 | $ 330 - $ 390 | $ 600 - $ 680 | $ 1,200 - $ 1,800 | $ 2,300 - $ 2,800 |
| **Average Annual Costs with Hardness Reduction Treatment** | | **$ 310** | **$ 90** | **$ 160** | **$ 360** | **$ 640** | **$ 1,500** | **$ 2,550** |
| **Summary** | | | | | | | | |
| Average Annual Costs with Current Treatment | See Table 13.1 | $ 1,240 | $ 845 | $ 1,340 | $ 2,800 | $ 4,820 | $ 10,500 | $ 37,500 |
| Average Annual Costs with Hardness Reduction Treatment | | $ 310 | $ 90 | $ 160 | $ 360 | $ 640 | $ 1,500 | $ 2,550 |
| **Annual Cost Savings for Customers** | **$ -** | **$ 930** | **$ 755** | **$ 1,180** | **$ 2,440** | **$ 4,180** | **$ 9,000** | **$ 34,950** |
| Total Number of Customers | 6,474 | 27 | 287 | 97 | 61 | 54 | 19 | 8 |
| **Estimated Total Annual Customer Cost Savings** | **$ 4,678,000** | **$ 8,000** | **$ 26,000** | **$ 16,000** | **$ 22,000** | **$ 35,000** | **$ 29,000** | **$ 20,000** |
| | | | | | | | **Potential Total Annual Customer Cost Savings** | **$ 4,834,000** |

See Appendix H for detailed calculations

### 13.5 Water Treatment Options

With a new water treatment process, raw water from Wells 4, 5, and 10 would be treated at a proposed water treatment plant located south of the Fox River. Raw water from Wells 8 and 9 would be treated at an upsized Well 9 water treatment plant located north of the Fox River. A raw water transmission main between Well 8 and 9 would be installed, and the Well 8 water treatment plant would remain for pretreatment to remove iron. All options below would include new treatment equipment at the Main Filter Plant and the upsized Well 9 Treatment Plant.

It is anticipated that if Kaukauna Utilities changes its current treatment process, a pilot test will be required by the DNR. The pilot study will add to the timeline of the project and add cost to the project compared to not changing the treatment process. As an example, the current Wisconsin DNR Administrative Code Chapter NR811.50 (3) requires a pilot length of two to seven months for reverse osmosis or nanofiltration treatment.

Each water treatment option has a summary of estimated capital and operating costs shown below. These estimated costs are shown in detail in **Appendix A.**

#### 13.5.1 Water Treatment Option 1: Keep Existing Water Treatment Process - Filtration

Water treatment option 1 is to keep the existing treatment process. This process involves filtration for iron removal and the addition of potassium permanganate and manganese sulfate for radium removal.

This option is beneficial due to the operators at Kaukauna Utilities being familiar with the existing treatment technique. It involves treatment for the major constituents of concern in the water: iron and radium. The drawback with this type of radium removal is the cost of potassium permanganate and manganese sulfate chemical which is approximately $60,000 per year for Kaukauna Utilities. The chemical cost is a major contribution to operations and maintenance costs for the water utility. **Table 14** summarizes the capital and operational costs associated with Option 1.

Table 14: Preliminary Cost Estimate: Option 1 – Keep Existing Water Treatment Process - Filtration

| Description | Capital Cost | Annual Operating Cost | 20-Years Operating Cost | Capital Cost + 20-Year Operating Cost |
|---|---|---|---|---|
| **Alternative 1 - Option 1 Filtration** | $0 | $488,000 | $9,700,000 | $9,700,000 |
| **Alternative 2 - Option 1 Filtration** | $3,100,000 | $488,000 | $9,700,000 | $12,800,000 |
| **Alternative 3 - Option 1 Filtration** | $7,300,000 | $488,000 | $9,700,000 | $17,100,000 |
| **Alternative 4 - Option 1 Filtration** | $8,300,000 | $488,000 | $9,700,000 | $18,000,000 |

This option also allows Kaukauna Utilities' water customers to have no change in water quality. This is beneficial because changing water quality can have a negative connotation with water customers. However, by not changing the current water quality, the water customers would still be receiving water high in hardness because the existing treatment technique does not remove water hardness. This results in the cost of water softening to remain on water customers.

### 13.5.2 Water Treatment Option 2: Ion Exchange Treatment Process

Water treatment option 2 is ion exchange water treatment. Ion exchange functions as a large-scale water softener. With the simplicity of the treatment technique, there is a benefit to operators who are already familiar with the water softening process. This treatment equipment is also easy to maintain and only requires salt for regenerating the resin media. This treatment process also eliminates the need for potassium permanganate and manganese sulfate for radium removal. This process would result in higher operational costs compared to the current treatment method. Ion exchange would still require filtration prior to the ion exchange system to remove iron. Ion exchange is also the treatment method used in the neighboring communities of Little Chute and Kimberly.

This process has the main benefit of reducing hardness in water. This process would benefit water customers because they would no longer have to keep and maintain their water softeners. A summary of the costs of water softening for customers is included in **Table 13.**

The main drawback of ion exchange is the high operational costs associated with buying salt. This cost outweighs the cost savings from eliminating the need for potassium permanganate and manganese sulfate. **Table 15** summarizes the capital and operating costs for Option 2.

Table 15: Preliminary Cost Estimate: Option 2 – Ion Exchange Treatment Process

| Description | Capital Cost | Annual Operating | 20-Years Operating | Capital Cost + 20-Year Operating Cost |
|---|---|---|---|---|
| **Alternative 3 - Option 2 Ion Exchange** | $15,500,000 | $670,000 | $13,400,000 | $28,900,000 |
| **Alternative 4 - Option 2 Ion Exchange** | $16,000,000 | $670,000 | $13,400,000 | $29,400,000 |

Ion exchange also discharges chlorides to the Heart of the Valley Wastewater Treatment Plant. The wastewater treatment plant is currently nearing their chloride limit. If reached, the plant would need to add a process to remove chlorides from the effluent water.

Lastly, it is anticipated that a chemical would need to be added for pH adjustment to make the water less corrosive. The ion exchange treatment process does not change the end use water quality in the system. This treatment process shifts the water softening from the customer to the Utility. It is anticipated that the amount of sodium in the treated water at the point of use will remain approximately the same as what the customers are now using with residential, commercial, and industrial water softeners operating. This means the wear on customer appliances and water heaters will be the same. It is possible the pH adjustment chemical will lengthen the life of water heaters, but there will still be higher wear associated with softened water compared to reverse osmosis or nano-filtered water because of the sodium content.

### 13.5.3 Water Treatment Option 3: Reverse Osmosis or Nanofiltration Treatment Process

Water treatment option 3 is reverse osmosis or nanofiltration treatment. This treatment process consists of pushing water through a semipermeable membrane using high pressure. Pressure filters would still be required for this option as pretreatment to remove iron. Reverse osmosis or nanofiltration treatment would replace the potassium permanganate and manganese sulfate chemical addition for the removal of radium. An antiscalant chemical would need to be added to the treatment process to not foul the membranes quickly. The operational cost savings would be a net zero cost associated with the chemicals.

The main difference between reverse osmosis and nanofiltration is the pressure needed to force the water through the membrane. Reverse osmosis uses a membrane that is less permeable than the membrane used in nanofiltration. The reverse osmosis membrane has smaller holes than the nanofiltration membrane. This difference in membrane means less constituents get through the reverse osmosis membrane than the nanofiltration membrane, but more power is required for reverse osmosis treatment. Reverse osmosis and nanofiltration result in the same finished water quality.

A major benefit of reverse osmosis or nanofiltration over Option 1 (filtration only) is that it removes water hardness. This treatment process would have the same benefits to the customers described in Option 2 associated with the removal of customer water softening. These cost savings are summarized in **Table 13**. Reverse osmosis or nanofiltration has the additional benefit of not adding sodium to the water like Option 2 does. This treatment process aids the wastewater treatment plant in lowering chloride levels while still removing hardness from water.

There are currently four reverse osmosis water treatment plants approved by the DNR in Wisconsin. Waupun Public Utilities and Stanley Municipal Waterworks have reverse osmosis treatment plants in operation. Winneconne Water Utility’s reverse osmosis water treatment plant is in construction and will be in operation soon. The City of Prescott Municipal Water Utility reverse osmosis treatment plant is planned to start construction in summer of 2024.

Municipalities in Minnesota have been incorporating reverse osmosis treatment to treat water hardness for longer than Wisconsin. The first reverse osmosis water treatment plant was constructed in 1998 in Madison, Minnesota. A summary of the three reverse osmosis water treatment plants in Minnesota that would be very similar to Kaukauna’s raw water quality are included below in **Table 16**.

Table 16: Minnesota Reverse Osmosis Water Treatment Plants

| **Municipality** | **Year Placed in Service** | **Average Day Demand (MGD)** | **Raw Water Hardness (mg/L, gpg)** | | **Finished Water Hardness (mg/L, gpg)** | |
|---|---|---|---|---|---|---|
| Northfield | In construction | 2.0 | 310 | 18 | 95 | 5.5 |
| Redwood Falls | 2011 | 1.5 | 1,015 | 59 | 215 | 12.5 |
| St. Peter | 2011 | 1.1 | 413 | 24 | 86 | 5.0 |

Redwood Falls, Minnesota accomplishes an 80% decrease in water hardness, a similar goal to Kaukauna Utilities. The communities in Minnesota that use reverse osmosis for water hardness treatment demonstrate that this treatment technique can be a feasible option for municipalities.

Reverse osmosis or nanofiltration has higher capital costs than Option 1, but lower capital costs than Option 2. Reverse osmosis or nanofiltration has higher operating costs than Option 1 and 2. **Table 17** summarizes the capital and operating cost estimates.

Table 17: Preliminary Cost Estimate: Option 3 - Reverse Osmosis or Nanofiltration

| Description | Capital Cost | Annual Operating Cost | 20-Years Operating Cost | Capital Cost + 20-Year Operating Cost |
|---|---|---|---|---|
| **Alternative 3 - Option 3 Reverse Osmosis** | $13,900,000 | $950,000 | $19,000,000 | $32,900,000 |
| **Alternative 4 - Option 3 Reverse Osmosis** | $14,400,000 | $950,000 | $19,000,000 | $33,400,000 |

Reverse osmosis or nanofiltration treatment for Kaukauna Utilities would have a waste stream of approximately 17%-20% of the water pumped. The water hardness, sulfates, total dissolved solids, radium, and strontium will get filtered out and concentrated into a stream of wastewater to be sent to the wastewater treatment facility or to a surface water discharge point. The cost of sending this waste stream to the wastewater treatment facility would be high.

Through conversations with the DNR, if the radium and iron is removed in the pressure filters and the pressure filter backwash water is sent to the wastewater treatment plant, then the reverse osmosis waste stream may be approved to be sent directly to surface water. Kaukauna Utilities has applied for a General Discharge Permit from the DNR to discharge the reverse osmosis waste stream directly to surface water. If this permit is approved, then the high cost for sending the waste stream to the wastewater treatment facility would not be a factor. The wastewater treatment cost for the reverse osmosis waste stream is not included in Table 17.

If reverse osmosis or nanofiltration treatment is chosen, the wells would have to produce approximately 17%-20% more water to account for the waste stream. The water calculations that were performed in Section 10 were reevaluated with this additional water demand. These calculations are summarized in

**Table** 18.

Table 18: Demand Calculations with Reverse Osmosis or Nanofiltration

| Scenario | Equation 1 Maximum Day | Equation 2 Average Day | Equation 3 Fire Flow on Maximum Day | Equation 4 Maximum Hour |
|---|---|---|---|---|
| **Current Demand + 17%** | (327) | (182) | 1,173 | 1,318 |
| **Future 2043 Demand + 17% - FWC** | (821) | (415) | 679 | 1,085 |
| **Future 2043 Demand + 17% - with Well 9** | 479 | 885 | 1,979 | 2,385 |

With Well 9 out of service, the water system could not meet the current or future average daily demand when pumping at 12 hours per day and could not meet the current or future maximum daily demand when pumping at 18 hours per day. With Well 9 in service, the water system can handle current and future demand with the additional water needs of reverse osmosis or nanofiltration.

The above calculations for average day demand were made by using a pumping time of 12 hours per day. This 12-hour pumping time leads to the conclusion that Kaukauna Utilities cannot provide the current water demand on average day with a reverse osmosis or nanofiltration treatment system and Well 9 out of service. If the wells are run for 13.1 hours, they will supply current average day demand with reverse osmosis or nanofiltration treatment and Well 9 out of service.

**If Kaukauna Utilities chooses to go with the reverse osmosis or nanofiltration water treatment process, Well 5 pumping capacity should be increased from 250 gpm to 500 gpm. The pumping capacity change would require approval from the DNR. This increase in water supply capacity would allow the system to meet current average day demand with reverse osmosis or nanofiltration water treatment with a spare capacity of 3 gpm. The Main Filter Plant is currently not sized for this additional flow from Well 5**.

The above calculations for maximum day demand used a pumping time of 18 hours per day. This 18-hour pumping time leads to the conclusion that Kaukauna Utilities cannot provide the water demand on current maximum day with a reverse osmosis or nanofiltration treatment system with Well 9 out of service. One solution to this is to run the pumps for 19.2 hours during current maximum day instead of 18 hours if Well 9 is out of service. Kaukauna Utilities' wells can handle extra pumping per day in the short term (such as on the maximum day when Well 9 is out of service), but this is not a recommended long-term solution to water supply needs.

### 13.5.4 Water Treatment Option 4: Pellet Softening Treatment Process

Water treatment option 4 is pellet softening treatment. With pellet softening, water is pushed through a fluidized bed of sand. The chemistry concept of pellet softening is the same as lime softening. A catalyst, either caustic soda (sodium hydroxide) or lime (calcium hydroxide), is used to increase pH of the water and to precipitate calcium which will reduce water hardness. The chemistry process requires the source water to have a water hardness that is high in calcium and low in magnesium. Kaukauna has 225 mg/L calcium and 20 mg/L magnesium, so Kaukauna is a good fit based on chemistry.

Pellet softening uses a tall vertical tank with a fast loading rate to produce a calcium pellet. The vertical tank would be approximately 20 feet tall and would be required to be built indoors. The tank is open to the atmosphere on top. The chemistry seems to be stable compared to lime softening since there is a fast loading rate. Sand is added to the tank as seed material. The calcium will precipitate and attach itself to the sand particle. The sand particle will grow to 200-300% of the original size. The pellet is extracted when the pressure difference above and below the strainer plate has reached the predetermined differential. The waste pellet is placed in a waste dumpster and 95% dewatered two hours later. There is about a 1% waste of source water with pellet softening. The calcium pellet can be landfilled, land applied, or fed to livestock. The calcium pellet may be able to be sold to concrete companies or drywall manufacturers. Sand needs to be added daily as a seed.

Calcium hardness is estimated to be reduced by 80-90%. Magnesium hardness would not be reduced with pellet softening. This magnesium issue is not a concern for Kaukauna, as 90% of the water hardness in the raw water is from calcium. With 90% calcium hardness reduction, pellet softening would reduce the overall water hardness to approximately 150 mg/L (9.0 grains per gallon), which is higher than the targeted hardness range discussed above in Section 13.3. Pellet softening also reduces iron and manganese.

There is no data from the pellet softening manufacturers for radium and strontium removal, but lime softening removes both radium and strontium and the chemistry is the same as pellet softening. It is expected that pellet softening would also reduce strontium as much as 40-80% and radium as much as 50-80%, but this would need to be confirmed during pilot testing. The iron filter would not be necessary as pretreatment for pellet softening.

The operations of pellet softening are automated to minimize Kaukauna Utilities' staff onsite time; however, this treatment process would require additional vendor and operator oversight for waste disposal and sand replenishment. The pellet reactor works best to run 24 hours a day but can work if it runs at least eight hours straight and then is turned off. Sand needs to be added a minimum of once per day.

The capital cost of pellet softening is higher than reverse osmosis or nanofiltration. The operational costs and operating labor are lower than reverse osmosis.

Table 19: Preliminary Cost Estimate: Option 4 – Pellet Softening

| Description | Capital Cost | Annual Operating Cost | 20-Year Operating Cost | Capital Cost + 20-Year Operating Cost |
|---|---|---|---|---|
| **Alternative 3 - Option 4 Pellet Softening** | $16,400,000 | $900,000 | $18,000,000 | $34,400,000 |
| **Alternative 4 - Option 4 Pellet Softening** | $16,200,000 | $900,000 | $18,000,000 | $34,200,000 |

A pellet softening system has never been installed or piloted in Wisconsin. A township in Pennsylvania installed a municipal pellet softening system in 2018, approved by the Pennsylvania DNR. Pellet softening is being piloted in Illinois and Indiana for industrial use. Because this technology is new to Wisconsin and the Midwest, the DNR would likely require more extensive pilot testing than if Kaukauna Utilities selected a more common treatment process that already has been approved by the DNR.

A major benefit of pellet softening is that it removes calcium hardness, iron, manganese, strontium, and radium. Pellet softening has the benefit of leaving the carbonates in the water which helps stabilize the water from being corrosive. This treatment process aids the wastewater treatment plant in lowering chloride levels while still removing hardness from water. The downfall to pellet softening is the total water hardness is anticipated to only be removed to 150 mg/L. At this level some customers may choose to keep their water softener.

Pellet softening would require more operations oversight than reverse osmosis treatment. There is also waste disposal associated with pellet softening that would need to be picked up weekly. Pellet softening would require more training for the operators and result in increased Utility operations time.

### 13.5.5 Water Treatment Option 5: Change from Groundwater Source to Surface Water Source

Water treatment option 5 is for Kaukauna Utilities to switch to surface water as a source of water. This option has the benefit of eliminating the issue of radium and high water hardness associated with Kaukauna's groundwater. There are two communities nearby that are wholesale suppliers for surface water. The source surface water does not contain radium and contains a water hardness level between 120-160 mg/L. This surface water option was studied in Section 10.3 of this report. The capital and operating cost estimates for surface water source are summarized in **Table 8** in Section 10.3.4.

## 13.6 Other Water Treatment Processes Considered but Not Pursued as Options

### 13.6.1 Lime Softening

Lime softening is a treatment technique that involves adding lime and soda ash to untreated water. The hardness and alkalinity in the water is precipitated out and creates a residual sludge. This sludge must be disposed of with approval of the wastewater treatment plant. This treatment method is not preferred due to the operation and maintenance requirements. Lime feeders and lines carrying lime slurry to the point of application can be difficult to maintain. In addition, operators must understand the chemistry behind lime softening and test the water full-time to ensure the process is working as desired. Lime softening also does not address Kaukauna's high iron or radium. This treatment technique was not pursued as an option due to these drawbacks.

### 13.6.2 Electrodialysis Reversal Treatment

Electrodialysis reversal treatment uses electricity to separate out ions through membranes. Electrodialysis reversal treatment is effective for removal of water hardness and metal ions, like iron.

This treatment technique would necessitate additional treatment for organics and radium. The main advantage of electrodialysis reversal treatment is it has higher water recovery than reverse osmosis treatment, which is an option discussed below. This treatment technique was not pursued as an option due to the high capital costs and operating costs.

### 13.6.3 Distillation

Distillation is a process that relies on evaporation to remove contaminants from water. The process involves heating water to form steam, where contaminants will not evaporate. The steam is then cooled and condenses as purified water. Distillation is effective at removing iron, water hardness, and some microorganisms. There is a high energy cost for heating and cooling distilled water. Additionally, there is maintenance associated with cleaning the scale from the equipment that builds up as contaminants are distilled from the drinking water. If this is not cleaned periodically, the energy costs increase for heating the water. Because of the high water hardness of Kaukauna's water, distillation would result in heavy scaling of the equipment and maintenance would be intensive for the operator. Distillation was not pursued as an option for treatment for Kaukauna Utilities due to the high operation and maintenance costs associated with it.

### 13.6.4 Freezing Water

Freezing water can separate out hardness from water because the contaminants will not freeze with the water. The process involves freezing water and then thawing, letting the first water thawed to be removed from the solution. The contaminants will be contained in the initial water that is thawed. This process has been found to be effective at water hardness removal. It does not result in the same scaling issues as distillation because of the low heat involved. This is not a practical solution for a large-scale system due to the energy costs associated with freezing and thawing the water.

### 13.7 Water Treatment Recommendations

The risks and benefits for each water treatment option are included in **Appendix G**. The capital costs plus the annual operating costs for a 20-year period for each water treatment option are shown in **Figure 5**.

**A new treatment process is recommended for raw water in the water system. The recommended alternative is Option 3 which is to use a reverse osmosis or nanofiltration treatment process. This treatment process would benefit customers by lowering water hardness to a standard level and allow customers to save on the costs of water softening if they choose to eliminate their water softener. Additionally, the treatment process removes the high radium and iron in the raw water supply. This treatment process will also remove strontium and lower the total dissolved solids.**

**It is strongly discouraged to use the ion exchange water treatment process due to the additional discharge of chlorides to the wastewater treatment process. The DNR is trying to set lower limits of chloride discharges for the wastewater treatment plants. Some other states have banned the installation of ion exchange systems due to the high chloride discharge.**

**A schematic of the proposed water system is shown in Figure 11 in Appendix B. If Kaukauna Utilities chooses to go with the reverse osmosis or nanofiltration treatment option, it is recommended that a predesign study be done to analyze cost differences between reverse osmosis and nanofiltration at the time closer to purchase. Cost information from two suppliers, Water Surplus and Tonka Water, have been obtained for this report. Correspondence with these suppliers is included in Appendix J. Reverse osmosis has a lower initial capital cost but a higher operating cost due to pumping compared to nanofiltration. The costs in the report are based on reverse osmosis because at the time of the report the nanofiltration capital cost was significantly higher than reverse osmosis and one supplier felt that significantly higher capital cost would not be offset by operating costs. Also, one supplier found a Low E reverse osmosis membrane which would have lower energy usage than traditional reverse osmosis.**

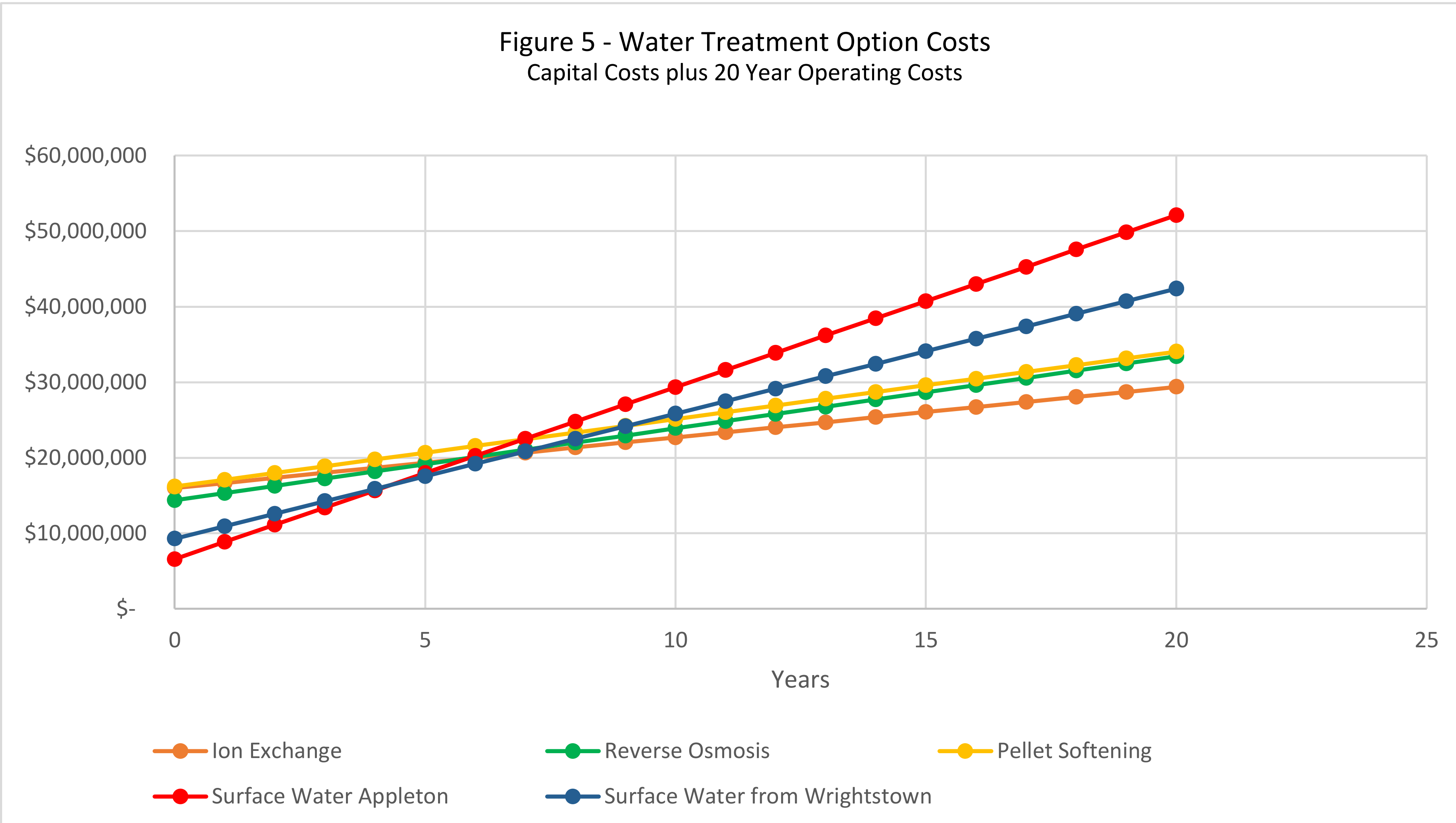
Figure 5 - Water Treatment Option Costs
Capital Costs plus 20 Year Operating Costs
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$-
0
5
10
15
20
25
Years
Ion Exchange
Reverse Osmosis
Pellet Softening
Surface Water Appleton
Surface Water from Wrightstown

## 14. Water Distribution System

The water distribution system for Kaukauna Utilities was studied with a computer water model prepared in the Bentley WaterCAD software. This computer water model includes the layout of the existing system and future system expansions Kaukauna Utilities is considering. Maps of the computer water model for each scenario and results are included in **Appendix K.**

### 14.1 Computer Water Model Calibration

The water system was drawn in WaterCAD using existing system maps and information from Kaukauna Utilities. The model includes pipes, junctions, reservoirs, and storage tanks. The pipes and junctions are drawn according to the existing system layout. Pipes include information on pipe sizes, material, and C-factors. The C-factor is a number that indicates the friction in a pipe and is determined by the pipe material and age. The model junctions are points of intersection for pipes, and they include information on elevation at each point. For the Kaukauna Utilities water model, the ground elevation for each point was used. There are two elevated storage tanks that model the existing Ann Street Water Tower and Industrial Park Water Tower.

The model was calibrated with empirical fire flow data obtained from the Utility. The data included static pressure, residual pressure, and fire flow at hydrants throughout the system. For each fire flow test, the elevated storage tank operating level was recorded at the time of the fire flow. This information was then compared to the model fire flow results.

First, static pressure was considered. To match the model to the field results, the elevated storage tank initial water heights were set to the height at which each hydrant test was performed. Then, the corresponding junction in the model was checked to see how the static pressure compared. Generally, the model matched the field results. There was an average difference between static pressures in the field and model of 1 pound per square inch (psi).

When the static pressures were representative of the field data, fire flow and residual pressures were considered. WaterCAD has a calculation option that will run each junction at fire flow down to a minimum pressure. For our calibration, the pressure minimum was set to 30 psi. The minimum pressure required by DNR is 20 psi. 30 psi was used for calibration and for studying the model to account for the additional 10 psi pressure drop that would be caused by the hydrant and the hydrant lead, which are not included in the model.

The field results did not have residual pressures as low as those in the model, which went down to 30 psi. In order to compare residual pressures in the field to the model, a conversion equation was used on the field data to convert the fire flow at field residual pressure to the 30 psi used in the model. Then, the flow rate at each junction was compared to the converted field flow rate. Calibration was then done by changing the C-factors of the pipes. The water distribution system has three types of pipe materials: PVC, ductile iron, and cast iron. There were many combinations of C-factors input into the model, but it was determined that using the C-factors 90, 120, and 130 for cast iron, ductile iron, and PVC respectively most closely matched the existing water system. There was an average difference in fire flows of -18 gpm when comparing the field fire flow to the converted model fire flow.

### 14.2 Computer Water Model Results

The existing water system is considered the base water model. After establishing a base model, changes to the water system could be investigated such as pipe upsizing and water main extensions. The two main factors studied are static pressure and fire flow.

The DNR has requirements for static pressure and fire flows in a public water system. The minimum static pressure to a customer is 35 psi. Kaukauna Utilities has residential customers currently at 50 psi. The minimum fire flow allowed by DNR is 500 gpm at 20 psi. This fire flow is a low-pressure situation and not ideal for firefighting. There are other guidelines for fire flow established by Insurance Services Office, Inc. (ISO) and are listed in **Table 20.**

Table 20: ISO Recommended Fire Flows

| Type of Property | Recommended Fire Flow (gpm) |
|---|---|
| Residential | 550- 750 |
| Schools | 3,000- 3,500 |
| Commercial | 1,000- 3,000 |
| Industrial | 2,000- 3,000 |

Each scenario is described below, and a summary of the fire flows for each scenario are included in **Table 22** at the end of the section. The computer water modeling results are shown in **Appendix K**.

#### 14.2.1 Scenario 1: Hillcrest Water Main Pipe Upsizing

The first scenario incorporates upsized piping along Hillcrest Drive and Boyd Street, from Dodge Street to County Highway CE. The Hillcrest Drive pipe connects to 12-inch PVC piping at both intersections. This scenario upsized all the piping along this street to 12-inch PVC. The existing system has a combination of 10-inch and 8-inch PVC and ductile iron piping. No additional piping was added to the system for this scenario.

This scenario addresses low pressures and low fire flows in the residential area in the southeast portion of Kaukauna. The 12-inch water main along Hillcrest Drive resulted in higher fire flows in this area. This upgrade would be completed when the pavement on Hillcrest Drive reaches the end of its useful life in 10-15 years.

#### 14.2.2 Scenario 2: Loop at Evergreen Drive

The second scenario involved the addition of a 12-inch PVC loop to a dead end at the north side of the water system at Evergreen Drive. The loop connects at the dead end on Evergreen Drive, follows County Highway CC south of USH 41, and connects to the existing system at the intersection of Mera Lane and Alyssa Street.

This scenario adds redundancy to the system by adding another crossing under USH 41. It also raises fire flow in the areas near the loop. For example, the junction at the end of Evergreen Drive currently has a fire flow of 3,301 gpm @ 30 psi. By adding the loop, the fire flow at the end of Evergreen Drive increases to 5,294 gpm @ 30 psi.

**14.2.3 Scenario 3: 12-Inch Southeast Expansion – No Additional Pressure Zones**
Scenario 3 includes the addition of 12-inch PVC water main to the southeast portion of Kaukauna. This was modeled as future residential development. The water main addition extends east to Outagamie Road, south to County Highway KK, and north to County Highway ZZ.

This scenario successfully delivers acceptable fire flow and pressures to most of the expansion. There are low fire flows and low static pressures in the most southeast corner of the expansion. The southeast corner begins east of Military Road and south of Weiler Road. There is a hill in this area that is the cause of low pressures. The minimum static pressure with this scenario is 25 psi and the lowest fire flow is 316 gpm @ 30 psi. This fire flow is below the DNR minimum of 500 gpm @ 20 psi. Kaukauna Utilities could successfully expand to the southeast including all but the most southeast corner before needing to consider another pressure zone or another alternative for this area.

**14.2.4 Scenario 4: 16-Inch Southeast Expansion – No Additional Pressure Zones**
Scenario 4 has the same extension as Scenario 3 but includes 16-inch diameter PVC water main instead of 12-inch diameter PVC water main. The same situation occurs in the southeast corner of the extension. The minimum static pressure with this scenario is 25 psi and a minimum fire flow of 536 gpm @ 30 psi. Kaukauna Utilities could expand with this scenario to all but the most southeast corner before needing to consider an additional pressure zone or another solution to the low pressure in this area.

**14.2.5 Scenario 5: 12-Inch Southeast Expansion—Pressure Zone Addition**
Scenario 5 includes the same pipe extension as Scenario 3 with the addition of another pressure zone to the water system. The new pressure zone includes areas of the existing system that have the lowest pressures. The map showing the delineation between the two pressure zones is included in **Appendix K.**

This scenario has the benefit of being able to supply water with an acceptable static pressure and acceptable fire flow to the most southeast portion of the extension. The addition of another pressure zone also raises pressure in the neighborhood to the north of County Highway CE at the far east of the existing water system. This area has the lowest pressures in the existing water system and is a concern for Kaukauna Utilities. This scenario has the drawback of the cost associated with isolating parts of the existing water system and creating dead ends in the water system. Another drawback of adding a pressure zone to the water system is the cost of an additional elevated storage tank.

**14.2.6 Scenario 6: 16-Inch Southeast Expansion—Pressure Zone Addition**
Scenario 6 includes the southeast expansion with 16-inch piping and a pressure zone addition to the water system. This scenario results in slightly higher fire flows available compared to Scenario 5 but has the same drawbacks.

**14.2.7 Scenario 7: 12-Inch North Expansion**
Scenario 7 involves an expansion of the water system to the north of Kaukauna, addressing anticipated development of the industrial area. The expansion connects to the existing system at Evergreen Drive, runs north on STH 55 to County Road UU. County Highway UU is the northernmost end of this expansion. It then runs east across STH 41, where it turns south on County Line Road. It then is anticipated to connect to the existing system at the intersection of

County Highway ZZ and Outagamie Road. This connection point is a part of the southeast expansion water main. In this scenario, all piping is 12-inch PVC.

This expansion allows for acceptable static pressure and fire flow throughout the junctions. Because of the relatively flat topography of the area, there is no need for an additional pressure zone to the north.

#### 14.2.8 Scenario 8: 16-Inch North Expansion

Scenario 8 has the same north expansion as Scenario 7, but with all 16-inch PVC piping throughout. The upsize in piping allows for slightly higher fire flows throughout the expansion. Both scenarios result in adequate static pressures and fire flows.

#### 14.2.9 Scenario 9: Tower Drive Replacement and Loop to Edgewood Drive

Scenario 9 looks at the part of the water system near the Industrial Park Water Tower. Currently, there is a 16-inch ductile iron pipe on Tower Drive between the water tower location and Eastline Road. Kaukauna Utilities is looking to replace this 16-inch pipe with a 12-inch pipe. This scenario also includes looping from the water tower location to the north, under STH 41, to the intersection of County Road JJ and Maloney Road.

A summary of how these changes to the water system affect fire flows is included in **Table** 21. Junction J-719 is at the intersection of County Road JJ and Maloney Road. Junction J-489 is located at the intersection of Tower Drive and Eastline Road.

Table 21: Scenario 9 Fire Flows

| **Scenario** | **J-719 Fire Flow (gpm)** | **J-489 Fire Flow (gpm)** |
|---|---:|---:|
| Current | 4,775 | 10,000 |
| Downsize Tower Drive Pipe to 12-inch | 4,688 | 10,000 |
| Downsize Tower Drive Pipe to 12-inch and Add Loop to North | 6,523 | 10,000 |

There is marginal benefit to fire flows to keep the 16-inch pipe. Downsizing to a 12-inch pipe would not affect the system’s fire flow capability and would save capital costs. Looping to the north has a benefit to fire flows on the north side of STH 41.

[INSERT FIRE FLOW TABLE AND MODEL DIAGRAMS HERE]

*Table 22: Fire Flow*

| | |
|---|---|

### 14.3 Water Distribution System Recommendations

**A potential improvement to the water distribution system includes upsizing the water main on Hillcrest Drive from the current 8 and 10-inch piping to 12-inch piping. This improvement would benefit the areas of low fire flow in the southeast of the existing water system and would allow for higher fire flows in the future expansion to the southeast.**

**Additionally, Kaukauna Utilities can stay on one pressure zone until development to the southeast necessitates the addition of a second pressure zone. It is projected Kaukauna Utilities can add to the water system to the southeast, to an area east of County Road GG and south of Weiler Road, before needing to add another pressure zone. By staying with one pressure zone as long as possible, it would minimize maintenance labor and postpone adding dead ends in the water system until another pressure zone is needed. Once development reaches this area, a second pressure zone should be evaluated as well as the possible need for another elevated storage tank for the second pressure zone.**

# Appendix A

# Cost Estimates

**Kaukauna Utilities**

**Alternative 2 - Replace Pressure Filter Tank at Current Location**

**Option 1 - Keep Existing Water Treatment Process - Filtration**

October 20, 2023

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Main Filter Plant Building Renovations** | | | | |
| Renovate Existing WTP Building | LS | 1 | $ 200,000 | $ 200,000 |
| Generators - Well 4, 5, 10, & Treatment Plant | Ea | 1 | $ 370,000 | $ 370,000 |
| Pressure Filter Tank | Ea | 1 | $ 900,000 | $ 900,000 |
| Site Piping | LS | 1 | $ 200,000 | $ 200,000 |
| Chemical Feed Equipment | LS | 1 | $ 15,000 | $ 15,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Demolition of Pressure Filter | LS | 1 | $ 100,000 | $ 100,000 |
| **Well 8 & 9 Improvements** | | | | |
| Replace Pressure Filter Media - Well 9 only | Ea | 1 | $ 100,000 | $ 100,000 |
| Subtotal | | | | $ 2,085,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 188,000 |
| Contingency | 15% | | | $ 313,000 |
| Engineering | 20% | | | $ 417,000 |
| Admin/ Legal | 2% | | | $ 42,000 |
| **Total Capital Cost** | | | | **$ 3,045,000** |

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Main Filter Plant at New Site** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Chemical Feed - HMO | $ 30,000 |
| Media Replacement - 15 years | $ 3,012 |
| Wells Running - Electric Cost | $ 69,069 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Well 8 & 9** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Chemical Feed - HMO | $ 30,000 |
| Media Replacement - every 15 years | $ 3,012 |
| Well 8+9 Running - Electric Cost | $ 96,052 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Total Annual Operating Cost** | **$ 488,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 9,760,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 12,805,000** |

**Kaukauna Utilities**

**Alternative 3 - Rebuild Water Treatment Plant Building and Reservoirs at Current Location**

**Option 1 - Keep Existing Water Treatment Process - Filtration**

October 24, 2023

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Main Filter Plant Site Renovations** | | | | |
| Renovate Existing WTP Building | LS | 1 | $ 200,000 | $ 200,000 |
| Generators - Well 4, 5, 10, & Treatment Plant | Ea | 1 | $ 370,000 | $ 370,000 |
| Pressure Filter Tank | Ea | 1 | $ 900,000 | $ 900,000 |
| Site Piping | LS | 1 | $ 200,000 | $ 200,000 |
| Chemical Feed Equipment | LS | 1 | $ 15,000 | $ 15,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Booster Pump Station Renovations | LS | 1 | $ 100,000 | $ 100,000 |
| Replace Booster Pump and Piping | LS | 1 | $ 300,000 | $ 300,000 |
| Ground Storage Reservoir - 600,000 Gal | Ea | 1 | $ 2,000,000 | $ 2,000,000 |
| Demolition of Reserviors, Booster Pump, Piping, & Pressure Filter | LS | 1 | $ 400,000 | $ 400,000 |
| **Well 8 & 9 Improvements** | | | | |
| Generators - Well 8 and 9 | Ea | 1 | $ 230,000 | $ 230,000 |
| Replace Pressure Filter Media - Well 9 only | Ea | 1 | $ 100,000 | $ 100,000 |
| Subtotal | | | | $ 5,015,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 451,000 |
| Contingency | 15% | | | $ 752,000 |
| Engineering | 20% | | | $ 1,003,000 |
| Admin/ Legal | 2% | | | $ 100,000 |
| **Total Capital Cost** | | | | **$ 7,321,000** |

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Main Filter Plant at New Site** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Chemical Feed - HMO | $ 30,000 |
| Media Replacement - 15 years | $ 3,012 |
| Wells Running - Electric Cost | $ 69,069 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Well 8 & 9** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Chemical Feed - HMO | $ 30,000 |
| Media Replacement - every 15 years | $ 3,012 |
| Well 8+9 Running - Electric Cost | $ 96,052 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Total Annual Operating Cost** | **$ 488,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 9,760,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 17,081,000** |

**Kaukauna Utilities**

**Alternative 3 - Rebuild Water Treatment Plant Building and Reservoirs at Current Location**

**Option 2 - Ion Exchange Water Treatment Process**

October 20, 2023

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Main Filter Plant Site Renovations** | | | | |
| Renovate Existing WTP Building & Addition | LS | 1 | $ 1,000,000 | $ 1,000,000 |
| Generators - Well 4, 5, 10, & Treatment Plant | Ea | 1 | $ 370,000 | $ 370,000 |
| Pressure Filter Tank | Ea | 1 | $ 725,000 | $ 725,000 |
| Site Piping | LS | 1 | $ 200,000 | $ 200,000 |
| Ion Exchange | LS | 1 | $ 1,780,000 | $ 1,780,000 |
| Chemical Feed Equipment | LS | 1 | $ 30,000 | $ 30,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Ground Storage Reservoir - 600,000 Gal | Ea | 1 | $ 2,000,000 | $ 2,000,000 |
| Demolition of Reserviors, Booster Pump, Piping, & Pressure Filter | Ea | 1 | $ 400,000 | $ 400,000 |
| **Well 8 & 9 Improvements** | | | | |
| Generators - Well 8 & 9 | Ea | 1 | $ 230,000 | $ 230,000 |
| Replace Pressure Filter Media - Well 9 only | Ea | 1 | $ 100,000 | $ 100,000 |
| Ion Exchange | LS | 1 | $ 1,780,000 | $ 1,780,000 |
| Chemical Feed Equipment | LS | 1 | $ 30,000 | $ 30,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Transmission Main to New Site | LF | 6500 | $ 200 | $ 1,300,000 |
| Reservoirs | Ea | 1 | $ 300,000 | $ 300,000 |
| Subtotal | | | | $ 10,645,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 958,000 |
| Contingency | 15% | | | $ 1,597,000 |
| Engineering | 20% | | | $ 2,129,000 |
| Admin/ Legal | 2% | | | $ 213,000 |
| **Total Capital Cost** | | | | **$ 15,542,000** |

**Kaukauna Utilities**

**Alternative 3 - Rebuild Water Treatment Plant Building and Reservoirs at Current Location**

**Option 2 - Ion Exchange Water Treatment Process**

October 20, 2023

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Main Filter Plant at New Site** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Salt Costs + labor | $ 114,554 |
| Energy | $ 2,130 |
| Resin Changeout - Every 10 Years + labor | $ 7,320 |
| Well Running | $ 69,069 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Well 8 & 9** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Well 8+9 Running | $ 96,052 |
| Salt Costs | $ 114,554 |
| Energy | $ 2,130 |
| Resin Changeout - Every 10 Years | $ 7,320 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Total Annual Operating Cost** | **$ 670,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 13,400,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 28,942,000** |

**Kaukauna Utilities**

**Alternative 3 - Rebuilt at Current Main Filter Plant Site**

**Option 3 - Reverse Osmosis/Nanofiltration Water Treatment Process**

October 20, 2023

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Main Filter Plant Site Renovations** | | | | |
| Renovate Existing WTP Building & Addition | LS | 1 | $ 1,000,000 | $ 1,000,000 |
| Generators - Well 4, 5, 10, & Treatment Plant | Ea | 1 | $ 370,000 | $ 370,000 |
| Pressure Filter Tank | Ea | 1 | $ 725,000 | $ 725,000 |
| Site Piping | LS | 1 | $ 200,000 | $ 200,000 |
| RO/ Nano Treatment | Ea | 1 | $ 1,254,000 | $ 1,254,000 |
| Booster Pump to RO | Ea | 1 | $ 40,000 | $ 40,000 |
| Chemical Feed Equipment | LS | 1 | $ 45,000 | $ 45,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Ground Storage Reservoir - 600,000 Gal | LS | 1 | $ 2,000,000 | $ 2,000,000 |
| Demolition of Reserviors, Booster Pump, Piping, & Pressure Filter | Ea | 1 | $ 400,000 | $ 400,000 |
| **Well 8 & 9 Improvements** | | | | |
| Generators - Well 8 and 9 | Ea | 1 | $ 230,000 | $ 230,000 |
| Replace Pressure Filter Media - Well 9 only | Ea | 1 | $ 100,000 | $ 100,000 |
| RO/ Nano Treatment | Ea | 1 | $ 1,144,000 | $ 1,144,000 |
| Booster Pump to RO | Ea | 1 | $ 40,000 | $ 40,000 |
| Chemical Feed Equipment | LS | 1 | $ 45,000 | $ 45,000 |
| SCADA Improvements | LS | 1 | $ 100,000 | $ 100,000 |
| Transmission Main to New Site | LF | 6500 | $ 200 | $ 1,300,000 |
| Reservoir | LS | 1 | $ 300,000 | $ 300,000 |
| Subtotal | | | | $ 9,493,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 854,000 |
| Contingency | 15% | | | $ 1,424,000 |
| Engineering | 20% | | | $ 1,899,000 |
| Admin/ Legal | 2% | | | $ 190,000 |
| **Total Capital Cost** | | | | **$ 13,860,000** |

**Kaukauna Utilities**

**Alternative 3 - Rebuilt at Current Main Filter Plant Site**

**Option 3 - Reverse Osmosis/Nanofiltration Water Treatment Process**

October 20, 2023

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Main Filter Plant at New Site** | |
| Antiscalant Chemical | $ 21,627 |
| Chemical cleaning (1/yr) | $ 25,625 |
| Cartridge replacement | $ 20,970 |
| Metabisulfite | $ 11,834 |
| Membrane replacement | $ 132,770 |
| Booster Pump for RO | $ 26,250 |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Well Running * 1.2 | $ 82,883 |
| Labor | $ 82,401 |
| Maintenance of Wells | $ 15,000 |
| **Well 8 & 9** | |
| Antiscalant Chemical | $ 21,627 |
| Chemical cleaning (1/yr) | $ 25,625 |
| Cartridge replacement | $ 20,970 |
| Metabisulfite | $ 11,834 |
| Membrane replacement | $ 132,770 |
| Booster Pump for RO | $ 26,250 |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Well 8+9 Running * 1.2 | $ 115,262 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Total Annual Operating Cost** | **$ 952,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 19,040,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 32,900,000** |

**Kaukauna Utilities**
**Alternative 3 - Rebuilt at Current Main Filter Plant Site**
**Option 4 - Pellet Softening Water Treatment Process**
February 22, 2024

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Main Filter Plant at New Site** | | | | |
| Renovate Existing WTP Building & Addition | LS | 1 | $ 1,500,000 | $ 1,500,000 |
| Generators - Well 4, 5, 10, & Treatment Plant | Ea | 1 | $ 370,000 | $ 370,000 |
| Pressure Filter Tank | Ea | 1 | $ 725,000 | $ 725,000 |
| Site Piping | LS | 1 | $ 200,000 | $ 200,000 |
| Pellet Softener | Ea | 1 | $ 1,415,000 | $ 1,415,000 |
| Chemical Feed Equipment | Ea | 6 | $ 10,000 | $ 60,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Ground Storage Reservoir - 600,000 Gal | LS | 1 | $ 2,000,000 | $ 2,000,000 |
| **Well 8 & 9 Improvements** | | | | |
| WTP Building Addition | Ea | 1 | $ 800,000 | $ 800,000 |
| Generators - Well 8 and 9 | Ea | 1 | $ 230,000 | $ 230,000 |
| Iron Filter - Change Media Only | Ea | 1 | $ 75,000 | $ 75,000 |
| Pellet Softener | Ea | 1 | $ 1,415,000 | $ 1,415,000 |
| Chemical Feed Equipment | Ea | 2 | $ 10,000 | $ 20,000 |
| SCADA Improvements | LS | 1 | $ 100,000 | $ 100,000 |
| Transmission Main to New Site | LF | 6500 | $ 200 | $ 1,300,000 |
| Reservoir | LS | 1 | $ 300,000 | $ 300,000 |
| **Main Filter Plant Site** | | | | |
| Demolition of Reserviors, Booster Pump, Piping, & Pressure Filter & Repurpose Main Filter Plant Building | Ea | 1 | $ 500,000 | $ 500,000 |
| Subtotal | | | | $ 11,210,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 1,009,000 |
| Contingency | 15% | | | $ 1,682,000 |
| Engineering | 20% | | | $ 2,242,000 |
| Admin/ Legal | 2% | | | $ 224,000 |
| **Total Capital Cost** | | | | **$ 16,367,000** |

**Kaukauna Utilities**

**Alternative 3 - Rebuilt at Current Main Filter Plant Site**

**Option 4 - Pellet Softening Water Treatment Process**

February 22, 2024

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Main Filter Plant at New Site** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Pellet Softening O&M | $ 177,302 |
| pH Down Chemical | $ 25,000 |
| Chemical Feed - HMO | $ 30,000 |
| Iron Filter Media Replacement - 15 years | $ 3,012 |
| Well Running | $ 69,069 |
| Maintenance of Wells | $ 15,000 |
| Labor | $ 85,000 |
| **Well 8 & 9** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Pellet Softening O&M | $ 177,302 |
| pH Down Chemical | $ 25,000 |
| Well 8+9 Running | $ 96,052 |
| Labor | $ 85,000 |
| Maintenance of Wells | $ 15,000 |
| **Total Annual Operating Cost** | **$ 903,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 18,060,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 34,427,000** |

**Kaukauna Utilities**

**Alternative 4 - New Water Treatment Plant Building at New Site**

**Option 1 - Keep Existing Water Treatment Process - Filtration**

October 24, 2023

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Water Treatment Plant at New Site** | | | | |
| New WTP Building | LS | 1 | $ 1,500,000 | $ 1,500,000 |
| Generators - Well 4, 5, 10, & Treatment Plant | Ea | 1 | $ 370,000 | $ 370,000 |
| Pressure Filter Tank | Ea | 1 | $ 725,000 | $ 725,000 |
| Site Piping | LS | 1 | $ 225,000 | $ 225,000 |
| Chemical Feed Equipment | LS | 1 | $ 60,000 | $ 60,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Transmission Main to/from New Site | LF | 1400 | $ 200 | $ 280,000 |
| Ground Storage Reservoir - 600,000 Gal | Ea | 1 | $ 1,500,000 | $ 1,500,000 |
| **Well 8 & 9 Improvements** | | | | |
| Generators - Well 8 and 9 | Ea | 1 | $ 230,000 | $ 230,000 |
| Replace Pressure Filter Media - Well 9 only | Ea | 1 | $ 75,000 | $ 75,000 |
| **Main Filter Plant Site** | | | | |
| Demolition of Reserviors, Booster Pump, Piping, & Pressure Filter & Repurpose Main Filter Plant Building | Ea | 1 | $ 500,000 | $ 500,000 |
| Subtotal | | | | $ 5,665,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 510,000 |
| Contingency | 15% | | | $ 850,000 |
| Engineering | 20% | | | $ 1,133,000 |
| Admin/ Legal | 2% | | | $ 113,000 |
| **Total Capital Cost** | | | | **$ 8,271,000** |

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Main Filter Plant at New Site** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Chemical Feed - HMO | $ 30,000 |
| Media Replacement - 15 years | $ 3,012 |
| Wells Running - Electric Cost | $ 69,069 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Well 8 & 9** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Chemical Feed - HMO | $ 30,000 |
| Media Replacement - every 15 years | $ 3,012 |
| Well 8+9 Running - Electric Cost | $ 96,052 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Total Annual Operating Cost** | **$ 488,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 9,760,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 18,031,000** |

**Kaukauna Utilities**

**Alternative 4 - New Water Treatment Plant Building at New Site**

**Option 2 - Ion Exchange Water Treatment Process**

October 24, 2023

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Water Treatment Plant at New Site** | | | | |
| New WTP Building | LS | 1 | $ 1,500,000 | $ 1,500,000 |
| Generators - Well 4, 5, 10, & Treatment Plant | Ea | 1 | $ 370,000 | $ 370,000 |
| Pressure Filter Tank | Ea | 1 | $ 725,000 | $ 725,000 |
| Site Piping | LS | 1 | $ 150,000 | $ 150,000 |
| Ion Exchange | LS | 1 | $ 1,780,000 | $ 1,780,000 |
| Chemical Feed Equipment | LS | 1 | $ 30,000 | $ 30,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Transmission Main to/from New Site | LF | 1400 | $ 200 | $ 280,000 |
| Ground Storage Reservoir - 600,000 Gal | Ea | 1 | $ 1,500,000 | $ 1,500,000 |
| **Well 8 & 9 Improvements** | | | | |
| Generators - Well 8 and 9 | Ea | 1 | $ 230,000 | $ 230,000 |
| Replace Pressure Filter Media - Well 9 only | Ea | 1 | $ 75,000 | $ 75,000 |
| Ion Exchange | LS | 1 | $ 1,780,000 | $ 1,780,000 |
| Chemical Feed Equipment | LS | 1 | $ 30,000 | $ 30,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Transmission Main to New Site | LF | 6500 | $ 200 | $ 1,300,000 |
| Reservoir - Well 9 | Ea | 1 | $ 300,000 | $ 300,000 |
| **Main Filter Plant Site** | | | | |
| Demolition of Reserviors, Booster Pump, Piping, & Pressure Filter & Repurpose Main Filter Plant Building | Ea | 1 | $ 500,000 | $ 500,000 |
| Subtotal | | | | $ 10,950,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 986,000 |
| Contingency | 15% | | | $ 1,643,000 |
| Engineering | 20% | | | $ 2,190,000 |
| Admin/ Legal | 2% | | | $ 219,000 |
| **Total Capital Cost** | | | | **$ 15,988,000** |

**Kaukauna Utilities**

**Alternative 4 - New Water Treatment Plant Building at New Site**

**Option 2 - Ion Exchange Water Treatment Process**

October 24, 2023

Annual Operating Costs

| Item | Cost Estimate | |
|---|---|---|
| **Main Filter Plant  at New Site** | | |
| Chemical Feed - Chlorine + Orthophosphate | $ | 50,000 |
| Salt Costs + labor | $ | 114,554 |
| Energy | $ | 2,130 |
| Resin Changeout - Every 10 Years + labor | $ | 7,320 |
| Well Running | $ | 69,069 |
| Labor | $ | 63,385 |
| Maintenance of Wells | $ | 15,000 |
| **Well 8 & 9** | | |
| Chemical Feed - Chlorine + Orthophosphate | $ | 50,000 |
| Well 8+9 Running | $ | 96,052 |
| Salt Costs | $ | 114,554 |
| Energy | $ | 2,130 |
| Resin Changeout - Every 10 Years | $ | 7,320 |
| Labor | $ | 63,385 |
| Maintenance of Wells | $ | 15,000 |
| **Total Annual Operating Cost** | **$** | **670,000** |

| | | |
|---|---|---|
| **20-year annual operating cost** | **$** | **13,400,000** |
| **Capital cost plus 20-year annual operating cost** | **$** | **29,388,000** |

**Kaukauna Utilities**

**Alternative 4 - New Main Filter Plant Site**

**Option 3 - Reverse Osmosis/Nanofiltration Water Treatment Process**

October 24, 2023

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Main Filter Plant at New Site** | | | | |
| New WTP Building | LS | 1 | $ 1,500,000 | $ 1,500,000 |
| Generators - Well 4, 5, 10, & Treatment Plant | Ea | 1 | $ 370,000 | $ 370,000 |
| Pressure Filter Tank | Ea | 1 | $ 725,000 | $ 725,000 |
| Site Piping | LS | 1 | $ 200,000 | $ 200,000 |
| RO/ Nano Treatment | Ea | 1 | $ 1,254,000 | $ 1,254,000 |
| Booster Pump to RO | Ea | 1 | $ 40,000 | $ 40,000 |
| Chemical Feed Equipment | LS | 1 | $ 45,000 | $ 45,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Transmission Main to/from New Site | LF | 1400 | $ 200 | $ 280,000 |
| Ground Storage Reservoir - 600,000 Gal | LS | 1 | $ 1,500,000 | $ 1,500,000 |
| **Well 8 & 9 Improvements** | | | | |
| Generators - Well 8 and 9 | Ea | 1 | $ 230,000 | $ 230,000 |
| Replace Pressure Filter Media - Well 9 only | Ea | 1 | $ 75,000 | $ 75,000 |
| RO/ Nano Treatment | Ea | 1 | $ 1,144,000 | $ 1,144,000 |
| Booster Pump to RO | Ea | 1 | $ 40,000 | $ 40,000 |
| Chemical Feed Equipment | LS | 1 | $ 45,000 | $ 45,000 |
| SCADA Improvements | LS | 1 | $ 100,000 | $ 100,000 |
| Transmission Main to New Site | LF | 6500 | $ 200 | $ 1,300,000 |
| Reservoir | LS | 1 | $ 300,000 | $ 300,000 |
| **Main Filter Plant Site** | | | | |
| Demolition of Reserviors, Booster Pump, Piping, & Pressure Filter & Repurpose Main Filter Plant Building | Ea | 1 | $ 500,000 | $ 500,000 |
| Subtotal | | | | $ 9,848,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 886,000 |
| Contingency | 15% | | | $ 1,477,000 |
| Engineering | 20% | | | $ 1,970,000 |
| Admin/ Legal | 2% | | | $ 197,000 |
| **Total Capital Cost** | | | | **$ 14,378,000** |

**Kaukauna Utilities**

**Alternative 4 - New Main Filter Plant Site**

**Option 3 - Reverse Osmosis/Nanofiltration Water Treatment Process**

October 24, 2023

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Main Filter Plant at New Site** | |
| Antiscalant Chemical | $ 21,627 |
| Chemical cleaning (1/yr) | $ 25,625 |
| Cartridge replacement | $ 20,970 |
| Metabisulfite | $ 11,834 |
| Membrane replacement | $ 132,770 |
| Booster Pump for RO | $ 26,250 |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Well Running * 1.2 | $ 82,883 |
| Labor | $ 82,401 |
| Maintenance of Wells | $ 15,000 |
| **Well 8 & 9** | |
| Antiscalant Chemical | $ 21,627 |
| Chemical cleaning (1/yr) | $ 25,625 |
| Cartridge replacement | $ 20,970 |
| Metabisulfite | $ 11,834 |
| Membrane replacement | $ 132,770 |
| Booster Pump for RO | $ 26,250 |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Well 8+9 Running * 1.2 | $ 115,262 |
| Labor | $ 63,385 |
| Maintenance of Wells | $ 15,000 |
| **Total Annual Operating Cost** | **$ 952,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 19,040,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 33,418,000** |

**Kaukauna Utilities**

**Alternative 4 - New Main Filter Plant Site**

**Option 4 - Pellet Softening Water Treatment Process**

February 22, 2024

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Main Filter Plant at New Site** | | | | |
| New WTP Building | LS | 1 | $ 1,600,000 | $ 1,600,000 |
| Generators - Well 4, 5, 10, & Treatment Plant | Ea | 1 | $ 370,000 | $ 370,000 |
| Pressure Filter Tank | Ea | 1 | $ 725,000 | $ 725,000 |
| Site Piping | LS | 1 | $ 200,000 | $ 200,000 |
| Pellet Softener | Ea | 1 | $ 1,415,000 | $ 1,415,000 |
| Chemical Feed Equipment | Ea | 6 | $ 10,000 | $ 60,000 |
| SCADA Improvements | LS | 1 | $ 200,000 | $ 200,000 |
| Transmission Main to/from New Site | LF | 1400 | $ 200 | $ 280,000 |
| Ground Storage Reservoir - 600,000 Gal | LS | 1 | $ 1,500,000 | $ 1,500,000 |
| **Well 8 & 9 Improvements** | | | | |
| WTP Building Addition | Ea | 1 | $ 800,000 | $ 800,000 |
| Generators - Well 8 and 9 | Ea | 1 | $ 230,000 | $ 230,000 |
| Iron Filter - Change Media Only | Ea | 1 | $ 75,000 | $ 75,000 |
| Pellet Softener | Ea | 1 | $ 1,415,000 | $ 1,415,000 |
| Chemical Feed Equipment | Ea | 2 | $ 10,000 | $ 20,000 |
| SCADA Improvements | LS | 1 | $ 100,000 | $ 100,000 |
| Transmission Main to New Site | LF | 6500 | $ 200 | $ 1,300,000 |
| Reservoir | LS | 1 | $ 300,000 | $ 300,000 |
| **Main Filter Plant Site** | | | | |
| Demolition of Reserviors, Booster Pump, Piping, & Pressure Filter & Repurpose Main Filter Plant Building | Ea | 1 | $ 500,000 | $ 500,000 |
| Subtotal | | | | $ 11,090,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 998,000 |
| Contingency | 15% | | | $ 1,664,000 |
| Engineering | 20% | | | $ 2,218,000 |
| Admin/ Legal | 2% | | | $ 222,000 |
| **Total Capital Cost** | | | | **$ 16,192,000** |

**Kaukauna Utilities**

**Alternative 4 - New Main Filter Plant Site**

**Option 4 - Pellet Softening Water Treatment Process**

February 22, 2024

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Main Filter Plant at New Site** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Pellet Softening O&M | $ 177,302 |
| pH Down Chemical | $ 25,000 |
| Chemical Feed - HMO | $ 30,000 |
| Iron Filter Media Replacement - 15 years | $ 3,012 |
| Well Running | $ 69,069 |
| Maintenance of Wells | $ 15,000 |
| Labor | $ 85,000 |
| **Well 8 & 9** | |
| Chemical Feed - Chlorine + Orthophosphate | $ 50,000 |
| Pellet Softening O&M | $ 177,302 |
| pH Down Chemical | $ 25,000 |
| Well 8+9 Running | $ 96,052 |
| Labor | $ 85,000 |
| Maintenance of Wells | $ 15,000 |
| **Total Annual Operating Cost** | **$ 903,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 18,060,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 34,252,000** |

**Kaukauna Utilities**

**Surface Water From Appleton**

August 10, 2023

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Surface Water from Appleton** | | | | |
| Water main Connection | LF | 14500 | $ 200 | $ 2,900,000 |
| Booster Pump | Ea | 1 | $ 1,500,000 | $ 1,500,000 |
| Generator | Ea | 1 | $ 100,000 | $ 100,000 |
| | | | | |
| | | | | |
| Subtotal | | | | $ 4,500,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 405,000 |
| Contingency | 15% | | | $ 675,000 |
| Engineering | 20% | | | $ 900,000 |
| Admin/ Legal | 2% | | | $ 90,000 |
| **Total Capital Cost** | | | | **$ 6,570,000** |

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Surface Water from Appleton** | |
| Purchased water | $ 2,078,059 |
| Base Charge | $ 2,664 |
| Fire Protection Cost | $ 141,536 |
| Maintenance of wells | $ 50,000 |
| Maintenance of pipeline | $ 5,000 |
| | |
| | |
| **Total Annual Operating Cost** | **$ 2,277,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 45,540,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 52,110,000** |

**Kaukauna Utilities**
**Surface Water From Green Bay**
August 10, 2023

Capital Costs

| Item | Unit | Qty | Unit Price | Cost Estimate |
|---|---|---|---|---|
| **Surface Water from Green Bay** | | | | |
| Water main Connection | LF | 23760 | $ 200 | $ 4,752,000 |
| Booster Pump | Ea | 1 | $ 1,500,000 | $ 1,500,000 |
| Generator | Ea | 1 | $ 100,000 | $ 100,000 |
| | | | | |
| | | | | |
| Subtotal | | | | $ 6,352,000 |
| Inflation 3% per year, 3 years | 9% | | | $ 572,000 |
| Contingency | 15% | | | $ 953,000 |
| Engineering | 20% | | | $ 1,270,000 |
| Admin/ Legal | 2% | | | $ 127,000 |
| **Total Capital Cost** | | | | **$ 9,274,000** |

Annual Operating Costs

| Item | Cost Estimate |
|---|---|
| **Surface Water from Green Bay** | |
| Purchased water | $ 1,207,073 |
| Conveyance Cost | $ 392,890 |
| Maintenance of wells | $ 50,000 |
| Maintenance of pipeline | $ 5,000 |
| | |
| | |
| | |
| **Total Annual Operating Cost** | **$ 1,655,000** |

| | |
|---|---|
| **20-year annual operating cost** | **$ 33,100,000** |
| **Capital cost plus 20-year annual operating cost** | **$ 42,374,000** |

# APPENDIX B

# Water Study Report Figures

Table of Figures

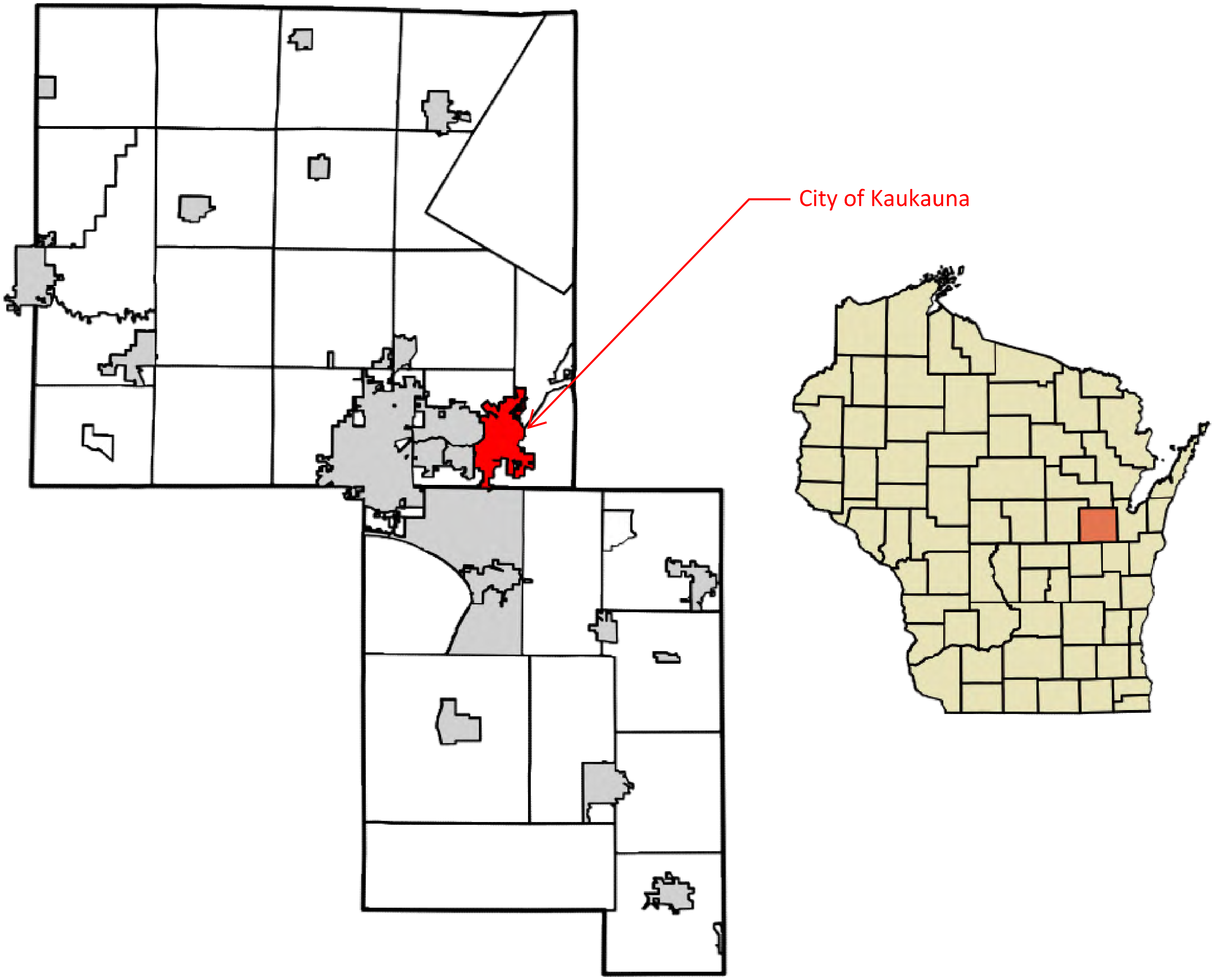


Figure 1: General Location Map

# KAUKAUNA UTILITIES

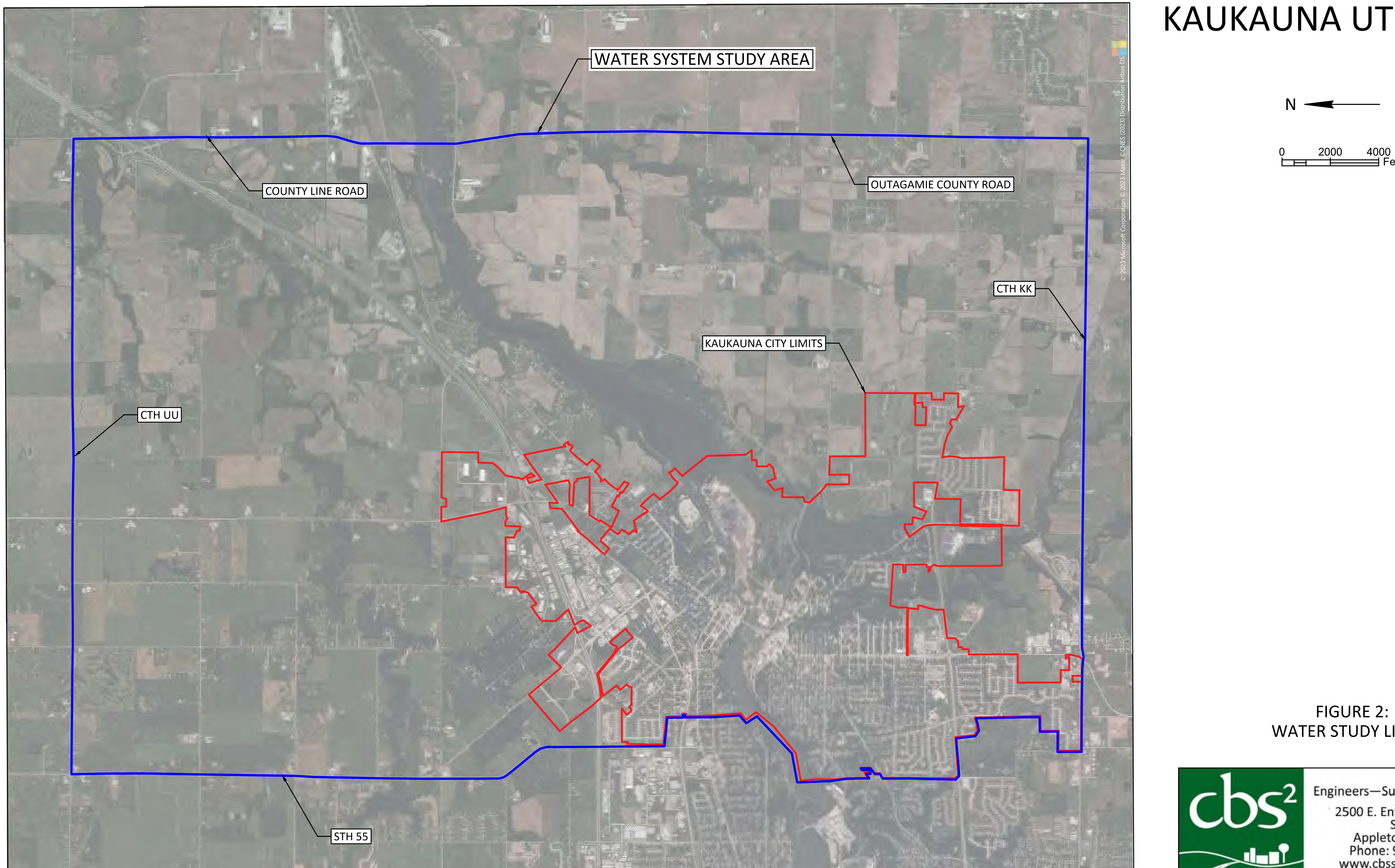


FIGURE 2:
WATER STUDY LIMITS


Engineers—Surveyors—Architects
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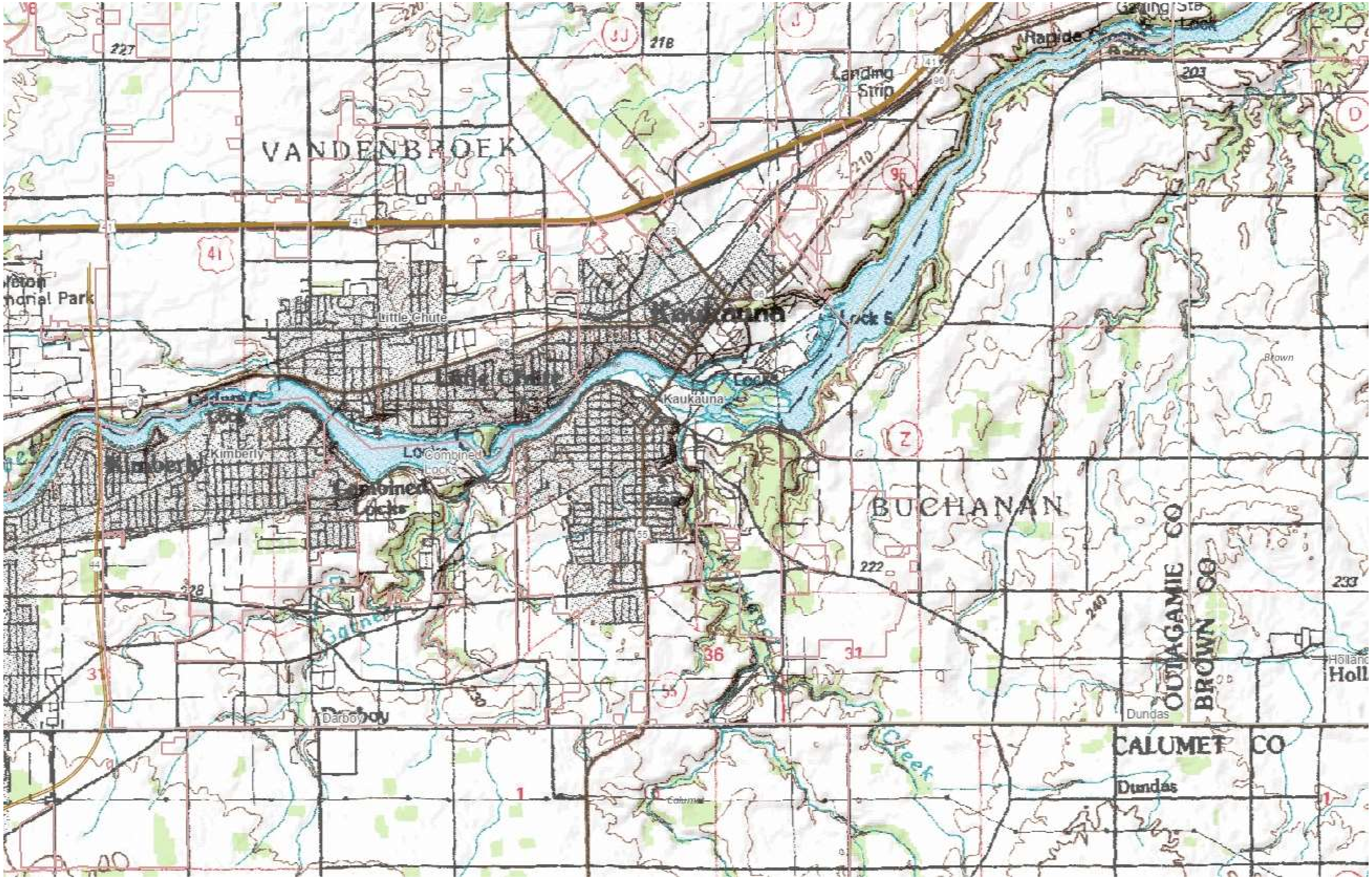
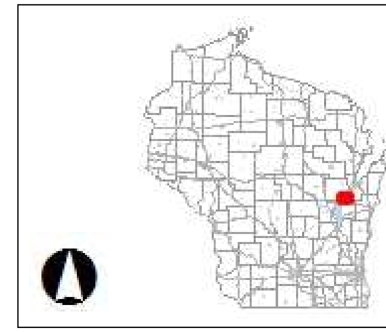
Suite A
Appleton, WI 54913
Phone: 920.574.3135
www.cbssquaredinc.com

# Figure 3: Topographic Map



## Legend

County Boundary

Cities, Towns & Villages

City

Village

Civil Town

| 1.5 | 0 | 0.75 | 1.5 Miles |
|---|---|---|---|

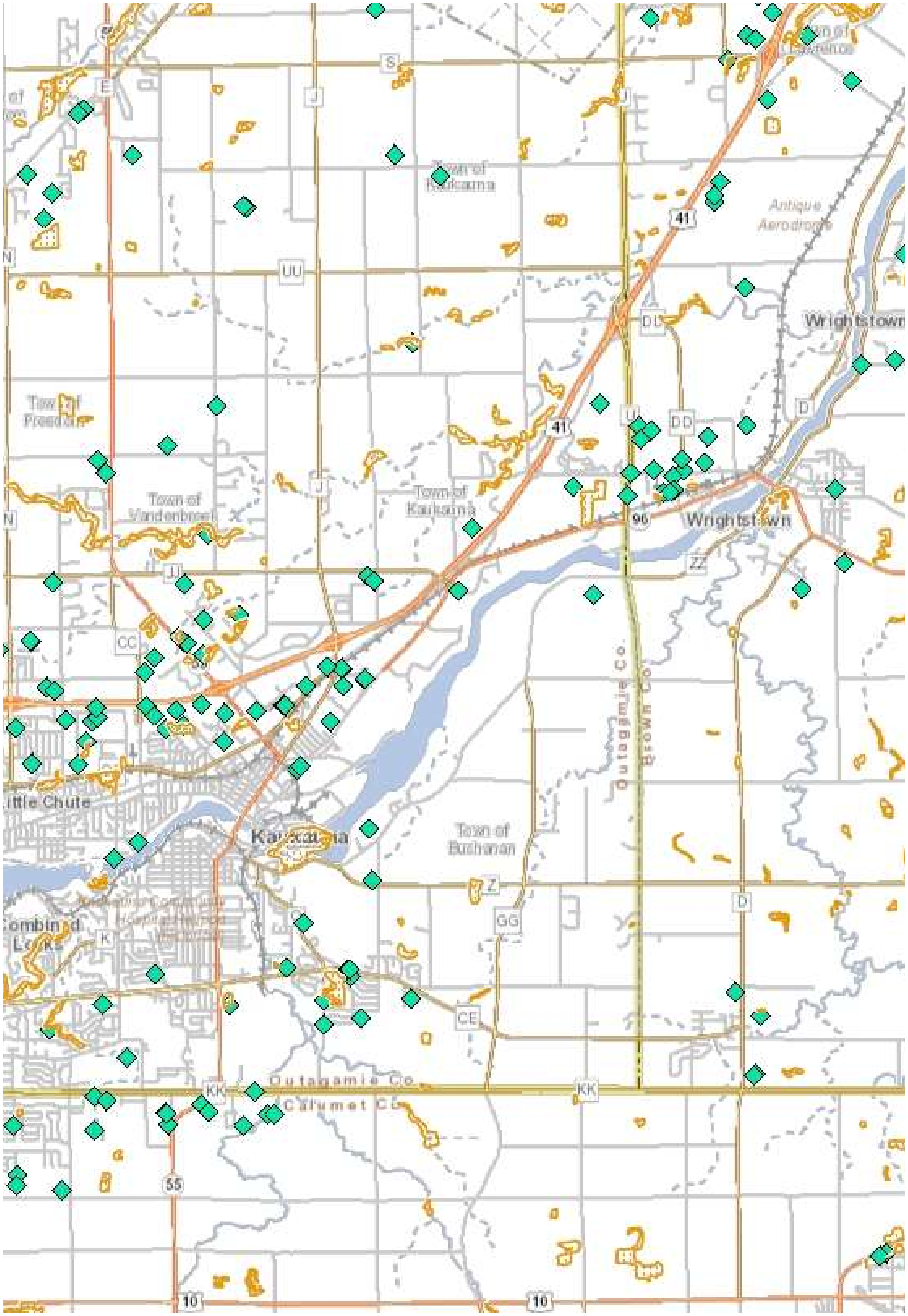
1:47,520

NAD_1983_HARN_Wisconsin_TM



## Notes

# Figure 4: Wetland Inventory Map




## Legend

- Wetland Class Areas
- Wetland Class Areas
- Filled Areas
- Wetland Class Areas
- Wetland Class Points
  - Dammed pond
  - Excavated pond
  - Filled/drained wetland
  - Wetland too small to delineate
  - Filled excavated pond
- Filled Points
- Wetland Class Areas
- Filled Areas
- Wetland Identifications and Confirmations
- Municipality
- State Boundaries
- County Boundaries
- Major Roads
  - Interstate Highway
  - State Highway
  - US Highway
- County and Local Roads
  - County HWY
  - Local Road
- Railroads
- Tribal Lands
- Rivers and Streams
- Intermittent Streams
- Lakes and Open water

3.0 0 1.50 3.0 Miles

1: 95,040

NAD_1983_HARN_Wisconsin_TM

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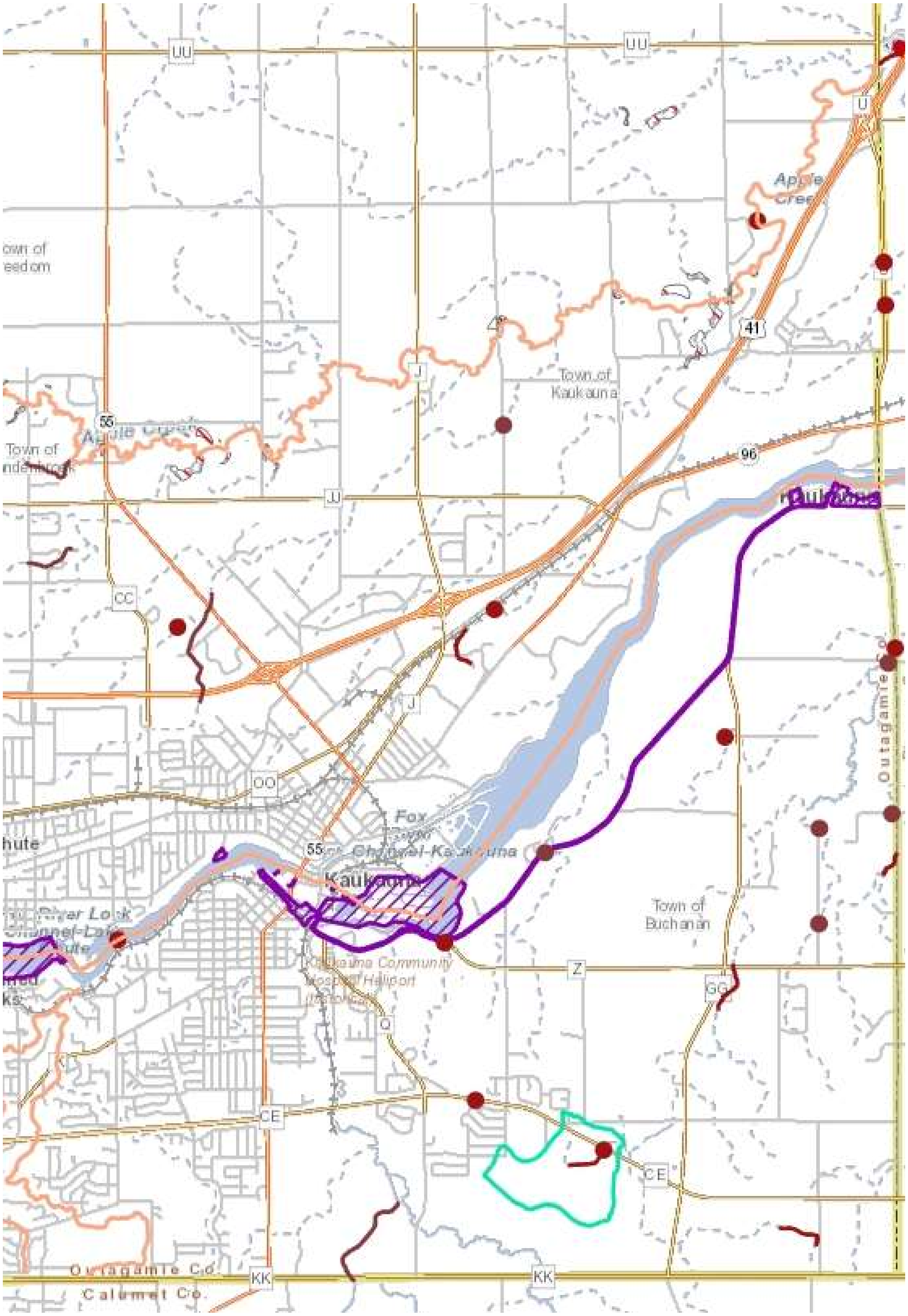
## Notes

# Figure 5: Floodplain Map




## Legend

2D Water Surface Elevation Grid
- High : 937.629
- Low : 853.184

Levees

Geomarks

Floodplain Analysis Lines
- Case by Case Analysis for Development in Floodplain
- Dam Failure Analysis
- Encroachment Analysis
- Flood Insurance Study
- Flood Storage Analysis
- Floodplain Study (Locally Funded)
- Hydrology/Hydraulics developed at a Dam
- <all other values>

Floodplain Analysis Catchments

Floodplain Analysis Points
- Case by Case Analysis for Development in Floodplain
- Dam Failure Analysis
- Encroachment Analysis
- Flood Insurance Study
- Flood Storage Analysis
- Floodplain Study (Locally Funded)
- Hydrology/Hydraulics developed at a Dam
- <all other values>

Record Flood Levels

FERC Project Area Boundaries

Floodplain Storage

Cross Sections

Floodplains
- Flood Fringe
- Floodway

Statewide Paper FIRM Index

2.0 0 1.00 2.0 Miles

1: 63,360

NAD_1983_HARN_Wisconsin_TM

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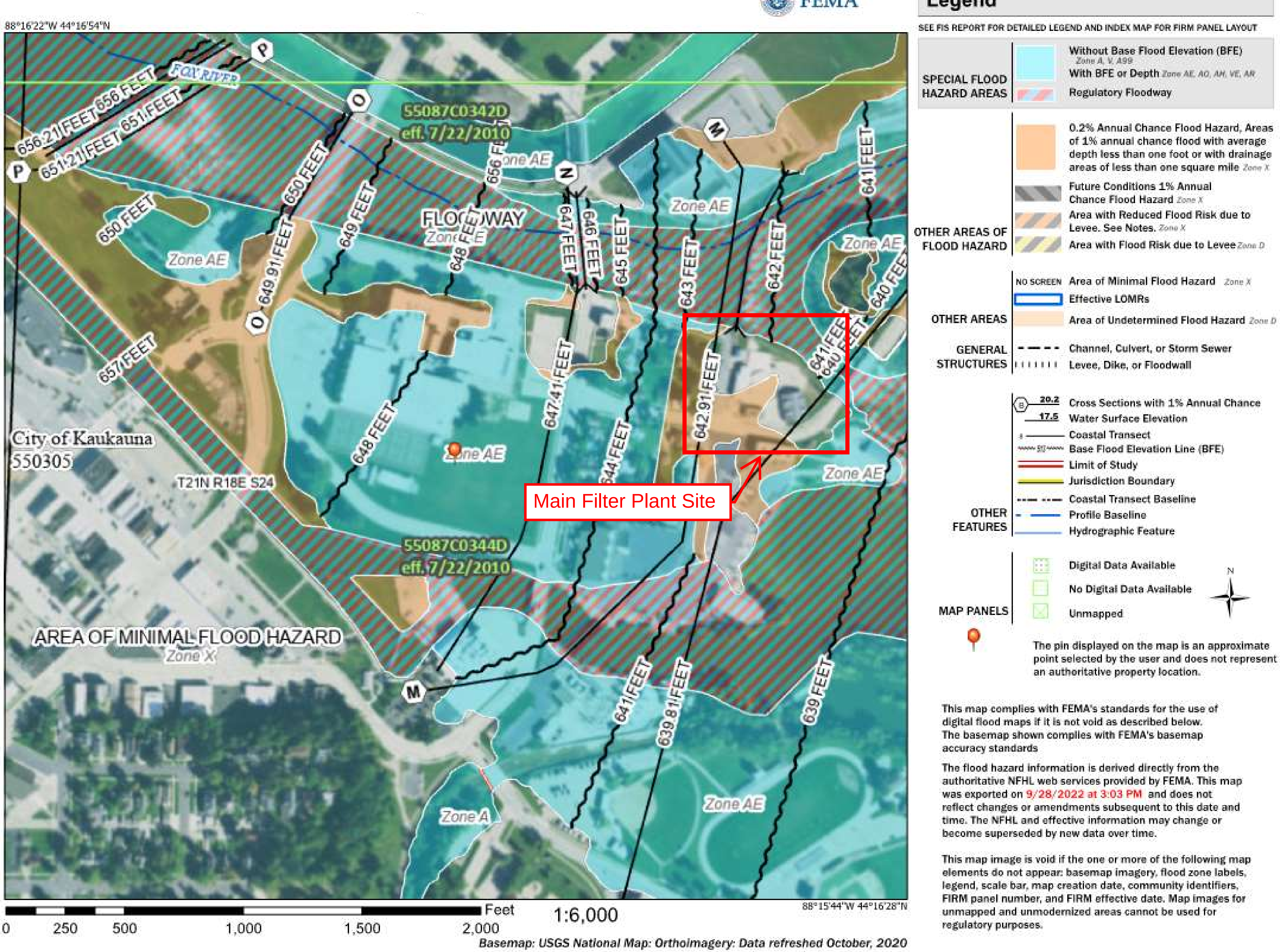
## Notes

Figure 6: Floodplain Map, Main Filter Plant Location



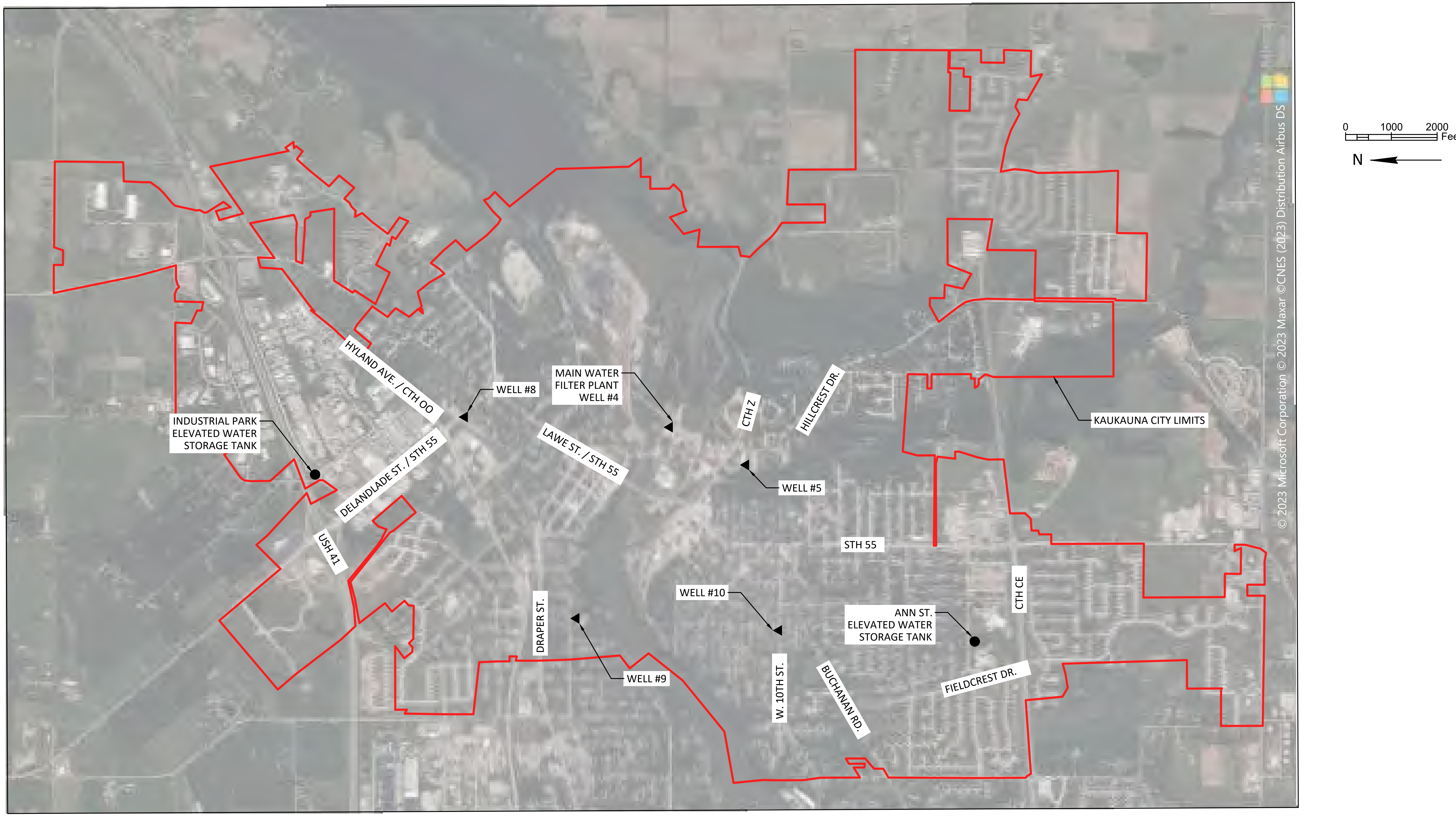



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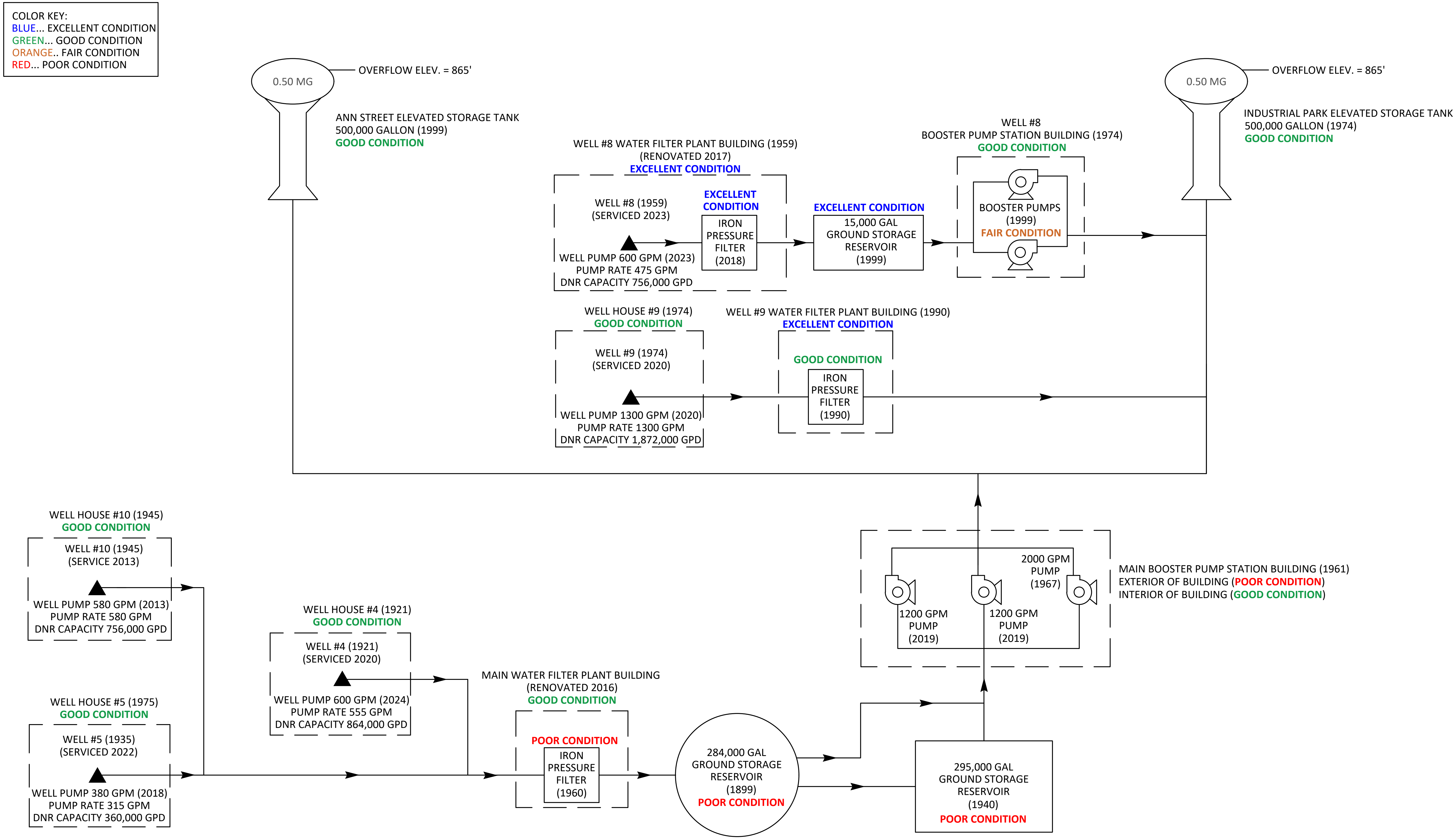
FIGURE 7:
KAUKAUNA WATER FACILITIES LOCATION MAP

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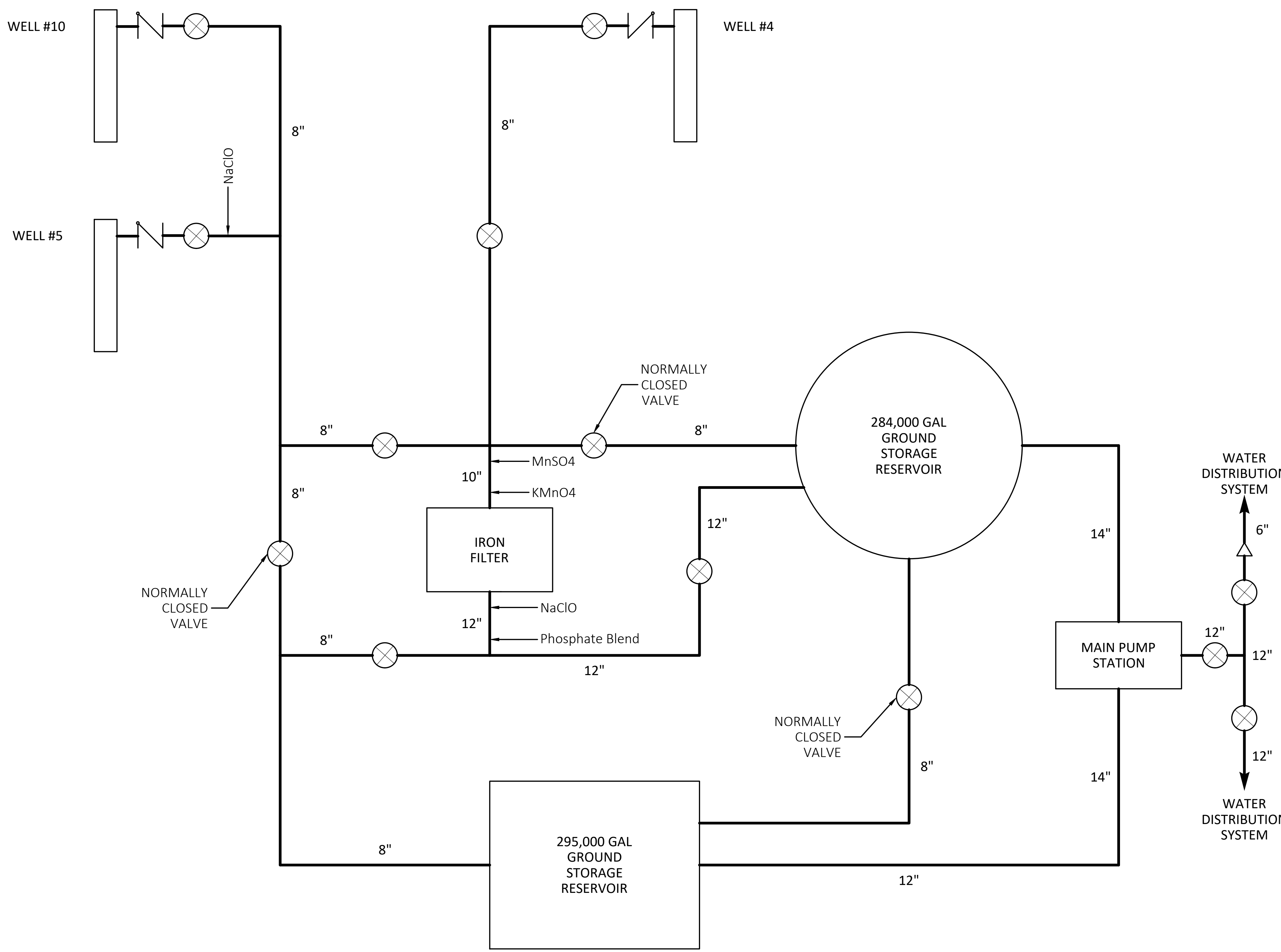
NOTE:
KAUKAUNA WATER DISTRIBUTION SYSTEM
HAS ONE PRESSURE ZONE.

FIGURE #8
SCHEMATIC OF EXISTING WATER SYSTEM

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NOTE: MANGANESE SULFATE AND POTASSIUM PERMANGANATE ARE INJECTED SEPARATELY INTO THE WATER PIPE TO MIX INSIDE THE WATER PIPE TO FORM HYDROUS MANGANESE OXIDE (HMO) SOLUTION.

FIGURE 9
SCHEMATIC OF MAIN FILTER PLANT TREATMENT PROCESS

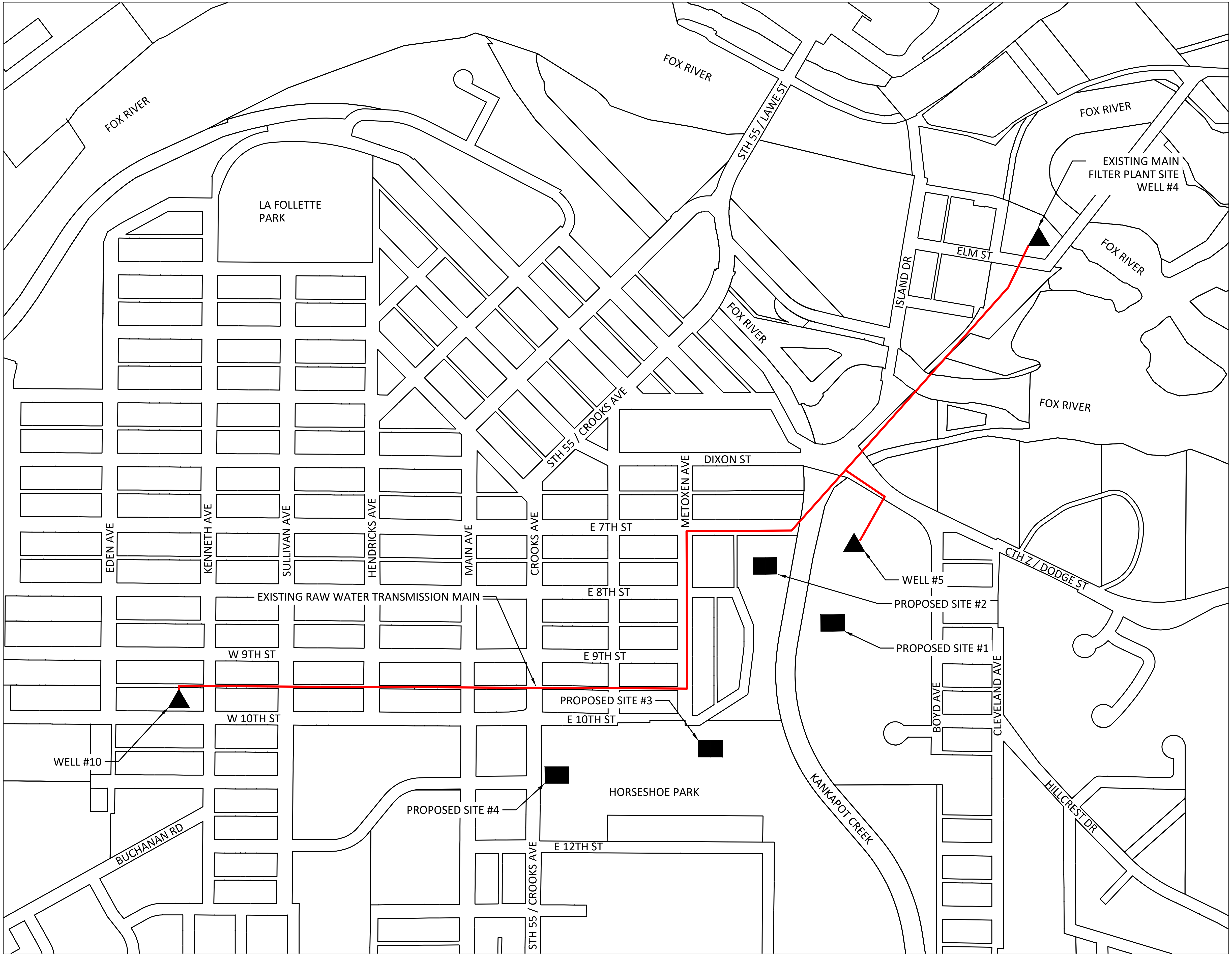


FIGURE 10:
PROPOSED MAIN FILTER PLANT SITES


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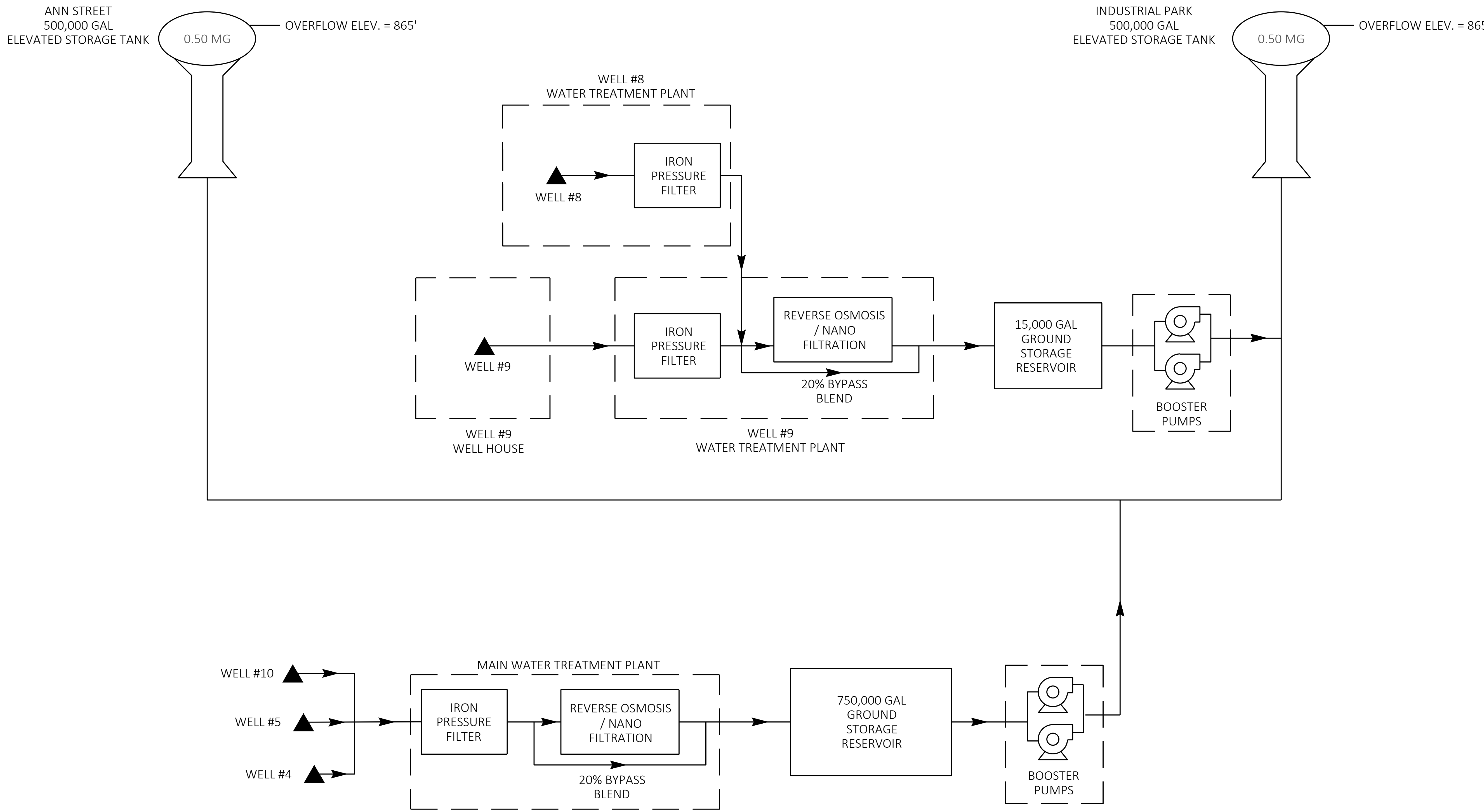


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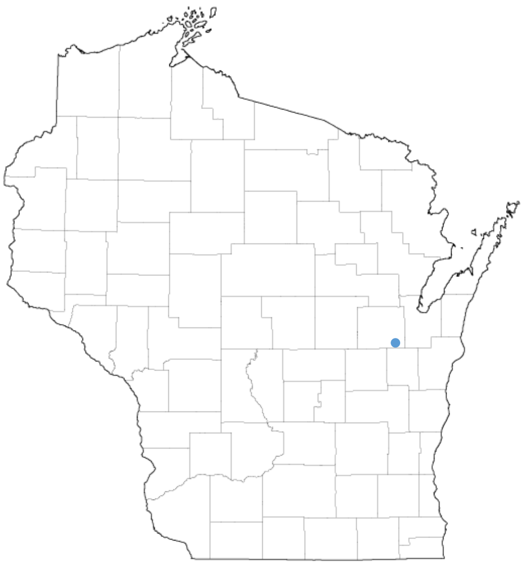
NOTE: KAUKAUNA WATER DISTRIBUTION SYSTEM HAS ONE PRESSURE ZONE

FIGURE 11
SCHEMATIC OF PROPOSED WATER SYSTEM

# APPENDIX C

# Condition Report for Existing Water Filter Plants



KAUKAUNA UTILITIES
Outagamie County, WI

# Kaukauna Utilities

## Condition Report for Existing Water Filter Plants

October 23, 2023

Prepared by:
CBS Squared, Inc.
2500 E Enterprise Avenue
Appleton, WI 54913
920.574.3135

KAUKA 22001

## Table of Contents



## Table of Figures



## Appendices

# Introduction

The purpose of this report is to document the evaluation performed by CBS Squared, Inc. of the three water filter plants owned by Kaukauna Utilities. The evaluation includes evaluating the existing structures and water filter plant equipment. Kaukauna Utilities is currently in the process of a detailed water system study and is looking into water system upgrades. This report documents the condition of the existing water filter plants.

# Main Water Filter Plant Site

The existing Main Water Filter Plant site is located at 304 Elm Street. The existing Main Filter Plant Site Plan Drawing is shown in **Appendix A**. The Main Filter Plant Site was originally constructed in 1899. The Main Filter Plant Site treats and stores water from Wells 4, 5, and 10. The Main Filter Plant Building has a pressure filter tank. The treatment includes chemical addition for radium removal and pressure filtration for radium and iron removal. The finished potable water is then stored in two ground storage reservoirs. The finished potable water is then pumped into the distribution system using booster pumps. The Main Filter Plant Site has several structures:

1. Main Filter Plant building which houses the chemical feed equipment and pressure filter tank
2. Two ground storage water reservoirs
3. Maintenance Facility building that includes the Well #4 Well House
4. Booster Pump Station building
5. Water Storage Facility building

## *Floodplain*

The DNR defines the following terms in DNR Wisconsin Administrative Code Chapter NR116.03:

> Floodway: The channel of a river or stream, and those portions of the floodplain adjoining the channel required to carry the regional flood discharge.
>
> Floodplain: That land which has been or may be covered by flood water during the regional flood. The floodplain includes the floodway, floodfringe, shallow depth flooding, flood storage and coastal floodplain areas.

None of the Main Filter Plant is located in the floodway of the Fox River but part of the Main Filter Plant site is located in the 100-year floodplain as established by US Federal Emergency Management Agency (FEMA). The FEMA mapping is located in **Appendix D**. The FEMA mapping shows that the southwest area of the Main Filter Plant site would be flooded during a 100-year flood event with 1 foot of water or less. The Main Filter Plant Building, the Maintenance Facility, Well #4 Well House, and part of Ground storage Reservoir #1 would be flooded with 1 foot of water or less.

The current DNR Wisconsin Administrative Code Chapter NR811.25(d) requires a floor elevation at least 2 feet above the regional flood elevation as determined in s. NR116.07(4). The excerpt from the current DNR code is shown in **Appendix E**. We anticipate that the DNR would require a water facility to comply with current code when a major renovation is performed to that water facility.

*Year-Round Dry Land Access*

The current DNR Wisconsin Administrative Code Chapter NR811.25(d) states: Buildings shall be provided with year-round dry land access. The current DNR Wisconsin Administrative Code Chapter NR811.63(3) Year-Round Access states: Storage facilities shall be located in an area accessible during the entire year. If necessary, road improvements shall be installed to provide year-round dry land access. The excerpt from the current DNR code is shown in **Appendix E**. The DNR will not provide clarification if the current Main Filter Plant site meets the requirement of year-round dry land access. The existing site is grandfathered in the Wisconsin Administrative Code until a major renovation occurs at the site, then the DNR would decide if the site complies with the current code.

*Main Filter Plant Building*

The Main Filter Plant Building is located in the 100-year floodplain as shown on the FEMA mapping located in **Appendix D**. The Main Filter Plant building was last renovated in 2016. The renovation included a new roof, new doors, and repairing the exterior brick. The windows are original block windows. The building is currently in good condition. There is no standby power at this facility.

Figure 1: Main Filter Plant Building

*Main Filter Plant – Pressure Filter Tank*

There is one horizontal pressure filter tank inside the Main Filter Plant building. The pressure filter tank is over 60 years old and is in extremely poor condition. The pressure filter tank is made of steel and coated with paint on the inside and outside for corrosion protection. The pressure filter tank works using low pressure around 10-15 pounds per square inch. The pressure filter tank was leaking in 2016. Upon visual inspection of the interior of the pressure filter tank in 2016, the tank was failing due to pitting of the interior steel surface caused by corrosion. The tank was repaired in 2016 by installing a concrete liner inside the bottom half of the tank to extend the useful life of the pressure filter. This type of repair was possible due to the low working pressure of the tank. This type of repair was estimated to extend the life of the tank another 10 years. The repair has been a good temporary solution because the pressure filter tank is still producing satisfactory water quality. The pressure filter tank currently has signs of mineral buildup on the exterior of the tank in two locations due to the tank starting to leak.

Metal thickness testing of the pressure filter tank wall was performed on September 28, 2023 using a R7900 Ultrasonic Thickness Gauge tester manufactured by Reed Instruments. The instrument can detect a metal thickness range of 0.03 inch-15.7 inch with an accuracy of +/-0.1 percent. The instrument uses ultrasonic sound waves to pass through the object and listens for the sound waves to bounce back. The instrument then calculates the thickness of the object. The instrument can detect thickness in metals, plastics, ceramics, composites, epoxies, and glass by entering the sound velocity for each type of media being tested. The instrument can detect a metal thickness reading through painted steel. The only type of media being tested was painted steel so a sound velocity of 5920 meters per second was entered into the instrument. Testing time is less than 1 second for instrument to display a reading at each location. The thickness tester instrument information is included in **Appendix F**.

Several locations on the pressure filter were selected for testing. A grid was set up at each location. The columns across the top were labeled A -Z. The rows were labeled in sequential numbering. The metal thickness of the tank varied greatly over the testing locations. Thickness testing locations and results are included in **Appendix G.** The results show that the 60-year old pressure filter tank has severe pitting on the interior of the tank walls. This result is consistent with the visual inspection performed on the interior of the tank in 2016. The structural integrity of the tank is in poor condition.

Figure 2: Main Pressure Filter Tank

Figure 3: Main Pressure Filter Tank

### *Main Filter Plant Site – Ground Storage Reservoirs*

The Main Filter Plant Site has two ground storage reservoirs for storing finished water. Ground Storage Reservoir #1 is circular and was constructed in 1899. Ground Storage Reservoir #1 has a capacity of 284,000 gallons and is approximately 60 feet in diameter and 18 feet deep. Ground Storage Reservoir #2 is rectangular and was constructed in 1940. Ground Storage Reservoir #2 has a capacity of 295,000 gallons and is approximately 13 feet deep.

The structures have outlived their useful life Reservoir #1 is located in the floodplain., Reservoir #2 is not located in the floodplain. The bottom of both reservoirs are located below the groundwater table. The elevation of each reservoir violates the current DNR Wisconsin Administrative Code Chapter NR 811.63(1), Floodway and Floodplain, which states:

(a) Floodway. Storage facilities may not be located within a floodway, as defined by in s.NR116.03 (22).
(b) Floodplain. If it is necessary to locate a reservoir in a floodplain, as defined in s. NR 116.03 (16), outside of the floodway, the lowest elevation of the bottom floor, including sumps, shall be a minimum of 2 feet above the regional flood elevation as determined in s. NR116.07 (4). All projects shall conform to the requirements of that chapter.

The excerpt from the current DNR code is shown in **Appendix E**. The regional flood elevation refers to the 100-year flood elevation. Existing reservoir #1 is located in the 100-year floodplain. Reservoir #2 is not located in the 100-year floodplain. The bottom floor of each reservoir is located below the 100-year floodplain and the groundwater table. The existing reservoirs are grandfathered in the Wisconsin

Administrative Code until a major renovation occurs on site to the reservoirs.   We anticipate that the DNR may require the reservoirs to be brought up to the current code at the time the major renovation occurs.

Figure 4: Reservoir #1 at Main Filter Plant

Figure 5: Reservoir #2 at Main Filter Plant

*Main Filter Plant Site – Maintenance Facility Building and Well #4 Well House*

The Maintenance Facility Building and Well 4 Well House are located in the 100-year floodplain as shown on the FEMA mapping located in **Appendix D**. The Maintenance Facility building is the green building shown in Figure 4 and is in poor condition. The Maintenance Facility Building is a post and beam construction consisting of a galvanized metal roof and sheet metal exterior walls. The roof is rusted and shows signs of leaking on the interior. The roof is in poor condition and is nearing the end of its useful life. The metal exterior walls are in fair condition.

Well 4 Well House Building is the white building shown in Figure 4 and is in good condition. The well house door is in poor condition. The floor elevation is not located 2 feet above the 100-year floodplain. We anticipate that the DNR may require the first floor to be raised during the next major renovation to Well #4 Well House. There is no standby power at this facility.

Figure 6: Maintenance Building and Well #4 Well House

*Main Filter Plant Site – Booster Pump Station Building*

The Booster Pump Station Building is attached to the North end of the Maintenance Facility Building. The Booster Pump Station Building has a concrete basement and concrete walls with a galvanized metal roof and metal exterior walls. The exterior of the building is in poor condition. The interior of the building is in good condition.

The Booster Pump Station Building is not located in the 100-year floodplain as shown on the FEMA mapping located in **Appendix D**. The first floor of the building is located 2 feet above the 100-year flood plain.

The Booster Pump Station building houses three booster pumps. Two booster pumps operate regularly. The third booster pump is for emergency backup use only. The third booster pump is operated by an engine driven right-angle drive which is not considered a good emergency backup pump. The third booster pump will only provide water until the two ground storage reservoirs are empty. The two standard booster pumps are in good condition but nearing the end of their useful life.


Figure 7: Booster Pump Station Building

Several locations on the booster pump suction and discharge piping were selected for pipe thickness testing. A grid was set up at each location. The columns across the top were labeled A -Z. The rows were labeled in sequential numbering. The metal thickness of the pipe was relatively the same over the testing locations. Thickness testing locations and results are included in **Appendix H.** The results show that the suction and discharge piping is in good condition.

*Main Filter Plant Site – Water Storage Facility*
The Water Storage Facility building was built in 2021. The building is in excellent condition.

Figure 8: Water Storage Facility Building

## Well 8 Water Filter Plant Site

The existing Well 8 Site is located at 311 Delanglade Street (1099 Blackwell Street) and 1101 Blackwell Street. The existing Well 8 Water Filter Plant Site Plan Drawing is shown in **Appendix B**. Well 8 Site consists of a Water Filter Plant Building, a ground storage reservoir, and a Booster Pump Station Building. Well 8 Water Filter Plant Building is located at 311 Delanglade Street (1099 Blackwell Street) at the Southwest corner of the intersection of Delanglade Street and Blackwell Street. Well 8 Water Filter Plant Building contains Well 8, a Pressure Filter Tank, and chemical feed systems. Well 8 Water Filter Plant building was originally built in 1959. Well 8 Water Filter Plant Building was recently renovated in 2018. The Well 8 Water Filter Plant building is in excellent condition. There is no standby power at this site.

There is one horizontal pressure filter tank inside the Well 8 Water Filter Plant building. The pressure filter tank is in excellent condition. The current pressure filter tank was installed in 2018 along with the media bed, underdrain piping, and diffuser piping. The pressure filter tank is made of steel and coated with paint on the inside and outside for corrosion protection. The pressure filter tank works using low pressure around 10-15 pounds per square inch but is at 53-65 pounds per square inch (distribution system pressure) during backwash cycles.

The metal thickness testing on the pressure filter tank confirmed the excellent condition of the tank.  The metal thickness readings were very consistent between all the readings.  No signs of pitting were found.  Results from the metal thickness testing are included in **Appendix J.**

Figure 9: Well 8 Pressure Filter Tank

Well 8 Ground Storage Reservoir and Booster Pump Station Building are located at 1101 Blackwell Street at the Northeast corner of the intersection of Delanglade Street and Blackwell Street.  The ground storage reservoir has a capacity of 15,000 gallons.  The ground storage reservoir was built in 1999.  The ground storage reservoir is in excellent condition.  The booster pumps at well 8 are located in the Booster Pump Station Building.  The building and booster pumps are in good condition.

## Well 9 Water Filter Plant Site

The existing Well 9 Site is located at Riverside Park.  The existing Well 9 Water Filter Plant Site Plan Drawing is shown in **Appendix C**.  Well 9 Site consists of two buildings.  A Well House building and a Water Filter Plant building.  The Well 9 Well House building was originally built in 1974.  The Well House is constructed of exterior stone and interior concrete block.  The Well House building is in very good condition.

The Water Filter Plant building was originally built in 1990.  The Water Filter Plant building is constructed of exterior brick and interior concrete block.  The Well 9 Filter Plant building is in excellent condition.

Well 9 Site has a generator for backup power. The generator is only sized to run the heaters, lights, and chemical pumps. The generator is not sized to run the well pump motors. The well pump is equipped with a right-angle drive with a natural gas motor which was installed in 2015 and operates the well pump at 850 gallons per minute during an electrical outage instead of 1300 gallons per minute normally.

There are two horizontal pressure filter tanks inside the Well 9 Water Filter Plant building. The pressure filter tanks were installed in 1990. The pressure filter tank is made of steel and coated with paint on the inside and outside for corrosion protection. The pressure filter tank works using 75-82 pounds per square inch (distribution system pressure) all the time. The media was replaced in 2010 along with the media bed, underdrain piping, and diffuser piping.

Several locations on the pressure filter tanks were selected for testing. A grid was set up at each location. The columns across the top were labeled A -Z. The rows were labeled in sequential numbering. The metal thickness of the tank varied slightly over the testing locations. Thickness testing locations and results are included in **Appendix K.** The results show that the 33-year old pressure filter tank has some moderate pitting on the interior of the tank walls. This result is consistent with the visual inspection performed on the interior of the tank in 2010. The structural integrity of the tank is in good condition.


Figure 10: Well 9 Pressure Filter Tank

## Chemical Feed System Equipment

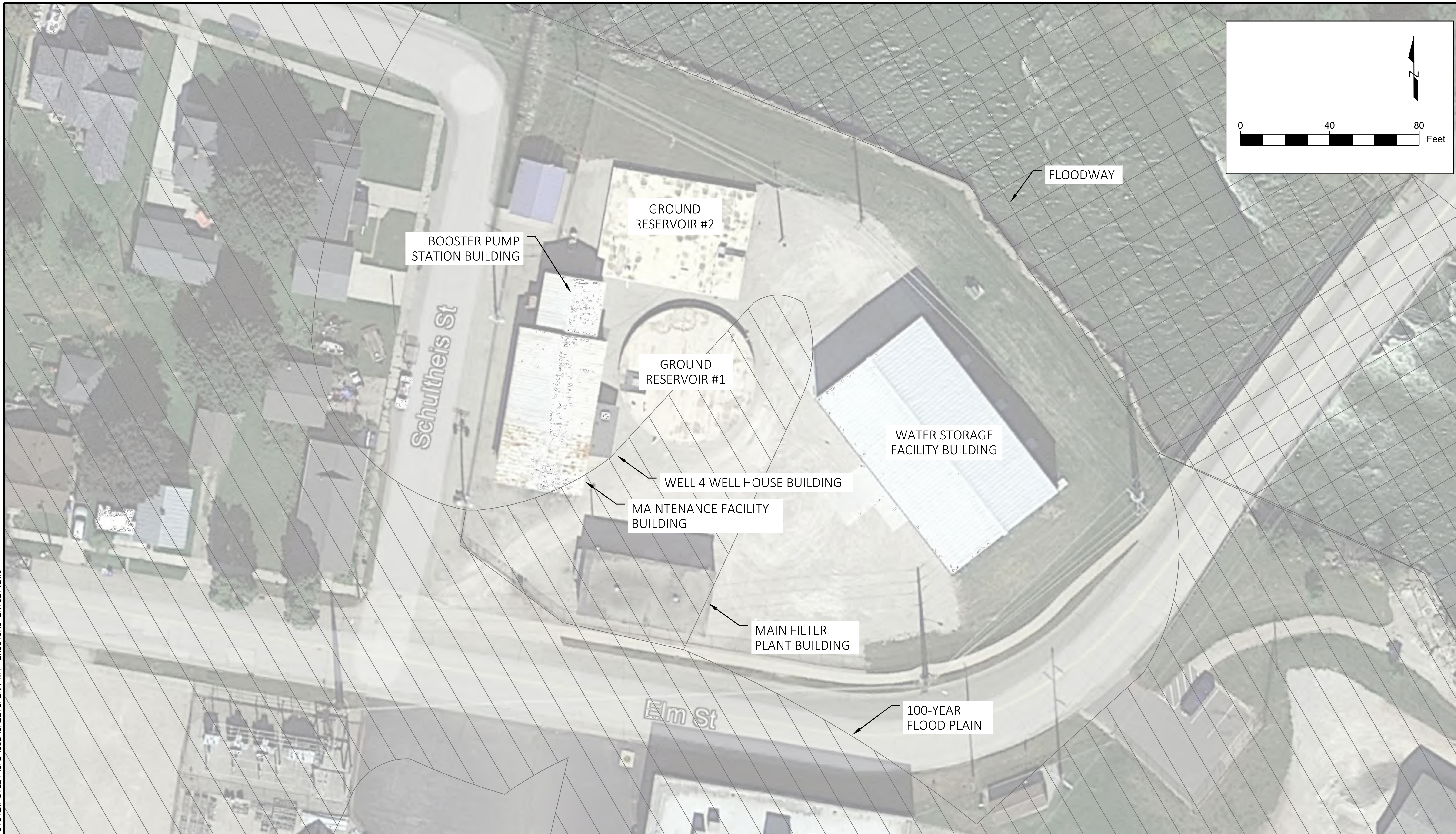
There are four chemical feed systems used at each well:

1. Manganese sulfate – For radium removal
2. Potassium permanganate - For radium removal
3. Sodium hypochlorite – For iron removal and disinfection
4. Orthophosphate polyphosphate blend – For corrosion control

In 2022, the chemical feed system equipment for sodium silicate was replaced and the chemical feed system for orthophosphate polyphosphate blend was added. The new chemical feed system equipment for sodium hypochlorite and orthophosphate polyphosphate blend included new chemical pumps, new chemical storage tanks, and new containment tanks. The chemical feed equipment for sodium hypochlorite and orthophosphate polyphosphate blend are in excellent condition at all Water Filter Plants. The chemical feed equipment for manganese sulfate and potassium permanganate are in good condition.

# Appendix A

# Existing Main Filter Plant Site Plan Drawing




P:\KAUKA\22001 WATER SYSTEM STUDY\CAD\C3D\SHEETS\PLAN\MFP EXISTING LAYOUT.DWG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| | | REVISIONS | |
|---|---|---|---|
| DRAWN BY: | CDV | DATE: | DESCRIPTION: |
| DATE: | 10/17/2023 | | |
| CHECKED BY: | JW | | |
| HORIZ. SCALE: | | | |
| VERT. SCALE: | | | |
| PROJECT NO. KAUKA22001 | | | |

**EXISTING CONDITION REPORT**
**KAUKAUNA, WI**

**EXISTING MAIN FILTER PLANT SITE PLAN**

SHEET
1

# APPENDIX B

# Existing Well 8 Filter Plant Site Plan Drawing


P:\KAUKA\22001 WATER SYSTEM STUDY\CAD\C3D\SHEETSPLAN\WFP EXISTING LAYOUT.DWG

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| DATE: | 10/17/2023 | | |
| CHECKED BY: | JW | | |
| HORIZ. SCALE: | | | |
| VERT. SCALE: | | | |
| PROJECT NO. KAUKA22001 | | | |

**EXISTING CONDITION REPORT**
**KAUKAUNA, WI**

**EXISTING WELL 8 WATER FILTER PLANT SITE PLAN**

SHEET
1

# APPENDIX C

# Existing Well 9 Filter Plant Site Plan Drawing


P:\KAUKA\22001 WATER SYSTEM STUDY\CAD\C3D\SHEETSPLAN\WFP EXISTING LAYOUT.DWG

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| | | REVIEWS | |
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| DRAWN BY: | CDV | **REVISIONS** | |
| DATE: | 10/17/2023 | DATE: | DESCRIPTION: |
| CHECKED BY: | JW | | |
| HORIZ. SCALE: | | | |
| VERT. SCALE: | | | |
| PROJECT NO. KAUKA22001 | | | |

**EXISTING CONDITION REPORT**
**KAUKAUNA, WI**

**EXISTING WELL 9 WATER FILTER PLANT SITE PLAN**

SHEET
1

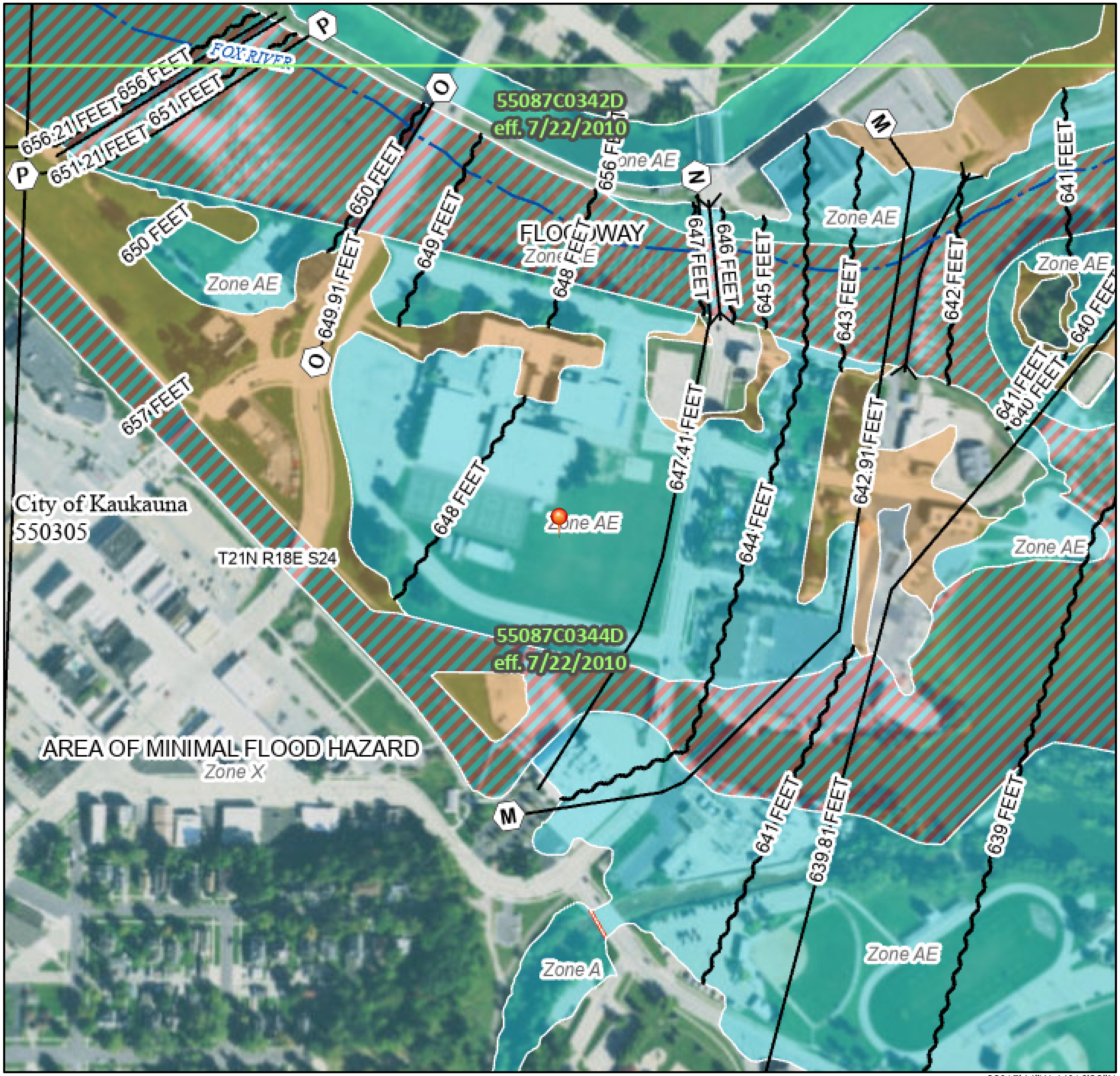
# APPENDIX D

## Federal Emergency Management Agency:
## 100-year flood map

# National Flood Hazard Layer FIRMette

FEMA

88°16'22"W 44°16'54"N




Feet

0 250 500 1,000 1,500 2,000

1:6,000

88°15'44"W 44°16'28"N

*Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020*

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

**SPECIAL FLOOD HAZARD AREAS**
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

**OTHER AREAS OF FLOOD HAZARD**
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

**OTHER AREAS**
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

**GENERAL STRUCTURES**
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

**OTHER FEATURES**
- B 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

**MAP PANELS**
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 9/28/2022 at 3:03 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

# APPENDIX E

# Wisconsin Department of Natural Resources Administrative Code: NR811.25 & NR811.63

# Chapter NR 811

## REQUIREMENTS FOR THE OPERATION AND DESIGN OF COMMUNITY WATER SYSTEMS



**Note:** Chapter NR 111 as it existed on April 30, 1992 was repealed and a new chapter NR 811 was created effective May 1, 1992. Chapter NR 811 as it existed on November 30, 2010, was repealed and a new chapter NR 811 was created effective December 1, 2010.

**NR 811.01 Applicability.** This chapter governs the general operation, design and construction of community water systems and the construction of any water system serving 7 or more single family homes, 10 or more duplex living units, 10 or more mobile homes, 10 or more condominium units or 10 or more apartment units. One duplex equals 2 living units. The standards for design and construction shall be considered minimum standards for new facilities and the minimum standards to which facilities in existence on December 1, 2010, shall be upgraded when improvements are undertaken at those facilities except for sys-of good quality and high stream flow for future release to the treatment facilities.

**(2)** CONSTRUCTION. Off–stream raw water storage reservoirs shall be constructed to assure all of the following:

(a) Water quality is protected by controlling runoff into the reservoir.

(b) Dikes are structurally sound and protected against wave action and erosion.

(c) Intake structures meet the requirements of s. NR 811.22.

(d) Point of influent flow is separated from the point of withdrawal.

(e) Water is regularly circulated to prevent stagnation.

(f) The reservoir is surrounded by a fence and unauthorized access is prevented.

(g) The reservoir is covered, where practical.

(h) The requirements of s. NR 811.47 (7) are met if the reservoir is to be used as a pre–sedimentation basin.

**History:** CR 09–073: cr. Register November 2010 No. 659, eff. 12–1–10.

**NR 811.232 Intake chemical treatment.** If the department determines that chemical treatment is warranted for taste and odor control or the control of zebra and other mussels and other nuisance organisms in an intake, the following requirements shall be met:

**(1)** Chemical treatment shall be installed in accordance with subch. VI and plans and specifications shall be approved by the department prior to installation.

**(2)** Solution piping and diffusers shall be installed within the intake pipe or in a suitable carrier pipe. Provisions shall be made to prevent dispersal of chemicals into the water environment outside the intake. Diffusers shall be located and designed to protect all intake structure components.

**(3)** A spare solution line shall be installed to provide redundancy and to facilitate the use of alternate chemicals, where practicable.

**(4)** A sample line out to the intake shall be provided which will allow for collecting raw water samples unless the chemical control system will be shut off for periods sufficient to collect raw water samples at the shore well.

**History:** CR 09–073: cr. Register November 2010 No. 659, eff. 12–1–10; renumbering of (1) to (4) made under s. 13.92 (4) (b) 1., Stats., Register November 2010 No. 659.

## Subchapter IV — Pumping Stations, Pumphouses, and Water Treatment Plant Buildings

**NR 811.24 General requirements.** All water system related buildings shall be designed to maintain the sanitary quality of the water supply. Buildings subject to the requirements of this subchapter include surface water and groundwater water treatment plant buildings, structures and pumping stations, well pumphouses and enclosures, and booster pumping stations. Uses of the buildings shall be compatible with the protection of the water supply.

**History:** CR 09–073: cr. Register November 2010 No. 659, eff. 12–1–10.

**NR 811.25 Buildings. (1)** CONSTRUCTION. All water system related buildings under s. NR 811.24 shall meet all of the following requirements:

(a) Have adequate space for the installation of additional pumping units, water treatment equipment, chemical feed equipment, or controls, if needed, and for the safe servicing of all equipment.

(b) Be durable, fire and weather resistant, and constructed in a manner to maximize sanitary protection of the water supply.

(c) Be secure. Buildings shall have at least one outward opening door to the outside. All doors, windows, and hatches shall have locks. Any security alarms installed shall be connected to telemetry control and SCADA systems where such systems are used.

(d) Be landscaped to conduct surface drainage away from the station and have a floor elevation at least 6 inches above the finished grade and at least 2 feet above the regional flood elevation as determined in s. NR 116.07 (4). Buildings shall be provided with year round dry land access. Below grade installations may be permitted only if the terrain at the site is such that a gravity drain system can be provided. Subsurface pits or pumprooms and inaccessible installations intended to house well heads, pumps, pump motors, or pump controls for pumping stations are prohibited except for below grade booster pumping stations as allowed per s. NR 811.80 (3) and (4).

(e) Provide for all floors to drain so that floor runoff does not enter the treatment process or source water. Floors shall be sloped to a drain or sump.

(f) Provide a suitable outlet for drainage water from pump glands so that the disposal of any drainage water is piped to waste or otherwise disposed of in a controlled manner. Pump gland drainage piping shall not be directly connected to a hub drain or a floor drain.

(g) Be provided with concrete floors.

(h) Be provided with at least one floor drain meeting the following requirements:

1. Floor drains and hub drains shall be properly separated from a well. A floor or hub drain and associated piping accepting water from pump gland drainage, a pressure relief or control valve, a sampling faucet, or the floor shall be located no closer than 2 feet to the outer well casing. No building drain piping, except that piping leading to the aforementioned floor or hub drains, containing blackwater or graywater, may be located closer than 8 feet to the outer well casing.

2. Floor drains and hub drains shall have a discharge location that complies with all of the following requirements:

a. Floor drains and hub drains may be connected to a sanitary sewer where available if the building floor elevation is at least one foot above the rim elevation of the nearest upstream sanitary sewer manhole. If a sanitary sewer is available but a manhole is not located nearby or the manhole does not comply with the upstream location or the one foot requirement, the department may require installation of an additional manhole on the sanitary sewer main or on the sanitary building sewer.

**Note:** The department recommends that the floor drains from chemical feed rooms discharge to a sanitary sewer whenever practicable.

b. Floor drains and hub drains may discharge to the ground surface if the building drain and building sewer piping will only carry water from the floor or hub drain, the discharge location shall be at least 25 feet from the pumphouse, the exterior invert of the building sewer pipe shall be at least 6 inches below the building floor elevation and the exterior pipe opening shall be covered with a corrosion resistant rodent screen. A greater distance may be required for drains of pump stations serving wells constructed in sand and gravel formations. The piping shall terminate in a location that will not allow backflow of surface water into the building.

c. Floor drains and hub drains may discharge to a buried tank located a minimum of 50 feet from the well if the discharge to the building drain and building sewer piping will contain only water from pump gland drainage, a pressure relief or control valve, a sampling faucet or floor drainage. These buried tanks may not be installed unless approved by the department's bureau of watershed management wastewater section prior to installation. Floor drains and hub drains may discharge to a POWTS holding component located a minimum of 200 feet from the well if the discharge will contain toilet, sink or other sanitary or domestic waste. These POWTS holding components may not be installed unless approved by the department of safety and professional services prior to installation. In either case the rim elevation of the access manhole to the tank shall be at least one foot below the building equipment consisting of a pressure gauge, a pressure relief valve, a water sight glass, an automatic air blow–off, and pressure or probe operated start–stop controls for the pumps.

**(4)** Each tank not equipped with a bladder or diaphragm to separate the air and water and with a gross volume of 500 gallons or more or that will be painted inside shall be provided with an access manhole. If the tank interior is to be painted it shall be painted with NSF/ANSI approved paints in accordance with s. NR 810.09 (5).

**(5)** Each tank not equipped with a bladder or diaphragm to separate the air and water and with a gross volume of 500 gallons or more shall be provided with an automatically controlled air compressor to add air to the tank. All compressors used to routinely add air to tanks shall be oil–less. Larger capacity compressors that are not oil–less may be used temporarily to fill a tank upon startup, repair or service but shall be fitted with one or more filters and any other appurtenances necessary to remove particulates and oil from the air prior to injection.

**(6)** Each tank equipped with a diaphragm or bladder shall be equipped with an air inlet for adding air manually, a pressure relief valve for each tank or bank of tanks sized to handle the maximum flow rate, and pressure–operated start up and shut down controls for the well pump.

**(7)** The gross volume, in gallons, of any tank or combination of tanks, shall be at least 10 times the capacity of the largest pump, rated in gallons per minute, unless the proposed pump motor or motors will be controlled by a variable output control device in a manner intended to reduce the volume of required pressure tank storage in accordance with s. NR 811.34 (6). For a standard installation, the required storage volume is intended to provide a minimum pump run time of 2 to 3 minutes.

**(8)** Each tank shall be identified by stamping or labeling showing the manufacturer's name, a serial number, the tank volume, the allowable working pressure, and the year fabricated.

**(9)** Each tank not equipped with a bladder or diaphragm to separate the air and water and with a gross volume of 500 gallons or more shall be constructed of steel and have a 0.25 inch minimum side wall and head wall thickness.

**History:** CR 09–073: cr. Register November 2010 No. 659, eff. 12–1–10.

## Subchapter IX — Storage Facilities

**NR 811.62 Volume and pressure. (1)** VOLUME REQUIREMENTS. A sufficient quantity of water, as determined from engineering studies, shall be maintained in elevated storage when only one pumping unit to the distribution system is available to serve the water system. This shall be at least an average–day supply under normal operating conditions. When more than one distribution pump is available, the storage shall be in accordance with standard engineering practice. Standard engineering practice is based upon an engineering review of existing and future water supply needs including: type of service and population served; average day, maximum day, peak hour and fire flow demands and durations; water source quality, availability and treatment, pump capacities, auxiliary power, storage capacity, water distribution and costs.

**(2)** PRESSURE REQUIREMENTS. Storage facilities shall be designed to meet all the following requirements:

(a) *Minimum and maximum pressures.* The storage facilities shall be designed to meet the minimum and maximum pressure requirements specified in s. NR 811.66 (1).

(b) *Fire flows and residual pressures.* When fire protection is to be provided, the storage facilities shall be designed in conjunction with distribution system design to provide the minimum fire flows and residual pressures specified in s. NR 811.70 (6).

(c) *Alternative means for maintaining pressure.* A hydro–pneumatic tank, booster pumping facilities, or other reliable means shall be provided to maintain system pressure when a gravity storage reservoir or tank is not available.

**(3)** ELEVATED STORAGE REQUIREMENT WAIVED. The department may waive the requirement for elevated storage if the system is designed to serve less than 50 homes, if it is not economically feasible to provide elevated storage, if elevated storage facilities are proposed for a later development phase, or if service is proposed for domestic use only.

**History:** CR 09–073: cr. Register November 2010 No. 659, eff. 12–1–10.

**NR 811.63 Location.** Storage facilities shall be located in accordance with all the following requirements:

**(1)** FLOODWAY AND FLOODPLAIN. (a) *Floodway.* Storage facilities may not be located within a floodway, as defined in s. NR 116.03 (22).

(b) *Floodplain.* If it is necessary to locate a reservoir in a floodplain, as defined in s. NR 116.03 (16), outside of the floodway, the lowest elevation of the bottom floor, including sumps, shall be a minimum of 2 feet above the regional flood elevation as determined in s. NR 116.07 (4). All projects shall conform to the requirements of that chapter.

**Note:** Refer to ch. NR 116 for floodplain and floodway requirements.

**(2)** GRADING. The area surrounding structures shall be graded in a manner that will prevent surface water from standing within 50 feet of the structure.

**(3)** YEAR–ROUND ACCESS. Storage facilities shall be located in an area accessible during the entire year. If necessary, road improvements shall be installed to provide year–round dry land access. Storage facilities and access roads shall be located on property owned by the water supply owner or for which the owner has obtained easements.

**(4)** FLOOR ELEVATIONS. The department recommends that the lowest elevations of floors and sump floors of ground level reservoirs and standpipes should be placed at or above the normal ground surface. If the department allows the floor or sump to be below the normal ground surface, it shall be placed a minimum of 2 feet above the groundwater table. Borings shall be made to determine groundwater elevations if that information is not available.

**(5)** CONTAMINATION SOURCES. (a) Sewers, drains, fuel storage tanks, standing water, and similar sources of contamination shall be kept a minimum of 50 feet from the reservoir.

(b) The department may approve gravity or force main sewers within 50 feet of a reservoir if the sewer or force main is constructed of water main class pipe meeting the requirements of s. NR 811.69 and is pressure tested in place to meet the requirements of s. NR 811.12 (5) (d) 2.

**(6)** ROOF SURFACE ABOVE GRADE. (a) The top roof surface of a ground level reservoir may not be less than 2 feet above normal ground surface.

(b) The department shall require a higher exposed elevation if high groundwater, poor surface drainage, or tight soils are encountered that will deter subsurface drainage or if necessary to provide positive pressures for pump intake or discharge lines in accordance with s. NR 811.37.

**Note:** It is recommended that no more than one–half of the reservoir depth be constructed below grade.

(c) The department may except clearwells constructed under filters from the 2 foot requirement when the total design gives the same protection.

**History:** CR 09–073: cr. Register November 2010 No. 659, eff. 12–1–10.

**NR 811.64 Construction details. (1)** MATERIALS. Materials used in the construction of storage facilities shall meet all the following requirements:

(a) *General requirements.* The materials and designs used for finished water storage structures shall provide stability and durability as well as protect the quality of the stored water. Unless the design engineer can justify the use of other materials, the depart-

# APPENDIX F

# Thickness Testing Instrument Information

R7900

REED INSTRUMENTS

# Ultrasonic Thickness Gauge


WARRANTY 1 YEAR WARRANTY

# Instruction Manual

REED Instruments
1-877-849-2127 | info@reedinstruments.com | www.reedinstruments.com

# Table of Contents



*continued...*

# Introduction

Thank you for purchasing your REED R7900 Ultrasonic Thickness Gauge. Please read the following instructions carefully before using your instrument. By following the steps outlined in this manual your meter will provide years of reliable service.

# Product Quality

This product has been manufactured in an ISO9001 facility and has been calibrated during the manufacturing process to meet the stated product specifications. If a certificate of calibration is required please contact the nearest authorized REED distributor or authorized Service Center. Please note an additional fee for this service will apply.

# Security

Never attempt to repair or modify your instrument. Dismantling your product, other than for the purpose of replacing batteries, may cause damage that will not be covered under the manufacturer's warranty. Servicing should only be provided by an authorized service center.

# Features

- Measures a wide range of material including; metals, plastic, ceramics, composites, epoxies, glass, and other ultrasonic conductive materials
- Easy-to-read backlit LCD display
- User selectable unit of measure (in/mm)
- Internal memory stores up to 500 measurements
- Displays sound velocity at the touch of a button
- Zero adjustment button
- User adjustable High/Low alarms
- Built-in two-point calibration function
- Auto sleep, shut off and low battery indicator

## Specifications

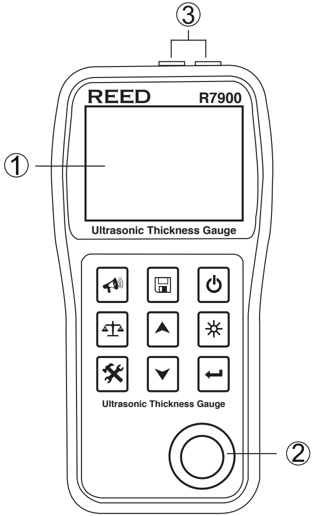
| | |
|---|---|
| Measuring Range: | 0.03 to 15.7" (0.65 to 400mm) |
| Accuracy: | ±0.04mm (< 10mm)<br>±(0.1% rdg.+ 0.04mm) (< 100mm)<br>±(0.3% rdg.) (> 100mm) |
| Resolution: | 0.01mm or 0.1mm (< 100mm)<br>0.1mm (>100mm) |
| Velocity Range: | 1000 to 9999 m/s (0.039 to 0.394 in/µs) |
| Compatible Materials: | Ultrasonic conductive materials (ie. metals, plastics, ceramics, composites, epoxies, glass) |
| Sampling Time: | Less than 1 second |
| Display: | 4-Digit, LCD |
| Backlit Display: | Yes |
| Probe Length: | 3' (36") |
| Internal Memory: | Yes (up to 500 readings, 5 files up to 100 each) |
| Low Battery Indicator: | Yes |
| Power Supply: | 2 AA Batteries |
| Battery Life: | Approx. 100 hours (Alkaline) |
| Product Certifications: | CE |
| Operating Temperature: | 32 to 122°F (0 to 50°C) |
| Storage Temperature: | -4 to 140°F (-20 to 60°C) |
| Operating Humidity Range: | 20 to 80% |
| Dimensions: | 5.9 x 2.9 x 1.3" (150 x 74 x 32mm) |
| Weight: | 8.4oz (238g) |

## Included

- Ultrasonic Couplant Gel
- Probe
- Hard Carrying Case
- Batteries

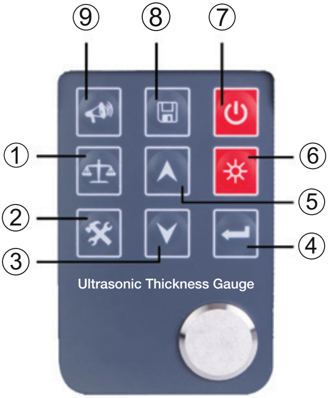
## Instrument Description

1. LCD Display
2. Calibration Test Block
3. Probe Inputs

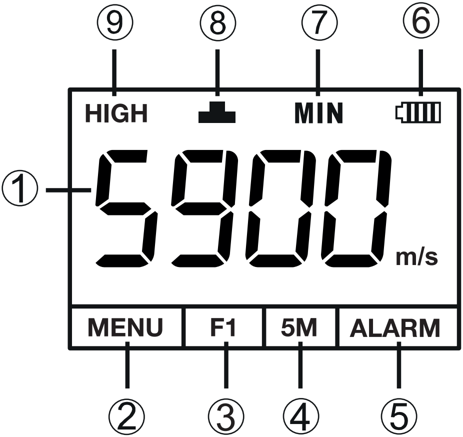



## Keyboard Description

1. Zero Button
2. Mode Button
3. Down Button
4. Enter Button
5. Up Button
6. Backlight ON/OFF Button
7. Power Button
8. Save/Browse Button
9. Velocity Button



# Display Description




1. Measured Value
2. Menu Settings
3. Saved File Name
4. Ultrasonic Sensor Frequency
5. Alarm Thickness Settings
6. Battery Indicator
7. Minimum Capture Mode
8. Coupling Indicator
9. Gain Indicator

# Operating Instructions

1. Insert the ultrasonic sensor into the probe sockets on the meter.
2. Press, hold an release the ⏻ button for 2 seconds to turn the meter on. Press the ⏻ button to turn the meter off.
3. The LCD will briefly display information about the meter, and then show the current set sound velocity.

## *Setting Ultrasonic Sensor Frequency*

1. Press the button to highlight the ultrasonic sensor frequency setting on the display.
2. Continuously press the button to toggle between 2MHz, 5MHz, 7MHz, 10MHz and ZW frequencies.
3. To exit, press the button or by carrying out a measurement.

## *Zero Calibration*

1. After setting the correct ultrasonic sensor frequency, set the sound velocity to 5900m/s (see *Adjusting the Sound Velocity* for details).
2. Select the proper receiving gain (see *System Setup* for details).
3. Coat the 4mm calibration test block with coupling gel (R7950) and place the sensor on the calibration test block while ensuring the coupling indicator "" appears on the LCD display.
4. Once the coupling indicator appears on the LCD display press the button to initiate zero calibration.
5. The meter will beep and then the screen will indicate that the calibration is complete.
6. If zero calibration is not properly completed the meter will retain the original value.
7. To delete the calibration data, see *Memory Manager* section for details.

## *Adjusting the Sound Velocity*

1. While the meter is on, press the button and the meter will display the current sound velocity.
2. Press the button to switch between the 5 pre-loaded sound velocities, or press the ▲ and ▼ buttons to match the sound velocity of the material under test as shown in the following table.

*continued...*

| Material | Sound Velocity (m/s) | (inch/µs) |
|---|---|---|
| Aluminum | 6320 to 6400 | 0.250 |
| Zinc | 4170 | 0.164 |
| Silver | 3607 | 0.142 |
| Gold | 3251 | 0.128 |
| Tin | 2960 | 0.117 |
| Steel, Common | 5920 | 0.233 |
| Steel, Stainless | 5740 | 0.226 |
| Brass | 4399 | 0.173 |
| Copper | 4720 | 0.186 |
| Iron | 5930 | 0.233 |
| Case Iron | 4400 to 5820 | 0.173 to 0.229 |
| Lead | 2400 | 0.094 |
| Nylon | 2680 | 0.105 |
| Titanium | 5990 | 0.236 |
| SUS | 5970 | 0.240 |
| Epoxy Resin | 2540 | 0.100 |
| Ice | 3988 | 0.222 |
| Plexiglass | 2692 | 0.106 |
| Grey Cast | 4600 | 0.180 |
| Porcelain | 5842 | 0.230 |
| Glass (Quartz) | 5570 | 0.220 |
| Polystyrene | 2337 | 0.092 |
| PVC | 2388 | 0.094 |
| Quartz Glass | 5639 | 0.222 |
| Rubber, Vulcanized | 2311 | 0.091 |
| Teflon | 1422 | 0.058 |
| Water | 1473 | 0.058 |

*continued...*

## *Preparing the Measurement Surface*

1. Clean any dust, dirt or rust off the object, and remove any coating such as paint.
2. Smooth the surface of the object by grinding or polishing it. You can also use a coupling gel with a high viscosity.

**Important Note**: In any ultrasonic measurement scenario, the shape and roughness of the desired test material are of great importance. Rough, uneven surfaces will prevent the ultrasonic sensor from seating properly against the surface, thus limiting the penetration of ultrasound through the material, resulting in unstable and therefore, unreliable measurements.

## *Taking Thickness Measurements*

1. Set the sound velocity on the meter (see *Adjusting the Sound Velocity* for details).
2. Apply coupling gel on the material, place the sensor firmly against the desired measurement area.

**Note**: For most applications a single droplet of coupling gel is sufficient.

3. Verify that the coupling Indicator "" appears on the LCD display.
4. Read the measurement on the LCD display.
5. When you remove the ultrasonic sensor the value will stay on the LCD and the coupling indicator "" will disappear.
6. Press the button to save the measurement if applicable.
7. If the coupling indicator "" does not appear on the display, or the measured values appear to be erratic, verify that there is an adequate amount of coupling gel in between the ultrasonic sensor and the material under test. It is also important that the ultrasonic sensor sits flat against the material.

## *Auto Power OFF*

To preserve battery life, the meter is programmed to turn itself after approximately 3 minutes of inactivity. To disable this option, please see *System Setup* section for details.

*continued…*

## *Sound Velocity Measurements of a Material with a Known Thickness*

The sound velocity of a material can be measured using a test piece with a known thickness. Select a test piece with a minimum wall thickness of 20.0mm. Turn off the minimum capturing function (see *System Setup* section for details) prior to taking measurement.

1. Measure the test piece with a caliper or micrometer to confirm the thickness.
2. Apply coupling gel on the material, place the sensor firmly against the desired measurement area.

**Note**: For most applications a single droplet of coupling gel is sufficient.

3. Remove the ultrasonic sensor from the measurement area and adjust the measuring display until the actual thickness is met by pressing the ▲ and ▼ buttons and press the button to confirm your selection.
4. The LCD will display the sound velocity.
5. Press the button to save the value if applicable.

## *Sound Velocity Calibration*

1. Start by performing a zero calibration to the ultrasonic sensor.
2. Measure the actual thickness of the test piece with a caliper or micrometer.
3. Select a sound velocity from the pre-loaded list (choose any one).
4. Apply coupling gel on the material, place the sensor firmly against the desired measurement area.

**Note**: For most applications a single droplet of coupling gel is sufficient.

5. The LCD will display a measurement reading of the test piece.

**Note**: The reading will be off as the sound velocity is not correct.

6. Remove the ultrasonic sensor from the test piece, go into the velocity interface by pressing the button and increasing the current sound velocity a little at a time by pressing the ▲ button.

*continued...*

7. Take another measurement of the test piece to verify if the thickness reading is getting closer to the known thickness or not. If for some reason it is now farther away than before, reduce the velocity a little by pressing the ▼ button. Check the thickness again to make sure that you are getting closer. Continue adjusting the sound velocity until the thickness reading is correct.
8. Once you have reached the known thickness of the test piece, press the 💾 button to confirm your sound velocity setting. From this point, the sound velocity is calibrated and you can now take measurements of the same material with confidence.

## *Two Point Calibration*

1. Select two standard samples of the same material to be measured, among which one has a thickness equal to or slightly higher than the tested piece, and the thickness of another test piece is slightly lower than the tested piece.
2. Before carrying out 2-point calibration, turn off the "Minimum Capture" function and erase the CAL data in the "Memory Manager".
3. Set the 2-point calibration to ON in the "System Setup" menu.
4. Press twice on the 🛠 button to return to the main display.
5. Press the ↵ button at any time during measurement to enter the 2-Point CAL.
6. Measure the thinner standard test piece.
7. Remove the ultrasonic sensor from the test piece and use the ▲ and ▼ buttons to adjust the measurement to standard value.
8. Press the ↵ button and the LCD will prompt to measure the thicker piece.
9. Measure the thicker standard test piece.
10. Remove the ultrasonic sensor from the test piece and use the ▲ and ▼ buttons to adjust the measurement to standard value.
11. Press the ↵ button when the two-point calibration is completed.

*continued...*

### *Setting Alarm Thickness Limits*

The R7900 will alarm when the measured value is beyond the pre-set limits. When the measurement is lower than the low pre-set limit or higher than the high pre-set limit, the alarm will sound. To enter the alarm setting, follow steps 1 through 6 below.

1. Press the button to highlight the "Alarm" setting on the LCD.
2. Press the button to adjust the LOW limit.
3. Press the and buttons to adjust the user defined LOW alarm value.
4. Press the button to save the LOW limit, and to set the HIGH limit.
5. Press the and buttons to adjust the user defined HIGH alarm value, and press the button to save the HIGH limit.
6. To exit the limit setting, press the button or by carrying out a measurement.

### *Minimum Capture Measurements*

When the ultrasonic sensor couples with the test piece it will display the current measurement. When it is lifted away it will display the minimum value of the measurement carried out while the MIN Indicator flashes for several seconds. Measurements taken during the MIN indictor flashing cycle will continue to be part of the minimum value capturing. If you carry out measurements after the MIN Indicator stops flashing the minimum value capturing will re-start. The MIN indicator will only display when the minimum capture function is ON (see *System Setup* section for details).

## Measurement Methods

There are three base measurement methods:

1. **Single measurement method**: This method involves measuring the thickness at a single point.
2. **Double measurement method**: This method involves performing two thickness measurements near a single spot rotating the ultrasonic sensor from 0 to 90° respectively, with respect to the split face (see Figure A).Take the smaller of the two indicated values as the thickness of the material.

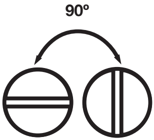



Figure A

*continued...*

3. **Multi-point measurement**: This method involves performing a number of measurements within a circle having a maximum diameter of about 1.18" (30mm) (see image below). Take the minimum indicated value as the thickness of the material.

## Menu Options

The menu function controls the settings and functions of the meter. To enter the menu, press the button to highlight the menu option on the LCD and press the button.

### *System Setup*

1. While in the menu, highlight the "System Setup" option and press the button to enter this menu.
2. Press the and buttons to scroll through the "System Setup" menu.
3. When the required setting as shown below, is highlighted, press the button to select it and toggle between units.

**Note**: To set brightness, press button to enter the setting, and use the and buttons to adjust the brightness.

4. Once completed, press the button to save and exit.

### *System Setup Menu Settings are as follows:*

1. **Measurement Units**: Metric and Imperial
2. **Receiving Gain**: LOW (resolution of 0.1mm) and HIGH (resolution of 0.01mm). LOW is mainly used for measuring coarse material with high scatter and small sound absorption, such as cast aluminum, cast copper, and other metallic parts.
3. **Minimum Capture Measurement**: OFF and ON
4. **2-Point Calibration**: OFF and ON
5. **Auto Down**: Power-saving mode ON (default)

*continued…*

6. **Baud Rate**: 1200, 2400, 4800, 9600
7. **Set Brightness**: UP to darken, DOWN to lighten

## *Memory Manager*

1. While in the menu, highlight the "Memory Manager" option and press the ↵ button to enter this menu.
2. Press the ▲ and ▼ buttons to scroll through the "Memory Manager" menu.
3. Press the ↵ button to select the required option as shown below:
   - **Erase File**: Clears selected files
   - **Erase All Data**: Clears all saved files
   - **Erase CAL data:** Clears calibrating data
4. Press the ↵ button again to confirm (YES) or "Menu" to escape.

## *System Reset*

While in the menu, highlight the "About Software" option and press the ↵ button to enter this menu. Press the ⚖ button to restore the meter to its factory default settings for. Upon completion, the meter will shut down.

# Internal Memory Operation

The internal memory is divided into 5 files, F1 to F5. Each file can save up to 100 measurement values.

**Note:** Before saving your data, be sure to set the file number first.

1. Press the button to highlight the "Save File Name" on the LCD.
2. Press the button to scroll through the memory files, F1 to F5.
3. Press the button to save and exit.

## *Reviewing Stored Data*

1. Press the button to highlight the "Save File Name" on the LCD.
2. Press the button to scroll through the memory files, F1 to F5.
3. Press the button to select the appropriate file number and to view the saved values.
4. Press the and buttons to scroll through the saved values.
5. If required, press the button to erase the current saved value.

# Maintenance

## *Cleaning the Test Piece*

After taking a measurement, clean the test pieces to prevent them from rusting. If the pieces are not to be used for a long period of time, coat them with oil to prevent rust.

## *Protecting the Ultrasonic Sensor*

Be sure to clean the ultrasonic sensor and cable after each use. Grease, oil and dust will cause the cable to dry out and shorten life expectancy. The temperature of the surface being measured should not exceed 140°F (60°C).

## *Replacing the Ultrasonic Sensor*

The degradation and wear of the probe's interlayer plate will influence measurements. Replace the probe when the following occurs:

- If it always displays the same value when measuring different thicknesses or;
- When a measurement displays no value.

## Battery Replacement

1. When the low battery symbol appears on the display, replace the batteries.
2. Remove the battery cover on the back and insert two new AA batteries.

**Note**: If the unit will not be used for a long period of time, remove the batteries to avoid battery leakage and corrosion of the battery contacts.

## Applications

- Monitoring and verifying pipes and pressure vessels
- Industrial manufacturing

## Accessories and Replacement Parts

- **R7900-PROBE** Replacement Probe
- **R7950** Ultrasonic Couplant Gel
- **R7950/5L** Ultrasonic Couplant Gel, 5L
- **R7950/12** Ultrasonic Couplant Gel, pack of 12
- **R9060** 5-Step Calibration Block
- **CA-52A** Soft Carrying Case
- **R8888** Hard Carrying Case

Don't see your part listed here? For a complete list of all accessories and replacement parts visit your product page on www.reedinstruments.com.

# Appendix

## *Measurements on Cylindrical Surfaces*

When measuring cylindrical material, such as pipes or oil tubes, it is important to properly adjust the angle between the ultrasonic sensor's crosstalk interlayer plate and the axial line of the material being measured.

1. Couple the sensor with the material being measures.
2. Make the sensor's crosstalk interlayer plate perpendicular or parallel to the axial line of the material under test.
3. Shake the sensor vertically along the axial line of the material under test, the readouts displayed on screen will change regularly.
4. Use the minimum readout.

The standard for selecting the angle between the sensor's crosstalk interlayer plate and the axial line of the material under test depends on the curvature of the material under test. For a pipe with a large diameter the sensor's crosstalk interlayer plate should be perpendicular to the axial line of the material under test. For a pipe with small diameter, the sensor's crosstalk interlayer plate can be both parallel and perpendicular to the axial line of the material under test, and take the minimum readout as the thickness.

## *Measuring Compound Profiles*

When the material being measured has a compound profile (such as a bend in a pipe), one can use the procedures to measure cylindrical surfaces. The exception is that one should have two analyses and get two results when the sensor's crosstalk interlayer plate is both parallel and perpendicular to the axial line of the material under test. Take the minimum readout as the material thickness.

## *Measuring an Un-Parallel Surface*

To get a satisfactory ultrasonic response, the other surface of the material under test must be parallel to or co-axial with the surface being measured, otherwise it will cause a measuring error or even provide no displayed reading.

*continued...*

## *Influence of Material's Temperature*

Both the thickness and transmitting speed of ultrasonic waves are influenced by temperature. If there is a high requirement of measuring accuracy, please use one of the comparison methods listed below:

1. Use a test piece of the same material being measured, under the same temperature.
2. Obtain the temperature compensation coefficient.
3. Use this coefficient to correct the actual measurement of the material being tested.

## *Material with Large Attenuation*

Material with porous and coarse particles (such as fibre) will cause a large scatter and energy attenuation in the ultrasonic wave. This will cause abnormal readings or provide no readings on the display (generally, the abnormal readings are less than the actual thickness). These type of materials cannot be measured by our ultrasonic thickness gauges.

## *Measuring Castings*

Castings will cause large attenuations in sound energy due to coarse crystal particles and a not-so-dense structure. The attenuation is due to the material's scatter and absorption of sound energy. Coarse out-phase structures and coarse crystal particles will cause abnormal reflection (i.e. a grass-shaped or tree-shaped echo) resulting in errors in the readings. When the crystal particle is coarse, the anisotropy in flexibility in metal's crystallizing direction will be obvious. This results in difference in sound velocities in different directions, with the maximum difference being up to 5.5%. The compactness in different positions of the workpiece is different, which will also cause difference in sound velocity. All of these will produce inaccuracies in the measurements.

*While measuring castings pay attention to the following:*

1. When measuring casting with an un-machined surface use engine oil, consistent grease, or water glass as a coupling gel.
2. Calibrate the sound velocity for the material under test with a standard test piece having the same material and measuring direction as that of the material being measured.
3. If necessary, take a 2-point calibration.

*continued...*

## *Preventing Errors*

### *Reference Test Pieces*

To maintain high accuracy when taking measurements of different materials, it is important to use a standard test piece that resembles the material and conditions being measured. The ideal reference test pieces should be a group of test pieces with different thicknesses made of the same materials that is going to be measured. The test pieces can provide calibrating factors for the meter (such as the microstructure of the material, heat-treating condition, direction of particles, surface roughness, etc.). To meet the highest requirements of accuracy a set of reference test pieces are critical.

Under most situations satisfactory measuring accuracies can be met with only one reference test piece. This should be the same material and similar thickness to the material under test. Take an even-surfaced object, measure it by using a micrometer, then use it as a test piece.

For thin material, when its thickness is near to the low limit of the sensor's measuring range, you can use a test piece to determine the accurate low limit. Never measure a material with a thickness lower than the low limit.

When the material under test is thick, especially an alloy with complex internal structure, select a test piece similar to the object from a group of test pieces, giving you an idea of calibration.

For most casting and forging, their internal structures have some direction. In different directions, the sound velocity will experience some change. To solve this problem, the test piece should have an internal structure with same direction as that of the material under test, and the transmitting direction of sound wave in it should also be same as that of the material.

Under certain circumstances, referring to a material speed-of-sound table can replace reference test pieces. The value in the speed-of-sound table may have some difference from the actual measured values due to difference in the material's physical and chemical characteristics. This is usually used for measuring low-carbon steel, and can only be taken as a rough measurement.

*continued...*

## *Ultra-Thin Material*

An error will occur when the thickness of a material under test is less than the low limit of the ultrasonic sensor. When necessary, measure the minimum limit thickness by comparing it with test pieces. When measuring an ultra-thin material, sometimes errors called "double refraction" may occur. This results in a displayed measuring reading that is twice the actual thickness of the material under test. Another error result is called "pulse envelop or cyclic leap". This results in the measured value being larger than the actual thickness. To prevent these kinds of errors repeat the measurement to confirm the results.

### *Rust, Corrosion, and Pits*

Rust and pits on the surface of the object will cause irregular change in the measured reading. In extreme situations it will even cause no readings on the display. To avoid errors, orient the sensor's crosstalk interlayer plate in different directions to take multiple measurements.

### *Error in Identifying Material*

If you calibrate the meter with one material and then measure another material, an error will occur. Be careful in selecting the correct sound velocity.

### *Degradation of Probe*

The surface of the probe is allyl resin. Over time its roughness will increase resulting in reduced sensitivity. If it is determined that this is the reason for the errors, grind the surface with sandpaper or oilstone to make it smooth again. If the readings are still not stable, the sensor must be replaced.

### *Overlapped Material and Compound Material*

It is impossible to measure uncoupled overlapped material because the ultrasonic wave can't pass through an uncoupled space. Since the ultrasonic wave can't transmit in a compound material in even speed you cannot use an ultrasonic thickness-gauge to measure overlapped material and compound material.

### *Influence of Metal Surface Oxidation*

Some metals can produce a dense oxidation layer on the surface, such as aluminum. Even though the layer is in close contact with the substrate and provides no obvious interface, the ultrasonic wave will have different transmitting speeds in these two materials which will cause an error.

*continued...*

In addition, different thicknesses in oxidation layers will cause different errors. Make a reference piece from a batch of objects by measuring with a micrometer or calliper, and using it to calibrate the instrument.

### *Abnormal Readout of Thickness*

The operator should be able to identify an abnormal measuring reading. Generally the rust, corrosion, pit, and internal defect of the material under test will cause abnormal measuring readings.

### *Utilization and Selection of a Coupling Gel (R7950)*

Coupling gel is used for transmitting high-frequency energy between the ultrasonic gel and the material under test. If the type of gel or utilization is wrong, or the utilization it will cause an error. For most applications a single droplet of coupling gel coated evenly is sufficient. When measuring a smooth surface use a gel with low viscosity (such as the coupling gel provided or light engine oil). When measuring a coarse object surface, vertical surface or top surface, use a gel with high viscosity (such as glycerin grease, consistent grease, and lubricating grease, etc.).

## Product Care

To keep your instrument in good working order we recommend the following:

- Store your product in a clean, dry place.
- Change the battery as needed.
- If your instrument isn't being used for a period of one month or longer please remove the battery.
- Clean your product and accessories with biodegradable cleaner. Do not spray the cleaner directly on the instrument. Use on external parts only.

# Product Warranty

REED Instruments guarantees this instrument to be free of defects in material or workmanship for a period of one (1) year from date of shipment. During the warranty period, REED Instruments will repair or replace, at no charge, products or parts of a product that proves to be defective because of improper material or workmanship, under normal use and maintenance. REED Instruments total liability is limited to repair or replacement of the product. REED Instruments shall not be liable for damages to goods, property, or persons due to improper use or through attempts to utilize the instrument under conditions which exceed the designed capabilities. In order to begin the warranty service process, please contact us by phone at 1-877-849-2127 or by email at info@reedinstruments.com to discuss the claim and determine the appropriate steps to process the warranty.

# Product Disposal and Recycling

Please follow local laws and regulations when disposing or recycling your instrument. Your product contains electronic components and must be disposed of separately from standard waste products.

# Product Support

If you have any questions on your product, please contact your authorized REED distributor or REED Instruments Customer Service by phone at 1-877-849-2127 or by email at info@reedinstruments.com.

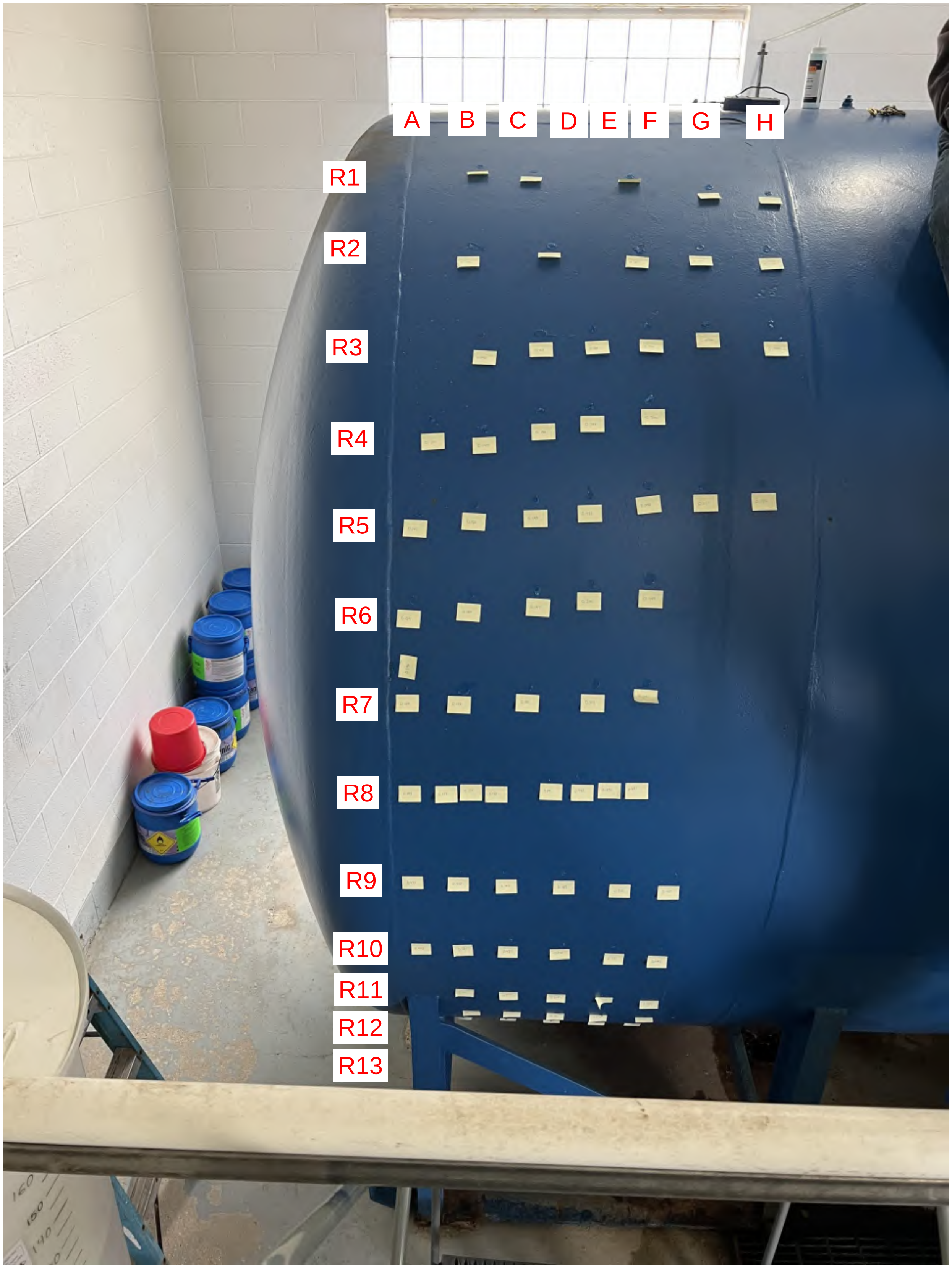
Please visit **www.REEDInstruments.com** for the most up-to-date manuals, datasheets, product guides and software.

*Product specifications subject to change without notice.*

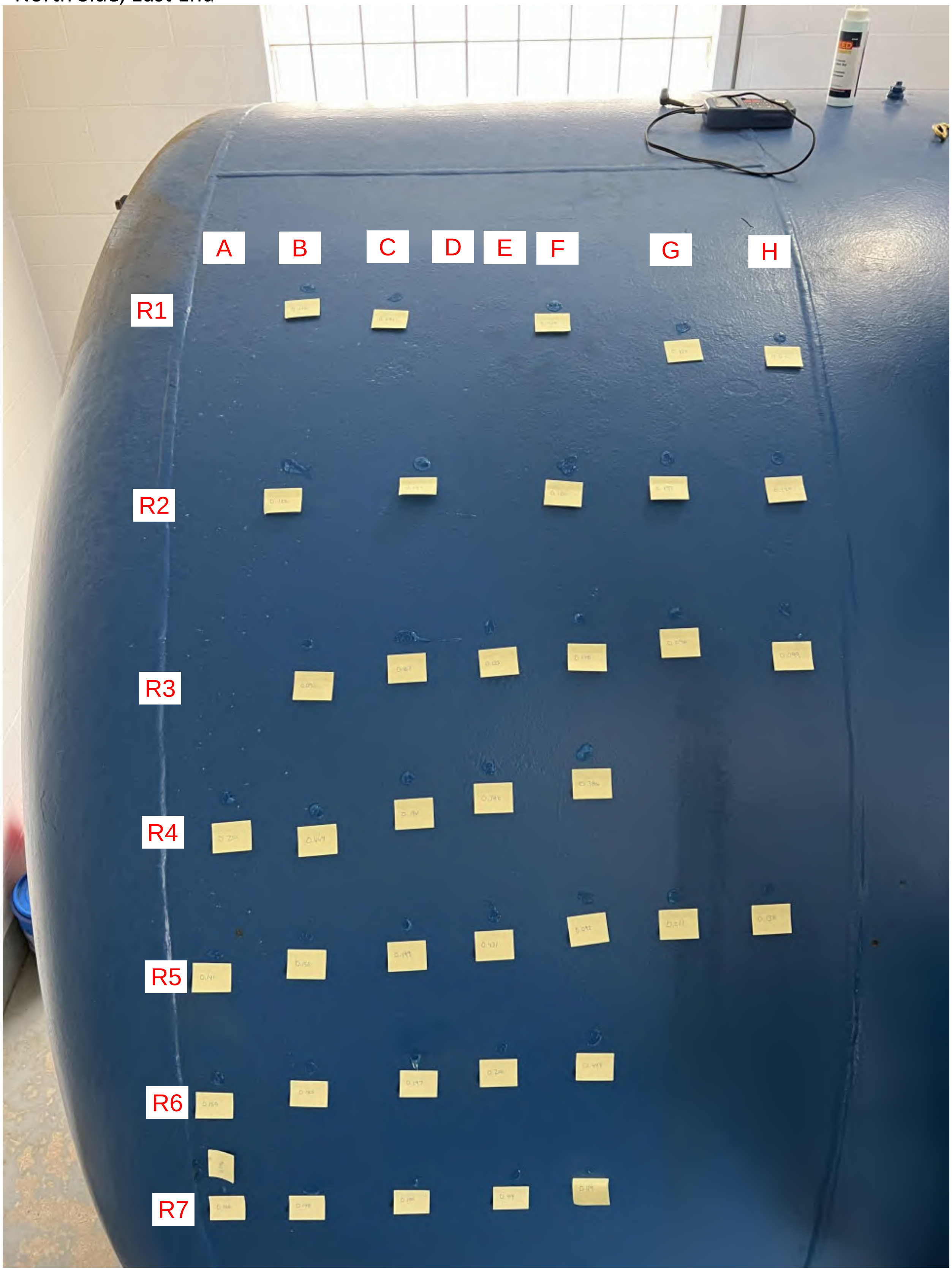
# APPENDIX G

# Main Filter Plant: Pressure Filter Tank Thickness Test Results

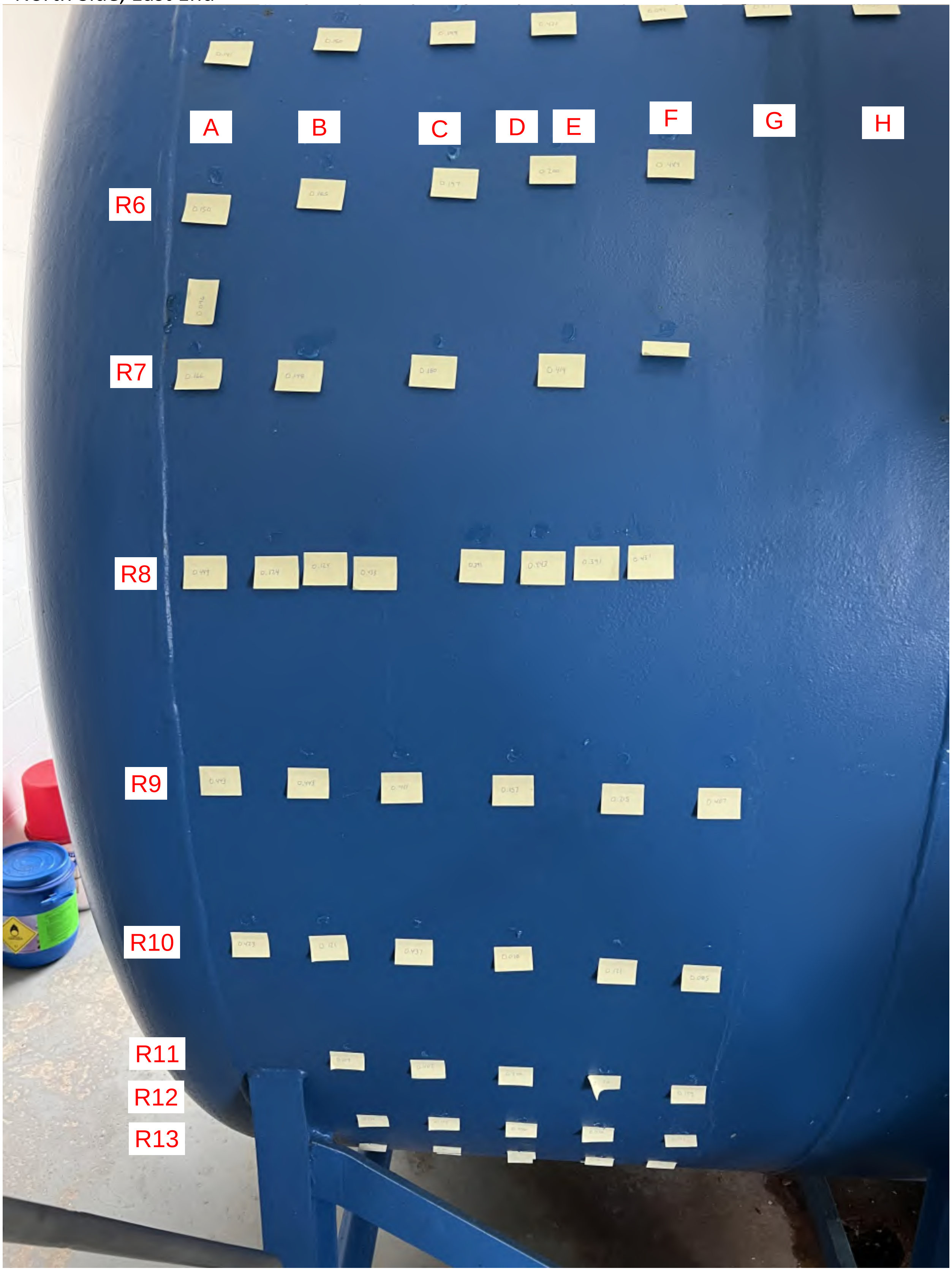
Main Filter Plant
Pressure Tank
North Side, East End



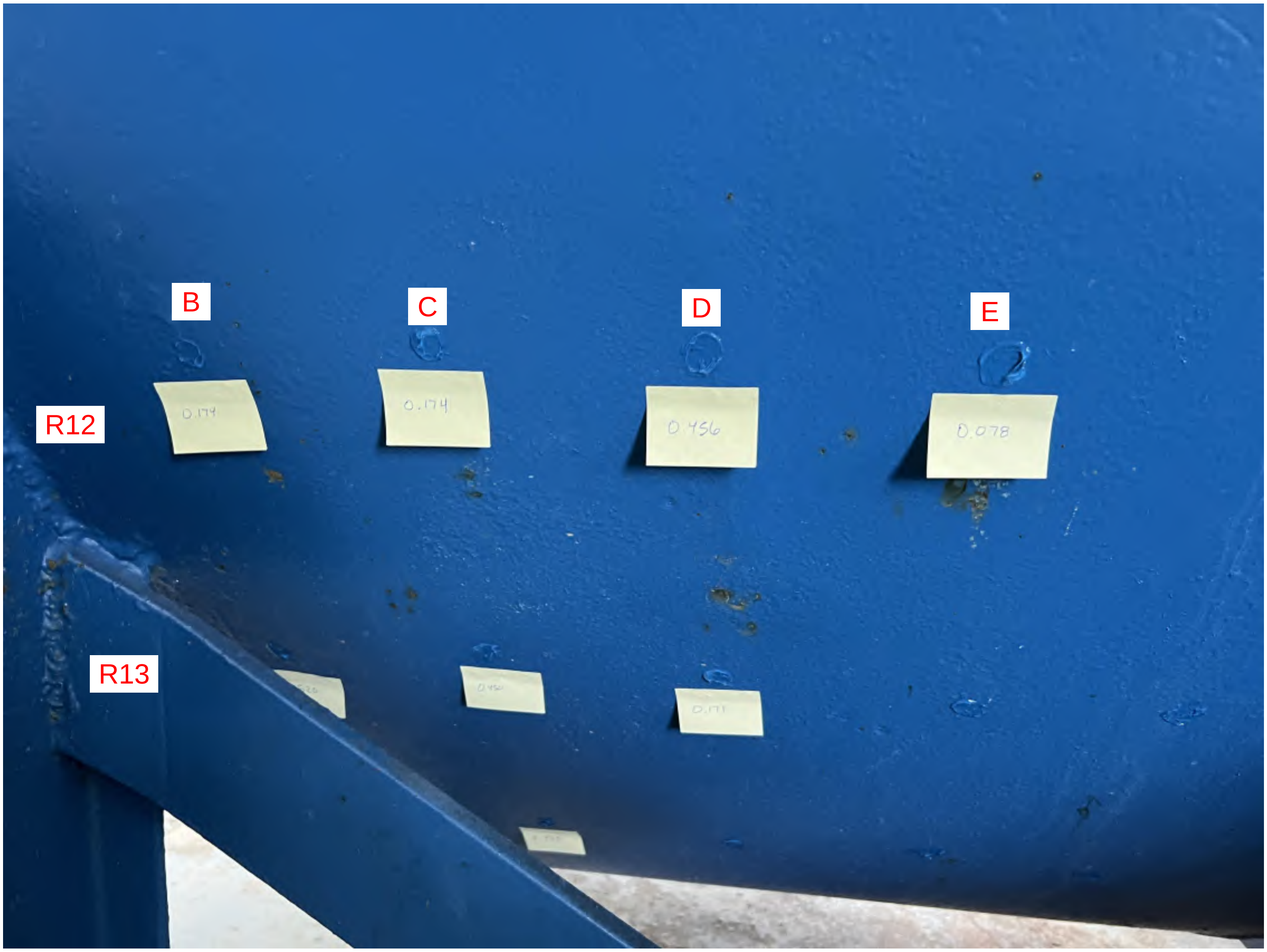
Main Filter Plant
Pressure Tank
North Side, East End



Main Filter Plant
Pressure Tank
North Side, East End



Main Filter Plant
Pressure Tank
North Side, East End



## Main Filter Plant - Pressure Filter Tank

North Side East End

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| R1 | | 0.456 | | | | 0.438 | 0.133 | 0.102 |
| R2 | | 0.132 | 0.157 | | | 0.150 | 0.197 | 0.228 |
| R3 | | 0.090 | 0.463 | 0.135 | | 0.148 | 0.096 | 0.099 |
| R4 | 0.210 | 0.449 | 0.194 | 0.382 | | 0.386 | | |
| R5 | 0.141 | 0.150 | 0.199 | 0.431 | | 0.092 | 0.211 | 0.138 |
| R6 | 0.150 | 0.185 | 0.197 | 0.200 | | 0.449 | | |
| R7 | 0.166 | 0.148 | 0.180 | 0.414 | | 0.119 | | |
| R8 | 0.449 | 0.124 | 0.433 | 0.391 | 0.391 | 0.431 | | |
| R9 | 0.443 | 0.443 | 0.411 | 0.157 | 0.215 | 0.407 | | |
| R10 | 0.423 | 0.121 | 0.437 | 0.078 | 0.121 | 0.085 | | |
| R11 | | 0.209 | 0.402 | 0.248 | 0.135 | 0.139 | | |
| R12 | | 0.174 | 0.174 | 0.456 | | | | |
| R13 | | 0.520 | 0.450 | 0.171 | | | | |

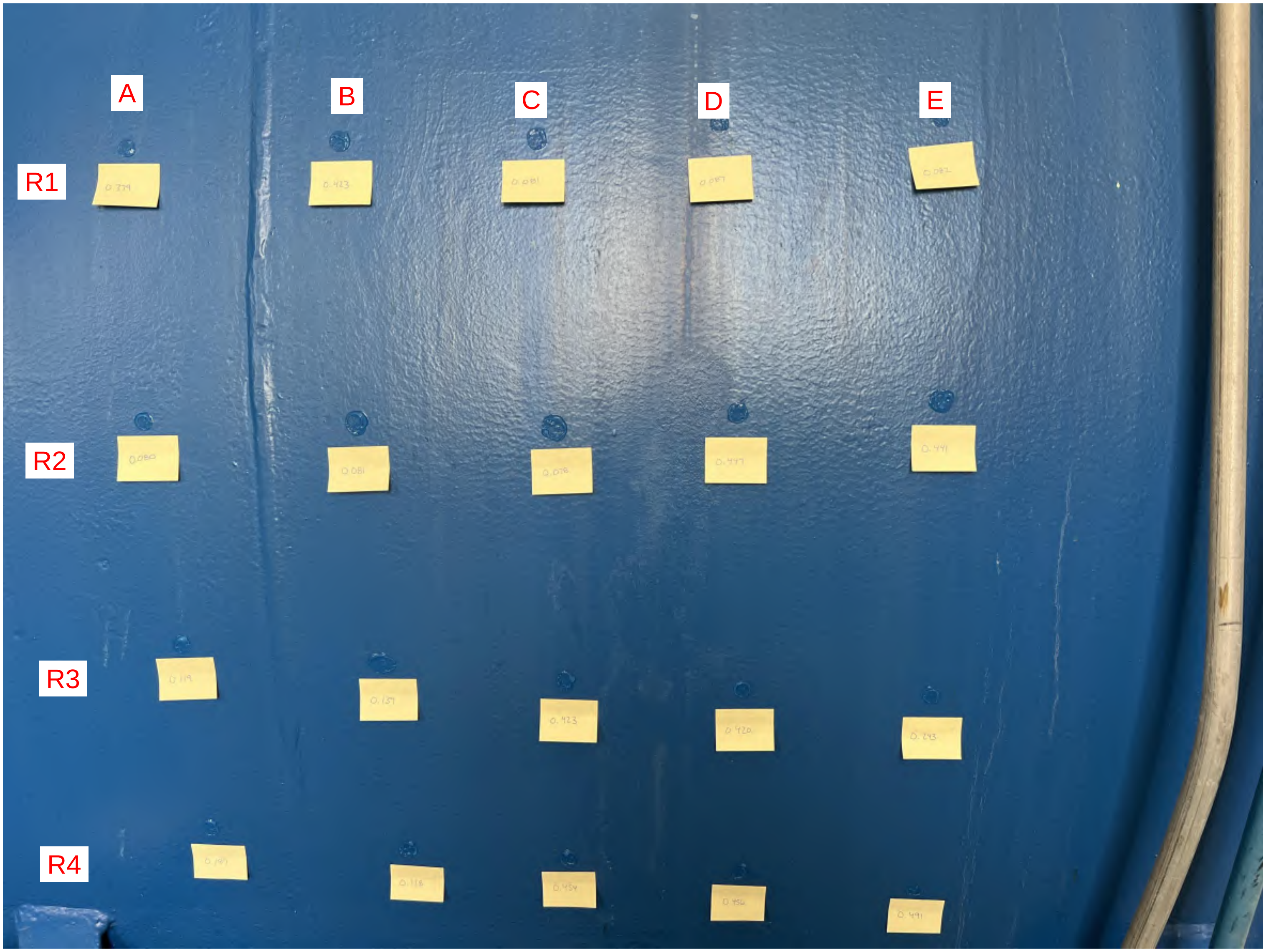
Main Filter Plant
Pressure Tank
North Side, Center

Main Filter Plant
Pressure Tank
North Side, Center

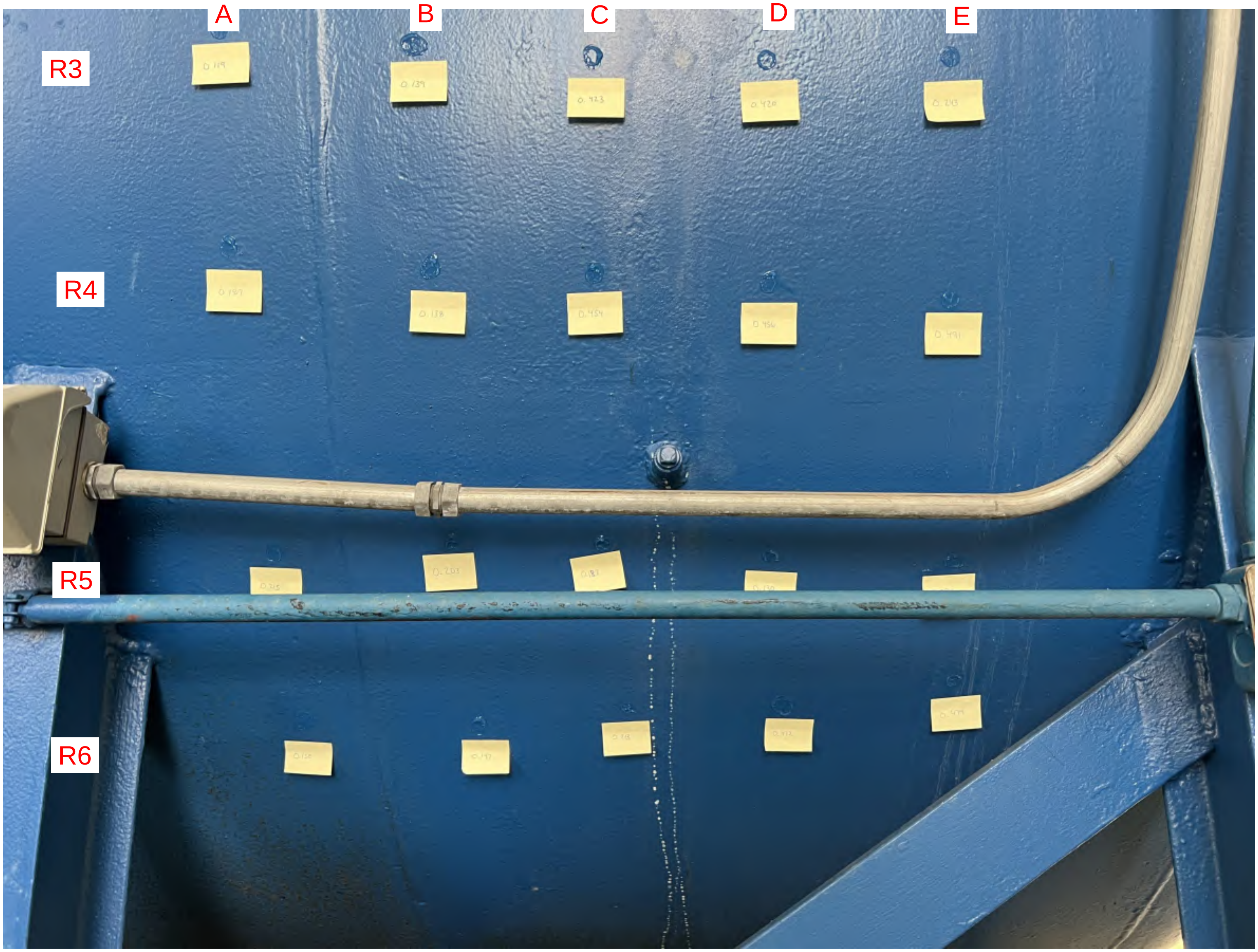
| Main Filter Plant - Pressure Filter Tank | | | | | | |
|---|---|---|---|---|---|---|
| North Side Center | | | | | | |
| | A | B | C | D | E | F |
| R1 | 0.165 | 0.157 | 0.118 | 0.175 | 0.167 | 0.141 |
| R2 | 0.444 | | 0.257 | 0.239 | 0.174 | 0.207 |
| R3 | | | 0.153 | | 0.148 | 0.144 |
| R4 | | 0.157 | 0.127 | 0.146 | 0.132 | 0.169 |

Main Filter Plant
Pressure Tank
North Side, West End

Main Filter Plant
Pressure Tank
North Side, West End

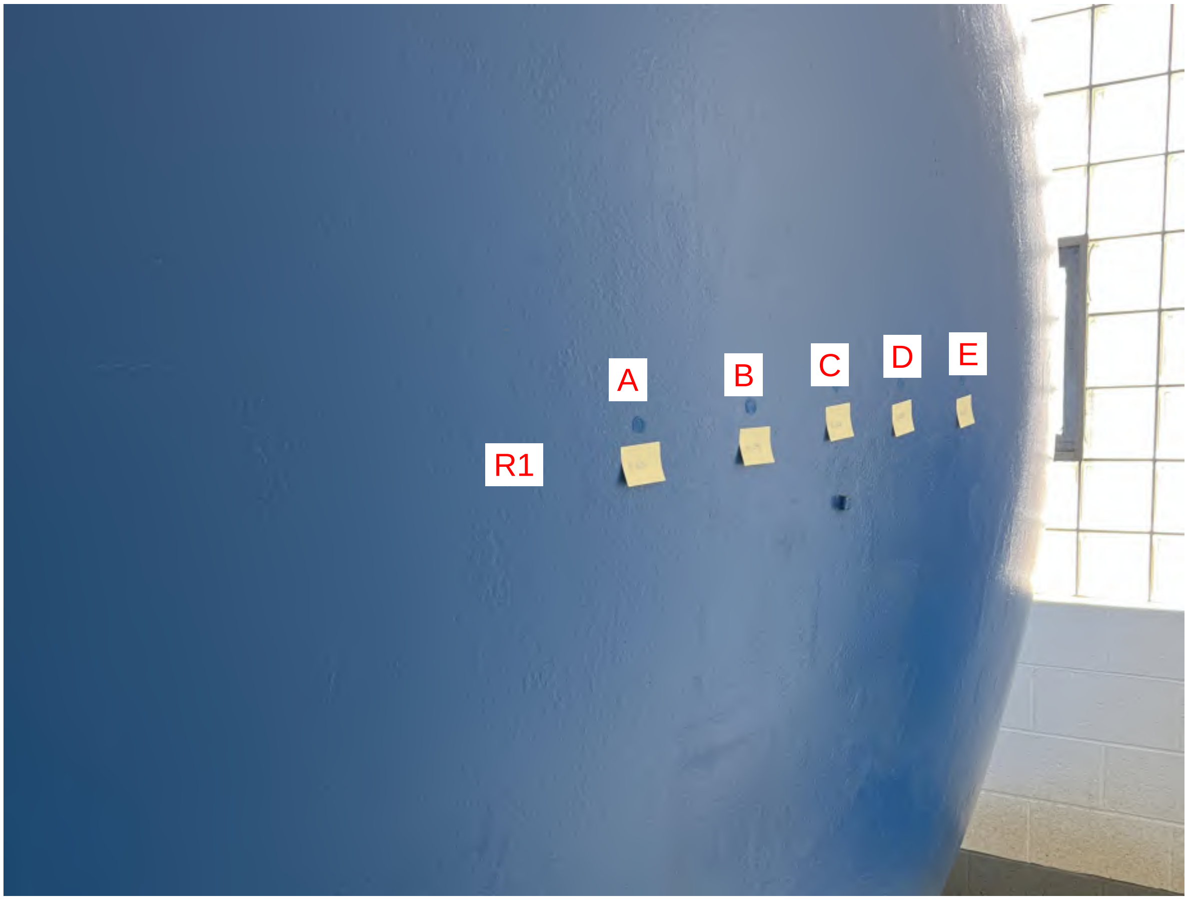


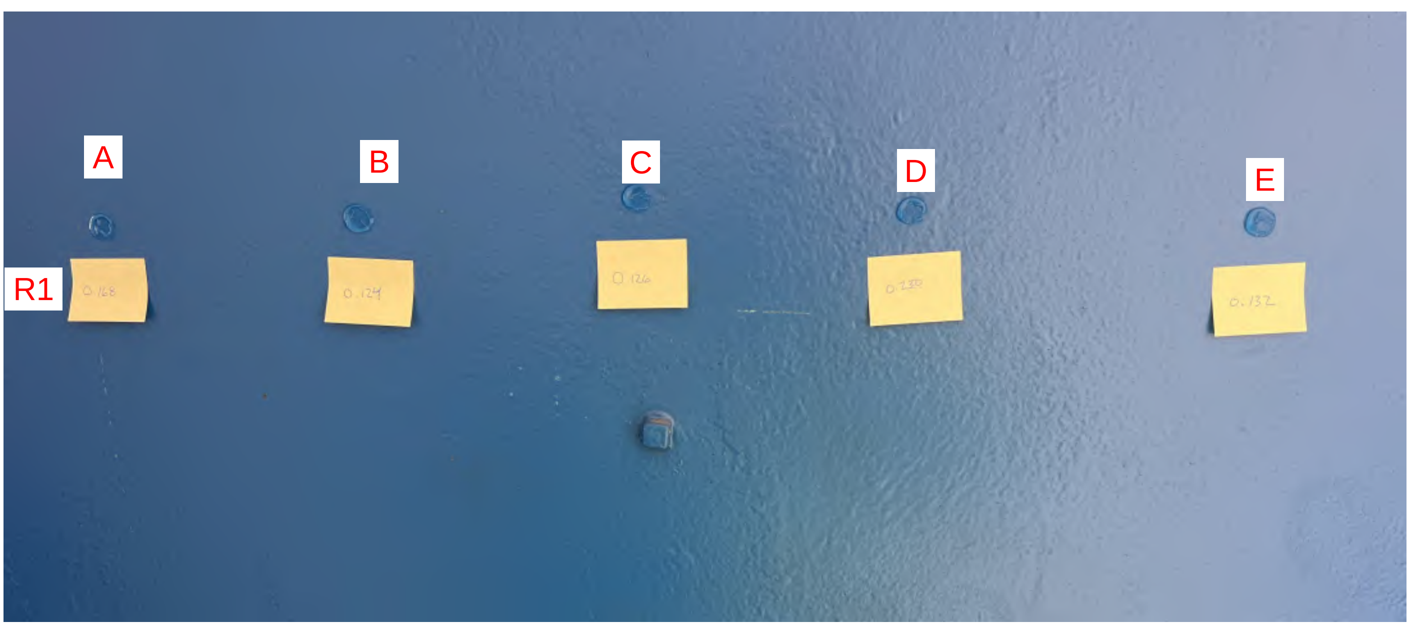
Main Filter Plant
Pressure Tank
North Side, West End



| Main Filter Plant - Pressure Filter Tank | | | | | |
|---|---|---|---|---|---|
| North Side, West End | | | | | |
| | A | B | C | D | E |
| R1 | 0.379 | 0.423 | 0.081 | 0.087 | 0.082 |
| R2 | | | | 0.447 | 0.441 |
| R3 | 0.119 | 0.139 | 0.423 | 0.420 | 0.243 |
| R4 | 0.187 | 0.138 | 0.454 | 0.456 | 0.491 |
| R5 | 0.215 | 0.203 | 0.182 | 0.130 | |
| R6 | 0.150 | 0.147 | 0.213 | 0.472 | 0.479 |

Main Filter Plant
Pressure Tank
West Side



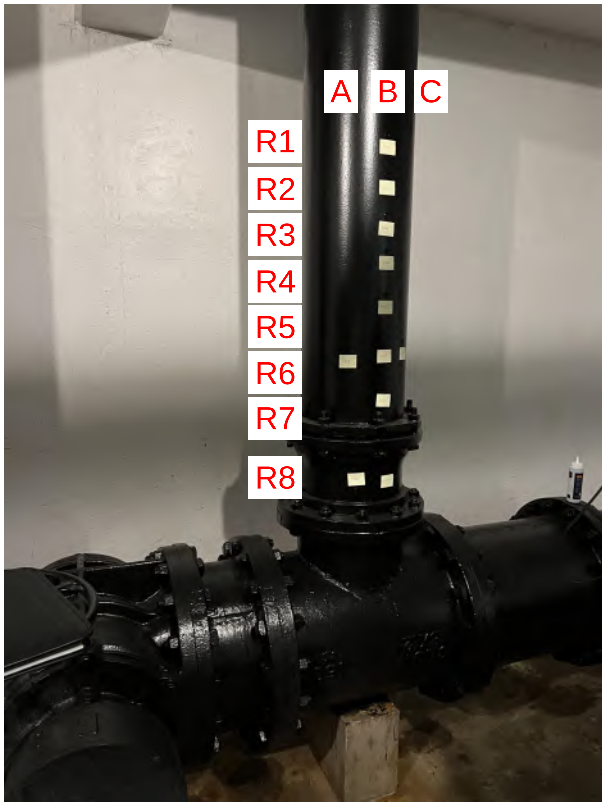
| Main Filter Plant - Pressure Filter Tank | | | | | |
|---|---|---|---|---|---|
| West Side | | | | | |
| | A | B | C | D | E |
| R1 | 0.168 | 0.124 | 0.126 | 0.23 | 0.132 |

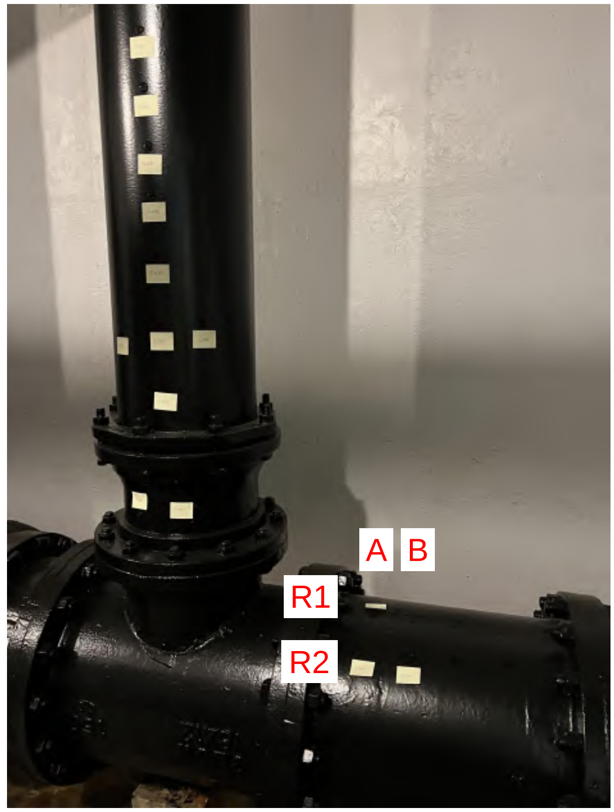
# APPENDIX H

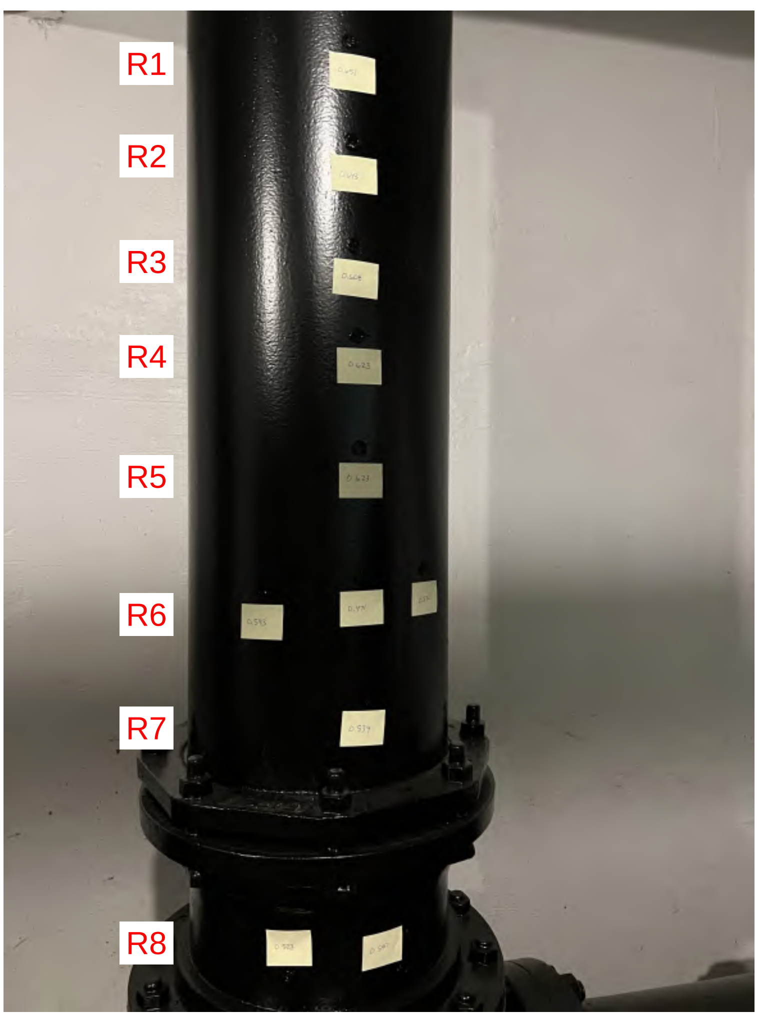
## Booster Pump Station: Piping Thickness Test Results

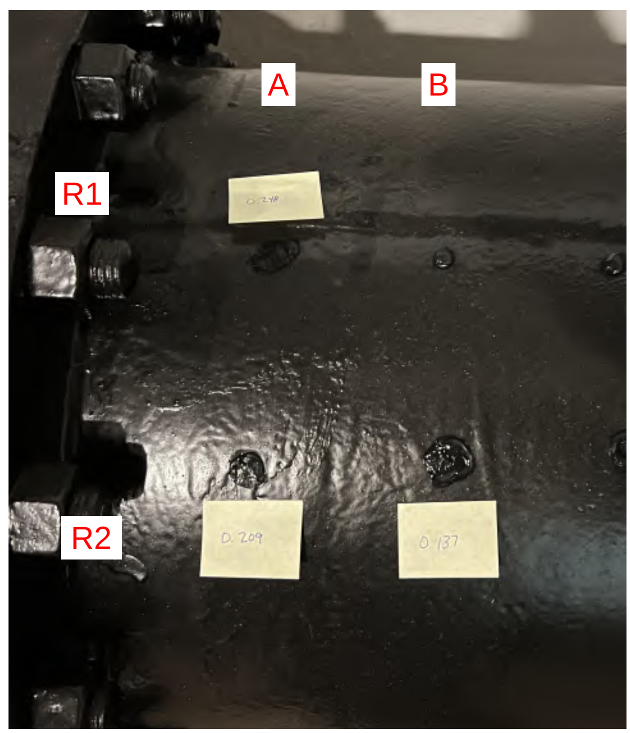
Booster Station
Pressing Piping
Vertical Pipe 1

Booster Station
Pressing Piping
Horizontal Pipe 1



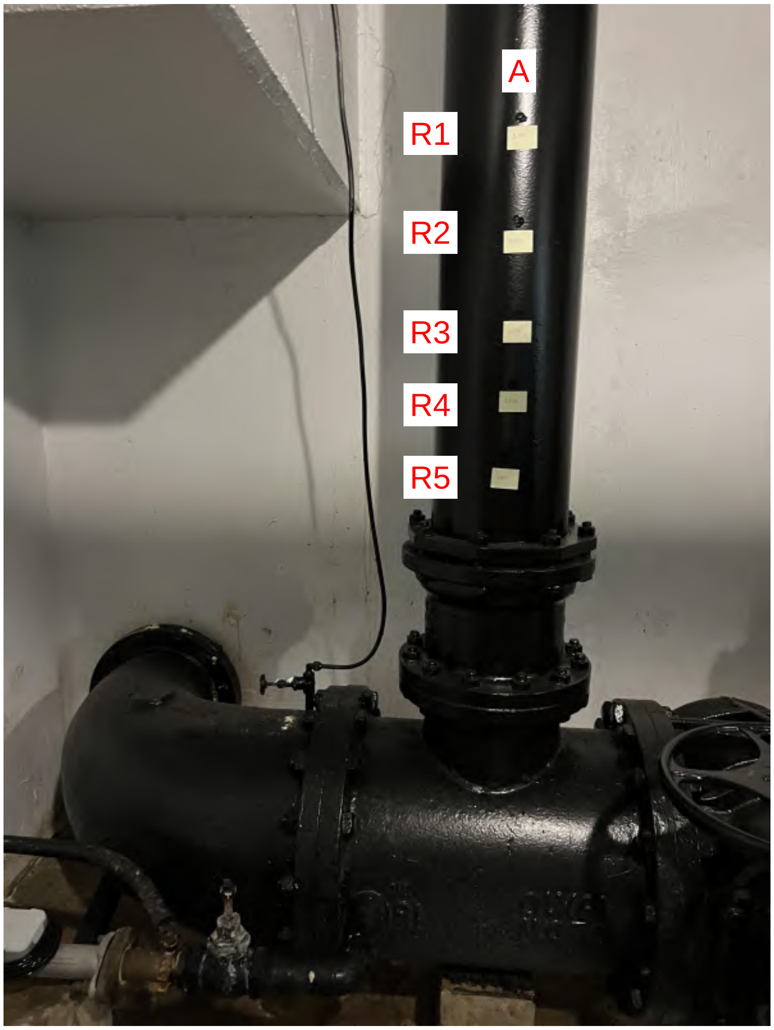



| Booster Station | | | |
|---|---|---|---|
| Pressure Piping - Vertical Pipe 1 | | | |
| | A | B | C |
| R1 | | 0.651 | |
| R2 | | 0.643 | |
| R3 | | 0.608 | |
| R4 | | 0.623 | |
| R5 | | 0.623 | |
| R6 | 0.593 | 0.471 | 0.572 |
| R7 | | 0.534 | |
| R8 | 0.523 | 0.587 | |

| Booster Station | | |
|---|---|---|
| Pressure Piping - Horizontal Pipe 1 | | |
| | A | B |
| R1 | 0.248 | |
| R2 | 0.209 | 0.137 |

Booster Station
Pressing Piping
Vertical Pipe 2





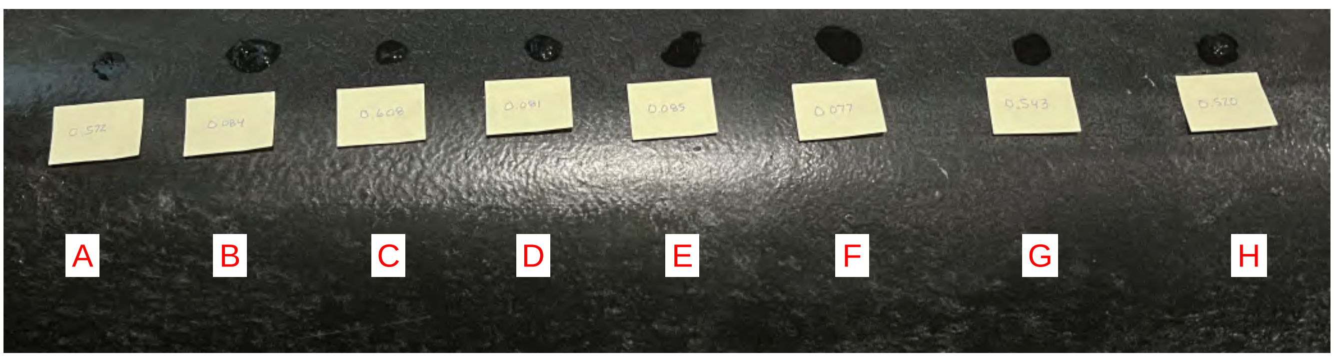
**Booster Station**

Pressure Piping - Vertical Pipe 2

| | A |
|---|---|
| R1 | 0.502 |
| R2 | 0.522 |
| R3 | 0.515 |
| R4 | 0.526 |
| R5 | 0.535 |

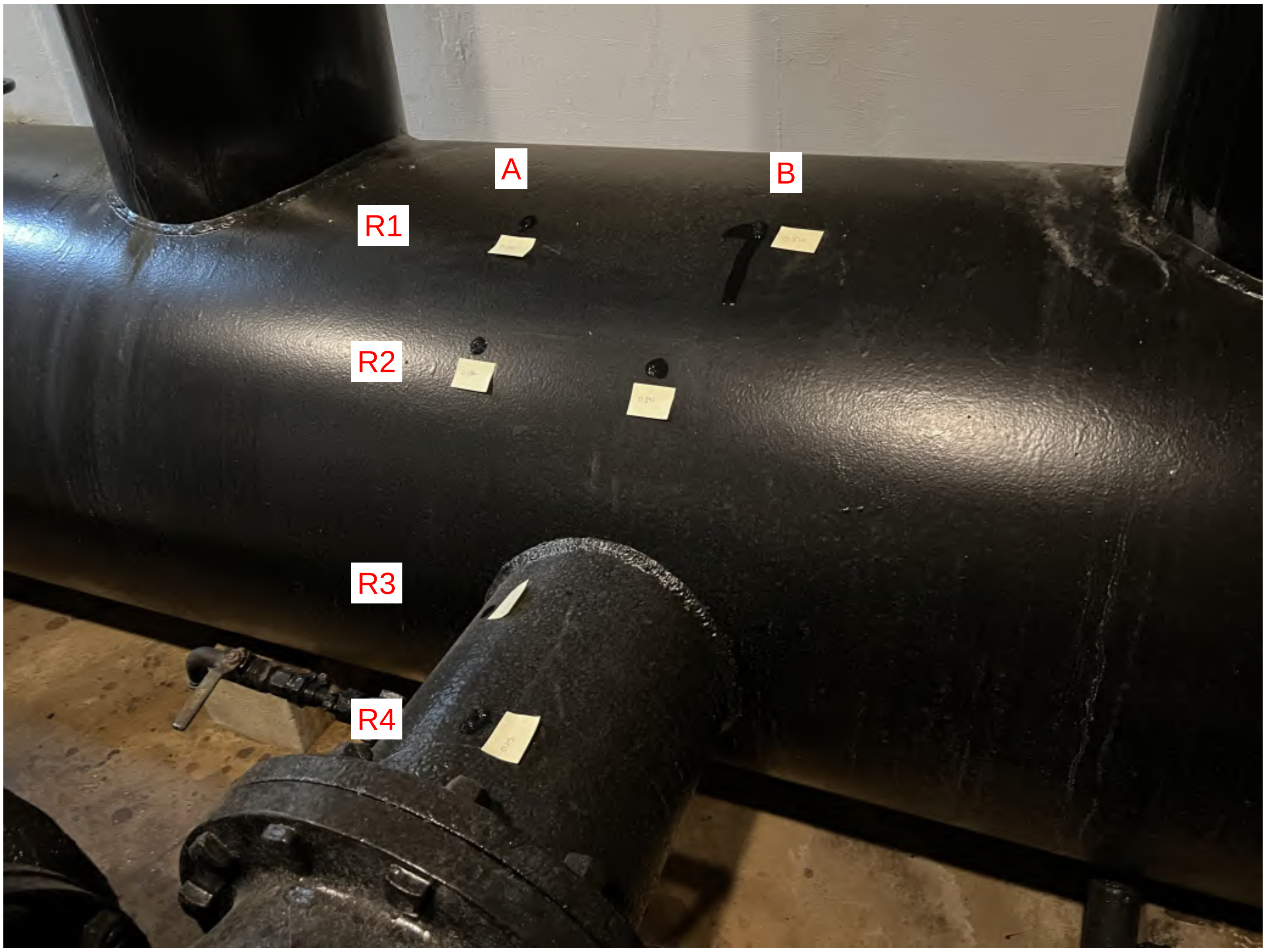
Booster Station
Suction Piping
12 Pipe


R1

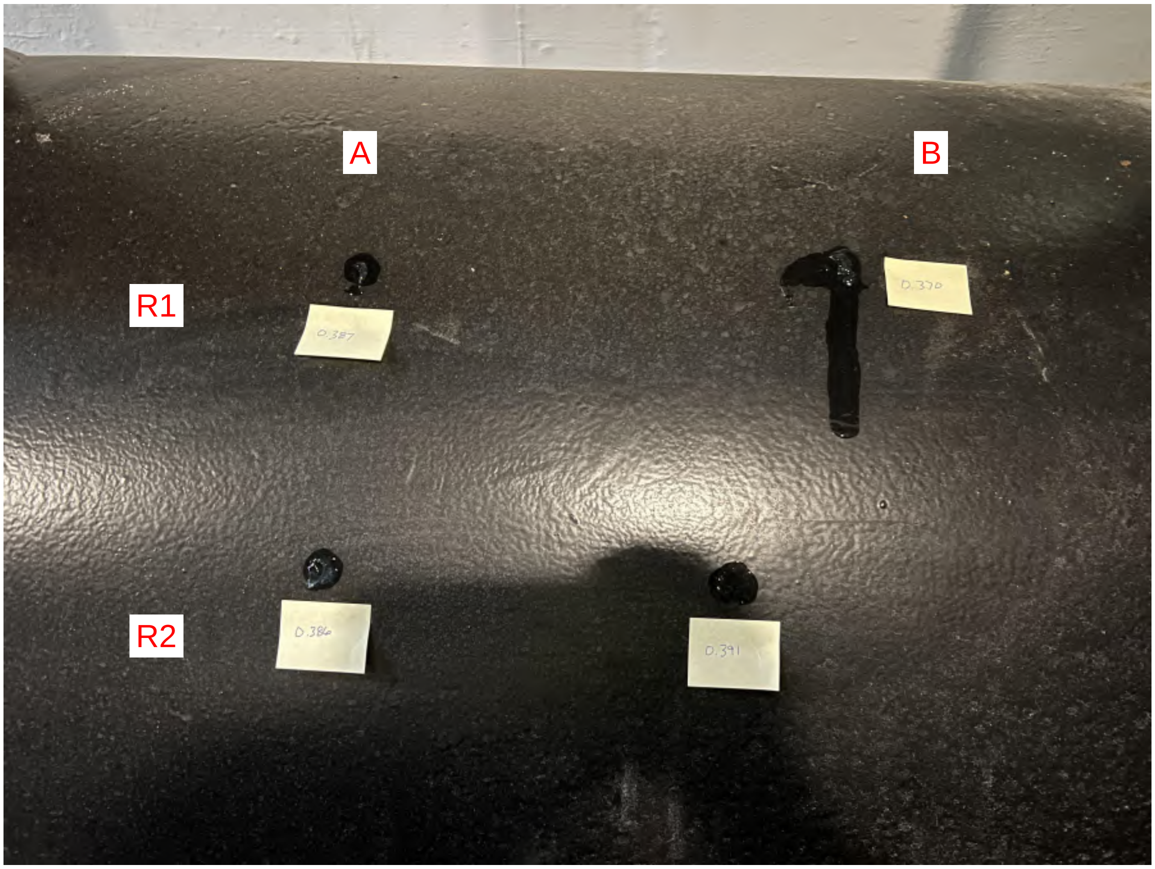


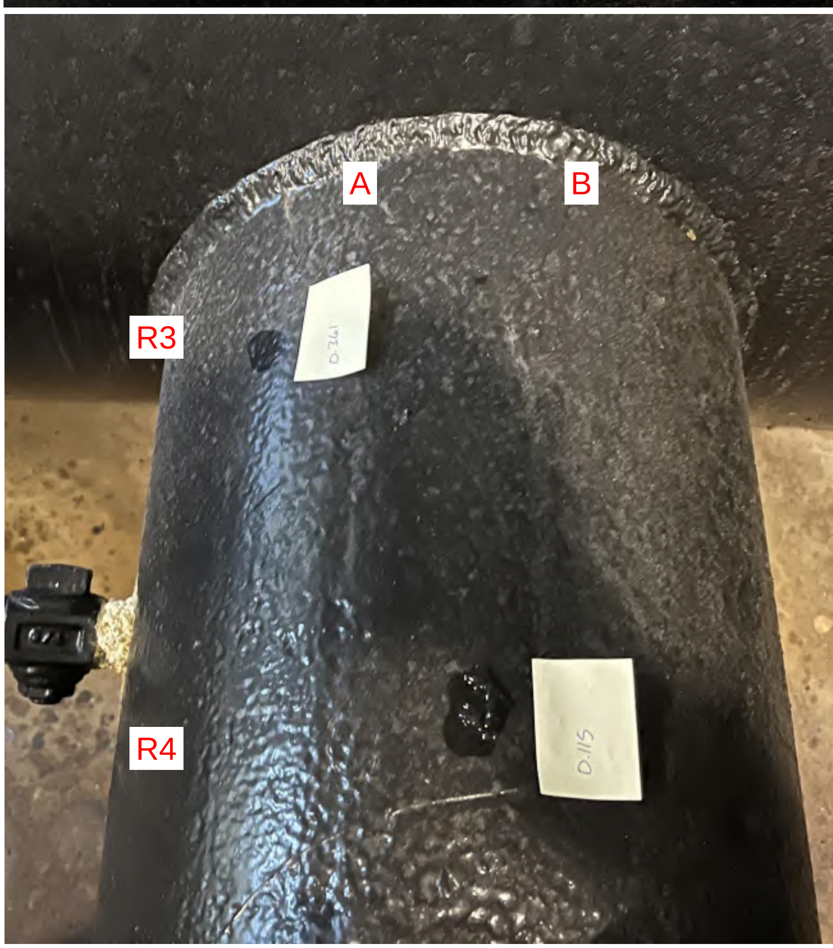

| **Booster Station** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Suction Pipe - 12 Pipe | | | | | | | | |
| | A | B | C | D | E | F | G | H |
| R1 | 0.572 | 0.084 | 0.608 | 0.081 | 0.085 | 0.077 | 0.543 | 0.520 |

Booster Station
Suction Piping
Middle Large Header Pipe



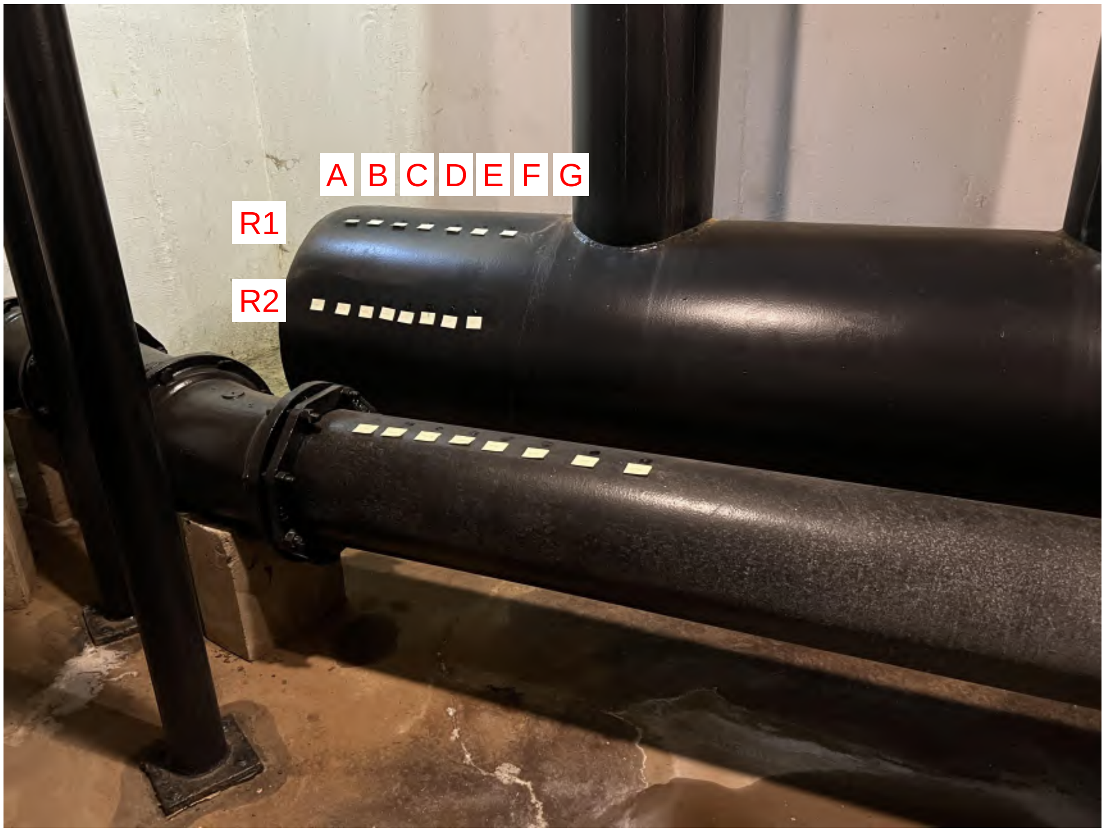
Booster Station
Suction Piping
Middle Large Header Pipe

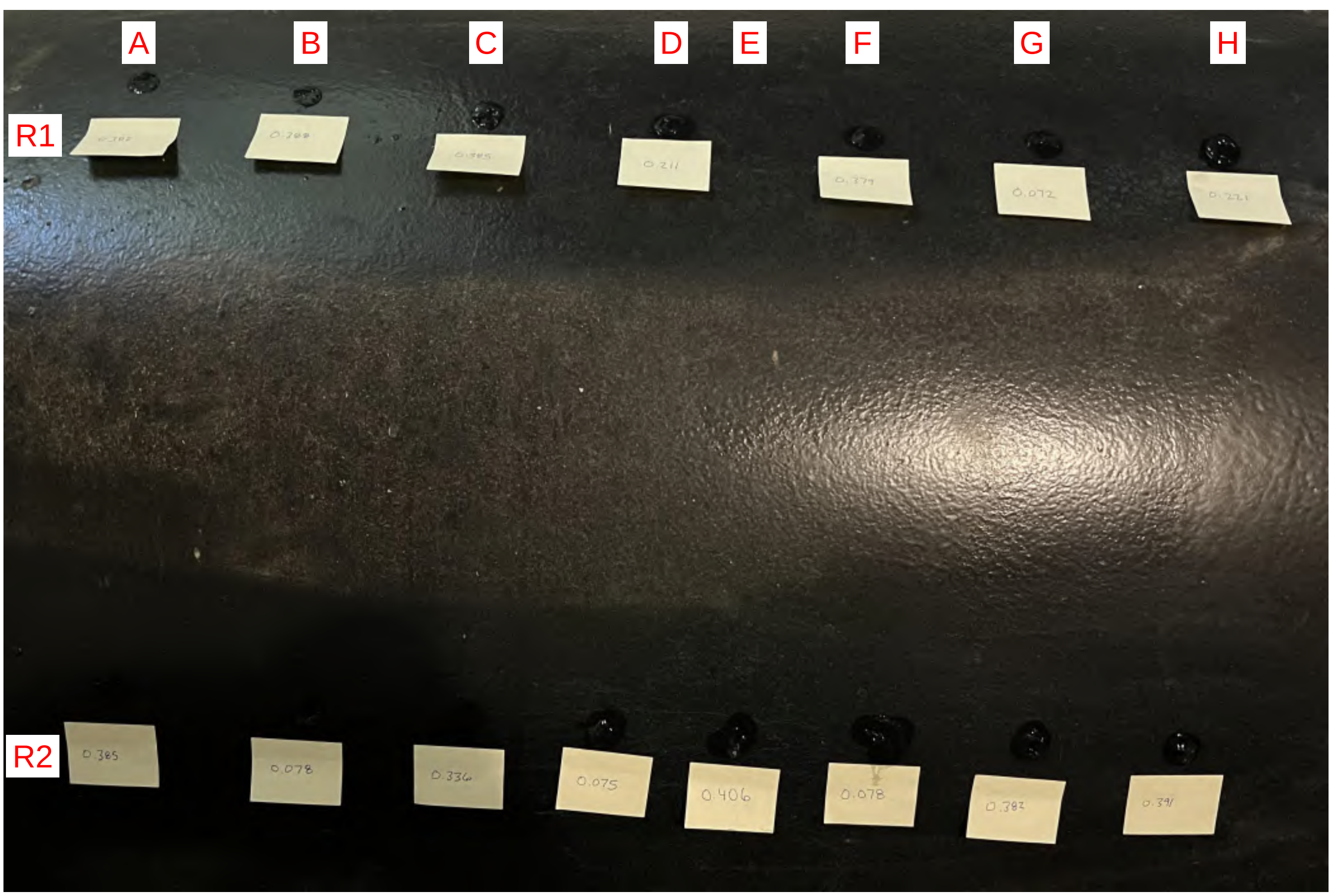



| **Booster Station** | | |
|---|---|---|
| Suction Pipe - Middle Large Header Pipe | | |
| | A | B |
| R1 | 0.387 | 0.370 |
| R2 | 0.386 | 0.391 |
| R3 | 0.361 | |
| R4 | | 0.115 |

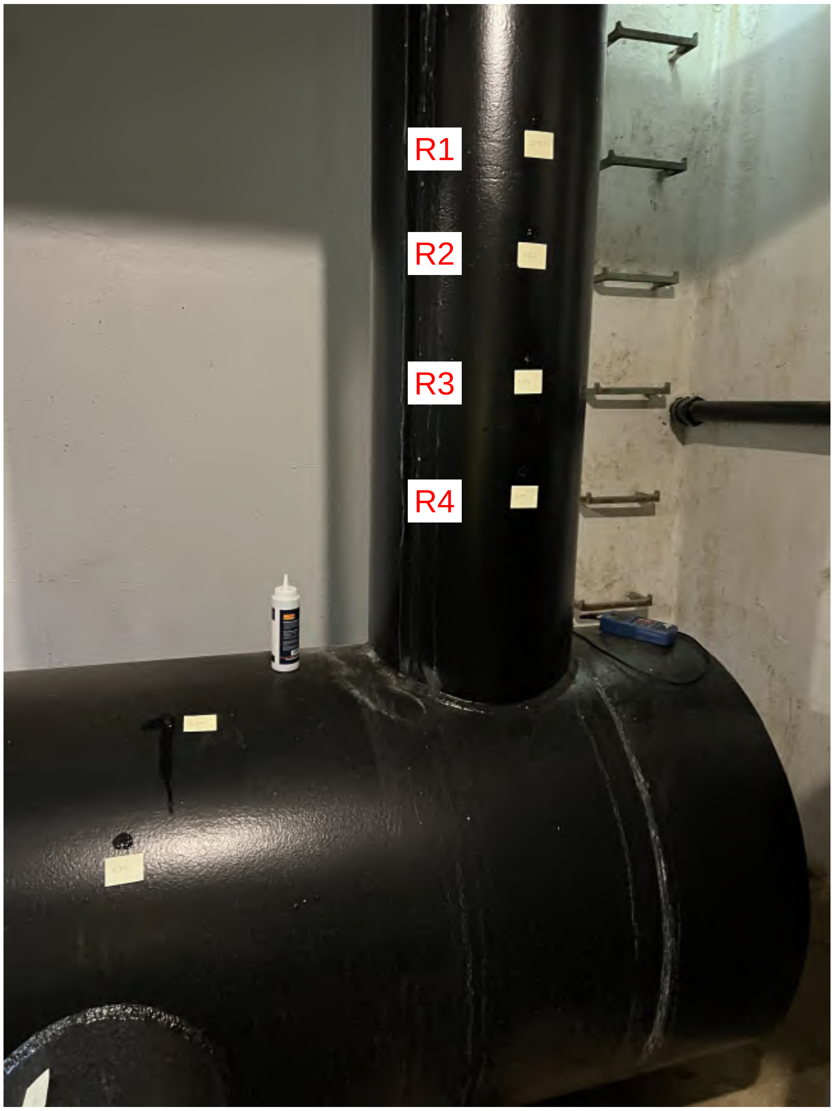
Booster Station
Suction Piping
North Large Header Pipe



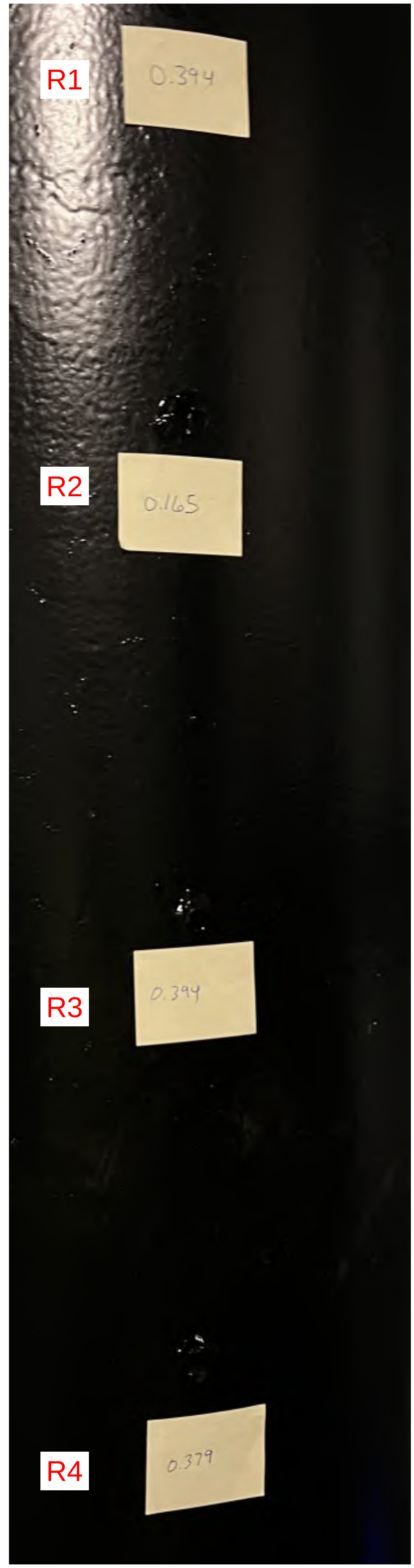



| **Booster Station** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Suction Pipe - North Large Header Pipe | | | | | | | | |
| | A | B | C | D | E | F | G | H |
| R1 | 0.382 | 0.388 | 0.385 | 0.211 | | 0.379 | | 0.221 |
| R2 | 0.385 | | 0.336 | | 0.406 | | 0.382 | 0.391 |

Booster Station
Suction Piping
South Large Header Pipe




A

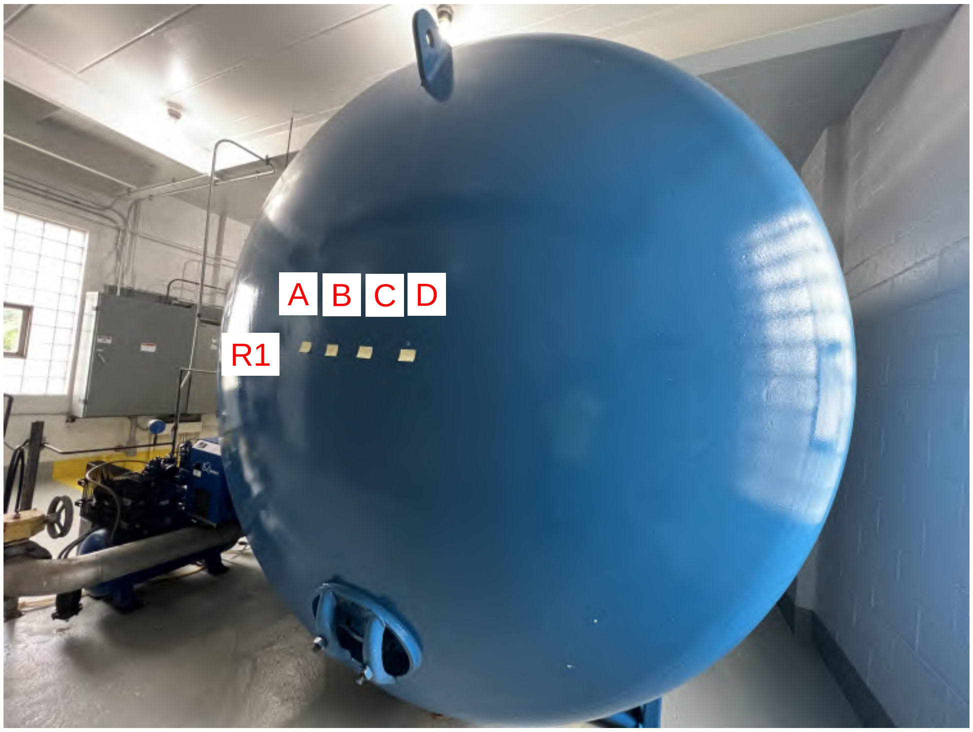


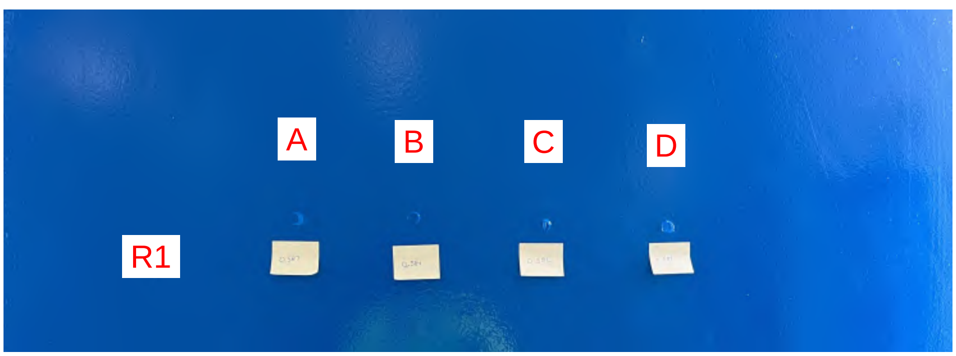

| Booster Station | |
|---|---|
| Suction Pipe - South Large Header | |
| | A |
| R1 | 0.394 |
| R2 | 0.165 |
| R3 | 0.394 |
| R4 | 0.379 |

# APPENDIX J

# Well 8 Filter Plant: Pressure Filter Tank Thickness Test Results

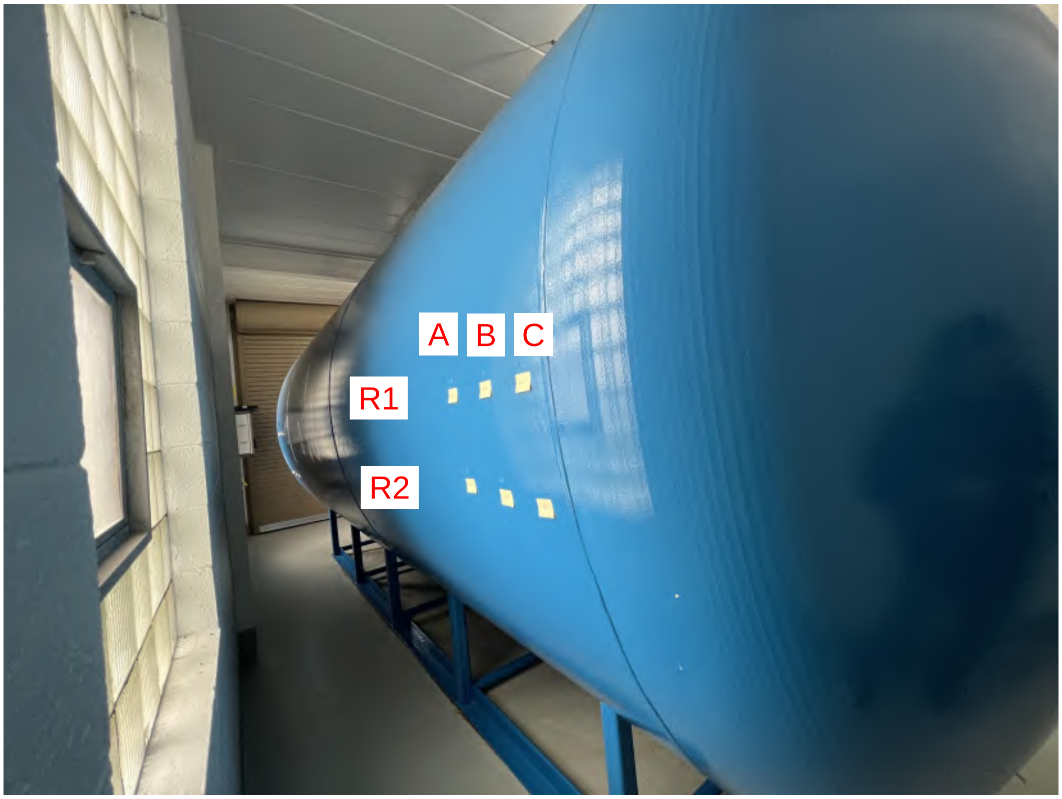
Well 8
Pressure Tank
North End

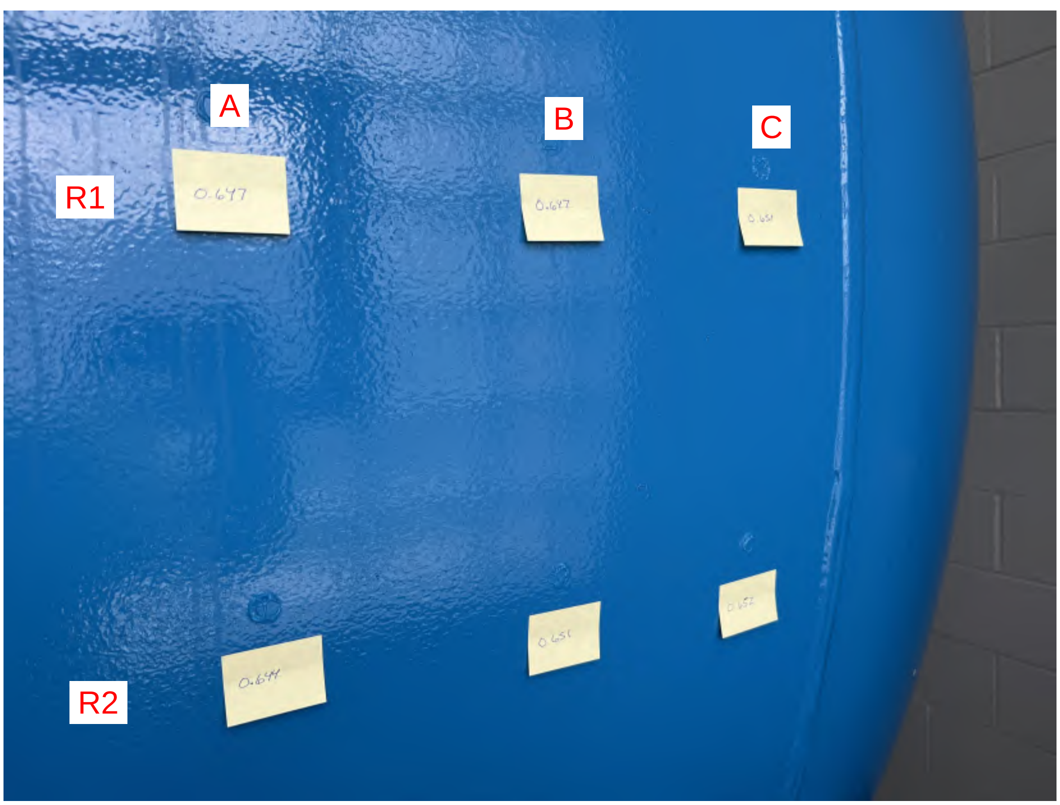



| **Well 8** | | | | |
|---|---|---|---|---|
| North End | | | | |
| | A | B | C | D |
| R1 | 0.587 | 0.584 | 0.582 | 0.582 |

Well 8
Pressure Tank
West Side, South End



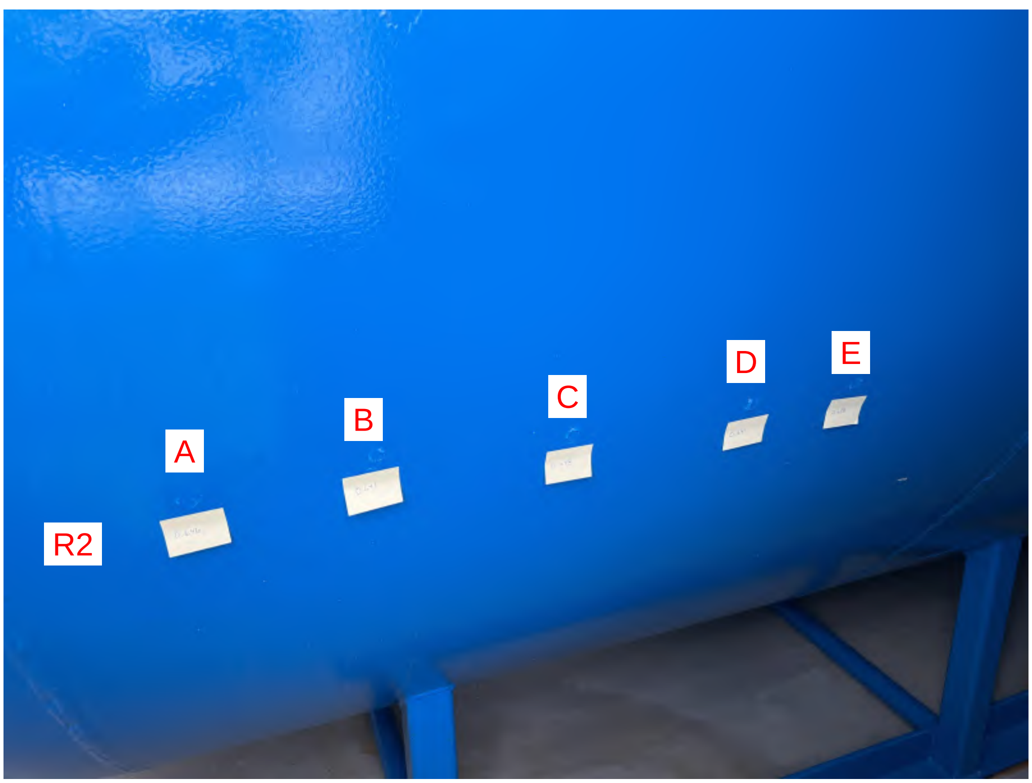



| Well 8 | | | |
|---|---|---|---|
| West Side, South End | | | |
| | A | B | C |
| R1 | 0.647 | 0.647 | 0.651 |
| R2 | 0.644 | 0.651 | 0.652 |

Well 8
Pressure Tank
West Side, North End


| **Well 8** | | | | | |
|---|---|---|---|---|---|
| West Side, North End | | | | | |
| | A | B | C | D | E |
| R1 | 0.647 | 0.644 | 0.644 | 0.647 | 0.644 |
| R2 | 0.646 | 0.641 | 0.648 | 0.641 | 0.638 |

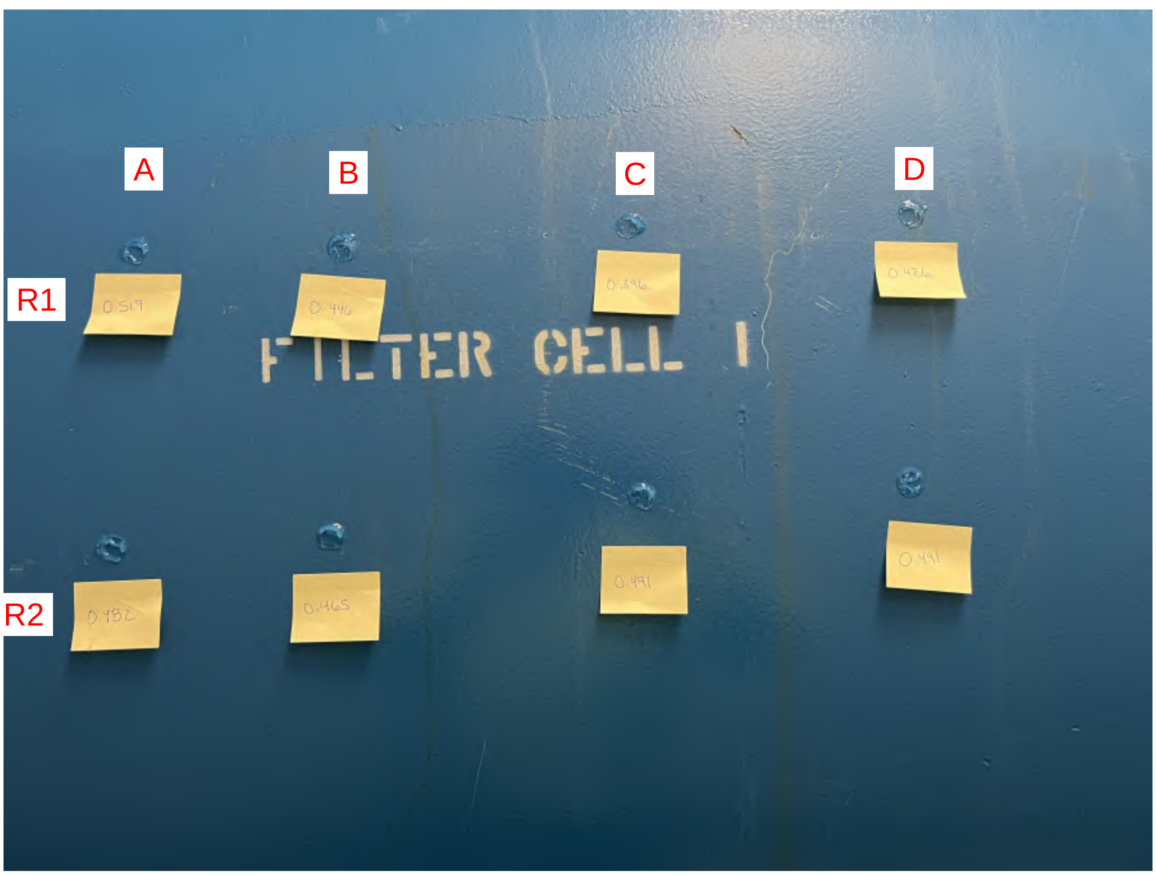
Well 8
Pressure Tank
West Side, North End

# APPENDIX K

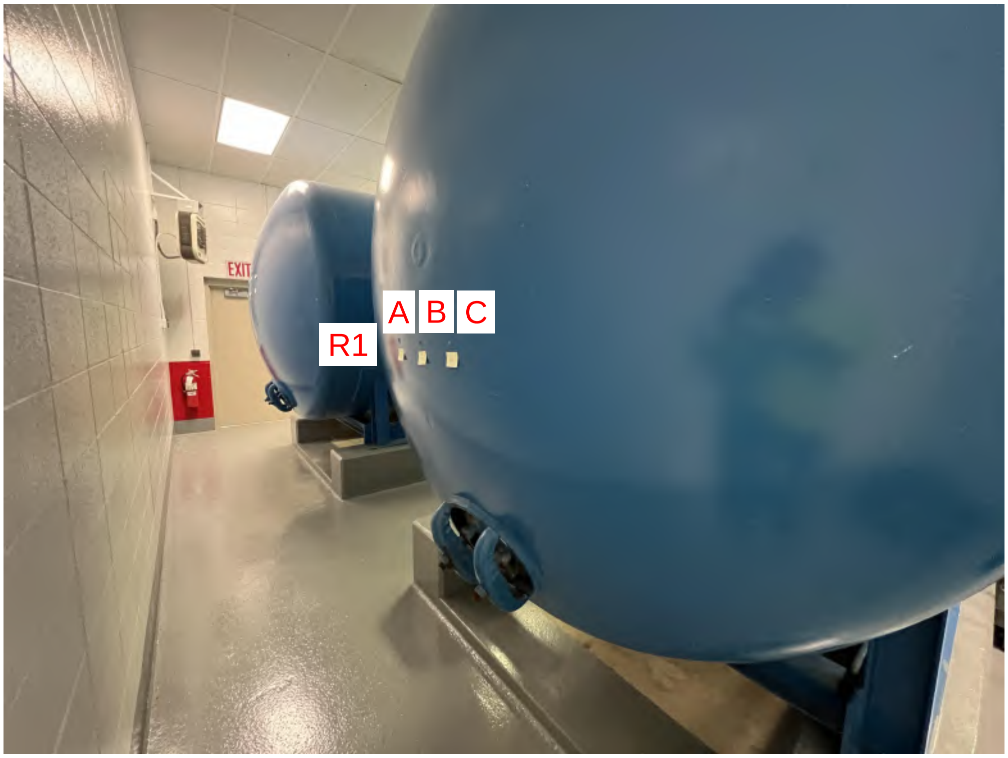
# Well 9 Filter Plant: Pressure Filter Tank Thickness Test Results

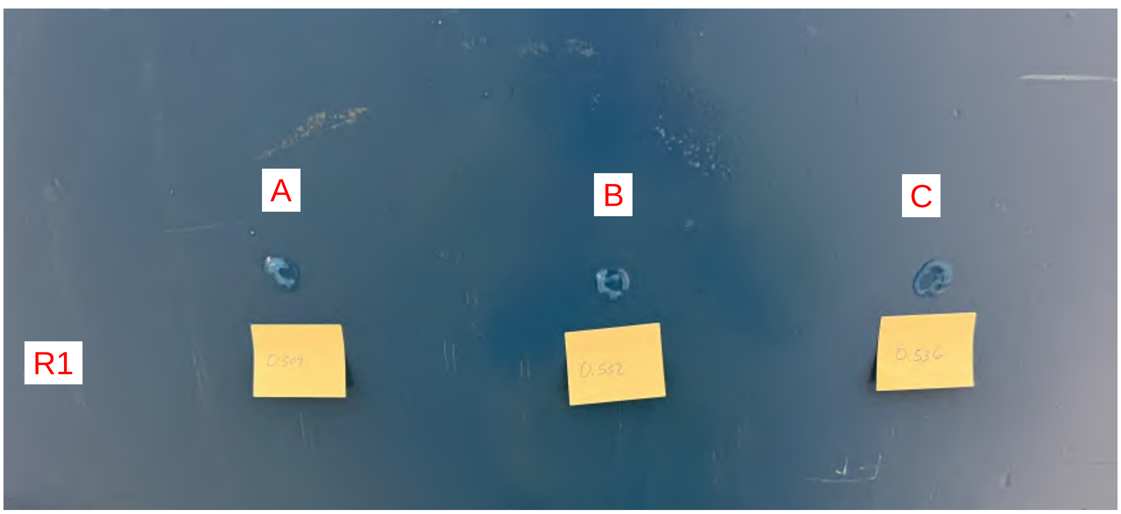
Well 9
Pressure Tank
East Tank, East Side, South End

| Well 9 | | | | |
|---|---|---|---|---|
| East Tank, East Side, South End | | | | |
| | A | B | C | D |
| R1 | 0.519 | 0.446 | 0.396 | 0.426 |
| R2 | 0.482 | 0.465 | 0.491 | 0.491 |

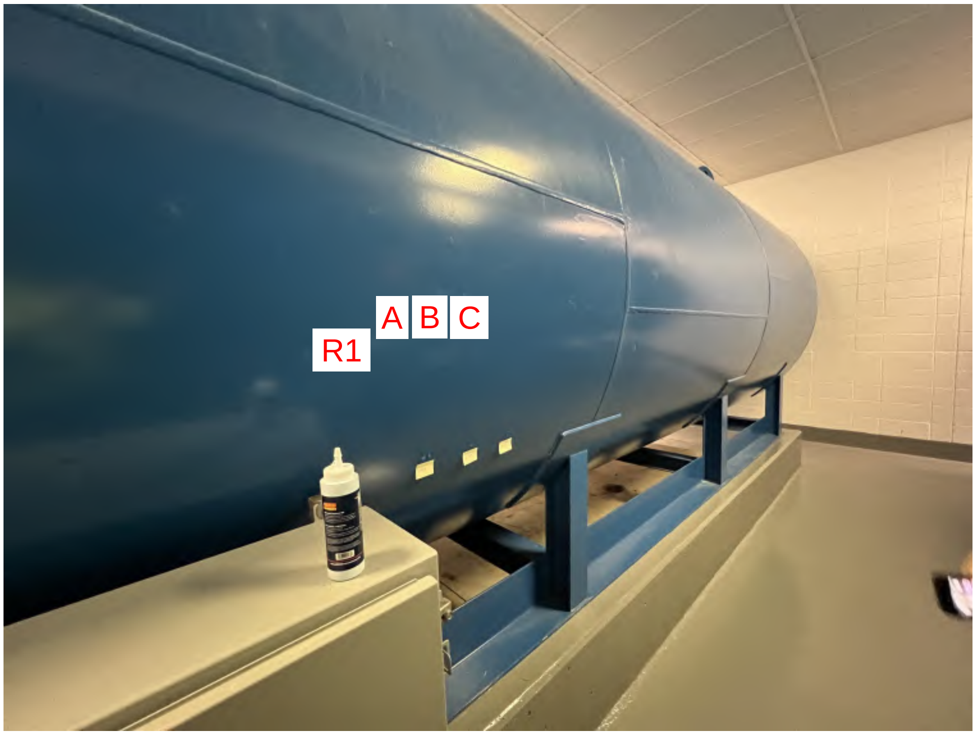
Well 9
Pressure Tank
East Tank, South End

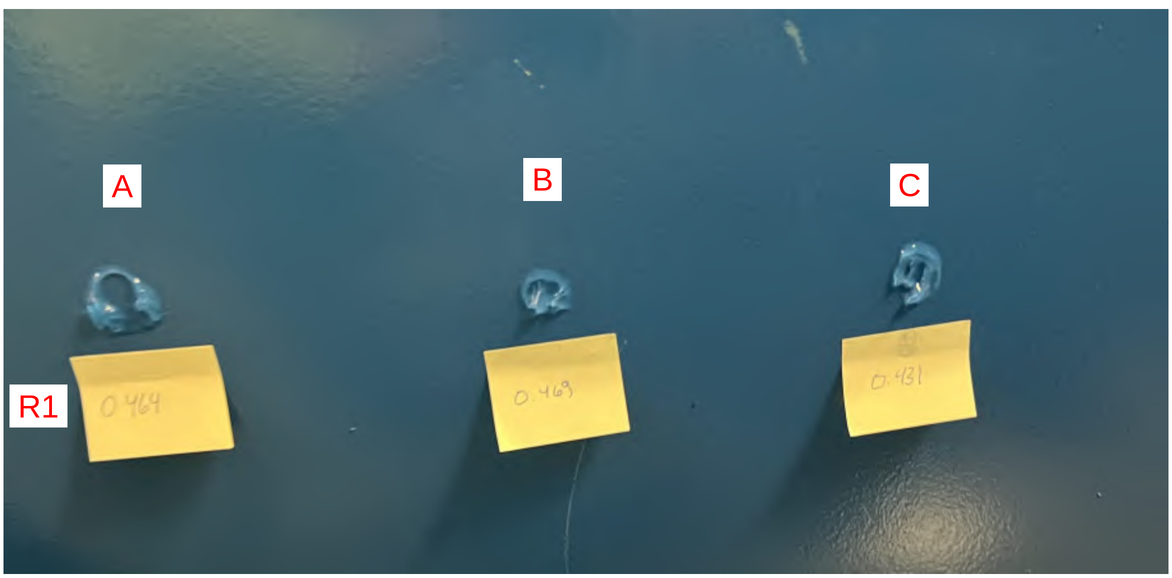



| **Well 9** | | | |
|---|---|---|---|
| East Tank, South End | | | |
| | A | B | C |
| R1 | 0.509 | 0.532 | 0.536 |

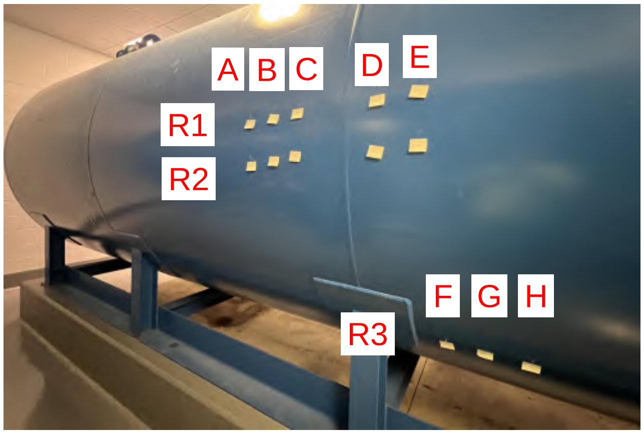
Well 9
Pressure Tank
East Tank, West Side, Middle



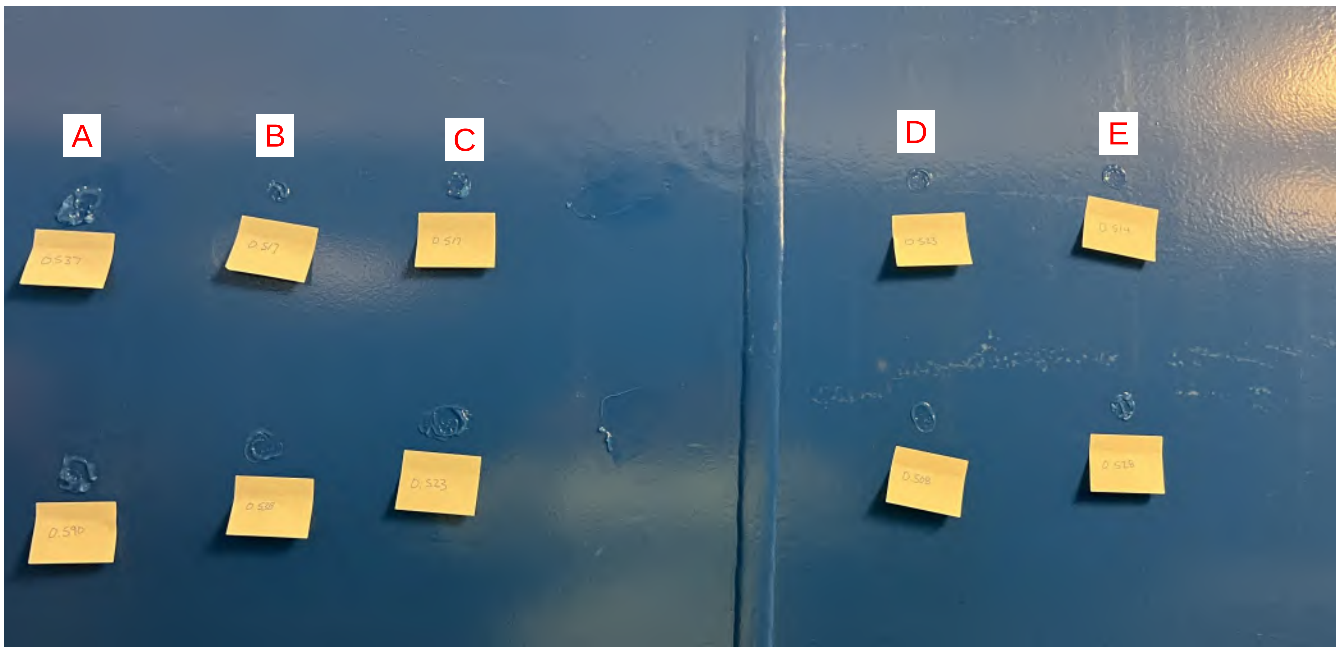




| Well 9 | | | |
|---|---|---|---|
| East Tank, West Side, Middle | | | |
| | A | B | C |
| R1 | 0.464 | 0.469 | 0.431 |

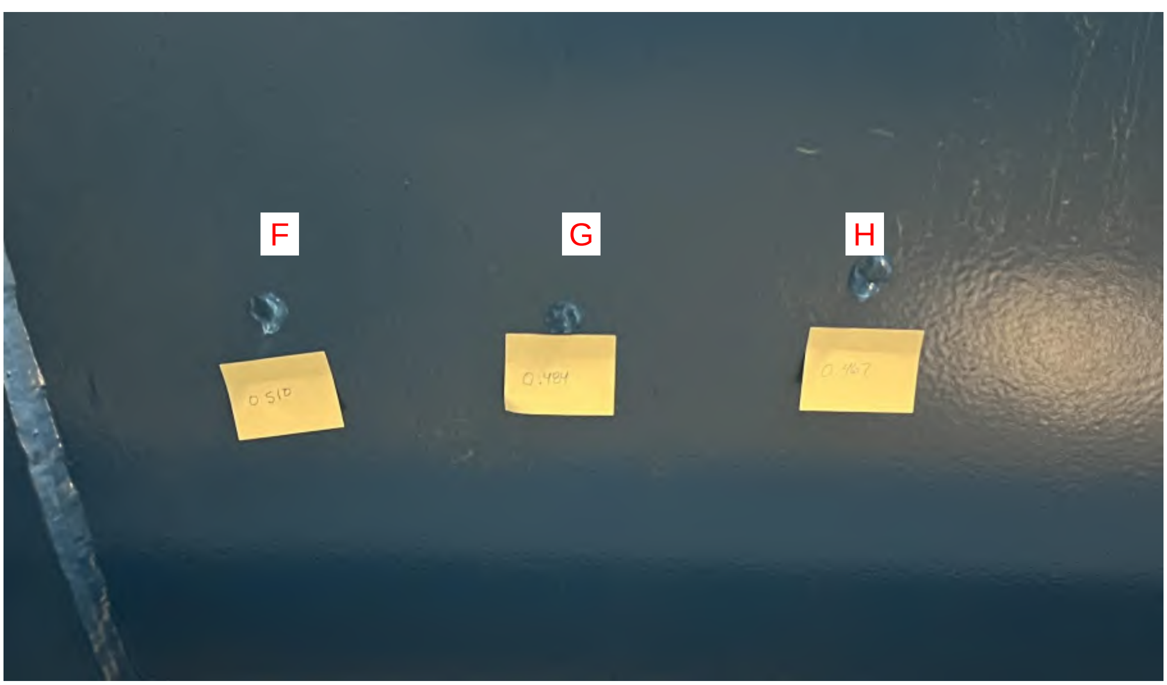
Well 9
Pressure Tank
West Tank, East Side, Middle




R1
R2

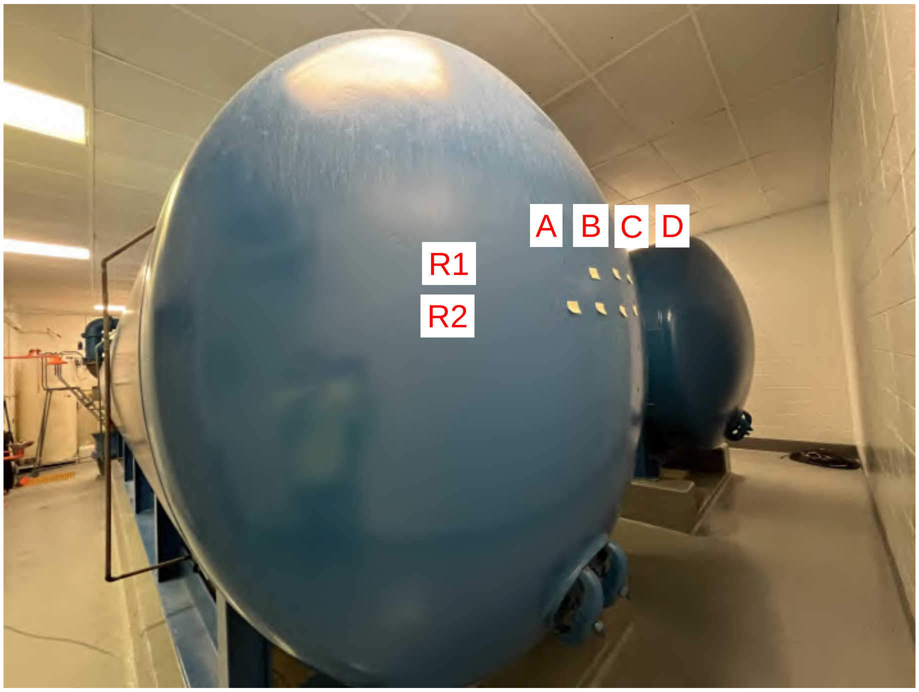


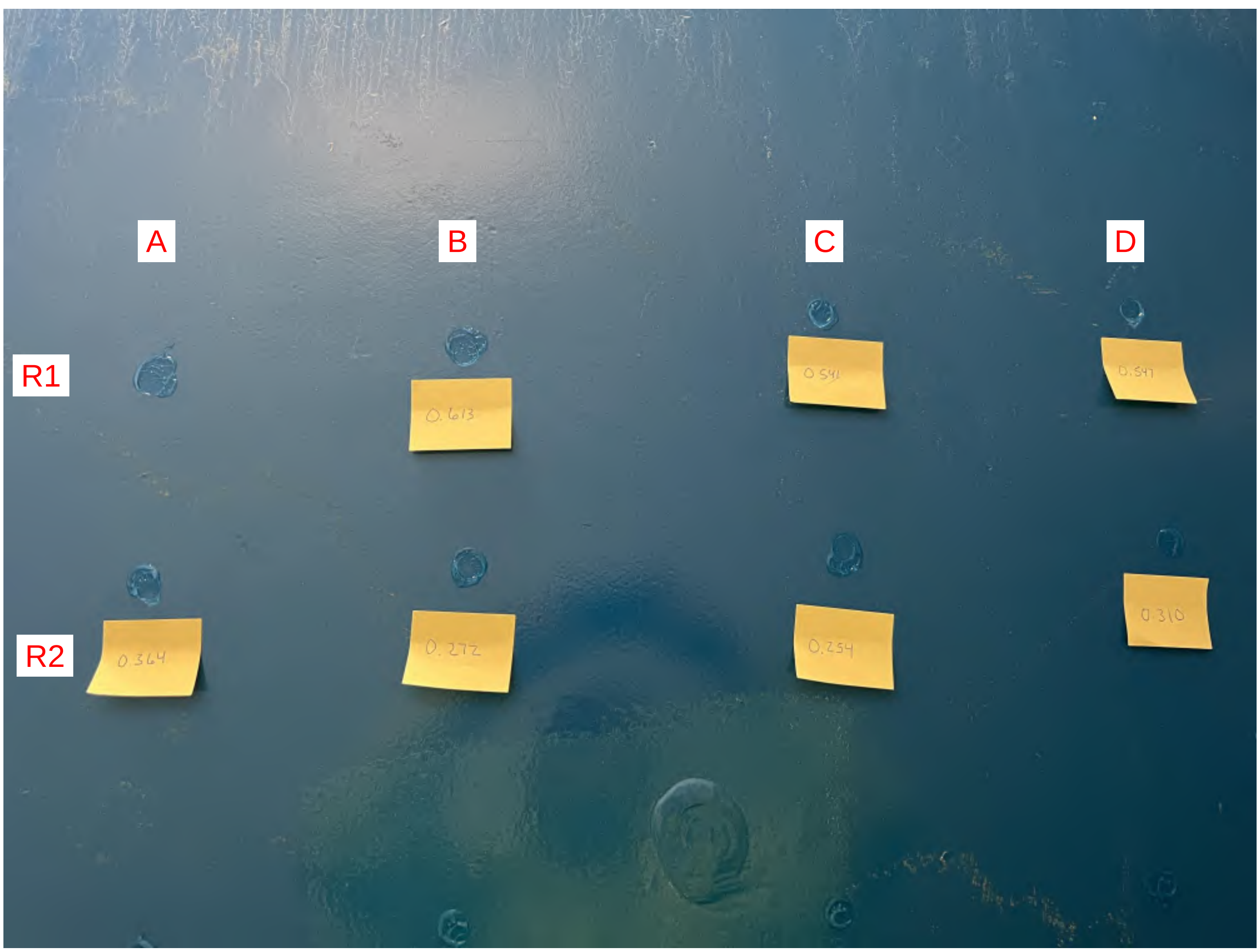

R3



| **Well 9** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| West Tank, East Side, Middle | | | | | | | | |
| | A | B | C | D | E | F | G | H |
| R1 | 0.537 | 0.517 | 0.517 | 0.523 | 0.514 | | | |
| R2 | 0.590 | 0.538 | 0.523 | 0.508 | 0.528 | | | |
| R3 | | | | | | 0.510 | 0.484 | 0.467 |

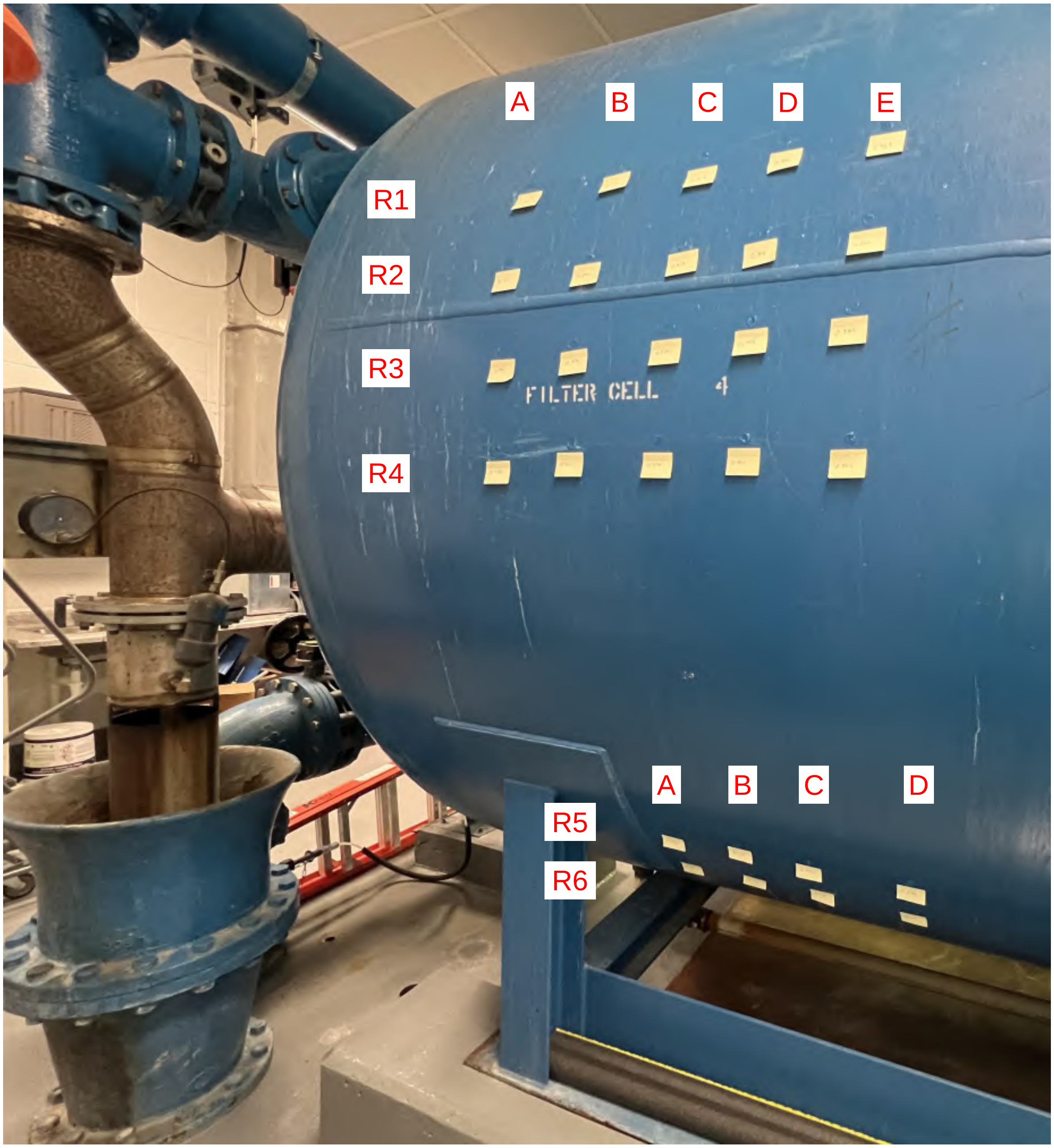
Well 9
Pressure Tank
West Tank, South End



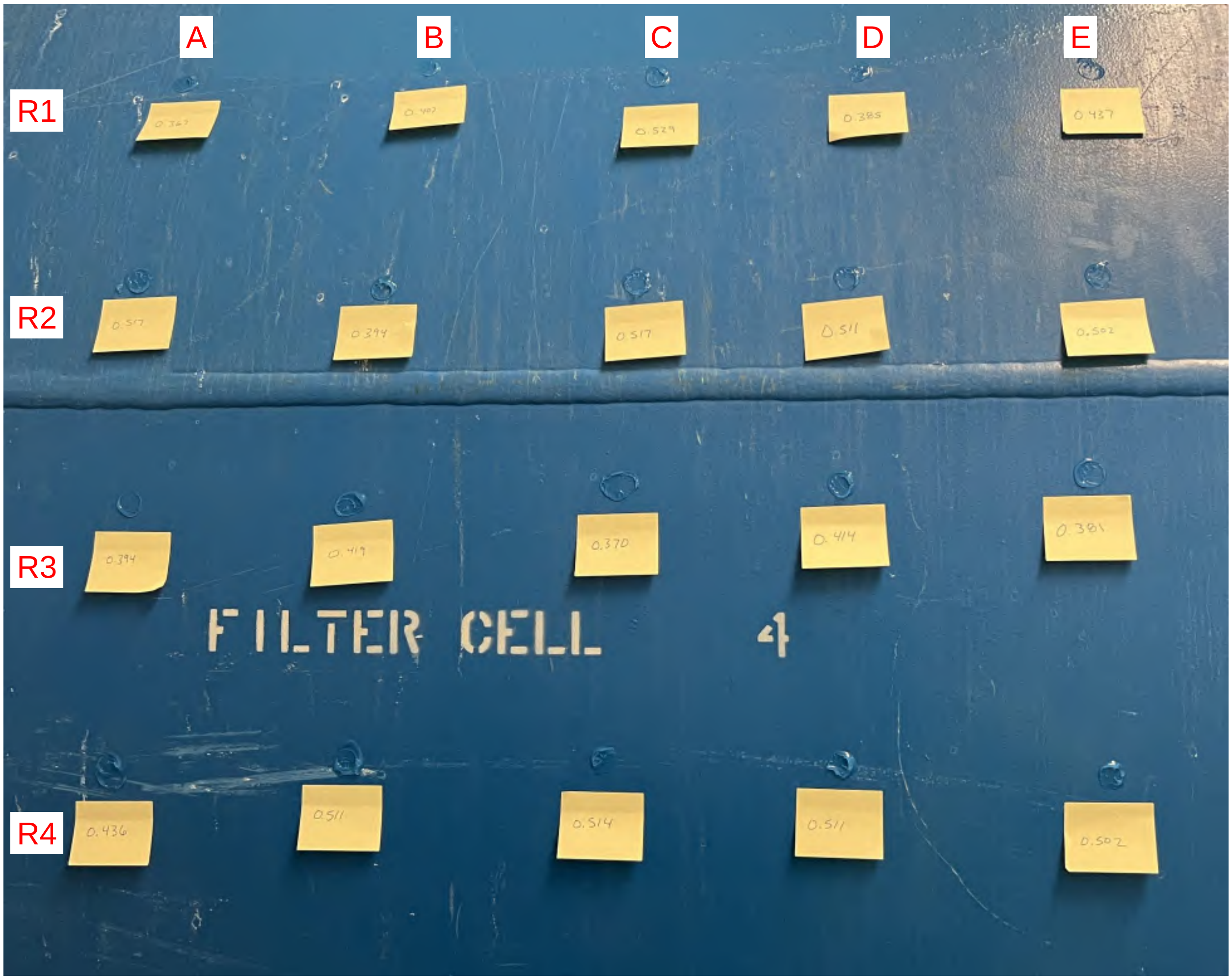



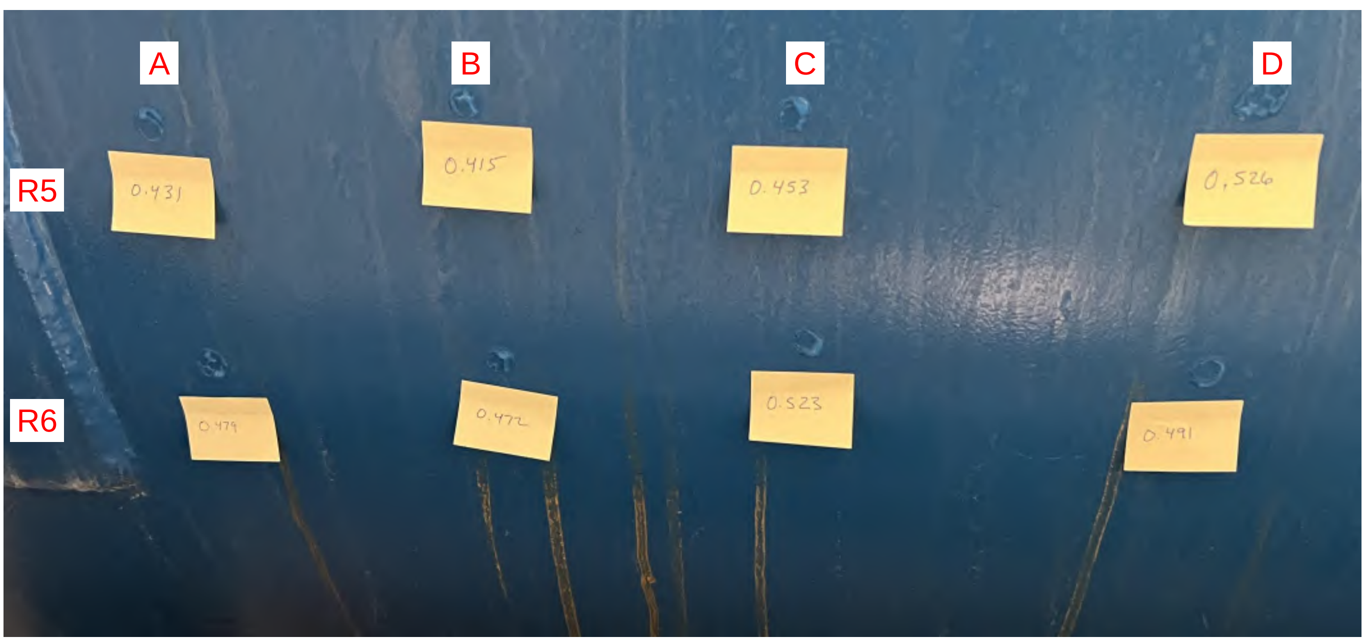
| Well 9 | | | | |
|---|---|---|---|---|
| West Tank, South End | | | | |
| | A | B | C | D |
| R1 | | 0.613 | 0.541 | 0.547 |
| R2 | 0.364 | 0.272 | 0.254 | 0.310 |

Well 9
Pressure Tank
West Tank, West Side, North End



Well 9
Pressure Tank
West Tank, West Side, North End



| **Well 9** | | | | | |
|---|---|---|---|---|---|
| West Tank, South End | | | | | |
| | A | B | C | D | E |
| R1 | 0.367 | 0.407 | 0.529 | 0.385 | 0.437 |
| R2 | 0.517 | 0.394 | 0.517 | 0.511 | 0.502 |
| R3 | 0.394 | 0.419 | 0.370 | 0.414 | 0.381 |
| R4 | 0.436 | 0.511 | 0.514 | 0.511 | 0.502 |
| R5 | 0.431 | 0.415 | 0.453 | 0.526 | |
| R6 | 0.479 | 0.420 | 0.523 | 0.491 | |

# APPENDIX D

# Water Demand Summary and Calculations

2017 - 2022 Water Demand Breakdown

| | 2022 | | | 2021 | | | 2020 | | | 2019 | | | 2018 | | | 2017 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Customer Classification | No. of Customers | Metered Water Use (gal) | % of Total Flow | No. of Customers | Metered Water Use (gal) | % of Total Flow | No. of Customers | Metered Water Use (gal) | % of Total Flow | No. of Customers | Metered Water Use (gal) | % of Total Flow | No. of Customers | Metered Water Use (gal) | % of Total Flow | No. of Customers | Metered Water Use (gal) | % of Total Flow |
| Residential | 6,354 | 235,529,000 | 67% | 6,263 | 235,008,000 | 67% | 6,167 | 243,177,000 | 69% | 6,083 | 224,918,000 | 66% | 6,015 | 227,084,000 | 65% | 5,983 | 220,464,000 | 67% |
| Commercial | 408 | 48,301,000 | 14% | 397 | 46,457,000 | 13% | 397 | 43,227,000 | 12% | 398 | 51,086,000 | 15% | 397 | 50,533,000 | 15% | 396 | 46,678,000 | 14% |
| Industrial | 26 | 39,477,000 | 11% | 20 | 39,363,000 | 11% | 20 | 38,398,000 | 11% | 20 | 33,654,000 | 10% | 19 | 38,939,000 | 11% | 19 | 30,771,000 | 9% |
| Public | 33 | 10,095,000 | 3% | 32 | 10,301,000 | 3% | 32 | 10,155,000 | 3% | 32 | 11,546,000 | 3% | 32 | 11,791,000 | 3% | 31 | 12,259,000 | 4% |
| Multifamily Residential | 133 | 18,202,000 | 5% | 132 | 18,256,000 | 5% | 132 | 18,660,000 | 5% | 132 | 18,753,000 | 6% | 132 | 19,419,000 | 6% | 132 | 17,682,000 | 5% |
| **Total** | **6,954** | **351,604,000** | | **6,844** | **349,385,000** | | **6,748** | **353,617,000** | | **6,665** | **339,957,000** | | **6,595** | **347,766,000** | | **6,561** | **327,854,000** | |
| | | | | | | | | | | | | | | | | | | |
| Total Gallons Pumped into Dist. System | | 473,362,000 | | | 422,636,000 | | | 409,484,000 | | | 416,569,000 | | | 432,995,000 | | | 432,714,000 | |
| Average Day Demand | | 1,300,445 | | | 1,161,088 | | | 1,121,874 | | | 1,144,420 | | | 1,189,547 | | | 1,188,775 | |
| Total Water Loss | | 23% | | | 10% | | | 6% | | | 9% | | | 10% | | | 12% | |
| | | | | | | | | | | | | | | | | | | |
| Maximum Day Demand | | 2,213,000 | | | 1,922,000 | | | 1,827,000 | | | 2,192,000 | | | 2,030,000 | | | 2,288,000 | |
| Day of Max Demand | | 5/24/2022 | | | 8/17/2021 | | | 4/22/2020 | | | 1/17/2017 | | | 6/15/2018 | | | 6/27/2017 | |
| Reason for Max Day | | Water main break | | | Hydrant flushing | | | Hydrant flushing | | | Water main break | | | Hydrant flushing | | | Hydrant flushing | |
| Max Day Ratio | | 1.70 | | | 1.66 | | | 1.63 | | | 1.92 | | | 1.71 | | | 1.92 | |
| | | | | | | | | | | | | | | | | | | |
| Population | | 17,372 | | | 17,170 | | | 17,088 | | | 16,274 | | | 16,219 | | | 16,080 | |
| Average Person per Household | | 2.73 | | | 2.74 | | | 2.77 | | | 2.68 | | | 2.70 | | | 2.69 | |
| Residential gpcd | | 37.2 | | | 37.6 | | | 39.0 | | | 38.0 | | | 38.5 | | | 37.7 | |
| Total gpcd | | 55.60 | | | 55.90 | | | 56.70 | | | 57.39 | | | 58.91 | | | 56.01 | |

## PSC Numerical Project Justification Equations

Equation 1: Maximum Day Demand

$$\mathrm{SC} = [\mathrm{FWC} * 18\ \mathrm{hr}/24\ \mathrm{hr}] - \mathrm{MD}$$

Equation 2: Average Day Demand

$$\mathrm{SC} = [\mathrm{FWC} * 12\ \mathrm{hr}/24\ \mathrm{hr}] - \mathrm{AD}$$

Equation 3: Fire Flow Demand and Maximum Day Demand

$$\mathrm{SC} = \mathrm{FWC} + \frac{\mathrm{ES}}{\mathrm{T} * 60} - \mathrm{F} - \frac{\mathrm{R} + \mathrm{MD}}{24 * 60}$$

Equation 4: Maximum Hour Demand

$$\mathrm{SC} = \mathrm{FWC} + \frac{\mathrm{ES}}{60} - \frac{\mathrm{R} + \mathrm{MH} * 60}{60}$$

## Firm Well Capacity (FWC)

**Firm well capacity is the total well capacity of the wells in the system, with the largest well out of service.*

$$\text{Well 4} = 555\ \text{gpm}$$

$$\text{Well 5} = 315\ \text{gpm}$$

$$\text{Well 10} = 580\ \text{gpm}$$

$$\text{Well 8} = 475\ \text{gpm}$$

$$\text{Well 9} = 1{,}300\ \text{gpm}$$

$$\text{FWC} = \text{Total capacity} - \text{Well 9} = 1{,}925\ \text{gpm}$$

Additional calculations were performed with different well capacities. Some scenarios were evaluated with Well 9 also running to show how the system performs in a better-case scenario than FWC. Although this does not provide the most conservative calculation, it was performed to show Kaukauna how their system can perform when all the wells are operational.

## Customer Demand

**Current Average Day Demand (AD)**

2022 PSC WEGS report total gallons of water of 473,362,000 gallons.

This also assumes as 12-hour pumping day.

$$473{,}362{,}000\ \text{gal/ year} \div 365\ \text{days} \ \div 12\ \text{pumping hours/day} \ \div 60\ \text{min/hr} = \mathbf{1{,}801\ gpm}$$

**Current Maximum Day Demand (MD)**

Using average maximum day from PSC WEGS reports 2017-2022 and an 18-hour pumping day.

$$2{,}078{,}667\ \text{gal} \div 24 \div 18 = \mathbf{1{,}925\ gpm}$$

**Current Maximum Hour Demand (MH)**

$$1{,}925 \text{ gpm x } 2 = \mathbf{2{,}028\ gpm}$$

20-Year Projections

| Year | Total Water Demand (gal) | Average Day Demand (gal) | Maximum Day Demand (gal) |
|---|---|---|---|
| 2000 | 464,305,000 | 1,272,068 | 2,252,000 |
| 2001 | 484,189,000 | 1,326,545 | 1,961,000 |
| 2002 | 501,160,000 | 1,373,041 | 2,011,000 |
| 2003 | 536,283,000 | 1,469,268 | 2,204,000 |
| 2004 | 512,887,000 | 1,405,170 | 3,026,000 |
| 2005 | 534,648,000 | 1,464,789 | 2,336,000 |
| 2006 | 516,376,000 | 1,414,729 | 2,495,000 |
| 2007 | 510,719,000 | 1,399,230 | 2,261,000 |
| 2008 | 506,623,000 | 1,388,008 | 2,556,000 |
| 2009 | 471,048,000 | 1,290,542 | 2,135,000 |
| 2010 | 430,703,000 | 1,180,008 | 2,308,000 |
| 2011 | 444,951,000 | 1,219,044 | 2,022,000 |
| 2012 | 457,694,000 | 1,253,956 | 1,862,000 |
| 2013 | 444,685,000 | 1,218,315 | 1,929,000 |
| 2014 | 469,407,000 | 1,286,047 | 1,911,000 |
| 2015 | 435,258,500 | 1,192,489 | 2,057,000 |
| 2016 | 432,127,000 | 1,183,910 | 2,064,000 |
| 2017 | 432,714,000 | 1,185,518 | 2,288,000 |
| 2018 | 432,995,000 | 1,186,288 | 2,030,000 |
| 2019 | 416,569,000 | 1,141,285 | 2,192,000 |
| 2020 | 409,484,000 | 1,121,874 | 1,827,000 |
| 2021 | 422,636,000 | 1,157,907 | 1,922,000 |
| 2022 | 473,362,000 | 1,296,882 | 2,213,000 |
| 2025 | 480,497,991 | 1,316,433 | 2,316,922 |
| 2030 | 492,631,168 | 1,349,674 | 2,375,427 |
| 2035 | 505,070,722 | 1,383,755 | 2,435,410 |
| 2040 | 517,824,391 | 1,418,697 | 2,496,907 |
| 2043 | 525,630,658 | 1,440,084 | 2,534,548 |

Projections were determined assuming a 0.5% annual growth rate, starting from the total water demand from 2022. This was decided on as the growth rate following discussions with Kaukauna Utilities.

Future max day determined by multiplying average day by 2.53. This ratio of MD:AD demand is the average of MD:AD demand from the PSC WEGS reports from 2017-2022.

**Future Average Day (AD)**

$$1{,}440{,}084 \text{ gal} \div 12 \text{ pumping} \frac{\text{hours}}{\text{day}} \div 60 \frac{\text{min}}{\text{hr}} = \mathbf{2{,}000\ gpm}$$

**Future Maximum Day (MD)**

$$2{,}534{,}548 \text{ gal} \div 24 \div 18 = \mathbf{2{,}347\ gpm}$$

**Future Maximum Hour (MH)**

$$2{,}347 \text{ gpm x } 2 = \mathbf{4{,}928\ gpm}$$

Additional demand scenarios were also considered. In the report, an RO treatment system is being considered for all wells. This would involve a waste stream of approximately 17% of total water pumped. Therefore, calculations for the RO scenario include an additional 1.17% demand in the system.

Calculations were also performed for maximum day demand assuming a 24-hour pumping day instead of 18-hour pumping day. This would be a realistic short-term solution to meet maximum day demand with Well 9 down.

## Fire Demand

Using ISO Fire Demands for schools.

$$\text{Maximum fire flow} = 3{,}500 \text{ gpm (F)}$$

$$\text{Maximum fire flow duration} = 3 \text{ hr (T)}$$

$$\text{Maximum fire flow volume} = 630{,}000 \text{ gal}$$

## Storage

Current Water Storage (ES)

Assuming 10% of the water tower capacity must be set aside for operational needs.

$$1\text{M gal x } 0.90 = 900{,}000 \text{ gal}$$

Note: following discussions with the sanitary district, it was determined to use a reserve (R) of 0 for a more conservative estimate of demand needs.

## Equation Results

| Scenario | Equation 1 - Max Day | Equation 2 - Average Day | Equation 3 - Fire Flow on Max Day | Equation 4 - Max Hour |
|---|---|---|---|---|
| Current | 0 | 124 | 1,500 | 12,883 |
| Future - FWC | (422) | (75) | 1,078 | 11,997 |
| Future - With Well 9 | 878 | 1,225 | | |
| Current Demand + RO | (327) | (182) | 1,173 | 1,318 |
| Future - FWC + RO | (821) | (415) | 679 | 1,085 |
| Future - with Well 9, RO | 479 | 885 | 1,979 | 2,385 |

Current Demand + RO treatment, assuming a 24-hour pumping day for maximum day demand

236 gpm spare capacity

Future Demand + RO treatment, assuming a 24-hour pumping day for maximum day demand

-134 gpm spare capacity

# APPENDIX E

# Water Quality Testing Results

3/6/2023 RESULTS - RAW WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

# Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 23003991
Report Date: 3/6/2023
Sampled By: CLIENT

PO#: 14351
# Samples: 5

Sample Number: 53008864
Sample ID: RAW WATER WELL #4
Sample Date: 2/22/2023
Date Received: 2/22/2023

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| TEMPERATURE | 53.2 | F | | | | EPA170.1 | 2/22/2023 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 185 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| CHLORIDE | 9.3 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| CONDUCTIVITY-LAB | 1360 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 2/24/2023 | |
| FLUORIDE | 1.7 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| HARDNESS AS CACO3 | 754 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 3/1/2023 | |
| M-ALKALINITY | 185 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| P-ALKALINITY | <20 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| pH-LAB | 7.2 | S.U. | | | | SM4500HB | 2/22/2023 | |
| SILICA, DISSOLVED | 6.6 | mg/l | 0.95 | 3.2 | 5 | SM4500SiO2C | 3/1/2023 | |
| SULFATE | 583 | mg/l | 18 | 60 | 35 | EPA300.0 | 2/28/2023 | |
| SUSPENDED SOLIDS | <2.0 | mg/l | 2.0 | 2.0 | | SM2540D | 2/23/2023 | |
| TOTAL DIS. SOLIDS | 1088 | mg/l | 20 | 20 | | SM2540C | 2/24/2023 | |
| TURBIDITY-LAB | 8.3 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 2/24/2023 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <0.014 | mg/l | 0.014 | 0.047 | 1 | EPA200.7 | 3/1/2023 | |
| BARIUM, TOTAL | <0.0004 | mg/l | 0.0004 | 0.0013 | 1 | EPA200.7 | 3/1/2023 | |
| BORON | 0.123 | mg/l | 0.0035 | 0.012 | 1 | EPA200.7 | 3/1/2023 | |
| CALCIUM, TOTAL | 271 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 3/1/2023 | |
| IRON, TOTAL | 0.61 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 3/1/2023 | |
| MAGNESIUM, TOTAL | 19 | mg/l | 0.02 | 0.07 | 1 | EPA200.7 | 3/1/2023 | |
| MANGANESE, TOTAL | 0.021 | mg/l | 0.0007 | 0.0023 | 1 | EPA200.7 | 3/2/2023 | |
| METALS DIGESTION | DONE | | | | | EPA200.2 | 2/28/2023 | |
| POTASSIUM, TOTAL | 4.69 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| SODIUM, TOTAL | 13 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| STRONTIUM, TOTAL | 24 | mg/l | 2.0 | 6.67 | 10 | EPA200.7 | 3/2/2023 | |
| NUTRIENTS | | | | | | | | |
| AMMONIA NITROGEN | 0.12 | mg/l | 0.11 | 0.37 | 1 | SM4500NH3G | 2/27/2023 | |
| NITRATE NITROGEN | <0.10 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| PHOSPHORUS, TOTAL | <0.03 | mg/l | 0.03 | 0.10 | 1 | EPA365.4 | 3/2/2023 | |
| ORGANICS | | | | | | | | |
| TOTAL ORGANIC CARBON | 0.698 | mg/l | 0.284 | 0.946 | 1 | SM5310C | 2/24/2023 | 47,J |

3/6/2023 RESULTS - RAW WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

# Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

Sample Number: 53008865
Sample ID: RAW WATER WELL #5
Sample Date: 2/22/2023
Date Received: 2/22/2023

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| TEMPERATURE | 52.1 | C | | | | EPA170.1 | 2/22/2023 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 180 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| CHLORIDE | 13 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 2/28/2023 | |
| CONDUCTIVITY-LAB | 1390 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 2/24/2023 | |
| FLUORIDE | 1.7 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| HARDNESS AS CACO3 | 778 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 3/1/2023 | |
| M-ALKALINITY | 180 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| P-ALKALINITY | <20 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| pH-LAB | 7.2 | S.U. | | | | SM4500HB | 2/22/2023 | |
| SILICA, DISSOLVED | 5.6 | mg/l | 0.95 | 3.2 | 5 | SM4500SiO2C | 3/1/2023 | |
| SULFATE | 607 | mg/l | 18 | 60 | 35 | EPA300.0 | 2/28/2023 | |
| SUSPENDED SOLIDS | <2.0 | mg/l | 2.0 | 2.0 | | SM2540D | 2/23/2023 | |
| TOTAL DIS. SOLIDS | 1173 | mg/l | 20 | 20 | | SM2540C | 2/24/2023 | |
| TURBIDITY-LAB | 11 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 2/24/2023 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <0.014 | mg/l | 0.014 | 0.047 | 1 | EPA200.7 | 3/1/2023 | |
| BARIUM, TOTAL | <0.0004 | mg/l | 0.0004 | 0.0013 | 1 | EPA200.7 | 3/1/2023 | |
| BORON | 0.128 | mg/l | 0.0035 | 0.012 | 1 | EPA200.7 | 3/1/2023 | |
| CALCIUM, TOTAL | 279 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 3/1/2023 | |
| IRON, TOTAL | 0.81 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 3/1/2023 | |
| MAGNESIUM, TOTAL | 20 | mg/l | 0.02 | 0.07 | 1 | EPA200.7 | 3/1/2023 | |
| MANGANESE, TOTAL | 0.024 | mg/l | 0.0007 | 0.0023 | 1 | EPA200.7 | 3/2/2023 | |
| METALS DIGESTION | DONE | | | | | EPA200.2 | 2/28/2023 | |
| POTASSIUM, TOTAL | 4.86 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| SODIUM, TOTAL | 16 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| STRONTIUM, TOTAL | 21 | mg/l | 0.0002 | 0.0007 | 1 | EPA200.7 | 3/1/2023 | |
| NUTRIENTS | | | | | | | | |
| AMMONIA NITROGEN | <0.11 | mg/l | 0.11 | 0.37 | 1 | SM4500NH3G | 2/27/2023 | |
| NITRATE NITROGEN | <0.10 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| PHOSPHORUS, TOTAL | <0.03 | mg/l | 0.03 | 0.10 | 1 | EPA365.4 | 3/2/2023 | |
| ORGANICS | | | | | | | | |
| TOTAL ORGANIC CARBON | 0.656 | mg/l | 0.284 | 0.946 | 1 | SM5310C | 2/24/2023 | 47,J |

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

# Analytical Report

Sample Number: 53008866
Sample ID: RAW WATER WELL #8
Sample Date: 2/22/2023
Date Received: 2/22/2023

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| TEMPERATURE | 52.7 | C | | | | EPA170.1 | 2/22/2023 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 175 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| CHLORIDE | 7.5 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| CONDUCTIVITY-LAB | 1090 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 2/24/2023 | |
| FLUORIDE | 1.8 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| HARDNESS AS CACO3 | 565 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 3/1/2023 | |
| M-ALKALINITY | 175 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| P-ALKALINITY | <20 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| pH-LAB | 7.2 | S.U. | | | | SM4500HB | 2/22/2023 | |
| SILICA, DISSOLVED | 6.6 | mg/l | 0.95 | 3.2 | 5 | SM4500SiO2C | 3/1/2023 | |
| SULFATE | 441 | mg/l | 13 | 43 | 25 | EPA300.0 | 2/28/2023 | |
| SUSPENDED SOLIDS | <2.0 | mg/l | 2.0 | 2.0 | | SM2540D | 2/23/2023 | |
| TOTAL DIS. SOLIDS | 862 | mg/l | 20 | 20 | | SM2540C | 2/24/2023 | |
| TURBIDITY-LAB | 8.8 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 2/24/2023 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <0.014 | mg/l | 0.014 | 0.047 | 1 | EPA200.7 | 3/1/2023 | |
| BARIUM, TOTAL | 0.0023 | mg/l | 0.0004 | 0.0013 | 1 | EPA200.7 | 3/1/2023 | |
| BORON | 0.11 | mg/l | 0.0035 | 0.012 | 1 | EPA200.7 | 3/1/2023 | |
| CALCIUM, TOTAL | 195 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 3/1/2023 | |
| IRON, TOTAL | 0.55 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 3/1/2023 | |
| MAGNESIUM, TOTAL | 19 | mg/l | 0.02 | 0.07 | 1 | EPA200.7 | 3/1/2023 | |
| MANGANESE, TOTAL | 0.022 | mg/l | 0.0007 | 0.0023 | 1 | EPA200.7 | 3/2/2023 | |
| METALS DIGESTION | DONE | | | | | EPA200.2 | 2/28/2023 | |
| POTASSIUM, TOTAL | 4.20 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| SODIUM, TOTAL | 11 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| STRONTIUM, TOTAL | 20 | mg/l | 0.0002 | 0.0007 | 1 | EPA200.7 | 3/1/2023 | |
| NUTRIENTS | | | | | | | | |
| AMMONIA NITROGEN | 0.12 | mg/l | 0.11 | 0.37 | 1 | SM4500NH3G | 2/27/2023 | |
| NITRATE NITROGEN | <0.10 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| PHOSPHORUS, TOTAL | <0.03 | mg/l | 0.03 | 0.10 | 1 | EPA365.4 | 3/2/2023 | |
| ORGANICS | | | | | | | | |
| TOTAL ORGANIC CARBON | 0.871 | mg/l | 0.284 | 0.946 | 1 | SM5310C | 2/24/2023 | 47,J |

3/6/2023 RESULTS - RAW WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

# Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

Sample Number: 53008867
Sample ID: RAW WATER WELL #9
Sample Date: 2/22/2023
Date Received: 2/22/2023

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| TEMPERATURE | 52.8 | C | | | | EPA170.1 | 2/22/2023 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 205 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| CHLORIDE | 5.8 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| CONDUCTIVITY-LAB | 1170 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 2/24/2023 | |
| FLUORIDE | 1.6 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| HARDNESS AS CACO3 | 619 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 3/1/2023 | |
| M-ALKALINITY | 205 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| P-ALKALINITY | <20 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| pH-LAB | 7.2 | S.U. | | | | SM4500HB | 2/22/2023 | |
| SILICA, DISSOLVED | 8.7 | mg/l | 0.95 | 3.2 | 5 | SM4500SiO2C | 3/1/2023 | |
| SULFATE | 451 | mg/l | 13 | 43 | 25 | EPA300.0 | 2/28/2023 | |
| SUSPENDED SOLIDS | <2.0 | mg/l | 2.0 | 2.0 | | SM2540D | 2/23/2023 | |
| TOTAL DIS. SOLIDS | 918 | mg/l | 20 | 20 | | SM2540C | 2/24/2023 | |
| TURBIDITY-LAB | 7.6 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 2/24/2023 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <0.014 | mg/l | 0.014 | 0.047 | 1 | EPA200.7 | 3/1/2023 | |
| BARIUM, TOTAL | <0.0004 | mg/l | 0.0004 | 0.0013 | 1 | EPA200.7 | 3/1/2023 | |
| BORON | 0.11 | mg/l | 0.0035 | 0.012 | 1 | EPA200.7 | 3/1/2023 | |
| CALCIUM, TOTAL | 210 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 3/1/2023 | |
| IRON, TOTAL | 0.53 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 3/1/2023 | |
| MAGNESIUM, TOTAL | 23 | mg/l | 0.02 | 0.07 | 1 | EPA200.7 | 3/1/2023 | |
| MANGANESE, TOTAL | 0.014 | mg/l | 0.0007 | 0.0023 | 1 | EPA200.7 | 3/2/2023 | |
| METALS DIGESTION | DONE | | | | | EPA200.2 | 2/28/2023 | |
| POTASSIUM, TOTAL | 4.38 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| SODIUM, TOTAL | 10 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| STRONTIUM, TOTAL | 26 | mg/l | 0.0002 | 0.0007 | 1 | EPA200.7 | 3/1/2023 | |
| NUTRIENTS | | | | | | | | |
| AMMONIA NITROGEN | 0.13 | mg/l | 0.11 | 0.37 | 1 | SM4500NH3G | 2/27/2023 | |
| NITRATE NITROGEN | <0.10 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| PHOSPHORUS, TOTAL | <0.03 | mg/l | 0.03 | 0.10 | 1 | EPA365.4 | 3/2/2023 | |
| ORGANICS | | | | | | | | |
| TOTAL ORGANIC CARBON | 0.876 | mg/l | 0.284 | 0.946 | 1 | SM5310C | 2/24/2023 | 47,J |

3/6/2023 RESULTS - RAW WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

**Analytical Report**

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

Sample Number: 53008868
Sample ID: RAW WATER WELL #10
Sample Date: 2/22/2023
Date Received: 2/22/2023

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| TEMPERATURE | 52.3 | C | | | | EPA170.1 | 2/22/2023 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 198 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| CHLORIDE | 10 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| CONDUCTIVITY-LAB | 1050 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 2/24/2023 | |
| FLUORIDE | 1.6 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| HARDNESS AS CACO3 | 536 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 3/1/2023 | |
| M-ALKALINITY | 198 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| P-ALKALINITY | <20 | mg/l | 20 | 67 | | SM2320B | 2/24/2023 | |
| pH-LAB | 7.2 | S.U. | | | | SM4500HB | 2/22/2023 | |
| SILICA, DISSOLVED | 8.5 | mg/l | 0.95 | 3.2 | 5 | SM4500SiO2C | 3/1/2023 | |
| SULFATE | 381 | mg/l | 13 | 43 | 25 | EPA300.0 | 2/28/2023 | |
| SUSPENDED SOLIDS | <2.0 | mg/l | 2.0 | 2.0 | | SM2540D | 2/23/2023 | |
| TOTAL DIS. SOLIDS | 802 | mg/l | 20 | 20 | | SM2540C | 2/24/2023 | |
| TURBIDITY-LAB | 9.0 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 2/24/2023 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <0.014 | mg/l | 0.014 | 0.047 | 1 | EPA200.7 | 3/1/2023 | |
| BARIUM, TOTAL | <0.0004 | mg/l | 0.0004 | 0.0013 | 1 | EPA200.7 | 3/1/2023 | |
| BORON | 0.124 | mg/l | 0.0035 | 0.012 | 1 | EPA200.7 | 3/1/2023 | |
| CALCIUM, TOTAL | 178 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 3/1/2023 | |
| IRON, TOTAL | 0.59 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 3/1/2023 | |
| MAGNESIUM, TOTAL | 22 | mg/l | 0.02 | 0.07 | 1 | EPA200.7 | 3/1/2023 | |
| MANGANESE, TOTAL | 0.018 | mg/l | 0.0007 | 0.0023 | 1 | EPA200.7 | 3/2/2023 | |
| METALS DIGESTION | DONE | | | | | EPA200.2 | 2/28/2023 | |
| POTASSIUM, TOTAL | 4.68 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| SODIUM, TOTAL | 14 | mg/l | 0.15 | 0.50 | 1 | EPA200.7 | 3/1/2023 | |
| STRONTIUM, TOTAL | 27 | mg/l | 0.0002 | 0.0007 | 1 | EPA200.7 | 3/1/2023 | |
| NUTRIENTS | | | | | | | | |
| AMMONIA NITROGEN | 0.13 | mg/l | 0.11 | 0.37 | 1 | SM4500NH3G | 2/27/2023 | |
| NITRATE NITROGEN | <0.10 | mg/l | 0.10 | 0.33 | 1 | EPA300.0 | 2/22/2023 | |
| PHOSPHORUS, TOTAL | <0.03 | mg/l | 0.03 | 0.10 | 1 | EPA365.4 | 3/2/2023 | |
| ORGANICS | | | | | | | | |
| TOTAL ORGANIC CARBON | 0.771 | mg/l | 0.284 | 0.946 | 1 | SM5310C | 2/24/2023 | 47,J |

Quality Assurance Code(s):

J. Analyte detected between the LOD and LOQ.

47.Analyzed by Badger Laboratories, Inc Certification #750110460

All LOD/LOQs adjusted for dilution and/or solids content.

LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

3/6/2023 RESULTS - RAW WATER

23003991

# SAMPLE REQUEST & CHAIN OF CUSTODY FORM

**BADGER LABS**
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

| | |
|---|---|
| CLIENT NAME / ADDRESS: Kaukauna | TURN AROUND TIME<br>STANDARD 10 DAY: ☐<br>RUSH (200% UPCHARGE): ☐<br>DATE NEEDED: ______ |
| BILLING ADDRESS/ EMAIL: | |
| REPORT TO: | PO NUMBER: |
| EMAIL: | |
| PHONE: | FAX: |
| PROJECT NAME/ SITE: | |

MATRIX
DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ______

GROUNDWATER SAMPLES (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

CERTIFICATIONS

NEENAH WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

GREEN BAY WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

STEVENS POINT WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

ANALYTICAL REQUESTS

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | | | | | | | | | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 8864 | | | 1 | 1 | 1 | | | DW | | | | | | | | | | 3991 | | |
| | 65 | | | \| | \| | \| | | | \| | | | | | | | | | | | | |
| | 66 | | | \| | \| | \| | | | \| | | | | | | | | | | | | |
| | 67 | | | \| | \| | \| | | | \| | | | | | | | | | | | | |
| | 68 | | | \| | \| | \| | | | \| | | | | | | | | | | | | |
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CHAIN OF CUSTODY RECORD

| FILLED IN BY CLIENT | FILLED IN BY BADGER LABS | ADDITIONAL COMMENTS: |
|---|---|---|
| SAMPLED BY: | RECEIVED/SAMPLED BY: | |
| DATE/TIME SAMPLED: | DATE/TIME RECEIVED: | |
| RELINQUISHED BY: | LOGGED IN: BSB 2/22/23 | |
| DELIVERY METHOD: | ICE?: Y N | |

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 7

Sample Number: 52036566
Sample ID: EP-8
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 1.37 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 54 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.71 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 9.3 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1060 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 618 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.9 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 430 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 215 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 19 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.48 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

Sample Number: 52036567
Sample ID: EP-9
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 1.37 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 54 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.80 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 7.2 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1140 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 670 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.3 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.8 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 464 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.20 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 229 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 3.9 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.52 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

**Analytical Report**

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

Sample Number: 52036568
Sample ID: EP-400
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 1.45 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 54 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.83 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 12 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1240 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 727 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.3 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 528 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 256 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | H1 |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 21 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.53 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

Sample Number: 52036569
Sample ID: 777 ISLAND ST
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 0.96 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 58 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.26 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 12 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1220 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 719 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 7.2 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 536 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 253 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | 0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 37 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.75 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

Analytical Report

Sample Number: 52036570
Sample ID: 2700 NORTHRIDGE DR
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 0.98 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 61 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.25 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 9.1 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1100 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 638 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.6 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 440 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 221 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 6.8 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.75 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

Sample Number: 52036571
Sample ID: 406 W 10TH ST
Sample Date: 10/20/2022
Date Received: 10/21/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 0.98 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 58 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.30 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 7.8 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1120 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 677 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.2 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 456 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 232 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 3.5 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.60 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

**Analytical Report**

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

Sample Number: 52036572
Sample ID: 1701 CTY HWY CE
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 1.05 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 59 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.33 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 11 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1000 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 706 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 7.2 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 485 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 247 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 14 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.75 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

Quality Assurance Code(s):
H1. Spiked sample recovery outside the established quality control limits. Recovery was low.

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 7

Sample Number: 52036566
Sample ID: EP-8
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 1.37 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 54 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.71 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 9.3 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1060 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 618 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.9 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 430 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 215 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 19 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.48 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

Sample Number: 52036567
Sample ID: EP-9
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 1.37 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 54 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.80 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 7.2 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1140 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 670 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.3 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.8 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 464 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.20 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 229 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 3.9 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.52 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

**Analytical Report**

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

Sample Number: 52036568
Sample ID: EP-400
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 1.45 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 54 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.83 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 12 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1240 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 727 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.3 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 528 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 256 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | H1 |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 21 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.53 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

Sample Number: 52036569
Sample ID: 777 ISLAND ST
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 0.96 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 58 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.26 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 12 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1220 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 719 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 7.2 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 536 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 253 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | 0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 37 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.75 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

11/10/2022 RESULTS - TREATED WATER



501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

Sample Number: 52036570
Sample ID: 2700 NORTHRIDGE DR
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 0.98 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 61 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.25 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 9.1 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1100 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 638 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.6 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 440 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 221 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 6.8 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.75 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

Sample Number: 52036571
Sample ID: 406 W 10TH ST
Sample Date: 10/20/2022
Date Received: 10/21/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 0.98 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 58 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.30 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 7.8 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1120 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 677 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 6.2 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 456 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 232 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 3.5 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.60 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

# Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

Sample Number: 52036572
Sample ID: 1701 CTY HWY CE
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| FIELD PARAMETER | | | | | | | | |
| FREE CHLORINE | 1.05 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |
| TEMPERATURE | 59 | F | | | | EPA170.1 | 10/20/2022 | |
| TOTAL CHLORINE | 1.33 | mg/l | | | | | 10/20/2022 | |
| GENERAL ANALYSIS | | | | | | | | |
| ALKALINITY, TOTAL AS CACO3 | 200 | mg/l | 20 | 67 | | SM2320B | 10/28/2022 | |
| CHLORIDE | 11 | mg/l | 0.20 | 0.67 | 2 | EPA300.0 | 10/31/2022 | |
| CONDUCTIVITY-LAB | 1000 | umho/cm | 0.1 | 0.1 | | EPA120.1 | 11/2/2022 | |
| HARDNESS AS CACO3 | 706 | mg/l | 0.28 | 0.93 | 1 | EPA200.7 | 11/7/2022 | |
| pH-LAB | 7.4 | S.U. | | | | SM4500HB | 10/21/2022 | |
| SILICA | 7.2 | mg/l | | | | SM4500SiO2C | 10/20/2022 | |
| SULFATE | 485 | mg/l | 10 | 33 | 20 | EPA300.0 | 11/1/2022 | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/25/2022 | |
| METALS | | | | | | | | |
| ALUMINUM, TOTAL | <14 | ug/l | 14 | 47 | 1 | EPA200.7 | 11/7/2022 | |
| CALCIUM, TOTAL | 247 | mg/l | 0.08 | 0.27 | 1 | EPA200.7 | 11/7/2022 | |
| IRON, TOTAL | <0.06 | mg/l | 0.06 | 0.20 | 1 | EPA200.7 | 11/7/2022 | |
| MANGANESE, TOTAL | 14 | ug/l | 0.7 | 2.3 | 1 | EPA200.7 | 11/7/2022 | |
| NUTRIENTS | | | | | | | | |
| ORTHO PHOSPHORUS | 2.75 | mg/l | 0.01 | 0.03 | | | 10/20/2022 | |

Quality Assurance Code(s):

H1. Spiked sample recovery outside the established quality control limits. Recovery was low.

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
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# Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6775
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036775
Sample ID: 1 0F 2 125ML 224 BROTHERS 1ST DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.10 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6776
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036776
Sample ID: 1 0F 2 125ML 224 BROTHERS 2ND DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.32 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6777
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036777
Sample ID: 1 LITER 224 BROTHERS 3RD DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.15 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.31 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6778
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036778
Sample ID: 1 LITER 224 BROTHERS 4TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | <0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.18 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6779
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036779
Sample ID: 1 LITER 224 BROTHERS 5TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.16 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6780
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036780
Sample ID: 1 LITER 224 BROTHERS 6TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | <0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.16 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6781
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036781
Sample ID: 1 LITER 224 BROTHERS 7TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.15 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6782
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036782
Sample ID: 1 LITER 224 BROTHERS 8TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.13 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6783
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036783
Sample ID: 1 LITER 224 BROTHERS 9TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.15 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.11 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6784
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036784
Sample ID: 1 LITER 224 BROTHERS 10TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.11 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6785
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036785
Sample ID: 1 LITER 224 BROTHERS 11TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.15 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.11 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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**Analytical Report**

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6786
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036786
Sample ID: 1 LITER 224 BROTHERS 12TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.11 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6787
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036787
Sample ID: 1 LITER 224 BROTHERS 13TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.11 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6788
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036788
Sample ID: 1 LITER 224 BROTHERS 14TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.12 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

BADGER LABS
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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6789
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036789
Sample ID: 1 OF 2 125ml 321 W 12TH ST 1ST DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.15 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.70 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

BADGER LABS
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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6790
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036790
Sample ID: 1 OF 2 125ml 321 W 12TH ST 2ND DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.68 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6791
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036791
Sample ID: 1 LITER 321 W 12TH ST 3RD DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.4 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

11/10/2022 RESULTS - TREATED WATER

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# Analytical Report

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6792
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036792
Sample ID: 1 LITER 321 W 12TH ST 4TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 2.1 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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# Analytical Report

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6793
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036793
Sample ID: 1 LITER 321 W 12TH ST 5TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.8 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6794
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036794
Sample ID: 1 LITER 321 W 12TH ST 6TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.5 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6795
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036795
Sample ID: 1 LITER 321 W 12TH ST 7TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.4 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6796
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036796
Sample ID: 1 LITER 321 W 12TH ST 8TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.4 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
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Amanda Kordus

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6796
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036796
Sample ID: 1 LITER 321 W 12TH ST 8TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.4 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6797
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036797
Sample ID: 1 LITER 321 W 12TH ST 9TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.1 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
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KAUKAUNA UTILITIES
777 ISLAND STREET
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Attn: EUGENE KLISTER

Project Number: 22016126 6798
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036798
Sample ID: 1 LITER 321 W 12TH ST 10TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.15 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.1 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
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Amanda Kordus

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6799
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036799
Sample ID: 1 LITER 321 W 12TH ST 11TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.91 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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# Analytical Report

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6800
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036800
Sample ID: 1 LITER 321 W 12TH ST 12TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | <0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.67 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6801
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036801
Sample ID: 1 LITER 321 W 12TH ST 13TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.58 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
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Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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# Analytical Report

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6802
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036802
Sample ID: 1 LITER 321 W 12TH ST 14TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.66 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6803
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036803
Sample ID: 1 OF 2 125 ml 224 DIEDRICHST 1ST DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.15 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.91 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6804
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036804
Sample ID: 1 OF 2 125 ml 224 DIEDRICHST 2ND DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.1 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 10/28/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6805
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036805
Sample ID: 1 LITER 224 DIEDRICHST 3RD DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.9 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/2/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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# Analytical Report

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6806
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036806
Sample ID: 1 LITER 224 DIEDRICHST 4TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.6 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/2/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6807
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036807
Sample ID: 1 LITER 224 DIEDRICHST 5TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.2 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/2/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6808
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036808
Sample ID: 1 LITER 224 DIEDRICHST 6TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.1 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/2/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

11/10/2022 RESULTS - TREATED WATER

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# Analytical Report

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6809
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036809
Sample ID: 1 LITER 224 DIEDRICHST 7TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.1 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/2/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6810
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036810
Sample ID: 1 LITER 224 DIEDRICHST 8TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 1.0 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/2/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6811
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036811
Sample ID: 1 LITER 224 DIEDRICHST 9TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.81 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6812
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036812
Sample ID: 1 LITER 224 DIEDRICHST 10TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.78 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6813
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036813
Sample ID: 1 LITER 224 DIEDRICHST 11TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.82 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6814
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036814
Sample ID: 1 LITER 224 DIEDRICHST 12TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.81 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
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Amanda Kordus

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6815
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036815
Sample ID: 1 LITER 224 DIEDRICHST 13TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.20 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.82 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6816
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036816
Sample ID: 1 LITER 224 DIEDRICHST 14TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.82 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6817
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036817
Sample ID: 1 OF 2 125 ML 152 GARFIELD 1ST DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.20 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.16 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6818
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036818
Sample ID: 1 OF 2 125 ML 152 GARFIELD 2ND DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.15 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6819
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036819
Sample ID: 1 LITER 152 GARFIELD 3RD DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.15 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.38 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

| | |
|---|---|
| Project Number: | 22016126 6820 |
| Report Date: | 11/10/2022 |
| Sampled By: | CLIENT |
| PO#: | 13489 |
| # Samples: | 1 |

| | |
|---|---|
| Sample Number: | 52036820 |
| Sample ID: | 1 LITER 152 GARFIELD 4TH DRAW |
| Sample Date: | 10/20/2022 |
| Date Received: | 10/20/2022 |

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.29 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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**Analytical Report**

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6821
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036821
Sample ID: 1 LITER 152 GARFIELD 5TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.24 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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11/10/2022 RESULTS - TREATED WATER

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# Analytical Report

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6822
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036822
Sample ID: 1 LITER 152 GARFIELD 6TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.22 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6823
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036823
Sample ID: 1 LITER 152 GARFIELD 7TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.21 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6824
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036824
Sample ID: 1 LITER 152 GARFIELD 8TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.21 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

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KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6825
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036825
Sample ID: 1 LITER 152 GARFIELD 9TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.20 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6826
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036826
Sample ID: 1 LITER 152 GARFIELD 10TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.20 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

# Analytical Report

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6827
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036827
Sample ID: 1 LITER 152 GARFIELD 11TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.20 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6828
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036828
Sample ID: 1 LITER 152 GARFIELD 12TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.19 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

**Analytical Report**

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6829
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036829
Sample ID: 1 LITER 152 GARFIELD 13TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.18 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Kordus

BL:gr

11/10/2022 RESULTS - TREATED WATER

BADGER LABS
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
EST. 1966

Analytical Report

501 West Bell Street
Neenah, WI 54956-4868
P: 920.729.1100 | T: 1.800.776.7196
F: 920.729.4945

KAUKAUNA UTILITIES
777 ISLAND STREET
KAUKAUNA, WI 54130

Attn: EUGENE KLISTER

Project Number: 22016126 6830
Report Date: 11/10/2022
Sampled By: CLIENT

PO#: 13489
# Samples: 1

Sample Number: 52036830
Sample ID: 1 LITER 152 GARFIELD 14TH DRAW
Sample Date: 10/20/2022
Date Received: 10/20/2022

| Parameter | Results | Units | LOD | LOQ | Dil. | Method | Analyzed | Codes |
|---|---|---|---|---|---|---|---|---|
| GENERAL ANALYSIS | | | | | | | | |
| TURBIDITY-LAB SCREENING | 0.10 | NTU | 0.10 | 0.10 | 1 | EPA180.1 | 10/26/2022 | |
| METALS | | | | | | | | |
| LEAD, TOTAL | 0.17 | ug/l | 0.02 | 0.07 | 1 | EPA200.8 | 11/8/2022 | |

All LOD/LOQs adjusted for dilution and/or solids content.
LOD = Limit of Detection LOQ = Limit of Quantitation

BADGER LABORATORIES, INC.
WDNR Certified Lab #445023150
Approved By:

Amanda Bordus

BL:gr

22016126

# SAMPLE REQUEST & CHAIN OF CUSTODY FORM

**BADGER LABS**
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

CLIENT NAME / ADDRESS: Kaukauna Utilities

BILLING ADDRESS/ EMAIL: 777 Island St

REPORT TO: Eugene Klister

PO NUMBER:

EMAIL: eklister@ku-wi.org

PHONE: 920-419-3565

FAX:

PROJECT NAME/ SITE:

TURN AROUND TIME
STANDARD 10 DAY: ☐
RUSH (200% UPCHARGE): ☐
DATE NEEDED: ____

MATRIX
DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ____

GROUNDWATER SAMPLES (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

ANALYTICAL REQUESTS: See Att. Sheet

CERTIFICATIONS
NEENAH WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205
GREEN BAY WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450
STEVENS POINT WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | SAMPLE # (LAB USE ONLY) | DATE | TIME | NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | Analytical Requests | | | | | | | | PROJECT # (LAB USE ONLY) | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EP-8 | 38564 | 10-20 | 9:30 | Am | | | | | DW | G | X | | | | | | | | 16126 | | |
| EP-8 | | 10-20 | 9:30 | Am | | | | | DW | G | X | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| Free Chlorine | | | 1.37 | | | | | | | | | | | | | | | | | | |
| Total Chlorine | | | 1.71 | | | | | | | | | | | | | | | | | | |
| Silicate | | | 7.2 | | | | | | | | | | | | | | | | | | |
| Orthophosphate | | | 2.48 | | | | | | | | | | | | | | | | | | |
| Temperature | | | 54° | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |

CHAIN OF CUSTODY RECORD

| FILLED IN BY CLIENT | FILLED IN BY BADGER LABS | ADDITIONAL COMMENTS: |
|---|---|---|
| SAMPLED BY: Eugene Klister | RECEIVED/SAMPLED BY: GR | |
| DATE/TIME SAMPLED: 10-20-22 | DATE/TIME RECEIVED: OCT 20 2022 210PM | |
| RELINQUISHED BY: | LOGGED IN: ms | |
| DELIVERY METHOD: EK Client | ICE?: Y N | |

## SAMPLE REQUEST & CHAIN OF CUSTODY FORM

# BADGER LABS

ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966


Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481


**CLIENT NAME / ADDRESS:** Kaukauna Utilities

**BILLING ADDRESS/ EMAIL:** 777 Island St

**REPORT TO:** Eugene Klister

**PO NUMBER:**

**EMAIL:** eklister@ku-wi.org

**PHONE:** 920-419-3565 **FAX:**

**PROJECT NAME/ SITE:**

**TURN AROUND TIME**

STANDARD 10 DAY: ☐
RUSH (200% UPCHARGE): ☐
DATE NEEDED: ________

**MATRIX**

DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ________

**GROUNDWATER SAMPLES** (CHECK ONE)

Field Filtered ☐
Lab filtered ☐

**ANALYTICAL REQUESTS**

See Att. Sheet

**CERTIFICATIONS**

**NEENAH** WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

**GREEN BAY** WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

**STEVENS POINT** WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | SAMPLE COLLECTION: TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | ANALYTICAL REQUESTS | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EP-9 | 36567 | 10-20 | 10:00AM | | | | | | DW | G | X | 1414 | | |
| EP-9 | | 10-20 | 10:00AM | | | | | | DW | G | X | | | |
| | | | | | | | | | | | | | | |
| Free Chlorine | | | 1.37 | | | | | | | | | | | |
| Total Chlorine | | | 1.80 | | | | | | | | | | | |
| Silicate | | | 6.2 | | | | | | | | | | | |
| Orthophosphate | | | 2.52 | | | | | | | | | | | |
| Temperature | | | 54° | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

**FILLED IN BY CLIENT**

SAMPLED BY: Eugene Klister

DATE/TIME SAMPLED: 10-20-22

RELINQUISHED BY:

DELIVERY METHOD: Client

**FILLED IN BY BADGER LABS**

RECEIVED/SAMPLED BY: GR

DATE/TIME RECEIVED: OCT 20 2022 210 PM

LOGGED IN: BSS

ICE?: Y / N

**ADDITIONAL COMMENTS:**

## SAMPLE REQUEST & CHAIN OF CUSTODY FORM

**BADGER LABS**
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CLIENT NAME / ADDRESS:** Kaukauna Utilities

**BILLING ADDRESS/ EMAIL:** 777 Island St

**REPORT TO:** Eugene Klister

**PO NUMBER:**

**EMAIL:** eklister@ku-wi.org

**PHONE:** 920-419-3565

**FAX:**

**PROJECT NAME/ SITE:**

**TURN AROUND TIME**
STANDARD 10 DAY: ☐
RUSH (200% UPCHARGE): ☐
DATE NEEDED: ______

**MATRIX**
DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ______

**GROUNDWATER SAMPLES** (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

**ANALYTICAL REQUESTS**
See Att. Sheet

**CERTIFICATIONS**

**NEENAH** WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

**GREEN BAY** WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

**STEVENS POINT** WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | ANALYTICAL REQUESTS | | | | | | | | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EP-400 | 36568 | 10-20 | 10:30AM | | | | | | DW | G | X | | | | | | | | 16124 | | |
| EP-400 | | 10-20 | 10:30AM | | | | | | DW | G | X | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| Free Chlorine | | | 1.45 | | | | | | | | | | | | | | | | | | |
| Total Chlorine | | | 1.83 | | | | | | | | | | | | | | | | | | |
| Silicate | | | 6.6 | | | | | | | | | | | | | | | | | | |
| Orthophosphate | | | 2.53 | | | | | | | | | | | | | | | | | | |
| Temperature | | | 54° | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

| FILLED IN BY CLIENT | FILLED IN BY BADGER LABS | ADDITIONAL COMMENTS: |
|---|---|---|
| SAMPLED BY: Eugene Klister | RECEIVED/SAMPLED BY: EGR | |
| DATE/TIME SAMPLED: 10-20-22 | DATE/TIME RECEIVED: OCT 20 2022 210 PM | |
| RELINQUISHED BY: | LOGGED IN: MS | |
| DELIVERY METHOD: Client | ICE?: Y N | |

## SAMPLE REQUEST & CHAIN OF CUSTODY FORM

# BADGER LABS

ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

| CLIENT NAME / ADDRESS | TURN AROUND TIME |
|---|---|
| Kaukauna Utilities | STANDARD 10 DAY: ☐ |
| BILLING ADDRESS/ EMAIL: 777 Island St | RUSH (100% UPCHARGE): ☐ |
| | DATE NEEDED: |
| REPORT TO: Eugene Klister — PO NUMBER: | MATRIX |
| EMAIL: eKlister@ku-wi.org | DW = DRINKING WATER; WW = WASTEWATER; GW = GROUNDWATER; CW = COOLING WATER; S = SOLID/SLUDGE; P = PAPER; F = FUEL; OTHER: |
| PHONE: 920-419-3565 — FAX: | |
| PROJECT NAME/ SITE: | |

GROUNDWATER SAMPLES (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

ANALYTICAL REQUESTS: See Att. Sheet

## CERTIFICATIONS

**NEENAH** WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

**GREEN BAY** WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

**STEVENS POINT** WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | | | | | | | | | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 777 Island St | | 10-20 | 11:00AM | | | | | | DW | G | X | | | | | | | | 16126 | | |
| 777 Island St | | 10-20 | 11:00AM | | | | | | DW | G | X | | | | | | | | | | |
| | 36568 | | | | | | | | | | | | | | | | | | | | |
| Free Chlorine | | | .96 | | | | | | | | | | | | | | | | | | |
| Total Chlorine | | | 1.26 | | | | | | | | | | | | | | | | | | |
| Silicate | | | 7.2 | | | | | | | | | | | | | | | | | | |
| Orthophosphate | | | 2.75 | | | | | | | | | | | | | | | | | | |
| Temperature | | | 58° | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |

### CHAIN OF CUSTODY RECORD

| FILLED IN BY CLIENT | FILLED IN BY BADGER LABS | ADDITIONAL COMMENTS: |
|---|---|---|
| SAMPLED BY: Eugene Klister | RECEIVED/SAMPLED BY: GR | |
| DATE/TIME SAMPLED: 10-20-22 | DATE/TIME RECEIVED: OCT 20 2022 2:10PM | |
| RELINQUISHED BY: | LOGGED IN: MS | |
| DELIVERY METHOD: Client | ICE?: Y / N | |

## SAMPLE REQUEST & CHAIN OF CUSTODY FORM

# BADGER LABS

ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CERTIFICATIONS**

**NEENAH** WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

**GREEN BAY** WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

**STEVENS POINT** WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

CLIENT NAME / ADDRESS: Kaukauna Utilities

BILLING ADDRESS/ EMAIL: 777 Island St

REPORT TO: Eugene Klister
PO NUMBER:

EMAIL: eklister@ku-wi.org

PHONE: 920-419-3565
FAX:

PROJECT NAME/ SITE:

**TURN AROUND TIME**
STANDARD 10 DAY: ☐
RUSH (200% UPCHARGE): ☐
DATE NEEDED: ______

**MATRIX**
DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ______

**GROUNDWATER SAMPLES** (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

**ANALYTICAL REQUESTS**: See Att. Sheet

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | SAMPLE COLLECTION: TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | | | | | | | | | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2700 Northridge Dr | | 10-20 | 11:30 AM | | | | | | DW | G | X | | | | | | | | 16626 | | |
| 2700 Northridge Dr | | 10-20 | 11:30 AM | | | | | | DW | G | X | | | | | | | | | | |
| | 36570 | | | | | | | | | | | | | | | | | | | | |
| Free Chlorine | | | .98 | | | | | | | | | | | | | | | | | | |
| Total Chlorine | | | 1.25 | | | | | | | | | | | | | | | | | | |
| Silicate | | | 6.3 | | | | | | | | | | | | | | | | | | |
| Orthophosphate | | | 2.75 | | | | | | | | | | | | | | | | | | |
| Temperature | | | 61° | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

| FILLED IN BY CLIENT | FILLED IN BY BADGER LABS | ADDITIONAL COMMENTS: |
|---|---|---|
| SAMPLED BY: Eugene Klister | RECEIVED/SAMPLED BY: GR | |
| DATE/TIME SAMPLED: 10-20-22 | DATE/TIME RECEIVED: OCT 20 2022 210 PM | |
| RELINQUISHED BY: | LOGGED IN: P | |
| DELIVERY METHOD: Client | ICE?: Y / N | |

# SAMPLE REQUEST & CHAIN OF CUSTODY FORM

**BADGER LABS**
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

| | |
|---|---|
| CLIENT NAME / ADDRESS: Kaukauna Utilities | TURN AROUND TIME: STANDARD 10 DAY: ☐ RUSH (100% UPCHARGE): ☐ DATE NEEDED: ______ |
| BILLING ADDRESS/ EMAIL: 777 Island St | |
| REPORT TO: Eugene Klister / PO NUMBER: | MATRIX: DW = DRINKING WATER, WW = WASTEWATER, GW = GROUNDWATER, CW = COOLING WATER, S = SOLID/SLUDGE, P = PAPER, F = FUEL, OTHER: ______ |
| EMAIL: eklister@ku-wi.org | |
| PHONE: 920-419-3565 FAX: | |
| PROJECT NAME/ SITE: | |

GROUNDWATER SAMPLES (CHECK ONE): Field Filtered ☐ Lab filtered ☐

ANALYTICAL REQUESTS: See Att. Sheet

CERTIFICATIONS

NEENAH WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

GREEN BAY WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

STEVENS POINT WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | | | | | | | | | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 406 W | 10th St | 10-20 | 12:30 | PM | | | | | DW | G | X | | | | | | | | 16174 | | |
| 406 W | 10th St | 10-20 | 12:30 | PM | | | | | DW | G | X | | | | | | | | | | |
| | 36571 | | | | | | | | | | | | | | | | | | | | |
| Free Chlorine | | | .98 | | | | | | | | | | | | | | | | | | |
| Total Chlorine | | | 1.30 | | | | | | | | | | | | | | | | | | |
| Silicate | | | 6.8 | | | | | | | | | | | | | | | | | | |
| Orthophosphate | | | 2.60 | | | | | | | | | | | | | | | | | | |
| Temperature | | | 58° | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |

CHAIN OF CUSTODY RECORD

| FILLED IN BY CLIENT | FILLED IN BY BADGER LABS | ADDITIONAL COMMENTS: |
|---|---|---|
| SAMPLED BY: Eugene Klister | RECEIVED/SAMPLED BY: GR | |
| DATE/TIME SAMPLED: 10-20-22 | DATE/TIME RECEIVED: OCT 20 ... 210 PM | |
| RELINQUISHED BY: | LOGGED IN: MSS | |
| DELIVERY METHOD: Client | ICE?: Y / N | |

# SAMPLE REQUEST & CHAIN OF CUSTODY FORM

# BADGER LABS

ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CLIENT NAME / ADDRESS:** Kaukauna Utilities

**BILLING ADDRESS/ EMAIL:** 777 Island St

**REPORT TO:** Eugene Klister

**PO NUMBER:**

**EMAIL:** eklister@ku-wi.org

**PHONE:** 920-419-3565

**FAX:**

**PROJECT NAME/ SITE:**

**TURN AROUND TIME**

STANDARD 10 DAY: ☐

RUSH (100% UPCHARGE): ☐

DATE NEEDED: ____

**MATRIX**

DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ____

**GROUNDWATER SAMPLES** (CHECK ONE)

Field Filtered ☐

Lab filtered ☐

**ANALYTICAL REQUESTS**

See Att. Sheet

**CERTIFICATIONS**

**NEENAH** WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

**GREEN BAY** WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

**STEVENS POINT** WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | | | | | | | | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1701 Cty | Hy CE | 10-20 | 1:00PM | | | | | | DW | G | X | | | | | | | 16116 | | |
| 1701 Cty | Hy CE | 10-20 | 1:00PM | | | | | | DW | G | X | | | | | | | | | |
| | 36572 | | | | | | | | | | | | | | | | | | | |
| Free Chlorine | | | 1.05 | | | | | | | | | | | | | | | | | |
| Total Chlorine | | | 1.33 | | | | | | | | | | | | | | | | | |
| Silicate | | | 6.9 | | | | | | | | | | | | | | | | | |
| Orthophosphate | | | 2.75 | | | | | | | | | | | | | | | | | |
| Temperature | | | 59° | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

| FILLED IN BY CLIENT | FILLED IN BY BADGER LABS | ADDITIONAL COMMENTS: |
|---|---|---|
| SAMPLED BY: Eugene Klister | RECEIVED/SAMPLED BY: GR | |
| DATE/TIME SAMPLED: 10-20-22 | DATE/TIME RECEIVED: OCT 20 [illegible] 210PM | |
| RELINQUISHED BY: | LOGGED IN: pSD | |
| DELIVERY METHOD: Client | ICE? Y / N | |

# SAMPLE REQUEST & CHAIN OF CUSTODY FORM

**BADGER LABS**
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CLIENT NAME / ADDRESS**
Kaukauna Utilities

**BILLING ADDRESS/ EMAIL**
777 Island St

**REPORT TO:** Eugene Klister
**PO NUMBER:**
**EMAIL:** eKlister@KU-wi.org
**PHONE:** 920-419-3565
**FAX:**
**PROJECT NAME/ SITE:**

**TURN AROUND TIME**
STANDARD 10 DAY: ☐
RUSH (200% UPCHARGE): ☐
DATE NEEDED: ____

**MATRIX**
DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ____

**GROUNDWATER SAMPLES** (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

**ANALYTICAL REQUESTS**

**CERTIFICATIONS**

**NEENAH** WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

**GREEN BAY** WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

**STEVENS POINT** WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | Lead | | | | | | | | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 224 Brothers | 11+h | 10-20-22 | | 36887 | | | | | DW | G | X | | | | | | | | 16124 | | |
| | | | | | | | | | | | | | | | | | | | | | |
| | 12+h | | | 36888 | | | | | | | | | | | | | | | | | |
| | Small Bottle #1 | 36775 | | | | | | | | | | | | | | | | | | | |
| | #2 | 36776 | | | | | | | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

**FILLED IN BY CLIENT**
**SAMPLED BY:** Eugene Klister
**DATE/TIME SAMPLED:** 10-20-22 7:00AM
**RELINQUISHED BY:**
**DELIVERY METHOD:** Client

**FILLED IN BY BADGER LABS**
**RECEIVED/SAMPLED BY:** GR
**DATE/TIME RECEIVED:** 210PM
**LOGGED IN:** [illegible]
**ICE?:** (Y) / N

**ADDITIONAL COMMENTS:**

**SAMPLE REQUEST & CHAIN OF CUSTODY FORM**

# BADGER LABS

ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CERTIFICATIONS**

NEENAH WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

GREEN BAY WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

STEVENS POINT WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

CLIENT NAME / ADDRESS: Kaukauna Utilities

BILLING ADDRESS/ EMAIL: 777 Island St

REPORT TO: Eugene Klister

PO NUMBER:

EMAIL: eklister@ku-wi.org

PHONE: 920-419-3565 FAX:

PROJECT NAME/ SITE:

**TURN AROUND TIME**

STANDARD 10 DAY: ☐

RUSH (200% UPCHARGE): ☐

DATE NEEDED: ______

**MATRIX**

DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ______

**GROUNDWATER SAMPLES** (CHECK ONE)

Field Filtered ☐

Lab filtered ☐

**ANALYTICAL REQUESTS**

| SAMPLE ID | SAMPLE # (LAB USE ONLY) | DATE (SAMPLE COLLECTION) | TIME (SAMPLE COLLECTION) | NP (PRESERVATIVE) | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | Lead | | | | | | | | PROJECT # (LAB USE ONLY) | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 224 Brothers St | 1st Draw | 10-20-22 | | | | 36777 | | | DW | G | X | | | | | | | | 16126 | | |
| | 2nd | | | | | 78 | | | | | | | | | | | | | | | |
| | 3rd | | | | | 79 | | | | | | | | | | | | | | | |
| | 4th | | | | | 80 | | | | | | | | | | | | | | | |
| | 5th | | | | | 81 | | | | | | | | | | | | | | | |
| | 6th | | | | | 82 | | | | | | | | | | | | | | | |
| | 7th | | | | | 83 | | | | | | | | | | | | | | | |
| | 8th | | | | | 84 | | | | | | | | | | | | | | | |
| | 9th | | | | | 85 | | | | | | | | | | | | | | | |
| | 10th | | | | | 86 | | | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

**FILLED IN BY CLIENT**

SAMPLED BY: Eugene Klister

DATE/TIME SAMPLED: 10-20-22 7:00AM

RELINQUISHED BY:

DELIVERY METHOD: Client

**FILLED IN BY BADGER LABS**

RECEIVED/SAMPLED BY: GR

DATE/TIME RECEIVED: OCT 20 2022 210PM

LOGGED IN:

ICE?: Y / N

**ADDITIONAL COMMENTS:**

# SAMPLE REQUEST & CHAIN OF CUSTODY FORM

**BADGER LABS**
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CERTIFICATIONS**

**NEENAH** WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

**GREEN BAY** WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

**STEVENS POINT** WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

**CLIENT NAME / ADDRESS:** Kaukauna Utilities

**BILLING ADDRESS/ EMAIL:** 777 Island St

**REPORT TO:** Eugene Klister

**PO NUMBER:**

**EMAIL:** eklister@ku-wi.org

**PHONE:** 920-419-3565

**FAX:**

**PROJECT NAME/ SITE:**

**TURN AROUND TIME**

STANDARD 10 DAY: ☐

RUSH (200% UPCHARGE): ☐

DATE NEEDED: ____

**MATRIX**

DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ____

**GROUNDWATER SAMPLES** (CHECK ONE)

Field Filtered ☐

Lab filtered ☐

**ANALYTICAL REQUESTS**

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | Lead | | | | | | | | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 321 W 12th St | 11th | 10-20-22 | | 36801 | | | | | DW | G | X | | | | | | | | | | |
| \| | 12th | \| | | 36802 | | | | | \| | \| | \| | | | | | | | | | | |
| \| | Small Bottle #1 | \| | 36789 | | | | | | \| | \| | \| | | | | | | | | | | |
| \| | #2 | \| | 36790 | | | | | | \| | \| | \| | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
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**CHAIN OF CUSTODY RECORD**

**FILLED IN BY CLIENT**

**SAMPLED BY:** Eugene Klister

**DATE/TIME SAMPLED:** 10-20-22 6:30AM

**RELINQUISHED BY:**

**DELIVERY METHOD:** Client

**FILLED IN BY BADGER LABS**

**RECEIVED/SAMPLED BY:** GR

**DATE/TIME RECEIVED:** OCT 20 2022 2:10PM

**LOGGED IN:**

**ICE?:** Y / N

**ADDITIONAL COMMENTS:**

## SAMPLE REQUEST & CHAIN OF CUSTODY FORM

**BADGER LABS**
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CERTIFICATIONS**

NEENAH WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

GREEN BAY WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

STEVENS POINT WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

CLIENT NAME / ADDRESS: Kaukauna Utilities

BILLING ADDRESS/ EMAIL: 777 Island St

REPORT TO: Eugene Klister

PO NUMBER:

EMAIL: eklister@ku-wi.org

PHONE: 920-419-3565

FAX:

PROJECT NAME/ SITE:

TURN AROUND TIME
STANDARD 10 DAY: ☐
RUSH (200% UPCHARGE): ☐
DATE NEEDED: ____

MATRIX
DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ____

GROUNDWATER SAMPLES (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

ANALYTICAL REQUESTS

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | lead | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 321 W 12th St | 1st Draw | 10-20-22 | | | | 36791 | | | DW | G | X | 16124 | | |
| | 2nd | | | | | 92 | | | | | | | | |
| | 3rd | | | | | 93 | | | | | | | | |
| | 4th | | | | | 94 | | | | | | | | |
| | 5th | | | | | 95 | | | | | | | | |
| | 6th | | | | | 96 | | | | | | | | |
| | 7th | | | | | 97 | | | | | | | | |
| | 8th | | | | | 98 | | | | | | | | |
| | 9th | | | | | 99 | | | | | | | | |
| | 10th | | | | | 36800 | | | | | | | | |

CHAIN OF CUSTODY RECORD

FILLED IN BY CLIENT
SAMPLED BY: Eugene Klister
DATE/TIME SAMPLED: 10-20-22 6:30 AM
RELINQUISHED BY:
DELIVERY METHOD: client

FILLED IN BY BADGER LABS
RECEIVED/SAMPLED BY: GR
DATE/TIME RECEIVED: 210PM
LOGGED IN: lo
ICE?: Y N

ADDITIONAL COMMENTS:

## SAMPLE REQUEST & CHAIN OF CUSTODY FORM

# BADGER LABS

ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CLIENT NAME / ADDRESS:** Kaukauna Utilities

**BILLING ADDRESS/ EMAIL:** 777 Island St

**REPORT TO:** Eugene Klister

**PO NUMBER:**

**EMAIL:** eklister@ku-wi.org

**PHONE:** 920-419-3565 **FAX:**

**PROJECT NAME/ SITE:**

**TURN AROUND TIME**
STANDARD 10 DAY: ☐
RUSH (100% UPCHARGE): ☐
DATE NEEDED: ________

**MATRIX**
DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ________

**GROUNDWATER SAMPLES** (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

**ANALYTICAL REQUESTS**

**CERTIFICATIONS**

NEENAH WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

GREEN BAY WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

STEVENS POINT WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | LAB USE ONLY: SAMPLE # | SAMPLE COLLECTION: DATE | TIME | PRESERVATIVE: NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | Lead | LAB USE ONLY: PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 224 Diedrich St | 11+h | 10-20-22 | | | 36805 | | | | DW | G | X | 16114 | | |
| | 12+h | \| | | | 36816 | | | | \| | \| | \| | | | |
| | Small Bottle #1 | \| | 36803 | | | | | | \| | \| | \| | | | |
| | #2 | \| | 36804 | | | | | | \| | \| | \| | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

**FILLED IN BY CLIENT**
SAMPLED BY: Homeowner
DATE/TIME SAMPLED: 10-20-22 5:00AM
RELINQUISHED BY:
DELIVERY METHOD: Client ~~EX~~

**FILLED IN BY BADGER LABS**
RECEIVED/SAMPLED BY: GR
DATE/TIME RECEIVED: [illegible] 20 [illegible] 210 PM
LOGGED IN: [illegible]
ICE?: Y / N

**ADDITIONAL COMMENTS:**

## SAMPLE REQUEST & CHAIN OF CUSTODY FORM

**BADGER LABS**
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES est. 1966
Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CLIENT NAME / ADDRESS:** Kaukauna Utilities
**BILLING ADDRESS/ EMAIL:** 777 Island St
**REPORT TO:** Eugene Klister
**PO NUMBER:**
**EMAIL:** eklister@ku-wi.org
**PHONE:** 920-419-3565
**FAX:**
**PROJECT NAME/ SITE:**

**TURN AROUND TIME**
STANDARD 10 DAY: ☐
RUSH (100% UPCHARGE): ☐
DATE NEEDED: ______

**MATRIX**
DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ______

**GROUNDWATER SAMPLES** (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

**ANALYTICAL REQUESTS:** Lead

**CERTIFICATIONS**
NEENAH WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205
GREEN BAY WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450
STEVENS POINT WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | SAMPLE # (LAB USE ONLY) | DATE | TIME | NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | Lead | | | | | | | PROJECT # (LAB USE ONLY) | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 224 Diedrich St | 1st Draw | 10-20-22 | | | 368005 | | | | DW | G | X | | | | | | | 16124 | | |
| | 2nd | | | | | | 6 | | | | | | | | | | | | | |
| | 3rd | | | | | | 7 | | | | | | | | | | | | | |
| | 4th | | | | | | 8 | | | | | | | | | | | | | |
| | 5th | | | | | | 9 | | | | | | | | | | | | | |
| | 6th | | | | | | 10 | | | | | | | | | | | | | |
| | 7th | | | | | | 11 | | | | | | | | | | | | | |
| | 8th | | | | | | 12 | | | | | | | | | | | | | |
| | 9th | | | | | | 13 | | | | | | | | | | | | | |
| | 10th | | | | | | 14 | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

**FILLED IN BY CLIENT**
SAMPLED BY: Homeowner
DATE/TIME SAMPLED: 10-20-22 5:00 AM
RELINQUISHED BY:
DELIVERY METHOD: Client

**FILLED IN BY BADGER LABS**
RECEIVED/SAMPLED BY: GR
DATE/TIME RECEIVED: [illegible] 2:10 PM
LOGGED IN: BCS
ICE?: Y / N

ADDITIONAL COMMENTS:

## SAMPLE REQUEST & CHAIN OF CUSTODY FORM

# BADGER LABS

ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CERTIFICATIONS**

**NEENAH** WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205

**GREEN BAY** WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450

**STEVENS POINT** WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

**CLIENT NAME / ADDRESS:** Kaukauna Utilities

**BILLING ADDRESS/ EMAIL:** 777 Island St

**REPORT TO:** Eugene Klister

**PO NUMBER:**

**EMAIL:** eklister@ku-wi.org

**PHONE:** 920-419-3565

**FAX:**

**PROJECT NAME/ SITE:**

**TURN AROUND TIME**

STANDARD 10 DAY: ☐
RUSH (200% UPCHARGE): ☐
DATE NEEDED: ______

**MATRIX**

DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ______

**GROUNDWATER SAMPLES** (CHECK ONE)

Field Filtered ☐
Lab filtered ☐

**ANALYTICAL REQUESTS**

| SAMPLE ID | SAMPLE # (LAB USE ONLY) | DATE (SAMPLE COLLECTION) | TIME (SAMPLE COLLECTION) | NP (PRESERVATIVE) | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | Lead | | | | | | | | PROJECT # (LAB USE ONLY) | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 152 Garfield | 11+h | 10-20-22 | | | 36829 | | | | DW | G | X | | | | | | | | 16626 | | |
| | 12+h | | | | 36830 | | | | | | | | | | | | | | | | |
| | Small Bottle #1 | | 36817 | | | | | | | | | | | | | | | | | | |
| | #2 | | 36818 | | | | | | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

**FILLED IN BY CLIENT**

**SAMPLED BY:** Eugene Klister

**DATE/TIME SAMPLED:** 10-20-22 7:30AM

**RELINQUISHED BY:**

**DELIVERY METHOD:** Client

**FILLED IN BY BADGER LABS**

**RECEIVED/SAMPLED BY:** GR

**DATE/TIME RECEIVED:** OCT 20 2022 210PM

**LOGGED IN:** M

**ICE?:** Y / N

**ADDITIONAL COMMENTS:**

## SAMPLE REQUEST & CHAIN OF CUSTODY FORM

**BADGER LABS**
ANALYTICAL LABORATORY & ENVIRONMENTAL SERVICES
est. 1966

Neenah: 501 W. Bell St. Neenah, WI 54956
Green Bay: 2150 Memorial Drive Suite 106 Green Bay, WI 54303
Stevens Point: 3426 E. Maria Drive Stevens Point, WI 54481

**CLIENT NAME / ADDRESS:** Kaukauna Utilities

**BILLING ADDRESS/ EMAIL:** 777 Island St

**REPORT TO:** Eugene Klister

**PO NUMBER:**

**EMAIL:** eklister@ku-wi.org

**PHONE:** 920-419-3565 **FAX:**

**PROJECT NAME/ SITE:**

**TURN AROUND TIME**
STANDARD 10 DAY: ☐
RUSH (200% UPCHARGE): ☐
DATE NEEDED: ____

**MATRIX**
DW = DRINKING WATER
WW = WASTEWATER
GW = GROUNDWATER
CW = COOLING WATER
S = SOLID/SLUDGE
P = PAPER
F = FUEL
OTHER: ____

**GROUNDWATER SAMPLES** (CHECK ONE)
Field Filtered ☐
Lab filtered ☐

**CERTIFICATIONS**
**NEENAH** WISCONSIN
HQ-WDNR Cert. Lab #445023150
HQ-DATCP Cert. #105-205
**GREEN BAY** WISCONSIN
GB-WDNR Cert. Lab #405222620
GB-DATCP Cert. #105-450
**STEVENS POINT** WISCONSIN
SP-WDNR Cert Lab #750124210
SP-DATCP Cert #105-525

| SAMPLE ID | SAMPLE # (LAB USE ONLY) | DATE | TIME | NP | H2SO4 | HNO3 | HCL | NAOH | MATRIX (SEE ABOVE) | GRAB or COMPOSITE | ANALYTICAL REQUESTS: Lead | | | | | | | | PROJECT # | pH OK | DATE REC'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 152 Garfield | 1st Draw | 10-20-22 | | | | 36819 | | | DW | G | X | | | | | | | | 16174 | | |
| | 2nd | | | | | 20 | | | | | | | | | | | | | | | |
| | 3rd | | | | | 21 | | | | | | | | | | | | | | | |
| | 4th | | | | | 22 | | | | | | | | | | | | | | | |
| | 5th | | | | | 23 | | | | | | | | | | | | | | | |
| | 6th | | | | | 24 | | | | | | | | | | | | | | | |
| | 7th | | | | | 25 | | | | | | | | | | | | | | | |
| | 8th | | | | | 26 | | | | | | | | | | | | | | | |
| | 9th | | | | | 27 | | | | | | | | | | | | | | | |
| | 10th | | | | | 28 | | | | | | | | | | | | | | | |

**CHAIN OF CUSTODY RECORD**

**FILLED IN BY CLIENT**
SAMPLED BY: Eugene Klister
DATE/TIME SAMPLED: 10-20-22 7:30 AM
RELINQUISHED BY:
DELIVERY METHOD: Client

**FILLED IN BY BADGER LABS**
RECEIVED/SAMPLED BY: GR
DATE/TIME RECEIVED: OCT 20 2022 210PM
LOGGED IN: B
ICE?: Y / N

**ADDITIONAL COMMENTS:**

# APPENDIX F

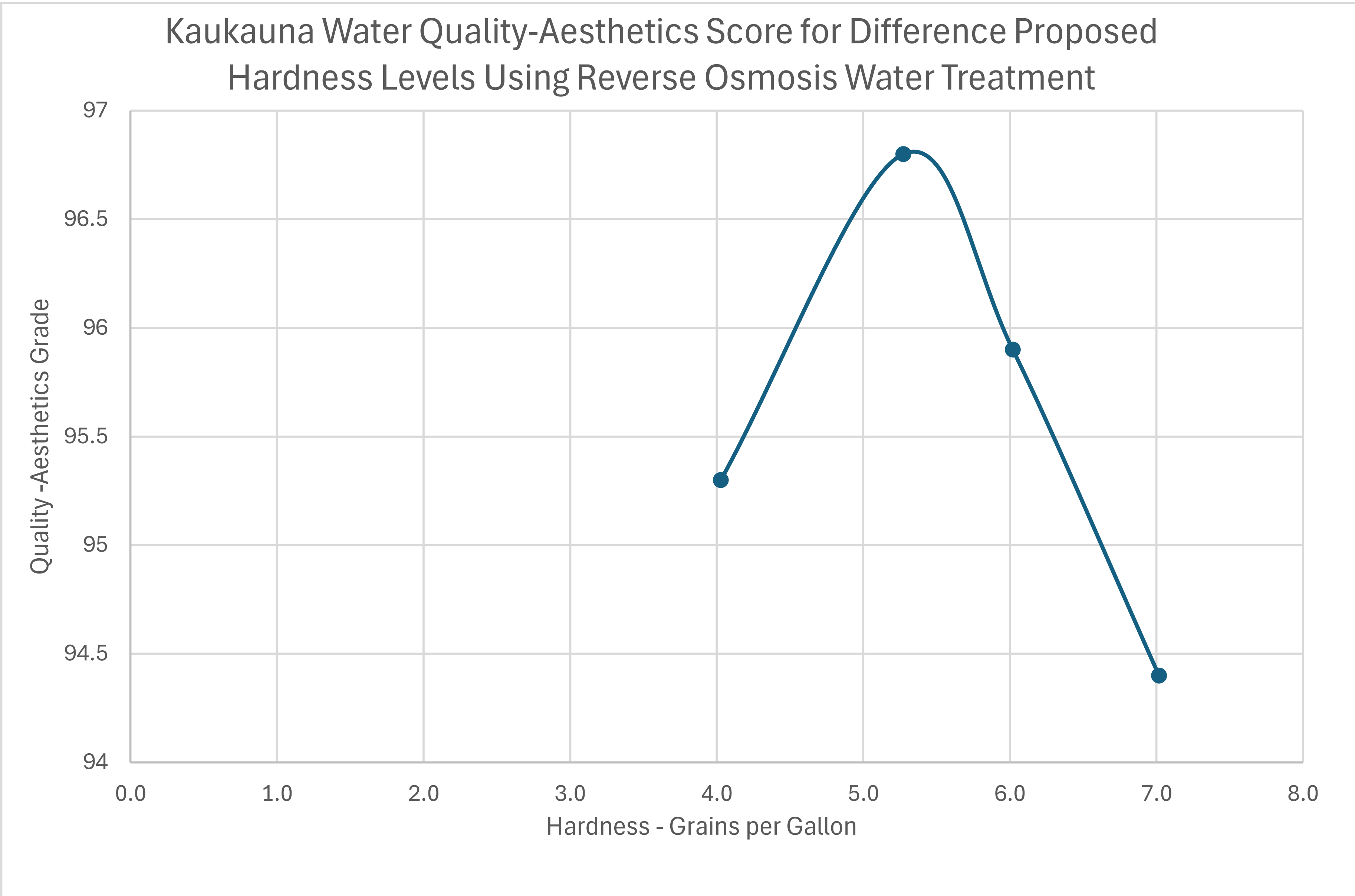
# Water Hardness Supplemental Information

# G.1 UW MADISON WATER QUALITY BETA PROGRAM

Kaukauna Utility Water Aestics Score
2/5/2024

| Item | Secondary MCL mg/L | Weight | Existing Water | Percent MCL | Individual Score | Weighted Score | | |
|---|---|---|---|---|---|---|---|---|
| Iron | 0.3 | 25.0% | 0 | 0% | 100 | 25 | | |
| Hardness | NA | 25.0% | 710 | | 0 | 0 | | |
| manganese | 0.05 | 25.0% | 0.031 | 62% | 85 | 21.25 | | |
| Alkalinity | NA | 6.0% | 150 | | 85 | 5.1 | | |
| Chloride | 250 | 6.0% | 16 | 6% | 99 | 5.94 | | |
| Sulfate | 250 | 6.0% | 531 | 212% | 0 | 0 | | |
| Aluminum | 0.2 | 3.5% | 0 | 0% | 100 | 3.5 | | |
| Fluoride | 2 | 3.5% | 1.7 | 85% | 80 | 2.8 | | |
| | | 100.0% | | | Total Score | **63.6** | Kaukana | D- |

Score calculated based on formulas from
UW Madison - Water System Excellence Project Beta Report v1.0 dated September 14, 2023




Information is based on UW - Wisconsin: Water System Excellence Project - Wisconsin Water Utility Report Cards Beta Report V1.0

# Water System Excellence Project

***Wisconsin Water Utility Report Cards for 2020***

**Beta Report v1.0**

14 September 2023

Manuel P. Teodoro
Robert Abrahamian

Robert M. La Follette
School of Public Affairs
UNIVERSITY OF WISCONSIN–MADISON

# Executive Summary

The Water System Excellence Project (WSEP) publishes report cards for drinking water utilities in Wisconsin. These report cards provide clear, accessible information to the public about water quality, infrastructure integrity, operational efficiency, financial strength, and communications. Through clear and intuitive public reporting, the WSEP seeks to make the performance and conditions of these critical but often invisible systems more visible to the people of Wisconsin.

**The challenge.** Although drinking water is essential, most citizens know little about the systems that provide it. A central challenge for the elected officials who govern and professionals who manage drinking water is that water utilities' prices are much more visible than their quality. In economic terms, drinking water quality is a case of *information asymmetry*: utility managers understand the chemical, environmental, capital, and financial properties of water utilities, but the general public does not. By contrast, the price of water service is immediately and perfectly observable: when bills arrive, utility customers learn exactly what that water service costs. Since citizens only vaguely observe their water utilities' quality, they cannot properly evaluate the tradeoff between water's quality and its price.

These information asymmetries create parallel challenges for utility managers and policymakers. Operating natural monopolies and facing political pressure to keep prices low, managers and policymakers have little means of demonstrating the value and performance of their water systems. There are few ways to distinguish a great water utility from one that merely avoids disasters and meets minimum regulatory requirements.

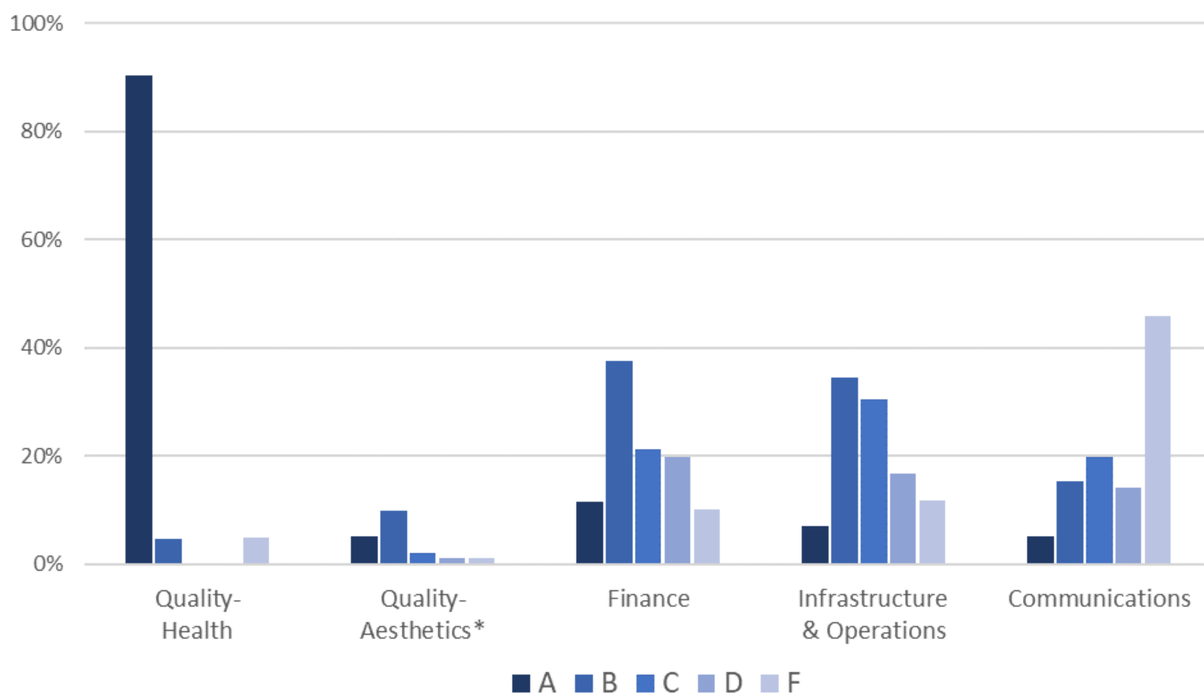
**A solution: report cards.** This initial WSEP study offers a set report cards for all 506 water utilities regulated by the Wisconsin Public Service Commission for the year 2020, using a mix of publicly available and original data. By communicating performance comprehensively, but also clearly and simply, these report cards are meant to recognize strong performance, facilitate accountability, and provide feedback to policymakers and the public. Just as in a school, report cards include grades for multiple subjects—*Water Quality-Health, Water Quality-Aesthetics, Finance, Infrastructure & Operations,* and *Communications*—with each grade based on multiple performance indicators. The initial set of grades in this report is the first of its kind and serves as proof of concept and as a baseline for future development. This Beta 1.0 version of the report is aimed at Wisconsin's drinking water sector leaders to familiarize themselves with WSEP's goals and methodology.

*Empirical evidence of excellence* is the central principle behind WSEP grading. Grades are based on *observable*, *measurable outcomes*, not on formal policies or procedures. WSEP grading standards also recognize potentially wide variation in performance. In so doing, WSEP grades distinguish failing systems from mediocre systems, and good systems from truly great systems. In crafting these report cards, the WSEP consulted with experts in each graded area. Expert panelists include retired utility managers, consultants, research scientists, and university professors. Their disciplinary backgrounds include engineering, chemistry, economics, finance, communications, and public management.

**First results.** The initial 2020 grades that emerge from this study are at once reassuring and concerning. Figure E1 summarizes WSEP grades across all five subjects. Excellent overall performance on *Quality-Health* demonstrates that the vast majority of Wisconsin's water utilities fulfill their fundamental mission of providing safe, healthy drinking water. More than 91 percent of the state's water utilities earned A grades according to WSEP's demanding rubric. Collectively, Wisconsin's water utilities perform far better than what is required of them by law.

On the other hand, statewide results for *Finance* and *Infrastructure & Operations* raise concerns for sustainability. Most utilities earned solid grades for *Finance* though a significant minority of utilities produced poor marks. Overall *Infrastructure & Operations* grades were troubling: more than 40% of the state's utilities earned strong grades on the subject, but a majority received mediocre or poor marks. Weak financial, capital, and/or operational performance are likely to erode water quality and public confidence in the long run. *Communications* grades were mostly poor: nearly half of Wisconsin's utilities failed, and barely five percent earned A grades. Overall aesthetic quality is difficult to gauge, owing to the large number utilities with incomplete data.

**Figure E1. 2020 Water System Excellence Project grade distribution by subject**




**Excludes 81% of utilities that received "Incomplete" for* Quality-Aesthetics.

As any student knows, earning good grades in a demanding discipline is not easy. Taken together, these results indicate that our state's water utility leaders maintain sound water quality, often under difficult financial, capital, and operating conditions. Improvements in these aspects of water systems will ensure that Wisconsinites enjoy excellent tap water service well into the future. Sustainable excellence is possible for every Wisconsin water system; we hope that this initial WSEP report moves us forward toward that goal.

# Contents

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# Introduction

The Water System Excellence Project (WSEP) publishes report cards for drinking water utilities in Wisconsin. These report cards will provide clear and accessible information to the public about water quality, infrastructure integrity, operational efficiency, financial strength, and communications. Through clear and intuitive public reporting, the WSEP seeks to make the performance and conditions of these critical but often invisible systems more visible to the people of Wisconsin.

## The challenge

Safe and reliable drinking water service is essential for health and prosperity. As in most of the United States, drinking water utility service in Wisconsin is also principally a local government function. More than 4 million Wisconsin residents receive their drinking water from a utility, and nearly 98% are owned and operated by local government.

Although drinking water is ubiquitous and essential, most citizens know little about these critical systems. Drinking water systems are buried – literally and figuratively. A central challenge, then, for the elected officials who govern and professionals who manage and regulate water is that *water utilities' prices are much more visible than their quality*.

In economic terms, drinking water quality is a case of information asymmetry: utility managers understand the chemical, environmental, capital, operational, and financial properties of water utilities that determine their safety and sustainability, but the general public does not. Water mains that are strong and well-maintained or crumbling and leaky look the same to customers. Water that barely meets regulatory requirements is in many ways indistinguishable from pristine tap water from the customer's perspective. Unless water systems fail egregiously, ordinary citizens have little way to know how well or poorly their utilities perform.

To reduce the gap between public and professional knowledge, the Safe Drinking Water Act (SDWA) requires water systems to notify the public of water quality violations and to publish annual Consumer Confidence Reports (CCRs). These CCRs indicate levels of various federally regulated contaminants in tap water – but not dozens of other compounds that also affect a ratepayers' experience with the water, especially taste and odor. Unfortunately, CCRs are often poorly designed and difficult to comprehend; empirical studies demonstrate that they do not communicate effectively or improve consumer confidence.[1] Moreover, CCRs do not provide customers with information about utility performance beyond water quality, such as infrastructure integrity, financial strength, aesthetics, operations, or communications. In short, water utility quality is very difficult for most people to observe with any accuracy.

By contrast, the price of water service is immediately and perfectly observable: when bills arrive, utility customers—who are also voters—learn exactly what that water service costs them. And naturally, customers prefer lower prices, which means managers and local elected

[1] Johnson (2003); Nicholas and Vedachalam (2021); Roy et al. (2015).

officials who set service rates face consistent pressure to keep prices low with relatively little attendant attention to quality or sustainability.[2]

Combined, the opacity of water utilities' performance and clarity of their prices carry pernicious consequences for water systems. Since citizens only vaguely observe their water utilities' quality, they cannot properly evaluate the tradeoff between water's quality and its price. Consequently, citizens cannot adequately reward elected officials who improve water utilities, but they can (and sometimes do) punish politicians at the ballot box for rate increases. Local governments tend to underinvest in their water systems until regulatory violations or catastrophic failures occur.

Similarly, since it is hard for water system managers to demonstrate the value of their work in terms of anything but monthly bills and regulatory compliance, they have little professional incentive to innovate or improve their systems. There are few ways to distinguish a great water utility from one that is merely meeting the minimum regulatory requirements. Rather than pursuing greater quality, resilience, or sustainability, utility managers tend to manage to regulatory standards because they are politically defensible.[3] Operating natural monopolies and facing political pressure to keep prices low, utility managers have few ways to demonstrate the value of the services they provide. The leaders who govern water systems are thus stuck between a rate increase rock and a regulatory hard place. The result is a water utility management paradigm that is fundamentally negative: oriented toward loss avoidance instead of gains.

In sum, the public does not understand the quality of their water systems, which erodes utility accountability to citizens, causes policymakers to underinvest in utilities, and disincentivizes excellence for utility managers.

## A solution: report cards

The WSEP offers a set of report cards that communicate water utilities' performance comprehensively, but also clearly and simply. Organizational report cards facilitate accountability, reward performance for managers, and provide feedback to an organization's governing body.[4] Report cards distill and transform vast and complicated performance information into a form that lay persons can easily understand.

With report cards in hand, utility leaders can set clear improvement targets and show how their efforts improved the system's performance. Mayors, councilmembers, legislators, and regulators can identify and redress poor performance, or trumpet improvements and strong performance. For both managers and politicians, report cards can help to demonstrate the reasons for the unpleasant rate increases that infrastructure investments require. At the same time, report cards will make it easier for voters and activists to reward elected officials for

[2] Hansen and Mullin (2022).
[3] Teodoro (2011).
[4] Gormley and Weimer (1999).

water system excellence and hold them accountable for failures.

To these ends, the WSEP developed report cards for all 506 water utilities currently regulated by the Wisconsin Public Services Commission. Just as in a school or college, these report cards include grades for multiple "subjects:" 1) *Quality-health*; 2) *Quality-Aesthetics*; 3) *Finance*; 4) *Infrastructure & Operations*; and 5) *Communications.* Just as a course grade in school is based on performance on multiple assignments and exams, we assigned grades for each of these subjects based on multiple utility performance indicators, with greater or lesser weights assigned to each indicator.

### Crafting report cards

Beginning in 2021, the WSEP convened and consulted with experts in each area of water utility performance. Our expert panelists include retired utility managers, consultants who work with utilities, research scientists, and university professors. Their disciplinary backgrounds include engineering, chemistry, economics, finance, communications, and public management. In order to avoid conflicts of interest, we sought experts who are from outside of Wisconsin and who do not currently own or manage water utilities. We also promised confidentiality to our expert advisors in order to facilitate candid advice. The standards advanced here are wholly the responsibility of WSEP.

We provided our experts on each of the five subjects a list of variables and descriptive statistics for utility data from the Wisconsin Department of Natural Resources (DNR), Public Service Commission of Wisconsin (PSC), and U.S. Environmental Protection Agency's Safe Drinking Water Information System (SDWIS). With these data as a starting point, we discussed with our experts the meaning and significance of various indicators for evaluating utility quality and performance. This process was iterative, typically involving 3-5 meetings. After settling on a rubric for each subject, we applied the rubrics to data to Wisconsin's utilities.

*Empirical evidence of excellence* is the guiding principle that drives our rubric development. A focus on *empirical evidence* means that WSEP grades are based on observable, measurable outcomes (e.g., contaminant levels, water loss, financial reserve levels, information accessibility), not on formal policies or procedures (e.g., asset management plans, rate studies, succession plans, cybersecurity policies). In colloquial terms, WSEP grades on achievement, not effort. WSEP grading does not award "extra credit" or "bonus" points to utilities for anything other than measurable performance.

Our focus on *excellence* means that WSEP grades are meant to distinguish failing systems from mediocre systems, and good systems from truly great systems. Thus, our grading scheme involves accumulation of credit for accomplishments, not deduction of credit for failures. In other words, utilities do not start with a perfect score from which we deduct points for deficiencies or failures. Rather, each utility starts with a score of zero, and then earns excellent (A), good (B), fair (C), passing (D), or failing (F) grades by demonstrating performance across a host of indicators. That is, our grading scheme seeks not only to identify failing systems, but also to recognize a potentially wide variation in performance. From this perspective, meeting regulatory requirements is a *minimum* standard, not a standard of excellence. Utilities that merely meet regulatory requirements will receive passing WSEP marks, but not great marks.

Finally, WSEP assigns separate grades for each of the five subjects rather than blending them into a single overall grade. Keeping subjects separate helps the public, policymakers, and utility leaders understand their areas of relative strength and weakness.

### Why Wisconsin?

Wisconsin is an ideal place to craft comprehensive water system report cards. The Badger State is sufficiently large and diverse to demonstrate how report cards can work across urban, suburban, and rural communities. At the same time, Wisconsin is sufficiently homogenous to allow valid comparison of most aspects of utility quality and performance within the state. Crucially, Wisconsin's unique regulatory institutions collect data on water quality, utility finances, and water system integrity in ways that other states do not. Utility regulation was born in Wisconsin with the founding of the PSC in 1907, built in large part on models developed by University of Wisconsin researchers; more than 30 states followed suit over the next decade, ushering in an era of modern utility governance. A century later, WSEP seeks to transform utility governance once again from the shores of Lake Mendota.

### Proof of concept

This initial set of utility grades serves as a pilot or "beta test" for the WSEP as a proof of concept and baseline for future development. The present study offers an annual grade based mainly on data from calendar year 2020. We expect to issue similar report cards biennially going forward, with rubrics that evolve over time to reflect changing realities.

## Drinking water report cards in other states

Similar recent efforts at public reporting of drinking water system performance in three other states—New Jersey, California, and Louisiana—merit brief discussion. Each of these states' policies involve public reporting of utility performance in an effort to improve performance and accountability.

### New Jersey

In 2017, the state of New Jersey enacted the Water Quality Accountability Act (WQAA), which required the state's water utilities to submit a variety of data on safety, reliability, finances, and management to the state's Department of Environmental Protection (DEP). The state amended the WQAA in 2021 to require (among other things) the DEP to publish "a report card for each water purveyor in the State" on its website. In fulfillment of this mandate, DEP publishes the WQAA reporting data on a publicly available online dashboard, where residents may look up their own utilities and find a variety of information about them.[5] However, DEP does not assign letter grades or provide evaluative guidelines for these data.

### California

In 2019, California's Senate Bill 200 authorized the California Water Board to craft an annual needs assessment for the Golden State's water utilities as a way to help inform state allocations resources to failing or at-risk small community water systems. The Board published its first *Drinking Water Needs Assessment* in 2021; two subsequent assessments were published in 2022 and 2023. The California *Needs Assessment* is in principle a risk assessment of small systems. As such, California's methodology looks only at small systems and evaluates their risks of "failing to sustainably provide a sufficient amount of safe and affordable drinking water."[6] The California Water Board's assessment of resources, capital conditions, operating costs, and affordability yields a four-category classification, with small systems classified as either "not at-risk," "potentially at risk," "at-risk," or "HR2W."[7] The final designation applies to systems that consistently fail to meet primary drinking water standards under the SDWA. Since the California effort is intended to guide allocation of state funding to small systems based on the severity of their needs, the California assessments evaluate only small systems (i.e., systems that serve populations of 3,300 or fewer) and focus on the risk of failure, not performance.

### Louisiana

In 2021, the Louisiana Legislature authorized its state Department of Health (LDH) to develop letter grades for community water system accountability and performance. After a two year process, the LDH issued letter grades for each of the state's drinking water systems based on compliance with federal water quality rules, state water quality rules, financial sustainability, operation and maintenance, infrastructure, customer satisfaction, and secondary contaminants. LDH combines data on all of these topics to calculate a numerical grade on a 100-point scale, which then converts to a single letter grade (A, B, C, D, or F) for each utility.

Louisiana's grading system follows a penalty or demerit principle: utilities are presumed to start with a perfect 100 score, from which LDH deducts points for various failures.[8] For example, violation of a state or federal SDWA Maximum Contaminant Limit (MCL), a boil water notice, or a failure to submit a rate study each result in a five-point deduction. The Louisiana rubric also limits the deductions that a utility can receive on any single subject. For example, federal SDWA violation deductions are capped at 30. Louisiana's rubric also allows a utility to earn up to ten "extra points" for various plans and programs, such as an asset management plan or

[5] https://www.state.nj.us/dep/watersupply/dwc_systems.html

[6] Abhold et al. (2021), 13.

[7] HR2W is an abbreviation for "Human Right to Water," which refers to a 2016 California law that declared a "human right to water" in the state.

[8] https://ldh.la.gov/assets/oph/Center-EH/engineering/Grade_Rule/CWS_Accountability_Rule_LR.pdf

management training program.[9]

Like California's, Louisiana's assessment also proceeds under a compliance paradigm: LDH's rubric evaluates performance strictly in terms of failures and deficiencies. Although Louisiana's letter grades imply recognition of strong performance, the definition of performance is rooted in regulatory compliance, not achievement of excellence.

### Why WSEP is different

Efforts to evaluate and publicly report on water system quality in New Jersey, California, and Louisiana are encouraging, and together reflect a growing movement toward greater transparency and accountability for American water utilities. However, their origins, purposes, and forms are markedly different from WSEP's in at least three important ways.

First, the WSEP offers an independent assessment of drinking water utility performance, unaligned with any state regulatory agency or interest group. The New Jersey, California, and Louisiana reporting programs are products of state government agencies that emerged from state legislation. As such, institutional and political constraints shape these states' assessments and reporting processes to some extent. By contrast, the WSEP is a project of the La Follette School of Public Affairs at the University of Wisconsin-Madison, which affords the present effort a remarkable degree of independence. That independence allows WSEP to set rigorous performance standards free from political or commercial considerations.

Second, the WSEP's grading rubric is based entirely on empirically observable outcomes, not plans or procedures. This exclusive focus on measurable results sets WSEP apart from New Jersey's and Louisiana, which include some aspects of planning and programming.

Third and most critically, WSEP's focus on *excellence* puts utility performance at the heart of its assessment, with letter grades as a means of distilling and communicating utility performance. California's and Louisiana's assessment regimes each focus on failures and deficiencies (albeit in different ways); their goals are to identify failing systems in hopes of remediating them. New Jersey's report cards provide the public with ample information, but do not distill that information in a way that communicates performance to lay persons. WSEP's principal goal is to communicate utility performance in a way that not only identifies failures, but also distinguishes the good from the merely adequate, and the truly great from the merely good. *WSEP's aim is not only to point out failure, but also to highlight achievement.*

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[9] In capping deductions and offering "extra points," Louisiana's rubric potentially allows utilities to perform quite poorly and yet retain an apparently solid or even strong grade. For example, a utility that violated MCLs dozens of times would be penalized only 30 points, since the rubric limits MCL deductions to 30. The same utility could then earn back ten "extra points" for participating in a management program and filing a well assessment program with the state. The utility's final score would be 80 (100 – 30 points for MCL violations + 5 for management program participation + 5 for well assessment program), resulting in an overall letter grade of B for a utility that sent contaminated water to its customers for most of the year.

### Five subjects

As noted above, WSEP report cards include grades for five "subjects:"

- Water Quality-Health
- Water Quality-Aesthetics
- Infrastructure & Operations
- Finance
- Communications

Here we offer brief introductions to each subject; the report provides detailed rubrics and results for each.

### Water Quality-Health

Delivering safe, healthy drinking water is the primary objective of any water utility. WSEP grades for *Quality-Health* are based on regulated contaminant levels, with separate assessments of acute contaminants (which pose an immediate risk to human health) and chronic contaminants (which can cause negative health effects after continuous exposure over a long period of time). The SDWA regulates both types of contaminants through primary MCLs; water utilities violate the SDWA when they exceed an MCL.

As with every WSEP grade, distinguishing between adequate, good, and excellent performance is a guiding principle of our approach to evaluating water quality. To that end, our grading scheme views compliance with MCLs as defined in state and federal rules as a minimum expectation, and our grading scale calculates grades as a function of observed contaminant levels relative to their MCLs. Exceedances of MCLs that result in formal violations reflect failures of a utility's health mission, and so a utility that formally violates an MCL automatically fails the Q*uality-Health* subject.

### Water Quality-Aesthetics

Secondary contaminants, or "aesthetics" of water quality, are important because the taste, odor, color, and other aesthetic conditions are usually the most noticeable and unpleasant for consumers. If the water has a poor taste or is discolored, consumers may be less trusting of the water system and be more likely to purchase bottled water, even if the water is perfectly safe in terms of human health.[10]

*Quality-Aesthetics* grades are based on the EPA's National Secondary Drinking Water Regulations (NSDWRs). The secondary drinking water regulations set non-mandatory water quality standards for 15 contaminants, which are not enforced by EPA and state regulators, except for fluoride. The "secondary maximum contaminant levels" (SMCLs) are established as guidelines to assist public water systems in managing their water supply for aesthetics – such as

[10] See for example: Doria, Pidgeon, and Hunter (2009); Teodoro, Zuhlke, and Switzer (2022).

taste, color, and odor. We included contaminants such as iron, manganese, hardness, and alkalinity, with data from the Wisconsin Department of Natural Resources.

Unfortunately, relatively few Wisconsin utilities report data on all of these secondary contaminants that we use in grading. Due to data availability constraints, we have *Quality-Aesthetics* grades for only 97 utilities; those with missing data are marked as "incomplete."

### Finance

Finance is a critical component of overall water utility performance: financial strength is crucial for a utility's sustainability, affordability is critical for a utility's public health mission, and progressive pricing is important for equity. Balancing rising costs and the need to invest in infrastructure with affordability and equity is challenging.

Our assessment of water utility financial strength involves capital financing capacity, liquidity, affordability, and proportionality in pricing. Utilities received strong marks for showing ample financing capacity and financial liquidity to handle unexpected contingencies, and for low taxes on water utility revenue. Utilities also earned credit for low residential service prices at modest volumes and for progressive water rate structures (i.e., increasing prices at higher volumes).

### Infrastructure & Operations

Physical integrity and operational effectiveness are both essential to water system excellence and sustainability. Since a utility's capital and operations are intrinsically linked, we combine both into a single "subject": Infrastructure accounts for half of the *Infrastructure & Operations* grade, and Operations accounts for the other half. Water utilities' infrastructure needs vary widely, depending on factors such as source water and customer demand.

The infrastructure grade focuses on transmission and distribution system integrity using data on water loss, replacement rate, and especially main breaks. The Operations grade includes energy consumption and several measurements of operating expenses.

### Communications

Transparency and access to key utility information are vital for public trust, accountability, good governance, and confidence in leadership. By quantifying and assessing utilities *Communications,* WSEP seeks to encourage water utility leaders to consider public communication a strategic imperative and a core element of their utilities' overall performance. In the 21st century, effective communications depend principally on "e-governance": access to information via the Internet, mobile devices, and social media. These media present new challenges, but also opened up new opportunities for communicating with the public.

WSEP *Communications* grades reflect two constructs: transparency and interactivity. *Transparency* relates to the type of information and accessibility of that information, while *interactivity* relates to how much a utility interacts with and provides opportunities for the public to interact with their water utility.

Utilities earned credit for *transparency* with the presence of a website, the use of social media, and by providing various information online in multiple languages. WSEP awarded *interactivity* credit to utilities that provided information on how the public could contact them via telephone, email, social media, and/or public meetings.

### The promise

The WSEP aims to depict water utility performance in clear, intuitive report cards as a step toward transforming water utility governance in Wisconsin and beyond. Similar concepts have been developed and introduced in other states, demonstrating the salience of this issue and the appetite among the public and policymakers to make water system performance more transparent. Report cards can incentivize and reward strong performance by highlighting excellence; they also can identify weaknesses within utilities, across utilities, and statewide. Report cards can improve accountability and help elected officials make sound decisions for these most critical systems.

The balance of this report includes separate detailed descriptions and discussions of each subject, followed by an overall summary and discussion of WSEP grades across Wisconsin. An appendix to the report offers a subject-by-subject summary of grades for each utility.

## QUALITY – HEALTH

Providing safe drinking water is the primary objective of any water utility, and water quality is essential to a successful water system and to maintaining the public's trust. Water quality challenges involve public health. Given the high-profile crises in places such as Flint, Michigan; Jackson, Mississippi; and East Palestine, Ohio; it is difficult to overstate the importance of safe, healthy drinking water. Water *Quality-Health* is thus the first and arguably the most important subject on the WSEP report card.

Although providing safe and reliable drinking water is an essential service and primary objective for any municipal government or water utility, the public has little understanding of their water's quality from a health perspective. Conventionally, the SDWA-mandated CCR (also known as an annual drinking water quality report, sent to all customers by July 1 of each year) is the primary means of communicating tap water health and safety to the general public.[11] However, past research indicates that CCRs are difficult for water customers to interpret and often fail to communicate drinking water quality accurately and effectively.[12] A central aim of WSEP, then, is to convey drinking water quality to the public in a more intuitively meaningful way.

We graded water *Quality – Health* based on utilities' regulated contaminant levels as reported in sampling data from the Wisconsin DNR. Following recommendations from experts, we categorized contaminants as either *acute* or *chronic* according to classifications from the EPA[13] and Minnesota Department of Health.[14] We then assigned scores separately for each type of contaminant. Acute contaminants are substances that can adversely affect human health seriously in a short period of time (hours to days). Chronic contaminants can cause increased risk of negative health effects after continuous exposure over a long period of time.[15]

For example, coliform bacteria is an acute contaminant, and can cause symptoms within a matter of hours or days. Chronic contaminants such as PFAS, arsenic, and nitrates, can increase the risk of cancers and other health conditions after extended exposure at high or relatively low levels. In Wisconsin, particularly in the central sands region, water often contains elevated levels of nitrates due to the heavy agricultural land use, irrigation, and sandy soils. High nitrate levels thus drive concern for both private wells and municipal water systems. Elevated levels of nitrates can lead to conditions such as infant methemoglobinemia, or "blue baby syndrome."[16]

Data for calculating *Quality-Health* grades were drawn from the Wisconsin DNR for 2019-2020 and the EPA's SDWIS for violations in 2020.

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[11] https://www.epa.gov/ccr/consumer-confidence-report-rule-and-rule-history-water-systems
[12] Evans and Carpenter (2019); Johnson (2003).
[13] https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations
[14] https://www.health.state.mn.us/communities/environment/risk/guidance/gw/table.html

[16] https://www.dhs.wisconsin.gov/water/blue-baby-syndrome.htm

## Grading *Quality-Health*

Each utility earned a numerical score on a 0-100 scale for each SDWA-regulated contaminant. The *Quality-Health* grade is an aggregation of scores for all of the individual contaminants, with *acute* contaminants accounting for 75 percent and *chronic* contaminants 25 percent of the total grade. The overall *Quality-Health* grade, then, is a weighted average score of all contaminants.

### Numerical contaminant scores

Distinguishing between adequate, good, and excellent performance is a guiding principle of WSEP's approach to evaluating water quality. To that end, our grading scheme views compliance with MCLs as defined in state and federal rules as a minimum expectation. Put another way, MCL compliance alone will earn a utility merely passing marks. Achieving excellence in water quality means providing water with contaminants well below MCLs.

**Table 1. *Quality-Health* grading rubric based on SDWA Maximum Contaminant Limits**

| Grade Range | MCL Range |
|---|---|
| A | <50% |
| B | 50-80% |
| C | 80-100% |
| D | > MCL one reading |
| F | MCL violation |

Note: Numerical scores based on linear interpolation within grade ranges.

To that end, we created a scale that calculated grades as a function of the maximum contaminant level observed each year relative to each contaminant's MCL. Utilities received "A" grades for contaminant readings ranging from 0% - 50% of MCL, "B" grades ranging from 50-80% of MCL, "C" grades ranging from 80-100% of MCL, and "D" grades for one reading exceeding the MCL. Utilities received an "F" or failing grade if they received a SDWA violation in 2020 based on the SDWIS data from the EPA. Table 1 summarizes this rubric.

A corresponding 0-100 numerical grading scale applies to each contaminant using linear interpolation. For example, a sampled contaminant value of zero is scored as 100, while a sample at 50% of the MCL for that contaminant scores 90; a sample at 51% of the MCL would score 89, while a sample at 80% of the MCL would score 80, and so on. Table 2 offers an illustration of this scoring system for Nitrate, one of the acute contaminants, with five hypothetical contaminant levels and their respective numerical scores.

In the event that there were no data for a specific contaminant for a particular utility, we counted this as a non-detection and therefore a 100% grade. Grades for each individual contaminant were averaged to produce overall *acute* and *chronic* scores for each utility.

**Table 2. Illustrative example of contaminant level grading—Nitrate**

| MCL = 10 mg/L | | |
|---|---|---|
| **Maximum Sample (mg/L)** | **Percent MCL (%)** | **Score (0-100)** |
| 0.00 | 0 | 100 |
| 1.10 | 11.0 | 98 |
| 6.50 | 65.0 | 85 |
| 9.10 | 91.0 | 75 |
| 11.7 | 117.0 | 54 |

Note: Numerical scores based on linear interpolation within grade ranges in Table 1.

The nature of Total Coliform measurement and management required a different approach to scoring. The MCL for coliform requires that “no more than 5.0% samples are total coliform-positive (TC-positive) in a month.” If a utility had zero percent (0%) positive in 2020, the utility earned an “A” grade; if the percentage was under 1%, it earned a “B” grade. If the percentage was 1-2%, it earned a “C” grade, and if the percentage was 2-5%, it earned a “D” grade. We assigned percentages greater than 5% an “F” grade, which was reported as 0% for the acute contaminant weighting system described above. Table 3 summarizes the Total Coliform grading scale.

**Table 3. *Quality-Health* grading rubric for Total Coliform**

| Grade Range | Percent Positive Samples (% TC-positive) |
|---|---|
| A | 0 |
| B | <1.0 |
| C | 1.0-2.0 |
| D | 2.0-2.5 |
| F | >5.0 |

Note: Numerical scores based on linear interpolation within grade ranges.

**Table 4. Average and median scores for *acute* contaminants, 2020**

| Contaminant | Average | Median |
|---|---|---|
| Cadmium | 100.0 | 100.0 |
| Coliform | 84.2 | 100.0 |
| Copper | 89.2 | 95.2 |
| Dalapon | 100.0 | 100.0 |
| o-Dichlorobenzene | 100.0 | 100.0 |
| p-Dichlorobenzene | 100.0 | 100.0 |
| Di(2-ethylhexyl) adipate | 100.0 | 100.0 |
| Nitrate (NO3-N) | 87.0 | 97.7 |
| Nitrite (NO2-N) | 100.0 | 100.0 |
| Oxamyl (Vydate) | 100.0 | 100.0 |

Tables 4 and 5 list the statewide average scores for acute and chronic contaminants, respectively.

**Table 5. Average and median scores for *chronic* contaminants, 2020**

| Contaminant | Average | Median | Contaminant | Average | Median |
|---|---|---|---|---|---|
| Arsenic | 90.9 | 99.2 | Ethylene Dibromide (EDB) | 100.0 | 100.0 |
| Alachlor (Lasso) | 99.6 | 100.0 | Glyphosate | 100.0 | 100.0 |
| Antimony Total | 99.8 | 100.0 | Heptachlor | 100.0 | 100.0 |
| Atrazine | 100 | 100.0 | Heptachlor Epoxide | 100.0 | 100.0 |
| Barium | 92.7 | 99.6 | Hexachlorobenzene (HCB) | 100.0 | 100.0 |
| Benzene | 93.8 | 100.0 | Hexachlorocyclopentadiene | 100.0 | 100.0 |
| Beryllium Total | 99.8 | 100.0 | Lead | 73.7 | 93.4 |
| Carbofuran | 100.0 | 100.0 | Mercury | 100.0 | 100.0 |
| Carbon Tetrachloride | 100.0 | 100.0 | Methoxychlor | 100.0 | 100.0 |
| Chloramine | 99.5 | 100.0 | PCB, Total | 100.0 | 100.0 |
| Chlordane | 100.0 | 100.0 | Pentachlorophenol | 100.0 | 100.0 |
| Chromium | 100.0 | 100.0 | Picloram | 100.0 | 100.0 |
| Copper | 89.2 | 95.2 | Radium (226 + 228) | 86.5 | 95.0 |
| Cyanide | 100.0 | 100.0 | Selenium | 99.9 | 100.0 |
| 2,4-D | 100.0 | 100.0 | 2,4,5-TP (Silvex) | 100.0 | 100.0 |
| 1,2-Dibromo-3-Chloropro (DBCP) | 100.0 | 100.0 | Simazine | 100.0 | 100.0 |
| 1,2-Dichloroethane | 100.0 | 100.0 | Styrene | 100.0 | 100.0 |
| 1,1-Dichloroethylene | 99.8 | 100.0 | Tetrachloroethylene | 99.8 | 100.0 |
| cis-1,2-dichloroethylene | 100.0 | 100.0 | Thallium total | 99.6 | 100.0 |
| trans-1,2-dichloroethylene | 100.0 | 100.0 | Toluene | 100.0 | 100.0 |
| Dichloromethane | 99.9 | 100.0 | Toxaphene | 100.0 | 100.0 |
| 1,2-Dichloropropane | 100.0 | 100.0 | 1,2,4-Trichlorobenzene | 100.0 | 100.0 |
| Di(2-ethylhexyl) phthalate | 100.0 | 100.0 | 1,1,1-Trichloroethane | 100.0 | 100.0 |
| Dinoseb | 100.0 | 100.0 | 1,1,2-Trichloroethane | 100.0 | 100.0 |
| Diquat | 100.0 | 100.0 | Trichloroethylene | 99.6 | 100.0 |
| Endothall | 100.0 | 100.0 | TTHM | 95.9 | 98.2 |
| Endrin | 100.0 | 100.0 | Combined Uranium | 99.4 | 99.8 |
| Ethylbenzene | 100.0 | 100.0 | Vinyl Chloride | 100.0 | 100.0 |
| | | | Xylenes | 100.0 | 100.0 |

### *Quality-Health* grades across Wisconsin

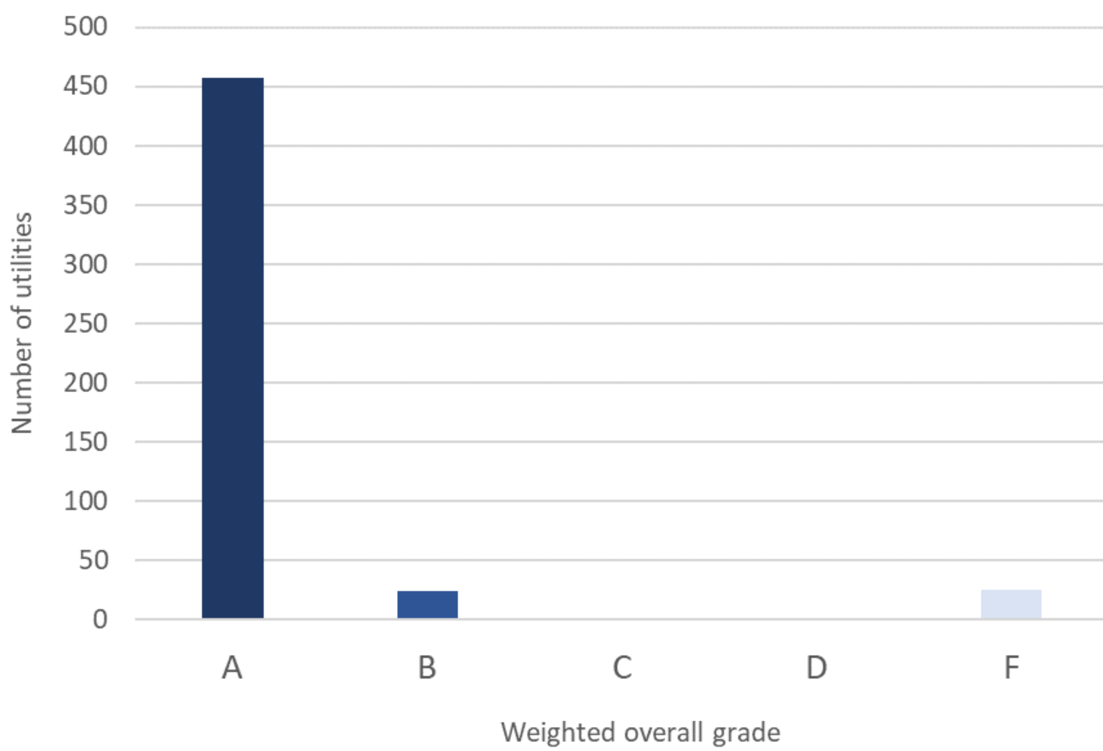
Detected contaminant levels were very low across the state, resulting in the very high scores seen in Table 4 (weighted at 75%) and Table 5 (weighted at 25%). These scores translated into excellent overall *Quality – Health* grades in 2020: the score grade was in the B-range or better and the median score was in the A-range for every regulated contaminant. Table 6 and Figure 1 show how these strong scores translate into grades. These results are very impressive and validating for Wisconsin's water sector, likely reflecting management and policies that make regulatory compliance a principal goal.

**Table 6. Summary of *Quality-Health* scores, 2020**

| | Acute | Chronic | Weighted Total* |
|---|---|---|---|
| Average | 96.2 | 98.7 | 92.0 |
| Median | 98.6 | 99.4 | 98.7 |
| Maximum | 100.0 | 100.0 | 100.0 |
| Minimum | 78.6 | 90.7 | 0.0 |
| Standard Deviation | 4.7 | 1.7 | 21.3 |

*Includes automatic F grades (scored at zero) for MCL violations.

**Figure 1. Distribution of *Quality-Health* grades, 2020**




Grades for *Quality – Health* in 2020 were, with few exceptions, excellent. It is worth emphasizing that attaining consistently high scores under the WSEP rubrics requires more than mere compliance with SDWA regulations; to earn an A grade, a utility must maintain contaminant levels far below what is required by law. Nonetheless, more than 90 percent of Wisconsin utilities earned A grades for water quality, indicating that a vast majority of the state's water systems do not simply comply with SDWA regulations; rather, they deliver water with contaminant levels far below regulatory standards. No utilities received "C" or "D" grades.

The handful of utilities that failed their *Quality-Health* grade received their "F" grades due to specific MCL violations.

## QUALITY – AESTHETICS

Secondary contaminants, or "aesthetics" of water quality, are important because the taste, odor, color, and other aesthetic conditions are usually the most noticeable for consumers. If tap water has a poor taste, unpleasant odor, or is discolored, consumers may be less trusting of the water system and be more likely to purchase bottled water, even if the water is perfectly safe in terms of human health.[17]

The Environmental Protection Agency has established National Secondary Drinking Water Regulations (NSDWRs) in addition to National Primary Drinking Water Regulations. The secondary drinking water regulations set non-mandatory water quality standards for 15 contaminants. These standards are not subject to enforcement by EPA and state regulators, except for fluoride. Rather, these "secondary maximum contaminant levels" (SMCLs) are guidelines to assist public water systems in managing their water supply for aesthetic quality.[18]

Although SMCLs are not subject to federal enforcement, EPA requires a special notice for exceedance of the fluoride SMCL of 2.0 mg/L. Community water systems that exceed the fluoride SMCL of 2 mg/L, but do not exceed the MCL of 4.0 mg/L for fluoride, must provide public notice to persons served no later than 12 months from the day the water system learns of the exceedance.

Unfortunately, relatively few Wisconsin utilities collect data on the full set of secondary contaminants because these contaminants are not strictly regulated under the SDWA. Aesthetics are so central to customer perceptions that a grade for secondary contaminants is an important part of any overall utility evaluation scheme, but the significant amount of missing data presents us with a unique challenge. Therefore, the grades that follow are only for the 97 utilities that had sufficient secondary contaminant data available for evaluation; utilities with missing aesthetic data we marked as "Incomplete."

WSEP water *Quality-Aesthetics* grades are based on iron, manganese, hardness, chloride, sulfate, alkalinity, aluminum, and fluoride, as these have the greatest effect on drinking water's color, taste, and/or odor.[19] The rubric weights these indicators variously based on their aesthetic impacts. All data for the "Aesthetics" portion of this report were collected from the Wisconsin Department of Natural Resources public water utility database, for years 2019-2020.

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[17] Doria, Pidgeon, and Hunter (2009); Teodoro, Zuhlke, and Switzer (2022).
[18] https://www.epa.gov/sdwa/secondary-drinking-water-standards-guidance-nuisance-chemicals
[19] DNR maintains data on zinc, conductivity, pH, and others for a small number of utilities. We considered, but ultimately did not include, zinc as a secondary contaminant because there were fewer than 25 utilities that reported data for zinc. Omitting zinc brought us from 35 utilities with data for the secondary contaminants to 97 utilities. However, we suggest including zinc in future iterations of the report cards as data become more available.

### Numerical contaminant scores

Scoring for secondary contaminants followed a methodology similar to our scoring for *Quality-Health*: utilities earn grades by maintaining secondary contaminant levels relative to SMCLs. Our scores for *Quality-Aesthetics* are based on average sampled contaminant levels, rather than the maximum samples that we used to score *Quality-Health.* We used the rubric in Table 7 to score iron, manganese, chloride, sulfate, aluminum, and fluoride. We applied a separate rubric to alkalinity and hardness (discussed further, below).

**Table 7. *Quality-Aesthetics* scoring based on SDWA Secondary Maximum Contaminant Limits**

| Grade Range | SMCL Range |
|---|---|
| A | <50% |
| B | 50-75% |
| C | 75-125% |
| D | 125-150% |
| F | >150% |

Note: Numerical scores based on linear interpolation within grade ranges.
Scores reach zero at 200% of the SMCL.

Once again, a corresponding 0-100 numerical grading scale applies to each secondary contaminant using linear interpolation. For example, a sampled contaminant value of zero is scored as 100, while a sample at 50% of the SMCL for that contaminant scores 90; a sample at 51% of the MCL would score 89, while a sample at 75% of the MCL would score 80, and so on. Scores “zero out” at 200% of the SMCL. Table 8 offers an illustration of this scoring system for

**Table 8. Illustrative example of secondary contaminant level grading—Iron**

| SMCL = 0.3 mg/L | | |
|---|---|---|
| **Average Sample (mg/L)** | **Percent MCL (%)** | **Score (0-100)** |
| 0.00 | 0 | 100 |
| 0.05 | 17.3 | 97 |
| 0.26 | 85.8 | 78 |
| 0.40 | 133.3 | 67 |
| 0.70 | 233.3 | 0 |

Note: Numerical scores based on linear interpolation within grade ranges in Table 2.

Iron, with five hypothetical contaminant levels and their respective numerical scores.

WSEP *Quality-Aesthetics* grades weigh secondary contaminants more or less heavily depending on their relative impact on aesthetics. Iron, manganese, and hardness are most heavily weighted, contributing 25.0% each to the total grade. Alkalinity, Chloride, and Sulfate scores account for 6.0% each, with Aluminum and Fluoride each weighed at 3.5%. Table 9 summarizes these weights.

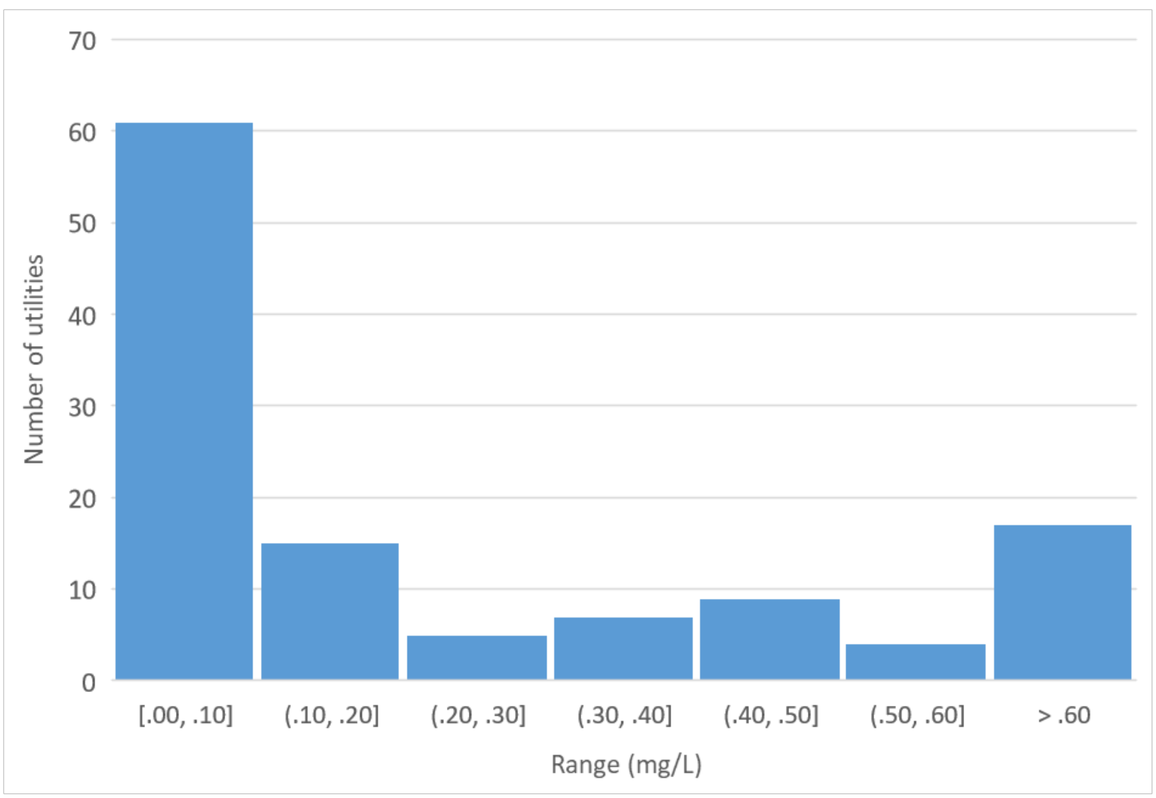
**Table 9. Secondary contaminant weighting for *Quality-Aesthetics* grades**

| Contaminant | Secondary MCL (mg/L) | Weight (%) |
|---|---|---|
| Iron | 0.30 | 25.0 |
| Hardness | N/A | 25.0 |
| Manganese | 0.05 | 25.0 |
| Alkalinity | N/A | 6.0 |
| Chloride | 250.00 | 6.0 |
| Sulfate | 250.00 | 6.0 |
| Aluminum | 0.20 | 3.5 |
| Fluoride | 2.00 | 3.5 |

Note: Numerical scores based on linear interpolation within grade ranges in Table 2.

Each of the secondary contaminants that contributes to *Quality-Aesthetics* scores is discussed briefly here.

**Figure 2. Distribution of average iron samples (mg/L), 2020**

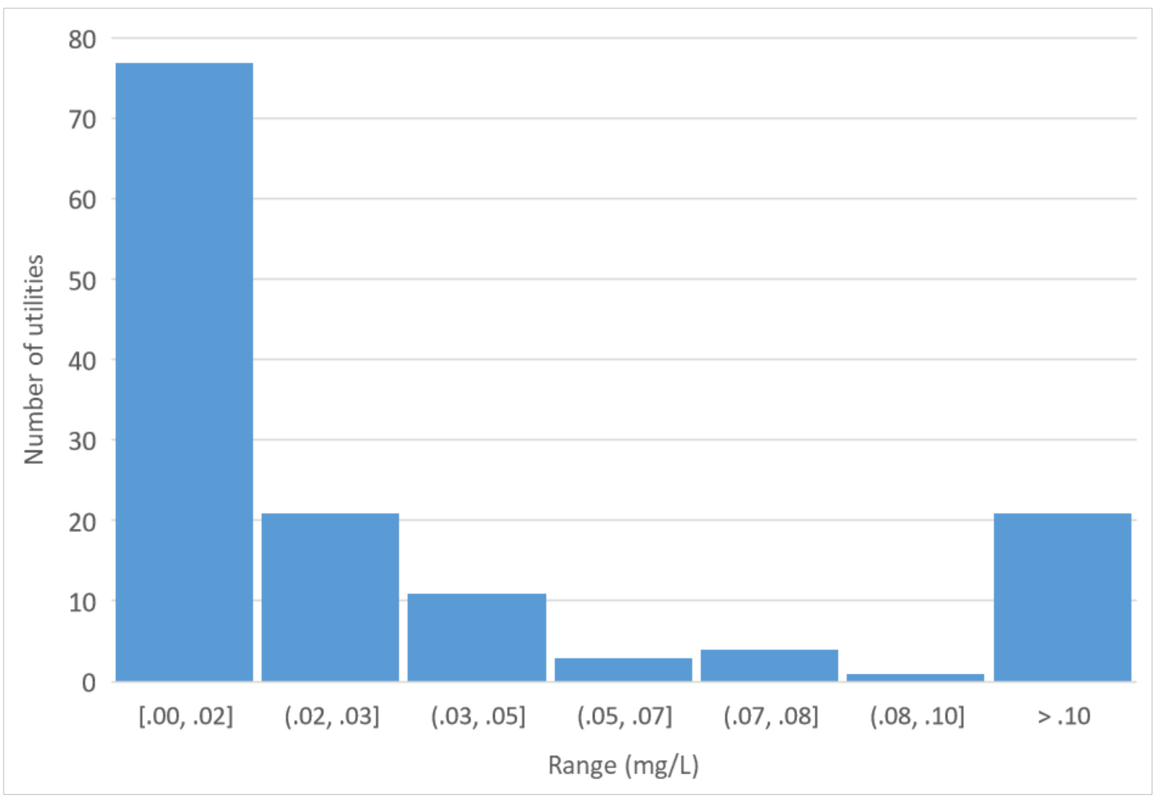


*Iron*

Many areas in Wisconsin and throughout the United States have high levels of iron in the soils. Iron in water does not typically present a health risk, but water with high levels of iron is usually very noticeable and can cause customers to question their tap water's safety. Iron can give water a metallic taste and affect how beverages and food taste. Iron can also cause red, brown, or yellowish stains on dishes, plumbing fixtures, and laundry. Heavy iron concentrations can cause clogs in wells, pumps, dishwashers, and other fixtures and appliances. Iron accounts for 25% of the *Quality-Aesthetics* grade due to its significant potential impact on the color and taste of water.

Figure 2 shows the distribution of average iron readings for each sampled utility in 2020. The utilities for which DNR had iron data in 2020 scored an average of 75.3 out of 100 for iron.

**Figure 3. Distribution of average manganese samples (mg/L), 2020**




*Manganese*

Manganese is common in minerals and soils and is often present with iron. Like iron, manganese can turn the water brown or rust color, and cause staining of laundry and plumbing fixtures, and give the water an off taste or odor. Manganese is part of a healthy diet at low levels; very high levels may adversely affect the nervous system, kidneys, and reproduction.

According to the Wisconsin Department of Health Services, public water systems in Wisconsin are supposed to test for manganese every nine years. Similar to iron, our *Quality-Aesthetics* grade weights manganese at 25% owing to its impacts on color and taste.

Figure 3 shows the distribution of average manganese samples in 2020. The utilities for which DNR had manganese data in 2020 scored an average of 77.6 out of 100 for manganese.

### *Chloride*

Drinking water containing chloride is generally not harmful to health, but high amounts of chloride can cause drinking water to have a salty taste and can corrode pipes and plumbing fixtures. Nationally, high amounts of chloride are associated with contamination from saltwater intrusion, septic tanks, and road salting. Road salting in Wisconsin and other cold regions has significant impacts on both groundwater and surface water, and so presents a serious challenge for drinking water utilities. EPA has set the secondary drinking water standard at 250 mg/L.[20]

**Figure 4. Distribution of average chloride samples (mg/L), 2020**

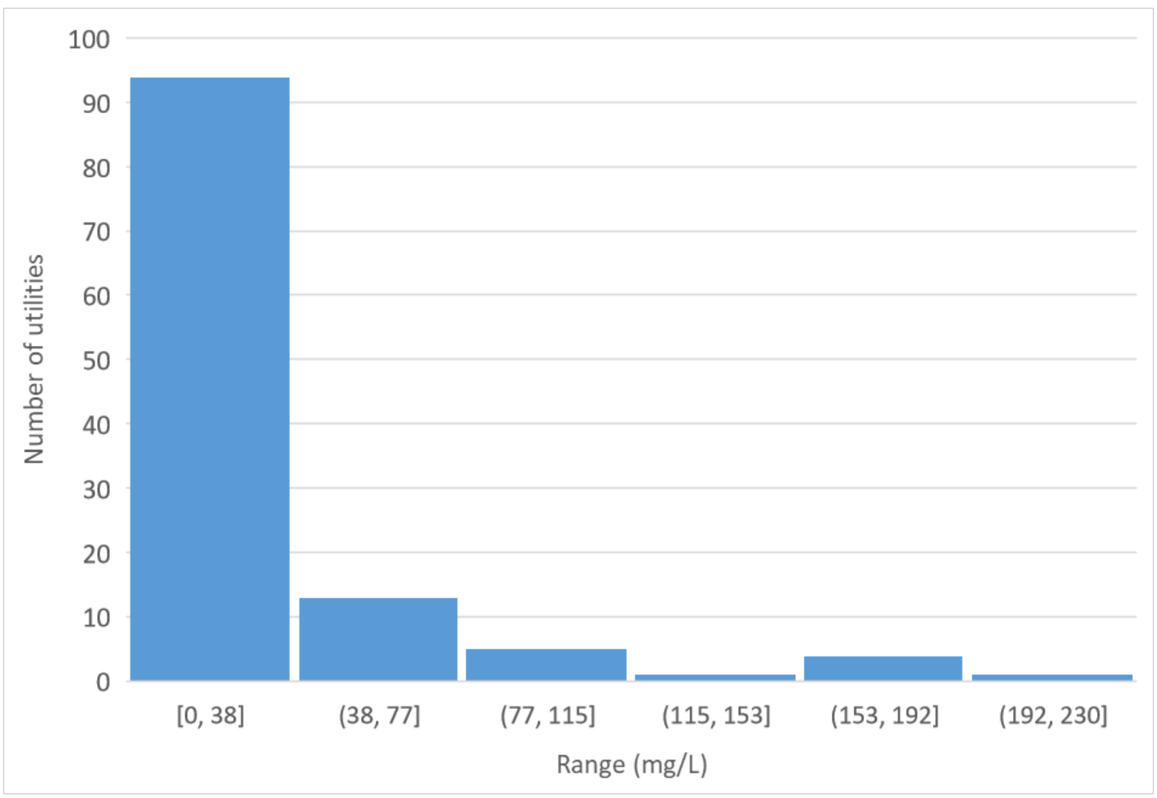
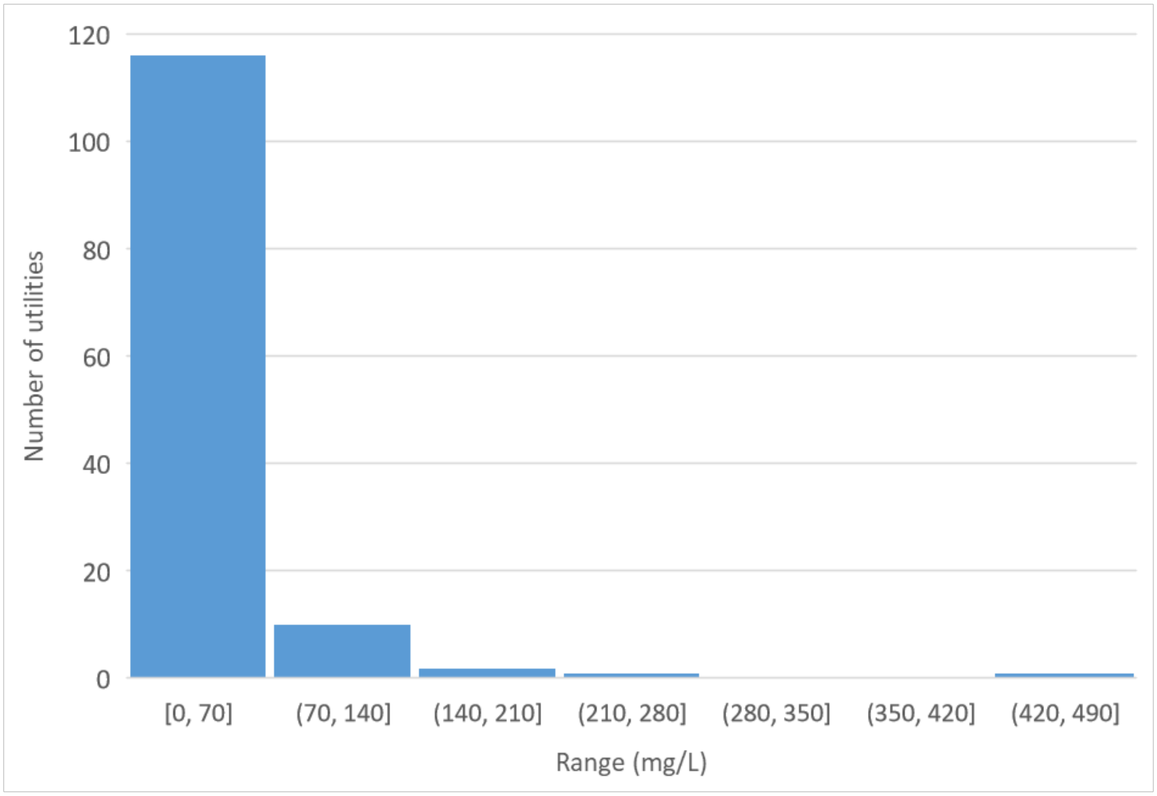



Figure 4 shows the distribution of average chloride samples in 2020. We weighted chloride at 6% of the total *Quality-Aesthetics* grade because the effects are generally less pronounced than

[20] https://www.maine.gov/dhhs/mecdc/public-health-systems/health-and-environmental-testing/chloride.htm

iron, manganese, and hardness. The utilities for which DNR had chloride data in 2020 scored an average of 97.5 out of 100 for chloride.

**Figure 5. Distribution of average sulfate samples (mg/L), 2020**



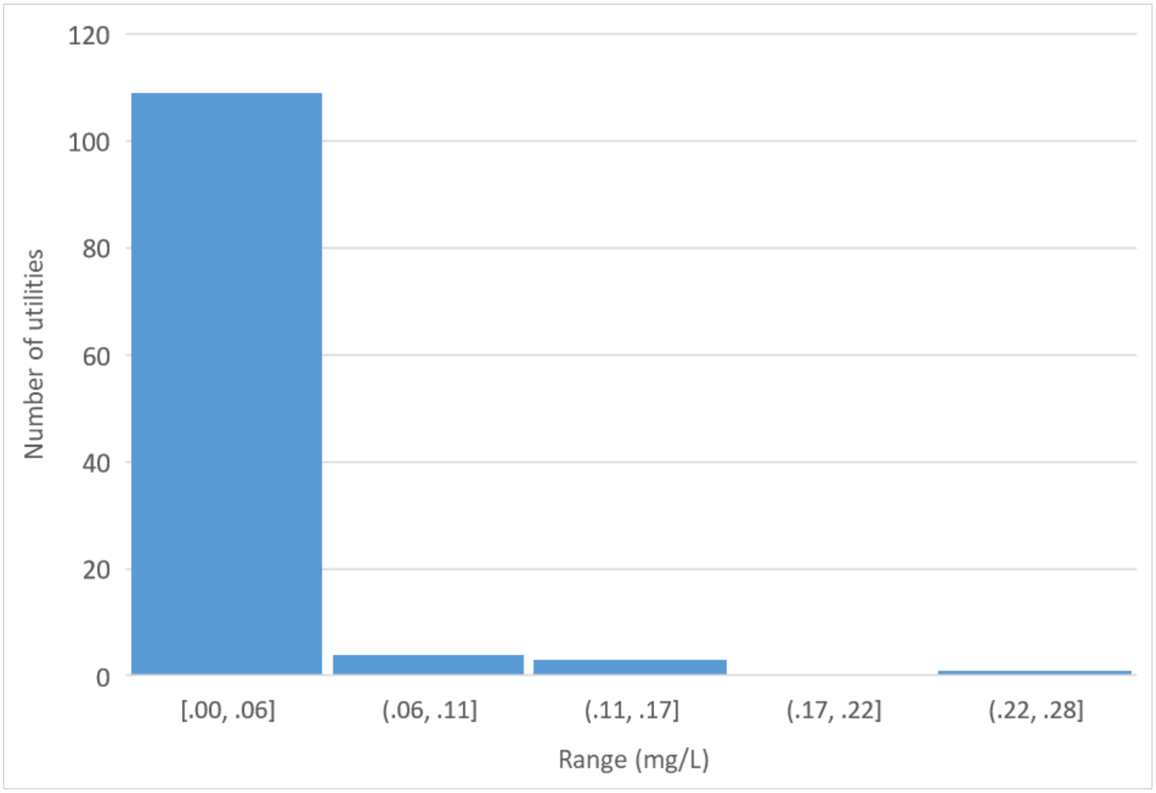

### *Sulfate*

Sulfate occurs naturally in most groundwater in Wisconsin and in many regions. At higher levels (more than 250 mg/L), sulfate can give water a bitter or medicinal taste and can have laxative effects. We weighted sulfate at 6% of the total *Quality-Aesthetics* grade. Public health officials recommend only using water with sulfate levels lower than 500 mg/L for infant formula, as infants are more sensitive to sulfate than adults.[21]

Figure 5 shows the distribution of average sulfate samples in 2020. The utilities for which DNR had sulfate data scored an average of 97.0 out of 100 for sulfate.

[21] https://www.health.state.mn.us/communities/environment/water/wells/waterquality/sulfate.html

**Figure 6. Distribution of average aluminum samples (mg/L), 2020**




*Aluminum*

Drinking water can contain aluminum if it comes from groundwater aquifers with aluminum metals. The main concern with aluminum is its effect on the color of water; most people do not experience health effects from exposure to aluminum.[22] The SMCL for Aluminum is 0.20 mg/L, and the score for this contaminant contributes 3.5% to the total *Quality-Aesthetics* grade. Figure 6 shows the distribution of average aluminum samples in 2020. The utilities for which DNR had chloride data in 2020 scored an average of 98.6 out of 100 for chloride.

*Fluoride*

Fluoride is a naturally occurring mineral, at low levels. Communities add fluoride to protect teeth and oral health. As stated previously, EPA requires a special notice for exceedance of the fluoride SMCL of 2.0 mg/L. If community water systems exceed the SCML of 2.0 mg/L but not the MCL of 4.0 mg/L, the system must provide public notice no later than 12 months from the day the water system learns of the exceedance.[23]

According to the Wisconsin Department of Health Services:

- Fluoride levels less than 0.7 mg/L are too low for oral health protection.

[22] https://dhs.wisconsin.gov/chemical/aluminum.htm
[23] https://dhs.wisconsin.gov/water/hazards.htm

- Fluoride levels between 0.7 and 2.0 mg/L support good oral health.
- Fluoride levels between 2.0 and 4.0 mg/L are too high for young children.
- Fluoride levels greater than 4.0 mg/L are too high for everyone.

WSEP scoring for fluoride follows these levels, as summarized in Table 9. The fluoride score contributes 3.5% to the total *Quality-Aesthetics* grade. Unlike the other secondary contaminants, DNR has fluoride data for nearly all of the state's water utilities.

**Table 9. *Quality-Aesthetics* scoring for fluoride**

| Grade Range | Fluoride level (mg/L) |
|---|---|
| A | 1.1-1.5 |
| B | 0.7-1.1; 1.5-1.7 |
| C | 0.0-0.7; 1.7-2.0 |
| D | 2.0-4.0 |
| F | >4.0 |

Note: Numerical scores based on linear interpolation within grade ranges.
Scores reach zero at 5.0 mg/L.

Figure 7 shows the distribution of average fluoride samples in 2020.

**Figure 7. Distribution of average fluoride samples (mg/L), 2020**

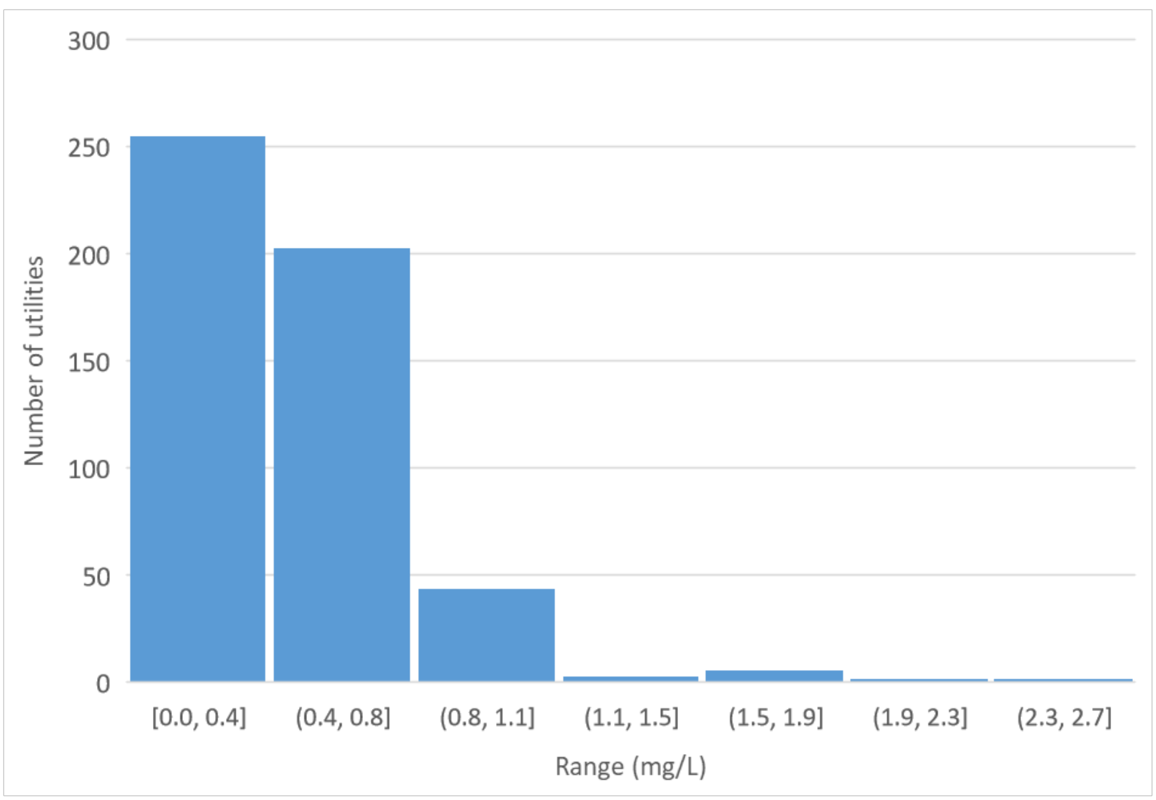
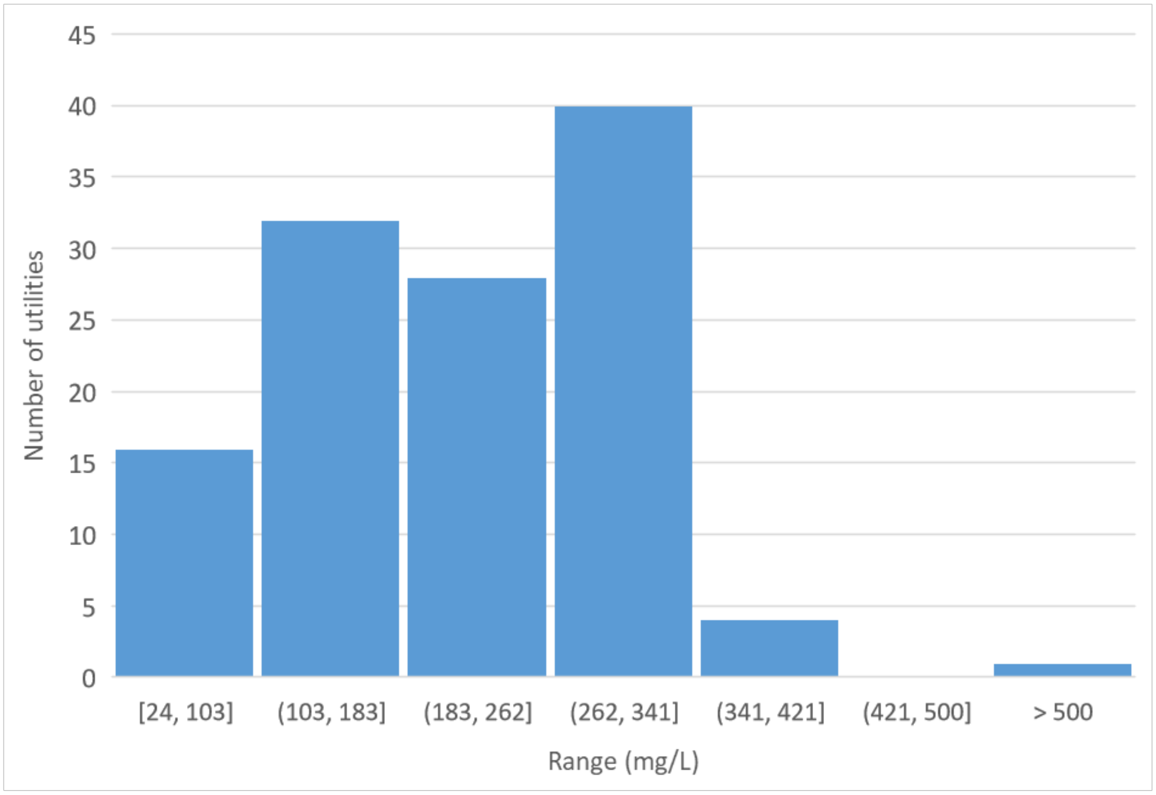


**Figure 8. Distribution of average alkalinity samples (mg/L), 2020**




### *Alkalinity*

Alkalinity primarily results from dissolving limestone or dolomite in groundwater, and alkalinity and total hardness are generally nearly equal in concentration because they form from the same minerals. Water with low levels of alkalinity (<150 mg/L) is more likely to be corrosive; high alkalinity (>150 mg/L) may contribute to scaling.[24] Since ideal alkalinity levels are nonlinear, we applied a different rubric when scoring alkalinity see Table 10. Scores again applied linear interpolation within grading ranges, with grades zeroing out at 500.

**Table 10. *Quality-Aesthetics* grading rubric for alkalinity**

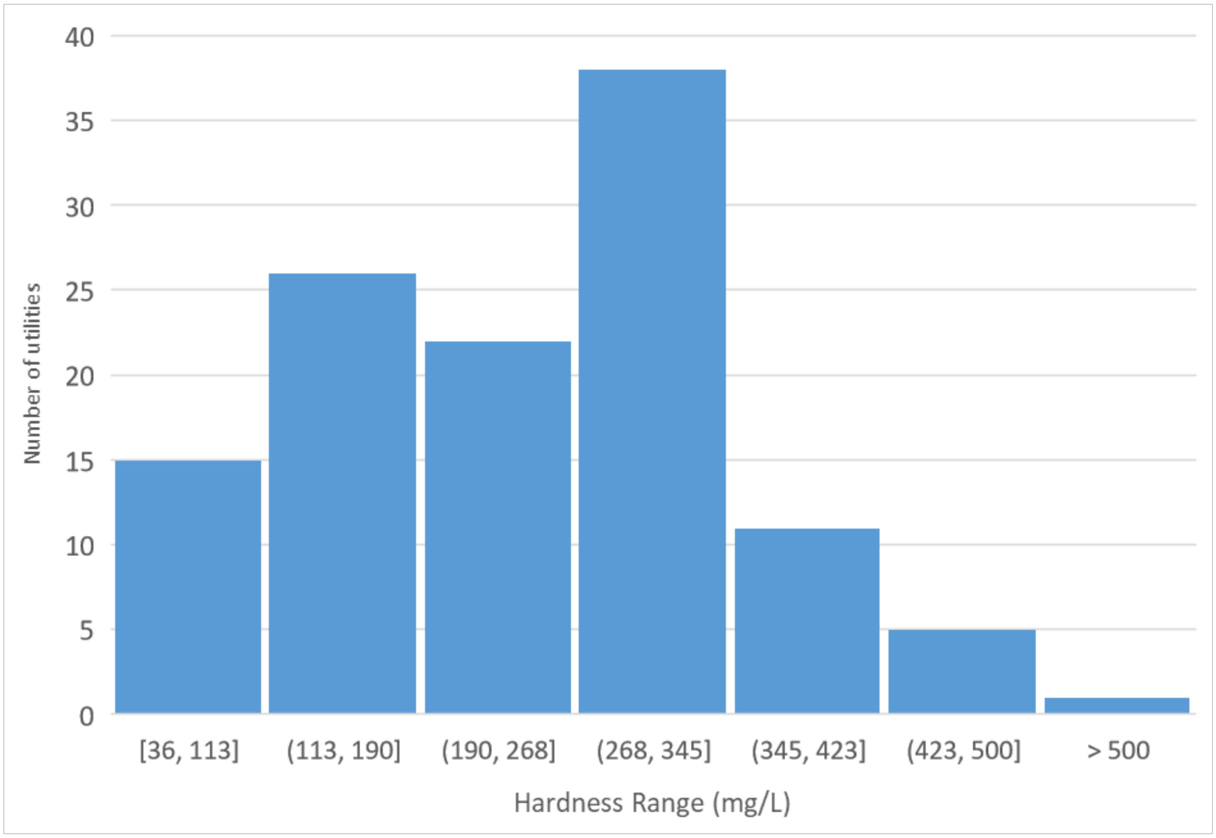
| Grade Range | Contaminant range (mg/L) |
|---|---|
| A | 75-100 |
| B | 30-75; 100-200 |
| C | <30; 200-300 |
| D | 300-400 |
| F | >400 |

Note: Numerical scores based on linear interpolation within grade ranges.
Scores reach zero at 500 mg/L.

[24] https://www3.uwsp.edu/cnr-ap/weal/Documents/HOPinterp.pdf

Figure 8 shows the distribution of average alkalinity samples in 2020. The utilities for which DNR had alkalinity data in 2020 scored an average of 77.7 out of 100 for alkalinity, which comprises 6% of the total *Quality-Aesthetics* grade.

**Figure 9. Distribution of average hardness (mg/L), 2020**




*Hardness*

Water hardness refers to the amount of dissolved calcium and magnesium in the water. Hard water leads to the formation of soap scum and causes residue on dishes and other appliances. When hard water is heated, solid deposits of calcium carbonate can form, causing scale that can reduce the life of equipment, increase heating costs, and lower the efficiency of appliances.[25] Hardness of 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft; water at 61 to 120 mg/L is moderately hard; 121 to 180 mg/L is hard; and more than 180 mg/L is very hard.[26] To account for the nonlinear aesthetic properties of hardness, we applied the rubric in Table 11 to score hardness. Figure 9 shows the distribution of hardness across Wisconsin utilities in 2020.

Hardness is immediately observable to many people, and so we weighted hardness at 25% of the total *Quality-Aesthetics* grade due to the inconvenience and costs that hard water has on

[25] https://dhs.wisconsin.gov/publications/p4/p45013b.pdf
[26] https://extension.psu.edu/water-softening

residential consumers' appliances and experiences with the water. The utilities for which DNR had hardness data in 2020 scored an average of 68.3 out of 100 for hardness.

**Table 11. *Quality-Aesthetics* grading rubric for hardness**

| Grade Range | Contaminant range (mg/L) |
|---|---|
| A | 60-120 |
| B | 17-60; 120-150 |
| C | <17; 150-180 |
| D | 180-360 |
| F | >360 |

Note: Numerical scores based on linear interpolation within grade ranges.
Scores reach zero at 500 mg/L.

### *Quality-Aesthetics* grades across Wisconsin

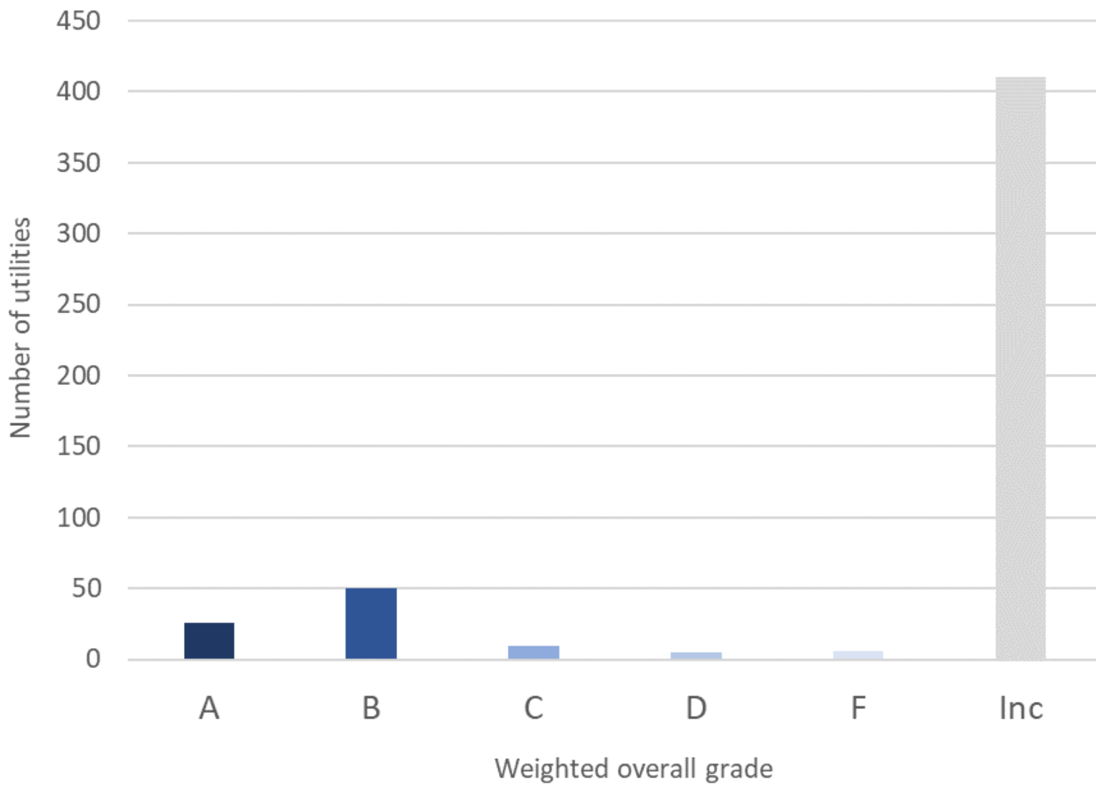
Although data are limited for *Quality-Aesthetics*, the overall grades for utilities that reported data to DNR are relatively high, with an average of 83.9% and median of 87.1% (see Table 12). Figure 10 depicts the statewide distribution of *Quality-Aesthetics* grades. In light of aesthetics' significance for customer perceptions and trust, we hope that more utilities will collect and report these secondary contaminants in the future.

**Table 12. Summary of *Quality-Aesthetics* scores, 2020***

| *All scores 0-100* | **Iron** | **Hardness** | **Manganese** | **Alkalinity** | **Chloride** | **Sulfate** | **Aluminum** |
|---|---|---|---|---|---|---|---|
| Average | 75.3 | 68.3 | 77.6 | 77.7 | 97.5 | 97.0 | 98.6 |
| Median | 94.1 | 65.7 | 94.1 | 76.4 | 98.8 | 98.8 | 100.0 |
| Maximum | 100.0 | 100.0 | 100.0 | 98.4 | 100.0 | 100.0 | 100.0 |
| Minimum | 0.0 | 0.0 | 0.0 | 0.0 | 76.6 | 4.8 | 64.0 |
| Standard Dev. | 35.2 | 17.5 | 35.1 | 11.1 | 4.2 | 8.7 | 4.6 |

*Excludes 410 utilities with Incomplete data.

**Figure 10. Distribution of *Quality-Aesthetics* grades, 2020**




## FINANCE

Pioneering environmental engineer Abel Wolman once observed that: "Just as there is no escape from a hydrologic cycle, there is no escape from the dollar."[27] Financial strength is crucial for a utility's sustainability, and affordability is critical for a utility's public health mission. Proper maintenance and operation of a utility's water infrastructure is expensive; a utility must be financially sound in order to be sustainable and affordable in the long term.

Financial performance is an ongoing challenge for water utilities. The water infrastructure that serves much of Wisconsin is old, and many of the state's communities are stagnant or shrinking in population.[28] Rising costs and emerging contaminants such as PFAS present challenges for community water systems that must sustain quality services. Balancing these needs with affordability is difficult.

[27] Wolman (1958).
[28] Bash et al. (2020).

## Elements of Finance grade

Our assessment of water utility financial strength involves measures of capital financing capacity and resiliency, as well as measures of affordability and proportionality in pricing. This section outlines the rubric for the Finance section of the report cards, and provides some data, including the grades for Wisconsin's municipal water systems. WSEP *Finance* grades rely on publicly available PSC data for 2020.

**Table 13. Components of the *Finance* grade**

| Metrics | Weight (%) |
|---|---|
| Financial strength | |
| Capital capacity: Debt-to-Asset Ratio | 20 |
| Financial performance: Return on Equity | 20 |
| Liquidity: Operating reserves | 20 |
| Rates and revenue | |
| Tax burden: PILOT ratio | 10 |
| Affordability: Hours at Minimum Wage | 20 |
| Proportionality: Poehler Index | 10 |

Table 13 summarizes the measures that comprise the *Finance* grade and the weight applied to each. Each of these elements is reported in detail, below.

### *Capital financing capacity: Debt-to-Equity Ratio*

Debt-to-Equity ratio (D/A ratio) is a conventional, time-honored measure of a utility's overall debt obligations relative to its assets, and so reflects the degree to which the utility relies on debt to finance its infrastructure and operations. Crucially for sustainability purposes, the D/A ratio measures a utility's capacity to finance significant capital needs and control its own financial fate. In general, a low D/A ratio indicates financial strength, flexibility, and a capacity to take on significant new costs should they become necessary. A high D/A ratio indicates a financially constrained utility that may be forced to raise rates dramatically in order to pay for needed investments.

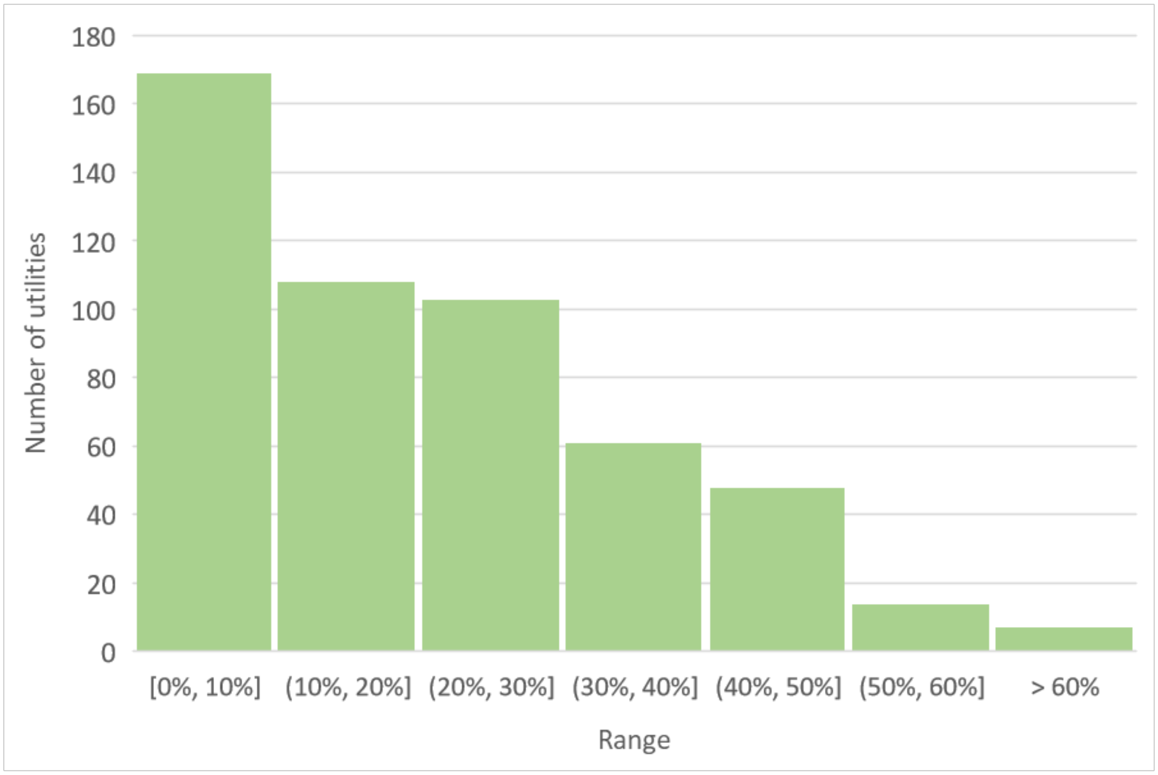
**Table 14. *Finance* scoring rubric for debt-to-asset ratio**

| Grade Range | Debt-to-Asset Ratio (%) | Score Range |
|---|---|---|
| A | 0-20 | 90-100 |
| B | 20-30 | 80-90 |
| C | 30-45 | 70-80 |
| D | 45-60 | 60-70 |
| F | >60 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at 75% D/A ratio.

We calculated D/A ratio by dividing the "outstanding debt" by "total assets" from the publicly available data from the Public Service Commission of Wisconsin. Table 14 shows the scoring rubric we applied to Wisconsin utilities.

**Figure 11. Distribution of debt-to-asset ratio, 2020**



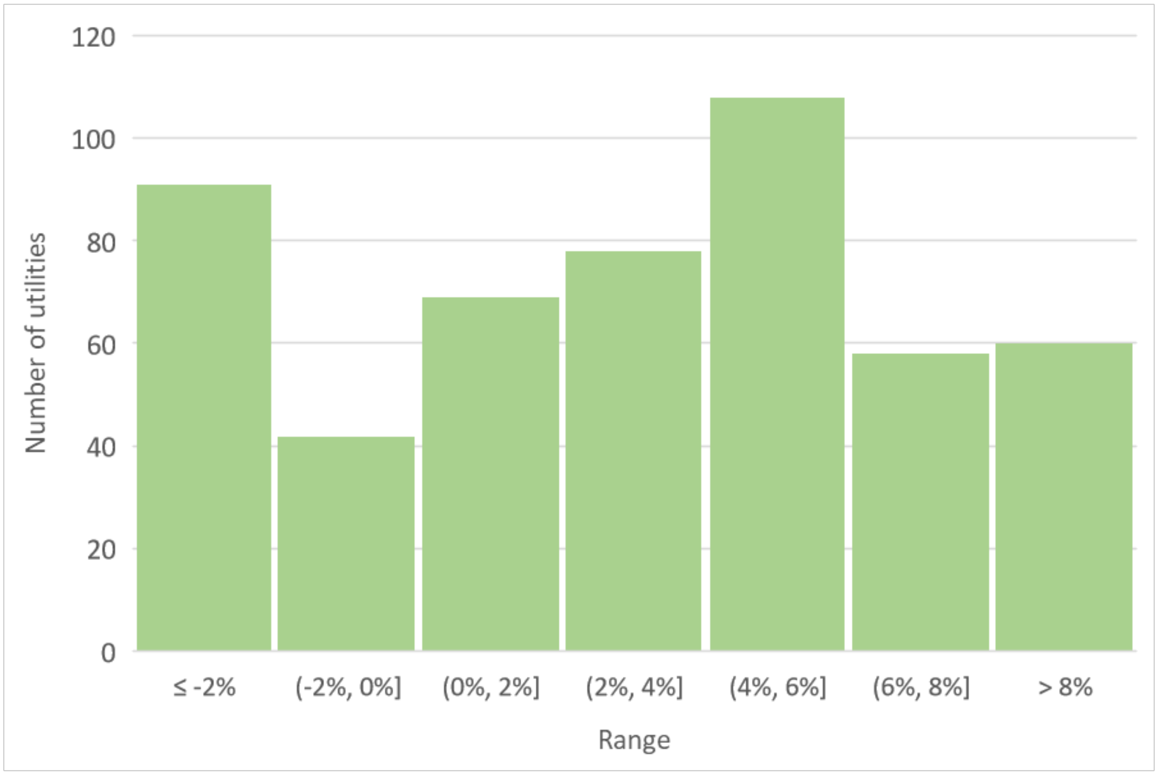

As Figure 11 indicates, a substantial majority of Wisconsin's water utilities enjoyed strong D/A ratios in 2020. These ratios translated into strong WSEP performance, with an average score of 89.4 and median of 96.0; nearly 75% of Wisconsin utilities earned A or B grades for D/A ratio.

**Table 15.** ***Finance*** **scoring rubric for Return on Equity**

| Grade Range | Return on Equity (%) | Score Range |
|---|---|---|
| A | >4.0 | 90-100 |
| B | 3.0-4.0 | 80-90 |
| C | 2.0-3.0 | 70-80 |
| D | 0.0-2.0 | 60-70 |
| F | -2.0-0.0 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at -2.0% ROE.

**Figure 12. Distribution of return on equity, 2020**




*Financial performance: Return on Equity*

Return on Equity (ROE) is a utility's net income divided by its financial equity. ROE is a measurement of a utility's profitability and how efficiently it generates those "profits."[29] A lower ROE can minimize rate increases, but also can lead to decreased cash flow that can stunt future capital investment in the long term. A higher ROE indicates stronger financial conditions and ability to provide returns for debt management and future investment, while a lower ROE indicates a utility in more precarious financial condition. Calculating ROE followed the PSC's methodology; Appendix A reports the ROE methodology in detail.

Utilities earned ROE scores according to the ranges specified in Table 15. Wisconsin water utilities' average ROE scores in 2020 was 67.3, but as Figure 12 shows, ROE was irregularly distributed: more than half scored in the A range, but another 40% were in the D-F range, while just 9% received grades in the C range.

*Liquidity: Days of Operating Reserve*

Water utility systems have no margin for failure, as they are expected to provide uninterrupted service 24 hours a day, 7 days a week, 365 days a year. Maintaining adequate operating reserves enhances a water system's ability to manage potential risks and meet capital needs and other unanticipated events that might hinder short-term cash flow. The level of operating

[29] The PSC provides data on "Return on Rate Base" but not return on equity. Return on rate base is the value of the utility's assets minus accumulated depreciation, and return on equity, ideally, should result in a net operating income that provides for the cost of debt and a fair return on equity for investors.

reserves maintained by a water system is important for both short- and long-term financial management.

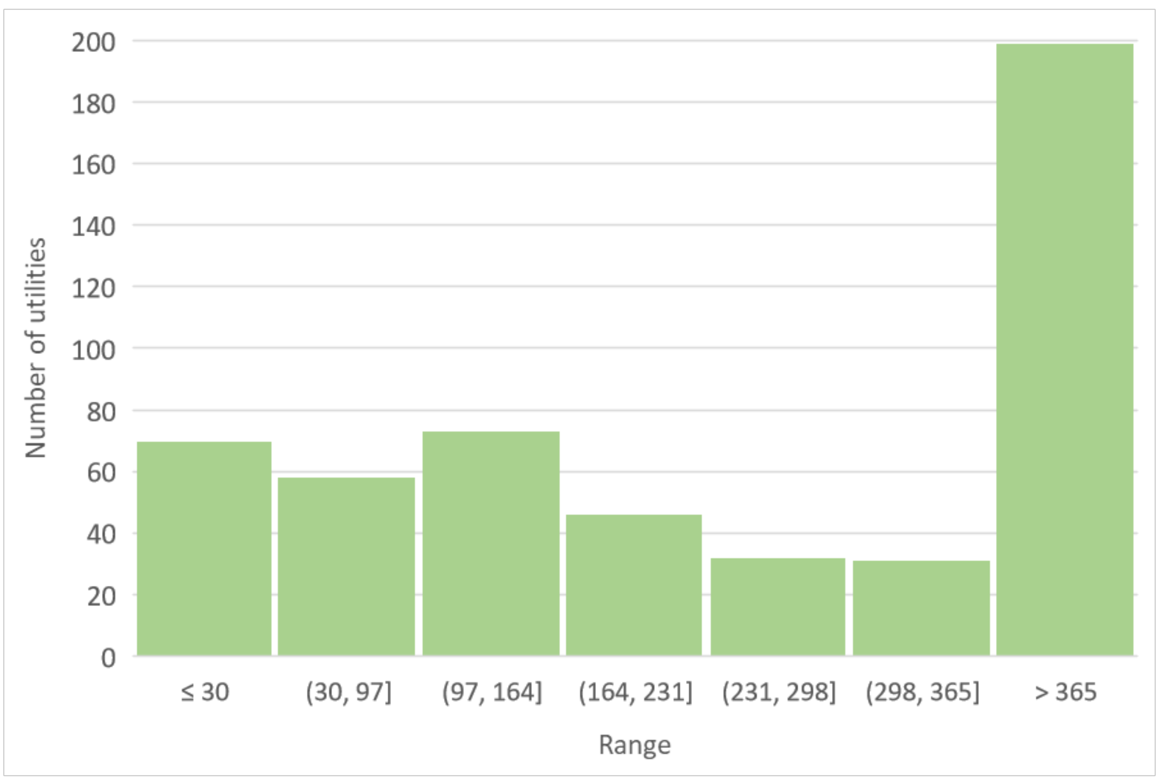
WSEP evaluates financial liquidity in terms of *days of operating reserve,* which is calculated by taking the total cash balance at the end of the year and dividing it by the total operating expenses per day. This calculation gives us the total days of operating reserve. For days of operating reserve, the higher the number of days, the more capacity the utility has to manage risk, and therefore the higher the grade earned by the utility. Utilities with fewer days of operating reserve have less capacity to manage short-term financial risk, and so earn lower marks. Table 16 reports our scoring rubric for days of operating reserve.

**Table 16. *Finance* scoring rubric for days of operating reserve**

| Grade Range | Days of Operating Reserve | Score Range |
|---|---|---|
| A | 270-210 | 90-100 |
| B | 210-150 | 80-90 |
| C | 150-120 | 70-80 |
| D | 120-90 | 60-70 |
| F | <90 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at 30 days.

**Figure 13. Distribution of days of operating reserve, 2020**



Like ROE, Wisconsin water utilities' liquidity as measured in days of operating reserve was bimodally distributed in 2020. As Figure 13 shows, well over half had ample operating reserves and scored in the A range. At the same time, another 31% were in the D-F range, while just 14% received grades in the B-C range. Taken together these results show a stark divide between a majority of financially resilient utilities and a sizeable minority of financially precarious utilities.

#### *PILOT Ratio*

Tax-exempt properties do not contribute to the operation of municipal governments to the same extent that non-exempt properties do. Wisconsin law defines properties that are eligible for tax exemption; entities that meet the legal criteria for exemption are not required to pay local property taxes. Common tax-exempt entities include nonprofit organizations, churches, hospitals, state agencies, federal agencies, and universities. Municipal utilities also are tax exempt in Wisconsin. However, municipal utilities may transfer utility revenue to their general government owners as "Payments in lieu of taxes" or "PILOT."

Unlike PILOT arrangements for tax-exempt entities such as non-profits, hospitals, and universities, water PILOTs are effectively taxes that municipalities charge to their own utilities and, ultimately, their ratepayers. Although water utility PILOT is in effect another form of taxation, it is regressive because residential water prices are relatively insensitive to income (unlike, for example, property taxes). Municipalities that use their utilities to extract tax revenue through PILOT effectively hide and shift their local tax burden to ratepayers rather than property owners.[30] Municipal utilities should minimize PILOTs by their own water systems as a matter of efficiency, transparency, and fairness.

**Table 17. *Finance* scoring rubric for PILOT ratio**

| Grade Range | PILOT to Property Tax Equivalent Ratio | Score Range |
|---|---|---|
| A | 0.00-0.50 | 90-100 |
| B | 0.50-0.95 | 80-90 |
| C | 0.95-1.05 | 70-80 |
| D | 1.05-1.15 | 60-70 |
| F | >1.15 | 0-60 |

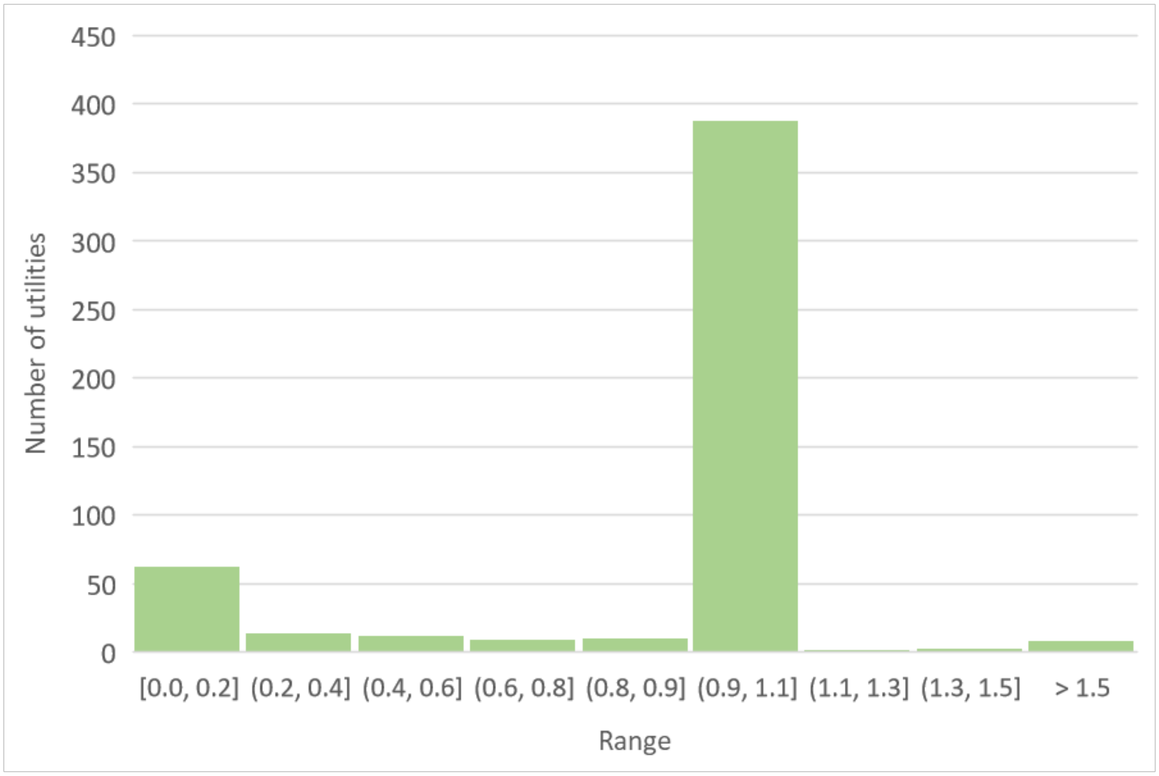
Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at 2.0 PILOT ratio.

For grading purposes, the "PILOT Ratio" is the ratio of annual PILOT payments by the utility to the municipality to the property tax equivalent, which is the assessed property value and associated tax that a utility *would* have paid if it were a privately owned business. A lower value for this metric indicates that there is little to no PILOT, and higher value indicates that a utility pays significantly more in PILOT than the property tax equivalent value. Those utilities and municipalities with a value of 1.0 indicates that the PILOT and property tax equivalent value are

[30] Teodoro (2021).

identical. A PILOT Ratio of 0.0 earns a perfect 100 score, a ratio of 1.0 earns 75, and ratios greater than 1.15 fall into failing range. Table 17 shows this rubric.

**Figure 14. Distribution of days of PILOT ratio, 2020**




Wisconsin water utilities' PILOT ratio score averaged 78.1. As Figure 14 shows, a large majority of utilities made PILOT payments at or near their property tax equivalents, and so earned marks in the C range. However, 17% of utilities made little or no PILOT payments and so earned scores at or near 100. Meanwhile, a small minority of utilities—about 3.1%—paid significantly more in PILOT than their property tax equivalents and so earned marks in the D-F range.

*Affordability: Hours at Minimum Wage*

So long as water utilities operate on a fee-for-service basis and rely on rate revenue, the affordability of basic service will be critical to their fundamental missions. At a time when many utilities are facing infrastructure challenges, financial constraints, shifts in demographics, and water quality and quantity concerns, we should all be concerned about utilities taking on large amounts of debt or passing these costs on to ratepayers by increasing rates.

We calculate affordability as hours of labor at minimum wage (HM) required to pay for residential water service at 6,000 gallons per month (typical indoor use for a family of four).[31] HM helps illustrate affordability in an intuitively meaningful way. It simply asks, "how many hours at the minimum wage would one need to work each month to afford their water bills?"

[31] Teodoro (2018).

This metric is gaining traction in several communities across the country and has been adopted formally as a utility affordability metric by the California Public Utilities Commission.[32] Table 18 shows the scoring rubric we applied to residential prices in order to calculate affordability marks for utilities.

HM carries some important limitations as a metric of affordability. First, HM is not sensitive to the costs of other essential goods and services, such as housing, health care, food, home energy, or taxes. Second, minimum wage is a problematic standard of purchasing power, especially in places such as Wisconsin, where the minimum wage remains at the federal minimum wage of $7.25. This minimum wage has not been changed since 2009, and thus is so low that it is functionally meaningless in much of the state and country. Further, in the aftermath of the COVID-19 pandemic, supply chain and labor challenges, wages (and inflation) have increased at a much faster pace than minimum wage laws.

**Table 18. *Finance* scoring rubric for Hours at Minimum Wage to pay for a month of residential water service at 6,000 gallons**

| Grade Range | Hours of Minimum Wage | Score Range |
|---|---|---|
| A | 1.5-4.0 | 90-100 |
| B | 4.0-6.0 | 80-90 |
| C | 6.0-8.0 | 70-80 |
| D | 8.0-10.0 | 60-70 |
| F | >10.0 | 0-60 |

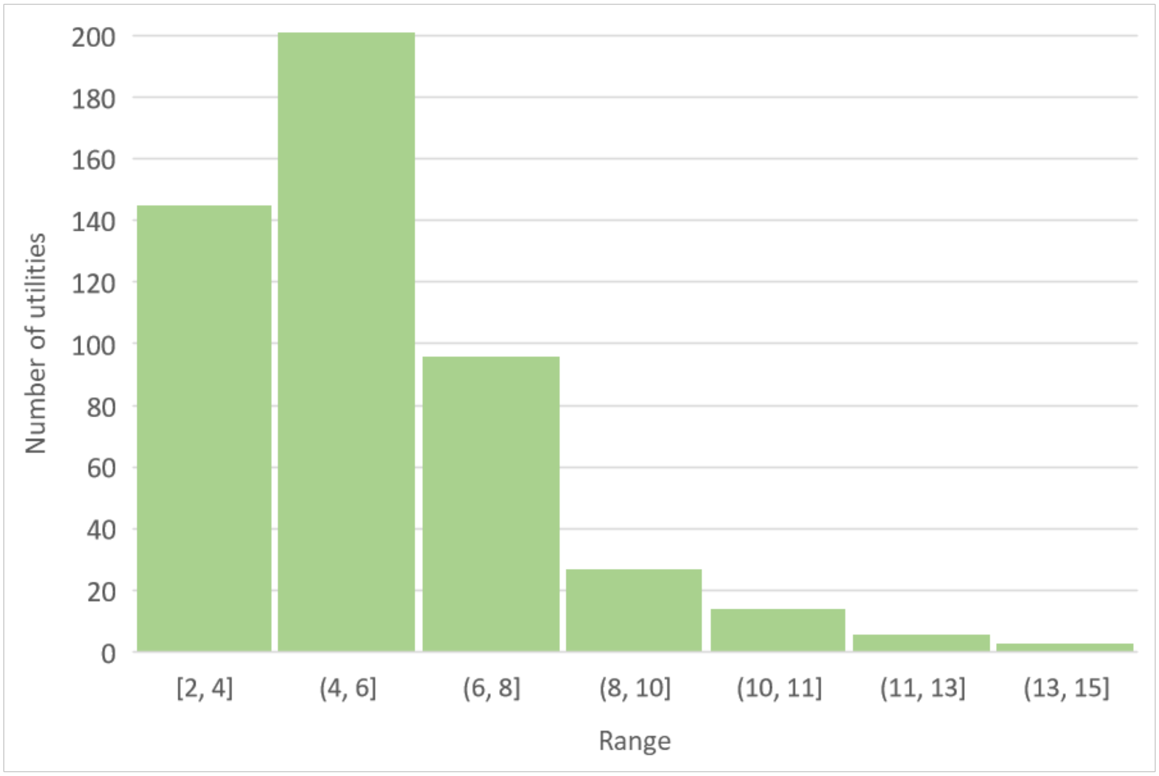
Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at 22.0 HM.

When developing this metric, we discussed using a figure more aligned with the "real minimum wage" in Dane County, Wisconsin (roughly $12.50-$14.50 in 2020), but for purposes of consistency we decided it would be better to rely on the state's minimum wage and simply bear in mind its limitations.

Wisconsin water utilities' overall performance on affordability was very strong in 2020, with an average score of 85.3 and a median of 87.5. More than a third of utilities earned scores in the A range, and three quarters scored in the B range or better, as Figure 15 shows.

[32] https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/affordability

**Figure 15. Distribution of hours at minimum wage required to pay for a month of residential water service, 2020**




*Proportionality: Poehler Index*

In addition to raising revenue, water rates distribute a water utility's costs to its customers in different ways. Most utilities charge a combination of fixed and volumetric prices, but these prices may collect more or less revenue from different customers depending on how much water they use. According to the principle of *proportionality,* customers who use more water should pay higher prices per unit consumed; customers who use less should pay less.

To that end, we measure price proportionality or progressivity, with the "Poehler Index."[33] Its name derives from the 2015 drought in California, when Amy Poehler's Beverly Hills home used an astonishing 85,000 gallons of water per month for her family of four.[34] The Poehler index measures progressivity – by calculating the total monthly water bill for a customer at 6,000 gallons (a relatively conservative family), and at 85,000 gallons (Amy Poehler), then dividing that price by each customer's total volume to arrive at average unit costs of water at each level of consumption. The ratio of the two unit prices is the Amy Poehler Index (API) or Poehler Index.

A value of 1.0 means that Amy Poehler and the conservative family pay the same unit price for water. Values less than 1.0 indicate regressive rates (Amy Poehler pays less than a conservative

[33] https://mannyteodoro.com/?p=1400.

[34] Brodwin and Mosher (2016).

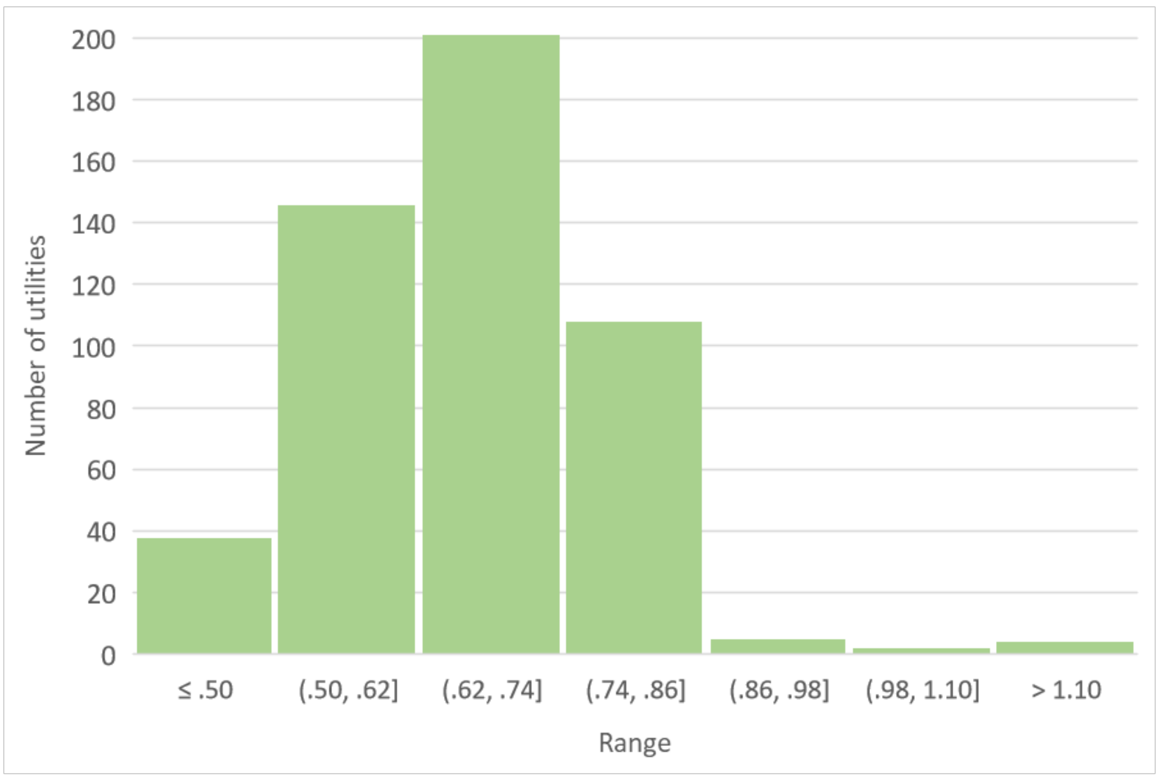
family), and values greater than 1.0 indicate progressive rates (Amy Poehler pays more than a conservative family). Table 19 shows the scoring rubric we applied to residential prices in order to calculate price proportionality marks for utilities.

**Table 19. *Finance* scoring rubric for the Poehler Index**

| Grade Range | Amy Poehler Index | Score Range |
|---|---|---|
| A | 3.00-1.75 | 90-100 |
| B | 1.75-1.25 | 80-90 |
| C | 1.25-0.75 | 70-80 |
| D | 0.75-0.50 | 60-70 |
| F | <0.50 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at Poehler Index = 0.4.

**Figure 16. Distribution of Amy Poehler Index, 2020**




Price proportionality scores were generally mediocre to poor across Wisconsin water utilities in 2020, with an average score of 58.3, and a median of 82.8. Roughly a third of utilities scored in failing range, and 64.2 percent earned D range grades, as Figure 16 shows. No utilities earned an A grade for price proportionality, and just one (Madison Water Utility) scored in the B range.

These poor proportionality marks reflect the predominant rate structures in Wisconsin, where most utilities use a combination of a fixed monthly charge and uniform or declining volumetric charges. These rate structures effectively charge higher unit prices to more conservative residential customers and lower prices to higher volume water users. Perhaps unsurprisingly, progressive pricing is more common in more water-scarce regions of the United States, where inclining block rate structures are meant to encourage conservation; promoting residential water efficiency is a less pressing concern in water-rich Wisconsin. Nonetheless, equity considerations make pricing proportionality an important aspect of financial performance.

### *Finance* grades across Wisconsin

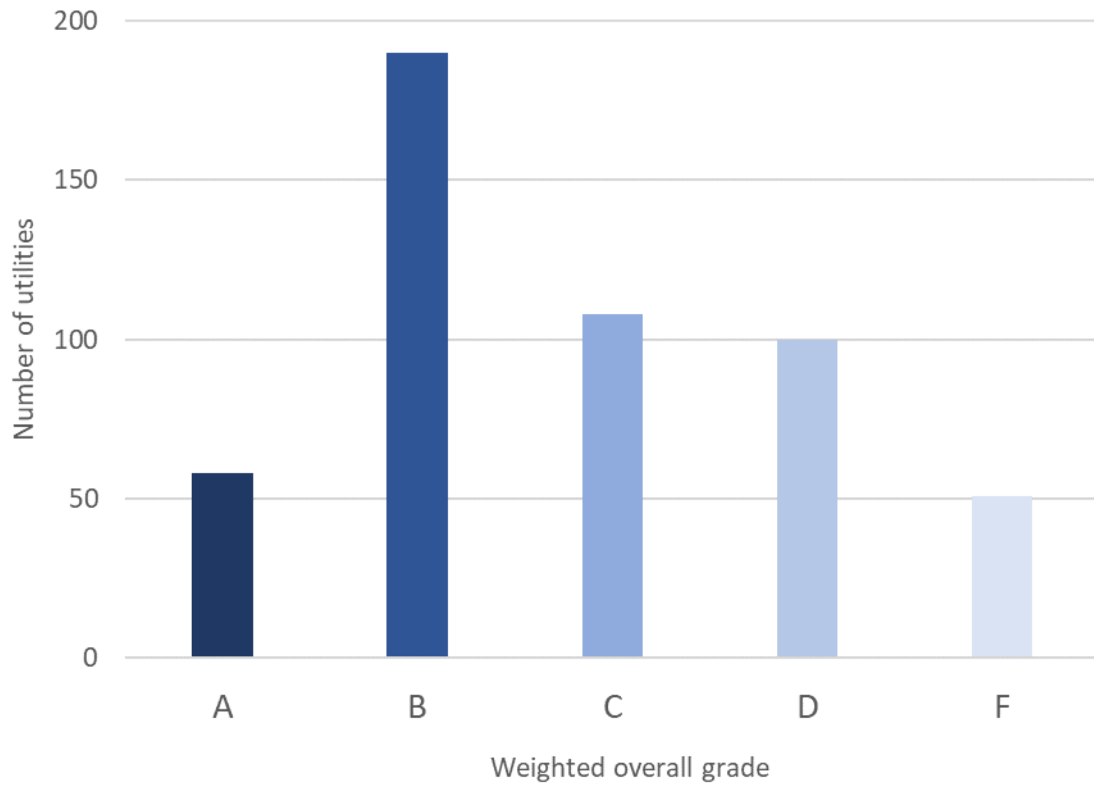
Overall grades for *Finance* in 2020 statewide were widely distributed, skewing somewhat high. Table 20 and Figure 17 depict these scores and their corresponding grades statewide. The average overall score was 76.3 and median was 79.6, but as Figure 17 shows, the modal grade was in the B range.

**Table 20. Summary of *Finance* scores, 2020**

| *All scores 0-100* | D/A Ratio | ROE | Operating Reserves | PILOT Ratio | HM | Poehler Index | Overall Grade |
|---|---|---|---|---|---|---|---|
| Average | 89.3 | 67.6 | 72.9 | 78.2 | 85.3 | 58.4 | **76.3** |
| Median | 96.0 | 82.0 | 96.7 | 75.0 | 87.5 | 64.0 | **79.6** |
| Maximum | 100.0 | 100.0 | 100.0 | 100.0 | 99.0 | 84.0 | **95.4** |
| Minimum | 0.0 | 0.0 | 0.0 | 0.1 | 33.8 | 0.0 | **0.0** |
| Standard Dev. | 13.8 | 37.8 | 37.3 | 12.3 | 10.0 | 16.1 | **13.4** |

These mixed results reflect some divergent underlying scores. Most Wisconsin utilities scored strongly on D/A ratio and affordability. On the other hand, ROE and operating reserves were bimodally distributed, with utilities having either very strong or very weak scores on these metrics. Performance was especially poor on price proportionality, since most Wisconsin utilities employ flat or declining block rate structures.

**Figure 17. Distribution of *Finance* grades, 2020**




## INFRASTRUCTURE & OPERATIONS

Physical integrity and operational effectiveness are both essential to water system excellence. Early in WSEP's development, we anticipated grading *infrastructure* and *operations* as separate subjects. However, after extensive exploration, discussion, and consultation with experts it became clear that operations and infrastructure are inextricably linked. That is, the physical integrity of a water system is directly related to how that system operates, and vice versa. Excellent management of any utility involves optimizing the mix of capital, labor, and other operating expenses. It follows that we should evaluate the two separately, but that their evaluations should contribute equally to an overall *Infrastructure & Operations* grade.

Table 21 shows how various metrics associated with infrastructure quality and operational efficiency contribute to total *Infrastructure & Operations* grades.

**Table 21. *Infrastructure & Operations* grade weights**

| Factor | Weight (%) |
|---|---|
| Infrastructure | |
| Main breaks | 25.00 |
| Water loss | 12.50 |
| Main replacement rate (unweighted) | 6.25 |
| Main replacement rate (size weighted) | 6.25 |
| Operations | |
| Energy consumption | 10.00 |
| Operating expense per 1,000 gallons | 7.50 |
| Operating expense per mile of main | 7.50 |
| Operating expense per customer | 7.50 |
| Operating expense per capita | 7.50 |
| SDWA management compliance | 10.00 |

### Infrastructure

Infrastructure accounts for half of the *Infrastructure & Operations* grade. Water utilities' infrastructure needs vary widely, depending on their source water, hydrological conditions, and customer demands. Most obviously, surface water and ground water sources require very different kinds of water treatment facilities and processes. In crafting our rubric, we consulted with drinking water engineering experts, as well as resources from the Water Research Foundation[35] and American Water Works Association.[36] In order to establish universally applicable grading standards with available data, our infrastructure grade focuses on transmission and distribution systems. These metrics include main and service breaks per 100 miles of main, water loss per 100 miles of main, and replacement rate.

By excluding other elements of infrastructure we do not mean to diminish their importance; our interest here is in crafting a rubric that can apply to all utilities. Future WSEP efforts may include development of specific infrastructure rubrics for surface and ground water systems.

### Main Breaks per 100 Miles of Main

Main breaks are critical and tangible indicators of a drinking water system's integrity. Each main break is literally a system failure, as it potentially disrupts homes, businesses, schools, and governments. Moreover, main breaks risk loss of water pressure and can lead to the introduction of biological pathogens into a potable water supply. Customers who experience main breaks report lower trust in their tap water and reduced trust in government generally.[37] In light of their gravity, we weighted main breaks as 50% of the *infrastructure* grade, and therefore 25% of the total *Infrastructure & Operations* grade.

[35] Friedman (2010).
[36] American Water Works Association (2022).
[37] Teodoro, Zuhlke, and Switzer (2022).

Following AWWA convention, breaks per 100 miles of main per year is our measure of main breaks. According to the Partnership for Safe Water, main break frequency should be no greater than 15 breaks per 100 miles of distribution pipelines.[38] To calculate this metric, we simply counted the total number of "main breaks" and "service breaks" for each utility in 2020 as recorded by the PSC. Table 22 shows the rubric we applied to score main breaks:

**Table 22. *Infrastructure & Operations* scoring rubric for main breaks per 100 miles**

| Grade Range | Breaks per 100 miles of main | Score Range |
|---|---|---|
| A | <15 | 90-100 |
| B | 16-20 | 80-90 |
| C | 21-25 | 70-80 |
| D | 26-30 | 60-70 |
| F | >30 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at 60 breaks per 100 miles of main.

**Figure 18. Distribution of breaks per 100 miles of main, 2020**

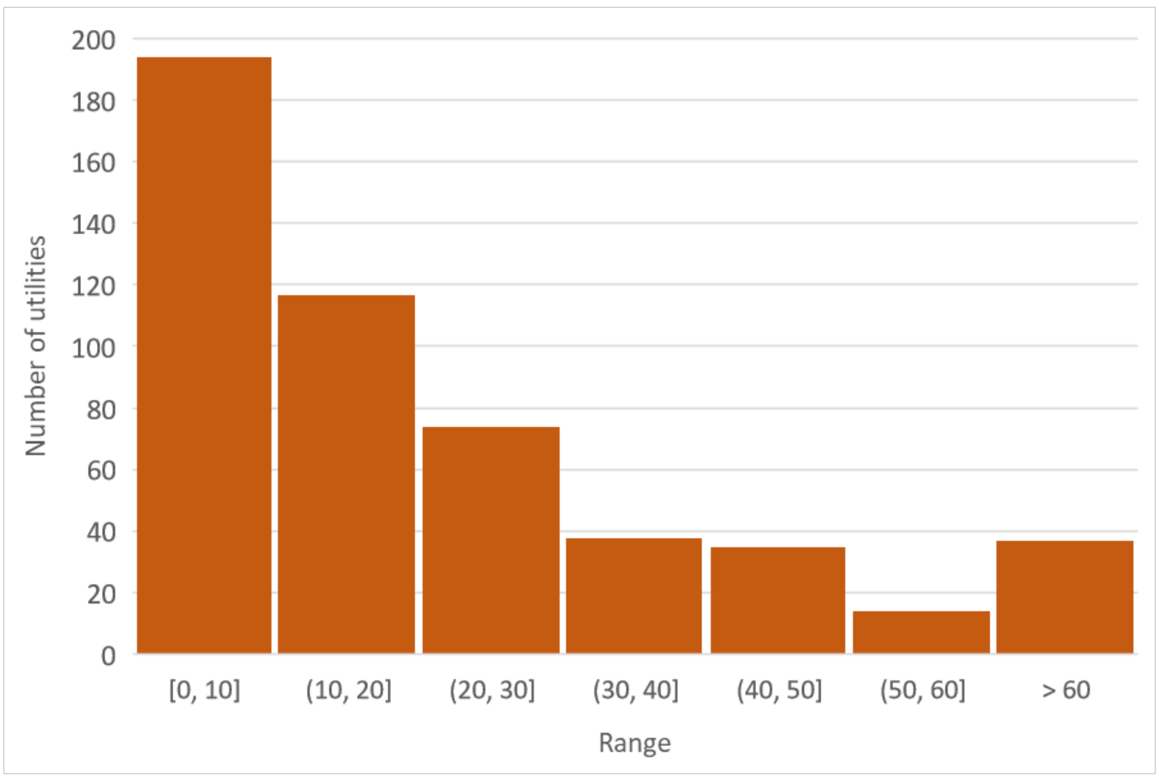



Figure 18 shows the distribution of breaks per 100 miles of main in 2020 across Wisconsin. About half performed very strongly, with fewer than 15 breaks per 100 miles of main; 38

[38] Friedman (2010).

utilities reported no main breaks at all in 2020. On the other hand, 23.1% of the state's utilities scored in the failing range with more than 30 breaks a year per 100 miles of main.

### Water Loss per 100 Miles of Main

Water loss is another critical indicator of drinking water system integrity and capital condition; it comprises 25% of the total *Infrastructure* grade. Following AWWA guidance, we measure water loss as water lost in gallons per 100 miles of main, rather than water loss as a percentage of total water produced. The data are from the Public Service Commission of Wisconsin's municipal utilities data portal. Table 23 shows the rubric we applied to score water loss:

**Table 23. *Infrastructure & Operations* scoring rubric for water loss per 100 miles of main**

| Grade Range | Water loss per 100 miles of main (thousand gallons) | Score Range |
|---|---|---|
| A | 0-20 | 90-100 |
| B | 20-40 | 80-90 |
| C | 40-80 | 70-80 |
| D | 80-120 | 60-70 |
| F | >120 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at 250,000 gallons lost per 100 miles of main.

**Figure 19. Distribution of water loss per 100 miles of main (thousands of gallons), 2020**

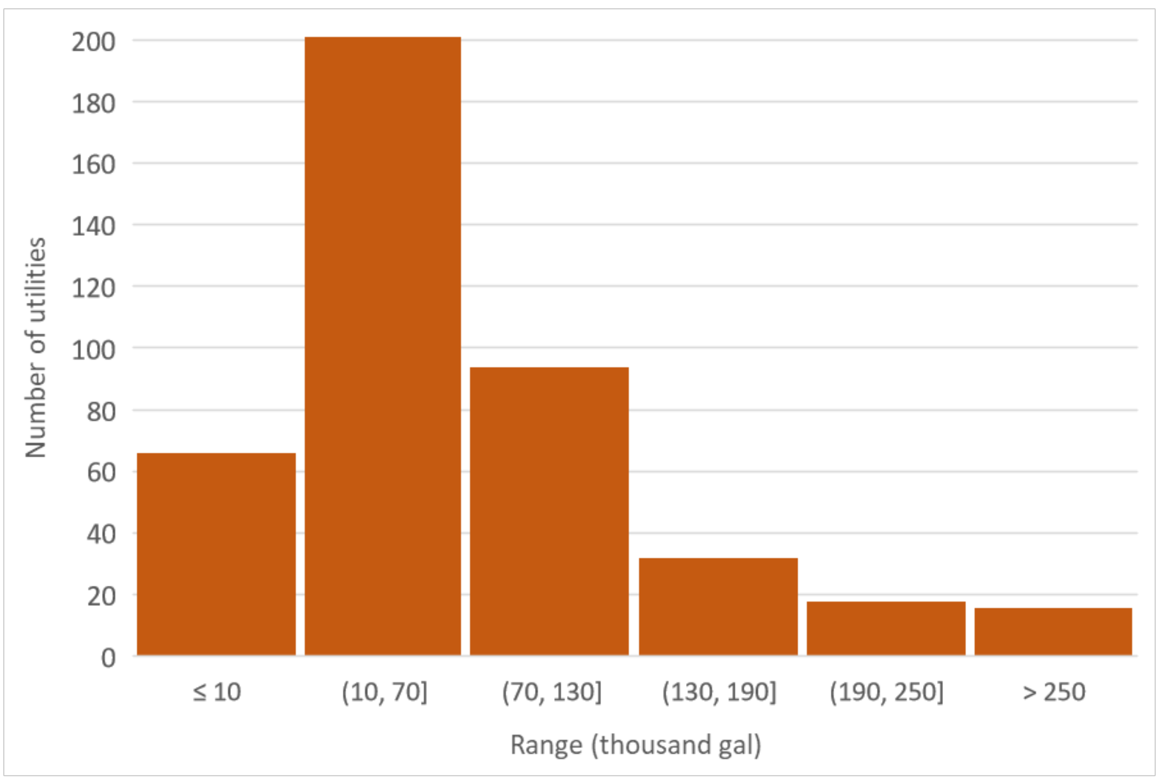


Figure 19 shows the distribution of water loss per 100 miles of main in 2020 across Wisconsin. Performance was mixed: 42.9% of utilities scored in the A or B ranges, but another 15.3% scored in the failing range.

### Main Replacement Rate

Regular, ongoing asset replacement is critical to a healthy utility, and so replacement rate comprises another 25% of the infrastructure grade, or 12.5% of the overall *Infrastructure & Operations* grade. Maintaining a steady pace of replacements helps ensure reliable, resilient service and avoids "rate shocks" that can occur when assets fail and require major investments.

We measure replacement rate as feet of distribution pipe added per year, divided by the total length of main in service for each water utility. We transform this value into a "replacement rate," which is effectively the number of years required to replace the entire distribution system if replacements continue at their current pace. Since asset replacement often is "lumpy" (i.e., large investments in single years with little or no investment in others), we calculated replacement rate as a five-year rolling average. Thus, the values calculated here for 2020 include distribution system replacements from 2016-2020.

We calculated this replacement rate twice: once as a simple average replacement rate, and once as a weighted average replacement rate with larger mains weighted more heavily than smaller mains based on their flow capacity (discussed further, below). These unweighted and weighted averages contribute equally (6.25% each) to the *Infrastructure & Operations* grade.

A 2018 Utah State University study on main breaks and drinking water infrastructure provided useful context for developing our replacement rate scoring methodology.[39] The study indicated that replacement rates should be between 1% and 1.6%, equating to 100 – 106-year replacement schedules. If a utility did not have any new feet of pipe added during the 5-year period, we coded their replacement rate as 1,000 years, and they received 0 points (0%) for this grade. Table 23 shows the rubric we applied to score replacement rate:

**Table 23. *Infrastructure & Operations* scoring rubric for main replacement rate in years**

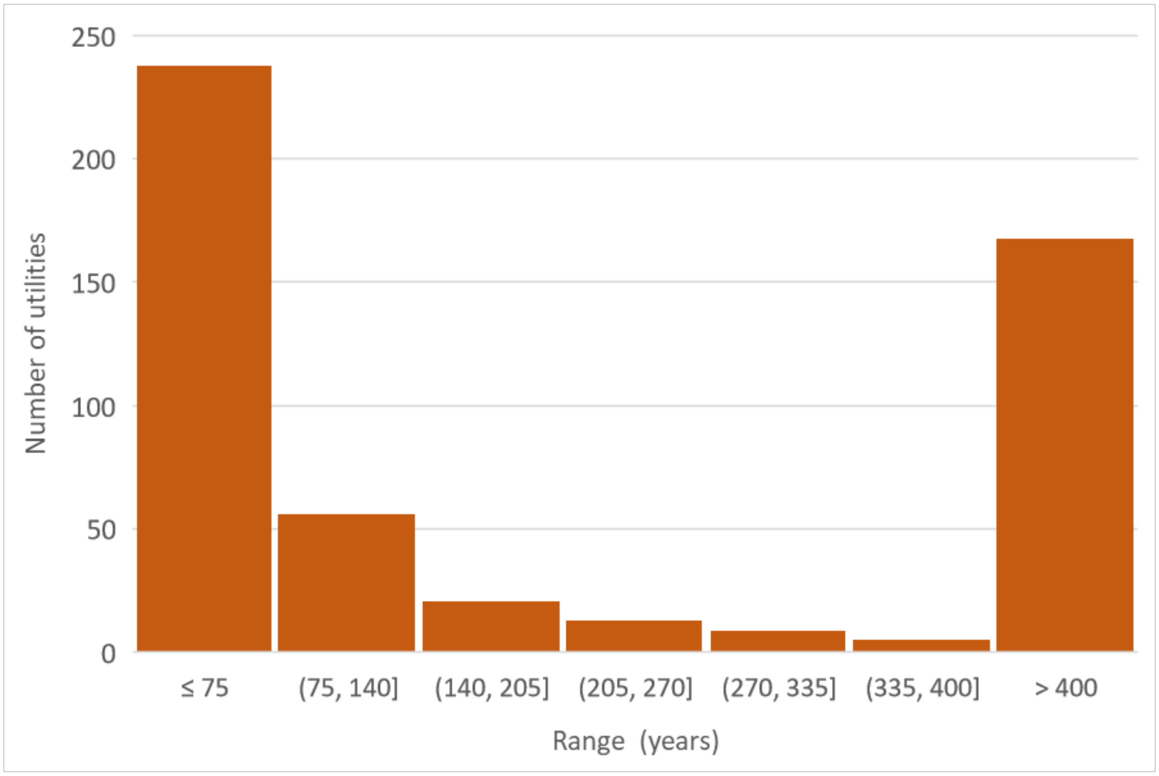
| Grade Range | Replacement Rate (years required to replace entire system) | Score Range |
|---|---|---|
| A | 0-75 | 90-100 |
| B | 75-125 | 80-90 |
| C | 125-175 | 70-80 |
| D | 175-225 | 60-70 |
| F | >225 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at 400 years. Systems with zero distribution system replacements from 2016-2020 were scored zero.

[39] Folkman (2018).

The distribution of main replacement rate in Figure 23 reveals a stark divide in capital replacement investment in 2020. Close to half (46.1%) of Wisconsin's water utilities earned grades in the A range, with replacement rates of under 75 years. At the same time, more than a third (37.3%) of the state's utilities fell into the failing range; 148 of those utilities replaced no mains at all from 2016-2020.

**Figure 20. Distribution of main replacement rate (years), 2020**



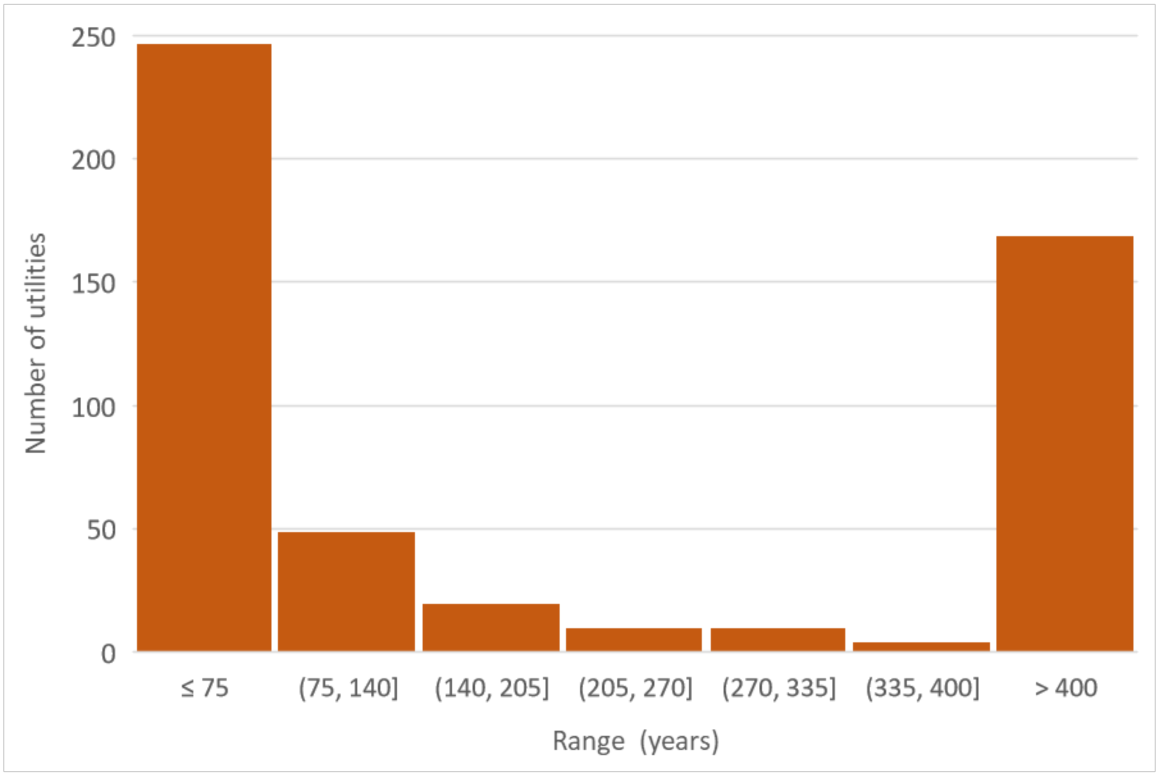

## Weighted Main Replacement Rate

Although all water mains are important, they are not all equally important to a drinking water system. Large diameter mains are most critical, since they carry water to large facilities and large numbers of customers; smaller mains serve fewer customers. Recognizing these differences, we also calculated an average replacement rate that weighs main replacement as a function of main size.

As with unweighted replacement rate, we calculated weighted average replacement rate as the average number of feet of main replaced over a five-year period (2016-2020) relative to the utility's total feet of main in service. However, for this metric we weighted feet of main replaced according to a flow factor based on pipe diameter, velocity, and maximum flow. The "number of feet" was then multiplied by its flow weight, which gave us a "weighted replacement rate. Appendix B reports the flow weights used in this calculation.

As with the unweighted replacement rate, if a utility added no new pipe during the 5-year period, we coded their replacement rate to be 1,000 years – therefore giving them 0 points for this grade. Scoring for weighted average replacement rate followed the same rubric as applied to unweighted replacement rate (see Table 23).

**Figure 21. Distribution of diameter-weighted main replacement rate (years), 2020**




Unsurprisingly, the weighted distribution of main replacement closely resembles the unweighted distribution, as the bimodal distribution in Figure 21 indicates.

### Operations

Operations accounts for the other half of the *Infrastructure & Operations* grade. The operations metrics employed here include measures of efficiency, including energy consumption relative to production and various measures of operating expenses. Compliance with SDWA management requirements also contributes to the *Infrastructure & Operations* grade.

#### Energy Consumption: kWh per million gallons per year

Energy is one of the largest operating expenses for many utilities, so energy efficiency is an important indicator of operational performance. Following the AWWA Benchmarking report, WSEP uses kBTU per million gallons per year as the metric of energy use. We calculate this metric by dividing total energy consumption in kilowatt hours (kWH) per year by total water sold in millions of gallons (MG). Table 24 shows the scoring rubric for energy consumption.

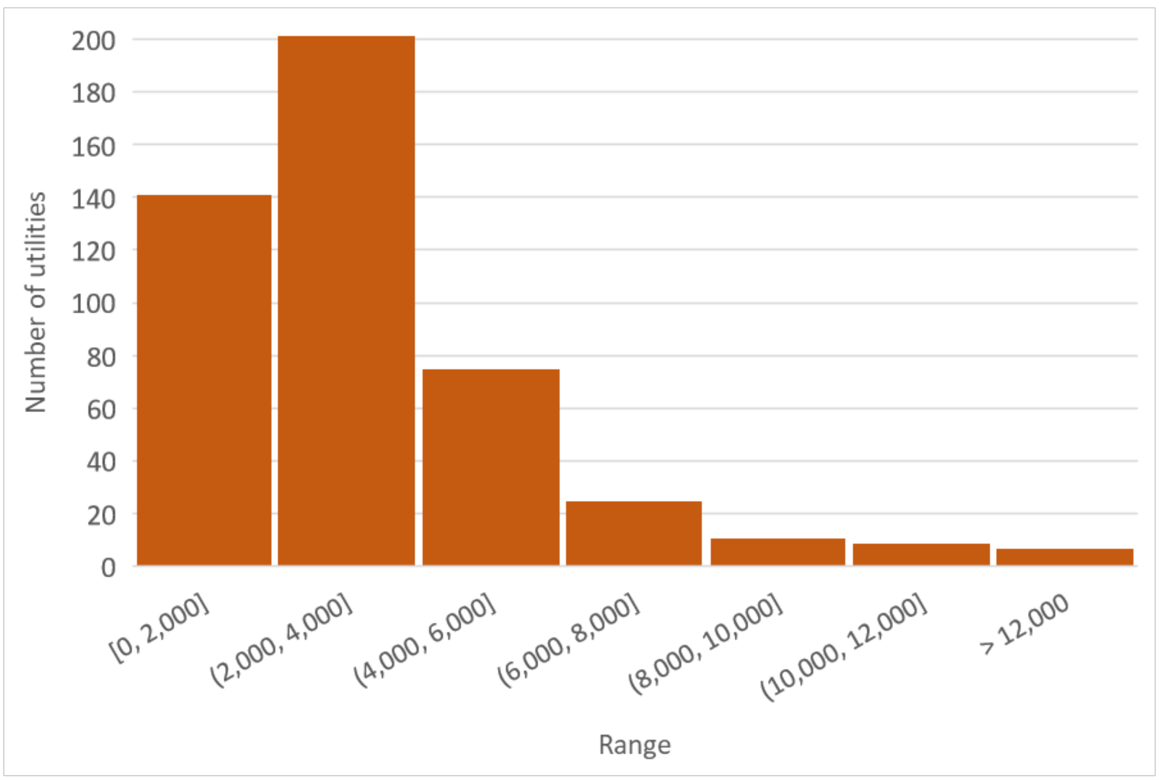
**Table 24.** ***Infrastructure & Operations*** **scoring rubric for energy consumption**

| Grade Range | Energy consumption (kWH per million gallons) | Score Range |
|---|---|---|
| A | 0-1,500 | 90-100 |
| B | 1,500-3,000 | 80-90 |
| C | 3,000-4,500 | 70-80 |
| D | 4,500-6,000 | 60-70 |
| F | >6,000 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at 12,000 kWH/MG.

Figure 22 shows that energy efficiency was relatively strong across Wisconsin utilities in 2020, with 58.1% earning marks in the A-B range. However, a sizable minority of utilities scored in the failing range, consuming more than 6,000 kWH for every million gallons of water sold.

**Figure 22. Distribution of energy consumption (kWH/MG), 2020**



### Total Operating Expenses per Thousand Gallons

Operating expenditures contribute directly to the rates that customers pay. WSEP grades evaluate operating efficiency in four different ways, starting with total operating expenses per thousand gallons of water sold. Table 25 shows the scoring rubric we applied to operating expenses per thousand gallons. This rubric reflects the distribution of results for 2020 and is likely to change in the future due to overall cost inflation.

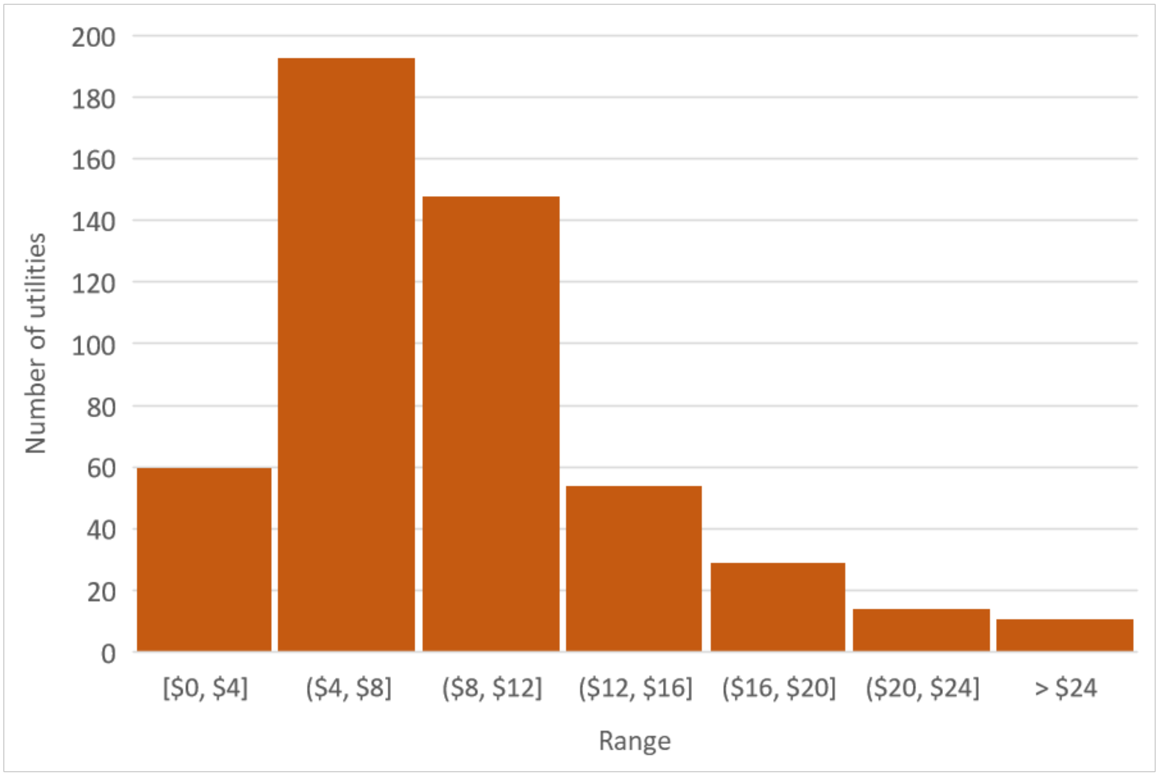
**Table 25. *Infrastructure & Operations* scoring rubric for operating expenses per 1,000 gallons**

| Grade Range | Total Operating Expenses per 1,000 Gallons ($) | Score Range |
|---|---|---|
| A | 0.25-5.00 | 90-100 |
| B | 5.00-8.00 | 80-90 |
| C | 8.00-12.00 | 70-80 |
| D | 12.00-16.00 | 60-70 |
| F | >16.00 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at $24.00 per thousand gallons.

Figure 23 shows the distribution of operating expenses per thousand gallons of water sold in 2020 across Wisconsin utilities. Performance on this measure of energy efficiency was generally strong in 2020, with 23.1% of utilities earning marks in the A range, and another 57.5% earning grades in the B-C range. However, nearly 10 percent scored in the failing range, with operating expenses of greater than $16.00 per thousand gallons.

**Figure 23. Distribution of total operating expenses per 1,000 gallons ($)**




## Total Operating Expenses per Mile of Main

As a complement to operating expenses per thousand gallons, we also calculated total operating expenses per mile of main as an indicator of operational efficiency. To that end, we converted total feet of main into miles, then divided total annual operating expenses by that length. We established a grading scale according to the distribution of those values; Table 26 shows the scoring rubric we applied. This rubric is likely to change in the future due to overall cost inflation.

**Table 26. *Infrastructure & Operations* scoring rubric for operating expenses per mile of main**

| Grade Range | Total Operating Expenses per Mile ($) | Score Range |
|---|---|---|
| A | 0-18,000 | 90-100 |
| B | 18,000-24,000 | 80-90 |
| C | 24,000-30,000 | 70-80 |
| D | 30,000-40,000 | 60-70 |
| F | >40,000 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at $50,000 per mile.

**Figure 24. Distribution of total operating expenses per mile of main ($)**

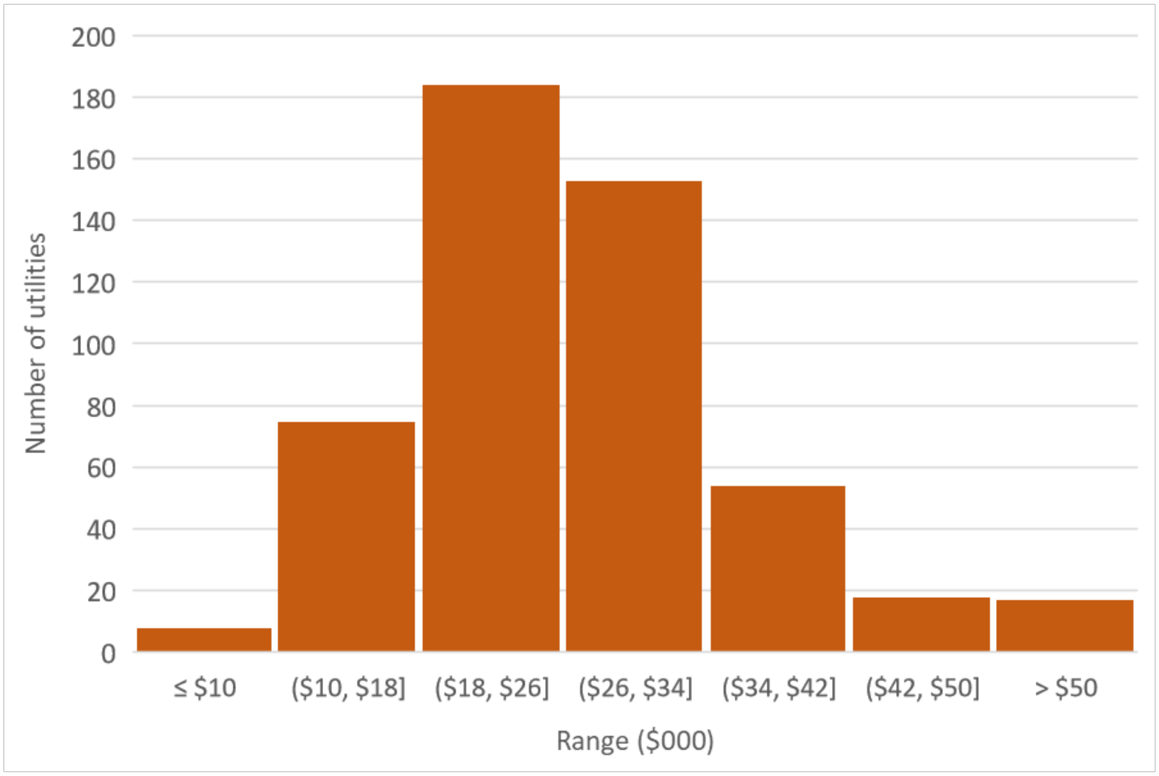



Figure 24 shows the distribution of operating expenses per mile of main in 2020 across Wisconsin utilities. Performance on this measure of energy efficiency was roughly normal in distribution, with roughly three quarters of utilities scoring in the B-D range and just 16.3% earning marks in the A range.

### Total Operating Expenses per Customer

Operating expenses per customer is another useful indicator of operational efficiency. Once again, we set the rubric for operating expenses per customer based on its overall distribution; Table 27 reports the scoring rubric. As with other operational expense indicators, this rubric is likely to change over time due to general cost inflation.

**Table 27. *Infrastructure & Operations* scoring rubric for operating expenses per customer connection**

| Grade Range | Total Operating Expenses per Customer Connection ($) | Score Range |
|---|---|---|
| A | 90-250 | 90-100 |
| B | 250-400 | 80-90 |
| C | 400-550 | 70-80 |
| D | 550-700 | 60-70 |
| F | >700 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at $1,600 per customer connection.

**Figure 25. Distribution of total operating expenses per customer connection ($)**

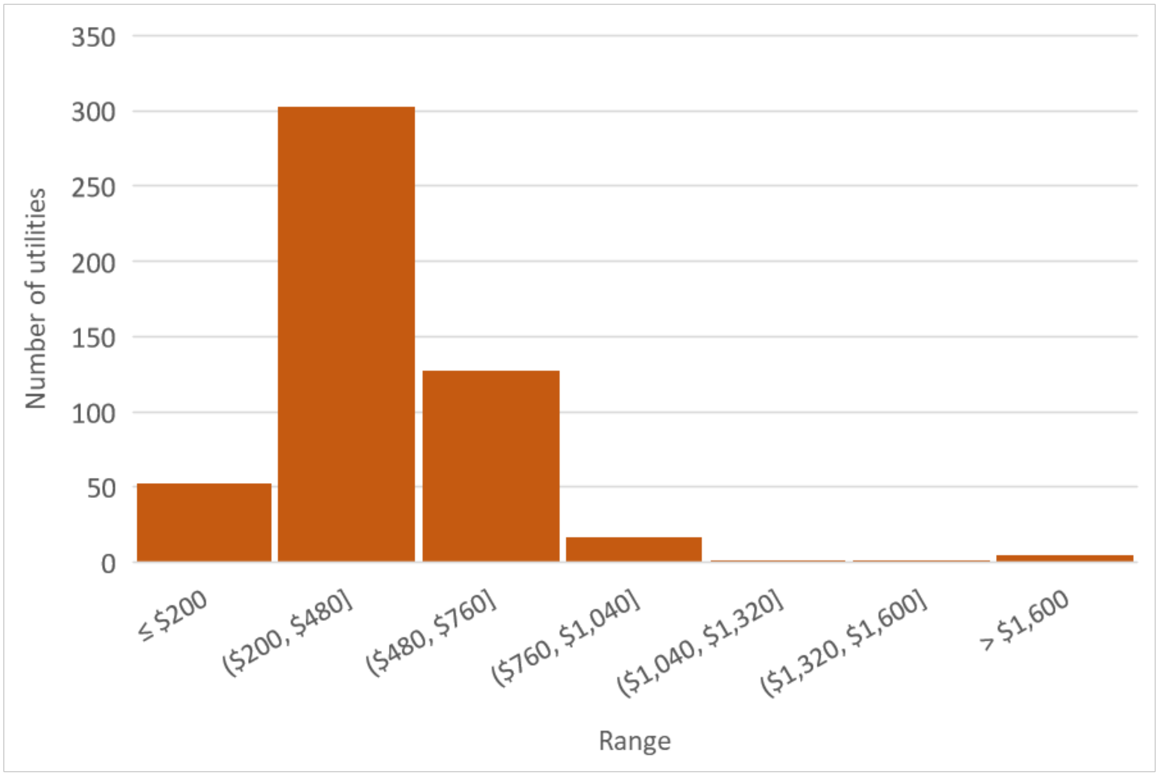



Figure 25 shows the distribution of operating expenses per customer connection in 2020 across Wisconsin utilities. Performance on this measure of energy efficiency was generally strong, with more than half of utilities scoring in the A-B range and just 6.7% in the failing range.

**Table 28. *Infrastructure & Operations* scoring rubric for operating expenses per customer connection**

| Grade Range | Total Operating Expenses per Capita ($) | Score Range |
|---|---|---|
| A | 80-150 | 90-100 |
| B | 150-200 | 80-90 |
| C | 200-250 | 70-80 |
| D | 250-300 | 60-70 |
| F | >300 | 0-60 |

Note: Numerical scores based on linear interpolation within grade ranges. Scores reach zero at $600 per capita.

### Total Operating Expenses Per Capita

Our last indicator of operating efficiency is total operating expenses per capita. We drew service population data from EPA's SDWIS, then simply divided total operating expenses by the service population. Table 28 shows the scoring rubric applied to this metric; as with other expense indicators, this rubric is likely to change over time due to general cost inflation.

**Figure 26. Distribution of total operating expenses per capita ($)**

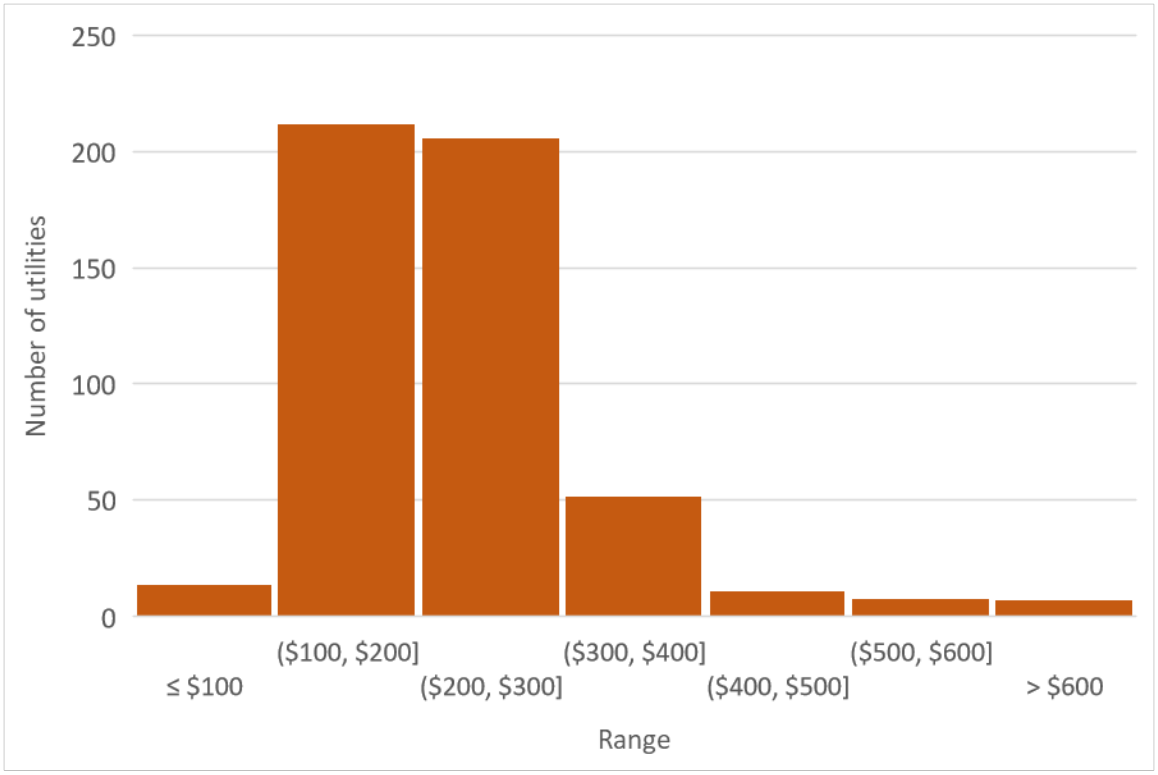



Figure 26 shows the distribution of operating expenses per customer connection in 2020 across Wisconsin utilities. Performance on this measure of energy efficiency was generally strong, with more than half of utilities scoring in the A-B range and just 6.7% in the failing range.

### SDWA Management Compliance

Compliance with SDWA management rules is the final factor contributing to the Operations grade. Under SDWA, utilities must follow a series of management protocols, including maintaining appropriate staffing levels, collecting and submitting data to Wisconsin DNR, reporting water quality to the public, and more. Unlike SDWA health violations, management violations do not necessarily or immediately endanger public health or environmental quality. However, adherence to these rules is a function of organizational management, and so although it is a relatively “blunt instrument,” SDWA management compliance allows for valid, comparable measurement across a wide range of utilities. Table 29 reports our scoring rubric for SDWA compliance.

**Table 29. *Infrastructure & Operations* scoring rubric for SDWA management compliance**

| Grade Range | SDWA management violations in 2020 | Score |
|---|---|---|
| A | 0 | 100 |
| B | 1 | 80 |
| C | 2 | 70 |
| D | 3 | 60 |
| F | >3 | 0-50 |

Note: Numerical scores beyond four violations are based on linear interpolation within grade ranges. Scores reach zero at twelve violations.

Fortunately, the overwhelming majority of Wisconsin utilities had no SDWA management violations at all in 2020. Eleven utilities committed a single management violation each, and just one committed two violations.

### *Infrastructure & Operations* grades across Wisconsin

Tables 30 and 31, respectively, summarize scoring for all the metrics that contribute to the Infrastructure and Operations portions of the *Infrastructure & Operations* grade. Figure 27 depicts the overall *Infrastructure & Operations* grades that emerge from these scores.

Statewide performance on *Infrastructure & Operations* was mixed. Just 6.9% of Wisconsin's utilities earned A grades in this subject, with the bulk of systems earning B and C marks (34.4% and 30.4%, respectively); meanwhile, 11.7% Wisconsin utilities received failing marks for *Infrastructure & Operations.* Overall performance for *Infrastructure* was lower than for *Operations*. Particularly notable are the high numbers of main breaks and very long main replacement rates that negatively impacted grades for many utilities.

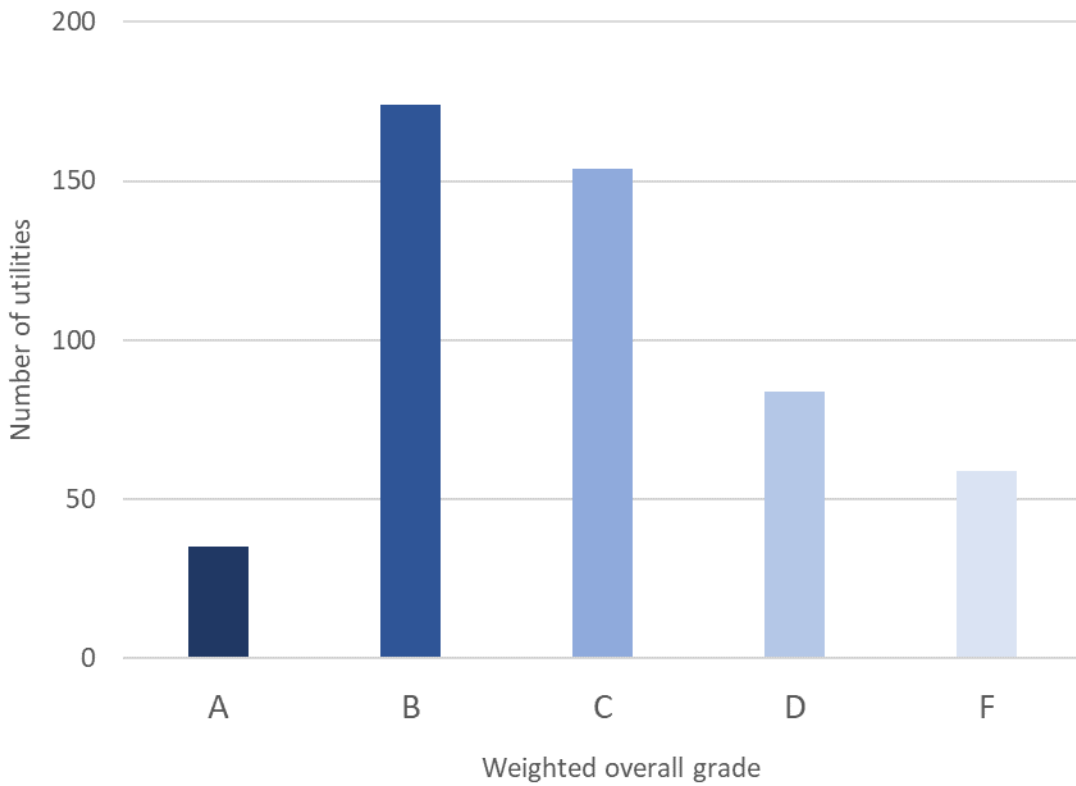
**Table 30. Summary of infrastructure scores for *Infrastructure & Operations* grade, 2020**

| *All scores 0-100* | Breaks per 100 miles of main | Water loss per 100 miles of main | Replacement rate | Weighted replacement rate |
|---|---|---|---|---|
| Average | 74.9 | 73.8 | 59.3 | 59.4 |
| Median | 90.0 | 78.4 | 86.6 | 88.8 |
| Maximum | 100.0 | 100.0 | 99.2 | 99.7 |
| Minimum | 0.0 | 0.0 | 0.0 | 0.0 |
| Standard Dev. | 30.8 | 22.8 | 43.1 | 43.8 |

**Table 31. Summary of operations scores for *Infrastructure & Operations* grade, 2020**

| | | Total Operating Expenses | | | | |
|---|---|---|---|---|---|---|
| *All scores 0-100* | **kWH per MG** | **Per 1,000 Gallons** | **Per Mile of Main** | **Per Customer** | **Per Capita** | **SDWA Management Compliance** |
| Average | 78.7 | 76.6 | 71.1 | 79.4 | 74.8 | 99.5 |
| Median | 82.7 | 80.0 | 80.0 | 81.0 | 78.3 | 100.0 |
| Maximum | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Minimum | 33.1 | 0.0 | 0.0 | 0.0 | 0.0 | 70.0 |
| Standard Dev. | 14.4 | 19.7 | 18.9 | 14.1 | 18.7 | 3.2 |

**Figure 27. Distribution of *Infrastructure & Operations* grades, 2020**




## COMMUNICATIONS

Water utilities were long regarded as a "silent service," but over the past twenty years water sector leaders have recognized that communicating with the public is central to a utility's success.[40] Such engagement is particularly important in Wisconsin, where nearly all drinking water utilities are owned and operated by municipal governments. For municipal utilities

[40] Lafrance (2012).

transparency and public engagement contribute to trust in both tap water and institutions of government.[41]

In order to maintain the public's trust, customers must have ready access to information about their water's quality, their water's price, and their water utility organizations. In the digital age, the dominant communications media are electronic: today's utilities can engage with the public via the internet, mobile phones, and virtual meetings, alongside more traditional methods. The prevalence and increasing use of e-governance in the United States makes communications even more relevant as an important indicator of a utility's overall performance. The use of technology such as the internet and mobile devices to provide public services – such as drinking water – has increased substantially, underscoring the importance of having accessible websites and providing information in a transparent and intentional way. To these ends, WSEP seeks to recognize and encourage water utilities' efforts to communicate and interact with the public.

### Elements of *Communications* grade

Unlike the other four subjects, there currently are no widely accepted or time-honored standards or metrics for evaluating water utility communications. There also is very little rigorous research on effective communications for municipal water utilities. In absence of such standards or research literature, we consulted with a panel of experts on e-government in the United States to craft a framework and rubric for evaluating water utility communications in Wisconsin.

**Table 32. *Communications* grade weights**

| Factor | Weight (%) |
|---|---|
| Transparency | |
| CCR easily available online | 20 |
| Rates and pricing easily available online | 20 |
| Website information & accessibility | 35 |
| Interactivity | |
| Telephone | 5 |
| Webform / email | 5 |
| Meetings | 5 |
| Social media | 10 |

Two constructs comprise the *Communications* grade: transparency and interactivity. *Transparency* relates to accessibility of key information about a water utility; *interactivity* relates to how much a utility both interacts with and provides opportunities for the public to interact with their water utility. Based on advice from our panel of experts we developed a *Communications* grade that captures these two elements, with 75% of the grade allotted to transparency, and interactivity contributing to the remaining 25% of the grade. Table 32

[41] Teodoro, Zuhlke, and Switzer (2022).

summarizes the elements of the *Communications* grade; detailed scoring rubrics for each factor follow in the discussion below.

The WSEP's emphasis on online communications for purposes of grading is not meant to imply that the elements scored here are the only important features of a water utility's online presence, or that online communication is the only, best, or most important way for a utility to communicate with the public. Utilities may communicate with the public in near infinite ways that can and should go well beyond the scoring rubric applied here. However, the standards applied in *Communications* scoring here are comparable and achievable statewide. In that sense, they represent reasonable "minimum" levels of transparency and interactivity. Future WSEP rubrics will hopefully evolve as the state's water sector advances.

### Data collection

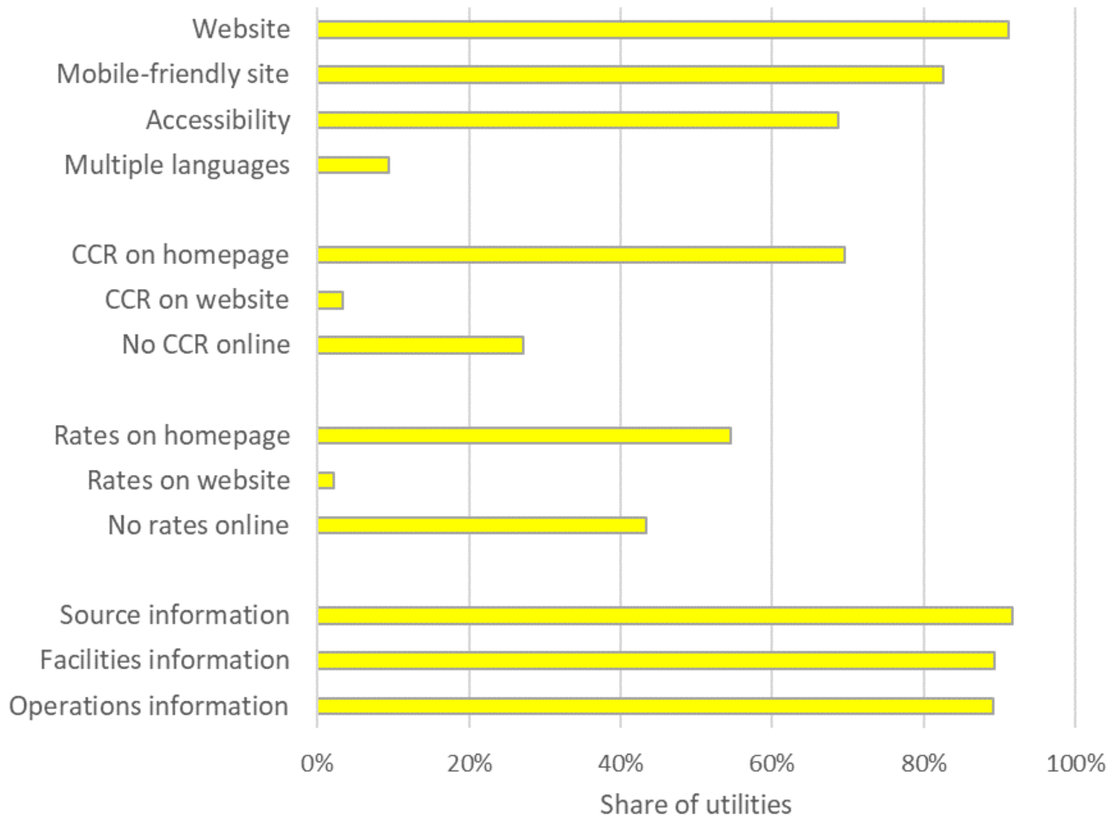
More than any other subject, grading utility communications required significant original data collection from municipality and utility websites, and social media accounts. Here we describe data collection and coding processes. The data reported here were collected from January through May 2022.

Collecting communications data required many hours of careful labor, including searching for and visiting each water utility website and navigating to find various indicators of transparency and interactivity. The methodology and explanation of data collection is below; the explanation of the rubric and weighting of variables is explained in this section.

### Transparency

Transparency scores are based on the design of and information available on utilities' websites. Transparency accounts for 75 points of the 100 total points available for the *Communications* grade. Figure 28 shows the distribution of performance on WSEP's indicators of transparency. Scoring rules for each of these conditions are described below.

**Figure 28. Distribution of online transparency indicators, 2020**




## Consumer Confidence Report

The federally mandated CCR is one of the most important elements of public information for an American water utility. The Safe Drinking Water Act (1974) requires that each community water system provide a CCR to its customers annually, either by mail or online. The CCR provides information about a utility's water quality with reference to specific contaminants. Although utilities may fulfill this formal regulatory requirement through postal mailing, posting CCRs online reflects a commitment to transparency by making them immediately available to anyone at any time.

**Table 33. *Communications* scoring rubric for CCR and rates availability online**

| Condition | Score (out of 20 possible) |
|---|---|
| CCR / rates easily available with link from home page | 20 |
| CCR / rates present on official website via search or browsing | 15 |
| CCR / rates unavailable from utility | 0 |

Utilities earned up to 20 points for their CCRs, depending on how easily accessible it was. A utility earned the full 20 points if the current CCR was easily accessible either on a utility website's homepage, on the water/utility department homepage, or through a dropdown menu on the website. The utility earned 15 points if the current CCR was present on an official utility or city website but required difficult navigation and/or searching to access it. Utilities received zero points if there was no CCR available online or if the only CCR available was out of date. Table 33 shows the WSEP scoring rubric for CCR availability.

### Rates

Along with quality, information about rates is also one of the most important aspects of any utility's publicly available information. In Wisconsin, the PSC establishes rates and monitors public water utilities' financial condition and sufficiency. The PSC has helpful information about rate setting, including statewide bill comparison and the quarterly water comparison tool. The PSC also works with the Environmental Finance Center at the University of North Carolina, Chapel Hill to develop and maintain the Wisconsin Residential Water Rates Dashboard. However, these tools may not be immediately apparent to utility customers. Thus, it is important for utilities to provide rates information to their own customers. Adequate rates information includes clear, easily understood tables or text that communicates the fixed periodic charges and volumetric charges that customers pay for service.

As with CCRs, utilities earned up to 20 points for their rates information, depending on how easily accessible it was. A utility earned the full 20 points if its current rates were easily accessible either on a utility website's homepage, on the water/utility department homepage, or through a dropdown menu on the website. The utility earned 15 points if current rates were present on an official utility or city website but required difficult navigation and/or searching to access. Utilities received zero points if there was no rates information available online or if the only rates available were out of date. Table 33 shows the WSEP scoring rubric for rates availability.

### Website

A clearly designed, regularly maintained website is a useful platform for utilities to communicate information to the public and to facilitate interaction. Today building and maintaining a simple website is easy thanks to widely available and often free or inexpensive tools. Utilities earned up to 35 points for various aspects of their websites; Table 34 summarizes our website scoring rubric for transparency.

A utility earned 5 points if it had any website and/or if the municipality had a website with information about the water utility, or 0 if it did not. That is, if a utility did not have a website but the utility information was provided on the municipality's website, it received 5 points. Utilities also earned credit for various aspects of website design and content. Specifically:

- **Mobile friendly.** Today most consumers own a mobile device that can access the internet. In fact, 97 percent of Americans have a cell phone, including more than 85 percent owning a smartphone,[42] and Wisconsin households own an estimated 10 million mobile phones.[43] Further, nearly a quarter of rural Wisconsinites are without access to high-speed internet at home. By 2021 mobile access to the internet reached virtual parity with traditional desktop access in the United States.[44] In light of these conditions and trends, utilities earned 5 points if their website designs were "mobile-friendly" (i.e., optimized to display on mobile devices), and zero if the website was not mobile-friendly. A utility that had no website but did have a social media presence earned 5 points for mobile-friendly design by providing information via social media.

- **Accessibility.** Web accessibility is the practice of ensuring there are no barriers that prevent website engagement by people with physical disabilities, situational disabilities, and/or restrictions on bandwidth. To evaluate website accessibility, WSEP scores relied on the Web Accessibility Evaluation Tool (WAVE), which provides a summary information about accessibility for any website.[45] The WAVE tool provides six categories for accessibility, including Accessible Rich Internet Applications (ARIA), which helps with dynamic content and advanced user interface controls developed with HTML, JavaScript, and related platforms and technologies. ARIA enables users with disabilities – especially people who rely on screen readers and people who cannot use a mouse – to access websites. For website scoring, we entered the utility's website URL into the WAVE tool. Utilities that scored greater than zero for ARIA earned 5 points for accessibility; of ARIA number was zero, utilities received zero (0) points for accessibility.

**Table 34. *Communications* website transparency scoring rubric**

| Condition | Score |
|---|---|
| Design features | |
| Utility has a website or municipality has website with utility information | 5 |
| Website design is mobile-friendly | 5 |
| Website accessibility (ARIA) | 5 |
| Website available in multiple languages or optimized for translation | 10 |
| Information | |
| Source water | 4 |
| Facilities | 3 |
| Operations | 3 |
| Total possible | 35 |

[42] https://www.pewresearch.org/internet/fact-sheet/mobile/
[43] https://dnr.wi.gov/files/PDF/pubs/wa/wa1874.pdf
[44] https://gs.statcounter.com/platform-market-share/desktop-mobile-tablet/united-states-of-america/2021
[45] https://wave.webaim.org/

- **Language.** According to the U.S. Census Bureau, 8.7% of Wisconsin residents spoke a language at home other than English. Websites that provided information in multiple languages thus earned 10 points for their utilities. "Multiple languages" could mean that the website is translated by the municipality or utility itself, or that it has enabled an automated translation toolbar (e.g., Google Translate) on the website that allows users to translate the page. Utilities without these multiple language features earned no points for multiple languages.

- **Source water.** Information about the utility's water source helps the public understand where their drinking water comes from and the efforts required to protect, sustain, and extract that source water. Utilities whose websites included information about source water earned 4 points, otherwise they scored zero. Typically, utilities earned these points by posting information about the utility's wells or aquifer or referring to surface water sources such as Lake Michigan or Lake Superior.

- **Facilities.** Information about the utility's facilities source helps the public understand the investments and infrastructure required to provide excellent drinking water service. Typical facilities information included text descriptions and/or images of treatment facilities, pumphouses, water towers, water treatment process, water main data, and/or other information about facilities. Utilities whose websites included information about facilities earned 3 points, otherwise they scored zero.

- **Operations.** Information about the utility's operations and operators source helps the public understand the supplies, energy, and skilled labor required to provide excellent drinking water service. Typical operations information included descriptions of staff and personnel, water treatment, number of customers, volume of water treated/pumped, water main information, and other relevant information. Utilities whose websites included information about operations earned 3 points, otherwise they scored zero.

### Interactivity

A water utility that actively engages and interacts with its customers is more likely to understand the concerns and needs of its community. In this context, interactivity means that utilities' online information included means of collecting feedback or fora where ratepayers and customers can voice their concerns. Interactivity also included whether utility websites or social media included information about public meetings and how customers can reach the utility by telephone or email. Interactivity accounts for 25 points of the 100 total points that comprise the *Communications* grade. Table 35 shows how various types of online information contribute to WSEP interactivity scores.

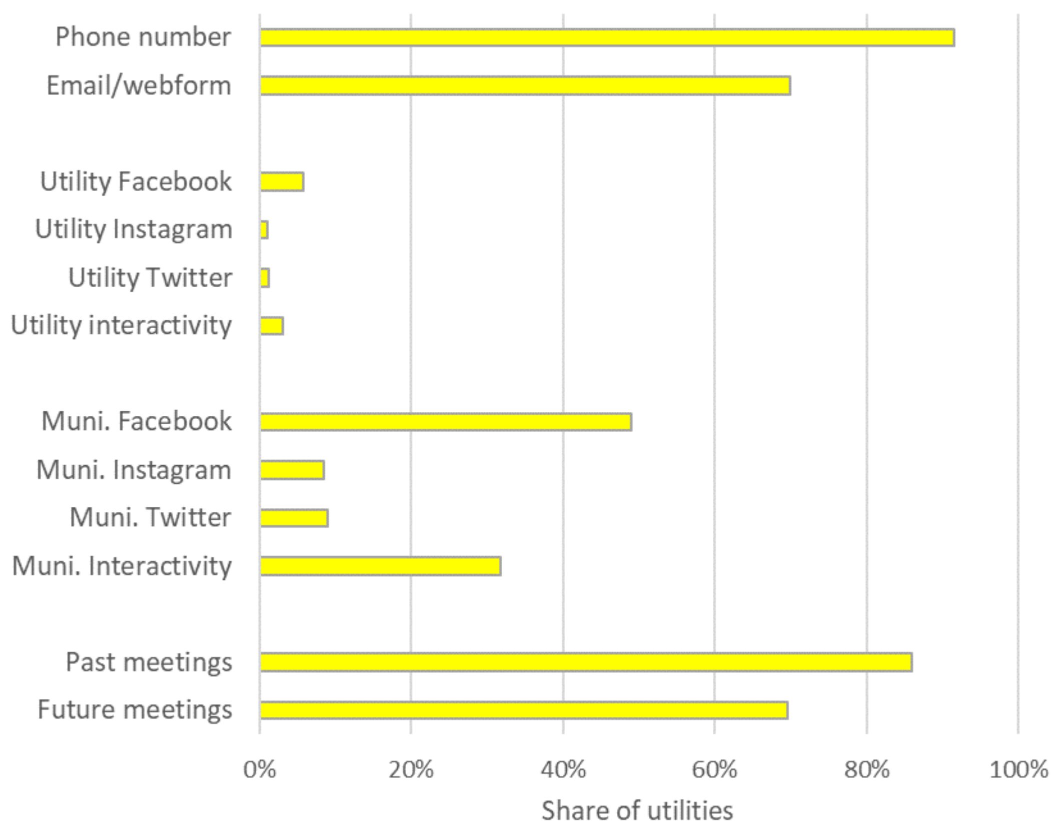
 

**Table 35. *Communications* online interactivity scoring rubric**

| Condition | Score |
|---|---|
| <u>Customer contact channels</u> | |
| Phone number | 5 |
| Email or webform | 5 |
| <u>Social media</u> | |
| Utility | 5 |
| Municipality | 5 |
| <u>Meetings</u> | |
| Past meeting agendas, minutes, or video recordings | 2.5 |
| Future meeting schedules/agendas | 2.5 |
| Total possible | 25 |

Figure 29 shows the distribution of performance on WSEP's indicators of interactivity. Scoring rules for each of these conditions are described below.

**Figure 29. Distribution of online interactivity indicators, 2020**



### Phone Number

Telephone remains the conventional method of communication between utility organizations and their customers. An easily available phone number allows customers to speak with someone about their bills, water quality, maintenance or construction projects, or other concerns. Utilities whose websites or social media accounts included a phone number to contact the utility earned 5 points, otherwise they received zero points.

### Email / webform

Electronic communications are more convenient and efficient than phone calls for many customers, especially for those whose work schedules do not allow them to call during regular business hours or individuals with certain disabilities. Utilities can facilitate electronic communication by providing an email address for general inquiries on their websites or social media accounts. Utilities whose websites or social media accounts included an email address or webform for electronic submission of queries earned 5 points, otherwise they received zero points.

### Social Media

We collected data both on the social media accounts of the utility, and the social media accounts of each utility's municipality. Based on the advice of e-government experts, we collected data on Facebook, Instagram, and Twitter, as these are the social media platforms that experts indicated were the most widely used and popular platforms in 2020. For each platform (Facebook, Instagram, Twitter), utilities earned one point for each current account with evidence of posts or activity within the past 90 days. Utilities scored 0 if they did not have an account, or if the account was not current or showed no evidence of activity within 90 days. Utilities and their municipalities also earned credit for social media interactivity. Utilities/municipalities received 2 points if there was evidence of interacting with the public within 90 days on any of the three scored platforms, zero otherwise.

WSEP separately scored social media for both utilities and their municipal governments. For example, if a utility had a social media account specifically for its water utility, it earned one point for that account; if the utility's municipality also had a social media account for general government, it also received a 1 for that value.

### Past Meetings

Official meetings of relevant governing bodies, such as water utility boards, city councils, town boards, village boards, or committees allow the public to understand the governance of their own critical infrastructure. Public information about completed, or *past* meetings, can help the public access important information about their local government, and is critical for transparency and government accountability. Utilities earned 2.5 points if information such as minutes, agendas, or video recordings of past meetings of the municipality's legislative body (e.g., city council, village board, etc.) was available online; if such information on past meetings was not available online, they scored zero.

### Future Meetings

Notice of *future* official meetings of relevant governing bodies, such as water utility boards, city councils, town boards, village boards, or committees gives the public an opportunity to speak with elected or appointed officials regarding their water utility. Utilities earned 2.5 points if schedule and/or agenda information for future meetings was available online via websites or social media; We scored this on a binary, (1/0) scale. If the website included information about upcoming meetings, they scored 1; if such information on past meetings was not available online, they scored zero.

#### *Communications* grades across Wisconsin

Table 36 summarizes *Communications* scores; Figure 30 depicts the overall *Communications* grades that emerge from these scores.

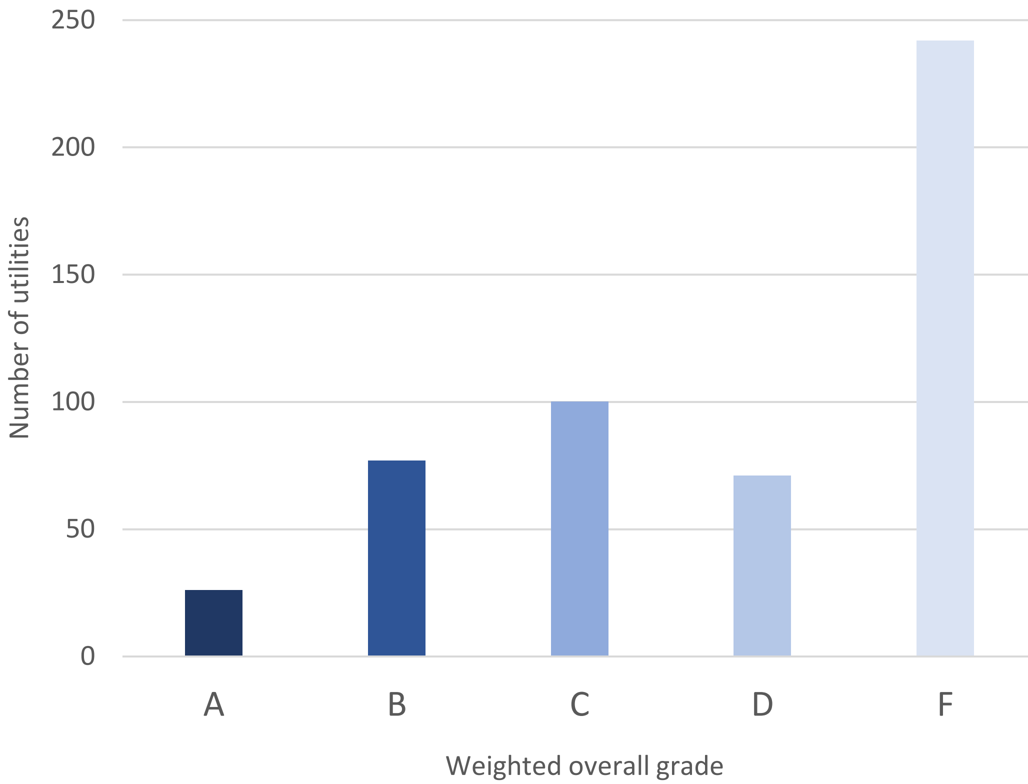
. **Table 36. Summary of *Communications* scores, 2020**

| | Total Score |
|---|---|
| Average | 54.6 |
| Median | 62.5 |
| Maximum | 100.0 |
| Minimum | 0.0 |
| Standard Deviation | 26.7 |

Among the graded subjects, average *Communications* grades were easily the lowest across Wisconsin's utilities: just 5% of the state's utilities earned A grades for *Communications,* and nearly 47% received failing marks. Inspection of the subject's individual components indicates that most utilities had a website with basic information about the utility, contact information, and notices of past and future meetings. Failure to provide rates information and a lack of communications in multiple languages were the most common weaknesses for transparency, while low social media engagement was the most common weakness for interactivity.

While statewide performance on this subject is poor overall, it is also an area in which utilities can improve their grades very quickly and at little cost. For example, creating simple social media accounts with monthly posts that link to rates and CCRs will help many utilities in this regard. Opening and maintaining social media accounts requires little investment relative to its potential communication impact. With a modicum of effort, every utility in the state can earn strong marks for *Communications.*

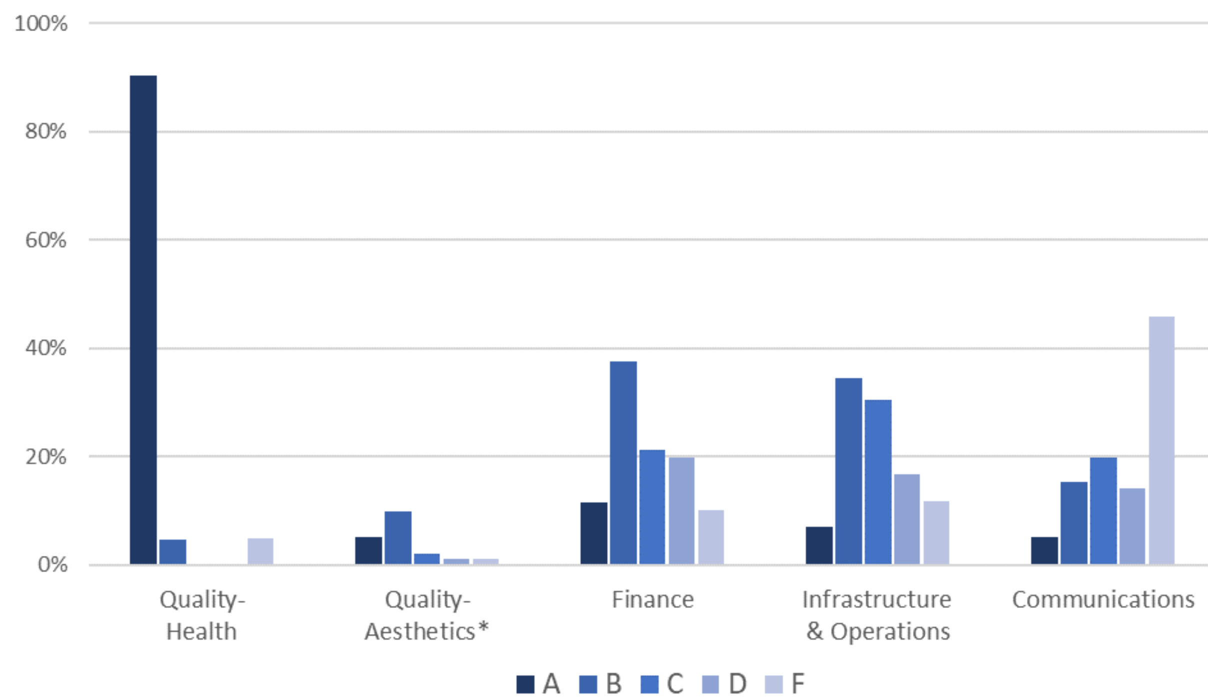
**Figure 30. Distribution of *Communications* grades, 2020**




## CONCLUSION

The WSEP's goal is to provide clear and accessible information to the public and to policymakers about Wisconsin drinking water utilities' water quality, infrastructure, financial strength, and communications. The initial WSEP grades serve as a pilot or "beta test" –a proof of concept and baseline for future development. This report is intended to provide water utility leaders and other stakeholders with the first round of grades and the methodology used to create them. Figure 31 shows the overall distribution of grades across all five WSEP subjects; Table 37 converts the average grades earned across the state onto a four-point academic scale.

**Figure 31. 2020 WSEP grade distribution by subject**




**Excludes 81% of utilities that received "Incomplete" for* Quality-Aesthetics*.*

**Table 37. Statewide average WSEP grades by subject, 2020**

| Subject | Average (100-point scale) | Average (academic 4-point scale) |
|---|---|---|
| Quality-Health | 92.1 | 3.75 |
| Quality-Aesthetics* | 83.9 | 2.88 |
| Finance | 75.5 | 2.21 |
| Infrastructure & Operations | 75.7 | 2.08 |
| Communications | 54.6 | 1.20 |

*Based on data for 97 utilities with complete secondary contaminant data.

## How good are Wisconsin's water utilities?

The initial grades that emerge from this study are at once reassuring and troubling. Very strong overall performance on *Quality-Health* demonstrates that Wisconsin's water utilities are fulfilling their most fundamental mission of providing safe, healthy drinking water. Despite WSEP's demanding rubric, more than 90% of the state's water utilities earned A grades for *Quality-Health*—evidence that, when it comes to drinking water safety, Wisconsin's water utility leaders perform far better than what is required of them by law. It is difficult to gauge Wisconsin water's overall aesthetic quality, owing to the large number of "incomplete" marks we assigned due to missing data.

On the other hand, overall performance on *Finance* and *Infrastructure & Operations* raises some concerns about the sustainability of these critical systems. Most utilities earned solid or strong grades for *Finance* though a significant minority of utilities earned poor marks here, which drags down the state's overall average on that subject. Aggregate results for *Infrastructure & Operations* grades were less impressive. More than 40% of the state's utilities earned strong marks on the subject in 2020, but a majority of utilities received mediocre (C) or poor (D-F) *Infrastructure & Operations* marks. In the long run, poor financial, capital, and/or operational performance are likely to erode water quality—and public confidence in the state's water systems. Maintaining that public confidence will be a challenge, especially as WSEP *Communications* grades were mostly poor: nearly half of Wisconsin's utilities failed the subject, and barely one in twenty earned an A grade. Fortunately, significant improvements to communications are possible at relatively low cost.

Taken together, these results suggest that Wisconsin's water utility leaders manage to maintain sound water quality, often under difficult financial, capital, and operating conditions. Improvements to performance in these aspects of water systems will ensure that Wisconsinites enjoy excellent tap water quality well into the future.

As any student knows, earning good grades requires effort and commitment; making straight A's in a demanding discipline is a rare and admirable feat. The WSEP recognizes truly excellent performance among Wisconsin's water utilities and helps identify areas for improvement for individual utilities and for the state as a whole. Excellence is possible for every Wisconsin water system; we hope that this initial WSEP report will move us closer to that goal.

### Next steps forward

WSEP efforts to date indicate at least three clear paths for the project going forward: 1) refining and updating WSEP grades with data from 2022-2023; 2) identifying correlates and causes of water utility performance; and 3) disseminating findings to help improve management and policy.

With the initial rubrics established and "beta" report cards calculated, an obvious next step is to recalculate grades with more recent data. WSEP's work to date has been to develop grading rubrics for Wisconsin water utilities and to calculate their grades for 2020. This process required significant effort to gather and compile a wide variety of data, as well as lengthy consultative processes with water sector experts across the country. The global COVID-19 pandemic complicated that effort, as it is possible that the pandemic affected aspects of utility performance in ways that make 2020 an exceptional year. Calculating grades for 2022-2023 will test the durability and soundness of the rubric, and its findings will help put any pandemic-related oddities in context. We hope to replicate the WSEP grades biennially going forward, compiling a rich store of data to fuel rigorous analysis of utility performance.

The second clear avenue for future work is to analyze the correlates and causes of water utility performance. This initial WSEP report is entirely descriptive, not analytical—the grades in this report reveal performance across the five graded subjects, but do not explain why some utilities perform better than others. In other words, this report offers the *what* and *where,* but not the *why* or *how.* With the initial 2020 grades in hand, WSEP will set out to identify key correlates of performance. For example, cursory inspection of 2020 grades suggests that, perhaps unsurprisingly, performance seems to correlate positively with utility size, with larger utilities mostly outperforming smaller ones. At the same time, there are some notable high performers among small systems. Further analysis and research will examine the reasons for those patterns and identify the small systems that "punch above their weight." Other potentially important correlates of water utility performance include source water, local economic conditions, local political processes, and more.

Third, these initial WSEP grades provide an opportunity to frame public conversations about the organization, management, and policies that shape this most basic of basic services in Wisconsin.

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# Appendix A | Return on Equity (ROE) formula

**Return on Equity = Weighted Cost of Earning Equity/% Earning Equity**

***% Earning Equity = Earning Equity/Total Earning Capital Structure***

Equity = Account 200 + Account 216.1 + Account 216.2

Earning Equity = Account 200 (Schedule F-15) + Account 216.1 (Schedule F-02)

Total Earning Capital Structure = Earning Equity + Debt

Debt = Account 221 (Schedule F-17) + Account 223 (Schedule F-18) + Account 224 (F-18) + Account 231 (F-18) (Also could include Account 233 (Payables to Municipality) on Schedule F-22))

***Weighted/Proportion of Debt used to Finance Assets = Return on Rate Base (ROR) – Weighted Cost of Debt***

Return on Rate Base (Schedule F-23) = Net Operating Income/Average Net Rate Base

Weighted Cost of Debt = Cost of Debt x % Debt

Cost of Debt = 2021 Interest/2020 EOY Total Debt Balance

% Debt = Debt/Total Earning Capital Structure

# Appendix B | Main flow weights

The table below shows the flow weights used to calculate weighted average replacement rates as part of the *Infrastructure & Operations* grade.

| **Pipe diameter (inches)** | **Maximum Flow at 3 ft/sec (cubic ft/sec)** | **Weight (2" Base)** |
|---|---|---|
| 0.75 | 0.11 | 0.14 |
| 1.00 | 0.20 | 0.25 |
| 1.25 | 0.31 | 0.39 |
| 2.00 | 0.79 | 1.00 |
| 3.00 | 1.77 | 2.25 |
| 4.00 | 3.14 | 4.00 |
| 6.00 | 7.07 | 9.00 |
| 8.00 | 12.57 | 16.00 |
| 10.00 | 19.63 | 25.00 |
| 12.00 | 28.27 | 36.00 |
| 16.00 | 50.27 | 64.00 |
| 18.00 | 63.62 | 81.00 |
| 20.00 | 78.54 | 100.00 |
| 24.00 | 113.10 | 144.00 |
| 28.00 | 153.94 | 196.00 |
| 30.00 | 176.71 | 225.00 |
| 36.00 | 254.47 | 324.00 |
| 42.00 | 346.36 | 441.00 |
| 48.00 | 452.39 | 576.00 |
| 54.00 | 572.56 | 729.00 |
| 60.00 | 706.86 | 900.00 |
| 72.00 | 1,017.88 | 1,296.00 |

# Appendix C | Utility report cards

| Grade Color Key | A (>90) | B (80-90) | C (70-80) | D (60-70) | F (<60) |
|---|---|---|---|---|---|

| Name | Quality - Health | Quality - Aesthetics | Finance | Infrastructure & Operations | Communications |
|---|---|---|---|---|---|
| ABBOTSFORD MUNICIPAL WATER UTILITY | 98 | | 79 | 78 | 65 |
| ADAMS MUNICIPAL WATER AND SEWER UTIL | 99 | | 63 | 78 | 70 |
| ADELL MUN SEWER AND WATER UTILITY | 91 | | 84 | 68 | 43 |
| ALBANY MUN WATER AND SEWER UTILITY | 99 | | 77 | 69 | 51 |
| ALGOMA UTILITY COMMISSION | 99 | | 75 | 77 | 73 |
| ALLOUEZ VILLAGE OF WATER DEPT | 99 | 61 | 73 | 74 | 75 |
| ALMA MUNICIPAL WATER UTILITY | 100 | | 53 | 63 | 66 |
| ALMA CENTER WATER UTILITY | 0 | 94 | 73 | 70 | 15 |
| ALMENA MUNICIPAL WATER UTILITY | 99 | | 69 | 91 | 31 |
| ALTOONA MUN WATER AND SEWER UTILITY | 91 | 98 | 93 | 85 | 70 |
| AMERY MUN JOINT WTR & SWR UTY | 99 | | 89 | 81 | 70 |
| AMHERST VILL OF WATER UTILITY | 97 | | 81 | 70 | 43 |
| ANTIGO UTILITIES | 91 | 96 | 79 | 84 | 70 |
| APPLETON WATER DEPT | 97 | 97 | 87 | 75 | 75 |
| ARCADIA ELECTRIC & WATER UTILITY | 100 | | 87 | 74 | 93 |
| ARENA MUNICIPAL WATER UTILITY | 99 | | 90 | 78 | 71 |
| ARGYLE MUN ELECTRIC & WATER UTIL | 99 | 87 | 83 | 73 | 25 |
| ARLINGTON WATER UTILITY | 99 | | 59 | 59 | 14 |
| ASHLAND WATER UTILITY | 0 | | 82 | 80 | 77 |
| ASHWAUBENON WATER AND SEWER UTILITY | 98 | 71 | 70 | 76 | 75 |
| ATHENS MUNICIPAL WATER UTILITY | 99 | 94 | 71 | 74 | 43 |
| AUGUSTA; CITY OF MUN WTR & SWR UTY | 0 | | 63 | 73 | 28 |
| AVOCA MUNICIPAL WATER UTILITY | 98 | | 83 | 75 | 68 |
| BAGLEY MUNICIPAL WATER UTILITY | 99 | | 59 | 51 | 5 |
| BALDWIN MUNICIPAL WATER UTILITY | 92 | | 93 | 82 | 76 |
| BALSAM LAKE MUN WATER UTILITY | 91 | | 79 | 77 | 45 |
| BANGOR MUNICIPAL UTILITY | 92 | | 67 | 89 | 68 |
| BARABOO CITY WATER WORKS | 90 | | 65 | 86 | 73 |
| BARNEVELD MUNICIPAL WATER UTILITY | 98 | | 70 | 69 | 48 |
| BARRON LIGHT AND WATER UTILITY | 99 | | 85 | 88 | 56 |
| BAY CITY VILLAGE OF WATER UTILITY | 99 | | 72 | 76 | 48 |
| BAYFIELD WATER & SEWER UTILITY | 100 | | 91 | 73 | 65 |
| BEAR CREEK WATER UTILITY | 100 | 81 | 78 | 66 | 30 |
| BEAVER DAM WATER UTILITY | 100 | | 85 | 86 | 83 |
| BELGIUM MUNICIPAL WATER UTILITY | 99 | | 92 | 89 | 81 |
| BELLEVILLE MUN WATER & SEWER UTY | 100 | | 78 | 92 | 81 |
| BELLEVUE WATER UTILITY | 98 | 57 | 64 | 80 | 79 |
| BELMONT MUN WATER AND ELECTRIC UTIL | 99 | 87 | 78 | 65 | 51 |
| BELOIT WATER UTILITY | 0 | 87 | 80 | 80 | 65 |
| BENTON MUN ELECTRIC AND WATER UTIL | 100 | | 47 | 62 | 71 |
| BERLIN MUN WATER AND SEWER UTILITY | 98 | | 83 | 87 | 73 |
| BIRCHWOOD MUNICIPAL WATER UTILITY | 94 | | 94 | 53 | 28 |
| BIRNAMWOOD MUNICIPAL WATER UTILITY | 99 | | 95 | 84 | 28 |
| BIRON MUN WATER UTILITY | 99 | | 62 | 83 | 45 |
| BLACK CREEK MUN WATER & SEWER UTIL | 97 | | 81 | 68 | 45 |
| BLACK EARTH VILL OF WATER UTILITY | 100 | | 75 | 89 | 30 |
| BLACK RIVER FALLS MUN ELEC & WTR | 99 | | 85 | 77 | 75 |
| BLAIR MUNICIPAL WATER UTILITY | 99 | 95 | 88 | 79 | 40 |
| BLANCHARDVILLE MUN WATER UTILITY | 92 | | 68 | 63 | 0 |
| BLOOMER CITY OF WATER UTILITY | 98 | 95 | 81 | 78 | 50 |
| BLOOMINGTON MUNICIPAL WATER UTILITY | 100 | | 85 | 91 | 45 |
| BLUE MOUNDS VILL OF MUNICIPAL WT UT | 100 | | 86 | 69 | 70 |
| BLUE RIVER MUN WATER AND SEWER UTIL | 100 | | 83 | 75 | 0 |
| BONDUEL WATER & SEWER UTILITY | 98 | | 88 | 88 | 60 |
| BOSCOBEL MUNICIPAL UTILITIES | 99 | 77 | 89 | 88 | 80 |
| BOWLER WATER AND SEWER UTILITY | 98 | | 63 | 62 | 20 |
| BOYCEVILLE MUNICIPAL WATER UTILITY | 98 | | 73 | 89 | 50 |
| BOYD MUN WATER AND SEWER UTILITY | 99 | | 86 | 74 | 71 |

| Grade Color Key | A (>90) | B (80-90) | C (70-80) | D (60-70) | F (<60) |
|---|---|---|---|---|---|

| Name | Quality - Health | Quality - Aesthetics | Finance | Infrastructure & Operations | Communications |
|---|---|---|---|---|---|
| BRANDON SEWER & WATER UTIL | 100 | | 83 | 76 | 28 |
| BRILLION MUNICIPAL WATER UTILITY | 98 | 90 | 66 | 84 | 70 |
| BRISTOL WATER UTILITY | 99 | | 91 | 58 | 50 |
| BRODHEAD WATER AND LIGHT COMMISSION | 99 | | 90 | 79 | 78 |
| BROOKFIELD MUNICIPAL WATER UTILITY | 0 | 59 | 71 | 86 | 92 |
| BROOKLYN WATER UTILITY | 99 | | 82 | 79 | 73 |
| BROWN DEER WATER PUBLIC UTILITY | 91 | | 79 | 88 | 93 |
| BROWNSVILLE WATER UTILITY | 91 | | 80 | 56 | 68 |
| BROWNTOWN MUNICIPAL WATER UTILITY | 100 | | 50 | 43 | 70 |
| BRUCE MUN WATER & SEWER UTILITY | 97 | | 78 | 50 | 46 |
| BURLINGTON MUNICIPAL WATERWORKS | 99 | | 87 | 73 | 84 |
| BUTLER PUBLIC WATER UTILITY | 83 | | 64 | 52 | 53 |
| BUTTERNUT MUNICIPAL WATER DEPT | 100 | | 58 | 61 | 18 |
| CADOTT LIGHT AND WATER MUN UTILITY | 99 | | 67 | 78 | 15 |
| CALEDONIA VILLAGE OF WATER UTILITY | 89 | | 80 | 73 | 56 |
| CAMBRIA MUNICIPAL WATER UTILITY | 98 | | 70 | 66 | 18 |
| CAMBRIDGE MUNICIPAL WATER UTILITY | 100 | | 73 | 74 | 0 |
| CAMERON VILL OF MUNICIPAL WTR UTY | 99 | | 63 | 79 | 72 |
| CAMPBELLSPORT MUN WATER UTILITY | 99 | | 80 | 71 | 68 |
| CAMP DOUGLAS MUNICIPAL WATER UTILITY | 99 | | 78 | 90 | 71 |
| CASCADE WATER UTILITY | 92 | 80 | 65 | 84 | 31 |
| CASHTON MUN ELECTRIC AND WATER UTIL | 99 | | 89 | 89 | 46 |
| CASSVILLE WATER & SEWER UT | 99 | | 64 | 73 | 29 |
| CAZENOVIA VILL OF WATER UTILITY | 94 | | 87 | 79 | 0 |
| CEDARBURG LIGHT AND WATER COMMISSION | 90 | | 72 | 83 | 78 |
| CEDAR GROVE MUNICIPAL WATER UTILITY | 99 | | 70 | 73 | 45 |
| CENTURIA MUN WATER AND SEWER UTILITY | 99 | | 63 | 49 | 48 |
| CHASEBURG WATER & SEWER UTILITY | 100 | | 86 | 70 | 6 |
| CHETEK MUNICIPAL WATER UTILITY | 100 | | 86 | 87 | 70 |
| CHILTON MUNICIPAL WATER UTILITY | 96 | | 83 | 79 | 73 |
| CHIPPEWA FALLS DEPT OF PUBLIC UTIL | 97 | | 91 | 85 | 90 |
| CLAYTON MUNICIPAL WATER UTILITY | 99 | | 69 | 93 | 70 |
| CLEAR LAKE MUNICIPAL WATER UTILITY | 99 | | 86 | 68 | 35 |
| CLEVELAND WATER UTILITY | 99 | 83 | 45 | 70 | 68 |
| CLINTON MUNICIPAL WATERWORKS | 99 | | 80 | 69 | 65 |
| CLINTONVILLE WATER & ELECTRIC UTY | 99 | | 86 | 87 | 96 |
| CLYMAN UTILITY COMMISSION | 100 | | 70 | 67 | 40 |
| COBB MUNICIPAL WATER UTILITY | 100 | 77 | 83 | 74 | 48 |
| COCHRANE MUNICIPAL WATER UTILITY | 100 | | 93 | 92 | 43 |
| COLBY CITY OF MUN WATER UTILITY | 97 | | 75 | 87 | 50 |
| COLEMAN WATER UTILITY | 99 | 83 | 46 | 89 | 70 |
| COLFAX MUN WATER AND SEWER UTILITY | 99 | | 86 | 76 | 45 |
| COLOMA MUNICIPAL WATER UTILITY | 98 | | 77 | 61 | 66 |
| COLUMBUS WATER AND LIGHT DEPT | 0 | 93 | 87 | 84 | 81 |
| COMBINED LOCKS WATER UTILITY | 90 | | 83 | 67 | 74 |
| COON VALLEY MUNICIPAL WATER UTILITY | 100 | | 67 | 67 | 48 |
| CORNELL MUN WATER AND ELECTRIC UTIL | 99 | | 85 | 71 | 57 |
| COTTAGE GROVE WATER & SEWER UTIL | 100 | | 84 | 92 | 73 |
| CRANDON WATER AND SEWER UTILITY | 92 | | 69 | 93 | 23 |
| CRIVITZ VILLAGE OF WATER UTILITY | 99 | | 64 | 76 | 57 |
| CROSS PLAINS WATER UTIL | 99 | | 83 | 60 | 73 |
| CUBA CITY ELECTRIC & WATER UTILITY | 99 | | 90 | 87 | 80 |
| CUDAHY CITY OF WATER UTILITY | 92 | 94 | 85 | 56 | 93 |
| CUMBERLAND MUNICIPAL UTILITY | 92 | | 90 | 82 | 70 |
| CURTISS MUNICIPAL WTR & SWR UTY | 92 | | 90 | 72 | 45 |
| DALLAS MUNICIPAL WATER UTILITY | 92 | | 71 | 81 | 10 |
| DANE WATER & SEWER UTY | 92 | | 89 | 79 | 70 |
| DARIEN WATER WORKS & SEWER SYSTEM | 99 | | 58 | 57 | 80 |

| Grade Color Key | A (>90) | B (80-90) | C (70-80) | D (60-70) | F (<60) |
|---|---|---|---|---|---|

| Name | Quality - Health | Quality - Aesthetics | Finance | Infrastructure & Operations | Communications |
|---|---|---|---|---|---|
| DARLINGTON MUN WATER AND SEWER UTIL | 100 | 87 | 92 | 84 | 80 |
| DEERFIELD WATER UTILITY | 98 | | 84 | 74 | 74 |
| DEFOREST MUNICIPAL WATER UTILITY | 99 | | 91 | 95 | 74 |
| DELAVAN WATER & SEWAGE COMMISSION | 90 | | 57 | 84 | 60 |
| DELAFIELD MUNICIPAL WATER UTILITY | 100 | | 90 | 66 | 71 |
| DENMARK MUNICIPAL WATER UTILITY | 95 | 27 | 85 | 80 | 69 |
| DE PERE WATER DEPARTMENT | 96 | 67 | 63 | 79 | 77 |
| DICKEYVILLE WATER UTILITY | 98 | | 71 | 85 | 50 |
| DODGEVILLE WATER UTILITY | 99 | | 67 | 77 | 83 |
| DORCHESTER VILLAGE OF WATER UTILITY | 100 | | 81 | 67 | 39 |
| DOUSMAN WATER UTILITY | 99 | | 81 | 88 | 34 |
| DRESSER MUNICIPAL WATER UTILITY | 92 | | 26 | 48 | 63 |
| DURAND MUNICIPAL WATER UTILITY | 92 | | 77 | 59 | 76 |
| EAGLE VILL OF MUNICIPAL WTR UTY | 90 | 73 | 83 | 86 | 58 |
| EAGLE RIVER LIGHT AND WATER COMM | 100 | | 70 | 89 | 30 |
| EASTMAN WATER UTILITY | 100 | | 86 | 70 | 18 |
| EAST TROY VILL OF MUN WTR UTY | 99 | | 88 | 80 | 74 |
| EAU CLAIRE MUNICIPAL WATER UTILITY | 92 | 73 | 87 | 89 | 94 |
| EDGAR MUNICIPAL WATER UTILITY | 99 | | 92 | 83 | 61 |
| EDGERTON MUNICIPAL WATER UTILITY | 99 | 89 | 90 | 80 | 47 |
| ELEVA MUNICIPAL WATER UTILITY | 100 | | 73 | 74 | 6 |
| ELKHART LAKE WATER DEPT | 99 | | 81 | 88 | 80 |
| ELKHORN LIGHT AND WATER | 97 | 98 | 85 | 78 | 72 |
| ELK MOUND MUN WATER & SEWER UTY | 100 | 88 | 68 | 77 | 62 |
| ELLSWORTH MUN WATER AND SEWER UTIL | 98 | | 73 | 70 | 31 |
| ELMWOOD MUNICIPAL WATER UTILITY | 99 | | 91 | 76 | 71 |
| ELROY MUN ELECTRIC AND WATER UTY | 98 | | 68 | 86 | 81 |
| EMBARRASS WATER AND SEWER UTIL | 97 | | 86 | 81 | 0 |
| ETTRICK MUN WATER AND SEWER UTILITY | 100 | | 67 | 80 | 0 |
| EVANSVILLE CITY OF WATER & LIGHT | 99 | | 86 | 87 | 81 |
| EXELAND MUNICIPAL WATER UTILITY | 99 | | 75 | 66 | 0 |
| FAIRCHILD MUNICIPAL WATER UTILITY | 98 | | 60 | 67 | 44 |
| FAIRWATER MUN WATER UTILITY | 100 | | 72 | 76 | 66 |
| FALL CREEK MUNICIPAL WATER UTILITY | 90 | | 77 | 89 | 49 |
| FALL RIVER MUNICIPAL WATER UTILITY | 99 | | 88 | 92 | 46 |
| FENNIMORE WATER AND LIGHT PLANT | 99 | | 85 | 90 | 79 |
| FITCHBURG WATER UTILITY | 97 | | 94 | 91 | 93 |
| FLORENCE UTILITY COMMISSION | 99 | | 81 | 88 | 76 |
| FOND DU LAC WATER UTILITY | 90 | 88 | 65 | 73 | 85 |
| FONTANA MUNICIPAL WATER UTILITY | 99 | | 63 | 72 | 51 |
| FOOTVILLE WATER UTILITY | 96 | | 64 | 74 | 50 |
| FORT ATKINSON CITY OF WATER UTILITY | 91 | | 83 | 78 | 94 |
| FOUNTAIN CITY WATER UTILITY | 100 | | 52 | 45 | 63 |
| FOX LAKE CITY OF WATER UTILITY | 99 | | 91 | 82 | 58 |
| FOX POINT VILL OF WATER UTILITY | 90 | | 66 | 73 | 80 |
| FRANKLIN MUNICIPAL WATER UTILITY | 99 | 78 | 70 | 86 | 80 |
| FREDERIC WATER COMMISSION | 92 | 86 | 65 | 75 | 45 |
| FREDONIA MUNICIPAL WATER UTILITY | 92 | | 91 | 74 | 23 |
| FRIENDSHIP VILLAGE OF WATER UTILITY | 90 | | 79 | 74 | 0 |
| FRIESLAND MUNICIPAL WATER UTILITY | 92 | 87 | 67 | 59 | 23 |
| FULTON WATER UTILITY | 91 | | 90 | 82 | 50 |
| GALESVILLE CITY OF MUN WTR & SWR UT | 99 | 94 | 89 | 69 | 68 |
| GAYS MILLS VILL OF MUN WTR UTY | 100 | | 92 | 79 | 51 |
| GENOA MUN WATER AND SEWER UTILITY | 0 | | 86 | 54 | 8 |
| GENOA CITY VILLAGE OF MUN WATER UT | 92 | 77 | 89 | 79 | 51 |
| GERMANTOWN WATER UTILITY | 98 | | 70 | 90 | 83 |
| GILLETT WATER AND SEWER COMM | 99 | | 80 | 87 | 80 |
| GILMAN WATER UTILITY | 99 | | 64 | 70 | 19 |

| Grade Color Key | A (>90) | B (80-90) | C (70-80) | D (60-70) | F (<60) |
|---|---|---|---|---|---|

| Name | Quality - Health | Quality - Aesthetics | Finance | Infrastructure & Operations | Communications |
|---|---|---|---|---|---|
| GLENBEULAH MUN WATER UTILITY | 99 | | 85 | 83 | 20 |
| GLENDALE WATER UTILITY | 91 | | 63 | 79 | 68 |
| GLENWOOD CITY MUN WATER UTILITY | 100 | | 71 | 83 | 23 |
| GLEN FLORA; VILLAGE OF; WATER UTY | 99 | | 47 | 22 | 0 |
| GRAFTON WATER & WASTEWATER UTILITY | 85 | | 94 | 92 | 85 |
| GRANTON MUNICIPAL WATER UTILITY | 98 | | 88 | 65 | 33 |
| GRANTSBURG VILL OF MUN WTR UTY | 100 | | 90 | 89 | 51 |
| GRATIOT MUNICIPAL WATER UTILITY | 0 | | 54 | 50 | 8 |
| GREEN BAY WATER UTILITY | 95 | 92 | 85 | 62 | 95 |
| GREENDALE VILLAGE OF WATER UT | 91 | | 79 | 69 | 53 |
| GREEN LAKE CITY OF WATER UTILITY | 97 | | 68 | 72 | 50 |
| GREENWOOD CITY OF WATER UTILITY | 91 | | 77 | 76 | 43 |
| GRESHAM MUNICIPAL WATER AND SEWER UT | 91 | | 43 | 79 | 49 |
| LAKE HALLIE (VILLAGE OF) PUBLIC WORK | 97 | | 86 | 93 | 50 |
| HAMMOND MUNICIPAL WATER UTILITY | 99 | | 91 | 86 | 45 |
| HARTFORD CITY OF UTILITIES | 98 | | 68 | 80 | 85 |
| HARTLAND MUN WATER UTILITY | 93 | | 90 | 87 | 82 |
| HATLEY VILLAGE OF WATER UTILITY | 99 | | 65 | 76 | 23 |
| HAUGEN VILLAGE OF WATER UTILITY | 98 | 63 | 68 | 53 | 40 |
| HAWKINS MUN WATER AND SEWER UTILITY | 100 | | 67 | 57 | 30 |
| HAYWARD CITY OF WATERWORKS AND SWR | 99 | | 89 | 94 | 53 |
| HAZEL GREEN MUNICIPAL UTILITY | 88 | | 90 | 80 | 24 |
| HIGHLAND MUNICIPAL WATER UTILITY | 99 | | 82 | 86 | 48 |
| HILBERT MUNICIPAL WATER UTILITY | 97 | | 61 | 85 | 23 |
| HILLSBORO MUN WATER UTY | 0 | 93 | 75 | 51 | 51 |
| HIXTON MUNICIPAL WATER UTILITY | 99 | | 77 | 75 | 24 |
| HOBART VILLAGE OF WATER UTILITY | 98 | | 86 | 88 | 81 |
| HOLLANDALE WATER UTILITY | 92 | | 55 | 41 | 16 |
| HOLMEN MUNICIPAL WATER UTILITY | 89 | | 91 | 95 | 44 |
| HORICON CITY OF WATER UTILITY | 99 | | 63 | 82 | 80 |
| HORTONVILLE VILLAGE OF WTR & SWR | 96 | | 83 | 71 | 56 |
| HOWARD VILLAGE OF WTR & SWR DEP | 98 | 43 | 69 | 66 | 74 |
| HUDSON PUBLIC UTILITIES | 98 | | 66 | 89 | 73 |
| HURLEY CITY OF WATER UTILITY | 90 | | 50 | 53 | 0 |
| HUSTISFORD UTILITIES | 99 | | 81 | 53 | 60 |
| HUSTLER MUNICIPAL WATER UTILITY | 99 | | 67 | 76 | 0 |
| INDEPENDENCE MUNICIPAL WATER UTILITY | 100 | | 83 | 88 | 43 |
| IOLA MUNICIPAL WATER UTILITY | 99 | | 61 | 72 | 40 |
| IRON RIDGE MUNICIPAL WATER UTILITY | 94 | | 66 | 85 | 58 |
| IRONTON WATER UTILITY | 99 | | 86 | 72 | 0 |
| JACKSON VILL OF WATER UTILITY | 99 | | 61 | 75 | 75 |
| JANESVILLE WATER UTILITY | 97 | 82 | 71 | 68 | 85 |
| JEFFERSON WATER AND ELECTRIC DEPT | 92 | | 87 | 84 | 81 |
| JOHNSON CREEK WATER UTILITY | 99 | 87 | 56 | 49 | 68 |
| JUNCTION CITY WATER UTILITY | 99 | | 75 | 56 | 15 |
| JUNEAU UTILITY COMMISSION | 0 | 78 | 71 | 76 | 73 |
| KAUKAUNA UTILITIES | 99 | | 85 | 81 | 88 |
| KELLNERSVILLE WATER UTILITY | 98 | | 73 | 88 | 0 |
| KENDALL MUNICIPAL WATER UTILITY | 98 | 82 | 53 | 82 | 26 |
| KENOSHA WATER UTILITY | 99 | 94 | 70 | 63 | 94 |
| KEWASKUM MUNICIPAL WATER UTILITY | 92 | | 92 | 80 | 50 |
| KEWAUNEE MUNICIPAL WATER UTILITY | 99 | | 58 | 75 | 51 |
| KIEL CITY OF UTILITIES | 95 | | 79 | 85 | 76 |
| KIMBERLY MUNICIPAL WATER UTILITY | 92 | | 90 | 58 | 58 |
| KNAPP MUN WATER AND SEWER UTILITY | 100 | | 95 | 79 | 0 |
| KOHLER MUNICIPAL WATER UTILITY | 90 | | 93 | 74 | 72 |
| KRONENWETTER WATER UTILITY | 99 | | 93 | 97 | 78 |
| LA CROSSE WATER UTILITY | 98 | 83 | 93 | 63 | 83 |

| Grade Color Key | A (>90) | B (80-90) | C (70-80) | D (60-70) | F (<60) |
|---|---|---|---|---|---|

| Name | Quality - Health | Quality - Aesthetics | Finance | Infrastructure & Operations | Communications |
|---|---|---|---|---|---|
| LADYSMITH MUNICIPAL WATER UTILITY | 99 | | 43 | 79 | 70 |
| LA FARGE MUN WATER AND SEWER UTILITY | 99 | 82 | 78 | 70 | 28 |
| LAKE DELTON VILLAGE OF WATER UTIL | 99 | | 78 | 77 | 75 |
| LAKE GENEVA UTILITY COMMISSION | 97 | | 75 | 84 | 69 |
| LAKE MILLS LIGHT AND WATER DEPT | 90 | 82 | 63 | 77 | 75 |
| LANCASTER MUNICIPAL WATER UTILITY | 98 | | 79 | 85 | 43 |
| LANNON MUNICIPAL WATER UTILITY | 92 | | 84 | 57 | 53 |
| LA VALLE MUNICIPAL WATER UTILITY | 0 | | 60 | 48 | 30 |
| LAWRENCE TOWN OF WATER UTILITY | 99 | | 66 | 89 | 66 |
| LENA MUNICIPAL WATER & SEWER UTY | 99 | | 81 | 54 | 60 |
| LINDEN MUNICIPAL WATER UTILITY | 100 | | 80 | 83 | 30 |
| LITTLE CHUTE MUNICIPAL WATER DEPT | 100 | | 82 | 84 | 70 |
| LIVINGSTON MUNICIPAL WATER UTILITY | 100 | | 81 | 70 | 25 |
| LODI MUNICIPAL LIGHT AND WATER UTILI | 98 | 89 | 68 | 69 | 80 |
| LOGANVILLE MUN WATER & SEWER UTILITY | 99 | | 69 | 51 | 23 |
| LOMIRA MUNICIPAL WATER UTILITY | 99 | | 69 | 87 | 73 |
| LONE ROCK UTILITIES | 98 | 90 | 71 | 75 | 40 |
| LOWELL MUN WATER AND SEWER UTILITY | 99 | | 64 | 49 | 24 |
| LOYAL MUNICIPAL WATER UTILITY | 97 | | 64 | 83 | 19 |
| LUCK MUNICIPAL WATER UTILITY | 98 | | 66 | 68 | 38 |
| LUXEMBURG MUNICIPAL WATER UTILITY | 99 | | 75 | 92 | 61 |
| LYNDON STATION MUN WATER UTILITY | 100 | 98 | 66 | 59 | 18 |
| MADISON WATER UTILITY | 99 | 86 | 80 | 83 | 100 |
| MAIDEN ROCK; VILLAGE OF; MUN WTR UTY | 99 | | 59 | 67 | 0 |
| MANAWA MUNICIPAL WATER UTILITY | 98 | | 86 | 69 | 68 |
| MANITOWOC PUBLIC UTILITIES | 99 | 95 | 67 | 62 | 83 |
| MAPLE BLUFF VILLAGE OF MUN WTR UTY | 91 | | 56 | 77 | 46 |
| MARATHON VILLAGE OF WTR & SWR UTY | 99 | | 85 | 76 | 83 |
| MARIBEL MUN WTR & SWR UTY | 99 | | 66 | 75 | 0 |
| MARINETTE MUNICIPAL WATER UTILITY | 99 | | 69 | 85 | 65 |
| MARION MUN WATER AND SEWER UTILITY | 99 | | 86 | 67 | 58 |
| MARKESAN MUN WATER PLANT | 98 | 87 | 87 | 91 | 51 |
| MARSHALL WATER AND SEWER UTILITY | 98 | | 72 | 89 | 83 |
| MARSHFIELD UTILITIES | 98 | 87 | 89 | 78 | 78 |
| MATTOON MUNICIPAL WATER UTILITY | 99 | | 90 | 68 | 0 |
| MAUSTON CITY OF MUNICIPAL WTR UTY | 99 | | 90 | 84 | 83 |
| MAYVILLE MUNICIPAL WATER UTILITY | 91 | 85 | 90 | 87 | 59 |
| MAZOMANIE WATER UTILITY | 99 | | 75 | 90 | 45 |
| MCFARLAND WATER & SEWER UTILITY | 99 | | 85 | 87 | 84 |
| MEDFORD WATER WORKS | 96 | | 87 | 88 | 60 |
| MELLEN MUN WATER UTILITY | 92 | | 71 | 61 | 0 |
| MELROSE MUNICIPAL WATER UTILITY | 100 | | 79 | 68 | 58 |
| MENASHA - TOWN OF - UTILITY DISTRICT | 99 | | 81 | 79 | 81 |
| MENASHA ELECTRIC & WATER UTILITIES | 92 | | 78 | 67 | 88 |
| MENOMONEE FALLS VILLAGE OF WTR UTY | 99 | | 70 | 76 | 93 |
| MENOMONIE CITY OF WATER DEPT | 99 | | 87 | 80 | 65 |
| MEQUON MUNICIPAL WATER UTILITY | 90 | | 90 | 90 | 80 |
| MERRILL WATER UTILITY | 91 | | 77 | 88 | 83 |
| MERRILLAN MUN ELECTRIC & WTR UTIL | 100 | | 76 | 63 | 74 |
| MERRIMAC MUNICIPAL WATER UTILITY | 100 | | 78 | 76 | 66 |
| MIDDLETON MUNICIPAL WATER UTILITY | 99 | | 90 | 89 | 83 |
| MILLADORE VILLAGE OF WATER UTILITY | 99 | | 63 | 74 | 0 |
| MILLTOWN VIL OF WATER UTY | 83 | | 67 | 50 | 20 |
| MILTON CITY OF MUN WTR UTY | 97 | | 92 | 80 | 75 |
| MILWAUKEE WATER WORKS | 99 | 94 | 68 | 75 | 95 |
| MINERAL POINT MUN WATER UTILITY | 0 | | 77 | 55 | 61 |
| MINONG VILLAGE OF WATER UTILITY | 100 | | 66 | 78 | 23 |
| MISHICOT WATER UTILITY & SEW DEPT | 99 | | 86 | 76 | 71 |

| Grade Color Key | A (>90) | B (80-90) | C (70-80) | D (60-70) | F (<60) |
|---|---|---|---|---|---|

| Name | Quality - Health | Quality - Aesthetics | Finance | Infrastructure & Operations | Communications |
|---|---|---|---|---|---|
| MONDOVI MUN WATER AND SEWER UTILITY | 100 | | 85 | 69 | 66 |
| MONONA WATER UTILITY | 99 | | 88 | 87 | 90 |
| MONROE MUNICIPAL WATER UTILITY | 99 | 89 | 61 | 65 | 85 |
| MONTELLO CITY OF WATER UTILITY | 99 | | 72 | 84 | 70 |
| MONTFORT MUNICIPAL WATER UTILITY | 100 | | 78 | 85 | 63 |
| MONTICELLO VILLAGE OF WATER UTY | 98 | | 86 | 63 | 61 |
| MONTREAL MUNICIPAL WATER UTILITY | 99 | | 83 | 46 | 30 |
| MOSINEE MUNICIPAL WATER AND SEWER UT | 98 | | 63 | 85 | 60 |
| MT CALVARY VILL OF MUN WTR& SWR | 99 | | 73 | 80 | 21 |
| MOUNT HOPE MUNICIPAL WATER UTILITY | 100 | | 73 | 78 | 0 |
| MOUNT HOREB WATER AND SEWER UTILITY | 94 | | 93 | 88 | 84 |
| MOUNT STERLING MUN WATER UTILITY | 92 | | 46 | 62 | 0 |
| MUKWONAGO MUNICIPAL WATER UTILITY | 99 | | 70 | 87 | 83 |
| MUSCODA LIGHT AND WATER UTILITY | 99 | | 82 | 83 | 76 |
| MUSKEGO CITY OF WATER PUBLIC UTY | 92 | | 86 | 91 | 80 |
| NECEDAH VILL OF MUN WATER UTILITY | 99 | | 75 | 54 | 10 |
| NEENAH CITY OF WATER UTILITY | 90 | | 89 | 81 | 93 |
| NEILLSVILLE CITY OF MUN WTR UTY | 99 | | 77 | 71 | 76 |
| NEKOOSA MUNICIPAL WATER UTILITY | 99 | | 83 | 76 | 51 |
| NELSON WATER AND SEWER DEPARTMENT | 99 | | 76 | 73 | 60 |
| NEW AUBURN MUNICIPAL WATER UTILITY | 92 | | 60 | 67 | 73 |
| NEW BERLIN WATER UTILITY | 83 | | 91 | 87 | 74 |
| NEW GLARUS LIGHT AND WATER WORKS | 99 | | 87 | 90 | 66 |
| NEW HOLSTEIN PUBLIC UTILITY | 97 | | 80 | 88 | 79 |
| NEW LISBON CITY OF ELEC & WATER UT | 99 | | 84 | 85 | 48 |
| NEW LONDON ELECTRIC & WATER UTILITY | 91 | 87 | 85 | 76 | 75 |
| NEW RICHMOND MUNICIPAL WATER UTILITY | 92 | | 73 | 91 | 78 |
| NIAGARA MUNICIPAL WATER UTILITY | 99 | | 83 | 88 | 41 |
| NICHOLS MUNICIPAL WATER UTILITY | 100 | | 72 | 65 | 28 |
| NORTH FOND DU LAC WATER UTILITY | 0 | 63 | 89 | 61 | 51 |
| NORTH FREEDOM MUN WATER UTILITY | 98 | | 80 | 77 | 63 |
| NORWALK MUNICIPAL WATER UTILITY | 100 | | 64 | 57 | 41 |
| OAK CREEK WATER & SEWER UTILITY | 91 | | 88 | 82 | 85 |
| OAKDALE WATER UTILITY VILLAGE OF | 97 | | 87 | 75 | 6 |
| OAKFIELD VILLAGE OF MUN WTR UTY | 100 | | 70 | 59 | 73 |
| OCONOMOWOC CITY OF UTILITIES | 98 | | 91 | 89 | 95 |
| OCONTO UTILITY COMMISSION | 0 | | 88 | 92 | 63 |
| OCONTO FALLS WATER AND LIGHT COMM | 99 | | 87 | 89 | 75 |
| OLIVER MUNICIPAL WATER PLANT | 100 | | 41 | 60 | 25 |
| OMRO CITY OF WTR UTY | 93 | 55 | 74 | 85 | 73 |
| ONALASKA MUNICIPAL WATER UTILITY | 93 | 87 | 48 | 89 | 81 |
| ONTARIO MUNICIPAL WATER UTILITY | 100 | | 72 | 80 | 24 |
| OOSTBURG MUNICIPAL WATER UTILITY | 100 | | 81 | 75 | 64 |
| OREGON MUN WATER AND SEWER UTILITY | 98 | 89 | 93 | 88 | 71 |
| ORFORDVILLE MUNICIPAL WATER UTILITY | 99 | | 46 | 77 | 25 |
| OSCEOLA MUNICIPAL WATER UTILITY | 99 | | 87 | 84 | 80 |
| OSHKOSH CITY OF WATER UTILITY | 97 | 94 | 87 | 85 | 83 |
| OSSEO MUN WATER AND SEWER UTILITY | 99 | 92 | 90 | 84 | 73 |
| OWEN MUN WATER UTILITY | 90 | | 82 | 70 | 70 |
| PADDOCK LAKE MUN WATER UTILITY | 92 | | 60 | 42 | 75 |
| PALMYRA VILLAGE OF WTR & SWR UTY | 99 | | 92 | 78 | 74 |
| PARDEEVILLE MUN WATER UTY | 99 | | 75 | 87 | 70 |
| PARK FALLS MUNICIPAL WATER UTILITY | 92 | 95 | 63 | 64 | 83 |
| PATCH GROVE MUNICIPAL WATER UTILITY | 100 | | 91 | 52 | 0 |
| PENCE TOWN OF MUN WTR DEPT | 90 | | 88 | 71 | 0 |
| BLOOMFIELD VILLAGE OF UTILITY DEPART | 98 | | 95 | 76 | 65 |
| PEPIN MUNICIPAL WATER UTILITY | 90 | 89 | 48 | 57 | 60 |
| PESHTIGO MUN WATER UTILITY | 99 | | 85 | 80 | 45 |

| Grade Color Key | A (>90) | B (80-90) | C (70-80) | D (60-70) | F (<60) |
|---|---|---|---|---|---|

| Name | Quality - Health | Quality - Aesthetics | Finance | Infrastructure & Operations | Communications |
|---|---|---|---|---|---|
| PEWAUKEE VILLAGE OF WATER UTILITY | 0 | | 82 | 63 | 85 |
| PEWAUKEE CITY OF WATER UTILITY | 0 | | 52 | 79 | 84 |
| PHILLIPS MUN WATER WORKS | 99 | | 82 | 90 | 30 |
| PIGEON FALLS MUNICIPAL WATER UTILITY | 100 | 89 | 28 | 42 | 0 |
| PITTSVILLE MUN WATER UTILITY | 98 | | 86 | 76 | 65 |
| PLAIN MUNICIPAL WATER UTILITY | 99 | | 82 | 62 | 26 |
| PLAINFIELD VILL OF WATER UTILITY | 99 | | 49 | 71 | 18 |
| PLATTEVILLE WATER & SEWER UTILITY | 97 | 83 | 80 | 84 | 69 |
| PLEASANT PRAIRIE VILL OF WTR UTY | 90 | | 91 | 84 | 84 |
| PLOVER VILL OF MUN WTR UTY | 97 | | 75 | 94 | 93 |
| PLYMOUTH UTILITIES | 90 | | 87 | 82 | 55 |
| PORTAGE WATER UTILITY | 99 | | 87 | 89 | 68 |
| PORT EDWARDS WATER UTILITY | 100 | | 93 | 80 | 43 |
| PORT WASHINGTON MUN WATER UTILITY | 92 | | 87 | 82 | 83 |
| POTOSI MUNICIPAL WATER UTILITY | 99 | | 92 | 53 | 6 |
| POUND VILL OF WATER & SWR UTY | 100 | | 54 | 68 | 78 |
| POYNETTE MUNICIPAL WATER UTILITY | 99 | | 82 | 74 | 80 |
| PRAIRIE DU CHIEN MUN WATER UTILITY | 92 | | 70 | 74 | 80 |
| PRAIRIE DU SAC MUN ELECTRIC & WTR | 100 | | 88 | 82 | 69 |
| PRENTICE VILLAGE OF WTR & SWR UTY | 84 | | 87 | 68 | 43 |
| PRESCOTT CITY OF MUN WTR UTY | 98 | | 91 | 95 | 90 |
| PRINCETON MUN WATER & ELECTRIC UTIL | 99 | | 82 | 83 | 63 |
| PULASKI WATER DEPT | 0 | 71 | 86 | 73 | 51 |
| RACINE WATER WORKS COMMISSION | 92 | 94 | 82 | 77 | 93 |
| RADISSON WATER AND SEWER UTILITY | 92 | 87 | 79 | 72 | 23 |
| RANDOLPH MUNICIPAL WATER UTILITY | 98 | | 64 | 84 | 45 |
| RANDOM LAKE MUNICIPAL WATER DEPT | 92 | | 77 | 54 | 53 |
| READSTOWN MUNICIPAL WATER UTILITY | 100 | | 70 | 56 | 36 |
| REDGRANITE WATER UTILITY | 99 | | 47 | 80 | 38 |
| REEDSBURG UTILITY COMMISSION | 97 | | 73 | 91 | 79 |
| REEDSVILLE MUNICIPAL WATER UTILITY | 0 | | 80 | 55 | 61 |
| REESEVILLE WATER UTILITY | 99 | | 92 | 86 | 49 |
| REWEY MUNICIPAL WATER UTILITY | 0 | | 67 | 37 | 0 |
| RHINELANDER CITY OF WATER UTY | 99 | | 85 | 85 | 73 |
| RIB LAKE VILLAGE OF WATER UTILITY | 100 | | 83 | 77 | 66 |
| RICE LAKE MUN WATER & ELECTRIC UTIL | 90 | | 91 | 73 | 71 |
| RICHLAND CENTER WATER UTILITY | 99 | 88 | 66 | 87 | 83 |
| RIDGEWAY VILL OF MUN WATER UTY | 99 | | 64 | 83 | 66 |
| RIO MUNICIPAL WATER UTILITY | 99 | 90 | 89 | 68 | 68 |
| RIPON WATER UTILITY | 99 | | 80 | 73 | 50 |
| RIVER FALLS MUNICIPAL UTILITY | 92 | | 94 | 92 | 74 |
| ROBERTS VILL OF WATER UTILITY | 99 | | 86 | 79 | 46 |
| ROCKLAND MUN WATER AND SEWER UTILITY | 100 | | 81 | 79 | 46 |
| ROCK SPRINGS MUNICIPAL UTILITY | 0 | | 61 | 64 | 24 |
| ROME TOWN OF WATER UTILITY | 91 | | 82 | 66 | 70 |
| ROTHSCHILD MUNICIPAL WATER UTILITY | 92 | 90 | 77 | 86 | 71 |
| ST CLOUD WATER & SEWER UTY | 99 | | 79 | 76 | 39 |
| ST CROIX FALLS MUN WATER UTILITY | 99 | | 91 | 85 | 50 |
| ST NAZIANZ WATER UTILITY | 99 | | 85 | 89 | 50 |
| SAUK CITY MUN WATER & LIGHT UTIL | 99 | 88 | 63 | 88 | 63 |
| SAUKVILLE MUN WATER UTILITY | 99 | | 87 | 68 | 91 |
| SCHOFIELD MUN WATER & SEWER UTILITY | 99 | | 86 | 65 | 0 |
| SCOTT TOWN OF WATER UTILITY | 98 | | 77 | 85 | 25 |
| SEYMOUR MUN WATER UTILITY | 99 | | 91 | 70 | 44 |
| SHARON WATERWORKS & SEWER SYSTEM | 98 | | 76 | 71 | 61 |
| SHAWANO CITY OF WATER & SEWER UTILIT | 96 | 88 | 71 | 90 | 85 |
| SHEBOYGAN WATER UTILITY | 99 | | 65 | 82 | 83 |
| SHEBOYGAN FALLS UTILITIES | 90 | | 88 | 88 | 73 |

| Grade Color Key | A (>90) | B (80-90) | C (70-80) | D (60-70) | F (<60) |
|---|---|---|---|---|---|

| Name | Quality - Health | Quality - Aesthetics | Finance | Infrastructure & Operations | Communications |
|---|---|---|---|---|---|
| SHELDON MUNICIPAL WATER UTILITY | 91 | | 73 | 68 | 0 |
| SHELL LAKE MUNICIPAL UTILITIES | 92 | | 86 | 85 | 38 |
| SHERWOOD VILLAGE OF WTR & SWR UTY | 100 | 98 | 69 | 71 | 83 |
| SHIOCTON MUNICIPAL UTILITY | 100 | | 55 | 54 | 51 |
| SHOREWOOD MUNICIPAL WATER UTILITY | 90 | | 81 | 66 | 94 |
| SHOREWOOD HILLS VILL OF WATER UTY | 91 | | 65 | 70 | 65 |
| SHULLSBURG WATER UTILITY | 99 | 90 | 60 | 84 | 45 |
| SIREN MUNICIPAL WATER UTILITY | 0 | | 86 | 81 | 26 |
| SISTER BAY WATER AND SEWER UTILITY | 97 | | 91 | 78 | 65 |
| SLINGER UTILITIES | 91 | 61 | 83 | 84 | 63 |
| SOLDIERS GROVE VILL OF MUN WTR UTY | 100 | | 71 | 78 | 44 |
| SOMERS WATER UTILITY TOWN OF | 90 | | 70 | 85 | 75 |
| SOMERSET VILLAGE OF WATER UTILITY | 99 | 59 | 48 | 83 | 68 |
| SOUTH MILWAUKEE WATER UTILITY | 92 | | 77 | 69 | 83 |
| SOUTH WAYNE MUNICIPAL WATER UTILITY | 100 | | 63 | 82 | 55 |
| SPARTA MUNICIPAL WATER DEPT | 94 | | 91 | 91 | 70 |
| SPENCER MUNICIPAL WATER UTILITY | 100 | | 86 | 87 | 38 |
| SPOONER MUNICIPAL UTILITIES | 99 | | 92 | 82 | 80 |
| SPRING GREEN MUNICIPAL WATER UTILITY | 99 | | 64 | 79 | 40 |
| SPRING VALLEY WATERWORKS | 99 | | 48 | 87 | 70 |
| STANLEY MUNICIPAL WATERWORKS | 99 | | 85 | 67 | 48 |
| STAR PRAIRIE MUNICIPAL WATER UTILITY | 92 | | 63 | 39 | 50 |
| STETSONVILLE WATER UTILITY | 0 | 91 | 59 | 80 | 65 |
| STEVENS POINT MUN WATER UTILITY | 98 | | 88 | 85 | 84 |
| STOCKBRIDGE WATER UTILITY | 99 | | 51 | 73 | 80 |
| STODDARD MUNICIPAL WATER UTILITY | 92 | | 85 | 64 | 14 |
| STOUGHTON WATER UTILITY | 98 | 84 | 91 | 75 | 78 |
| STRATFORD MUN WATER & ELECTRIC UTIL | 98 | | 82 | 75 | 73 |
| STRUM MUNICIPAL UTILITIES | 100 | | 83 | 85 | 46 |
| STURGEON BAY UTILITIES | 92 | | 77 | 80 | 86 |
| SUAMICO WATER UTILITY | 99 | | 91 | 67 | 29 |
| SUN PRAIRIE UTILITIES | 91 | 88 | 87 | 92 | 88 |
| SURING VILLAGE OF WATER UTILITY | 99 | 87 | 59 | 63 | 65 |
| SUSSEX VILLAGE OF WTR PUBLIC UTY | 99 | 82 | 71 | 80 | 85 |
| TAYLOR VILLAGE OF WATER UTILITY | 100 | | 67 | 89 | 23 |
| TENNYSON WATER UTILITY | 99 | | 58 | 65 | 6 |
| THERESA MUN WATER AND SEWER UTILITY | 99 | | 65 | 76 | 70 |
| THORP MUN WATER AND SEWER UTILITY | 90 | 91 | 77 | 81 | 43 |
| TIGERTON MUNICIPAL WATER & SEWER UTY | 96 | | 71 | 62 | 65 |
| TOMAH WATER UTILITY | 96 | | 86 | 92 | 83 |
| TOMAHAWK MUN WATER & SEWER UTILITY | 100 | | 79 | 76 | 78 |
| TONY MUNICIPAL WATER UTILITY | 100 | | 77 | 73 | 0 |
| TREMPEALEAU MUN ELECTRIC & WTR UTY | 99 | | 83 | 80 | 68 |
| TURTLE LAKE MUN WATER & SEWER UTIL | 99 | | 89 | 60 | 70 |
| TWO RIVERS WATER & LIGHT UTILITY | 84 | | 65 | 81 | 63 |
| UNION CENTER VILLAGE OF WTR UTY | 98 | | 55 | 66 | 51 |
| UNION GROVE MUNICIPAL WATER UTILITY | 100 | | 83 | 73 | 70 |
| VALDERS PUBLIC UTILITY | 97 | | 89 | 86 | 75 |
| VERONA WATER UTILITY | 98 | | 92 | 89 | 94 |
| VESPER MUN WATER AND SEWER UTILITY | 99 | | 78 | 75 | 25 |
| VIOLA MUN WATER AND ELECTRIC UTILITY | 99 | | 69 | 83 | 48 |
| VIROQUA CITY OF MUN WATER UTILITY | 99 | | 85 | 83 | 80 |
| WALDO WATER AND SEWER UTILITY | 92 | 83 | 89 | 81 | 66 |
| WALWORTH MUN WATER AND SEWER UTILITY | 0 | 88 | 73 | 66 | 63 |
| WARRENS MUN WTR & SWR UTILITIES | 100 | | 81 | 73 | 48 |
| WASHBURN MUN WATER AND SEWER UTILITY | 99 | | 83 | 79 | 80 |
| WATERFORD VILLAGE OF WTR & SWR UTY | 99 | | 89 | 91 | 73 |
| WATERLOO WATER AND LIGHT COMM | 0 | 78 | 75 | 87 | 81 |

| Grade Color Key | A (>90) | B (80-90) | C (70-80) | D (60-70) | F (<60) |
|---|---|---|---|---|---|

| Name | Quality - Health | Quality - Aesthetics | Finance | Infrastructure & Operations | Communications |
|---|---|---|---|---|---|
| WATERTOWN WATER DEPARTMENT | 99 | 89 | 88 | 85 | 94 |
| WAUKESHA WATER UTILITY CITY OF | 0 | 86 | 79 | 89 | 80 |
| WAUNAKEE WATER AND LIGHT COMMISSION | 99 | | 93 | 91 | 89 |
| WAUPACA WATER UTILITY | 96 | | 84 | 81 | 83 |
| WAUPUN PUBLIC UTILITIES | 99 | | 88 | 82 | 78 |
| WAUSAU WATER UTILITY | 97 | | 83 | 94 | 94 |
| WAUSAUKEE WTR & SWR UTY | 0 | | 73 | 75 | 28 |
| WAUWATOSA WATER UTILITY | 90 | | 83 | 65 | 84 |
| WAUTOMA PUBLIC WATER UTILITY | 99 | | 82 | 83 | 36 |
| WAUZEKA MUNICIPAL WATER UTILITY | 99 | | 72 | 55 | 8 |
| WEBSTER VILL OF MUN WATER UTILITY | 92 | | 84 | 76 | 23 |
| WEST ALLIS MUNICIPAL WATER UTILITY | 90 | | 62 | 82 | 95 |
| WEST BARABOO MUN WTR & SWR UTY | 99 | | 83 | 82 | 46 |
| WEST BEND CITY OF WATER UTY | 84 | 81 | 70 | 80 | 55 |
| WESTBY CITY OF MUN ELEC & WTR UTY | 100 | | 84 | 67 | 65 |
| WESTON WATER UTILITY | 91 | | 87 | 90 | 83 |
| WEST SALEM MUN JOINT WTR & SWR UTIL | 91 | | 94 | 84 | 46 |
| WESTPORT WATER UTILITY DISTRICT | 100 | | 95 | 82 | 51 |
| WEYAUWEGA CITY OF WATER & SEWER UTY | 99 | | 88 | 79 | 73 |
| WEYERHAEUSER MUNICIPAL WATER UTILITY | 100 | | 38 | 59 | 45 |
| WHEELER VILL OF MUN WTR UTY | 99 | | 48 | 62 | 0 |
| WHITEFISH BAY VILLAGE OF WTR UTY | 90 | | 78 | 66 | 85 |
| WHITEHALL MUNICIPAL WATER UTILITY | 100 | | 67 | 71 | 30 |
| WHITE LAKE VILLAGE OF WTR UTY | 92 | | 48 | 59 | 13 |
| WHITELAW MUN WATER AND SEWER UTIL | 98 | | 52 | 52 | 0 |
| WHITEWATER MUNICIPAL WATER UTILITY | 99 | 86 | 64 | 88 | 85 |
| WHITING MUN WATER AND SEWER UTILITY | 98 | | 89 | 82 | 45 |
| WILLIAMS BAY MUNICIPAL WATER UTILITY | 85 | | 72 | 71 | 50 |
| WILSON VILLAGE OF MUN WTR UTY | 99 | | 91 | 74 | 0 |
| WILTON MUNICIPAL WATER & SEWER UTY | 100 | | 59 | 83 | 25 |
| WIND POINT MUNICIPAL WATER UTILITY | 90 | | 85 | 80 | 81 |
| WINNECONNE WATER UTILITY | 98 | | 70 | 73 | 76 |
| WINTER VILLAGE OF WATER UTILITY | 99 | | 82 | 72 | 0 |
| WISCONSIN DELLS MUN WATER UTILITY | 98 | | 88 | 78 | 66 |
| WISCONSIN RAPIDS WATER WORKS & LIGHT | 96 | 95 | 85 | 86 | 74 |
| WITHEE MUNICIPAL WATER UTILITY | 100 | | 86 | 57 | 68 |
| WITTENBERG MUN WTR & SWR UTILITY | 98 | | 66 | 77 | 68 |
| WONEWOC ELEC & WTR UTY | 100 | | 85 | 83 | 38 |
| WOODVILLE WATER AND SEWER UTY | 99 | | 84 | 88 | 0 |
| WRIGHTSTOWN VILLAGE OF WTR UTILITY | 98 | | 48 | 72 | 83 |
| WYOCENA MUN WATER & SEWER UTILITY | 99 | | 77 | 56 | 65 |
| YUBA MUNICIPAL WATERWORKS | 87 | 89 | 75 | 72 | 0 |

# Appendix D | Illustrative report card calculation: Eau Claire, Wisconsin

This appendix provides a detailed illustration of WSEP grade calculations by focusing on Eau Claire's drinking water utility. Eau Claire's report card was strong overall, with a total weighted grade of 86.8% across all five subjects. Detailed discussion of each element for each subject follows, below.

## Quality-Health

Eau Claire scored very well overall for *Quality – Health*, with a total weighted grade of 91. Eau Claire's performance for chronic contamination was exceptionally strong, with a grade of 99.2 that contributed 25% to the utility's overall grade. The Eau Claire municipal water utility had a positivity rate of 11 percent for Total Coliform, resulting in a weighted grade of 89.5 for acute contaminants (contributing 75% to the overall grade). Eau Claire also had no SDWA health violations, which would have resulted in an automatic failing grade. Table D1 provides details on Eau Claire's contaminant levels and corresponding scores; Table D2 reports these details for chronic contaminants.

**Table D1. *Quality-Health* values and scores for acute contaminants, Eau Claire, 2020**

| Contaminant | Value | Score |
|---|---|---|
| Cadmium | 0 mg/L | 100.0 |
| Coliform, Total | 11% positive | 0.0 |
| Copper | 38 µg/L | 99.6 |
| Dalapon | 0 µg/L | 100.0 |
| o-Dichlorobenzene | 0 µg/L | 100.0 |
| p-Dichlorobenzene | 0 µg/L | 100.0 |
| 1,1-Dichloroethylene | 0 mg/L | 100.0 |
| Nitrate (NO3-N) | 2.4 mg/L | 95.4 |
| Nitrite (NO2-N) | 0 mg/L | 100.0 |
| Oxamyl (Vydate) | 0 µg/L | 100.0 |
| Violations? | | None |
| **Acute Average** | | 89.5 |

**Table D2. *Quality-Health* values and scores for chronic contaminants, Eau Claire, 2020**

| Contaminant | Value | Score | Contaminant | Value | Score |
|---|---|---|---|---|---|
| Arsenic | .00027 mg/L | 99.6 | Glyphosate | 0 µg/L | 100.0 |
| Alachlor (Lasso) | 0 mg/L | 100.0 | Heptachlor | 0 µg/L | 100.0 |
| Antimony Total | 0 mg/L | 100.0 | Heptachlor Epoxide | 0 µg/L | 100.0 |
| Atrazine | 0 µg/L | 100.0 | Hexachlorobenzene (HCB) | 0 µg/L | 100.0 |
| Barium | .03 mg/L | 99.8 | Hexachlorocyclopentadiene | 0 µg/L | 100.0 |
| Benzene | 0 µg/L | 100.0 | Lead | 14 µg/L | 73.5 |
| Beryllium Total | 0 mg/L | 100.0 | Mercury | 0 µg/L | 100.0 |
| Carbofuran | 0 µg/L | 100.0 | Methoxychlor | 0 µg/L | 100.0 |
| Carbon Tetrachloride | 0 µg/L | 100.0 | PCB, Total | 0 µg/L | 100.0 |
| Chloramine | 1.13 mg/L | 94.4 | Pentachlorophenol | 0 µg/L | 100.0 |
| Chlordane | 0 µg/L | 100.0 | Picloram | 0 µg/L | 100.0 |
| Chromium | .00085 mg/L | 100.0 | Radium (226 + 228) | .813 pCi/L | 96.8 |
| Cyanide | 0 mg/L | 100.0 | Selenium | 0 µg/L | 100.0 |
| 2,4-D | 0 µg/L | 100.0 | 2,4,5-TP (Silvex) | 0 µg/L | 100.0 |
| 1,2-Dibromo-3-Chloropro (DBCP) | 0 µg/L | 100.0 | Simazine | 0 µg/L | 100.0 |
| 1,2-Dichloroethane | 0 µg/L | 100.0 | Styrene | 0 µg/L | 100.0 |
| cis-1,2-dichloroethylene | 0 µg/L | 100.0 | Tetrachloroethylene | 0 µg/L | 100.0 |
| trans-1,2-dichloroethylene | 0 µg/L | 100.0 | Thallium total | 0 µg/L | 100.0 |
| Dichloromethane | 0 µg/L | 100.0 | Toluene | 0 µg/L | 100.0 |
| 1,2-Dichloropropane | 0 µg/L | 100.0 | Toxaphene | 0 µg/L | 100.0 |
| Di(2-ethylhexyl) adipate | 0 µg/L | 100.0 | 1,2,4-Trichlorobenzene | 0 µg/L | 100.0 |
| Di(2-ethylhexyl) phthalate | 0 µg/L | 100.0 | 1,1,1-Trichloroethane | 0 µg/L | 100.0 |
| Dinoseb | 0 µg/L | 100.0 | 1,1,2-Trichloroethane | 0 µg/L | 100.0 |
| Diquat | 0 µg/L | 100.0 | Trichloroethylene | 0 µg/L | 100.0 |
| Endothall | 0 µg/L | 100.0 | TTHM | 27.3 µg/L | 93.2 |
| Endrin | 0 µg/L | 100.0 | Combined Uranium | 0 µg/L | 100.0 |
| Ethylbenzene | 0 µg/L | 100.0 | Vinyl Chloride | 0 µg/L | 100.0 |
| Ethylene Dibromide (EDB) | 0 µg/L | 100.0 | Xylenes, total | 0 µg/L | 100.0 |
| Violations? | | | | None | |
| **Chronic Average** | | | | **99.2** | |

## Quality-Aesthetics

Eau Claire earned solid marks for *Quality-Aesthetics*. In particular, Eau Claire performed very well for hardness (99.7%), and Iron (100%), which are both weighted heavily at 25 percent. Eau Claire customers should be overall confident in the aesthetic quality of their drinking water. The main reduction in the grade came from the zero grade for Manganese, which is weighted at 25 percent. Like iron, manganese can turn the water brown or rust color, and cause staining of laundry and plumbing fixtures, and give the water an off taste or odor. Table D3 shows details for Eau Claire's *Quality-Aesthetics* grade.

**Table D3. *Quality-Aesthetics* values and scores, Eau Claire, 2020**

| Contaminant | Value | Score | Weight (%) |
|---|---|---|---|
| Hardness | 150 mg/L | 96.67 | 25.0 |
| Iron | 0.011 mg/L | 100.0 | 25.0 |
| Manganese | 1.5 mg/L | 0.0 | 25.0 |
| Chloride | 26 mg/L | 98.2 | 6.0 |
| Sulfate | 6.3 mg/L | 99.6 | 6.0 |
| Alkalinity | 130 mg/L | 92.8 | 6.0 |
| Fluoride | 0.6 mg/L | 77.1 | 3.5 |
| Aluminum | 0 mg/L | 100.0 | 3.5 |
| **Weighted Average** | | **73.4** | |

## Finance

Eau Claire's overall *Finance* performance was strong in 2020, with an overall grade of 86.9. Eau Claire performed particularly strongly with debt to assets ratio (100%) and days of operating reserve (100%), each of which is weighted at 20 percent. These indicate that Eau Claire has relatively low debt levels and has more than 9 months of operating reserve, which are both critical measures for overall financial strength. The main indicators that lowered the finance grade were price proportionality, measured with the Poehler Index (weighted at 10 percent), and return on equity (weighted at 10 percent). Table D4 shows the detailed calculation of Eau Claire's *Finance* grade.

**Table D4. *Finance* values and scores, Eau Claire, 2020**

| Indicator | Value | Score | Weight (%) |
|---|---|---|---|
| Debt to Assets Ratio | 16.0% | 100.0 | 20.0 |
| Monthly bill in Hours of Minimum Wage | 3.3 | 93.0 | 20.0 |
| Days of Operating Reserve | 305.3 | 100.0 | 25.0 |
| Poehler Index | 0.73 | 68.0 | 6.0 |
| Return on Equity | 2.1% | 70.0 | 6.0 |
| PILOT/Property Tax Equivalent | 1.0 | 75.0 | 6.0 |
| **Weighted Average** | | **86.9** | |

## Infrastructure & Operations

Eau Claire exhibited very strong overall performance for *Infrastructure & Operations*. In particular, Eau Claire performed very well in main breaks per 100 miles of main (94.7%), replacement rate (94.0%) and weighted replacement rate (95.9%), as well as total operating expenses per thousand gallons (95.8%) and total operating expenses per customer (96.7%). With main and service breaks per 100 miles weighted at 50 percent for Infrastructure, Eau Claire's grade of 94.7 helps offset the relatively poor mark (65.1 percent) for water loss per 100 miles. Eau Claire also scored a perfect 100 for Safe Drinking Water Act Management Compliance. Table D5 provide details for Eau Claire's 2020 *Infrastructure & Operations* grade.

**Table D5. *Infrastructure & Operations* values and scores, Eau Claire, 2020**

| | | | |
|---|---|---|---|
| **<u>INFRASTRUCTURE</u>** | | | |
| **Indicator** | **Value** | **Score** | **Weight (%)** |
| Main & Service Breaks per 100 miles | 8.6 | 94.7 | 50.0 |
| Water Loss per 100 miles (gallons) | 99,577 | 65.1 | 25.0 |
| Replacement Rate (years) | 45.9 | 94.0 | 12.5 |
| Weighted Replacement Rate (years) | 31.3 | 95.9 | 12.5 |
| *Infrastructure* Weighted Average (50% overall) | | 86.9 | |
| ***<u>OPERATIONS</u>*** | | | |
| ***Indicator*** | **Value** | **Score** | **Weight (%)** |
| kWh per Million Gallons per Year | 2,647.85 | 82.7 | 20.0 |
| Operating Expenses per Thousand Gallons ($) | 3.43 | 95.8 | 15.0 |
| Operating Expenses per Mile of Pipe ($) | 22,410 | 74.4 | 15.0 |
| Operating Expenses per Customer ($) | 154.39 | 96.7 | 15.0 |
| Operating Expenses per Capita ($) | 130.63 | 93.3 | 15.0 |
| SDWA Management compliance (violations) | 0.00 | 100.0 | 20.0 |
| *Operations* Weighted Average (50% overall) | | 90.6 | |
| **Total *Infrastructure & Operations* grade** | | **89.0** | |

## Communications

Eau Claire performed exceptionally well for *Communications*, with an overall grade of 94.0. Eau Claire makes a significant amount of information easily available on their website and are relatively interactive on their municipal social media accounts. Eau Claire's online resources include information about their source water, facilities, operations, as well as the rates and consumer confidence report – both of which are valued at 20 points. The only areas where Eau Claire could have performed better were with social media. Establishing a utility-specific social media presence and using their municipal social media accounts more often would yield a near-perfect overall *Communications* score for Eau Claire. Table D6 provides full scoring detail for Eau Claire's 2020 *Communications* grade.

**Table D6. *Communications* values and scores, Eau Claire, 2020**

| Indicator | Possible Points | Points Earned |
|---|---|---|
| Website Present | 5.0 | 5.0 |
| Mobile-friendly | 5.0 | 5.0 |
| Accessibility | 5.0 | 5.0 |
| Non-English | 10.0 | 10.0 |
| Consumer Confidence Report | 20.0 | 20.0 |
| Rates | 20.0 | 20.0 |
| Source Water Information | 4.0 | 4.0 |
| Facilities Information | 3.0 | 3.0 |
| Operations Information | 3.0 | 3.0 |
| Phone Number | 5.0 | 5.0 |
| Webform/Email | 5.0 | 5.0 |
| Past Meetings | 2.5 | 2.5 |
| Future Meetings | 2.5 | 2.5 |
| Utility Social Media | 5.0 | 0.0 |
| Municipal Social Media | 5.0 | 4.0 |
| **Total** | **100.0** | **94.0** |

***Water System Excellence Project***

***Hardness Summary***

***Data year: 2020***

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| ABBOTSFORD MUNICIPAL WATER UTILITY | | | |
| ADAMS MUNICIPAL WATER AND SEWER UTIL | | | |
| ADELL MUN SEWER AND WATER UTILITY | | | |
| ALBANY MUN WATER AND SEWER UTILITY | | | |
| ALGOMA UTILITY COMMISSION | | | |
| ALLOUEZ VILLAGE OF WATER DEPT | 225.00 | 240 | 67.6 |
| ALMA MUNICIPAL WATER UTILITY | | | |
| ALMA CENTER WATER UTILITY | 60.00 | 60 | 90.0 |
| ALMENA MUNICIPAL WATER UTILITY | | | |
| ALTOONA MUN WATER AND SEWER UTILITY | 110.78 | 140 | 93.3 |
| AMERY MUN JOINT WTR & SWR UTY | | | |
| AMHERST VILL OF WATER UTILITY | | | |
| ANTIGO UTILITIES | 135.56 | 230 | 85.0 |
| APPLETON WATER DEPT | 74.09 | 76 | 94.7 |
| APPLEWOOD HILL WATER UTILITY | | | |
| ARCADIA ELECTRIC & WATER UTILITY | | | |
| ARENA MUNICIPAL WATER UTILITY | | | |
| ARGYLE MUN ELECTRIC & WATER UTIL | 307.00 | 337 | 63.0 |
| ARLINGTON WATER UTILITY | | | |
| ASHLAND WATER UTILITY | | | |
| ASHWAUBENON WATER AND SEWER UTILITY | 227.50 | 260 | 67.4 |
| ATHENS MUNICIPAL WATER UTILITY | 112.00 | 112 | 92.7 |
| AUGUSTA; CITY OF MUN WTR & SWR UTY | | | |
| AVOCA MUNICIPAL WATER UTILITY | | | |
| BAGLEY MUNICIPAL WATER UTILITY | | | |
| BALDWIN MUNICIPAL WATER UTILITY | | | |
| BALSAM LAKE MUN WATER UTILITY | | | |
| BANGOR MUNICIPAL UTILITY | | | |
| BARABOO CITY WATER WORKS | | | |
| BARNEVELD MUNICIPAL WATER UTILITY | | | |
| BARRON LIGHT AND WATER UTILITY | | | |
| BAY CITY VILLAGE OF WATER UTILITY | | | |
| BAYFIELD WATER & SEWER UTILITY | | | |
| BEAR CREEK WATER UTILITY | 237.00 | 237 | 66.9 |
| BEAVER DAM WATER UTILITY | | | |
| BELGIUM MUNICIPAL WATER UTILITY | | | |
| BELLEVILLE MUN WATER & SEWER UTY | | | |

***Water System Excellence Project***
***Hardness Summary***
***Data year: 2020***

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| BELLEVUE WATER UTILITY | 305.00 | 400 | 63.2 |
| BELMONT MUN WATER AND ELECTRIC UTIL | 261.00 | 351 | 65.6 |
| BELOIT WATER UTILITY | 338.81 | 389 | 61.3 |
| BENTON MUN ELECTRIC AND WATER UTIL | | | |
| BERLIN MUN WATER AND SEWER UTILITY | | | |
| BIRCHWOOD MUNICIPAL WATER UTILITY | | | |
| BIRNAMWOOD MUNICIPAL WATER UTILITY | | | |
| BIRON MUN WATER UTILITY | | | |
| BLACK CREEK MUN WATER & SEWER UTIL | | | |
| BLACK EARTH VILL OF WATER UTILITY | | | |
| BLACK RIVER FALLS MUN ELEC & WTR | | | |
| BLAIR MUNICIPAL WATER UTILITY | 51.75 | 63 | 87.9 |
| BLANCHARDVILLE MUN WATER UTILITY | | | |
| BLOOMER CITY OF WATER UTILITY | 43.29 | 60 | 86.1 |
| BLOOMINGTON MUNICIPAL WATER UTILITY | | | |
| BLUE MOUNDS VILL OF MUNICIPAL WT UT | | | |
| BLUE RIVER MUN WATER AND SEWER UTIL | | | |
| BONDUEL WATER & SEWER UTILITY | | | |
| BOSCOBEL MUNICIPAL UTILITIES | 271.67 | 290 | 65.0 |
| BOWLER WATER AND SEWER UTILITY | | | |
| BOYCEVILLE MUNICIPAL WATER UTILITY | | | |
| BOYD MUN WATER AND SEWER UTILITY | | | |
| BRANDON SEWER & WATER UTIL | 372.00 | 372 | 55.0 |
| BRILLION MUNICIPAL WATER UTILITY | 156.80 | 390 | 78.0 |
| BRISTOL WATER UTILITY | | | |
| BRODHEAD WATER AND LIGHT COMMISSION | | | |
| BROKAW VILLAGE OF WATER UTILITY | | | |
| BROOKFIELD MUNICIPAL WATER UTILITY | 370.00 | 370 | 55.8 |
| BROOKLYN WATER UTILITY | | | |
| BROWN DEER WATER PUBLIC UTILITY | | | |
| BROWNSVILLE WATER UTILITY | 430.00 | 430 | 30.2 |
| BROWNTOWN MUNICIPAL WATER UTILITY | | | |
| BRUCE MUN WATER & SEWER UTILITY | | | |
| BURLINGTON MUNICIPAL WATERWORKS | | | |
| BUTLER PUBLIC WATER UTILITY | | | |
| BUTTERNUT MUNICIPAL WATER DEPT | | | |
| CADOTT LIGHT AND WATER MUN UTILITY | | | |

***Water System Excellence Project***

***Hardness Summary***

***Data year: 2020***

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| CALEDONIA VILLAGE OF WATER UTILITY | | | |
| CAMBRIA MUNICIPAL WATER UTILITY | | | |
| CAMBRIDGE MUNICIPAL WATER UTILITY | 299.00 | 299 | 63.5 |
| CAMERON VILL OF MUNICIPAL WTR UTY | | | |
| CAMPBELL WATER UTILITY | | | |
| CAMPBELLSPORT MUN WATER UTILITY | | | |
| CAMP DOUGLAS MUNICIPAL WATER UTILITY | | | |
| CASCADE WATER UTILITY | 300.00 | 300 | 63.4 |
| CASHTON MUN ELECTRIC AND WATER UTIL | | | |
| CASSVILLE WATER & SEWER UT | | | |
| CAZENOVIA VILL OF WATER UTILITY | | | |
| CEDARBURG LIGHT AND WATER COMMISSION | | | |
| CEDAR GROVE MUNICIPAL WATER UTILITY | | | |
| CENTURIA MUN WATER AND SEWER UTILITY | | | |
| CHASEBURG WATER & SEWER UTILITY | | | |
| CHETEK MUNICIPAL WATER UTILITY | | | |
| CHILTON MUNICIPAL WATER UTILITY | | | |
| CHIPPEWA FALLS DEPT OF PUBLIC UTIL | | | |
| CLAYTON MUNICIPAL WATER UTILITY | | | |
| CLEAR LAKE MUNICIPAL WATER UTILITY | | | |
| CLEVELAND WATER UTILITY | 346.13 | 397 | 60.9 |
| CLINTON MUNICIPAL WATERWORKS | | | |
| CLINTONVILLE WATER & ELECTRIC UTY | | | |
| CLYMAN UTILITY COMMISSION | | | |
| COBB MUNICIPAL WATER UTILITY | 280.00 | 280 | 64.5 |
| COCHRANE MUNICIPAL WATER UTILITY | | | |
| COLBY CITY OF MUN WATER UTILITY | | | |
| COLEMAN WATER UTILITY | 248.24 | 270 | 66.3 |
| COLFAX MUN WATER AND SEWER UTILITY | | | |
| COLOMA MUNICIPAL WATER UTILITY | | | |
| COLUMBUS WATER AND LIGHT DEPT | 128.08 | 271 | 87.3 |
| COMBINED LOCKS WATER UTILITY | | | |
| COON VALLEY MUNICIPAL WATER UTILITY | | | |
| CORNELL MUN WATER AND ELECTRIC UTIL | | | |
| COTTAGE GROVE WATER & SEWER UTIL | | | |
| CRANDON WATER AND SEWER UTILITY | | | |
| CRIVITZ VILLAGE OF WATER UTILITY | 190.00 | 190 | 69.5 |

***Water System Excellence Project***

***Hardness Summary***

***Data year: 2020***

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| CROSS PLAINS WATER UTIL | | | |
| CUBA CITY ELECTRIC & WATER UTILITY | | | |
| CUDAHY CITY OF WATER UTILITY | 140.00 | 140 | 83.4 |
| CUMBERLAND MUNICIPAL UTILITY | | | |
| CURTISS MUNICIPAL WTR & SWR UTY | | | |
| DALLAS MUNICIPAL WATER UTILITY | | | |
| DALTON VOLUNTEER FIRE DEPT INC | | | |
| DANE WATER & SEWER UTY | | | |
| DARIEN WATER WORKS & SEWER SYSTEM | | | |
| DARLINGTON MUN WATER AND SEWER UTIL | 305.00 | 320 | 63.2 |
| DEERFIELD WATER UTILITY | | | |
| DEFOREST MUNICIPAL WATER UTILITY | | | |
| DELAVAN WATER & SEWAGE COMMISSION | | | |
| DELAFIELD MUNICIPAL WATER UTILITY | | | |
| DENMARK MUNICIPAL WATER UTILITY | 450.00 | 450 | 21.6 |
| DE PERE WATER DEPARTMENT | 260.00 | 330 | 65.6 |
| DICKEYVILLE WATER UTILITY | | | |
| DODGEVILLE WATER UTILITY | | | |
| DORCHESTER VILLAGE OF WATER UTILITY | | | |
| DOUSMAN WATER UTILITY | | | |
| DRESSER MUNICIPAL WATER UTILITY | 215.00 | 230 | 68.1 |
| DURAND MUNICIPAL WATER UTILITY | | | |
| EAGLE VILL OF MUNICIPAL WTR UTY | 275.09 | 380 | 64.8 |
| EAGLE RIVER LIGHT AND WATER COMM | | | |
| EASTMAN WATER UTILITY | | | |
| EAST TROY VILL OF MUN WTR UTY | | | |
| EAU CLAIRE MUNICIPAL WATER UTILITY | 100.08 | 150 | 96.7 |
| EDGAR MUNICIPAL WATER UTILITY | | | |
| EDGERTON MUNICIPAL WATER UTILITY | 276.90 | 346 | 64.7 |
| ELEVA MUNICIPAL WATER UTILITY | | | |
| ELKHART LAKE WATER DEPT | | | |
| ELKHORN LIGHT AND WATER | 90.17 | 200 | 100.0 |
| ELK MOUND MUN WATER & SEWER UTY | 85.00 | 87 | 98.3 |
| ELLSWORTH MUN WATER AND SEWER UTIL | | | |
| ELMWOOD MUNICIPAL WATER UTILITY | | | |
| ELROY MUN ELECTRIC AND WATER UTY | | | |
| EMBARRASS WATER AND SEWER UTIL | | | |

*Water System Excellence Project*

***Hardness Summary***

***Data year: 2020***

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| ETTRICK MUN WATER AND SEWER UTILITY | | | |
| EVANSVILLE CITY OF WATER & LIGHT | | | |
| EXELAND MUNICIPAL WATER UTILITY | | | |
| FAIRCHILD MUNICIPAL WATER UTILITY | | | |
| FAIRWATER MUN WATER UTILITY | | | |
| FALL CREEK MUNICIPAL WATER UTILITY | | | |
| FALL RIVER MUNICIPAL WATER UTILITY | | | |
| FENNIMORE WATER AND LIGHT PLANT | | | |
| FITCHBURG WATER UTILITY | | | |
| FLORENCE UTILITY COMMISSION | | | |
| FOND DU LAC WATER UTILITY | 360.71 | 450 | 60.1 |
| FONTANA MUNICIPAL WATER UTILITY | | | |
| FOOTVILLE WATER UTILITY | | | |
| FORT ATKINSON CITY OF WATER UTILITY | | | |
| FOUNTAIN CITY WATER UTILITY | | | |
| FOX LAKE CITY OF WATER UTILITY | | | |
| FOX POINT VILL OF WATER UTILITY | | | |
| FRANKLIN MUNICIPAL WATER UTILITY | 290.00 | 290 | 64.0 |
| FREDERIC WATER COMMISSION | 176.67 | 190 | 71.4 |
| FREDONIA MUNICIPAL WATER UTILITY | | | |
| FRIENDSHIP VILLAGE OF WATER UTILITY | | | |
| FRIESLAND MUNICIPAL WATER UTILITY | 344.00 | 351 | 61.0 |
| FULTON WATER UTILITY | | | |
| GALESVILLE CITY OF MUN WTR & SWR UT | 111.75 | 115 | 93.0 |
| GAYS MILLS VILL OF MUN WTR UTY | | | |
| GENOA MUN WATER AND SEWER UTILITY | | | |
| GENOA CITY VILLAGE OF MUN WATER UT | 314.38 | 499 | 62.7 |
| GERMANTOWN WATER UTILITY | | | |
| GILLETT WATER AND SEWER COMM | | | |
| GILMAN WATER UTILITY | | | |
| GLENBEULAH MUN WATER UTILITY | | | |
| GLENDALE WATER UTILITY | | | |
| GLENWOOD CITY MUN WATER UTILITY | 157.00 | 157 | 77.7 |
| GLEN FLORA; VILLAGE OF; WATER UTY | | | |
| GRAFTON WATER & WASTEWATER UTILITY | | | |
| GRANTON MUNICIPAL WATER UTILITY | | | |
| GRANTSBURG VILL OF MUN WTR UTY | | | |

***Water System Excellence Project***
***Hardness Summary***
***Data year: 2020***

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| GRATIOT MUNICIPAL WATER UTILITY | | | |
| GREEN BAY WATER UTILITY | 142.76 | 440 | 82.7 |
| GREENDALE VILLAGE OF WATER UT | | | |
| GREEN LAKE CITY OF WATER UTILITY | | | |
| GREENWOOD CITY OF WATER UTILITY | | | |
| GRESHAM MUNICIPAL WATER AND SEWER UT | | | |
| LAKE HALLIE (VILLAGE OF) PUBLIC WORK | | | |
| HAMMOND MUNICIPAL WATER UTILITY | | | |
| HANCOCK MUNICIPAL WATER UTILITY | | | |
| HARTFORD CITY OF UTILITIES | | | |
| HARTLAND MUN WATER UTILITY | 417.14 | 470 | 35.7 |
| HATLEY VILLAGE OF WATER UTILITY | | | |
| HAUGEN VILLAGE OF WATER UTILITY | 160.00 | 160 | 76.7 |
| HAWKINS MUN WATER AND SEWER UTILITY | | | |
| HAYWARD CITY OF WATERWORKS AND SWR | | | |
| HAZEL GREEN MUNICIPAL UTILITY | | | |
| HIGHLAND MUNICIPAL WATER UTILITY | 201.00 | 201 | 68.9 |
| HILBERT MUNICIPAL WATER UTILITY | | | |
| HILLSBORO MUN WATER UTY | 150.92 | 173 | 80.0 |
| HIXTON MUNICIPAL WATER UTILITY | | | |
| HOBART VILLAGE OF WATER UTILITY | 265.00 | 265 | 65.4 |
| HOLLANDALE WATER UTILITY | | | |
| HOLMEN MUNICIPAL WATER UTILITY | | | |
| HORICON CITY OF WATER UTILITY | | | |
| HORTONVILLE VILLAGE OF WTR & SWR | | | |
| HOWARD VILLAGE OF WTR & SWR DEP | 271.50 | 286 | 65.0 |
| HUDSON PUBLIC UTILITIES | | | |
| HURLEY CITY OF WATER UTILITY | | | |
| HUSTISFORD UTILITIES | | | |
| HUSTLER MUNICIPAL WATER UTILITY | | | |
| INDEPENDENCE MUNICIPAL WATER UTILITY | | | |
| IOLA MUNICIPAL WATER UTILITY | | | |
| KNIGHT TOWN OF MUN WATER UTILITY | | | |
| IRON RIDGE MUNICIPAL WATER UTILITY | | | |
| IRONTON WATER UTILITY | | | |
| JACKSON VILL OF WATER UTILITY | | | |
| JANESVILLE WATER UTILITY | 263.68 | 370 | 65.5 |

*Water System Excellence Project*
*Hardness Summary*
*Data year: 2020*

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| JEFFERSON WATER AND ELECTRIC DEPT | | | |
| JOHNSON CREEK WATER UTILITY | 280.00 | 300 | 64.5 |
| JUNCTION CITY WATER UTILITY | | | |
| JUNEAU UTILITY COMMISSION | 290.00 | 290 | 64.0 |
| KAUKAUNA UTILITIES | | | |
| KELLNERSVILLE WATER UTILITY | | | |
| KENDALL MUNICIPAL WATER UTILITY | 185.33 | 203 | 69.8 |
| KENOSHA WATER UTILITY | 141.56 | 150 | 83.0 |
| KEWASKUM MUNICIPAL WATER UTILITY | | | |
| KEWAUNEE MUNICIPAL WATER UTILITY | | | |
| KIEL CITY OF UTILITIES | | | |
| KIMBERLY MUNICIPAL WATER UTILITY | | | |
| KNAPP MUN WATER AND SEWER UTILITY | | | |
| KOHLER MUNICIPAL WATER UTILITY | | | |
| KRONENWETTER WATER UTILITY | | | |
| LA CROSSE WATER UTILITY | 305.65 | 418 | 63.2 |
| LADYSMITH MUNICIPAL WATER UTILITY | 140.00 | 140 | 83.4 |
| LA FARGE MUN WATER AND SEWER UTILITY | 160.44 | 234 | 76.7 |
| LAKE DELTON VILLAGE OF WATER UTIL | | | |
| LAKE GENEVA UTILITY COMMISSION | | | |
| LAKE MILLS LIGHT AND WATER DEPT | 327.00 | 327 | 61.9 |
| LANCASTER MUNICIPAL WATER UTILITY | | | |
| LANNON MUNICIPAL WATER UTILITY | | | |
| LA VALLE MUNICIPAL WATER UTILITY | | | |
| LAWRENCE TOWN OF WATER UTILITY | 197.00 | 197 | 69.1 |
| LENA MUNICIPAL WATER & SEWER UTY | | | |
| LINDEN MUNICIPAL WATER UTILITY | 313.00 | 313 | 62.7 |
| LITTLE CHUTE MUNICIPAL WATER DEPT | | | |
| LIVINGSTON MUNICIPAL WATER UTILITY | | | |
| LODI MUNICIPAL LIGHT AND WATER UTILI | 312.50 | 330 | 62.8 |
| LOGANVILLE MUN WATER & SEWER UTILITY | | | |
| LOMIRA MUNICIPAL WATER UTILITY | | | |
| LONE ROCK UTILITIES | 189.14 | 257 | 69.5 |
| LOWELL MUN WATER AND SEWER UTILITY | | | |
| LOYAL MUNICIPAL WATER UTILITY | | | |
| LUCK MUNICIPAL WATER UTILITY | | | |
| LUXEMBURG MUNICIPAL WATER UTILITY | | | |

***Water System Excellence Project***
***Hardness Summary***
***Data year: 2020***

| | Hardness (mg/L) | | |
|---|---|---|---|
| **Name** | **Mean** | **Max** | **Numerical Grade** |
| LYNDON STATION MUN WATER UTILITY | 97.00 | 97 | 97.7 |
| MADISON WATER UTILITY | 359.13 | 490 | 60.2 |
| MAIDEN ROCK; VILLAGE OF; MUN WTR UTY | | | |
| MANAWA MUNICIPAL WATER UTILITY | | | |
| MANITOWOC PUBLIC UTILITIES | 138.79 | 150 | 84.0 |
| MAPLE BLUFF VILLAGE OF MUN WTR UTY | | | |
| MARATHON VILLAGE OF WTR & SWR UTY | | | |
| MARIBEL MUN WTR & SWR UTY | | | |
| MARINETTE MUNICIPAL WATER UTILITY | | | |
| MARION MUN WATER AND SEWER UTILITY | | | |
| MARKESAN MUN WATER PLANT | 330.00 | 340 | 61.8 |
| MARSHALL WATER AND SEWER UTILITY | | | |
| MARSHFIELD UTILITIES | 249.62 | 310 | 66.2 |
| MATTOON MUNICIPAL WATER UTILITY | | | |
| MAUSTON CITY OF MUNICIPAL WTR UTY | | | |
| MAYVILLE MUNICIPAL WATER UTILITY | 321.67 | 460 | 62.3 |
| MAZOMANIE WATER UTILITY | | | |
| MCFARLAND WATER & SEWER UTILITY | | | |
| MEDFORD WATER WORKS | | | |
| MELLEN MUN WATER UTILITY | | | |
| MELROSE MUNICIPAL WATER UTILITY | | | |
| MELVINA MUNICIPAL WATER UTILITY | | | |
| MENASHA - TOWN OF - UTILITY DISTRICT | | | |
| MENASHA ELECTRIC & WATER UTILITIES | | | |
| MENOMONEE FALLS VILLAGE OF WTR UTY | | | |
| MENOMONIE CITY OF WATER DEPT | | | |
| MEQUON MUNICIPAL WATER UTILITY | | | |
| MERRILL WATER UTILITY | | | |
| MERRILLAN MUN ELECTRIC & WTR UTIL | | | |
| MERRIMAC MUNICIPAL WATER UTILITY | | | |
| MIDDLETON MUNICIPAL WATER UTILITY | | | |
| MILLADORE VILLAGE OF WATER UTILITY | | | |
| MILLTOWN VIL OF WATER UTY | | | |
| MILTON CITY OF MUN WTR UTY | | | |
| MILWAUKEE WATER WORKS | 134.81 | 140 | 85.3 |
| MINERAL POINT MUN WATER UTILITY | | | |
| MINONG VILLAGE OF WATER UTILITY | | | |

*Water System Excellence Project*
*Hardness Summary*
*Data year: 2020*

| | Hardness (mg/L) | | |
|---|---|---|---|
| **Name** | **Mean** | **Max** | **Numerical Grade** |
| MISHICOT WATER UTILITY & SEW DEPT | | | |
| MONDOVI MUN WATER AND SEWER UTILITY | | | |
| MONONA WATER UTILITY | | | |
| MONROE MUNICIPAL WATER UTILITY | 252.72 | 310 | 66.1 |
| MONTELLO CITY OF WATER UTILITY | | | |
| MONTFORT MUNICIPAL WATER UTILITY | | | |
| MONTICELLO VILLAGE OF WATER UTY | | | |
| MONTREAL MUNICIPAL WATER UTILITY | | | |
| MOSINEE MUNICIPAL WATER AND SEWER UT | | | |
| MT CALVARY VILL OF MUN WTR& SWR | | | |
| MOUNT HOPE MUNICIPAL WATER UTILITY | | | |
| MOUNT HOREB WATER AND SEWER UTILITY | | | |
| MOUNT STERLING MUN WATER UTILITY | | | |
| MUKWONAGO MUNICIPAL WATER UTILITY | | | |
| MUSCODA LIGHT AND WATER UTILITY | | | |
| MUSKEGO CITY OF WATER PUBLIC UTY | 891.00 | 891 | 0.0 |
| NECEDAH VILL OF MUN WATER UTILITY | | | |
| NEENAH CITY OF WATER UTILITY | | | |
| NEILLSVILLE CITY OF MUN WTR UTY | | | |
| NEKOOSA MUNICIPAL WATER UTILITY | | | |
| NELSON WATER AND SEWER DEPARTMENT | | | |
| NEW AUBURN MUNICIPAL WATER UTILITY | | | |
| NEW BERLIN WATER UTILITY | | | |
| NEW GLARUS LIGHT AND WATER WORKS | | | |
| NEW HOLSTEIN PUBLIC UTILITY | | | |
| NEW LISBON CITY OF ELEC & WATER UT | | | |
| NEW LONDON ELECTRIC & WATER UTILITY | 278.18 | 480 | 64.6 |
| NEW RICHMOND MUNICIPAL WATER UTILITY | | | |
| NIAGARA MUNICIPAL WATER UTILITY | | | |
| NICHOLS MUNICIPAL WATER UTILITY | | | |
| NORTH FOND DU LAC WATER UTILITY | 245.00 | 330 | 66.5 |
| NORTH FREEDOM MUN WATER UTILITY | | | |
| NORWALK MUNICIPAL WATER UTILITY | | | |
| OAK CREEK WATER & SEWER UTILITY | | | |
| OAKDALE WATER UTILITY VILLAGE OF | | | |
| OAKFIELD VILLAGE OF MUN WTR UTY | | | |
| OCONOMOWOC CITY OF UTILITIES | | | |

***Water System Excellence Project***
***Hardness Summary***
***Data year: 2020***

| | Hardness (mg/L) | | |
|---|---|---|---|
| **Name** | **Mean** | **Max** | **Numerical Grade** |
| OCONTO UTILITY COMMISSION | 160.00 | 160 | 76.7 |
| OCONTO FALLS WATER AND LIGHT COMM | | | |
| OLIVER MUNICIPAL WATER PLANT | | | |
| OMRO CITY OF WTR UTY | 312.50 | 340 | 62.8 |
| ONALASKA MUNICIPAL WATER UTILITY | 338.95 | 392 | 61.3 |
| ONTARIO MUNICIPAL WATER UTILITY | | | |
| OOSTBURG MUNICIPAL WATER UTILITY | | | |
| OREGON MUN WATER AND SEWER UTILITY | 313.15 | 347 | 62.7 |
| ORFORDVILLE MUNICIPAL WATER UTILITY | | | |
| OSCEOLA MUNICIPAL WATER UTILITY | | | |
| OSHKOSH CITY OF WATER UTILITY | 139.12 | 170 | 83.7 |
| OSSEO MUN WATER AND SEWER UTILITY | 112.50 | 148 | 92.7 |
| OWEN MUN WATER UTILITY | | | |
| PADDOCK LAKE MUN WATER UTILITY | | | |
| PALMYRA VILLAGE OF WTR & SWR UTY | | | |
| PARDEEVILLE MUN WATER UTY | 278.00 | 278 | 64.6 |
| PARK FALLS MUNICIPAL WATER UTILITY | 122.50 | 160 | 89.3 |
| PATCH GROVE MUNICIPAL WATER UTILITY | | | |
| PENCE TOWN OF MUN WTR DEPT | | | |
| BLOOMFIELD VILLAGE OF UTILITY DEPART | | | |
| PEPIN MUNICIPAL WATER UTILITY | 288.70 | 313 | 64.1 |
| PESHTIGO MUN WATER UTILITY | | | |
| PEWAUKEE VILLAGE OF WATER UTILITY | | | |
| PEWAUKEE CITY OF WATER UTILITY | | | |
| PHILLIPS MUN WATER WORKS | | | |
| PIGEON FALLS MUNICIPAL WATER UTILITY | 35.67 | 39 | 84.3 |
| PITTSVILLE MUN WATER UTILITY | | | |
| PLAIN MUNICIPAL WATER UTILITY | | | |
| PLAINFIELD VILL OF WATER UTILITY | | | |
| PLATTEVILLE WATER & SEWER UTILITY | 288.15 | 330 | 64.1 |
| PLEASANT PRAIRIE VILL OF WTR UTY | | | |
| PLOVER VILL OF MUN WTR UTY | | | |
| PLYMOUTH UTILITIES | | | |
| PORTAGE WATER UTILITY | | | |
| PORT EDWARDS WATER UTILITY | | | |
| PORT WASHINGTON MUN WATER UTILITY | | | |
| POTOSI MUNICIPAL WATER UTILITY | | | |

***Water System Excellence Project***
***Hardness Summary***
***Data year: 2020***

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| POUND VILL OF WATER & SWR UTY | | | |
| POYNETTE MUNICIPAL WATER UTILITY | | | |
| PRAIRIE DU CHIEN MUN WATER UTILITY | | | |
| PRAIRIE DU SAC MUN ELECTRIC & WTR | | | |
| PRENTICE VILLAGE OF WTR & SWR UTY | | | |
| PRESCOTT CITY OF MUN WTR UTY | | | |
| PRINCETON MUN WATER & ELECTRIC UTIL | | | |
| PULASKI WATER DEPT | 286.00 | 300 | 64.2 |
| RACINE WATER WORKS COMMISSION | 137.31 | 140 | 84.3 |
| RADISSON WATER AND SEWER UTILITY | 147.00 | 147 | 81.0 |
| RANDOLPH MUNICIPAL WATER UTILITY | | | |
| RANDOM LAKE MUNICIPAL WATER DEPT | | | |
| RAY HUPPERT UTILITY INCORPORATED | | | |
| READSTOWN MUNICIPAL WATER UTILITY | | | |
| REDGRANITE WATER UTILITY | | | |
| REEDSBURG UTILITY COMMISSION | | | |
| REEDSVILLE MUNICIPAL WATER UTILITY | | | |
| REESEVILLE WATER UTILITY | | | |
| REWEY MUNICIPAL WATER UTILITY | 283.00 | 283 | 64.4 |
| RHINELANDER CITY OF WATER UTY | | | |
| RIB LAKE VILLAGE OF WATER UTILITY | | | |
| RICE LAKE MUN WATER & ELECTRIC UTIL | | | |
| RICHLAND CENTER WATER UTILITY | 225.00 | 250 | 67.6 |
| RIDGEWAY VILL OF MUN WATER UTY | | | |
| RIO MUNICIPAL WATER UTILITY | 248.25 | 254 | 66.3 |
| RIPON WATER UTILITY | | | |
| RIVER FALLS MUNICIPAL UTILITY | | | |
| ROBERTS VILL OF WATER UTILITY | | | |
| ROCKLAND MUN WATER AND SEWER UTILITY | | | |
| ROCK SPRINGS MUNICIPAL UTILITY | | | |
| ROME TOWN OF WATER UTILITY | | | |
| ROTHSCHILD MUNICIPAL WATER UTILITY | 157.50 | 180 | 77.7 |
| ST CLOUD WATER & SEWER UTY | | | |
| ST CROIX IMPROVEMENTS INC | | | |
| ST CROIX FALLS MUN WATER UTILITY | | | |
| ST NAZIANZ WATER UTILITY | | | |
| SAUK CITY MUN WATER & LIGHT UTIL | 285.80 | 291 | 64.3 |

***Water System Excellence Project***
***Hardness Summary***
***Data year: 2020***

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| SAUKVILLE MUN WATER UTILITY | | | |
| SCHOFIELD MUN WATER & SEWER UTILITY | | | |
| SCOTT TOWN OF WATER UTILITY | 352.00 | 352 | 60.6 |
| SEYMOUR MUN WATER UTILITY | | | |
| SHARON WATERWORKS & SEWER SYSTEM | | | |
| SHAWANO CITY OF WATER & SEWER UTILIT | 349.29 | 380 | 60.7 |
| SHEBOYGAN WATER UTILITY | | | |
| SHEBOYGAN FALLS UTILITIES | | | |
| SHELDON MUNICIPAL WATER UTILITY | | | |
| SHELL LAKE MUNICIPAL UTILITIES | | | |
| SHERWOOD VILLAGE OF WTR & SWR UTY | 99.71 | 110 | 97.0 |
| SHIOCTON MUNICIPAL UTILITY | | | |
| SHOREWOOD MUNICIPAL WATER UTILITY | | | |
| SHOREWOOD HILLS VILL OF WATER UTY | | | |
| SHULLSBURG WATER UTILITY | 240.50 | 347 | 66.7 |
| SIREN MUNICIPAL WATER UTILITY | | | |
| SISTER BAY WATER AND SEWER UTILITY | | | |
| SLINGER UTILITIES | 489.17 | 510 | 4.9 |
| SOLDIERS GROVE VILL OF MUN WTR UTY | | | |
| SOMERS WATER UTILITY TOWN OF | | | |
| SOMERSET VILLAGE OF WATER UTILITY | 199.50 | 201 | 69.0 |
| SOUTH MILWAUKEE WATER UTILITY | | | |
| SOUTH WAYNE MUNICIPAL WATER UTILITY | 331.00 | 331 | 61.7 |
| SPARTA MUNICIPAL WATER DEPT | | | |
| SPENCER MUNICIPAL WATER UTILITY | | | |
| SPOONER MUNICIPAL UTILITIES | | | |
| SPRING GREEN MUNICIPAL WATER UTILITY | | | |
| SPRING VALLEY WATERWORKS | | | |
| STANLEY MUNICIPAL WATERWORKS | | | |
| STAR PRAIRIE MUNICIPAL WATER UTILITY | | | |
| STETSONVILLE WATER UTILITY | 115.00 | 130 | 91.7 |
| STEVENS POINT MUN WATER UTILITY | | | |
| STOCKBRIDGE WATER UTILITY | | | |
| STODDARD MUNICIPAL WATER UTILITY | | | |
| STOUGHTON WATER UTILITY | 313.21 | 360 | 62.7 |
| STRATFORD MUN WATER & ELECTRIC UTIL | | | |
| STRUM MUNICIPAL UTILITIES | | | |

***Water System Excellence Project***

***Hardness Summary***

***Data year: 2020***

| Name | Hardness (mg/L) Mean | Max | Numerical Grade |
|---|---|---|---|
| STURGEON BAY UTILITIES | | | |
| SUAMICO WATER UTILITY | 230.00 | 230 | 67.3 |
| SUN PRAIRIE UTILITIES | 343.53 | 390 | 61.1 |
| SURING VILLAGE OF WATER UTILITY | 180.00 | 180 | 70.0 |
| SUSSEX VILLAGE OF WTR PUBLIC UTY | 350.00 | 350 | 60.7 |
| TAYLOR VILLAGE OF WATER UTILITY | | | |
| TENNYSON WATER UTILITY | | | |
| THERESA MUN WATER AND SEWER UTILITY | | | |
| THORP MUN WATER AND SEWER UTILITY | 193.33 | 220 | 69.3 |
| TIGERTON MUNICIPAL WATER & SEWER UTY | | | |
| TOMAH WATER UTILITY | | | |
| TOMAHAWK MUN WATER & SEWER UTILITY | | | |
| TONY MUNICIPAL WATER UTILITY | | | |
| TREMPEALEAU MUN ELECTRIC & WTR UTY | | | |
| TURTLE LAKE MUN WATER & SEWER UTIL | | | |
| TWO RIVERS WATER & LIGHT UTILITY | | | |
| UNION CENTER VILLAGE OF WTR UTY | | | |
| UNION GROVE MUNICIPAL WATER UTILITY | | | |
| VALDERS PUBLIC UTILITY | | | |
| VERONA WATER UTILITY | | | |
| VESPER MUN WATER AND SEWER UTILITY | | | |
| VIOLA MUN WATER AND ELECTRIC UTILITY | | | |
| VIROQUA CITY OF MUN WATER UTILITY | | | |
| WALDO WATER AND SEWER UTILITY | 341.75 | 348 | 61.2 |
| WALWORTH MUN WATER AND SEWER UTILITY | 349.20 | 430 | 60.7 |
| WARRENS MUN WTR & SWR UTILITIES | | | |
| WASHBURN MUN WATER AND SEWER UTILITY | | | |
| WATERFORD VILLAGE OF WTR & SWR UTY | | | |
| WATERLOO WATER AND LIGHT COMM | 442.50 | 490 | 25.0 |
| WATERTOWN WATER DEPARTMENT | 242.90 | 390 | 66.6 |
| WAUKESHA WATER UTILITY CITY OF | 310.87 | 440 | 62.9 |
| WAUNAKEE WATER AND LIGHT COMMISSION | | | |
| WAUPACA WATER UTILITY | | | |
| WAUPUN PUBLIC UTILITIES | | | |
| WAUSAU WATER UTILITY | | | |
| WAUSAUKEE WTR & SWR UTY | | | |
| WAUWATOSA WATER UTILITY | | | |

***Water System Excellence Project***
***Hardness Summary***
***Data year: 2020***

| | Hardness (mg/L) | | |
|---|---|---|---|
| **Name** | **Mean** | **Max** | **Numerical Grade** |
| WAUTOMA PUBLIC WATER UTILITY | | | |
| WAUZEKA MUNICIPAL WATER UTILITY | | | |
| WEBSTER VILL OF MUN WATER UTILITY | | | |
| WEST ALLIS MUNICIPAL WATER UTILITY | 140.00 | 140 | 83.4 |
| WEST BARABOO MUN WTR & SWR UTY | | | |
| WEST BEND CITY OF WATER UTY | 372.90 | 580 | 55.0 |
| WESTBY CITY OF MUN ELEC & WTR UTY | | | |
| WESTON WATER UTILITY | | | |
| WEST SALEM MUN JOINT WTR & SWR UTIL | | | |
| WESTPORT WATER UTILITY DISTRICT | | | |
| WEYAUWEGA CITY OF WATER & SEWER UTY | | | |
| WEYERHAEUSER MUNICIPAL WATER UTILITY | | | |
| WHEELER VILL OF MUN WTR UTY | | | |
| WHITEFISH BAY VILLAGE OF WTR UTY | | | |
| WHITEHALL MUNICIPAL WATER UTILITY | | | |
| WHITE LAKE VILLAGE OF WTR UTY | | | |
| WHITELAW MUN WATER AND SEWER UTIL | | | |
| WHITEWATER MUNICIPAL WATER UTILITY | 326.67 | 370 | 62.0 |
| WHITING MUN WATER AND SEWER UTILITY | | | |
| WILLIAMS BAY MUNICIPAL WATER UTILITY | | | |
| WILSON VILLAGE OF MUN WTR UTY | | | |
| WILTON MUNICIPAL WATER & SEWER UTY | | | |
| WIND POINT MUNICIPAL WATER UTILITY | | | |
| WINNECONNE WATER UTILITY | | | |
| WINTER VILLAGE OF WATER UTILITY | | | |
| WISCONSIN DELLS MUN WATER UTILITY | | | |
| WISCONSIN RAPIDS WATER WORKS & LIGHT | 61.64 | 63 | 90.3 |
| WITHEE MUNICIPAL WATER UTILITY | | | |
| WITTENBERG MUN WTR & SWR UTILITY | | | |
| WONEWOC ELEC & WTR UTY | | | |
| WOODVILLE WATER AND SEWER UTY | | | |
| WRIGHTSTOWN VILLAGE OF WTR UTILITY | 496.00 | 687 | 1.9 |
| WYOCENA MUN WATER & SEWER UTILITY | | | |
| YORKVILLE TOWN OF WATER UTILITY | | | |
| YUBA MUNICIPAL WATERWORKS | 259.75 | 277 | 65.7 |

# G.2 HARDNESS TESTING

Water Hardness Converstion Chart

| Hardness CaCO3 Grains | Hardness CaCO3 mg/L | | Hardness CaCO3 Grains | Hardness CaCO3 mg/L | | Hardness CaCO3 Grains | Hardness CaCO3 mg/L | |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 9 | | 11 | 188 | | 31 | 530 | |
| 1.0 | 17 | | 12 | 205 | | 32 | 547 | Well 10 |
| 1.5 | 26 | | 13 | 222 | | 33 | 564 | |
| 2.0 | 34 | | 14 | 239 | | 34 | 581 | Well 8 |
| 2.5 | 43 | | 15 | 257 | | 35 | 599 | |
| 3.0 | 51 | | 16 | 274 | | 36 | 616 | |
| 3.5 | 60 | | 17 | 291 | | 37 | 633 | Avg Well 8&9 |
| 4.0 | 68 | | 18 | 308 | | 38 | 650 | Well 9 |
| 4.5 | 77 | | 19 | 325 | | 39 | 667 | |
| 5.0 | 86 | | 20 | 342 | | 40 | 684 | Avg MFP |
| 5.5 | 94 | | 21 | 359 | | 41 | 701 | |
| 6.0 | 103 | | 22 | 376 | | 42 | 718 | |
| 6.5 | 111 | | 23 | 393 | | 43 | 735 | |
| 7.0 | 120 | | 24 | 410 | | 44 | 752 | |
| 7.5 | 128 | | 25 | 428 | | 45 | 770 | Well 4& 5 |
| 8.0 | 137 | | 26 | 445 | | 46 | 787 | |
| 8.5 | 145 | | 27 | 462 | | 47 | 804 | |
| 9.0 | 154 | | 28 | 479 | | 48 | 821 | |
| 9.5 | 162 | | 29 | 496 | | 49 | 838 | |
| 10.0 | 171 | | 30 | 513 | | 50 | 855 | |

1/24/2024

Kaukauna uses a Hach 5 EP test kit for determining hardness

This test kit is for a range of 1-30 Grains per gallon for Hardness

(17-513 mg/l) or advertised as 20-400 mg/l

Conclusion. This range does not meet Kaukauna's water range for Hardness.

The Hach test method 8204 for the digital titration method with EDTA will fit into the range of Kaukauna's hardness. There are substances that interfere with the total hardness test: Orthophosphate, Polyphosphate, and Strontium. The raw water samples are taken before the Orthophosphate and Polyphosphate chemicals are added to the water. The strontium interferes with the test and precipitates with the calcium and is counted as calcium. See correspondence with Hach.

Need Model HAC-DT Range is 10-4,000 mg/l $468

HA-71A is only 1-20 mg/l and 17-342 mg/l (1-20 GPG)

# Hardness Test, 1–30 gpg

**For test kit 145400 (Model 5-EP)** DOC326.98.00020

**Additional copies available on www.hach.com**

## Test preparation

- Rinse tube with the sample water before testing. Rinse tube and bottle with deionized water after testing.
- When titrating, count each drop of titrant. Hold the dropper vertically. Swirl after each drop is added.
- Accuracy is not affected by undissolved powder.
- To check reagent accuracy, use a standard solution in place of the sample (see Optional items).
- Interferences—high levels of iron or manganese will interfere and cause an orange-brown or brown color to form after the UniVer® 3 Reagent is added. If this occurs:
  1. Add 1 to 3 drops of Hardness 3 Titrant Reagent to the sample before adding the UniVer 3 Hardness Reagent.
  2. Immediately add drops of Hardness 3 Titrant Reagent until the pink to blue color change occurs.
  3. Count all the drops of Hardness 3 Titrant Reagent used to determine the hardness of the sample, including the drops added before the UniVer 3 Hardness Reagent.

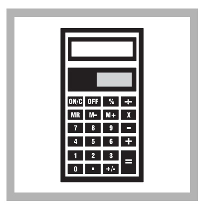
***CAUTION: Handle chemical standards and reagents carefully. Review Material Safety Data Sheets for safe handling, storage and disposal information.***

## Test procedure

**1.** Add one full measuring tube of sample to the bottle.

**2.** Add one UniVer 3 Hardness Reagent Powder Pillow to the bottle. Swirl to mix.

**3.** Add Hardness 3 Titrant Reagent by drops. Count the drops until the color changes from pink to blue. Hold the dropper vertically. Swirl to mix after each drop.



**4.** Calculate the results. Each drop of Hardness 3 Titrant Reagent equals 1 grain per gallon hardness as calcium carbonate ($CaCO_3$).

***Note:** The result can be expressed in mg/L by multiplying the number of grains per gallon by 17.1.*

## Replacement items

| Description | Unit | Catalog no. |
|---|---|---|
| Bottle, square mixing | 6/pkg | 43906 |
| Hardness 3 Titrant Reagent | 100 mL MDB[1] | 42632 |
| Measuring Tube, plastic, 5.83-mL | each | 43800 |
| UniVer 3 Hardness Reagent Powder Pillows | 100/pkg | 96299 |

[1]Marked dropping bottle

## Optional items

| Description | Unit | Catalog no. |
|---|---|---|
| Deionized Water | 500 mL | 27249 |
| Hardness Standard Solution, 20 gpg as $CaCO_3$ | 500 mL | 47949 |

 For technical assistance or ordering information: visit www.hach.com, call 800-227-4224 or email techhelp@hach.com Edition 1 January 2007

# Hardness, Calcium

DOC316.53.01175

## Titration Method with EDTA

Method 8204

10–4000 mg/L as $CaCO_3$

Digital Titrator

**Scope and application:** For water, wastewater and seawater.

## Test preparation

### Before starting

| |
|---|
| Magnesium is not included in the results but must be in the sample for a sharp endpoint. If the sample does not contain magnesium, add 1 to 2 drops of Magnesium Standard Solution, 10-g/L as $CaCO_3$, to the sample before the test is started. |
| As an alternative to the CalVer 2 Calcium Indicator Power Pillow (85299), use two CalVer 2 Calcium Indicator Power Pillows (94799) or 0.1 g scoop of CalVer 2 Calcium Indicator Powder. |
| The optional TitraStir Titration Stand can hold the Digital Titrator and stir the sample. |
| Review the Safety Data Sheets (MSDS/SDS) for the chemicals that are used. Use the recommended personal protective equipment. |
| Dispose of reacted solutions according to local, state and federal regulations. Refer to the Safety Data Sheets for disposal information for unused reagents. Refer to the environmental, health and safety staff for your facility and/or local regulatory agencies for further disposal information. |

### Items to collect

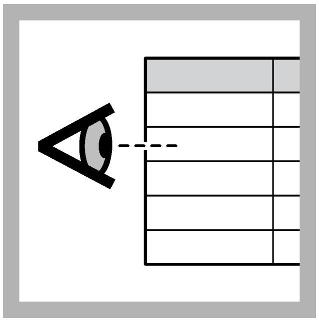
| Description | Quantity |
|---|---|
| CalVer 2 Calcium Indicator Powder Pillow | 1 pillow |
| Potassium Hydroxide Standard Solution, 8 N | 1 or 2 mL |
| EDTA Titration Cartridge (refer to Sample volumes and digit multipliers on page 3) | 1 |
| Digital Titrator | 1 |
| Delivery tube for Digital Titrator | 1 |
| Graduated cylinder (use a size that is applicable to the selected sample volume) | 1 |
| Erlenmeyer flask, 250 mL | 1 |
| Water, deionized | varies |

Refer to Consumables and replacement items on page 5 for order information.

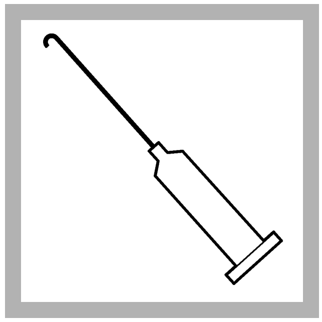
### Sample collection

- Collect samples in clean glass or plastic bottles that have been cleaned with a detergent and rinsed with 1:1 nitric acid and deionized water.
- To preserve samples for later analysis, adjust the sample pH to 2 or less with concentrated nitric acid (about 2 mL per liter). No acid addition is necessary if the sample is tested immediately.
- Keep the preserved samples at room temperature for a maximum of 6 months.
- Before analysis, adjust the pH to 7 with Potassium Hydroxide Standard Solution.
- Correct the test result for the dilution caused by the volume additions.

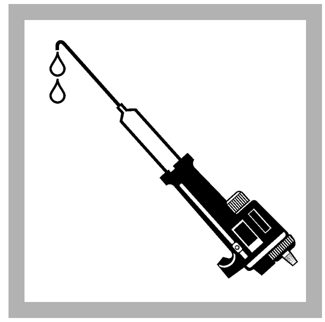
## Test procedure



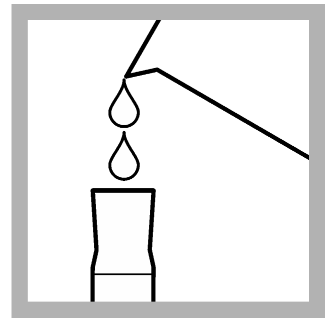
**1.** Select a sample volume and titration cartridge from Table 1 on page 3.



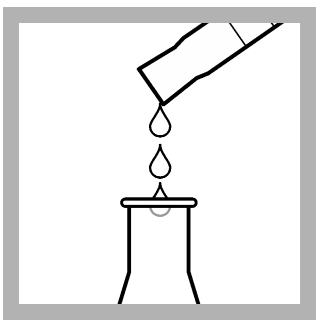
**2.** Insert a clean delivery tube into the digital titration cartridge. Attach the cartridge to the Digital Titrator.



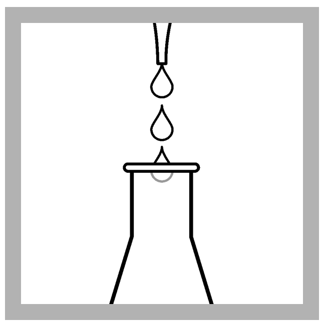
**3.** Hold the Digital Titrator with the cartridge tip up. Turn the delivery knob to eject air and a few drops of titrant. Reset the counter to zero and clean the tip.



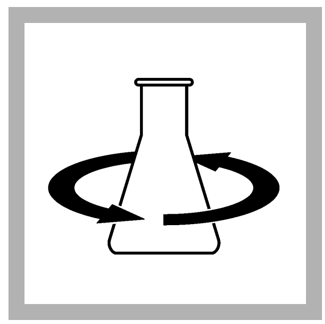
**4.** Use a graduated cylinder or a pipet[1] to measure the sample volume from Table 1 on page 3.



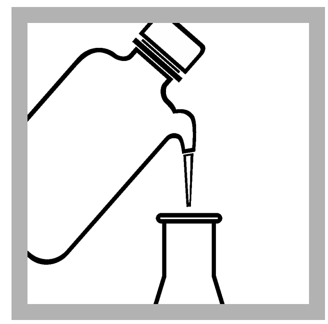
**5.** Pour the sample into a clean, 250-mL Erlenmeyer flask.



**6.** If the sample volume is 100 mL, add 2 mL of 8 N Potassium Hydroxide Standard Solution. If the sample volume is 50 mL or less, add 1 mL of 8 N Potassium Hydroxide Standard Solution.

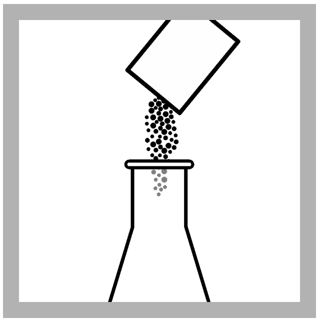


**7.** Swirl to mix.

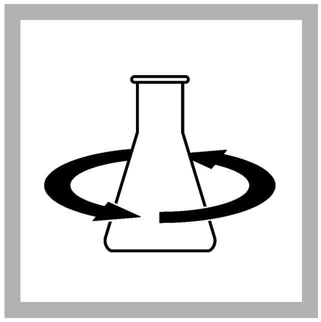


**8.** If the sample volume is less than 100 mL, dilute to approximately 100 mL with deionized water.

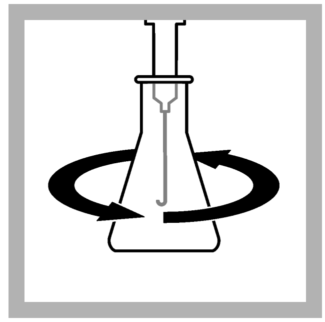
[1] Titration accuracy has a direct relation to the accuracy of the sample volume measurement. For smaller volumes, it is recommended to use a pipet to increase accuracy.



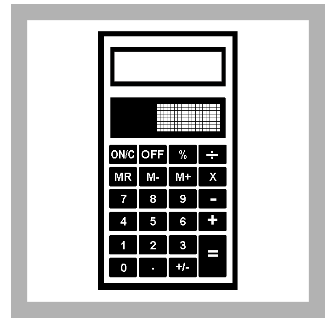
**9.** Add the contents of one CalVer 2 Calcium Indicator Powder Pillow.



**10.** Swirl to mix.



**11.** Put the end of the delivery tube fully into the solution. Swirl the flask. Turn the knob on the Digital Titrator to add titrant to the solution. Continue to swirl the flask. Add titrant until the color changes from red to pure blue. Record the number of digits on the counter.




**12.** Use the multiplier in Table 1 on page 3 to calculate the concentration. Digits used × digit multiplier = mg/L (or Gdh) Ca as $CaCO_3$.

## Sample volumes and digit multipliers

Select a range in Table 1 or Table 2 as applicable, then read across the table row to find the applicable information for this test. Use the digit multiplier to calculate the concentration in the test procedure.

**Example:** A 50-mL sample was titrated with 0.800 M EDTA titration cartridge and the counter showed 250 digits at the endpoint. The concentration is 250 digits × 2.0 = 500 mg/L as $CaCO_3$ (or with the 0.714 M EDTA titration cartridge, 250 x 0.1 = 25 mg/L Gdh).

**Table 1 Sample volumes and digit multipliers—mg/L**

| Range (mg/L as $CaCO_3$) | Sample volume (mL) | Titration cartridge | Digit multiplier |
|---|---|---|---|
| 10–40 | 100 | 0.0800 M EDTA | 0.1 |
| 40–160 | 25 | 0.0800 M EDTA | 0.4 |
| 100–400 | 100 | 0.800 M EDTA | 1.0 |
| 200–800 | 50 | 0.800 M EDTA | 2.0 |
| 500–2000 | 20 | 0.800 M EDTA | 5.0 |
| 1000–4000 | 10 | 0.800 M EDTA | 10.0 |

**Table 2 Sample volumes and digit multipliers—Gdh**

| Range (Gdh as $CaCO_3$) | Sample volume (mL) | Titration cartridge | Digit multiplier |
|---|---|---|---|
| 1–4 | 100 | 0.1428 M EDTA | 0.01 |
| 4–16 | 25 | 0.1428 M EDTA | 0.04 |
| 10–40 | 50 | 0.714 M EDTA | 0.1 |
| 25–100 | 20 | 0.714 M EDTA | 0.25 |
| > 100 | 10 | 0.714 M EDTA | 0.5 |

## Conversion units

To change the units or chemical form of the test result, multiply the test result by the factor in Table 3.

**Table 3 Conversions**

| mg/L Ca as $CaCO_3$ to... | multiply by... | Example |
|---|---|---|
| mg/L as Ca | 0.40 | 1000 mg/L as $CaCO_3$ x 0.40 = 400 mg/L Ca |
| German degrees hardness (Gdh) | 0.056 | 1000 mg/L as $CaCO_3$ × 0.056 = 56 Gdh |
| Grains per gallon (gpg) | 0.058 | 1000 mg/L as $CaCO_3$ x 0.058 = 58 gpg |

## Interferences

**WARNING**

Chemical hazard. Potassium cyanide is toxic. Make sure to add potassium cyanide to the sample after the Potassium Hydroxide has been added. Keep cyanide solutions at more than pH 11 to prevent exposure to hydrogen cyanide gas. Dispose of reacted solutions according to local, state and federal regulations.

An interfering substance can prevent the color change at the titration endpoint. A smaller sample volume can often dilute the interfering substance to a level at which the substance does not interfere. Table 4 shows the substances that can interfere with this test.

**Table 4 Interferences**

| Interfering substance | Interference level |
|---|---|
| Acidity | 10,000 mg/L acidity as $CaCO_3$ does not interfere. |
| Alkalinity | 10,000 mg/L alkalinity as $CaCO_3$ does not interfere. |
| Aluminum | Causes a slow endpoint. The sample can contain a maximum of 200 mg/L aluminum if sufficient time is given for the color change. |
| Barium | Barium is titrated at the same time with calcium and interferes with this test, but it is unusual to find high levels of Barium in natural waters. |
| Chloride | The chloride level in seawater does not interfere. Solutions that are saturated with chloride do not show a sharp endpoint. |
| Cobalt | Interferes directly. Add 0.5 grams of potassium cyanide after the Potassium Hydroxide during the test procedure to remove the interference from a maximum of 20 mg/L cobalt. |
| Copper | Interferes at 0.1 mg/L copper. Add 0.5 grams of potassium cyanide after the Potassium Hydroxide during the test procedure to remove the interference from a maximum of 100 mg/L copper. |
| Iron | More than 8 mg/L iron causes an orange-red to green endpoint. Results are accurate to 20 mg/L iron with this endpoint. |
| Magnesium | The formation of magnesium hydroxide at the high test pH prevents interference from 200 mg/L magnesium. Samples with more than 200 mg/L magnesium do not give a distinct endpoint. |
| Manganese | Interferes at more than 5 mg/L manganese. |
| Nickel | Interferes at 0.5 mg/L nickel. Add 0.5 grams of potassium cyanide after the Potassium Hydroxide during the test procedure to remove the interference from a maximum of 200 mg/L nickel. |
| Orthophosphate | Forms calcium phosphate and causes a slow endpoint. If sufficient time is given to let the calcium phosphate dissolve during the titration, the orthophosphate will not interfere with the test. |
| Polyphosphates | Interfere directly and are included in the test result. |
| Strontium | Strontium is titrated at the same time with calcium and interferes with this test, but it is unusual to find high levels of Strontium in natural waters. |
| Temperature | Samples at 20 °C (68 °F) or colder should be titrated slowly near the endpoint to give sufficient time for the color change. |

Table 4 Interferences (continued)

| Interfering substance | Interference level |
|---|---|
| Zinc | Interferes at 5 mg/L zinc. Add 0.5 grams of potassium cyanide after the Potassium Hydroxide during the test procedure to remove the interference from a maximum of 100 mg/L zinc. |
| Highly buffered samples or extreme sample pH | Can prevent the correct pH adjustment (of the sample) by the reagents. Sample pretreatment may be necessary. |

## Accuracy check

### Standard additions method (sample spike)

Use the standard additions method to validate the test procedure, reagents, apparatus, technique and to find if there is an interference in the sample.

Items to collect:

- Hardness Voluette Ampule Standard Solution, 10,000 mg/L as $CaCO_3$
- Ampule Breaker
- Pipet, TenSette, 0.1–1.0 mL and pipet tips

1. Use the test procedure to measure the concentration of the sample.
2. Use a TenSette pipet to add 0.1 mL of the standard solution to the titrated sample.
3. Titrate the spiked sample to the endpoint. Record the number of digits on the counter.
4. Add one more 0.1-mL addition of the standard solution to the titrated sample.
5. Titrate the spiked sample to the endpoint. Record the number of digits on the counter.
6. Add one more 0.1-mL addition of the standard solution to the titrated sample.
7. Titrate the spiked sample to the endpoint. Record the number of digits on the counter.
8. Compare the actual result to the correct result. The correct result for this titration is 10 digits of 0.800 M titration cartridge or 100 digits of 0.0800 titration cartridge (11 digits of 0.714 M or 56 digits of 0.1428 M titrant) for each 0.1-mL addition of the standard solution. If much more or less titrant was used, there can be a problem with user technique, reagents, apparatus or an interference.

## Summary of method

Potassium hydroxide is added to the sample to adjust the pH to 12 to 13, which causes a magnesium hydroxide precipitate to form. CalVer 2 Calcium Indicator is then added, which reacts with calcium to give a red color. The EDTA titrant is added, which reacts with all the free calcium. After the EDTA has reacted with all of the free calcium ions, the EDTA removes the calcium from the indicator. The indicator color then changes from red to blue.

## Consumables and replacement items

### Required reagents

| Description | Quantity/Test | Unit | Item no. |
|---|---|---|---|
| Reagent set, 10–160 mg/L range (approximately 100 tests): | — | each | 2447200 |
| CalVer 2 Calcium Indicator Powder Pillows | 1 pillow | 100/pkg | 85299 |
| Potassium Hydroxide Standard Solution, 8 N | 1–2 mL | 100 mL MDB | 28232H |
| EDTA Titration Cartridge, 0.0800 M | varies | each | 1436401 |
| Reagent set, 100–4000 mg/L range (approximately 100 tests): | — | each | 2447500 |
| CalVer 2 Calcium Indicator Powder Pillows | 1 pillow | 100/pkg | 85299 |
| Potassium Hydroxide Standard Solution, 8 N | 1–2 mL | 100 mL MDB | 28232H |
| EDTA Titration Cartridge, 0.800 M | varies | each | 1439901 |

## Consumables and replacement items (continued)

| Description | Quantity/Test | Unit | Item no. |
|---|---|---|---|
| Reagent set, 1–16 G.d.h. range (approximately 100 tests): | — | each | 2447300 |
| CalVer 2 Calcium Indicator Powder Pillows | 1 pillow | 100/pkg | 85299 |
| Potassium Hydroxide Standard Solution, 8 N | 1–2 mL | 100 mL MDB | 28232H |
| EDTA Titration Cartridge, 0.1428 M | varies | each | 1496001 |
| Reagent set, 10–100 G.d.h. range (approximately 100 tests): | — | each | 2447400 |
| CalVer 2 Calcium Indicator Powder Pillows | 1 pillow | 100/pkg | 85299 |
| Potassium Hydroxide Standard Solution, 8 N | 1–2 mL | 100 mL MDB | 28232H |
| EDTA Titration Cartridge, 0.714 M | varies | each | 1495901 |

### Required apparatus

| Description | Quantity/test | Unit | Item no. |
|---|---|---|---|
| Graduated cylinders—Select one or more for the sample volume: | | | |
| Cylinder, graduated, 5 mL | 1 | each | 50837 |
| Cylinder, graduated, 10 mL | 1 | each | 50838 |
| Cylinder, graduated, 25 mL | 1 | each | 50840 |
| Cylinder, graduated, 50 mL | 1 | each | 50841 |
| Cylinder, graduated, 100 mL | 1 | each | 50842 |
| Digital Titrator | 1 | each | 1690001 |
| Delivery tube for Digital Titrator, J-hook tip | 1 | 5/pkg | 1720500 |
| Flask, Erlenmeyer, 250 mL | 1 | each | 50546 |
| Pipet, TenSette®, 0.1–1.0 mL | 1 | each | 1970001 |
| Pipet tips, for TenSette® Pipet, 0.1–1.0 mL | 1 | 50/pkg | 2185696 |

### Recommended standards

| Description | Unit | Item no. |
|---|---|---|
| Calcium Hardness Standard Solution, 10,000-mg/L as $CaCO_3$, 10-mL Voluette ampule | 16/pkg | 218710 |
| Hardness Quality Control Standard, high range | 500 mL | 2833349 |
| Hardness Quality Control Standard, low range | 500 mL | 2833449 |

### Optional reagents and apparatus

| Description | Unit | Item no. |
|---|---|---|
| Ampule Breaker, 10-mL Voluette® Ampules | each | 2196800 |
| CalVer® 2 Calcium Indicator Powder | 113 g | 28114H |
| CDTA Magnesium Salt Powder Pillow | 100/pkg | 1408099 |
| Delivery tube for Digital Titrator, 90-degree bend for use with TitraStir Titration Stand | 5/pkg | 4157800 |
| Magnesium Standard Solution, 10 g/L as $CaCO_3$ | 29 mL | 102233 |
| Nitric Acid, concentrated | 500 mL | 15249 |
| Nitric Acid Solution, 1:1 | 500 mL | 254049 |
| Pipet filler, safety bulb | each | 1465100 |

## Optional reagents and apparatus (continued)

| Description | Unit | Item no. |
|---|---|---|
| Pipet, volumetric, Class A, 10 mL | each | 1451538 |
| Pipet, volumetric Class A, 20 mL | each | 1451520 |
| Pipet, volumetric, Class A, 25 mL | each | 1451540 |
| Potassium Cyanide, ACS | 100 g | 76714 |
| Potassium Hydroxide, 8 N | 500 mL | 28249 |
| Sampling bottle with cap, low density polyethylene, 500 mL | 12/pkg | 2087079 |
| Sampling bottle, with cap, low density polyethylene, 250 mL | 12/pkg | 2087076 |
| Spoon, measuring, 0.1 g | each | 51100 |
| Stir bar, octagonal | each | 2095352 |
| TitraStir® Titration Stand, 115 VAC | each | 1940000 |
| TitraStir® Titration Stand, 230 VAC | each | 1940010 |

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Outside the U.S.A. – **Contact the HACH office or distributor serving you.**
On the Worldwide Web – **www.hach.com**; E-mail – **techhelp@hach.com**

**HACH** COMPANY
WORLD HEADQUARTERS
Telephone: (970) 669-3050
FAX: (970) 669-2932



11/2019, Edition 9

## Jeff Wolford

**From:** US - Tech Help <techhelp@hach.com>
**Sent:** Tuesday, January 30, 2024 9:51 AM
**To:** avandenheuvel@ku-wi.org
**Cc:** Jeff Wolford
**Subject:** Fwd: Hardness Testing - HACH Case # 01240323 [ ref:!00Di00c0fJ.!5003q01eKv7L:ref ]

Hello Jeff,

I am wondering if the different labs are reporting total versus calcium hardness and that is why the values are different. Are the units the same in each lab report?

<u>What happens when you use the Hach 5-EP for testing hardness in the 600-800 mg/L range? How far does the accuracy get thrown off. Can you use half the sample volume and then multiple the number of drops by 2?</u>

We do not know how the accuracy is changed outside of the reported method limits. Please see the below article about deviations from the method. The best solution for a higher concentration outside of the range is to perform a dilution.

Can Hach advise on how deviations from the method procedure will impact results?

What is the purpose of dilution and instructions for performing a dilution?

For the HAC-DT test: for strontium - Do you know how it interferes with the test? Does strontium just count as Calcium in the total hardness of CaCO3?

Hardness in water is caused by dissolved minerals, primarily divalent cations, including calcium (Ca2+), iron (Fe2+), strontium (Sr2+), zinc (Zn2+) and manganese (Mn2+). Calcium and magnesium ions are usually the only ions present in significant concentrations as it is unusual to have high strontium in natural waters.
The result of this test method linked below, if strontium is present, is strontium and calcium, so yes it does "count" as calcium, but this method is not a total hardness test as it does not measure magnesium.

**Hardness, Calcium, Titration Method 8204 using EDTA, Digital Titrator**

I see that strontium interferes with the straight Calcium test too? (Method 8204) Does strontium just count as Calcium so the value is still accurate for (Calcium + Strontium)? We have a strontium test results so maybe I can just subtract the value.

Yes, this is a correct statement. I would definitely suggest verifying the result with a separate strontium test method.

Thank you for contacting HACH Technical Support

**Grace** | Technical Advisor
Hach | [www.hach.com](www.hach.com)
800-227-4224 | USA Mountain Time Zone | Techhelp@hach.com
We value your feedback! Click here to contact a Hach Manager

--------------- Original Message ---------------
**From:** Andy Vanden Heuvel [avandenheuvel@ku-wi.org]
**Sent:** 1/29/2024 5:16 PM
**To:** jwolford@cbssquaredinc.com; techhelp@hach.com
**Subject:** Re: Hardness Testing - HACH Case # 01240323 [ ref:!00Di00c0fJ.!5003q01eKv7L:ref ]

Jeff,
That's fine we can get samples done anywhere but we get our samples done at badger labs. So not sure how labs can be that much different

Andy Vanden Heuvel
Water Superintendent

KAUKAUNA UTILITIES
920-858-9180
avandenheuvel@ku-wi.org
www.kaukaunautilities.com

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**From:** Jeff Wolford <jwolford@cbssquaredinc.com>
**Sent:** Monday, January 29, 2024 4:44:39 PM
**To:** US - Tech Help <techhelp@hach.com>
**Cc:** Andy Vanden Heuvel <avandenheuvel@ku-wi.org>
**Subject:** RE: Hardness Testing - HACH Case # 01240323 [ ref:!00Di00c0fJ.!5003q01eKv7L:ref ]

Grace

The reason I am questioning this information is the water utility is using the wrong test kit for hardness and the results between field, and two laboratories vary a lot.  We had the water sample sent out to two different labs and those two labs vary by more than  150 mg/l which is significant.  So I would like to try to narrow down the issue and get stable hardness results.  Then we can design a hardness removal system.

What happens when you use the Hach 5-EP for testing hardness in the 600-800 mg/L range? How far does the accuracy get thrown off. Can you use half the sample volume and then multiple the number of drops by 2?

For the HAC-DT test: for strontium - Do you know how it interferes with the test? Does strontium just count as Calcium in the total hardness of CaCO3?

I see that strontium interferes with the straight Calcium test too? (Method 8204) Does strontium just count as Calcium so the value is still accurate for (Calcium + Strontium)? We have a strontium test results so maybe I can just subtract the value.

**Jeff Wolford, PE**

CBS Squared, Inc.

2500 E. Enterprise Ave. Suite A

Appleton, WI 54913

920.621.0296

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**From:** US - Tech Help <techhelp@hach.com>
**Sent:** Monday, January 29, 2024 3:27 PM
**To:** Jeff Wolford <jwolford@cbssquaredinc.com>
**Subject:** Fwd: Hardness Testing - HACH Case # 01240323 [ ref:!00Di00c0fJ.!5003q01eKv7L:ref ]

Hello Jeff,

Apologies but it looks like our email got lost!

The HAC-DT is the correct option for the test range you are in. There is no pretreatment information listed that would allow you to address strontium interference.  It just references the following:

*Strontium is titrated at the same time with calcium and interferes with this test, but it is unusual to find high levels of Strontium in natural waters.*

So the more strontium in your water the higher the interference level would be. Unfortunately, I do not show that we have a test method where this is not an interference.

Thank you for contacting HACH Technical Support

**Grace** | Technical Advisor
Hach | www.hach.com
800-227-4224 | USA Mountain Time Zone | Techhelp@hach.com
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--------------- Original Message ---------------
**From:** Jeff Wolford [jwolford@cbssquaredinc.com]
**Sent:** 1/29/2024 10:54 AM
**To:** techhelp@hach.com
**Subject:** RE: Hach 01240323

I have not received a response back on my question.

**Jeff Wolford, PE**

CBS Squared, Inc.

2500 E. Enterprise Ave. Suite A

Appleton, WI 54913

920.621.0296

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**From:** Global Technical Support <techhelp@hach.com>
**Sent:** Monday, January 29, 2024 9:16 AM
**To:** Jeff Wolford <jwolford@cbssquaredinc.com>
**Subject:** Hach 01240323

Hello Dear Valued Hach Customer,

This is a courtesy reminder that your ticket is not closed yet. If you are aware of this please disregard. Otherwise, please reply if this is still an ongoing issue or to let us know it should be closed.

Thank you for contacting HACH Technical Support
**HACH Global Technical Support Team**

Do you have additional questions about Hach products?
Find answers at any time by searching our knowledge tool at www.hach.com. If you do not find the answer you are looking for, submit questions using the Ask A Question link.

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# G.3 WATER SOFTENER INFORMATION

# Purchasing and Maintaining A Water Softener

Energy Saver

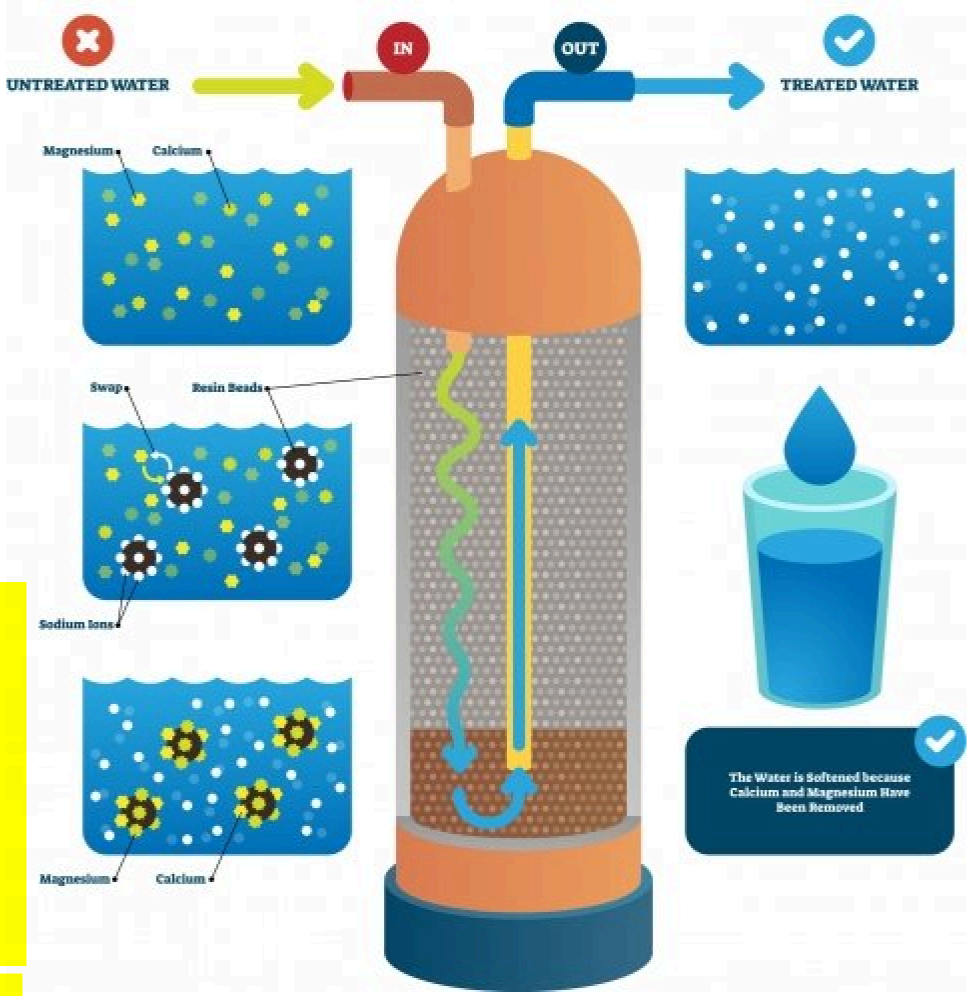


A water softener has many benefits are an excellent option for homes with light to heavy hard water.   Because it reduces water hardness by removing of heavy minerals like calcium, iron, and magnesium from the water supply coming into the home, a water softener prevents common water problems including mineral deposits and scale buildup on leading to leaky faucets and clogged pipes, damage to water-based appliances, chalky films on dishwasher cleaned glasses, dry skin and hair after showering, and faded colored clothing from the washing machine.

A water softener solves these issues by preventing heavy minerals from binding or flowing through the water. Softened water can:

- Save money in the long term
- Provide cleaner hair and softer skin
- Brighten and soften clothes
- Clean dishes and glasses better
- Reduce time spent cleaning
- Make drinking water clearer and better tasting

# How a Water Softener Works




There are many water softeners on the market, but almost all rely on the same principle—ion exchange, a chemical process that substitutes sodium (sometimes potassium) for the minerals that make water hard. In a conventional system, water passes through a tank with a bed of resin beads saturated with sodium, exchanging any calcium and magnesium ions in the water with sodium ions. When the minerals attach to the beads, the sodium that had been on the beads enters the volume of water. By the time household water exits the system, it is no longer hard.

Over time, the resin bed becomes flush with the minerals that have been drawn out of the hard water. At that point, the water softener must go through a "regeneration" cycle, during which sodium-rich water restores the resin beads to their initial sodium-saturated state. Upon completion of the cycle, the softener returns to regular operation, softening the household water that passes through it.

# Types of Water Softeners

Water softeners work by either drawing heavy minerals out of the water using a process called ion exchange or by neutralizing these minerals so that they are unable to bind together and remain soluble in the water.

There are two main types of water softeners that do this, although in different ways:

- Salt-based, including dual-tank systems
- Salt-free, including magnetic systems

## Salt-Based Water Softeners

Salt-based water softeners are the most commonly used and effective softener types. Most water softener systems are salt-based systems, so there are a high number of salt-based options available. They come in a variety of sizes and are appropriate for just about every dwelling.

A salt-based water softener typically works by drawing heavy minerals in the water, like calcium and magnesium, into a resin within the softener and exchanging them for sodium (salt). By removing the heavy minerals, the water returns to a healthy neutral state.

The downside to these softeners is that the resin then needs to be recharged with salt. For most homes, this will need to be done about once a week. These water softeners are also much larger than salt-free or magnetic softeners, making them not the best choice for smaller spaces.

However, there are portable water softeners that are salt-based.  Designed specifically for portable functionality, these softeners are an excellent choice for an RV, a large boat, an mini/micro home, or an efficiency apartment. An included hose allows the user to connect directly to an outdoor faucet or campground water supply for instant access to softened water for cleaning, drinking, and bathing.

These sand-based 16,000-grain capacity water softeners can be recharged using simple table salt, but they do require frequent recharging with regular use. However, with the reduced size, there is also a lower price, making this option easier on the wallet for simple, low volume instances.

While salt-based water softeners do add salt to the water, it is only in trace amounts that rarely get noticed.  This level of sodium is *safely within the recommended range for healthy individuals, but those with low-sodium diets may wish to opt for a salt-free water softener (read next section) that uses potassium, not sodium.*

### DUAL-TANK WATER SOFTENERS

A dual-tank water softener is a salt-based softener with two resin tanks. This style is often the best water softener to use for well water due to its better ability to filter heavy minerals. These tanks function in the same way as a single-tank salt-based softener, except that when one tank is in the regeneration cycle, the other tank is still providing softened water to the household.

Dual-tank softeners aren't necessary for most homes, and due to their size, they can be challenging to place and install. They also carry a higher price tag than the other styles and do need to be recharged. However, a dual-tank water softener can handle more water per regeneration cycle and never run out of softened water.

## Salt-Free Water Softeners

Understanding how the different types of salt-free water softeners work, as well as how much water they can treat on a daily basis, is integral to purchasing the right unit.

As indicated by their name, salt-free water softeners don't use salt to remove heavy minerals from water; in fact, they don't remove the heavy deposits at all. Instead, they condition the water so these particles cannot build up on faucets and showerheads. While the minerals remain in the water, they are put through a conditioning process.

Salt-free water softeners tend to cost more initially, do not use salt or electricity. These models are also smaller than salt-based systems, so they can easily be used for small- to large-size houses. However, these units may struggle with very high levels of hard water and households with higher than average water usage.

### ELECTROMAGNETIC AND MAGNETIC

Electromagnetic water softeners take up almost no space at all so are great for small spaces. Similar to other salt-free water softeners, electromagnetic water softeners do not remove particles that cause hardness in water but rather use a magnetic field to strip negative or positive ions from heavy minerals to magnetize the grains and neutralize them, which prevents them from clinging to surfaces and causing scaling because they are no longer positively or negatively charged, the minerals cannot bond to each other. Instead, they remain entirely soluble in the water. These systems plug into a standard outlet and don't need to be plumbed into a home, making them an attractive low-maintenance option for softening water. Magnetic models perform the same task but don't need electricity and require little to no maintenance. However, they are not as powerful and are only suitable for small homes.

### POLYPHOSPHATES

Instead of removing impurities from the water, the use of polyphosphates conditions the water so impurities cannot create scaling on plumbing or faucets using a filtration cartridge. This type of system is used primarily in restaurants and other commercial settings to protect appliances from scaling.

### FULL FILTRATION

Full filtration systems not only soften water, but they also remove other contaminants in drinking water. This type of salt-free water softener functions by passing the water through a filter that crystallizes minerals, preventing them from sticking to one another and creating the scaling that can damage pipes and appliances. They also remove other contaminants, including herbicides, bacteria, viruses, pesticides, and chlorine. Filters on these water softeners can be pricey and typically last 6 months to 1 year.

It is important to be mindful that there is a difference between a water softener and a water purifier. It is safe to drink water from a water softener if the only contaminants are hardening minerals. The water softener will remove the hardening minerals or neutralize them so they cannot bind together. However, a water softener is not a water filter and will not remove any other harmful particles. As such, it should only be relied on to soften water, not purify it. If you're unsure about the safety of your drinking water, contact your local health department, test it yourself, or send out a sample for to be expert-tested.

### FLOW RATE

A salt-free water-conditioning system functions between the main water line that enters a home and all of the water receptacles in a home, treating the water as it flows into the home's plumbing.

Salt-free systems that use filtration can affect the flow of water, potentially slowing it. Electromagnetic water treatment systems aren't plumbed into a home's water system, so they don't affect a home's flow rate. With that in mind, the water softeners with filtration systems must have a flow rate that meets the demands of the household to prevent drops in water pressure.

The average household, homes with one to three bathrooms, requires a filtration system with a flow rate of between 8 and 12 gallons per minute. Larger households require around 15 gallons per minute.

### INSTALLATION

One of the main advantages of a salt-free water softener is that they're generally much easier to install than salt-based water softener systems. While the latter typically requires professional installation, a salt-free system is typically an easy DIY job.

Electromagnetic salt-free water softeners don’t require any plumbing and typically take about 15 minutes to install. This type of water softener has wires that wrap around the water supply pipe with a power source that sends electromagnetic waves through the wire.

Full filtration systems and whole-house systems are more involved as they need to be attached to the incoming water supply pipe but are still relatively quick and easy to install.

# What to Consider When Choosing A Water Softener System

Unlike more common consumer items, water softener systems are often not widely understood products, so it can be difficult for consumers to judge the best systems. Before choosing a water softener, take a few minutes to recognize the most important shopping considerations to keep in mind.

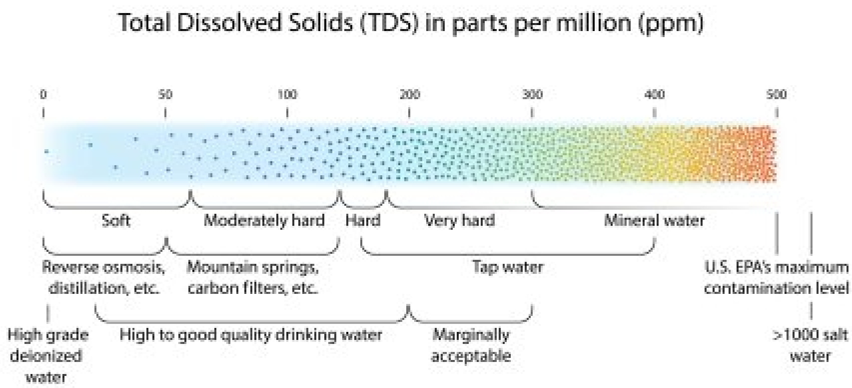
## Usage and Hardness

Water softeners come in different sizes to meet the needs of different households. Determining which size a household needs depends on usage and hardness.

Determining water usage is as simple as multiplying the number of people in a household by gallons per day. The average person uses 75 gallons of water per day. So, for example, a family of three will use an average of 225 gallons of water per day.

**Water hardness** or softness is measured using grains per gallon (gpg), where one grain is equal to 0.002 ounces of calcium carbonate dissolved in 1 gallon of water.

- 0–3 gpg is considered soft water.
- 3.5–7 gpg is considered moderate and ideal.
- >7.5 gpg is regarded as hard water and should be treated with a water softener.




Multiply the water hardness by the water usage in the home to determine what size water softener is needed.. For example, a home that uses 225 gallons of water per day with a water hardness of 10 grains per gallon requires a water softener with a capacity of 2,250 grains per day.

## Capacity

A water softener's capacity is the measurement of grains per week that the unit can handle before needing to be replenished.

Small water softeners come with weekly grain capacities of 16,000, 24,000, and 32,000. These are ideal for RVs, apartments, and small houses. Medium water softeners have grain capacities of 40,000, 48,000, and 64,000. Use these models for **medium to large households**. For big families and large properties, a residential water softener with a grain capacity of 80,000 or 100,000 would be most appropriate.

Keep in mind that the harder the water, the more grains the system will need to handle it. A 40,000-grain system would operate very differently with 3 gpg water running through it than if it had 10 gpg water to manage.

## Available Area

Salt-based, and even some salt-free water softeners can take up a lot of space. The area where the water softener will be installed needs to be measured and compared to the manufacturer's installation specifications.

Most salt-free water softeners are smaller than the salt-based models. They are installed directly on the waterline and hang down only 1 or 2 feet, depending on the brand. Similar in size to the salt-free softeners, portable salt-based water softeners are an alternative option for small homes or RVs that prefer a salt-based model to remove heavy metals entirely.

Magnetic water softeners take up the least amount of space, and you can install them without cutting into your plumbing. Typically, these smaller softeners can be mounted directly on the pipe and do not interfere with your floor space. These softeners are the best option to save space in smaller homes, RVs, or apartments.

## Bypass Valve

A valve controls the flow of water through a pipe, closing, or opening when necessary. A bypass valve works in the same way as a regular valve, but its purpose, when used with a water softener, is to divert the flow of water away from the softener, giving you access to the hard water running into the home.

If you have just purchased a water softener, this feature may seem pointless. However, a bypass valve can save you time and money by preventing your water softener from using excess salt or energy to soften the water used for watering the lawn or washing the deck.

For those purposes, the bypass valve may be used to divert the flow of water around the softener and back into the pipes. Once completed, just close the bypass valve and restore the flow of water through the softener.

## Regeneration Cycles

Salt-based water softeners must be regenerated or refreshed when their salt content runs out. This can be regulated using a metered system or with a timed system.

### METERED WATER SOFTENERS

Metered water softeners work by counting the gallons of water that pass through the water softener and automatically regenerating when necessary. This system is great for vacation homes or cottages with long periods of disuse because the system will only regenerate when necessary.

### TIMED WATER SOFTENERS

Timed water softeners are set to automatically regenerate the salt within the softener at a designated time. These softeners allow for more control over the scheduled regeneration but will use more salt than necessary if the regeneration intervals are too short. This system could also result in hard water passing through the pipes if the regeneration intervals are too long.

Whether or not the system provides water softening during regeneration—and whether it's a manual or automatic process—depends on the sophistication of the appliance.

Fully automatic water softeners are the most expensive, but features alone do not dictate price. Size matters too. The correct size for a given home takes into account **daily water use** as well as the hardness of the water. A simple sizing calculation involves multiplying the number of household members by the number of gallons used per person, per day. Next, multiply the number of gallons consumed by the grains per gallon (GPG) figure. Then to accommodate for regeneration and days of heavy use, multiply your total by three. For the average four-person home, experts recommend a capacity of 33,000 GPG.

# Care & Maintenance Tips for Water Softeners

The average water softener lasts for 10-15 years. However, with proper maintenance and care, there are some ways to extend the life of a water softener well beyond this normal life span.

One of the most important and basic things to do is check the salt levels every 4-6 weeks. If the salt level of a water softener drops, then hard water will begin to return to the home's water system.

While checking the salt levels, also make sure to check on the condition of the brine tank as salt bridges may have formed over time. These bridges can prevent the resin beads from softening the water properly and must be cleared to ensure the proper functionality of the water softener.

Using the correct salt in for the water softener type is key to maintaining its functionality. Cubes or crystal salt is recommended for most available models but be sure to read the owner's manual to make sure.

## Cleaning the Water Softener

Flushing the resin bed with a water softener cleaner can help to remove iron and other heavy metals from the beads, allowing them to regenerate with salt properly.

To clean a water softener, begin by dumping all water and salt out of the tank and disposing of it. To do this, dig a hole in the yard away from any plants, line the hole with sand and gravel, and discard the excess brine. Then remove the brine grid from the base of the tank and set it aside. Next, use warm, soapy water and a long-handled brush to scrub the tank's interior, and then rinse with plain water.  Once rinsed, use a mixture of ¼ cup household bleach and 2 to 3 gallons of water to fill the tank. This mixture should sit for at least 15 minutes to kill any microorganisms. Rinse the reservoir once more, then replace the brine grid, refill with water, and replenish it with salt. Keep your water softener maintained to improve the water quality in the home and prevent any drops in water pressure due to mineral buildup.

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G1491

# *Drinking Water Treatment:* Water Softening (Ion Exchange)

**The presence of calcium (Ca) and/or magnesium (Mg) in water results in water being considered "hard." Calcium and magnesium ions in water react with heat, metallic plumbing, and chemical agents such as detergents to decrease the effectiveness of nearly any cleaning task. Hard water can be softened using an ion exchange softening process. This guide discusses the ion exchange water softening process and related equipment used for household water treatment.**

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*Sharon O. Skipton, Extension Water Quality Educator*
*Bruce I. Dvorak, Extension Environmental Engineering Specialist*

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An ion is an atom or molecule that has a positive or negative electrical charge. Calcium and magnesium ions are released into water as it dissolves rocks and minerals. These mineral ions in the water can cause scale buildup in plumbing, fixtures and appliances and affect their performance. In the hot water heater, heat removes some calcium carbonate and magnesium carbonate from the water, resulting in scale buildup, which can then slow the heating process and increase energy usage. Cleaning agents used with hard water are not able to completely remove dirt and grime. Clothes may become dingy and gray with time and feel harsh or scratchy. Glassware may become spotted as it dries. Films may be left on shower doors or curtains, walls, and tubs, and hair washed in hard water may look dull and not feel clean. Hard water is considered a nuisance problem, but removing hardness ions isn't necessary for health reasons.

A variety of techniques are marketed to manage hardness minerals. This NebGuide focuses on the ion exchange softening process which remains the most commonly used technique for managing hard water in residential settings.

## Contaminants removed by the water softening (ion exchange) process

The ion exchange water softening process can remove nearly all calcium and magnesium from source water. Softeners may also remove as much as 5-10 ppm (parts per million; ppm is equal to milligrams per liter, or mg/L) of iron and manganese. Consumers can check the water softener's manufacturer's rating for removal of these contaminants. Concentrations of iron and manganese greater than the softener's removal rating may require pretreatment such as greensand filters (see NebGuide G1280 *Drinking Water: Iron and Manganese*) to increase the lifespan of the softener.

## Contaminants not removed by the water softening (ion exchange) process

No one piece of treatment equipment manages all contaminants. All treatment methods have limitations and often water quality situations require a combination of treatment processes. Water softening does not remove bacteria, hydrogen sulfide, silt or sand, lead, nitrate, pesticides, and many other organic and inorganic compounds. Refer to Extension Circular EC703, *Drinking Water Treatment: An Overview* for a discussion of possible water quality problems and appropriate treatments for these contaminants. Further information can be obtained from the appropriate treatment guide in the Drinking Water Treatment series.

## Water Testing

Regardless of which water treatment system is considered, the water first should be tested to determine which contaminants are present. Public water systems routinely are tested for contaminants. Water utilities are required to publish Consumer Confidence Reports (CCRs), which inform consumers on the source of the water, concentration of contaminants present, potential health effects of those contaminants, and methods of treatment used by the utility. Depending on the population served by the water utility, CCRs may be mailed, published in newspapers, or posted on the Internet, but a copy of it can be obtained by contacting the local water utility. Public supplies must conform to federal standards established by the Safe Drinking Water Act. If contaminants exceed the Maximum Contaminant Level (MCL), the water must be treated by the water supplier to correct the problem and/or another source of potable water must be provided.

In contrast, monitoring private water systems is the consumer's responsibility. Therefore, contamination is more likely to go undetected in a private water supply. Knowing which contaminants may be present should guide the testing, since it's not economically feasible to test for all possible contaminants. Know which contaminants are present, their concentrations, and reasons for removal (i.e., health risks, tastes or odors, etc.) prior to selecting treatment methods or equipment. Refer to NebGuide G907 *Drinking Water: Testing for Quality* for testing information.

Testing laboratories, some city-county health departments, and some water treatment equipment dealers can test water for hardness. In addition, a variety of test kits and dip strips are available for hardness testing outside of a laboratory environment. When using these tests, users should understand the nature of the test and the accuracy of the test results. While some may provide accurate and reliable measurements from which decisions can be made, others may not. Greater reliability and accuracy can be expected with laboratory testing. In situations where considerable investment is necessary to correct a problem, verification of the severity of the problem by an approved laboratory is advisable.

It is also important to periodically re-test after installation of treatment devices to evaluate the effectiveness of the treatment equipment.

Water hardness is often expressed as grains of hardness per gallon of water (gpg) or milligrams of hardness per liter of water (mg/L). *Table I*, adapted from the Water Quality Association (WQA), shows hardness classifications. Hardness ions are typically combined with sulfate, chloride, carbonate, or bicarbonate ions. For consistency, concentrations are generally converted to the equivalent concentration as calcium carbonate ($CaCO_3$) and expressed in terms of hardness as calcium carbonate.

**Table I. Classification of water hardness (hardness as calcium carbonate).**

| Classification | mg/L or ppm | Grains per gallon, gpg |
|---|---|---|
| Soft | 0-17 | 0-1.0 |

| | | |
|---|---|---|
| Slightly hard | 17-60 | 1.0-3.5 |
| Moderately hard | 60-120 | 3.5-7.0 |
| Hard | 120-180 | 7.0-10.5 |
| Very hard | 180 & over | 10.5 & over |

## Treatment Principles

Household water softeners are ion exchange devices. Ion exchange involves removing the hardness ions calcium and magnesium and replacing them with non-hardness ions, typically sodium supplied by dissolved sodium chloride salt, or brine. The softener contains a microporous exchange resin, usually sulfonated polystyrene beads that are supersaturated with sodium to cover the bead surfaces. As water passes through this resin bed, calcium and magnesium ions attach to the resin beads and the loosely held sodium is released from the resin into the water. The softening process is illustrated in *Figure 1*.

After softening a large quantity of hard water the beads become saturated with calcium and magnesium ions. When this occurs, the exchange resin must be regenerated, or recharged. To regenerate, the ion exchange resin is flushed with a salt brine solution *(Figure 1*). The sodium ions in the salt brine solution are exchanged with the calcium and magnesium ions on the resin and excess calcium and magnesium is flushed out with wastewater.

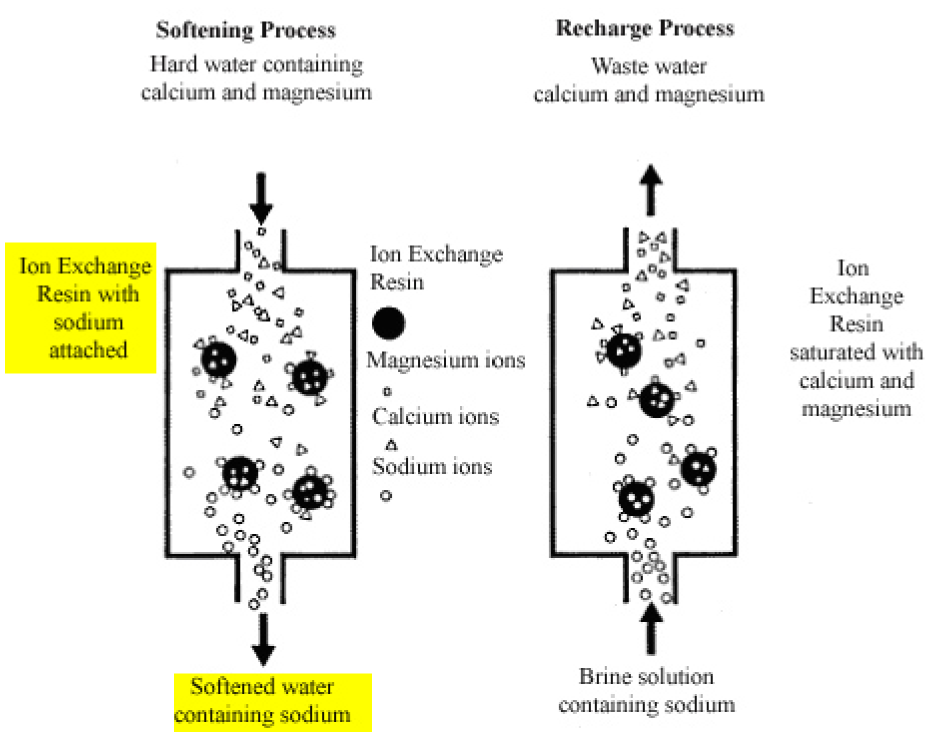


**Figure 1. The water softening and recharge process.**

Frequency of the regeneration or recharge cycle depends on the hardness of the water, the amount of water used, size of the softener, and capacity of the resins. Sixty to 120 minutes generally are required for the brine to pass through the unit and flush the tank before soft water is available again.

Through the softening process, sodium is added to water at a rate of about 8 mg/L for each grain per gallon (gpg) of hardness. After treatment, water that was 10 gpg of hardness will have about 80 mg/L of sodium. This means that for every liter (0.26 gallon) of water intake, there would be 80 mg of sodium intake. People on restricted sodium diets due to health reasons should account for increased intake through softened water and consult their physician. Drinking and cooking with softened water is often avoided by having a cold water line to the kitchen tap that bypasses the water softener. This provides hard water for drinking, cooking and other uses.

It is not recommended to repeatedly use softened water for plants, lawns or gardens due to the sodium content.

## Equipment

Ion exchange water softeners can be classified as one of four different types:

1. *Semi-automatic:* These require the operator to initiate the regeneration cycle. The necessary steps to complete regeneration and return to service are done automatically by the softener controls.

2. *Automatic:* Fully automatic softeners are typically equipped with a timer that automatically initiates the regeneration cycle and the required steps in that process. The operator only sets the timer and adds salt as needed. Regeneration is generally done during periods of low water usage, such as between midnight and 4 a.m.

3. *Demand-initiated regeneration (DIR):* Demand-initiated regeneration units initiate and handle regeneration operations automatically in response to the demand for treated water. Need for regeneration is determined by measuring gallons of water used or the change in electrical conductivity of the resin bed, or by sensing a change in water hardness. DIR units may have two softening tanks and a brine tank so that one tank can be softening while the other is recharging. DIR units may lead to less overall usage of salt and water since regeneration is only done when necessary.

4. *Off-site regeneration:* Rental units are available in which the resin tank is exchanged in the home and then recharged at a central location.

All types of softeners must be correctly installed and monitored for proper operation. If an automatic or DIR unit appears to use more salt than expected or water is not softened, have a service provider check the unit settings. The amount of salt used for softening depends on the number of people in the household, daily water usage, softener capacity, and water hardness. The appropriate size of water softener depends on several factors including the water hardness level, daily water use and water flow rate.

## Types of Salt

There are different types of salt available for water softeners. The choice depends upon the type of water softener and manufacturer design. Softeners are designed to use specific types of salt so it is important to follow manufacturer's recommendations regarding the salt type.

Compressed salt has undergone an evaporation and compression process that yields small particles referred to as pellets, nuggets, or beads. A variety of grades and formulations are available on the market. Products designed to manage iron (rust) may contain food-grade additives, such as citric acid. Compressed salt is sized according to manufacturer's specifications. The majority of softeners are designed for this type of salt.

Salt blocks for use in some softener brine tanks look similar to those used for livestock feeding. Blocks for livestock feeding, however, may contain additives incompatible with water softener units. Block salt should be used only in those units specifically designed for this form of salt. It should be high-grade evaporated salt without additives.

Rock salt may have high levels of soluble or insoluble impurities. If the impurities are calcium or magnesium salts, they may significantly reduce the effectiveness of the regeneration process and plug valves. Rock salt is only an option if suggested by the manufacturer and only those averaging less than 1 percent impurities should be used.

In certain situations, potassium chloride may be used for softener regeneration instead of sodium chloride. Potassium chloride can be more costly and more difficult to obtain than sodium chloride, however. Potassium chloride also adheres more strongly to the resin. This can reduce the exchange efficiency compared to sodium chloride and require more potassium chloride. Substituting potassium chloride for sodium chloride may be appropriate if health or environmental reasons necessitate restricting sodium; a water treatment professional should be consulted regarding this option.

## Maintenance

Maintenance of water softening equipment is somewhat dependent on the type of softener. Some degree of monitoring or managing the regeneration process is generally required. The softener must be kept regenerated to avoid hard water flowing into pipes and appliances. Regeneration does place additional load on a septic system. Approximately 50 gallons of water (roughly equal to that required for a load of laundry using an older washing machine, or two loads using a newer high-efficiency washing machine) is used to regenerate a water softener. Also, certain situations such as high concentrations of iron or manganese in the water can affect the exchange capacity of the resin. In this case the resin may eventually need to be cleaned or replaced. A water treatment professional should be consulted for guidance on cleaning or replacing the resin.

The brine tank requires periodic checking and cleaning. How frequently you clean it depends on the type and amount of salt and characteristics of the water being treated. Inspect the tank for scale build-up. The brine valve and float assembly, if used, should also be cleaned and inspected at least once a year.

Adequate backwashing of the resin bed is important to ensure efficient regeneration of the unit. If backwashing is to be done manually or is semiautomatic, the backwash should be continued until the water runs clear. If the unit is fully automatic and backwash time is adjustable, adjust the time so the backwash is long enough to produce clear water in the drain.

Excess iron (above 5 ppm) or hydrogen sulfide in the water can reduce the effectiveness of the water softener. The water should be tested for these contaminants and proper pre-softening equipment installed if required. NebGuides G1280 *Drinking Water: Iron and Manganese* and G1275 *Drinking Water: Sulfur (Sulfate and Hydrogen Sulfide)* discuss these contaminants. Sediment in the water can also reduce the effectiveness of the softener. The NebGuide G1492 *Drinking Water Treatment: Sediment Filtration* discusses options for sediment removal.

## Selection Requirements

Federal, state, or local laws do not regulate water softening home systems. The industry is self-regulated. The NSF (formerly the National Sanitation Foundation) and the Water Quality Association (WQA) evaluate performance, construction, advertising, and operation manual information. The NSF program establishes performance standards that must be met for endorsement and certification. The WQA program uses the same NSF standards and provides equivalent American National Standards Institute (ANSI) accredited product certifications. WQA certified products carry the Water Quality Association Gold Seal. Though these certifications and validations should not be the only criteria for choosing a water softening system, they are helpful to ensure effectiveness of the system.

Other important guidelines are discussed in NebGuide G1488 *Drinking Water Treatment: What You Need to Know When Selecting Water Treatment Equipment*. The NebGuide series on drinking water treatment focuses on contaminants most likely to be encountered in Nebraska drinking water supplies. Some water supplies may contain contaminants not addressed in this series, such as cryptosporidium, giardia, hexavalent chromium and others.

## Summary

Drinking water treatment by water softening (ion exchange) is one option for the homeowner in treating water problems. Calcium and magnesium ions in water decrease the effectiveness of most cleaning tasks and can cause film and scale buildup in and on plumbing and fixtures. Water softening is an effective method for reducing the calcium and magnesium mineral ions from the water. It can also reduce iron and manganese concentrations. Selection of an ion exchange water softening unit should be based on water analysis and assessment of the individual homeowner's needs and situation. Regular maintenance of the unit is a critical factor in maintaining effectiveness of the unit. NSF and the WQA test and certify products and this certification can help guide selection.

## Acknowledgment

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**This publication has been peer reviewed.**

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# How A Water Softener Works


- **Average Salt Amount - Normal Water Level**

  (salt_water_levels)

- **Frequency of Regeneration - How Often?**

  (frequency_of_regeneration)

- **Soft Water - Why does it feel slimy**

  (Soft-Water--Why-does-it-feel-slimy_c_388.html)


# Water Softener Basics

## Used for decades, this equipment is still a mystery to some.

**R**emoving unwanted minerals from water may be easier than removing the mystery from water softeners even though the devices have been used for more than 60 years.

Water softeners remove unwanted calcium and magnesium. These minerals, commonly referred to as lime, form scale in plumbing and soap curd on objects cleaned with hard water. Mineral particles even become deposited between cloth fibers, leaving laundry dingy while deteriorating the fabric.

Hardness is found most frequently in ground water though amounts vary geographically. It's measured in grains per gallon (GPG). There are 7,000 grains to a pound, yet water with as little as one GPG of calcium can cause severe scaling in commercial applications like boiler treatment. Water containing less than seven GPG is generally considered acceptable for home use.

**Softening Up**

In water softening - also called ion exchange softening - an ion, an electrically charged particle, is attracted to ions of the opposite charge. A strongly charged ion will bump a weaker ion away from its "mate" and leave it unattached.

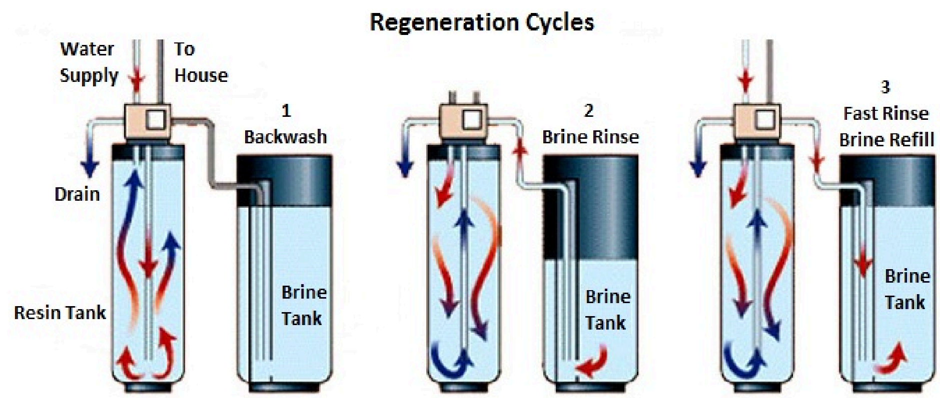
Both calcium and magnesium have strong positive charges, as does water-borne iron. The positive ions, called cations, are attracted to the strong negative ions, or anions, of the ion exchange resin found in water softeners. The resin looks like amber sand, but is actually a plastic bead-like material, coated temporarily with weakly bound sodium ions.

In addition to the resin, there are other important parts to water softeners. There is the resin tank, which is usually a fiberglass pressure vessel. Threaded into the top of the resin tank is the control valve, which directs water through the tank and makes regeneration possible. The last component is the brine tank, a storage area for salt and a few gallons of salt brine.

**How It Works**

Hard water enters the softener through the control valve and passes down through the resin bed. Calcium and magnesium have a strong attraction to the negatively-charged resin beads and become attached to them. Resin particles trade the weaker sodium cations for the magnesium and calcium particles in the water.

Eventually, the majority of the resin particles will pair with the strongly-charged magnesium and calcium particles. At that point, hard water bearing more of these elements passes through the softener unaffected. It's therefore necessary to periodically replenish the sodium originally present on the resin beads and dispose of the hardness-causing minerals removed from the water. This is usually a four-step process called regeneration.




Backwash is often the first step. Water flows through the unit in reverse, cleansing the resin of turbidity and precipitated iron. This short cycle is followed by the brine rinse cycle, where salt-laden water slowly passes through the resin to replace hardness-causing ions with sodium ions. The resin's preference for calcium and magnesium must be overcome by the strength of the brine solution, which bombards resin beads with millions of sodium ions. The over whelmed hardness ions are driven off and washed down the drain.

Next, the fast rinse cycle flushes the bed with raw water to remove the chlorides (salt brine and sodium chloride) and excess sodium. The last cycle is for brine tank refilling. Three pounds of salt are dissolved in every gallon of brine tank water for use during the next regeneration. The control valve then returns to the service position, making softened water available on demand.

Cargill Salt list of Salt related Questions and their Answers! (http://www.cargillsalt.com/dc_salt_about_faqs_water_cond.htm#P2_2988) - A must READ to better understand the Salt usage in your Softener System.

More Benefits of Conditioned Water (/manuals/Soft_Water_Benefits.pdf)

***Written by Rudy Wilfong***

**JANUARY 1991** GROUNDWATERAGE

**NOTE: The Brine Rinse cycle typically lasts for 50 minutes.**
**All the water is sucked out in 15 - 20 minutes.**
**The "Rinse" continues to slowly move / remove the salt water down through the Resin beads.**

**For more guidance on how much salt to use and how often to Recharge / Regenerate, see:**

## Average Salt Amount Needed and Normal Water Level In Brine Tank (/salt_water_levels)

Frequency of Regeneration - How Often Should Softener Recharge? plus Average Salt Amount Needed and Normal Water Level In Brine Tank (/frequency_of_regeneration)

Short Video showing / explaining How A Water Softener Operates

(https://youtu.be/F7u0zFr1srQ)And this video by Pentair Water referencing the Fleck 5600 (https://www.youtube.com/watch?v=eQ8pLDUHc_8)

**Products [3]**

(  )


Cleaner - Sani-System Liquid Sanitizer Concentrate Water Softeners (ss24n-c7000.htm)

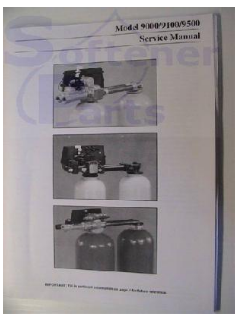
$4.00


Hardness Drops with Iron and pH levels - Test Kit Professional Method (test2401.htm)

$175.00

ADD TO CART (ADD_CART.ASP?QUICK=1&ITEM_ID=2250&CAT_ID=154)

ADD TO CART (ADD_CART.ASP?QUICK=1&ITEM_ID=2263&CA




Manual for Fleck 9000 Softener (fpm9000.htm)

$10.00

Links

# Average Salt Amount - Normal Water Level

The amount of salt needed to properly recharge a water softener is mostly based on the amount of resins being recharged.
3/4 cu.ft. resin = 6 - 9 lbs.
1 cu.ft. resin = 8 - 10 lbs.
1.5 cu.ft resin = 12 - 15 lbs.
Typically,

8 lbs. of salt for 8" x 44" tanks,
9 lbs salt for 9" x 48" tanks,
and
12 lbs. salt for 10" x 54" tanks is average.
If there is a lot of iron ( over 2 ppm )
or if the water is really hard ( over 30 grains ),
then **2 - 4 lbs. extra** should be used.

So, an average residential system will use 6 - 12 lbs of salt per regeneration at least once a week.
Very hard water, or water high in iron, may require regenerating every 2 or 3 days.
The result is you will be using at least 30 - 40 lbs. of salt per month if hardness is not too high, or amount of water used low.
Well water ( usually very hard and often containing iron ) will commonly require using 80 - 120 lbs. of salt per month.
Simply multiply the pounds of salt per regeneration times the number of regenerations in a month to calculate your monthly average usage.

P.S. If you run out of Salt, don't expect to have soft water after a few days. And it may take more than one regeneration to get the water feeling soft again once you've added salt.
I recommend keeping the salt level above the water level in your Brine Tank.
When you start seeing the water level ( normally between 6 - 12 inches ) then it's time to think about adding more salt ( 40 - 120 lbs. ).

QUESTION:
Does it matter which type of salt is used? Pellets or solar salt crystals? Is one better than the other?
**ANSWER:**
Either will work.

Recommend the solar salt crystals as they dissolve 100%, as opposed to the Pellets that leave an un-dissolved residue in the bottom of the brine tank. And this residue builds up until it clogs the flow of the brine water in and especially, out of the salt tank, requiring that the tank be dumped, emptied, and re-filled with new salt ( plus 4 gallons new water ) every 1 - 2 years on average.

## Below is a photo of a "Starved" softener

-- These "crums" under the water are not going to DISSOLVE enough ( or at all if "old" ) to make a strong "brine solution" to Recharge the RESINS ( the **KEY to Soft Water (/how_a_water_softener_works)** ).

**In simplest terms:**

The Control Valve should be adding 3 - 4 gallons of water at the end of regeneration process ( Brine Refill ). A level of 6 - 12 inches, depending on the amount of salt in the brine tank, and the shape of the brine tank ( square or round ).

During Brine Rinse ( long 50 minute cycle ), the valve should suck out the 3 - 4 gallons of water in about 20 minutes ( less than 1/4 gpm ), and once water level drops to the last couple of inches of the salt tank, the "air check" will close off, to prevent any "air" from getting sucked into the Valve. The Brine Rinse ( slow suction and slow rinse ) will continue for another 30 minutes, as it slowly rinses the salt water through the Resin Tank, allowing it to Recharge the Resin beads.

How Much Water Should be in Salt Tank Video

(https://www.youtube.com/watch?v=DmJhc8dMP0U)What type of Salt to Use Video (https://www.youtube.com/watch?v=ZkgGVCwHc2I)

How A Water Softener Works (/how_a_water_softener_works)

Sodium Levels in Water when Softened (/sodium_in_water)

## NOTE: Have the names for System Saver II, Rust Remover, and Solar Salt changed?

Yes, System Saver II has been renamed Clean and Protect and Solar Salt has been renamed Pure and Natural. Rust Remover has been renamed Clean and Protect plus Rust Remover and has been reformulated to not only remove 15 time more iron then plain salt but also extend appliance life. Also, the artwork has been updated for all of the products.

**Products [3]**

(Cleaner--Rus


_p_2405.html)

(


)

Cleaner - Rust Out Resin Cleaner (Cleaner--Rust-Out-Resin-Cleaner_p_2405.html)

$3.59

Cleaner - Sani-System Liquid Sanitizer Concentrate Water Softeners (ss24n-c7000.htm)

$4.00

**ADD TO CART (ADD_CART.ASP?QUICK=1&ITEM_ID=2405&CAT_ID=269)**

**ADD TO CART (ADD_CART.ASP?QUICK=1&ITEM_ID=2250&CA**

(Cleaner--Soften


er_p_2406.html)

Cleaner - Softener Mate Resin Cleaner (Cleaner--Softener-Mate-Resin-Cleaner_p_2406.html)

$3.50

**ADD TO CART (ADD_CART.ASP?QUICK=1&ITEM_ID=2406&CAT_ID=269)**

Links

# Frequency of Regeneration - How Often?

There is no simple formula, as there are many "variables" that must be considered when "setting" a water softener valve regeneration frequency.

First is the "quality" of the water you are treating, and then amount of water to be used ( number of people in household ),

What is the **hardness level** of your water before any filters? ( grains per gallon or ppm )
What is the **iron level ( if any )** of your water before any filters? ( ppm = Parts Per Million )
What is the **pH level** of your water from the source ( before any filters )?

How many people use the water in your home?

And the **last variable is the CAPACITY or Amount of RESINS** in the media tank.
Common Tank Sizes and Amount of Resins Inside

8" x 35" 0.64 cu. ft. ( 20,480 grains )
**8" x 44" 0.75 cu. ft. ( 24,000 grains )**
9" x 35" 0.75 cu. ft. ( 24,000 grains )
9" x 40" 1.00 cu.ft. ( 32,000 grains )
**9" x 48" 1.00 cu. ft. ( 32,000 grains )**
10" x 35" 1.00 cu. ft.( 32,000 grains )
10" x 40" 1.00 cu .ft. ( 32,000 grains )
10" x 44" 1.25 cu. ft. ( 40,000 grains )
**10" x 54" 1.50 cu. ft. ( 48,000 grains )**
12" x 52" 2.00 cu. ft. ( 64,000 grains )
13" x 54" 2.50 cu. ft. ( 80,000 grains )

Then, it's a question of whether your valve is a simple "day timer" ( operating on the days you "SET" ), or a metered "demand" timer, that counts and tracks the amount of water used.

For an example of the "math" or calculations of "capacity" between regenerations, I'd refer you to this article about how to figure the gallons setting on the mechanical FLECK Metered valves,
see:

**How to Set Meter Program Gallons** (/setting_econominder_program_meter_wheel)

And the last thing that matters somewhat is the **amount of SALT** used with each Regeneration,

****The amount of salt needed is mostly based on the amount of resins being recharged.

3/4 cu.ft. resin = 6 - 9 lbs.
1 cu.ft. resin = 8 - 10 lbs.
1.5 cu.ft resin = 12 - 15 lbs.

Typically,

9 lbs for 8 - 9 inch diameter resin tanks,
and 12 lbs. of salt for 10" tanks is average.
If there is a lot of iron ( over 2 ppm ) or if the water is really hard ( over 30 grains ),
then **an extra 2 - 4 lbs. of salt per regeneration should be used.**

**COMMON Frequency of Regeneration**
A typical residential system will use 6 - 12 lbs of salt per regeneration at least once a week.
Very hard water ( over 30 grains ), or water high in iron ( over 1 ppm ), may require regenerating every 2 or 3 days.
The result is you will be using at least 30 - 40 lbs. of salt, and more common you will be using 60 - 100 lbs. of salt per month.

P.S. **If you run out of Salt, don't expect to have soft water after a few days.**
And it may take **more than one regeneration to get the water feeling soft again once you've added salt.**

## I recommend keeping the salt level above the water level in your Brine Tank.

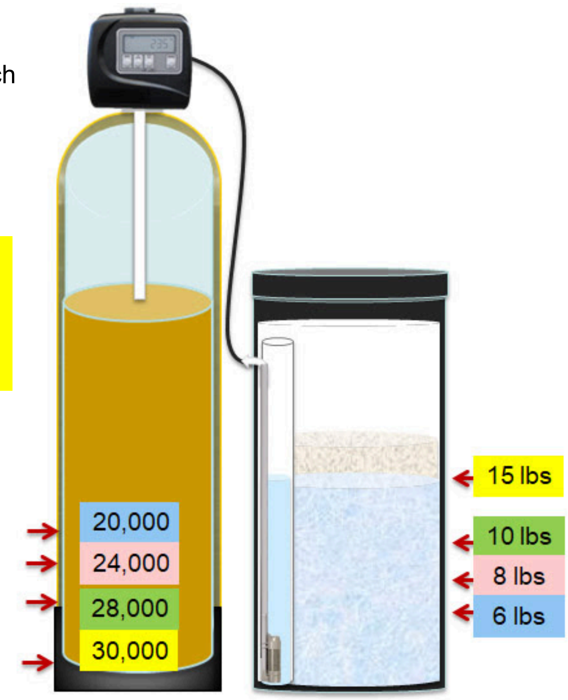
When you start seeing the water level ( normally between 8 - 12 inches ) then it's time to think about adding more salt ( 40 - 120 lbs. ).

**Here is a photo of a "Starved" Brine tank** ( only a few Pellet "crums" under lots of water ).
You want the water to be covered by the salt, not the other way around.

# Understanding Water Softener Capacity

## A Brief Excerpt from our Clack Seminar

Cation Exchange Water Softeners have a Maximum Hardness Removal Capacity, depending on the amount of Softening Resin which has been loaded into the Mineral Tank, and the amount of SALT used during each **Regeneration**.



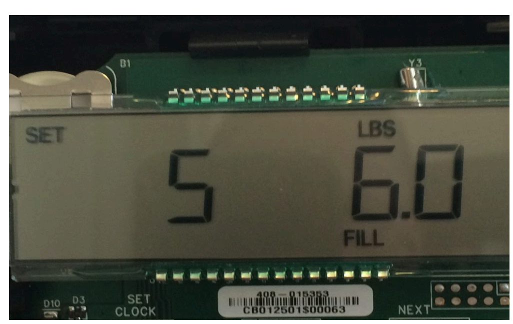

Increasing the amount of **Salt (Brine)** used to Regenerate the Resin Bed, will increase the amount of **Capacity Recovered**, per cubic foot of Resin, but will **Decrease** the **Efficiency** of the Water Softener.

***Variable (Brine) Dosages for a 9X48 - One Cubic Foot Water Softener***

- *3 Lbs. of salt will dissolve into 1 gallon of water.*
- Regenerating @ 15 lbs. SALT per Cubic Foot of Resin will yield 30,000 grains capacity.
    - 15 Lbs. of salt will require the softener control valve to fill the brine tank with 5 gallons of water.
    - Equal to 2133 grains per lb. of SALT
- Regenerating @ 10 lbs. SALT per Cubic Foot of Resin will yield 27,000 grains capacity.
    - 10 Lbs. of salt will require the softener control valve to fill the brine tank with 3-1/3 Gallons Of Water.
    - Equal to 2700 grains per lb. of SALT
- Regenerating @ 8 lbs. SALT per Cubic Foot of Resin will yield 24,000 grains capacity.
    - 8 Lbs. of salt will require the softener control valve to fill the brine tank with 2-2/3 gallons of water.
    - Equal to 3000 grains per lb. of SALT
- Regenerating @ 6 lbs. SALT per Cubic Foot of Resin will yield 20,000 grains capacity.
    - 6 Lbs. of salt will require the softener control valve to fill the brine tank with 2 gallons of water.
    - Equal to 3333 grains per lb. of SALT

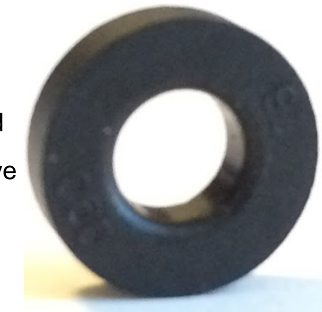
******MOST EFFICIENT******

In the programming of the control valve you can check the **Brine Tank Refill** time setting or the **LBS of Salt** setting, to be sure you have the proper **Salt Dosage** programmed into the control valve.




Be sure the proper **Injector** is installed in the control valve. To verify the correct injector for the system size, refer to the attached Clack Valve Injector Chart. (https://nelsencorp.us9.list-manage.com/track/click?u=c010013afc1b663fba36a7b25&id=d9246dd60e&e=fbf46dc7bf)


Be sure the proper **Drain Line Flow Control Button** (DLFC) is installed in the control valve and that the button is installed in the correct orientation, the rounded bevel edge is facing the water flow from the control valve to the drain.



**Products [1]**

(

)

Cleaner - Sani-System Liquid Sanitizer Concentrate Water Softeners (ss24n-

$4.00

**ADD TO CART (ADD_CART.ASP?QUICK=1&ITEM_ID=2250&CAT_ID=268)**

Links

# G.4 CORROSIVE WATER

# Corrosion and Soft Water

***By Joseph F. Harrison, PE, CWS-VI; Duane Nowlin, PhD, St. Paul Minnesota***

*Excerpted from WQA's Corrosion QuickCourse™*

## CORROSION

The metals used in plumbing systems are rarely found in nature in forms that are directly useful, by humans. Instead, they exist as ores, stable mineral compounds with chemical and physical properties quite different from those of the pure metals. To make these minerals useful, they must be processed using the electrochemical methods to reduce the ores to elemental metals.

This reduction of ores is necessary because elemental plumbing metals are not inherently stable. With time and exposure to the natural environment, the elemental metals are converted to the more stable mineral compounds. This action - corrosion - changes the chemical and physical properties of the metals, frequently destroys the usefulness of a metallic article or structure, and is a completely natural process.

Thus, corrosion has been defined as the natural reversion of a metal to an ore.

## CORROSION CHEMISTRY

Although the corrosion chemistry of each metal differs in details, the general principles apply to most of the commonly used metals. Thus, the reactions of iron in the following examples illustrate these basic principles.

Water is widely recognized as a solvent for virtually all materials. When water and iron are in contact, a few molecules of iron go into solution with a reaction which leaves a few electrons behind in the mass of metal. If no other factors are involved, however, this reaction would stop, for the charge of electrons developed in the metal would inhibit further reaction. The loss of metal into the water can be discharged.

Free hydrogen ions found in all water, to at least some extent, provide a means of removing the excess electrons from the mass of metal. The electrons and the hydrogen ions react to first form atomic hydrogen, and then molecular hydrogen gas. As the hydrogen forms, it too tends to inhibit further corrosion by forming a very thin gaseous film at the surface of the metal. This "polarizing" film can be effective in reducing water to metal contact and, thus, in reducing corrosion. Yet, it is clear that anything which breaks down this barrier film tends to increase the rate of corrosion.

Dissolved oxygen in the water will react with the hydrogen, converting it to water, and destroying the film. High water velocities tend to sweep the film away, exposing fresh metal to the water. Similarly, solid particles in the water can brush the hydrogen film from the metal.

Other corrosion accelerating forces include high concentration of free hydrogen ions (acid water) which speed the release of the electrons, and high water temperatures that increase virtually all chemical reaction rates. Thus, a variety of natural and environmental factors can have significant effects on the corrosion rate of iron, even when no other metals or special conditions are involved.

## ELECTROLYTIC CELLS

It is rare that a plumbing system contains nothing but simple, pure iron. Electrolytic cells of various types are common in most systems.

The galvanic cell, set up when dissimilar metals are in contact with each other and with conductive water, generates electricity. The flow of electrons created by such a cell accelerates the corrosion of iron in contact with copper or brass, for example, by stimulating the flow of electrons away from the iron.

Clearly, it is difficult to eliminate all dissimilar metals in a plumbing system. Yet, even if this were possible, minor impurities in the iron could create galvanic cells. Such impurities are present in all commercial grades of plumbing materials, for they are difficult to remove at reasonable costs.

Differential aeration cells, created when the dissolved oxygen concentration varies between adjacent areas on iron, have similar reactions and effects. Such conditions can develop under scale or rust, at rivets, joints or crevices, or under deposits of organic matter such as slimes or iron bacteria. Thus, a partially coated surface may actually accelerate this type of corrosion.

In some circumstances, even temperature or stress variations between adjacent sections of a common metal can create electrolytic cells. Stray electric currents, sometimes caused by breakdowns of electrical systems grounded to plumbing, can cause major corrosion where the current leaves the pipe and a special form of electrolytic cell is created.

# Corrosion and Soft Water

*continued from page 18*



## CORROSION ACCELERATORS

As indicated above, at least some corrosion will occur whenever a metal is exposed to water, and a number of factors will accelerate corrosion. These include:

1. **Low pH** – Acid waters clearly accelerate corrosion by providing a plentiful supply of hydrogen ions. Although even absolutely pure water contains some free hydrogen ions, free carbon dioxide in the water can multiply the hydrogen ion concentration many times. When carbon dioxide dissolves in water, it reacts with the water to form carbonic acid, a so-called weak acid, but an effective source of acidity. Even more acidity is sometimes encountered in acid mine waters, or in those contaminated with industrial wastes.
2. **Dissolved oxygen** – This gas works to destroy the protective hydrogen film and to oxidize dissolved iron to an insoluble form. Deposits of rust in a plumbing system can form differential aeration cells and accelerate corrosion.
3. **High mineral concentrations** – The electrical conductivity of water increases with its dissolved mineral concentration. Thus, highly mineralized waters readily conduct the electrical currents of electrolytic cells and accelerate this type of corrosion.
4. **Water temperatures** – High water temperatures not only accelerate the chemical reaction of corrosion, but also may reverse normally protective systems. For example, zinc galvanizing protects iron or steel at normal temperatures by “plating” a protective deposit over exposed iron at a pit or break in the zinc coating. However, at temperatures above 160° F., the iron will attempt to deposit on the zinc, thus creating a deep pit or hole where the iron is exposed.
5. Other physical factors, including high flow velocities; solid particles in the water, and deposits on metal surfaces may cause or accelerate corrosion.

## CORROSION IN HARD AND SOFT WATER

From the above, it is clear why many natural waters have strong corrosive activities. In sections of New England and the far Northwest, much of the underground strata is granite which has very low solubility, does not neutralize natural carbon dioxide concentration, and has little on dissolved oxygen. Thus, groundwaters in these areas are corrosive because of the acidity due to carbon dioxide and the dissolved oxygen present.

Sections of the southeastern states, where much of the underground structure is organic matter, have waters, which are low in minerals and oxygen, but high in carbonic acid derived from decaying organic matter. The corrosive nature of these low hardness waters is well established.

At the other end of the range are many waters found in the Southwest, where extremely high hardness and mineral concentrations are common. Although usually alkaline in nature, these waters have high electrical conductivities, and in arid regions, may have high dissolved oxygen concentrations. Thus, these highly mineralized waters are known to be extremely corrosive, but for different reasons than the naturally soft, acid waters.

The lowest rates of corrosion are usually found with well waters of moderate mineral concentrations in limestone regions. Such waters have little dissolved oxygen, and the natural carbon dioxide has been largely neutralized by the alkalinity dissolved from the underground minerals. The conductivity is relatively low, so galvanic corrosion is not serious under usual circumstances. This water is found in wells over most of the Midwest.

Surface water supplies frequently follow the trends of water quality of groundwaters in a region, but usually have lower mineral concentrations because of the dilution effects of rain and snow. However, surface waters are almost always saturated with dissolved oxygen from the air, and this element often produces serious corrosion.

Thus, it is evident that all water is corrosive to the metals in plumbing systems to at least some degree, and that both naturally soft and naturally very hard waters can produce high corrosion rates.

## CORROSION IN SOFTENED WATER

The removal of hardness with an ion exchange water softener does not affect the factors which cause or accelerate corrosion. Softening does not change the pH or carbon dioxide concentration, the dissolved oxygen concentration, or the total chemical concentration of minerals. A softener may reduce the amounts of solid particles in the water, but obviously cannot change other physical factors such as temperature, flow rates through pipes, or volumes of water used. Thus, ion exchange softening neither causes nor controls corrosion.

Unfortunately, certain methods of calculating the probable corrosive potential of natural waters have been misapplied to softened waters, with misleading results. The Langelier Index, and some of its modifications, may be used to indicate whether or not particular water will precipitate calcium carbonate scale at a given temperature. This information certainly is useful to those responsible for operating many systems.

# Corrosion and Soft Water

*continued from page 19*

Further, when applied to natural waters, these methods of calculation may indicate that when such an excess of carbon dioxide over alkalinity exists in the water, the precipitation of calcium carbonate would be impossible. Such excesses of carbon dioxide clearly make waters strongly corrosive, as demonstrated by the low pH waters found in New England and the Northwest.

These methods, however, should not be applied to water softened by ion exchange since there is no real chemical similarity with the naturally soft acid water. The removal of calcium by a softener obviously prevents scale formation. Yet, as indicated above, it does not change either the carbon dioxide content of the water or the natural alkalinity which tends to neutralize the carbon dioxide. Thus, softening will not make a water more acid or affect the other corrosion accelerating factors.

Some persons argue that the precipitation of calcium carbonate scale will protect the metals from corrosion. While some scales are capable of such protection, other scales are porous or soft, and thus, nonprotective. Further, it is rare that scale formation is uniform, for the heaviest scale usually forms at points of heat transfer and at low points in a system. In a water heater, for example, most scale forms at the bottom where heat is applied, while the top of the heater tank may show little or no scale. Thus, even in hard, scale-forming waters, thousands of water heaters fail every year due to corrosion. Examinations of these heaters usually show that corrosion has occurred under or through the scale or in locations where protective scale has not formed. Thus, it is clear that corrosion protection is not assured simply because a water will precipitate calcium carbonate, as indicated by various calculations or test methods. Further, none of these methods take into account the effects of dissolved oxygen, water flow velocities, the presence or absence of solid particles, the volume of water through the system, or other environmental factors which affect the rate of corrosion.

As stated by Schneider and Stumm of Harvard University; [1]

"It is a commonly accepted belief that the corrosive behavior of a natural water is influenced predominantly by pH and calcium carbonate saturation (frequently expressed by the Langelier Saturation Index). The results of extensive studies involving both field and laboratory investigations indicate that this concept presents an oversimplified picture of the problem. As corrosion in natural waters depends on so many interdependent variables, no simple equation or index is capable of describing adequately the corrosive potential of a water, and no generally applicable recipe for appropriate corrective treatment can be given."

## CORROSION CONTROL PROCEDURES

When corrosion does occur in a water supply, several corrective treatments are useful in reducing the corrosion rate. Clearly, the best method is to prevent water to metal contact, and a number of coating and plating procedures are used for this purpose. Yet, these methods are not always possible or economically feasible, and a number of chemical treatments have been developed to condition the water to reduce the corrosion rates to reasonable levels.

In industrial systems or where the water will not be used for human consumption, oxygen scavengers are frequently used to reduce this corrosive gas in the water. High concentrations of "passivating" chemicals are common in reticulating systems because of the inhibiting effects. Yet, neither of these approaches are applied to water used in households because of the possible toxic effects of the chemicals, and because some make the water unsuitable for general household use producing heavy stains or discolorations.

Thus, corrosion control methods for municipal and household water systems are currently limited to two approaches; neutralization of acidity with alkaline materials, and the feeding of small amounts of chemicals, which tend to line the water system with protective films.

Calcite (calcium carbonate) and magnesia (magnesium oxide) filters have long been used to neutralize household acid waters. As water flows through beds of these minerals, the acidity dissolves enough of the filter media to produce essentially neutral water. Other installations use chemical solution feeders to introduce solutions of soda ash (sodium carbonate) or caustic soda (sodium hydroxide) to the water in proportion to the acidity, producing a neutral or slightly alkaline water. Some municipal systems use lime (calcium hydroxide) to increase alkalinity and pH. Several types of polyphosphates and silicates may be fed into water systems for corrosion control. In some cases, slowly soluble forms are fed with "pot"-type feeders, while in others solutions are fed with chemical solution pumps. Both the silicates and polyphosphates tend to form thin films on the interior surfaces of the plumbing, thus reducing the water to metal contact. Feeds should be essentially continuous, however, to form and maintain the protective films.

References:
[1] *Schneider, Carl R. and Stumm, Werner: "Evaluation of Corrosion in Distribution Systems." Journal AWWA May 1964, pp. 621-631.*


# Is Softened Water Corrosive?

No! The removal of hardness does not effect corrosion.

Water is an essential resource that we rely on for various purposes, including drinking, cooking and cleaning. However, the quality of water can vary depending on its source, and in some cases, it may contain minerals that can cause problems like limescale buildup in pipes and appliances. To combat this issue, many people turn to water softeners, which remove the mineral content to create softened water. While softened water has its benefits, there has been ongoing debate about whether it can potentially be corrosive.

## How does a water softener work?

Water softening involves the removal of "hardness minerals" such as calcium and magnesium ions, which are responsible for limescale formation. The process typically uses an ion exchange resin, which traps the calcium and magnesium ions and replaces them with sodium ions, resulting in softened water.

## Doesn’t salty water cause corrosion?

Some people express concerns that softened water may be corrosive due to the increased sodium content. The idea is that the higher levels of these ions in softened water could lead to accelerated corrosion of metal pipes, fixtures, and appliances, potentially causing damage and increased maintenance costs.

## What do studies actually show?

- pH Levels: Softened water generally has a slightly elevated pH level due to the presence of sodium ions. This mildly alkaline will actually lessen corrosion to some extent as it creates a protective layer on the metal surfaces, hindering the progression of corrosion.
- Reduced Hardness Minerals: By removing hardness minerals, water softeners also eliminate one of the primary catalysts for corrosion. The absence of calcium and magnesium ions decreases the potential for limescale buildup and reduces the likelihood of corrosion caused by these minerals.
- Sodium Content: Although the increased sodium content in softened water may raise concerns, it is important to consider the concentration levels. In most cases, the amount of sodium added during water softening is not significant enough to cause significant corrosion issues.

## So is softened water corrosive?

After looking at all of the evidence above, it can be concluded that softened water, when properly treated, does not pose a significant risk of corrosion. While the slightly alkaline nature of softened water can provide a protective layer on metal surfaces, the absence of hardness minerals and the relatively low levels of sodium make it unlikely to cause extensive corrosion damage. However, as with any water treatment method, it is crucial to consider individual circumstances and consult professionals, such as your local AIWSE member when necessary.

Remember, if you have concerns about water quality or potential corrosion, it is best to consult with your local AIWSE member who can assess your specific situation and provide appropriate recommendations.

CLICK LINK FOR FILE.

**Paul Webb**

HAS WORKED IN WATER TREATMENT, PLUMBING AND CONSTRUCTION THROUGHOUT HIS CAREER.

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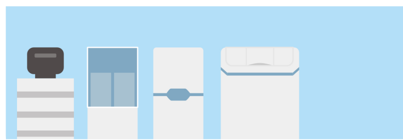
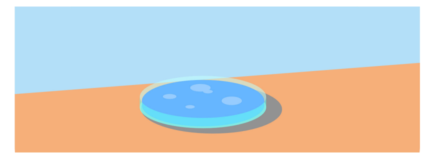
## 3 Ways Not To Waste Money on Water Softeners

## What Water Softener Is The Best?



## Can I Drink Softened Water?

## Testing the Waters



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## Contact the AIWSE

# Soft Water Not For Drinking? – Is Softened Water Corrosive?

An end-user forwarded a link to me last week and she had lots of concerns…

She saw it on a website for a company touting a “salt-free” softener/scale control system. Naturally the salt-free company was using the material to “bash” softened water and ion exchange softening systems in general…This is a common tactic employed by uneducated and sometimes even unethical people. She is in the process of purchasing a Crusader Twin Analyst Softener from her plumber and she wants to make sure that her buying decision is a wise one; the concerns raised by the article caused her to rethink even wanting to soften her water at all.

Hard water contains calcium and/or magnesium ions. These ions make soap hard to lather, giving hard water its name. For water to be called “soft”, it must be devoid of these hardness ions. **There is a significant difference between “naturally soft” water and “ion exchange softened” water.**

Naturally soft water is water that generally tends to be aggressive, since it has no significant buffering mineral content to begin with. Naturally soft water usually contains carbonic acid (derived from carbon dioxide), tending to lower the pH of the water, which contributes to corrosive conditions and can cause significant problems in homes, business, and industry. Since naturally soft water is so potentially detrimental, many people will recommend adding calcium/magnesium hardness to water to protect from corrosion. When water is acidic, it makes logical sense to add hardness to balance the pH and raise the total alkalinity to protect from corrosion. This is the essence of the Langlier Saturation Index (LSI), which essentially draws a correlation between calcium hardness, and water's tendency to be "corrosive" or scaling".

Some well-intentioned, but uneducated people feel that keeping water "hard" is the safest for building operations and possibly even for human consumption. This is a counter-intuitive approach, since hardness can cause issues like scaling and soap interference; and water hardness is comprised of inorganic minerals, not the organic minerals that the human body requires for proper nutrition. Scaling can be addressed in a number of ways, including novel technologies like Next ScaleStop without actually removing it from the water. The calcium/magnesium hardness will still interfere with soap though and still be present to cause issues when evaporated.

Hard water scale used to only be considered an aesthetic issue, but in today's climate of energy efficiency and environmental sensitivity, one would be foolish to overlook all the benefits of softened water.

**Softened water can:**

- **Reduce the energy costs to heat water**
- **Reduce the amount of soap/detergent required to clean clothing**
- **Reduce or eliminate the use of dishwasher rinse-aids**
- **Reduce or eliminate the use of harsh chemical cleansers**
- **Minimize bacterial growth in washing machines**
- **Prolong the working life of faucets and fixtures**
- **Prolong the working life of appliances like dishwashers, steam irons, humidifiers, washing machines and ice makers**
- **Prolong the working life of water heaters and boilers**
- **Lower the overall carbon footprint of a home or business**

**There are a number of ways for hardness to be removed/isolated from interfering with soap:**

- Evaporation/distillation (potentially corrosive)
- Sequestration (generally not corrosive)
- Membrane Separation (potentially corrosive)
- CDI/EDI (potentially corrosive)

- Ion exchange softening (generally not corrosive)

A water quality improvement process can only be called “softening” if it physically removes of completely sequestrates the hardness ions to a level at or below 1 grain per gallon (17.1ppm). All methods of softening (except sequestration and ion exchange) will remove both the hardness ions as well as the buffering carbonates attached to them, and that is where the potential for corrosion can begin. Without buffering alkalinity, softened water can become corrosive, especially if it contains dissolved carbon dioxide.

The most cost-effective method currently is simple ion exchange, where calcium and/or magnesium ions are exchange with sodium or potassium ions to form relatively benign byproducts like sodium carbonate and sodium bicarbonate which contribute to the taste and feel of ion-exchange softened water. Langlier’s hypothesis is accurate until one brings ion exchange softening into the equation. Ion exchange softening doesn’t remove the carbonates and bicarbonates from the water, thereby not making the water more acidic or corrosive. Once this principle is understood, you can see the significant difference between “naturally soft” and “ion-exchange softened” water.

Ion exchange softened water is not generally corrosive. Why do I say “generally”? – In certain conditions, if the conductivity of the water is already high, such as water with 30 gpg (grains per gallon) of hardness or higher, the softening process will contribute enough sodium/potassium to the water that is becomes very conductive which can indeed accelerate galvanic corrosion reactions.

So what does this mean? – Softened water is safe, softened water is generally good for the environment, softened water is good for your home, softened water is good for your business, and softened water is very good for your pocketbook.

An article was published back in 2006 by the Nashville Water district. It is obvious the the city of Nashville didn’t have all the facts and the article was probably posted by an over-zealous employee who was missing some information. The WQA acted swiftly to address the issue and published the following:

http://wqa.org/sitelogic.cfm?ID=850#2000anchor

“***Each year, WQA communicates with cities, regulators, newspapers, and other media to correct misinformation about our industry’s products and services. In January 2006, the focus turned to Nashville, Tennessee. Their Metro Water Services department posted false and misleading information about consumption of softened water on its Web site. WQA contacted the agency in writing, refuted the article’s claims, and requested the misinformation be removed from the Web site. After receiving no response, an article was published in the January 2006 issue of WQA Industry Update. That WQA article was later picked up by another publication, which further directed the spotlight on Nashville’s Metro Water Services. As a result, the public information officer for the water agency pulled the article. She has since asked her staff to work WQA to clear up any misleading or inaccurate information about softened water. WQA members: If you are dealing with a municipality that is***

***making false or misleading statements about water softeners or other technologies, contact WQA immediately, and we will work to correct the information.***"

This is just another good reason to join the WQA if you haven't already done so.

# Here's the original article for your entertainment:

*"Soft water is neither healthy nor desirable for drinking! If you were a steam iron or a washing machine it would be great, but we are neither! There are good reasons you should not be drinking soft water!*

*Water is a universal solvent. Most materials, especially metals, are partially soluble in water. If that water is heated or softened it becomes much more aggressive at leaching metals from water lines. Lead in soldered joints and copper in pipe are particularly vulnerable and these are two of the heavy metals which shouldn't be present in significant amounts in your drinking water.*

***WATER HARDNESS***
*Calcium and magnesium are two minerals which make water "hard." Both of these minerals are classed as "contaminants," but that's a poor choice in terminology, for calcium is essential in our diet! A softener merely exchanges one group of non-toxic elements for another group of non-toxic elements. Water hardness is measured either in grains per gallon (GPG) or as calcium hardness in milligrams per liter (mg/l) or parts per million (ppm). GPG is based on calcium hardness. To convert from calcium hardness ppm, just divide by a factor of 17.2 and this gives you hardness in GPG. A soft or slightly hard water has up to 3.5 GPG; moderately hard water runs from 3.5 to 10.5 GPG; and very hard water is greater than 10.5 GPG. If your water is over 7 GPG, you might want to consider a softener just for the laundry.*

*Metro water is on the low side of moderately hard at 4.1 GPG (that is 70 mg/l of calcium hardness. This is an excellent value and highly desirable! Cities which have soft water are having difficulty meeting the new lead standards in tap water. Metro has had none of these difficulties in meeting the new standards!*

***SOFT WATER***
*A soft water is aggressive at leaching metals (like lead) from your lines and faucets. Most faucets are solid brass (with a relatively high lead content) and are chrome plated. This means that if you have soft water, there is a great chance that your initial drawing of cold water will have a higher lead content than normal. Hot or warm water from the tap should never be used for cooking, shortcuts, drinking water, beverages, or infant formula as it could be higher in heavy metals like lead!*

***WATER SOFTENERS***

*Besides making the water more corrosive and aggressive at leaching metals from your lines and fixtures, the zeolite beads from water softening systems may back-siphon into your toilet tanks, and the soft water may attack vital plumbing parts. While supposedly solving one set of problems, the softener could possibly introduce other problems which you may or may not be aware of! A water softener, besides leaching lead and other metals from your plumbing, can increase your sodium intake. In a water softening device hard water flows through synthetic resin beads. Sodium ions (salt) are loosely attached to each bead and the water exchanges hardness ions (calcium and magnesium) for the soft sodium ions. These devices can also be costly to run since they can waste up to 120 gallons for every 1,000 delivered.*

*A water softener is not designed (nor is it effective) to remove lead and other metals, chlorine, taste/odor compounds, nor chlorine by-products. Its purpose is only to make a hard water soft. Water treated to remove chlorine may encourage the formation of black rings in toilet bowls!*

***IN CONCLUSION…***

*Soft water is great for laundry, bathing, steam irons, and auto batteries, but definitely not for anything else. If you are contemplating installing a softener, there are serious questions you should ask: who will test the effectiveness of the softener, how often will these tests be run, and how will my drinking water quality be affected?*

*Metro Water Services does not test any home water treatment device, including softeners, and does not recommend the use of particular devices!"*

Crazy article, huh? – It's no small wonder that Nashville city quickly removed the article after it was brought to their attention by water industry professionals. Unfortunately, it's contents have been repeated by a few other sites and the mistruths live on…

*Categories: General, Opinions, Tutorials*

*Tags: acid, calcium, conditioner, corrosion, distillation, nanofiltration, reverse osmosis, sequestration, utah, water, water softener, wqa*

NEW DELHI'S "SUPERBUGS"

COMMON PESTICIDES DISRUPT CRUCIAL HUMAN HORMONES

# 11 Replies to “Soft Water not for Drinking? – Is softened water corrosive?”

### Missy Siegrist

November 2, 2012 at 1:58 am

Calscium is really necessary for the formation of strong bones and nails. ..

### Nicky Peil

February 27, 2013 at 7:04 am

Calcium is the most abundant mineral in the body and is necessary for proper muscle contraction, blood vessel health, hormone and enzyme production and the transmission of nervous system impulses, according to the Office of Dietary Supplements. Supplements of calcium are usually in the forms of calcium carbonate and calcium citrate — the calcium salt of citric acid. Though both are well-absorbed, calcium citrate can be taken at any time, with or without food, whereas calcium carbonate needs the production of stomach acid and food intake for absorption.,

My own webpage

<.http://www.healthmedicinecentral.com/heart-skipping-beats/

### Mark

November 12, 2016 at 8:24 pm

Hi Greg,

Thank you for this article! I was in the same state of mind after seeing that article from the city of Nashville. I feel confident about our decision in purchasing an ion exchange water softener. We have city water here in the Cincinnati area. Several seller's of water softening systems tell us we should have a carbon filter installed in line prior to the softener. My concern here is that a carbon filter would remove the chlorine added to the water that, in my understanding, is designed to kill/prevent bacterial growth. I'm concerned there a greater possibility of bacteria growth in the resin tank and leading to biofilm in our water lines. Is this a misguided concern?

We are planning on having a 50 micron sediment filter before the water softener. We will have a separate cold water line that will run to the kitchen cold water side of the facet and outdoor bibs. We plan to use potassium rather than salt.

Thank you for your informative site!

---

Greg

November 14, 2016 at 4:39 pm

Hi Mark, thank you for the kind words.

Dechlorination is a good suggestion to protect a water softener's resin from oxidative damage. You're right though in that there is a potential for bacterial growth downstream without the residual chlorine.

From reviewing Cincinnati's Consumer Confidence Report, it looks like their total chlorine level typically averages around 1ppm. Chlorine at this level can indeed reduce the softening resin's usage life to degree dependent on the crosslinkage of the resin (lower x-linkages will degrade faster and higher x-linkages will be slower). Their Total Trihalomethane level (TTHM) is averaging around 45 ppb as well, so I would certainly want to at least dechlorinate and remove the disinfection byproducts with Activated Carbon. Some tips for protecting yourself properly, would be:

1. Prefilter at 100 micron to protect the moving parts downstream.

2. Dechlorinate with either a high flow cartridge, or (preferably) a self-backwashing carbon filter designed with antibacterial (bacteriostatic) components like KDF-55.

3. Purchase a softener that includes a day override feature (most electronic controllers have this) to ensure that it will flush at least once a week to minimize the potential of bacterial growth.

4. Utilize an antibacterial treatment in your brine tank to protect from the growth of halophilic bacteria in the brine, as well as disinfecting the s er

when it regenerates.
5. Install an Ultraviolet (UV) sterilizer after your softener to disinfect the water as it passes downstream.

Most importantly, have your water system installer disinfect their installation as well as your downstream piping when they perform the installation to ensure that you have a clean start.

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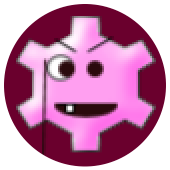

Eric

August 29, 2019 at 12:44 pm

Hi Greg,

Thank you very much for your informative article. I'm in Southern California and I'm planning to install a water softener as well and I'm wondering if I'd need to follow your advice above for Mark? I'm also planning on installing a carbon filter prior to the softener as well. I've attached the link to the city's water report from 2018, thank you very much in advance!

https://static1.squarespace.com/static/51c9af85e4b0ba13e3125d7c/t/5d5eca5e6e782d00015fcedf/1566493279632/2018+SSWC+CCR.pdf

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Greg

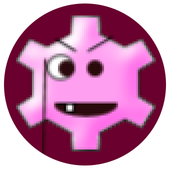
August 29, 2019 at 7:43 pm

Hi Eric,

On your water supply, the recommendations to Mark would be applicable.

According to the CCR, the water supply has not violated any microbiological limits, so a UV certainly isn't mandatory.
If you'd like extra protection, the UV will be relatively cheap peace of mind for you.

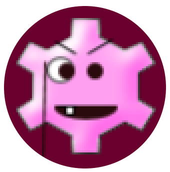
Good luck, and I hope that you enjoy your water!



### Eric

September 13, 2019 at 12:35 am

Thanks Greg, can you recommend a self-backwashing carbon filter with antibacterial properties? Thank you!



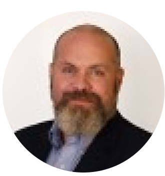
### Eric

June 1, 2020 at 10:24 pm

Hi Greg,

Is there a way to "reduce" Chlorine but NOT remove all of it to make sure it's still doing it's job inside the house which is to disinfect the waterline?

Right now I'm thinking of just installing a Cotton sediment filter before the water softener and NOT install a carbon filter so that I don't have to worry about bacterial growth in the waterline? What do you think?



### Greg

June 11, 2020 at 6:49 am

Hi Eric,

A cotton (cellulose) sediment filter can promote bacterial growth, so definitely do not dechlorinate before it.

Yes, you could reduce the chlorine and not remove it entirely by using a blending valve around your chlorine filter.
Bear in mind that it will blend back chlorine and disinfection byproducts at the same time, so it is not ideal.

One approach that works very well is to remove the chlorine and disinfection byproducts followed-up with an Ultraviolet sterilizer to ensure protection from waterborne bacteria. If your water softener is rated for the level of incoming chlorine, then removing chlorine after the softener would help to keep the softener sanitary.

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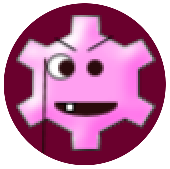

### Eric

June 11, 2020 at 8:22 am

Hi Greg,

Thanks for your reply! Are you suggesting that a GAC filter in place of sediment filter may be better?

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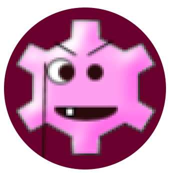

### Eric

June 11, 2020 at 8:28 am

I don’t want to go with an Ultraviolet sterilizer due to cost concern, thank you!

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# Leave a Reply

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# Water Softeners and Corrosion

MARCH 15, 2019 14 MINS READ



***By Bryanna Poczatek and Eric Yeggy***

This article aims to address the common misperception that cation-exchange water softening causes corrosion. This is not the case: a properly configured water softener does not make the treated water more corrosive. Here are a few confusing facts that often lead people to this erroneous conclusion. First, naturally soft water is typically corrosive. Therefore, softened water must also be corrosive, right? This is a fallacy because naturally soft water tends to be corrosive due to low pH and low TDS, while cation-exchange softening causes neither of these conditions.

Second, calcium carbonate scale is often cited as a form of corrosion control and since softeners prevent the formation of scale by removing calcium and magnesium, they must therefore cause corrosion, right? Again, this is a fallacy. Despite a lack of scientific evidence supporting the premise that calcium carbonate scale forms a uniform protective layer that protects consumers from lead or copper corrosion, this practice continues to be referenced as a form of corrosion control.

People in Flint, MI began complaining about the water quality shortly after the city began using the Flint River as source water. Ironically, the state responded by blaming the complaints on the high level of hardness in the Flint River water.1 Obviously, the hardness did not protect anyone in Flint from lead corrosion. Below we will examine these misconceptions in more detail and review the science related to softeners and corrosion. But first let's take a closer look at corrosion.

***Impacts of corrosion***

Corrosion is a natural process in which a material is degraded by the environment, sometimes to a more stable chemical state through oxidation or reduction reactions. This is a big problem in water distribution systems where metal pipes are continuously being corroded. Corrosion can cause many undesirable effects in plumbing. The physical effects of corrosion include leaks, color in the water and on surfaces, sediment and particulate in the water, taste and odor issues, and physical failure of the pipes.2

Corrosion can also cause dangerous byproducts to be released into the drinking water. Two of the most common corrosion byproducts in plumbing systems are lead and copper; both have serious health implications. Lead can enter the drinking water by being corroded from lead service connections, lead solder used in copper piping or brass/bronze fixtures. Children are the most at risk for the dangers from lead as they absorb 40-50 percent of the lead they ingest, while adults only absorb around 3-10 percent. Pregnant women are also at high risk of lead poisoning. Possible health effects from ingesting lead include low birth weight, developmental delays, lower IQ, damaged hearing, reduced attention span, kidney damage and reproductive damage.2,3

Copper is another common byproduct of corrosion. Copper is essential to human health, however, too little or too much is unhealthy. Copper combines with proteins to produce enzymes that act as catalysts for various body functions. It is important that copper is consumed daily as the body is unable to synthesize copper. Yet when too much is ingested, copper poisoning can occur. Symptoms of copper poisoning include stomach distress, intestinal distress, liver and kidney damage and complications of Wilson's disease (a genetic disorder that causes copper to accumulate in the liver, brain and other organs).2

***Accelerators of corrosion***

Corrosion is an inevitable, natural process that occurs in all metals exposed to water with dissolved salts. There are many complex factors that accelerate corrosion; however, common corrosion accelerators include the following.2

1. High velocity and/or turbulence
2. High temperature
3. Low TDS
4. Dissimilar metal contact
5. Low pH
6. Carbon dioxide
7. Biofilm accumulation: microbially influenced corrosion
8. Chemical agents such as chlorine, chloramines and dissolved oxygen
9. An elevated chloride-to-sulfate mass ratio (CSMR)

**Evaluation of corrosion risk due to CSMR**

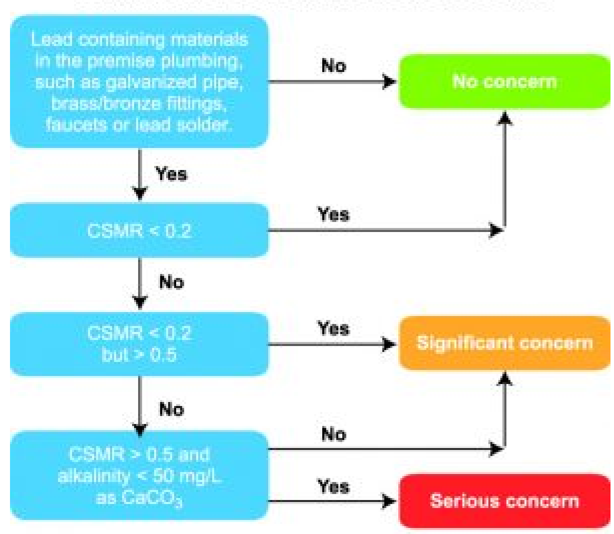


Chart adapted from 2010 Water Research Foundation and EPA study
*Impact of Chloride : Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water*

High velocity and turbulence (lots of turns, or piping that is too narrow for the service flowrate) can accelerate the degradation of the pipe through mechanical erosion and cavitation. Erosion is the physical degradation of the pipe due to fast-moving turbulent water. Cavitation happens when water is moved quickly or suddenly forced in a new direction, leaving low-pressure voids that often appear as bubbles. As these low-pressure bubbles collapse, a shock wave is formed, which can damage piping and fixtures. Heat accelerates almost all chemical reactions and corrosion is no exception. Temperatures of over 70°C (158°F) especially increase the rate of corrosion. Water that has been completely demineralized (such as RO and DI water) is hungry for ions. This is what makes demineralized water—or water in which all TDS have been removed—corrosive. For this reason, WQA recommends that common metal pipe and fittings (e.g., copper, galvanized, brass, bronze) should not be used downstream of a RO or DI treatment system. Softeners do not remove the TDS and do not cause this type of corrosion. A softener is simply capturing some cations (mostly calcium and magnesium) and releasing other cations in the process (usually sodium or sometimes potassium).

The use of dissimilar metals in the plumbing can lead to galvanic corrosion. Direct contact between dissimilar metals will initiate the formation of a galvanic cell, which is created whenever two different types of metal are conductively connected to each other, and then immersed in an electrolyte such as water. Within the galvanic cell, the more anodic metal will be corroded and an electrical current is created because of the process. A common example of this is when galvanized pipe is directly connected to copper pipe. It is also worth noting that while using a brass fitting to bridge the gap between galvanized and copper pipe will not accelerate this galvanic activity, it also will not completely prevent it.[4,5,6] Dielectric couplings can be used to mitigate this direct contact between the dissimilar metals. A dielectric coupling contains an insulating material that physically separates contact between the two metals.

The deposition of scale can also create mini-galvanic cells. Scale does not exist as a homogeneous layer. Microscopic examination of scale deposits has revealed that as scale accumulates, different types of metals can be incorporated into the scale. These different types of metals that are present in the scale are conductively connected and act as galvanic cells in miniature.

Low pH also increases the corrosiveness of water. pH is the measure of hydrogen ion activity in a solution and is used to express the intensity of the acidity of a solution. Solutions with a low pH (< 7) are acids; solutions with a high pH (> 7) are bases. Acids are compounds that release hydrogen ions, which oxidize the metals in pipes, accelerating corrosion. Carbon dioxide will potentially contribute to the formation of carbonic acid, thereby making the water more corrosive. The presence of high levels of carbon dioxide tends to correlate with specific geologic conditions.

Another common accelerator of corrosion is biofilm accumulation, which causes microbially influenced corrosion (MIC), a form of localized corrosion. Bacteria attach to a surface of a pipe, colonize and grow, forming a biofilm. The biofilm is nutrient-dense and resistant to disinfectants such as chlorine. MIC is a complex phenomenon and biofilms influence corrosion in a multitude of ways. Theories on the mechanisms involved include increasing electron transfer, destroying the surface protective film layers, changing the redox potential of pipe surfaces and creating acidic corrosive substances.[7]

Certain chemicals (such as chlorine, chloramine and dissolved oxygen) can also make water more corrosive. For example, the presence of oxidizing agents such as dissolved oxygen can cause metals to lose electrons and lead to corrosion.

Another common cause of corrosion is removal of sulfate, and/or addition of chloride, referred to as an elevated CSMR. Increasing the CSMR will accelerate corrosion in the presence of materials that contain lead. A July 2007 paper published in the *AWWA Journal*, “Chloride-to-sulfate mass ratio and lead leaching to water,” summarized this effect as follows: “While sulfates inhibit corrosion by forming passive protective film layers and reducing galvanic currents between dissimilar metals, chlorides prevent the formation of such passive layers and stimulate galvanic current.”[8] If the source water contains natural levels of chloride and treatment is installed to remove sulfate, this will push the CSMR up and potentially accelerate corrosion. Another way that the CSMR could be elevated is by improper configuration of a softener with inadequate rinse time. If salt remains in the softener bed after regeneration, due to inadequate rinse time, the chloride in that salt will drive up the CSMR and potentially accelerate corrosion.

The potential risk caused by the CSMR can be evaluated in this way. If there are materials in the premise plumbing that contain lead (such as galvanized pipe, brass/bronze fittings, faucets or lead solder) and the CSMR is at or above 0.2, there is a significant risk of corrosion and lead exposure for the customer. If there are materials in the premise plumbing that contain lead and the CSMR is > 0.5 with an alkalinity < 50 mg/L as CaCO3, there is a serious risk of corrosion and lead exposure.9

***Common misperceptions about softened water and corrosion***

One of the factors that causes people to erroneously conclude that cation-exchange softened water is more corrosive than hard water is the erroneous assumption that naturally soft water is similar to cation-exchange softened water. Naturally soft water and softened water are different in many ways. Naturally soft water is very corrosive. It is commonly found in surface waters of the Pacific northwest, New England and the southeastern US. It is corrosive because it has a low pH and low TDS. Cation-exchange softening does not lower the pH (might slightly raise it, making water less corrosive) and does not lower the TDS.10

Another common misperception is that calcium-carbonate scale is an effective form of corrosion control. There is a lack of scientific evidence supporting this claim, however. Scale does not form in uniform homogeneous layers that would protect pipe from corrosion. Scale can be porous or soft and is highly irregular. Corrosion can still occur under conditions that are favorable to the formation of hard-water scale or even when hard-water scale is already present.

***Research studies on softeners and corrosion***

Many research studies have investigated the effects of cation-exchange softened water on corrosion. One such study, "Leaching of Metals from Household Plumbing Materials: Impact of Home Water Softeners," was conducted by the US EPA National Risk Management Research Lab. Their objectives were to evaluate metal leaching from metallic pipes and faucets and determine any changes of the critical chemical characteristics of the water passing through the water softener that would accelerate the rate of corrosion. Two different water qualities were used in the study: lime-softened finished tap water with a hardness of 160 mg/L and groundwater with a hardness of 300 mg/L. The researchers concluded there is no evidence that ion-exchange softened water systematically produced higher metal levels than the non-softened waters under otherwise identical conditions.10

Another study done by the British Standards Institute for the UK Water Treatment Association examined the corrosivity of natural hard water versus ion-exchange softened water against a range of metals, including aluminum, mild steel, copper, brass and stainless steel. Two identical model central water-heating systems were installed and removed after one, three and six months for determination of corrosion rates, using visual inspection and chemical analysis. This study concluded there was no significant difference in the corrosion rates for brass, copper, mild steel and stainless steel between the two rigs. There was initially a higher rate of corrosion of aluminum from ion-exchange softened water, but this decreased continually over time.11

A third study done at the METALogic research institute in Belgium, "*In situ* corrosion investigation on the effect of hard and softened water to domestic copper and galvanized steel drinking water systems," investigated the long-term effects of ion-exchange softened water on corrosion. Four representative domestic drinking-water installations were used: two for the behavior of copper corrosion and two for the behavior of galvanized-steel corrosion. The corrosion rate was measured after six and 12 months. Analysis also included measurement of the pH, redox potential, conductivity and hardness. These researchers did not find any evidence that corrosion in copper or galvanized steel pipe is more severe when in contact with softened water compared to hard water.12

***Conclusion***

Corrosion is a complex phenomenon and there are many factors that accelerate corrosion in the drinking-water distribution system and premise plumbing. For years, there has been confusion surrounding cation-exchange softened water and corrosion, making it important to distinguish between naturally soft water and cation-exchange softened water. Naturally soft water is corrosive as it has a low pH and low TDS; however, cation-exchange water softening does not contribute to any factors that accelerate corrosion. Also, there is a lack of scientific evidence supporting the claim that hard-water scale is an effective form of corrosion control. Thus, considering all these factors, as well as results from research studies, WQA's position is that a properly configured cation-exchange water softener does not make water more corrosive.

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***About the authors***

*Bryanna Poczatek is the Technical Affairs Coordinator at the Water Quality Association. She joined the association in 2016 as an Associate Project Leader in the Product Certification Department. In early 2017, Poczatek transferred to the Technical Affairs department and works alongside Director Eric Yeggy on various technical projects. Poczatek represents the industry as a voting member of the Water Equipment & Policy Research Center Industry Advisory Board, funded through the National Science Foundation (WEP IUCRC). She also participates in numerous industry committees and task forces through NSF International and other organizations. Prior to joining WQA, Poczatek worked as a Project Coordinator for Syngenta Crop Protection LLC and as a Research Assistant in the Biochemistry,*

*Biophysics and Molecular Biology Department at Iowa State University. She holds a Bachelor's Degree in biology from Iowa State University.*

*Eric Yeggy is the Technical Affairs Director for WQA; he joined WQA in 2009. Yeggy represents the industry as a voting member of the ASPE Plumbing Standards Committee and the IAPMO We-Stand Committee, as well as participating in numerous industry committees and task forces through NSF International and other organizations. He plans and coordinates the activities of the WQA Water Sciences Committee and the WQA Industry Research Committee. Yeggy also serves in a voluntary role as the Scientific Consultant for the Water Quality Research Foundation (the WQRF). Prior to joining WQA, he began his career in the environmental testing industry where he gained a wide range of experience in analytical chemistry and managing quality systems. Yeggy holds a Bachelor's Degree in chemistry from the University of Northern Iowa.*

***About the organization***
*WQA is a not-for-profit international trade association representing the residential, commercial and industrial water treatment industries. More information is available on corrosion accelerators through WQA's educational materials. Core and Premier members can also contact the WQA Technical Affairs department and request the latest research on these corrosion accelerators. The association's position paper on this topic can be obtained by contacting the authors in the WQA Technical Affairs department.*

corrosion Water softeners

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European Water Treatment Association

# Softening Water Does Not Increase Corrosivity

Water that has been softened by ion exchange, is sometimes misrepresented to be more corrosive due to the softening process. This is usually because it is incorrectly associated with naturally soft water. Hard water which has been softened, and naturally soft water, are very different.

**Softened water and naturally soft water**. The main constituents of hard water are calcium and magnesium together with bicarbonate, sulphate, chloride, nitrate. When the water is passed through an ion exchange water softener, the calcium and magnesium ions are replaced by sodium ions; the anions (bicarbonate, chloride, sulphate, etc), and hence the alkalinity, remain unchanged.

Naturally soft water, on the other hand, contains very little dissolved solids; its pH is often low and buffering capacity is negligible. Hence, naturally soft water is often very corrosive to metals.

So ion exchange softened[1] water has not undergone any change which affects the parameters which might increase corrosivity[2], such as dissolved oxygen, pH, temperature, conductivity, chloride level, sulphate level, etc.

**Historical Evidence**. Water softeners have been used for many years. The technology dates back to 1903 when Robert Gans first patented the process. Softened water was necessary to protect steam engines against scale deposition in the engine boiler tubes. Similarly, water softeners have been used domestically since 1916 (link to advert – see below). For over 100 years, no specific mention, concern or requirements relating to increase in corrosivity have been found necessary for domestic or industrial softening applications.

The water softener industry, through trade associations such as the EWTA, UAE, Aqua Belgica, UKWTA and WQA, is alert to any operational issues which water softening may incur. Throughout the world, there is not one situation, of which these associations are aware, where water softening has been the proven cause of a corrosion failure. It should be borne in mind that the WQA (Water Quality Association, USA), with more than 2,400 members, represents about 50% of the world softener market.

**The Misconceptions**. Some boiler manufacturers are under the misapprehension that softened water is more corrosive. Situations have been encountered where a heating system has failed and the boiler manufacturer has negated its warranty because a softener was fitted to the premises. In all of these situations that have been investigated, the failure was eventually attributed to a cause other than softened water.

In addition, indiscriminate application of somewhat ageing prediction tools such as the Langelier Saturation Index, without taking account of more recent advances in the understanding of the factors that influence corrosion, can lead to misdiagnosis of corrosive conditions. The Langelier Index was developed to determine whether a water source is potentially scale-forming or scale-dissolving (agressive). Although it was not intended to be applied to softened or naturally soft water, its hypothesis was that a thin, uniform

[1] Note that water treated by reverse osmosis (RO) is termed demineralised because virtually all of the dissolved solids are removed. RO water is therefore corrosive to plumbing fittings and, for domestic applications, should only be fitted at point of use.

[2] Note: corrosivity and aggressivity are often confused; they are ***not*** the same. A corrosive water will attack metals and cause damage to plumbing systems. An aggressive water tends to dissolve scale (calcium carbonate) but is not necessarily corrosive.

layer of scale deposition can, under carefully controlled conditions, contribute to a protective barrier. However, in normal household plumbing applications, widely variable physical and chemical conditions render a deposit that is very variable in thickness, porosity, morphology, location, etc, such that reliable prediction of a beneficial effect is not possible. Deposition is usually restricted to the hottest parts of the boiler.
But, the scale can in fact exacerbate the corrosion problem in that formation of crevices, and/or bacteriological activity, can cause accelerated localised corrosion with consequent failure and property damage.

**Investigation.** Expert opinion has been sought internationally. NSF (National Sanitation Foundation, USA) provides an international testing and certification service for water treatment products and food. When questioned by WRc-NSF, its joint venture company in the UK, as to their awareness or possible concern about potential for increased corrosivity of softened water, its response (link to NSF reply) was that, in their international experience, they are not aware of any such issue and it would be addressed in product standards if they were necessity.

**Chemical Inhibitors.** Water treatment with a corrosion inhibitor is often advisable or necessary depending upon water quality parameters which are known to affect corrosion. In such circumstances, an appropriate inhibitor should be selected. Some inhibitors may increase the corrosivity of softened water and so selection should be based, not only on whether an inhibitor is required but whether the inhibitor is suitable for the quality of the water being used.

In the UK, chemical inhibitors are tested and certified by the BuildCert scheme which is operated by WRc-NSF (link to their website). The test process involves aeration procedures which result in displacement of carbon dioxide from the water and consequent rise in pH. This is significant with respect to aluminium as most aluminium components in a heating system will begin to corrode at a pH above 9. This evolution of carbon dioxide will not occur in a closed loop heating system because the carbon dioxide gas cannot escape (even in a vented tank system, the hot water is under the pressure head below the tank and the carbon dioxide is held in solution). Arguably, this challenges the representativeness of the test, but, even if it is over-excessive, an inhibitor which passes is more than capable of meeting the real-life conditions.

**Definitive Experience**. The predominant cation and anion in ion exchange softened water are usually sodium and bicarbonate, respectively, and sodium bicarbonate is used in closed circuit systems to assist in corrosion control by buffering (stabilising) the pH between 8.0 and 8.5.

Moreover, pitting corrosion of copper in hot water systems can be caused by localised deposits of iron, manganese or aluminium impurities in the water[3]. Ion exchange water softening will effectively remove these impurities at point of entry.

The positions of European trade associations (UAE, Aqua Belgica, UKWTA) and international (WQA) are clear and based on extensive experience and expertise.

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[3] Harfst F.H., (1998). Corrosion in copper pipes can be prevented., *Water Technology*, Vol. 22 No. 3.

Click below for these national position statements:
UAE
Aqua Belgica
UKWTA
WQA

**Laboratory Evidence**. Tests have been conducted which have compared the corrosivity of hard water before and after softening. A study by the USEPA (United States Environmental Protection Agency) was undertaken between 1994 and 1996 comparing the corrosion and corrosive properties of hard water with that after softening by ion exchange[4]. The results showed no pattern of higher leaching from lead, copper, brass and galvanised materials nor significant deterioration in the water quality parameters that influence corrosion rate. Similar results were obtained from tests in Belgium (click here to view report on Belgian corrosion study).

**BSI Study on Corrosion in Hard and Softened Water**
During 2011, a study was conducted by BSI on behalf of the UKWTA to investigate any difference in corrosion between two heating systems set up in BSI laboratory in Loughborough (click here for the full report); one system filled with hard water and the other with base exchange softened water. Each system was identical and comprised a gas fired boiler with 10 radiators and was operated on a 2 hours on and 2 off cycle over 6 months. Each system was fitted with corrosion coupons. No inhibitors were used.

The overall conclusion was that there was no significant difference in corrosion observed between the system operating on hard water and the one operating on softened water. The initial corrosion rate of aluminium was higher, over the first few weeks, in the softened water system but settled to an insignificant rate with the formation of a protective layer. The corrosion rate of steel was less in the softened water but insignificant in terms of system life (100 years for 5 mm wall thickness). The corrosion rate of copper was 3 to 5 time higher in hard water than softened – but, again, insignificant in terms of system life. Similar, although even less significant, results were observed for brass and stainless steel. Examination of the radiators and boiler by sectioning showed no significant corrosion for either system.

**CONCLUSION** Water softening by base exchange does not increase corrosivity.

[4] Sorg T. J., Schock M.R. and Lytle D.A., (April 1998). Leaching of Metals from Household Plumbing Materials: Impact of Home Water Softeners, *USEPA*.

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ewta
European Water Treatment Association

american WATER HEATERS

# Technical Bulletin

## Water Softeners

Models Affected: All

**Pros of Owning a Softener:**

A water softener is the most economical way of effectively dealing with very hard water. In hard-water situations, softeners will pay for themselves in several ways. In a gas water heater, a softener will prevent the buildup of scale, which can increase operating costs by as much as 29 percent. Once scale has built up, a higher temperature setting is required to keep the water at the temperature you want. Scale also can damage electric elements to short out regularly. Scale buildup can clog plumbing pipes and can cause bathroom toilets to flush sluggishly because of scale on the rim openings. Softeners also prevent calcium deposits, which can ruin the appearance of fixtures.

These are the practical reasons for buying a softener, but there are esthetic ones, too. Shampoos and soaps don't lather or clean as well with hard water. Therefore, hard water requires the use of more soap, fabric softeners and conditioners, which can add up to an estimated 20 percent of each dollar you spend at the supermarket. At that rate, it wouldn't take long to offset the $20-a-month cost required to rent a softener and keep it in salt. Finally, you will spend less time scrubbing spots from fixtures, shower doors and tiles.

**The Cons of Owning a Softener:**

The reasons mentioned above are good arguments if you have very hard water. If your water tests at only 7- to 12- grains hardness, then softeners begin to appear to be a foolish investment; they are expensive pieces of machinery requiring maintenance, lots of salt and several hundred extra gallons of water per month.

Another reason not to install a softener might be personal preference. Some people simply do not like the feel of softened water. They have difficulty going from squeaky clean to slippery clean.

Softened water for drinking is another concern, especially for people on low-sodium diets, although the issue is a controversial one. Softened water is said to be low in chloride, and some tests suggest it is not the sodium that threatens health, but the chloride side of the sodium-chloride compound. A spokesperson for the American Heart Association reported that test results have been too conflicting to take an official stand in this matter.

One way around the problem is to isolate the hard-water lines connecting to the cold sides of the kitchen and bath faucets, since it is the cold water being used for cooking and drinking. If your home is not plumbed in this way, retrofit piping can be difficult and expensive to install. As a result, many softeners are connected to existing systems.

# Technical Bulletin

A much greater health concern than sodium in he water is the presence of metals stripped from piping. Soft water is naturally more corrosive than hard water. The Environmental Protection Agency (EPA) noted this fact in a recent ruling banning lead-based solders in residential plumbing systems. EPA tests showed that soft water is likely to leach lead from lead pipes and lead-soldered joints, thus posing a threat of low-level lead poisoning.

**Study by the Gas Institute**

Another study, conducted by the Gas Institute, found that softened water accelerates the depletion of anode rods in water heaters. Anode rods ordinarily keep heater tanks from rusting for five years. When the life of an anode is shortened, the life of the heater is as well.

Finally, there is the problem of brine disposal. Some sanitation officials are worried about the effects of salt on sewage treatment. For instance, certain counties in California and Michigan, plus the entire state of Connecticut, have banned the purge of softener brine into public sewers.

Softener owners in these areas must contract to have their brine collected periodically. The problem is that affordable collection is likely to be too infrequent. With softener resin becoming depleted every three to six days, a collection every two weeks, for example, would leave softener effectiveness severely impaired at least one week out of the two.

**Choosing a Softener**

If you decide to buy a softener, do lots of comparison shopping, and do not overlook the idea of buying a used softener. Softeners last 15 years on average, and used models offer up to 50 percent in savings. Many used models come with warranties.

The two types of softeners prevailing on the market today are those with demand regulating valves and those having nondemand valves. Nondemand water softeners are controlled by timers and are naturally less efficient because they automatically purge the resin tank with brine at a set time, whether you have processed enough water to warrant a purge or not.

Demand softeners feature more efficient control valves that use flow meters, resistance sensors or hardness sensing probes within the resin. Flow meters are more efficient than timers, however models with sensing probes are best.

Sensing probes are able to detect an ion or resistance imbalance and trigger recharging based on actual need. These softeners accommodate the daily fluctuations in water hardness and volume. If you live in a regulated area, demandactivated models may be required in order to meet efficiency standards.

WATER HEATERS

# Technical Bulletin

Nondemand models are less expensive and usually start at $500. Demand models are likely to exceed $800 and may cost as much as $1,600. Check the efficiency rating of each model. If you feel you would like a softener, but are not sure, consider a rental. Most rental plans offer consumers a buy-out option after six months.

**Sizing the Softener**

Other factors influencing price are warranty coverage and unit size. Sizing is very important and should be estimated with care. To make an estimate, start by assigning 75 gallons of daily water use to each member of your family and adding the total for one day. Then multiply this figure by the grain hardness of your water.

Finally, multiply the result by three, which gives you the minimum capacity needed. Most softeners can process 20,000 to 30,000 grains of hardness between purges. You will need to size your softener so that it can handle at least a three-day supply of water.

If you have any questions or concerns related to water softeners, contact our
Product Service & Support Department immediately at:

**1-800-999-9515**

## G.5 RECOMMENDED HARDNESS LEVEL

# Water Hardness in Treated Water

## *Communities in Fox Valley*

| Community | Hardness (GPG) | Average | Source | Notes |
|---|---|---|---|---|
| Kimberly | 5-6 | 5.5 | | |
| Darboy | 5-6 | 5.5 | Lab Testing by Utility included in CCR | |
| Little Chute | 7-8 | 7.5 | Tested by KU personnel using testing equipment | |
| Wrightstown | 9.1 | 9.1 | Lab Testing by Utility confirmed via phone discussion with Utility personnel | Estimates 90% of softeners were removed or bypassed |
| Appleton | 4-5 | 4.5 | Confirmed by WDNR personnel | Lime Softening |
| Freedom | 7 | 7 | | Ion Exchange |
| Fox Crossing | 1.7-3.1 | 2.4 | Lab Testing by Utility confirmed via phone discussion with Utility personnel | |

## *Communities with RO System*

| Community | Hardness (GPG) | Average | Source | Notes |
|---|---|---|---|---|
| Waupun, WI | 4-6 | 5 | Lab Testing by Utility confirmed via phone discussion with Utility personnel | |
| Stanley, WI | 6 | 6 | Lab Testing by Utility confirmed via phone discussion with Utility personnel | |
| Winneconne, WI | 5 | 5 | Lab Testing by Utility confirmed via phone discussion with Utility personnel | Raw water is 20 GPG, Blend 17%-20%, Gross Alpha main reason for RO |
| Northfield, MN | 5-6 | 5.5 | Lab Testing by Utility confirmed via phone discussion with Utility personnel | Manganese main reason for RO |
| St. Peter, MN | 5 | 5 | Lab Testing by Utility confirmed via phone discussion with Utility personnel | Raw water is 24 GPG |
| Redwood Falls, MN | 14-15 | 14.5 | Lab Testing by Utility confirmed via phone discussion with Utility personnel | Raw water is 63-64 GPG, Blend 25%, 10.5 years on membranes, use manufacturer specified chemicals |

# Water Hardness in Treated Water

## *Data obtained from WDNR*

| Community | WDNR Data | Average |
|---|---|---|
| Algoma | 7 | 7 |
| Brillion | 5.2-8.5 | 6.85 |
| Chilton | 6.7 | 6.7 |
| Darboy | 6-7 | 6.5 |
| Fox Crossing | 2-4.8 | 3.4 |
| Freedom | 2 | 2 |
| Kimberly | 5-8.4 | 6.7 |
| Little Chute | 6-13.5 | 9.75 |

## *Miscellaneous Water Systems*

| | | |
|---|---|---|
| Bloomington, MN | | 5.2 |
| Waukesha | | 8 |
| Milwaukee | | 8 |
| **Average Hardness** | | 6.4 |

Homeowner's Package

# Interpreting Drinking Water Quality Results

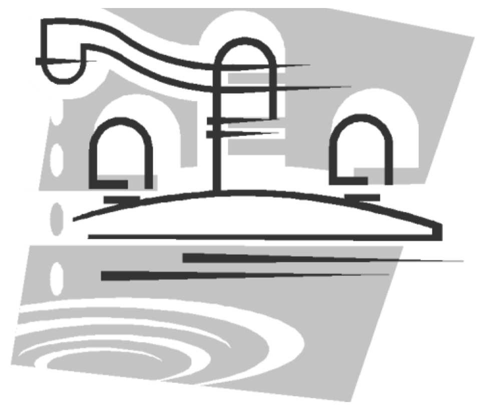
*Identifying Problems and Solutions*

**INDIVIDUAL TESTS:**



## Using this fact sheet

This fact sheet is intended to help you interpret the results of commonly recommended analyses for drinking water from private wells in Wisconsin.



Some of these tests are important because they deal with health related contaminants; the other tests will tell you about important characteristics of your well water, such as how hard or corrosive it is.

## Bacteria - Coliform

**Your result is either:**

**ABSENT** = No coliform bacteria are present. Your water supply is bacteriologically safe. No further action is needed at this time. Consider testing your well again in a year for bacteria or sooner if you notice a sudden change in taste, color or odor.

***or***

**PRESENT** = Coliform bacteria are present; water supply is considered bacteriologically **unsafe**. *Until the source of the problem is identified and corrected, we recommend using an alternative source of drinking water or boiling water for 5 minutes before using for drinking or cooking*

Coliform bacteria are microorganisms that are found in surface water and soil. This test is used as an indicator of the sanitary condition of your well. It is the most important test to perform on a well. A sanitary well should <u>not</u> contain any coliform bacteria.

While coliform bacteria do not usually cause disease, their presence in a water sample indicates a potential pathway for fecal wastes and other disease causing organisms to enter your well. If human or animal wastes are contaminating the water, gastrointestinal diseases, hepatitis, or other diseases may result. If coliform bacteria is present, many laboratories will also test for *E.coli,* a type of fecal coliform. The presence of *E. coli* in a water sample is more conclusive evidence of fecal contamination which represents an even greater health risk than the presence of coliform bacteria.
(Continued on p. 2.)

***Additional information about bacteria in wells:***

*In areas where fractured bedrock aquifers are overlain by thin soils, bacteria in a well may be the result of geologic conditions which do not allow for adequate filtration of water before reaching a well. You may suspect this if water suddenly changes color or odor following large rain events. For wells that are consistently contaminated with bacteria, disinfection may not solve the problem. In this case the best solution may be to drill a new well.*

# Bacteria – Coliform continued…

**What should you do if coliform bacteria are present?**

If coliform bacteria are present in a water sample we recommend carefully resampling to rule out sampling error.

If a second test confirms the original test, take corrective action outlined here:

**1.** Check well for sanitary defects. Some common examples include:

- Well cap is loose or missing (well cap should be a vermin proof cap).
- Casing is cracked or rusted through, or casing does not extend 12 inches above grade.
- Inadequate grout (seal or fill around well casing).

**2.** After correcting any visible defects, disinfect with a dilute bleach solution using the procedure outlined by the Department of Natural Resources brochure entitled “Bacteriological Contamination of Drinking Water Wells”.

**3.** Test again after bleach dissipates to ensure that the procedure was effective.

# Hardness - Total

Hardness measures the amount of calcium and magnesium in water. Hardness is primarily caused by water slowly dissolving rocks that contain calcium and magnesium.

There are no health concerns associated with drinking hard water, however it is often undesirable because it can cause lime buildup (scaling) in pipes and water heaters. Hard water reacts with soap which can decrease its cleaning ability and hard water also causes build up of soap scum and/or graying of white laundry over time.

Some people that use hard water for showering may notice problems with dry skin.

Calcium and magnesium are essential nutrients, however drinking hard water is generally not a significant source of calcium and magnesium dietary needs.

Water that is naturally low in total hardness (referred to as soft water) may be corrosive.

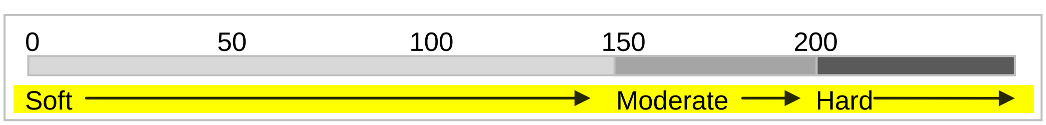
*Note the water softening industry measures hardness in grains per gallon. 1 grain per gallon = 17.1 mg/L $CaCO_3$.*

**Acceptable Results:**

Total hardness is a test for overall water quality; there are no health concerns related to total hardness. Values near 150 mg/L are generally ideal from an aesthetic viewpoint. Water less than 150 mg/L are considered soft water while values greater than 200 mg/L are considered hard water.

**Sources:**

Primarily dissolved carbonate minerals from soil and rock materials. When carbonate minerals dissolve they increase the amount of calcium and magnesium ions in water.




## Corrective Action for Hard or Corrosive Water

***If you are experiencing problems with hard water:***

- Consider softening water using a water softener. Softened water removes calcium and magnesium and replaces it with another cation (usually sodium). Many people choose not to soften the cold water tap used for drinking and cooking.

***If you are experiencing problems with corrosion of household plumbing:***

- Install a water treatment device (neutralizer) designed to make water less corrosive.
- Install plastic plumbing which will not develop pinhole leaks or leach metals.
- If you have a shallow well, drilling deeper may produce less corrosive water.
- Water allowed to contact unprotected metal plumbing for extended periods can dissolve unsafe levels of copper and/or lead. If levels of copper or lead in drinking water are a concern, run water for a few minutes before using for drinking or cooking.

# Alkalinity

Alkalinity is a measure of water's ability to neutralize acids. It results primarily from dissolving limestone or dolomite minerals in the aquifer.

Alkalinity and total hardness are usually nearly equal in concentration (when they are both reported in mg/L $CaCO_3$ (calcium carbonate) because they form from the same minerals. If alkalinity is much greater than total hardness, it may indicate that your water has passed through a water softener.

If alkalinity is much less than total hardness it may signify elevated levels of chloride, nitrate or sulfate.

Water with low levels of alkalinity (less than 150 mg/L) is more likely to be corrosive. High alkalinity water (greater than 150 mg/L) may contribute to scaling.

**Acceptable results:**

This is a test for overall water quality. There are no health concerns related to alkalinity. The value should be roughly 75% to 100% of the total hardness value in an unsoftened sample.

**Sources:**

Primarily dissolved carbonate from soil or rock materials.

# Conductivity

Conductivity is a measure of the ability of water to conduct an electrical current. It is related to the amount of dissolved substances (or ions) in water, but does not give an indication of which minerals are present.

Conductivity (measured in umhos/cm at 25° C) is about twice the total hardness value (mg/L $CaCO_3$) in most uncontaminated waters.

Changes in conductivity over time may indicate changes in your overall water quality.

**Acceptable results:**

This is a test for overall water quality, there is no health standard associated with conductivity.

A normal conductivity value is roughly twice the total hardness in unsoftened water samples. If conductivity is much greater than two times the hardness, it may indicate the presence of other ions such as chloride, nitrate, or sulfate which may be human-influenced or naturally occurring.

**Sources:**

Natural or human-related dissolved substances in water.

# pH

The pH test measures the concentration of hydrogen ions in a solution. The concentration of hydrogen determines if a solution is acidic or basic. A change of 1 pH unit is a 10-fold change in acid level. The lower the pH, the more corrosive water will be.

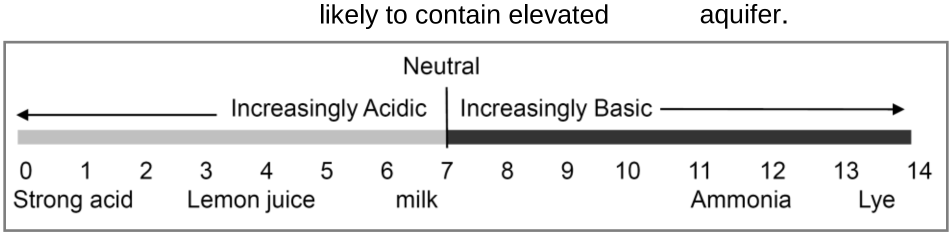
pH values are often slightly higher in the laboratory than at your well, because carbon dioxide gas leaves water when it is exposed to air.

**Acceptable results:**

There is no health standard for pH; however corrosive water (pH less than 7) is more likely to contain elevated levels of copper or lead if these materials are in your household plumbing.

Typical groundwater pH values in Wisconsin range from 6.5 to 8.5.

**Sources:** Low values are most often caused by lack of carbonate minerals in the aquifer.




***Did you know that your well water is actually groundwater?***

*Groundwater is water that occupies void spaces between soil particles or cracks in rock below the land surface. It is a local resource that originates as precipitation which infiltrates into the ground. The type of soil and bedrock that a well is drilled into often determines water's pH, saturation index, or the amount of hardness or alkalinity in water. The type of soil and bedrock in a region also determines how quickly contaminants can reach groundwater. Human activities are often responsible for elevated levels of contaminants such as nitrate and chloride.*

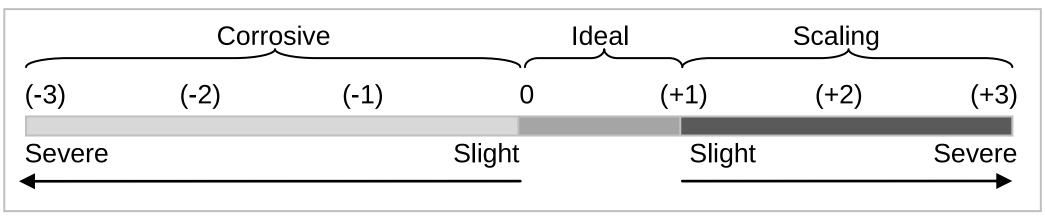
# Saturation Index

The saturation index is a measure of water's ability to corrode or form scale. It is calculated using values from pH, alkalinity, total hardness and conductivity tests.

A negative value indicates that water is likely to be corrosive, while a positive value indicates a tendency for scale (calcium carbonate) to precipitate (form a solid and settle out) from water.

Water is a good solvent and will attack unprotected metal plumbing. Corrosive water can sometimes have health implications if it causes elements like lead and copper from pipes and solder to dissolve into drinking water. Symptoms of corrosive water may include pinhole leaks in pipes or green stains in sinks.

Lime precipitate (scale) is a natural protection against corrosion. Too much scale, however, will plug pipes and water heaters thereby decreasing their efficiency. Water softeners are an effective form of treatment to prevent scale buildup but may also decrease protection from corrosion that natural water may have provided.




**Acceptable results:**

This is a test for overall water quality, there is no health standard associated with the saturation index.

Values between 0 and 1 are considered desirable. However the relationship between saturation index and corrosivity/scaling is imperfect.

Because copper and lead are health related concerns you may still need to test your water to determine whether corrosion of these metals is occurring.

**Sources:**

Low values may be caused by lack of natural carbonate minerals in the aquifer. Low values also occur when hardness is removed with a water softener. High values relate to high water hardness and alkalinity.

*Nutrient management is an important strategy to minimize nitrogen losses in areas where fertilizer use is the primary source of nitrate in groundwater.*

*Not only does it help improve our groundwater, it also improves fertilizer use efficiency.*

# Nitrogen-Nitrate

Nitrate is a chemical commonly found in agricultural and lawn fertilizer. It is also formed when waste materials such as manure or septic effluent decompose.

Infants less than 6 months of age should not drink water (or formula made with water) that contains more than 10 mg/L of nitrate-nitrogen. This is because of concerns related to methemoglobinemia (also called blue-baby disease), a condition in infants which inhibits the bloods ability to carry oxygen. If not caught early and treated, this condition can be fatal.

Some studies suggest that high nitrate water may be linked to birth defects and miscarriages, so pregnant women should also avoid drinking water over 10 mg/L.

The natural level of nitrate in Wisconsin's groundwater is less than 1 mg/L. Elevated nitrate levels can be an indicator of other

(continued on p. 5)

# Nitrogen-Nitrate continued…

potential contaminants. If nitrate levels are elevated you may want to consider testing for pesticides if you know that they are used nearby.

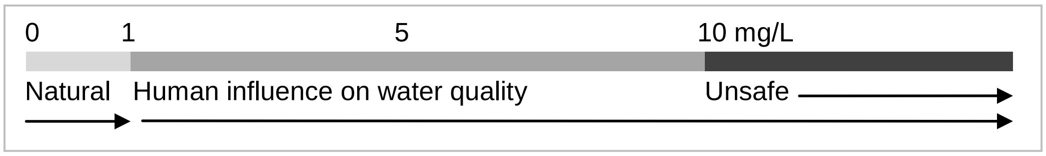
**Acceptable results:**

The drinking water standard for nitrate-nitrogen is 10 mg/L. Water greater than 10 mg/L should ***not*** be consumed by infants less than 6 months of age or pregnant women. *The WI Dept. of Public Health recommends people of all ages avoid long-term consumption of water with nitrate concentrations greater than 10 mg/L.*

Less than 2 mg/L is preferred. If feed is also high in nitrate, problems for livestock may occur if the concentration of nitrate in well water is between 20-40 mg/L.

**Sources:**

Fertilizers, septic systems, animal wastes, land spreading of bio-solids.




## Corrective Action for Nitrate

If possible, eliminate the contamination source. Unfortunately it may take years to observe any reduction in nitrate levels. As a result an alternative solution is usually necessary. Below are some actions that may reduce nitrate levels.

- Extending the casing depth, lowering the depth of the existing well, or drilling a new well *may* result in water with lower nitrate concentrations.
- Use bottled water for drinking and cooking.
- Connect to a public water supply if possible.
- Use a water treatment device designed to reduce nitrate levels.*
  ***Only** reverse osmosis (RO), distillation and anion exchange are treatment methods capable of reducing nitrate levels. When purchasing a water treatment device, only purchase those that have been approved by the WI Dept. of Commerce. Ask them to provide a copy of the product approval letter if you are unsure.*

# Chloride

In most areas of Wisconsin, chloride concentrations are naturally low. Higher concentrations usually indicate contamination from septic systems, road salt, fertilizer, animal waste or other wastes.

Chloride is not toxic, but some people can detect a salty taste when high levels of chloride are present. Water with high chloride may also have elevated sodium content. High chloride may also speed up corrosion in plumbing (just as road salt does to your car).

**Acceptable results:**

Chloride has no health standard. Levels less than 10 mg/L are desirable. Levels more than 250 mg/L may cause a salty taste or corrosion of some metals. Sodium (which is sometimes found with chloride) may be a concern for individuals on physician prescribed "no salt diets".

**Sources:**

Septic systems, road salt, fertilizer, animal waste, landfills, or naturally occurring mineral deposits.

***Water testing and units of measure:***

*Many minerals and contaminants in water are reported as concentration. When comparing test results to water quality standards it is important to check that you are comparing values with the same unit of measure. Some labs report nitrate concentrations as parts per million (ppm) while some use the term milligram per liter (mg/L).*

***1 mg/L = 1 ppm***

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Revised July 2009 by Kevin Masarik

**www.uwsp.edu/cnr/watersheds**

# Additional Information

**The following websites contain more information on private wells and water testing:**

Central Wisconsin Groundwater Center

www.uwsp.edu/cnr/gndwater/privatewells/index.htm

Wisconsin Department of Natural Resources

http://dnr.wi.gov/org/water/dwg/prih2o.htm

# Other Useful Publications

**Answers to Your Questions About Groundwater.** DNR. PUB DG-049 2003

**Bacteriological Contamination of Private Wells**. DNR. PUB DG-003-2005

**Better Homes and Groundwater.** DNR. PUB-DG-070 2004

**Choosing a Water Treatment Device.** UWEX. G3558-5

**Do Deeper Wells Mean Better Water?** UWEX. G3652

**Improving Your Private Well Water Quality.** UWEX. G3826

**Tests for Drinking Water from Private Wells.** DNR. PUB DG-023-04REV

**You and Your Well.** DNR. PUB-DG-002 2003

For copies of **WI Department of Natural Resources (DNR)** publications please call (608)266-0821 or visit http://www.dnr.state.wi.us/org/water/dwg/pubbro.htm

For copies of **UW-Extension (UWEX)** publications visit http://learningstore.uwex.edu or call (877)947-7827.

The Wisconsin Geological and Natural History Survey has many excellent geology and groundwater resources including maps available from their office. If interested in what resources are available call (608)263-7389 or for a complete listing visit their website at: http://www.uwex.edu/wgnhs/pubs.htm

# Understanding and Dealing With Hard Water

Energy Saver



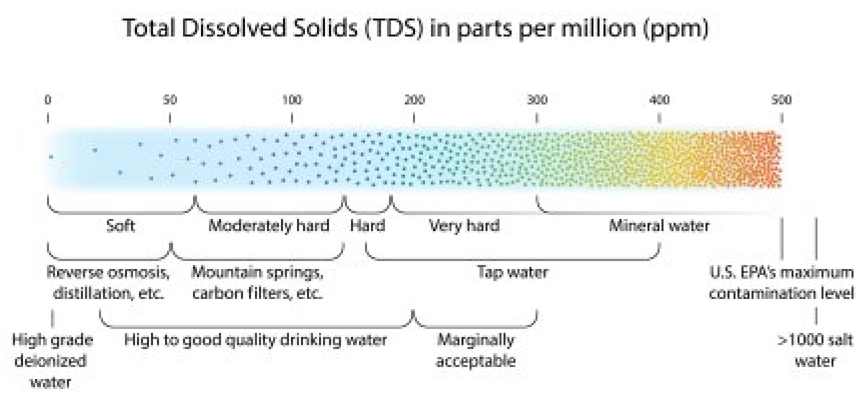
Hard water is a common phenomenon. While it poses no health risks, it affects the day-to-day life of the household in any number of ways. Dishes might emerge from the dishwasher polka-dotted with hazy white spots, fresh laundry can feel like sandpaper to the touch, and plumbing fixtures like faucets develop a chalky film.

# What Is Hard Water?

Before reaching the municipal supply, water absorbs mineral content from rocks and soil.  Some of this content, like calcium and magnesium, are hard minerals that not only make soap less effective.  They also gradually lead to limescale buildup, which, when it occurs within pipes, reduces water pressure and flow, and only gets worse over time. Hard water also negatively impacts the efficiency and lifespan of any appliance that requires water for operation. This might not be such a big deal for a coffeemaker, but it has the same effect on water heaters and refrigerators.

Water hardness or softness is measured using grains per gallon (gpg), where one grain is equal to 0.002 ounces of calcium carbonate dissolved in 1 gallon of water.

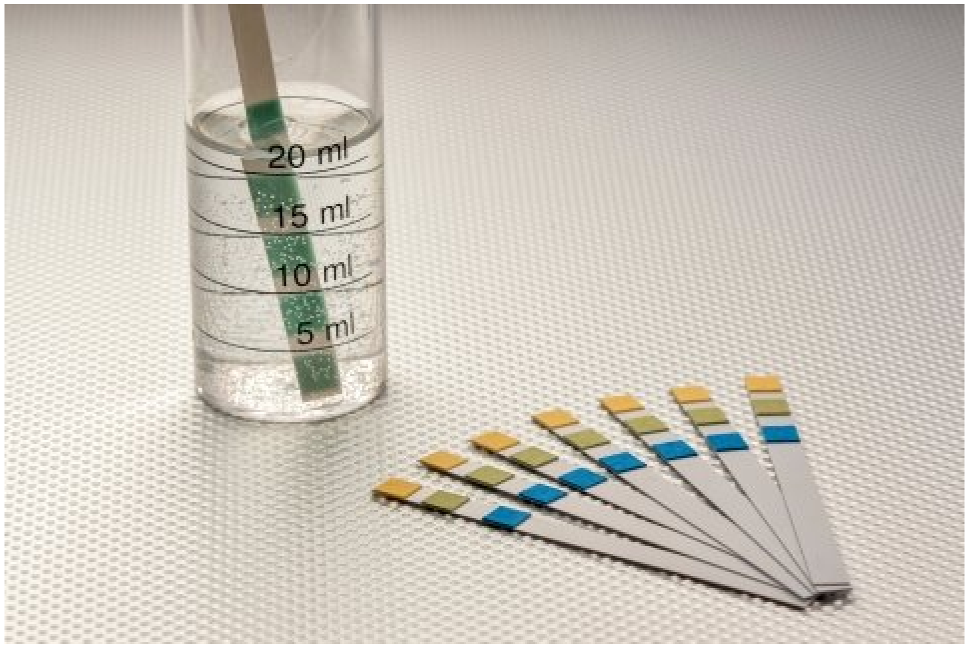
- 0–3 gpg is considered soft water.
- 3.5–7 gpg is considered moderate and ideal.
- >7.5 gpg is regarded as hard water and should be treated with a water softener.




# Hard Water Solutions

With hard water, it pays to be proactive. Correcting a hard water problem can eliminate a slew of inconveniences as well as help prevent a variety of plumbing headaches that cost a bundle to resolve. Keep an eye out for the telltale signs of hard water, of course, but even better is to conduct a little research. Start by contacting the local municipality or water utility; many provide a free report detailing what's in the local water. Alternatively, purchase a water test kit at a local home center, hardware store, or online retailer.  If it turns out the water is hard, **purchasing a water softener** will correct the situation.

# Water Testing




Different testing methods measure water hardness on different scales, either grains per gallon (GPG) or parts per million (PPM). The question isn't whether or not water contains *any* calcium or magnesium, but whether concentrations of those minerals are high enough to affect the home's plumbing. While trace amounts are to be expected, water with calcium or magnesium levels at or above 7 GPG or 120 PPM officially qualifies as hard. If it turns out that water tests as hard, follow the lead of other homeowners in the same situation and consider installing a water softener.



**Purchasing and Maintaining A Water Softener**

Learn more 

Office of

Energy Saver

Office of Energy Efficiency & Renewable Energy
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Washington, DC 20585

An office of

# What is the Ideal Water Hardness Level?

April 12, 2023 William Chandler III

Take the Quiz

Water hardness is an important aspect of water quality that affects various aspects of our daily lives, from household chores to personal health. Understanding the ideal water hardness level can help you maintain the right balance in your water supply, providing numerous benefits for your home and family.

**While there is no "perfect" water hardness level, soft water is generally considered to have a GPG (grains per gallon) of 0 to 3, or a PPM of 0 – 51.** Anything that is higher than this is considered hard water, and you might need to use a water softener to help you.

If you want to remove dissolved minerals, such as dissolved calcium or dissolved magnesium, from your drinking water, you need to understand the water hardness scale and find the right water softener to help you.

# Understanding Water Hardness and Dissolved Minerals

Water hardness refers to the concentration of dissolved minerals, primarily calcium and magnesium, in the water. These minerals are naturally present in the earth's crust and dissolve into groundwater over time. Hard water has a high mineral content, while soft water has a low mineral content. Water hardness is typically measured in grains per gallon (gpg) or parts per million (ppm) of calcium carbonate ($CaCO_3$).

## Effects of Water Hardness

Water hardness can have both positive and negative effects on your household and personal health. Excess calcium, magnesium, and other dissolved minerals may exert the following effects:

### Positive Effects

Take the Quiz

- **Mineral Intake**: Hard water can contribute to your daily intake of essential minerals, such as calcium and magnesium, which are vital for bone health and overall well-being.
- **Taste**: Many people find that hard water has a better taste due to the presence of minerals.

### Negative Effects

- **Scale Buildup**: The minerals in hard water can accumulate on surfaces and form scale deposits, which can cause damage to appliances, plumbing fixtures, and heating systems.
- **Reduced Soap and Detergent Effectiveness**: Hard water can react with soap and detergents, forming a residue that is difficult to rinse off. This can lead to dingy laundry, spots on dishes, and reduced cleaning efficiency.
- **Skin and Hair Issues**: Hard water can leave a residue on your skin and hair, potentially causing dryness, irritation, and dullness.

It is critical to understand the benefits and drawbacks to make sure you have the right water hardness level in your home.

## Determining the Ideal Water Hardness Level: Measure Water Hardness

There is no universally agreed-upon ideal water hardness level, as different households and individuals may have different preferences and needs. You need to think about your overall water quality, alongside your hardness level, when you consider the health and efficiency of your plumbing appliances as well.

At the same time, a general guideline can be followed to determine a suitable water hardness level for most households:

Take the Quiz

| Water Hardness Level | Grains per Gallon (gpg) | Parts per Million (ppm) |
|---|---|---|
| Soft Water | 0-3 | 0-51 |
| Moderately Hard Water | 3-7 | 51-120 |
| Hard Water | 7-10 | 120-171 |
| Very Hard Water | 10+ | 171+ |

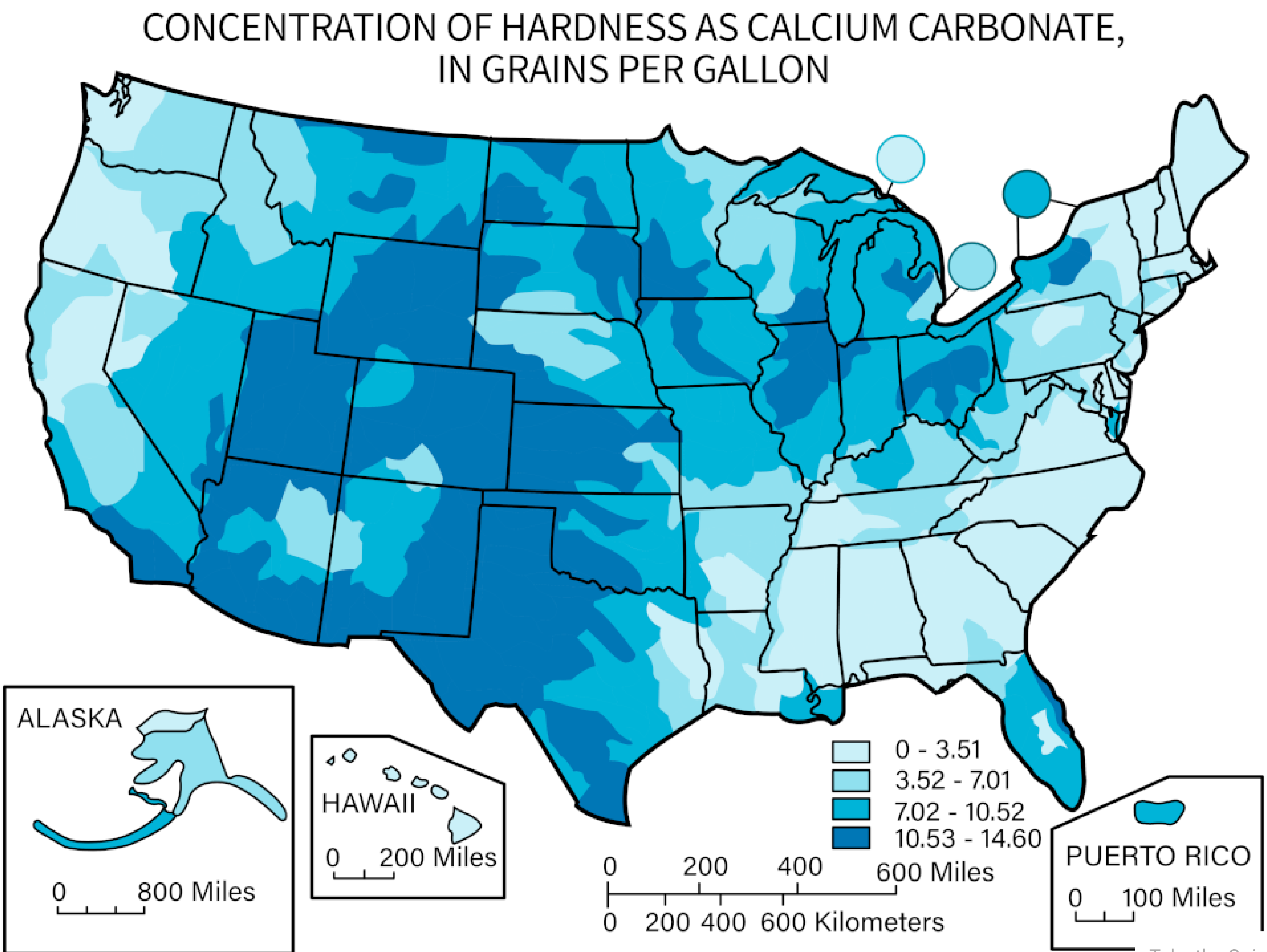
*Water hardness levels*

Most experts recommend aiming for a water hardness level between 3-7 gpg (51-120 ppm) for a balance of mineral intake and minimal negative effects. It is important to note that excessively soft water can be corrosive, potentially damaging your plumbing system and leaching metals, such as lead and copper, into your water supply.

For these reasons, you need to keep a close eye on your water hardness level and think about the health of your overall water supply.

# Testing Your Water Hardness Level

Take the Quiz


CONCENTRATION OF HARDNESS AS CALCIUM CARBONATE, IN GRAINS PER GALLON
ALASKA
0 800 Miles
HAWAII
0 200 Miles
0 - 3.51
3.52 - 7.01
7.02 - 10.52
10.53 - 14.60
0 200 400 600 Miles
0 200 400 600 Kilometers
PUERTO RICO
0 100 Miles
Take the Quiz

So, what do you need to do if you want to figure out your overall water hardness level? There are a few key points to consider:

To determine the hardness level of your water, you can:

- **Check Your Local Water Report**: Many municipalities provide water quality reports that include information on water hardness. You can usually find these reports online or request a copy from your local water provider.
- **Use a Test Kit**: You can purchase a water hardness test kit online or at a local home improvement store. These kits typically include test strips or liquid reagents that can measure the mineral content in your water.
- **Hire a Professional**: For a more comprehensive water analysis, consider hiring a professional water testing service. They can provide detailed information on water hardness and other water quality parameters.

Remember that you can also reach out to an expert at DROP if you need help getting figuring out your overall water supply's hardness level.

# Adjusting Your Water Hardness Level

If your water hardness level is outside the recommended range, you can take steps to improve it and maintain the ideal balance:

## Water Softeners

Water softeners are a popular and effective solution for reducing water hardness. They work by using a process called ion exchange, which replaces the calcium and magnesium ions in the water with sodium or potassium ions.

This reduces the mineral content and prevents scale buildup, soap scum, and other issues associated with hard water. Depending on your household, you will need the right size.

On your water softener, you can adjust the water hardness levels by changing your settings.

## Water Filters

In some cases, water filters can help improve water hardness levels by removing specific minerals or impurities.

Reverse osmosis (RO) systems, for example, can effectively reduce water hardness by removing a significant portion of the dissolved minerals. However, these systems can also remove beneficial minerals and may produce water that is too soft, so it is essential to find the right balance based on your specific needs.

## Water Conditioners

Water conditioners, also known as descalers or anti-scale systems, are another option for managing water hardness. These devices do not remove the minerals from the water but instead alter their crystalline structure, preventing them from forming scale deposits.

Water conditioners can be an attractive option for those who wish to maintain some mineral content in their water while minimizing the negative effects of water hardness.

# Maintaining the Ideal Water Hardness Level: Soft Water

Take the Quiz

Once you have achieved the desired water hardness level, it is important to monitor and maintain it to ensure optimal water quality:

- **Regular Testing**: Periodically test your water hardness level to ensure it remains within the recommended range. This can help you identify any changes in water quality and address them promptly.
- **Water Softener and Filter Maintenance**: Regularly maintain and service your water treatment equipment, such as water softeners and filters, to ensure they continue to operate effectively. This may include replacing filter cartridges, cleaning the brine tank, and adding salt to salt-based water softeners.
- **Professional Consultation**: If you are unsure about the best approach to managing your water hardness level or need assistance with water treatment equipment, consult a professional. They can provide expert guidance and recommendations tailored to your specific needs.

Keep in mind that you never have to go through this process on your own. You may want to reach out to an expert who can help you not only measure your water hardness level but also find the right water softener to help you.

# Check Out a Water Softener or Water Filter From DROP Today

Achieving and maintaining the ideal water hardness level can significantly improve the quality of your water, benefiting your household chores, appliances, and personal health. By understanding the concept of water hardness and taking the necessary steps to adjust and maintain it, you can enjoy the many advantages of well-balanced water.

Check out DROP's range of water softeners and water filters today to find the perfect solution for your water hardness needs. With DROP's innovative water treatment products, you can ensure clean, safe, and high-quality water for you and your family today to speak to a member of our team, and get the right water hardness level!

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## By William Chandler III

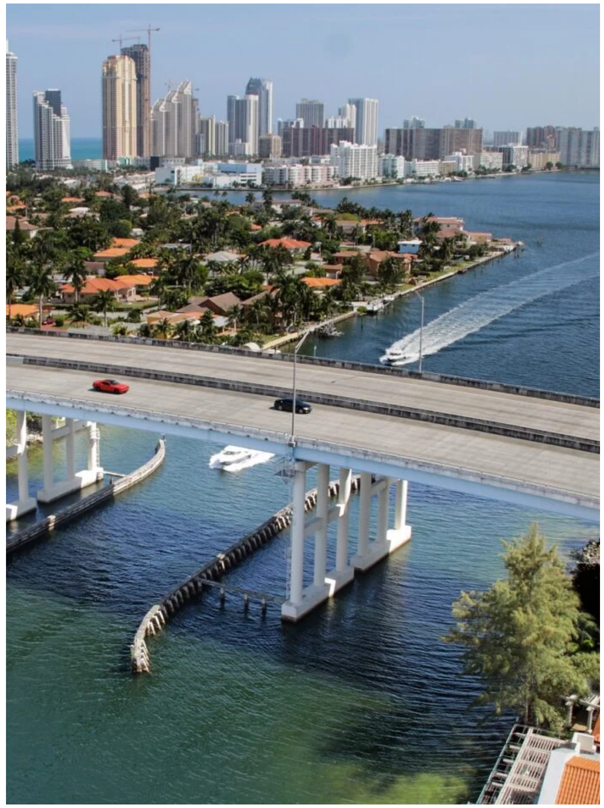
William Chandler III has been working in the water industry for over 20 years. Since 2016 he has been the Vice President of Chandler Systems Inc., owner of CSI Water Treatment, WaterSoft Inc., Clearion Water, and DROP.



See all posts by William Chandler III →

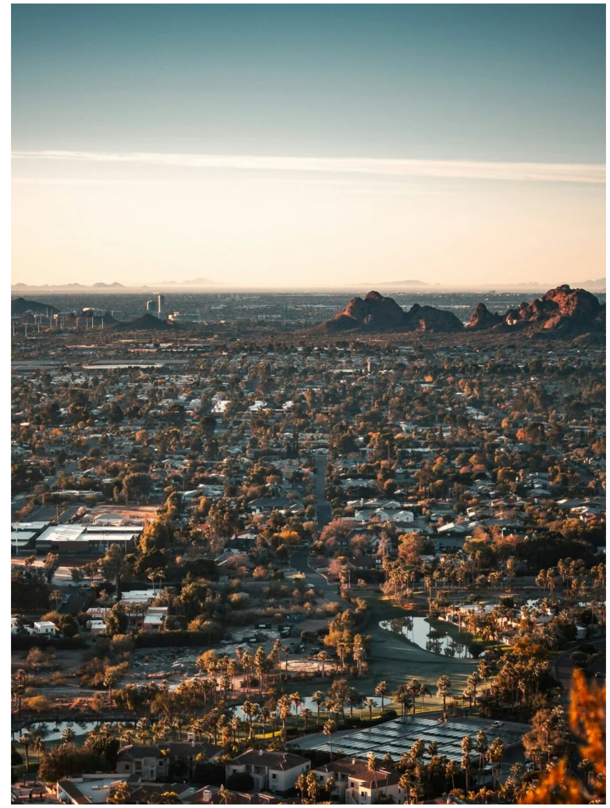

February 2, 2024

### Water Hardness in North Dakota Cities



January 25, 2024

### Water Hardness in Florida Cities



January 18, 2024

### Water Hardness in Arizona Cities

**1.833.BUY.DROP**
**1.833.289.3767**
220 Ohio St, Ashland, OH 44805

Take the Quiz

# What Is the Ideal Water Hardness for Drinking?

**The average person should drink at least 2.5 liters of water a day for optimum health**. And roughly, **71% drink from the tap** occasionally. Given such numbers, it's important to ensure that the water flowing from the tap is safe to drink.

But what if your tap water is hard water? A lot of people find hard water not palatable. Moreover, as hard water leaves behind residue and stains, many take caution and avoid drinking it altogether.

Learn more about **alkaline water systems** and water hardness to determine what the ideal drinking water is for you.

## What Is Water Hardness?

Water hardness refers to the amount of minerals, particularly, of Calcium and Magnesium, found in water. Minerals are naturally found in water; however, when they exceed 120mg/L, the high level of minerals begins to have negative effects. This is also when water is called hard, as opposed to being soft water, with only up to 60mg/L of minerals, or moderately hard water, with 60mg/L and 120mg/L amount of minerals.

## What Is the Ideal Water Hardness For Drinking?

Though water hardness has been proven to negatively impact pipes, tiles, and other household fixtures, as well as cause skin and hair dryness, it has not been proven to harm health. In fact, the high amounts of calcium and magnesium may even positively impact health.

Still, it is highly advisable to take things in moderation and both soft water and hard water have their respective benefits and drawbacks. On the one hand, having too little minerals in the water may contribute to mineral deficiency, whereas too much may result in overdose, though such cases are incredibly rare in healthy individuals.

The general rule of thumb is to drink clean water, with hardness being somewhere in the middle of soft and hard, 60 mg/L to 120 mg/L. Some also advise to not go beyond 170 mg/L, which indicates very high levels of calcium and magnesium.

But according to health authorities, there is no general health advice on restricting hardness in drinking water for health and safety reasons.

## How to Tell Water Hardness?

If you drink from the tap and use your water to clean your home, bath, and use with your appliances, you're probably wondering how to tell whether you have soft or hard water. To determine this, you can choose to purchase a test kit, send your water to get tested in a lab, or you can simply observe your water or conduct a quick soap test at home.

### Test Kit

There are test kits that allow you to measure water hardness. An inorganic chemical test (Kit C), for example, can be bought from labs and used at home. Another option is to bottle up some water and send it to a certified drinking water lab to test for hardness.

### Observation

Even without using test kits, one can tell whether water is hard or soft depending on the feel, smell, and usage of the water.

Unlike soft water which is odorless and leaves no residue behind, hard water smells sulfuric and tastes metallic; it also leaves behind residue when dry, which can easily be spotted on surfaces as discoloration or stains.

Recent News

Whole House Water Filtration Solutions in Dallas, Texas: Why the Puragain Filtersorb System is the Best Choice

Do You Need Both a Water Filtration System and a Water Softener?

How to Choose Between a Water Softener and Water Conditioner

Can Water Softeners Improve Your Family's Health?

Where Should a Water Softener Be Installed?

the water will cloud up. As soap doesn't react well with hard water, lots of bubbles in your solution means you have soft water, while lack of bubbles means you have hard water.

For the same reason that hard water reduces the usefulness of soaps, it is not advisable to use hard water for cleaning, bathing, and other similar uses.

## How to Make Hard Water Safe For Drinking?

One of the cautions against hard water is that they are often sourced from wells, and are likely to have metals besides the minerals. Though minerals are safe to consume, metals, and other substances are not.

As such, the best way to protect your health when drinking hard water is to make sure it is filtered thoroughly and rid of any harmful chemicals, pests, and metals, leaving behind only minerals which can have positive health benefits.

Still, many prefer to not drink hard water, not because they pose a danger to one's health but rather because it has a metallic taste and sulfuric smell. In such cases, it is advisable to install a water softener to reduce calcium and magnesium levels in the water to make it tasteless and odorless for more enjoyable drinking.

## How to Have Ideal Drinking Water?

So you've got hard water that you want to soften for a better drinking experience? Then you need a water softener to lessen the high levels of calcium and magnesium in your water.

When it comes to water softeners, there are 2 main types you can choose from; one uses salts, sodium chloride, and replaces the calcium and magnesium ions with sodium ions; meanwhile, the other uses potassium to neutralize or cure the water.

While using salts is the most common method to soften water, it does get rid of a lot of water during the ion exchange process. Not to mention, it leaves behind high levels of sodium chloride, which may be harmful for some people with specific dietary restrictions. For these reasons, many opt for the **salt free water softener system**.

Such systems involve the use of water conditioners which, when applied to hard water, crystallizes the minerals, making them easy to remove.

## Make Your Water Ideal For Drinking

Are you ready to improve your tap water and make it ideal for drinking? Reach out to Pur Again Water and have us install a water softening system that will transform your water from hard to soft, removing any smell or taste from your water. We also offer various water filtration systems as well as **alkaline water systems** which are guaranteed to make your water ideal for drinking.

Call PurAgain Water today to schedule an appointment or get a free quote!

This is a newly redesigned Water-Research.net page

Page Archive



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# Get Informed | Hardness

**Water described as "hard" is high in dissolved minerals, specifically calcium and magnesium. Hard water is not a health risk, but a nuisance because of mineral buildup on fixtures and poor soap and/or detergent performance.**

## What is Hardness?

When explaining hardness to the public, in some ways it is easier to say what hardness is not than what it is. Having hardness in your water is not bad, not toxic, does not mean you have elevated levels of **Lead**, **Arsenic**, or other dangerous minerals. It does not mean that your water will clog your piping with scale. The total hardness of the water is typically expressed or reported as the equivalent of concentration of calcium carbonate in water as mg CaCO3/L or reported as "grains per gallon" (gpg). (Note: 1 grain per gallon is 17.12 mg CaCO3/L). The only problem is that with this expression some individuals think that hardness is just the amount of calcium carbonate in the water. Calcium carbonate is composed of a cation (Ca++) (positive 2) and an anion (CO3--) (negative 2). The hardness of the water is related to the cation concentration and not the anion and it is not just "Calcium".

Cations have a charge that is positive and the charge can be +1 or higher. The total hardness of the water is actually the measure of the cations with a charge of 2 or more, i.e., "multivalent positively charged cations. This would include cations such as: calcium, magnesium, **Iron**, **Manganese**, **Barium**, **Strontium**, **Aluminum**, etc, but would not include the cations with a positive charge of 1 like **Sodium**, potassium, and **Lithium**.

The total hardness of the water can be described as the combination of temporary (carbonate hardness) and permanent hardness (non-carbonate hardness). Temporary hardness is the hardness that is associated with anions like carbonate, bicarbonate, and hydroxide (OH-) because when the water is heated and ultimately boiled the water will lose some of the carbonate as CO2 and the solution will become supersaturated with multivalent cations which will begin to form particles and precipitate from the water as a carbonate scale. This scale is typically white or gray, but may have other colors depending on the cation and can easily be removed by dissolving them in vinegar (a weak acid). Permanent hardness is the hardness that is associated with non-carbonate anions, like **Chloride**, **Sulfate**, and **Nitrate**.

The primary source of hardness in most drinking water is from natural sources. Water is a good solvent and picks up impurities easily. Pure water -- tasteless, colorless, and odorless -- is often called the universal solvent (not really true but it does dissolve many things). When water is combined with carbon dioxide from our atmosphere it forms a very weak carbonic acid, which is an even better solvent. As this water moves through soil and rock, it dissolves very small amounts of minerals and holds them in solution. Typically, it is calcium and magnesium dissolved in water that make water "hard." The degree of hardness becomes greater as the amount of divalent or multivalent cations dissolved in the water increases.

## How Does Hardness Become a problem?

Hardness can pose a potential problem if it is too low or too high. If the water hardness is too low, such as < 50 mg/L, the water may be corrosive to metal piping, fixtures, and appliances. If the hardness is high, it is possible for the multivalent cations to react with the carbonates in the water to produce chemical precipitates or "soap scum".

The amount of hardness minerals in water affects the amount of soap and detergent necessary for cleaning. Soap used in hard water combines with the minerals to form a sticky soap curd. Some synthetic detergents are less effective in hard water because the active ingredient is partially inactivated by hardness, even though it stays dissolved. Bathing with soap in hard water can leave a film on the skin that may prevent or inhibit the removal of "dirt", dead skin cells, oils, and bacteria. This film can also prevent the skin from returning to a more typical slightly acidic condition, i.e., pH 4 to about 6.5, and therefore result in irritation or possibly eczema. This film can also make hair look dull, lifeless, difficult to manage, and even make it feel dirty.

When doing laundry in hard water, soap curds lodge in fabric during washing to make fabric stiff and rough. Incomplete soil removal from laundry causes graying of white fabric and the loss of brightness in colors. Because of incomplete cleaning, the clothes may get a sour odor and continuous laundering in hard water can shorten the life of clothes. The soap curds can deposit on dishes, bathtubs and showers, and all water fixtures, contributing to nuisances.

## What are the Health Risks for Hardness?

Hard water is not a health hazard. The National Academy of Sciences states that drinking hard water contributes to the dietary need for calcium and magnesium. Researchers have studied water hardness and cardiovascular disease mortality. Such studies have been "epidemiological studies," which are statistical relationship studies. While some studies suggest a correlation between hard water and lower cardiovascular disease mortality, other studies do not suggest such a correlation. The National Research Council states that results at this time are inconclusive and recommends that further studies should be conducted.

Solid Report on this Issue - Suggested reading (**Source**) - a few quotes:

"The impact of water hardness of urinary stone formation remains unclear, despite a weak correlation between water hardness and urinary calcium, magnesium, and citrate excretion. Several studies have shown no association between water hardness and the incidence of urinary stone formation."

"Although, there is some evidence from epidemiological studies for a protective effect of magnesium or hardness on cardiovascular mortality, the evidence is being debated and does not prove causality."

Atopic dermatitis (or eczema) is an inflammatory, chronically relapsing, non-contagious and pruritic skin disorder. The environment plays an important part in the etiology of atopic eczema, but the specific causes are unknown. Exposure to hard water is thought to be a risk factor for eczema."

It is my professional experience that having some water hardness is good as long as the cations composing the hardness are not above a drinking water standard, the water is not creating nuisance, or the water is causing a premature failure of a heat exchange system or appliance or violates a manufacturers warranty. In general, individuals do not report aesthetic problems with their water until the hardness concentration typically exceeds 160 to 180 mg CaCO3/L. I am more concerned about water with very low hardness that may be associated with corrosion of fixtures and piping. If I had to have a preference, I would probably choose "moderately hard" water.

## What are the Standards for Hardness?

There is no specific drinking water standard for water hardness, but the associated secondary drinking water standards may include the total dissolved solids of the water, potential for corrosion or scale formation, or the elevated presence of some iron and manganese and other similar metals. The classification of hardness:

| Total Hardness Levels (mg CaCO3/L) | |
|---|---|
| Soft | 0 to 17.1 |
| Slightly Hard | > 17.1 to 60 |
| Moderately Hard | > 60 to 120 |
| Hard | >120 to 180 |
| Very Hard | > 180 |

(Source: Lehr, J. et. al., 1980. Domestic Water Treatment, New York, NY: McGraw-Hill Book Company - Note: This is a great desk reference if you can find it.)

## Get Te

There are some ha can occur when the hardness is too low or too high, but these issues can be controlled by changing both the cationic and the anionic concentrations in your water. Problems associated with hardness are not normally associated with an odor problem, but more typically an aesthetic problem, such as a coating, film, scale, hard water spots, and poor sudsing. Since hardness is a general term that covers a group of cations, it is normally necessary to conduct a comprehensive water test and not just test the hardness of the water. Your best course of action is to get your water tested and compile as much information as possible about your water supply source, well construction, surrounding land-use, and local geology.

### Level 1 | Observational Self-Testing

**Level 1 Testing** is done with simple observations that an individual can make with their own senses such as sight, smell, and taste. These observations can be readily apparent or can be observed as they change over time. In addition, accessible related information about the home can also be used to narrow down the cause of your water issues.

## Notes on Level 1 Testing for Hardness

Hard water interferes with almost every cleaning task from laundering and dish washing to bathing and personal grooming. Clothes laundered in hard water may look dingy and feel harsh and scratchy. Dishes and glasses may be spotted when dry. Hard water may cause a film on glass shower doors, shower walls, bathtubs, sinks, faucets, etc. Hair washed in hard water may feel sticky and look dull. Water flow may be reduced by deposits in pipes and aeration devices may have a chemical coating that appears white or gray.

## Observations for Hardness

Water hardness problems can be an issue if the hardness is too low or high.  Very low hardness may be associated with chemical **corrosion** of the water and a metallic or acidic taste and elevated hardness can be associated with chemical coatings, films, coatings, clogged piping, and dingy clothing.

### Try Our Level 1 Drinking Water Self-Diagnostic Tool

Have water issues? Answer our self-diagnosis questionnaire from your observations to get an initial diagnosis. Then follow our recommended steps to remediate your issue.

**Self-Diagnostic Tool**

# Level 2 | Do-It-Yourself Water Testing

**Level 2 Testing** is Do-It-Yourself testing that can be done in your own home using a Testing Kit. After you've done Level 1 Testing, Level 2 Testing can confirm if your observations are correct. If your test results reveal the presence of a contaminant that is cause for concern, you can either proceed to determine the best treatment (see below) or continue to Level 3 Testing.

## Notes on Level 2 Testing for Hardness

There are a number of low cost ways to measure the total hardness of your water at home. In most cases these at-home tests are very easy to use, but do not provide a very accurate or precise measure of the water hardness, but can provide a value to help you to determine if the water is soft, slightly hard, moderately hard, hard, or very hard.

**Recommended Level 2 Tests**

L2-AMAZ-H-13 | **Amazon**
Health Metric Drinking Water Test Kit for Municipal Tap and Well Water
View

L2-AMAZ-H-06 | **Amazon**
Hanna Instruments HI 9813-6N Waterproof pH/EC/TDS Temperature Meter Clean and Calibration Check
View



## Level 3 | Informational Water Testing

[Level 3 Testing](#) is done through an accredited Water Testing Laboratory. With Level 3 Testing, you can order a testing kit that is used to prepare your sample and submit it to the lab. By utilizing a lab, you have the assurance that a certified water expert had analyzed your water sample. If your test results reveal the presence of a contaminant that is cause for concern, you can either proceed to determine the best treatment options (see below) or continue to Level 4 Testing - Certified Testing.

## Notes on Level 3 Testing for Hardness

Most informational water tests provide testing for the total hardness and some test kits provide additional insight into the other cations and anions that are contained within the water. These comprehensive water testing kit results are needed to determine whether the water needs treatment and, if so, to help design the treatment system.

**Recommended Level 3 Tests**

| Code | Lab | Test | |
|---|---|---|---|
| L3-NATE-C-1 | National Testing Labs | City Water Basic | View |
| L3-NATE-C-2 | National Testing Labs | City Water Deluxe | View |
| L3-NATE-C-4 | National Testing Labs | Corrosion Check | View |
| L3-NATE-W-2 | National Testing Labs | Water Check Deluxe | View |
| L3-TASC-E-07 | Tap Score | Extended Well Water | View |
| L3-TASC-E-05 | Tap Score | Extended City Water Test | View |

## Level 4 | Certified Water Testing

A Level 4 Certified Test Test uses chain-of-custody with a water professional coming to your home to prepare the water sample and then works with an accredited laboratory in order to certify your test results. This type of testing not only gives you the highest level of assurance in the accuracy of your test results, but can also be used as a document in legal cases. For **Baseline Testing**, we recommend that you use Certified Testing.

### Notes on Level 4 Testing for Hardness

If you require certified testing for total hardness or a hardness-related issue, we strongly recommend completing the diagnostic analysis to ensure that the water does not show signs of having a bacteria problem or a problem related to the presence of a specific cation like **Aluminum**, **Iron**, and **Manganese** or elevated anions like **Chloride**, carbonates, bicarbonate, or **Sulfate**. If you need assistance, please **Contact** our team.

## Get Treatment | Hardness

In most cases pretreatment will not be necessary, but if you have a **Bacterial** problem or have high settleable solids or **Turbidity**, it may be necessary to install a whole-house pretreatment system that may include a disinfection system or a back washable/ disposable **Particle Filter**. The most common means to soften a water or to reduce the total hardness is the use of a water softener ion exchange system (using salt) or a non-precipitating water softener (no salt) that helps to sequester (bind the multivalent cations into complexes that keep them in solution) the multivalent cations. The "salt" based units will exchange sodium or potassium ions for the multivalent cations such as calcium and magnesium whereas, the "no salt or salt free" will typically sequester the multivalent cations by complexing them with additives such as NUVO (citric acid) and Aquios (polyphosphate). Another type of “no salt” system contains an active media, i.e., catalytic media, that removes the hardness cations by causing them to precipitate or crystalize. Typically, the NUVO and Aquios units are needed when we are only looking to slightly reduce the water hardness.

### Short-Term Treatment

In the short term and assuming you do not have a problem with any trace metals, you can boil the water and then filter the water. The process of boiling will cause some of the carbonate to be converted to $CO_2$ and the cations causing "temporary hardness" will form a precipitate that can be filtered from the water. You could also install a faucet-mounted or under-the-counter filtration system that contains a catalytic medium.  If you use one of the Aquios or Nuvo units, you may want to consider adding a point-of-use **Reverse Osmosis** unit.

**Recommended Short-Term Water Treatments**

ST-AMAZ-A-02 | **Amazon**

DIY Aquios AQFS220 Full-House Salt-Free Water-Softener and Filter System

View

ST-AMAZ-N-01 | **Amazon**

Nuvo H2O Dphb - a Home Water-Softener System

View

ST-CRYS-W-02 | **Crystal Quest**

DIY Water Softener and Whole-House Dual System

View



## Contact a KnowYourH2O Recommended Professional

Not Up for A DIY or you have a series of issues: Need Help Identifying a Local KnowYourH20 Team Professional? **Contact Us**

## Long-Term Treatment

In the long term, the choice of options depends on the situation and degree of your problem. If you are only looking to slightly reduce the hardness of the water and you have limited space, you may want to consider the NUVO or Aquios units which will require that you change one or more filter cartridges every 6 months. There are also no-salt systems that contain a catalytic medium which would have to be rebedded every 750,000 gallons or more depending on the degree of hardness. For very hard water, we suggest the standard "salt" based water softening systems. These systems will have an automatic backwash cycle and have a "salt" tank to create the brine that is used to regenerate the system. Do note, however, that such ion exchange systems add sodium to the water which could be a problem for people with high blood pressure.

### Recommended Long-Term Water Treatments

LT-CRYS-S-02 | **Crystal Quest**

DIY Salt-Free Water Softener Anti-Scale System

View

LT-FILT-W-02 | **Filter Water**

DIY Water Softener and Whole-House Dual System (Code A27AC)

View

LT-AMAZ-U-01 | **Amazon**

DIY Ukoke RO75GP 6 Stages Reverse Osmosis Water Filtration System, NSF/ANSI 58 & IAPMO Platinum Seal Certified

View

### Contact a KnowYourH2O Recommended Professional

Not Up for A DIY or you have a series of issues: Need Help Identifying a Local Know Your H20 Team Professional? **Contact Us**

## Recommended Reading

**Amazon**
Water Treatment Grade 1 WSO: AWWA Water System Operations WSO

**Amazon**
Water Treatment Grade 2 WSO: AWWA Water System Operations WSO

**Amazon**
Water Treatment Grades 3 and 4 WSO: AWWA Water System Operations WSO

## Archive Page Reference

This is a newly redesigned Water-Research.net page. To reference related archived Water-Research.net page(s) click the link(s) below:

Water Research Center - Drinking Water Hardwater Hardness Calcium Magnesium Scale Stained Laundry

# APPENDIX G

# Risk and Benefit Table for Main Filter Plant Alternatives

Kaukauna Utilities
Water Study
3/6/2024

| Risk Level | Benefit Level |
|---|---|
| High - Yes | Low - No |
| Medium | Medium |
| Low - No | High - Yes |

Water Treatment Options

| | |
|---|---|
| Option 1 | Keep Existing Filtration Treatment Process |
| Option 2 | Ion Exchange Treatment Process |
| Option 3 | Reverse Osmosis/ Nanofiltration Treatment Process |
| Option 4 | Pellet Softening |
| Option 5 | Change from Ground Water Source to Surface Water Source |

## Risks and Benefits for Main Filter Plant Alternatives and Water Treatment Options

| Description | Risk or Benefit | No Change | Replace Filter Tank at Existing Location | Rebuild Water Treatment Plant Building and Reservoirs at Current Location | | | | New Water Treatment Plant at New Site | | | | Switch to Surface Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Alternative 1 | Alternative 2 | Alternative 3 | | | | Alternative 4 | | | | |
| | | Option 1 | Option 1 | Option 1 | Option 2 | Option 3 | Option 4 | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 |
| Main Water Filter Plant | | | | | | | | | | | | |
| Boil Water Notice | Risk | High | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Potential for River Flooding | Risk | Medium | Medium | Medium | Medium | Medium | Medium | Low | Low | Low | Low | Low |
| Year Round Dry Land Access | Benefit | No -Medium | No -Medium | No -Medium | No -Medium | No -Medium | No -Medium | Yes | Yes | Yes | Yes | Yes |
| Facility Operates During Power Outage | Benefit | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Ground Storage Reservoirs | | | | | | | | | | | | |
| Boil Water Notice | Risk | High | High | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Groundwater Infiltration | Risk | High | High | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Potential for River Flooding | Risk | Medium | Medium | Medium | Medium | Medium | Medium | Low | Low | Low | Low | Low |
| Year Round Dry Land Access | Benefit | No -Medium | No -Medium | No -Medium | No -Medium | No -Medium | No -Medium | Yes | Yes | Yes | Yes | Yes |
| Facility Operates During Power Outage | Benefit | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Main Booster Pump Station | | | | | | | | | | | | |
| Boil Water Notice | Risk | High | High | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Draining Water Tower Fast | Risk | High | High | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Potential for River Flooding | Risk | Medium | Medium | Medium | Medium | Medium | Medium | Low | Low | Low | Low | Low |
| Year Round Dry Land Access | Benefit | No -Medium | No -Medium | No -Medium | No -Medium | No -Medium | No -Medium | Yes | Yes | Yes | Yes | Yes |
| Solves Pump Priming Issue | Benefit | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Facility Operates During Power Outage | Benefit | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Well 4 Site | | | | | | | | | | | | |
| Potential for River Flooding | Risk | Medium | Medium | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Year Round Dry Land Access | Benefit | No -Medium | No -Medium | No -Medium | No -Medium | No -Medium | No -Medium | Yes | Yes | Yes | Yes | Yes |
| Facility Operates During Power Outage | Benefit | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Well 5 Site | | | | | | | | | | | | |
| Facility Operates During Power Outage | Benefit | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Well 8 Water Filter Plant | | | | | | | | | | | | |
| Build Raw Water Transmission Main to Well 9 | Risk | No | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Facility Operates During Power Outage | Benefit | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Well 9 Water Filter Plant | | | | | | | | | | | | |
| Add Building to Well Site | Risk | No | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Replace Media in Existing Pressure Filter | Benefit | No | Yes | No | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Facility Operates During Power Outage | Benefit | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

Kaukauna Utilities
Water Study
3/6/2024

| Risk Level | Benefit Level |
|---|---|
| High - Yes | Low - No |
| Medium | Medium |
| Low - No | High - Yes |

Water Treatment Options

| | |
|---|---|
| Option 1 | Keep Existing Filtration Treatment Process |
| Option 2 | Ion Exchange Treatment Process |
| Option 3 | Reverse Osmosis/ Nanofiltration Treatment Process |
| Option 4 | Pellet Softening |
| Option 5 | Change from Ground Water Source to Surface Water Source |

## Risks and Benefits for Main Filter Plant Alternatives and Water Treatment Options

| Description | Risk or Benefit | No Change | Replace Filter Tank at Existing Location | Rebuild Water Treatment Plant Building and Reserviors at Current Location | | | | New Water Treatment Plant at New Site | | | | Switch to Surface Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Alternative 1 | Alternative 2 | Alternative 3 | | | | Alternative 4 | | | | |
| | | Option 1 | Option 1 | Option 1 | Option 2 | Option 3 | Option 4 | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 |
| Well 10 Site | | | | | | | | | | | | |
| Facility Operates During Power Outage | Benefit | No | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Water Treatment Process | | | | | | | | | | | | |
| Capital Costs | Risk | None | Low | Medium | Medium | High | High | Low | Medium | High | High | Medium |
| Operating Costs | Risk | Low | Low | Low | Medium | High | Medium | Low | Medium | High | Medium | High |
| Discharges Chlorides to the WWTP | Risk | No | No | No | Yes | No | No | No | Yes | No | No | No |
| Adds Sodium to the Water | Risk | No | No | No | Yes | No | Yes - Caustic, No - Lime | No | Yes | No | Yes - Caustic, No - Lime | No |
| Treatment Process Uses Excess Water | Risk | No | No | No | No | Yes | No | No | No | Yes | No | No |
| Uses Chemicals to remove Radium | Risk | Yes | Yes | Yes | No | No | Yes | Yes | No | No | Yes | No |
| Uses Chemicals for AntiScaling | Risk | No | No | No | No | Yes | No | No | No | Yes | No | No |
| Use Chemicals for pH Adjustment | Risk | No | No | No | Yes | No | Yes | No | Yes | No | Yes | No |
| New Treatment Process For Operators | Risk | No | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes | No |
| Operator Input | Risk | Low | Low | Low | Medium | Low | High | Low | Medium | Low | High | Low |
| Requires Centralized Treatment Plant | Risk | No | No | No | No | No | No | No | No | No | No | No |
| Requires 24-hour Well Run Time | Risk | No | No | No | No | No | No | No | No | No | No | No |
| Requires 8-hour Minimum Well Run Time | Risk | No | No | No | No | No | Yes | No | No | No | Yes | No |
| Liquid Waste | Risk | Yes | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | No | No |
| Liquid Waste Required to go to WWTP | Risk | Yes | Yes | Yes | Yes | Maybe | No | Yes | Yes | Maybe | No | No |
| Amount of Liquid Waste Produced | Risk | 6% | 6% | 6% | 6% | 17% | Minimal | 6% | 6% | 17% | Minimal | No |
| Removes Iron | Benefit | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Removes Manganese | Benefit | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Removes Calcium | Benefit | No | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Removes Magnesium | Benefit | No | No | No | Yes | Yes | No | No | Yes | Yes | No | Yes |
| Removes Radium | Benefit | Yes | Yes | Yes | Yes | Yes | 50-80% | Yes | Yes | Yes | 50-80% | Yes |
| Removes Hardness | Benefit | No | No | No | Yes | Yes | 80-90% | No | Yes | Yes | 80-90% | Yes |
| Removes Sulfate | Benefit | No | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Removes Total Dissolved Solids | Benefit | No | No | No | Yes | Yes | 80-90% | No | 100% | 100% | 80-90% | Yes |
| Removes Strontium | Benefit | No | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Removes PFAS | Benefit | No | No | No | No | Yes | No | No | No | Yes | No | Yes |
| Reduces existing Salt Usage by Customers | Benefit | No | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Extends life of customer water heaters | Benefit | No | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |

Kaukauna Utilities
Water Study
3/6/2024

| Risk Level | Benefit Level |
|---|---|
| High - Yes | Low - No |
| Medium | Medium |
| Low - No | High - Yes |

Water Treatment Options

| | |
|---|---|
| Option 1 | Keep Existing Filtration Treatment Process |
| Option 2 | Ion Exchange Treatment Process |
| Option 3 | Reverse Osmosis/ Nanofiltration Treatment Process |
| Option 4 | Pellet Softening |
| Option 5 | Change from Ground Water Source to Surface Water Source |

**Risks and Benefits for Main Filter Plant Alternatives and Water Treatment Options**

| Description | Risk or Benefit | No Change | Replace Filter Tank at Existing Location | Rebuild Water Treatment Plant Building and Reserviors at Current Location | | | | New Water Treatment Plant at New Site | | | | Switch to Surface Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Alternative 1 | Alternative 2 | Alternative 3 | | | | Alternative 4 | | | | |
| | | Option 1 | Option 1 | Option 1 | Option 2 | Option 3 | Option 4 | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 |
| Water Age Longer than 7 days | Risk | No | No | No | No | No | No | No | No | No | No | Yes |
| Maintain Wells as Backup & Pump to Waste | Risk | No | No | No | No | No | No | No | No | No | No | Yes |
| Single Source Water Supply Main | Risk | No | No | No | No | No | No | No | No | No | No | Yes |
| Raises Water Rates | Risk | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Kaukauna Utilities in Control of Water Rates | Benefit | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No |
| Potential to Save Customer Softening Costs | Benefit | No | No | No | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes |
| Grants Available | Benefit | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

# APPENDIX H

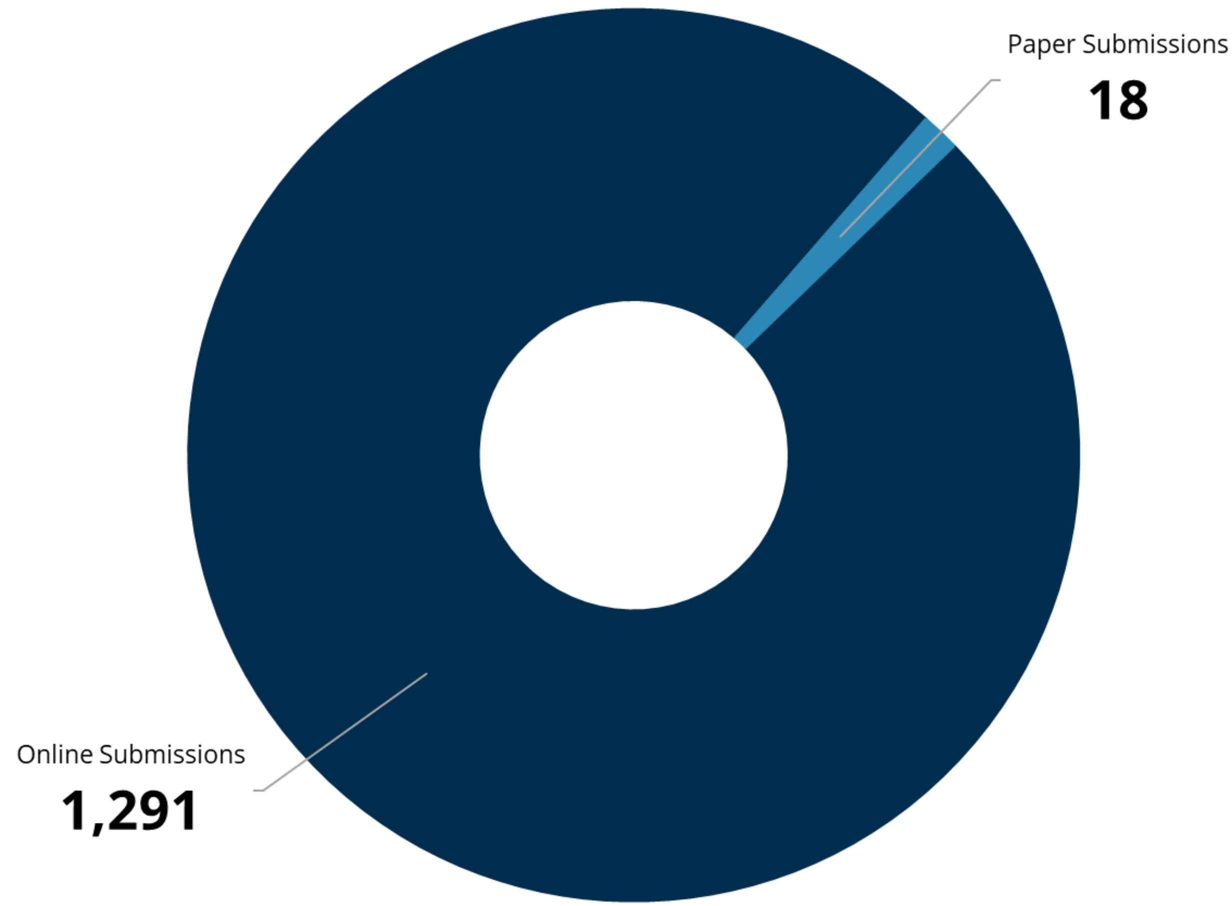
# Surveys and Water Softener Costs Details

KAUKAUNA UTILITIES

# WATER QUALITY & CUSTOMER SATISFACTION

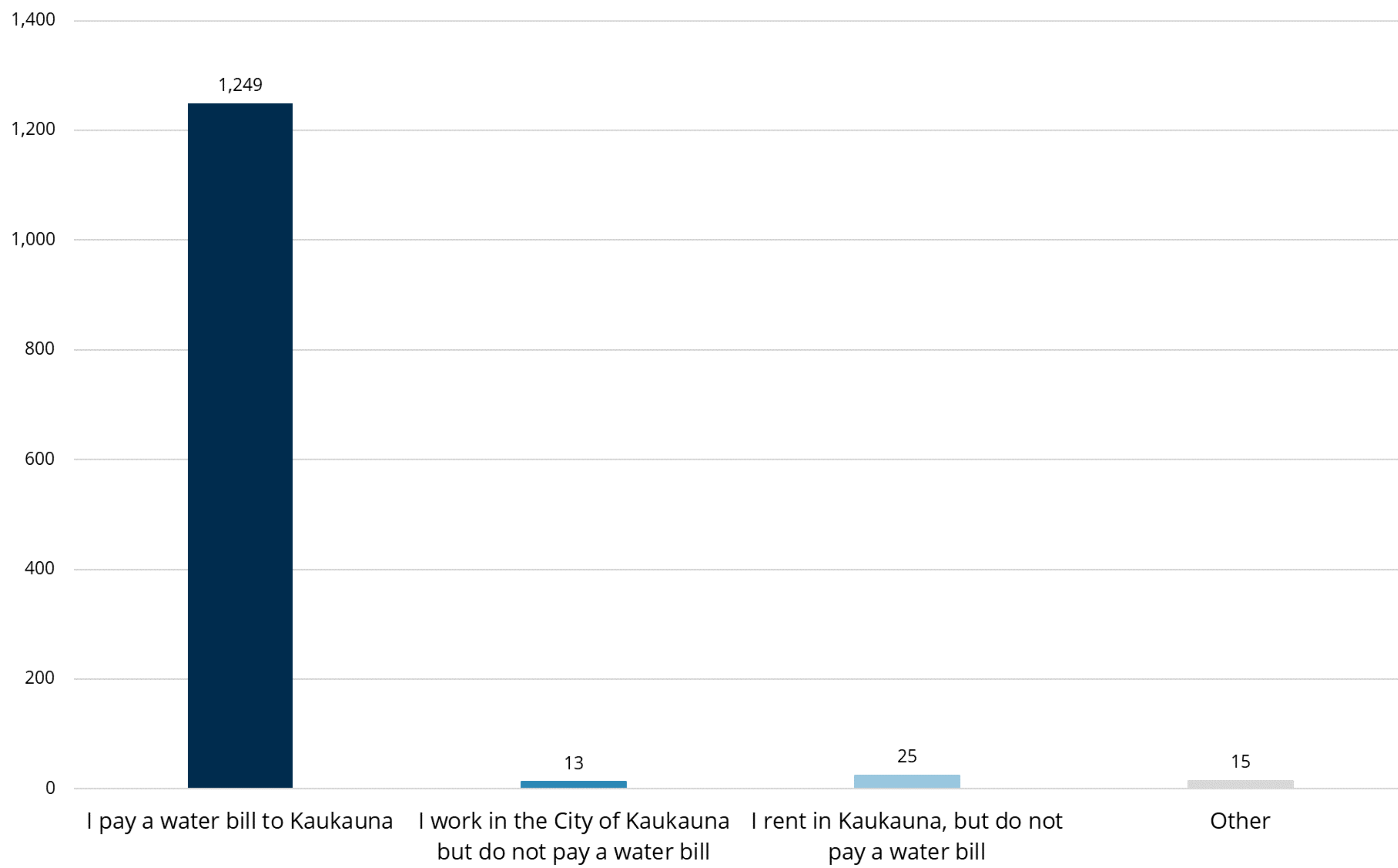
## Survey Analysis

# Total responses:



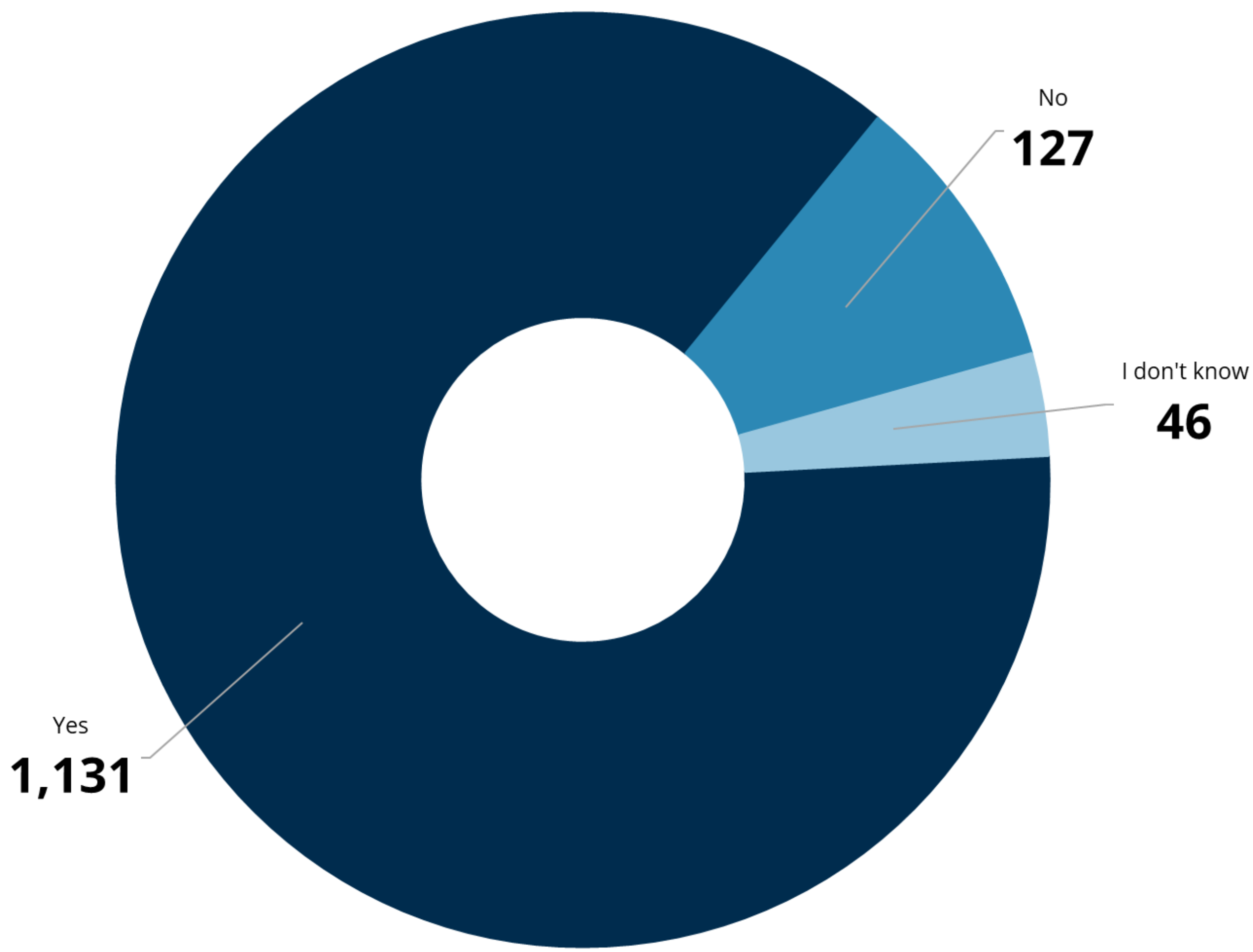
## **Q1:** Please select the option below that best describes you:

Answered: 1,302  Skipped: 7



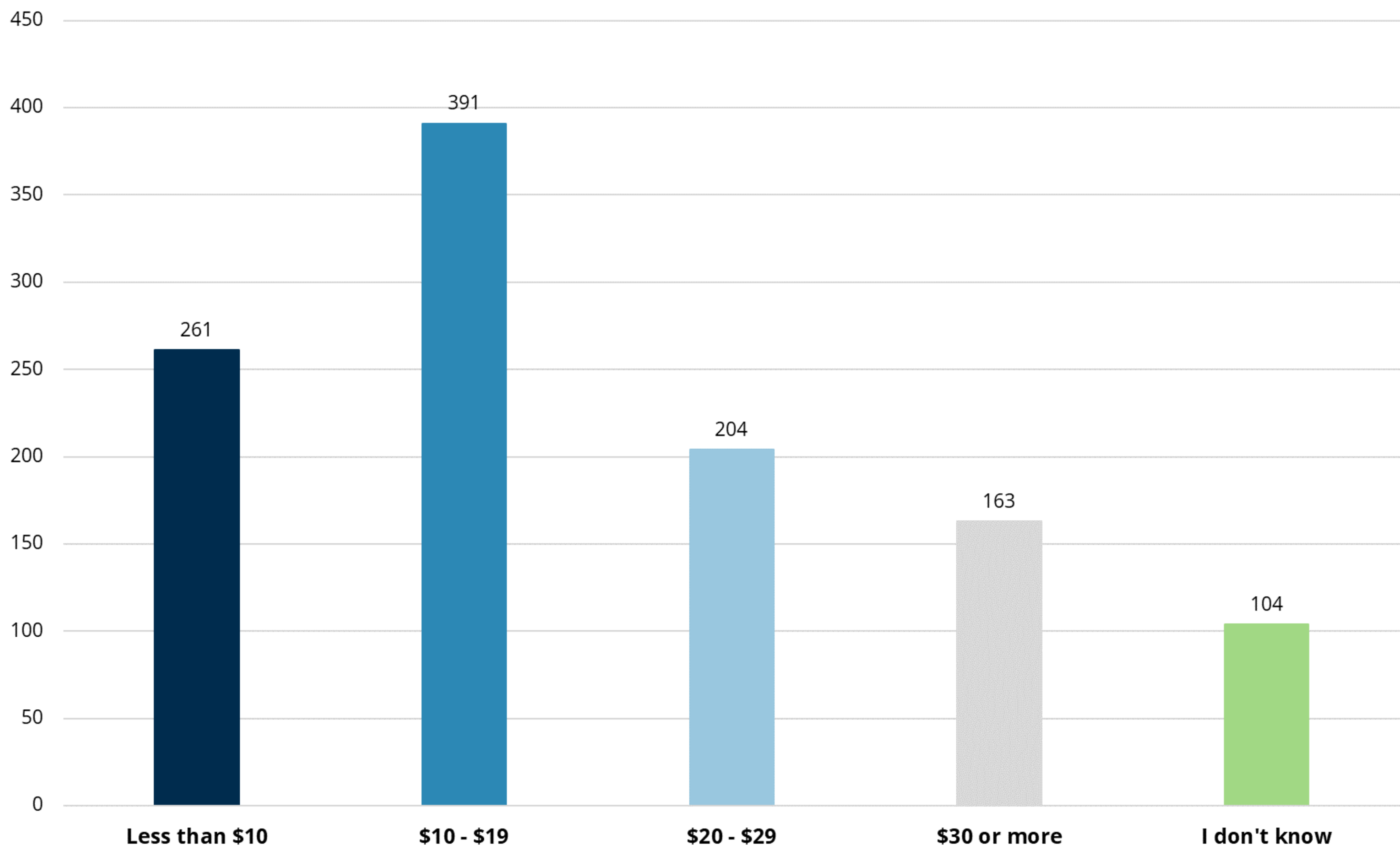
## **Q2:** Does your home or business have a water softener?

Answered: 1,304 Skipped: 5



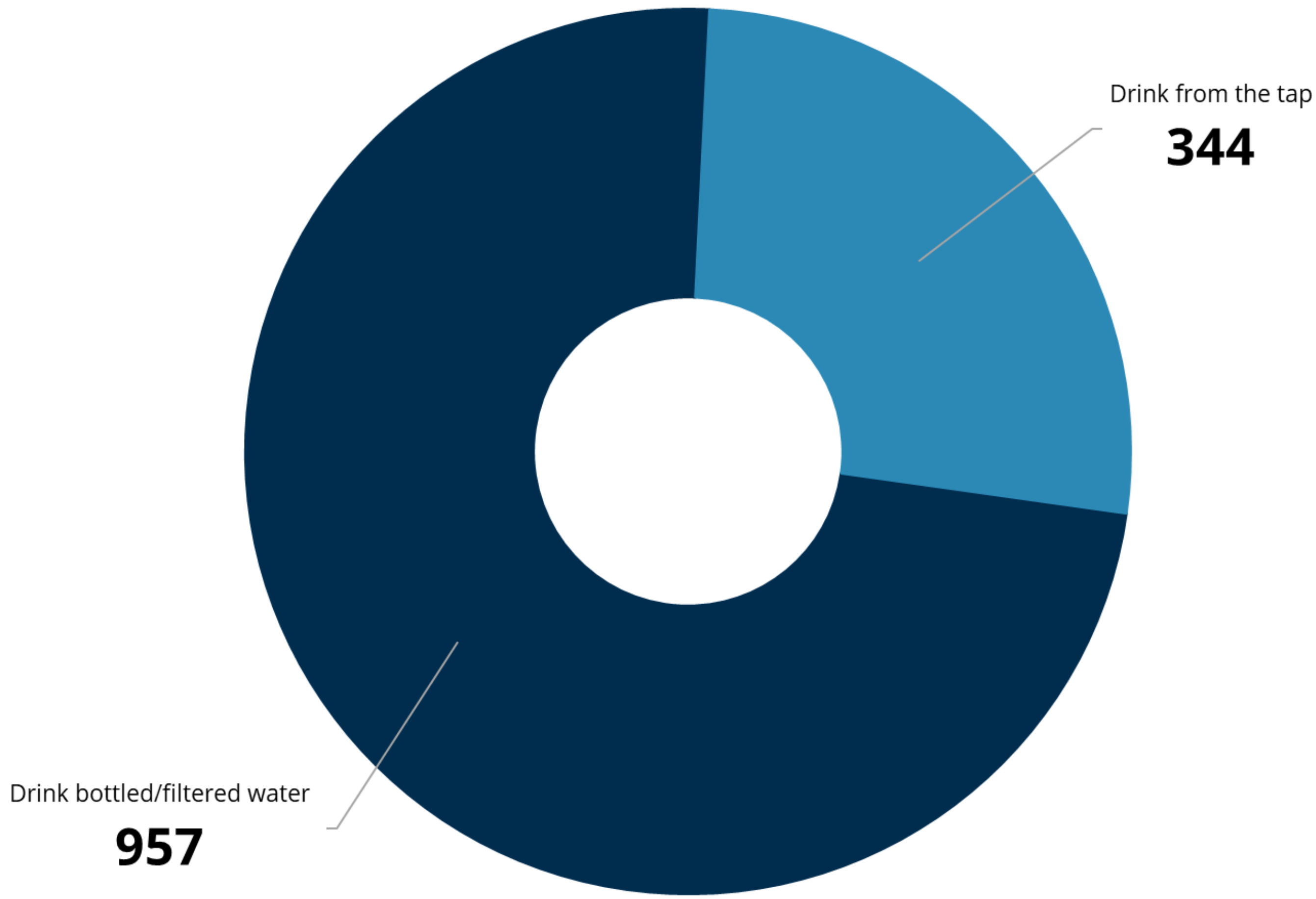
## **Q3:** About how much do you spend per month on your softening system (including salt and maintenance)?

Answered: 1,123  Skipped: 186



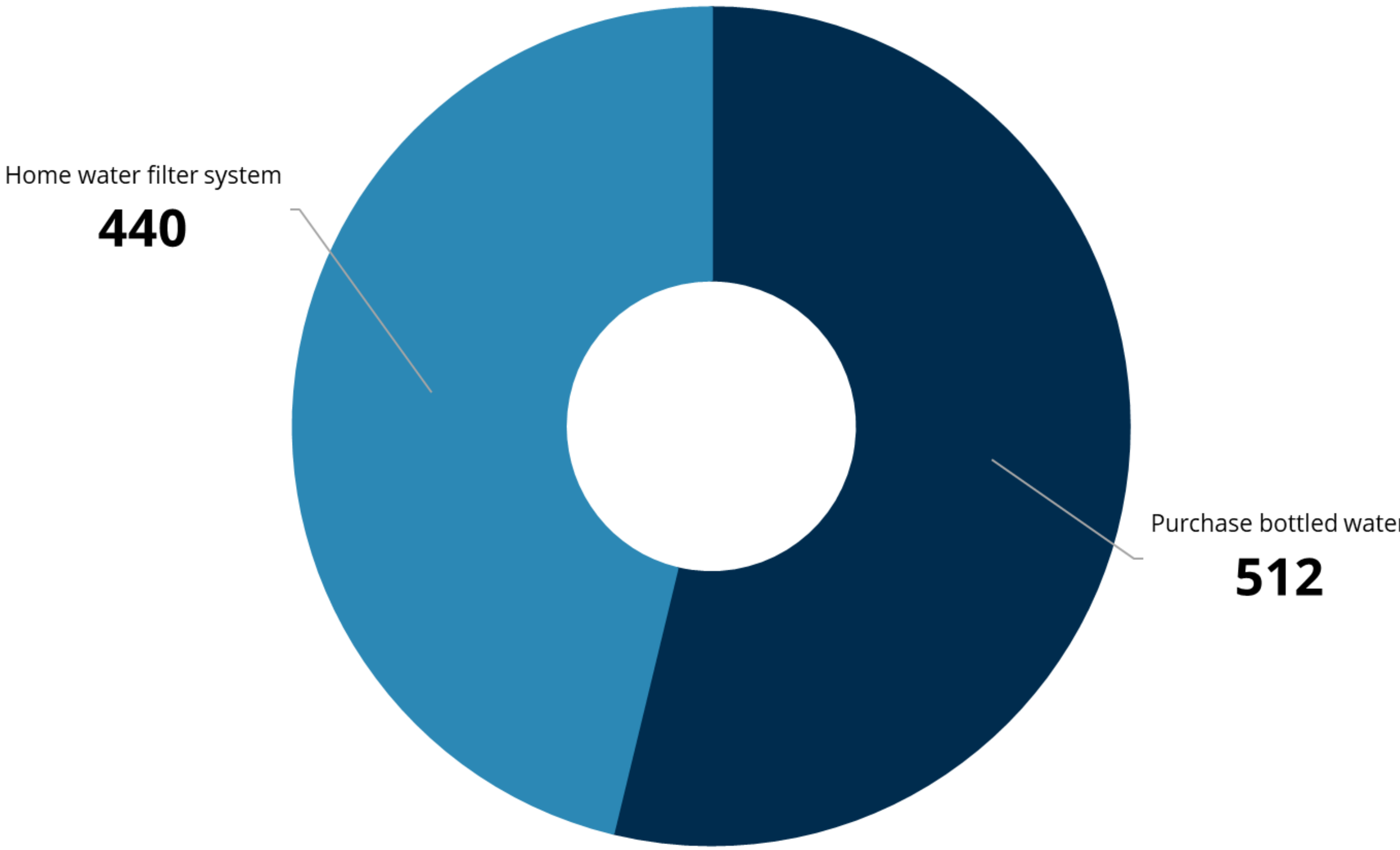
## **Q4:** Do you drink water from the tap or drink bottled/filtered water?

Answered: 1,301 Skipped: 8



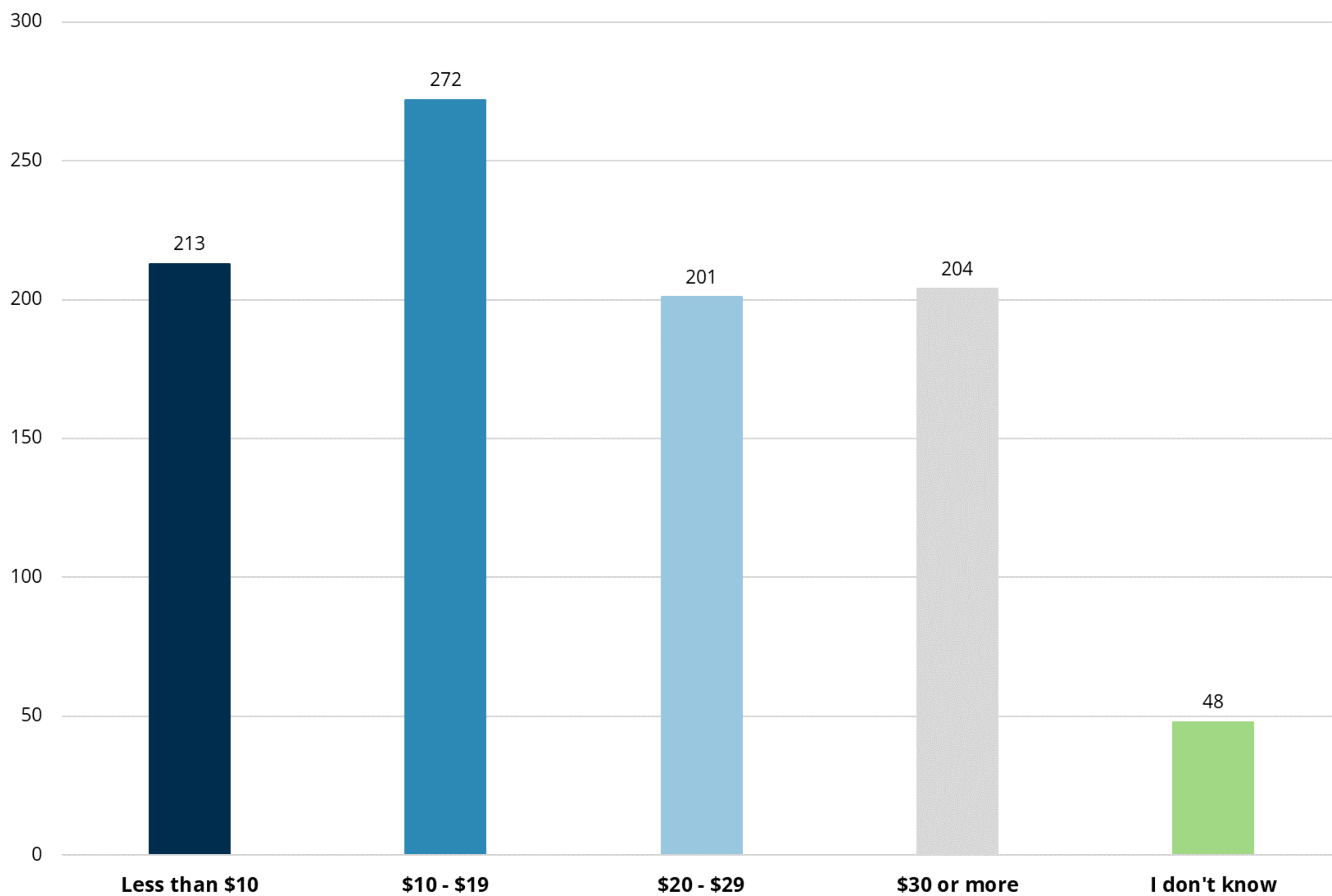
## **Q5:** If bottled/filtered water, do you purchase bottled water or have a home water filter system?

Answered: 952 Skipped: 357



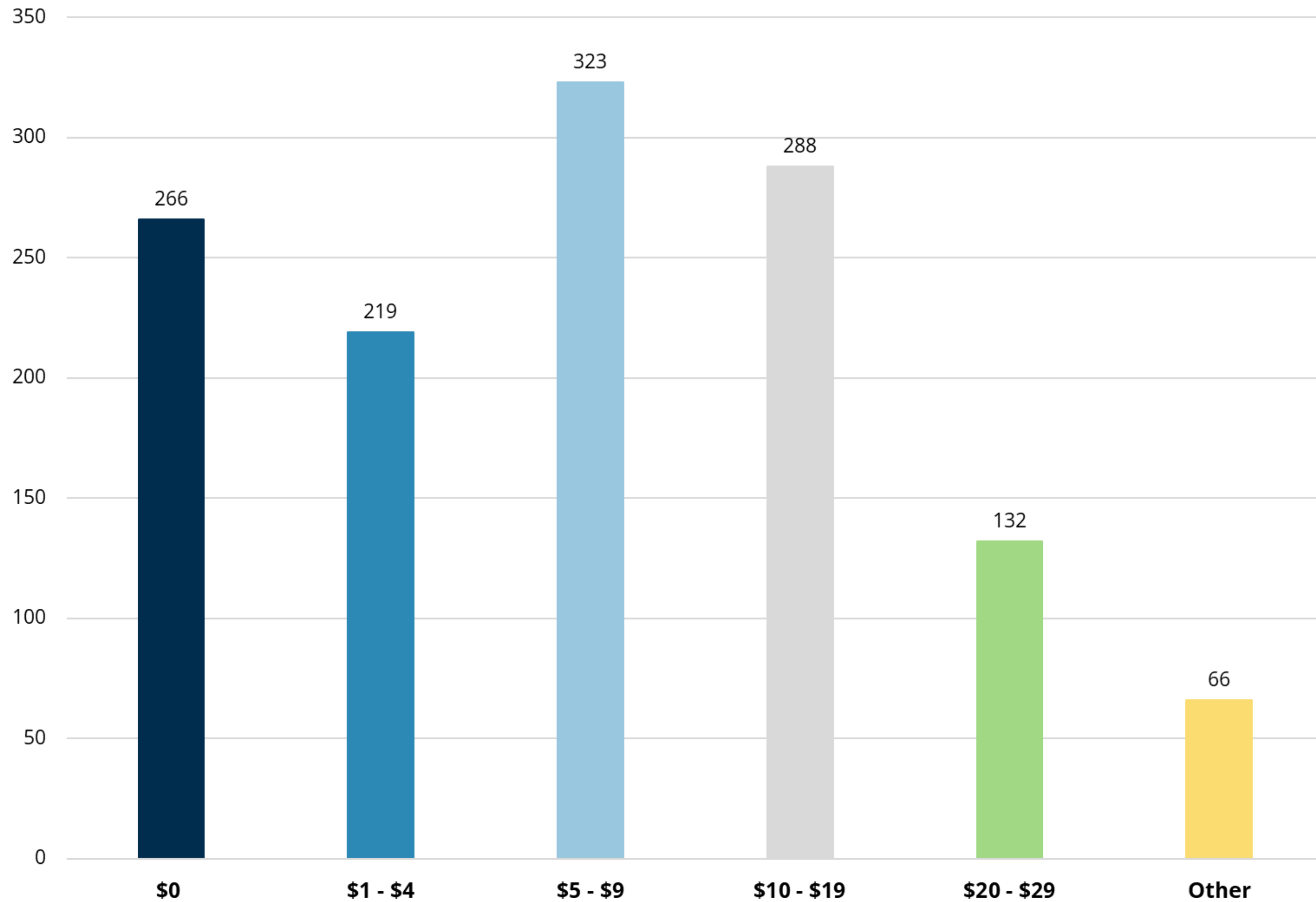
## **Q6:** If bottled/filtered water, about how much do you spend per month purchasing bottled water or maintaining your home water filter system?

Answered: 938  Skipped: 371



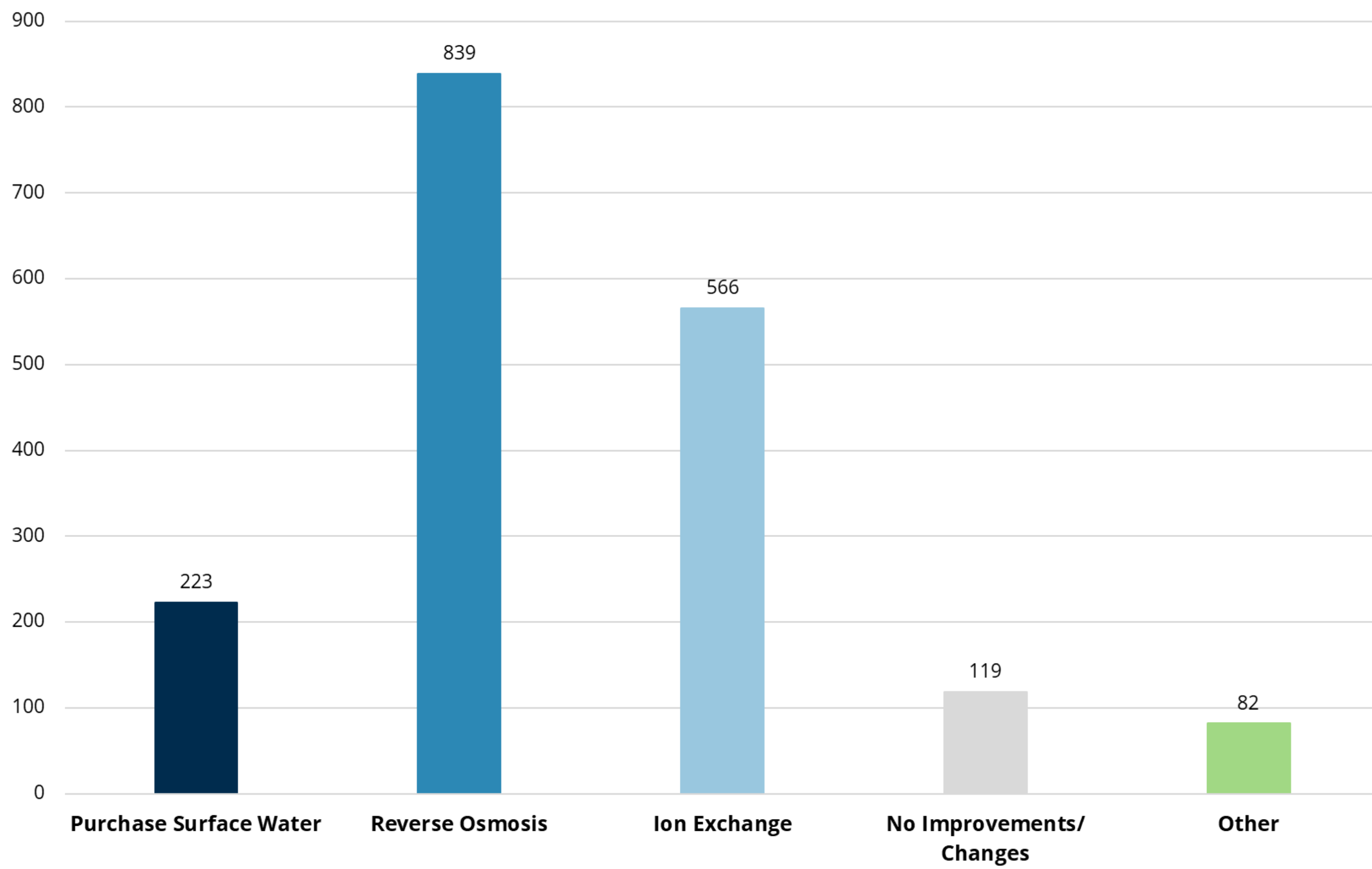
## **Q7:** How much would you be willing to pay, per month, for the utility to soften the water so you would no longer have to soften the water at your home or business?

Answered: 1,294  Skipped: 15



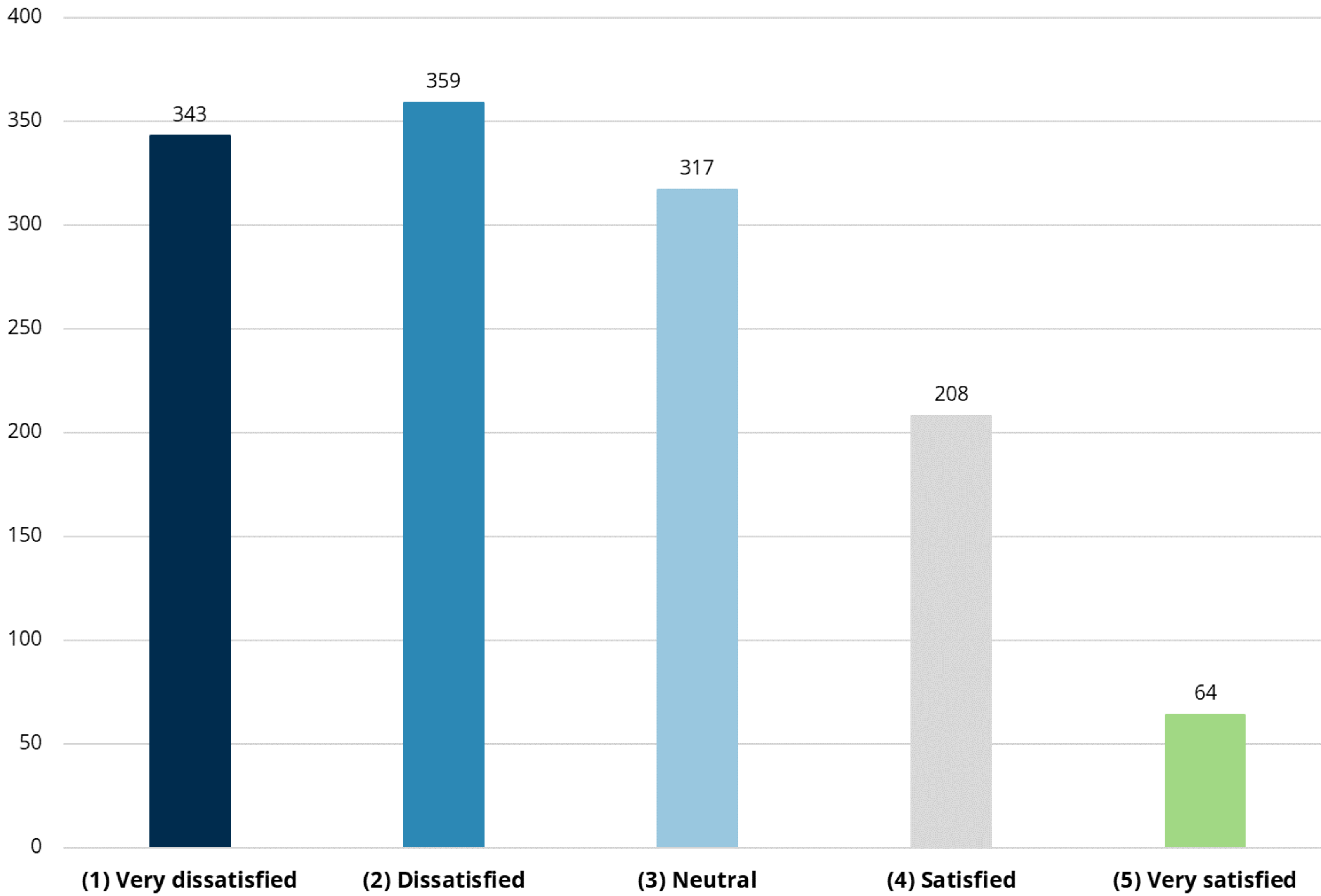
## **Q8:** What improvements or changes would you like to see to Kaukauna Utilities' water quality? *Please select all that apply.*

Answered: 1,281  Skipped: 28



**Q9:** On a scale of 1 (very dissatisfied) to 5 (very satisfied), how satisfied are you with your water quality from Kaukauna Utilities?

Answered: 1,291  Skipped: 18



## **Q10:** What is/are the reason/s for your answer?

*Key themes presented below:*

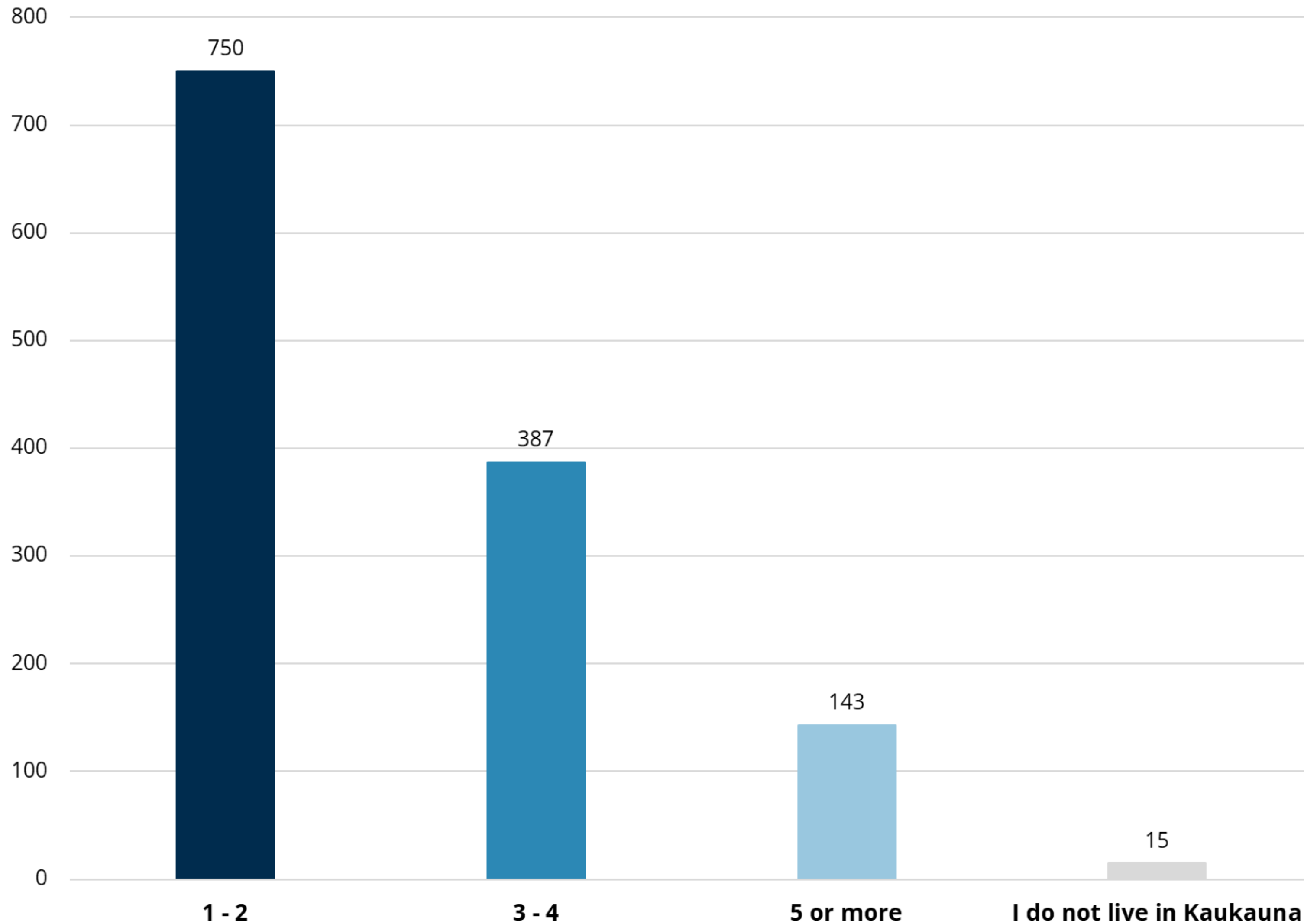
Wear on appliances
(faucets, fixtures, softeners,
water heaters, etc)

Poor quality
Hard water

Tastes bad
Won’t drink it

## **Q11:** How many people reside at your address?

Answered: 1,295 Skipped: 14



# **Plumber Survey -** Compiled Answers

| | | | Lifespan Questions (years) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Contractor | % of work in Kaukauna | Total Years of Service in Area | Water Softener - Kaukauna | Water Softener - Elsewhere | Water Heater - Kaukauna | Water Heater - Elsewhere | Dishwasher - Kaukauna | Dishwasher - Elsewhere | Clothes Washer - Kaukauna | Clothes Washer - Elsewhere | Fixtures - Kaukauna | Fixtures - Elsewhere | Salt Usage (lb/month) | Cost for Electric Water Heater |
| Plumber 1 | 15 | 32 | 10 - 15 | 10 - 15 | 6 | 10 - 15 | - | - | - | - | - | - | - | $ 950.00 |
| Plumber 2 | 10 | 20 | 10 - 12 | 15 - 20 | 7 - 8 | 10 - 15 | 5 - 15 | 10 - 15 | 5 - 10 | 10 - 15 | 5 - 10 | 20+ | - | $ 1,350.00 |
| Plumber 3 | 35 | 50 | 15 | 15 | 10 | 10 | 3 | 10 | - | - | 5 | 15 | 90 | $ 1,000.00 |
| Plumber 4 | 10 | 41 | - | - | 6 - 8 | 10 - 12 | 6 - 8 | 10 - 12 | - | - | - | - | - | $ 900.00 |
| Plumber 5 | 15 | 7 | 8 - 10 | - | 6 - 7 | 10 - 15 | 6 - 8 | 10 - 15 | - | - | 5 - 10 | 20+ | 60 | $ 1,000.00 |
| Plumber 6 | 50 | 25 | 15 | 15 | 8 - 12 | - | - | - | - | - | - | - | 50 - 100 | $ 1,000.00 |
| Plumber 7 | 50 | 42 | 10 - 20 | 10 - 20 | 1 - 7 | 20 | 10 - 12 | 10 - 12 | - | - | - | - | 93 | $ 1,400.00 |

## **Softening Company Survey -** Compiled Answers

| Company | % of work in Kaukauna | Total Years of Service in Area | Average Water Softener Age | Average Water Softener Cost | Cost for Water Softener - Commercial or Apartments | Salt Usage (lb/month) | Est. % of Homes/Businesses in Kaukauna with Water Softeners |
|---|---|---|---|---|---|---|---|
| Company 1 | 45 | 50 | 15 - 20 years | $ 1,550.00 | $5,000 - $20,000 | 100 | 99 |

## Current Water Softening Costs for Kaukauna Customers

Note - all cost estimates below are done for the 0.75" water meter. These costs are then scaled for larger meters. See below for scaling explanation.

### Salt Costs

| | | |
|---|---|---|
| Cost of Salt | $0.18 | per pound |
| | 100 | pounds per month for Kaukauna average residential customer* |
| | $18.00 | per month |
| | $216.00 | per year |

**Based on plumber survey, see Appendix G.*

### Water Softener Regeneration Costs

1. Water Cost

50 gallons per regeneration cycle

*High estimate: regeneration cycle every 2 days*

| | | | |
|---|---|---|---|
| | 2 | days | |
| | 9,125 | gallons for regeneration per year | |
| | 1,220 | cubic feet for regeneration per year | |
| $ | 11.61 | per 100 cubic feet total rate (water $2.86 + wastewater $8.75) | |
| $ | 141.61 | per year | high estimate |

*Low estimate: regeneration cycle every 7 days*

| | | | |
|---|---|---|---|
| | 7 | days | |
| | 2,607 | gallons for regeneration per year | |
| | 349 | cubic feet for regeneration per year | |
| $ | 11.61 | per 100 cubic feet total rate (water $2.86 + wastewater $8.75) | |
| $ | 40.46 | per year | low estimate |

| | | | | | |
|---|---|---|---|---|---|
| Total annual water regeneration costs | $ | 40.46 | - | $ 141.61 | |
| Average water cost for regeneration per year | | | $ 91.04 | | |

### Water Softener Replacement Costs

| | | | |
|---|---|---|---|
| Average Water Softener Installed Cost* | $ | 1,000.00 | |
| Lifespan of Water Softener in Kaukauna* | | 10 | Year |

**Based on plumber survey, see Appendix G.*

| | | |
|---|---|---|
| Cost per year | $ | 100.00 |

## Water Heater Replacement Costs

| | | | |
|---|---|---|---|
| Average Water Heater Installed Cost* | $ | 1,100.00 | |
| Lifespan of Water Heater in Kaukauna* | | 7 | Year |
| **Based on plumber survey, see Appendix G.* | $ | 157.14 | |

## Appliance Replacement Costs

| | | | |
|---|---|---|---|
| Dishwasher Cost | $ | 650.00 | |
| Dishwasher Installation Cost | $ | 200.00 | |
| Lifespan* | | 7 | Year |
| Cost per year | $ | 121.43 | |
| | | | |
| Clothes Washer Cost | $ | 800.00 | |
| Clothes Washer Installation Cost | $ | 150.00 | |
| Lifespan* | | 7 | Year |
| Cost per year | $ | 135.71 | |
| | | | |
| Total appliance replacement cost per year | $ | 257.14 | |

**Based on plumber survey, see Appendix G.*

## Customer Costs with Hardness Reduction Treatment

Note - all cost estimates below are done for the 0.75 inch water meter. These costs are then scaled for larger meters. See below for scaling explanation.

### Salt Costs

| | | |
|---|---|---|
| Kaukauna Avg Current Hardness | 635 | mg/L |
| Target Hardness | 120 | mg/L |
| Ratio Avg : Target | 0.19 | |

| | | |
|---|---|---|
| Cost of Salt | $0.18 | per pound |
| | 100 | pounds per month for Kaukauna residential customer for current hardness* |
| | 19 | pounds per month for target hardness |
| | $3.40 | per month |
| | $40.82 | per year |

**Based on plumber survey, see Appendix G.*

### Water Softener Regeneration Costs

1. Water Cost

| | | |
|---|---|---|
| | 50 | gallons per regeneration |

*High Estimate*

| | | |
|---|---|---|
| | 2 | current average days between regeneration |
| | 0.19 | ratio between target and current hardness |
| | 10.6 | days between regeneration with target hardness levels |
| | 1,724 | gallons for regeneration per year |
| | 231 | cubic feet for regeneration per year |
| $ | 11.61 | per 100 cubic feet total rate (water $2.86 + wastewater $8.75) |
| $ | 26.76 | per year high estimate |

*Low Estimate*

| | | |
|---|---|---|
| | 7 | current average days between regeneration |
| | 0.19 | ratio between target and current hardness |
| | 37 | days between regeneration with target hardness levels |
| | 493 | gallons for regeneration per year |
| | 66 | cubic feet for regeneration per year |
| $ | 11.61 | per 100 cubic feet total rate (water $2.86 + wastewater $8.75) |
| $ | 7.65 | high estimate per year |

| | | | | |
|---|---|---|---|---|
| Total annual water regeneration costs | $ 7.65 | - | $ 26.76 | |
| Average cost for regeneration per year | | $ 17.20 | | |

## Water Softener Replacement Costs

| | | | |
|---|---|---|---|
| Average Water Softener Cost* | $ | 1,000.00 | |
| Lifespan of Water Softener w Soft Water* | | 15 | Year |
| **Based on plumber survey, see Appendix G.* | | | |
| Cost per year | $ | 66.67 | |

## Water Heater Replacement Costs

| | | | |
|---|---|---|---|
| Average Water Heater Cost* | $ | 1,100.00 | |
| Lifespan of Water Heater w Soft Water* | | 12.5 | Year |
| **Based on plumber survey, see Appendix G.* | | | |
| Cost per year | $ | 88.00 | |

## Appliance Replacement Costs

| | | | |
|---|---|---|---|
| Dishwasher Cost | $ | 650.00 | |
| Dishwasher Install | $ | 200.00 | |
| Lifespan* | | 12.5 | Year |
| Cost per year | $ | 68.00 | |
| | | | |
| Clothes Washer Cost | $ | 800.00 | |
| Clothes Washer Install | $ | 150.00 | |
| Lifespan* | | 12.5 | Year |
| Cost per year | $ | 76.00 | |
| | | | |
| Total appliance replacement cost per year | $ | 144.00 | |

**Based on plumber survey, see Appendix G.*

**Scaling the above cost estimates for larger meters -**

| Meter Size (inch) | Cross Sectional Area of Service (Square inches) | Area Ratio to 0.75 inch Meter |
|---|---|---|
| 0.75 | 0.44 | 1.00 |
| 1.0 | 0.79 | 1.78 |
| 1.5 | 1.77 | 4.00 |
| 2.0 | 3.14 | 7.11 |
| 3.0 | 7.07 | 16.00 |
| 4.0 | 12.57 | 28.44 |

Use the ratio of the cross sectional areas as a multiplying factor for the average cost for each water service size.
Note that there is no difference between appliance replacement for 0.75 inch and 1.0 inch residential customers.

# PLUMBER SURVEY

PLUMBER 1
11/28/2023

1. Do you do plumbing work in the City of Kaukauna?
    a. YES 15 % OF THEIR WORK IS IN KAUKAUNA.
2. How long have you been doing business in the area?
    a. 32 YEARS.
3. Do you notice a water quality difference in Kaukauna vs other communities in the area?
    a. YES – KAUKAUNA IS WORSE.
4. What is the lifespan for X in Kaukauna? Is there a difference between Kaukauna and other communities?
    a. Softener – brand preference? HE DOESN'T DO MUCH WITH SOFTENERS, BUT WOULD SAY THEY GENERALLY LAST 10-15 YEARS.
    b. Water Heater – brand preference? IN KAUKAUNA, 5-6 YEARS. IN OTHER COMMUNITIES 10-15 YEARS.
    c. Dishwasher – NO INPUT.
    d. Clothes Washer – NO INPUT.
    e. Plumbing Fixtures – NO INPUT.
5. Do you know how much salt a typical Kaukauna customer goes through per month? NO INPUT.
6. What is the typical cost for a water heater at a residence? Installation cost?
    a. $1300 STANDARD INSTALLED
    b. $2200 POWER VENT INSTALLED
    c. $900-$1000 ELECTRIC. THIS IS MOST COMMON IN KAUKAUNA.
7. Have you noticed if Kaukauna has more emergency plumbing calls/requests vs other communities?
    a. NO
8. Please share any additional comments or suggestions regarding Kaukauna Utilities' water.
   WRIGHTSTOWN USED TO HAVE SIMILAR WATER QUALITY BEFORE SWITCHING TO SURFACE WATER. MANY IN THAT COMMUNITY HAVE GOTTEN RID OF WATER SOFTENERS.

# PLUMBER SURVEY

PLUMBER 2
12/7/2023

1. Do you do plumbing work in the City of Kaukauna?
    a. YES 5-10% OF THEIR WORK IS IN KAUKAUNA.
2. How long have you been doing business in the area?
    a. 20+ YEARS.
3. Do you notice a water quality difference in Kaukauna vs other communities in the area?
    a. YES – KAUKAUNA WATER IS MUCH HARDER.
4. What is the lifespan for X in Kaukauna? Is there a difference between Kaukauna and other communities?
    a. Softener – brand preference? 10-12 YEARS IN KAUKAUNA VS. 15-20 YEARS ELSEWHERE. THEY PREFER CLACK VALVES, FROM CAPITAL WATER CONDITIONING IN MADISON.
    b. Water Heater – brand preference? 7-8 YEARS IN KAUKAUNA VS. 10-15 YEARS ELSEWHERE.
    c. Dishwasher – 10-15 YEARS WITH WATER SOFTENER VS. 5-10 YEARS WITHOUT WATER SOFTENER (DEPENDS ON WATER SOFTENING AT RESIDENCE IN KAUKAUNA).
    d. Clothes Washer – 10-15 YEARS WITH WATER SOFTENER VS. 5-10 YEARS WITHOUT WATER SOFTENER (DEPENDS ON WATER SOFTENING AT RESIDENCE IN KAUKAUNA).
    e. Plumbing Fixtures – 5-10 YEARS IN KAUKAUNA VS. 20+ YEARS ELSEWHERE.
5. Do you know how much salt a typical Kaukauna customer goes through per month? NO.
6. What is the typical cost for a water heater at a residence? Installation cost?
    a. $2000+ POWER VENTED GAS
    b. $1500 STANDARD VENTED GAS
    c. $1300-1400 ELECTRIC
7. Have you noticed if Kaukauna has more emergency plumbing calls/requests vs other communities?
    a. NO
8. Please share any additional comments or suggestions regarding Kaukauna Utilities' water.

# PLUMBER SURVEY

PLUMBER 3

11/28/2023

1. Do you do plumbing work in the City of Kaukauna?
    a. YES 30-40% OF THEIR WORK IS DONE IN KAUKAUNA.
2. How long have you been doing business in the area?
    a. 50 YEARS
3. Do you notice a water quality difference in Kaukauna vs other communities in the area?
    a. YES – HE SEES HIGH HARDNESS, HIGH TDS, RADIUM HIGH.
4. What is the lifespan for X in Kaukauna? Is there a difference between Kaukauna and other communities?
    a. Softener – brand preference? 15 YR, ABOUT THE SAME
    b. Water Heater – brand preference? 10 YRS, ABOUT THE SAME
    c. Dishwasher – NO WATER SOFTENER 3 YR, W WATER SOFTENER 10 YR
    d. Clothes Washer
    e. Plumbing Fixtures – 5 YR NO WATER S, 15 YR W WATER S
5. Do you know how much salt a typical Kaukauna customer goes through per month? 1 LB/DAY/PERSON KAKAUNA
6. What is the typical cost for a water heater at a residence? Installation cost? $1,000 W INSTALL
7. Have you noticed if Kaukauna has more emergency plumbing calls/requests vs other communities?
    a. NO
8. Please share any additional comments or suggestions regarding Kaukauna Utilities' water.

# PLUMBER SURVEY

PLUMBER 4
12/7/2023

1. Do you do plumbing work in the City of Kaukauna?
    a. YES 10% OF WORK IS IN KAUKAUMNA
2. How long have you been doing business in the area?
    a. 41 YEARS
3. Do you notice a water quality difference in Kaukauna vs other communities in the area?
    a. YES – WATER IS HARDER AND IS HARDER ON FIXTURES AND APPLIANCES.
4. What is the lifespan for X in Kaukauna? Is there a difference between Kaukauna and other communities?
    a. Softener – brand preference? N/A
    b. Water Heater – brand preference? 6-8 YEARS IN KAUKAUNA, 10-12 YEARS ELSEWHERE
    c. Dishwasher 6-8 YEARS IN KAUKAUNA, 10-12 YEARS ELSEWHERE
    d. Clothes Washer N/A
    e. Plumbing Fixtures N/A
5. Do you know how much salt a typical Kaukauna customer goes through per month? N/A
6. What is the typical cost for a water heater at a residence? Installation cost? $900 ELECTRIC
7. Have you noticed if Kaukauna has more emergency plumbing calls/requests vs other communities?
    a. NO
8. Please share any additional comments or suggestions regarding Kaukauna Utilities' water.

# PLUMBER SURVEY

PLUMBER 5

12/4/2023

1. Do you do plumbing work in the City of Kaukauna?
    a. YES ABOUT 15% OF THEIR WORK IS IN KAUKAUNA.
2. How long have you been doing business in the area?
    a. 7 YEARS
3. Do you notice a water quality difference in Kaukauna vs other communities in the area?
    a. Yes – WORST WATER IN THE AREA DUE TO HIGH HARDNESS.
4. What is the lifespan for X in Kaukauna? Is there a difference between Kaukauna and other communities?
    a. Softener – brand preference? 8-10 YEARS KAUKAUNA, NOT NEEDED ELSEWHERE. BRAND PREFERENCE IS WATER RIGHT.
    b. Water Heater – brand preference? 6-7 YEARS WITH HARD WATER IN KAUKAUNA, 10-15 YEARS WITH SOFT WATER.
    c. Dishwasher 6-8 YEARS WITH HARD WATER, 10-15 WITH SOFTENED WATER.
    d. Clothes Washer N/A
    e. Plumbing Fixtures HALF THE LIFESPAN WITH HARD WATER.
5. Do you know how much salt a typical Kaukauna customer goes through per month? 60 LB/ MONTH, DEPENDING ON SIZE OF HOUSEHOLD.
6. What is the typical cost for a water heater at a residence? Installation cost? $900-1100 ELECTRIC INSTALLED.
7. Have you noticed if Kaukauna has more emergency plumbing calls/requests vs other communities?
    a. NO
8. Please share any additional comments or suggestions regarding Kaukauna Utilities' water. N/A

# PLUMBER SURVEY

PLUMBER 6

11/28/2023

1. Do you do plumbing work in the City of Kaukauna?
    a. Yes – 50% OF THEIR WORK IS IN KAUKAUNA.
2. How long have you been doing business in the area?
    a. 25 YEARS
3. Do you notice a water quality difference in Kaukauna vs other communities in the area?
    a. Yes
        i. If yes, what are the major differences? YES – MOSTLY DUE TO HARDNESS AND POSSIBLY AN ADDITIVE THAT'S PUT IN FOR TREATMENT. 75% OF THE HOUSES HAVE WATER SOFTENERS AND THEY ARE NEEDED. WATER THAT GOES THROUGH WATER HEATERS AND APPLIANCES SHOULD BE SOFTENED WATER AS LONG AS PEOPLE TAKE CARE OF THE SOFTENER. HE HAS SEEN THAT PEOPLE DON'T KEEP ENOUGH SALT IN THE WATER SOFTENER.
4. What is the lifespan for X in Kaukauna? Is there a difference between Kaukauna and other communities?
    a. Softener – brand preference? KAUKAUA WATER SOFTENERS WORK TWICE AS HARD. CAN REBED SYSTEM, AND THEN THEY'D BE GOOD TO GO. WILL BREAK DOWN TWICE AS FAST. DEPENDS ON THE SOFTENER – HE MOSTLY DOES HELLENBRAND (PACKER CITY SOFT WATER IS THE SUPPLIER). 15 YEAR LIFE BUT IT DEPENDS ON THE SOFTENER I.E. BOUGHT AT MENARDS WOULDN'T HOLD UP AS WELL.
    b. Water Heater – brand preference? YES – DEPENDS ON THE BRAND AND QUALITY OF WATER HEATER. IF MAINTENANCE IS KEPT UP ON THEM, FLUSH THEM OUT EVERY YEAR. WOULD STILL SAY THAT THERE IS A DIFFERENCE. HE USED TO LIVE IN KAUKAUNA AND HAD A WATER HEATER THAT LASTED 17 YEARS, BUT HE HAS SEEN 8 YEARS LIFESPAN. 10-12 YEARS OLD WOULD BE THE END OF THE LIFESPAN IN KAUKAUNA.
    c. Dishwasher – NO INPUT.
    d. Clothes Washer – NO INPUT.
    e. Plumbing Fixtures – NO INPUT.
5. Do you know how much salt a typical Kaukauna customer goes through per month? (1-2) 50 LB BAGS.
6. What is the typical cost for a water heater at a residence? Installation cost?
    a. ELECTRIC $1000 INSTALLED.
    b. CONVENTIONAL NATURAL GAS $1300-1400 INSTALLED.
    c. POWER VENT NATURAL GAS +$2000 INSTALLED.

7. Have you noticed if Kaukauna has more emergency plumbing calls/requests vs other communities?
    a. No
8. Please share any additional comments or suggestions regarding Kaukauna Utilities' water.

# PLUMBER SURVEY

PLUMBER 7

11/29/2023

1. Do you do plumbing work in the City of Kaukauna?
   a. YES 50% OF HIS WORK IS IN KAUKAUNA.
2. How long have you been doing business in the area?
   a. 42 YEARS
3. Do you notice a water quality difference in Kaukauna vs other communities in the area?
   a. YES – THE STATUS QUO IN KAUKAUNA IS TO HAVE A WATER SOFTENER DUE TO THE HIGH WATER HARDNESS.
4. What is the lifespan for X in Kaukauna? Is there a difference between Kaukauna and other communities?
   a. Softener – brand preference? 10-20 YEARS. NO DIFFERENCE BETWEEN KAUKAUNA AND OTHER COMMUNITIES. THIS PLUMBER INSTALLS WATER SOFTENERS THAT ARE BIGGER FOR KAUKAUNA. GETTING THEM AT A BIG BOX STORE WOULD NOT BE SIZED CORRECTLY FOR KAUKAUNA, TOO SMALL.
   b. Water Heater – brand preference? 3-7 YEARS IN KAUKAUNA WITH WATER SOFTENER. 1-3 YEARS IN KAUKAUNA WITHOUT WATER SOFTENER. OTHER COMMUNITIES WOULD SEE A LIFESPAN OF 20 YEARS.
   c. Dishwasher – 10-12 YEARS. NO DIFFERENCE BETWEEN KAUKAUNA AND OTHER COMMUNITIES IF WATER IS SOFTENED CORRECTLY. DEPENDS ON THE QUALITY OF DISHWASHER BOUGHT.
   d. Clothes Washer – NO INPUT.
   e. Plumbing Fixtures – NO INPUT.
5. Do you know how much salt a typical Kaukauna customer goes through per month? HE GOES THROUGH 7 BAGS IN THREE MONTHS. IF THE WATER SOFTENER IS OLDER, THIS WOULD BE HIGHER.
6. What is the typical cost for a water heater at a residence? Installation cost?
   a. $1400 INSTALLED FOR ELECTRIC
   b. $1600 INSTALLED FOR 40 GALLON GAS.
   c. ELECTRIC IS MORE COMMON IN KAUKAUNA BECAUSE KAUKAUNA HAS ITS OWN ELECTRIC COMPANY SO IT IS CHEAPER, BUT GAS IS MORE EFFICIENT.
7. Have you noticed if Kaukauna has more emergency plumbing calls/requests vs other communities?
   a. NO

8. Please share any additional comments or suggestions regarding Kaukauna Utilities' water.

# SOFTENING COMPANY SURVEY

Company 1
1/2024

1. Do you do business in the City of Kaukauna?
    a. YES 40-50% OF BUSINESS IS DONE IN CITY OF KAUKAUNA.
2. How long have you been doing business in the area?
    a. 50+ YEARS
3. How long does your average water softener last?
    a. 15-20 YEARS
    b. Do you notice any difference in Kaukauna?
        i. HIGH HARDNESS
4. What brand of water softener do you sell?
    a. CLACK
5. How much does an average water softener cost for a Kaukauna residence? How much does installation cost?
    a. $1550
6. How much does an average water softener cost for a commercial business or apartment complex in Kaukauna? How much does installation cost?
    a. $5,000 - $20,000
7. On average, how much salt does a Kaukauna home go through monthly?
    a. 100 LB
8. What percentage of Kaukauna homes and businesses would you estimate currently have water softeners ?
    a. 99%

# APPENDIX J

# Water Treatment Equipment

# H.1 TONKA - ION EXCHANGE INFO

# RIDION™

## Conventional Ion Exchange Technology

### ADVANTAGES

- PLC-based regeneration controls
- Unique non-plugging, non-corroding regenerant distribution system

## Proven, reliable ion exchange processes

Tonka Water, a Kurita brand's RidION™ ion exchange systems solve a broad range of water treatment issues from uranium removal, to hardness and barium reduction. RidION™ systems incorporate the newest technologies in resin regeneration, guaranteeing an efficient and effective process with custom controls for your system. Tonka Water's RidION™ systems incorporate the latest resin technology utilizing the highest quality resins furnished by well-known manufacturers. Our unique regenerant distribution system accomplishes complete and uniform regeneration of the resin. With over 200 conventional ion exchange installations in the United States alone, Tonka Water's approach is proven consistently effective.

**Treatment:**

- Arsenic
- Barium
- Hardness
- Nitrates/sulfate
- Organics
- Perchlorate
- Radium
- Fluoride
- Uranium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Tonka Water, a Kurita brand


KURITA

TONKAWATER™
a Kurita brand

May 8, 2023

Jeff Wolford, PE
CBS Squared, Inc.

RE: Kaukauna, WI
RidION™ Ion Exchange System for Softening
Preliminary Proposal and Budgetary Estimate

Dear Jeff,

In accordance with our understanding of the above project, Tonka Water, a Kurita brand, is pleased to provide information concerning the following process equipment. For this project, Tonka Water is proposing:

**<u>Tonka Water RidION™ Ion Exchange System for Hardness Removal</u>**

- Each vertical pressure vessel is to be constructed of carbon steel, ASME code stamped, and will include:
  - Schedule 80 PVC header-lateral inlet distributor with upturned elbows
  - Schedule 80 PVC header-lateral brine distribution grid
  - Cation exchange resin -- NSF approved
  - Graded support gravels
  - Schedule 80 PVC header-lateral underdrain with Tonka Water non-metallic gravel retaining nozzles (concrete subfill required by installing contractor)
  - Full interior finish painting; exterior blasted and primed at factory (finish painting by others on site)
- Additional components and services are included as follows:
  - System valves, including electrically actuated Bray wafer-style butterfly valves for system regeneration, including heaters but no limit switches
  - Ductile iron vessel facepiping (shipped loose for installation by others)
  - Backwash rate of flow meter
  - Vessel effluent flow meters, one per vessel
  - Fully automated Allen-Bradley PLC control system and panel
  - Skid -mounted brine delivery and dilution components, including brine pump, brine meter, valves, check valves, and other components for a fully functional brine delivery and dilution system.
  - Brine maker/salt storage silo, FRP construction, insulated for placement outdoors
  - Freight
  - Field services consisting of installation inspection, media installation supervision, start-up and operator training

TONKAWATER™
a Kurita brand

**Well 4, 5 and 10**

| | |
|---|---|
| **Total Design Flow:** | 1600 gpm |
| **Total Treated Flow:** | 1232.5 gpm |
| **Total Bypass Flow:** | 367.5 gpm |
| **Softener Load Rate:** | 2.7 gpm/sf |
| **Number of Vessels:** | 4 |
| **Dimensions:** | 12'-0'' diameter x 13'-2'' approx. overall height |
| **Working Pressure:** | 100 psi |
| **Test Pressure:** | 130 psi |
| **Raw Water Hardness:** | 653 mg/L |
| **Design Blended Effluent:** | 150 mg/L |
| **Resin - Depth:** | 48 inches |
| **Gravel - Depth:** | 15 inches |

**The budgetary price for this system is: $ 1,780,000.00**

**Well 8 and 9**

| | |
|---|---|
| **Total Design Flow:** | 1760 gpm |
| **Total Treated Flow:** | 1320.7 gpm |
| **Total Bypass Flow:** | 439.3 gpm |
| **Softener Load Rate:** | 2.9 gpm/sf |
| **Number of Vessels:** | 4 |
| **Dimensions:** | 12'-0'' diameter x 13'-2'' approx. overall height |
| **Working Pressure:** | 100 psi |
| **Test Pressure:** | 130 psi |
| **Raw Water Hardness:** | 601 mg/L |
| **Design Blended Effluent:** | 150 mg/L |
| **Resin - Depth:** | 48 inches |
| **Gravel - Depth:** | 15 inches |

**The budgetary price for this system is: $ 1,780,000.00**

We look forward to working with you on this water treatment project. If you have any questions, please feel free to call me at 612.708.6517

Sincerely,

Alan Schneider
Territory Manager

cc: Jason Metz, William/Reid, Ltd.

Hi Jeff

From our engineering team:

Here is the rundown of wastewater and rough operational cost comparisons for the IEX vs. NF softening systems. I used the Main WTP designs for this comparison:

Assumptions:

- Waste and energy/chemical/etc costs based on per MG finished water (treated + blend) for Main WTP design (Wells 4, 5, 10)
- Softening from ~667 mg/L total hardness to 150 mg/L
- Salt costs ~ $100/ton
- Antiscalant cost ~$10/lbs
- Metabisulfite (dechlorination) cost ~$2/lbs
- Energy cost ~$0.15/kWhr
- Energy costs calc'd based on pumping through system (DP for each)
- CIP frequency – every 6 months
- 1 mg/L chlorine residual to NF system
- Resin changeout every 10 years
- NF membrane changeout every 5 years

<u>WASTEWATER</u>

IEX: ~61,100 gallons per MG finished (6.1% waste)
NF: ~165,600 gallons per MG finished (16.5% waste)

<u>CHEMICAL CONSUMPTION COST</u>

IEX - Salt: ~$440 per MG finished

NF – Anti-Scalant: ~$56 per MG finished
NF – Metabisulfite: ~$50 per MG finished
NF – CIP: ~$2,000 per 6 months (actual may vary by need)

<u>OTHER CONSUMABLES</u>

IEX - Resin changeout (every 10 years): ~$61,000 (material and delivery cost ONLY – installation costs not included)

NF – Cartridge filters (Monthly): ~$950 monthly (material and shipping costs ONLY)
NF – DuPont NF90 changeout (every 5 years): ~$262,000 (material and shipping costs ONLY)

<u>ENERGY USE</u>

IEX - ~$9 per MG finished

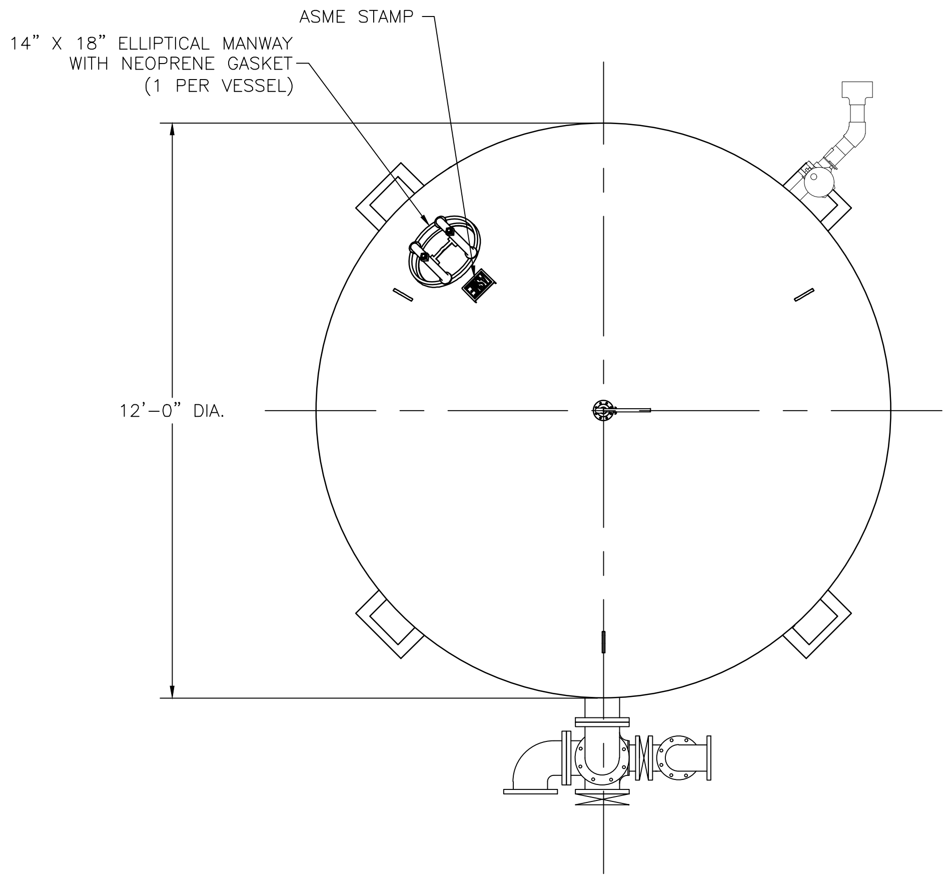
NF - ~$160 per MG finished

Hope this helps!

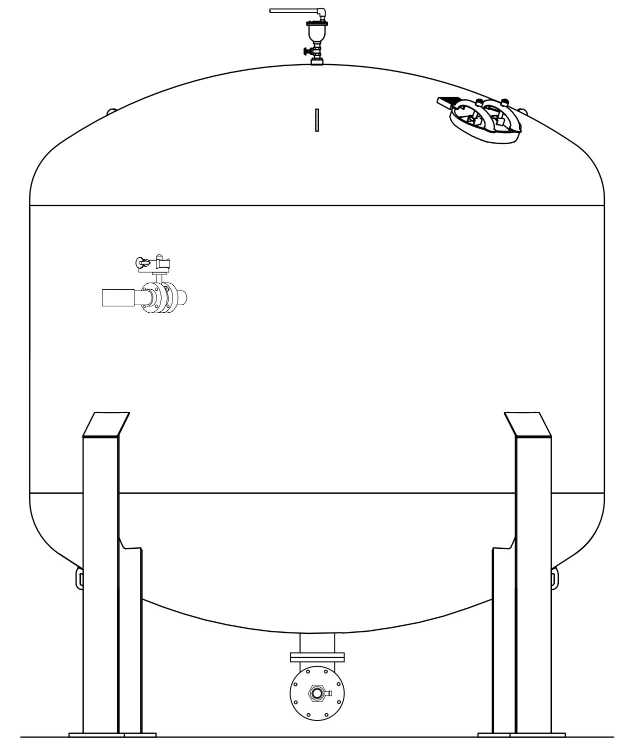
**Alan Schneider**
***Tonka Water Territory Manager***
**Mobile** 612-708-6517 | **Main** 800-530-1887 | a.schneider@kurita-water.com
**Kurita America Inc.** | **Tonka Water, a Kurita brand** | www.kuritaamerica.com

***How are we doing? Take our short survey!***

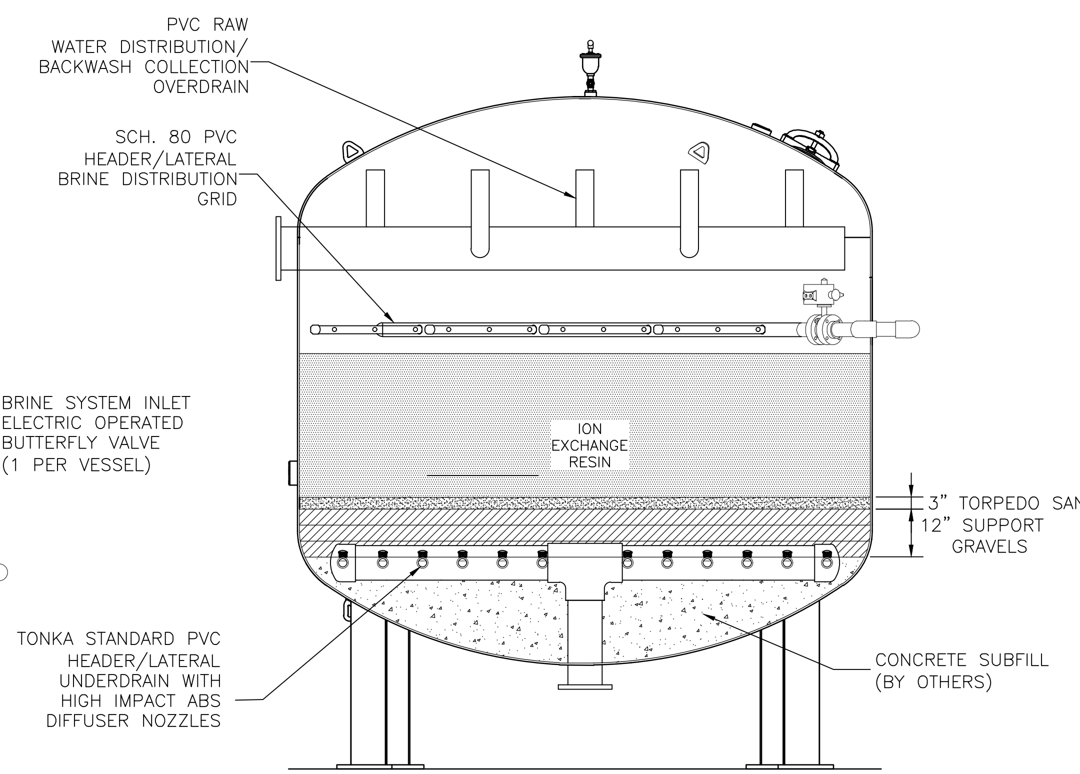
KURITA



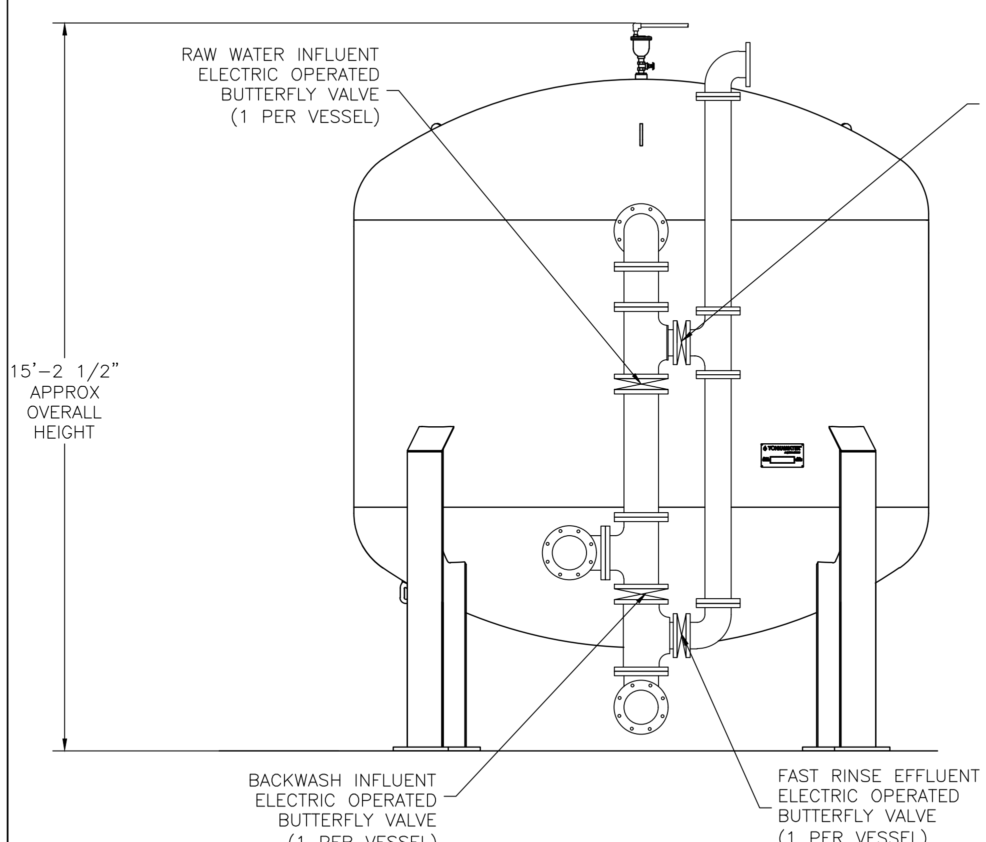

PLAN VIEW SINGLE VESSEL



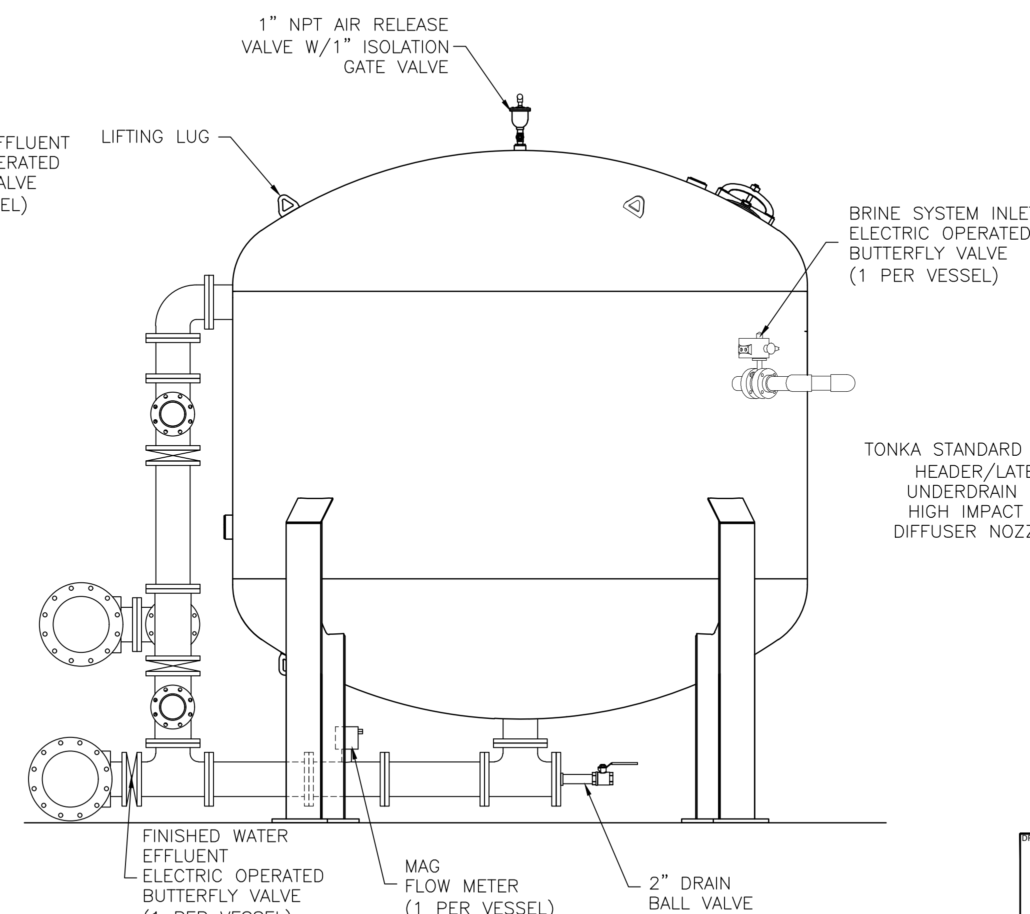
REAR ELEVATION SINGLE VESSEL




TYPICAL SECTION




FRONT ELEVATION SINGLE VESSEL




SIDE ELEVATION SINGLE VESSEL

| | | | |
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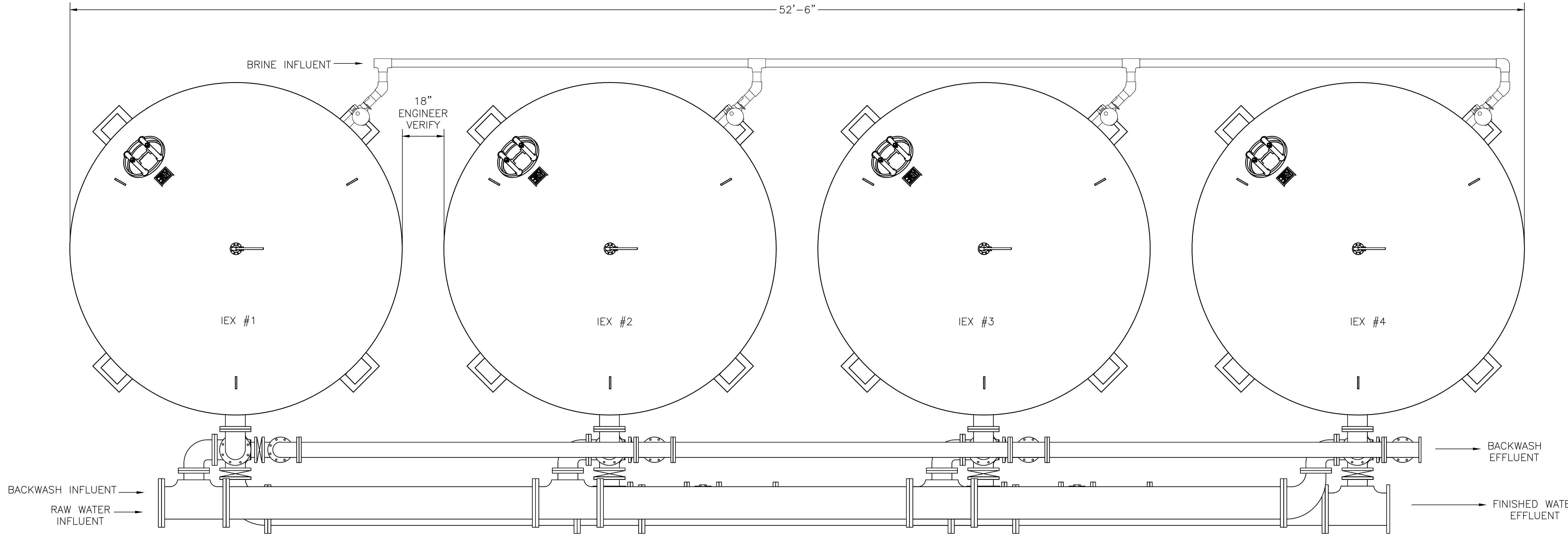
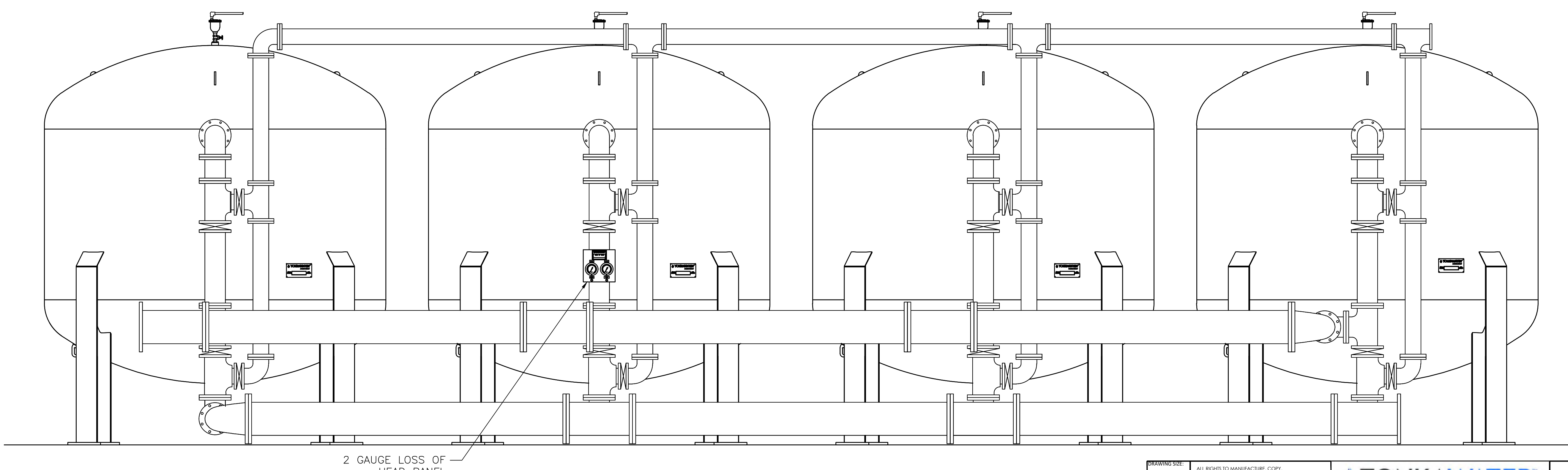
| DRAWN BY: MRR | START DATE: 05/08/2023 | RIDION™ SOFTENER SYSTEM 12'-0" DIA. EXAMPLE DRAWING | SHEET NUMBER: 1 OF 2 REV: 0 |
| PROJECT MGR: AMS | DWG. SCALE: NONE | | DRAWING NUMBER: 00077454 |
| APPR. BY: | APPR. DATE: | | PROJECT NUMBER: 20081 |




PROPOSED PLANT LAYOUT PLAN VIEW




PROPOSED PLANT LAYOUT ELEVATION VIEW

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| DRAWN BY: MRR | START DATE: 05/08/2023 | RIDION™ SOFTENER SYSTEM (4) 12'-0" DIA. EXAMPLE DRAWING | SHEET NUMBER: 2 OF 2 ; REV: 0 |
| PROJECT MGR: AMS | DWG. SCALE: NONE | | DRAWING NUMBER: 00077454 |
| APPR. BY: | APPR. DATE: | | PROJECT NUMBER: 20081 |

# H.2 TONKA - NANOFILTRATION INFO

# FLUX™ RO/NF

## Nanofiltration and Reverse Osmosis Treatment


## Tonka Water, a Kurita brand's Membrane Technologies

### We solve a broad range of treatment challenges with guaranteed results.

As a manufacturer of membrane systems, the Tonka Water brand brings you the latest technologies, as well as years of treatment experience. Being a single-source equipment provider, we are able to guarantee system performance of a stand alone membrane system or a membrane system combined with our other treatment equipment. Our Flux™ RO/NF membrane systems offer solutions across the full membrane filtration spectrum:

**Nanofiltration** for removal of nitrates, DBP precursors, dissolved organics, and softening applications.

**Reverse Osmosis** for desalination and removal of nitrates, chloride, other inorganic compounds and softening applications.

### BENEFITS

- Factory assembled and wired
- Shop tested and field ready
- Single responsible system supplier
- Integrated controls including pre-treatment and post-treatment
- Pilot and full-scale design capability - up to 900psi

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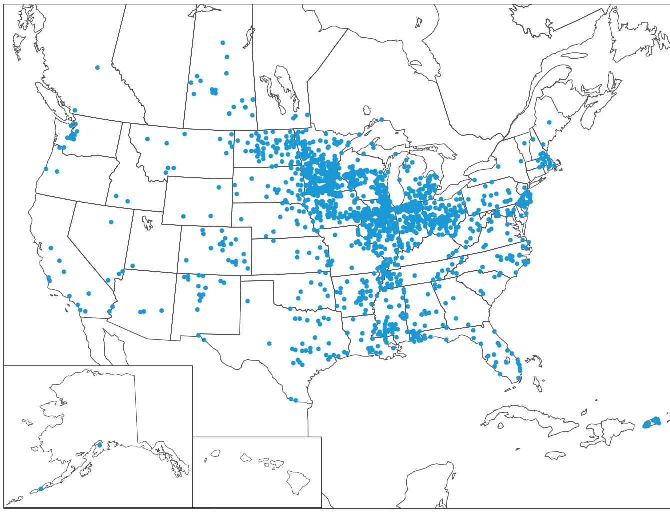


## *Tonka Water Brand Guarantee*

Tonka Water, a Kurita brand provides the best custom manufactured water treatment systems in the industry. Our people will deliver excellent service and support for your project from conceptual and cost-effective design, to construction and commissioning; and throughout the system warranty and operational life of the project.

*Thousands of quality water treatment installations since 1956.*

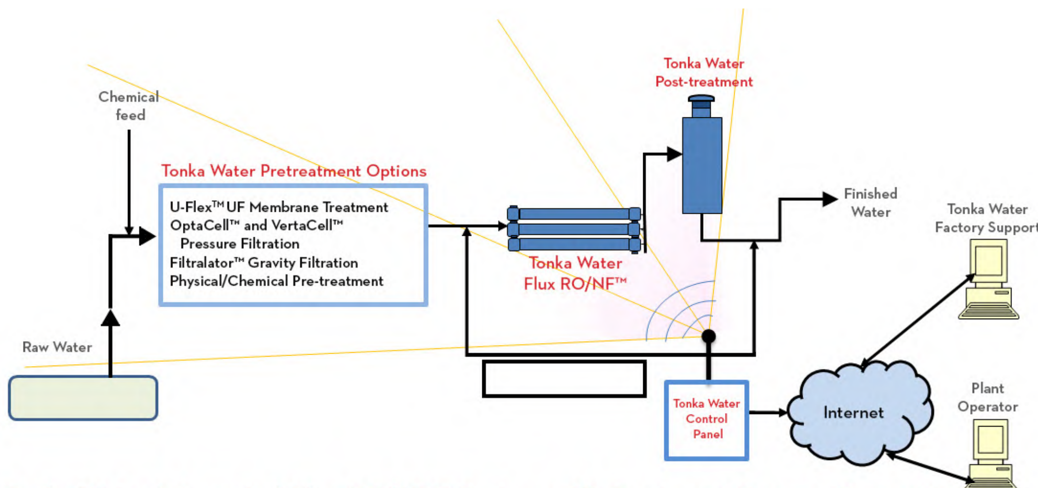
### Features:

- Fully automated
- State-of-the-art technology
- Internet-based control available
- Superior fouling and chemical resistance
- Full spectrum of NF/RO membrane elements
- Backed by Tonka Water guarantee
- Available in single- or two-pass configurations
- Softening

### Treatment:

- Color removal
- TDS reduction
- TOC removal
- Radium removal

## Eliminate fragmented responsibility with full system control and integrated start-up




Tonka Water Integrated Flux RO/NF™ System with Treatment Process Guarantee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TONKAWATER™
a Kurita brand

May 15, 2023

Jeff Wolford, P.E.
CBS Squared, Inc.

RE: Kaukauna, WI
Flux NF™ Nanofiltration System
Preliminary Proposal and Budgetary Estimate

Dear Jeff,

In accordance with our understanding of the above project, Tonka Water, a Kurita brand, is pleased to provide information concerning the following process equipment. For this project, Tonka Water is proposing:

**Main WTP (Wells 4, 5, 10):**

**Tonka Water Flux NF™ Nanofiltration System for Softening**

| | |
|---|---|
| **Design Parameters:** | |
| **Total Influent Flow:** | 1,600 gpm |
| **Treated Flow, per Train (skid):** | 444 gpm |
| **Bypass Flow, per Train (skid):** | 91 gpm |
| **Permeate flow, per Train (skid):** | 355 gpm |
| **Concentrate Waste Flow, per Train (skid) :** | 87 gpm |
| **Total Combined Effluent Flow:** | 1,338 gpm |
| **Total System Recovery:** | 83.4% |
| **Design Raw Water Hardness:** | 667 mg/L as $CaCO_3$ |
| **Design Blended Finished Total Hardness:** | 150 mg/L as $CaCO_3$ |
| **Number of Trains (skids):** | 3 |
| **Array:** | 9x6, 6L |
| **Elements:** | DuPont/FilmTec NF90-400/34i |
| **Total Number of Elements:** | 270 |
| **Approximate Skid Dimensions, Per:** | 7.5' wide x 25' long x 8' high |

- Tonka Water membrane skids are fully skid mounted, plumbed, wired and factory tested. Each membrane skid will include the following:
  - Painted steel skid
  - Cartridge pre-filter, 1 micron
  - Fiberglass membrane housings with cross-flow membranes

- High pressure feed pump with variable frequency drive
- Piping and valves. Low pressure will be Sch. 80 PVC; high pressure will be Sch. 10 type 316 stainless steel
- Meters and instrumentation for measuring and transmitting flow rates, pressures, pH, ORP, temperature, and conductivity, as required, for proper monitoring of the system
- Fully automated Allen-Bradley PLC control panel, mounted on main membrane skid
- Remote I/O panels, mounted on additional skids

- Additional components and services are included as follows:
  - One (1) Clean-In-Place (CIP) system, skid mounted, including chemical tank, heater, recirculation pump, valves, piping, and control panel.
  - Chemical feed systems for feeding sodium bisulfite and antiscalant to each skid/train. Each feed system consists of one (1) chemical feed pump assembly with platform for wall mounting (wall-mounting by others), one (1) chemical feed tank, and suction piping/tubing with foot valve. Feed tubing between the chemical feed pump and feed points are by others.
  - Freight
  - Field services consisting of installation inspection, start-up and operator training

**Second WTP (Wells 8 & 9):**

**Tonka Water Flux NF™ Nanofiltration System for Softening**

| **Design Parameters:** | |
|---|---|
| **Total Influent Flow:** | 1,750 gpm |
| **Treated Flow, per Train (skid):** | 467 gpm |
| **Bypass Flow, per Train (skid):** | 117 gpm |
| **Permeate flow, per Train (skid):** | 374 gpm |
| **Concentrate Waste Flow, per Train (skid) :** | 94 gpm |
| **Total Combined Effluent Flow:** | 1,473 gpm |
| **Total System Recovery:** | 84% |
| **Design Raw Water Total Hardness:** | 601 mg/L as $CaCO_3$ |
| **Design Blended Finished Total Hardness:** | 150 mg/L as $CaCO_3$ |
| **Number of Trains (skids):** | 3 |
| **Array:** | 9x6, 6L |
| **Elements:** | DuPont/FilmTec NF90-400/34i |
| **Total Number of Elements:** | 270 |
| **Approximate Skid Dimensions, Per:** | 7.5’ wide x 25’ long x 8’ high |

- Tonka Water membrane skids are fully skid mounted, plumbed, wired and factory tested. Each membrane skid will include the following:
  - Painted steel skid
  - Cartridge pre-filter, 1 micron

TONKAWATER™
a Kurita brand

- Fiberglass membrane housings with cross-flow membranes
- High pressure feed pump with variable frequency drive
- Piping and valves. Low pressure will be Sch. 80 PVC; high pressure will be Sch. 10 type 316 stainless steel
- Meters and instrumentation for measuring and transmitting flow rates, pressures, pH, ORP, temperature, and conductivity, as required, for proper monitoring of the system
- Fully automated Allen-Bradley PLC control panel, mounted on main membrane skid
- Remote I/O panels, mounted on additional skids

▪ Additional components and services are included as follows:
  - One (1) Clean-In-Place (CIP) system, skid mounted, including chemical tank, heater, recirculation pump, valves, piping, and control panel.
  - Chemical feed systems for feeding sodium bisulfite and antiscalant to each skid/train. Each feed system consists of one (1) chemical feed pump assembly with platform for wall mounting (wall-mounting by others), one (1) chemical feed tank, and suction piping/tubing with foot valve. Feed tubing between the chemical feed pump and feed points are by others.
  - Freight
  - Field services consisting of installation inspection, start-up and operator training

The budgetary price for EACH system is: $ 1,523,000

We look forward to working with you on this water treatment project. If you have any questions, please feel free to call me at 612.708.6517.

Sincerely,

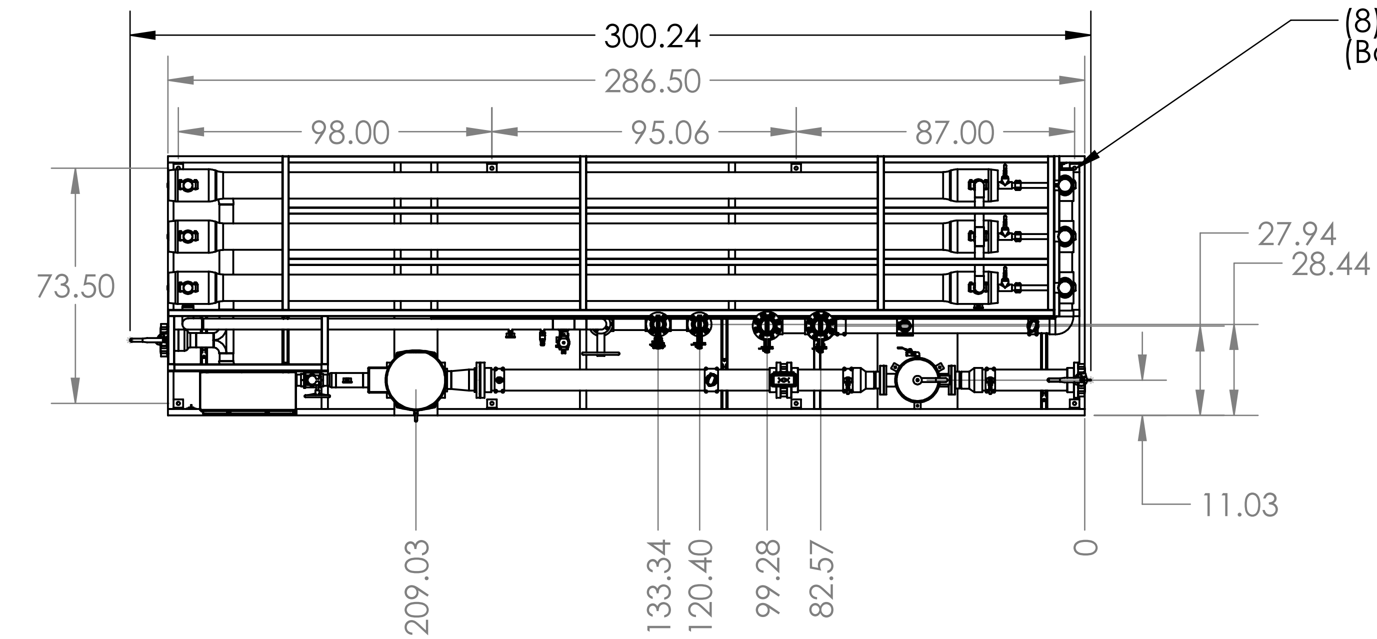
Alan Schneider
Territory Manager

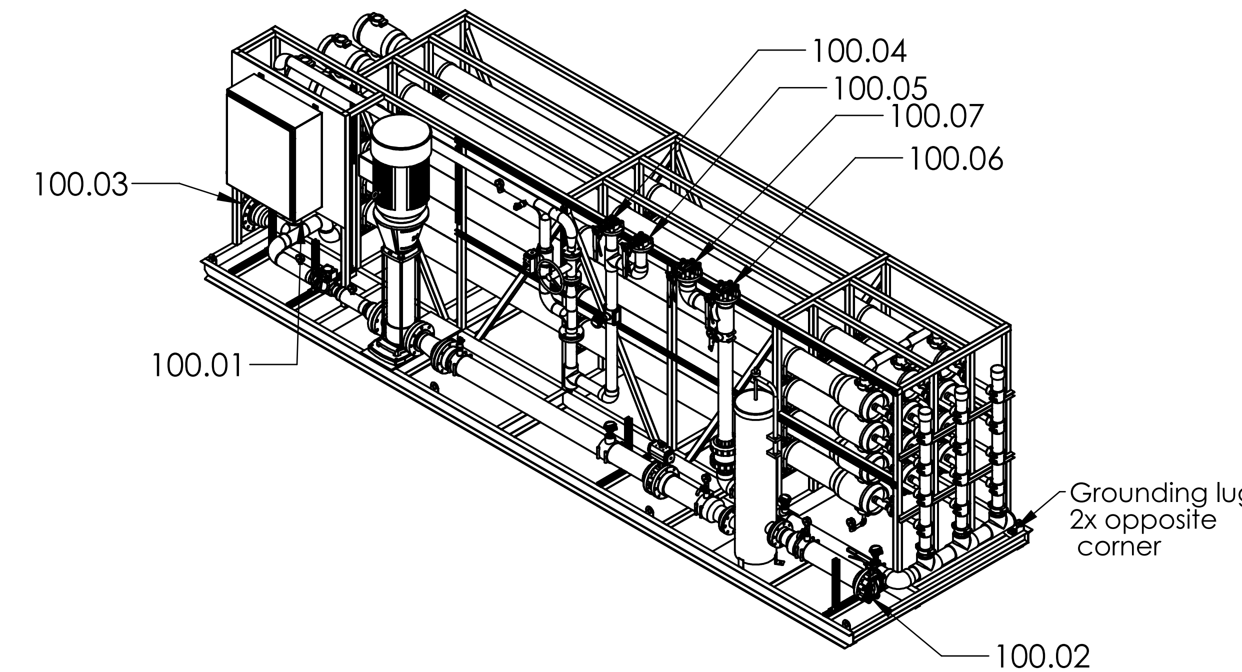
cc: Jason Metz, William/Reid, Ltd.

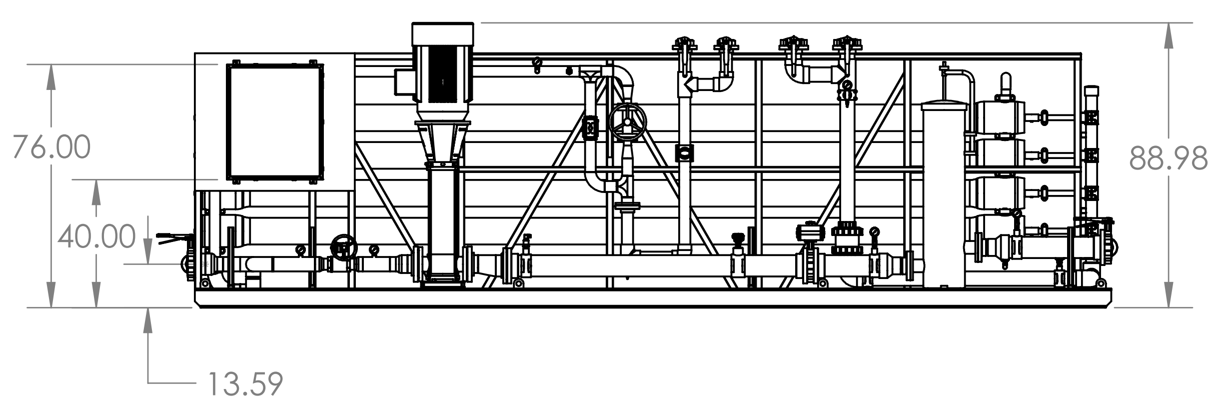
Attachments: NF treatment skid example drawing

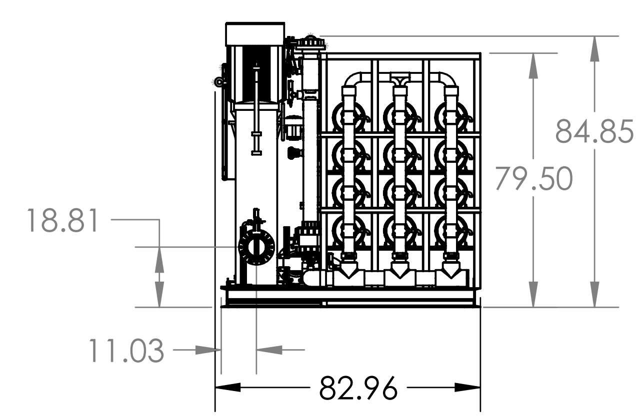
# H.3 TONKA - REVERSE OSMOSIS

| Connection # | Name | Size | Description |
|---|---|---|---|
| 100.01 | Air Inlet | 1/2" | Compression |
| 100.02 | Raw Water Inlet | 6" | 150# RF Flg. |
| 100.03 | CIP Inlet | 6" | 150# RF Flg. |
| 100.04 | Reject | 3" | 150# RF Flg. |
| 100.05 | Reject CIP Return | 3" | 150# RF Flg. |
| 100.06 | Permeate | 4" | 150# RF Flg. |
| 100.07 | Permeate CIP Return | 4" | 150# RF Flg. |




Design Specs:
1. Designed inlet flow:
2. Designed inlet pressure:
3. Designed product flow:

Notes:
1. Unloading and install by others.
2. All external loads supported by others.
3. Approx. operating weight: 13,000 lbs
4. Approx. shipping weight: 12,000 lbs
5. Electrical terminations by others.
6. Interconnecting piping by others.
7. Skid coating: Black Powder Coat
8. Skid material: Mild Steel
9. Piping material
   9a: Low pressure piping: Sch. 80 PVC
   9b: High pressure piping: 304SS
10. Allow for 48" of clearance on both ends of RO for membrane removal.
11. Allow for 48" of clearance above filter housing for filter removal.
12. Electrical conduit material to be:
13. Air line material to be: LLDPE



TOLERANCES UNLESS OTHERWISE NOTED
ALL DIMENSIONS SHOWN IN INCHES

| DECIMALS | ANGLES |
|---|---|
| .X ±3.0 | ±1° |
| .XX ±1.00 | FRAC |
| .XXX ±0.500 | ± N/A |

| REV. | DESCRIPTION | DATE | DRWN | CHK'D | APP'D |
|---|---|---|---|---|---|
| 0 | Initial Release | 10/31/14 | KAE | NEB | NEB |

U.S. WATER ENGINEERING & EQUIPMENT
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USHR 300 Silver
Designer: KAE
Date: 10/31/14
JOB NO.
Page: 1 of 1
USHR 300G Silver
REV 0

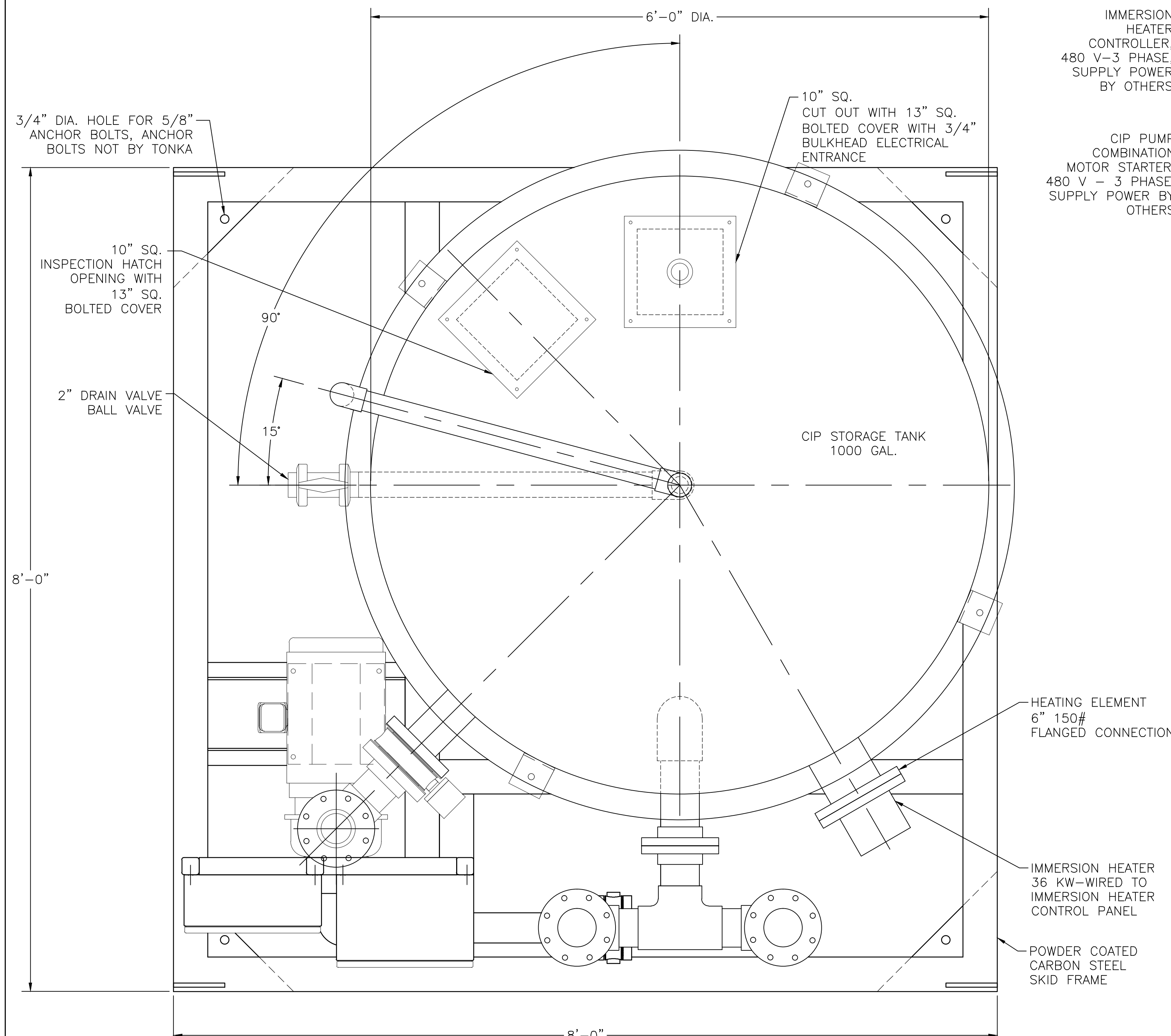
Y:\Travis\USHR\USHR-300\

NOTES:

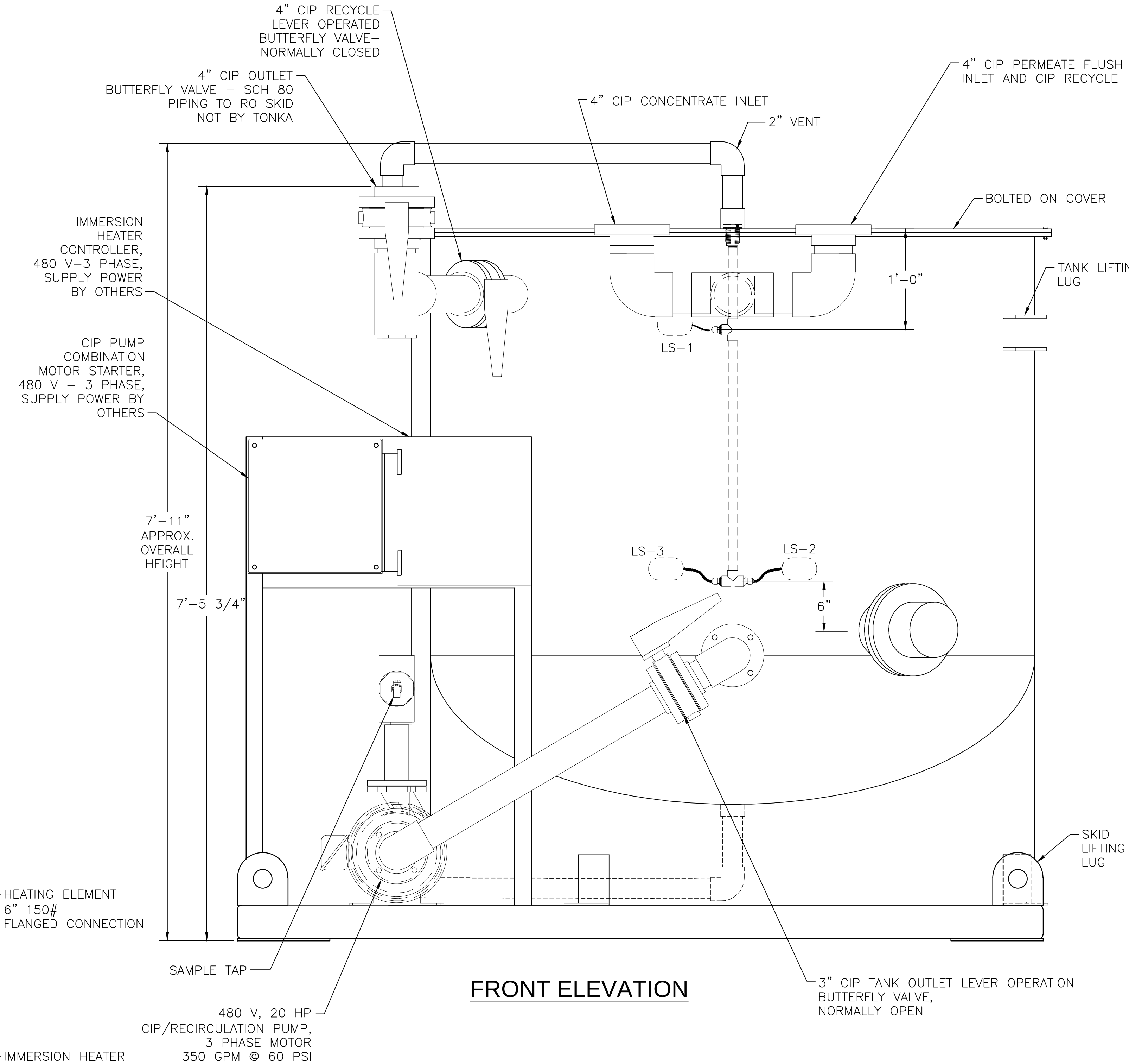
1. ALL PIPING AND VALVE MATERIAL: SCH. 80 PVC UNLESS NOTED.

**Paint Specifications**

| EXTERIOR PAINT SPECIFICATIONS | | | | | |
|---|---|---|---|---|---|
| **Paint Manufacturer** | **Series** | **Color** | **Coat** | **Blast profile** | **Dry Film Thickness** |
| IFS | Zinc Rich #ELSS90056CN | Grey | Prime | SSPC-SP6 | 1-1.5 Mils |
| IFS | Polyester #PLSF20309CN | Blue | Finish (2 coats) | | 1-2 Mils |
| | | | | | |
| | | | | | |
| **Total Prime DFT** | | | | | **3-5 Mils** |




PLAN VIEW




FRONT ELEVATION

| | | | |
|---|---|---|---|
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| DRAWN BY: MRR | START DATE: | CIP SKID 1000 GALLON TYPICAL DRAWING | SHEET NUMBER: 1 OF 1 |
| PROJECT MGR: | DWG. SCALE: NONE | | REV: 0 |
| APPR. BY: | APPR. DATE: | | DRAWING NUMBER: |
| | | | PROJECT NUMBER: 00000 |

# H.4 WATER SURPLUS - RO TREATMENT AND PRESSURE FILTER INFO

**From:** Jim Groose <Jim.Groose@watersurplus.com>
**Sent:** Monday, July 17, 2023 1:01 PM
**To:** Jeff Wolford <jwolford@cbssquaredinc.com>
**Cc:** Dileep Agnihotri <Dileep.A@watersurplus.com>; Jody Burgess <jody.burgess@watersurplus.com>
**Subject:** Kaukauna - Filtration and RO Treatment Budget Estimates

Jeff,

We have gone over the sizing for the RO and filtration system for the two sites. We have the following two sites that you specified for us to give you sizing recommendations and budgetary costs for each site. We would recommend that the systems be designed with Low E membranes because it will provide the softening at a lower RO operating pressure and save energy over the long haul. Nanofiltration produces permeate at a slightly lower pressure but has a significant cost adder for the NF membranes.

Site 1 – Wells 4, 5 and 10 – Pumping Capacity = 1,600 gpm – Average hardness = 665 mg/L as Ca $CO_3$

Site #2 – Wells 8 & 9 – Pumping Capacity = 1,750 gpm – Average Hardness = 630 mg/L as $CaCO_3$

The target hardness is the hardness of Lake Michigan around 130 mg/L. This is a 80.5% and 79.4% reduction from Sites 1 and 2, respectively.

**Reverse Osmosis (RO) System Design:**

With a target around 80% reduction, the two sites look like this for a process flow rate:

Site 1:

Influent to RO Systems (**3 RO skids**) = 1,330 gpm
Bypass Around RO System = 270 gpm
Permeate produced at 80% recovery = 1,064 gpm (355 gpm/skid)
Concentrate waste = 266 gpm
Blended Product = 1,330 gpm at 130 mg/L of hardness as $CaCO_3$

Site 2:

Influent to RO Systems (**2 RO skids**) = 1,450 gpm
Bypass Around RO System = 300 gpm
Permeate produced at 80% recovery = 1,160 gpm (580 gpm/skid)
Concentrate waste = 290 gpm
Blended Product = 1,450 gpm at 130 mg/L of hardness as $CaCO_3$

We did a performance projection with our ImpactRO design, and it is possible to achieve up to 85% recovery with lower pressure, better flux distribution which reduces future membrane cleanings, and makes membranes last longer. In addition, a patented micro-disruption design interrupts precipitation and provides longer lives between membrane cleanings.

**Pressure Filter Design:**

For Site #1, 1,600 gpm design, we would design with catalytic OxiPlus[75] filter media and a target 6.25 gpm/ft$^2$ surface loading rate. This would need 256 ft$^2$ of filter surface area which would be a 10’ diameter x 28’ OAL 4 cell horizontal filter. An alternate design would be 16 – 54” diameter filter vessels which represents a 6.29 gpm/ft$^2$ loading rate design. The advantage of the small vessel design is that one or two vessels can be taken offline and still treat the water prior to the RO. If you use the single horizontal vessel design, if something requires maintenance, the entire horizontal vessel must come offline. This provides a built-in redundancy.

For Site #2, 1,750 gpm design, we would design with catalytic OxiPlus75 filter media and a target 6.25 $gpm/ft^2$ surface loading rate. This would need 280 $ft^2$ of filter surface area which would be a 10' diameter x 30' OAL 4 cell horizontal filter. An alternate design would be 18 – 54" diameter filter vessels which represents a 6.11 $gpm/ft^2$ loading rate design. Again, the smaller vessel design has a bigger turn down ratio and more redundancy if a vessel should require repair or maintenance.

**Budget Equipment Pricing – 2023** (Correct for Inflation if project is 2024 or beyond):

Filters with Catalytic OxiPlus75 Filter Media, Face Piping, Controls and Compressor:

Site 1 – 10' dia x 28' OAL horizontal filter = $800,000
16 x 54" dia x 60" Straight Side vertical vessels = $725,000
Site 2 – 10' x 30' OAL horizontal filter = $850,000
18 x 54" dia x 60" Straight side vertical vessels = $775,000

RO Filters ImpactRO Design including common cartridge filter housing for all RO's, Low E Membranes, Pressure housings, High Pressure pump, 1 Master Control Panel (MCP), 2 Remote IO Panels (site #1) or 1 Remote IO Panel (Site #2), and one spare HMI with a stainless-steel structural frame for 30 year engineered life. It includes operating features which evens out the flux rate to the membranes, lowers the average pressure the RO operates at to lower power costs, reduces the frequency of chemical cleanings and lengthens the overall life of the membranes.

Site #1 – 3 – 355 gpm RO skids - $418,000 each or $1,254,000 total for three units.

Site #2 – 2 – 580 gpm RO skids - $572,000 each or $1,144,000 total for two units.

Please also set aside any budget you may need for:
1. Forwarding pumps to RO
2. Chemical feed pumps – Acid (maybe if pH is 7.5 or higher), Antiscalant, Dechlorination with sodium bisulfite
3. Inflation per year until project happens. Industrial/municipal inflation has been higher than Consumer Price Index (CPI).
4. Due to high Ca and hardness, you would need 2.2mg/L of Avista Vitec 7000 as Antiscalant.
5. We would also like to have full inorganic scan for each well. Strontium, barium, pH and other inorganics can dramatically affect recovery efficiencies. A full inorganic scan helps make sure we identify the best antiscalant to feed to the system.

Any questions about this information, let me know.

**JIM** GROOSE
**SENIOR VICE PRESIDENT**
**BUSINESS DEVELOPMENT**

WATER SURPLUS®

**Direct** 815.240.3705 | **Office** 815.636.8833 | **Email** jim.groose@watersurplus.com | **LinkedIn**
726 Beacon Street, Loves Park, IL 61111 | watersurplus.com
**Cell** 815.222.8444

# H.5 VEOLIA - PELLET SOFTENING

VEOLIA

# Why and When to Consider Pellet Softening



WATER TECHNOLOGIES

# Why and When to Use Pellet Softening

## Why Use Pellet Softening?

- Simple operation, no moving parts
- Small process footprint
- No mechanical dewatering of waste pellets required (pellets self-dewater to 95% solids)
- Reduces hardness, iron, manganese, along with other compounds that can be precipitated
- Can operate with caustic or lime for pH adjustment
- Pellets can be repurposed (crushed for reactor seed, construction fill, concrete production, animal feed supplement)

## When to Use Pellet Softening?

- Current or future disposal limitations for lime sludge or membrane brine
- Need to expand capacity but don’t have the space
- Lime softening operating costs increasing (sludge disposal, cost of lime, lime equipment failure, filter performance)
- New water source to be treated with high hardness
- Pretreatment to ion exchange: minimize brine production and extend media life
- Treatment of membrane brine / concentrate for potential recovery/reuse

VEOLIA

# ACTINA Pellet Softening Process

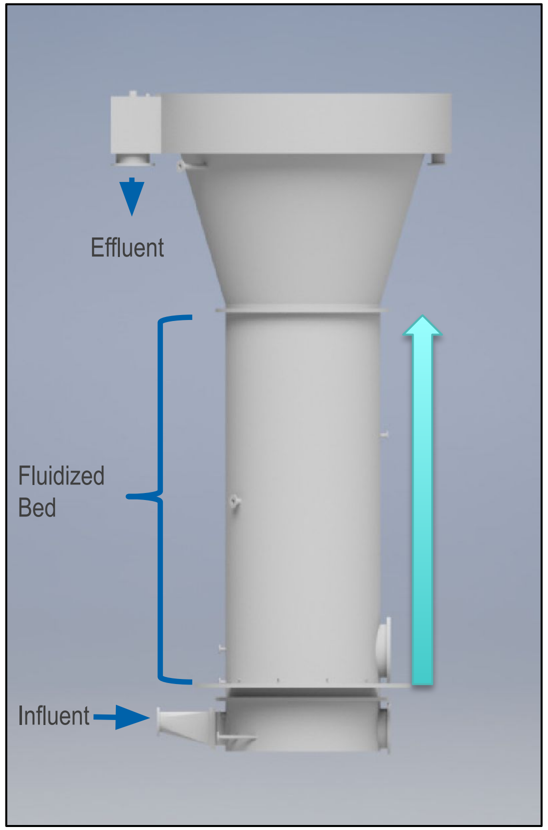


WATER TECHNOLOGIES

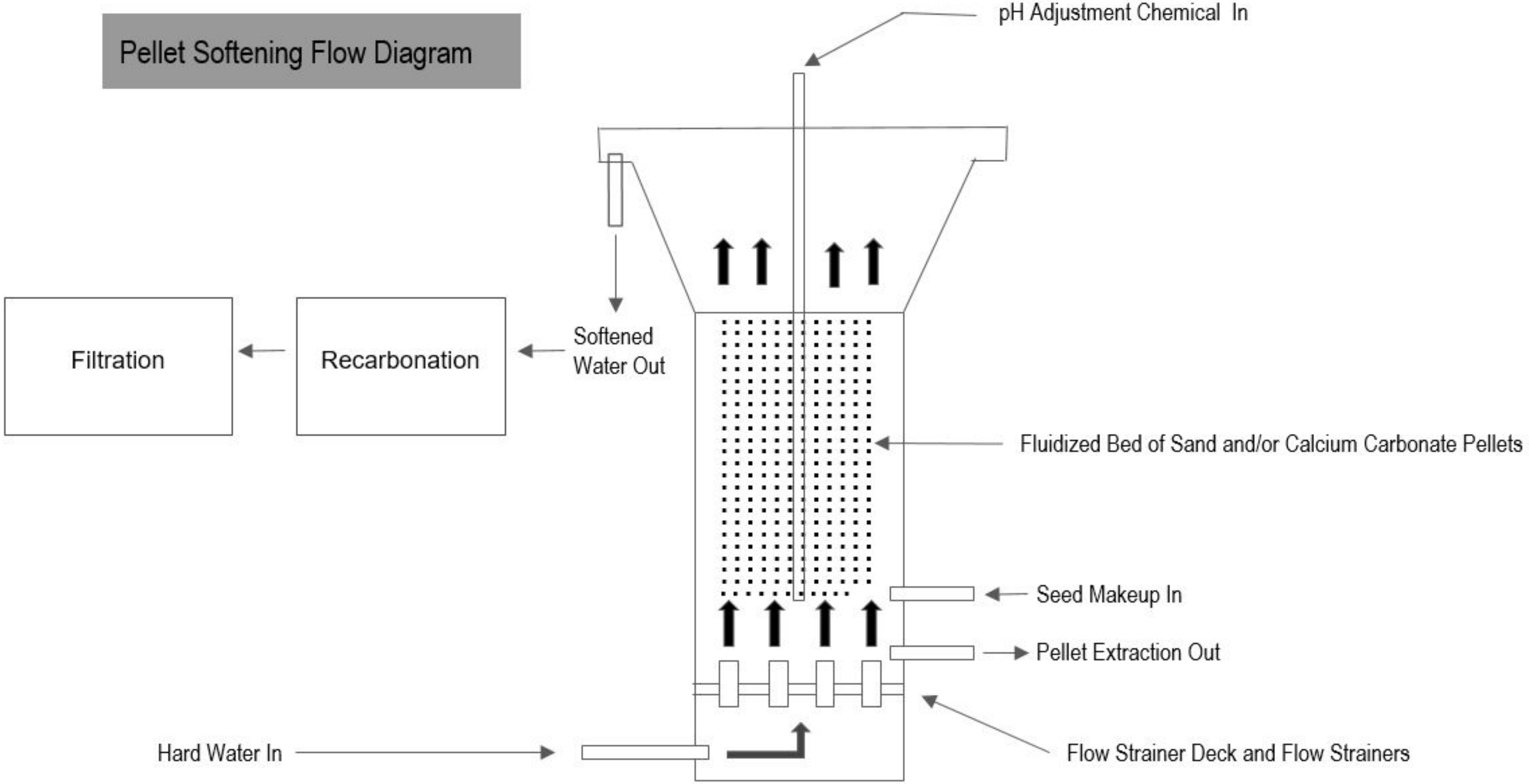
# ACTINA™ Pellet Softening Process

## What is it and what does it do?

- Simple, fluidized bed reactor that uses a catalyst (silica sand and/or crushed pellets) to promote calcium carbonate precipitation
- Reduces calcium hardness (70 – 90%) while producing a reusable, easily dewatered pellet
- Reduces Iron, Magnesium, Manganese, and other compounds through the precipitation reaction



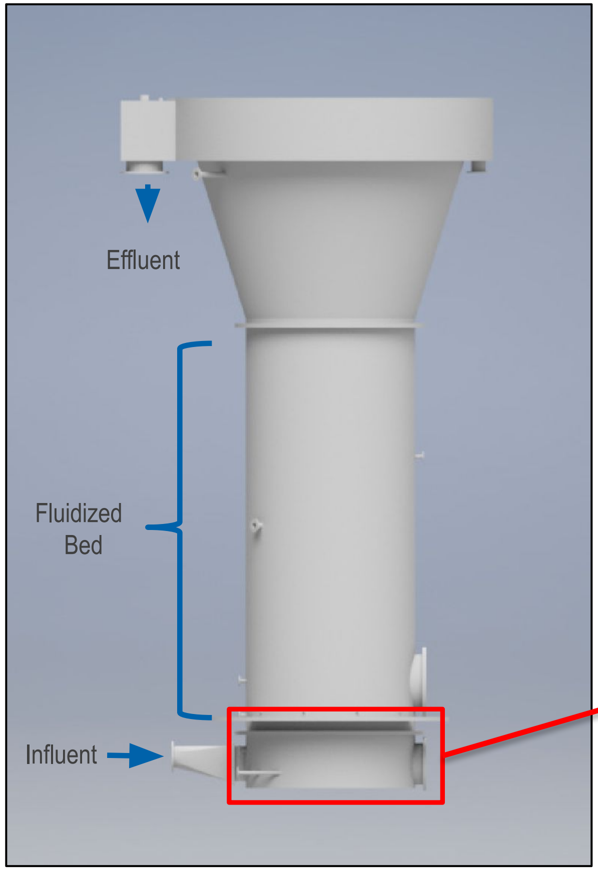

# ACTINA™ Pellet Softening Process Flow Diagram

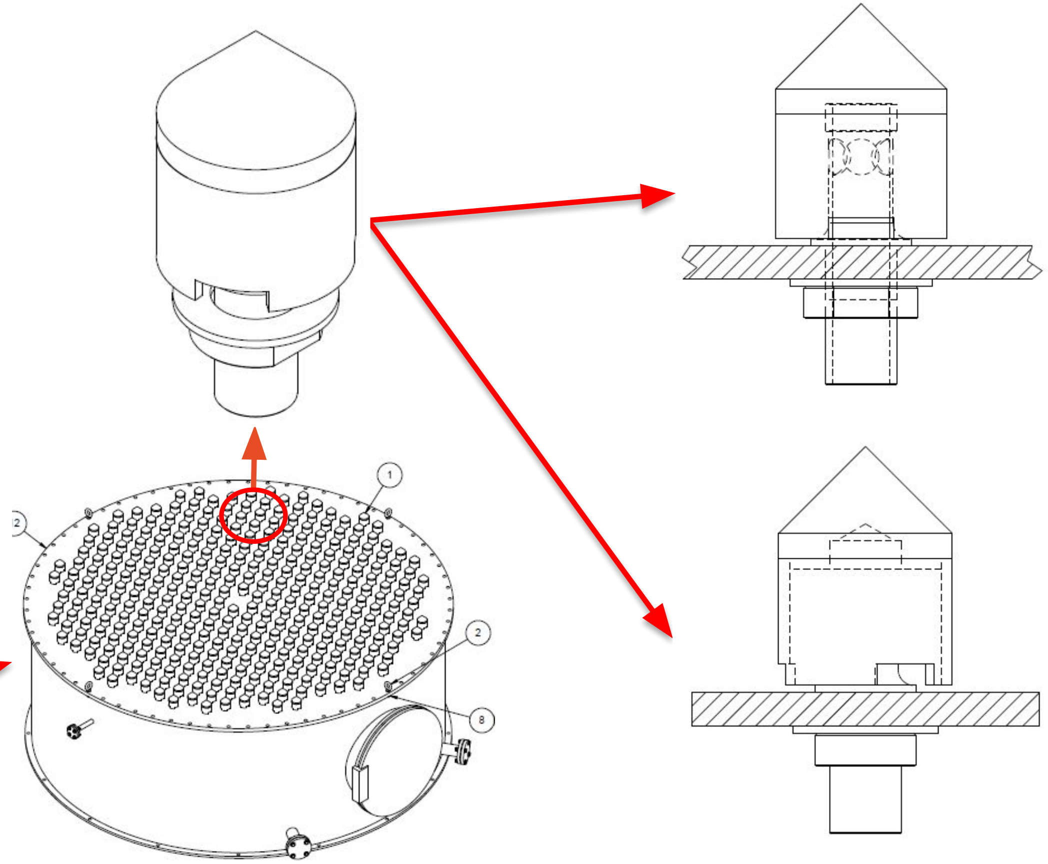


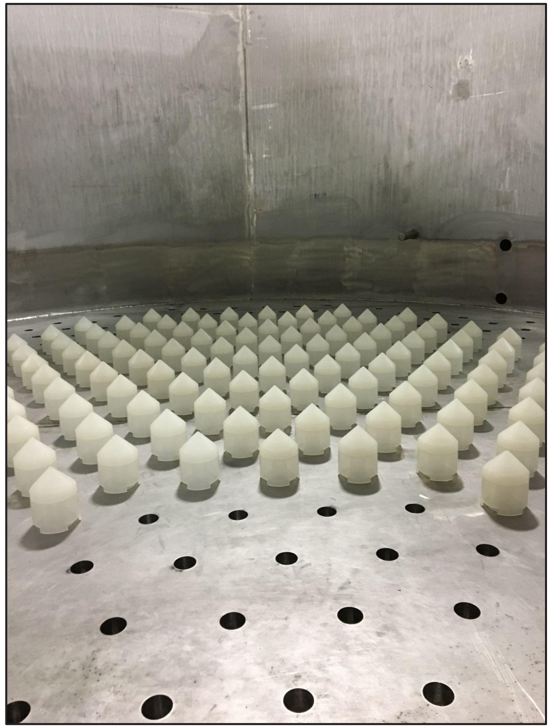
# ACTINA™ Pellet Softening Process (continued)

## How is the influent flow distributed through the reactor?

- At the bottom of the reactor is a strainer plate which has numerous flow distribution nozzle strainers installed
- Veolia's strainers are specifically designed for pellet softening and allow for material in raw water to pass
- Even distribution of flow is critical to pellet softening



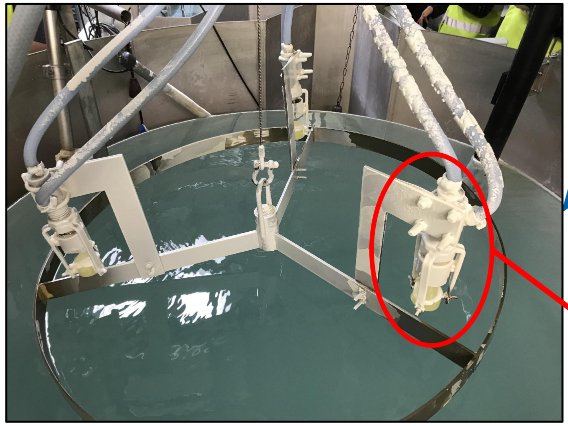



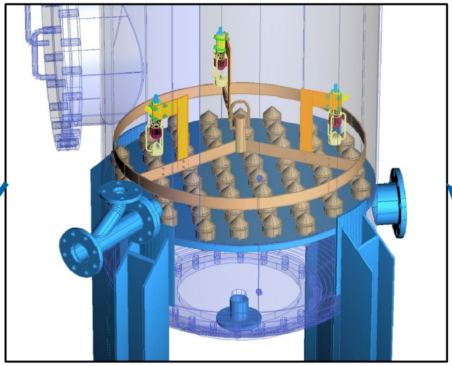


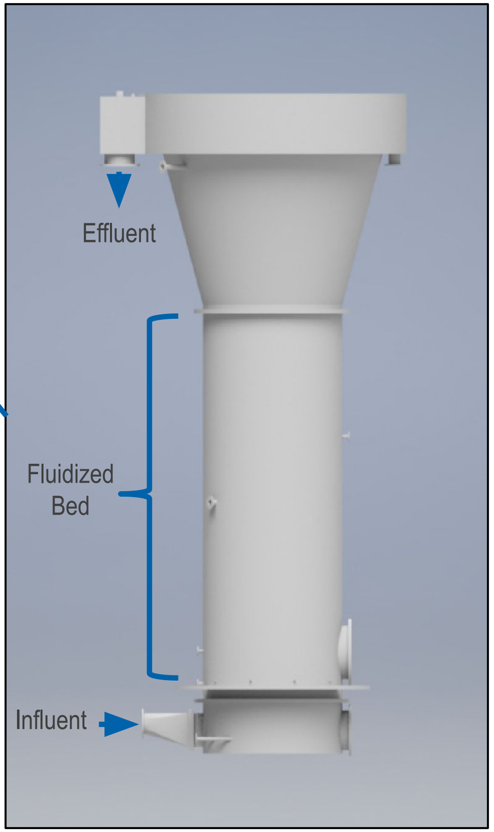
# ACTINA™ Pellet Softening Process (continued)

## What chemicals are required?

- Raw water pH is increased to 8.8 – 9.5 with caustic soda or lime to reduce calcium carbonate solubility
- Softened water (post ACTINA) pH is reduced with acid or $CO_2$ to stop the precipitation of calcium carbonate
- Caustic or lime + softened carrier water is pumped to a removable “Chandelier” that sits in the reactor, just above nozzle deck
- Exclusive Veolia Nozzle design ensures equal distribution of chemical across reactor cross section







# ACTINA™ Pellet Softening Process (continued)

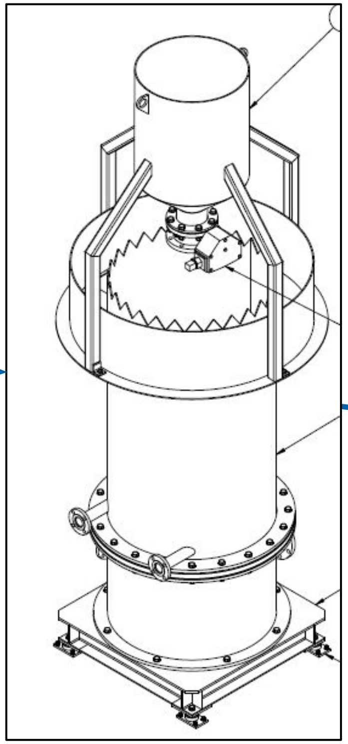
## What chemicals are required?

- The fluidized bed catalyst can be sand, or calcium carbonate pellets
- Softened water pH is reduced with acid or $CO_2$ to stop the precipitation of calcium carbonate
- Catalyst is added by pump or eductor into the side of the reactor or at the top
- Fresh catalyst is added periodically over the course of a day (2 to 3 x)
- Post pH adjustment is added into ACTINA effluent box

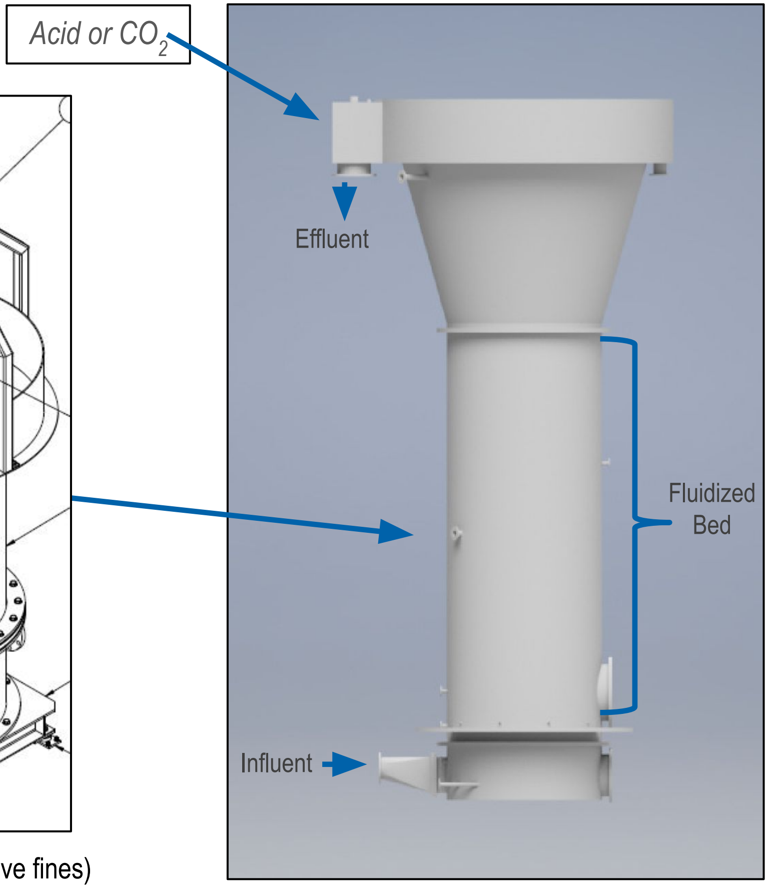
Small Capacity Systems Seed Eductor

Mid Capacity Systems Bulk Bag + Inductor

Large Capacity Systems Silo +Feed Auger



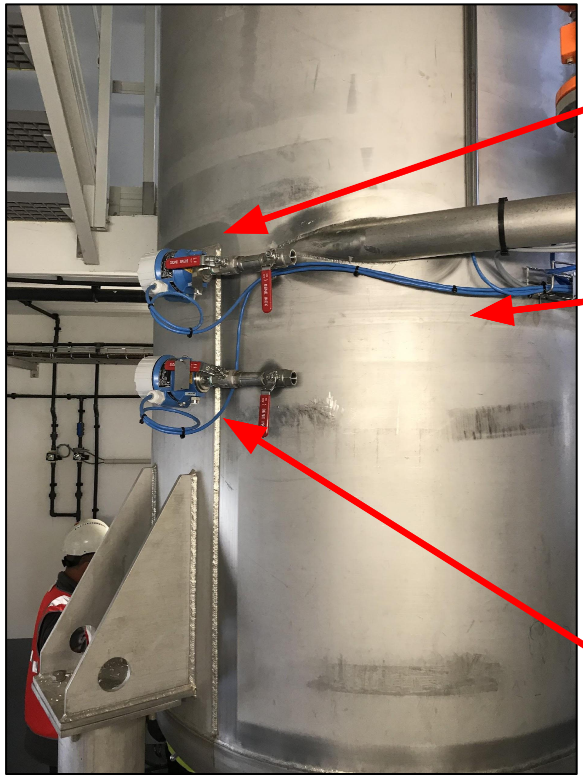
Typical Seed Washer (remove fines)

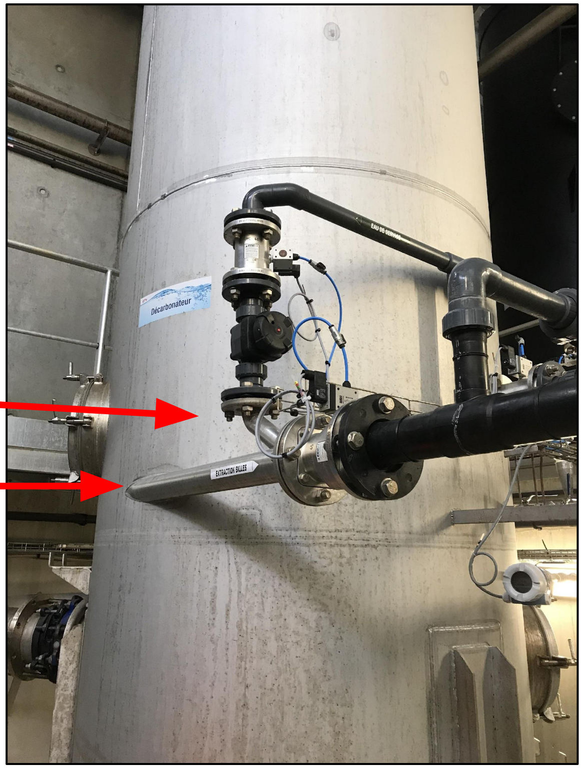


# ACTINA™ Pellet Softening Process (continued)

## When and how are the mature pellets extracted from the reactor?

- Pressure is continuously measured above and below strainer plate
- Once a predetermined differential pressure is reach the pellets are extracted by a pump or gravity
- After each extraction the pipe is flushed
- Pellet extraction and catalyst addition is automated, without stopping influent flow



# ACTINA™ Pellet Softening Process (continued)

## How are the extracted pellets dewatered and handled?

- Pellets are self draining – no mechanical dewatering required
- Bin with drain capabilities most common (1 or 1 + 1 standby)
- For larger facilities, a silo with truck unloading

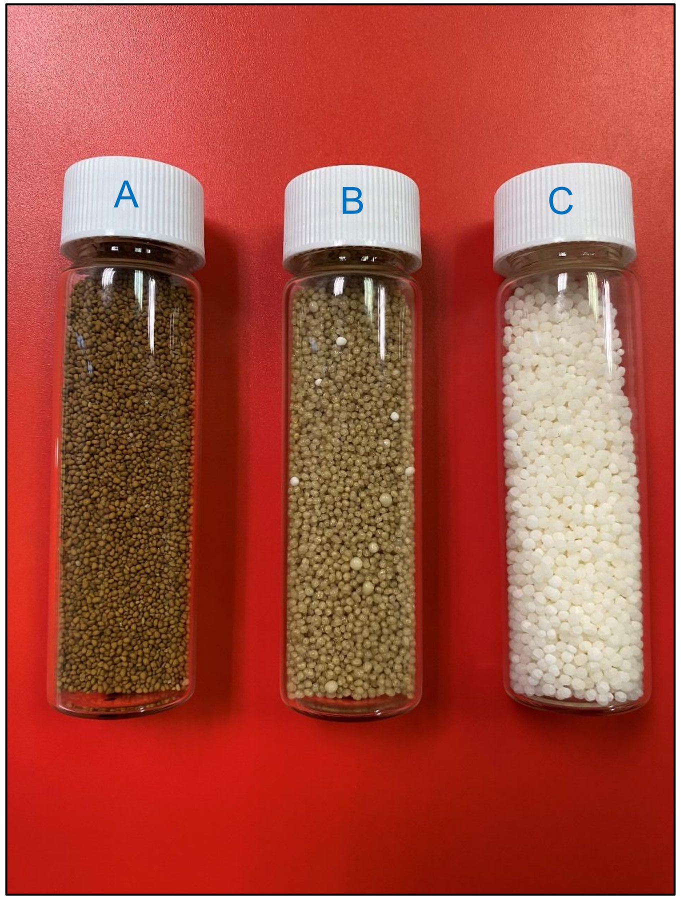
# ACTINA™
# Performance and O&M Cost Savings



WATER TECHNOLOGIES

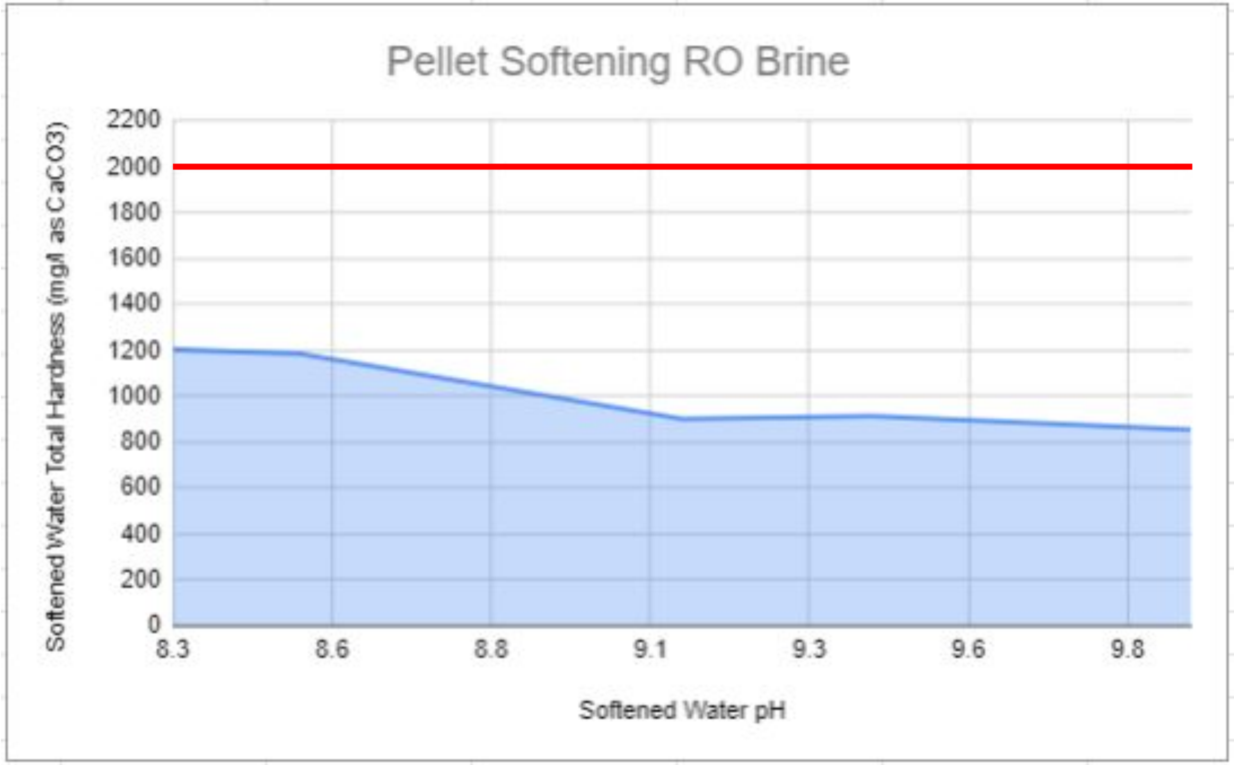
# Pellet Softening Expected Performance

| Parameter (mg/l) | pH Adjustment + Filtration |
|---|---|
| Total Hardness | 55 to 75 % |
| Calcium Hardness | 75 to 95% |
| Magnesium Hardness | 10 to 20% |
| Total Organic Carbon | 5 to 10% with NaOH |
| | 15 to 20% with lime |
| Iron | 50 to 85% |
| Manganese | 70 to 80% |
| Fluoride | 10 to 30% |
| Sulfate | 10  to 20% |

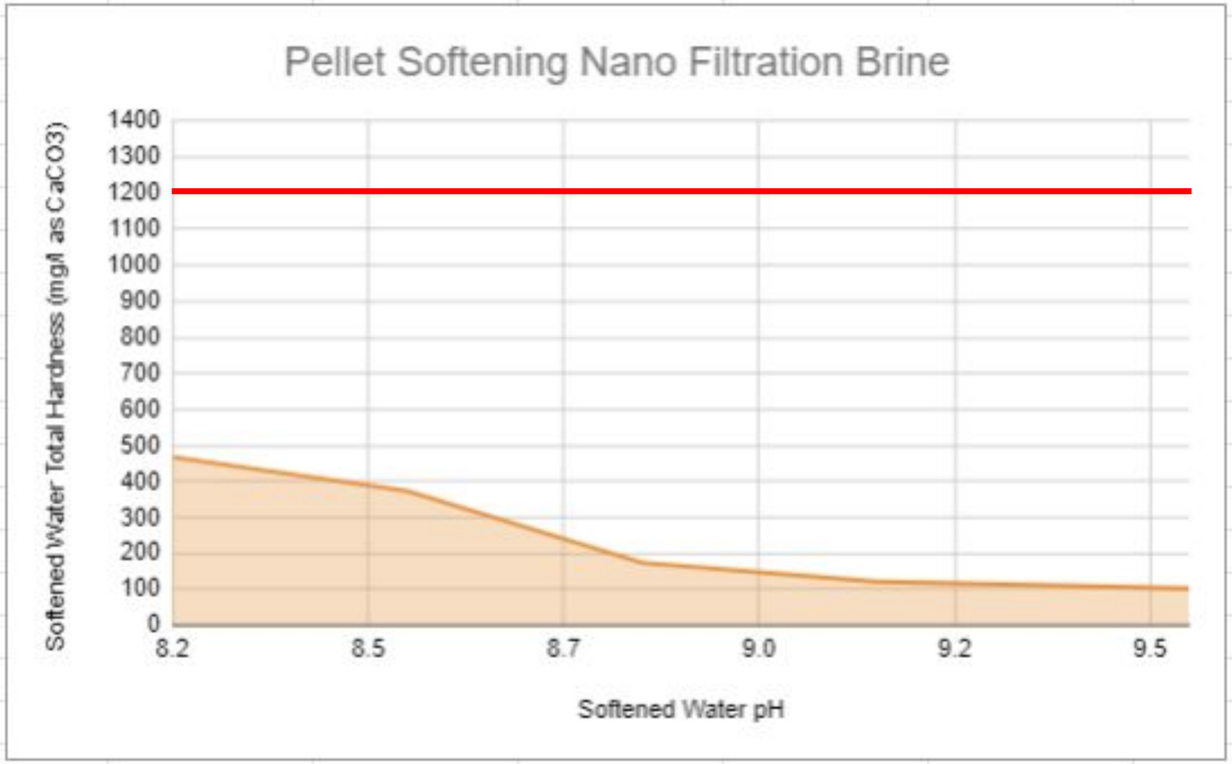



**Influent Groundwater Quality**
Vial A = Iron 3 mg/l, TH 300 mg/l
Vial B = Manganese 1 mg/l, TH 475 mg/l
Vial C = No Iron or Mn, TH  400 mg/l

# Pellet Softening Nano/RO Filtration Reject Performance Examples




Influent Total Hardness at Time of Testing



# Pellet Softening Operating Cost Example

## Boynton Beach, FL

*8 MGD Lime Softening Annual Chemical and Sludge Handling Costs (Existing)*

Lime = $480,000
Polymer = $27,000

Sludge Handling/Hauling = $100,000
Sludge Lagoon Dredging = $30,000

Yearly TOTAL = $637,000

Existing Lime Sludge Lagoon

***Estimated Pellet Softening Chemical and Pellet Handling Costs (with Caustic)***

Caustic = $340,000
Polymer = $0

Pellet Handling/Hauling = $30,000
Sludge Lagoon Dredging = $8,500
Catalyst (sand) = $40,000

Yearly TOTAL = $420,000

$220,000 savings per year

(Additional savings in labor and power not included in this number)

# Pellet Softening Life Cycle Cost Example (by Stantec)

## New Smyrna Beach, FL

*5 MGD Lime Softening Plant*

- Similar initial evaluation completed for chemical, sludge hauling and lagoon dredging was completed
- Pellet softening showed a $330,000 per year saving potential

- Four treatment options considered to increase capacity from 5 MGD to 8.3 MGD

**20 YEAR NPV COMPARISONS (Capital, OPEX, installation)**

*Membrane Softening at New Site = $44,100,000*
*Lime and Membrane Softening at Existing Site = $34,900,000*
*Expand Lime Softening at Existing Site = $29,120,000*
*Pellet Softening at Existing Site = $21,500,000*

✔ Pellet Softening:
✔ 42% less chemicals compared options with lime softening

✔ 95% less energy than membranes
✔ 50% less energy than lime softening

✔ 47% less labor than lime softening

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# ACTINA™ References and Installation Examples



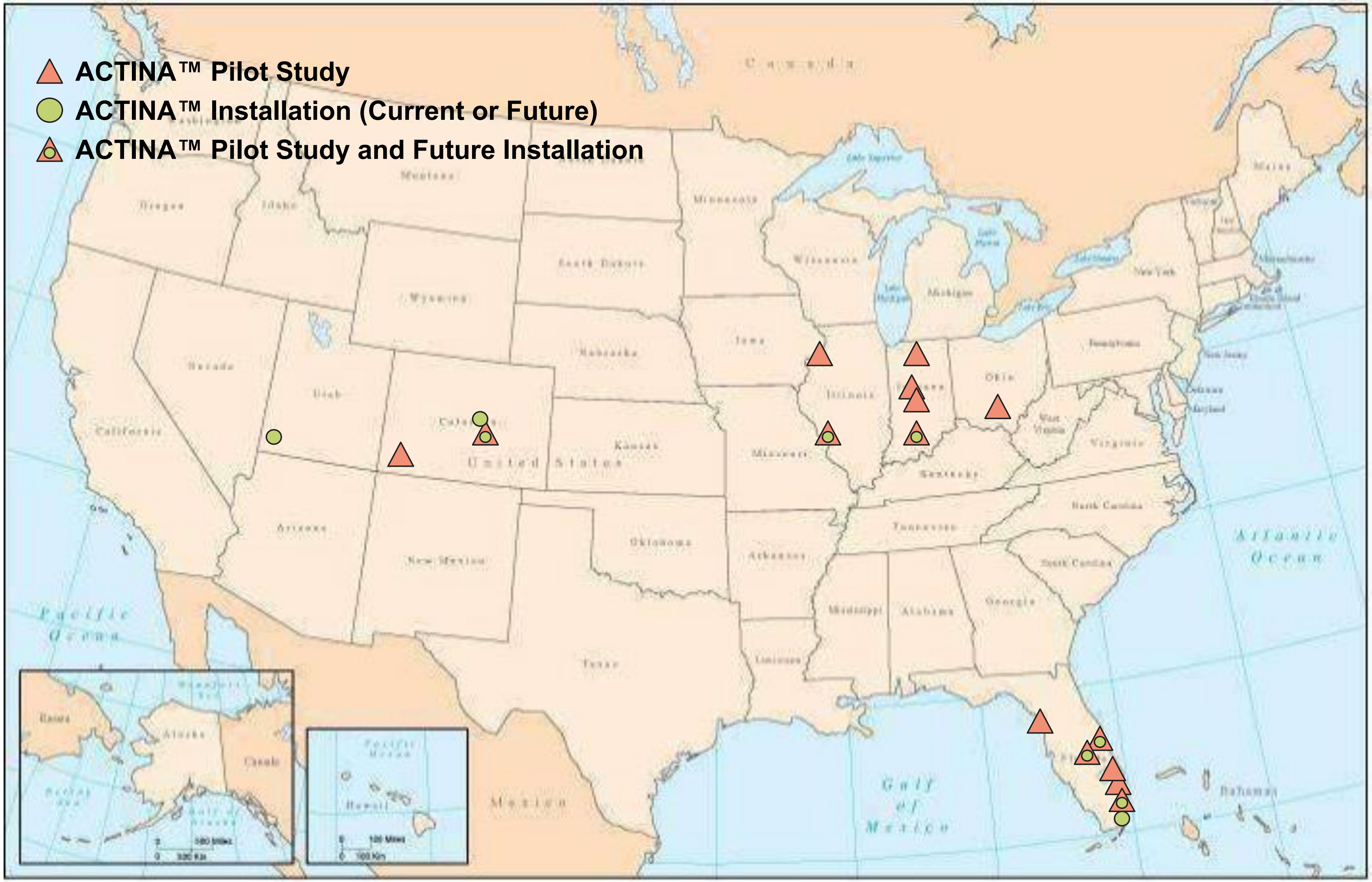
WATER TECHNOLOGIES

# ACTINA™ Installation Base

## 50+ Installations Worldwide

- 30 years of design experience
- Largest installation 80 MGD
- Smallest installations 0.2 MGD
- 17 installations 2 MGD or less
- 19 installations with flow rates 2 – 10 MGD
- 14 installations > 10 MGD
- Latest installations benefit from lessons learned and operating experience

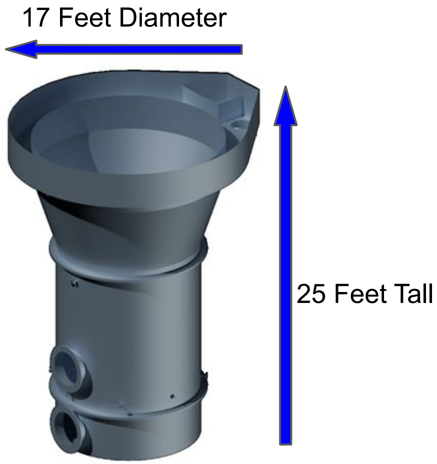
# ACTINA™ Pilot and Fullscale References - USA

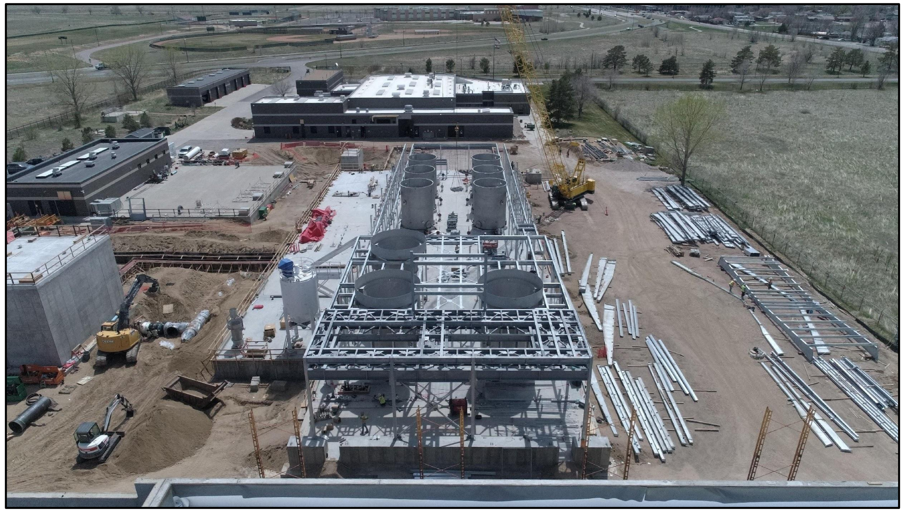


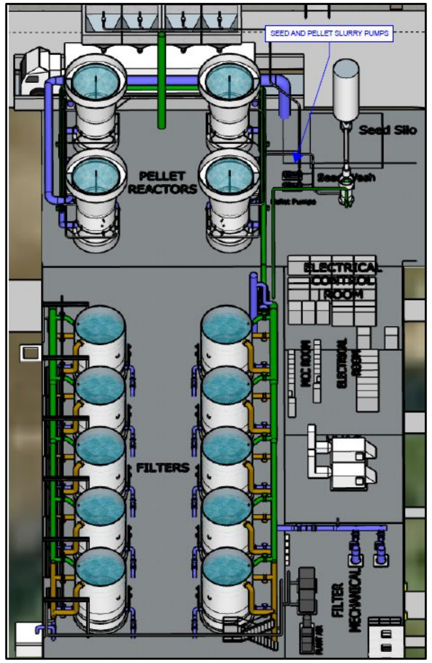
# ACTINA™ Installation Example

## South Adams County, Colorado

- *3 Pellet Reactors each rated for 4.6 MGD ( 13.8 MGD total)*
- *Media Filtration*
- *Ion Exchange (caustic carry water)*
- *Commissioned March 2021*






Courtesy of Carollo Engineering

# ACTINA™ Installation Example

## South Adams County, Colorado

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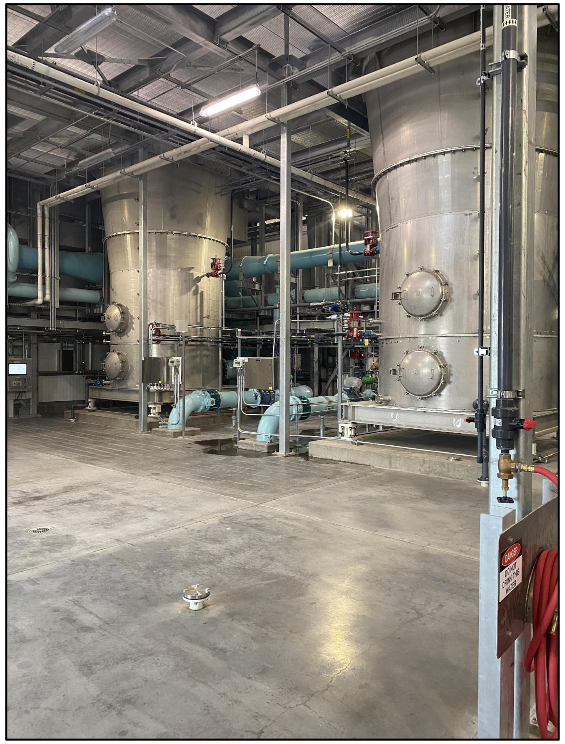

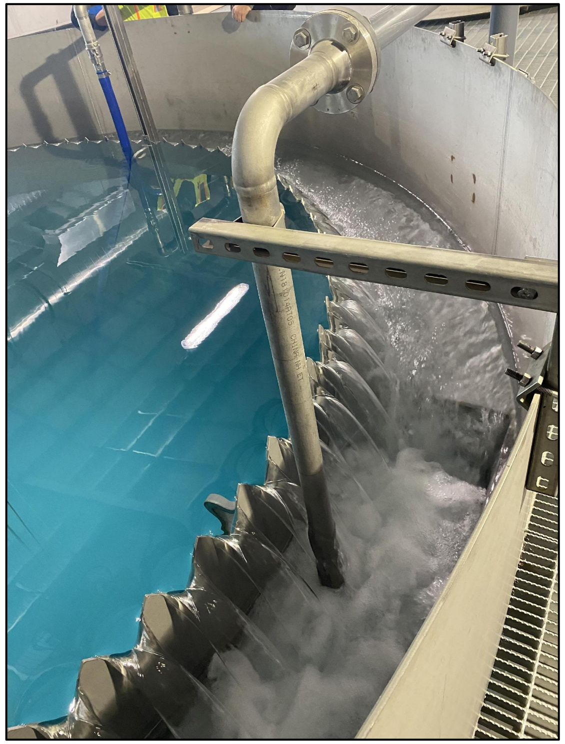

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# ACTINA ™
# Pilot Testing Discussion



WATER TECHNOLOGIES

# ACTINA™ Pilot Units

***Pilots are rated to treat 10 – 14 gpm***

- Pilots Consist of Two skids
  - ACTINA Reactor
  - Control Panel with Chemical Feed
- Can be used with caustic or lime
- Automatic control of pellet extraction
- Numerous reactor heights available to test

# Wrap-Up

Simple to Operate Technology

Self-Dewatering Pellets

30+ Years of Experience & Expertise

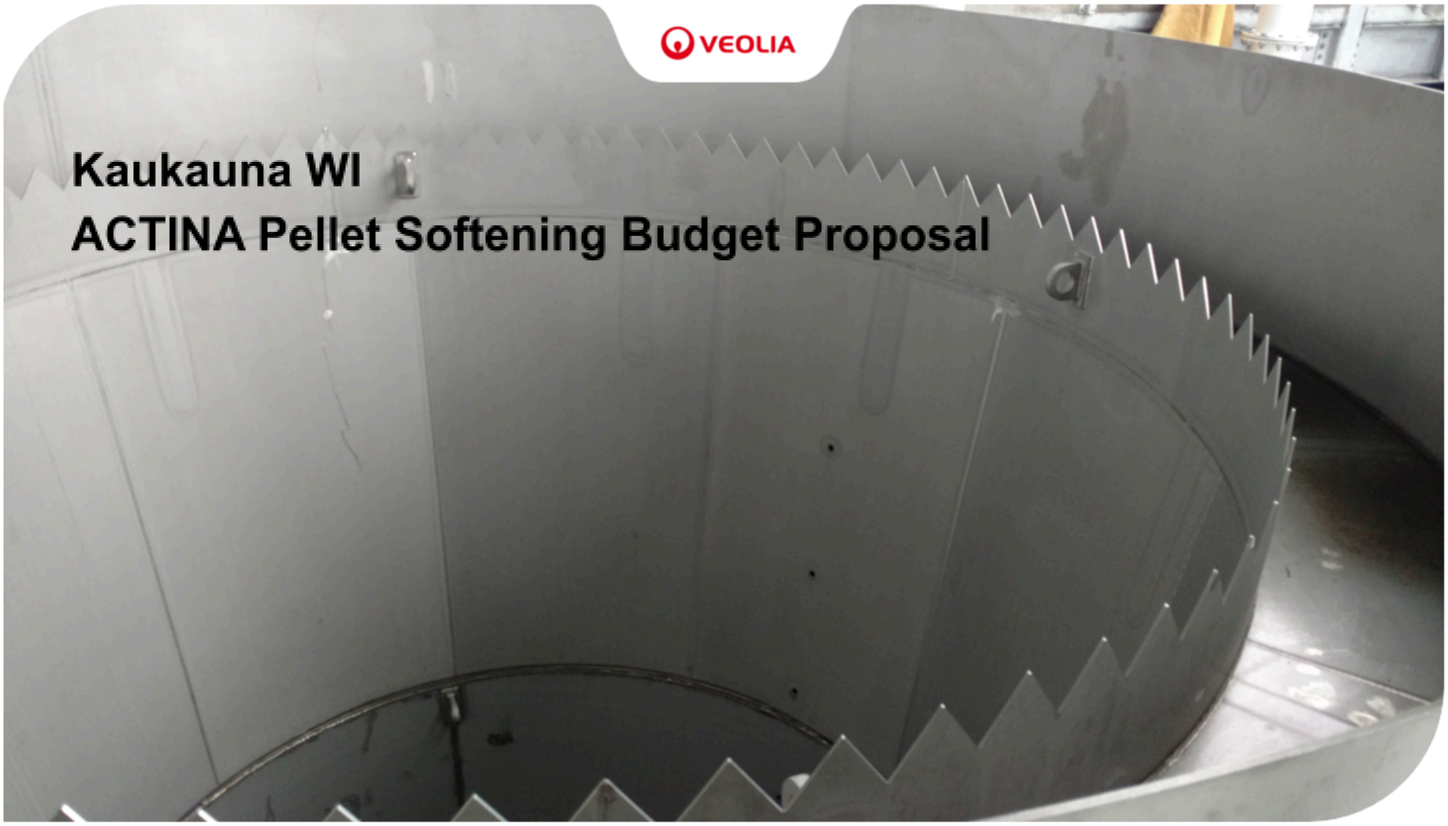
Demonstration Units Available

Additional Questions?

Harrison Fowler
Sales Engineer - Softening
harrison.fowler@veolia.com
910-625-5536



WATER TECHNOLOGIES



# Kaukauna WI
# ACTINA Pellet Softening Budget Proposal

Kruger Project: 5704149001

Proposal Date: 2/15/2024



**Veolia Water Technologies, Inc. (dba Kruger)**
4001 Weston Parkway ● Cary, NC 27513 USA
Tel: 919-677-8310 ● Fax: 919-677-0082
www.veoliawatertech.com

# 1. PRICING TERMS AND SCHEDULE

## 1.1. DESCRIPTION OF WORK

Kruger, an equipment supplier, proposes and agrees to furnish all labor services, materials, equipment, and all other items and facilities necessary to supply and deliver the equipment items as specified in these Proposal Documents and conditions stated herein.

## 1.2. PROPOSAL PRICE

Price includes ACTINA system as well as instrumentation and controls as detailed herein. Kruger's budget proposal is expressly conditioned upon the scope of supply, all terms and conditions, pricing and Kruger's Terms of Sale as included herein.

The price excludes sales and/or use taxes. Buyer agrees to provide the necessary tax-exempt certification or Reseller documentation for sales taxes exemption within thirty (30) days after receipt of a purchase agreement executed by all parties.

Kruger shall furnish and deliver (DDP Jobsite, freight estimated) ACTINA Equipment as well as instrumentation and controls, equipment drawings, start-up and other services, in conformance to the requirements set forth in this document for the Lump Sum price of:

**$2,830,000**

**Please note the price above is for the equipment and labor for both sites. There is currently no allowance for pilot testing in the price above.**

The price is valid for 14 days from the date of this Proposal. The proposed goods may be affected by the ongoing market fluctuations impacting material and shipping costs. Kruger reserves the right to re-evaluate the Proposal price prior to order acceptance.

The price above includes ***$120,000*** of shipping and freight costs. Please note that this shipping allowance is the total for both sites. Please note that shipping will be billed based on actual price at time of delivery.

## 1.3. LIQUIDATED DAMAGES

Kruger shall not accept liquidated damages from Buyer, unless otherwise agreed to in writing between Buyer and Supplier. In any event, Kruger shall not be liable for liquidated damages imposed on an installing general contractor by the Owner.

## 1.4. TERMS OF PAYMENT AND CONDITION OF SALE

The terms of payment are 30% upon execution of contract and 70% upon delivery of equipment to destination.

Payment shall not be contingent upon receipt of funds by the CONTRACTOR from the OWNER and there shall be no retention in payments due to Kruger. All payment terms are net 30 days from the date of invoice. Final payment shall not exceed 120 days from delivery of equipment. All other payment terms are as defined in Kruger's Standard Terms of Sale.

## 1.5. BONDS

Pricing does not include bonds. If bonds are required, Kruger shall provide a quotation as an adder that will be based upon a quotation from our Surety.

### 1.6. DELIVERY SCHEDULE

Equipment drawings will be submitted within 6 to 8 weeks of receipt of an executed Purchase Agreement signed by all parties.

All equipment will be delivered within 20-24 weeks of the delivery and acceptance of equipment drawings.

If Kruger is able to ship equipment sooner than the above schedule, the contractor must accept deliveries and provide adequate storage on-site for such equipment.

Operation and Maintenance Manuals will be submitted within 30 days prior to delivery of equipment.

### 1.7. CONTACT INFORMATION

This budget proposal is respectfully submitted by:

| | **Kruger Contact** |
|---|---|
| Name | Harrison Fowler |
| Company | Veolia Kruger |
| Address | Cary, NC |
| Mobile | (910) 625-5536 |
| Email | harrison.fowler@veolia.com |

### 1.8. PROPRIETARY INFORMATION

The information or data contained in this proposal is proprietary to Kruger and should not be copied, reproduced, duplicated, or disclosed to any third party, in whole or part, without the prior written consent of Kruger. This restriction will not apply to any information or data that is available to the public generally.

### 1.9. STATEMENT REGARDING COVID-19

Veolia shall not be held liable in the event of a non-compliance with its obligations set forth herein to the extent such non-compliance is due to the consequences of the Covid-19 pandemic including without limitation (i) obligation to comply with the legislation enacted or measures taken by the authorities to address the Covid-19 pandemic (including mandatory closures, requisitions, transport limitations, social distancing requirements), (ii) observance of hygiene and security rules and recommendations resulting from the Covid-19 pandemic, (iii) inability to supply or distribute to relevant personnel appropriate personal protective equipment for the tasks to be performed, as a result of shortages of supply resulting from the Covid-19 pandemic, (iv) inability of a Veolia subcontractor or supplier to comply with its obligations for the reasons mentioned above; and to the extent the resulting impediments cannot be reasonably overcome.

In the event such consequences of the Covid-19 pandemic render Veolia's performance hereunder more onerous than could have been anticipated at the date hereof the parties shall negotiate alternative contractual terms, including for delivery/performance dates or service levels, which reasonably allow for the impact of the consequences of the Covid-19 pandemic referred to here above.

## 1.10. CONTRACT PRICE

Veolia shall be entitled to an adjustment of the Contract Price and/or time of performance in connection with exceptional circumstances beyond Veolia's control such as, without limitation, raw materials shortages, sudden fluctuations of raw material pricing, extension, suspension or delay of the the project schedule, sudden disruption on production of Goods and/or spare parts required for the Project, which may affect the execution of Veolia's timely performance of the Work or affect it financially. Veolia shall notify the Owner accordingly within ten (10) days from the actual knowledge of such circumstances. Following submission of such notice, Veolia shall provide relevant justification reasonably satisfactory to the Owner to proceed to the necessary adjustments to the Contract Price and/or time of performance under the Contract.

# 2. KRUGER - TERMS OF SALE

1. Applicable Terms. These terms govern the purchase and sale of the equipment and related services, if any (collectively, "Equipment"), referred to in Seller's purchase order, quotation, proposal or acknowledgment, as the case may be ("Seller's Documentation"). Whether these terms are included in an offer or an acceptance by Seller, such offer or acceptance is conditioned on Buyer's assent to these terms. Seller rejects all additional or different terms in any of Buyer's forms or documents.

2. Payment. Buyer shall pay Seller the full purchase price as set forth in Seller's Documentation. Unless Seller's Documentation provides otherwise, freight, storage, insurance and all taxes, duties or other governmental charges relating to the Equipment shall be paid by Buyer. If Seller is required to pay any such charges, Buyer shall immediately reimburse Seller. All payments are due within 30 days after receipt of invoice. Buyer shall be charged the lower of 1 ½% interest per month or the maximum legal rate on all amounts not received by the due date and shall pay all of Seller's reasonable costs (including attorneys' fees) of collecting amounts due but unpaid. All orders are subject to credit approval.

3. Delivery. Delivery of the Equipment shall be in material compliance with the schedule in Seller's Documentation. Unless Seller's Documentation provides otherwise, Delivery terms are F.O.B. Seller's facility.

4. Ownership of Materials. All devices, designs (including drawings, plans and specifications), estimates, prices, notes, electronic data and other documents or information prepared or disclosed by Seller, and all related intellectual property rights, shall remain Seller's property. Seller grants Buyer a non-exclusive, non-transferable license to use any such material solely for Buyer's use of the Equipment. Buyer shall not disclose any such material to third parties without Seller's prior written consent.

5. Changes. Seller shall not implement any changes in the scope of work described in Seller's Documentation unless Buyer and Seller agree in writing to the details of the change and any resulting price, schedule or other contractual modifications. This includes any changes necessitated by a change in applicable law occurring after the effective date of any contract including these terms.

6. Warranty. Subject to the following sentence, Seller warrants to Buyer that the Equipment shall materially conform to the description in Seller's Documentation and shall be free from defects in material and workmanship. The foregoing warranty shall not apply to any Equipment that is specified or otherwise demanded by Buyer and is not manufactured or selected by Seller, as to which (i) Seller hereby assigns to Buyer, to the extent assignable, any warranties made to Seller and (ii) Seller shall have no other liability to Buyer under warranty, tort or any other legal theory. If Buyer gives Seller prompt written notice of breach of this warranty within 18 months from delivery or 1 year from beneficial use, whichever occurs first (the "Warranty Period"), Seller shall, at its sole option and as Buyer's sole remedy, repair or replace the subject parts or refund the purchase price therefore. If Seller determines that any claimed breach is not, in fact, covered by this warranty, Buyer shall pay Seller its then customary charges for any repair or replacement made by Seller. Seller's warranty is conditioned on Buyer's (a) operating and maintaining the Equipment in accordance with Seller's instructions, (b) not making any unauthorized repairs or alterations, and (c) not being in default of any payment obligation to Seller. Seller's warranty does not cover damage caused by chemical action or abrasive material, misuse or improper installation (unless installed by Seller). THE WARRANTIES SET FORTH IN THIS SECTION ARE SELLER'S SOLE AND EXCLUSIVE WARRANTIES AND ARE SUBJECT TO SECTION 10 BELOW. SELLER MAKES NO OTHER WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSE.

7. Indemnity. Seller shall indemnify, defend and hold Buyer harmless from any claim, cause of action or liability incurred by Buyer as a result of third party claims for personal injury, death or damage to tangible property, to the extent caused by Seller's negligence. Seller shall have the sole authority to direct the defense of and settle any indemnified claim. Seller's indemnification is conditioned on Buyer (a) promptly, within the Warranty Period, notifying Seller of any claim, and (b) providing reasonable cooperation in the defense of any claim.

8. Force Majeure. Neither Seller nor Buyer shall have any liability for any breach (except for breach of payment obligations) caused by extreme weather or other act of God, strike or other labor shortage or disturbance, fire, accident, war or civil disturbance, delay of carriers, failure of normal sources of supply, act of government or any other cause beyond such party's reasonable control.

9. Cancellation. If Buyer cancels or suspends its order for any reason other than Seller's breach, Buyer shall promptly pay Seller for work performed prior to cancellation or suspension and any other direct costs incurred by Seller as a result of such cancellation or suspension.

10. LIMITATION OF LIABILITY. NOTWITHSTANDING ANYTHING ELSE TO THE CONTRARY, SELLER SHALL NOT BE LIABLE FOR ANY CONSEQUENTIAL, INCIDENTAL, SPECIAL, PUNITIVE OR OTHER INDIRECT DAMAGES, AND SELLER'S TOTAL LIABILITY ARISING AT ANY TIME FROM THE SALE OR USE OF THE EQUIPMENT SHALL NOT EXCEED THE PURCHASE PRICE PAID FOR THE EQUIPMENT. THESE LIMITATIONS APPLY WHETHER THE LIABILITY IS BASED ON CONTRACT, TORT, STRICT LIABILITY OR ANY OTHER THEORY.

11. Miscellaneous. If these terms are issued in connection with a government contract, they shall be deemed to include those federal acquisition regulations that are required by law to be included. These terms, together with any quotation, purchase order or acknowledgement issued or signed by the Seller, comprise the complete and exclusive statement of the agreement between the parties (the "Agreement") and supersede any terms contained in Buyer's documents, unless separately signed by Seller. No part of the Agreement may be changed or canceled except by a written document signed by Seller and Buyer. No course of dealing or performance, usage of trade or failure to enforce any term shall be used to modify the Agreement. If any of these terms is unenforceable, such term shall be limited only to the extent necessary to make it enforceable, and all other terms shall remain in full force and effect. Buyer may not assign or permit any other transfer of the Agreement without Seller's prior written consent. The Agreement shall be governed by the laws of the State of North Carolina without regard to its conflict of laws provisions.

## 3. DESIGN SUMMARY

### 3.1. DESIGN CRITERIA

The proposed System is designed per the following design summary:

**Table 1: Influent & Effluent Design Criteria**

| Treatment Capacity | MGD |
|---|---|
| Treatment Flow | 2.3<br>&<br>2.52 |
| **Raw Water Characteristics** | **Value** |
| pH | 7.2 |
| Alkalinity, mg/L as $CaCO_3$ | 188.6 |
| Total Hardness, mg/L as $CaCO_3$ | 677 |
| Calcium, mg/L | 226.6 |
| Magnesium, mg/L | 20.6 |
| Strontium, mg/L | 23.6 |
| Iron, mg/L | 0.62 |
| **Softened Water Characteristics** | **Expected Effluent Performance** |
| Total Hardness, mg/L as $CaCO_3$ | 120-150 |

## 4. EQUIPMENT SCOPE OF SUPPLY

| Equipment Items | Qty | Description |
|---|---|---|
| 800 & 875 gpm (2.3 & 2.52 MGD Total Flow) Pellet Softening Reactor | 4 | • 304 SS construction, flat bottom<br>• One manways, one above and one below the strainer deck per reactor<br>• One pellet extraction pipes per reactor and an adjustable effluent weir<br>• Sufficient number of flow strainers to evenly distribute influent flow through the reactor bed<br>• Influent and Effluent flow flanged connections<br>• Two reactors designed for 800 gpm (2.3 MGD)<br>• Two reactors designed for 875 gpm (2.52 MGD) |
| Removable Caustic Soda Injection Chandelier | 5 | • One per reactor + one shelf spare<br>• 304 SS frame with lifting connection<br>• Sufficient number of chemical dispersion nozzles required for the size of the reactor |
| Sodium Hydroxide Feed Skid | 2 | • One skid per site<br>• Corrosion resistant chemical skid<br>• Volumetric metering pumps with variable speed drives<br>• Skid components to include:<br>○ Pressure relief valves<br>○ Check valves<br>○ Isolation valves<br>○ Calibration column<br>○ Pressure gauge<br>○ Piping and fittings |
| Seed Washer | 2 | • One seed washer per site<br>• 304 SS construction<br>• Flow strainers to evenly distribute flow through the washer<br>• Influent and outlet flow flanged connections<br>• Two seed extraction pipes with flanged connections |
| Pellet Extraction Pump | 4 | • 4 duty, one per reactor<br>• Belt driven, centrifugal slurry pump with food grade rubber casing liners and impeller<br>• Closed vane impeller<br>• Dry gland<br>• IEEE841 Motor<br>• Subframe and drip tray<br>• Standard paint finish<br>• 1 pump per reactor in duty |
| Seed Transfer Pump | 4 | • 4 duty, one per reactor<br>• V-Belt and pulley driven, cast iron centrifugal slurry pump with food grade rubber liner and open vane impeller<br>• Dry gland seal with drip pan<br>• TEFC, premium efficient, inverter duty motor, 230/460V, 3-phase, 60 Hz, 10 HP (Est.) |
| Carrier Water Softener | 2 | • One carrier water softener skid per site<br>• Two vessel, ion exchange softener<br>• Electronic controllers with digital display<br>• Polyethylene brine storage tank<br>• Automatic backwash flow controller<br>• Ion exchange media |

| | | |
|---|---|---|
| Valves | LOT | ● One (1) 9” Influent Automated Butterfly Valve (4 Total)<br>● One (1) 12” Effluent Automated Butterfly Valve (4 Total)<br>● Two (2) Automated Pinch Valves per Extraction Line (8 Total)<br>● One (1) Solenoid Valve per Extraction Line (4 Total)<br>● Manual valves as required |
| Spare Parts | 1 lot | ● 50 flow strainers |

### 4.1. Control Panel and Instrumentation

**ACTINA Control Panel**

Two (2) main PLC Based Control panels, one for each site, will be supplied to control the ACTINA Process based on operator setpoints. All field wiring and field terminations are by others. The Control Panel will be completely assembled, tested, and programmed for the required functionality. U. L. labeled Panel’s will be comprised of the following:

| Qty | Description | Manufacturer |
|---|---|---|
| 2 | NEMA 12 Enclosure | Saginaw |
| 2 | PLC Processor | Allen Bradley |
| 2 | HMI Operator Interface | Allen Bradley |
| 2 | PLC and Operator Interface Programming | Kruger |
| 2 | PLC site Start-Up and Testing | Kruger |

Per agreement with the owner, the ACTINA PLC will communicate with the Plant SCADA System via Allen Bradley Ethernet IP. Any third party modules, gateways or configuration required is the responsibility of the integrator.

Each PLC Control Panel will include the necessary input/output plus twenty percent (20%) “Live” spare wired signals for future or additional signal interface.

All PLC and Operator Interface programming are based on Kruger standards. Any requests or requirements that would deviate from this standard will result in additional costs. Kruger will be providing PLC/Operator Interface programming only for the Kruger supplied PLC Control Panel.

The PLC Program and Operator Interface Program and its associated Graphic screens developed by Kruger are for use on the Kruger supplied PLC and Operator Interface only. The Kruger supplied PLC Program and Operator Interface Program and its associated Graphic screens cannot be used, whole or any part for other uses.

Kruger will use Allen Bradley development software for PLC Programming and Operator Interface Programming; the development software is licensed to Kruger and will not be provided as part of this scope. Kruger will not be providing any PLC, Network, Operator Interface, SCADA, or Alarm Notification software.
Kruger will supply copies of the completed PLC and Operator Interface programs at job completion. Prior to supplying completed PLC and Operator Interface programs, Kruger requests that a non-disclosure agreement be signed and returned to Kruger.

Factory testing of the Kruger PLC Control Panel will be conducted by Kruger personnel at a Kruger selected Panel Facility. Kruger reserves the right to conduct this testing when it is deemed appropriate in regards to Kruger personnel. Kruger has an established Panel testing criteria and will conduct all Panel and Software testing per Kruger standards. When said Panel/Software testing is complete, a Test Report will be generated per Kruger standards. Other party's are welcome to witness panel testing at no expense to Kruger. Testing can be witnessed at an agreed upon date that does not impact delivery or start-up schedules.

No other Instruments, Control Panel Components (PLC or other components) will be supplied unless they are explicitly listed in this Scope of Supply.

**Field Instruments**

| Qty | Description | Manufacturer |
|---|---|---|
| 4 | Immersion pH Meter DPD1P1 w/ SC200 Transmitter | Hach |
| 4 | Solitax Turbidity Probe | Hach |
| 8 | Differential Pressure Transmitter (PMD75) | Endress+Hauser |

Kruger will calibrate and start-up Instruments supplied by Kruger. Instruments supplied by others will require calibration and start-up by others.

**IMPORTANT NOTE: NO ADDITIONAL TOOLS AND/OR SPARE PARTS OTHER THAN LISTED ABOVE WILL BE PROVIDED AS PART OF KRUGER'S SCOPE OF SUPPLY. OIL AND LUBRICANTS ARE NOT INCLUDED AS PART OF KRUGER'S SCOPE OF SUPPLY. THESE ARE TO BE THE RESPONSIBILITY OF THE CONTRACTOR.**

### 4.2. SCOPE OF WORK

Kruger is responsible for process design and equipment procurement required for the ACTINA process. Kruger scope of work does not include any equipment, materials or other services not specifically defined in this proposal. The equipment scope of supply shall include the equipment as shown in the attached scope of supply.

### 4.3. PROCESS DESIGN AND ENGINEERING

Kruger will perform engineering in accordance with the applicable national codes, standards, and/or regulations (except where otherwise noted) in effect at the time of this proposal. Reactor drawings will not be stamped by a professional engineer, if this is required a cost adder will apply. Additionally, Kruger will provide equipment drawings only, site layout and piping runs by others. Kruger is not responsible for the design, selection, installation, operation, or maintenance of any material, equipment, or services provided by others.

Kruger will provide process engineering and design support for the system as follows:

1. Technical instruction for operation and start-up of the system
2. Equipment drawings
3. Equipment installation instructions
4. O&M manuals

### 4.4. FIELD SERVICE

Kruger shall supply the following services of one (1) system-trained representative as detailed herein, per site:

- Ten (10) days, in not more than four (4) trips to assist with inspection check-out, start-up, and operator training.

NOTES:

- Please note that the trips and days describe above are for EACH site.
- Man-days are eight hour days Monday through Friday that include travel time.
- Man-days and/or trips required beyond those indicated above will be billed at Kruger's published standard rates at time of service, plus travel and lodging costs. Such additional days could become necessary for correction of improperly installed equipment or instrumentation, prolonged construction time, or Contractor's failure to properly coordinate start-up and training.

# 5. ITEMS NOT INCLUDED

## 5.1. SCOPE OF SUPPLY BY OTHERS

***Unless otherwise indicated in this Scope of Supply document, the Contractor shall furnish the following items. The Contractors scope is not necessarily limited to this list:***

1. Others shall provide access to the facilities for Kruger field personnel to inspect the installed Kruger equipment. This access shall include, but not be limited to, the following:
    a. Safe ingress and egress at the reactors.
    b. Provisions, such as scaffolding or lifting devices, to allow the Kruger inspector to gain close access to installed equipment for a complete and proper inspection.
    c. Sufficient lighting for safety and inspection visibility purposes.
    d. Provisions for atmospheric monitoring and ventilation, if necessary.
    e. Personnel available to provide remedy for items that can be corrected during or just after the inspection.
2. Receiving (preparation of receiving reports), unloading, storage, maintenance preservation and protection of all equipment, and materials provided by Kruger.
3. Installation of all equipment and materials provided by Kruger.
4. Supply and install all bulk storage tanks, pads, and supports not included in Kruger scope of supply.
5. Supply, fabrication, installation, cleaning, pickling, and/or passivation of all stainless steel piping components not provided by Kruger.
6. All cutting, welding, fitting, and finishing for all field fabricated piping.
7. Supply and installation of all flange gaskets and bolts for all piping components not supplied by Kruger.
8. Supply and installation of all pipe supports and connection points not supplied by Kruger.
9. Provide all motor control centers, motor starters, panels, transformers, and VFDs other than supplied by Kruger.
10. Install and terminate all motor control centers, motor starters, panels, transformers, and VFDs.
11. Supply and install all chandelier lifting systems and any required cabling
12. Supply and install all required caustic feed monitoring equipment to include rotameters, pressure gauges and safety panels to house the equipment
13. Supply and install all piping/tubing required to deliver caustic soda and softened carrier water to each pellet softening reactor and to each chandelier tubing manifold.
14. Supply and install all electrical power and control wiring and conduit to the equipment served plus interconnection between Kruger’s furnished equipment as required, including wire, cable, junction boxes, fittings, conduit, etc.
15. Provide softened carrier water for the delivery of caustic soda to each pellet softening reactor
16. Provide and install all stainless tubing with grease fittings routed to 4 feet above the floor for any grease fitting located above 5 feet.
17. Provide all anchor bolts, epoxy anchor adhesive / applicators and mounting hardware not provided by Kruger.
18. Provide and install all piping required to interconnect to the Supplier’s equipment.
19. Provide all nameplates, safety signs and labels.
20. The Contractor shall coordinate the installation and timing of interface points such as piping and electrical with the Supplier.
21. Video recording of any training activities.
22. Supply and install all sunshields, heat tracing and/or additional enclosures as needed when installing equipment and instrumentation outdoors.
23. Collecting samples from the process (including necessary labor, composite samplers, etc.) during the project, including startup, performance testing, and operation of the system.
24. Laboratory testing of process samples during the project, including startup, performance testing, and operation of the system.
25. Provide all chemicals, lubricants, glycol, oils, or grease and other supplies required for equipment start-up or plant operation.
26. Seismic calculations. If seismic calculations are required, they can be provided at additional cost.
27. All other equipment and services not otherwise listed as specifically supplied by Kruger.

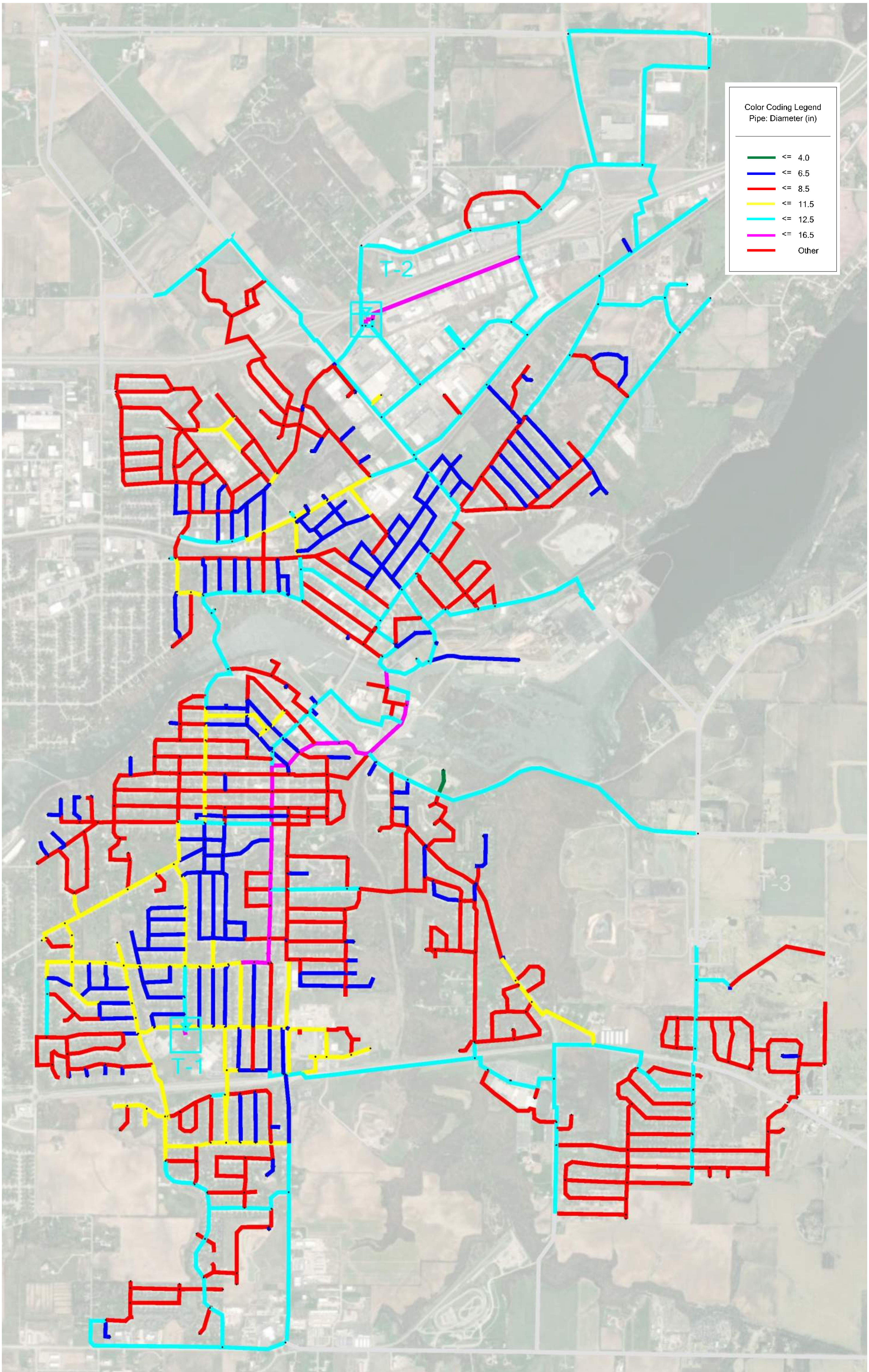
## 6. OPERATIONS INFORMATION

## 7. ACTINA REACTOR DRAWING

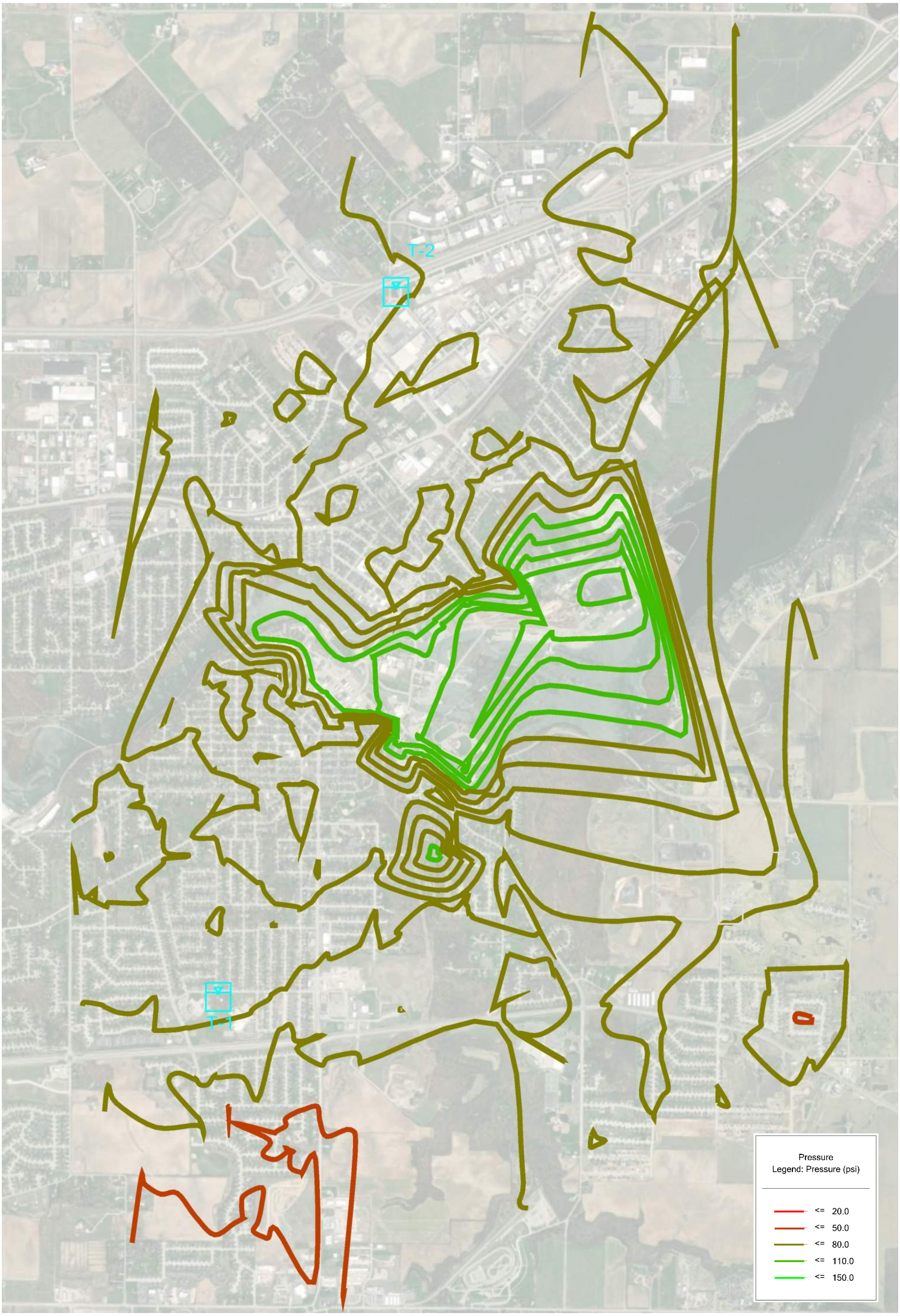
# APPENDIX K

# Computer Water Model Information

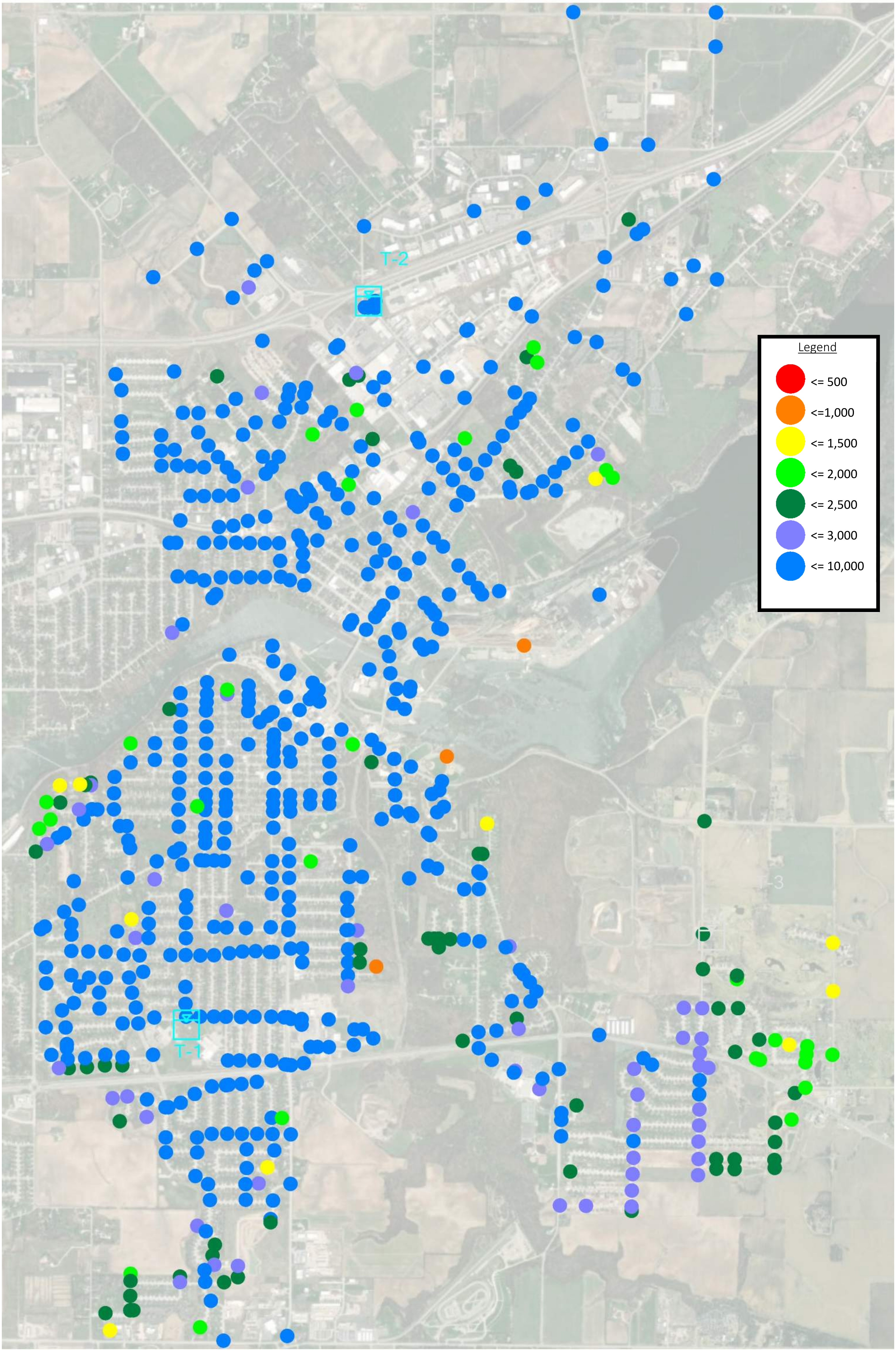
# KAUKAUNA EXISTING SYSTEM



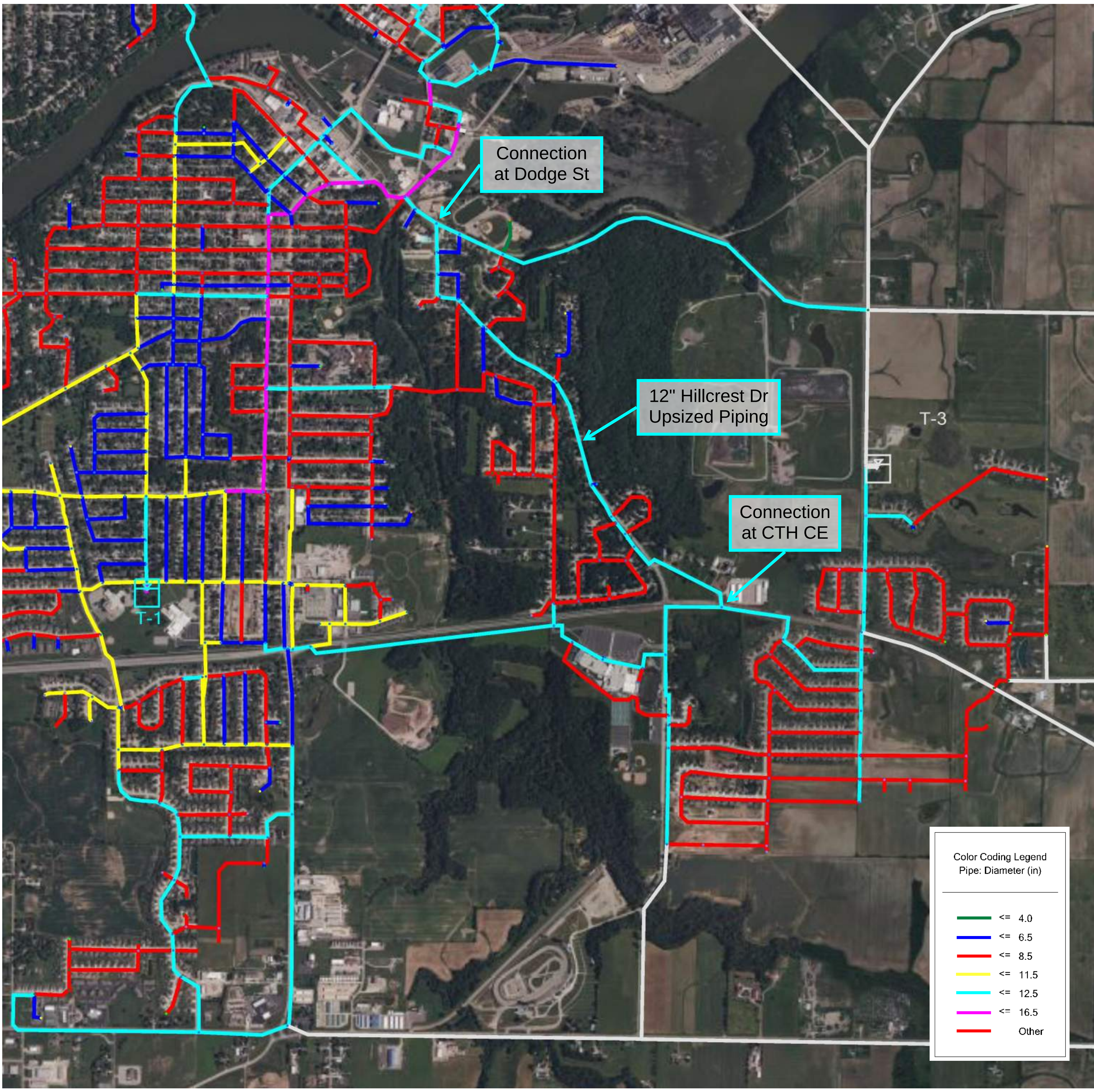
KAUKAUNA EXISTING SYSTEM - PRESSURE CONTOURS



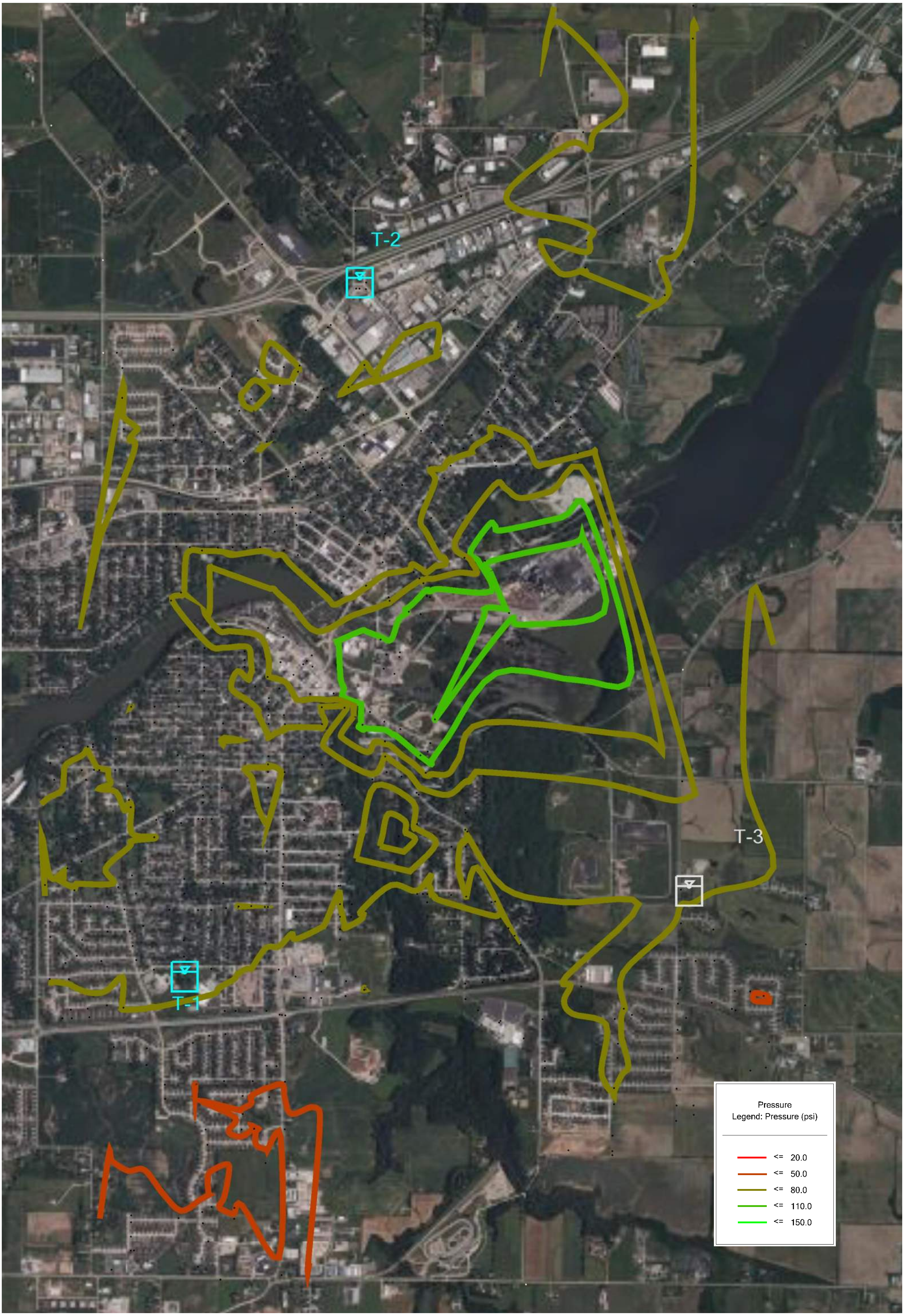
# KAUKAUNA EXISTING SYSTEM - FIRE FLOWS



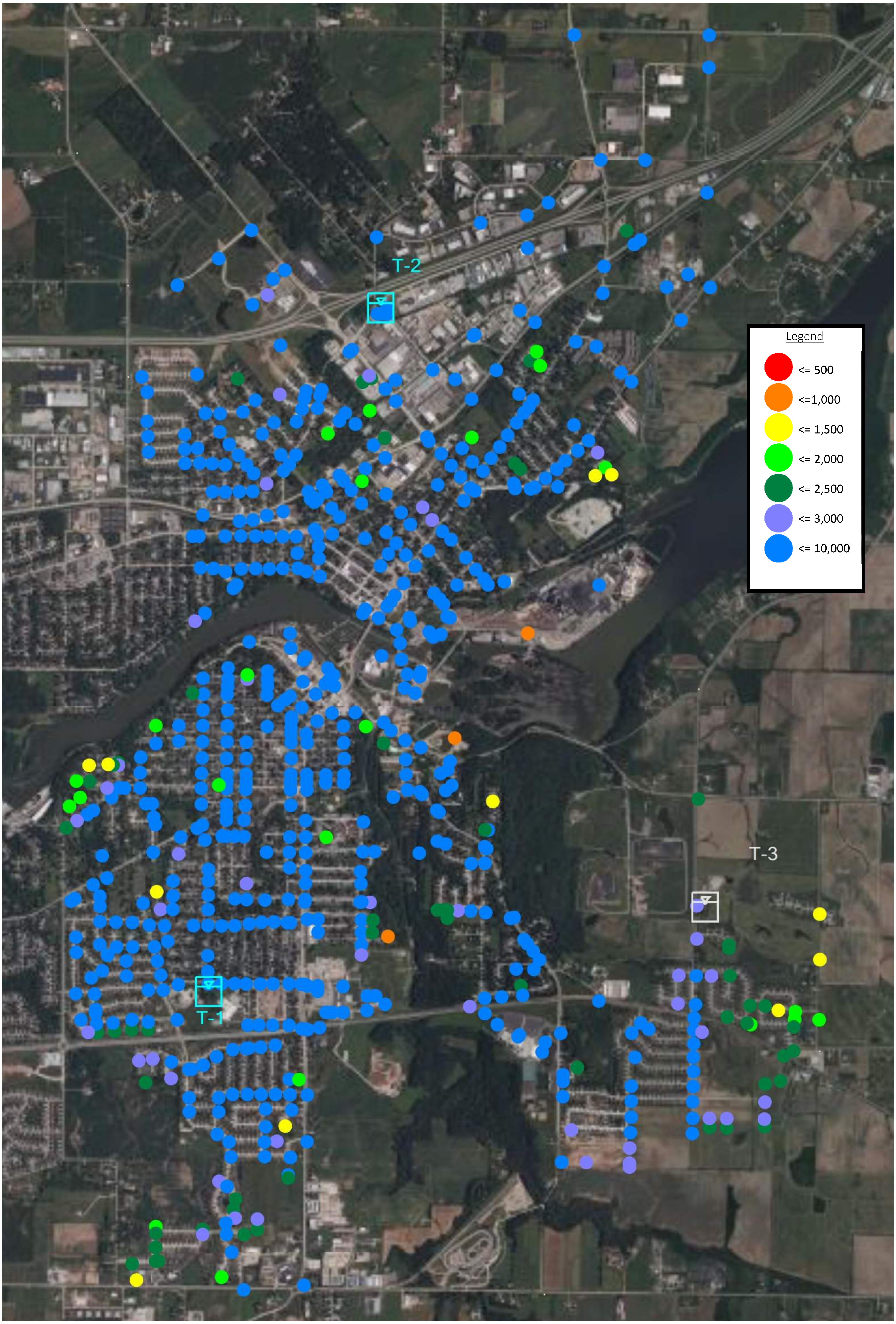
KAUKAUNA
SCENARIO 1: HILLCREST WATER MAIN PIPE UPSIZING



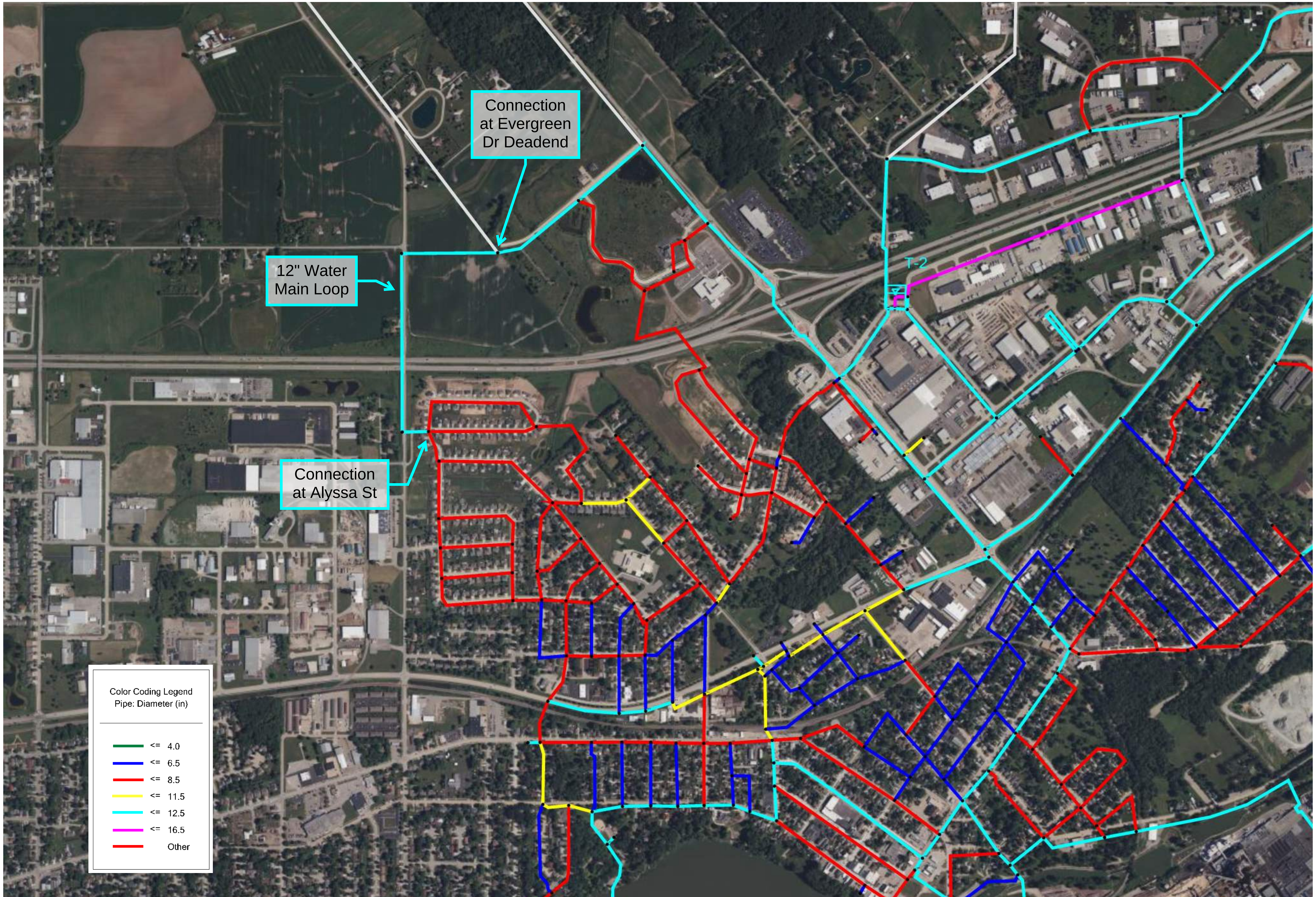
KAUKAUNA
SCENARIO 1: HILLCREST WATER MAIN PIPE UPSIZING
PRESSURE CONTOURS



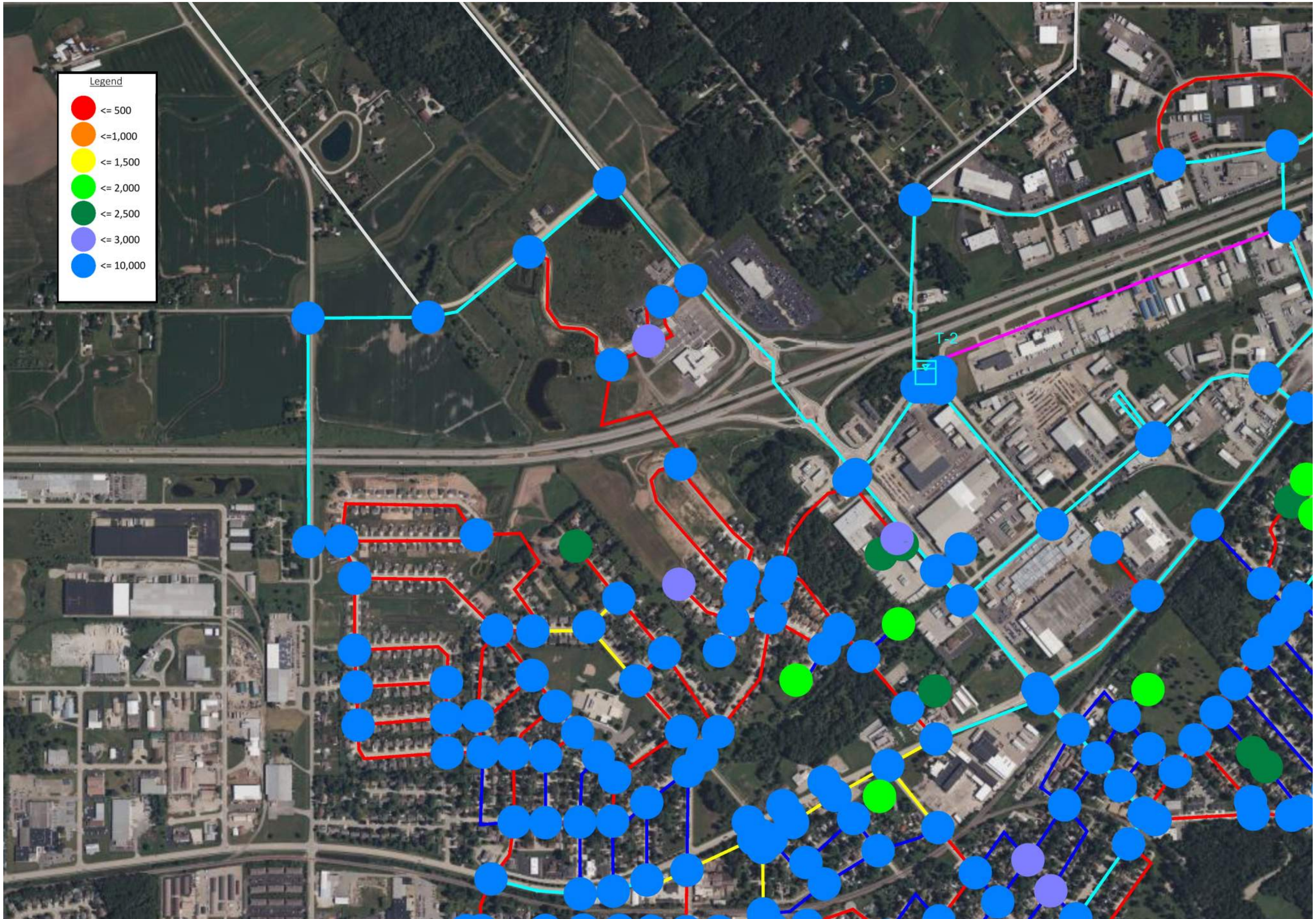
KAUKAUNA
SCENARIO 1: HILLCREST WATER MAIN PIPE UPSIZING
FIRE FLOWS



KAUKAUNA
SCENARIO 2: LOOP AT EVERGREEN DRIVE

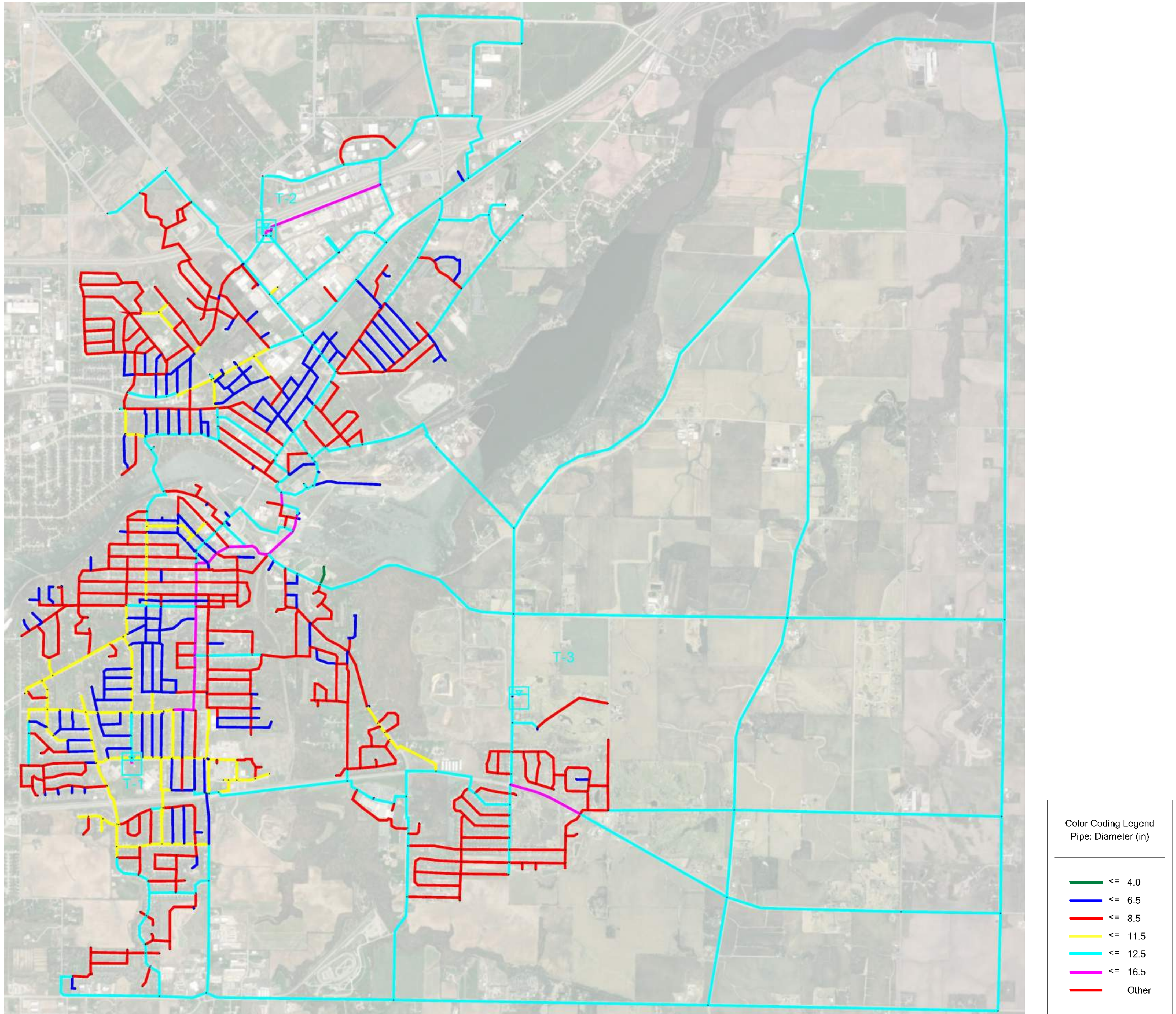


KAUKAUNA
SCENARIO 2: LOOP AT EVERGREEN DRIVE
FIRE FLOW

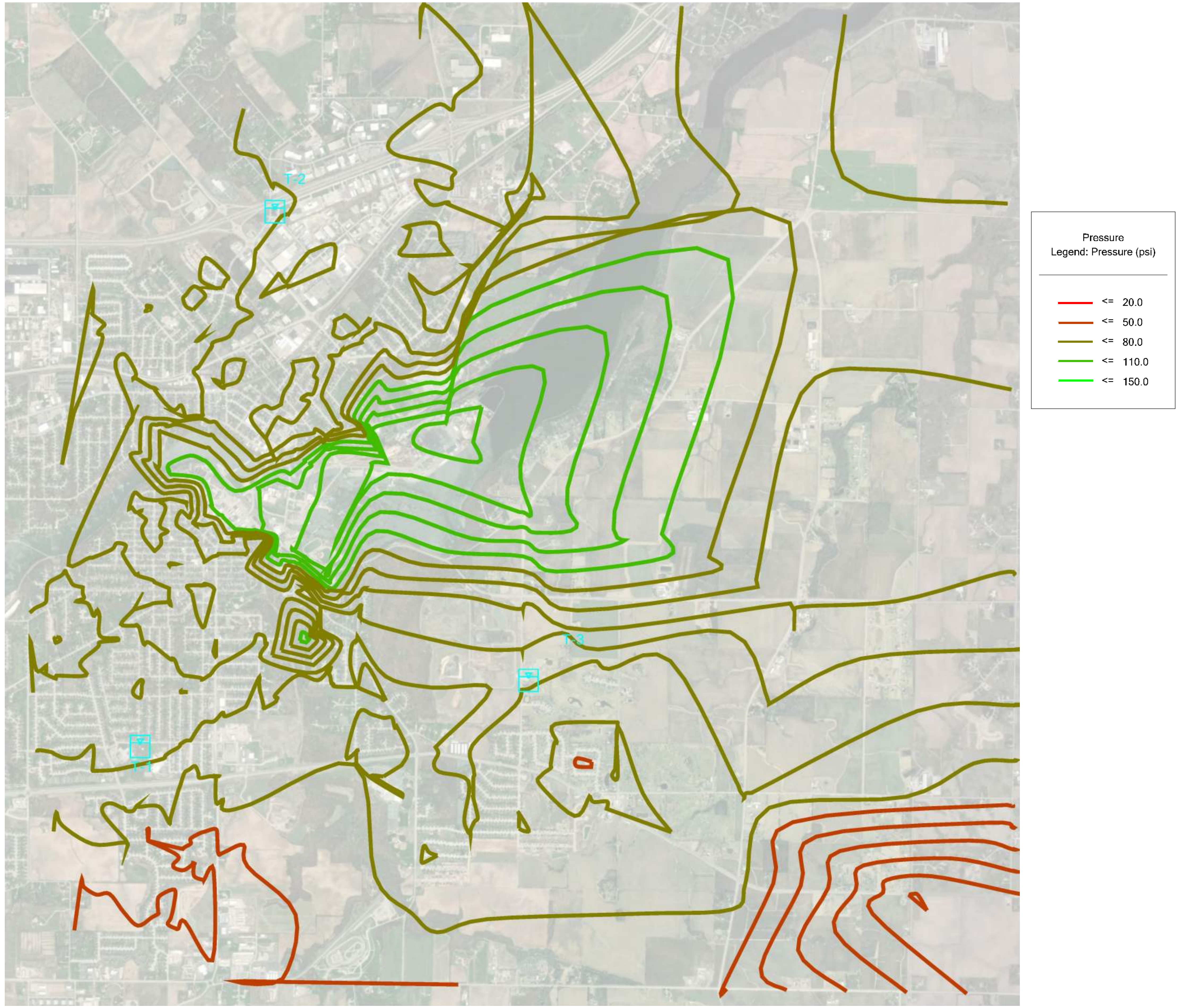


KAUKAUNA

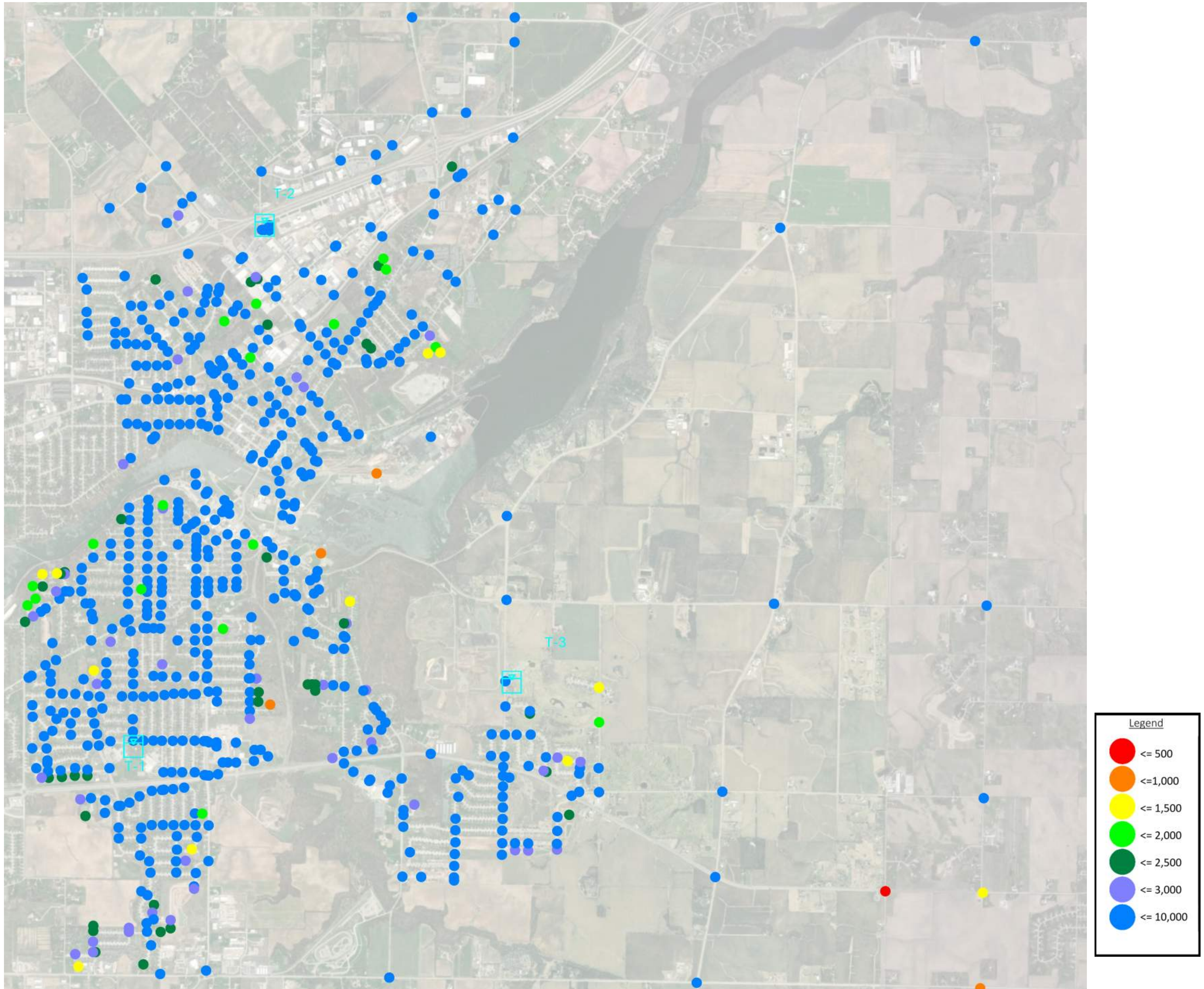
SCENARIO 3: 12-Inch SE Expansion - No Pressure Zone



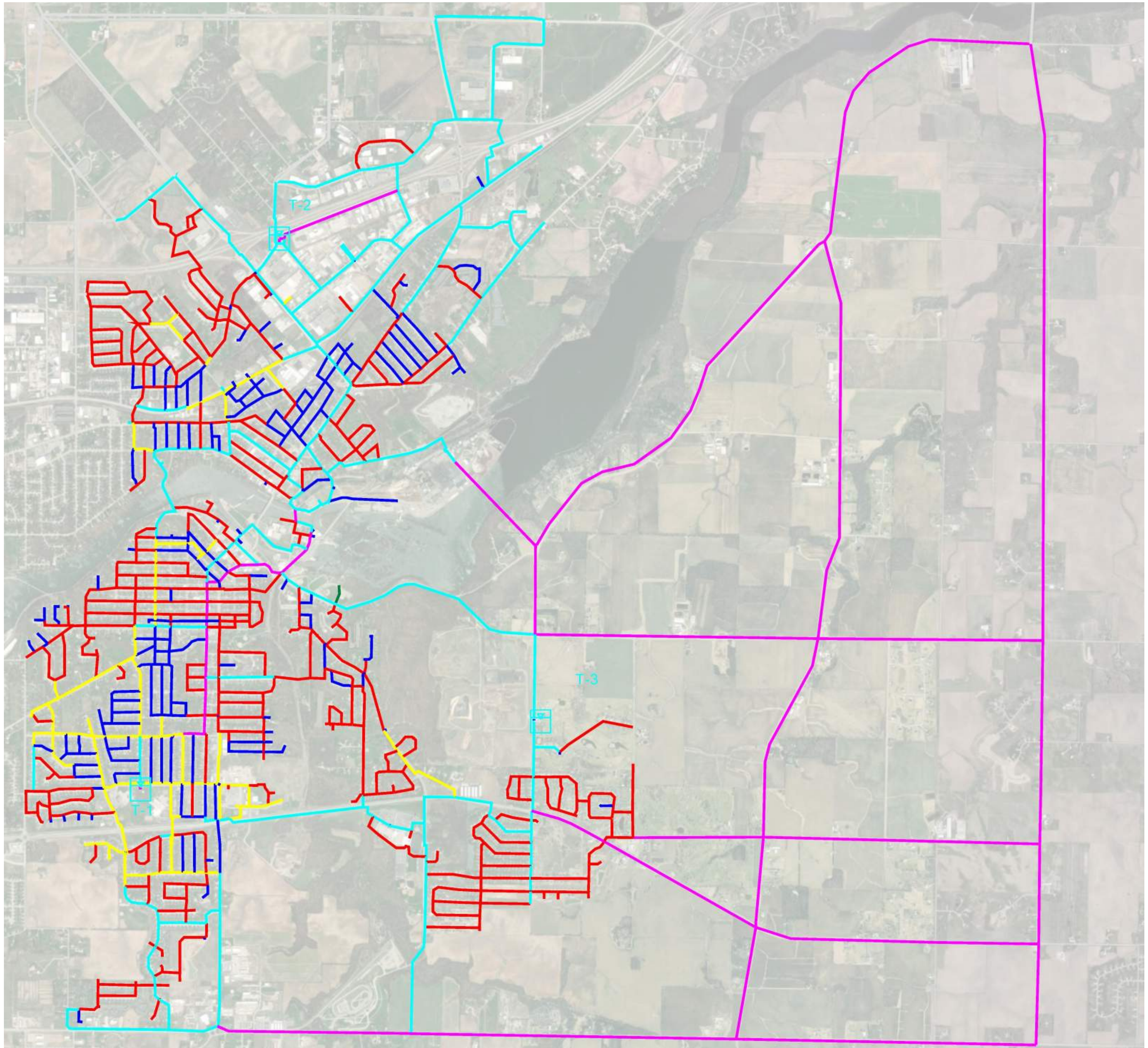
KAUKAUNA
SCENARIO 3: 12-Inch SE Expansion - No Pressure Zone
Pressure Contours

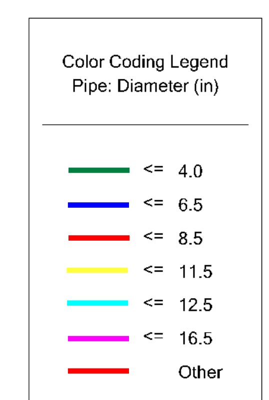


KAUKAUNA
SCENARIO 3: 12-Inch SE Expansion - No Pressure Zone
FIRE FLOW

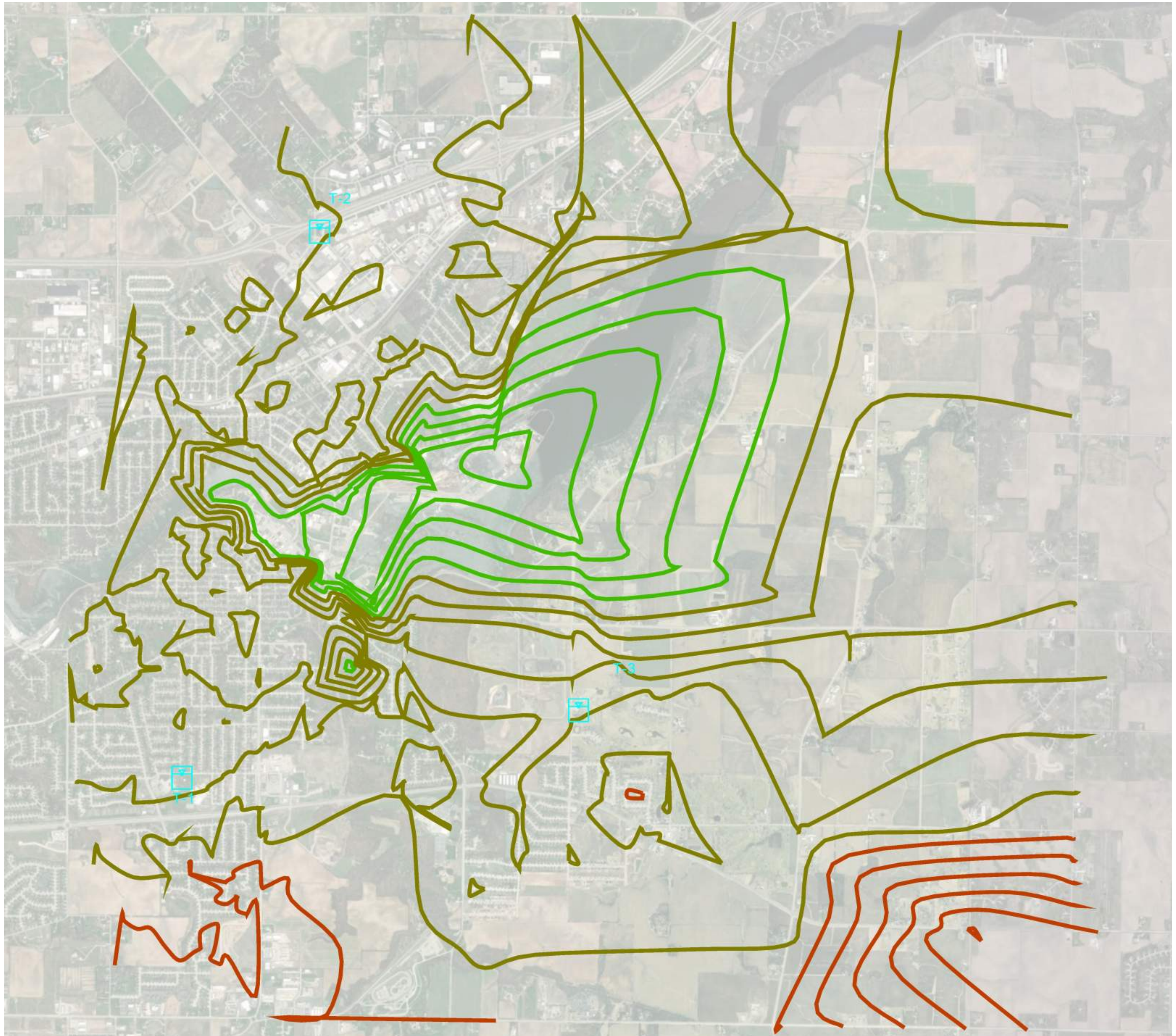


# KAUKAUNA
## SCENARIO 4: 16-Inch SE Expansion - No Pressure Zone



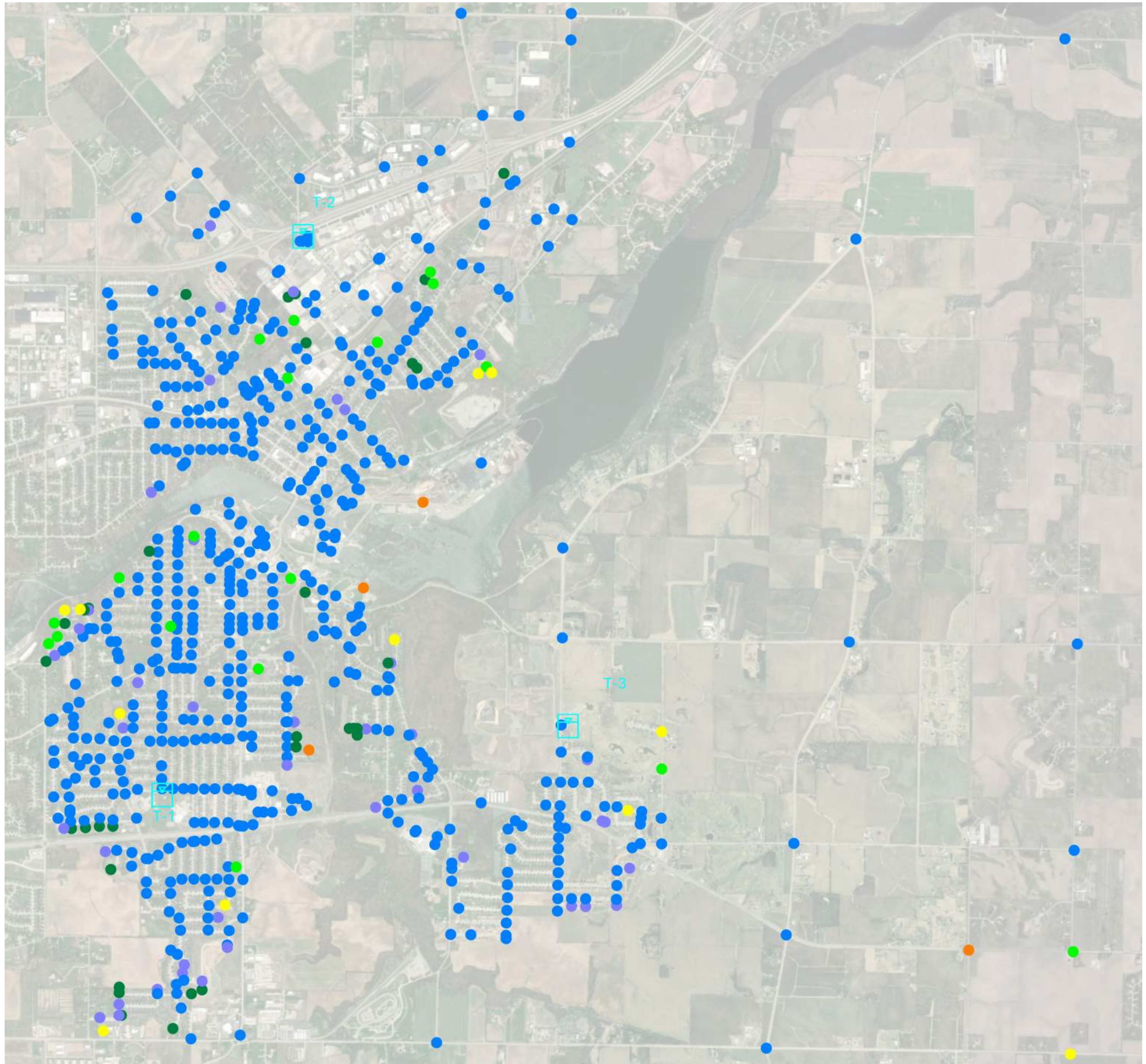
KAUKAUNA
SCENARIO 4: 16-Inch SE Expansion - No Pressure Zone
Pressure Contours

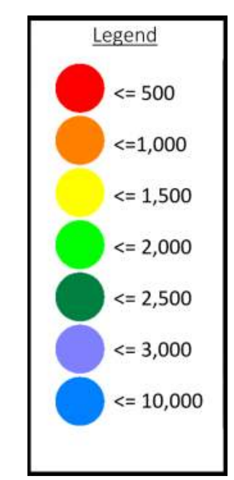



Pressure
Legend: Pressure (psi)

| | |
|---|---|
| <= | 20.0 |
| <= | 50.0 |
| <= | 80.0 |
| <= | 110.0 |
| <= | 150.0 |

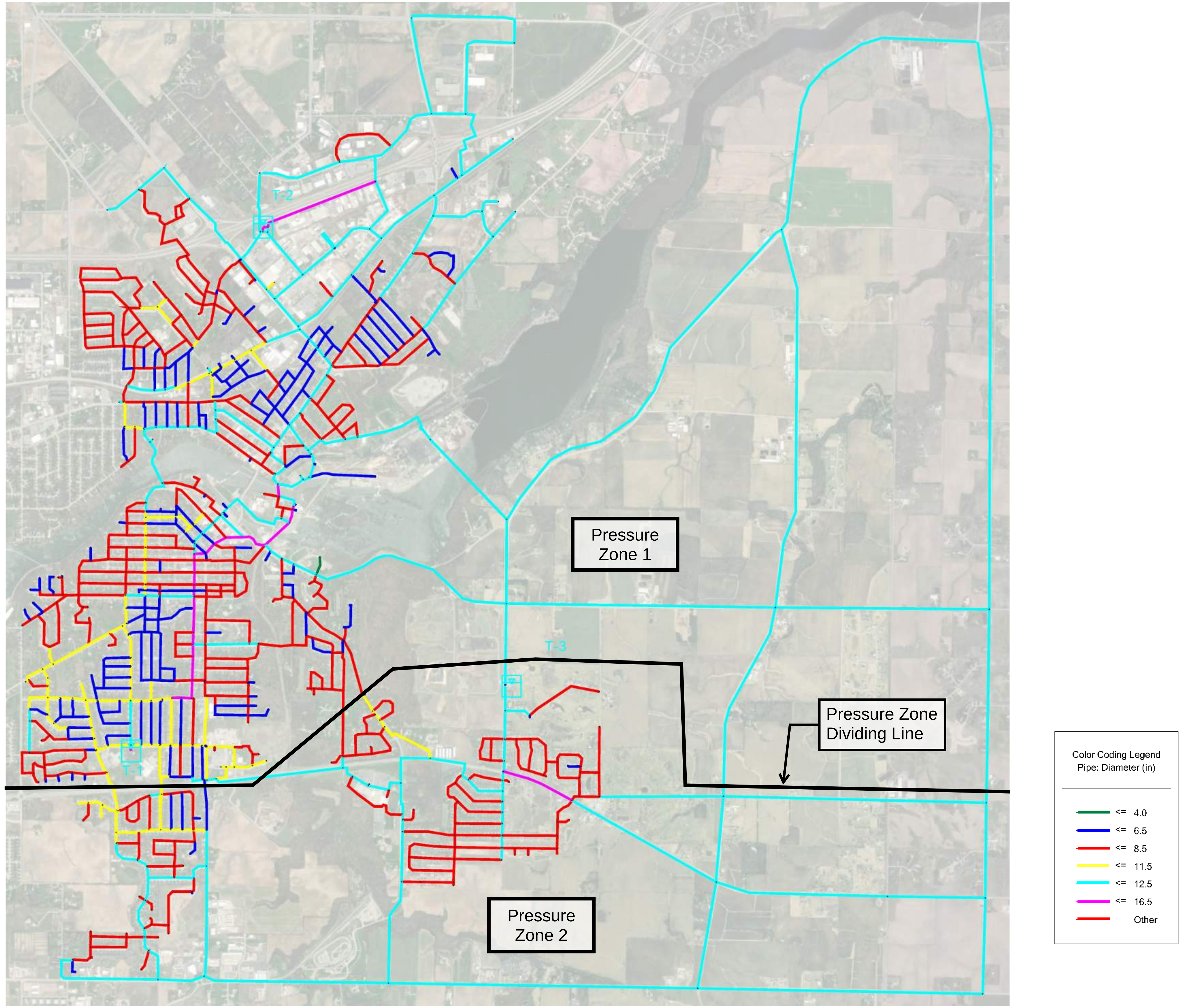
KAUKAUNA
SCENARIO 4: 16-Inch SE Expansion - No Pressure Zone
FIRE FLOW



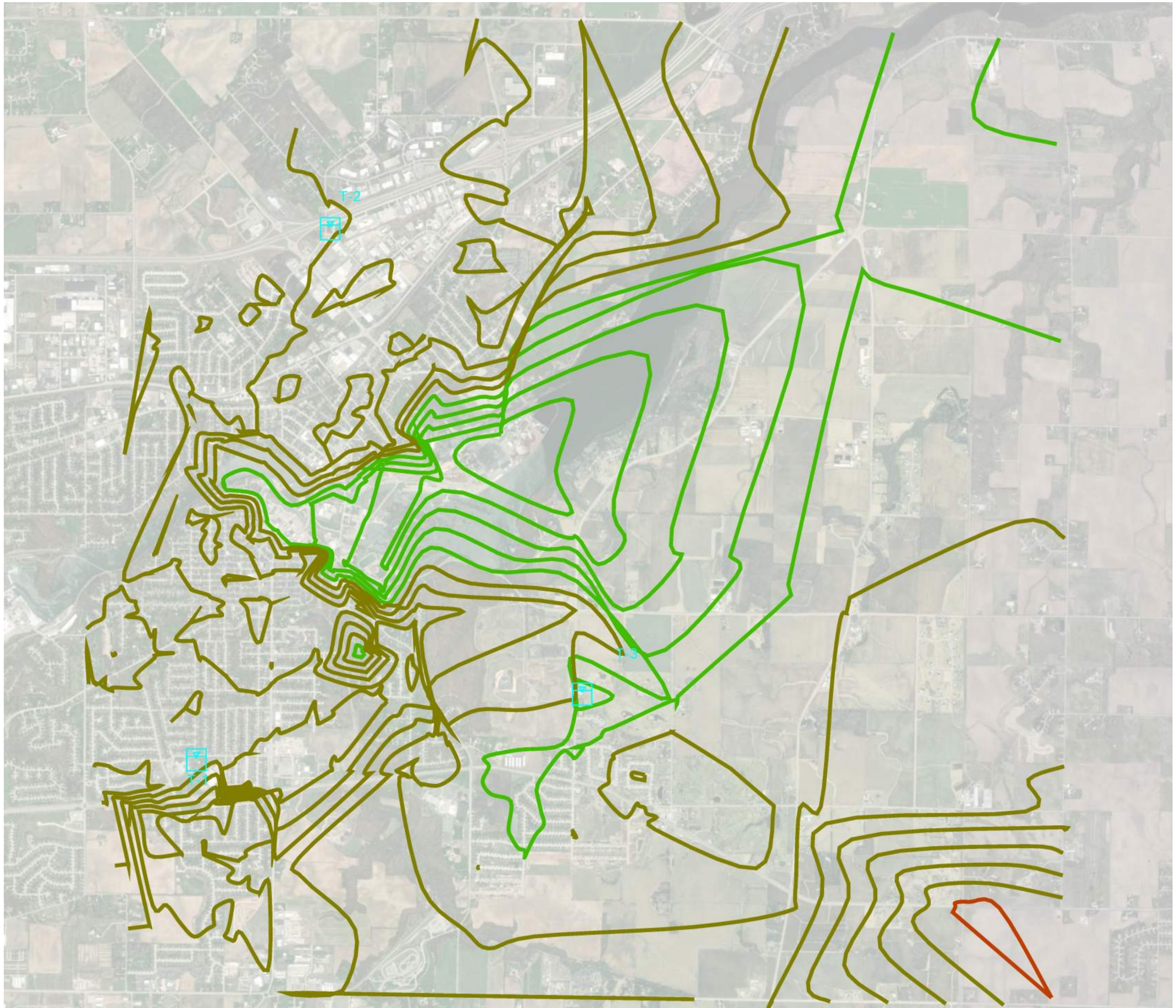



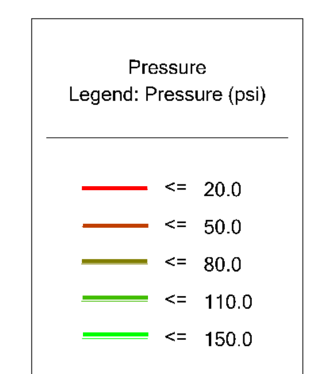
KAUKAUNA

SCENARIO 5: 12-Inch SE Expansion - Pressure Zone

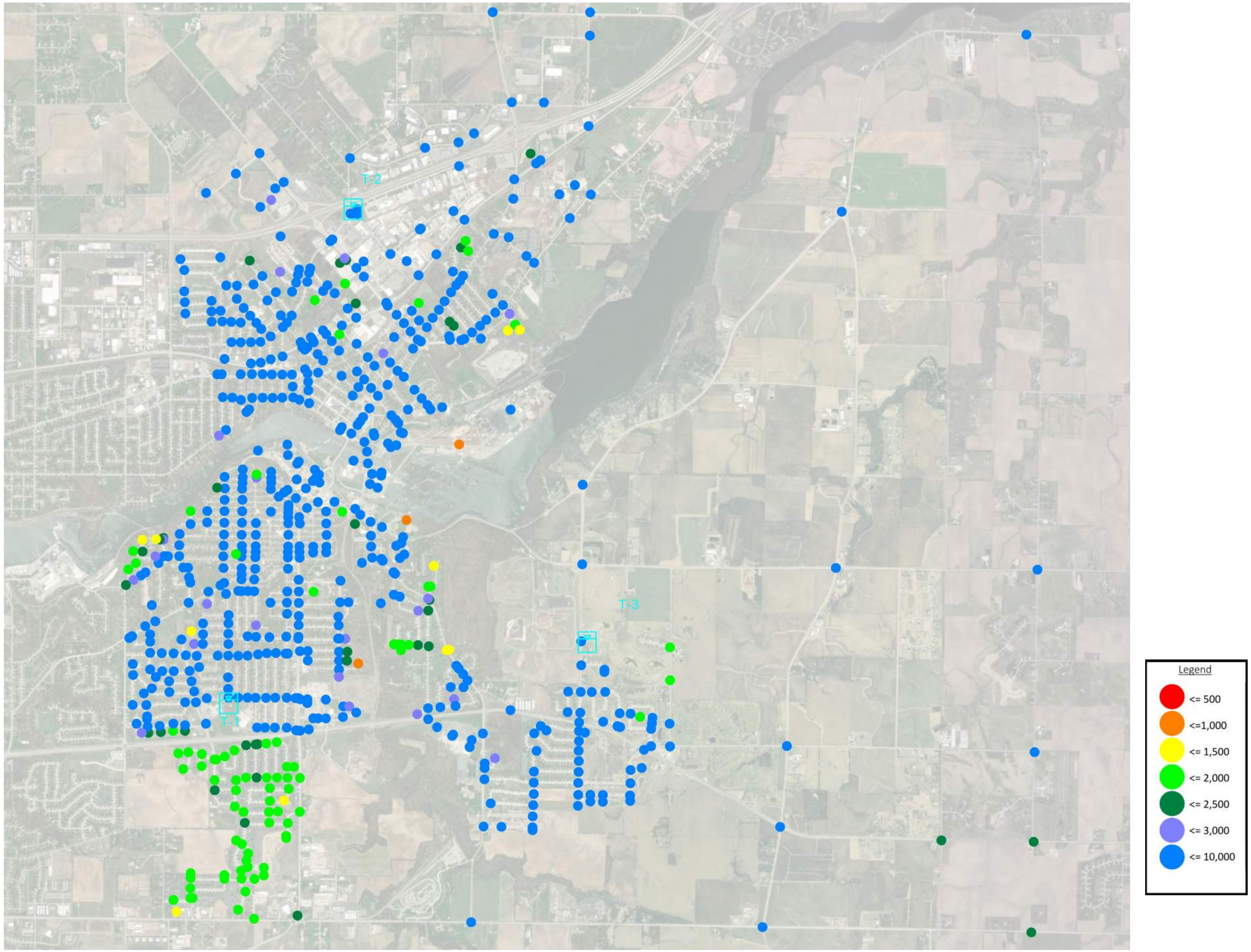


# KAUKAUNA
## SCENARIO 5: 12-Inch SE Expansion - Pressure Zone
## Pressure Contours

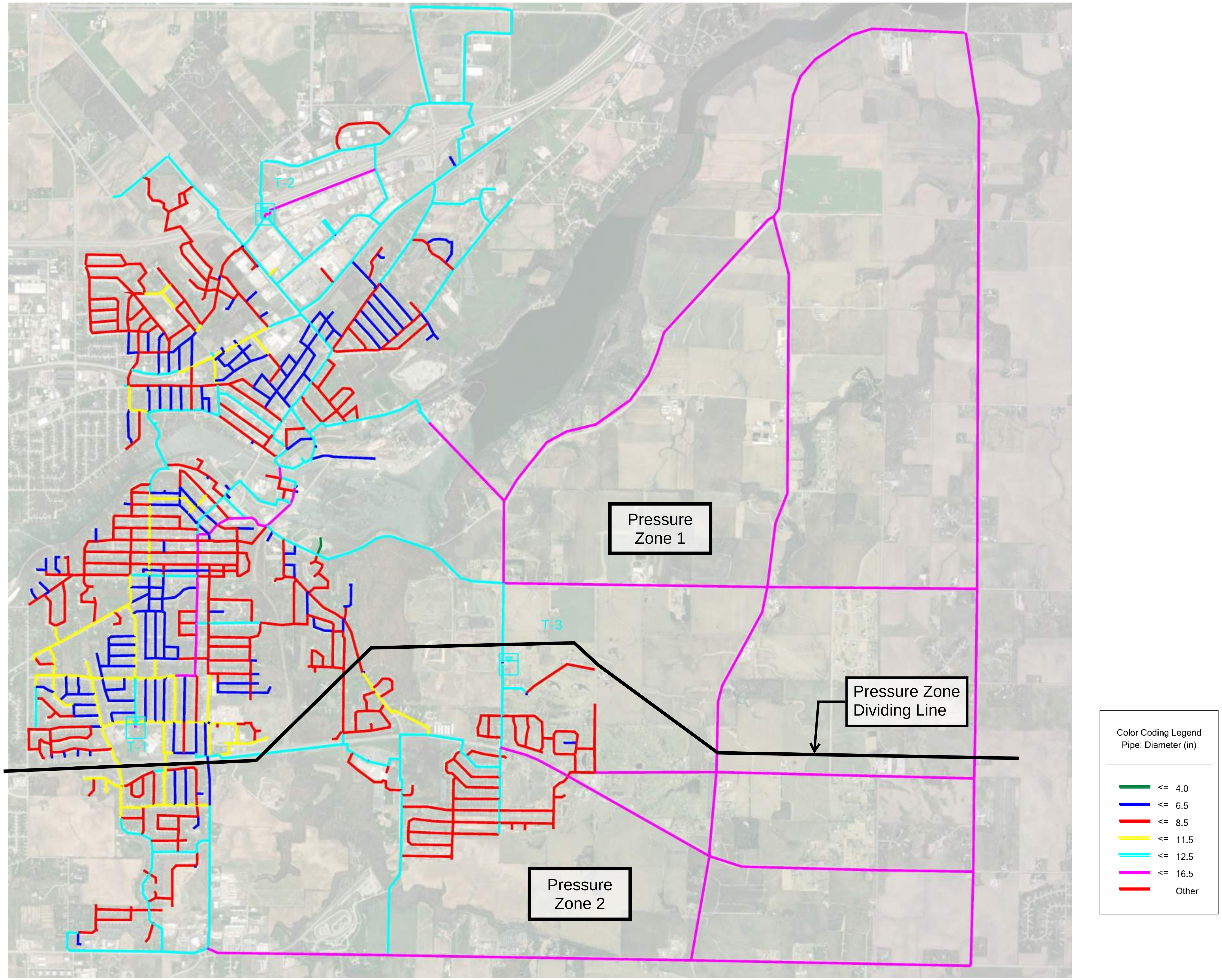


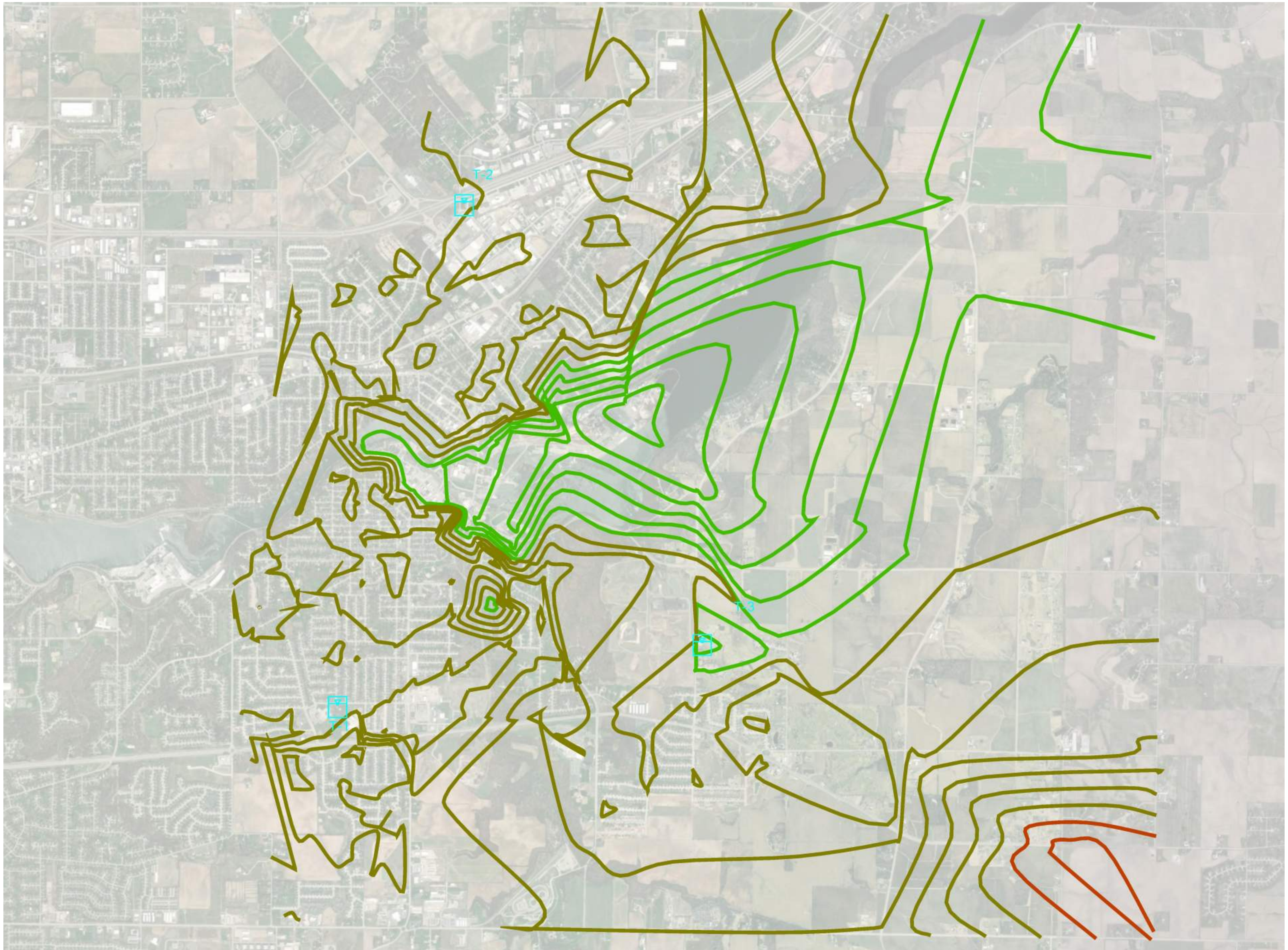
KAUKAUNA
SCENARIO 5: 12-Inch SE Expansion - Pressure Zone
FIRE FLOW



KAUKAUNA
SCENARIO 6: 16-Inch SE Expansion - Pressure Zone



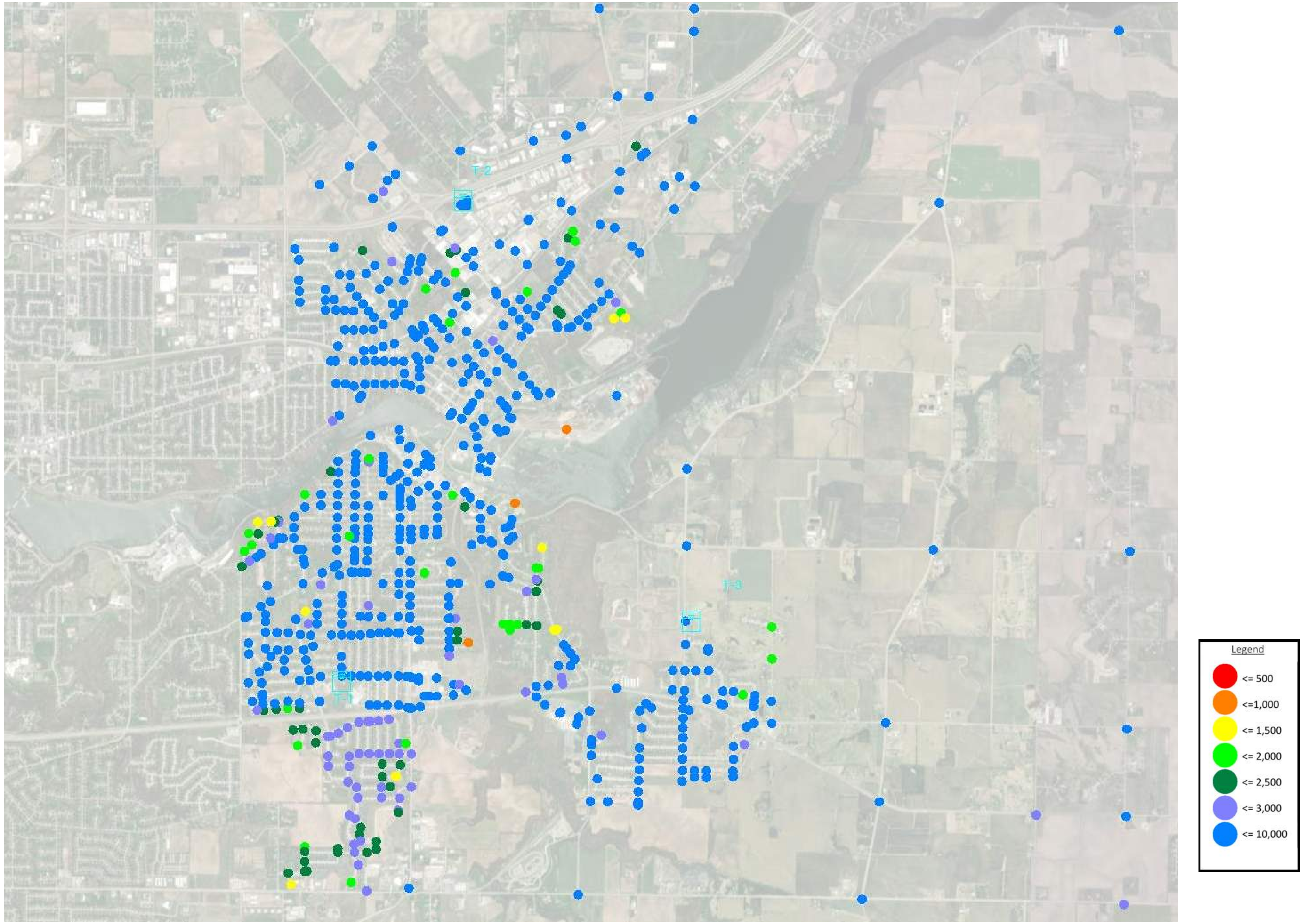
KAUKAUNA
SCENARIO 6: 16-Inch SE Expansion - Pressure Zone
Pressure Contours



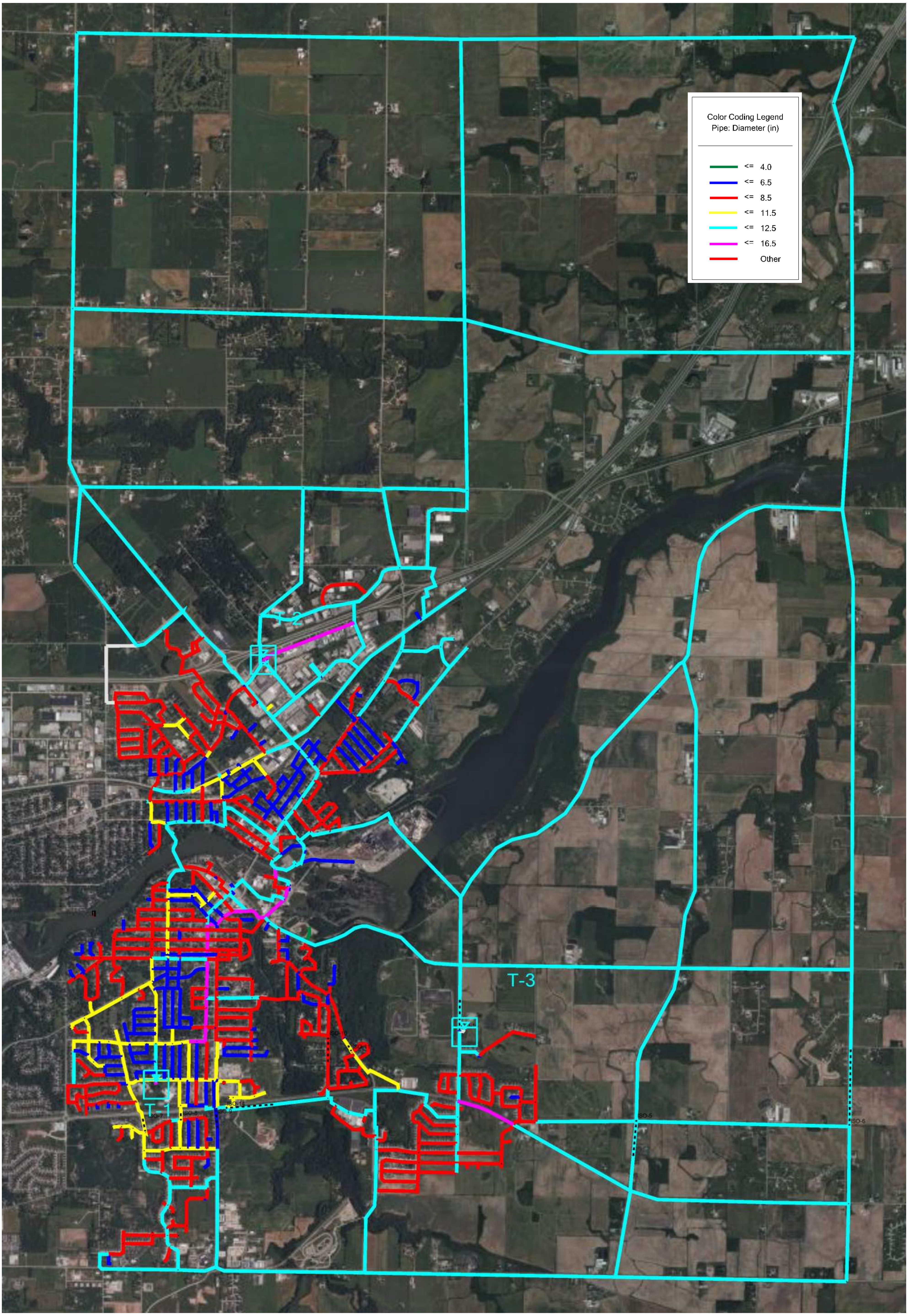

Pressure
Legend: Pressure (psi)

| | |
|---|---|
| <= | 20.0 |
| <= | 50.0 |
| <= | 80.0 |
| <= | 110.0 |
| <= | 150.0 |

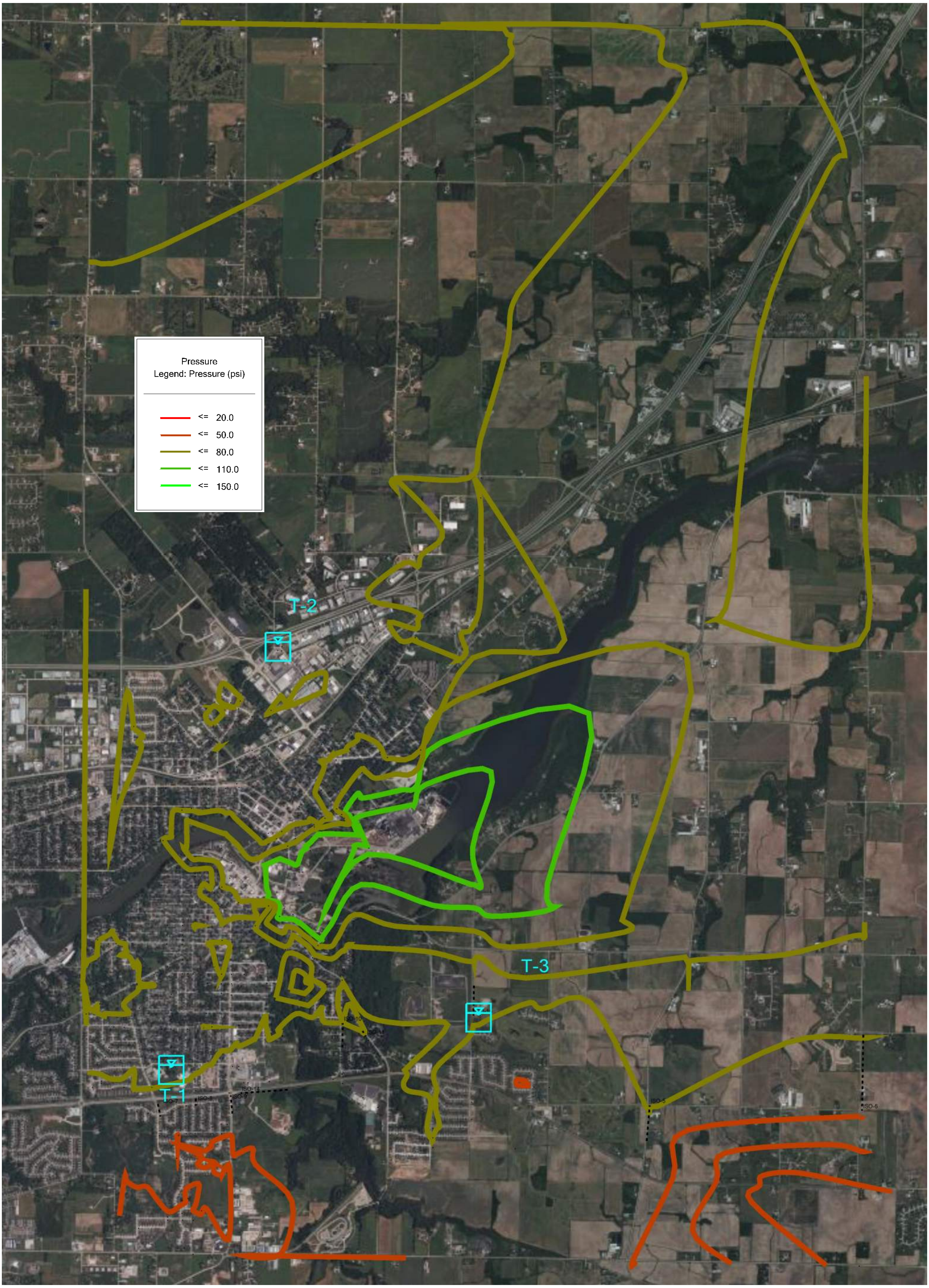
KAUKAUNA
SCENARIO 6: 16-Inch SE Expansion - Pressure Zone
FIRE FLOW



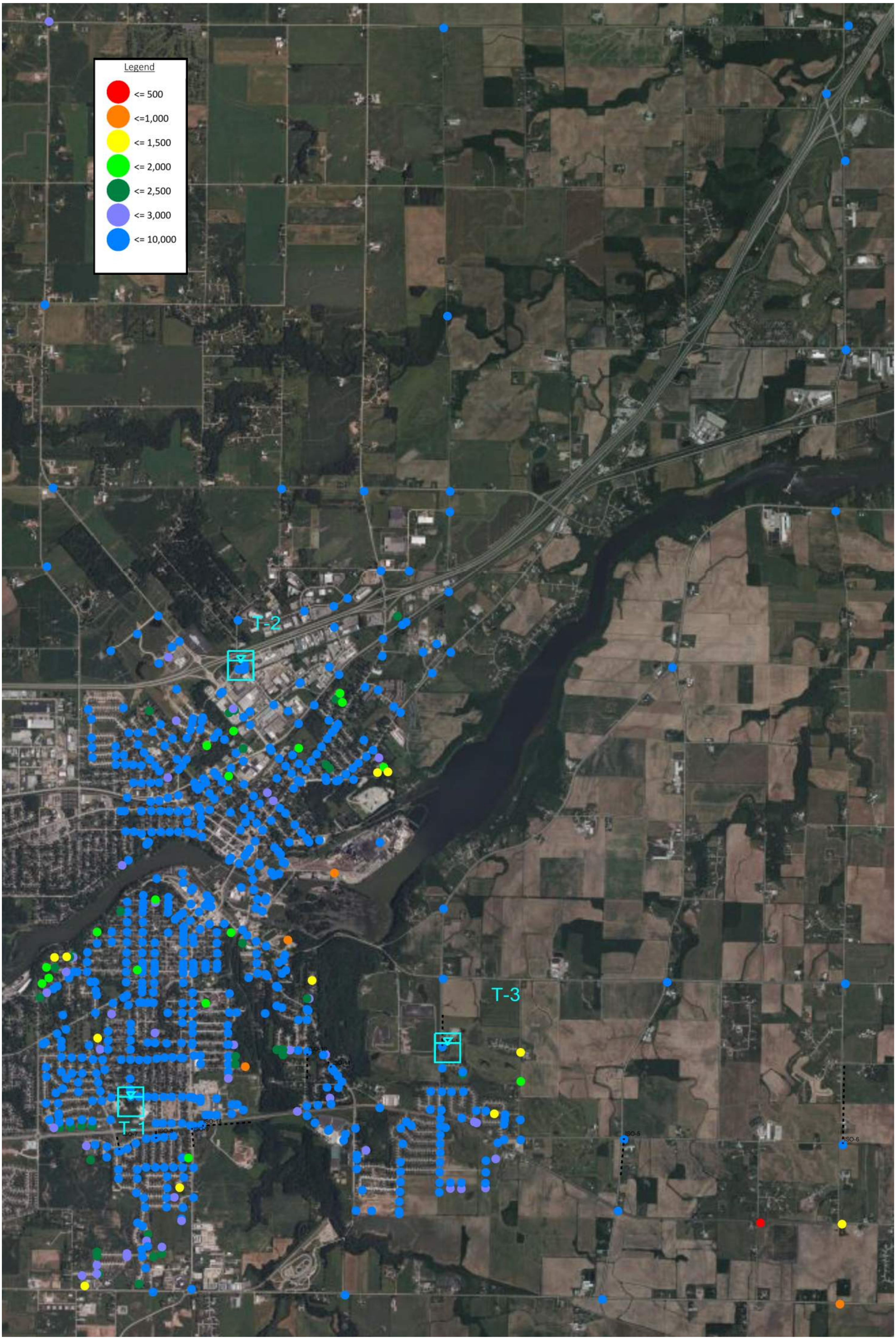
KAUKAUNA
SCENARIO 7: 12-Inch N Expansion



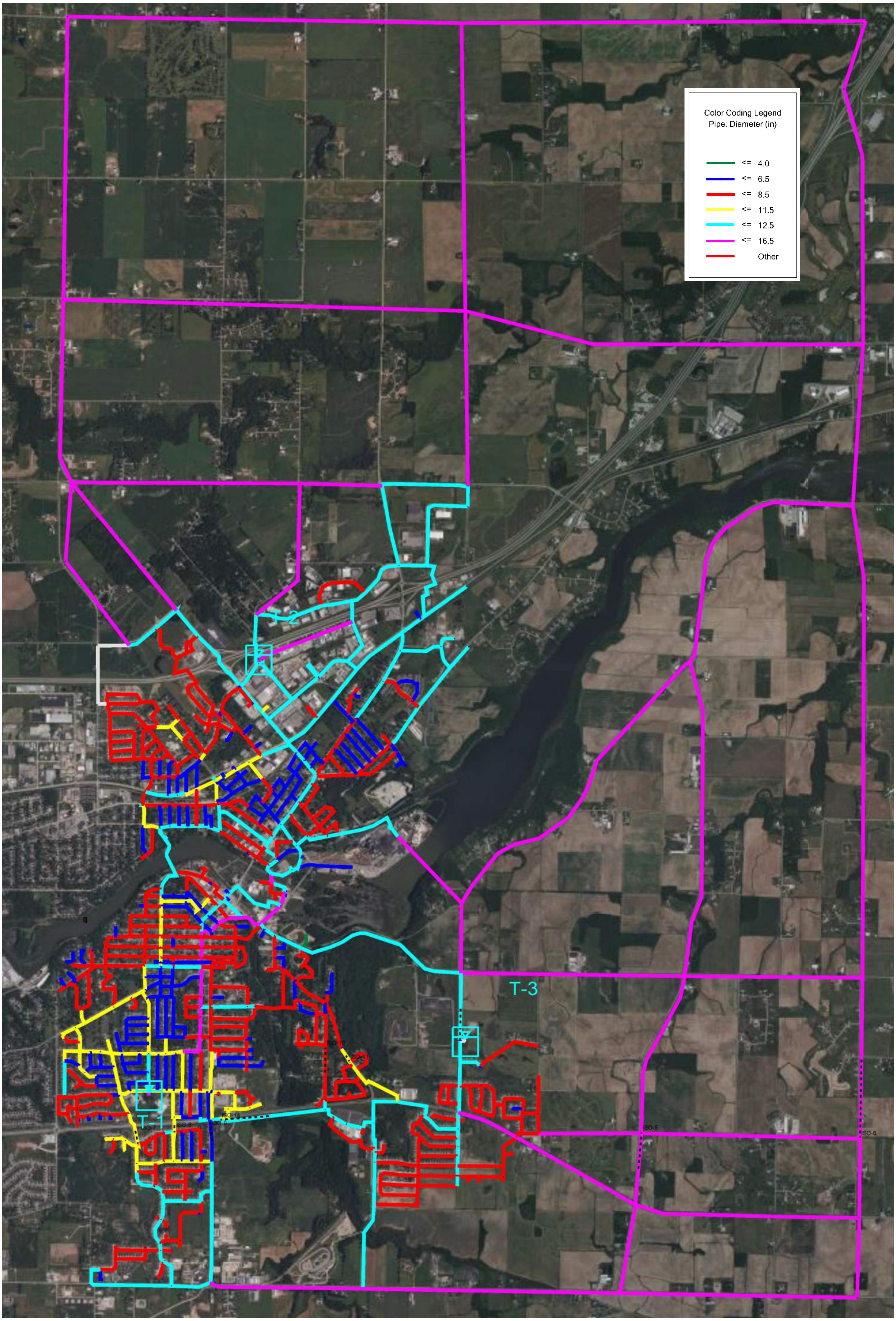
KAUKAUNA
SCENARIO 7: 12-Inch N Expansion
Pressure Contours



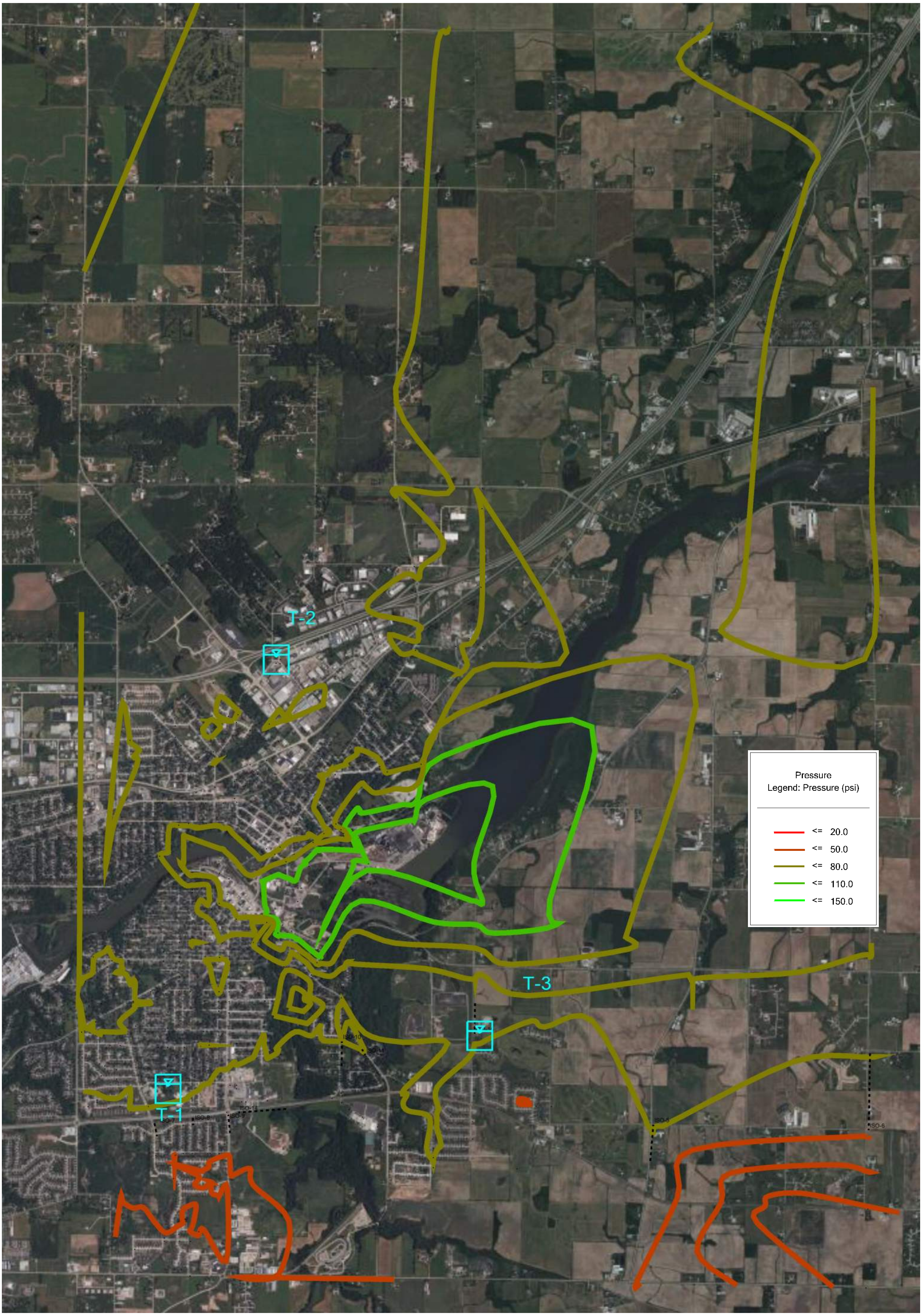
KAUKAUNA
SCENARIO 7: 12-Inch N Expansion
Fire Flows



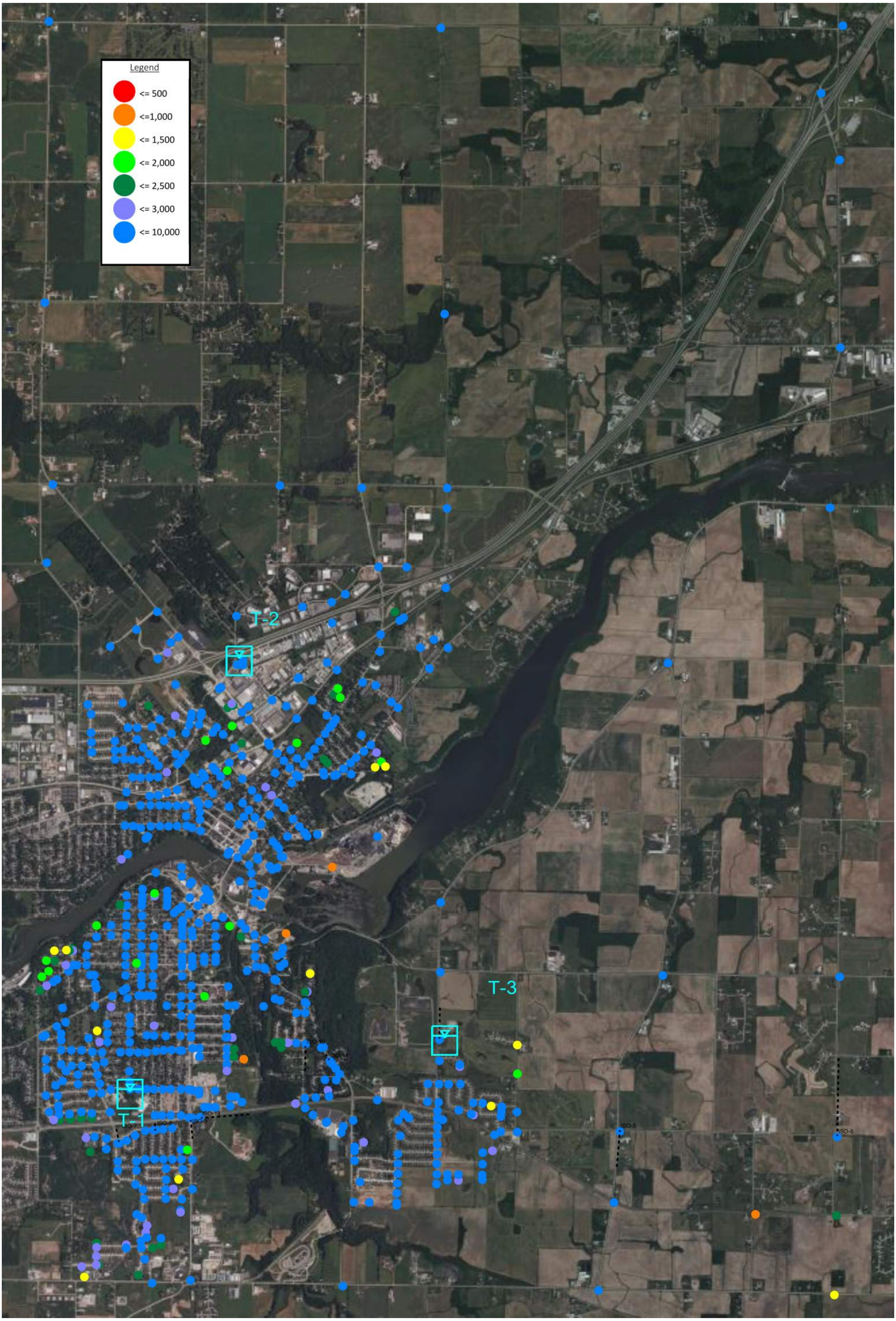
KAUKAUNA
SCENARIO 8: 16-Inch N Expansion



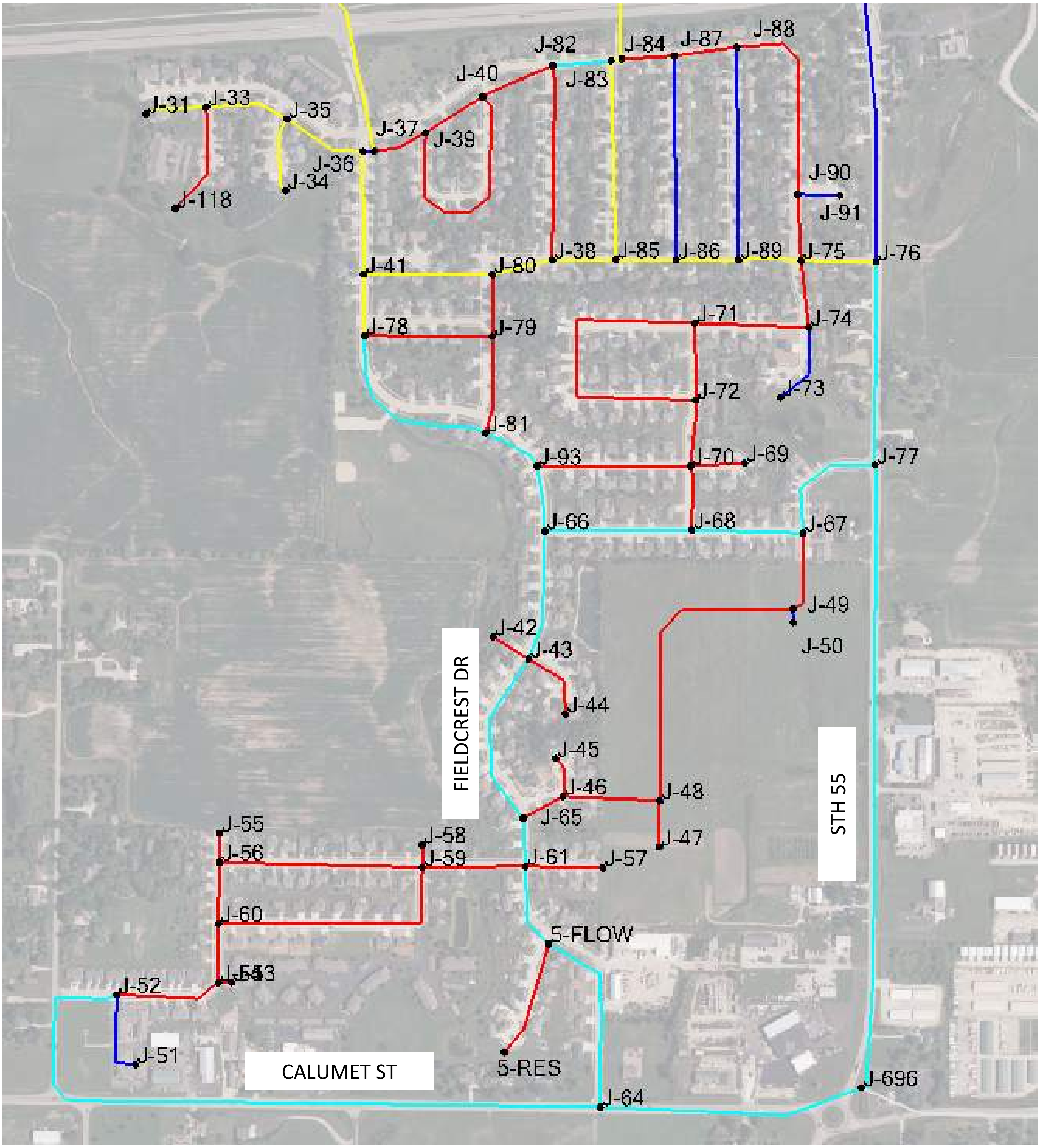
KAUKAUNA
SCENARIO 8: 16-Inch N Expansion
Pressure Contours



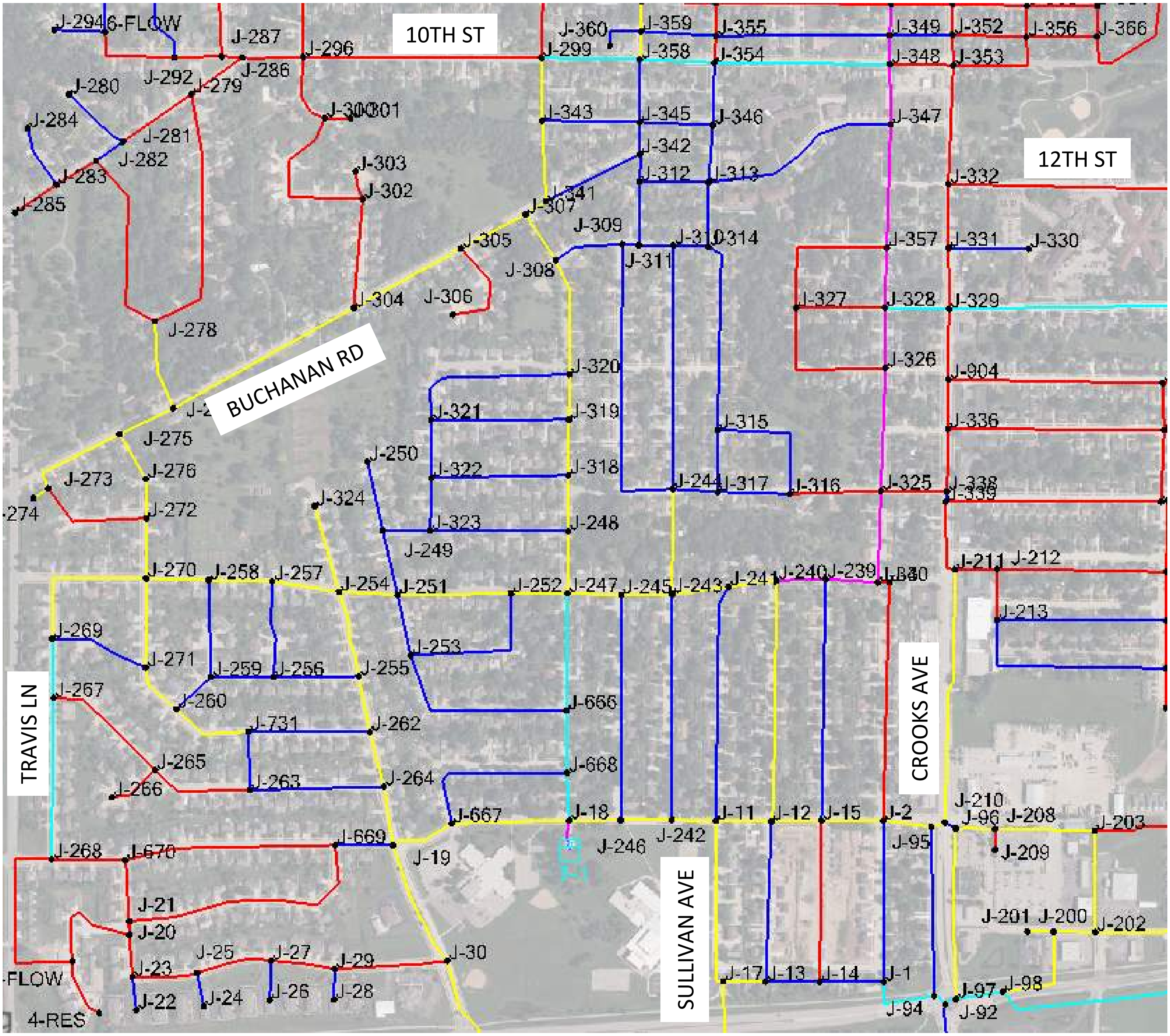
KAUKAUNA
SCENARIO 8: 16-Inch N Expansion
Fire Flows



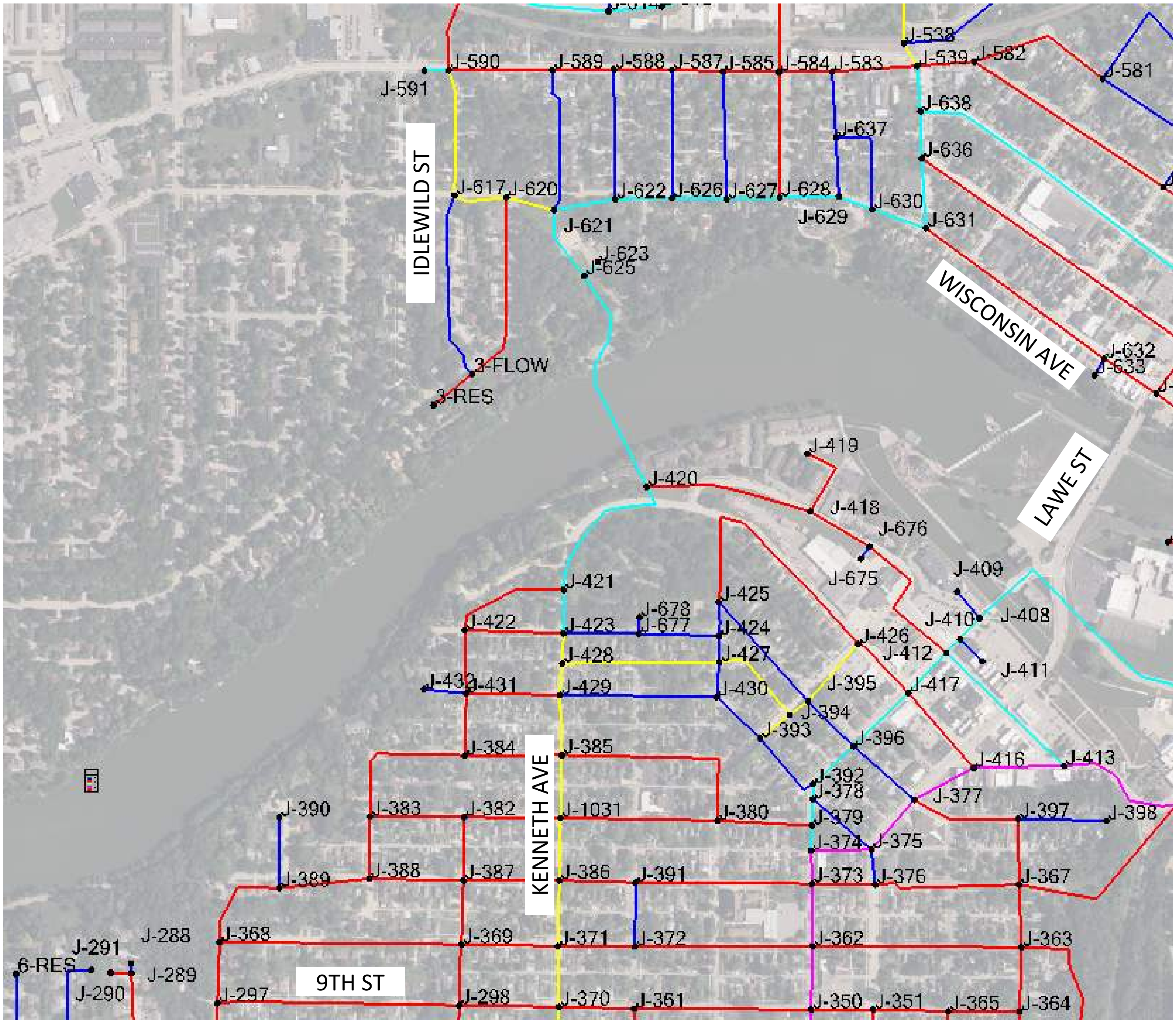
EXISTING SYSTEM - JUNCTION LABELS



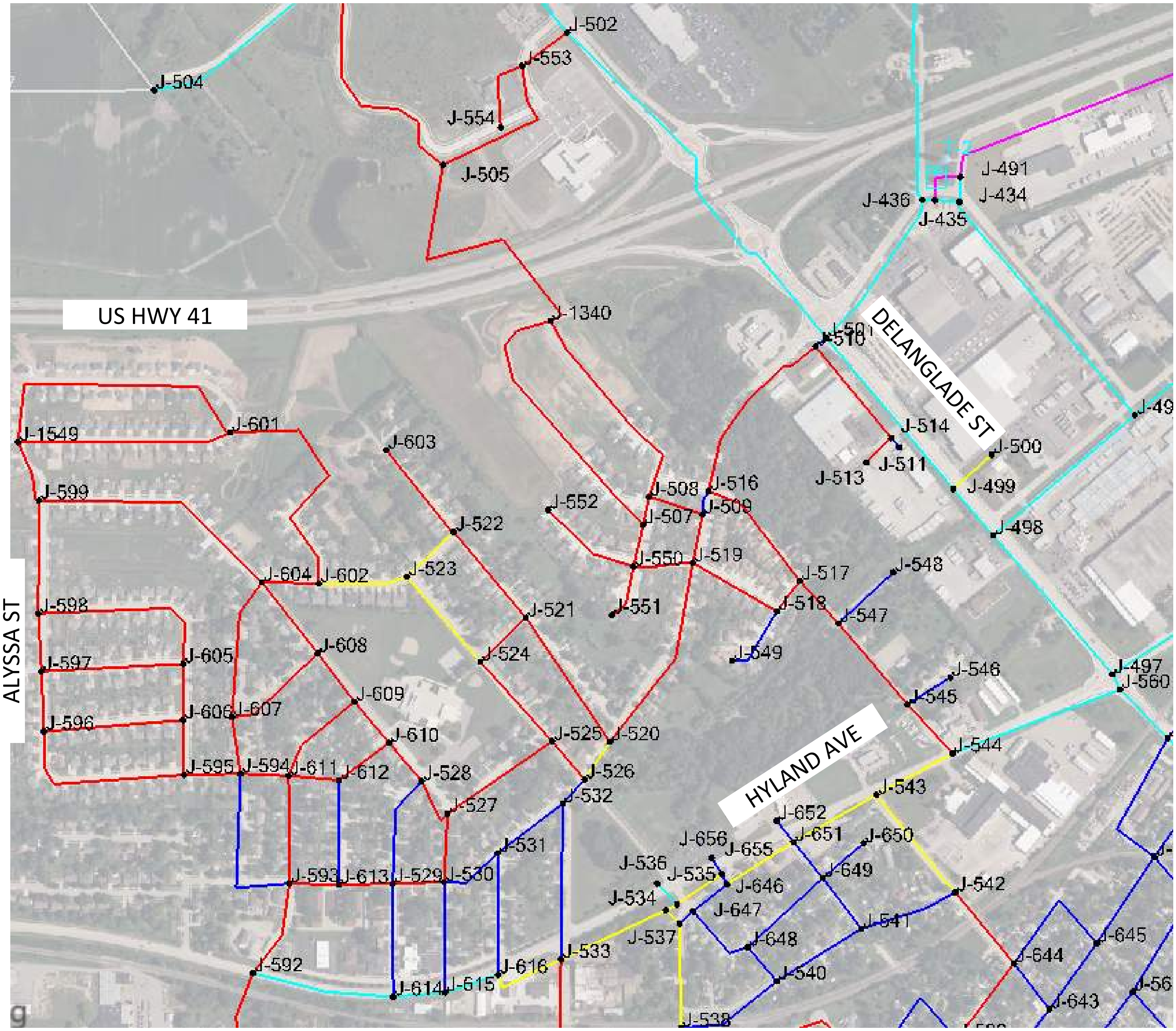
EXISTING SYSTEM - JUNCTION LABELS



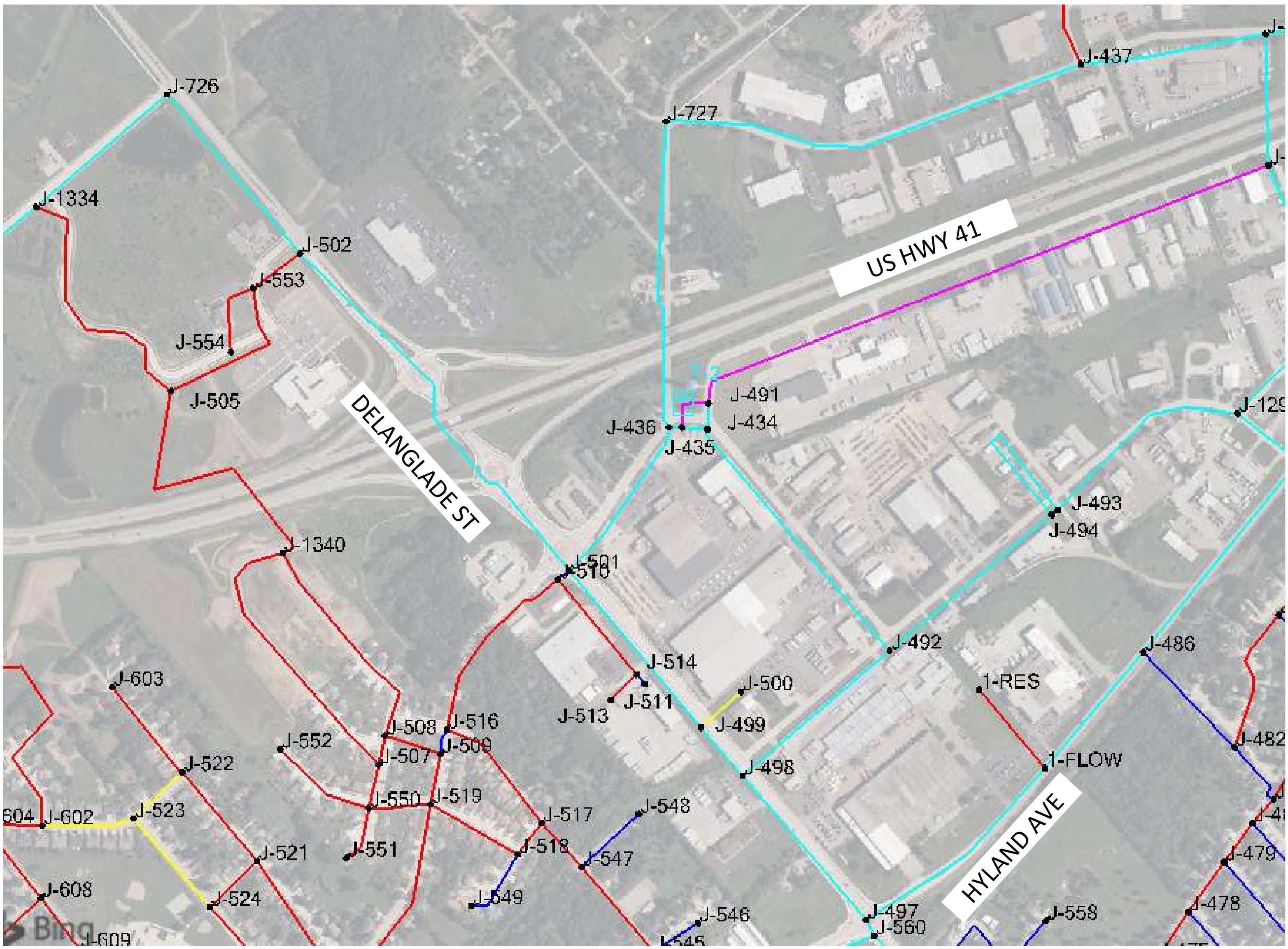
EXISTING SYSTEM - JUNCTION LABELS



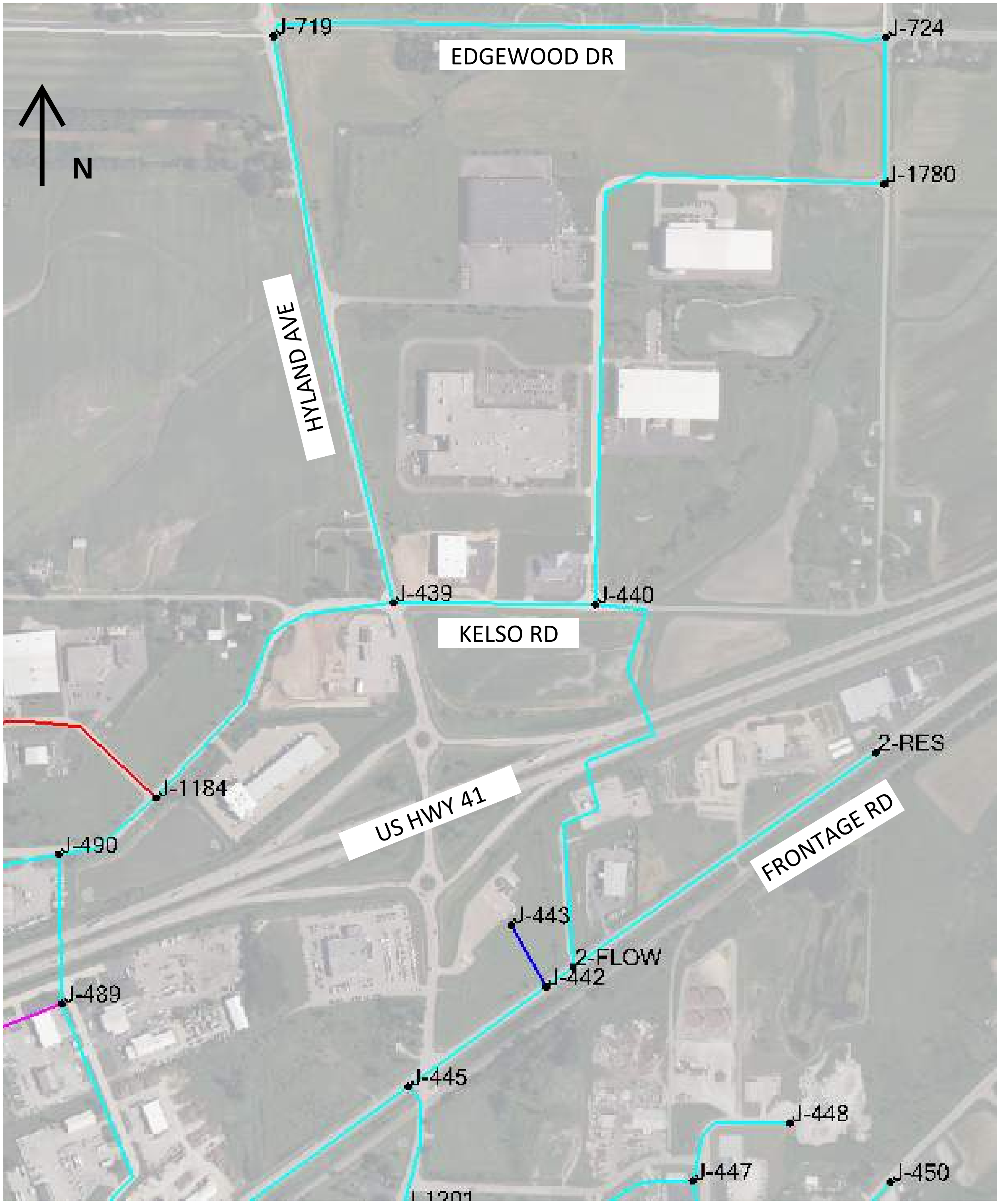
EXISTING SYSTEM - JUNCTION LABELS



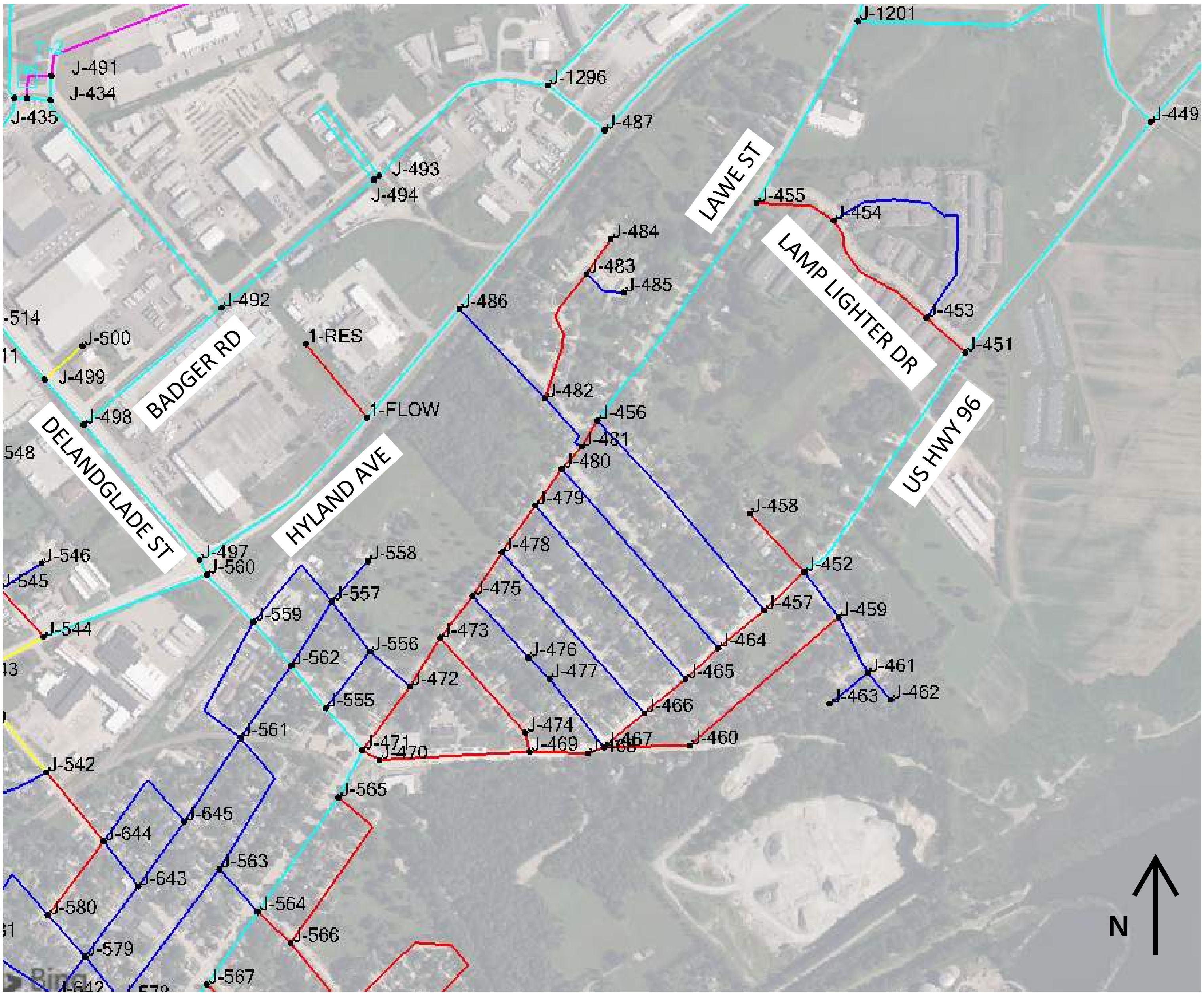
EXISTING SYSTEM - JUNCTION LABELS



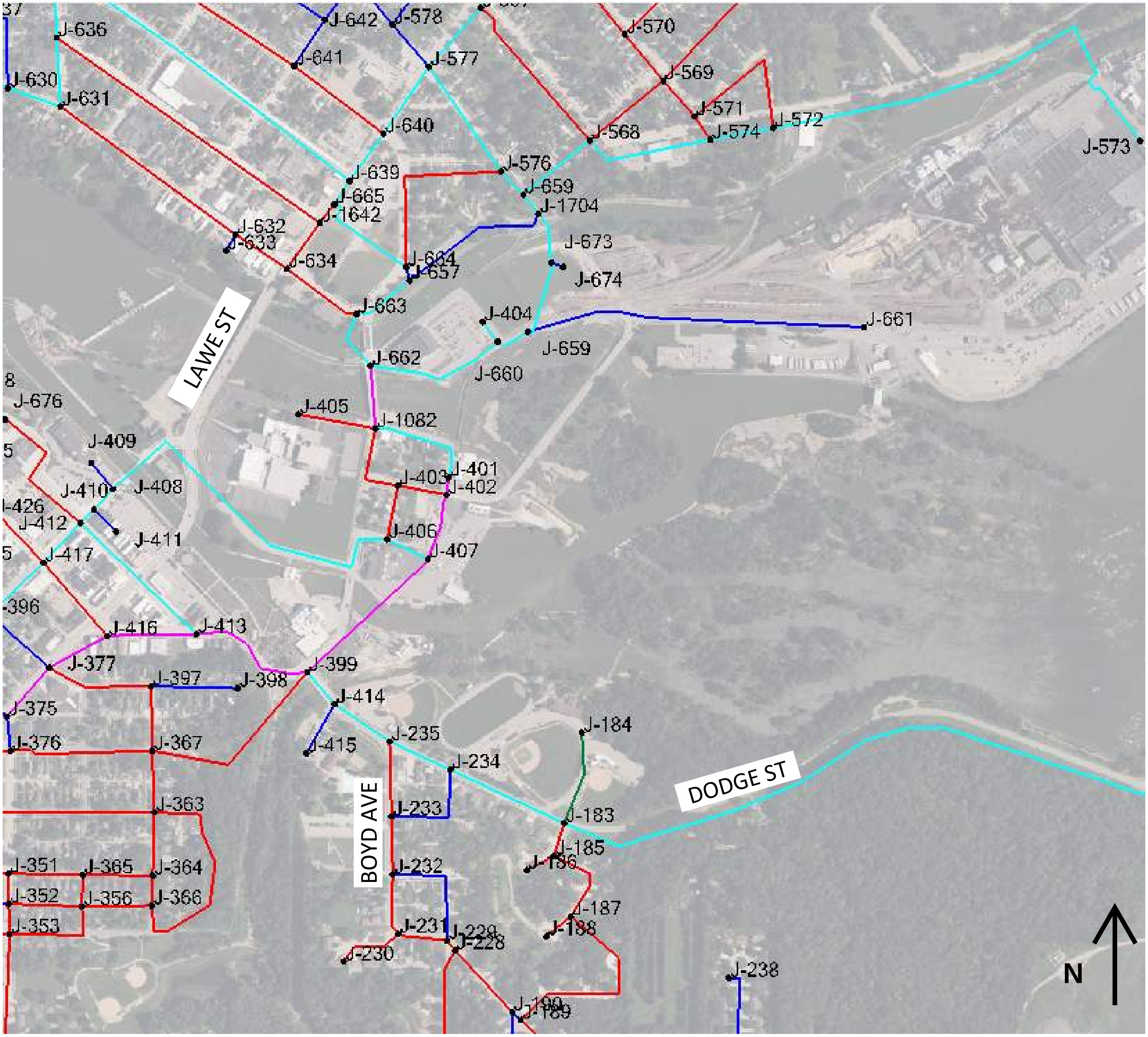
EXISTING SYSTEM - JUNCTION LABELS



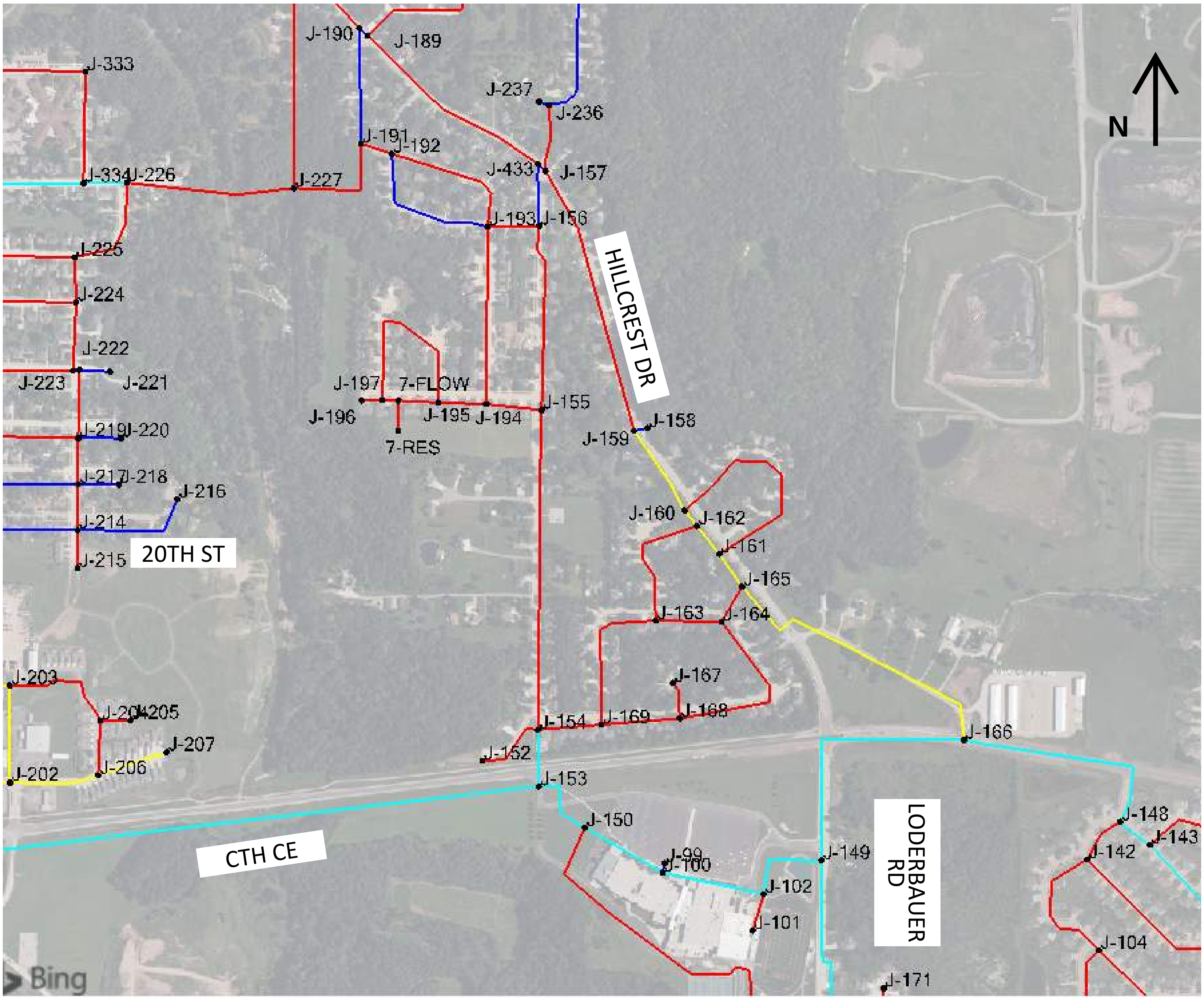
EXISTING SYSTEM - JUNCTION LABELS



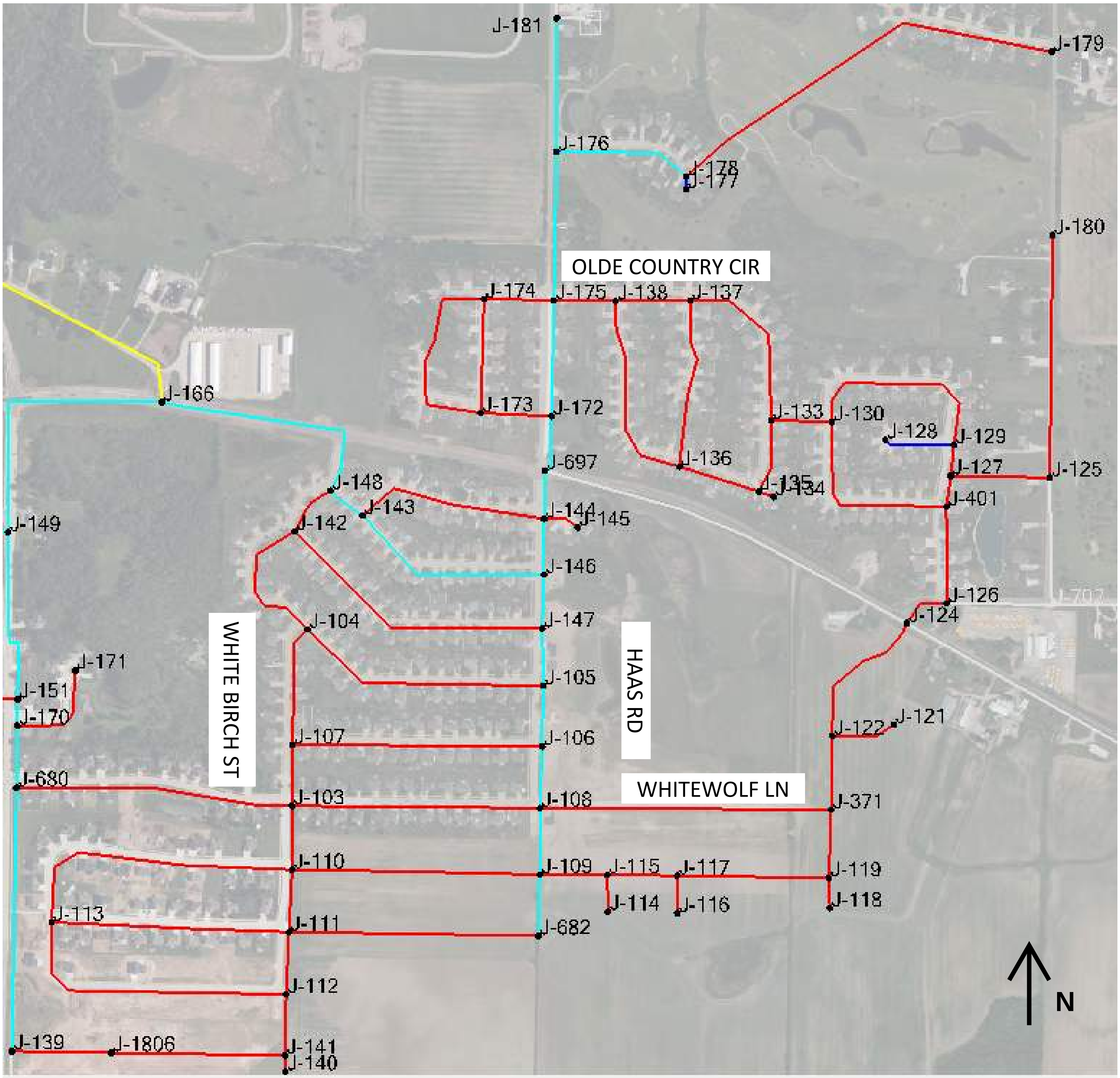
EXISTING SYSTEM - JUNCTION LABELS



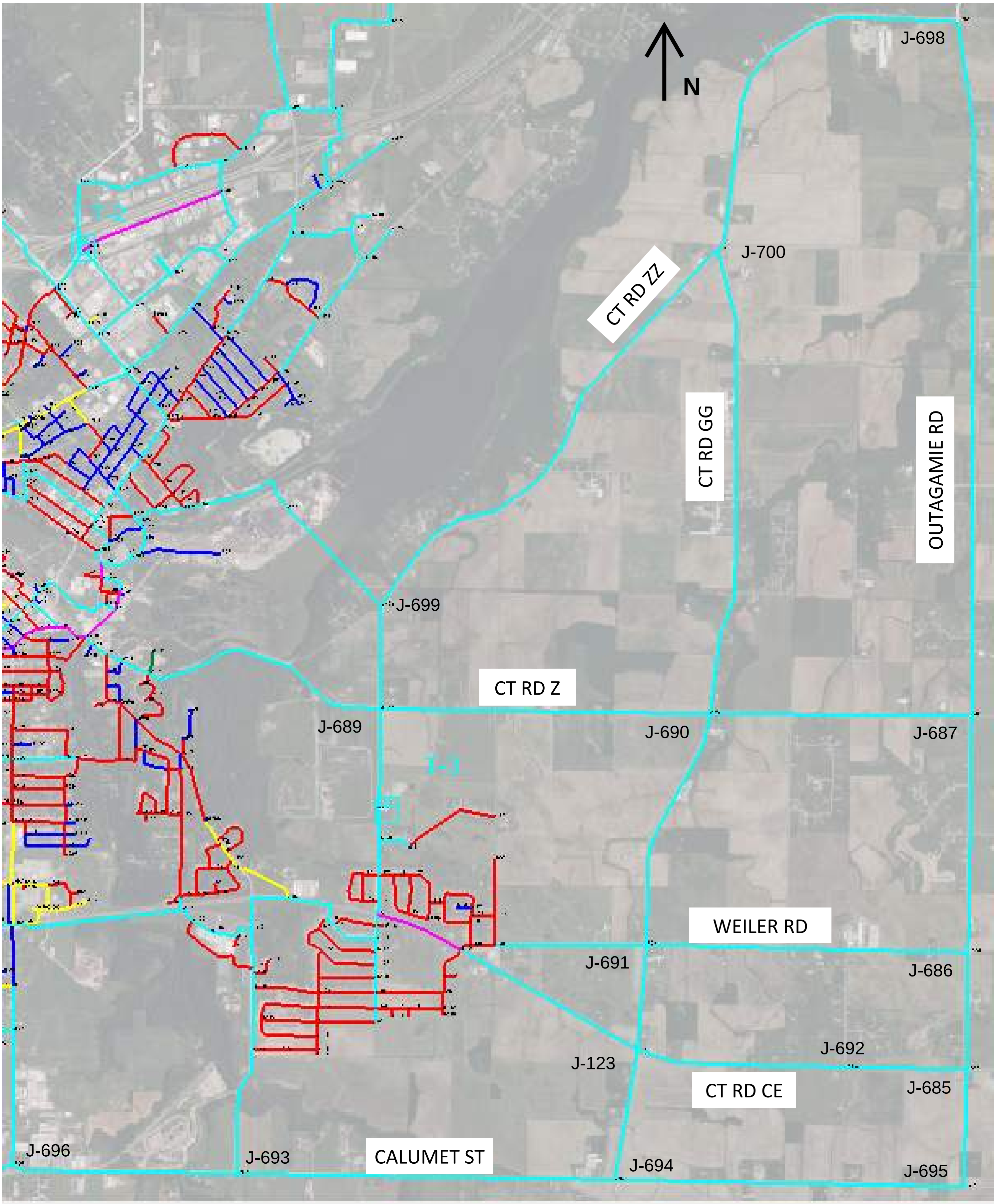
EXISTING SYSTEM - JUNCTION LABELS



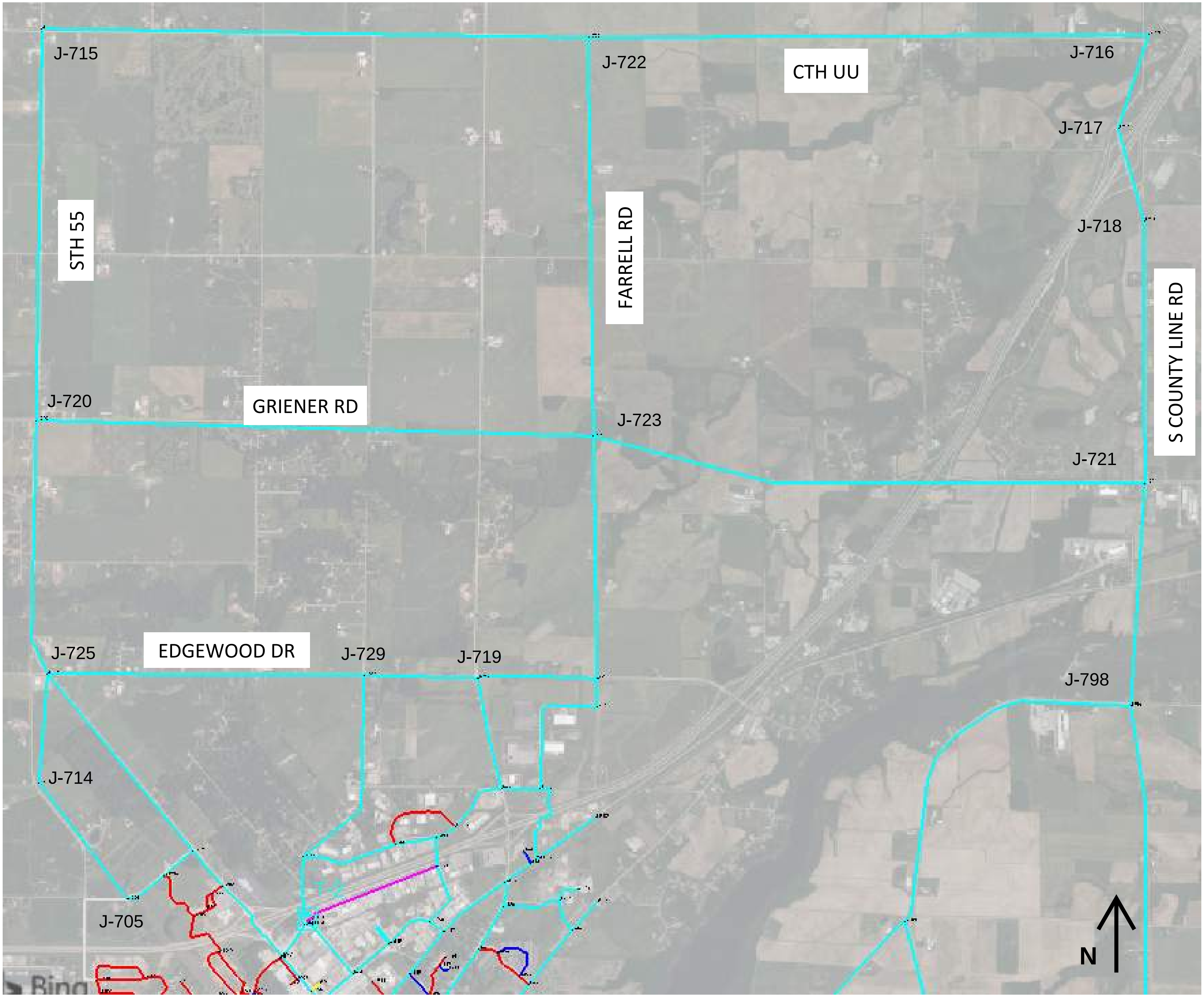
EXISTING SYSTEM - JUNCTION LABELS



SE EXPANSION - JUNCTION LABELS



NORTH EXPANSION - JUNCTION LABELS



SCENARIO 9: TOWER DRIVE DOWNSIZE AND LOOP TO NORTH

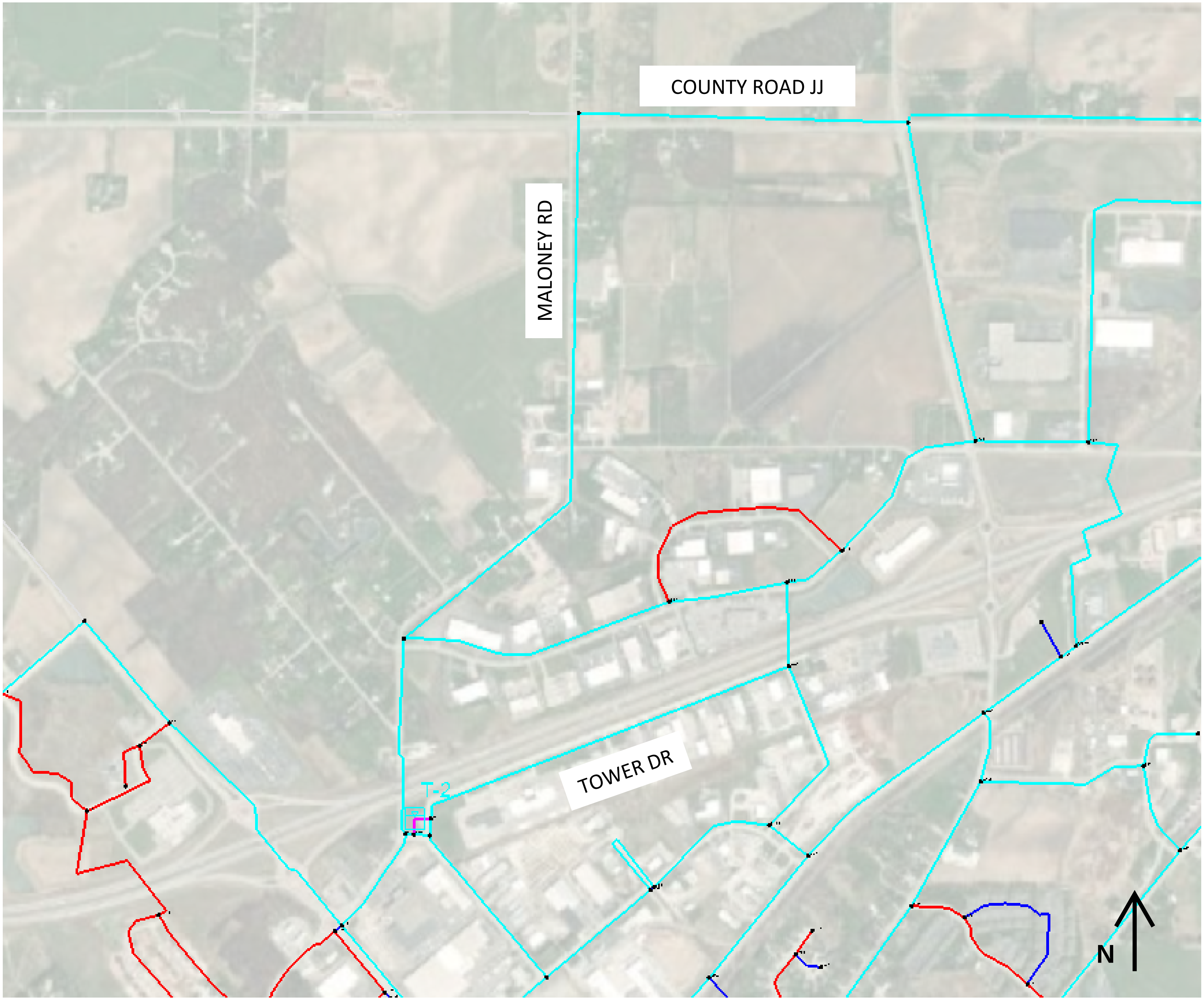


Table 1: Static Pressures

**BASE SCENARIO**

| ID | Label | Elevation (ft) | Is Active? | Demand (gpm) | Hydraulic Grade (ft) | Pressure (psi) |
|---|---|---|---|---|---|---|
| 1317 | 1-FLOW | 699.8 | TRUE | 1 | 859.91 | 69.3 |
| 1319 | 1-RES | 698 | TRUE | 3 | 859.9 | 70 |
| 1191 | 2-FLOW | 690 | TRUE | 1 | 859.93 | 73.5 |
| 1197 | 2-RES | 690 | TRUE | 1 | 859.93 | 73.5 |
| 1604 | 3-FLOW | 701 | TRUE | 1 | 859.82 | 68.7 |
| 1606 | 3-RES | 699 | TRUE | 1 | 859.82 | 69.6 |
| 1755 | 4-FLOW | 725.23 | TRUE | 1 | 859.85 | 58.2 |
| 1754 | 4-RES | 723.64 | TRUE | 1 | 859.85 | 58.9 |
| 201 | 5-FLOW | 746.82 | TRUE | 1 | 859.8 | 48.9 |
| 199 | 5-RES | 745.17 | TRUE | 1 | 859.8 | 49.6 |
| 805 | 6-FLOW | 719.81 | TRUE | 1 | 859.81 | 60.6 |
| 809 | 6-RES | 718 | TRUE | 1 | 859.81 | 61.4 |
| 573 | 7-FLOW | 721.97 | TRUE | 1 | 859.76 | 59.6 |
| 576 | 7-RES | 723.98 | TRUE | 1 | 859.76 | 58.7 |
| 34 | J-1 | 731.58 | TRUE | 1 | 859.79 | 55.5 |
| 36 | J-2 | 723.69 | TRUE | 1 | 859.81 | 58.9 |
| 40 | J-3 | 716.09 | TRUE | 1 | 859.81 | 62.2 |
| 56 | J-11 | 718.27 | TRUE | 1 | 859.84 | 61.3 |
| 60 | J-12 | 719.68 | TRUE | 1 | 859.82 | 60.6 |
| 63 | J-13 | 731.17 | TRUE | 1 | 859.82 | 55.7 |
| 67 | J-14 | 733.9 | TRUE | 1 | 859.81 | 54.5 |
| 70 | J-15 | 720.93 | TRUE | 1 | 859.81 | 60.1 |
| 77 | J-17 | 725.73 | TRUE | 1 | 859.82 | 58 |
| 80 | J-18 | 717.13 | TRUE | 1 | 859.98 | 61.8 |
| 84 | J-19 | 713.66 | TRUE | 1 | 859.87 | 63.3 |
| 87 | J-20 | 727.79 | TRUE | 1 | 859.85 | 57.1 |
| 89 | J-21 | 727.38 | TRUE | 1 | 859.85 | 57.3 |
| 93 | J-22 | 724.44 | TRUE | 1 | 859.85 | 58.6 |
| 95 | J-23 | 725 | TRUE | 1 | 859.85 | 58.3 |
| 98 | J-24 | 729 | TRUE | 1 | 859.85 | 56.6 |
| 100 | J-25 | 729.33 | TRUE | 1 | 859.85 | 56.5 |
| 103 | J-26 | 725.84 | TRUE | 1 | 859.85 | 58 |
| 105 | J-27 | 724 | TRUE | 1 | 859.85 | 58.8 |
| 108 | J-28 | 722 | TRUE | 1 | 859.85 | 59.6 |
| 110 | J-29 | 720.89 | TRUE | 1 | 859.85 | 60.1 |
| 113 | J-30 | 720.74 | TRUE | 1 | 859.85 | 60.2 |
| 117 | J-31 | 727.59 | TRUE | 1 | 859.81 | 57.2 |
| 120 | J-33 | 730 | TRUE | 1 | 859.81 | 56.2 |
| 123 | J-34 | 735.39 | TRUE | 1 | 859.81 | 53.8 |
| 125 | J-35 | 732 | TRUE | 1 | 859.81 | 55.3 |
| 128 | J-36 | 732 | TRUE | 1 | 859.81 | 55.3 |
| 132 | J-37 | 732 | TRUE | 1 | 859.82 | 55.3 |
| 135 | J-38 | 738.66 | TRUE | 1 | 859.81 | 52.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 139 | J-39 | 731.59 | TRUE | 1 | 859.82 | 55.5 |
| 142 | J-40 | 731.56 | TRUE | 1 | 859.82 | 55.5 |
| 146 | J-41 | 734.8 | TRUE | 1 | 859.81 | 54.1 |
| 149 | J-42 | 736 | TRUE | 1 | 859.8 | 53.6 |
| 151 | J-43 | 740.61 | TRUE | 1 | 859.8 | 51.6 |
| 154 | J-44 | 747.94 | TRUE | 1 | 859.8 | 48.4 |
| 156 | J-45 | 745.17 | TRUE | 1 | 859.8 | 49.6 |
| 158 | J-46 | 745.96 | TRUE | 1 | 859.8 | 49.3 |
| 161 | J-47 | 747.34 | TRUE | 1 | 859.8 | 48.7 |
| 163 | J-48 | 740.85 | TRUE | 1 | 859.8 | 51.5 |
| 166 | J-49 | 736.29 | TRUE | 1 | 859.8 | 53.4 |
| 168 | J-50 | 735.04 | TRUE | 1 | 859.8 | 54 |
| 170 | J-51 | 755.07 | TRUE | 1 | 859.8 | 45.3 |
| 172 | J-52 | 747.33 | TRUE | 1 | 859.8 | 48.7 |
| 175 | J-53 | 750.92 | TRUE | 1 | 859.8 | 47.1 |
| 177 | J-54 | 749.85 | TRUE | 1 | 859.8 | 47.6 |
| 180 | J-55 | 752.1 | TRUE | 1 | 859.8 | 46.6 |
| 182 | J-56 | 749.01 | TRUE | 1 | 859.8 | 47.9 |
| 185 | J-57 | 750.97 | TRUE | 1 | 859.8 | 47.1 |
| 187 | J-58 | 745.71 | TRUE | 1 | 859.8 | 49.4 |
| 188 | J-59 | 745.49 | TRUE | 1 | 859.8 | 49.5 |
| 192 | J-60 | 747 | TRUE | 1 | 859.8 | 48.8 |
| 196 | J-61 | 746 | TRUE | 1 | 859.8 | 49.2 |
| 204 | J-64 | 745.73 | TRUE | 1 | 859.8 | 49.4 |
| 208 | J-65 | 747.62 | TRUE | 1 | 859.8 | 48.5 |
| 212 | J-66 | 738 | TRUE | 1 | 859.8 | 52.7 |
| 215 | J-67 | 746.89 | TRUE | 1 | 859.8 | 48.9 |
| 219 | J-68 | 741.05 | TRUE | 1 | 859.8 | 51.4 |
| 222 | J-69 | 743.83 | TRUE | 1 | 859.81 | 50.2 |
| 224 | J-70 | 747 | TRUE | 1 | 859.81 | 48.8 |
| 227 | J-71 | 741.14 | TRUE | 1 | 859.81 | 51.3 |
| 229 | J-72 | 745.63 | TRUE | 1 | 859.81 | 49.4 |
| 233 | J-73 | 748.32 | TRUE | 1 | 859.81 | 48.2 |
| 235 | J-74 | 750.84 | TRUE | 1 | 859.81 | 47.1 |
| 238 | J-75 | 739.77 | TRUE | 1 | 859.81 | 51.9 |
| 240 | J-76 | 742.87 | TRUE | 1 | 859.8 | 50.6 |
| 244 | J-77 | 746.68 | TRUE | 1 | 859.8 | 48.9 |
| 248 | J-78 | 732 | TRUE | 1 | 859.81 | 55.3 |
| 251 | J-79 | 744.02 | TRUE | 1 | 859.81 | 50.1 |
| 253 | J-80 | 744.39 | TRUE | 1 | 859.81 | 49.9 |
| 257 | J-81 | 737.62 | TRUE | 1 | 859.81 | 52.9 |
| 261 | J-82 | 728 | TRUE | 1 | 859.81 | 57 |
| 264 | J-83 | 730.86 | TRUE | 1 | 859.81 | 55.8 |
| 268 | J-84 | 730.48 | TRUE | 1 | 859.81 | 56 |
| 271 | J-85 | 733 | TRUE | 1 | 859.81 | 54.9 |
| 275 | J-86 | 734.15 | TRUE | 1 | 859.81 | 54.4 |
| 278 | J-87 | 733 | TRUE | 1 | 859.81 | 54.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 282 | J-88 | 734.15 | TRUE | 1 | 859.81 | 54.4 |
| 285 | J-89 | 736.14 | TRUE | 1 | 859.81 | 53.5 |
| 289 | J-90 | 735 | TRUE | 1 | 859.81 | 54 |
| 292 | J-91 | 736.61 | TRUE | 1 | 859.81 | 53.3 |
| 294 | J-92 | 733 | TRUE | 1 | 859.79 | 54.9 |
| 298 | J-93 | 739 | TRUE | 1 | 859.81 | 52.3 |
| 302 | J-94 | 732.14 | TRUE | 1 | 859.79 | 55.2 |
| 305 | J-95 | 727 | TRUE | 1 | 859.8 | 57.5 |
| 309 | J-96 | 727.78 | TRUE | 1 | 859.79 | 57.1 |
| 312 | J-97 | 733 | TRUE | 1 | 859.79 | 54.9 |
| 316 | J-98 | 727.37 | TRUE | 1 | 859.79 | 57.3 |
| 319 | J-99 | 731.02 | TRUE | 1 | 859.74 | 55.7 |
| 321 | J-100 | 731.71 | TRUE | 1 | 859.74 | 55.4 |
| 324 | J-101 | 732.82 | TRUE | 1 | 859.74 | 54.9 |
| 326 | J-102 | 727.94 | TRUE | 1 | 859.74 | 57 |
| 329 | J-103 | 720.16 | TRUE | 1 | 859.73 | 60.4 |
| 331 | J-104 | 720.61 | TRUE | 1 | 859.73 | 60.2 |
| 333 | J-105 | 730.61 | TRUE | 1 | 859.73 | 55.9 |
| 335 | J-106 | 734.46 | TRUE | 1 | 859.73 | 54.2 |
| 337 | J-107 | 719.69 | TRUE | 1 | 859.73 | 60.6 |
| 341 | J-108 | 730.81 | TRUE | 1 | 859.73 | 55.8 |
| 344 | J-109 | 725.77 | TRUE | 1 | 859.73 | 58 |
| 346 | J-110 | 722 | TRUE | 1 | 859.73 | 59.6 |
| 348 | J-111 | 728.53 | TRUE | 1 | 859.73 | 56.8 |
| 350 | J-112 | 732.05 | TRUE | 1 | 859.73 | 55.2 |
| 352 | J-113 | 733.66 | TRUE | 1 | 859.73 | 54.5 |
| 356 | J-114 | 725.11 | TRUE | 1 | 859.73 | 58.2 |
| 358 | J-115 | 728.84 | TRUE | 1 | 859.73 | 56.6 |
| 361 | J-116 | 724.65 | TRUE | 1 | 859.73 | 58.4 |
| 363 | J-117 | 728.08 | TRUE | 1 | 859.73 | 57 |
| 118 | J-118 | 726.4 | TRUE | 1 | 859.81 | 57.7 |
| 366 | J-118 | 724 | TRUE | 1 | 859.72 | 58.7 |
| 368 | J-119 | 724.6 | TRUE | 1 | 859.72 | 58.5 |
| 374 | J-121 | 726.83 | TRUE | 1 | 859.72 | 57.5 |
| 376 | J-122 | 731.72 | TRUE | 1 | 859.72 | 55.4 |
| 379 | J-123 | 728.45 | FALSE | (N/A) | (N/A) | (N/A) |
| 381 | J-124 | 732 | TRUE | 1 | 859.72 | 55.3 |
| 384 | J-125 | 730.77 | TRUE | 1 | 859.72 | 55.8 |
| 386 | J-126 | 735.36 | TRUE | 1 | 859.72 | 53.8 |
| 390 | J-127 | 741.71 | TRUE | 1 | 859.72 | 51.1 |
| 393 | J-128 | 745.85 | TRUE | 1 | 859.72 | 49.3 |
| 395 | J-129 | 741 | TRUE | 1 | 859.72 | 51.4 |
| 398 | J-130 | 743.24 | TRUE | 1 | 859.72 | 50.4 |
| 405 | J-133 | 739.91 | TRUE | 1 | 859.72 | 51.8 |
| 407 | J-134 | 740.81 | TRUE | 1 | 859.72 | 51.4 |
| 409 | J-135 | 738.56 | TRUE | 1 | 859.72 | 52.4 |
| 412 | J-136 | 729.04 | TRUE | 1 | 859.72 | 56.5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 415 | J-137 | 726.81 | TRUE | 1 | 859.72 | 57.5 |
| 418 | J-138 | 725 | TRUE | 1 | 859.72 | 58.3 |
| 421 | J-139 | 728.47 | TRUE | 1 | 859.73 | 56.8 |
| 422 | J-140 | 724.78 | TRUE | 1 | 859.73 | 58.4 |
| 424 | J-141 | 726.05 | TRUE | 1 | 859.73 | 57.8 |
| 430 | J-142 | 720.22 | TRUE | 1 | 859.73 | 60.4 |
| 433 | J-143 | 722.45 | TRUE | 1 | 859.73 | 59.4 |
| 435 | J-144 | 726.09 | TRUE | 1 | 859.73 | 57.8 |
| 437 | J-145 | 727 | TRUE | 1 | 859.73 | 57.4 |
| 439 | J-146 | 725 | TRUE | 1 | 859.73 | 58.3 |
| 442 | J-147 | 725.83 | TRUE | 1 | 859.73 | 57.9 |
| 446 | J-148 | 721 | TRUE | 1 | 859.73 | 60 |
| 449 | J-149 | 724.94 | TRUE | 1 | 859.74 | 58.3 |
| 453 | J-150 | 732.98 | TRUE | 1 | 859.74 | 54.8 |
| 456 | J-151 | 726.29 | TRUE | 1 | 859.74 | 57.7 |
| 460 | J-152 | 731.93 | TRUE | 1 | 859.75 | 55.3 |
| 461 | J-153 | 732.13 | TRUE | 1 | 859.75 | 55.2 |
| 465 | J-154 | 732.01 | TRUE | 1 | 859.75 | 55.3 |
| 468 | J-155 | 721.14 | TRUE | 1 | 859.76 | 60 |
| 470 | J-156 | 724.9 | TRUE | 1 | 859.76 | 58.3 |
| 472 | J-157 | 715.91 | TRUE | 1 | 859.76 | 62.2 |
| 474 | J-158 | 714.98 | TRUE | 1 | 859.75 | 62.6 |
| 476 | J-159 | 715.11 | TRUE | 1 | 859.75 | 62.6 |
| 479 | J-160 | 725.93 | TRUE | 1 | 859.74 | 57.9 |
| 481 | J-161 | 730.96 | TRUE | 1 | 859.74 | 55.7 |
| 484 | J-162 | 727.76 | TRUE | 1 | 859.74 | 57.1 |
| 487 | J-163 | 738.05 | TRUE | 1 | 859.74 | 52.7 |
| 489 | J-164 | 732.54 | TRUE | 1 | 859.74 | 55 |
| 491 | J-165 | 730.62 | TRUE | 1 | 859.74 | 55.9 |
| 494 | J-166 | 718 | TRUE | 1 | 859.74 | 61.3 |
| 498 | J-167 | 738.93 | TRUE | 1 | 859.74 | 52.3 |
| 499 | J-168 | 740.45 | TRUE | 1 | 859.74 | 51.6 |
| 503 | J-169 | 742.53 | TRUE | 1 | 859.75 | 50.7 |
| 507 | J-170 | 726.53 | TRUE | 1 | 859.74 | 57.6 |
| 510 | J-171 | 725.61 | TRUE | 1 | 859.74 | 58 |
| 512 | J-172 | 725.48 | TRUE | 1 | 859.73 | 58.1 |
| 514 | J-173 | 727.52 | TRUE | 1 | 859.73 | 57.2 |
| 516 | J-174 | 723.98 | TRUE | 1 | 859.73 | 58.7 |
| 518 | J-175 | 724 | TRUE | 1 | 859.72 | 58.7 |
| 523 | J-176 | 725.03 | TRUE | 1 | 859.72 | 58.3 |
| 525 | J-177 | 728.06 | TRUE | 1 | 859.72 | 57 |
| 527 | J-178 | 727.54 | TRUE | 1 | 859.72 | 57.2 |
| 530 | J-179 | 730.62 | TRUE | 1 | 859.72 | 55.9 |
| 532 | J-180 | 731.87 | TRUE | 1 | 859.72 | 55.3 |
| 534 | J-181 | 717.64 | TRUE | 1 | 859.72 | 61.5 |
| 538 | J-183 | 633.58 | TRUE | 1 | 859.79 | 97.9 |
| 540 | J-184 | 628.59 | TRUE | 1 | 859.79 | 100 |

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|---|---|---|---|---|---|---|
| 542 | J-185 | 635.54 | TRUE | 1 | 859.79 | 97 |
| 544 | J-186 | 650.32 | TRUE | 1 | 859.79 | 90.6 |
| 546 | J-187 | 656.47 | TRUE | 1 | 859.79 | 88 |
| 548 | J-188 | 670.99 | TRUE | 1 | 859.79 | 81.7 |
| 550 | J-189 | 709.18 | TRUE | 1 | 859.78 | 65.2 |
| 552 | J-190 | 709 | TRUE | 1 | 859.78 | 65.2 |
| 554 | J-191 | 707.29 | TRUE | 1 | 859.78 | 66 |
| 556 | J-192 | 714.18 | TRUE | 1 | 859.77 | 63 |
| 558 | J-193 | 715.35 | TRUE | 1 | 859.76 | 62.5 |
| 563 | J-194 | 717 | TRUE | 1 | 859.76 | 61.8 |
| 566 | J-195 | 720 | TRUE | 1 | 859.76 | 60.5 |
| 568 | J-196 | 724.66 | TRUE | 1 | 859.76 | 58.4 |
| 570 | J-197 | 722.51 | TRUE | 1 | 859.76 | 59.4 |
| 578 | J-200 | 726 | TRUE | 1 | 859.79 | 57.9 |
| 581 | J-201 | 726 | TRUE | 1 | 859.79 | 57.9 |
| 583 | J-202 | 727 | TRUE | 1 | 859.79 | 57.5 |
| 586 | J-203 | 727.82 | TRUE | 1 | 859.79 | 57.1 |
| 590 | J-204 | 724.15 | TRUE | 1 | 859.79 | 58.7 |
| 593 | J-205 | 723.07 | TRUE | 1 | 859.79 | 59.2 |
| 595 | J-206 | 725.33 | TRUE | 1 | 859.79 | 58.2 |
| 598 | J-207 | 721.07 | TRUE | 1 | 859.79 | 60 |
| 600 | J-208 | 725.85 | TRUE | 1 | 859.79 | 58 |
| 603 | J-209 | 726 | TRUE | 1 | 859.79 | 57.9 |
| 605 | J-210 | 728 | TRUE | 1 | 859.8 | 57 |
| 608 | J-211 | 716.66 | TRUE | 1 | 859.8 | 61.9 |
| 610 | J-212 | 717 | TRUE | 1 | 859.8 | 61.8 |
| 612 | J-213 | 717.77 | TRUE | 1 | 859.8 | 61.5 |
| 614 | J-214 | 723 | TRUE | 1 | 859.8 | 59.2 |
| 616 | J-215 | 724.18 | TRUE | 1 | 859.8 | 58.7 |
| 618 | J-216 | 722.88 | TRUE | 1 | 859.8 | 59.2 |
| 620 | J-217 | 722 | TRUE | 1 | 859.8 | 59.6 |
| 622 | J-218 | 718.3 | TRUE | 1 | 859.8 | 61.2 |
| 624 | J-219 | 721 | TRUE | 1 | 859.8 | 60.1 |
| 626 | J-220 | 717.03 | TRUE | 1 | 859.8 | 61.8 |
| 630 | J-221 | 713.39 | TRUE | 1 | 859.8 | 63.3 |
| 632 | J-222 | 720.27 | TRUE | 1 | 859.8 | 60.4 |
| 635 | J-223 | 720.8 | TRUE | 1 | 859.8 | 60.1 |
| 637 | J-224 | 714 | TRUE | 1 | 859.8 | 63.1 |
| 639 | J-225 | 712 | TRUE | 1 | 859.8 | 63.9 |
| 641 | J-226 | 707.42 | TRUE | 1 | 859.8 | 65.9 |
| 643 | J-227 | 656.62 | TRUE | 1 | 859.79 | 87.9 |
| 646 | J-228 | 713.52 | TRUE | 1 | 859.79 | 63.3 |
| 649 | J-229 | 711.15 | TRUE | 1 | 859.79 | 64.3 |
| 651 | J-230 | 703.02 | TRUE | 1 | 859.79 | 67.8 |
| 653 | J-231 | 705.43 | TRUE | 1 | 859.79 | 66.8 |
| 656 | J-232 | 698.98 | TRUE | 1 | 859.79 | 69.6 |
| 659 | J-233 | 669.59 | TRUE | 1 | 859.79 | 82.3 |

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|---|---|---|---|---|---|---|
| 661 | J-234 | 635.73 | TRUE | 1 | 859.79 | 96.9 |
| 664 | J-235 | 639.3 | TRUE | 1 | 859.8 | 95.4 |
| 667 | J-236 | 716.62 | TRUE | 1 | 859.76 | 61.9 |
| 669 | J-237 | 719.71 | TRUE | 1 | 859.76 | 60.6 |
| 671 | J-238 | 703.62 | TRUE | 1 | 859.76 | 67.6 |
| 674 | J-239 | 720.62 | TRUE | 1 | 859.81 | 60.2 |
| 677 | J-240 | 721.45 | TRUE | 1 | 859.81 | 59.9 |
| 680 | J-241 | 713.52 | TRUE | 1 | 859.83 | 63.3 |
| 683 | J-242 | 716.76 | TRUE | 1 | 859.87 | 61.9 |
| 687 | J-243 | 710 | TRUE | 1 | 859.85 | 64.8 |
| 690 | J-244 | 713 | TRUE | 1 | 859.84 | 63.5 |
| 692 | J-245 | 712.09 | TRUE | 1 | 859.86 | 63.9 |
| 694 | J-246 | 714.92 | TRUE | 1 | 859.92 | 62.7 |
| 698 | J-247 | 709 | TRUE | 1 | 859.88 | 65.3 |
| 701 | J-248 | 708.85 | TRUE | 1 | 859.86 | 65.3 |
| 703 | J-249 | 715 | TRUE | 1 | 859.86 | 62.7 |
| 705 | J-250 | 717 | TRUE | 1 | 859.86 | 61.8 |
| 707 | J-251 | 711 | TRUE | 1 | 859.87 | 64.4 |
| 709 | J-252 | 710 | TRUE | 1 | 859.87 | 64.8 |
| 712 | J-253 | 713.36 | TRUE | 1 | 859.87 | 63.4 |
| 715 | J-254 | 712.52 | TRUE | 1 | 859.86 | 63.7 |
| 717 | J-255 | 714.31 | TRUE | 1 | 859.86 | 63 |
| 719 | J-256 | 712 | TRUE | 1 | 859.86 | 64 |
| 721 | J-257 | 713 | TRUE | 1 | 859.86 | 63.5 |
| 724 | J-258 | 713.77 | TRUE | 1 | 859.86 | 63.2 |
| 726 | J-259 | 712.53 | TRUE | 1 | 859.86 | 63.7 |
| 729 | J-260 | 712 | TRUE | 1 | 859.85 | 64 |
| 733 | J-262 | 716.59 | TRUE | 1 | 859.86 | 62 |
| 735 | J-263 | 715 | TRUE | 1 | 859.86 | 62.7 |
| 737 | J-264 | 715.31 | TRUE | 1 | 859.87 | 62.5 |
| 740 | J-265 | 714 | TRUE | 1 | 859.85 | 63.1 |
| 742 | J-266 | 715.21 | TRUE | 1 | 859.85 | 62.6 |
| 744 | J-267 | 718 | TRUE | 1 | 859.85 | 61.4 |
| 746 | J-268 | 719.86 | TRUE | 1 | 859.85 | 60.6 |
| 750 | J-269 | 716.36 | TRUE | 1 | 859.85 | 62.1 |
| 752 | J-270 | 717 | TRUE | 1 | 859.85 | 61.8 |
| 754 | J-271 | 714 | TRUE | 1 | 859.85 | 63.1 |
| 759 | J-272 | 720.04 | TRUE | 1 | 859.84 | 60.5 |
| 761 | J-273 | 718.81 | TRUE | 1 | 859.84 | 61 |
| 763 | J-274 | 718.66 | TRUE | 1 | 859.84 | 61.1 |
| 765 | J-275 | 721.72 | TRUE | 1 | 859.84 | 59.8 |
| 767 | J-276 | 722.94 | TRUE | 1 | 859.84 | 59.2 |
| 770 | J-277 | 725 | TRUE | 1 | 859.83 | 58.3 |
| 772 | J-278 | 733.47 | TRUE | 1 | 859.83 | 54.7 |
| 774 | J-279 | 724.61 | TRUE | 1 | 859.82 | 58.5 |
| 776 | J-280 | 716.97 | TRUE | 1 | 859.82 | 61.8 |
| 778 | J-281 | 723.35 | TRUE | 1 | 859.82 | 59 |

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|---|---|---|---|---|---|---|
| 781 | J-282 | 722.69 | TRUE | 1 | 859.82 | 59.3 |
| 784 | J-283 | 722.99 | TRUE | 1 | 859.82 | 59.2 |
| 786 | J-284 | 717.92 | TRUE | 1 | 859.82 | 61.4 |
| 788 | J-285 | 722.49 | TRUE | 1 | 859.82 | 59.4 |
| 790 | J-286 | 722.28 | TRUE | 1 | 859.81 | 59.5 |
| 792 | J-287 | 722.85 | TRUE | 1 | 859.81 | 59.3 |
| 794 | J-288 | 717.53 | TRUE | 1 | 859.81 | 61.6 |
| 796 | J-289 | 718.17 | TRUE | 1 | 859.81 | 61.3 |
| 799 | J-290 | 720.17 | TRUE | 1 | 859.81 | 60.4 |
| 801 | J-291 | 716.4 | TRUE | 1 | 859.81 | 62 |
| 802 | J-292 | 728.93 | TRUE | 1 | 859.81 | 56.6 |
| 807 | J-294 | 715 | TRUE | 1 | 859.81 | 62.7 |
| 811 | J-296 | 720.28 | TRUE | 1 | 859.81 | 60.4 |
| 813 | J-297 | 712.66 | TRUE | 1 | 859.81 | 63.7 |
| 815 | J-298 | 710.61 | TRUE | 1 | 859.81 | 64.5 |
| 817 | J-299 | 714.91 | TRUE | 1 | 859.81 | 62.7 |
| 820 | J-300 | 719.58 | TRUE | 1 | 859.81 | 60.7 |
| 822 | J-301 | 719.77 | TRUE | 1 | 859.81 | 60.6 |
| 824 | J-302 | 721.49 | TRUE | 1 | 859.82 | 59.8 |
| 826 | J-303 | 720.13 | TRUE | 1 | 859.82 | 60.4 |
| 828 | J-304 | 722.76 | TRUE | 1 | 859.83 | 59.3 |
| 830 | J-305 | 710.32 | TRUE | 1 | 859.83 | 64.7 |
| 832 | J-306 | 721.53 | TRUE | 1 | 859.83 | 59.8 |
| 834 | J-307 | 706 | TRUE | 1 | 859.83 | 66.6 |
| 836 | J-308 | 710.63 | TRUE | 1 | 859.83 | 64.6 |
| 838 | J-309 | 702.36 | TRUE | 1 | 859.83 | 68.1 |
| 841 | J-310 | 699.69 | TRUE | 1 | 859.82 | 69.3 |
| 843 | J-311 | 700.96 | TRUE | 1 | 859.82 | 68.7 |
| 846 | J-312 | 701.86 | TRUE | 1 | 859.82 | 68.3 |
| 848 | J-313 | 698.46 | TRUE | 1 | 859.81 | 69.8 |
| 850 | J-314 | 703.05 | TRUE | 1 | 859.82 | 67.8 |
| 853 | J-315 | 710.03 | TRUE | 1 | 859.82 | 64.8 |
| 855 | J-316 | 708.95 | TRUE | 1 | 859.81 | 65.3 |
| 857 | J-317 | 713.69 | TRUE | 1 | 859.82 | 63.2 |
| 861 | J-318 | 712.41 | TRUE | 1 | 859.86 | 63.8 |
| 863 | J-319 | 713.94 | TRUE | 1 | 859.85 | 63.1 |
| 865 | J-320 | 712.55 | TRUE | 1 | 859.85 | 63.7 |
| 867 | J-321 | 714 | TRUE | 1 | 859.85 | 63.1 |
| 870 | J-322 | 714 | TRUE | 1 | 859.86 | 63.1 |
| 873 | J-323 | 716.98 | TRUE | 1 | 859.86 | 61.8 |
| 877 | J-324 | 720.55 | TRUE | 1 | 859.86 | 60.3 |
| 880 | J-325 | 706.65 | TRUE | 1 | 859.81 | 66.3 |
| 882 | J-326 | 705.73 | TRUE | 1 | 859.81 | 66.7 |
| 884 | J-327 | 705.7 | TRUE | 1 | 859.81 | 66.7 |
| 886 | J-328 | 705.73 | TRUE | 1 | 859.81 | 66.7 |
| 889 | J-329 | 709.25 | TRUE | 1 | 859.81 | 65.1 |
| 891 | J-330 | 702.26 | TRUE | 1 | 859.81 | 68.2 |

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|---|---|---|---|---|---|---|
| 893 | J-331 | 706 | TRUE | 1 | 859.81 | 66.5 |
| 896 | J-332 | 703.52 | TRUE | 1 | 859.81 | 67.6 |
| 898 | J-333 | 698.76 | TRUE | 1 | 859.8 | 69.7 |
| 900 | J-334 | 710.64 | TRUE | 1 | 859.8 | 64.5 |
| 907 | J-336 | 708 | TRUE | 1 | 859.81 | 65.7 |
| 912 | J-338 | 711.15 | TRUE | 1 | 859.81 | 64.3 |
| 915 | J-339 | 712.15 | TRUE | 1 | 859.8 | 63.9 |
| 919 | J-340 | 716.12 | TRUE | 1 | 859.81 | 62.2 |
| 923 | J-341 | 706.05 | TRUE | 1 | 859.82 | 66.5 |
| 926 | J-342 | 707.69 | TRUE | 1 | 859.82 | 65.8 |
| 929 | J-343 | 714 | TRUE | 1 | 859.81 | 63.1 |
| 933 | J-345 | 710.64 | TRUE | 1 | 859.81 | 64.5 |
| 936 | J-346 | 709.85 | TRUE | 1 | 859.81 | 64.9 |
| 939 | J-347 | 692.57 | TRUE | 1 | 859.81 | 72.4 |
| 941 | J-348 | 691.48 | TRUE | 1 | 859.81 | 72.8 |
| 943 | J-349 | 702.43 | TRUE | 1 | 859.81 | 68.1 |
| 945 | J-350 | 706.77 | TRUE | 1 | 859.81 | 66.2 |
| 947 | J-351 | 702.42 | TRUE | 1 | 859.81 | 68.1 |
| 949 | J-352 | 703.59 | TRUE | 1 | 859.81 | 67.6 |
| 951 | J-353 | 699.66 | TRUE | 1 | 859.81 | 69.3 |
| 954 | J-354 | 709.41 | TRUE | 1 | 859.81 | 65.1 |
| 956 | J-355 | 704.39 | TRUE | 1 | 859.81 | 67.2 |
| 960 | J-356 | 704.08 | TRUE | 1 | 859.81 | 67.4 |
| 964 | J-357 | 697 | TRUE | 1 | 859.81 | 70.4 |
| 969 | J-358 | 715.19 | TRUE | 1 | 859.81 | 62.6 |
| 971 | J-359 | 709.27 | TRUE | 1 | 859.81 | 65.1 |
| 973 | J-360 | 716.89 | TRUE | 1 | 859.81 | 61.8 |
| 976 | J-361 | 699.52 | TRUE | 1 | 859.81 | 69.3 |
| 979 | J-362 | 698.91 | TRUE | 1 | 859.81 | 69.6 |
| 981 | J-363 | 700.99 | TRUE | 1 | 859.81 | 68.7 |
| 983 | J-364 | 708.84 | TRUE | 1 | 859.81 | 65.3 |
| 985 | J-365 | 707.02 | TRUE | 1 | 859.81 | 66.1 |
| 988 | J-366 | 704.51 | TRUE | 1 | 859.81 | 67.2 |
| 992 | J-367 | 697 | TRUE | 1 | 859.81 | 70.4 |
| 998 | J-368 | 712.68 | TRUE | 1 | 859.81 | 63.7 |
| 1000 | J-369 | 703.86 | TRUE | 1 | 859.81 | 67.5 |
| 1003 | J-370 | 703.99 | TRUE | 1 | 859.81 | 67.4 |
| 371 | J-371 | 730.98 | TRUE | 1 | 859.72 | 55.7 |
| 1007 | J-371 | 702.93 | TRUE | 1 | 859.81 | 67.9 |
| 1009 | J-372 | 697.52 | TRUE | 1 | 859.81 | 70.2 |
| 1012 | J-373 | 693 | TRUE | 1 | 859.81 | 72.2 |
| 1014 | J-374 | 692.31 | TRUE | 1 | 859.81 | 72.5 |
| 1016 | J-375 | 695.97 | TRUE | 1 | 859.81 | 70.9 |
| 1018 | J-376 | 697 | TRUE | 1 | 859.81 | 70.4 |
| 1021 | J-377 | 679.19 | TRUE | 1 | 859.81 | 78.1 |
| 1023 | J-378 | 693.2 | TRUE | 1 | 859.81 | 72.1 |
| 1026 | J-379 | 692 | TRUE | 1 | 859.81 | 72.6 |

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| 1029 | J-380 | 704.49 | TRUE | 1 | 859.81 | 67.2 |
| 1033 | J-382 | 706 | TRUE | 1 | 859.81 | 66.5 |
| 1035 | J-383 | 707.55 | TRUE | 1 | 859.81 | 65.9 |
| 1037 | J-384 | 707.41 | TRUE | 1 | 859.81 | 65.9 |
| 1039 | J-385 | 712.67 | TRUE | 1 | 859.81 | 63.7 |
| 1042 | J-386 | 709.41 | TRUE | 1 | 859.81 | 65.1 |
| 1044 | J-387 | 705 | TRUE | 1 | 859.81 | 67 |
| 1046 | J-388 | 712.24 | TRUE | 1 | 859.81 | 63.8 |
| 1048 | J-389 | 706.88 | TRUE | 1 | 859.81 | 66.2 |
| 1051 | J-390 | 698 | TRUE | 1 | 859.81 | 70 |
| 1058 | J-391 | 704 | TRUE | 1 | 859.81 | 67.4 |
| 1062 | J-392 | 693.32 | TRUE | 1 | 859.81 | 72 |
| 1064 | J-393 | 685.26 | TRUE | 1 | 859.81 | 75.5 |
| 1066 | J-394 | 680.59 | TRUE | 1 | 859.81 | 77.5 |
| 1068 | J-395 | 675.95 | TRUE | 1 | 859.81 | 79.5 |
| 1070 | J-396 | 687.74 | TRUE | 1 | 859.81 | 74.4 |
| 1074 | J-397 | 698.73 | TRUE | 1 | 859.81 | 69.7 |
| 1076 | J-398 | 703.81 | TRUE | 1 | 859.81 | 67.5 |
| 1079 | J-399 | 647.43 | TRUE | 1 | 859.81 | 91.9 |
| 401 | J-401 | 741 | TRUE | 1 | 859.72 | 51.4 |
| 1084 | J-401 | 643 | TRUE | 1 | 859.81 | 93.8 |
| 1087 | J-402 | 643 | TRUE | 1 | 859.81 | 93.8 |
| 1091 | J-403 | 644.36 | TRUE | 1 | 859.81 | 93.2 |
| 1094 | J-404 | 645.97 | TRUE | 1 | 859.82 | 92.5 |
| 1096 | J-405 | 646.02 | TRUE | 1 | 859.81 | 92.5 |
| 1098 | J-406 | 644 | TRUE | 1 | 859.81 | 93.4 |
| 1100 | J-407 | 642.63 | TRUE | 1 | 859.81 | 94 |
| 1104 | J-408 | 659 | TRUE | 1 | 859.81 | 86.9 |
| 1106 | J-409 | 660.11 | TRUE | 1 | 859.81 | 86.4 |
| 1108 | J-410 | 656.39 | TRUE | 1 | 859.81 | 88 |
| 1110 | J-411 | 655.19 | TRUE | 1 | 859.81 | 88.5 |
| 1112 | J-412 | 656 | TRUE | 1 | 859.81 | 88.2 |
| 1114 | J-413 | 653.83 | TRUE | 1 | 859.81 | 89.1 |
| 1117 | J-414 | 643.01 | TRUE | 1 | 859.8 | 93.8 |
| 1119 | J-415 | 646.63 | TRUE | 1 | 859.8 | 92.2 |
| 1124 | J-416 | 661.4 | TRUE | 1 | 859.81 | 85.8 |
| 1127 | J-417 | 658.92 | TRUE | 1 | 859.81 | 86.9 |
| 1130 | J-418 | 657.74 | TRUE | 1 | 859.81 | 87.4 |
| 1132 | J-419 | 658.05 | TRUE | 1 | 859.81 | 87.3 |
| 1134 | J-420 | 660 | TRUE | 1 | 859.81 | 86.4 |
| 1136 | J-421 | 704.97 | TRUE | 1 | 859.81 | 67 |
| 1138 | J-422 | 711.86 | TRUE | 1 | 859.81 | 64 |
| 1140 | J-423 | 710.29 | TRUE | 1 | 859.81 | 64.7 |
| 1143 | J-424 | 709.58 | TRUE | 1 | 859.81 | 65 |
| 1145 | J-425 | 706 | TRUE | 1 | 859.81 | 66.5 |
| 1147 | J-426 | 659.3 | TRUE | 1 | 859.81 | 86.8 |
| 1152 | J-427 | 707.92 | TRUE | 1 | 859.81 | 65.7 |

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| 1154 | J-428 | 711.64 | TRUE | 1 | 859.81 | 64.1 |
| 1157 | J-429 | 711 | TRUE | 1 | 859.81 | 64.4 |
| 1159 | J-430 | 705.06 | TRUE | 1 | 859.81 | 67 |
| 1165 | J-431 | 709 | TRUE | 1 | 859.81 | 65.2 |
| 1167 | J-432 | 706.97 | TRUE | 1 | 859.81 | 66.1 |
| 1171 | J-433 | 715.92 | TRUE | 1 | 859.76 | 62.2 |
| 1175 | J-434 | 710 | TRUE | 1 | 860 | 64.9 |
| 1177 | J-435 | 711.08 | TRUE | 1 | 860 | 64.4 |
| 1180 | J-436 | 710.97 | TRUE | 1 | 859.99 | 64.5 |
| 1182 | J-437 | 704.85 | TRUE | 1 | 859.98 | 67.1 |
| 1186 | J-439 | 698.88 | TRUE | 1 | 859.96 | 69.7 |
| 1188 | J-440 | 696 | TRUE | 1 | 859.95 | 70.9 |
| 1193 | J-442 | 690 | TRUE | 1 | 859.93 | 73.5 |
| 1195 | J-443 | 695.82 | TRUE | 1 | 859.93 | 71 |
| 1199 | J-445 | 699 | TRUE | 1 | 859.93 | 69.6 |
| 1203 | J-447 | 694 | TRUE | 1 | 859.91 | 71.8 |
| 1205 | J-448 | 693.12 | TRUE | 1 | 859.91 | 72.2 |
| 1207 | J-449 | 696 | TRUE | 1 | 859.91 | 70.9 |
| 1209 | J-450 | 711 | TRUE | 1 | 859.91 | 64.4 |
| 1211 | J-451 | 709.88 | TRUE | 1 | 859.9 | 64.9 |
| 1213 | J-452 | 715 | TRUE | 1 | 859.9 | 62.7 |
| 1215 | J-453 | 705.41 | TRUE | 1 | 859.9 | 66.8 |
| 1217 | J-454 | 707.98 | TRUE | 1 | 859.91 | 65.7 |
| 1220 | J-455 | 717.85 | TRUE | 1 | 859.91 | 61.5 |
| 1223 | J-456 | 703.5 | TRUE | 1 | 859.9 | 67.7 |
| 1225 | J-457 | 712.71 | TRUE | 1 | 859.9 | 63.7 |
| 1228 | J-458 | 710.81 | TRUE | 1 | 859.9 | 64.5 |
| 1230 | J-459 | 712.3 | TRUE | 1 | 859.89 | 63.9 |
| 1232 | J-460 | 699.24 | TRUE | 1 | 859.88 | 69.5 |
| 1234 | J-461 | 703.17 | TRUE | 1 | 859.88 | 67.8 |
| 1236 | J-462 | 698 | TRUE | 1 | 859.88 | 70 |
| 1238 | J-463 | 704.51 | TRUE | 1 | 859.88 | 67.2 |
| 1240 | J-464 | 705.31 | TRUE | 1 | 859.89 | 66.9 |
| 1242 | J-465 | 700.79 | TRUE | 1 | 859.89 | 68.8 |
| 1244 | J-466 | 696.64 | TRUE | 1 | 859.88 | 70.6 |
| 1246 | J-467 | 690.75 | TRUE | 1 | 859.88 | 73.2 |
| 1249 | J-468 | 688.79 | TRUE | 1 | 859.88 | 74 |
| 1251 | J-469 | 686.71 | TRUE | 1 | 859.88 | 74.9 |
| 1253 | J-470 | 692.02 | TRUE | 1 | 859.87 | 72.6 |
| 1255 | J-471 | 694.13 | TRUE | 1 | 859.87 | 71.7 |
| 1257 | J-472 | 701.74 | TRUE | 1 | 859.87 | 68.4 |
| 1259 | J-473 | 709.01 | TRUE | 1 | 859.88 | 65.3 |
| 1261 | J-474 | 686.83 | TRUE | 1 | 859.88 | 74.9 |
| 1264 | J-475 | 711.41 | TRUE | 1 | 859.88 | 64.2 |
| 1266 | J-476 | 691.23 | TRUE | 1 | 859.88 | 73 |
| 1268 | J-477 | 687.9 | TRUE | 1 | 859.88 | 74.4 |
| 1271 | J-478 | 706 | TRUE | 1 | 859.88 | 66.6 |

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|---|---|---|---|---|---|---|
| 1274 | J-479 | 703 | TRUE | 1 | 859.89 | 67.9 |
| 1277 | J-480 | 702 | TRUE | 1 | 859.89 | 68.3 |
| 1280 | J-481 | 702.43 | TRUE | 1 | 859.9 | 68.1 |
| 1283 | J-482 | 699 | TRUE | 1 | 859.9 | 69.6 |
| 1285 | J-483 | 706 | TRUE | 1 | 859.9 | 66.6 |
| 1287 | J-484 | 706 | TRUE | 1 | 859.9 | 66.6 |
| 1289 | J-485 | 708.74 | TRUE | 1 | 859.9 | 65.4 |
| 1291 | J-486 | 699.56 | TRUE | 1 | 859.91 | 69.4 |
| 1293 | J-487 | 702.41 | TRUE | 1 | 859.93 | 68.2 |
| 1298 | J-489 | 699 | TRUE | 1 | 859.97 | 69.6 |
| 1300 | J-490 | 698.55 | TRUE | 1 | 859.97 | 69.8 |
| 1304 | J-491 | 711.02 | TRUE | 1 | 860 | 64.5 |
| 1308 | J-492 | 695.43 | TRUE | 1 | 859.95 | 71.2 |
| 1310 | J-493 | 701 | TRUE | 1 | 859.95 | 68.8 |
| 1312 | J-494 | 699.99 | TRUE | 1 | 859.95 | 69.2 |
| 1321 | J-497 | 702 | TRUE | 1 | 859.89 | 68.3 |
| 1323 | J-498 | 697.73 | TRUE | 1 | 859.93 | 70.2 |
| 1326 | J-499 | 697.78 | TRUE | 1 | 859.94 | 70.2 |
| 1328 | J-500 | 699.87 | TRUE | 1 | 859.94 | 69.3 |
| 1330 | J-501 | 711.45 | TRUE | 1 | 859.94 | 64.2 |
| 1332 | J-502 | 716.07 | TRUE | 1 | 859.93 | 62.2 |
| 1336 | J-504 | 712.63 | TRUE | 1 | 859.93 | 63.7 |
| 1338 | J-505 | 716 | TRUE | 1 | 859.92 | 62.3 |
| 1342 | J-507 | 726.32 | TRUE | 1 | 859.88 | 57.8 |
| 1344 | J-508 | 728.98 | TRUE | 1 | 859.88 | 56.6 |
| 1346 | J-509 | 720.16 | TRUE | 1 | 859.88 | 60.5 |
| 1349 | J-510 | 712.17 | TRUE | 1 | 859.93 | 63.9 |
| 1352 | J-511 | 703.84 | TRUE | 1 | 859.93 | 67.5 |
| 1355 | J-513 | 706.1 | TRUE | 1 | 859.93 | 66.6 |
| 1356 | J-514 | 704.45 | TRUE | 1 | 859.93 | 67.3 |
| 1361 | J-516 | 720 | TRUE | 1 | 859.89 | 60.5 |
| 1364 | J-517 | 704.52 | TRUE | 1 | 859.88 | 67.2 |
| 1366 | J-518 | 705.4 | TRUE | 1 | 859.88 | 66.8 |
| 1368 | J-519 | 718.85 | TRUE | 1 | 859.88 | 61 |
| 1370 | J-520 | 719 | TRUE | 1 | 859.83 | 60.9 |
| 1372 | J-521 | 725.53 | TRUE | 1 | 859.82 | 58.1 |
| 1374 | J-522 | 713.21 | TRUE | 1 | 859.82 | 63.4 |
| 1376 | J-523 | 712 | TRUE | 1 | 859.82 | 64 |
| 1378 | J-524 | 717.43 | TRUE | 1 | 859.82 | 61.6 |
| 1381 | J-525 | 712 | TRUE | 1 | 859.82 | 64 |
| 1383 | J-526 | 721 | TRUE | 1 | 859.82 | 60.1 |
| 1386 | J-527 | 712.24 | TRUE | 1 | 859.82 | 63.9 |
| 1388 | J-528 | 718.08 | TRUE | 1 | 859.82 | 61.3 |
| 1390 | J-529 | 714 | TRUE | 1 | 859.82 | 63.1 |
| 1392 | J-530 | 716.43 | TRUE | 1 | 859.82 | 62 |
| 1395 | J-531 | 719.03 | TRUE | 1 | 859.82 | 60.9 |
| 1397 | J-532 | 721.4 | TRUE | 1 | 859.82 | 59.9 |

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|---|---|---|---|---|---|---|
| 1400 | J-533 | 707.68 | TRUE | 1 | 859.82 | 65.8 |
| 1402 | J-534 | 700.93 | TRUE | 1 | 859.82 | 68.7 |
| 1404 | J-535 | 703 | TRUE | 1 | 859.82 | 67.9 |
| 1406 | J-536 | 701 | TRUE | 1 | 859.82 | 68.7 |
| 1408 | J-537 | 707.65 | TRUE | 1 | 859.82 | 65.8 |
| 1410 | J-538 | 710.4 | TRUE | 1 | 859.82 | 64.7 |
| 1412 | J-539 | 708 | TRUE | 1 | 859.82 | 65.7 |
| 1414 | J-540 | 707.89 | TRUE | 1 | 859.83 | 65.7 |
| 1416 | J-541 | 703.02 | TRUE | 1 | 859.83 | 67.8 |
| 1418 | J-542 | 703.23 | TRUE | 1 | 859.84 | 67.8 |
| 1420 | J-543 | 701 | TRUE | 1 | 859.85 | 68.7 |
| 1422 | J-544 | 701.26 | TRUE | 1 | 859.87 | 68.6 |
| 1424 | J-545 | 705.25 | TRUE | 1 | 859.87 | 66.9 |
| 1426 | J-546 | 706.16 | TRUE | 1 | 859.87 | 66.5 |
| 1428 | J-547 | 698.82 | TRUE | 1 | 859.87 | 69.7 |
| 1430 | J-548 | 697.26 | TRUE | 1 | 859.87 | 70.4 |
| 1433 | J-549 | 714.13 | TRUE | 1 | 859.88 | 63.1 |
| 1436 | J-550 | 718.37 | TRUE | 1 | 859.88 | 61.2 |
| 1438 | J-551 | 717.77 | TRUE | 1 | 859.88 | 61.5 |
| 1440 | J-552 | 719 | TRUE | 1 | 859.88 | 61 |
| 1444 | J-553 | 714.74 | TRUE | 1 | 859.93 | 62.8 |
| 1446 | J-554 | 714.94 | TRUE | 1 | 859.93 | 62.7 |
| 1449 | J-555 | 705.15 | TRUE | 1 | 859.87 | 66.9 |
| 1451 | J-556 | 714.39 | TRUE | 1 | 859.87 | 62.9 |
| 1454 | J-557 | 710.61 | TRUE | 1 | 859.87 | 64.6 |
| 1456 | J-558 | 708.63 | TRUE | 1 | 859.87 | 65.4 |
| 1458 | J-559 | 705.13 | TRUE | 1 | 859.88 | 67 |
| 1460 | J-560 | 703 | TRUE | 1 | 859.89 | 67.9 |
| 1464 | J-561 | 702.51 | TRUE | 1 | 859.86 | 68.1 |
| 1466 | J-562 | 708.23 | TRUE | 1 | 859.87 | 65.6 |
| 1471 | J-563 | 713.49 | TRUE | 1 | 859.84 | 63.3 |
| 1473 | J-564 | 699.24 | TRUE | 1 | 859.84 | 69.5 |
| 1475 | J-565 | 693 | TRUE | 1 | 859.86 | 72.2 |
| 1477 | J-566 | 690 | TRUE | 1 | 859.84 | 73.5 |
| 1480 | J-567 | 707.3 | TRUE | 1 | 859.83 | 66 |
| 1482 | J-568 | 702 | TRUE | 1 | 859.83 | 68.3 |
| 1484 | J-569 | 691.8 | TRUE | 1 | 859.83 | 72.7 |
| 1486 | J-570 | 688 | TRUE | 1 | 859.83 | 74.3 |
| 1489 | J-571 | 688.25 | TRUE | 1 | 859.83 | 74.2 |
| 1491 | J-572 | 630 | TRUE | 1 | 859.83 | 99.4 |
| 1493 | J-573 | 610 | TRUE | 1 | 859.83 | 108.1 |
| 1495 | J-574 | 687.29 | TRUE | 1 | 859.83 | 74.6 |
| 1501 | J-576 | 695.89 | TRUE | 1 | 859.83 | 70.9 |
| 1503 | J-577 | 709.22 | TRUE | 1 | 859.83 | 65.2 |
| 1505 | J-578 | 719.76 | TRUE | 1 | 859.83 | 60.6 |
| 1507 | J-579 | 712.27 | TRUE | 1 | 859.83 | 63.8 |
| 1509 | J-580 | 704.76 | TRUE | 1 | 859.84 | 67.1 |

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|---|---|---|---|---|---|---|
| 1511 | J-581 | 702 | TRUE | 1 | 859.83 | 68.3 |
| 1513 | J-582 | 704.19 | TRUE | 1 | 859.82 | 67.3 |
| 1516 | J-583 | 705 | TRUE | 1 | 859.82 | 67 |
| 1518 | J-584 | 712.25 | TRUE | 1 | 859.82 | 63.8 |
| 1520 | J-585 | 711.92 | TRUE | 1 | 859.82 | 64 |
| 1523 | J-587 | 711.97 | TRUE | 1 | 859.82 | 64 |
| 1525 | J-588 | 715.65 | TRUE | 1 | 859.82 | 62.4 |
| 1527 | J-589 | 708.24 | TRUE | 1 | 859.82 | 65.6 |
| 1529 | J-590 | 698.07 | TRUE | 1 | 859.82 | 70 |
| 1531 | J-591 | 701.26 | TRUE | 1 | 859.82 | 68.6 |
| 1533 | J-592 | 713 | TRUE | 1 | 859.82 | 63.5 |
| 1535 | J-593 | 717 | TRUE | 1 | 859.82 | 61.8 |
| 1537 | J-594 | 711 | TRUE | 1 | 859.82 | 64.4 |
| 1539 | J-595 | 714 | TRUE | 1 | 859.82 | 63.1 |
| 1541 | J-596 | 724.05 | TRUE | 1 | 859.82 | 58.7 |
| 1543 | J-597 | 720.14 | TRUE | 1 | 859.82 | 60.4 |
| 1545 | J-598 | 718 | TRUE | 1 | 859.82 | 61.4 |
| 1547 | J-599 | 715 | TRUE | 1 | 859.82 | 62.7 |
| 1551 | J-601 | 713 | TRUE | 1 | 859.82 | 63.5 |
| 1554 | J-602 | 711 | TRUE | 1 | 859.82 | 64.4 |
| 1557 | J-603 | 718.89 | TRUE | 1 | 859.82 | 61 |
| 1559 | J-604 | 711 | TRUE | 1 | 859.82 | 64.4 |
| 1562 | J-605 | 714.84 | TRUE | 1 | 859.82 | 62.7 |
| 1565 | J-606 | 716 | TRUE | 1 | 859.82 | 62.2 |
| 1569 | J-607 | 711 | TRUE | 1 | 859.82 | 64.4 |
| 1571 | J-608 | 709 | TRUE | 1 | 859.82 | 65.3 |
| 1573 | J-609 | 712.1 | TRUE | 1 | 859.82 | 63.9 |
| 1575 | J-610 | 718.5 | TRUE | 1 | 859.82 | 61.1 |
| 1577 | J-611 | 712 | TRUE | 1 | 859.82 | 64 |
| 1579 | J-612 | 716.69 | TRUE | 1 | 859.82 | 61.9 |
| 1584 | J-613 | 715.08 | TRUE | 1 | 859.82 | 62.6 |
| 1591 | J-614 | 714.83 | TRUE | 1 | 859.82 | 62.7 |
| 1594 | J-615 | 711.8 | TRUE | 1 | 859.82 | 64 |
| 1597 | J-616 | 712.23 | TRUE | 1 | 859.82 | 63.9 |
| 1602 | J-617 | 708.95 | TRUE | 1 | 859.82 | 65.3 |
| 1608 | J-620 | 699.49 | TRUE | 1 | 859.82 | 69.4 |
| 1611 | J-621 | 699.21 | TRUE | 1 | 859.82 | 69.5 |
| 1614 | J-622 | 703.7 | TRUE | 1 | 859.82 | 67.5 |
| 1617 | J-623 | 677.55 | TRUE | 1 | 859.81 | 78.9 |
| 1620 | J-625 | 674.68 | TRUE | 1 | 859.81 | 80.1 |
| 1624 | J-626 | 707.6 | TRUE | 1 | 859.82 | 65.9 |
| 1626 | J-627 | 711.43 | TRUE | 1 | 859.82 | 64.2 |
| 1628 | J-628 | 712.35 | TRUE | 1 | 859.82 | 63.8 |
| 1630 | J-629 | 703.7 | TRUE | 1 | 859.82 | 67.5 |
| 1632 | J-630 | 701.54 | TRUE | 1 | 859.82 | 68.5 |
| 1634 | J-631 | 707.26 | TRUE | 1 | 859.82 | 66 |
| 1636 | J-632 | 708.25 | TRUE | 1 | 859.82 | 65.6 |

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|---|---|---|---|---|---|---|
| 1638 | J-633 | 708.28 | TRUE | 1 | 859.82 | 65.6 |
| 1640 | J-634 | 695.11 | TRUE | 1 | 859.82 | 71.3 |
| 1644 | J-636 | 704.58 | TRUE | 1 | 859.82 | 67.2 |
| 1647 | J-637 | 703.8 | TRUE | 1 | 859.82 | 67.5 |
| 1651 | J-638 | 705.91 | TRUE | 1 | 859.82 | 66.6 |
| 1653 | J-639 | 701 | TRUE | 1 | 859.82 | 68.7 |
| 1655 | J-640 | 706.73 | TRUE | 1 | 859.82 | 66.2 |
| 1657 | J-641 | 711.54 | TRUE | 1 | 859.82 | 64.2 |
| 1659 | J-642 | 709.2 | TRUE | 1 | 859.83 | 65.2 |
| 1663 | J-643 | 713.23 | TRUE | 1 | 859.84 | 63.4 |
| 1665 | J-644 | 707.77 | TRUE | 1 | 859.84 | 65.8 |
| 1667 | J-645 | 716.73 | TRUE | 1 | 859.84 | 61.9 |
| 1674 | J-646 | 705.03 | TRUE | 1 | 859.83 | 67 |
| 1676 | J-647 | 707.83 | TRUE | 1 | 859.83 | 65.8 |
| 1679 | J-648 | 720.04 | TRUE | 1 | 859.83 | 60.5 |
| 1682 | J-649 | 701.18 | TRUE | 1 | 859.83 | 68.6 |
| 1685 | J-650 | 701.62 | TRUE | 1 | 859.83 | 68.5 |
| 1687 | J-651 | 701.9 | TRUE | 1 | 859.84 | 68.3 |
| 1690 | J-652 | 703.24 | TRUE | 1 | 859.84 | 67.8 |
| 1696 | J-655 | 703.9 | TRUE | 1 | 859.83 | 67.5 |
| 1699 | J-656 | 700.26 | TRUE | 1 | 859.83 | 69 |
| 1702 | J-657 | 676.37 | TRUE | 1 | 859.82 | 79.4 |
| 1499 | J-659 | 695.33 | TRUE | 1 | 859.83 | 71.2 |
| 1706 | J-659 | 641 | TRUE | 1 | 859.82 | 94.7 |
| 1708 | J-660 | 643.52 | TRUE | 1 | 859.82 | 93.6 |
| 1712 | J-661 | 623.71 | TRUE | 4 | 859.81 | 102.1 |
| 1714 | J-662 | 663.25 | TRUE | 1 | 859.81 | 85 |
| 1717 | J-663 | 672.85 | TRUE | 1 | 859.82 | 80.9 |
| 1721 | J-664 | 681.97 | TRUE | 1 | 859.82 | 76.9 |
| 1723 | J-665 | 700.54 | TRUE | 1 | 859.82 | 68.9 |
| 1736 | J-666 | 713 | TRUE | 1 | 859.92 | 63.6 |
| 1740 | J-667 | 712 | TRUE | 1 | 859.92 | 64 |
| 1743 | J-668 | 715.96 | TRUE | 1 | 859.95 | 62.3 |
| 1747 | J-669 | 721 | TRUE | 1 | 859.86 | 60.1 |
| 1750 | J-670 | 718.36 | TRUE | 1 | 859.85 | 61.2 |
| 1761 | J-673 | 641.28 | TRUE | 1 | 859.82 | 94.6 |
| 1764 | J-674 | 640.35 | TRUE | 1 | 859.82 | 95 |
| 1766 | J-675 | 655.35 | TRUE | 1 | 859.81 | 88.5 |
| 1767 | J-676 | 657.65 | TRUE | 1 | 859.81 | 87.5 |
| 1771 | J-677 | 707.71 | TRUE | 1 | 859.81 | 65.8 |
| 1774 | J-678 | 709.38 | TRUE | 1 | 859.81 | 65.1 |
| 1786 | J-680 | 725.36 | TRUE | 0 | 859.73 | 58.1 |
| 1792 | J-682 | 726.32 | TRUE | 0 | 859.73 | 57.7 |
| 1809 | J-685 | 792 | FALSE | (N/A) | (N/A) | (N/A) |
| 1811 | J-686 | 740 | FALSE | (N/A) | (N/A) | (N/A) |
| 1813 | J-687 | 699 | FALSE | (N/A) | (N/A) | (N/A) |
| 1817 | J-689 | 694.06 | TRUE | 25 | 859.77 | 71.7 |

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|---|---|---|---|---|---|---|
| 1821 | J-690 | 696 | FALSE | (N/A) | (N/A) | (N/A) |
| 1824 | J-691 | 720 | FALSE | (N/A) | (N/A) | (N/A) |
| 1829 | J-692 | 802 | FALSE | (N/A) | (N/A) | (N/A) |
| 1832 | J-693 | 740 | FALSE | (N/A) | (N/A) | (N/A) |
| 1834 | J-694 | 742 | FALSE | (N/A) | (N/A) | (N/A) |
| 1836 | J-695 | 798 | FALSE | (N/A) | (N/A) | (N/A) |
| 1839 | J-696 | 746.01 | TRUE | 5 | 859.8 | 49.2 |
| 1845 | J-697 | 725.84 | TRUE | 0 | 859.73 | 57.9 |
| 1852 | J-698 | 663 | FALSE | (N/A) | (N/A) | (N/A) |
| 1855 | J-699 | 626.33 | FALSE | (N/A) | (N/A) | (N/A) |
| 1859 | J-700 | 677 | FALSE | (N/A) | (N/A) | (N/A) |
| 1906 | J-702 | 735 | FALSE | (N/A) | (N/A) | (N/A) |
| 1927 | J-707 | 714 | FALSE | (N/A) | (N/A) | (N/A) |
| 1929 | J-708 | 724 | FALSE | (N/A) | (N/A) | (N/A) |
| 1943 | J-714 | 709 | FALSE | (N/A) | (N/A) | (N/A) |
| 1945 | J-715 | 0 | FALSE | (N/A) | (N/A) | (N/A) |
| 1947 | J-716 | 0 | FALSE | (N/A) | (N/A) | (N/A) |
| 1949 | J-717 | 0 | FALSE | (N/A) | (N/A) | (N/A) |
| 1952 | J-718 | 94.23 | FALSE | (N/A) | (N/A) | (N/A) |
| 1956 | J-719 | 698.05 | TRUE | 0 | 859.95 | 70 |
| 1959 | J-720 | 0 | FALSE | (N/A) | (N/A) | (N/A) |
| 1962 | J-721 | 322.39 | FALSE | (N/A) | (N/A) | (N/A) |
| 1966 | J-722 | 0 | FALSE | (N/A) | (N/A) | (N/A) |
| 1969 | J-723 | 160.87 | FALSE | (N/A) | (N/A) | (N/A) |
| 1973 | J-724 | 697.19 | TRUE | 0 | 859.95 | 70.4 |
| 1977 | J-725 | 717 | FALSE | (N/A) | (N/A) | (N/A) |
| 1981 | J-726 | 714.1 | TRUE | 0 | 859.93 | 63.1 |
| 1985 | J-727 | 708.51 | TRUE | 0 | 859.98 | 65.5 |
| 1990 | J-729 | 709 | FALSE | (N/A) | (N/A) | (N/A) |
| 731 | J-731 | 713 | TRUE | 1 | 859.86 | 63.5 |
| 904 | J-904 | 710.34 | TRUE | 1 | 859.81 | 64.7 |
| 1031 | J-1031 | 713.26 | TRUE | 1 | 859.81 | 63.4 |
| 1082 | J-1082 | 649.29 | TRUE | 1 | 859.81 | 91.1 |
| 1184 | J-1184 | 696.23 | TRUE | 1 | 859.97 | 70.8 |
| 1201 | J-1201 | 697 | TRUE | 1 | 859.91 | 70.5 |
| 1296 | J-1296 | 700.72 | TRUE | 1 | 859.95 | 68.9 |
| 1334 | J-1334 | 712.37 | TRUE | 1 | 859.93 | 63.8 |
| 1340 | J-1340 | 714.13 | TRUE | 1 | 859.89 | 63.1 |
| 1549 | J-1549 | 717.5 | TRUE | 1 | 859.82 | 61.6 |
| 1642 | J-1642 | 699.3 | TRUE | 1 | 859.82 | 69.4 |
| 1704 | J-1704 | 666.38 | TRUE | 1 | 859.82 | 83.7 |
| 1780 | J-1780 | 697.01 | TRUE | 0 | 859.95 | 70.5 |
| 1806 | J-1806 | 727.59 | TRUE | 0 | 859.73 | 57.2 |

## Table 2: Fire Flow Results

| BASE SCENARIO | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Junction Label | Fire Flow (Available) (gpm) | Satisfies Fire Flow Constraints? | Fire Flow Status | Flow (Needed) (gpm) | Flow (Available) (gpm) | Pressure (Calculated Residual) (psi) | Pressure (Calculated System Lower Limit) (psi) | Junction w/ Minimum Pressure |
| 1-FLOW | 8,625 | TRUE | Passed | 500 | 8,626 | 30 | 30.8 | 1-RES |
| 1-RES | 3,068 | TRUE | Passed | 500 | 3,071 | 30 | 44.7 | J-51 |
| 2-FLOW | 7,371 | TRUE | Passed | 500 | 7,372 | 30 | 30 | 2-RES |
| 2-RES | 4,072 | TRUE | Passed | 500 | 4,073 | 30 | 44.7 | J-51 |
| 3-FLOW | 2,802 | TRUE | Passed | 500 | 2,803 | 30 | 30.9 | 3-RES |
| 3-RES | 2,395 | TRUE | Passed | 500 | 2,396 | 30 | 39.7 | 3-FLOW |
| 4-FLOW | 3,288 | TRUE | Passed | 500 | 3,289 | 30 | 30.7 | 4-RES |
| 4-RES | 2,386 | TRUE | Passed | 500 | 2,387 | 30 | 42.5 | 4-FLOW |
| 5-FLOW | 2,737 | TRUE | Passed | 500 | 2,738 | 30 | 27.7 | J-51 |
| 5-RES | 1,669 | TRUE | Passed | 500 | 1,670 | 30 | 38 | J-51 |
| 6-FLOW | 1,955 | TRUE | Passed | 500 | 1,956 | 30 | 30.8 | 6-RES |
| 6-RES | 1,272 | TRUE | Passed | 500 | 1,273 | 30 | 44.8 | J-51 |
| 7-FLOW | 2,064 | TRUE | Passed | 500 | 2,065 | 30 | 29.1 | J-196 |
| 7-RES | 1,859 | TRUE | Passed | 500 | 1,860 | 30 | 34.2 | J-196 |
| J-1 | 4,846 | TRUE | Passed | 500 | 4,847 | 30 | 34.3 | J-128 |
| J-2 | 6,881 | TRUE | Passed | 500 | 6,882 | 30 | 31.8 | J-128 |
| J-3 | 7,655 | TRUE | Passed | 500 | 7,656 | 30 | 35 | J-51 |
| J-11 | 8,084 | TRUE | Passed | 500 | 8,085 | 30 | 30.2 | J-51 |
| J-12 | 7,762 | TRUE | Passed | 500 | 7,763 | 30 | 30.3 | J-51 |
| J-13 | 4,488 | TRUE | Passed | 500 | 4,489 | 30 | 34.5 | J-51 |
| J-14 | 3,671 | TRUE | Passed | 500 | 3,672 | 30 | 40.6 | J-51 |
| J-15 | 7,178 | TRUE | Passed | 500 | 7,179 | 30 | 32.1 | J-14 |
| J-17 | 5,465 | TRUE | Passed | 500 | 5,466 | 30 | 28.1 | J-51 |
| J-18 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.5 | 42.3 | J-51 |
| J-19 | 9,082 | TRUE | Passed | 500 | 9,083 | 30 | 29.4 | J-51 |
| J-20 | 4,037 | TRUE | Passed | 500 | 4,038 | 30 | 33.6 | J-23 |
| J-21 | 4,134 | TRUE | Passed | 500 | 4,135 | 30 | 35.6 | J-20 |
| J-22 | 1,995 | TRUE | Passed | 500 | 1,996 | 30 | 43.9 | J-51 |
| J-23 | 3,660 | TRUE | Passed | 500 | 3,661 | 30 | 30.2 | J-22 |
| J-24 | 1,861 | TRUE | Passed | 500 | 1,862 | 30 | 44 | J-51 |
| J-25 | 3,235 | TRUE | Passed | 500 | 3,236 | 30 | 30.1 | J-24 |
| J-26 | 1,804 | TRUE | Passed | 500 | 1,805 | 30 | 43.9 | J-51 |
| J-27 | 3,352 | TRUE | Passed | 500 | 3,353 | 30 | 29.2 | J-26 |
| J-28 | 2,085 | TRUE | Passed | 500 | 2,086 | 30 | 43.4 | J-51 |
| J-29 | 3,651 | TRUE | Passed | 500 | 3,652 | 30 | 29.5 | J-28 |
| J-30 | 6,156 | TRUE | Passed | 500 | 6,157 | 30 | 29.6 | J-51 |
| J-31 | 2,455 | TRUE | Passed | 500 | 2,456 | 30 | 33.5 | J-33 |
| J-33 | 2,657 | TRUE | Passed | 500 | 2,658 | 30 | 31 | J-31 |

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|---|---|---|---|---|---|---|---|---|
| J-34 | 2,565 | TRUE | Passed | 500 | 2,566 | 30 | 37 | J-51 |
| J-35 | 3,124 | TRUE | Passed | 500 | 3,125 | 30 | 28.5 | J-34 |
| J-36 | 4,025 | TRUE | Passed | 500 | 4,026 | 30 | 26.9 | J-51 |
| J-37 | 4,543 | TRUE | Passed | 500 | 4,544 | 30 | 26.1 | J-51 |
| J-38 | 3,963 | TRUE | Passed | 500 | 3,964 | 30 | 25.9 | J-51 |
| J-39 | 3,810 | TRUE | Passed | 500 | 3,811 | 30 | 30.1 | J-51 |
| J-40 | 3,743 | TRUE | Passed | 500 | 3,744 | 30 | 30.3 | J-51 |
| J-41 | 4,045 | TRUE | Passed | 500 | 4,046 | 30 | 24.6 | J-51 |
| J-42 | 2,588 | TRUE | Passed | 500 | 2,589 | 30 | 32.1 | J-51 |
| J-43 | 3,259 | TRUE | Passed | 500 | 3,260 | 30 | 25.3 | J-51 |
| J-44 | 1,938 | TRUE | Passed | 500 | 1,939 | 30 | 37.4 | J-51 |
| J-45 | 2,051 | TRUE | Passed | 500 | 2,052 | 30 | 35.7 | J-46 |
| J-46 | 2,493 | TRUE | Passed | 500 | 2,494 | 30 | 30.3 | J-45 |
| J-47 | 1,772 | TRUE | Passed | 500 | 1,773 | 30 | 38 | J-48 |
| J-48 | 2,290 | TRUE | Passed | 500 | 2,291 | 30 | 27.2 | J-47 |
| J-49 | 2,668 | TRUE | Passed | 500 | 2,669 | 30 | 30.5 | J-50 |
| J-50 | 2,161 | TRUE | Passed | 500 | 2,162 | 30 | 36.5 | J-51 |
| J-51 | 927 | TRUE | Passed | 500 | 928 | 30 | 43.2 | J-55 |
| J-52 | 2,100 | TRUE | Passed | 500 | 2,101 | 30 | 26.6 | J-51 |
| J-53 | 1,807 | TRUE | Passed | 500 | 1,808 | 30 | 32 | J-54 |
| J-54 | 1,929 | TRUE | Passed | 500 | 1,930 | 30 | 29.5 | J-53 |
| J-55 | 1,610 | TRUE | Passed | 500 | 1,611 | 30 | 34 | J-56 |
| J-56 | 1,854 | TRUE | Passed | 500 | 1,855 | 30 | 28.7 | J-55 |
| J-57 | 1,792 | TRUE | Passed | 500 | 1,793 | 30 | 37.2 | J-51 |
| J-58 | 1,977 | TRUE | Passed | 500 | 1,978 | 30 | 31.3 | J-55 |
| J-59 | 2,181 | TRUE | Passed | 500 | 2,182 | 30 | 28.4 | J-55 |
| J-60 | 2,024 | TRUE | Passed | 500 | 2,025 | 30 | 28.6 | J-55 |
| J-61 | 2,858 | TRUE | Passed | 500 | 2,859 | 30 | 26.7 | J-51 |
| J-64 | 2,735 | TRUE | Passed | 500 | 2,736 | 30 | 26.6 | J-51 |
| J-65 | 2,856 | TRUE | Passed | 500 | 2,857 | 30 | 27.5 | J-51 |
| J-66 | 3,655 | TRUE | Passed | 500 | 3,656 | 30 | 23.5 | J-51 |
| J-67 | 3,202 | TRUE | Passed | 500 | 3,203 | 30 | 28.1 | J-51 |
| J-68 | 3,477 | TRUE | Passed | 500 | 3,478 | 30 | 25.6 | J-51 |
| J-69 | 2,212 | TRUE | Passed | 500 | 2,213 | 30 | 36.9 | J-51 |
| J-70 | 2,960 | TRUE | Passed | 500 | 2,961 | 30 | 31.2 | J-51 |
| J-71 | 2,684 | TRUE | Passed | 500 | 2,685 | 30 | 30.9 | J-72 |
| J-72 | 2,618 | TRUE | Passed | 500 | 2,619 | 30 | 33.5 | J-71 |
| J-73 | 1,104 | TRUE | Passed | 500 | 1,105 | 30 | 43 | J-51 |
| J-74 | 2,546 | TRUE | Passed | 500 | 2,547 | 30 | 31.1 | J-73 |
| J-75 | 3,771 | TRUE | Passed | 500 | 3,772 | 30 | 25.8 | J-74 |
| J-76 | 3,514 | TRUE | Passed | 500 | 3,515 | 30 | 27.1 | J-51 |
| J-77 | 3,248 | TRUE | Passed | 500 | 3,249 | 30 | 27.7 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-78 | 4,035 | TRUE | Passed | 500 | 4,036 | 30 | 23.5 | J-51 |
| J-79 | 3,323 | TRUE | Passed | 500 | 3,324 | 30 | 30 | J-51 |
| J-80 | 3,634 | TRUE | Passed | 500 | 3,635 | 30 | 28.1 | J-51 |
| J-81 | 3,779 | TRUE | Passed | 500 | 3,780 | 30 | 24.3 | J-51 |
| J-82 | 4,631 | TRUE | Passed | 500 | 4,633 | 30 | 22.3 | J-51 |
| J-83 | 4,689 | TRUE | Passed | 500 | 4,690 | 30 | 22.1 | J-51 |
| J-84 | 4,676 | TRUE | Passed | 500 | 4,677 | 30 | 21.9 | J-51 |
| J-85 | 4,251 | TRUE | Passed | 500 | 4,252 | 30 | 23.6 | J-51 |
| J-86 | 4,034 | TRUE | Passed | 500 | 4,035 | 30 | 25 | J-51 |
| J-87 | 3,720 | TRUE | Passed | 500 | 3,722 | 30 | 29 | J-51 |
| J-88 | 3,303 | TRUE | Passed | 500 | 3,304 | 30 | 31.7 | J-51 |
| J-89 | 3,891 | TRUE | Passed | 500 | 3,892 | 30 | 25.6 | J-51 |
| J-90 | 3,117 | TRUE | Passed | 500 | 3,118 | 30 | 29.3 | J-91 |
| J-91 | 1,601 | TRUE | Passed | 500 | 1,602 | 30 | 41.2 | J-51 |
| J-92 | 5,252 | TRUE | Passed | 500 | 5,253 | 30 | 30.5 | J-94 |
| J-93 | 3,680 | TRUE | Passed | 500 | 3,681 | 30 | 24.3 | J-51 |
| J-94 | 5,250 | TRUE | Passed | 500 | 5,251 | 30 | 30.3 | J-92 |
| J-95 | 6,421 | TRUE | Passed | 500 | 6,422 | 30 | 31.2 | J-210 |
| J-96 | 5,305 | TRUE | Passed | 500 | 5,306 | 30 | 31.5 | J-209 |
| J-97 | 5,280 | TRUE | Passed | 500 | 5,281 | 30 | 30.4 | J-92 |
| J-98 | 5,398 | TRUE | Passed | 500 | 5,399 | 30 | 28.1 | J-128 |
| J-99 | 2,570 | TRUE | Passed | 500 | 2,571 | 30 | 32.4 | J-128 |
| J-100 | 3,115 | TRUE | Passed | 500 | 3,116 | 30 | 25.6 | J-128 |
| J-101 | 2,377 | TRUE | Passed | 500 | 2,378 | 30 | 33.7 | J-128 |
| J-102 | 3,135 | TRUE | Passed | 500 | 3,136 | 30 | 23.9 | J-128 |
| J-103 | 2,790 | TRUE | Passed | 500 | 2,791 | 30 | 21.9 | J-128 |
| J-104 | 2,590 | TRUE | Passed | 500 | 2,591 | 30 | 25 | J-128 |
| J-105 | 2,602 | TRUE | Passed | 500 | 2,603 | 30 | 24.3 | J-128 |
| J-106 | 2,496 | TRUE | Passed | 500 | 2,497 | 30 | 26 | J-128 |
| J-107 | 2,682 | TRUE | Passed | 500 | 2,683 | 30 | 23.4 | J-128 |
| J-108 | 2,569 | TRUE | Passed | 500 | 2,570 | 30 | 24.7 | J-128 |
| J-109 | 2,650 | TRUE | Passed | 500 | 2,651 | 30 | 23.3 | J-128 |
| J-110 | 2,667 | TRUE | Passed | 500 | 2,668 | 30 | 23.9 | J-128 |
| J-111 | 2,468 | TRUE | Passed | 500 | 2,469 | 30 | 27.4 | J-128 |
| J-112 | 2,288 | TRUE | Passed | 500 | 2,289 | 30 | 30.6 | J-128 |
| J-113 | 2,086 | TRUE | Passed | 500 | 2,087 | 30 | 33 | J-128 |
| J-114 | 2,030 | TRUE | Passed | 500 | 2,031 | 30 | 32.4 | J-128 |
| J-115 | 2,225 | TRUE | Passed | 500 | 2,226 | 30 | 29.5 | J-128 |
| J-116 | 1,930 | TRUE | Passed | 500 | 1,931 | 30 | 33.3 | J-128 |
| J-117 | 2,099 | TRUE | Passed | 500 | 2,100 | 30 | 30.8 | J-128 |
| J-118 | 1,866 | TRUE | Passed | 500 | 1,867 | 30 | 40.6 | J-51 |
| J-118 | 1,951 | TRUE | Passed | 500 | 1,952 | 30 | 31.7 | J-128 |

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|---|---|---|---|---|---|---|---|---|
| J-119 | 2,125 | TRUE | Passed | 500 | 2,126 | 30 | 28.9 | J-128 |
| J-121 | 1,693 | TRUE | Passed | 500 | 1,694 | 30 | 33.4 | J-128 |
| J-122 | 1,915 | TRUE | Passed | 500 | 1,916 | 30 | 29.5 | J-128 |
| J-124 | 1,780 | TRUE | Passed | 500 | 1,781 | 30 | 28.5 | J-128 |
| J-125 | 1,431 | TRUE | Passed | 500 | 1,432 | 30 | 29.5 | J-180 |
| J-126 | 1,712 | TRUE | Passed | 500 | 1,713 | 30 | 28.8 | J-128 |
| J-127 | 1,569 | TRUE | Passed | 500 | 1,570 | 30 | 28.6 | J-128 |
| J-128 | 962 | TRUE | Passed | 500 | 963 | 30 | 42.3 | J-129 |
| J-129 | 1,553 | TRUE | Passed | 500 | 1,554 | 30 | 27.9 | J-128 |
| J-130 | 1,622 | TRUE | Passed | 500 | 1,623 | 30 | 29.7 | J-128 |
| J-133 | 1,748 | TRUE | Passed | 500 | 1,749 | 30 | 29.2 | J-128 |
| J-134 | 1,610 | TRUE | Passed | 500 | 1,611 | 30 | 32.5 | J-135 |
| J-135 | 1,722 | TRUE | Passed | 500 | 1,723 | 30 | 29 | J-134 |
| J-136 | 1,948 | TRUE | Passed | 500 | 1,949 | 30 | 26.4 | J-134 |
| J-137 | 2,036 | TRUE | Passed | 500 | 2,037 | 30 | 25.5 | J-128 |
| J-138 | 2,192 | TRUE | Passed | 500 | 2,193 | 30 | 23.7 | J-128 |
| J-139 | 2,519 | TRUE | Passed | 500 | 2,520 | 30 | 29.4 | J-128 |
| J-140 | 2,180 | TRUE | Passed | 500 | 2,181 | 30 | 32.3 | J-141 |
| J-141 | 2,285 | TRUE | Passed | 500 | 2,286 | 30 | 30.5 | J-140 |
| J-142 | 2,707 | TRUE | Passed | 500 | 2,708 | 30 | 23.3 | J-128 |
| J-143 | 2,843 | TRUE | Passed | 500 | 2,844 | 30 | 20.7 | J-128 |
| J-144 | 2,665 | TRUE | Passed | 500 | 2,666 | 30 | 22.2 | J-128 |
| J-145 | 2,253 | TRUE | Passed | 500 | 2,254 | 30 | 29.2 | J-128 |
| J-146 | 2,747 | TRUE | Passed | 500 | 2,748 | 30 | 21.5 | J-128 |
| J-147 | 2,724 | TRUE | Passed | 500 | 2,725 | 30 | 22.1 | J-128 |
| J-148 | 2,916 | TRUE | Passed | 500 | 2,917 | 30 | 19.9 | J-128 |
| J-149 | 3,185 | TRUE | Passed | 500 | 3,186 | 30 | 21.9 | J-128 |
| J-150 | 3,241 | TRUE | Passed | 500 | 3,242 | 30 | 25.2 | J-128 |
| J-151 | 2,993 | TRUE | Passed | 500 | 2,994 | 30 | 23.8 | J-128 |
| J-152 | 2,200 | TRUE | Passed | 500 | 2,201 | 30 | 38.5 | J-128 |
| J-153 | 3,508 | TRUE | Passed | 500 | 3,509 | 30 | 24.4 | J-128 |
| J-154 | 3,441 | TRUE | Passed | 500 | 3,442 | 30 | 25.6 | J-128 |
| J-155 | 2,925 | TRUE | Passed | 500 | 2,926 | 30 | 30.9 | J-196 |
| J-156 | 2,921 | TRUE | Passed | 500 | 2,922 | 30 | 37.4 | J-196 |
| J-157 | 3,126 | TRUE | Passed | 500 | 3,127 | 30 | 28.4 | J-237 |
| J-158 | 2,443 | TRUE | Passed | 500 | 2,445 | 30 | 36.6 | J-128 |
| J-159 | 3,133 | TRUE | Passed | 500 | 3,134 | 30 | 28.9 | J-163 |
| J-160 | 3,058 | TRUE | Passed | 500 | 3,059 | 30 | 28.3 | J-163 |
| J-161 | 2,960 | TRUE | Passed | 500 | 2,961 | 30 | 29.3 | J-163 |
| J-162 | 3,035 | TRUE | Passed | 500 | 3,036 | 30 | 28.3 | J-163 |
| J-163 | 2,638 | TRUE | Passed | 500 | 2,639 | 30 | 32.8 | J-169 |
| J-164 | 2,851 | TRUE | Passed | 500 | 2,852 | 30 | 30.1 | J-168 |

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|---|---|---|---|---|---|---|---|---|
| J-165 | 3,013 | TRUE | Passed | 500 | 3,014 | 30 | 28.6 | J-163 |
| J-166 | 3,263 | TRUE | Passed | 500 | 3,264 | 30 | 18.8 | J-128 |
| J-167 | 1,969 | TRUE | Passed | 500 | 1,970 | 30 | 35.2 | J-168 |
| J-168 | 2,294 | TRUE | Passed | 500 | 2,295 | 30 | 30.7 | J-167 |
| J-169 | 2,633 | TRUE | Passed | 500 | 2,634 | 30 | 31.8 | J-168 |
| J-170 | 2,955 | TRUE | Passed | 500 | 2,956 | 30 | 24.1 | J-128 |
| J-171 | 1,947 | TRUE | Passed | 500 | 1,948 | 30 | 37.2 | J-128 |
| J-172 | 2,530 | TRUE | Passed | 500 | 2,531 | 30 | 22.8 | J-128 |
| J-173 | 2,243 | TRUE | Passed | 500 | 2,244 | 30 | 27.7 | J-128 |
| J-174 | 2,305 | TRUE | Passed | 500 | 2,306 | 30 | 26.4 | J-128 |
| J-175 | 2,483 | TRUE | Passed | 500 | 2,484 | 30 | 22.5 | J-128 |
| J-176 | 2,242 | TRUE | Passed | 500 | 2,243 | 30 | 27 | J-128 |
| J-177 | 1,773 | TRUE | Passed | 500 | 1,774 | 30 | 34.6 | J-128 |
| J-178 | 2,038 | TRUE | Passed | 500 | 2,039 | 30 | 28.7 | J-179 |
| J-179 | 1,020 | TRUE | Passed | 500 | 1,021 | 30 | 43.7 | J-128 |
| J-180 | 1,040 | TRUE | Passed | 500 | 1,041 | 30 | 39.3 | J-128 |
| J-181 | 2,216 | TRUE | Passed | 500 | 2,217 | 30 | 27.4 | J-128 |
| J-183 | 7,998 | TRUE | Passed | 500 | 7,999 | 30 | 3.8 | J-689 |
| J-184 | 744 | TRUE | Passed | 500 | 745 | 30 | 45.1 | J-51 |
| J-185 | 6,517 | TRUE | Passed | 500 | 6,518 | 30 | 23.6 | J-186 |
| J-186 | 4,727 | TRUE | Passed | 500 | 4,728 | 30 | 40.8 | J-128 |
| J-187 | 4,990 | TRUE | Passed | 500 | 4,991 | 30 | 23.7 | J-188 |
| J-188 | 3,820 | TRUE | Passed | 500 | 3,821 | 30 | 42.5 | J-128 |
| J-189 | 4,622 | TRUE | Passed | 500 | 4,623 | 30 | 35.8 | J-128 |
| J-190 | 4,681 | TRUE | Passed | 500 | 4,682 | 30 | 36.1 | J-128 |
| J-191 | 4,040 | TRUE | Passed | 500 | 4,041 | 30 | 31.3 | J-192 |
| J-192 | 3,484 | TRUE | Passed | 500 | 3,485 | 30 | 37.3 | J-196 |
| J-193 | 3,357 | TRUE | Passed | 500 | 3,358 | 30 | 30.4 | J-196 |
| J-194 | 2,846 | TRUE | Passed | 500 | 2,847 | 30 | 26.7 | J-196 |
| J-195 | 2,252 | TRUE | Passed | 500 | 2,253 | 30 | 28 | J-196 |
| J-196 | 1,872 | TRUE | Passed | 500 | 1,873 | 30 | 33.9 | J-197 |
| J-197 | 2,024 | TRUE | Passed | 500 | 2,025 | 30 | 29.1 | J-196 |
| J-200 | 4,474 | TRUE | Passed | 500 | 4,475 | 30 | 30 | J-201 |
| J-201 | 3,982 | TRUE | Passed | 500 | 3,983 | 30 | 35.3 | J-200 |
| J-202 | 4,344 | TRUE | Passed | 500 | 4,345 | 30 | 31.2 | J-206 |
| J-203 | 4,325 | TRUE | Passed | 500 | 4,326 | 30 | 33.3 | J-204 |
| J-204 | 3,403 | TRUE | Passed | 500 | 3,404 | 30 | 30.5 | J-205 |
| J-205 | 2,797 | TRUE | Passed | 500 | 2,798 | 30 | 38.6 | J-204 |
| J-206 | 3,695 | TRUE | Passed | 500 | 3,696 | 30 | 31.8 | J-207 |
| J-207 | 3,094 | TRUE | Passed | 500 | 3,095 | 30 | 37.7 | J-206 |
| J-208 | 4,868 | TRUE | Passed | 500 | 4,869 | 30 | 29.9 | J-209 |
| J-209 | 3,766 | TRUE | Passed | 500 | 3,767 | 30 | 39.8 | J-128 |

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|---|---|---|---|---|---|---|---|---|
| J-210 | 6,346 | TRUE | Passed | 500 | 6,347 | 30 | 32.2 | J-95 |
| J-211 | 5,607 | TRUE | Passed | 500 | 5,608 | 30 | 32.3 | J-212 |
| J-212 | 4,505 | TRUE | Passed | 500 | 4,506 | 30 | 30.4 | J-213 |
| J-213 | 3,477 | TRUE | Passed | 500 | 3,478 | 30 | 39.8 | J-215 |
| J-214 | 2,720 | TRUE | Passed | 500 | 2,721 | 30 | 29.5 | J-215 |
| J-215 | 2,269 | TRUE | Passed | 500 | 2,270 | 30 | 38.2 | J-214 |
| J-216 | 798 | TRUE | Passed | 500 | 799 | 30 | 45 | J-51 |
| J-217 | 3,276 | TRUE | Passed | 500 | 3,277 | 30 | 29.5 | J-215 |
| J-218 | 1,835 | TRUE | Passed | 500 | 1,836 | 30 | 44.3 | J-51 |
| J-219 | 3,983 | TRUE | Passed | 500 | 3,984 | 30 | 30 | J-215 |
| J-220 | 1,916 | TRUE | Passed | 500 | 1,917 | 30 | 44.2 | J-51 |
| J-221 | 2,304 | TRUE | Passed | 500 | 2,305 | 30 | 43.9 | J-51 |
| J-222 | 4,413 | TRUE | Passed | 500 | 4,414 | 30 | 33 | J-221 |
| J-223 | 4,857 | TRUE | Passed | 500 | 4,858 | 30 | 32 | J-222 |
| J-224 | 5,682 | TRUE | Passed | 500 | 5,683 | 30 | 36.8 | J-223 |
| J-225 | 5,895 | TRUE | Passed | 500 | 5,897 | 30 | 38.6 | J-224 |
| J-226 | 7,500 | TRUE | Passed | 500 | 7,501 | 30 | 32.6 | J-334 |
| J-227 | 6,261 | TRUE | Passed | 500 | 6,262 | 30 | 23.4 | J-191 |
| J-228 | 4,773 | TRUE | Passed | 500 | 4,774 | 30 | 32.6 | J-229 |
| J-229 | 4,718 | TRUE | Passed | 500 | 4,719 | 30 | 32.7 | J-228 |
| J-230 | 2,898 | TRUE | Passed | 500 | 2,899 | 30 | 43.5 | J-51 |
| J-231 | 4,420 | TRUE | Passed | 500 | 4,421 | 30 | 31 | J-230 |
| J-232 | 4,919 | TRUE | Passed | 500 | 4,920 | 30 | 34.5 | J-231 |
| J-233 | 6,445 | TRUE | Passed | 500 | 6,446 | 30 | 27.4 | J-232 |
| J-234 | 9,683 | TRUE | Passed | 500 | 9,684 | 30 | 6 | J-689 |
| J-235 | 10,000 | TRUE | Passed | 500 | 10,001 | 41 | 18.5 | J-689 |
| J-236 | 2,265 | TRUE | Passed | 500 | 2,266 | 30 | 28.7 | J-237 |
| J-237 | 1,898 | TRUE | Passed | 500 | 1,899 | 30 | 38.8 | J-236 |
| J-238 | 1,081 | TRUE | Passed | 500 | 1,082 | 30 | 44.8 | J-51 |
| J-239 | 9,923 | TRUE | Passed | 500 | 9,924 | 30 | 28.9 | J-128 |
| J-240 | 9,656 | TRUE | Passed | 500 | 9,657 | 30 | 30 | J-128 |
| J-241 | 8,011 | TRUE | Passed | 500 | 8,012 | 30 | 35.1 | J-51 |
| J-242 | 7,799 | TRUE | Passed | 500 | 7,800 | 30 | 35.3 | J-51 |
| J-243 | 9,325 | TRUE | Passed | 500 | 9,326 | 30 | 33.7 | J-51 |
| J-244 | 5,195 | TRUE | Passed | 500 | 5,196 | 30 | 41 | J-51 |
| J-245 | 9,577 | TRUE | Passed | 500 | 9,578 | 30 | 34.5 | J-51 |
| J-246 | 8,855 | TRUE | Passed | 500 | 8,856 | 30 | 37.6 | J-51 |
| J-247 | 10,000 | TRUE | Passed | 500 | 10,001 | 40 | 35.2 | J-51 |
| J-248 | 7,091 | TRUE | Passed | 500 | 7,092 | 30 | 33.2 | J-318 |
| J-249 | 2,424 | TRUE | Passed | 500 | 2,425 | 30 | 29.1 | J-250 |
| J-250 | 1,326 | TRUE | Passed | 500 | 1,327 | 30 | 44.8 | J-51 |
| J-251 | 7,307 | TRUE | Passed | 500 | 7,308 | 30 | 37.6 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-252 | 7,252 | TRUE | Passed | 500 | 7,253 | 30 | 38.7 | J-51 |
| J-253 | 3,136 | TRUE | Passed | 500 | 3,137 | 30 | 43.7 | J-51 |
| J-254 | 7,778 | TRUE | Passed | 500 | 7,779 | 30 | 26.5 | J-324 |
| J-255 | 7,134 | TRUE | Passed | 500 | 7,135 | 30 | 36.1 | J-51 |
| J-256 | 4,152 | TRUE | Passed | 500 | 4,153 | 30 | 41.7 | J-51 |
| J-257 | 7,102 | TRUE | Passed | 500 | 7,103 | 30 | 36.4 | J-51 |
| J-258 | 7,063 | TRUE | Passed | 500 | 7,064 | 30 | 36.4 | J-51 |
| J-259 | 4,413 | TRUE | Passed | 500 | 4,414 | 30 | 41.3 | J-51 |
| J-260 | 6,261 | TRUE | Passed | 500 | 6,262 | 30 | 33.7 | J-731 |
| J-262 | 7,158 | TRUE | Passed | 500 | 7,159 | 30 | 35.6 | J-51 |
| J-263 | 4,227 | TRUE | Passed | 500 | 4,228 | 30 | 40 | J-266 |
| J-264 | 7,629 | TRUE | Passed | 500 | 7,630 | 30 | 34 | J-51 |
| J-265 | 3,968 | TRUE | Passed | 500 | 3,969 | 30 | 29.5 | J-266 |
| J-266 | 2,788 | TRUE | Passed | 500 | 2,789 | 30 | 43.3 | J-51 |
| J-267 | 6,047 | TRUE | Passed | 500 | 6,048 | 30 | 32.6 | J-268 |
| J-268 | 5,308 | TRUE | Passed | 500 | 5,309 | 30 | 32.4 | 4-FLOW |
| J-269 | 6,196 | TRUE | Passed | 500 | 6,197 | 30 | 31.8 | J-267 |
| J-270 | 7,532 | TRUE | Passed | 500 | 7,533 | 30 | 32.8 | J-272 |
| J-271 | 6,451 | TRUE | Passed | 500 | 6,452 | 30 | 35.2 | J-260 |
| J-272 | 6,446 | TRUE | Passed | 500 | 6,447 | 30 | 30.4 | J-276 |
| J-273 | 4,918 | TRUE | Passed | 500 | 4,919 | 30 | 30.1 | J-274 |
| J-274 | 4,540 | TRUE | Passed | 500 | 4,541 | 30 | 34.2 | J-273 |
| J-275 | 6,094 | TRUE | Passed | 500 | 6,095 | 30 | 32.3 | J-278 |
| J-276 | 5,881 | TRUE | Passed | 500 | 5,882 | 30 | 35.2 | J-275 |
| J-277 | 5,909 | TRUE | Passed | 500 | 5,910 | 30 | 28.3 | J-278 |
| J-278 | 4,295 | TRUE | Passed | 500 | 4,296 | 30 | 38.4 | J-283 |
| J-279 | 3,864 | TRUE | Passed | 500 | 3,865 | 30 | 34 | J-281 |
| J-280 | 1,439 | TRUE | Passed | 500 | 1,440 | 30 | 44.7 | J-51 |
| J-281 | 3,170 | TRUE | Passed | 500 | 3,171 | 30 | 32.8 | J-280 |
| J-282 | 3,018 | TRUE | Passed | 500 | 3,019 | 30 | 29.9 | J-283 |
| J-283 | 2,395 | TRUE | Passed | 500 | 2,396 | 30 | 30.2 | J-285 |
| J-284 | 1,381 | TRUE | Passed | 500 | 1,382 | 30 | 44.8 | J-51 |
| J-285 | 2,027 | TRUE | Passed | 500 | 2,028 | 30 | 37.7 | J-283 |
| J-286 | 4,282 | TRUE | Passed | 500 | 4,283 | 30 | 27.1 | J-292 |
| J-287 | 3,487 | TRUE | Passed | 500 | 3,488 | 30 | 27.4 | J-292 |
| J-288 | 2,044 | TRUE | Passed | 500 | 2,045 | 30 | 35.3 | J-290 |
| J-289 | 2,306 | TRUE | Passed | 500 | 2,307 | 30 | 29.1 | J-290 |
| J-290 | 2,123 | TRUE | Passed | 500 | 2,124 | 30 | 34.4 | J-289 |
| J-291 | 1,148 | TRUE | Passed | 500 | 1,149 | 30 | 44.9 | J-51 |
| J-292 | 2,488 | TRUE | Passed | 500 | 2,489 | 30 | 33.9 | 6-FLOW |
| J-294 | 1,385 | TRUE | Passed | 500 | 1,386 | 30 | 44.3 | 6-FLOW |
| J-296 | 6,057 | TRUE | Passed | 500 | 6,058 | 30 | 30.1 | J-292 |

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|---|---|---|---|---|---|---|---|---|
| J-297 | 6,212 | TRUE | Passed | 500 | 6,213 | 30 | 39.3 | J-292 |
| J-298 | 8,195 | TRUE | Passed | 500 | 8,196 | 30 | 36.1 | J-51 |
| J-299 | 9,128 | TRUE | Passed | 500 | 9,129 | 30 | 34.2 | J-51 |
| J-300 | 4,058 | TRUE | Passed | 500 | 4,059 | 30 | 29.9 | J-301 |
| J-301 | 3,275 | TRUE | Passed | 500 | 3,276 | 30 | 39.9 | J-300 |
| J-302 | 3,690 | TRUE | Passed | 500 | 3,691 | 30 | 30.6 | J-303 |
| J-303 | 3,039 | TRUE | Passed | 500 | 3,040 | 30 | 38.9 | J-302 |
| J-304 | 5,421 | TRUE | Passed | 500 | 5,422 | 30 | 36.1 | J-302 |
| J-305 | 5,640 | TRUE | Passed | 500 | 5,641 | 30 | 25.1 | J-306 |
| J-306 | 2,375 | TRUE | Passed | 500 | 2,376 | 30 | 44.1 | J-51 |
| J-307 | 7,596 | TRUE | Passed | 500 | 7,597 | 30 | 30 | J-306 |
| J-308 | 6,710 | TRUE | Passed | 500 | 6,711 | 30 | 39 | J-51 |
| J-309 | 3,578 | TRUE | Passed | 500 | 3,579 | 30 | 43 | J-51 |
| J-310 | 3,407 | TRUE | Passed | 500 | 3,408 | 30 | 43.1 | J-51 |
| J-311 | 3,874 | TRUE | Passed | 500 | 3,876 | 30 | 40.2 | J-309 |
| J-312 | 3,806 | TRUE | Passed | 500 | 3,807 | 30 | 42.7 | J-51 |
| J-313 | 4,303 | TRUE | Passed | 500 | 4,304 | 30 | 42.1 | J-51 |
| J-314 | 3,201 | TRUE | Passed | 500 | 3,202 | 30 | 43.3 | J-51 |
| J-315 | 2,585 | TRUE | Passed | 500 | 2,586 | 30 | 43.8 | J-51 |
| J-316 | 4,403 | TRUE | Passed | 500 | 4,404 | 30 | 41.7 | J-51 |
| J-317 | 3,261 | TRUE | Passed | 500 | 3,262 | 30 | 43.2 | J-51 |
| J-318 | 6,447 | TRUE | Passed | 500 | 6,448 | 30 | 34 | J-319 |
| J-319 | 6,156 | TRUE | Passed | 500 | 6,157 | 30 | 34.8 | J-321 |
| J-320 | 6,193 | TRUE | Passed | 500 | 6,194 | 30 | 34.3 | J-319 |
| J-321 | 3,227 | TRUE | Passed | 500 | 3,228 | 30 | 43.5 | J-51 |
| J-322 | 3,435 | TRUE | Passed | 500 | 3,436 | 30 | 41.7 | J-323 |
| J-323 | 3,034 | TRUE | Passed | 500 | 3,035 | 30 | 42.2 | J-250 |
| J-324 | 4,155 | TRUE | Passed | 500 | 4,156 | 30 | 41.8 | J-51 |
| J-325 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.4 | 28.5 | J-128 |
| J-326 | 10,000 | TRUE | Passed | 500 | 10,001 | 39 | 28.8 | J-128 |
| J-327 | 6,741 | TRUE | Passed | 500 | 6,742 | 30 | 37.9 | J-51 |
| J-328 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.8 | 28.9 | J-128 |
| J-329 | 9,858 | TRUE | Passed | 500 | 9,860 | 30 | 28.2 | J-128 |
| J-330 | 1,707 | TRUE | Passed | 500 | 1,708 | 30 | 44.5 | J-51 |
| J-331 | 5,824 | TRUE | Passed | 500 | 5,825 | 30 | 31.6 | J-330 |
| J-332 | 6,111 | TRUE | Passed | 500 | 6,112 | 30 | 39.2 | J-51 |
| J-333 | 4,438 | TRUE | Passed | 500 | 4,439 | 30 | 41.6 | J-51 |
| J-334 | 7,532 | TRUE | Passed | 500 | 7,533 | 30 | 33.3 | J-226 |
| J-336 | 6,426 | TRUE | Passed | 500 | 6,427 | 30 | 38 | J-51 |
| J-338 | 7,065 | TRUE | Passed | 500 | 7,066 | 30 | 35.8 | J-339 |
| J-339 | 6,105 | TRUE | Passed | 500 | 6,106 | 30 | 35.6 | J-215 |
| J-340 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.7 | 28.5 | J-128 |

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|---|---|---|---|---|---|---|---|---|
| J-341 | 7,296 | TRUE | Passed | 500 | 7,297 | 30 | 36 | J-306 |
| J-342 | 3,928 | TRUE | Passed | 500 | 3,929 | 30 | 42.6 | J-51 |
| J-343 | 6,997 | TRUE | Passed | 500 | 6,999 | 30 | 38.3 | J-51 |
| J-345 | 4,730 | TRUE | Passed | 500 | 4,731 | 30 | 41.7 | J-51 |
| J-346 | 3,554 | TRUE | Passed | 500 | 3,555 | 30 | 43 | J-51 |
| J-347 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.3 | 29.8 | J-128 |
| J-348 | 10,000 | TRUE | Passed | 500 | 10,001 | 48 | 30 | J-128 |
| J-349 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.1 | 30 | J-128 |
| J-350 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.2 | 30 | J-128 |
| J-351 | 8,243 | TRUE | Passed | 500 | 8,244 | 30 | 35.4 | J-128 |
| J-352 | 8,499 | TRUE | Passed | 500 | 8,500 | 30 | 34.6 | J-128 |
| J-353 | 9,043 | TRUE | Passed | 500 | 9,044 | 30 | 32.9 | J-128 |
| J-354 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.2 | 31 | J-128 |
| J-355 | 8,456 | TRUE | Passed | 500 | 8,457 | 30 | 35.5 | J-51 |
| J-356 | 7,948 | TRUE | Passed | 500 | 7,949 | 30 | 35.1 | J-365 |
| J-357 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.3 | 29.3 | J-128 |
| J-358 | 9,878 | TRUE | Passed | 500 | 9,879 | 30 | 31.7 | J-128 |
| J-359 | 9,628 | TRUE | Passed | 500 | 9,629 | 30 | 26.7 | J-360 |
| J-360 | 1,495 | TRUE | Passed | 500 | 1,496 | 30 | 44.7 | J-51 |
| J-361 | 8,126 | TRUE | Passed | 500 | 8,127 | 30 | 36.2 | J-51 |
| J-362 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.3 | 30.2 | J-128 |
| J-363 | 7,678 | TRUE | Passed | 500 | 7,679 | 30 | 37 | J-51 |
| J-364 | 6,847 | TRUE | Passed | 500 | 6,848 | 30 | 38.4 | J-366 |
| J-365 | 7,234 | TRUE | Passed | 500 | 7,235 | 30 | 37.7 | J-51 |
| J-366 | 6,709 | TRUE | Passed | 500 | 6,710 | 30 | 37.9 | J-364 |
| J-367 | 8,249 | TRUE | Passed | 500 | 8,250 | 30 | 35.6 | J-128 |
| J-368 | 5,711 | TRUE | Passed | 500 | 5,712 | 30 | 40.4 | J-51 |
| J-369 | 8,327 | TRUE | Passed | 500 | 8,328 | 30 | 36 | J-51 |
| J-370 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.8 | 30.9 | J-360 |
| J-371 | 2,088 | TRUE | Passed | 500 | 2,089 | 30 | 28.6 | J-128 |
| J-371 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.2 | 31.2 | J-128 |
| J-372 | 6,754 | TRUE | Passed | 500 | 6,755 | 30 | 38.7 | J-51 |
| J-373 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.8 | 30.4 | J-128 |
| J-374 | 10,000 | TRUE | Passed | 500 | 10,001 | 47 | 30.5 | J-128 |
| J-375 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.4 | 30.5 | J-128 |
| J-376 | 7,679 | TRUE | Passed | 500 | 7,680 | 30 | 37.2 | J-51 |
| J-377 | 10,000 | TRUE | Passed | 500 | 10,001 | 51 | 30.5 | J-128 |
| J-378 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.3 | 30.7 | J-128 |
| J-379 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.6 | 30.6 | J-128 |
| J-380 | 6,436 | TRUE | Passed | 500 | 6,437 | 30 | 39.4 | J-51 |
| J-382 | 6,944 | TRUE | Passed | 500 | 6,945 | 30 | 38.5 | J-51 |
| J-383 | 6,380 | TRUE | Passed | 500 | 6,381 | 30 | 39.5 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-384 | 6,657 | TRUE | Passed | 500 | 6,658 | 30 | 39.2 | J-51 |
| J-385 | 8,742 | TRUE | Passed | 500 | 8,743 | 30 | 35.2 | J-128 |
| J-386 | 9,417 | TRUE | Passed | 500 | 9,419 | 30 | 33 | J-128 |
| J-387 | 8,105 | TRUE | Passed | 500 | 8,106 | 30 | 35.6 | J-388 |
| J-388 | 6,105 | TRUE | Passed | 500 | 6,106 | 30 | 39.8 | J-51 |
| J-389 | 4,836 | TRUE | Passed | 500 | 4,837 | 30 | 33.8 | J-390 |
| J-390 | 1,826 | TRUE | Passed | 500 | 1,827 | 30 | 44.5 | J-51 |
| J-391 | 6,498 | TRUE | Passed | 500 | 6,499 | 30 | 39.2 | J-51 |
| J-392 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.1 | 30.7 | J-128 |
| J-393 | 7,325 | TRUE | Passed | 500 | 7,326 | 30 | 37.7 | J-430 |
| J-394 | 8,606 | TRUE | Passed | 500 | 8,607 | 30 | 28.4 | J-424 |
| J-395 | 8,783 | TRUE | Passed | 500 | 8,784 | 30 | 26.1 | J-425 |
| J-396 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.8 | 30.8 | J-128 |
| J-397 | 5,943 | TRUE | Passed | 500 | 5,944 | 30 | 27.8 | J-398 |
| J-398 | 1,617 | TRUE | Passed | 500 | 1,618 | 30 | 44.6 | J-51 |
| J-399 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.7 | 30 | J-128 |
| J-401 | 1,627 | TRUE | Passed | 500 | 1,628 | 30 | 28.4 | J-128 |
| J-401 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.4 | 32.2 | J-128 |
| J-402 | 10,000 | TRUE | Passed | 500 | 10,001 | 62 | 32.1 | J-128 |
| J-403 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.8 | 32.4 | J-128 |
| J-404 | 9,579 | TRUE | Passed | 500 | 9,580 | 30 | 36.3 | J-128 |
| J-405 | 4,492 | TRUE | Passed | 500 | 4,493 | 30 | 42.7 | J-51 |
| J-406 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.6 | 31.7 | J-128 |
| J-407 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.9 | 31.7 | J-128 |
| J-408 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.5 | 31 | J-128 |
| J-409 | 3,335 | TRUE | Passed | 500 | 3,336 | 30 | 43.4 | J-51 |
| J-410 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.9 | 31 | J-128 |
| J-411 | 3,403 | TRUE | Passed | 500 | 3,404 | 30 | 43.3 | J-51 |
| J-412 | 10,000 | TRUE | Passed | 500 | 10,001 | 55.5 | 31 | J-128 |
| J-413 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.6 | 30.4 | J-128 |
| J-414 | 10,000 | TRUE | Passed | 500 | 10,001 | 54.1 | 27.2 | J-128 |
| J-415 | 1,919 | TRUE | Passed | 500 | 1,920 | 30 | 44.4 | J-51 |
| J-416 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.3 | 30.5 | J-128 |
| J-417 | 10,000 | TRUE | Passed | 500 | 10,001 | 54.7 | 30.9 | J-128 |
| J-418 | 5,259 | TRUE | Passed | 500 | 5,260 | 30 | 29.9 | J-419 |
| J-419 | 3,344 | TRUE | Passed | 500 | 3,345 | 30 | 43.5 | J-51 |
| J-420 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.5 | 32 | J-421 |
| J-421 | 8,752 | TRUE | Passed | 500 | 8,753 | 30 | 31.8 | J-423 |
| J-422 | 6,428 | TRUE | Passed | 500 | 6,429 | 30 | 39.8 | J-51 |
| J-423 | 8,610 | TRUE | Passed | 500 | 8,611 | 30 | 32.7 | J-422 |
| J-424 | 4,523 | TRUE | Passed | 500 | 4,524 | 30 | 42.2 | J-51 |
| J-425 | 3,891 | TRUE | Passed | 500 | 3,892 | 30 | 42.8 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-426 | 8,928 | TRUE | Passed | 500 | 8,929 | 30 | 23.5 | J-425 |
| J-427 | 7,362 | TRUE | Passed | 500 | 7,363 | 30 | 34 | J-424 |
| J-428 | 8,701 | TRUE | Passed | 500 | 8,702 | 30 | 34.7 | J-423 |
| J-429 | 8,680 | TRUE | Passed | 500 | 8,681 | 30 | 34.7 | J-428 |
| J-430 | 3,746 | TRUE | Passed | 500 | 3,747 | 30 | 43 | J-51 |
| J-431 | 6,838 | TRUE | Passed | 500 | 6,839 | 30 | 30.9 | J-432 |
| J-432 | 2,184 | TRUE | Passed | 500 | 2,185 | 30 | 44.3 | J-51 |
| J-433 | 3,377 | TRUE | Passed | 500 | 3,378 | 30 | 30 | J-237 |
| J-434 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 45 | J-51 |
| J-435 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 45 | J-51 |
| J-436 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.7 | 44.8 | J-51 |
| J-437 | 8,324 | TRUE | Passed | 500 | 8,325 | 30 | 44.5 | J-51 |
| J-439 | 6,582 | TRUE | Passed | 500 | 6,583 | 30 | 31.7 | J-719 |
| J-440 | 6,473 | TRUE | Passed | 500 | 6,474 | 30 | 32.1 | J-1780 |
| J-442 | 7,526 | TRUE | Passed | 500 | 7,527 | 30 | 27.5 | J-443 |
| J-443 | 2,062 | TRUE | Passed | 500 | 2,063 | 30 | 45.1 | J-51 |
| J-445 | 8,710 | TRUE | Passed | 500 | 8,711 | 30 | 30.8 | J-455 |
| J-447 | 5,980 | TRUE | Passed | 500 | 5,981 | 30 | 27.1 | J-450 |
| J-448 | 4,774 | TRUE | Passed | 500 | 4,775 | 30 | 39.8 | J-450 |
| J-449 | 5,674 | TRUE | Passed | 500 | 5,675 | 30 | 23.5 | J-450 |
| J-450 | 3,875 | TRUE | Passed | 500 | 3,876 | 30 | 44.6 | J-51 |
| J-451 | 5,472 | TRUE | Passed | 500 | 5,473 | 30 | 35 | J-452 |
| J-452 | 4,984 | TRUE | Passed | 500 | 4,985 | 30 | 31.8 | J-458 |
| J-453 | 4,639 | TRUE | Passed | 500 | 4,640 | 30 | 39.8 | J-454 |
| J-454 | 4,465 | TRUE | Passed | 500 | 4,466 | 30 | 42.8 | J-453 |
| J-455 | 5,943 | TRUE | Passed | 500 | 5,944 | 30 | 38.1 | J-454 |
| J-456 | 5,994 | TRUE | Passed | 500 | 5,995 | 30 | 37.1 | J-455 |
| J-457 | 4,775 | TRUE | Passed | 500 | 4,776 | 30 | 39.9 | J-452 |
| J-458 | 2,780 | TRUE | Passed | 500 | 2,781 | 30 | 44.8 | J-51 |
| J-459 | 2,707 | TRUE | Passed | 500 | 2,708 | 30 | 33.4 | J-463 |
| J-460 | 3,717 | TRUE | Passed | 500 | 3,718 | 30 | 33.5 | J-459 |
| J-461 | 1,536 | TRUE | Passed | 500 | 1,537 | 30 | 29.4 | J-463 |
| J-462 | 1,351 | TRUE | Passed | 500 | 1,352 | 30 | 37.4 | J-463 |
| J-463 | 1,236 | TRUE | Passed | 500 | 1,237 | 30 | 42.5 | J-461 |
| J-464 | 4,836 | TRUE | Passed | 500 | 4,837 | 30 | 38.1 | J-457 |
| J-465 | 4,989 | TRUE | Passed | 500 | 4,990 | 30 | 36.4 | J-464 |
| J-466 | 5,282 | TRUE | Passed | 500 | 5,283 | 30 | 37.6 | J-465 |
| J-467 | 5,951 | TRUE | Passed | 500 | 5,952 | 30 | 29 | J-460 |
| J-468 | 5,878 | TRUE | Passed | 500 | 5,879 | 30 | 33.5 | J-459 |
| J-469 | 6,417 | TRUE | Passed | 500 | 6,418 | 30 | 35.4 | J-474 |
| J-470 | 7,639 | TRUE | Passed | 500 | 7,640 | 30 | 42 | J-51 |
| J-471 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.7 | 33.7 | J-556 |

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|---|---|---|---|---|---|---|---|---|
| J-472 | 6,516 | TRUE | Passed | 500 | 6,517 | 30 | 40.7 | J-473 |
| J-473 | 5,987 | TRUE | Passed | 500 | 5,988 | 30 | 36.6 | J-475 |
| J-474 | 5,582 | TRUE | Passed | 500 | 5,583 | 30 | 43.6 | J-51 |
| J-475 | 5,152 | TRUE | Passed | 500 | 5,153 | 30 | 40.9 | J-478 |
| J-476 | 2,202 | TRUE | Passed | 500 | 2,203 | 30 | 41.3 | J-477 |
| J-477 | 2,232 | TRUE | Passed | 500 | 2,233 | 30 | 39.1 | J-476 |
| J-478 | 5,108 | TRUE | Passed | 500 | 5,109 | 30 | 39.4 | J-475 |
| J-479 | 5,249 | TRUE | Passed | 500 | 5,250 | 30 | 39.6 | J-478 |
| J-480 | 5,574 | TRUE | Passed | 500 | 5,575 | 30 | 37.7 | J-479 |
| J-481 | 5,916 | TRUE | Passed | 500 | 5,917 | 30 | 35.7 | J-480 |
| J-482 | 3,080 | TRUE | Passed | 500 | 3,081 | 30 | 25.8 | J-485 |
| J-483 | 1,896 | TRUE | Passed | 500 | 1,897 | 30 | 28.8 | J-485 |
| J-484 | 1,743 | TRUE | Passed | 500 | 1,744 | 30 | 34.1 | J-485 |
| J-485 | 1,415 | TRUE | Passed | 500 | 1,416 | 30 | 45.1 | J-51 |
| J-486 | 8,877 | TRUE | Passed | 500 | 8,878 | 30 | 41.1 | 1-FLOW |
| J-487 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.4 | 43 | J-51 |
| J-489 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.8 | 44.2 | J-51 |
| J-490 | 10,000 | TRUE | Passed | 500 | 10,001 | 36 | 38.5 | J-437 |
| J-491 | 10,000 | TRUE | Passed | 500 | 10,001 | 63 | 45.1 | J-51 |
| J-492 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.3 | 43.4 | J-51 |
| J-493 | 9,463 | TRUE | Passed | 500 | 9,464 | 30 | 36.5 | J-494 |
| J-494 | 9,582 | TRUE | Passed | 500 | 9,583 | 30 | 35.2 | J-493 |
| J-497 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.6 | 41.2 | J-51 |
| J-498 | 10,000 | TRUE | Passed | 500 | 10,001 | 47 | 42.6 | J-51 |
| J-499 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.9 | 39 | J-500 |
| J-500 | 6,429 | TRUE | Passed | 500 | 6,430 | 30 | 44 | J-51 |
| J-501 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.6 | 37.8 | J-502 |
| J-502 | 4,732 | TRUE | Passed | 500 | 4,733 | 30 | 31.3 | J-726 |
| J-504 | 3,021 | TRUE | Passed | 500 | 3,022 | 30 | 40.4 | J-1334 |
| J-505 | 3,720 | TRUE | Passed | 500 | 3,721 | 30 | 42.3 | J-554 |
| J-507 | 4,120 | TRUE | Passed | 500 | 4,121 | 30 | 33 | J-508 |
| J-508 | 4,119 | TRUE | Passed | 500 | 4,120 | 30 | 34 | J-507 |
| J-509 | 4,841 | TRUE | Passed | 500 | 4,842 | 30 | 30.8 | J-508 |
| J-510 | 5,490 | TRUE | Passed | 500 | 5,491 | 30 | 32.6 | J-513 |
| J-511 | 2,209 | TRUE | Passed | 500 | 2,210 | 30 | 37.8 | J-513 |
| J-513 | 2,251 | TRUE | Passed | 500 | 2,252 | 30 | 37.5 | J-514 |
| J-514 | 2,543 | TRUE | Passed | 500 | 2,544 | 30 | 29.3 | J-513 |
| J-516 | 4,806 | TRUE | Passed | 500 | 4,807 | 30 | 38 | J-508 |
| J-517 | 5,252 | TRUE | Passed | 500 | 5,253 | 30 | 30.2 | J-549 |
| J-518 | 4,776 | TRUE | Passed | 500 | 4,777 | 30 | 26.2 | J-549 |
| J-519 | 5,128 | TRUE | Passed | 500 | 5,129 | 30 | 29.7 | J-508 |
| J-520 | 4,315 | TRUE | Passed | 500 | 4,316 | 30 | 32.5 | J-521 |

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|---|---|---|---|---|---|---|---|---|
| J-521 | 3,551 | TRUE | Passed | 500 | 3,552 | 30 | 37 | J-603 |
| J-522 | 3,726 | TRUE | Passed | 500 | 3,727 | 30 | 27.5 | J-603 |
| J-523 | 4,064 | TRUE | Passed | 500 | 4,065 | 30 | 27.8 | J-603 |
| J-524 | 3,922 | TRUE | Passed | 500 | 3,923 | 30 | 29.7 | J-521 |
| J-525 | 4,363 | TRUE | Passed | 500 | 4,364 | 30 | 31.4 | J-521 |
| J-526 | 4,205 | TRUE | Passed | 500 | 4,206 | 30 | 33.5 | J-521 |
| J-527 | 4,292 | TRUE | Passed | 500 | 4,293 | 30 | 32.6 | J-528 |
| J-528 | 3,969 | TRUE | Passed | 500 | 3,970 | 30 | 35.4 | J-610 |
| J-529 | 4,184 | TRUE | Passed | 500 | 4,185 | 30 | 36.9 | J-613 |
| J-530 | 4,207 | TRUE | Passed | 500 | 4,208 | 30 | 38.1 | J-596 |
| J-531 | 2,700 | TRUE | Passed | 500 | 2,701 | 30 | 44.4 | J-51 |
| J-532 | 2,909 | TRUE | Passed | 500 | 2,910 | 30 | 44.4 | J-51 |
| J-533 | 7,597 | TRUE | Passed | 500 | 7,598 | 30 | 31.8 | J-532 |
| J-534 | 8,448 | TRUE | Passed | 500 | 8,449 | 30 | 29.7 | J-535 |
| J-535 | 7,863 | TRUE | Passed | 500 | 7,864 | 30 | 30.9 | J-536 |
| J-536 | 7,094 | TRUE | Passed | 500 | 7,095 | 30 | 36.5 | J-535 |
| J-537 | 8,045 | TRUE | Passed | 500 | 8,046 | 30 | 35.6 | J-647 |
| J-538 | 8,537 | TRUE | Passed | 500 | 8,538 | 30 | 36.5 | J-648 |
| J-539 | 9,672 | TRUE | Passed | 500 | 9,673 | 30 | 31 | J-538 |
| J-540 | 2,906 | TRUE | Passed | 500 | 2,907 | 30 | 42.4 | J-648 |
| J-541 | 3,142 | TRUE | Passed | 500 | 3,143 | 30 | 44.3 | J-51 |
| J-542 | 6,256 | TRUE | Passed | 500 | 6,257 | 30 | 40.9 | J-644 |
| J-543 | 8,426 | TRUE | Passed | 500 | 8,427 | 30 | 34.9 | J-542 |
| J-544 | 9,438 | TRUE | Passed | 500 | 9,439 | 30 | 33.7 | J-546 |
| J-545 | 5,219 | TRUE | Passed | 500 | 5,220 | 30 | 29.6 | J-546 |
| J-546 | 2,020 | TRUE | Passed | 500 | 2,021 | 30 | 44.9 | J-51 |
| J-547 | 4,897 | TRUE | Passed | 500 | 4,898 | 30 | 30.7 | J-548 |
| J-548 | 1,754 | TRUE | Passed | 500 | 1,755 | 30 | 45 | J-51 |
| J-549 | 1,603 | TRUE | Passed | 500 | 1,604 | 30 | 45 | J-51 |
| J-550 | 4,232 | TRUE | Passed | 500 | 4,233 | 30 | 29.7 | J-552 |
| J-551 | 2,824 | TRUE | Passed | 500 | 2,825 | 30 | 44.7 | J-51 |
| J-552 | 2,276 | TRUE | Passed | 500 | 2,277 | 30 | 44.9 | J-51 |
| J-553 | 3,756 | TRUE | Passed | 500 | 3,757 | 30 | 29.9 | J-554 |
| J-554 | 2,452 | TRUE | Passed | 500 | 2,453 | 30 | 45 | J-51 |
| J-555 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.6 | 32.2 | J-556 |
| J-556 | 3,860 | TRUE | Passed | 500 | 3,861 | 30 | 44.2 | J-51 |
| J-557 | 3,423 | TRUE | Passed | 500 | 3,424 | 30 | 30.9 | J-558 |
| J-558 | 1,746 | TRUE | Passed | 500 | 1,748 | 30 | 44.9 | J-51 |
| J-559 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.1 | 36.8 | J-557 |
| J-560 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.9 | 41 | J-51 |
| J-561 | 3,550 | TRUE | Passed | 500 | 3,551 | 30 | 44.2 | J-51 |
| J-562 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.6 | 34.4 | J-556 |

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|---|---|---|---|---|---|---|---|---|
| J-563 | 2,727 | TRUE | Passed | 500 | 2,728 | 30 | 44.5 | J-51 |
| J-564 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.7 | 33.8 | J-563 |
| J-565 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.6 | 37.4 | J-556 |
| J-566 | 7,719 | TRUE | Passed | 500 | 7,720 | 30 | 41 | J-51 |
| J-567 | 9,586 | TRUE | Passed | 500 | 9,587 | 30 | 36.4 | J-578 |
| J-568 | 8,476 | TRUE | Passed | 500 | 8,477 | 30 | 37.1 | J-574 |
| J-569 | 7,048 | TRUE | Passed | 500 | 7,049 | 30 | 37.8 | J-570 |
| J-570 | 6,433 | TRUE | Passed | 500 | 6,434 | 30 | 41.8 | J-51 |
| J-571 | 6,828 | TRUE | Passed | 500 | 6,829 | 30 | 38.9 | J-574 |
| J-572 | 8,236 | TRUE | Passed | 500 | 8,237 | 30 | 19.6 | J-574 |
| J-573 | 4,625 | TRUE | Passed | 500 | 4,626 | 30 | 43.1 | J-51 |
| J-574 | 7,280 | TRUE | Passed | 500 | 7,281 | 30 | 33 | J-571 |
| J-576 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.3 | 34.5 | J-568 |
| J-577 | 10,000 | TRUE | Passed | 500 | 10,001 | 31 | 33.6 | J-578 |
| J-578 | 3,040 | TRUE | Passed | 500 | 3,041 | 30 | 44.2 | J-51 |
| J-579 | 4,041 | TRUE | Passed | 500 | 4,042 | 30 | 43.7 | J-51 |
| J-580 | 4,120 | TRUE | Passed | 500 | 4,121 | 30 | 43.7 | J-51 |
| J-581 | 3,895 | TRUE | Passed | 500 | 3,896 | 30 | 43.7 | J-51 |
| J-582 | 6,090 | TRUE | Passed | 500 | 6,091 | 30 | 38.8 | J-581 |
| J-583 | 6,586 | TRUE | Passed | 500 | 6,587 | 30 | 41.3 | J-51 |
| J-584 | 7,397 | TRUE | Passed | 500 | 7,398 | 30 | 36.4 | J-585 |
| J-585 | 5,725 | TRUE | Passed | 500 | 5,726 | 30 | 38.2 | J-587 |
| J-587 | 5,319 | TRUE | Passed | 500 | 5,320 | 30 | 37.8 | J-588 |
| J-588 | 4,970 | TRUE | Passed | 500 | 4,971 | 30 | 42.6 | J-587 |
| J-589 | 5,140 | TRUE | Passed | 500 | 5,141 | 30 | 38.3 | J-588 |
| J-590 | 6,506 | TRUE | Passed | 500 | 6,508 | 30 | 28.6 | J-591 |
| J-591 | 5,967 | TRUE | Passed | 500 | 5,968 | 30 | 35.8 | J-590 |
| J-592 | 5,697 | TRUE | Passed | 500 | 5,698 | 30 | 35.5 | J-596 |
| J-593 | 4,202 | TRUE | Passed | 500 | 4,203 | 30 | 35.8 | J-596 |
| J-594 | 4,097 | TRUE | Passed | 500 | 4,098 | 30 | 26 | J-596 |
| J-595 | 3,330 | TRUE | Passed | 500 | 3,331 | 30 | 27 | J-596 |
| J-596 | 2,795 | TRUE | Passed | 500 | 2,796 | 30 | 34.9 | J-597 |
| J-597 | 2,906 | TRUE | Passed | 500 | 2,907 | 30 | 31.3 | J-596 |
| J-598 | 2,990 | TRUE | Passed | 500 | 2,991 | 30 | 31.9 | J-597 |
| J-599 | 3,177 | TRUE | Passed | 500 | 3,178 | 30 | 31.2 | J-1549 |
| J-601 | 2,801 | TRUE | Passed | 500 | 2,802 | 30 | 34.4 | J-1549 |
| J-602 | 4,018 | TRUE | Passed | 500 | 4,019 | 30 | 31.7 | J-1549 |
| J-603 | 2,135 | TRUE | Passed | 500 | 2,136 | 30 | 44.7 | J-51 |
| J-604 | 4,030 | TRUE | Passed | 500 | 4,031 | 30 | 30.2 | J-596 |
| J-605 | 2,972 | TRUE | Passed | 500 | 2,973 | 30 | 30.8 | J-596 |
| J-606 | 3,075 | TRUE | Passed | 500 | 3,076 | 30 | 29.5 | J-596 |
| J-607 | 3,882 | TRUE | Passed | 500 | 3,883 | 30 | 31 | J-596 |

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|---|---|---|---|---|---|---|---|---|
| J-608 | 4,008 | TRUE | Passed | 500 | 4,009 | 30 | 31.1 | J-596 |
| J-609 | 4,075 | TRUE | Passed | 500 | 4,076 | 30 | 31.1 | J-596 |
| J-610 | 3,979 | TRUE | Passed | 500 | 3,980 | 30 | 34 | J-596 |
| J-611 | 4,281 | TRUE | Passed | 500 | 4,282 | 30 | 28.4 | J-596 |
| J-612 | 3,781 | TRUE | Passed | 500 | 3,782 | 30 | 35.6 | J-596 |
| J-613 | 3,905 | TRUE | Passed | 500 | 3,906 | 30 | 38.5 | J-596 |
| J-614 | 5,888 | TRUE | Passed | 500 | 5,889 | 30 | 34.2 | J-596 |
| J-615 | 6,167 | TRUE | Passed | 500 | 6,168 | 30 | 30.4 | J-614 |
| J-616 | 6,301 | TRUE | Passed | 500 | 6,302 | 30 | 32.2 | J-615 |
| J-617 | 6,222 | TRUE | Passed | 500 | 6,223 | 30 | 40.3 | 3-FLOW |
| J-620 | 7,153 | TRUE | Passed | 500 | 7,154 | 30 | 28.7 | J-617 |
| J-621 | 8,706 | TRUE | Passed | 500 | 8,707 | 30 | 28.7 | J-617 |
| J-622 | 8,319 | TRUE | Passed | 500 | 8,320 | 30 | 32.9 | J-626 |
| J-623 | 8,555 | TRUE | Passed | 500 | 8,556 | 30 | 34 | J-617 |
| J-625 | 9,435 | TRUE | Passed | 500 | 9,437 | 30 | 28 | J-617 |
| J-626 | 8,133 | TRUE | Passed | 500 | 8,134 | 30 | 33.1 | J-627 |
| J-627 | 8,049 | TRUE | Passed | 500 | 8,050 | 30 | 34.7 | J-628 |
| J-628 | 8,236 | TRUE | Passed | 500 | 8,237 | 30 | 33.4 | J-627 |
| J-629 | 8,712 | TRUE | Passed | 500 | 8,714 | 30 | 31.3 | J-628 |
| J-630 | 8,909 | TRUE | Passed | 500 | 8,910 | 30 | 32 | J-629 |
| J-631 | 8,920 | TRUE | Passed | 500 | 8,921 | 30 | 36 | J-630 |
| J-632 | 4,856 | TRUE | Passed | 500 | 4,857 | 30 | 30 | J-633 |
| J-633 | 2,921 | TRUE | Passed | 500 | 2,922 | 30 | 44.1 | J-51 |
| J-634 | 7,471 | TRUE | Passed | 500 | 7,472 | 30 | 30.1 | J-633 |
| J-636 | 9,506 | TRUE | Passed | 500 | 9,507 | 30 | 33.3 | J-631 |
| J-637 | 3,559 | TRUE | Passed | 500 | 3,560 | 30 | 43.8 | J-51 |
| J-638 | 9,900 | TRUE | Passed | 500 | 9,901 | 30 | 33.3 | J-539 |
| J-639 | 10,000 | TRUE | Passed | 500 | 10,001 | 34 | 36.5 | J-640 |
| J-640 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.2 | 35.4 | J-641 |
| J-641 | 5,189 | TRUE | Passed | 500 | 5,190 | 30 | 42.7 | J-51 |
| J-642 | 3,794 | TRUE | Passed | 500 | 3,795 | 30 | 43.8 | J-51 |
| J-643 | 2,909 | TRUE | Passed | 500 | 2,910 | 30 | 44.4 | J-51 |
| J-644 | 4,989 | TRUE | Passed | 500 | 4,990 | 30 | 37.3 | J-645 |
| J-645 | 2,530 | TRUE | Passed | 500 | 2,531 | 30 | 44.6 | J-51 |
| J-646 | 6,886 | TRUE | Passed | 500 | 6,887 | 30 | 38.8 | J-648 |
| J-647 | 4,521 | TRUE | Passed | 500 | 4,522 | 30 | 43.4 | J-51 |
| J-648 | 2,754 | TRUE | Passed | 500 | 2,755 | 30 | 44.4 | J-51 |
| J-649 | 3,472 | TRUE | Passed | 500 | 3,473 | 30 | 29.8 | J-650 |
| J-650 | 1,755 | TRUE | Passed | 500 | 1,756 | 30 | 44.8 | J-51 |
| J-651 | 7,336 | TRUE | Passed | 500 | 7,337 | 30 | 29.4 | J-652 |
| J-652 | 2,864 | TRUE | Passed | 500 | 2,865 | 30 | 44.4 | J-51 |
| J-655 | 6,844 | TRUE | Passed | 500 | 6,846 | 30 | 31.6 | J-656 |

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|---|---|---|---|---|---|---|---|---|
| J-656 | 3,347 | TRUE | Passed | 500 | 3,348 | 30 | 44.1 | J-51 |
| J-657 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.1 | 35.6 | J-128 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.5 | 31.7 | J-568 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.6 | 35.6 | J-128 |
| J-660 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.9 | 35.4 | J-128 |
| J-661 | 798 | TRUE | Passed | 500 | 803 | 30 | 45.1 | J-51 |
| J-662 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.5 | 34.2 | J-128 |
| J-663 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.6 | 35.1 | J-128 |
| J-664 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.5 | 36.5 | J-128 |
| J-665 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.9 | 36.8 | J-639 |
| J-666 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.9 | 38.2 | J-51 |
| J-667 | 9,277 | TRUE | Passed | 500 | 9,278 | 30 | 34.4 | J-51 |
| J-668 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.6 | 40.3 | J-51 |
| J-669 | 4,031 | TRUE | Passed | 500 | 4,032 | 30 | 40.7 | J-21 |
| J-670 | 4,582 | TRUE | Passed | 500 | 4,583 | 30 | 33.8 | J-21 |
| J-673 | 10,000 | TRUE | Passed | 500 | 10,001 | 37 | 36.3 | J-128 |
| J-674 | 4,065 | TRUE | Passed | 500 | 4,066 | 30 | 43.4 | J-51 |
| J-675 | 3,792 | TRUE | Passed | 500 | 3,793 | 30 | 43 | J-51 |
| J-676 | 5,325 | TRUE | Passed | 500 | 5,326 | 30 | 31 | J-675 |
| J-677 | 2,321 | TRUE | Passed | 500 | 2,322 | 30 | 29.3 | J-678 |
| J-678 | 1,734 | TRUE | Passed | 500 | 1,735 | 30 | 44.6 | J-51 |
| J-680 | 2,920 | TRUE | Passed | 500 | 2,920 | 30 | 24.2 | J-128 |
| J-682 | 2,567 | TRUE | Passed | 500 | 2,567 | 30 | 24.8 | J-128 |
| J-689 | 2,303 | TRUE | Passed | 500 | 2,328 | 30 | 44.1 | J-51 |
| J-696 | 2,670 | TRUE | Passed | 500 | 2,675 | 30 | 29.2 | J-51 |
| J-697 | 2,598 | TRUE | Passed | 500 | 2,598 | 30 | 22.5 | J-128 |
| J-719 | 4,427 | TRUE | Passed | 500 | 4,427 | 30 | 39.7 | J-724 |
| J-724 | 4,265 | TRUE | Passed | 500 | 4,265 | 30 | 34.1 | J-1780 |
| J-726 | 3,959 | TRUE | Passed | 500 | 3,959 | 30 | 31.6 | J-504 |
| J-727 | 7,584 | TRUE | Passed | 500 | 7,584 | 30 | 44.7 | J-51 |
| J-731 | 5,506 | TRUE | Passed | 500 | 5,507 | 30 | 39.3 | J-51 |
| J-904 | 6,508 | TRUE | Passed | 500 | 6,509 | 30 | 37.9 | J-51 |
| J-1031 | 8,911 | TRUE | Passed | 500 | 8,912 | 30 | 34.5 | J-128 |
| J-1082 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.5 | 33.8 | J-128 |
| J-1184 | 9,001 | TRUE | Passed | 500 | 9,002 | 30 | 37.6 | J-439 |
| J-1201 | 7,844 | TRUE | Passed | 500 | 7,845 | 30 | 26.1 | J-455 |
| J-1296 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.5 | 43.3 | J-51 |
| J-1334 | 3,683 | TRUE | Passed | 500 | 3,684 | 30 | 29.9 | J-504 |
| J-1340 | 3,788 | TRUE | Passed | 500 | 3,789 | 30 | 39.4 | J-508 |
| J-1549 | 2,827 | TRUE | Passed | 500 | 2,828 | 30 | 35.3 | J-601 |
| J-1642 | 8,335 | TRUE | Passed | 500 | 8,336 | 30 | 39.2 | J-51 |
| J-1704 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.4 | 34.7 | J-568 |

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|---|---|---|---|---|---|---|---|---|
| J-1780 | 4,346 | TRUE | Passed | 500 | 4,346 | 30 | 32.4 | J-724 |
| J-1806 | 2,252 | TRUE | Passed | 500 | 2,252 | 30 | 32.6 | J-128 |
| **Scenario 1: Hillcrest Water Main Pipe Upsizing** | | | | | | | | |
| 1-FLOW | 8,628 | TRUE | Passed | 500 | 8,629 | 30 | 30.8 | 1-RES |
| 1-RES | 3,068 | TRUE | Passed | 500 | 3,071 | 30 | 44.7 | J-51 |
| 2-FLOW | 7,372 | TRUE | Passed | 500 | 7,373 | 30 | 30 | 2-RES |
| 2-RES | 4,072 | TRUE | Passed | 500 | 4,073 | 30 | 44.7 | J-51 |
| 3-FLOW | 2,802 | TRUE | Passed | 500 | 2,803 | 30 | 30.9 | 3-RES |
| 3-RES | 2,395 | TRUE | Passed | 500 | 2,396 | 30 | 39.7 | 3-FLOW |
| 4-FLOW | 3,288 | TRUE | Passed | 500 | 3,289 | 30 | 30.7 | 4-RES |
| 4-RES | 2,386 | TRUE | Passed | 500 | 2,387 | 30 | 42.5 | 4-FLOW |
| 5-FLOW | 2,741 | TRUE | Passed | 500 | 2,742 | 30 | 27.7 | J-51 |
| 5-RES | 1,670 | TRUE | Passed | 500 | 1,671 | 30 | 38 | J-51 |
| 6-FLOW | 1,955 | TRUE | Passed | 500 | 1,956 | 30 | 30.8 | 6-RES |
| 6-RES | 1,272 | TRUE | Passed | 500 | 1,273 | 30 | 44.8 | J-51 |
| 7-FLOW | 2,116 | TRUE | Passed | 500 | 2,117 | 30 | 29.1 | J-196 |
| 7-RES | 1,899 | TRUE | Passed | 500 | 1,900 | 30 | 34.4 | J-196 |
| J-1 | 5,017 | TRUE | Passed | 500 | 5,018 | 30 | 35.1 | J-94 |
| J-2 | 7,002 | TRUE | Passed | 500 | 7,003 | 30 | 33.3 | J-95 |
| J-3 | 7,676 | TRUE | Passed | 500 | 7,677 | 30 | 35.1 | J-51 |
| J-11 | 8,121 | TRUE | Passed | 500 | 8,123 | 30 | 30.4 | J-51 |
| J-12 | 7,813 | TRUE | Passed | 500 | 7,814 | 30 | 30.5 | J-51 |
| J-13 | 4,503 | TRUE | Passed | 500 | 4,504 | 30 | 34.6 | J-51 |
| J-14 | 3,690 | TRUE | Passed | 500 | 3,691 | 30 | 40.7 | J-51 |
| J-15 | 7,257 | TRUE | Passed | 500 | 7,258 | 30 | 32.4 | J-14 |
| J-17 | 5,485 | TRUE | Passed | 500 | 5,486 | 30 | 28.1 | J-51 |
| J-18 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.5 | 42.3 | J-51 |
| J-19 | 9,085 | TRUE | Passed | 500 | 9,086 | 30 | 29.4 | J-51 |
| J-20 | 4,038 | TRUE | Passed | 500 | 4,039 | 30 | 33.6 | J-23 |
| J-21 | 4,134 | TRUE | Passed | 500 | 4,135 | 30 | 35.6 | J-20 |
| J-22 | 1,995 | TRUE | Passed | 500 | 1,996 | 30 | 43.9 | J-51 |
| J-23 | 3,660 | TRUE | Passed | 500 | 3,661 | 30 | 30.2 | J-22 |
| J-24 | 1,861 | TRUE | Passed | 500 | 1,862 | 30 | 44 | J-51 |
| J-25 | 3,236 | TRUE | Passed | 500 | 3,237 | 30 | 30.1 | J-24 |
| J-26 | 1,804 | TRUE | Passed | 500 | 1,805 | 30 | 43.9 | J-51 |
| J-27 | 3,352 | TRUE | Passed | 500 | 3,353 | 30 | 29.2 | J-26 |
| J-28 | 2,085 | TRUE | Passed | 500 | 2,086 | 30 | 43.4 | J-51 |
| J-29 | 3,652 | TRUE | Passed | 500 | 3,653 | 30 | 29.5 | J-28 |
| J-30 | 6,160 | TRUE | Passed | 500 | 6,161 | 30 | 29.6 | J-51 |
| J-31 | 2,457 | TRUE | Passed | 500 | 2,458 | 30 | 33.5 | J-33 |
| J-33 | 2,659 | TRUE | Passed | 500 | 2,660 | 30 | 31 | J-31 |
| J-34 | 2,567 | TRUE | Passed | 500 | 2,569 | 30 | 37.1 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-35 | 3,127 | TRUE | Passed | 500 | 3,128 | 30 | 28.5 | J-34 |
| J-36 | 4,031 | TRUE | Passed | 500 | 4,032 | 30 | 27 | J-51 |
| J-37 | 4,549 | TRUE | Passed | 500 | 4,550 | 30 | 26.2 | J-51 |
| J-38 | 3,970 | TRUE | Passed | 500 | 3,972 | 30 | 25.9 | J-51 |
| J-39 | 3,815 | TRUE | Passed | 500 | 3,816 | 30 | 30.1 | J-51 |
| J-40 | 3,748 | TRUE | Passed | 500 | 3,749 | 30 | 30.3 | J-51 |
| J-41 | 4,052 | TRUE | Passed | 500 | 4,053 | 30 | 24.6 | J-51 |
| J-42 | 2,590 | TRUE | Passed | 500 | 2,591 | 30 | 32.1 | J-51 |
| J-43 | 3,264 | TRUE | Passed | 500 | 3,265 | 30 | 25.3 | J-51 |
| J-44 | 1,939 | TRUE | Passed | 500 | 1,940 | 30 | 37.4 | J-51 |
| J-45 | 2,053 | TRUE | Passed | 500 | 2,054 | 30 | 35.7 | J-46 |
| J-46 | 2,496 | TRUE | Passed | 500 | 2,497 | 30 | 30.3 | J-45 |
| J-47 | 1,774 | TRUE | Passed | 500 | 1,775 | 30 | 38 | J-48 |
| J-48 | 2,292 | TRUE | Passed | 500 | 2,293 | 30 | 27.2 | J-47 |
| J-49 | 2,671 | TRUE | Passed | 500 | 2,672 | 30 | 30.5 | J-50 |
| J-50 | 2,162 | TRUE | Passed | 500 | 2,163 | 30 | 36.5 | J-51 |
| J-51 | 927 | TRUE | Passed | 500 | 928 | 30 | 43.2 | J-55 |
| J-52 | 2,102 | TRUE | Passed | 500 | 2,103 | 30 | 26.6 | J-51 |
| J-53 | 1,808 | TRUE | Passed | 500 | 1,809 | 30 | 32 | J-54 |
| J-54 | 1,931 | TRUE | Passed | 500 | 1,932 | 30 | 29.5 | J-53 |
| J-55 | 1,611 | TRUE | Passed | 500 | 1,612 | 30 | 34 | J-56 |
| J-56 | 1,855 | TRUE | Passed | 500 | 1,856 | 30 | 28.7 | J-55 |
| J-57 | 1,793 | TRUE | Passed | 500 | 1,794 | 30 | 37.3 | J-51 |
| J-58 | 1,979 | TRUE | Passed | 500 | 1,980 | 30 | 31.3 | J-55 |
| J-59 | 2,183 | TRUE | Passed | 500 | 2,184 | 30 | 28.4 | J-55 |
| J-60 | 2,026 | TRUE | Passed | 500 | 2,027 | 30 | 28.6 | J-55 |
| J-61 | 2,862 | TRUE | Passed | 500 | 2,863 | 30 | 26.7 | J-51 |
| J-64 | 2,739 | TRUE | Passed | 500 | 2,740 | 30 | 26.6 | J-51 |
| J-65 | 2,860 | TRUE | Passed | 500 | 2,861 | 30 | 27.5 | J-51 |
| J-66 | 3,662 | TRUE | Passed | 500 | 3,663 | 30 | 23.5 | J-51 |
| J-67 | 3,207 | TRUE | Passed | 500 | 3,208 | 30 | 28.1 | J-51 |
| J-68 | 3,483 | TRUE | Passed | 500 | 3,484 | 30 | 25.6 | J-51 |
| J-69 | 2,214 | TRUE | Passed | 500 | 2,215 | 30 | 36.9 | J-51 |
| J-70 | 2,965 | TRUE | Passed | 500 | 2,966 | 30 | 31.2 | J-51 |
| J-71 | 2,687 | TRUE | Passed | 500 | 2,688 | 30 | 30.9 | J-72 |
| J-72 | 2,621 | TRUE | Passed | 500 | 2,622 | 30 | 33.5 | J-71 |
| J-73 | 1,105 | TRUE | Passed | 500 | 1,106 | 30 | 43 | J-51 |
| J-74 | 2,550 | TRUE | Passed | 500 | 2,551 | 30 | 31.1 | J-73 |
| J-75 | 3,779 | TRUE | Passed | 500 | 3,780 | 30 | 25.8 | J-74 |
| J-76 | 3,521 | TRUE | Passed | 500 | 3,522 | 30 | 27.1 | J-51 |
| J-77 | 3,254 | TRUE | Passed | 500 | 3,255 | 30 | 27.7 | J-51 |
| J-78 | 4,042 | TRUE | Passed | 500 | 4,043 | 30 | 23.5 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-79 | 3,328 | TRUE | Passed | 500 | 3,329 | 30 | 30 | J-51 |
| J-80 | 3,641 | TRUE | Passed | 500 | 3,642 | 30 | 28.1 | J-51 |
| J-81 | 3,786 | TRUE | Passed | 500 | 3,787 | 30 | 24.3 | J-51 |
| J-82 | 4,641 | TRUE | Passed | 500 | 4,642 | 30 | 22.3 | J-51 |
| J-83 | 4,700 | TRUE | Passed | 500 | 4,701 | 30 | 22.1 | J-51 |
| J-84 | 4,686 | TRUE | Passed | 500 | 4,687 | 30 | 21.9 | J-51 |
| J-85 | 4,259 | TRUE | Passed | 500 | 4,260 | 30 | 23.6 | J-51 |
| J-86 | 4,041 | TRUE | Passed | 500 | 4,042 | 30 | 25 | J-51 |
| J-87 | 3,727 | TRUE | Passed | 500 | 3,728 | 30 | 29.1 | J-51 |
| J-88 | 3,308 | TRUE | Passed | 500 | 3,309 | 30 | 31.7 | J-51 |
| J-89 | 3,898 | TRUE | Passed | 500 | 3,899 | 30 | 25.6 | J-51 |
| J-90 | 3,121 | TRUE | Passed | 500 | 3,122 | 30 | 29.3 | J-91 |
| J-91 | 1,602 | TRUE | Passed | 500 | 1,603 | 30 | 41.2 | J-51 |
| J-92 | 5,508 | TRUE | Passed | 500 | 5,509 | 30 | 30.5 | J-94 |
| J-93 | 3,687 | TRUE | Passed | 500 | 3,688 | 30 | 24.3 | J-51 |
| J-94 | 5,496 | TRUE | Passed | 500 | 5,497 | 30 | 30.4 | J-92 |
| J-95 | 6,560 | TRUE | Passed | 500 | 6,561 | 30 | 31.3 | J-210 |
| J-96 | 5,483 | TRUE | Passed | 500 | 5,485 | 30 | 31.6 | J-209 |
| J-97 | 5,549 | TRUE | Passed | 500 | 5,550 | 30 | 30.4 | J-92 |
| J-98 | 5,713 | TRUE | Passed | 500 | 5,714 | 30 | 30.3 | J-97 |
| J-99 | 2,904 | TRUE | Passed | 500 | 2,905 | 30 | 35.3 | J-128 |
| J-100 | 3,750 | TRUE | Passed | 500 | 3,751 | 30 | 27.2 | J-128 |
| J-101 | 2,672 | TRUE | Passed | 500 | 2,673 | 30 | 36.5 | J-128 |
| J-102 | 3,789 | TRUE | Passed | 500 | 3,790 | 30 | 25.5 | J-128 |
| J-103 | 3,240 | TRUE | Passed | 500 | 3,241 | 30 | 23 | J-128 |
| J-104 | 2,954 | TRUE | Passed | 500 | 2,955 | 30 | 26.6 | J-128 |
| J-105 | 3,051 | TRUE | Passed | 500 | 3,052 | 30 | 24.6 | J-128 |
| J-106 | 2,921 | TRUE | Passed | 500 | 2,922 | 30 | 26.4 | J-128 |
| J-107 | 3,079 | TRUE | Passed | 500 | 3,080 | 30 | 24.9 | J-128 |
| J-108 | 2,998 | TRUE | Passed | 500 | 2,999 | 30 | 25.1 | J-128 |
| J-109 | 3,077 | TRUE | Passed | 500 | 3,078 | 30 | 24 | J-128 |
| J-110 | 3,069 | TRUE | Passed | 500 | 3,070 | 30 | 25.3 | J-128 |
| J-111 | 2,820 | TRUE | Passed | 500 | 2,821 | 30 | 28.9 | J-128 |
| J-112 | 2,584 | TRUE | Passed | 500 | 2,585 | 30 | 32.3 | J-128 |
| J-113 | 2,317 | TRUE | Passed | 500 | 2,318 | 30 | 34.9 | J-128 |
| J-114 | 2,213 | TRUE | Passed | 500 | 2,214 | 30 | 34.4 | J-128 |
| J-115 | 2,485 | TRUE | Passed | 500 | 2,486 | 30 | 31.1 | J-128 |
| J-116 | 2,086 | TRUE | Passed | 500 | 2,087 | 30 | 34.6 | J-117 |
| J-117 | 2,314 | TRUE | Passed | 500 | 2,315 | 30 | 31.5 | J-116 |
| J-118 | 1,867 | TRUE | Passed | 500 | 1,868 | 30 | 40.6 | J-51 |
| J-118 | 2,111 | TRUE | Passed | 500 | 2,112 | 30 | 33.5 | J-128 |
| J-119 | 2,334 | TRUE | Passed | 500 | 2,335 | 30 | 30.3 | J-118 |

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|---|---|---|---|---|---|---|---|---|
| J-121 | 1,803 | TRUE | Passed | 500 | 1,804 | 30 | 34.9 | J-128 |
| J-122 | 2,090 | TRUE | Passed | 500 | 2,091 | 30 | 30.5 | J-128 |
| J-124 | 1,922 | TRUE | Passed | 500 | 1,923 | 30 | 29.2 | J-128 |
| J-125 | 1,503 | TRUE | Passed | 500 | 1,504 | 30 | 29.5 | J-180 |
| J-126 | 1,847 | TRUE | Passed | 500 | 1,848 | 30 | 29.3 | J-128 |
| J-127 | 1,689 | TRUE | Passed | 500 | 1,690 | 30 | 28.6 | J-128 |
| J-128 | 994 | TRUE | Passed | 500 | 995 | 30 | 42.9 | J-129 |
| J-129 | 1,667 | TRUE | Passed | 500 | 1,668 | 30 | 27.9 | J-128 |
| J-130 | 1,758 | TRUE | Passed | 500 | 1,759 | 30 | 29.9 | J-128 |
| J-133 | 1,907 | TRUE | Passed | 500 | 1,908 | 30 | 29.5 | J-128 |
| J-134 | 1,737 | TRUE | Passed | 500 | 1,738 | 30 | 32.8 | J-135 |
| J-135 | 1,869 | TRUE | Passed | 500 | 1,870 | 30 | 29 | J-134 |
| J-136 | 2,124 | TRUE | Passed | 500 | 2,125 | 30 | 26.6 | J-134 |
| J-137 | 2,229 | TRUE | Passed | 500 | 2,230 | 30 | 26.1 | J-128 |
| J-138 | 2,427 | TRUE | Passed | 500 | 2,428 | 30 | 24.2 | J-134 |
| J-139 | 2,882 | TRUE | Passed | 500 | 2,883 | 30 | 31.5 | J-128 |
| J-140 | 2,399 | TRUE | Passed | 500 | 2,400 | 30 | 32.8 | J-141 |
| J-141 | 2,544 | TRUE | Passed | 500 | 2,545 | 30 | 30.5 | J-140 |
| J-142 | 3,127 | TRUE | Passed | 500 | 3,128 | 30 | 24.6 | J-128 |
| J-143 | 3,360 | TRUE | Passed | 500 | 3,361 | 30 | 21 | J-128 |
| J-144 | 3,111 | TRUE | Passed | 500 | 3,112 | 30 | 22.5 | J-128 |
| J-145 | 2,518 | TRUE | Passed | 500 | 2,519 | 30 | 30.9 | J-128 |
| J-146 | 3,228 | TRUE | Passed | 500 | 3,229 | 30 | 21.6 | J-128 |
| J-147 | 3,199 | TRUE | Passed | 500 | 3,200 | 30 | 22.3 | J-128 |
| J-148 | 3,465 | TRUE | Passed | 500 | 3,466 | 30 | 20.1 | J-128 |
| J-149 | 3,894 | TRUE | Passed | 500 | 3,895 | 30 | 23 | J-128 |
| J-150 | 3,931 | TRUE | Passed | 500 | 3,932 | 30 | 26.5 | J-128 |
| J-151 | 3,587 | TRUE | Passed | 500 | 3,588 | 30 | 25.2 | J-128 |
| J-152 | 2,371 | TRUE | Passed | 500 | 2,373 | 30 | 41 | J-128 |
| J-153 | 4,258 | TRUE | Passed | 500 | 4,259 | 30 | 25.7 | J-128 |
| J-154 | 4,148 | TRUE | Passed | 500 | 4,149 | 30 | 27.2 | J-128 |
| J-155 | 3,071 | TRUE | Passed | 500 | 3,072 | 30 | 31 | J-196 |
| J-156 | 3,083 | TRUE | Passed | 500 | 3,084 | 30 | 37.9 | J-196 |
| J-157 | 5,203 | TRUE | Passed | 500 | 5,204 | 30 | 25.9 | J-128 |
| J-158 | 3,034 | TRUE | Passed | 500 | 3,035 | 30 | 37.4 | J-128 |
| J-159 | 4,676 | TRUE | Passed | 500 | 4,677 | 30 | 23.9 | J-128 |
| J-160 | 4,264 | TRUE | Passed | 500 | 4,265 | 30 | 25.8 | J-128 |
| J-161 | 4,045 | TRUE | Passed | 500 | 4,046 | 30 | 27.2 | J-128 |
| J-162 | 4,187 | TRUE | Passed | 500 | 4,188 | 30 | 26.3 | J-128 |
| J-163 | 3,254 | TRUE | Passed | 500 | 3,255 | 30 | 33.6 | J-169 |
| J-164 | 3,593 | TRUE | Passed | 500 | 3,594 | 30 | 30.3 | J-168 |
| J-165 | 4,040 | TRUE | Passed | 500 | 4,041 | 30 | 26.5 | J-128 |

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|---|---|---|---|---|---|---|---|---|
| J-166 | 4,091 | TRUE | Passed | 500 | 4,092 | 30 | 18.8 | J-128 |
| J-167 | 2,173 | TRUE | Passed | 500 | 2,174 | 30 | 36.4 | J-168 |
| J-168 | 2,636 | TRUE | Passed | 500 | 2,637 | 30 | 30.7 | J-167 |
| J-169 | 3,129 | TRUE | Passed | 500 | 3,130 | 30 | 32.5 | J-168 |
| J-170 | 3,529 | TRUE | Passed | 500 | 3,530 | 30 | 25.6 | J-128 |
| J-171 | 2,099 | TRUE | Passed | 500 | 2,100 | 30 | 39.8 | J-128 |
| J-172 | 2,902 | TRUE | Passed | 500 | 2,903 | 30 | 23.2 | J-128 |
| J-173 | 2,506 | TRUE | Passed | 500 | 2,507 | 30 | 28.9 | J-128 |
| J-174 | 2,574 | TRUE | Passed | 500 | 2,575 | 30 | 27.7 | J-128 |
| J-175 | 2,823 | TRUE | Passed | 500 | 2,824 | 30 | 23.1 | J-128 |
| J-176 | 2,494 | TRUE | Passed | 500 | 2,495 | 30 | 27.6 | J-179 |
| J-177 | 1,904 | TRUE | Passed | 500 | 1,905 | 30 | 35.5 | J-179 |
| J-178 | 2,234 | TRUE | Passed | 500 | 2,235 | 30 | 28.7 | J-179 |
| J-179 | 1,048 | TRUE | Passed | 500 | 1,049 | 30 | 44.7 | J-128 |
| J-180 | 1,070 | TRUE | Passed | 500 | 1,071 | 30 | 40.1 | J-128 |
| J-181 | 2,430 | TRUE | Passed | 500 | 2,431 | 30 | 28.9 | J-179 |
| J-183 | 8,144 | TRUE | Passed | 500 | 8,145 | 30 | 3.8 | J-689 |
| J-184 | 744 | TRUE | Passed | 500 | 745 | 30 | 45.1 | J-51 |
| J-185 | 6,628 | TRUE | Passed | 500 | 6,629 | 30 | 23.6 | J-186 |
| J-186 | 4,775 | TRUE | Passed | 500 | 4,776 | 30 | 39.3 | J-128 |
| J-187 | 5,155 | TRUE | Passed | 500 | 5,156 | 30 | 23.7 | J-188 |
| J-188 | 3,905 | TRUE | Passed | 500 | 3,906 | 30 | 41.8 | J-128 |
| J-189 | 6,635 | TRUE | Passed | 500 | 6,636 | 30 | 24.5 | J-128 |
| J-190 | 6,683 | TRUE | Passed | 500 | 6,685 | 30 | 24.5 | J-128 |
| J-191 | 4,221 | TRUE | Passed | 500 | 4,222 | 30 | 31.7 | J-192 |
| J-192 | 3,621 | TRUE | Passed | 500 | 3,622 | 30 | 38.5 | J-196 |
| J-193 | 3,524 | TRUE | Passed | 500 | 3,525 | 30 | 31 | J-196 |
| J-194 | 2,968 | TRUE | Passed | 500 | 2,969 | 30 | 26.7 | J-196 |
| J-195 | 2,317 | TRUE | Passed | 500 | 2,318 | 30 | 28 | J-196 |
| J-196 | 1,914 | TRUE | Passed | 500 | 1,915 | 30 | 34 | J-197 |
| J-197 | 2,074 | TRUE | Passed | 500 | 2,075 | 30 | 29.1 | J-196 |
| J-200 | 4,621 | TRUE | Passed | 500 | 4,622 | 30 | 30 | J-201 |
| J-201 | 4,089 | TRUE | Passed | 500 | 4,090 | 30 | 35.5 | J-200 |
| J-202 | 4,477 | TRUE | Passed | 500 | 4,478 | 30 | 31.2 | J-206 |
| J-203 | 4,451 | TRUE | Passed | 500 | 4,452 | 30 | 33.4 | J-204 |
| J-204 | 3,465 | TRUE | Passed | 500 | 3,466 | 30 | 30.5 | J-205 |
| J-205 | 2,832 | TRUE | Passed | 500 | 2,833 | 30 | 38.8 | J-204 |
| J-206 | 3,776 | TRUE | Passed | 500 | 3,777 | 30 | 31.8 | J-207 |
| J-207 | 3,140 | TRUE | Passed | 500 | 3,141 | 30 | 38 | J-206 |
| J-208 | 5,016 | TRUE | Passed | 500 | 5,017 | 30 | 29.9 | J-209 |
| J-209 | 3,838 | TRUE | Passed | 500 | 3,839 | 30 | 40.7 | J-208 |
| J-210 | 6,487 | TRUE | Passed | 500 | 6,488 | 30 | 32.3 | J-95 |

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|---|---|---|---|---|---|---|---|---|
| J-211 | 5,633 | TRUE | Passed | 500 | 5,634 | 30 | 32.3 | J-212 |
| J-212 | 4,518 | TRUE | Passed | 500 | 4,519 | 30 | 30.4 | J-213 |
| J-213 | 3,483 | TRUE | Passed | 500 | 3,484 | 30 | 39.8 | J-215 |
| J-214 | 2,723 | TRUE | Passed | 500 | 2,724 | 30 | 29.5 | J-215 |
| J-215 | 2,271 | TRUE | Passed | 500 | 2,272 | 30 | 38.2 | J-214 |
| J-216 | 798 | TRUE | Passed | 500 | 799 | 30 | 45 | J-51 |
| J-217 | 3,281 | TRUE | Passed | 500 | 3,282 | 30 | 29.5 | J-215 |
| J-218 | 1,836 | TRUE | Passed | 500 | 1,837 | 30 | 44.3 | J-51 |
| J-219 | 3,991 | TRUE | Passed | 500 | 3,992 | 30 | 30 | J-215 |
| J-220 | 1,917 | TRUE | Passed | 500 | 1,918 | 30 | 44.3 | J-51 |
| J-221 | 2,305 | TRUE | Passed | 500 | 2,306 | 30 | 43.9 | J-51 |
| J-222 | 4,422 | TRUE | Passed | 500 | 4,423 | 30 | 33 | J-221 |
| J-223 | 4,868 | TRUE | Passed | 500 | 4,869 | 30 | 32 | J-222 |
| J-224 | 5,695 | TRUE | Passed | 500 | 5,696 | 30 | 36.9 | J-223 |
| J-225 | 5,909 | TRUE | Passed | 500 | 5,910 | 30 | 38.7 | J-224 |
| J-226 | 7,544 | TRUE | Passed | 500 | 7,545 | 30 | 32.6 | J-334 |
| J-227 | 6,585 | TRUE | Passed | 500 | 6,586 | 30 | 25.3 | J-191 |
| J-228 | 6,728 | TRUE | Passed | 500 | 6,729 | 30 | 26.8 | J-128 |
| J-229 | 6,835 | TRUE | Passed | 500 | 6,836 | 30 | 26.6 | J-128 |
| J-230 | 3,399 | TRUE | Passed | 500 | 3,401 | 30 | 42.9 | J-128 |
| J-231 | 7,049 | TRUE | Passed | 500 | 7,050 | 30 | 26.6 | J-128 |
| J-232 | 7,553 | TRUE | Passed | 500 | 7,554 | 30 | 25.3 | J-128 |
| J-233 | 9,230 | TRUE | Passed | 500 | 9,231 | 30 | 17.6 | J-128 |
| J-234 | 9,978 | TRUE | Passed | 500 | 9,979 | 30 | 5.8 | J-689 |
| J-235 | 10,000 | TRUE | Passed | 500 | 10,001 | 46 | 16.2 | J-128 |
| J-236 | 2,832 | TRUE | Passed | 500 | 2,834 | 30 | 28.7 | J-237 |
| J-237 | 2,225 | TRUE | Passed | 500 | 2,226 | 30 | 41.3 | J-236 |
| J-238 | 1,127 | TRUE | Passed | 500 | 1,128 | 30 | 44.8 | J-51 |
| J-239 | 9,956 | TRUE | Passed | 500 | 9,957 | 30 | 29.6 | J-51 |
| J-240 | 9,687 | TRUE | Passed | 500 | 9,688 | 30 | 30.3 | J-51 |
| J-241 | 8,021 | TRUE | Passed | 500 | 8,022 | 30 | 35.2 | J-51 |
| J-242 | 7,816 | TRUE | Passed | 500 | 7,817 | 30 | 35.5 | J-51 |
| J-243 | 9,330 | TRUE | Passed | 500 | 9,331 | 30 | 33.8 | J-51 |
| J-244 | 5,196 | TRUE | Passed | 500 | 5,197 | 30 | 41 | J-51 |
| J-245 | 9,580 | TRUE | Passed | 500 | 9,581 | 30 | 34.5 | J-51 |
| J-246 | 8,864 | TRUE | Passed | 500 | 8,865 | 30 | 37.8 | J-51 |
| J-247 | 10,000 | TRUE | Passed | 500 | 10,001 | 40 | 35.2 | J-51 |
| J-248 | 7,091 | TRUE | Passed | 500 | 7,092 | 30 | 33.2 | J-318 |
| J-249 | 2,424 | TRUE | Passed | 500 | 2,425 | 30 | 29.1 | J-250 |
| J-250 | 1,326 | TRUE | Passed | 500 | 1,327 | 30 | 44.8 | J-51 |
| J-251 | 7,308 | TRUE | Passed | 500 | 7,309 | 30 | 37.7 | J-51 |
| J-252 | 7,253 | TRUE | Passed | 500 | 7,254 | 30 | 38.7 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-253 | 3,136 | TRUE | Passed | 500 | 3,137 | 30 | 43.7 | J-51 |
| J-254 | 7,780 | TRUE | Passed | 500 | 7,781 | 30 | 26.5 | J-324 |
| J-255 | 7,135 | TRUE | Passed | 500 | 7,136 | 30 | 36.1 | J-51 |
| J-256 | 4,153 | TRUE | Passed | 500 | 4,154 | 30 | 41.7 | J-51 |
| J-257 | 7,103 | TRUE | Passed | 500 | 7,104 | 30 | 36.5 | J-51 |
| J-258 | 7,064 | TRUE | Passed | 500 | 7,065 | 30 | 36.4 | J-51 |
| J-259 | 4,413 | TRUE | Passed | 500 | 4,414 | 30 | 41.3 | J-51 |
| J-260 | 6,262 | TRUE | Passed | 500 | 6,263 | 30 | 33.7 | J-731 |
| J-262 | 7,159 | TRUE | Passed | 500 | 7,160 | 30 | 35.6 | J-51 |
| J-263 | 4,228 | TRUE | Passed | 500 | 4,229 | 30 | 40 | J-266 |
| J-264 | 7,631 | TRUE | Passed | 500 | 7,632 | 30 | 34.1 | J-51 |
| J-265 | 3,969 | TRUE | Passed | 500 | 3,970 | 30 | 29.5 | J-266 |
| J-266 | 2,788 | TRUE | Passed | 500 | 2,789 | 30 | 43.3 | J-51 |
| J-267 | 6,047 | TRUE | Passed | 500 | 6,049 | 30 | 32.6 | J-268 |
| J-268 | 5,308 | TRUE | Passed | 500 | 5,309 | 30 | 32.4 | 4-FLOW |
| J-269 | 6,197 | TRUE | Passed | 500 | 6,198 | 30 | 31.8 | J-267 |
| J-270 | 7,533 | TRUE | Passed | 500 | 7,534 | 30 | 32.8 | J-272 |
| J-271 | 6,451 | TRUE | Passed | 500 | 6,453 | 30 | 35.2 | J-260 |
| J-272 | 6,447 | TRUE | Passed | 500 | 6,448 | 30 | 30.4 | J-276 |
| J-273 | 4,918 | TRUE | Passed | 500 | 4,919 | 30 | 30.1 | J-274 |
| J-274 | 4,540 | TRUE | Passed | 500 | 4,541 | 30 | 34.2 | J-273 |
| J-275 | 6,094 | TRUE | Passed | 500 | 6,095 | 30 | 32.3 | J-278 |
| J-276 | 5,881 | TRUE | Passed | 500 | 5,882 | 30 | 35.2 | J-275 |
| J-277 | 5,909 | TRUE | Passed | 500 | 5,910 | 30 | 28.3 | J-278 |
| J-278 | 4,295 | TRUE | Passed | 500 | 4,296 | 30 | 38.4 | J-283 |
| J-279 | 3,864 | TRUE | Passed | 500 | 3,865 | 30 | 34 | J-281 |
| J-280 | 1,439 | TRUE | Passed | 500 | 1,440 | 30 | 44.7 | J-51 |
| J-281 | 3,170 | TRUE | Passed | 500 | 3,171 | 30 | 32.8 | J-280 |
| J-282 | 3,018 | TRUE | Passed | 500 | 3,019 | 30 | 29.9 | J-283 |
| J-283 | 2,395 | TRUE | Passed | 500 | 2,396 | 30 | 30.2 | J-285 |
| J-284 | 1,381 | TRUE | Passed | 500 | 1,382 | 30 | 44.8 | J-51 |
| J-285 | 2,027 | TRUE | Passed | 500 | 2,028 | 30 | 37.7 | J-283 |
| J-286 | 4,282 | TRUE | Passed | 500 | 4,283 | 30 | 27.1 | J-292 |
| J-287 | 3,487 | TRUE | Passed | 500 | 3,488 | 30 | 27.4 | J-292 |
| J-288 | 2,044 | TRUE | Passed | 500 | 2,045 | 30 | 35.3 | J-290 |
| J-289 | 2,306 | TRUE | Passed | 500 | 2,307 | 30 | 29.1 | J-290 |
| J-290 | 2,123 | TRUE | Passed | 500 | 2,124 | 30 | 34.4 | J-289 |
| J-291 | 1,148 | TRUE | Passed | 500 | 1,149 | 30 | 44.9 | J-51 |
| J-292 | 2,488 | TRUE | Passed | 500 | 2,489 | 30 | 33.9 | 6-FLOW |
| J-294 | 1,385 | TRUE | Passed | 500 | 1,386 | 30 | 44.3 | 6-FLOW |
| J-296 | 6,057 | TRUE | Passed | 500 | 6,058 | 30 | 30.1 | J-292 |
| J-297 | 6,213 | TRUE | Passed | 500 | 6,214 | 30 | 39.3 | J-292 |

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|---|---|---|---|---|---|---|---|---|
| J-298 | 8,199 | TRUE | Passed | 500 | 8,200 | 30 | 36.1 | J-51 |
| J-299 | 9,132 | TRUE | Passed | 500 | 9,133 | 30 | 34 | J-128 |
| J-300 | 4,058 | TRUE | Passed | 500 | 4,059 | 30 | 29.9 | J-301 |
| J-301 | 3,275 | TRUE | Passed | 500 | 3,276 | 30 | 39.9 | J-300 |
| J-302 | 3,690 | TRUE | Passed | 500 | 3,691 | 30 | 30.6 | J-303 |
| J-303 | 3,039 | TRUE | Passed | 500 | 3,040 | 30 | 38.9 | J-302 |
| J-304 | 5,421 | TRUE | Passed | 500 | 5,422 | 30 | 36.1 | J-302 |
| J-305 | 5,640 | TRUE | Passed | 500 | 5,641 | 30 | 25.1 | J-306 |
| J-306 | 2,375 | TRUE | Passed | 500 | 2,376 | 30 | 44.1 | J-51 |
| J-307 | 7,596 | TRUE | Passed | 500 | 7,597 | 30 | 30 | J-306 |
| J-308 | 6,710 | TRUE | Passed | 500 | 6,711 | 30 | 39 | J-51 |
| J-309 | 3,578 | TRUE | Passed | 500 | 3,579 | 30 | 43 | J-51 |
| J-310 | 3,407 | TRUE | Passed | 500 | 3,408 | 30 | 43.1 | J-51 |
| J-311 | 3,875 | TRUE | Passed | 500 | 3,876 | 30 | 40.2 | J-309 |
| J-312 | 3,806 | TRUE | Passed | 500 | 3,807 | 30 | 42.7 | J-51 |
| J-313 | 4,303 | TRUE | Passed | 500 | 4,304 | 30 | 42.1 | J-51 |
| J-314 | 3,201 | TRUE | Passed | 500 | 3,202 | 30 | 43.3 | J-51 |
| J-315 | 2,586 | TRUE | Passed | 500 | 2,587 | 30 | 43.8 | J-51 |
| J-316 | 4,404 | TRUE | Passed | 500 | 4,405 | 30 | 41.7 | J-51 |
| J-317 | 3,261 | TRUE | Passed | 500 | 3,262 | 30 | 43.2 | J-51 |
| J-318 | 6,447 | TRUE | Passed | 500 | 6,448 | 30 | 34 | J-319 |
| J-319 | 6,156 | TRUE | Passed | 500 | 6,158 | 30 | 34.8 | J-321 |
| J-320 | 6,193 | TRUE | Passed | 500 | 6,194 | 30 | 34.3 | J-319 |
| J-321 | 3,227 | TRUE | Passed | 500 | 3,228 | 30 | 43.5 | J-51 |
| J-322 | 3,435 | TRUE | Passed | 500 | 3,436 | 30 | 41.7 | J-323 |
| J-323 | 3,034 | TRUE | Passed | 500 | 3,035 | 30 | 42.2 | J-250 |
| J-324 | 4,155 | TRUE | Passed | 500 | 4,156 | 30 | 41.9 | J-51 |
| J-325 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.5 | 29.3 | J-128 |
| J-326 | 10,000 | TRUE | Passed | 500 | 10,001 | 39 | 29.3 | J-128 |
| J-327 | 6,743 | TRUE | Passed | 500 | 6,744 | 30 | 38 | J-51 |
| J-328 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.8 | 29.4 | J-128 |
| J-329 | 9,880 | TRUE | Passed | 500 | 9,881 | 30 | 28.9 | J-128 |
| J-330 | 1,707 | TRUE | Passed | 500 | 1,708 | 30 | 44.5 | J-51 |
| J-331 | 5,827 | TRUE | Passed | 500 | 5,828 | 30 | 31.6 | J-330 |
| J-332 | 6,112 | TRUE | Passed | 500 | 6,113 | 30 | 39.3 | J-51 |
| J-333 | 4,441 | TRUE | Passed | 500 | 4,442 | 30 | 41.7 | J-51 |
| J-334 | 7,569 | TRUE | Passed | 500 | 7,570 | 30 | 33.4 | J-226 |
| J-336 | 6,441 | TRUE | Passed | 500 | 6,442 | 30 | 38.1 | J-51 |
| J-338 | 7,085 | TRUE | Passed | 500 | 7,086 | 30 | 35.8 | J-339 |
| J-339 | 6,124 | TRUE | Passed | 500 | 6,125 | 30 | 35.7 | J-215 |
| J-340 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.9 | 29.5 | J-128 |
| J-341 | 7,296 | TRUE | Passed | 500 | 7,297 | 30 | 36 | J-306 |

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|---|---|---|---|---|---|---|---|---|
| J-342 | 3,929 | TRUE | Passed | 500 | 3,930 | 30 | 42.6 | J-51 |
| J-343 | 6,998 | TRUE | Passed | 500 | 6,999 | 30 | 38.3 | J-51 |
| J-345 | 4,730 | TRUE | Passed | 500 | 4,731 | 30 | 41.7 | J-51 |
| J-346 | 3,554 | TRUE | Passed | 500 | 3,555 | 30 | 43 | J-51 |
| J-347 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.3 | 29.6 | J-128 |
| J-348 | 10,000 | TRUE | Passed | 500 | 10,001 | 48 | 29.5 | J-128 |
| J-349 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.1 | 29.5 | J-128 |
| J-350 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.2 | 29.4 | J-128 |
| J-351 | 8,246 | TRUE | Passed | 500 | 8,247 | 30 | 35 | J-128 |
| J-352 | 8,502 | TRUE | Passed | 500 | 8,503 | 30 | 34.2 | J-128 |
| J-353 | 9,046 | TRUE | Passed | 500 | 9,047 | 30 | 32.5 | J-128 |
| J-354 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.3 | 30.4 | J-128 |
| J-355 | 8,459 | TRUE | Passed | 500 | 8,460 | 30 | 35.2 | J-128 |
| J-356 | 7,951 | TRUE | Passed | 500 | 7,952 | 30 | 35.1 | J-365 |
| J-357 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.4 | 29.5 | J-128 |
| J-358 | 9,884 | TRUE | Passed | 500 | 9,885 | 30 | 31.2 | J-128 |
| J-359 | 9,633 | TRUE | Passed | 500 | 9,634 | 30 | 26.7 | J-360 |
| J-360 | 1,495 | TRUE | Passed | 500 | 1,496 | 30 | 44.7 | J-51 |
| J-361 | 8,129 | TRUE | Passed | 500 | 8,130 | 30 | 36 | J-128 |
| J-362 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.4 | 29.4 | J-128 |
| J-363 | 7,683 | TRUE | Passed | 500 | 7,684 | 30 | 36.6 | J-128 |
| J-364 | 6,850 | TRUE | Passed | 500 | 6,851 | 30 | 38.4 | J-51 |
| J-365 | 7,236 | TRUE | Passed | 500 | 7,237 | 30 | 37.6 | J-51 |
| J-366 | 6,711 | TRUE | Passed | 500 | 6,712 | 30 | 37.9 | J-364 |
| J-367 | 8,262 | TRUE | Passed | 500 | 8,263 | 30 | 34.8 | J-128 |
| J-368 | 5,712 | TRUE | Passed | 500 | 5,713 | 30 | 40.3 | J-51 |
| J-369 | 8,332 | TRUE | Passed | 500 | 8,333 | 30 | 35.8 | J-128 |
| J-370 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.8 | 30.6 | J-128 |
| J-371 | 2,312 | TRUE | Passed | 500 | 2,313 | 30 | 29.7 | J-128 |
| J-371 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.3 | 30.5 | J-128 |
| J-372 | 6,757 | TRUE | Passed | 500 | 6,758 | 30 | 38.7 | J-51 |
| J-373 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.9 | 29.5 | J-128 |
| J-374 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.1 | 29.4 | J-128 |
| J-375 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.6 | 29.3 | J-128 |
| J-376 | 7,688 | TRUE | Passed | 500 | 7,689 | 30 | 36.6 | J-128 |
| J-377 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.3 | 29.1 | J-128 |
| J-378 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.5 | 29.5 | J-128 |
| J-379 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.8 | 29.5 | J-128 |
| J-380 | 6,441 | TRUE | Passed | 500 | 6,442 | 30 | 39.4 | J-51 |
| J-382 | 6,948 | TRUE | Passed | 500 | 6,949 | 30 | 38.5 | J-51 |
| J-383 | 6,383 | TRUE | Passed | 500 | 6,384 | 30 | 39.4 | J-51 |
| J-384 | 6,662 | TRUE | Passed | 500 | 6,663 | 30 | 39.2 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-385 | 8,754 | TRUE | Passed | 500 | 8,755 | 30 | 34.5 | J-128 |
| J-386 | 9,427 | TRUE | Passed | 500 | 9,428 | 30 | 32.3 | J-128 |
| J-387 | 8,110 | TRUE | Passed | 500 | 8,111 | 30 | 35.6 | J-388 |
| J-388 | 6,107 | TRUE | Passed | 500 | 6,108 | 30 | 39.8 | J-51 |
| J-389 | 4,836 | TRUE | Passed | 500 | 4,837 | 30 | 33.8 | J-390 |
| J-390 | 1,826 | TRUE | Passed | 500 | 1,827 | 30 | 44.5 | J-51 |
| J-391 | 6,501 | TRUE | Passed | 500 | 6,502 | 30 | 39.1 | J-51 |
| J-392 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.3 | 29.5 | J-128 |
| J-393 | 7,333 | TRUE | Passed | 500 | 7,334 | 30 | 37.7 | J-430 |
| J-394 | 8,619 | TRUE | Passed | 500 | 8,620 | 30 | 28.5 | J-424 |
| J-395 | 8,796 | TRUE | Passed | 500 | 8,797 | 30 | 26.2 | J-425 |
| J-396 | 10,000 | TRUE | Passed | 500 | 10,001 | 40 | 29.6 | J-128 |
| J-397 | 5,949 | TRUE | Passed | 500 | 5,950 | 30 | 27.8 | J-398 |
| J-398 | 1,617 | TRUE | Passed | 500 | 1,618 | 30 | 44.6 | J-51 |
| J-399 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.4 | 27.5 | J-128 |
| J-401 | 1,758 | TRUE | Passed | 500 | 1,759 | 30 | 28.5 | J-128 |
| J-401 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 30.4 | J-128 |
| J-402 | 10,000 | TRUE | Passed | 500 | 10,001 | 62.5 | 30.3 | J-128 |
| J-403 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.2 | 30.7 | J-128 |
| J-404 | 9,598 | TRUE | Passed | 500 | 9,599 | 30 | 35.1 | J-128 |
| J-405 | 4,495 | TRUE | Passed | 500 | 4,496 | 30 | 42.6 | J-51 |
| J-406 | 10,000 | TRUE | Passed | 500 | 10,001 | 58 | 29.8 | J-128 |
| J-407 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.4 | 29.7 | J-128 |
| J-408 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.8 | 29.4 | J-128 |
| J-409 | 3,336 | TRUE | Passed | 500 | 3,337 | 30 | 43.3 | J-51 |
| J-410 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.2 | 29.5 | J-128 |
| J-411 | 3,404 | TRUE | Passed | 500 | 3,405 | 30 | 43.3 | J-51 |
| J-412 | 10,000 | TRUE | Passed | 500 | 10,001 | 55.8 | 29.5 | J-128 |
| J-413 | 10,000 | TRUE | Passed | 500 | 10,001 | 62 | 28.6 | J-128 |
| J-414 | 10,000 | TRUE | Passed | 500 | 10,001 | 56.2 | 22.7 | J-128 |
| J-415 | 1,921 | TRUE | Passed | 500 | 1,922 | 30 | 44.4 | J-51 |
| J-416 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.6 | 29 | J-128 |
| J-417 | 10,000 | TRUE | Passed | 500 | 10,001 | 54.9 | 29.6 | J-128 |
| J-418 | 5,261 | TRUE | Passed | 500 | 5,262 | 30 | 29.9 | J-419 |
| J-419 | 3,345 | TRUE | Passed | 500 | 3,346 | 30 | 43.4 | J-51 |
| J-420 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.6 | 32.2 | J-421 |
| J-421 | 8,766 | TRUE | Passed | 500 | 8,767 | 30 | 31.8 | J-423 |
| J-422 | 6,433 | TRUE | Passed | 500 | 6,434 | 30 | 39.8 | J-51 |
| J-423 | 8,624 | TRUE | Passed | 500 | 8,625 | 30 | 32.7 | J-422 |
| J-424 | 4,525 | TRUE | Passed | 500 | 4,526 | 30 | 42.1 | J-51 |
| J-425 | 3,893 | TRUE | Passed | 500 | 3,894 | 30 | 42.8 | J-51 |
| J-426 | 8,941 | TRUE | Passed | 500 | 8,942 | 30 | 23.6 | J-425 |

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|---|---|---|---|---|---|---|---|---|
| J-427 | 7,372 | TRUE | Passed | 500 | 7,373 | 30 | 34.1 | J-424 |
| J-428 | 8,715 | TRUE | Passed | 500 | 8,716 | 30 | 34.7 | J-423 |
| J-429 | 8,693 | TRUE | Passed | 500 | 8,694 | 30 | 34.8 | J-428 |
| J-430 | 3,747 | TRUE | Passed | 500 | 3,748 | 30 | 43 | J-51 |
| J-431 | 6,844 | TRUE | Passed | 500 | 6,845 | 30 | 30.9 | J-432 |
| J-432 | 2,185 | TRUE | Passed | 500 | 2,186 | 30 | 44.3 | J-51 |
| J-433 | 5,246 | TRUE | Passed | 500 | 5,247 | 30 | 25.8 | J-128 |
| J-434 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 45 | J-51 |
| J-435 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 45 | J-51 |
| J-436 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.7 | 44.8 | J-51 |
| J-437 | 8,324 | TRUE | Passed | 500 | 8,325 | 30 | 44.5 | J-51 |
| J-439 | 6,582 | TRUE | Passed | 500 | 6,583 | 30 | 31.7 | J-719 |
| J-440 | 6,474 | TRUE | Passed | 500 | 6,475 | 30 | 32.1 | J-1780 |
| J-442 | 7,527 | TRUE | Passed | 500 | 7,528 | 30 | 27.5 | J-443 |
| J-443 | 2,062 | TRUE | Passed | 500 | 2,063 | 30 | 45.1 | J-51 |
| J-445 | 8,711 | TRUE | Passed | 500 | 8,712 | 30 | 30.8 | J-455 |
| J-447 | 5,981 | TRUE | Passed | 500 | 5,982 | 30 | 27.1 | J-450 |
| J-448 | 4,774 | TRUE | Passed | 500 | 4,775 | 30 | 39.8 | J-450 |
| J-449 | 5,675 | TRUE | Passed | 500 | 5,676 | 30 | 23.5 | J-450 |
| J-450 | 3,875 | TRUE | Passed | 500 | 3,876 | 30 | 44.6 | J-51 |
| J-451 | 5,473 | TRUE | Passed | 500 | 5,474 | 30 | 35 | J-452 |
| J-452 | 4,985 | TRUE | Passed | 500 | 4,986 | 30 | 31.8 | J-458 |
| J-453 | 4,639 | TRUE | Passed | 500 | 4,640 | 30 | 39.8 | J-454 |
| J-454 | 4,465 | TRUE | Passed | 500 | 4,466 | 30 | 42.8 | J-453 |
| J-455 | 5,944 | TRUE | Passed | 500 | 5,945 | 30 | 38.1 | J-454 |
| J-456 | 5,995 | TRUE | Passed | 500 | 5,996 | 30 | 37.1 | J-455 |
| J-457 | 4,776 | TRUE | Passed | 500 | 4,777 | 30 | 39.9 | J-452 |
| J-458 | 2,781 | TRUE | Passed | 500 | 2,782 | 30 | 44.8 | J-51 |
| J-459 | 2,707 | TRUE | Passed | 500 | 2,708 | 30 | 33.4 | J-463 |
| J-460 | 3,717 | TRUE | Passed | 500 | 3,718 | 30 | 33.5 | J-459 |
| J-461 | 1,536 | TRUE | Passed | 500 | 1,537 | 30 | 29.4 | J-463 |
| J-462 | 1,351 | TRUE | Passed | 500 | 1,352 | 30 | 37.4 | J-463 |
| J-463 | 1,236 | TRUE | Passed | 500 | 1,237 | 30 | 42.5 | J-461 |
| J-464 | 4,837 | TRUE | Passed | 500 | 4,838 | 30 | 38.1 | J-457 |
| J-465 | 4,990 | TRUE | Passed | 500 | 4,991 | 30 | 36.4 | J-464 |
| J-466 | 5,283 | TRUE | Passed | 500 | 5,284 | 30 | 37.6 | J-465 |
| J-467 | 5,952 | TRUE | Passed | 500 | 5,953 | 30 | 29 | J-460 |
| J-468 | 5,879 | TRUE | Passed | 500 | 5,880 | 30 | 33.5 | J-459 |
| J-469 | 6,419 | TRUE | Passed | 500 | 6,420 | 30 | 35.4 | J-474 |
| J-470 | 7,643 | TRUE | Passed | 500 | 7,644 | 30 | 42 | J-51 |
| J-471 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.7 | 33.8 | J-556 |
| J-472 | 6,518 | TRUE | Passed | 500 | 6,519 | 30 | 40.8 | J-473 |

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|---|---|---|---|---|---|---|---|---|
| J-473 | 5,989 | TRUE | Passed | 500 | 5,990 | 30 | 36.6 | J-475 |
| J-474 | 5,583 | TRUE | Passed | 500 | 5,584 | 30 | 43.6 | J-51 |
| J-475 | 5,153 | TRUE | Passed | 500 | 5,154 | 30 | 40.9 | J-478 |
| J-476 | 2,202 | TRUE | Passed | 500 | 2,203 | 30 | 41.3 | J-477 |
| J-477 | 2,232 | TRUE | Passed | 500 | 2,233 | 30 | 39.1 | J-476 |
| J-478 | 5,109 | TRUE | Passed | 500 | 5,110 | 30 | 39.4 | J-475 |
| J-479 | 5,250 | TRUE | Passed | 500 | 5,251 | 30 | 39.6 | J-478 |
| J-480 | 5,575 | TRUE | Passed | 500 | 5,576 | 30 | 37.7 | J-479 |
| J-481 | 5,917 | TRUE | Passed | 500 | 5,918 | 30 | 35.7 | J-480 |
| J-482 | 3,080 | TRUE | Passed | 500 | 3,081 | 30 | 25.8 | J-485 |
| J-483 | 1,896 | TRUE | Passed | 500 | 1,897 | 30 | 28.8 | J-485 |
| J-484 | 1,743 | TRUE | Passed | 500 | 1,744 | 30 | 34.1 | J-485 |
| J-485 | 1,415 | TRUE | Passed | 500 | 1,416 | 30 | 45.1 | J-51 |
| J-486 | 8,880 | TRUE | Passed | 500 | 8,881 | 30 | 41.1 | 1-FLOW |
| J-487 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.4 | 43 | J-51 |
| J-489 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.8 | 44.2 | J-51 |
| J-490 | 10,000 | TRUE | Passed | 500 | 10,001 | 36 | 38.5 | J-437 |
| J-491 | 10,000 | TRUE | Passed | 500 | 10,001 | 63 | 45.1 | J-51 |
| J-492 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.3 | 43.4 | J-51 |
| J-493 | 9,464 | TRUE | Passed | 500 | 9,465 | 30 | 36.5 | J-494 |
| J-494 | 9,584 | TRUE | Passed | 500 | 9,585 | 30 | 35.2 | J-493 |
| J-497 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.7 | 41.2 | J-51 |
| J-498 | 10,000 | TRUE | Passed | 500 | 10,001 | 47 | 42.6 | J-51 |
| J-499 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.9 | 39 | J-500 |
| J-500 | 6,429 | TRUE | Passed | 500 | 6,430 | 30 | 44 | J-51 |
| J-501 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.6 | 37.8 | J-502 |
| J-502 | 4,733 | TRUE | Passed | 500 | 4,734 | 30 | 31.3 | J-726 |
| J-504 | 3,021 | TRUE | Passed | 500 | 3,022 | 30 | 40.4 | J-1334 |
| J-505 | 3,720 | TRUE | Passed | 500 | 3,721 | 30 | 42.3 | J-554 |
| J-507 | 4,120 | TRUE | Passed | 500 | 4,121 | 30 | 33 | J-508 |
| J-508 | 4,119 | TRUE | Passed | 500 | 4,120 | 30 | 34 | J-507 |
| J-509 | 4,842 | TRUE | Passed | 500 | 4,843 | 30 | 30.8 | J-508 |
| J-510 | 5,490 | TRUE | Passed | 500 | 5,491 | 30 | 32.6 | J-513 |
| J-511 | 2,209 | TRUE | Passed | 500 | 2,210 | 30 | 37.8 | J-513 |
| J-513 | 2,251 | TRUE | Passed | 500 | 2,252 | 30 | 37.5 | J-514 |
| J-514 | 2,543 | TRUE | Passed | 500 | 2,544 | 30 | 29.3 | J-513 |
| J-516 | 4,807 | TRUE | Passed | 500 | 4,808 | 30 | 38 | J-508 |
| J-517 | 5,253 | TRUE | Passed | 500 | 5,254 | 30 | 30.2 | J-549 |
| J-518 | 4,776 | TRUE | Passed | 500 | 4,777 | 30 | 26.2 | J-549 |
| J-519 | 5,129 | TRUE | Passed | 500 | 5,130 | 30 | 29.7 | J-508 |
| J-520 | 4,316 | TRUE | Passed | 500 | 4,317 | 30 | 32.5 | J-521 |
| J-521 | 3,552 | TRUE | Passed | 500 | 3,553 | 30 | 37 | J-603 |

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|---|---|---|---|---|---|---|---|---|
| J-522 | 3,727 | TRUE | Passed | 500 | 3,728 | 30 | 27.5 | J-603 |
| J-523 | 4,065 | TRUE | Passed | 500 | 4,066 | 30 | 27.8 | J-603 |
| J-524 | 3,923 | TRUE | Passed | 500 | 3,924 | 30 | 29.7 | J-521 |
| J-525 | 4,364 | TRUE | Passed | 500 | 4,365 | 30 | 31.4 | J-521 |
| J-526 | 4,206 | TRUE | Passed | 500 | 4,207 | 30 | 33.5 | J-521 |
| J-527 | 4,293 | TRUE | Passed | 500 | 4,294 | 30 | 32.6 | J-528 |
| J-528 | 3,970 | TRUE | Passed | 500 | 3,971 | 30 | 35.4 | J-610 |
| J-529 | 4,185 | TRUE | Passed | 500 | 4,186 | 30 | 36.9 | J-613 |
| J-530 | 4,209 | TRUE | Passed | 500 | 4,210 | 30 | 38.1 | J-596 |
| J-531 | 2,700 | TRUE | Passed | 500 | 2,701 | 30 | 44.4 | J-51 |
| J-532 | 2,910 | TRUE | Passed | 500 | 2,911 | 30 | 44.3 | J-51 |
| J-533 | 7,605 | TRUE | Passed | 500 | 7,606 | 30 | 31.8 | J-532 |
| J-534 | 8,459 | TRUE | Passed | 500 | 8,460 | 30 | 29.7 | J-535 |
| J-535 | 7,872 | TRUE | Passed | 500 | 7,873 | 30 | 30.9 | J-536 |
| J-536 | 7,100 | TRUE | Passed | 500 | 7,101 | 30 | 36.5 | J-535 |
| J-537 | 8,055 | TRUE | Passed | 500 | 8,056 | 30 | 35.6 | J-647 |
| J-538 | 8,551 | TRUE | Passed | 500 | 8,552 | 30 | 36.5 | J-648 |
| J-539 | 9,692 | TRUE | Passed | 500 | 9,693 | 30 | 31 | J-538 |
| J-540 | 2,906 | TRUE | Passed | 500 | 2,907 | 30 | 42.4 | J-648 |
| J-541 | 3,143 | TRUE | Passed | 500 | 3,144 | 30 | 44.2 | J-51 |
| J-542 | 6,260 | TRUE | Passed | 500 | 6,261 | 30 | 40.9 | J-644 |
| J-543 | 8,434 | TRUE | Passed | 500 | 8,435 | 30 | 34.9 | J-542 |
| J-544 | 9,447 | TRUE | Passed | 500 | 9,448 | 30 | 33.7 | J-546 |
| J-545 | 5,221 | TRUE | Passed | 500 | 5,222 | 30 | 29.6 | J-546 |
| J-546 | 2,020 | TRUE | Passed | 500 | 2,021 | 30 | 44.9 | J-51 |
| J-547 | 4,898 | TRUE | Passed | 500 | 4,899 | 30 | 30.7 | J-548 |
| J-548 | 1,754 | TRUE | Passed | 500 | 1,756 | 30 | 45 | J-51 |
| J-549 | 1,603 | TRUE | Passed | 500 | 1,604 | 30 | 45 | J-51 |
| J-550 | 4,233 | TRUE | Passed | 500 | 4,234 | 30 | 29.7 | J-552 |
| J-551 | 2,825 | TRUE | Passed | 500 | 2,826 | 30 | 44.7 | J-51 |
| J-552 | 2,276 | TRUE | Passed | 500 | 2,277 | 30 | 44.9 | J-51 |
| J-553 | 3,756 | TRUE | Passed | 500 | 3,757 | 30 | 29.9 | J-554 |
| J-554 | 2,452 | TRUE | Passed | 500 | 2,453 | 30 | 45 | J-51 |
| J-555 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.7 | 32.3 | J-556 |
| J-556 | 3,861 | TRUE | Passed | 500 | 3,862 | 30 | 44.1 | J-51 |
| J-557 | 3,424 | TRUE | Passed | 500 | 3,425 | 30 | 30.9 | J-558 |
| J-558 | 1,747 | TRUE | Passed | 500 | 1,748 | 30 | 44.9 | J-51 |
| J-559 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.2 | 36.8 | J-557 |
| J-560 | 10,000 | TRUE | Passed | 500 | 10,001 | 44 | 40.9 | J-51 |
| J-561 | 3,550 | TRUE | Passed | 500 | 3,551 | 30 | 44.2 | J-51 |
| J-562 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.6 | 34.4 | J-556 |
| J-563 | 2,728 | TRUE | Passed | 500 | 2,729 | 30 | 44.5 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-564 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.8 | 33.9 | J-563 |
| J-565 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.7 | 37.4 | J-556 |
| J-566 | 7,727 | TRUE | Passed | 500 | 7,728 | 30 | 40.9 | J-51 |
| J-567 | 9,606 | TRUE | Passed | 500 | 9,607 | 30 | 36.4 | J-578 |
| J-568 | 8,490 | TRUE | Passed | 500 | 8,491 | 30 | 37.1 | J-574 |
| J-569 | 7,055 | TRUE | Passed | 500 | 7,056 | 30 | 37.8 | J-570 |
| J-570 | 6,438 | TRUE | Passed | 500 | 6,439 | 30 | 41.8 | J-51 |
| J-571 | 6,835 | TRUE | Passed | 500 | 6,836 | 30 | 38.9 | J-574 |
| J-572 | 8,243 | TRUE | Passed | 500 | 8,244 | 30 | 19.6 | J-574 |
| J-573 | 4,626 | TRUE | Passed | 500 | 4,627 | 30 | 43.1 | J-51 |
| J-574 | 7,287 | TRUE | Passed | 500 | 7,288 | 30 | 33.1 | J-571 |
| J-576 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.5 | 34.7 | J-568 |
| J-577 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.2 | 33.7 | J-578 |
| J-578 | 3,040 | TRUE | Passed | 500 | 3,041 | 30 | 44.2 | J-51 |
| J-579 | 4,043 | TRUE | Passed | 500 | 4,044 | 30 | 43.7 | J-51 |
| J-580 | 4,121 | TRUE | Passed | 500 | 4,122 | 30 | 43.7 | J-51 |
| J-581 | 3,896 | TRUE | Passed | 500 | 3,897 | 30 | 43.7 | J-51 |
| J-582 | 6,095 | TRUE | Passed | 500 | 6,096 | 30 | 38.8 | J-581 |
| J-583 | 6,592 | TRUE | Passed | 500 | 6,593 | 30 | 41.2 | J-51 |
| J-584 | 7,406 | TRUE | Passed | 500 | 7,407 | 30 | 36.4 | J-585 |
| J-585 | 5,730 | TRUE | Passed | 500 | 5,731 | 30 | 38.3 | J-587 |
| J-587 | 5,323 | TRUE | Passed | 500 | 5,324 | 30 | 37.8 | J-588 |
| J-588 | 4,973 | TRUE | Passed | 500 | 4,974 | 30 | 42.6 | J-51 |
| J-589 | 5,143 | TRUE | Passed | 500 | 5,144 | 30 | 38.3 | J-588 |
| J-590 | 6,512 | TRUE | Passed | 500 | 6,513 | 30 | 28.6 | J-591 |
| J-591 | 5,971 | TRUE | Passed | 500 | 5,972 | 30 | 35.8 | J-590 |
| J-592 | 5,701 | TRUE | Passed | 500 | 5,702 | 30 | 35.5 | J-596 |
| J-593 | 4,204 | TRUE | Passed | 500 | 4,205 | 30 | 35.8 | J-596 |
| J-594 | 4,098 | TRUE | Passed | 500 | 4,099 | 30 | 26 | J-596 |
| J-595 | 3,330 | TRUE | Passed | 500 | 3,331 | 30 | 27 | J-596 |
| J-596 | 2,795 | TRUE | Passed | 500 | 2,796 | 30 | 34.9 | J-597 |
| J-597 | 2,906 | TRUE | Passed | 500 | 2,907 | 30 | 31.3 | J-596 |
| J-598 | 2,991 | TRUE | Passed | 500 | 2,992 | 30 | 31.9 | J-597 |
| J-599 | 3,178 | TRUE | Passed | 500 | 3,179 | 30 | 31.2 | J-1549 |
| J-601 | 2,801 | TRUE | Passed | 500 | 2,802 | 30 | 34.4 | J-1549 |
| J-602 | 4,019 | TRUE | Passed | 500 | 4,020 | 30 | 31.7 | J-1549 |
| J-603 | 2,135 | TRUE | Passed | 500 | 2,136 | 30 | 44.7 | J-51 |
| J-604 | 4,031 | TRUE | Passed | 500 | 4,032 | 30 | 30.2 | J-596 |
| J-605 | 2,972 | TRUE | Passed | 500 | 2,973 | 30 | 30.8 | J-596 |
| J-606 | 3,076 | TRUE | Passed | 500 | 3,077 | 30 | 29.5 | J-596 |
| J-607 | 3,883 | TRUE | Passed | 500 | 3,884 | 30 | 31 | J-596 |
| J-608 | 4,009 | TRUE | Passed | 500 | 4,010 | 30 | 31.1 | J-596 |

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|---|---|---|---|---|---|---|---|---|
| J-609 | 4,076 | TRUE | Passed | 500 | 4,077 | 30 | 31.1 | J-596 |
| J-610 | 3,980 | TRUE | Passed | 500 | 3,981 | 30 | 34 | J-596 |
| J-611 | 4,282 | TRUE | Passed | 500 | 4,283 | 30 | 28.4 | J-596 |
| J-612 | 3,782 | TRUE | Passed | 500 | 3,783 | 30 | 35.6 | J-596 |
| J-613 | 3,906 | TRUE | Passed | 500 | 3,907 | 30 | 38.5 | J-596 |
| J-614 | 5,892 | TRUE | Passed | 500 | 5,893 | 30 | 34.2 | J-596 |
| J-615 | 6,171 | TRUE | Passed | 500 | 6,172 | 30 | 30.4 | J-614 |
| J-616 | 6,306 | TRUE | Passed | 500 | 6,307 | 30 | 32.2 | J-615 |
| J-617 | 6,228 | TRUE | Passed | 500 | 6,229 | 30 | 40.3 | 3-FLOW |
| J-620 | 7,161 | TRUE | Passed | 500 | 7,162 | 30 | 28.7 | J-617 |
| J-621 | 8,720 | TRUE | Passed | 500 | 8,721 | 30 | 28.7 | J-617 |
| J-622 | 8,331 | TRUE | Passed | 500 | 8,332 | 30 | 32.9 | J-626 |
| J-623 | 8,566 | TRUE | Passed | 500 | 8,567 | 30 | 34.1 | J-617 |
| J-625 | 9,449 | TRUE | Passed | 500 | 9,450 | 30 | 28 | J-617 |
| J-626 | 8,145 | TRUE | Passed | 500 | 8,146 | 30 | 33.1 | J-627 |
| J-627 | 8,062 | TRUE | Passed | 500 | 8,063 | 30 | 34.7 | J-628 |
| J-628 | 8,249 | TRUE | Passed | 500 | 8,250 | 30 | 33.4 | J-627 |
| J-629 | 8,727 | TRUE | Passed | 500 | 8,728 | 30 | 31.3 | J-628 |
| J-630 | 8,924 | TRUE | Passed | 500 | 8,925 | 30 | 32 | J-629 |
| J-631 | 8,936 | TRUE | Passed | 500 | 8,937 | 30 | 36.1 | J-630 |
| J-632 | 4,859 | TRUE | Passed | 500 | 4,860 | 30 | 30 | J-633 |
| J-633 | 2,922 | TRUE | Passed | 500 | 2,923 | 30 | 44.1 | J-51 |
| J-634 | 7,482 | TRUE | Passed | 500 | 7,483 | 30 | 30.1 | J-633 |
| J-636 | 9,525 | TRUE | Passed | 500 | 9,526 | 30 | 33.3 | J-631 |
| J-637 | 3,560 | TRUE | Passed | 500 | 3,561 | 30 | 43.8 | J-51 |
| J-638 | 9,921 | TRUE | Passed | 500 | 9,922 | 30 | 33.3 | J-539 |
| J-639 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.2 | 35.9 | J-128 |
| J-640 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.4 | 35.5 | J-641 |
| J-641 | 5,192 | TRUE | Passed | 500 | 5,193 | 30 | 42.7 | J-51 |
| J-642 | 3,795 | TRUE | Passed | 500 | 3,796 | 30 | 43.8 | J-51 |
| J-643 | 2,910 | TRUE | Passed | 500 | 2,911 | 30 | 44.4 | J-51 |
| J-644 | 4,991 | TRUE | Passed | 500 | 4,992 | 30 | 37.3 | J-645 |
| J-645 | 2,530 | TRUE | Passed | 500 | 2,531 | 30 | 44.6 | J-51 |
| J-646 | 6,892 | TRUE | Passed | 500 | 6,893 | 30 | 38.8 | J-648 |
| J-647 | 4,522 | TRUE | Passed | 500 | 4,523 | 30 | 43.3 | J-51 |
| J-648 | 2,755 | TRUE | Passed | 500 | 2,756 | 30 | 44.4 | J-51 |
| J-649 | 3,473 | TRUE | Passed | 500 | 3,474 | 30 | 29.8 | J-650 |
| J-650 | 1,755 | TRUE | Passed | 500 | 1,756 | 30 | 44.8 | J-51 |
| J-651 | 7,341 | TRUE | Passed | 500 | 7,342 | 30 | 29.4 | J-652 |
| J-652 | 2,864 | TRUE | Passed | 500 | 2,865 | 30 | 44.4 | J-51 |
| J-655 | 6,850 | TRUE | Passed | 500 | 6,851 | 30 | 31.6 | J-656 |
| J-656 | 3,348 | TRUE | Passed | 500 | 3,349 | 30 | 44.1 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-657 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.3 | 34.4 | J-128 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.6 | 31.9 | J-568 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.8 | 34.3 | J-128 |
| J-660 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.1 | 34.1 | J-128 |
| J-661 | 798 | TRUE | Passed | 500 | 803 | 30 | 45.1 | J-51 |
| J-662 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.8 | 32.8 | J-128 |
| J-663 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.8 | 33.8 | J-128 |
| J-664 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.7 | 35.3 | J-128 |
| J-665 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.1 | 35.7 | J-128 |
| J-666 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.9 | 38.3 | J-51 |
| J-667 | 9,279 | TRUE | Passed | 500 | 9,280 | 30 | 34.5 | J-51 |
| J-668 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.7 | 40.4 | J-51 |
| J-669 | 4,031 | TRUE | Passed | 500 | 4,032 | 30 | 40.7 | J-21 |
| J-670 | 4,583 | TRUE | Passed | 500 | 4,584 | 30 | 33.8 | J-21 |
| J-673 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.2 | 35.1 | J-128 |
| J-674 | 4,066 | TRUE | Passed | 500 | 4,067 | 30 | 43.3 | J-51 |
| J-675 | 3,793 | TRUE | Passed | 500 | 3,794 | 30 | 43 | J-51 |
| J-676 | 5,328 | TRUE | Passed | 500 | 5,329 | 30 | 31 | J-675 |
| J-677 | 2,321 | TRUE | Passed | 500 | 2,322 | 30 | 29.3 | J-678 |
| J-678 | 1,734 | TRUE | Passed | 500 | 1,735 | 30 | 44.6 | J-51 |
| J-680 | 3,465 | TRUE | Passed | 500 | 3,465 | 30 | 25.7 | J-128 |
| J-682 | 2,956 | TRUE | Passed | 500 | 2,956 | 30 | 25.9 | J-128 |
| J-689 | 2,309 | TRUE | Passed | 500 | 2,334 | 30 | 44.1 | J-51 |
| J-696 | 2,673 | TRUE | Passed | 500 | 2,678 | 30 | 29.2 | J-51 |
| J-697 | 3,005 | TRUE | Passed | 500 | 3,005 | 30 | 22.9 | J-128 |
| J-719 | 4,427 | TRUE | Passed | 500 | 4,427 | 30 | 39.7 | J-724 |
| J-724 | 4,265 | TRUE | Passed | 500 | 4,265 | 30 | 34.1 | J-1780 |
| J-726 | 3,959 | TRUE | Passed | 500 | 3,959 | 30 | 31.6 | J-504 |
| J-727 | 7,584 | TRUE | Passed | 500 | 7,584 | 30 | 44.7 | J-51 |
| J-731 | 5,506 | TRUE | Passed | 500 | 5,507 | 30 | 39.3 | J-51 |
| J-904 | 6,521 | TRUE | Passed | 500 | 6,522 | 30 | 38 | J-51 |
| J-1031 | 8,921 | TRUE | Passed | 500 | 8,922 | 30 | 33.8 | J-128 |
| J-1082 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.8 | 32.3 | J-128 |
| J-1184 | 9,002 | TRUE | Passed | 500 | 9,003 | 30 | 37.6 | J-439 |
| J-1201 | 7,846 | TRUE | Passed | 500 | 7,847 | 30 | 26.1 | J-455 |
| J-1296 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.5 | 43.2 | J-51 |
| J-1334 | 3,684 | TRUE | Passed | 500 | 3,685 | 30 | 29.9 | J-504 |
| J-1340 | 3,788 | TRUE | Passed | 500 | 3,789 | 30 | 39.4 | J-508 |
| J-1549 | 2,828 | TRUE | Passed | 500 | 2,829 | 30 | 35.3 | J-601 |
| J-1642 | 8,350 | TRUE | Passed | 500 | 8,351 | 30 | 39 | J-51 |
| J-1704 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.6 | 34.9 | J-568 |
| J-1780 | 4,346 | TRUE | Passed | 500 | 4,346 | 30 | 32.4 | J-724 |

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|---|---|---|---|---|---|---|---|---|
| J-1806 | 2,504 | TRUE | Passed | 500 | 2,504 | 30 | 34.9 | J-128 |
| **Scenario 2: Loop at Evergreen Drive** | | | | | | | | |
| 1-FLOW | 8,637 | TRUE | Passed | 500 | 8,638 | 30 | 30.8 | 1-RES |
| 1-RES | 3,069 | TRUE | Passed | 500 | 3,072 | 30 | 44.7 | J-51 |
| 2-FLOW | 7,373 | TRUE | Passed | 500 | 7,374 | 30 | 30 | 2-RES |
| 2-RES | 4,072 | TRUE | Passed | 500 | 4,073 | 30 | 44.7 | J-51 |
| 3-FLOW | 2,816 | TRUE | Passed | 500 | 2,817 | 30 | 30.9 | 3-RES |
| 3-RES | 2,404 | TRUE | Passed | 500 | 2,405 | 30 | 39.8 | 3-FLOW |
| 4-FLOW | 3,290 | TRUE | Passed | 500 | 3,291 | 30 | 30.7 | 4-RES |
| 4-RES | 2,387 | TRUE | Passed | 500 | 2,388 | 30 | 42.5 | 4-FLOW |
| 5-FLOW | 2,741 | TRUE | Passed | 500 | 2,742 | 30 | 27.7 | J-51 |
| 5-RES | 1,670 | TRUE | Passed | 500 | 1,671 | 30 | 38 | J-51 |
| 6-FLOW | 1,957 | TRUE | Passed | 500 | 1,958 | 30 | 30.8 | 6-RES |
| 6-RES | 1,273 | TRUE | Passed | 500 | 1,274 | 30 | 44.8 | J-51 |
| 7-FLOW | 2,066 | TRUE | Passed | 500 | 2,067 | 30 | 29.1 | J-196 |
| 7-RES | 1,860 | TRUE | Passed | 500 | 1,861 | 30 | 34.2 | J-196 |
| J-1 | 4,862 | TRUE | Passed | 500 | 4,863 | 30 | 34.4 | J-128 |
| J-2 | 6,916 | TRUE | Passed | 500 | 6,917 | 30 | 31.9 | J-128 |
| J-3 | 7,701 | TRUE | Passed | 500 | 7,702 | 30 | 35.2 | J-51 |
| J-11 | 8,115 | TRUE | Passed | 500 | 8,116 | 30 | 30.4 | J-51 |
| J-12 | 7,798 | TRUE | Passed | 500 | 7,799 | 30 | 30.4 | J-51 |
| J-13 | 4,498 | TRUE | Passed | 500 | 4,499 | 30 | 34.6 | J-51 |
| J-14 | 3,678 | TRUE | Passed | 500 | 3,679 | 30 | 40.7 | J-51 |
| J-15 | 7,211 | TRUE | Passed | 500 | 7,212 | 30 | 32.2 | J-14 |
| J-17 | 5,479 | TRUE | Passed | 500 | 5,480 | 30 | 28.1 | J-51 |
| J-18 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.6 | 42.3 | J-51 |
| J-19 | 9,107 | TRUE | Passed | 500 | 9,108 | 30 | 29.5 | J-51 |
| J-20 | 4,042 | TRUE | Passed | 500 | 4,043 | 30 | 33.6 | J-23 |
| J-21 | 4,138 | TRUE | Passed | 500 | 4,139 | 30 | 35.6 | J-20 |
| J-22 | 1,996 | TRUE | Passed | 500 | 1,997 | 30 | 43.9 | J-51 |
| J-23 | 3,663 | TRUE | Passed | 500 | 3,664 | 30 | 30.2 | J-22 |
| J-24 | 1,862 | TRUE | Passed | 500 | 1,863 | 30 | 44 | J-51 |
| J-25 | 3,238 | TRUE | Passed | 500 | 3,239 | 30 | 30.1 | J-24 |
| J-26 | 1,805 | TRUE | Passed | 500 | 1,806 | 30 | 43.9 | J-51 |
| J-27 | 3,355 | TRUE | Passed | 500 | 3,356 | 30 | 29.2 | J-26 |
| J-28 | 2,086 | TRUE | Passed | 500 | 2,087 | 30 | 43.4 | J-51 |
| J-29 | 3,655 | TRUE | Passed | 500 | 3,656 | 30 | 29.5 | J-28 |
| J-30 | 6,168 | TRUE | Passed | 500 | 6,169 | 30 | 29.7 | J-51 |
| J-31 | 2,457 | TRUE | Passed | 500 | 2,458 | 30 | 33.5 | J-33 |
| J-33 | 2,659 | TRUE | Passed | 500 | 2,660 | 30 | 31 | J-31 |
| J-34 | 2,568 | TRUE | Passed | 500 | 2,569 | 30 | 37.1 | J-51 |
| J-35 | 3,127 | TRUE | Passed | 500 | 3,128 | 30 | 28.5 | J-34 |

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|---|---|---|---|---|---|---|---|---|
| J-36 | 4,032 | TRUE | Passed | 500 | 4,033 | 30 | 26.9 | J-51 |
| J-37 | 4,551 | TRUE | Passed | 500 | 4,552 | 30 | 26.2 | J-51 |
| J-38 | 3,970 | TRUE | Passed | 500 | 3,971 | 30 | 25.9 | J-51 |
| J-39 | 3,816 | TRUE | Passed | 500 | 3,817 | 30 | 30.1 | J-51 |
| J-40 | 3,748 | TRUE | Passed | 500 | 3,749 | 30 | 30.3 | J-51 |
| J-41 | 4,052 | TRUE | Passed | 500 | 4,053 | 30 | 24.6 | J-51 |
| J-42 | 2,590 | TRUE | Passed | 500 | 2,591 | 30 | 32.1 | J-51 |
| J-43 | 3,264 | TRUE | Passed | 500 | 3,265 | 30 | 25.3 | J-51 |
| J-44 | 1,939 | TRUE | Passed | 500 | 1,940 | 30 | 37.4 | J-51 |
| J-45 | 2,053 | TRUE | Passed | 500 | 2,054 | 30 | 35.7 | J-46 |
| J-46 | 2,496 | TRUE | Passed | 500 | 2,497 | 30 | 30.3 | J-45 |
| J-47 | 1,774 | TRUE | Passed | 500 | 1,775 | 30 | 38 | J-48 |
| J-48 | 2,292 | TRUE | Passed | 500 | 2,293 | 30 | 27.2 | J-47 |
| J-49 | 2,671 | TRUE | Passed | 500 | 2,672 | 30 | 30.5 | J-50 |
| J-50 | 2,162 | TRUE | Passed | 500 | 2,163 | 30 | 36.5 | J-51 |
| J-51 | 927 | TRUE | Passed | 500 | 928 | 30 | 43.2 | J-55 |
| J-52 | 2,102 | TRUE | Passed | 500 | 2,103 | 30 | 26.6 | J-51 |
| J-53 | 1,808 | TRUE | Passed | 500 | 1,809 | 30 | 32 | J-54 |
| J-54 | 1,931 | TRUE | Passed | 500 | 1,932 | 30 | 29.5 | J-53 |
| J-55 | 1,611 | TRUE | Passed | 500 | 1,612 | 30 | 34 | J-56 |
| J-56 | 1,855 | TRUE | Passed | 500 | 1,856 | 30 | 28.7 | J-55 |
| J-57 | 1,793 | TRUE | Passed | 500 | 1,794 | 30 | 37.3 | J-51 |
| J-58 | 1,979 | TRUE | Passed | 500 | 1,980 | 30 | 31.3 | J-55 |
| J-59 | 2,183 | TRUE | Passed | 500 | 2,184 | 30 | 28.4 | J-55 |
| J-60 | 2,026 | TRUE | Passed | 500 | 2,027 | 30 | 28.6 | J-55 |
| J-61 | 2,862 | TRUE | Passed | 500 | 2,863 | 30 | 26.7 | J-51 |
| J-64 | 2,739 | TRUE | Passed | 500 | 2,740 | 30 | 26.6 | J-51 |
| J-65 | 2,860 | TRUE | Passed | 500 | 2,861 | 30 | 27.5 | J-51 |
| J-66 | 3,661 | TRUE | Passed | 500 | 3,662 | 30 | 23.5 | J-51 |
| J-67 | 3,207 | TRUE | Passed | 500 | 3,208 | 30 | 28.1 | J-51 |
| J-68 | 3,483 | TRUE | Passed | 500 | 3,484 | 30 | 25.6 | J-51 |
| J-69 | 2,214 | TRUE | Passed | 500 | 2,215 | 30 | 36.9 | J-51 |
| J-70 | 2,965 | TRUE | Passed | 500 | 2,966 | 30 | 31.2 | J-51 |
| J-71 | 2,687 | TRUE | Passed | 500 | 2,688 | 30 | 30.9 | J-72 |
| J-72 | 2,621 | TRUE | Passed | 500 | 2,622 | 30 | 33.5 | J-71 |
| J-73 | 1,105 | TRUE | Passed | 500 | 1,106 | 30 | 43 | J-51 |
| J-74 | 2,550 | TRUE | Passed | 500 | 2,551 | 30 | 31.1 | J-73 |
| J-75 | 3,778 | TRUE | Passed | 500 | 3,779 | 30 | 25.8 | J-74 |
| J-76 | 3,520 | TRUE | Passed | 500 | 3,521 | 30 | 27.1 | J-51 |
| J-77 | 3,253 | TRUE | Passed | 500 | 3,254 | 30 | 27.7 | J-51 |
| J-78 | 4,042 | TRUE | Passed | 500 | 4,043 | 30 | 23.5 | J-51 |
| J-79 | 3,328 | TRUE | Passed | 500 | 3,329 | 30 | 30 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-80 | 3,641 | TRUE | Passed | 500 | 3,642 | 30 | 28.1 | J-51 |
| J-81 | 3,786 | TRUE | Passed | 500 | 3,787 | 30 | 24.3 | J-51 |
| J-82 | 4,641 | TRUE | Passed | 500 | 4,642 | 30 | 22.3 | J-51 |
| J-83 | 4,699 | TRUE | Passed | 500 | 4,700 | 30 | 22.1 | J-51 |
| J-84 | 4,686 | TRUE | Passed | 500 | 4,687 | 30 | 21.9 | J-51 |
| J-85 | 4,259 | TRUE | Passed | 500 | 4,260 | 30 | 23.6 | J-51 |
| J-86 | 4,041 | TRUE | Passed | 500 | 4,042 | 30 | 25 | J-51 |
| J-87 | 3,726 | TRUE | Passed | 500 | 3,727 | 30 | 29.1 | J-51 |
| J-88 | 3,308 | TRUE | Passed | 500 | 3,309 | 30 | 31.7 | J-51 |
| J-89 | 3,898 | TRUE | Passed | 500 | 3,899 | 30 | 25.6 | J-51 |
| J-90 | 3,120 | TRUE | Passed | 500 | 3,122 | 30 | 29.3 | J-91 |
| J-91 | 1,602 | TRUE | Passed | 500 | 1,603 | 30 | 41.2 | J-51 |
| J-92 | 5,273 | TRUE | Passed | 500 | 5,274 | 30 | 30.5 | J-94 |
| J-93 | 3,686 | TRUE | Passed | 500 | 3,687 | 30 | 24.3 | J-51 |
| J-94 | 5,270 | TRUE | Passed | 500 | 5,271 | 30 | 30.3 | J-92 |
| J-95 | 6,453 | TRUE | Passed | 500 | 6,454 | 30 | 31.2 | J-210 |
| J-96 | 5,325 | TRUE | Passed | 500 | 5,326 | 30 | 31.5 | J-209 |
| J-97 | 5,301 | TRUE | Passed | 500 | 5,302 | 30 | 30.4 | J-92 |
| J-98 | 5,419 | TRUE | Passed | 500 | 5,420 | 30 | 28.2 | J-128 |
| J-99 | 2,574 | TRUE | Passed | 500 | 2,575 | 30 | 32.5 | J-128 |
| J-100 | 3,122 | TRUE | Passed | 500 | 3,123 | 30 | 25.6 | J-128 |
| J-101 | 2,380 | TRUE | Passed | 500 | 2,381 | 30 | 33.8 | J-128 |
| J-102 | 3,141 | TRUE | Passed | 500 | 3,142 | 30 | 23.9 | J-128 |
| J-103 | 2,794 | TRUE | Passed | 500 | 2,795 | 30 | 21.9 | J-128 |
| J-104 | 2,594 | TRUE | Passed | 500 | 2,595 | 30 | 25 | J-128 |
| J-105 | 2,606 | TRUE | Passed | 500 | 2,607 | 30 | 24.3 | J-128 |
| J-106 | 2,500 | TRUE | Passed | 500 | 2,501 | 30 | 26 | J-128 |
| J-107 | 2,686 | TRUE | Passed | 500 | 2,687 | 30 | 23.4 | J-128 |
| J-108 | 2,573 | TRUE | Passed | 500 | 2,574 | 30 | 24.7 | J-128 |
| J-109 | 2,653 | TRUE | Passed | 500 | 2,654 | 30 | 23.3 | J-128 |
| J-110 | 2,671 | TRUE | Passed | 500 | 2,672 | 30 | 23.9 | J-128 |
| J-111 | 2,471 | TRUE | Passed | 500 | 2,472 | 30 | 27.4 | J-128 |
| J-112 | 2,291 | TRUE | Passed | 500 | 2,292 | 30 | 30.6 | J-128 |
| J-113 | 2,089 | TRUE | Passed | 500 | 2,090 | 30 | 33.1 | J-128 |
| J-114 | 2,032 | TRUE | Passed | 500 | 2,033 | 30 | 32.5 | J-128 |
| J-115 | 2,227 | TRUE | Passed | 500 | 2,228 | 30 | 29.5 | J-128 |
| J-116 | 1,932 | TRUE | Passed | 500 | 1,933 | 30 | 33.3 | J-128 |
| J-117 | 2,101 | TRUE | Passed | 500 | 2,102 | 30 | 30.8 | J-128 |
| J-118 | 1,867 | TRUE | Passed | 500 | 1,868 | 30 | 40.6 | J-51 |
| J-118 | 1,953 | TRUE | Passed | 500 | 1,954 | 30 | 31.8 | J-128 |
| J-119 | 2,127 | TRUE | Passed | 500 | 2,128 | 30 | 28.9 | J-128 |
| J-121 | 1,694 | TRUE | Passed | 500 | 1,695 | 30 | 33.4 | J-128 |

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|---|---|---|---|---|---|---|---|---|
| J-122 | 1,917 | TRUE | Passed | 500 | 1,918 | 30 | 29.5 | J-128 |
| J-124 | 1,782 | TRUE | Passed | 500 | 1,783 | 30 | 28.5 | J-128 |
| J-125 | 1,432 | TRUE | Passed | 500 | 1,433 | 30 | 29.5 | J-180 |
| J-126 | 1,714 | TRUE | Passed | 500 | 1,715 | 30 | 28.8 | J-128 |
| J-127 | 1,571 | TRUE | Passed | 500 | 1,572 | 30 | 28.6 | J-128 |
| J-128 | 963 | TRUE | Passed | 500 | 964 | 30 | 42.3 | J-129 |
| J-129 | 1,554 | TRUE | Passed | 500 | 1,555 | 30 | 27.9 | J-128 |
| J-130 | 1,623 | TRUE | Passed | 500 | 1,624 | 30 | 29.7 | J-128 |
| J-133 | 1,750 | TRUE | Passed | 500 | 1,751 | 30 | 29.2 | J-128 |
| J-134 | 1,612 | TRUE | Passed | 500 | 1,613 | 30 | 32.5 | J-135 |
| J-135 | 1,724 | TRUE | Passed | 500 | 1,725 | 30 | 29 | J-134 |
| J-136 | 1,950 | TRUE | Passed | 500 | 1,951 | 30 | 26.4 | J-134 |
| J-137 | 2,038 | TRUE | Passed | 500 | 2,039 | 30 | 25.5 | J-128 |
| J-138 | 2,195 | TRUE | Passed | 500 | 2,196 | 30 | 23.7 | J-128 |
| J-139 | 2,523 | TRUE | Passed | 500 | 2,524 | 30 | 29.4 | J-128 |
| J-140 | 2,182 | TRUE | Passed | 500 | 2,183 | 30 | 32.3 | J-141 |
| J-141 | 2,288 | TRUE | Passed | 500 | 2,289 | 30 | 30.5 | J-140 |
| J-142 | 2,710 | TRUE | Passed | 500 | 2,711 | 30 | 23.3 | J-128 |
| J-143 | 2,847 | TRUE | Passed | 500 | 2,848 | 30 | 20.7 | J-128 |
| J-144 | 2,669 | TRUE | Passed | 500 | 2,670 | 30 | 22.2 | J-128 |
| J-145 | 2,256 | TRUE | Passed | 500 | 2,257 | 30 | 29.2 | J-128 |
| J-146 | 2,751 | TRUE | Passed | 500 | 2,752 | 30 | 21.5 | J-128 |
| J-147 | 2,728 | TRUE | Passed | 500 | 2,730 | 30 | 22.1 | J-128 |
| J-148 | 2,921 | TRUE | Passed | 500 | 2,922 | 30 | 19.9 | J-128 |
| J-149 | 3,191 | TRUE | Passed | 500 | 3,192 | 30 | 21.9 | J-128 |
| J-150 | 3,248 | TRUE | Passed | 500 | 3,249 | 30 | 25.2 | J-128 |
| J-151 | 2,999 | TRUE | Passed | 500 | 3,000 | 30 | 23.8 | J-128 |
| J-152 | 2,203 | TRUE | Passed | 500 | 2,204 | 30 | 38.6 | J-128 |
| J-153 | 3,517 | TRUE | Passed | 500 | 3,518 | 30 | 24.4 | J-128 |
| J-154 | 3,449 | TRUE | Passed | 500 | 3,450 | 30 | 25.6 | J-128 |
| J-155 | 2,930 | TRUE | Passed | 500 | 2,931 | 30 | 30.9 | J-196 |
| J-156 | 2,926 | TRUE | Passed | 500 | 2,927 | 30 | 37.5 | J-196 |
| J-157 | 3,131 | TRUE | Passed | 500 | 3,132 | 30 | 28.4 | J-237 |
| J-158 | 2,446 | TRUE | Passed | 500 | 2,447 | 30 | 36.6 | J-128 |
| J-159 | 3,138 | TRUE | Passed | 500 | 3,139 | 30 | 28.9 | J-163 |
| J-160 | 3,063 | TRUE | Passed | 500 | 3,064 | 30 | 28.3 | J-163 |
| J-161 | 2,966 | TRUE | Passed | 500 | 2,967 | 30 | 29.3 | J-163 |
| J-162 | 3,041 | TRUE | Passed | 500 | 3,042 | 30 | 28.3 | J-163 |
| J-163 | 2,643 | TRUE | Passed | 500 | 2,644 | 30 | 32.8 | J-169 |
| J-164 | 2,856 | TRUE | Passed | 500 | 2,857 | 30 | 30.1 | J-168 |
| J-165 | 3,019 | TRUE | Passed | 500 | 3,020 | 30 | 28.6 | J-163 |
| J-166 | 3,269 | TRUE | Passed | 500 | 3,270 | 30 | 18.8 | J-128 |

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|---|---|---|---|---|---|---|---|---|
| J-167 | 1,971 | TRUE | Passed | 500 | 1,972 | 30 | 35.2 | J-168 |
| J-168 | 2,298 | TRUE | Passed | 500 | 2,299 | 30 | 30.7 | J-167 |
| J-169 | 2,638 | TRUE | Passed | 500 | 2,639 | 30 | 31.8 | J-168 |
| J-170 | 2,960 | TRUE | Passed | 500 | 2,961 | 30 | 24.2 | J-128 |
| J-171 | 1,949 | TRUE | Passed | 500 | 1,950 | 30 | 37.3 | J-128 |
| J-172 | 2,533 | TRUE | Passed | 500 | 2,535 | 30 | 22.8 | J-128 |
| J-173 | 2,245 | TRUE | Passed | 500 | 2,246 | 30 | 27.7 | J-128 |
| J-174 | 2,307 | TRUE | Passed | 500 | 2,309 | 30 | 26.4 | J-128 |
| J-175 | 2,486 | TRUE | Passed | 500 | 2,487 | 30 | 22.5 | J-128 |
| J-176 | 2,245 | TRUE | Passed | 500 | 2,246 | 30 | 27 | J-128 |
| J-177 | 1,775 | TRUE | Passed | 500 | 1,776 | 30 | 34.6 | J-128 |
| J-178 | 2,040 | TRUE | Passed | 500 | 2,041 | 30 | 28.7 | J-179 |
| J-179 | 1,020 | TRUE | Passed | 500 | 1,021 | 30 | 43.7 | J-128 |
| J-180 | 1,041 | TRUE | Passed | 500 | 1,042 | 30 | 39.3 | J-128 |
| J-181 | 2,218 | TRUE | Passed | 500 | 2,219 | 30 | 27.5 | J-128 |
| J-183 | 8,034 | TRUE | Passed | 500 | 8,035 | 30 | 3.8 | J-689 |
| J-184 | 744 | TRUE | Passed | 500 | 745 | 30 | 45.1 | J-51 |
| J-185 | 6,538 | TRUE | Passed | 500 | 6,539 | 30 | 23.6 | J-186 |
| J-186 | 4,736 | TRUE | Passed | 500 | 4,737 | 30 | 41 | J-128 |
| J-187 | 5,001 | TRUE | Passed | 500 | 5,002 | 30 | 23.7 | J-188 |
| J-188 | 3,826 | TRUE | Passed | 500 | 3,827 | 30 | 42.6 | J-128 |
| J-189 | 4,637 | TRUE | Passed | 500 | 4,638 | 30 | 36 | J-128 |
| J-190 | 4,696 | TRUE | Passed | 500 | 4,697 | 30 | 36.2 | J-128 |
| J-191 | 4,049 | TRUE | Passed | 500 | 4,050 | 30 | 31.3 | J-192 |
| J-192 | 3,491 | TRUE | Passed | 500 | 3,492 | 30 | 37.4 | J-196 |
| J-193 | 3,363 | TRUE | Passed | 500 | 3,364 | 30 | 30.4 | J-196 |
| J-194 | 2,850 | TRUE | Passed | 500 | 2,851 | 30 | 26.7 | J-196 |
| J-195 | 2,255 | TRUE | Passed | 500 | 2,256 | 30 | 28 | J-196 |
| J-196 | 1,874 | TRUE | Passed | 500 | 1,875 | 30 | 33.9 | J-197 |
| J-197 | 2,026 | TRUE | Passed | 500 | 2,027 | 30 | 29.1 | J-196 |
| J-200 | 4,486 | TRUE | Passed | 500 | 4,487 | 30 | 30 | J-201 |
| J-201 | 3,992 | TRUE | Passed | 500 | 3,993 | 30 | 35.3 | J-200 |
| J-202 | 4,355 | TRUE | Passed | 500 | 4,356 | 30 | 31.2 | J-206 |
| J-203 | 4,336 | TRUE | Passed | 500 | 4,337 | 30 | 33.3 | J-204 |
| J-204 | 3,409 | TRUE | Passed | 500 | 3,410 | 30 | 30.5 | J-205 |
| J-205 | 2,800 | TRUE | Passed | 500 | 2,801 | 30 | 38.6 | J-204 |
| J-206 | 3,702 | TRUE | Passed | 500 | 3,703 | 30 | 31.8 | J-207 |
| J-207 | 3,099 | TRUE | Passed | 500 | 3,100 | 30 | 37.8 | J-206 |
| J-208 | 4,883 | TRUE | Passed | 500 | 4,884 | 30 | 29.9 | J-209 |
| J-209 | 3,774 | TRUE | Passed | 500 | 3,775 | 30 | 39.9 | J-128 |
| J-210 | 6,378 | TRUE | Passed | 500 | 6,379 | 30 | 32.2 | J-95 |
| J-211 | 5,628 | TRUE | Passed | 500 | 5,629 | 30 | 32.3 | J-212 |

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|---|---|---|---|---|---|---|---|---|
| J-212 | 4,517 | TRUE | Passed | 500 | 4,518 | 30 | 30.4 | J-213 |
| J-213 | 3,483 | TRUE | Passed | 500 | 3,484 | 30 | 39.8 | J-215 |
| J-214 | 2,723 | TRUE | Passed | 500 | 2,724 | 30 | 29.5 | J-215 |
| J-215 | 2,271 | TRUE | Passed | 500 | 2,272 | 30 | 38.2 | J-214 |
| J-216 | 798 | TRUE | Passed | 500 | 799 | 30 | 45 | J-51 |
| J-217 | 3,282 | TRUE | Passed | 500 | 3,283 | 30 | 29.5 | J-215 |
| J-218 | 1,836 | TRUE | Passed | 500 | 1,837 | 30 | 44.3 | J-51 |
| J-219 | 3,993 | TRUE | Passed | 500 | 3,994 | 30 | 30 | J-215 |
| J-220 | 1,917 | TRUE | Passed | 500 | 1,918 | 30 | 44.3 | J-51 |
| J-221 | 2,306 | TRUE | Passed | 500 | 2,307 | 30 | 43.9 | J-51 |
| J-222 | 4,425 | TRUE | Passed | 500 | 4,426 | 30 | 33 | J-221 |
| J-223 | 4,873 | TRUE | Passed | 500 | 4,874 | 30 | 32 | J-222 |
| J-224 | 5,704 | TRUE | Passed | 500 | 5,705 | 30 | 36.9 | J-223 |
| J-225 | 5,920 | TRUE | Passed | 500 | 5,921 | 30 | 38.7 | J-224 |
| J-226 | 7,546 | TRUE | Passed | 500 | 7,548 | 30 | 32.6 | J-334 |
| J-227 | 6,280 | TRUE | Passed | 500 | 6,281 | 30 | 23.5 | J-191 |
| J-228 | 4,790 | TRUE | Passed | 500 | 4,791 | 30 | 32.6 | J-229 |
| J-229 | 4,734 | TRUE | Passed | 500 | 4,735 | 30 | 32.7 | J-228 |
| J-230 | 2,903 | TRUE | Passed | 500 | 2,904 | 30 | 43.6 | J-51 |
| J-231 | 4,432 | TRUE | Passed | 500 | 4,433 | 30 | 31 | J-230 |
| J-232 | 4,935 | TRUE | Passed | 500 | 4,936 | 30 | 34.5 | J-231 |
| J-233 | 6,471 | TRUE | Passed | 500 | 6,472 | 30 | 27.4 | J-232 |
| J-234 | 9,745 | TRUE | Passed | 500 | 9,747 | 30 | 6 | J-689 |
| J-235 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.9 | 19.4 | J-689 |
| J-236 | 2,267 | TRUE | Passed | 500 | 2,268 | 30 | 28.7 | J-237 |
| J-237 | 1,899 | TRUE | Passed | 500 | 1,900 | 30 | 38.8 | J-236 |
| J-238 | 1,082 | TRUE | Passed | 500 | 1,083 | 30 | 44.9 | J-51 |
| J-239 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.1 | 29.2 | J-128 |
| J-240 | 9,746 | TRUE | Passed | 500 | 9,747 | 30 | 30.2 | J-51 |
| J-241 | 8,051 | TRUE | Passed | 500 | 8,052 | 30 | 35.3 | J-51 |
| J-242 | 7,818 | TRUE | Passed | 500 | 7,819 | 30 | 35.4 | J-51 |
| J-243 | 9,373 | TRUE | Passed | 500 | 9,374 | 30 | 33.9 | J-51 |
| J-244 | 5,208 | TRUE | Passed | 500 | 5,209 | 30 | 41.1 | J-51 |
| J-245 | 9,621 | TRUE | Passed | 500 | 9,622 | 30 | 34.7 | J-51 |
| J-246 | 8,868 | TRUE | Passed | 500 | 8,869 | 30 | 37.8 | J-51 |
| J-247 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.2 | 35.5 | J-51 |
| J-248 | 7,111 | TRUE | Passed | 500 | 7,112 | 30 | 33.2 | J-318 |
| J-249 | 2,426 | TRUE | Passed | 500 | 2,427 | 30 | 29.1 | J-250 |
| J-250 | 1,326 | TRUE | Passed | 500 | 1,327 | 30 | 44.9 | J-51 |
| J-251 | 7,326 | TRUE | Passed | 500 | 7,327 | 30 | 37.8 | J-253 |
| J-252 | 7,270 | TRUE | Passed | 500 | 7,271 | 30 | 38.9 | J-51 |
| J-253 | 3,138 | TRUE | Passed | 500 | 3,139 | 30 | 43.7 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-254 | 7,801 | TRUE | Passed | 500 | 7,802 | 30 | 26.5 | J-324 |
| J-255 | 7,151 | TRUE | Passed | 500 | 7,152 | 30 | 36.2 | J-51 |
| J-256 | 4,157 | TRUE | Passed | 500 | 4,158 | 30 | 41.7 | J-51 |
| J-257 | 7,120 | TRUE | Passed | 500 | 7,121 | 30 | 36.6 | J-51 |
| J-258 | 7,081 | TRUE | Passed | 500 | 7,082 | 30 | 36.5 | J-51 |
| J-259 | 4,418 | TRUE | Passed | 500 | 4,419 | 30 | 41.3 | J-51 |
| J-260 | 6,274 | TRUE | Passed | 500 | 6,275 | 30 | 33.7 | J-731 |
| J-262 | 7,175 | TRUE | Passed | 500 | 7,176 | 30 | 35.7 | J-51 |
| J-263 | 4,232 | TRUE | Passed | 500 | 4,233 | 30 | 40 | J-266 |
| J-264 | 7,647 | TRUE | Passed | 500 | 7,648 | 30 | 34.2 | J-51 |
| J-265 | 3,972 | TRUE | Passed | 500 | 3,973 | 30 | 29.5 | J-266 |
| J-266 | 2,789 | TRUE | Passed | 500 | 2,790 | 30 | 43.3 | J-51 |
| J-267 | 6,059 | TRUE | Passed | 500 | 6,060 | 30 | 32.6 | J-268 |
| J-268 | 5,316 | TRUE | Passed | 500 | 5,317 | 30 | 32.4 | 4-FLOW |
| J-269 | 6,209 | TRUE | Passed | 500 | 6,210 | 30 | 31.8 | J-267 |
| J-270 | 7,555 | TRUE | Passed | 500 | 7,556 | 30 | 32.9 | J-272 |
| J-271 | 6,465 | TRUE | Passed | 500 | 6,466 | 30 | 35.2 | J-260 |
| J-272 | 6,464 | TRUE | Passed | 500 | 6,466 | 30 | 30.4 | J-276 |
| J-273 | 4,927 | TRUE | Passed | 500 | 4,928 | 30 | 30.1 | J-274 |
| J-274 | 4,548 | TRUE | Passed | 500 | 4,549 | 30 | 34.2 | J-273 |
| J-275 | 6,112 | TRUE | Passed | 500 | 6,113 | 30 | 32.3 | J-278 |
| J-276 | 5,896 | TRUE | Passed | 500 | 5,897 | 30 | 35.2 | J-275 |
| J-277 | 5,928 | TRUE | Passed | 500 | 5,929 | 30 | 28.3 | J-278 |
| J-278 | 4,306 | TRUE | Passed | 500 | 4,307 | 30 | 38.4 | J-283 |
| J-279 | 3,871 | TRUE | Passed | 500 | 3,872 | 30 | 34 | J-281 |
| J-280 | 1,440 | TRUE | Passed | 500 | 1,441 | 30 | 44.7 | J-51 |
| J-281 | 3,174 | TRUE | Passed | 500 | 3,175 | 30 | 32.8 | J-280 |
| J-282 | 3,022 | TRUE | Passed | 500 | 3,023 | 30 | 29.9 | J-283 |
| J-283 | 2,397 | TRUE | Passed | 500 | 2,398 | 30 | 30.2 | J-285 |
| J-284 | 1,381 | TRUE | Passed | 500 | 1,382 | 30 | 44.8 | J-51 |
| J-285 | 2,028 | TRUE | Passed | 500 | 2,029 | 30 | 37.7 | J-283 |
| J-286 | 4,292 | TRUE | Passed | 500 | 4,293 | 30 | 27.1 | J-292 |
| J-287 | 3,493 | TRUE | Passed | 500 | 3,494 | 30 | 27.4 | J-292 |
| J-288 | 2,046 | TRUE | Passed | 500 | 2,047 | 30 | 35.3 | J-290 |
| J-289 | 2,308 | TRUE | Passed | 500 | 2,309 | 30 | 29.1 | J-290 |
| J-290 | 2,124 | TRUE | Passed | 500 | 2,125 | 30 | 34.4 | J-289 |
| J-291 | 1,149 | TRUE | Passed | 500 | 1,150 | 30 | 44.9 | J-51 |
| J-292 | 2,491 | TRUE | Passed | 500 | 2,492 | 30 | 33.9 | 6-FLOW |
| J-294 | 1,385 | TRUE | Passed | 500 | 1,386 | 30 | 44.3 | 6-FLOW |
| J-296 | 6,083 | TRUE | Passed | 500 | 6,085 | 30 | 30.1 | J-292 |
| J-297 | 6,242 | TRUE | Passed | 500 | 6,243 | 30 | 39.4 | J-292 |
| J-298 | 8,262 | TRUE | Passed | 500 | 8,263 | 30 | 36.3 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-299 | 9,218 | TRUE | Passed | 500 | 9,219 | 30 | 34.4 | J-51 |
| J-300 | 4,067 | TRUE | Passed | 500 | 4,068 | 30 | 29.9 | J-301 |
| J-301 | 3,280 | TRUE | Passed | 500 | 3,281 | 30 | 40 | J-300 |
| J-302 | 3,697 | TRUE | Passed | 500 | 3,698 | 30 | 30.6 | J-303 |
| J-303 | 3,043 | TRUE | Passed | 500 | 3,044 | 30 | 38.9 | J-302 |
| J-304 | 5,438 | TRUE | Passed | 500 | 5,439 | 30 | 36.1 | J-302 |
| J-305 | 5,656 | TRUE | Passed | 500 | 5,657 | 30 | 25.1 | J-306 |
| J-306 | 2,377 | TRUE | Passed | 500 | 2,378 | 30 | 44.2 | J-51 |
| J-307 | 7,631 | TRUE | Passed | 500 | 7,632 | 30 | 30.1 | J-306 |
| J-308 | 6,734 | TRUE | Passed | 500 | 6,735 | 30 | 39.2 | J-51 |
| J-309 | 3,583 | TRUE | Passed | 500 | 3,584 | 30 | 43.1 | J-51 |
| J-310 | 3,411 | TRUE | Passed | 500 | 3,412 | 30 | 43.2 | J-51 |
| J-311 | 3,881 | TRUE | Passed | 500 | 3,882 | 30 | 40.2 | J-309 |
| J-312 | 3,812 | TRUE | Passed | 500 | 3,813 | 30 | 42.8 | J-51 |
| J-313 | 4,312 | TRUE | Passed | 500 | 4,313 | 30 | 42.2 | J-51 |
| J-314 | 3,205 | TRUE | Passed | 500 | 3,206 | 30 | 43.4 | J-51 |
| J-315 | 2,588 | TRUE | Passed | 500 | 2,589 | 30 | 43.9 | J-51 |
| J-316 | 4,413 | TRUE | Passed | 500 | 4,414 | 30 | 41.8 | J-51 |
| J-317 | 3,265 | TRUE | Passed | 500 | 3,266 | 30 | 43.2 | J-51 |
| J-318 | 6,464 | TRUE | Passed | 500 | 6,465 | 30 | 34 | J-319 |
| J-319 | 6,173 | TRUE | Passed | 500 | 6,174 | 30 | 34.8 | J-321 |
| J-320 | 6,210 | TRUE | Passed | 500 | 6,211 | 30 | 34.3 | J-319 |
| J-321 | 3,230 | TRUE | Passed | 500 | 3,231 | 30 | 43.6 | J-51 |
| J-322 | 3,438 | TRUE | Passed | 500 | 3,439 | 30 | 41.8 | J-323 |
| J-323 | 3,037 | TRUE | Passed | 500 | 3,038 | 30 | 42.2 | J-250 |
| J-324 | 4,160 | TRUE | Passed | 500 | 4,161 | 30 | 41.9 | J-51 |
| J-325 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.9 | 29.1 | J-128 |
| J-326 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.6 | 29.4 | J-128 |
| J-327 | 6,774 | TRUE | Passed | 500 | 6,775 | 30 | 38.1 | J-51 |
| J-328 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.4 | 29.6 | J-128 |
| J-329 | 9,958 | TRUE | Passed | 500 | 9,959 | 30 | 28.5 | J-128 |
| J-330 | 1,708 | TRUE | Passed | 500 | 1,709 | 30 | 44.5 | J-51 |
| J-331 | 5,848 | TRUE | Passed | 500 | 5,849 | 30 | 31.6 | J-330 |
| J-332 | 6,138 | TRUE | Passed | 500 | 6,139 | 30 | 39.4 | J-51 |
| J-333 | 4,448 | TRUE | Passed | 500 | 4,449 | 30 | 41.7 | J-51 |
| J-334 | 7,580 | TRUE | Passed | 500 | 7,581 | 30 | 33.4 | J-226 |
| J-336 | 6,455 | TRUE | Passed | 500 | 6,456 | 30 | 38.1 | J-51 |
| J-338 | 7,103 | TRUE | Passed | 500 | 7,104 | 30 | 35.8 | J-339 |
| J-339 | 6,131 | TRUE | Passed | 500 | 6,132 | 30 | 35.7 | J-215 |
| J-340 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.3 | 29 | J-128 |
| J-341 | 7,329 | TRUE | Passed | 500 | 7,330 | 30 | 36.1 | J-306 |
| J-342 | 3,936 | TRUE | Passed | 500 | 3,937 | 30 | 42.7 | J-51 |

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|---|---|---|---|---|---|---|---|---|
| J-343 | 7,035 | TRUE | Passed | 500 | 7,036 | 30 | 38.5 | J-51 |
| J-345 | 4,743 | TRUE | Passed | 500 | 4,744 | 30 | 41.8 | J-51 |
| J-346 | 3,560 | TRUE | Passed | 500 | 3,561 | 30 | 43.1 | J-51 |
| J-347 | 10,000 | TRUE | Passed | 500 | 10,001 | 47 | 30.5 | J-128 |
| J-348 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.7 | 30.7 | J-128 |
| J-349 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.8 | 30.7 | J-128 |
| J-350 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.9 | 30.7 | J-128 |
| J-351 | 8,308 | TRUE | Passed | 500 | 8,309 | 30 | 35.7 | J-128 |
| J-352 | 8,571 | TRUE | Passed | 500 | 8,572 | 30 | 34.9 | J-128 |
| J-353 | 9,124 | TRUE | Passed | 500 | 9,125 | 30 | 33.2 | J-128 |
| J-354 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.9 | 31.6 | J-128 |
| J-355 | 8,524 | TRUE | Passed | 500 | 8,525 | 30 | 35.7 | J-51 |
| J-356 | 8,009 | TRUE | Passed | 500 | 8,010 | 30 | 35.1 | J-365 |
| J-357 | 10,000 | TRUE | Passed | 500 | 10,001 | 44 | 29.9 | J-128 |
| J-358 | 9,996 | TRUE | Passed | 500 | 9,997 | 30 | 32 | J-128 |
| J-359 | 9,731 | TRUE | Passed | 500 | 9,732 | 30 | 26.7 | J-360 |
| J-360 | 1,495 | TRUE | Passed | 500 | 1,497 | 30 | 44.7 | J-51 |
| J-361 | 8,184 | TRUE | Passed | 500 | 8,185 | 30 | 36.4 | J-51 |
| J-362 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.1 | 30.9 | J-128 |
| J-363 | 7,733 | TRUE | Passed | 500 | 7,734 | 30 | 37.2 | J-51 |
| J-364 | 6,891 | TRUE | Passed | 500 | 6,892 | 30 | 38.4 | J-366 |
| J-365 | 7,282 | TRUE | Passed | 500 | 7,283 | 30 | 37.9 | J-51 |
| J-366 | 6,748 | TRUE | Passed | 500 | 6,749 | 30 | 38 | J-364 |
| J-367 | 8,316 | TRUE | Passed | 500 | 8,317 | 30 | 35.9 | J-128 |
| J-368 | 5,736 | TRUE | Passed | 500 | 5,737 | 30 | 40.5 | J-51 |
| J-369 | 8,395 | TRUE | Passed | 500 | 8,396 | 30 | 36.2 | J-51 |
| J-370 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.5 | 31.7 | J-360 |
| J-371 | 2,090 | TRUE | Passed | 500 | 2,091 | 30 | 28.7 | J-128 |
| J-371 | 10,000 | TRUE | Passed | 500 | 10,001 | 31 | 31.8 | J-128 |
| J-372 | 6,792 | TRUE | Passed | 500 | 6,793 | 30 | 38.9 | J-51 |
| J-373 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.6 | 31.1 | J-128 |
| J-374 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.8 | 31.2 | J-128 |
| J-375 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.2 | 31.2 | J-128 |
| J-376 | 7,734 | TRUE | Passed | 500 | 7,735 | 30 | 37.4 | J-51 |
| J-377 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.9 | 31.2 | J-128 |
| J-378 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.2 | 31.4 | J-128 |
| J-379 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.5 | 31.3 | J-128 |
| J-380 | 6,475 | TRUE | Passed | 500 | 6,476 | 30 | 39.6 | J-51 |
| J-382 | 6,990 | TRUE | Passed | 500 | 6,991 | 30 | 38.7 | J-51 |
| J-383 | 6,417 | TRUE | Passed | 500 | 6,418 | 30 | 39.6 | J-51 |
| J-384 | 6,705 | TRUE | Passed | 500 | 6,706 | 30 | 39.4 | J-51 |
| J-385 | 8,849 | TRUE | Passed | 500 | 8,850 | 30 | 35.5 | J-128 |

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|---|---|---|---|---|---|---|---|---|
| J-386 | 9,526 | TRUE | Passed | 500 | 9,527 | 30 | 33.3 | J-128 |
| J-387 | 8,172 | TRUE | Passed | 500 | 8,173 | 30 | 35.7 | J-388 |
| J-388 | 6,138 | TRUE | Passed | 500 | 6,139 | 30 | 40 | J-51 |
| J-389 | 4,852 | TRUE | Passed | 500 | 4,853 | 30 | 33.8 | J-390 |
| J-390 | 1,827 | TRUE | Passed | 500 | 1,828 | 30 | 44.5 | J-51 |
| J-391 | 6,535 | TRUE | Passed | 500 | 6,536 | 30 | 39.3 | J-51 |
| J-392 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.9 | 31.4 | J-128 |
| J-393 | 7,374 | TRUE | Passed | 500 | 7,375 | 30 | 37.9 | J-430 |
| J-394 | 8,680 | TRUE | Passed | 500 | 8,681 | 30 | 28.6 | J-424 |
| J-395 | 8,858 | TRUE | Passed | 500 | 8,859 | 30 | 26.3 | J-425 |
| J-396 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.7 | 31.5 | J-128 |
| J-397 | 5,972 | TRUE | Passed | 500 | 5,973 | 30 | 27.8 | J-398 |
| J-398 | 1,618 | TRUE | Passed | 500 | 1,619 | 30 | 44.7 | J-51 |
| J-399 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.6 | 30.7 | J-128 |
| J-401 | 1,629 | TRUE | Passed | 500 | 1,630 | 30 | 28.4 | J-128 |
| J-401 | 10,000 | TRUE | Passed | 500 | 10,001 | 62.4 | 33 | J-128 |
| J-402 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 32.9 | J-128 |
| J-403 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.9 | 33.2 | J-128 |
| J-404 | 9,673 | TRUE | Passed | 500 | 9,674 | 30 | 36.9 | J-128 |
| J-405 | 4,503 | TRUE | Passed | 500 | 4,504 | 30 | 42.8 | J-51 |
| J-406 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.6 | 32.4 | J-128 |
| J-407 | 10,000 | TRUE | Passed | 500 | 10,001 | 65 | 32.4 | J-128 |
| J-408 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.4 | 31.7 | J-128 |
| J-409 | 3,339 | TRUE | Passed | 500 | 3,340 | 30 | 43.4 | J-51 |
| J-410 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.8 | 31.7 | J-128 |
| J-411 | 3,408 | TRUE | Passed | 500 | 3,409 | 30 | 43.4 | J-51 |
| J-412 | 10,000 | TRUE | Passed | 500 | 10,001 | 56.5 | 31.7 | J-128 |
| J-413 | 10,000 | TRUE | Passed | 500 | 10,001 | 62.5 | 31.1 | J-128 |
| J-414 | 10,000 | TRUE | Passed | 500 | 10,001 | 54.9 | 27.9 | J-128 |
| J-415 | 1,920 | TRUE | Passed | 500 | 1,921 | 30 | 44.5 | J-51 |
| J-416 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.2 | 31.2 | J-128 |
| J-417 | 10,000 | TRUE | Passed | 500 | 10,001 | 55.6 | 31.6 | J-128 |
| J-418 | 5,278 | TRUE | Passed | 500 | 5,279 | 30 | 29.9 | J-419 |
| J-419 | 3,350 | TRUE | Passed | 500 | 3,351 | 30 | 43.5 | J-51 |
| J-420 | 10,000 | TRUE | Passed | 500 | 10,001 | 36 | 33.3 | J-421 |
| J-421 | 8,880 | TRUE | Passed | 500 | 8,881 | 30 | 31.8 | J-423 |
| J-422 | 6,481 | TRUE | Passed | 500 | 6,482 | 30 | 40 | J-51 |
| J-423 | 8,733 | TRUE | Passed | 500 | 8,734 | 30 | 32.8 | J-422 |
| J-424 | 4,541 | TRUE | Passed | 500 | 4,542 | 30 | 42.3 | J-51 |
| J-425 | 3,903 | TRUE | Passed | 500 | 3,904 | 30 | 42.9 | J-51 |
| J-426 | 8,996 | TRUE | Passed | 500 | 8,997 | 30 | 23.7 | J-425 |
| J-427 | 7,428 | TRUE | Passed | 500 | 7,429 | 30 | 34.1 | J-424 |

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|---|---|---|---|---|---|---|---|---|
| J-428 | 8,821 | TRUE | Passed | 500 | 8,822 | 30 | 34.8 | J-423 |
| J-429 | 8,792 | TRUE | Passed | 500 | 8,793 | 30 | 34.9 | J-428 |
| J-430 | 3,756 | TRUE | Passed | 500 | 3,757 | 30 | 43.1 | J-51 |
| J-431 | 6,894 | TRUE | Passed | 500 | 6,895 | 30 | 30.9 | J-432 |
| J-432 | 2,187 | TRUE | Passed | 500 | 2,188 | 30 | 44.3 | J-51 |
| J-433 | 3,384 | TRUE | Passed | 500 | 3,385 | 30 | 30 | J-237 |
| J-434 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 45 | J-51 |
| J-435 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 45 | J-51 |
| J-436 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.8 | 44.7 | J-51 |
| J-437 | 8,324 | TRUE | Passed | 500 | 8,325 | 30 | 44.5 | J-51 |
| J-439 | 6,583 | TRUE | Passed | 500 | 6,584 | 30 | 31.7 | J-719 |
| J-440 | 6,474 | TRUE | Passed | 500 | 6,475 | 30 | 32.1 | J-1780 |
| J-442 | 7,529 | TRUE | Passed | 500 | 7,530 | 30 | 27.5 | J-443 |
| J-443 | 2,062 | TRUE | Passed | 500 | 2,063 | 30 | 45.1 | J-51 |
| J-445 | 8,716 | TRUE | Passed | 500 | 8,717 | 30 | 30.8 | J-455 |
| J-447 | 5,984 | TRUE | Passed | 500 | 5,985 | 30 | 27.1 | J-450 |
| J-448 | 4,776 | TRUE | Passed | 500 | 4,777 | 30 | 39.8 | J-450 |
| J-449 | 5,678 | TRUE | Passed | 500 | 5,679 | 30 | 23.5 | J-450 |
| J-450 | 3,876 | TRUE | Passed | 500 | 3,877 | 30 | 44.6 | J-51 |
| J-451 | 5,476 | TRUE | Passed | 500 | 5,477 | 30 | 35 | J-452 |
| J-452 | 4,989 | TRUE | Passed | 500 | 4,990 | 30 | 31.8 | J-458 |
| J-453 | 4,641 | TRUE | Passed | 500 | 4,642 | 30 | 39.8 | J-454 |
| J-454 | 4,467 | TRUE | Passed | 500 | 4,469 | 30 | 42.9 | J-453 |
| J-455 | 5,948 | TRUE | Passed | 500 | 5,949 | 30 | 38.1 | J-454 |
| J-456 | 6,000 | TRUE | Passed | 500 | 6,001 | 30 | 37.1 | J-455 |
| J-457 | 4,779 | TRUE | Passed | 500 | 4,780 | 30 | 39.9 | J-452 |
| J-458 | 2,782 | TRUE | Passed | 500 | 2,783 | 30 | 44.8 | J-51 |
| J-459 | 2,708 | TRUE | Passed | 500 | 2,709 | 30 | 33.4 | J-463 |
| J-460 | 3,719 | TRUE | Passed | 500 | 3,720 | 30 | 33.5 | J-459 |
| J-461 | 1,536 | TRUE | Passed | 500 | 1,537 | 30 | 29.4 | J-463 |
| J-462 | 1,351 | TRUE | Passed | 500 | 1,352 | 30 | 37.4 | J-463 |
| J-463 | 1,236 | TRUE | Passed | 500 | 1,237 | 30 | 42.5 | J-461 |
| J-464 | 4,840 | TRUE | Passed | 500 | 4,841 | 30 | 38.1 | J-457 |
| J-465 | 4,994 | TRUE | Passed | 500 | 4,995 | 30 | 36.4 | J-464 |
| J-466 | 5,288 | TRUE | Passed | 500 | 5,289 | 30 | 37.6 | J-465 |
| J-467 | 5,959 | TRUE | Passed | 500 | 5,960 | 30 | 29 | J-460 |
| J-468 | 5,886 | TRUE | Passed | 500 | 5,887 | 30 | 33.5 | J-459 |
| J-469 | 6,429 | TRUE | Passed | 500 | 6,430 | 30 | 35.4 | J-474 |
| J-470 | 7,670 | TRUE | Passed | 500 | 7,671 | 30 | 42.2 | J-51 |
| J-471 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.2 | 34.3 | J-556 |
| J-472 | 6,535 | TRUE | Passed | 500 | 6,536 | 30 | 40.8 | J-473 |
| J-473 | 6,000 | TRUE | Passed | 500 | 6,001 | 30 | 36.6 | J-475 |

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|---|---|---|---|---|---|---|---|---|
| J-474 | 5,590 | TRUE | Passed | 500 | 5,591 | 30 | 43.7 | J-51 |
| J-475 | 5,160 | TRUE | Passed | 500 | 5,161 | 30 | 40.9 | J-478 |
| J-476 | 2,203 | TRUE | Passed | 500 | 2,204 | 30 | 41.3 | J-477 |
| J-477 | 2,232 | TRUE | Passed | 500 | 2,233 | 30 | 39.1 | J-476 |
| J-478 | 5,114 | TRUE | Passed | 500 | 5,115 | 30 | 39.5 | J-475 |
| J-479 | 5,254 | TRUE | Passed | 500 | 5,255 | 30 | 39.6 | J-478 |
| J-480 | 5,580 | TRUE | Passed | 500 | 5,581 | 30 | 37.7 | J-479 |
| J-481 | 5,922 | TRUE | Passed | 500 | 5,923 | 30 | 35.7 | J-480 |
| J-482 | 3,081 | TRUE | Passed | 500 | 3,082 | 30 | 25.8 | J-485 |
| J-483 | 1,896 | TRUE | Passed | 500 | 1,897 | 30 | 28.8 | J-485 |
| J-484 | 1,743 | TRUE | Passed | 500 | 1,744 | 30 | 34.1 | J-485 |
| J-485 | 1,415 | TRUE | Passed | 500 | 1,416 | 30 | 45.1 | J-51 |
| J-486 | 8,886 | TRUE | Passed | 500 | 8,887 | 30 | 41.1 | 1-FLOW |
| J-487 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.4 | 43.1 | J-51 |
| J-489 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.8 | 44.2 | J-51 |
| J-490 | 10,000 | TRUE | Passed | 500 | 10,001 | 36 | 38.5 | J-437 |
| J-491 | 10,000 | TRUE | Passed | 500 | 10,001 | 63 | 45.1 | J-51 |
| J-492 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.3 | 43.4 | J-51 |
| J-493 | 9,464 | TRUE | Passed | 500 | 9,465 | 30 | 36.5 | J-494 |
| J-494 | 9,583 | TRUE | Passed | 500 | 9,584 | 30 | 35.2 | J-493 |
| J-497 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.8 | 41.4 | J-51 |
| J-498 | 10,000 | TRUE | Passed | 500 | 10,001 | 47 | 42.5 | J-51 |
| J-499 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.1 | 39.2 | J-500 |
| J-500 | 6,438 | TRUE | Passed | 500 | 6,439 | 30 | 43.9 | J-51 |
| J-501 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.8 | 41.6 | J-508 |
| J-502 | 5,933 | TRUE | Passed | 500 | 5,934 | 30 | 32.2 | J-554 |
| J-504 | 4,843 | TRUE | Passed | 500 | 4,844 | 30 | 33.9 | J-707 |
| J-505 | 4,122 | TRUE | Passed | 500 | 4,123 | 30 | 44.4 | J-51 |
| J-507 | 4,120 | TRUE | Passed | 500 | 4,121 | 30 | 33 | J-508 |
| J-508 | 4,119 | TRUE | Passed | 500 | 4,120 | 30 | 34 | J-507 |
| J-509 | 4,844 | TRUE | Passed | 500 | 4,845 | 30 | 30.7 | J-508 |
| J-510 | 5,519 | TRUE | Passed | 500 | 5,520 | 30 | 32.6 | J-513 |
| J-511 | 2,211 | TRUE | Passed | 500 | 2,212 | 30 | 37.8 | J-513 |
| J-513 | 2,253 | TRUE | Passed | 500 | 2,254 | 30 | 37.5 | J-514 |
| J-514 | 2,545 | TRUE | Passed | 500 | 2,546 | 30 | 29.3 | J-513 |
| J-516 | 4,807 | TRUE | Passed | 500 | 4,808 | 30 | 38 | J-508 |
| J-517 | 5,257 | TRUE | Passed | 500 | 5,258 | 30 | 30.2 | J-549 |
| J-518 | 4,780 | TRUE | Passed | 500 | 4,781 | 30 | 26.2 | J-549 |
| J-519 | 5,138 | TRUE | Passed | 500 | 5,139 | 30 | 29.6 | J-508 |
| J-520 | 4,833 | TRUE | Passed | 500 | 4,834 | 30 | 34.4 | J-526 |
| J-521 | 4,082 | TRUE | Passed | 500 | 4,083 | 30 | 38.8 | J-603 |
| J-522 | 4,308 | TRUE | Passed | 500 | 4,309 | 30 | 27.5 | J-603 |

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|---|---|---|---|---|---|---|---|---|
| J-523 | 4,869 | TRUE | Passed | 500 | 4,870 | 30 | 27.8 | J-603 |
| J-524 | 4,592 | TRUE | Passed | 500 | 4,593 | 30 | 31 | J-521 |
| J-525 | 5,022 | TRUE | Passed | 500 | 5,023 | 30 | 33.8 | J-521 |
| J-526 | 4,775 | TRUE | Passed | 500 | 4,776 | 30 | 35.8 | J-520 |
| J-527 | 4,969 | TRUE | Passed | 500 | 4,970 | 30 | 34.6 | J-528 |
| J-528 | 4,605 | TRUE | Passed | 500 | 4,606 | 30 | 37.8 | J-610 |
| J-529 | 4,710 | TRUE | Passed | 500 | 4,711 | 30 | 39.3 | J-613 |
| J-530 | 4,728 | TRUE | Passed | 500 | 4,729 | 30 | 41.2 | J-529 |
| J-531 | 2,798 | TRUE | Passed | 500 | 2,799 | 30 | 44.5 | J-51 |
| J-532 | 3,038 | TRUE | Passed | 500 | 3,039 | 30 | 44.5 | J-51 |
| J-533 | 8,168 | TRUE | Passed | 500 | 8,169 | 30 | 34.7 | J-616 |
| J-534 | 8,765 | TRUE | Passed | 500 | 8,766 | 30 | 29.7 | J-535 |
| J-535 | 8,115 | TRUE | Passed | 500 | 8,116 | 30 | 30.9 | J-536 |
| J-536 | 7,277 | TRUE | Passed | 500 | 7,278 | 30 | 36.8 | J-535 |
| J-537 | 8,322 | TRUE | Passed | 500 | 8,323 | 30 | 35.7 | J-647 |
| J-538 | 8,816 | TRUE | Passed | 500 | 8,817 | 30 | 37 | J-648 |
| J-539 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.3 | 31.4 | J-538 |
| J-540 | 2,916 | TRUE | Passed | 500 | 2,917 | 30 | 42.5 | J-648 |
| J-541 | 3,153 | TRUE | Passed | 500 | 3,154 | 30 | 44.3 | J-51 |
| J-542 | 6,304 | TRUE | Passed | 500 | 6,305 | 30 | 41 | J-644 |
| J-543 | 8,529 | TRUE | Passed | 500 | 8,530 | 30 | 35 | J-542 |
| J-544 | 9,530 | TRUE | Passed | 500 | 9,531 | 30 | 33.8 | J-546 |
| J-545 | 5,232 | TRUE | Passed | 500 | 5,233 | 30 | 29.6 | J-546 |
| J-546 | 2,022 | TRUE | Passed | 500 | 2,023 | 30 | 44.9 | J-51 |
| J-547 | 4,903 | TRUE | Passed | 500 | 4,904 | 30 | 30.7 | J-548 |
| J-548 | 1,755 | TRUE | Passed | 500 | 1,756 | 30 | 45 | J-51 |
| J-549 | 1,604 | TRUE | Passed | 500 | 1,605 | 30 | 45 | J-51 |
| J-550 | 4,233 | TRUE | Passed | 500 | 4,234 | 30 | 29.7 | J-552 |
| J-551 | 2,825 | TRUE | Passed | 500 | 2,826 | 30 | 44.7 | J-51 |
| J-552 | 2,276 | TRUE | Passed | 500 | 2,277 | 30 | 44.9 | J-51 |
| J-553 | 4,292 | TRUE | Passed | 500 | 4,293 | 30 | 29.9 | J-554 |
| J-554 | 2,593 | TRUE | Passed | 500 | 2,594 | 30 | 44.9 | J-51 |
| J-555 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.1 | 32.7 | J-556 |
| J-556 | 3,867 | TRUE | Passed | 500 | 3,868 | 30 | 44.2 | J-51 |
| J-557 | 3,427 | TRUE | Passed | 500 | 3,428 | 30 | 30.9 | J-558 |
| J-558 | 1,747 | TRUE | Passed | 500 | 1,748 | 30 | 45 | J-51 |
| J-559 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.5 | 37.2 | J-557 |
| J-560 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.2 | 41.2 | J-51 |
| J-561 | 3,556 | TRUE | Passed | 500 | 3,557 | 30 | 44.2 | J-51 |
| J-562 | 10,000 | TRUE | Passed | 500 | 10,001 | 31 | 34.9 | J-556 |
| J-563 | 2,732 | TRUE | Passed | 500 | 2,733 | 30 | 44.5 | J-51 |
| J-564 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.6 | 34.6 | J-563 |

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|---|---|---|---|---|---|---|---|---|
| J-565 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.3 | 37.9 | J-556 |
| J-566 | 7,772 | TRUE | Passed | 500 | 7,773 | 30 | 41.2 | J-51 |
| J-567 | 9,726 | TRUE | Passed | 500 | 9,727 | 30 | 36.7 | J-578 |
| J-568 | 8,576 | TRUE | Passed | 500 | 8,577 | 30 | 37.1 | J-574 |
| J-569 | 7,099 | TRUE | Passed | 500 | 7,100 | 30 | 37.9 | J-570 |
| J-570 | 6,469 | TRUE | Passed | 500 | 6,470 | 30 | 42 | J-51 |
| J-571 | 6,875 | TRUE | Passed | 500 | 6,876 | 30 | 39 | J-574 |
| J-572 | 8,285 | TRUE | Passed | 500 | 8,286 | 30 | 19.8 | J-574 |
| J-573 | 4,634 | TRUE | Passed | 500 | 4,635 | 30 | 43.3 | J-51 |
| J-574 | 7,335 | TRUE | Passed | 500 | 7,336 | 30 | 33.1 | J-571 |
| J-576 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.4 | 35.6 | J-568 |
| J-577 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.2 | 34.7 | J-578 |
| J-578 | 3,048 | TRUE | Passed | 500 | 3,049 | 30 | 44.3 | J-51 |
| J-579 | 4,059 | TRUE | Passed | 500 | 4,060 | 30 | 43.8 | J-51 |
| J-580 | 4,137 | TRUE | Passed | 500 | 4,138 | 30 | 43.8 | J-51 |
| J-581 | 3,913 | TRUE | Passed | 500 | 3,914 | 30 | 43.8 | J-51 |
| J-582 | 6,161 | TRUE | Passed | 500 | 6,162 | 30 | 38.9 | J-581 |
| J-583 | 6,733 | TRUE | Passed | 500 | 6,734 | 30 | 41.5 | J-51 |
| J-584 | 7,665 | TRUE | Passed | 500 | 7,666 | 30 | 36.8 | J-585 |
| J-585 | 5,848 | TRUE | Passed | 500 | 5,849 | 30 | 38.6 | J-587 |
| J-587 | 5,417 | TRUE | Passed | 500 | 5,418 | 30 | 38.1 | J-588 |
| J-588 | 5,056 | TRUE | Passed | 500 | 5,057 | 30 | 42.8 | J-51 |
| J-589 | 5,231 | TRUE | Passed | 500 | 5,232 | 30 | 38.6 | J-588 |
| J-590 | 6,705 | TRUE | Passed | 500 | 6,706 | 30 | 28.6 | J-591 |
| J-591 | 6,128 | TRUE | Passed | 500 | 6,129 | 30 | 36.1 | J-590 |
| J-592 | 6,232 | TRUE | Passed | 500 | 6,233 | 30 | 37.4 | J-614 |
| J-593 | 4,798 | TRUE | Passed | 500 | 4,799 | 30 | 38.8 | J-613 |
| J-594 | 5,075 | TRUE | Passed | 500 | 5,076 | 30 | 27.9 | J-596 |
| J-595 | 3,977 | TRUE | Passed | 500 | 3,978 | 30 | 28 | J-596 |
| J-596 | 3,273 | TRUE | Passed | 500 | 3,274 | 30 | 36.2 | J-597 |
| J-597 | 3,444 | TRUE | Passed | 500 | 3,445 | 30 | 32.1 | J-596 |
| J-598 | 3,616 | TRUE | Passed | 500 | 3,617 | 30 | 32.4 | J-597 |
| J-599 | 4,428 | TRUE | Passed | 500 | 4,429 | 30 | 35.6 | J-596 |
| J-601 | 3,786 | TRUE | Passed | 500 | 3,787 | 30 | 41.1 | J-708 |
| J-602 | 5,036 | TRUE | Passed | 500 | 5,037 | 30 | 32.3 | J-521 |
| J-603 | 2,250 | TRUE | Passed | 500 | 2,251 | 30 | 44.8 | J-51 |
| J-604 | 5,126 | TRUE | Passed | 500 | 5,127 | 30 | 33.9 | J-596 |
| J-605 | 3,489 | TRUE | Passed | 500 | 3,490 | 30 | 32.4 | J-596 |
| J-606 | 3,632 | TRUE | Passed | 500 | 3,633 | 30 | 30.8 | J-596 |
| J-607 | 4,759 | TRUE | Passed | 500 | 4,760 | 30 | 34.8 | J-596 |
| J-608 | 4,894 | TRUE | Passed | 500 | 4,895 | 30 | 35.5 | J-596 |
| J-609 | 4,932 | TRUE | Passed | 500 | 4,933 | 30 | 34.4 | J-610 |

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|---|---|---|---|---|---|---|---|---|
| J-610 | 4,736 | TRUE | Passed | 500 | 4,737 | 30 | 36.6 | J-528 |
| J-611 | 5,234 | TRUE | Passed | 500 | 5,235 | 30 | 31.2 | J-612 |
| J-612 | 4,419 | TRUE | Passed | 500 | 4,420 | 30 | 39.8 | J-610 |
| J-613 | 4,388 | TRUE | Passed | 500 | 4,389 | 30 | 42.1 | J-593 |
| J-614 | 6,493 | TRUE | Passed | 500 | 6,494 | 30 | 35.1 | J-615 |
| J-615 | 6,800 | TRUE | Passed | 500 | 6,801 | 30 | 30.9 | J-614 |
| J-616 | 6,917 | TRUE | Passed | 500 | 6,918 | 30 | 32.8 | J-615 |
| J-617 | 6,377 | TRUE | Passed | 500 | 6,378 | 30 | 40.5 | 3-FLOW |
| J-620 | 7,340 | TRUE | Passed | 500 | 7,341 | 30 | 28.9 | J-617 |
| J-621 | 8,987 | TRUE | Passed | 500 | 8,988 | 30 | 29 | J-617 |
| J-622 | 8,590 | TRUE | Passed | 500 | 8,591 | 30 | 33.2 | J-626 |
| J-623 | 8,736 | TRUE | Passed | 500 | 8,737 | 30 | 35.1 | J-617 |
| J-625 | 9,669 | TRUE | Passed | 500 | 9,670 | 30 | 28.8 | J-623 |
| J-626 | 8,404 | TRUE | Passed | 500 | 8,405 | 30 | 33.4 | J-627 |
| J-627 | 8,326 | TRUE | Passed | 500 | 8,328 | 30 | 35 | J-628 |
| J-628 | 8,531 | TRUE | Passed | 500 | 8,532 | 30 | 33.7 | J-627 |
| J-629 | 9,005 | TRUE | Passed | 500 | 9,006 | 30 | 31.7 | J-628 |
| J-630 | 9,202 | TRUE | Passed | 500 | 9,203 | 30 | 32.2 | J-629 |
| J-631 | 9,214 | TRUE | Passed | 500 | 9,215 | 30 | 36.3 | J-630 |
| J-632 | 4,893 | TRUE | Passed | 500 | 4,894 | 30 | 30 | J-633 |
| J-633 | 2,931 | TRUE | Passed | 500 | 2,932 | 30 | 44.2 | J-51 |
| J-634 | 7,567 | TRUE | Passed | 500 | 7,568 | 30 | 30.3 | J-633 |
| J-636 | 9,834 | TRUE | Passed | 500 | 9,835 | 30 | 33.6 | J-631 |
| J-637 | 3,584 | TRUE | Passed | 500 | 3,585 | 30 | 43.9 | J-51 |
| J-638 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.7 | 35.2 | J-539 |
| J-639 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.5 | 37.8 | J-51 |
| J-640 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.6 | 36.9 | J-641 |
| J-641 | 5,231 | TRUE | Passed | 500 | 5,232 | 30 | 42.9 | J-51 |
| J-642 | 3,811 | TRUE | Passed | 500 | 3,812 | 30 | 43.9 | J-51 |
| J-643 | 2,916 | TRUE | Passed | 500 | 2,917 | 30 | 44.4 | J-51 |
| J-644 | 5,016 | TRUE | Passed | 500 | 5,017 | 30 | 37.4 | J-645 |
| J-645 | 2,534 | TRUE | Passed | 500 | 2,535 | 30 | 44.6 | J-51 |
| J-646 | 7,002 | TRUE | Passed | 500 | 7,003 | 30 | 39.2 | J-648 |
| J-647 | 4,566 | TRUE | Passed | 500 | 4,567 | 30 | 43.5 | J-51 |
| J-648 | 2,765 | TRUE | Passed | 500 | 2,766 | 30 | 44.5 | J-51 |
| J-649 | 3,486 | TRUE | Passed | 500 | 3,487 | 30 | 29.8 | J-650 |
| J-650 | 1,758 | TRUE | Passed | 500 | 1,759 | 30 | 44.9 | J-51 |
| J-651 | 7,438 | TRUE | Passed | 500 | 7,439 | 30 | 29.4 | J-652 |
| J-652 | 2,872 | TRUE | Passed | 500 | 2,873 | 30 | 44.5 | J-51 |
| J-655 | 6,996 | TRUE | Passed | 500 | 6,997 | 30 | 31.6 | J-656 |
| J-656 | 3,367 | TRUE | Passed | 500 | 3,369 | 30 | 44.2 | J-51 |
| J-657 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.4 | 36.5 | J-128 |

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|---|---|---|---|---|---|---|---|---|
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.6 | 32.8 | J-568 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.7 | 36.4 | J-128 |
| J-660 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.1 | 36.2 | J-128 |
| J-661 | 798 | TRUE | Passed | 500 | 803 | 30 | 45.1 | J-51 |
| J-662 | 10,000 | TRUE | Passed | 500 | 10,001 | 52.7 | 35.1 | J-128 |
| J-663 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.8 | 36 | J-128 |
| J-664 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.9 | 37.3 | J-128 |
| J-665 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.4 | 37.7 | J-51 |
| J-666 | 10,000 | TRUE | Passed | 500 | 10,001 | 41 | 38.4 | J-51 |
| J-667 | 9,292 | TRUE | Passed | 500 | 9,293 | 30 | 34.6 | J-51 |
| J-668 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.7 | 40.5 | J-51 |
| J-669 | 4,035 | TRUE | Passed | 500 | 4,036 | 30 | 40.7 | J-21 |
| J-670 | 4,588 | TRUE | Passed | 500 | 4,589 | 30 | 33.8 | J-21 |
| J-673 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.2 | 37.1 | J-128 |
| J-674 | 4,074 | TRUE | Passed | 500 | 4,075 | 30 | 43.5 | J-51 |
| J-675 | 3,800 | TRUE | Passed | 500 | 3,801 | 30 | 43.1 | J-51 |
| J-676 | 5,344 | TRUE | Passed | 500 | 5,345 | 30 | 31 | J-675 |
| J-677 | 2,324 | TRUE | Passed | 500 | 2,325 | 30 | 29.3 | J-678 |
| J-678 | 1,736 | TRUE | Passed | 500 | 1,737 | 30 | 44.6 | J-51 |
| J-680 | 2,925 | TRUE | Passed | 500 | 2,925 | 30 | 24.2 | J-128 |
| J-682 | 2,571 | TRUE | Passed | 500 | 2,571 | 30 | 24.9 | J-128 |
| J-689 | 2,306 | TRUE | Passed | 500 | 2,331 | 30 | 44.2 | J-51 |
| J-696 | 2,673 | TRUE | Passed | 500 | 2,678 | 30 | 29.2 | J-51 |
| J-697 | 2,601 | TRUE | Passed | 500 | 2,601 | 30 | 22.5 | J-128 |
| J-707 | 4,613 | TRUE | Passed | 500 | 4,613 | 30 | 35.4 | J-708 |
| J-708 | 4,344 | TRUE | Passed | 500 | 4,344 | 30 | 34.7 | J-1549 |
| J-719 | 4,428 | TRUE | Passed | 500 | 4,428 | 30 | 39.7 | J-724 |
| J-724 | 4,266 | TRUE | Passed | 500 | 4,266 | 30 | 34.1 | J-1780 |
| J-726 | 5,293 | TRUE | Passed | 500 | 5,293 | 30 | 35.9 | J-1334 |
| J-727 | 7,584 | TRUE | Passed | 500 | 7,584 | 30 | 44.7 | J-51 |
| J-731 | 5,515 | TRUE | Passed | 500 | 5,516 | 30 | 39.4 | J-51 |
| J-904 | 6,539 | TRUE | Passed | 500 | 6,540 | 30 | 38.1 | J-51 |
| J-1031 | 9,015 | TRUE | Passed | 500 | 9,016 | 30 | 34.8 | J-128 |
| J-1082 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.6 | 34.7 | J-128 |
| J-1184 | 9,002 | TRUE | Passed | 500 | 9,003 | 30 | 37.6 | J-439 |
| J-1201 | 7,851 | TRUE | Passed | 500 | 7,852 | 30 | 26.1 | J-455 |
| J-1296 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.6 | 43.3 | J-51 |
| J-1334 | 5,303 | TRUE | Passed | 500 | 5,304 | 30 | 33.7 | J-504 |
| J-1340 | 3,808 | TRUE | Passed | 500 | 3,809 | 30 | 39.2 | J-508 |
| J-1549 | 4,627 | TRUE | Passed | 500 | 4,628 | 30 | 28.4 | J-708 |
| J-1642 | 8,473 | TRUE | Passed | 500 | 8,474 | 30 | 39.4 | J-51 |
| J-1704 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.5 | 35.8 | J-568 |

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|---|---|---|---|---|---|---|---|---|
| J-1780 | 4,346 | TRUE | Passed | 500 | 4,346 | 30 | 32.4 | J-724 |
| J-1806 | 2,255 | TRUE | Passed | 500 | 2,255 | 30 | 32.6 | J-128 |
| **Scenario 3: 12-Inch SE Expansion - No Pressure Zones** | | | | | | | | |
| *NOTE: to meet fire flow constraints, the minimum residual pressure was lowered to 24 psi. | | | | | | | | |
| 1-FLOW | 9,334 | TRUE | Passed | 500 | 9,335 | 24 | 18.7 | J-692 |
| 1-RES | 3,305 | TRUE | Passed | 500 | 3,308 | 24 | 23.4 | J-692 |
| 2-FLOW | 7,904 | TRUE | Passed | 500 | 7,905 | 24 | 21.7 | J-692 |
| 2-RES | 4,364 | TRUE | Passed | 500 | 4,365 | 24 | 23.4 | J-692 |
| 3-FLOW | 3,020 | TRUE | Passed | 500 | 3,022 | 24 | 22.5 | J-692 |
| 3-RES | 2,578 | TRUE | Passed | 500 | 2,579 | 24 | 23 | J-692 |
| 4-FLOW | 3,646 | TRUE | Passed | 500 | 3,647 | 24 | 22.3 | J-692 |
| 4-RES | 2,638 | TRUE | Passed | 500 | 2,639 | 24 | 23.2 | J-692 |
| 5-FLOW | 3,976 | TRUE | Passed | 500 | 3,977 | 24 | 18.1 | J-692 |
| 5-RES | 2,071 | TRUE | Passed | 500 | 2,072 | 24 | 22.2 | J-692 |
| 6-FLOW | 2,148 | TRUE | Passed | 500 | 2,149 | 24 | 23.4 | J-692 |
| 6-RES | 1,395 | TRUE | Passed | 500 | 1,396 | 24 | 24 | J-692 |
| 7-FLOW | 2,345 | TRUE | Passed | 500 | 2,346 | 24 | 21.1 | J-692 |
| 7-RES | 2,107 | TRUE | Passed | 500 | 2,108 | 24 | 21.6 | J-692 |
| J-1 | 5,672 | TRUE | Passed | 500 | 5,673 | 24 | 14.1 | J-692 |
| J-2 | 7,775 | TRUE | Passed | 500 | 7,776 | 24 | 10.1 | J-692 |
| J-3 | 8,414 | TRUE | Passed | 500 | 8,415 | 24 | 10.9 | J-692 |
| J-11 | 8,955 | TRUE | Passed | 500 | 8,956 | 24 | 10.5 | J-692 |
| J-12 | 8,613 | TRUE | Passed | 500 | 8,614 | 24 | 9.4 | J-692 |
| J-13 | 5,131 | TRUE | Passed | 500 | 5,132 | 24 | 17.2 | J-692 |
| J-14 | 4,137 | TRUE | Passed | 500 | 4,138 | 24 | 19.3 | J-692 |
| J-15 | 7,999 | TRUE | Passed | 500 | 8,000 | 24 | 10.1 | J-692 |
| J-17 | 6,330 | TRUE | Passed | 500 | 6,331 | 24 | 14.2 | J-692 |
| J-18 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.4 | 21.8 | J-692 |
| J-19 | 10,000 | TRUE | Passed | 500 | 10,001 | 24.4 | 14.1 | J-692 |
| J-20 | 4,501 | TRUE | Passed | 500 | 4,502 | 24 | 21.3 | J-692 |
| J-21 | 4,604 | TRUE | Passed | 500 | 4,605 | 24 | 21.3 | J-692 |
| J-22 | 2,209 | TRUE | Passed | 500 | 2,210 | 24 | 23.5 | J-692 |
| J-23 | 4,063 | TRUE | Passed | 500 | 4,064 | 24 | 21.8 | J-692 |
| J-24 | 2,075 | TRUE | Passed | 500 | 2,076 | 24 | 23.5 | J-692 |
| J-25 | 3,617 | TRUE | Passed | 500 | 3,618 | 24 | 22.2 | J-692 |
| J-26 | 2,002 | TRUE | Passed | 500 | 2,003 | 24 | 23.6 | J-692 |
| J-27 | 3,721 | TRUE | Passed | 500 | 3,723 | 24 | 22 | J-692 |
| J-28 | 2,303 | TRUE | Passed | 500 | 2,304 | 24 | 23.3 | J-692 |
| J-29 | 4,045 | TRUE | Passed | 500 | 4,046 | 24 | 21.5 | J-692 |
| J-30 | 7,013 | TRUE | Passed | 500 | 7,014 | 24 | 16.6 | J-692 |
| J-31 | 2,839 | TRUE | Passed | 500 | 2,840 | 24 | 21.5 | J-692 |
| J-33 | 3,112 | TRUE | Passed | 500 | 3,113 | 24 | 21 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-34 | 3,039 | TRUE | Passed | 500 | 3,040 | 24 | 21.1 | J-692 |
| J-35 | 3,751 | TRUE | Passed | 500 | 3,752 | 24 | 19.8 | J-692 |
| J-36 | 5,077 | TRUE | Passed | 500 | 5,078 | 24 | 16.8 | J-692 |
| J-37 | 5,663 | TRUE | Passed | 500 | 5,664 | 24 | 16.1 | J-692 |
| J-38 | 5,289 | TRUE | Passed | 500 | 5,290 | 24 | 15.7 | J-692 |
| J-39 | 4,664 | TRUE | Passed | 500 | 4,665 | 24 | 18 | J-692 |
| J-40 | 4,588 | TRUE | Passed | 500 | 4,589 | 24 | 18 | J-692 |
| J-41 | 5,353 | TRUE | Passed | 500 | 5,354 | 24 | 15.6 | J-692 |
| J-42 | 3,267 | TRUE | Passed | 500 | 3,268 | 24 | 20 | J-692 |
| J-43 | 4,575 | TRUE | Passed | 500 | 4,576 | 24 | 16.8 | J-692 |
| J-44 | 2,443 | TRUE | Passed | 500 | 2,444 | 24 | 21.7 | J-692 |
| J-45 | 2,600 | TRUE | Passed | 500 | 2,601 | 24 | 21.3 | J-692 |
| J-46 | 3,336 | TRUE | Passed | 500 | 3,337 | 24 | 19.8 | J-692 |
| J-47 | 2,204 | TRUE | Passed | 500 | 2,205 | 24 | 22.1 | J-692 |
| J-48 | 2,888 | TRUE | Passed | 500 | 2,889 | 24 | 20.8 | J-692 |
| J-49 | 3,382 | TRUE | Passed | 500 | 3,383 | 24 | 19.8 | J-692 |
| J-50 | 2,616 | TRUE | Passed | 500 | 2,617 | 24 | 21.3 | J-692 |
| J-51 | 1,140 | TRUE | Passed | 500 | 1,141 | 24 | 23.6 | J-692 |
| J-52 | 2,780 | TRUE | Passed | 500 | 2,781 | 24 | 20.7 | J-51 |
| J-53 | 2,350 | TRUE | Passed | 500 | 2,351 | 24 | 21.7 | J-692 |
| J-54 | 2,530 | TRUE | Passed | 500 | 2,531 | 24 | 21.3 | J-692 |
| J-55 | 2,061 | TRUE | Passed | 500 | 2,062 | 24 | 22.2 | J-692 |
| J-56 | 2,393 | TRUE | Passed | 500 | 2,394 | 24 | 21.6 | J-692 |
| J-57 | 2,310 | TRUE | Passed | 500 | 2,311 | 24 | 21.8 | J-692 |
| J-58 | 2,539 | TRUE | Passed | 500 | 2,540 | 24 | 21.3 | J-692 |
| J-59 | 2,867 | TRUE | Passed | 500 | 2,868 | 24 | 20.7 | J-692 |
| J-60 | 2,635 | TRUE | Passed | 500 | 2,636 | 24 | 21.1 | J-692 |
| J-61 | 4,148 | TRUE | Passed | 500 | 4,149 | 24 | 17.7 | J-692 |
| J-64 | 4,077 | TRUE | Passed | 500 | 4,078 | 24 | 17.6 | J-692 |
| J-65 | 4,147 | TRUE | Passed | 500 | 4,148 | 24 | 17.8 | J-692 |
| J-66 | 5,154 | TRUE | Passed | 500 | 5,155 | 24 | 15.4 | J-692 |
| J-67 | 4,614 | TRUE | Passed | 500 | 4,615 | 24 | 16.8 | J-692 |
| J-68 | 4,927 | TRUE | Passed | 500 | 4,928 | 24 | 16 | J-692 |
| J-69 | 2,747 | TRUE | Passed | 500 | 2,748 | 24 | 21.2 | J-692 |
| J-70 | 4,018 | TRUE | Passed | 500 | 4,019 | 24 | 18.5 | J-692 |
| J-71 | 3,394 | TRUE | Passed | 500 | 3,395 | 24 | 19.9 | J-692 |
| J-72 | 3,375 | TRUE | Passed | 500 | 3,376 | 24 | 20 | J-692 |
| J-73 | 1,309 | TRUE | Passed | 500 | 1,310 | 24 | 23.5 | J-692 |
| J-74 | 3,345 | TRUE | Passed | 500 | 3,346 | 24 | 20.1 | J-692 |
| J-75 | 5,136 | TRUE | Passed | 500 | 5,137 | 24 | 15.8 | J-692 |
| J-76 | 4,849 | TRUE | Passed | 500 | 4,850 | 24 | 16.4 | J-692 |
| J-77 | 4,706 | TRUE | Passed | 500 | 4,707 | 24 | 16.5 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-78 | 5,348 | TRUE | Passed | 500 | 5,349 | 24 | 15.4 | J-692 |
| J-79 | 4,413 | TRUE | Passed | 500 | 4,414 | 24 | 17.8 | J-692 |
| J-80 | 4,930 | TRUE | Passed | 500 | 4,931 | 24 | 16.6 | J-692 |
| J-81 | 5,183 | TRUE | Passed | 500 | 5,184 | 24 | 15.6 | J-692 |
| J-82 | 5,953 | TRUE | Passed | 500 | 5,954 | 24 | 14.2 | J-692 |
| J-83 | 6,087 | TRUE | Passed | 500 | 6,088 | 24 | 13.8 | J-692 |
| J-84 | 6,088 | TRUE | Passed | 500 | 6,089 | 24 | 13.8 | J-692 |
| J-85 | 5,610 | TRUE | Passed | 500 | 5,611 | 24 | 14.9 | J-692 |
| J-86 | 5,303 | TRUE | Passed | 500 | 5,304 | 24 | 15.6 | J-692 |
| J-87 | 4,657 | TRUE | Passed | 500 | 4,659 | 24 | 17.5 | J-692 |
| J-88 | 4,075 | TRUE | Passed | 500 | 4,076 | 24 | 18.8 | J-692 |
| J-89 | 5,157 | TRUE | Passed | 500 | 5,158 | 24 | 15.9 | J-692 |
| J-90 | 3,868 | TRUE | Passed | 500 | 3,869 | 24 | 19.1 | J-692 |
| J-91 | 1,856 | TRUE | Passed | 500 | 1,857 | 24 | 22.8 | J-692 |
| J-92 | 6,287 | TRUE | Passed | 500 | 6,288 | 24 | 11.8 | J-692 |
| J-93 | 5,141 | TRUE | Passed | 500 | 5,142 | 24 | 15.6 | J-692 |
| J-94 | 6,258 | TRUE | Passed | 500 | 6,259 | 24 | 12 | J-692 |
| J-95 | 7,336 | TRUE | Passed | 500 | 7,338 | 24 | 10.9 | J-692 |
| J-96 | 6,168 | TRUE | Passed | 500 | 6,169 | 24 | 13 | J-692 |
| J-97 | 6,345 | TRUE | Passed | 500 | 6,346 | 24 | 11.6 | J-692 |
| J-98 | 6,507 | TRUE | Passed | 500 | 6,508 | 24 | 10.5 | J-692 |
| J-99 | 3,629 | TRUE | Passed | 500 | 3,630 | 24 | 14.1 | J-692 |
| J-100 | 5,146 | TRUE | Passed | 500 | 5,147 | 24 | 6 | J-692 |
| J-101 | 3,341 | TRUE | Passed | 500 | 3,342 | 24 | 15.2 | J-692 |
| J-102 | 5,256 | TRUE | Passed | 500 | 5,257 | 24 | 4.7 | J-692 |
| J-103 | 4,766 | TRUE | Passed | 500 | 4,767 | 24 | 4.1 | J-692 |
| J-104 | 4,138 | TRUE | Passed | 500 | 4,139 | 24 | 8.1 | J-692 |
| J-105 | 4,817 | TRUE | Passed | 500 | 4,818 | 24 | 3 | J-692 |
| J-106 | 4,599 | TRUE | Passed | 500 | 4,600 | 24 | 4.7 | J-692 |
| J-107 | 4,396 | TRUE | Passed | 500 | 4,397 | 24 | 6.5 | J-692 |
| J-108 | 4,661 | TRUE | Passed | 500 | 4,662 | 24 | 4.3 | J-692 |
| J-109 | 4,665 | TRUE | Passed | 500 | 4,666 | 24 | 4.4 | J-692 |
| J-110 | 4,422 | TRUE | Passed | 500 | 4,423 | 24 | 6.5 | J-692 |
| J-111 | 4,017 | TRUE | Passed | 500 | 4,018 | 24 | 9.3 | J-692 |
| J-112 | 3,577 | TRUE | Passed | 500 | 3,578 | 24 | 12.2 | J-692 |
| J-113 | 3,091 | TRUE | Passed | 500 | 3,092 | 24 | 14.7 | J-692 |
| J-114 | 2,847 | TRUE | Passed | 500 | 2,848 | 24 | 15.6 | J-692 |
| J-115 | 3,418 | TRUE | Passed | 500 | 3,419 | 24 | 12.4 | J-692 |
| J-116 | 2,656 | TRUE | Passed | 500 | 2,657 | 24 | 16.5 | J-692 |
| J-117 | 3,111 | TRUE | Passed | 500 | 3,112 | 24 | 14.1 | J-692 |
| J-118 | 2,118 | TRUE | Passed | 500 | 2,119 | 24 | 22.6 | J-692 |
| J-118 | 2,778 | TRUE | Passed | 500 | 2,779 | 24 | 15.8 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-119 | 3,226 | TRUE | Passed | 500 | 3,227 | 24 | 13.3 | J-692 |
| J-121 | 2,477 | TRUE | Passed | 500 | 2,478 | 24 | 17.1 | J-692 |
| J-122 | 3,299 | TRUE | Passed | 500 | 3,300 | 24 | 12.7 | J-692 |
| J-123 | 4,087 | TRUE | Passed | 500 | 4,112 | 29.6 | 0 | J-692 |
| J-124 | 4,768 | TRUE | Passed | 500 | 4,769 | 24 | 0.9 | J-692 |
| J-125 | 3,210 | TRUE | Passed | 500 | 3,211 | 24 | 11.7 | J-692 |
| J-126 | 4,017 | TRUE | Passed | 500 | 4,018 | 24 | 6 | J-692 |
| J-127 | 3,224 | TRUE | Passed | 500 | 3,225 | 24 | 11.8 | J-692 |
| J-128 | 1,322 | TRUE | Passed | 500 | 1,323 | 24 | 21.5 | J-692 |
| J-129 | 2,958 | TRUE | Passed | 500 | 2,959 | 24 | 13.5 | J-692 |
| J-130 | 2,992 | TRUE | Passed | 500 | 2,993 | 24 | 13.5 | J-692 |
| J-133 | 3,007 | TRUE | Passed | 500 | 3,008 | 24 | 13.5 | J-692 |
| J-134 | 2,496 | TRUE | Passed | 500 | 2,497 | 24 | 16.5 | J-692 |
| J-135 | 2,753 | TRUE | Passed | 500 | 2,754 | 24 | 15.1 | J-692 |
| J-136 | 3,083 | TRUE | Passed | 500 | 3,084 | 24 | 13.2 | J-692 |
| J-137 | 3,270 | TRUE | Passed | 500 | 3,271 | 24 | 12 | J-692 |
| J-138 | 3,607 | TRUE | Passed | 500 | 3,608 | 24 | 9.9 | J-692 |
| J-139 | 4,846 | TRUE | Passed | 500 | 4,847 | 24 | 4.7 | J-692 |
| J-140 | 3,103 | TRUE | Passed | 500 | 3,104 | 24 | 14.9 | J-692 |
| J-141 | 3,387 | TRUE | Passed | 500 | 3,388 | 24 | 13.4 | J-692 |
| J-142 | 4,501 | TRUE | Passed | 500 | 4,502 | 24 | 5.5 | J-692 |
| J-143 | 5,207 | TRUE | Passed | 500 | 5,208 | 24 | 0.3 | J-692 |
| J-144 | 5,096 | TRUE | Passed | 500 | 5,097 | 24.1 | 0 | J-692 |
| J-145 | 3,519 | TRUE | Passed | 500 | 3,520 | 24 | 11.4 | J-692 |
| J-146 | 5,152 | TRUE | Passed | 500 | 5,153 | 24.4 | 0 | J-692 |
| J-147 | 5,072 | TRUE | Passed | 500 | 5,073 | 24 | 0.9 | J-692 |
| J-148 | 5,296 | TRUE | Passed | 500 | 5,297 | 24.3 | 0 | J-692 |
| J-149 | 5,587 | TRUE | Passed | 500 | 5,588 | 24 | 1.7 | J-692 |
| J-150 | 5,373 | TRUE | Passed | 500 | 5,374 | 24 | 5.4 | J-692 |
| J-151 | 5,325 | TRUE | Passed | 500 | 5,326 | 24 | 2.6 | J-692 |
| J-152 | 2,777 | TRUE | Passed | 500 | 2,778 | 24 | 18.4 | J-692 |
| J-153 | 5,678 | TRUE | Passed | 500 | 5,679 | 24 | 4.8 | J-692 |
| J-154 | 5,419 | TRUE | Passed | 500 | 5,420 | 24 | 6.3 | J-692 |
| J-155 | 3,439 | TRUE | Passed | 500 | 3,440 | 24 | 18.1 | J-692 |
| J-156 | 3,415 | TRUE | Passed | 500 | 3,416 | 24 | 18.5 | J-692 |
| J-157 | 3,647 | TRUE | Passed | 500 | 3,648 | 24 | 17.5 | J-692 |
| J-158 | 2,938 | TRUE | Passed | 500 | 2,939 | 24 | 18.2 | J-692 |
| J-159 | 4,029 | TRUE | Passed | 500 | 4,030 | 24 | 13.9 | J-692 |
| J-160 | 4,199 | TRUE | Passed | 500 | 4,200 | 24 | 12.7 | J-692 |
| J-161 | 4,174 | TRUE | Passed | 500 | 4,175 | 24 | 12.6 | J-692 |
| J-162 | 4,222 | TRUE | Passed | 500 | 4,223 | 24 | 12.5 | J-692 |
| J-163 | 3,698 | TRUE | Passed | 500 | 3,699 | 24 | 14.7 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-164 | 4,005 | TRUE | Passed | 500 | 4,006 | 24 | 13.3 | J-692 |
| J-165 | 4,342 | TRUE | Passed | 500 | 4,343 | 24 | 11.6 | J-692 |
| J-166 | 5,645 | TRUE | Passed | 500 | 5,646 | 24 | 0.4 | J-692 |
| J-167 | 2,503 | TRUE | Passed | 500 | 2,504 | 24 | 19.3 | J-692 |
| J-168 | 3,079 | TRUE | Passed | 500 | 3,080 | 24 | 17.2 | J-692 |
| J-169 | 3,825 | TRUE | Passed | 500 | 3,826 | 24 | 14.1 | J-692 |
| J-170 | 5,278 | TRUE | Passed | 500 | 5,279 | 24 | 2.8 | J-692 |
| J-171 | 2,541 | TRUE | Passed | 500 | 2,542 | 24 | 18.1 | J-692 |
| J-172 | 4,672 | TRUE | Passed | 500 | 4,673 | 24 | 2.5 | J-692 |
| J-173 | 3,634 | TRUE | Passed | 500 | 3,635 | 24 | 10.1 | J-692 |
| J-174 | 3,707 | TRUE | Passed | 500 | 3,708 | 24 | 9.6 | J-692 |
| J-175 | 4,390 | TRUE | Passed | 500 | 4,391 | 24 | 4.6 | J-692 |
| J-176 | 3,558 | TRUE | Passed | 500 | 3,559 | 24 | 10.5 | J-692 |
| J-177 | 2,442 | TRUE | Passed | 500 | 2,443 | 24 | 17 | J-692 |
| J-178 | 3,045 | TRUE | Passed | 500 | 3,046 | 24 | 13.7 | J-692 |
| J-179 | 1,220 | TRUE | Passed | 500 | 1,221 | 24 | 22 | J-692 |
| J-180 | 1,540 | TRUE | Passed | 500 | 1,541 | 24 | 20.6 | J-692 |
| J-181 | 3,276 | TRUE | Passed | 500 | 3,277 | 24 | 12.3 | J-692 |
| J-183 | 9,289 | TRUE | Passed | 500 | 9,290 | 36.4 | 0 | J-692 |
| J-184 | 778 | TRUE | Passed | 500 | 779 | 24 | 24.1 | J-692 |
| J-185 | 7,547 | TRUE | Passed | 500 | 7,548 | 24 | 7.2 | J-692 |
| J-186 | 5,267 | TRUE | Passed | 500 | 5,268 | 24 | 15 | J-692 |
| J-187 | 5,496 | TRUE | Passed | 500 | 5,497 | 24 | 14.1 | J-692 |
| J-188 | 4,168 | TRUE | Passed | 500 | 4,169 | 24 | 17.9 | J-692 |
| J-189 | 5,228 | TRUE | Passed | 500 | 5,229 | 24 | 14.4 | J-692 |
| J-190 | 5,273 | TRUE | Passed | 500 | 5,274 | 24 | 14.6 | J-692 |
| J-191 | 4,524 | TRUE | Passed | 500 | 4,525 | 24 | 16.7 | J-692 |
| J-192 | 3,942 | TRUE | Passed | 500 | 3,943 | 24 | 17.9 | J-692 |
| J-193 | 3,878 | TRUE | Passed | 500 | 3,879 | 24 | 17.4 | J-692 |
| J-194 | 3,288 | TRUE | Passed | 500 | 3,289 | 24 | 18.7 | J-692 |
| J-195 | 2,565 | TRUE | Passed | 500 | 2,566 | 24 | 20.6 | J-692 |
| J-196 | 2,126 | TRUE | Passed | 500 | 2,127 | 24 | 21.6 | J-692 |
| J-197 | 2,300 | TRUE | Passed | 500 | 2,301 | 24 | 21.2 | J-692 |
| J-200 | 5,183 | TRUE | Passed | 500 | 5,184 | 24 | 15.3 | J-692 |
| J-201 | 4,571 | TRUE | Passed | 500 | 4,572 | 24 | 17 | J-692 |
| J-202 | 5,023 | TRUE | Passed | 500 | 5,024 | 24 | 15.8 | J-692 |
| J-203 | 4,995 | TRUE | Passed | 500 | 4,996 | 24 | 16 | J-692 |
| J-204 | 3,849 | TRUE | Passed | 500 | 3,850 | 24 | 18.9 | J-692 |
| J-205 | 3,134 | TRUE | Passed | 500 | 3,135 | 24 | 20.4 | J-692 |
| J-206 | 4,208 | TRUE | Passed | 500 | 4,209 | 24 | 18 | J-692 |
| J-207 | 3,469 | TRUE | Passed | 500 | 3,470 | 24 | 19.7 | J-692 |
| J-208 | 5,616 | TRUE | Passed | 500 | 5,617 | 24 | 14.5 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-209 | 4,275 | TRUE | Passed | 500 | 4,276 | 24 | 18.1 | J-692 |
| J-210 | 7,271 | TRUE | Passed | 500 | 7,272 | 24 | 11 | J-692 |
| J-211 | 6,180 | TRUE | Passed | 500 | 6,181 | 24 | 15.5 | J-692 |
| J-212 | 4,951 | TRUE | Passed | 500 | 4,952 | 24 | 18.3 | J-692 |
| J-213 | 3,817 | TRUE | Passed | 500 | 3,818 | 24 | 20.5 | J-692 |
| J-214 | 3,003 | TRUE | Passed | 500 | 3,004 | 24 | 21.8 | J-692 |
| J-215 | 2,508 | TRUE | Passed | 500 | 2,509 | 24 | 22.5 | J-692 |
| J-216 | 880 | TRUE | Passed | 500 | 881 | 24 | 24.2 | J-692 |
| J-217 | 3,614 | TRUE | Passed | 500 | 3,615 | 24 | 20.8 | J-692 |
| J-218 | 2,012 | TRUE | Passed | 500 | 2,013 | 24 | 23.1 | J-692 |
| J-219 | 4,393 | TRUE | Passed | 500 | 4,394 | 24 | 19.5 | J-692 |
| J-220 | 2,098 | TRUE | Passed | 500 | 2,099 | 24 | 23 | J-692 |
| J-221 | 2,514 | TRUE | Passed | 500 | 2,515 | 24 | 22.5 | J-692 |
| J-222 | 4,864 | TRUE | Passed | 500 | 4,865 | 24 | 18.6 | J-692 |
| J-223 | 5,361 | TRUE | Passed | 500 | 5,362 | 24 | 17.6 | J-692 |
| J-224 | 6,227 | TRUE | Passed | 500 | 6,228 | 24 | 15.7 | J-692 |
| J-225 | 6,449 | TRUE | Passed | 500 | 6,450 | 24 | 15.2 | J-692 |
| J-226 | 8,207 | TRUE | Passed | 500 | 8,208 | 24 | 10.4 | J-692 |
| J-227 | 6,763 | TRUE | Passed | 500 | 6,764 | 24 | 11.1 | J-692 |
| J-228 | 5,374 | TRUE | Passed | 500 | 5,375 | 24 | 14.9 | J-692 |
| J-229 | 5,285 | TRUE | Passed | 500 | 5,286 | 24 | 15.2 | J-692 |
| J-230 | 3,160 | TRUE | Passed | 500 | 3,161 | 24 | 20.6 | J-692 |
| J-231 | 4,895 | TRUE | Passed | 500 | 4,896 | 24 | 16.5 | J-692 |
| J-232 | 5,441 | TRUE | Passed | 500 | 5,442 | 24 | 15.2 | J-692 |
| J-233 | 7,089 | TRUE | Passed | 500 | 7,090 | 24 | 10.6 | J-692 |
| J-234 | 9,918 | TRUE | Passed | 500 | 9,919 | 42.2 | 0 | J-692 |
| J-235 | 10,000 | TRUE | Passed | 500 | 10,001 | 49.8 | 1.5 | J-692 |
| J-236 | 2,566 | TRUE | Passed | 500 | 2,567 | 24 | 20.5 | J-692 |
| J-237 | 2,139 | TRUE | Passed | 500 | 2,140 | 24 | 21.5 | J-692 |
| J-238 | 1,177 | TRUE | Passed | 500 | 1,178 | 24 | 23.3 | J-692 |
| J-239 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.7 | 6.7 | J-692 |
| J-240 | 10,000 | TRUE | Passed | 500 | 10,001 | 28.1 | 6.8 | J-692 |
| J-241 | 8,752 | TRUE | Passed | 500 | 8,753 | 24 | 12 | J-692 |
| J-242 | 8,573 | TRUE | Passed | 500 | 8,574 | 24 | 14.8 | J-692 |
| J-243 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.1 | 10.9 | J-692 |
| J-244 | 5,662 | TRUE | Passed | 500 | 5,663 | 24 | 19 | J-692 |
| J-245 | 10,000 | TRUE | Passed | 500 | 10,001 | 27 | 12.5 | J-692 |
| J-246 | 9,694 | TRUE | Passed | 500 | 9,695 | 24 | 16.8 | J-692 |
| J-247 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.7 | 14.3 | J-692 |
| J-248 | 7,696 | TRUE | Passed | 500 | 7,697 | 24 | 16.9 | J-692 |
| J-249 | 2,649 | TRUE | Passed | 500 | 2,650 | 24 | 23.1 | J-250 |
| J-250 | 1,453 | TRUE | Passed | 500 | 1,454 | 24 | 24.1 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-251 | 7,953 | TRUE | Passed | 500 | 7,954 | 24 | 16.6 | J-692 |
| J-252 | 7,881 | TRUE | Passed | 500 | 7,882 | 24 | 17.1 | J-692 |
| J-253 | 3,421 | TRUE | Passed | 500 | 3,422 | 24 | 22.8 | J-692 |
| J-254 | 8,499 | TRUE | Passed | 500 | 8,500 | 24 | 15.5 | J-692 |
| J-255 | 7,818 | TRUE | Passed | 500 | 7,819 | 24 | 16.8 | J-692 |
| J-256 | 4,527 | TRUE | Passed | 500 | 4,528 | 24 | 21.3 | J-692 |
| J-257 | 7,763 | TRUE | Passed | 500 | 7,764 | 24 | 16.7 | J-692 |
| J-258 | 7,728 | TRUE | Passed | 500 | 7,729 | 24 | 16.7 | J-692 |
| J-259 | 4,814 | TRUE | Passed | 500 | 4,815 | 24 | 21 | J-692 |
| J-260 | 6,836 | TRUE | Passed | 500 | 6,837 | 24 | 18.2 | J-692 |
| J-262 | 7,876 | TRUE | Passed | 500 | 7,877 | 24 | 16.9 | J-692 |
| J-263 | 4,626 | TRUE | Passed | 500 | 4,627 | 24 | 21.2 | J-692 |
| J-264 | 8,402 | TRUE | Passed | 500 | 8,403 | 24 | 16.2 | J-692 |
| J-265 | 4,337 | TRUE | Passed | 500 | 4,338 | 24 | 21.5 | J-692 |
| J-266 | 3,050 | TRUE | Passed | 500 | 3,051 | 24 | 22.8 | J-692 |
| J-267 | 6,654 | TRUE | Passed | 500 | 6,655 | 24 | 18.5 | J-692 |
| J-268 | 5,853 | TRUE | Passed | 500 | 5,854 | 24 | 19.7 | J-692 |
| J-269 | 6,804 | TRUE | Passed | 500 | 6,805 | 24 | 18.3 | J-692 |
| J-270 | 8,275 | TRUE | Passed | 500 | 8,276 | 24 | 15.6 | J-692 |
| J-271 | 7,059 | TRUE | Passed | 500 | 7,060 | 24 | 17.8 | J-692 |
| J-272 | 7,090 | TRUE | Passed | 500 | 7,091 | 24 | 17.3 | J-692 |
| J-273 | 5,396 | TRUE | Passed | 500 | 5,397 | 24 | 19.9 | J-692 |
| J-274 | 4,980 | TRUE | Passed | 500 | 4,981 | 24 | 20.4 | J-692 |
| J-275 | 6,711 | TRUE | Passed | 500 | 6,712 | 24 | 17.8 | J-692 |
| J-276 | 6,489 | TRUE | Passed | 500 | 6,490 | 24 | 18.2 | J-692 |
| J-277 | 6,532 | TRUE | Passed | 500 | 6,533 | 24 | 17.9 | J-692 |
| J-278 | 4,813 | TRUE | Passed | 500 | 4,814 | 24 | 20.5 | J-692 |
| J-279 | 4,269 | TRUE | Passed | 500 | 4,270 | 24 | 21.1 | J-692 |
| J-280 | 1,576 | TRUE | Passed | 500 | 1,577 | 24 | 23.9 | J-692 |
| J-281 | 3,497 | TRUE | Passed | 500 | 3,498 | 24 | 22.1 | J-692 |
| J-282 | 3,327 | TRUE | Passed | 500 | 3,328 | 24 | 22.3 | J-692 |
| J-283 | 2,642 | TRUE | Passed | 500 | 2,643 | 24 | 23 | J-692 |
| J-284 | 1,514 | TRUE | Passed | 500 | 1,515 | 24 | 24 | J-692 |
| J-285 | 2,234 | TRUE | Passed | 500 | 2,235 | 24 | 23.4 | J-692 |
| J-286 | 4,716 | TRUE | Passed | 500 | 4,717 | 24 | 20.4 | J-692 |
| J-287 | 3,844 | TRUE | Passed | 500 | 3,845 | 24 | 21.4 | J-292 |
| J-288 | 2,240 | TRUE | Passed | 500 | 2,241 | 24 | 23.3 | J-692 |
| J-289 | 2,528 | TRUE | Passed | 500 | 2,529 | 24 | 23.1 | J-692 |
| J-290 | 2,333 | TRUE | Passed | 500 | 2,334 | 24 | 23.3 | J-692 |
| J-291 | 1,257 | TRUE | Passed | 500 | 1,258 | 24 | 24.1 | J-692 |
| J-292 | 2,768 | TRUE | Passed | 500 | 2,769 | 24 | 22.8 | J-692 |
| J-294 | 1,513 | TRUE | Passed | 500 | 1,514 | 24 | 23.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-296 | 6,656 | TRUE | Passed | 500 | 6,657 | 24 | 17 | J-692 |
| J-297 | 6,771 | TRUE | Passed | 500 | 6,772 | 24 | 16.3 | J-692 |
| J-298 | 8,933 | TRUE | Passed | 500 | 8,934 | 24 | 10.9 | J-692 |
| J-299 | 10,000 | TRUE | Passed | 500 | 10,001 | 24 | 8.3 | J-692 |
| J-300 | 4,454 | TRUE | Passed | 500 | 4,455 | 24 | 20.7 | J-692 |
| J-301 | 3,596 | TRUE | Passed | 500 | 3,597 | 24 | 21.9 | J-692 |
| J-302 | 4,060 | TRUE | Passed | 500 | 4,061 | 24 | 21.4 | J-692 |
| J-303 | 3,338 | TRUE | Passed | 500 | 3,339 | 24 | 22.3 | J-692 |
| J-304 | 5,973 | TRUE | Passed | 500 | 5,974 | 24 | 18.6 | J-692 |
| J-305 | 6,128 | TRUE | Passed | 500 | 6,129 | 24 | 18.3 | J-692 |
| J-306 | 2,615 | TRUE | Passed | 500 | 2,616 | 24 | 23 | J-692 |
| J-307 | 8,225 | TRUE | Passed | 500 | 8,226 | 24 | 14.3 | J-692 |
| J-308 | 7,295 | TRUE | Passed | 500 | 7,296 | 24 | 16.5 | J-692 |
| J-309 | 3,861 | TRUE | Passed | 500 | 3,862 | 24 | 21.5 | J-692 |
| J-310 | 3,668 | TRUE | Passed | 500 | 3,669 | 24 | 21.7 | J-692 |
| J-311 | 4,176 | TRUE | Passed | 500 | 4,177 | 24 | 21 | J-692 |
| J-312 | 4,105 | TRUE | Passed | 500 | 4,106 | 24 | 21 | J-692 |
| J-313 | 4,630 | TRUE | Passed | 500 | 4,631 | 24 | 20.1 | J-692 |
| J-314 | 3,457 | TRUE | Passed | 500 | 3,458 | 24 | 21.9 | J-692 |
| J-315 | 2,810 | TRUE | Passed | 500 | 2,811 | 24 | 22.6 | J-692 |
| J-316 | 4,780 | TRUE | Passed | 500 | 4,781 | 24 | 19.7 | J-692 |
| J-317 | 3,556 | TRUE | Passed | 500 | 3,557 | 24 | 21.7 | J-692 |
| J-318 | 7,021 | TRUE | Passed | 500 | 7,022 | 24 | 17.7 | J-692 |
| J-319 | 6,715 | TRUE | Passed | 500 | 6,716 | 24 | 18 | J-692 |
| J-320 | 6,745 | TRUE | Passed | 500 | 6,746 | 24 | 17.9 | J-692 |
| J-321 | 3,521 | TRUE | Passed | 500 | 3,522 | 24 | 22.4 | J-692 |
| J-322 | 3,747 | TRUE | Passed | 500 | 3,748 | 24 | 22.2 | J-692 |
| J-323 | 3,322 | TRUE | Passed | 500 | 3,323 | 24 | 22.6 | J-692 |
| J-324 | 4,572 | TRUE | Passed | 500 | 4,573 | 24 | 21.3 | J-692 |
| J-325 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.5 | 6.5 | J-692 |
| J-326 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.1 | 6.4 | J-692 |
| J-327 | 7,313 | TRUE | Passed | 500 | 7,314 | 24 | 13.8 | J-692 |
| J-328 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.9 | 6.4 | J-692 |
| J-329 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.4 | 5.8 | J-692 |
| J-330 | 1,842 | TRUE | Passed | 500 | 1,844 | 24 | 23.4 | J-692 |
| J-331 | 6,318 | TRUE | Passed | 500 | 6,319 | 24 | 16 | J-692 |
| J-332 | 6,615 | TRUE | Passed | 500 | 6,616 | 24 | 15.4 | J-692 |
| J-333 | 4,782 | TRUE | Passed | 500 | 4,783 | 24 | 19 | J-692 |
| J-334 | 8,264 | TRUE | Passed | 500 | 8,265 | 24 | 10.4 | J-692 |
| J-336 | 7,004 | TRUE | Passed | 500 | 7,005 | 24 | 14 | J-692 |
| J-338 | 7,734 | TRUE | Passed | 500 | 7,735 | 24 | 12.1 | J-692 |
| J-339 | 6,685 | TRUE | Passed | 500 | 6,686 | 24 | 14.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-340 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.9 | 6.6 | J-692 |
| J-341 | 7,901 | TRUE | Passed | 500 | 7,902 | 24 | 14.8 | J-692 |
| J-342 | 4,259 | TRUE | Passed | 500 | 4,260 | 24 | 20.8 | J-692 |
| J-343 | 7,640 | TRUE | Passed | 500 | 7,641 | 24 | 14.7 | J-692 |
| J-345 | 5,143 | TRUE | Passed | 500 | 5,144 | 24 | 19.3 | J-692 |
| J-346 | 3,861 | TRUE | Passed | 500 | 3,862 | 24 | 21.2 | J-692 |
| J-347 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.4 | 6.7 | J-692 |
| J-348 | 10,000 | TRUE | Passed | 500 | 10,001 | 48 | 6.8 | J-692 |
| J-349 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.2 | 6.8 | J-692 |
| J-350 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.3 | 6.8 | J-692 |
| J-351 | 8,935 | TRUE | Passed | 500 | 8,936 | 24 | 9.8 | J-692 |
| J-352 | 9,226 | TRUE | Passed | 500 | 9,227 | 24 | 9 | J-692 |
| J-353 | 9,792 | TRUE | Passed | 500 | 9,793 | 24 | 7.2 | J-692 |
| J-354 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.2 | 7.5 | J-692 |
| J-355 | 9,172 | TRUE | Passed | 500 | 9,173 | 24 | 9.8 | J-692 |
| J-356 | 8,626 | TRUE | Passed | 500 | 8,627 | 24 | 10.6 | J-692 |
| J-357 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.4 | 6.4 | J-692 |
| J-358 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.2 | 7.8 | J-692 |
| J-359 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.5 | 7.8 | J-692 |
| J-360 | 1,636 | TRUE | Passed | 500 | 1,637 | 24 | 23.7 | J-692 |
| J-361 | 8,775 | TRUE | Passed | 500 | 8,776 | 24 | 10.9 | J-692 |
| J-362 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.4 | 6.9 | J-692 |
| J-363 | 8,309 | TRUE | Passed | 500 | 8,310 | 24 | 11.5 | J-692 |
| J-364 | 7,454 | TRUE | Passed | 500 | 7,455 | 24 | 13.7 | J-692 |
| J-365 | 7,864 | TRUE | Passed | 500 | 7,865 | 24 | 12.6 | J-692 |
| J-366 | 7,272 | TRUE | Passed | 500 | 7,273 | 24 | 14.1 | J-692 |
| J-367 | 8,911 | TRUE | Passed | 500 | 8,912 | 24 | 9.9 | J-692 |
| J-368 | 6,225 | TRUE | Passed | 500 | 6,226 | 24 | 17.2 | J-692 |
| J-369 | 9,022 | TRUE | Passed | 500 | 9,023 | 24 | 10.5 | J-692 |
| J-370 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.7 | 7.7 | J-692 |
| J-371 | 3,449 | TRUE | Passed | 500 | 3,450 | 24 | 12 | J-692 |
| J-371 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.2 | 7.6 | J-692 |
| J-372 | 7,274 | TRUE | Passed | 500 | 7,275 | 24 | 14.5 | J-692 |
| J-373 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.9 | 6.9 | J-692 |
| J-374 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.1 | 6.9 | J-692 |
| J-375 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.6 | 6.8 | J-692 |
| J-376 | 8,284 | TRUE | Passed | 500 | 8,285 | 24 | 11.7 | J-692 |
| J-377 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.3 | 6.8 | J-692 |
| J-378 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.5 | 7 | J-692 |
| J-379 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.8 | 7 | J-692 |
| J-380 | 6,969 | TRUE | Passed | 500 | 6,970 | 24 | 15.1 | J-692 |
| J-382 | 7,529 | TRUE | Passed | 500 | 7,530 | 24 | 14.1 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-383 | 6,923 | TRUE | Passed | 500 | 6,924 | 24 | 15.4 | J-692 |
| J-384 | 7,222 | TRUE | Passed | 500 | 7,223 | 24 | 14.8 | J-692 |
| J-385 | 9,556 | TRUE | Passed | 500 | 9,558 | 24 | 8.9 | J-692 |
| J-386 | 10,000 | TRUE | Passed | 500 | 10,001 | 26 | 7.5 | J-692 |
| J-387 | 8,789 | TRUE | Passed | 500 | 8,790 | 24 | 11 | J-692 |
| J-388 | 6,654 | TRUE | Passed | 500 | 6,655 | 24 | 16.1 | J-692 |
| J-389 | 5,240 | TRUE | Passed | 500 | 5,241 | 24 | 18.9 | J-692 |
| J-390 | 1,964 | TRUE | Passed | 500 | 1,965 | 24 | 23.4 | J-692 |
| J-391 | 7,034 | TRUE | Passed | 500 | 7,035 | 24 | 15 | J-692 |
| J-392 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.2 | 7 | J-692 |
| J-393 | 7,826 | TRUE | Passed | 500 | 7,827 | 24 | 13.2 | J-692 |
| J-394 | 9,181 | TRUE | Passed | 500 | 9,182 | 24 | 9.7 | J-692 |
| J-395 | 9,348 | TRUE | Passed | 500 | 9,349 | 24 | 9.2 | J-692 |
| J-396 | 10,000 | TRUE | Passed | 500 | 10,001 | 40 | 7 | J-692 |
| J-397 | 6,409 | TRUE | Passed | 500 | 6,410 | 24 | 16.1 | J-692 |
| J-398 | 1,747 | TRUE | Passed | 500 | 1,748 | 24 | 23.5 | J-692 |
| J-399 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.7 | 6 | J-692 |
| J-401 | 3,330 | TRUE | Passed | 500 | 3,331 | 24 | 11.1 | J-692 |
| J-401 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.5 | 6.9 | J-692 |
| J-402 | 10,000 | TRUE | Passed | 500 | 10,001 | 62.2 | 6.9 | J-692 |
| J-403 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.9 | 7 | J-692 |
| J-404 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.6 | 7.9 | J-692 |
| J-405 | 4,711 | TRUE | Passed | 500 | 4,712 | 24 | 19.6 | J-692 |
| J-406 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.8 | 6.8 | J-692 |
| J-407 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.2 | 6.8 | J-692 |
| J-408 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.7 | 6.9 | J-692 |
| J-409 | 3,515 | TRUE | Passed | 500 | 3,516 | 24 | 21.4 | J-692 |
| J-410 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.1 | 6.9 | J-692 |
| J-411 | 3,581 | TRUE | Passed | 500 | 3,582 | 24 | 21.3 | J-692 |
| J-412 | 10,000 | TRUE | Passed | 500 | 10,001 | 55.8 | 6.9 | J-692 |
| J-413 | 10,000 | TRUE | Passed | 500 | 10,001 | 62.1 | 6.5 | J-692 |
| J-414 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.7 | 4.1 | J-692 |
| J-415 | 2,016 | TRUE | Passed | 500 | 2,017 | 24 | 23 | J-692 |
| J-416 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.7 | 6.7 | J-692 |
| J-417 | 10,000 | TRUE | Passed | 500 | 10,001 | 54.9 | 7 | J-692 |
| J-418 | 5,536 | TRUE | Passed | 500 | 5,537 | 24 | 18.3 | J-692 |
| J-419 | 3,521 | TRUE | Passed | 500 | 3,522 | 24 | 21.6 | J-692 |
| J-420 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.2 | 8.5 | J-692 |
| J-421 | 9,478 | TRUE | Passed | 500 | 9,479 | 24 | 9.5 | J-692 |
| J-422 | 6,999 | TRUE | Passed | 500 | 7,000 | 24 | 15.4 | J-692 |
| J-423 | 9,374 | TRUE | Passed | 500 | 9,375 | 24 | 9.7 | J-692 |
| J-424 | 4,913 | TRUE | Passed | 500 | 4,914 | 24 | 19.3 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-425 | 4,213 | TRUE | Passed | 500 | 4,214 | 24 | 20.4 | J-692 |
| J-426 | 9,432 | TRUE | Passed | 500 | 9,433 | 24 | 8.9 | J-692 |
| J-427 | 8,000 | TRUE | Passed | 500 | 8,001 | 24 | 12.8 | J-692 |
| J-428 | 9,492 | TRUE | Passed | 500 | 9,493 | 24 | 9.2 | J-692 |
| J-429 | 9,464 | TRUE | Passed | 500 | 9,465 | 24 | 9.2 | J-692 |
| J-430 | 4,051 | TRUE | Passed | 500 | 4,052 | 24 | 20.7 | J-692 |
| J-431 | 7,428 | TRUE | Passed | 500 | 7,429 | 24 | 14.4 | J-692 |
| J-432 | 2,367 | TRUE | Passed | 500 | 2,368 | 24 | 23 | J-692 |
| J-433 | 3,938 | TRUE | Passed | 500 | 3,939 | 24 | 16.8 | J-692 |
| J-434 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 24.1 | J-692 |
| J-435 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 24.2 | J-692 |
| J-436 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.7 | 23.6 | J-692 |
| J-437 | 9,023 | TRUE | Passed | 500 | 9,024 | 24 | 22.9 | J-692 |
| J-439 | 7,099 | TRUE | Passed | 500 | 7,100 | 24 | 22.8 | J-692 |
| J-440 | 6,968 | TRUE | Passed | 500 | 6,969 | 24 | 22.7 | J-692 |
| J-442 | 8,071 | TRUE | Passed | 500 | 8,072 | 24 | 21.5 | J-443 |
| J-443 | 2,218 | TRUE | Passed | 500 | 2,219 | 24 | 24.2 | J-692 |
| J-445 | 9,409 | TRUE | Passed | 500 | 9,410 | 24 | 20.2 | J-692 |
| J-447 | 6,431 | TRUE | Passed | 500 | 6,432 | 24 | 21.7 | J-692 |
| J-448 | 5,128 | TRUE | Passed | 500 | 5,129 | 24 | 22.5 | J-692 |
| J-449 | 6,110 | TRUE | Passed | 500 | 6,111 | 24 | 17.5 | J-450 |
| J-450 | 4,223 | TRUE | Passed | 500 | 4,224 | 24 | 23 | J-692 |
| J-451 | 5,963 | TRUE | Passed | 500 | 5,964 | 24 | 21.8 | J-692 |
| J-452 | 5,460 | TRUE | Passed | 500 | 5,461 | 24 | 22.1 | J-692 |
| J-453 | 5,032 | TRUE | Passed | 500 | 5,033 | 24 | 22.5 | J-692 |
| J-454 | 4,854 | TRUE | Passed | 500 | 4,855 | 24 | 22.6 | J-692 |
| J-455 | 6,534 | TRUE | Passed | 500 | 6,535 | 24 | 21.6 | J-692 |
| J-456 | 6,496 | TRUE | Passed | 500 | 6,497 | 24 | 21.4 | J-692 |
| J-457 | 5,218 | TRUE | Passed | 500 | 5,219 | 24 | 22.2 | J-692 |
| J-458 | 3,030 | TRUE | Passed | 500 | 3,031 | 24 | 23.6 | J-692 |
| J-459 | 2,954 | TRUE | Passed | 500 | 2,955 | 24 | 23.5 | J-692 |
| J-460 | 4,010 | TRUE | Passed | 500 | 4,011 | 24 | 22.8 | J-692 |
| J-461 | 1,661 | TRUE | Passed | 500 | 1,662 | 24 | 23.4 | J-463 |
| J-462 | 1,455 | TRUE | Passed | 500 | 1,456 | 24 | 24.3 | J-692 |
| J-463 | 1,338 | TRUE | Passed | 500 | 1,339 | 24 | 24.3 | J-692 |
| J-464 | 5,247 | TRUE | Passed | 500 | 5,248 | 24 | 22.1 | J-692 |
| J-465 | 5,393 | TRUE | Passed | 500 | 5,394 | 24 | 21.9 | J-692 |
| J-466 | 5,693 | TRUE | Passed | 500 | 5,694 | 24 | 21.6 | J-692 |
| J-467 | 6,391 | TRUE | Passed | 500 | 6,392 | 24 | 20.8 | J-692 |
| J-468 | 6,305 | TRUE | Passed | 500 | 6,306 | 24 | 20.8 | J-692 |
| J-469 | 6,881 | TRUE | Passed | 500 | 6,882 | 24 | 20 | J-692 |
| J-470 | 8,255 | TRUE | Passed | 500 | 8,256 | 24 | 17.2 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-471 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.6 | 14.1 | J-692 |
| J-472 | 7,073 | TRUE | Passed | 500 | 7,074 | 24 | 19.2 | J-692 |
| J-473 | 6,532 | TRUE | Passed | 500 | 6,533 | 24 | 20.3 | J-692 |
| J-474 | 5,980 | TRUE | Passed | 500 | 5,981 | 24 | 20.9 | J-692 |
| J-475 | 5,627 | TRUE | Passed | 500 | 5,628 | 24 | 21.4 | J-692 |
| J-476 | 2,361 | TRUE | Passed | 500 | 2,362 | 24 | 23.8 | J-692 |
| J-477 | 2,387 | TRUE | Passed | 500 | 2,389 | 24 | 23.8 | J-692 |
| J-478 | 5,548 | TRUE | Passed | 500 | 5,549 | 24 | 21.6 | J-692 |
| J-479 | 5,685 | TRUE | Passed | 500 | 5,686 | 24 | 21.7 | J-692 |
| J-480 | 6,033 | TRUE | Passed | 500 | 6,034 | 24 | 21.5 | J-692 |
| J-481 | 6,406 | TRUE | Passed | 500 | 6,407 | 24 | 21.4 | J-692 |
| J-482 | 3,321 | TRUE | Passed | 500 | 3,322 | 24 | 19.8 | J-485 |
| J-483 | 2,056 | TRUE | Passed | 500 | 2,057 | 24 | 22.8 | J-485 |
| J-484 | 1,890 | TRUE | Passed | 500 | 1,891 | 24 | 24.2 | J-692 |
| J-485 | 1,539 | TRUE | Passed | 500 | 1,540 | 24 | 24.3 | J-692 |
| J-486 | 9,602 | TRUE | Passed | 500 | 9,603 | 24 | 19.1 | J-692 |
| J-487 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.4 | 20.1 | J-692 |
| J-489 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.7 | 22.5 | J-692 |
| J-490 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.9 | 22.3 | J-692 |
| J-491 | 10,000 | TRUE | Passed | 500 | 10,001 | 63 | 24.3 | J-692 |
| J-492 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.3 | 20.9 | J-692 |
| J-493 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.9 | 20.5 | J-692 |
| J-494 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.8 | 20.5 | J-692 |
| J-497 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.9 | 16.8 | J-692 |
| J-498 | 10,000 | TRUE | Passed | 500 | 10,001 | 47 | 19.4 | J-692 |
| J-499 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.9 | 19.6 | J-692 |
| J-500 | 6,940 | TRUE | Passed | 500 | 6,941 | 24 | 21.7 | J-692 |
| J-501 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.6 | 20.6 | J-692 |
| J-502 | 5,186 | TRUE | Passed | 500 | 5,187 | 24 | 22.9 | J-692 |
| J-504 | 3,297 | TRUE | Passed | 500 | 3,298 | 24 | 23.8 | J-692 |
| J-505 | 4,075 | TRUE | Passed | 500 | 4,076 | 24 | 23.3 | J-692 |
| J-507 | 4,574 | TRUE | Passed | 500 | 4,575 | 24 | 22.5 | J-692 |
| J-508 | 4,592 | TRUE | Passed | 500 | 4,593 | 24 | 22.5 | J-692 |
| J-509 | 5,331 | TRUE | Passed | 500 | 5,332 | 24 | 21.9 | J-692 |
| J-510 | 5,991 | TRUE | Passed | 500 | 5,992 | 24 | 22.4 | J-692 |
| J-511 | 2,391 | TRUE | Passed | 500 | 2,393 | 24 | 24.1 | J-692 |
| J-513 | 2,442 | TRUE | Passed | 500 | 2,443 | 24 | 24.1 | J-692 |
| J-514 | 2,754 | TRUE | Passed | 500 | 2,755 | 24 | 23.3 | J-513 |
| J-516 | 5,292 | TRUE | Passed | 500 | 5,293 | 24 | 22 | J-692 |
| J-517 | 5,691 | TRUE | Passed | 500 | 5,692 | 24 | 21.4 | J-692 |
| J-518 | 5,177 | TRUE | Passed | 500 | 5,178 | 24 | 20.2 | J-549 |
| J-519 | 5,639 | TRUE | Passed | 500 | 5,640 | 24 | 21.5 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-520 | 4,742 | TRUE | Passed | 500 | 4,743 | 24 | 21.4 | J-692 |
| J-521 | 3,936 | TRUE | Passed | 500 | 3,937 | 24 | 22.1 | J-692 |
| J-522 | 4,068 | TRUE | Passed | 500 | 4,069 | 24 | 21.5 | J-603 |
| J-523 | 4,431 | TRUE | Passed | 500 | 4,432 | 24 | 21.5 | J-692 |
| J-524 | 4,301 | TRUE | Passed | 500 | 4,302 | 24 | 21.7 | J-692 |
| J-525 | 4,757 | TRUE | Passed | 500 | 4,758 | 24 | 21.2 | J-692 |
| J-526 | 4,633 | TRUE | Passed | 500 | 4,634 | 24 | 21.4 | J-692 |
| J-527 | 4,681 | TRUE | Passed | 500 | 4,682 | 24 | 21.2 | J-692 |
| J-528 | 4,356 | TRUE | Passed | 500 | 4,357 | 24 | 21.5 | J-692 |
| J-529 | 4,571 | TRUE | Passed | 500 | 4,572 | 24 | 21.2 | J-692 |
| J-530 | 4,609 | TRUE | Passed | 500 | 4,610 | 24 | 21.2 | J-692 |
| J-531 | 2,965 | TRUE | Passed | 500 | 2,966 | 24 | 22.9 | J-692 |
| J-532 | 3,205 | TRUE | Passed | 500 | 3,206 | 24 | 22.7 | J-692 |
| J-533 | 8,269 | TRUE | Passed | 500 | 8,270 | 24 | 15 | J-692 |
| J-534 | 9,158 | TRUE | Passed | 500 | 9,159 | 24 | 13.4 | J-692 |
| J-535 | 8,532 | TRUE | Passed | 500 | 8,533 | 24 | 14.7 | J-692 |
| J-536 | 7,676 | TRUE | Passed | 500 | 7,677 | 24 | 16.2 | J-692 |
| J-537 | 8,770 | TRUE | Passed | 500 | 8,771 | 24 | 14.1 | J-692 |
| J-538 | 9,345 | TRUE | Passed | 500 | 9,346 | 24 | 12.3 | J-692 |
| J-539 | 10,000 | TRUE | Passed | 500 | 10,001 | 28.1 | 10.6 | J-692 |
| J-540 | 3,154 | TRUE | Passed | 500 | 3,155 | 24 | 22.6 | J-692 |
| J-541 | 3,397 | TRUE | Passed | 500 | 3,398 | 24 | 22.4 | J-692 |
| J-542 | 6,784 | TRUE | Passed | 500 | 6,785 | 24 | 18.5 | J-692 |
| J-543 | 9,145 | TRUE | Passed | 500 | 9,146 | 24 | 15.2 | J-692 |
| J-544 | 10,000 | TRUE | Passed | 500 | 10,001 | 26 | 14.7 | J-692 |
| J-545 | 5,661 | TRUE | Passed | 500 | 5,662 | 24 | 20.9 | J-692 |
| J-546 | 2,190 | TRUE | Passed | 500 | 2,191 | 24 | 23.8 | J-692 |
| J-547 | 5,281 | TRUE | Passed | 500 | 5,282 | 24 | 21.6 | J-692 |
| J-548 | 1,888 | TRUE | Passed | 500 | 1,889 | 24 | 24 | J-692 |
| J-549 | 1,752 | TRUE | Passed | 500 | 1,753 | 24 | 24.1 | J-692 |
| J-550 | 4,649 | TRUE | Passed | 500 | 4,650 | 24 | 22.4 | J-692 |
| J-551 | 3,100 | TRUE | Passed | 500 | 3,101 | 24 | 23.4 | J-692 |
| J-552 | 2,501 | TRUE | Passed | 500 | 2,502 | 24 | 23.8 | J-692 |
| J-553 | 4,109 | TRUE | Passed | 500 | 4,110 | 24 | 23.4 | J-692 |
| J-554 | 2,682 | TRUE | Passed | 500 | 2,684 | 24 | 24 | J-692 |
| J-555 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.4 | 14.4 | J-692 |
| J-556 | 4,226 | TRUE | Passed | 500 | 4,227 | 24 | 22 | J-692 |
| J-557 | 3,730 | TRUE | Passed | 500 | 3,731 | 24 | 22.5 | J-692 |
| J-558 | 1,898 | TRUE | Passed | 500 | 1,899 | 24 | 23.9 | J-692 |
| J-559 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.7 | 15.3 | J-692 |
| J-560 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.2 | 16.3 | J-692 |
| J-561 | 3,840 | TRUE | Passed | 500 | 3,841 | 24 | 22.1 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-562 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.2 | 14.8 | J-692 |
| J-563 | 2,981 | TRUE | Passed | 500 | 2,982 | 24 | 22.7 | J-692 |
| J-564 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.8 | 11.5 | J-692 |
| J-565 | 10,000 | TRUE | Passed | 500 | 10,001 | 35 | 13.2 | J-692 |
| J-566 | 8,474 | TRUE | Passed | 500 | 8,475 | 24 | 14.2 | J-692 |
| J-567 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.5 | 10.3 | J-692 |
| J-568 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.4 | 7.7 | J-692 |
| J-569 | 8,116 | TRUE | Passed | 500 | 8,117 | 24 | 12.8 | J-692 |
| J-570 | 7,163 | TRUE | Passed | 500 | 7,164 | 24 | 15.5 | J-692 |
| J-571 | 8,254 | TRUE | Passed | 500 | 8,255 | 24 | 11.3 | J-692 |
| J-572 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.8 | 4.5 | J-692 |
| J-573 | 7,805 | TRUE | Passed | 500 | 7,806 | 24 | 4.3 | J-692 |
| J-574 | 9,231 | TRUE | Passed | 500 | 9,232 | 24 | 8.1 | J-692 |
| J-576 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.4 | 8.9 | J-692 |
| J-577 | 10,000 | TRUE | Passed | 500 | 10,001 | 33 | 9.7 | J-692 |
| J-578 | 3,346 | TRUE | Passed | 500 | 3,347 | 24 | 22.2 | J-692 |
| J-579 | 4,413 | TRUE | Passed | 500 | 4,414 | 24 | 21.1 | J-692 |
| J-580 | 4,466 | TRUE | Passed | 500 | 4,467 | 24 | 21.1 | J-692 |
| J-581 | 4,210 | TRUE | Passed | 500 | 4,211 | 24 | 21.2 | J-692 |
| J-582 | 6,611 | TRUE | Passed | 500 | 6,612 | 24 | 17.5 | J-692 |
| J-583 | 7,143 | TRUE | Passed | 500 | 7,144 | 24 | 16.5 | J-692 |
| J-584 | 8,083 | TRUE | Passed | 500 | 8,084 | 24 | 14.7 | J-692 |
| J-585 | 6,241 | TRUE | Passed | 500 | 6,242 | 24 | 18 | J-692 |
| J-587 | 5,796 | TRUE | Passed | 500 | 5,797 | 24 | 18.7 | J-692 |
| J-588 | 5,435 | TRUE | Passed | 500 | 5,436 | 24 | 19.3 | J-692 |
| J-589 | 5,578 | TRUE | Passed | 500 | 5,579 | 24 | 19 | J-692 |
| J-590 | 7,006 | TRUE | Passed | 500 | 7,007 | 24 | 16.6 | J-692 |
| J-591 | 6,439 | TRUE | Passed | 500 | 6,440 | 24 | 17.7 | J-692 |
| J-592 | 6,221 | TRUE | Passed | 500 | 6,222 | 24 | 18.6 | J-692 |
| J-593 | 4,607 | TRUE | Passed | 500 | 4,608 | 24 | 21.1 | J-692 |
| J-594 | 4,463 | TRUE | Passed | 500 | 4,464 | 24 | 20.3 | J-596 |
| J-595 | 3,637 | TRUE | Passed | 500 | 3,638 | 24 | 21.3 | J-596 |
| J-596 | 3,091 | TRUE | Passed | 500 | 3,092 | 24 | 22.8 | J-692 |
| J-597 | 3,197 | TRUE | Passed | 500 | 3,198 | 24 | 22.7 | J-692 |
| J-598 | 3,281 | TRUE | Passed | 500 | 3,282 | 24 | 22.6 | J-692 |
| J-599 | 3,474 | TRUE | Passed | 500 | 3,475 | 24 | 22.5 | J-692 |
| J-601 | 3,056 | TRUE | Passed | 500 | 3,057 | 24 | 22.9 | J-692 |
| J-602 | 4,377 | TRUE | Passed | 500 | 4,378 | 24 | 21.6 | J-692 |
| J-603 | 2,345 | TRUE | Passed | 500 | 2,346 | 24 | 23.5 | J-692 |
| J-604 | 4,389 | TRUE | Passed | 500 | 4,390 | 24 | 21.5 | J-692 |
| J-605 | 3,249 | TRUE | Passed | 500 | 3,250 | 24 | 22.7 | J-692 |
| J-606 | 3,366 | TRUE | Passed | 500 | 3,367 | 24 | 22.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-607 | 4,228 | TRUE | Passed | 500 | 4,229 | 24 | 21.7 | J-692 |
| J-608 | 4,356 | TRUE | Passed | 500 | 4,357 | 24 | 21.5 | J-692 |
| J-609 | 4,444 | TRUE | Passed | 500 | 4,445 | 24 | 21.4 | J-692 |
| J-610 | 4,369 | TRUE | Passed | 500 | 4,370 | 24 | 21.5 | J-692 |
| J-611 | 4,668 | TRUE | Passed | 500 | 4,669 | 24 | 21.2 | J-692 |
| J-612 | 4,143 | TRUE | Passed | 500 | 4,144 | 24 | 21.7 | J-692 |
| J-613 | 4,270 | TRUE | Passed | 500 | 4,271 | 24 | 21.5 | J-692 |
| J-614 | 6,444 | TRUE | Passed | 500 | 6,445 | 24 | 18.3 | J-692 |
| J-615 | 6,729 | TRUE | Passed | 500 | 6,730 | 24 | 17.9 | J-692 |
| J-616 | 6,880 | TRUE | Passed | 500 | 6,881 | 24 | 17.6 | J-692 |
| J-617 | 6,759 | TRUE | Passed | 500 | 6,760 | 24 | 16.9 | J-692 |
| J-620 | 7,710 | TRUE | Passed | 500 | 7,711 | 24 | 15 | J-692 |
| J-621 | 9,390 | TRUE | Passed | 500 | 9,391 | 24 | 11.1 | J-692 |
| J-622 | 9,007 | TRUE | Passed | 500 | 9,008 | 24 | 12.2 | J-692 |
| J-623 | 9,093 | TRUE | Passed | 500 | 9,094 | 24 | 11.5 | J-692 |
| J-625 | 10,000 | TRUE | Passed | 500 | 10,001 | 24.2 | 9.2 | J-692 |
| J-626 | 8,840 | TRUE | Passed | 500 | 8,841 | 24 | 12.7 | J-692 |
| J-627 | 8,787 | TRUE | Passed | 500 | 8,788 | 24 | 12.9 | J-692 |
| J-628 | 9,007 | TRUE | Passed | 500 | 9,008 | 24 | 12.5 | J-692 |
| J-629 | 9,461 | TRUE | Passed | 500 | 9,462 | 24 | 11.5 | J-692 |
| J-630 | 9,663 | TRUE | Passed | 500 | 9,664 | 24 | 11 | J-692 |
| J-631 | 9,735 | TRUE | Passed | 500 | 9,736 | 24 | 10.8 | J-692 |
| J-632 | 5,280 | TRUE | Passed | 500 | 5,281 | 24 | 19.2 | J-692 |
| J-633 | 3,171 | TRUE | Passed | 500 | 3,172 | 24 | 22.2 | J-692 |
| J-634 | 8,069 | TRUE | Passed | 500 | 8,070 | 24 | 13.8 | J-692 |
| J-636 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.7 | 10.2 | J-692 |
| J-637 | 3,847 | TRUE | Passed | 500 | 3,848 | 24 | 21.5 | J-692 |
| J-638 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.7 | 10.3 | J-692 |
| J-639 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.9 | 9.6 | J-692 |
| J-640 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.5 | 9.7 | J-692 |
| J-641 | 5,672 | TRUE | Passed | 500 | 5,673 | 24 | 18.9 | J-692 |
| J-642 | 4,128 | TRUE | Passed | 500 | 4,129 | 24 | 21.3 | J-692 |
| J-643 | 3,176 | TRUE | Passed | 500 | 3,177 | 24 | 22.6 | J-692 |
| J-644 | 5,426 | TRUE | Passed | 500 | 5,427 | 24 | 20.1 | J-692 |
| J-645 | 2,772 | TRUE | Passed | 500 | 2,773 | 24 | 23 | J-692 |
| J-646 | 7,479 | TRUE | Passed | 500 | 7,480 | 24 | 17.1 | J-692 |
| J-647 | 4,910 | TRUE | Passed | 500 | 4,911 | 24 | 20.6 | J-692 |
| J-648 | 3,029 | TRUE | Passed | 500 | 3,030 | 24 | 22.7 | J-692 |
| J-649 | 3,748 | TRUE | Passed | 500 | 3,749 | 24 | 22.1 | J-692 |
| J-650 | 1,895 | TRUE | Passed | 500 | 1,896 | 24 | 23.8 | J-692 |
| J-651 | 7,951 | TRUE | Passed | 500 | 7,952 | 24 | 16.6 | J-692 |
| J-652 | 3,096 | TRUE | Passed | 500 | 3,097 | 24 | 22.8 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-655 | 7,423 | TRUE | Passed | 500 | 7,424 | 24 | 16.8 | J-692 |
| J-656 | 3,610 | TRUE | Passed | 500 | 3,611 | 24 | 22.1 | J-692 |
| J-657 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.6 | 8.3 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.2 | 8.6 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.5 | 8 | J-692 |
| J-660 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.7 | 7.9 | J-692 |
| J-661 | 833 | TRUE | Passed | 500 | 837 | 24 | 24.3 | J-692 |
| J-662 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.6 | 7.4 | J-692 |
| J-663 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.9 | 8 | J-692 |
| J-664 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.4 | 9.1 | J-692 |
| J-665 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.7 | 9.4 | J-692 |
| J-666 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.7 | 17.5 | J-692 |
| J-667 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.2 | 17.1 | J-692 |
| J-668 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.5 | 19.7 | J-692 |
| J-669 | 4,449 | TRUE | Passed | 500 | 4,450 | 24 | 21.5 | J-692 |
| J-670 | 5,042 | TRUE | Passed | 500 | 5,043 | 24 | 20.8 | J-692 |
| J-673 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.9 | 8.3 | J-692 |
| J-674 | 4,267 | TRUE | Passed | 500 | 4,268 | 24 | 20.5 | J-692 |
| J-675 | 3,989 | TRUE | Passed | 500 | 3,990 | 24 | 20.8 | J-692 |
| J-676 | 5,607 | TRUE | Passed | 500 | 5,608 | 24 | 18.1 | J-692 |
| J-677 | 2,516 | TRUE | Passed | 500 | 2,517 | 24 | 22.8 | J-692 |
| J-678 | 1,883 | TRUE | Passed | 500 | 1,884 | 24 | 23.5 | J-692 |
| J-680 | 5,276 | TRUE | Passed | 500 | 5,276 | 24 | 2.4 | J-692 |
| J-682 | 4,353 | TRUE | Passed | 500 | 4,353 | 24 | 6.6 | J-692 |
| J-685 | 1,235 | TRUE | Passed | 500 | 1,260 | 24 | 20.3 | J-692 |
| J-686 | 3,485 | TRUE | Passed | 500 | 3,535 | 24 | 4.8 | J-692 |
| J-687 | 4,221 | TRUE | Passed | 500 | 4,246 | 24 | 2.2 | J-692 |
| J-689 | 5,934 | TRUE | Passed | 500 | 5,959 | 24 | 4.4 | J-692 |
| J-690 | 4,973 | TRUE | Passed | 500 | 4,998 | 28.9 | 0 | J-692 |
| J-691 | 4,401 | TRUE | Passed | 500 | 4,426 | 30.1 | 0 | J-692 |
| J-692 | 317 | FALSE | dual Pressure F | 500 | 317 | 24 | 25.8 | J-695 |
| J-693 | 4,315 | TRUE | Passed | 500 | 4,340 | 24 | 9.4 | J-692 |
| J-694 | 3,556 | TRUE | Passed | 500 | 3,581 | 24 | 6.1 | J-695 |
| J-695 | 681 | TRUE | Passed | 500 | 706 | 24 | 23.1 | J-692 |
| J-696 | 4,377 | TRUE | Passed | 500 | 4,382 | 24 | 16.1 | J-692 |
| J-697 | 5,005 | TRUE | Passed | 500 | 5,005 | 24.7 | 0 | J-692 |
| J-698 | 3,137 | TRUE | Passed | 500 | 3,162 | 24 | 13.6 | J-692 |
| J-699 | 6,943 | TRUE | Passed | 500 | 6,968 | 33.6 | 0 | J-692 |
| J-700 | 4,056 | TRUE | Passed | 500 | 4,081 | 24 | 9.8 | J-692 |
| J-702 | 3,799 | TRUE | Passed | 500 | 3,799 | 24 | 7 | J-692 |
| J-719 | 4,772 | TRUE | Passed | 500 | 4,772 | 24 | 23.6 | J-692 |
| J-724 | 4,594 | TRUE | Passed | 500 | 4,594 | 24 | 23.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-726 | 4,328 | TRUE | Passed | 500 | 4,328 | 24 | 23.3 | J-692 |
| J-727 | 8,247 | TRUE | Passed | 500 | 8,247 | 24 | 23.4 | J-692 |
| J-731 | 6,015 | TRUE | Passed | 500 | 6,016 | 24 | 19.4 | J-692 |
| J-904 | 7,109 | TRUE | Passed | 500 | 7,110 | 24 | 13.7 | J-692 |
| J-1031 | 9,755 | TRUE | Passed | 500 | 9,756 | 24 | 8.2 | J-692 |
| J-1082 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.5 | 7.2 | J-692 |
| J-1184 | 9,691 | TRUE | Passed | 500 | 9,692 | 24 | 22.2 | J-692 |
| J-1201 | 8,462 | TRUE | Passed | 500 | 8,463 | 24 | 20.4 | J-692 |
| J-1296 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.5 | 20.6 | J-692 |
| J-1334 | 4,020 | TRUE | Passed | 500 | 4,021 | 24 | 23.5 | J-692 |
| J-1340 | 4,140 | TRUE | Passed | 500 | 4,141 | 24 | 22.9 | J-692 |
| J-1549 | 3,100 | TRUE | Passed | 500 | 3,101 | 24 | 22.8 | J-692 |
| J-1642 | 9,055 | TRUE | Passed | 500 | 9,056 | 24 | 11.7 | J-692 |
| J-1704 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.2 | 8.5 | J-692 |
| J-1780 | 4,680 | TRUE | Passed | 500 | 4,680 | 24 | 23.6 | J-692 |
| J-1806 | 3,449 | TRUE | Passed | 500 | 3,449 | 24 | 13.1 | J-692 |
| **Scenario 4: 16-Inch SE Expansion - No Pressure Zone** | | | | | | | | |
| *NOTE: to meet fire flow constraints, the minimum residual pressure was lowered to 24 psi. | | | | | | | | |
| 1-FLOW | 9,351 | TRUE | Passed | 500 | 9,352 | 24 | 18.8 | J-692 |
| 1-RES | 3,306 | TRUE | Passed | 500 | 3,309 | 24 | 23.5 | J-692 |
| 2-FLOW | 7,909 | TRUE | Passed | 500 | 7,910 | 24 | 21.8 | J-692 |
| 2-RES | 4,365 | TRUE | Passed | 500 | 4,366 | 24 | 23.5 | J-692 |
| 3-FLOW | 3,022 | TRUE | Passed | 500 | 3,023 | 24 | 22.6 | J-692 |
| 3-RES | 2,579 | TRUE | Passed | 500 | 2,580 | 24 | 23 | J-692 |
| 4-FLOW | 3,650 | TRUE | Passed | 500 | 3,651 | 24 | 22.4 | J-692 |
| 4-RES | 2,640 | TRUE | Passed | 500 | 2,641 | 24 | 23.3 | J-692 |
| 5-FLOW | 4,348 | TRUE | Passed | 500 | 4,349 | 24 | 17 | J-692 |
| 5-RES | 2,122 | TRUE | Passed | 500 | 2,123 | 24 | 22.2 | J-692 |
| 6-FLOW | 2,148 | TRUE | Passed | 500 | 2,149 | 24 | 23.5 | J-692 |
| 6-RES | 1,395 | TRUE | Passed | 500 | 1,396 | 24 | 24.1 | J-692 |
| 7-FLOW | 2,359 | TRUE | Passed | 500 | 2,360 | 24 | 21.9 | J-692 |
| 7-RES | 2,119 | TRUE | Passed | 500 | 2,120 | 24 | 22.3 | J-692 |
| J-1 | 5,730 | TRUE | Passed | 500 | 5,731 | 24 | 15.4 | J-692 |
| J-2 | 7,833 | TRUE | Passed | 500 | 7,834 | 24 | 11.3 | J-692 |
| J-3 | 8,439 | TRUE | Passed | 500 | 8,440 | 24 | 11.6 | J-692 |
| J-11 | 9,020 | TRUE | Passed | 500 | 9,021 | 24 | 11.3 | J-692 |
| J-12 | 8,678 | TRUE | Passed | 500 | 8,679 | 24 | 10.4 | J-692 |
| J-13 | 5,186 | TRUE | Passed | 500 | 5,187 | 24 | 17.6 | J-692 |
| J-14 | 4,154 | TRUE | Passed | 500 | 4,155 | 24 | 19.8 | J-692 |
| J-15 | 8,058 | TRUE | Passed | 500 | 8,059 | 24 | 11.1 | J-692 |
| J-17 | 6,446 | TRUE | Passed | 500 | 6,447 | 24 | 14.5 | J-692 |
| J-18 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.4 | 21.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-19 | 10,000 | TRUE | Passed | 500 | 10,001 | 24.8 | 14.4 | J-692 |
| J-20 | 4,509 | TRUE | Passed | 500 | 4,510 | 24 | 21.5 | J-692 |
| J-21 | 4,612 | TRUE | Passed | 500 | 4,613 | 24 | 21.4 | J-692 |
| J-22 | 2,210 | TRUE | Passed | 500 | 2,211 | 24 | 23.6 | J-692 |
| J-23 | 4,069 | TRUE | Passed | 500 | 4,070 | 24 | 21.9 | J-692 |
| J-24 | 2,076 | TRUE | Passed | 500 | 2,077 | 24 | 23.6 | J-692 |
| J-25 | 3,623 | TRUE | Passed | 500 | 3,624 | 24 | 22.3 | J-692 |
| J-26 | 2,004 | TRUE | Passed | 500 | 2,005 | 24 | 23.7 | J-692 |
| J-27 | 3,729 | TRUE | Passed | 500 | 3,730 | 24 | 22.1 | J-692 |
| J-28 | 2,306 | TRUE | Passed | 500 | 2,307 | 24 | 23.4 | J-692 |
| J-29 | 4,056 | TRUE | Passed | 500 | 4,057 | 24 | 21.7 | J-692 |
| J-30 | 7,097 | TRUE | Passed | 500 | 7,098 | 24 | 16.7 | J-692 |
| J-31 | 2,879 | TRUE | Passed | 500 | 2,881 | 24 | 21.5 | J-692 |
| J-33 | 3,166 | TRUE | Passed | 500 | 3,167 | 24 | 21 | J-692 |
| J-34 | 3,094 | TRUE | Passed | 500 | 3,095 | 24 | 21.2 | J-692 |
| J-35 | 3,847 | TRUE | Passed | 500 | 3,848 | 24 | 19.7 | J-692 |
| J-36 | 5,310 | TRUE | Passed | 500 | 5,311 | 24 | 16.4 | J-692 |
| J-37 | 5,893 | TRUE | Passed | 500 | 5,894 | 24 | 15.8 | J-692 |
| J-38 | 5,652 | TRUE | Passed | 500 | 5,653 | 24 | 14.9 | J-692 |
| J-39 | 4,824 | TRUE | Passed | 500 | 4,825 | 24 | 17.8 | J-692 |
| J-40 | 4,751 | TRUE | Passed | 500 | 4,752 | 24 | 17.8 | J-692 |
| J-41 | 5,716 | TRUE | Passed | 500 | 5,717 | 24 | 14.7 | J-692 |
| J-42 | 3,405 | TRUE | Passed | 500 | 3,406 | 24 | 19.7 | J-692 |
| J-43 | 4,993 | TRUE | Passed | 500 | 4,994 | 24 | 15.5 | J-692 |
| J-44 | 2,515 | TRUE | Passed | 500 | 2,516 | 24 | 21.6 | J-692 |
| J-45 | 2,688 | TRUE | Passed | 500 | 2,689 | 24 | 21.2 | J-692 |
| J-46 | 3,525 | TRUE | Passed | 500 | 3,526 | 24 | 19.3 | J-692 |
| J-47 | 2,259 | TRUE | Passed | 500 | 2,261 | 24 | 22 | J-692 |
| J-48 | 2,997 | TRUE | Passed | 500 | 2,998 | 24 | 20.6 | J-692 |
| J-49 | 3,532 | TRUE | Passed | 500 | 3,533 | 24 | 19.5 | J-692 |
| J-50 | 2,685 | TRUE | Passed | 500 | 2,686 | 24 | 21.3 | J-692 |
| J-51 | 1,151 | TRUE | Passed | 500 | 1,152 | 24 | 23.7 | J-692 |
| J-52 | 2,911 | TRUE | Passed | 500 | 2,912 | 24 | 20.6 | J-692 |
| J-53 | 2,434 | TRUE | Passed | 500 | 2,435 | 24 | 21.6 | J-692 |
| J-54 | 2,631 | TRUE | Passed | 500 | 2,632 | 24 | 21.2 | J-692 |
| J-55 | 2,119 | TRUE | Passed | 500 | 2,120 | 24 | 22.2 | J-692 |
| J-56 | 2,477 | TRUE | Passed | 500 | 2,478 | 24 | 21.5 | J-692 |
| J-57 | 2,384 | TRUE | Passed | 500 | 2,385 | 24 | 21.7 | J-692 |
| J-58 | 2,632 | TRUE | Passed | 500 | 2,633 | 24 | 21.2 | J-692 |
| J-59 | 3,001 | TRUE | Passed | 500 | 3,002 | 24 | 20.4 | J-692 |
| J-60 | 2,743 | TRUE | Passed | 500 | 2,744 | 24 | 21 | J-692 |
| J-61 | 4,542 | TRUE | Passed | 500 | 4,544 | 24 | 16.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-64 | 4,519 | TRUE | Passed | 500 | 4,520 | 24 | 16.3 | J-692 |
| J-65 | 4,539 | TRUE | Passed | 500 | 4,540 | 24 | 16.6 | J-692 |
| J-66 | 5,661 | TRUE | Passed | 500 | 5,662 | 24 | 13.8 | J-692 |
| J-67 | 5,069 | TRUE | Passed | 500 | 5,070 | 24 | 15.5 | J-692 |
| J-68 | 5,405 | TRUE | Passed | 500 | 5,406 | 24 | 14.6 | J-692 |
| J-69 | 2,826 | TRUE | Passed | 500 | 2,827 | 24 | 21.1 | J-692 |
| J-70 | 4,280 | TRUE | Passed | 500 | 4,281 | 24 | 17.9 | J-692 |
| J-71 | 3,529 | TRUE | Passed | 500 | 3,530 | 24 | 19.7 | J-692 |
| J-72 | 3,521 | TRUE | Passed | 500 | 3,522 | 24 | 19.7 | J-692 |
| J-73 | 1,319 | TRUE | Passed | 500 | 1,320 | 24 | 23.6 | J-692 |
| J-74 | 3,491 | TRUE | Passed | 500 | 3,492 | 24 | 19.9 | J-692 |
| J-75 | 5,529 | TRUE | Passed | 500 | 5,530 | 24 | 14.8 | J-692 |
| J-76 | 5,238 | TRUE | Passed | 500 | 5,239 | 24 | 15.3 | J-692 |
| J-77 | 5,190 | TRUE | Passed | 500 | 5,191 | 24 | 15 | J-692 |
| J-78 | 5,728 | TRUE | Passed | 500 | 5,729 | 24 | 14.4 | J-692 |
| J-79 | 4,675 | TRUE | Passed | 500 | 4,676 | 24 | 17.3 | J-692 |
| J-80 | 5,273 | TRUE | Passed | 500 | 5,274 | 24 | 15.9 | J-692 |
| J-81 | 5,611 | TRUE | Passed | 500 | 5,612 | 24 | 14.5 | J-692 |
| J-82 | 6,306 | TRUE | Passed | 500 | 6,307 | 24 | 13.4 | J-692 |
| J-83 | 6,463 | TRUE | Passed | 500 | 6,464 | 24 | 13 | J-692 |
| J-84 | 6,476 | TRUE | Passed | 500 | 6,477 | 24 | 12.9 | J-692 |
| J-85 | 5,995 | TRUE | Passed | 500 | 5,996 | 24 | 13.9 | J-692 |
| J-86 | 5,647 | TRUE | Passed | 500 | 5,649 | 24 | 14.8 | J-692 |
| J-87 | 4,862 | TRUE | Passed | 500 | 4,863 | 24 | 17.1 | J-692 |
| J-88 | 4,222 | TRUE | Passed | 500 | 4,223 | 24 | 18.6 | J-692 |
| J-89 | 5,503 | TRUE | Passed | 500 | 5,504 | 24 | 15.1 | J-692 |
| J-90 | 4,011 | TRUE | Passed | 500 | 4,012 | 24 | 18.9 | J-692 |
| J-91 | 1,873 | TRUE | Passed | 500 | 1,874 | 24 | 22.9 | J-692 |
| J-92 | 6,372 | TRUE | Passed | 500 | 6,373 | 24 | 13.5 | J-692 |
| J-93 | 5,611 | TRUE | Passed | 500 | 5,612 | 24 | 14.2 | J-692 |
| J-94 | 6,339 | TRUE | Passed | 500 | 6,340 | 24 | 13.6 | J-692 |
| J-95 | 7,396 | TRUE | Passed | 500 | 7,397 | 24 | 12.2 | J-692 |
| J-96 | 6,229 | TRUE | Passed | 500 | 6,230 | 24 | 14.4 | J-692 |
| J-97 | 6,434 | TRUE | Passed | 500 | 6,435 | 24 | 13.3 | J-692 |
| J-98 | 6,606 | TRUE | Passed | 500 | 6,607 | 24 | 12.5 | J-692 |
| J-99 | 3,789 | TRUE | Passed | 500 | 3,790 | 24 | 16.6 | J-692 |
| J-100 | 5,587 | TRUE | Passed | 500 | 5,588 | 24 | 9.4 | J-692 |
| J-101 | 3,484 | TRUE | Passed | 500 | 3,485 | 24 | 17.4 | J-692 |
| J-102 | 5,742 | TRUE | Passed | 500 | 5,743 | 24 | 8.1 | J-692 |
| J-103 | 5,336 | TRUE | Passed | 500 | 5,337 | 24 | 7.4 | J-692 |
| J-104 | 4,544 | TRUE | Passed | 500 | 4,545 | 24 | 11.2 | J-692 |
| J-105 | 5,606 | TRUE | Passed | 500 | 5,607 | 24 | 5.3 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-106 | 5,315 | TRUE | Passed | 500 | 5,316 | 24 | 7.1 | J-692 |
| J-107 | 4,862 | TRUE | Passed | 500 | 4,863 | 24 | 9.7 | J-692 |
| J-108 | 5,356 | TRUE | Passed | 500 | 5,358 | 24 | 6.8 | J-692 |
| J-109 | 5,299 | TRUE | Passed | 500 | 5,300 | 24 | 7.2 | J-692 |
| J-110 | 4,888 | TRUE | Passed | 500 | 4,889 | 24 | 9.8 | J-692 |
| J-111 | 4,393 | TRUE | Passed | 500 | 4,394 | 24 | 12.3 | J-692 |
| J-112 | 3,847 | TRUE | Passed | 500 | 3,848 | 24 | 14.8 | J-692 |
| J-113 | 3,281 | TRUE | Passed | 500 | 3,282 | 24 | 17 | J-692 |
| J-114 | 2,997 | TRUE | Passed | 500 | 2,998 | 24 | 17.8 | J-692 |
| J-115 | 3,686 | TRUE | Passed | 500 | 3,687 | 24 | 15.1 | J-692 |
| J-116 | 2,782 | TRUE | Passed | 500 | 2,783 | 24 | 18.6 | J-692 |
| J-117 | 3,318 | TRUE | Passed | 500 | 3,319 | 24 | 16.5 | J-692 |
| J-118 | 2,135 | TRUE | Passed | 500 | 2,136 | 24 | 22.7 | J-692 |
| J-118 | 2,925 | TRUE | Passed | 500 | 2,926 | 24 | 18 | J-692 |
| J-119 | 3,455 | TRUE | Passed | 500 | 3,456 | 24 | 15.8 | J-692 |
| J-121 | 2,596 | TRUE | Passed | 500 | 2,597 | 24 | 19 | J-692 |
| J-122 | 3,590 | TRUE | Passed | 500 | 3,591 | 24 | 15.1 | J-692 |
| J-123 | 5,634 | TRUE | Passed | 500 | 5,659 | 30.6 | 0 | J-692 |
| J-124 | 5,989 | TRUE | Passed | 500 | 5,990 | 24 | 0.5 | J-692 |
| J-125 | 3,654 | TRUE | Passed | 500 | 3,655 | 24 | 13.8 | J-692 |
| J-126 | 4,870 | TRUE | Passed | 500 | 4,872 | 24 | 7.2 | J-692 |
| J-127 | 3,712 | TRUE | Passed | 500 | 3,713 | 24 | 13.6 | J-692 |
| J-128 | 1,362 | TRUE | Passed | 500 | 1,363 | 24 | 22.5 | J-692 |
| J-129 | 3,318 | TRUE | Passed | 500 | 3,319 | 24 | 15.5 | J-692 |
| J-130 | 3,348 | TRUE | Passed | 500 | 3,349 | 24 | 15.5 | J-692 |
| J-133 | 3,325 | TRUE | Passed | 500 | 3,326 | 24 | 15.7 | J-692 |
| J-134 | 2,678 | TRUE | Passed | 500 | 2,679 | 24 | 18.4 | J-692 |
| J-135 | 2,986 | TRUE | Passed | 500 | 2,987 | 24 | 17.2 | J-692 |
| J-136 | 3,357 | TRUE | Passed | 500 | 3,358 | 24 | 15.6 | J-692 |
| J-137 | 3,583 | TRUE | Passed | 500 | 3,584 | 24 | 14.6 | J-692 |
| J-138 | 4,008 | TRUE | Passed | 500 | 4,009 | 24 | 12.6 | J-692 |
| J-139 | 5,441 | TRUE | Passed | 500 | 5,442 | 24 | 7.4 | J-692 |
| J-140 | 3,258 | TRUE | Passed | 500 | 3,259 | 24 | 17.3 | J-692 |
| J-141 | 3,589 | TRUE | Passed | 500 | 3,590 | 24 | 16 | J-692 |
| J-142 | 5,025 | TRUE | Passed | 500 | 5,026 | 24 | 8.8 | J-692 |
| J-143 | 6,049 | TRUE | Passed | 500 | 6,051 | 24 | 3 | J-692 |
| J-144 | 6,119 | TRUE | Passed | 500 | 6,120 | 24 | 1.3 | J-692 |
| J-145 | 3,838 | TRUE | Passed | 500 | 3,839 | 24 | 14.1 | J-692 |
| J-146 | 6,162 | TRUE | Passed | 500 | 6,163 | 24 | 1.6 | J-692 |
| J-147 | 5,953 | TRUE | Passed | 500 | 5,954 | 24 | 3.1 | J-692 |
| J-148 | 6,161 | TRUE | Passed | 500 | 6,162 | 24 | 2.7 | J-692 |
| J-149 | 6,197 | TRUE | Passed | 500 | 6,198 | 24 | 5.4 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-150 | 5,829 | TRUE | Passed | 500 | 5,830 | 24 | 8.8 | J-692 |
| J-151 | 5,927 | TRUE | Passed | 500 | 5,928 | 24 | 6.1 | J-692 |
| J-152 | 2,836 | TRUE | Passed | 500 | 2,837 | 24 | 20 | J-692 |
| J-153 | 6,119 | TRUE | Passed | 500 | 6,120 | 24 | 8.3 | J-692 |
| J-154 | 5,797 | TRUE | Passed | 500 | 5,798 | 24 | 9.8 | J-692 |
| J-155 | 3,478 | TRUE | Passed | 500 | 3,479 | 24 | 19.5 | J-692 |
| J-156 | 3,448 | TRUE | Passed | 500 | 3,449 | 24 | 19.7 | J-692 |
| J-157 | 3,689 | TRUE | Passed | 500 | 3,690 | 24 | 18.9 | J-692 |
| J-158 | 2,989 | TRUE | Passed | 500 | 2,990 | 24 | 19.7 | J-692 |
| J-159 | 4,146 | TRUE | Passed | 500 | 4,147 | 24 | 16.3 | J-692 |
| J-160 | 4,368 | TRUE | Passed | 500 | 4,369 | 24 | 15.3 | J-692 |
| J-161 | 4,360 | TRUE | Passed | 500 | 4,361 | 24 | 15.2 | J-692 |
| J-162 | 4,402 | TRUE | Passed | 500 | 4,403 | 24 | 15.1 | J-692 |
| J-163 | 3,851 | TRUE | Passed | 500 | 3,852 | 24 | 16.9 | J-692 |
| J-164 | 4,181 | TRUE | Passed | 500 | 4,182 | 24 | 15.8 | J-692 |
| J-165 | 4,559 | TRUE | Passed | 500 | 4,560 | 24 | 14.4 | J-692 |
| J-166 | 6,290 | TRUE | Passed | 500 | 6,291 | 24 | 4.2 | J-692 |
| J-167 | 2,558 | TRUE | Passed | 500 | 2,559 | 24 | 20.6 | J-692 |
| J-168 | 3,176 | TRUE | Passed | 500 | 3,177 | 24 | 19 | J-692 |
| J-169 | 4,007 | TRUE | Passed | 500 | 4,008 | 24 | 16.4 | J-692 |
| J-170 | 5,879 | TRUE | Passed | 500 | 5,880 | 24 | 6.2 | J-692 |
| J-171 | 2,614 | TRUE | Passed | 500 | 2,615 | 24 | 19.8 | J-692 |
| J-172 | 5,514 | TRUE | Passed | 500 | 5,515 | 24 | 4.5 | J-692 |
| J-173 | 4,030 | TRUE | Passed | 500 | 4,031 | 24 | 12.8 | J-692 |
| J-174 | 4,107 | TRUE | Passed | 500 | 4,108 | 24 | 12.4 | J-692 |
| J-175 | 5,075 | TRUE | Passed | 500 | 5,076 | 24 | 7.1 | J-692 |
| J-176 | 3,920 | TRUE | Passed | 500 | 3,921 | 24 | 13.3 | J-692 |
| J-177 | 2,569 | TRUE | Passed | 500 | 2,570 | 24 | 19 | J-692 |
| J-178 | 3,282 | TRUE | Passed | 500 | 3,283 | 24 | 16.2 | J-692 |
| J-179 | 1,240 | TRUE | Passed | 500 | 1,241 | 24 | 22.9 | J-692 |
| J-180 | 1,594 | TRUE | Passed | 500 | 1,595 | 24 | 21.8 | J-692 |
| J-181 | 3,531 | TRUE | Passed | 500 | 3,532 | 24 | 15.1 | J-692 |
| J-183 | 9,936 | TRUE | Passed | 500 | 9,937 | 31.7 | 0 | J-692 |
| J-184 | 779 | TRUE | Passed | 500 | 780 | 24 | 24.2 | J-692 |
| J-185 | 7,641 | TRUE | Passed | 500 | 7,642 | 24 | 8.9 | J-692 |
| J-186 | 5,305 | TRUE | Passed | 500 | 5,306 | 24 | 16 | J-692 |
| J-187 | 5,533 | TRUE | Passed | 500 | 5,534 | 24 | 15.3 | J-692 |
| J-188 | 4,188 | TRUE | Passed | 500 | 4,189 | 24 | 18.7 | J-692 |
| J-189 | 5,276 | TRUE | Passed | 500 | 5,277 | 24 | 15.7 | J-692 |
| J-190 | 5,317 | TRUE | Passed | 500 | 5,318 | 24 | 15.9 | J-692 |
| J-191 | 4,554 | TRUE | Passed | 500 | 4,555 | 24 | 17.9 | J-692 |
| J-192 | 3,970 | TRUE | Passed | 500 | 3,971 | 24 | 19 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-193 | 3,915 | TRUE | Passed | 500 | 3,916 | 24 | 18.8 | J-692 |
| J-194 | 3,319 | TRUE | Passed | 500 | 3,320 | 24 | 19.9 | J-692 |
| J-195 | 2,582 | TRUE | Passed | 500 | 2,583 | 24 | 21.5 | J-692 |
| J-196 | 2,138 | TRUE | Passed | 500 | 2,139 | 24 | 22.3 | J-692 |
| J-197 | 2,313 | TRUE | Passed | 500 | 2,314 | 24 | 22 | J-692 |
| J-200 | 5,230 | TRUE | Passed | 500 | 5,231 | 24 | 16.6 | J-692 |
| J-201 | 4,605 | TRUE | Passed | 500 | 4,606 | 24 | 18.1 | J-692 |
| J-202 | 5,065 | TRUE | Passed | 500 | 5,066 | 24 | 17.1 | J-692 |
| J-203 | 5,036 | TRUE | Passed | 500 | 5,037 | 24 | 17.2 | J-692 |
| J-204 | 3,870 | TRUE | Passed | 500 | 3,871 | 24 | 19.8 | J-692 |
| J-205 | 3,147 | TRUE | Passed | 500 | 3,148 | 24 | 21.1 | J-692 |
| J-206 | 4,234 | TRUE | Passed | 500 | 4,235 | 24 | 19 | J-692 |
| J-207 | 3,485 | TRUE | Passed | 500 | 3,486 | 24 | 20.5 | J-692 |
| J-208 | 5,665 | TRUE | Passed | 500 | 5,666 | 24 | 15.8 | J-692 |
| J-209 | 4,300 | TRUE | Passed | 500 | 4,301 | 24 | 19 | J-692 |
| J-210 | 7,330 | TRUE | Passed | 500 | 7,331 | 24 | 12.3 | J-692 |
| J-211 | 6,197 | TRUE | Passed | 500 | 6,198 | 24 | 16.2 | J-692 |
| J-212 | 4,960 | TRUE | Passed | 500 | 4,961 | 24 | 18.8 | J-692 |
| J-213 | 3,822 | TRUE | Passed | 500 | 3,823 | 24 | 20.8 | J-692 |
| J-214 | 3,006 | TRUE | Passed | 500 | 3,007 | 24 | 22.1 | J-692 |
| J-215 | 2,510 | TRUE | Passed | 500 | 2,511 | 24 | 22.7 | J-692 |
| J-216 | 881 | TRUE | Passed | 500 | 882 | 24 | 24.3 | J-692 |
| J-217 | 3,619 | TRUE | Passed | 500 | 3,620 | 24 | 21.2 | J-692 |
| J-218 | 2,014 | TRUE | Passed | 500 | 2,015 | 24 | 23.3 | J-692 |
| J-219 | 4,400 | TRUE | Passed | 500 | 4,401 | 24 | 19.9 | J-692 |
| J-220 | 2,099 | TRUE | Passed | 500 | 2,100 | 24 | 23.2 | J-692 |
| J-221 | 2,516 | TRUE | Passed | 500 | 2,517 | 24 | 22.7 | J-692 |
| J-222 | 4,873 | TRUE | Passed | 500 | 4,874 | 24 | 19.1 | J-692 |
| J-223 | 5,372 | TRUE | Passed | 500 | 5,373 | 24 | 18.1 | J-692 |
| J-224 | 6,241 | TRUE | Passed | 500 | 6,242 | 24 | 16.4 | J-692 |
| J-225 | 6,464 | TRUE | Passed | 500 | 6,465 | 24 | 15.8 | J-692 |
| J-226 | 8,236 | TRUE | Passed | 500 | 8,237 | 24 | 11.3 | J-692 |
| J-227 | 6,799 | TRUE | Passed | 500 | 6,800 | 24 | 12.7 | J-692 |
| J-228 | 5,414 | TRUE | Passed | 500 | 5,415 | 24 | 16 | J-692 |
| J-229 | 5,322 | TRUE | Passed | 500 | 5,323 | 24 | 16.3 | J-692 |
| J-230 | 3,169 | TRUE | Passed | 500 | 3,170 | 24 | 21.1 | J-692 |
| J-231 | 4,922 | TRUE | Passed | 500 | 4,923 | 24 | 17.4 | J-692 |
| J-232 | 5,472 | TRUE | Passed | 500 | 5,473 | 24 | 16.2 | J-692 |
| J-233 | 7,137 | TRUE | Passed | 500 | 7,138 | 24 | 11.9 | J-692 |
| J-234 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.1 | 2 | J-692 |
| J-235 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.9 | 3.4 | J-692 |
| J-236 | 2,584 | TRUE | Passed | 500 | 2,585 | 24 | 21.4 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-237 | 2,150 | TRUE | Passed | 500 | 2,151 | 24 | 22.2 | J-692 |
| J-238 | 1,180 | TRUE | Passed | 500 | 1,181 | 24 | 23.7 | J-692 |
| J-239 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.9 | 7.7 | J-692 |
| J-240 | 10,000 | TRUE | Passed | 500 | 10,001 | 28.4 | 7.8 | J-692 |
| J-241 | 8,771 | TRUE | Passed | 500 | 8,772 | 24 | 12.6 | J-692 |
| J-242 | 8,603 | TRUE | Passed | 500 | 8,604 | 24 | 15.4 | J-692 |
| J-243 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.2 | 11.5 | J-692 |
| J-244 | 5,666 | TRUE | Passed | 500 | 5,667 | 24 | 19.2 | J-692 |
| J-245 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.1 | 12.9 | J-692 |
| J-246 | 9,712 | TRUE | Passed | 500 | 9,713 | 24 | 17.3 | J-692 |
| J-247 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.8 | 14.6 | J-692 |
| J-248 | 7,702 | TRUE | Passed | 500 | 7,703 | 24 | 17.1 | J-692 |
| J-249 | 2,649 | TRUE | Passed | 500 | 2,650 | 24 | 23.1 | J-250 |
| J-250 | 1,453 | TRUE | Passed | 500 | 1,454 | 24 | 24.2 | J-692 |
| J-251 | 7,963 | TRUE | Passed | 500 | 7,964 | 24 | 16.8 | J-692 |
| J-252 | 7,888 | TRUE | Passed | 500 | 7,889 | 24 | 17.3 | J-692 |
| J-253 | 3,422 | TRUE | Passed | 500 | 3,423 | 24 | 22.9 | J-692 |
| J-254 | 8,517 | TRUE | Passed | 500 | 8,518 | 24 | 15.7 | J-692 |
| J-255 | 7,836 | TRUE | Passed | 500 | 7,837 | 24 | 17 | J-692 |
| J-256 | 4,530 | TRUE | Passed | 500 | 4,531 | 24 | 21.5 | J-692 |
| J-257 | 7,778 | TRUE | Passed | 500 | 7,779 | 24 | 16.9 | J-692 |
| J-258 | 7,744 | TRUE | Passed | 500 | 7,745 | 24 | 16.9 | J-692 |
| J-259 | 4,818 | TRUE | Passed | 500 | 4,819 | 24 | 21.1 | J-692 |
| J-260 | 6,848 | TRUE | Passed | 500 | 6,849 | 24 | 18.4 | J-692 |
| J-262 | 7,897 | TRUE | Passed | 500 | 7,898 | 24 | 17.1 | J-692 |
| J-263 | 4,631 | TRUE | Passed | 500 | 4,632 | 24 | 21.4 | J-692 |
| J-264 | 8,431 | TRUE | Passed | 500 | 8,432 | 24 | 16.4 | J-692 |
| J-265 | 4,341 | TRUE | Passed | 500 | 4,342 | 24 | 21.7 | J-692 |
| J-266 | 3,051 | TRUE | Passed | 500 | 3,052 | 24 | 22.9 | J-692 |
| J-267 | 6,667 | TRUE | Passed | 500 | 6,668 | 24 | 18.7 | J-692 |
| J-268 | 5,864 | TRUE | Passed | 500 | 5,865 | 24 | 19.9 | J-692 |
| J-269 | 6,817 | TRUE | Passed | 500 | 6,818 | 24 | 18.4 | J-692 |
| J-270 | 8,293 | TRUE | Passed | 500 | 8,294 | 24 | 15.9 | J-692 |
| J-271 | 7,071 | TRUE | Passed | 500 | 7,072 | 24 | 18 | J-692 |
| J-272 | 7,100 | TRUE | Passed | 500 | 7,101 | 24 | 17.5 | J-692 |
| J-273 | 5,400 | TRUE | Passed | 500 | 5,402 | 24 | 20 | J-692 |
| J-274 | 4,984 | TRUE | Passed | 500 | 4,985 | 24 | 20.6 | J-692 |
| J-275 | 6,719 | TRUE | Passed | 500 | 6,720 | 24 | 17.9 | J-692 |
| J-276 | 6,497 | TRUE | Passed | 500 | 6,498 | 24 | 18.4 | J-692 |
| J-277 | 6,539 | TRUE | Passed | 500 | 6,540 | 24 | 18 | J-692 |
| J-278 | 4,816 | TRUE | Passed | 500 | 4,817 | 24 | 20.6 | J-692 |
| J-279 | 4,271 | TRUE | Passed | 500 | 4,272 | 24 | 21.2 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-280 | 1,576 | TRUE | Passed | 500 | 1,577 | 24 | 24 | J-692 |
| J-281 | 3,498 | TRUE | Passed | 500 | 3,499 | 24 | 22.2 | J-692 |
| J-282 | 3,328 | TRUE | Passed | 500 | 3,329 | 24 | 22.4 | J-692 |
| J-283 | 2,642 | TRUE | Passed | 500 | 2,643 | 24 | 23.1 | J-692 |
| J-284 | 1,514 | TRUE | Passed | 500 | 1,515 | 24 | 24 | J-692 |
| J-285 | 2,234 | TRUE | Passed | 500 | 2,235 | 24 | 23.5 | J-692 |
| J-286 | 4,719 | TRUE | Passed | 500 | 4,720 | 24 | 20.6 | J-692 |
| J-287 | 3,846 | TRUE | Passed | 500 | 3,847 | 24 | 21.4 | J-292 |
| J-288 | 2,240 | TRUE | Passed | 500 | 2,241 | 24 | 23.4 | J-692 |
| J-289 | 2,529 | TRUE | Passed | 500 | 2,530 | 24 | 23.1 | J-290 |
| J-290 | 2,334 | TRUE | Passed | 500 | 2,335 | 24 | 23.3 | J-692 |
| J-291 | 1,257 | TRUE | Passed | 500 | 1,258 | 24 | 24.2 | J-692 |
| J-292 | 2,769 | TRUE | Passed | 500 | 2,770 | 24 | 22.9 | J-692 |
| J-294 | 1,513 | TRUE | Passed | 500 | 1,514 | 24 | 24 | J-692 |
| J-296 | 6,662 | TRUE | Passed | 500 | 6,663 | 24 | 17.2 | J-692 |
| J-297 | 6,777 | TRUE | Passed | 500 | 6,778 | 24 | 16.7 | J-692 |
| J-298 | 8,949 | TRUE | Passed | 500 | 8,950 | 24 | 11.4 | J-692 |
| J-299 | 10,000 | TRUE | Passed | 500 | 10,001 | 24.2 | 8.9 | J-692 |
| J-300 | 4,456 | TRUE | Passed | 500 | 4,457 | 24 | 20.9 | J-692 |
| J-301 | 3,597 | TRUE | Passed | 500 | 3,598 | 24 | 22 | J-692 |
| J-302 | 4,061 | TRUE | Passed | 500 | 4,062 | 24 | 21.5 | J-692 |
| J-303 | 3,339 | TRUE | Passed | 500 | 3,340 | 24 | 22.4 | J-692 |
| J-304 | 5,977 | TRUE | Passed | 500 | 5,978 | 24 | 18.8 | J-692 |
| J-305 | 6,132 | TRUE | Passed | 500 | 6,133 | 24 | 18.5 | J-692 |
| J-306 | 2,616 | TRUE | Passed | 500 | 2,617 | 24 | 23.1 | J-692 |
| J-307 | 8,234 | TRUE | Passed | 500 | 8,235 | 24 | 14.7 | J-692 |
| J-308 | 7,301 | TRUE | Passed | 500 | 7,302 | 24 | 16.8 | J-692 |
| J-309 | 3,862 | TRUE | Passed | 500 | 3,863 | 24 | 21.6 | J-692 |
| J-310 | 3,670 | TRUE | Passed | 500 | 3,671 | 24 | 21.8 | J-692 |
| J-311 | 4,178 | TRUE | Passed | 500 | 4,179 | 24 | 21.2 | J-692 |
| J-312 | 4,107 | TRUE | Passed | 500 | 4,108 | 24 | 21.2 | J-692 |
| J-313 | 4,632 | TRUE | Passed | 500 | 4,633 | 24 | 20.3 | J-692 |
| J-314 | 3,458 | TRUE | Passed | 500 | 3,459 | 24 | 22 | J-692 |
| J-315 | 2,811 | TRUE | Passed | 500 | 2,812 | 24 | 22.7 | J-692 |
| J-316 | 4,784 | TRUE | Passed | 500 | 4,785 | 24 | 19.9 | J-692 |
| J-317 | 3,558 | TRUE | Passed | 500 | 3,559 | 24 | 21.9 | J-692 |
| J-318 | 7,026 | TRUE | Passed | 500 | 7,027 | 24 | 17.9 | J-692 |
| J-319 | 6,720 | TRUE | Passed | 500 | 6,721 | 24 | 18.3 | J-692 |
| J-320 | 6,750 | TRUE | Passed | 500 | 6,751 | 24 | 18.1 | J-692 |
| J-321 | 3,522 | TRUE | Passed | 500 | 3,523 | 24 | 22.5 | J-692 |
| J-322 | 3,749 | TRUE | Passed | 500 | 3,750 | 24 | 22.3 | J-692 |
| J-323 | 3,322 | TRUE | Passed | 500 | 3,323 | 24 | 22.7 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-324 | 4,575 | TRUE | Passed | 500 | 4,576 | 24 | 21.4 | J-692 |
| J-325 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.7 | 7.5 | J-692 |
| J-326 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.3 | 7.3 | J-692 |
| J-327 | 7,326 | TRUE | Passed | 500 | 7,327 | 24 | 14.4 | J-692 |
| J-328 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.1 | 7.3 | J-692 |
| J-329 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.7 | 6.9 | J-692 |
| J-330 | 1,843 | TRUE | Passed | 500 | 1,844 | 24 | 23.5 | J-692 |
| J-331 | 6,329 | TRUE | Passed | 500 | 6,330 | 24 | 16.4 | J-692 |
| J-332 | 6,626 | TRUE | Passed | 500 | 6,627 | 24 | 15.9 | J-692 |
| J-333 | 4,787 | TRUE | Passed | 500 | 4,788 | 24 | 19.4 | J-692 |
| J-334 | 8,292 | TRUE | Passed | 500 | 8,293 | 24 | 11.2 | J-692 |
| J-336 | 7,020 | TRUE | Passed | 500 | 7,021 | 24 | 14.7 | J-692 |
| J-338 | 7,755 | TRUE | Passed | 500 | 7,756 | 24 | 12.9 | J-692 |
| J-339 | 6,701 | TRUE | Passed | 500 | 6,702 | 24 | 15.3 | J-692 |
| J-340 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.1 | 7.6 | J-692 |
| J-341 | 7,909 | TRUE | Passed | 500 | 7,910 | 24 | 15.1 | J-692 |
| J-342 | 4,261 | TRUE | Passed | 500 | 4,262 | 24 | 21 | J-692 |
| J-343 | 7,650 | TRUE | Passed | 500 | 7,651 | 24 | 15.1 | J-692 |
| J-345 | 5,147 | TRUE | Passed | 500 | 5,148 | 24 | 19.6 | J-692 |
| J-346 | 3,863 | TRUE | Passed | 500 | 3,864 | 24 | 21.4 | J-692 |
| J-347 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.6 | 7.5 | J-692 |
| J-348 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.2 | 7.6 | J-692 |
| J-349 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.4 | 7.6 | J-692 |
| J-350 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.5 | 7.6 | J-692 |
| J-351 | 8,954 | TRUE | Passed | 500 | 8,955 | 24 | 10.4 | J-692 |
| J-352 | 9,248 | TRUE | Passed | 500 | 9,249 | 24 | 9.6 | J-692 |
| J-353 | 9,816 | TRUE | Passed | 500 | 9,817 | 24 | 8 | J-692 |
| J-354 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.4 | 8.3 | J-692 |
| J-355 | 9,190 | TRUE | Passed | 500 | 9,191 | 24 | 10.4 | J-692 |
| J-356 | 8,644 | TRUE | Passed | 500 | 8,645 | 24 | 11.2 | J-692 |
| J-357 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.7 | 7.4 | J-692 |
| J-358 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.4 | 8.5 | J-692 |
| J-359 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.6 | 8.5 | J-692 |
| J-360 | 1,637 | TRUE | Passed | 500 | 1,638 | 24 | 23.8 | J-692 |
| J-361 | 8,790 | TRUE | Passed | 500 | 8,791 | 24 | 11.4 | J-692 |
| J-362 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.6 | 7.7 | J-692 |
| J-363 | 8,325 | TRUE | Passed | 500 | 8,326 | 24 | 12.1 | J-692 |
| J-364 | 7,467 | TRUE | Passed | 500 | 7,468 | 24 | 14.2 | J-692 |
| J-365 | 7,879 | TRUE | Passed | 500 | 7,880 | 24 | 13.2 | J-692 |
| J-366 | 7,284 | TRUE | Passed | 500 | 7,285 | 24 | 14.6 | J-692 |
| J-367 | 8,930 | TRUE | Passed | 500 | 8,931 | 24 | 10.5 | J-692 |
| J-368 | 6,231 | TRUE | Passed | 500 | 6,232 | 24 | 17.5 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-369 | 9,037 | TRUE | Passed | 500 | 9,038 | 24 | 11 | J-692 |
| J-370 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.9 | 8.4 | J-692 |
| J-371 | 3,762 | TRUE | Passed | 500 | 3,763 | 24 | 14.4 | J-692 |
| J-371 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.4 | 8.3 | J-692 |
| J-372 | 7,283 | TRUE | Passed | 500 | 7,284 | 24 | 14.9 | J-692 |
| J-373 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.1 | 7.6 | J-692 |
| J-374 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.3 | 7.6 | J-692 |
| J-375 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.8 | 7.6 | J-692 |
| J-376 | 8,299 | TRUE | Passed | 500 | 8,300 | 24 | 12.2 | J-692 |
| J-377 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.5 | 7.5 | J-692 |
| J-378 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.7 | 7.7 | J-692 |
| J-379 | 10,000 | TRUE | Passed | 500 | 10,001 | 44 | 7.7 | J-692 |
| J-380 | 6,978 | TRUE | Passed | 500 | 6,979 | 24 | 15.5 | J-692 |
| J-382 | 7,539 | TRUE | Passed | 500 | 7,540 | 24 | 14.5 | J-692 |
| J-383 | 6,931 | TRUE | Passed | 500 | 6,932 | 24 | 15.8 | J-692 |
| J-384 | 7,231 | TRUE | Passed | 500 | 7,232 | 24 | 15.2 | J-692 |
| J-385 | 9,576 | TRUE | Passed | 500 | 9,577 | 24 | 9.4 | J-692 |
| J-386 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.1 | 8.2 | J-692 |
| J-387 | 8,803 | TRUE | Passed | 500 | 8,804 | 24 | 11.5 | J-692 |
| J-388 | 6,662 | TRUE | Passed | 500 | 6,663 | 24 | 16.4 | J-692 |
| J-389 | 5,244 | TRUE | Passed | 500 | 5,245 | 24 | 19.2 | J-692 |
| J-390 | 1,964 | TRUE | Passed | 500 | 1,965 | 24 | 23.5 | J-692 |
| J-391 | 7,043 | TRUE | Passed | 500 | 7,044 | 24 | 15.4 | J-692 |
| J-392 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.4 | 7.7 | J-692 |
| J-393 | 7,836 | TRUE | Passed | 500 | 7,837 | 24 | 13.6 | J-692 |
| J-394 | 9,195 | TRUE | Passed | 500 | 9,196 | 24 | 10.2 | J-692 |
| J-395 | 9,363 | TRUE | Passed | 500 | 9,364 | 24 | 9.7 | J-692 |
| J-396 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.2 | 7.7 | J-692 |
| J-397 | 6,418 | TRUE | Passed | 500 | 6,419 | 24 | 16.5 | J-692 |
| J-398 | 1,748 | TRUE | Passed | 500 | 1,749 | 24 | 23.6 | J-692 |
| J-399 | 10,000 | TRUE | Passed | 500 | 10,001 | 65 | 6.9 | J-692 |
| J-401 | 3,853 | TRUE | Passed | 500 | 3,854 | 24 | 12.9 | J-692 |
| J-401 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 7.4 | J-692 |
| J-402 | 10,000 | TRUE | Passed | 500 | 10,001 | 62.5 | 7.4 | J-692 |
| J-403 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.2 | 7.4 | J-692 |
| J-404 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.2 | 7.9 | J-692 |
| J-405 | 4,715 | TRUE | Passed | 500 | 4,716 | 24 | 19.7 | J-692 |
| J-406 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.1 | 7.4 | J-692 |
| J-407 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.5 | 7.3 | J-692 |
| J-408 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.9 | 7.6 | J-692 |
| J-409 | 3,517 | TRUE | Passed | 500 | 3,518 | 24 | 21.6 | J-692 |
| J-410 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.3 | 7.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-411 | 3,582 | TRUE | Passed | 500 | 3,583 | 24 | 21.5 | J-692 |
| J-412 | 10,000 | TRUE | Passed | 500 | 10,001 | 56 | 7.6 | J-692 |
| J-413 | 10,000 | TRUE | Passed | 500 | 10,001 | 62.3 | 7.3 | J-692 |
| J-414 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.3 | 5.4 | J-692 |
| J-415 | 2,017 | TRUE | Passed | 500 | 2,018 | 24 | 23.2 | J-692 |
| J-416 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.9 | 7.5 | J-692 |
| J-417 | 10,000 | TRUE | Passed | 500 | 10,001 | 55.1 | 7.7 | J-692 |
| J-418 | 5,540 | TRUE | Passed | 500 | 5,541 | 24 | 18.6 | J-692 |
| J-419 | 3,522 | TRUE | Passed | 500 | 3,523 | 24 | 21.7 | J-692 |
| J-420 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.4 | 8.8 | J-692 |
| J-421 | 9,496 | TRUE | Passed | 500 | 9,497 | 24 | 9.9 | J-692 |
| J-422 | 7,007 | TRUE | Passed | 500 | 7,009 | 24 | 15.7 | J-692 |
| J-423 | 9,392 | TRUE | Passed | 500 | 9,393 | 24 | 10.1 | J-692 |
| J-424 | 4,917 | TRUE | Passed | 500 | 4,918 | 24 | 19.6 | J-692 |
| J-425 | 4,216 | TRUE | Passed | 500 | 4,217 | 24 | 20.7 | J-692 |
| J-426 | 9,446 | TRUE | Passed | 500 | 9,447 | 24 | 9.5 | J-692 |
| J-427 | 8,013 | TRUE | Passed | 500 | 8,014 | 24 | 13.3 | J-692 |
| J-428 | 9,512 | TRUE | Passed | 500 | 9,513 | 24 | 9.7 | J-692 |
| J-429 | 9,483 | TRUE | Passed | 500 | 9,484 | 24 | 9.7 | J-692 |
| J-430 | 4,054 | TRUE | Passed | 500 | 4,055 | 24 | 20.9 | J-692 |
| J-431 | 7,438 | TRUE | Passed | 500 | 7,439 | 24 | 14.7 | J-692 |
| J-432 | 2,367 | TRUE | Passed | 500 | 2,368 | 24 | 23.1 | J-692 |
| J-433 | 3,983 | TRUE | Passed | 500 | 3,984 | 24 | 18.3 | J-692 |
| J-434 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 24.2 | J-692 |
| J-435 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 24.3 | J-692 |
| J-436 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.7 | 23.7 | J-692 |
| J-437 | 9,025 | TRUE | Passed | 500 | 9,026 | 24 | 23 | J-692 |
| J-439 | 7,101 | TRUE | Passed | 500 | 7,103 | 24 | 22.8 | J-692 |
| J-440 | 6,970 | TRUE | Passed | 500 | 6,971 | 24 | 22.8 | J-692 |
| J-442 | 8,076 | TRUE | Passed | 500 | 8,077 | 24 | 21.5 | J-443 |
| J-443 | 2,219 | TRUE | Passed | 500 | 2,220 | 24 | 24.3 | J-692 |
| J-445 | 9,420 | TRUE | Passed | 500 | 9,421 | 24 | 20.3 | J-692 |
| J-447 | 6,436 | TRUE | Passed | 500 | 6,437 | 24 | 21.8 | J-692 |
| J-448 | 5,131 | TRUE | Passed | 500 | 5,132 | 24 | 22.6 | J-692 |
| J-449 | 6,115 | TRUE | Passed | 500 | 6,116 | 24 | 17.5 | J-450 |
| J-450 | 4,225 | TRUE | Passed | 500 | 4,226 | 24 | 23.1 | J-692 |
| J-451 | 5,968 | TRUE | Passed | 500 | 5,969 | 24 | 21.9 | J-692 |
| J-452 | 5,465 | TRUE | Passed | 500 | 5,466 | 24 | 22.1 | J-692 |
| J-453 | 5,034 | TRUE | Passed | 500 | 5,035 | 24 | 22.6 | J-692 |
| J-454 | 4,857 | TRUE | Passed | 500 | 4,858 | 24 | 22.7 | J-692 |
| J-455 | 6,541 | TRUE | Passed | 500 | 6,542 | 24 | 21.6 | J-692 |
| J-456 | 6,502 | TRUE | Passed | 500 | 6,503 | 24 | 21.5 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-457 | 5,222 | TRUE | Passed | 500 | 5,223 | 24 | 22.2 | J-692 |
| J-458 | 3,030 | TRUE | Passed | 500 | 3,031 | 24 | 23.6 | J-692 |
| J-459 | 2,955 | TRUE | Passed | 500 | 2,956 | 24 | 23.6 | J-692 |
| J-460 | 4,012 | TRUE | Passed | 500 | 4,013 | 24 | 22.9 | J-692 |
| J-461 | 1,661 | TRUE | Passed | 500 | 1,662 | 24 | 23.4 | J-463 |
| J-462 | 1,455 | TRUE | Passed | 500 | 1,456 | 24 | 24.3 | J-692 |
| J-463 | 1,338 | TRUE | Passed | 500 | 1,339 | 24 | 24.4 | J-692 |
| J-464 | 5,251 | TRUE | Passed | 500 | 5,252 | 24 | 22.1 | J-692 |
| J-465 | 5,397 | TRUE | Passed | 500 | 5,398 | 24 | 22 | J-692 |
| J-466 | 5,699 | TRUE | Passed | 500 | 5,700 | 24 | 21.6 | J-692 |
| J-467 | 6,399 | TRUE | Passed | 500 | 6,400 | 24 | 20.9 | J-692 |
| J-468 | 6,313 | TRUE | Passed | 500 | 6,314 | 24 | 20.9 | J-692 |
| J-469 | 6,892 | TRUE | Passed | 500 | 6,893 | 24 | 20 | J-692 |
| J-470 | 8,284 | TRUE | Passed | 500 | 8,285 | 24 | 17.2 | J-692 |
| J-471 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.1 | 14 | J-692 |
| J-472 | 7,090 | TRUE | Passed | 500 | 7,091 | 24 | 19.2 | J-692 |
| J-473 | 6,544 | TRUE | Passed | 500 | 6,545 | 24 | 20.3 | J-692 |
| J-474 | 5,988 | TRUE | Passed | 500 | 5,989 | 24 | 20.9 | J-692 |
| J-475 | 5,634 | TRUE | Passed | 500 | 5,635 | 24 | 21.4 | J-692 |
| J-476 | 2,361 | TRUE | Passed | 500 | 2,362 | 24 | 23.8 | J-692 |
| J-477 | 2,388 | TRUE | Passed | 500 | 2,389 | 24 | 23.8 | J-692 |
| J-478 | 5,553 | TRUE | Passed | 500 | 5,554 | 24 | 21.7 | J-692 |
| J-479 | 5,690 | TRUE | Passed | 500 | 5,691 | 24 | 21.8 | J-692 |
| J-480 | 6,038 | TRUE | Passed | 500 | 6,039 | 24 | 21.6 | J-692 |
| J-481 | 6,412 | TRUE | Passed | 500 | 6,413 | 24 | 21.5 | J-692 |
| J-482 | 3,322 | TRUE | Passed | 500 | 3,323 | 24 | 19.8 | J-485 |
| J-483 | 2,056 | TRUE | Passed | 500 | 2,057 | 24 | 22.8 | J-485 |
| J-484 | 1,890 | TRUE | Passed | 500 | 1,891 | 24 | 24.2 | J-692 |
| J-485 | 1,539 | TRUE | Passed | 500 | 1,540 | 24 | 24.4 | J-692 |
| J-486 | 9,617 | TRUE | Passed | 500 | 9,618 | 24 | 19.1 | J-692 |
| J-487 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.5 | 20.2 | J-692 |
| J-489 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.8 | 22.6 | J-692 |
| J-490 | 10,000 | TRUE | Passed | 500 | 10,001 | 36 | 22.4 | J-692 |
| J-491 | 10,000 | TRUE | Passed | 500 | 10,001 | 63 | 24.4 | J-692 |
| J-492 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.3 | 21 | J-692 |
| J-493 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.9 | 20.6 | J-692 |
| J-494 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.9 | 20.6 | J-692 |
| J-497 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.1 | 16.9 | J-692 |
| J-498 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.1 | 19.5 | J-692 |
| J-499 | 10,000 | TRUE | Passed | 500 | 10,001 | 40 | 19.7 | J-692 |
| J-500 | 6,944 | TRUE | Passed | 500 | 6,945 | 24 | 21.8 | J-692 |
| J-501 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.7 | 20.7 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-502 | 5,187 | TRUE | Passed | 500 | 5,188 | 24 | 23 | J-692 |
| J-504 | 3,297 | TRUE | Passed | 500 | 3,298 | 24 | 23.8 | J-692 |
| J-505 | 4,076 | TRUE | Passed | 500 | 4,077 | 24 | 23.4 | J-692 |
| J-507 | 4,577 | TRUE | Passed | 500 | 4,578 | 24 | 22.6 | J-692 |
| J-508 | 4,595 | TRUE | Passed | 500 | 4,596 | 24 | 22.5 | J-692 |
| J-509 | 5,335 | TRUE | Passed | 500 | 5,336 | 24 | 21.9 | J-692 |
| J-510 | 5,994 | TRUE | Passed | 500 | 5,995 | 24 | 22.5 | J-692 |
| J-511 | 2,392 | TRUE | Passed | 500 | 2,393 | 24 | 24.2 | J-692 |
| J-513 | 2,442 | TRUE | Passed | 500 | 2,443 | 24 | 24.2 | J-692 |
| J-514 | 2,754 | TRUE | Passed | 500 | 2,755 | 24 | 23.3 | J-513 |
| J-516 | 5,295 | TRUE | Passed | 500 | 5,296 | 24 | 22.1 | J-692 |
| J-517 | 5,696 | TRUE | Passed | 500 | 5,697 | 24 | 21.5 | J-692 |
| J-518 | 5,181 | TRUE | Passed | 500 | 5,182 | 24 | 20.2 | J-549 |
| J-519 | 5,644 | TRUE | Passed | 500 | 5,645 | 24 | 21.6 | J-692 |
| J-520 | 4,747 | TRUE | Passed | 500 | 4,748 | 24 | 21.4 | J-692 |
| J-521 | 3,939 | TRUE | Passed | 500 | 3,940 | 24 | 22.2 | J-692 |
| J-522 | 4,070 | TRUE | Passed | 500 | 4,071 | 24 | 21.5 | J-603 |
| J-523 | 4,434 | TRUE | Passed | 500 | 4,435 | 24 | 21.6 | J-692 |
| J-524 | 4,305 | TRUE | Passed | 500 | 4,306 | 24 | 21.8 | J-692 |
| J-525 | 4,761 | TRUE | Passed | 500 | 4,763 | 24 | 21.3 | J-692 |
| J-526 | 4,637 | TRUE | Passed | 500 | 4,638 | 24 | 21.5 | J-692 |
| J-527 | 4,685 | TRUE | Passed | 500 | 4,686 | 24 | 21.2 | J-692 |
| J-528 | 4,360 | TRUE | Passed | 500 | 4,361 | 24 | 21.6 | J-692 |
| J-529 | 4,575 | TRUE | Passed | 500 | 4,576 | 24 | 21.3 | J-692 |
| J-530 | 4,613 | TRUE | Passed | 500 | 4,614 | 24 | 21.3 | J-692 |
| J-531 | 2,967 | TRUE | Passed | 500 | 2,968 | 24 | 22.9 | J-692 |
| J-532 | 3,206 | TRUE | Passed | 500 | 3,208 | 24 | 22.7 | J-692 |
| J-533 | 8,293 | TRUE | Passed | 500 | 8,294 | 24 | 15.1 | J-692 |
| J-534 | 9,190 | TRUE | Passed | 500 | 9,191 | 24 | 13.3 | J-692 |
| J-535 | 8,559 | TRUE | Passed | 500 | 8,560 | 24 | 14.7 | J-692 |
| J-536 | 7,695 | TRUE | Passed | 500 | 7,696 | 24 | 16.3 | J-692 |
| J-537 | 8,801 | TRUE | Passed | 500 | 8,802 | 24 | 14.1 | J-692 |
| J-538 | 9,387 | TRUE | Passed | 500 | 9,388 | 24 | 12.2 | J-692 |
| J-539 | 10,000 | TRUE | Passed | 500 | 10,001 | 28.5 | 10.6 | J-692 |
| J-540 | 3,155 | TRUE | Passed | 500 | 3,156 | 24 | 22.7 | J-692 |
| J-541 | 3,399 | TRUE | Passed | 500 | 3,400 | 24 | 22.5 | J-692 |
| J-542 | 6,798 | TRUE | Passed | 500 | 6,799 | 24 | 18.5 | J-692 |
| J-543 | 9,176 | TRUE | Passed | 500 | 9,177 | 24 | 15.1 | J-692 |
| J-544 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.3 | 14.7 | J-692 |
| J-545 | 5,667 | TRUE | Passed | 500 | 5,668 | 24 | 20.9 | J-692 |
| J-546 | 2,190 | TRUE | Passed | 500 | 2,191 | 24 | 23.8 | J-692 |
| J-547 | 5,285 | TRUE | Passed | 500 | 5,286 | 24 | 21.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-548 | 1,889 | TRUE | Passed | 500 | 1,890 | 24 | 24.1 | J-692 |
| J-549 | 1,752 | TRUE | Passed | 500 | 1,753 | 24 | 24.2 | J-692 |
| J-550 | 4,652 | TRUE | Passed | 500 | 4,653 | 24 | 22.5 | J-692 |
| J-551 | 3,101 | TRUE | Passed | 500 | 3,102 | 24 | 23.5 | J-692 |
| J-552 | 2,501 | TRUE | Passed | 500 | 2,502 | 24 | 23.8 | J-692 |
| J-553 | 4,110 | TRUE | Passed | 500 | 4,111 | 24 | 23.5 | J-692 |
| J-554 | 2,683 | TRUE | Passed | 500 | 2,684 | 24 | 24.1 | J-692 |
| J-555 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.8 | 14.4 | J-692 |
| J-556 | 4,231 | TRUE | Passed | 500 | 4,232 | 24 | 22.1 | J-692 |
| J-557 | 3,734 | TRUE | Passed | 500 | 3,735 | 24 | 22.6 | J-692 |
| J-558 | 1,898 | TRUE | Passed | 500 | 1,899 | 24 | 23.9 | J-692 |
| J-559 | 10,000 | TRUE | Passed | 500 | 10,001 | 36 | 15.3 | J-692 |
| J-560 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.5 | 16.4 | J-692 |
| J-561 | 3,843 | TRUE | Passed | 500 | 3,844 | 24 | 22.2 | J-692 |
| J-562 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.6 | 14.8 | J-692 |
| J-563 | 2,984 | TRUE | Passed | 500 | 2,985 | 24 | 22.8 | J-692 |
| J-564 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.7 | 11.4 | J-692 |
| J-565 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.6 | 13.1 | J-692 |
| J-566 | 8,551 | TRUE | Passed | 500 | 8,552 | 24 | 14 | J-692 |
| J-567 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.5 | 10.1 | J-692 |
| J-568 | 10,000 | TRUE | Passed | 500 | 10,001 | 28.1 | 7.2 | J-692 |
| J-569 | 8,300 | TRUE | Passed | 500 | 8,302 | 24 | 12.1 | J-692 |
| J-570 | 7,256 | TRUE | Passed | 500 | 7,257 | 24 | 15.2 | J-692 |
| J-571 | 8,584 | TRUE | Passed | 500 | 8,585 | 24 | 9.9 | J-692 |
| J-572 | 10,000 | TRUE | Passed | 500 | 10,001 | 40 | 3.3 | J-692 |
| J-573 | 7,961 | TRUE | Passed | 500 | 7,962 | 50.6 | 0 | J-692 |
| J-574 | 9,774 | TRUE | Passed | 500 | 9,775 | 24 | 5.6 | J-692 |
| J-576 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.5 | 8.7 | J-692 |
| J-577 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.9 | 9.6 | J-692 |
| J-578 | 3,350 | TRUE | Passed | 500 | 3,351 | 24 | 22.3 | J-692 |
| J-579 | 4,420 | TRUE | Passed | 500 | 4,421 | 24 | 21.2 | J-692 |
| J-580 | 4,471 | TRUE | Passed | 500 | 4,472 | 24 | 21.2 | J-692 |
| J-581 | 4,215 | TRUE | Passed | 500 | 4,216 | 24 | 21.3 | J-692 |
| J-582 | 6,628 | TRUE | Passed | 500 | 6,629 | 24 | 17.5 | J-692 |
| J-583 | 7,160 | TRUE | Passed | 500 | 7,161 | 24 | 16.5 | J-692 |
| J-584 | 8,107 | TRUE | Passed | 500 | 8,108 | 24 | 14.7 | J-692 |
| J-585 | 6,252 | TRUE | Passed | 500 | 6,253 | 24 | 18.1 | J-692 |
| J-587 | 5,805 | TRUE | Passed | 500 | 5,806 | 24 | 18.8 | J-692 |
| J-588 | 5,443 | TRUE | Passed | 500 | 5,444 | 24 | 19.4 | J-692 |
| J-589 | 5,585 | TRUE | Passed | 500 | 5,587 | 24 | 19.1 | J-692 |
| J-590 | 7,018 | TRUE | Passed | 500 | 7,019 | 24 | 16.7 | J-692 |
| J-591 | 6,449 | TRUE | Passed | 500 | 6,450 | 24 | 17.7 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-592 | 6,231 | TRUE | Passed | 500 | 6,232 | 24 | 18.7 | J-692 |
| J-593 | 4,611 | TRUE | Passed | 500 | 4,612 | 24 | 21.2 | J-692 |
| J-594 | 4,466 | TRUE | Passed | 500 | 4,467 | 24 | 20.3 | J-596 |
| J-595 | 3,640 | TRUE | Passed | 500 | 3,641 | 24 | 21.3 | J-596 |
| J-596 | 3,092 | TRUE | Passed | 500 | 3,093 | 24 | 22.9 | J-692 |
| J-597 | 3,198 | TRUE | Passed | 500 | 3,199 | 24 | 22.8 | J-692 |
| J-598 | 3,283 | TRUE | Passed | 500 | 3,284 | 24 | 22.7 | J-692 |
| J-599 | 3,476 | TRUE | Passed | 500 | 3,477 | 24 | 22.5 | J-692 |
| J-601 | 3,057 | TRUE | Passed | 500 | 3,058 | 24 | 22.9 | J-692 |
| J-602 | 4,380 | TRUE | Passed | 500 | 4,381 | 24 | 21.6 | J-692 |
| J-603 | 2,346 | TRUE | Passed | 500 | 2,347 | 24 | 23.5 | J-692 |
| J-604 | 4,393 | TRUE | Passed | 500 | 4,394 | 24 | 21.6 | J-692 |
| J-605 | 3,251 | TRUE | Passed | 500 | 3,252 | 24 | 22.7 | J-692 |
| J-606 | 3,368 | TRUE | Passed | 500 | 3,369 | 24 | 22.6 | J-692 |
| J-607 | 4,231 | TRUE | Passed | 500 | 4,232 | 24 | 21.8 | J-692 |
| J-608 | 4,360 | TRUE | Passed | 500 | 4,361 | 24 | 21.6 | J-692 |
| J-609 | 4,447 | TRUE | Passed | 500 | 4,448 | 24 | 21.5 | J-692 |
| J-610 | 4,373 | TRUE | Passed | 500 | 4,374 | 24 | 21.6 | J-692 |
| J-611 | 4,672 | TRUE | Passed | 500 | 4,673 | 24 | 21.2 | J-692 |
| J-612 | 4,146 | TRUE | Passed | 500 | 4,147 | 24 | 21.8 | J-692 |
| J-613 | 4,274 | TRUE | Passed | 500 | 4,275 | 24 | 21.6 | J-692 |
| J-614 | 6,456 | TRUE | Passed | 500 | 6,457 | 24 | 18.4 | J-692 |
| J-615 | 6,742 | TRUE | Passed | 500 | 6,743 | 24 | 18 | J-692 |
| J-616 | 6,894 | TRUE | Passed | 500 | 6,895 | 24 | 17.7 | J-692 |
| J-617 | 6,771 | TRUE | Passed | 500 | 6,772 | 24 | 17 | J-692 |
| J-620 | 7,726 | TRUE | Passed | 500 | 7,727 | 24 | 15.1 | J-692 |
| J-621 | 9,417 | TRUE | Passed | 500 | 9,418 | 24 | 11.2 | J-692 |
| J-622 | 9,034 | TRUE | Passed | 500 | 9,035 | 24 | 12.2 | J-692 |
| J-623 | 9,112 | TRUE | Passed | 500 | 9,113 | 24 | 11.7 | J-692 |
| J-625 | 10,000 | TRUE | Passed | 500 | 10,001 | 24.4 | 9.5 | J-692 |
| J-626 | 8,868 | TRUE | Passed | 500 | 8,869 | 24 | 12.7 | J-692 |
| J-627 | 8,816 | TRUE | Passed | 500 | 8,817 | 24 | 12.9 | J-692 |
| J-628 | 9,041 | TRUE | Passed | 500 | 9,042 | 24 | 12.5 | J-692 |
| J-629 | 9,498 | TRUE | Passed | 500 | 9,499 | 24 | 11.4 | J-692 |
| J-630 | 9,703 | TRUE | Passed | 500 | 9,704 | 24 | 10.9 | J-692 |
| J-631 | 9,781 | TRUE | Passed | 500 | 9,782 | 24 | 10.7 | J-692 |
| J-632 | 5,290 | TRUE | Passed | 500 | 5,291 | 24 | 19.3 | J-692 |
| J-633 | 3,173 | TRUE | Passed | 500 | 3,174 | 24 | 22.3 | J-692 |
| J-634 | 8,100 | TRUE | Passed | 500 | 8,101 | 24 | 13.8 | J-692 |
| J-636 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.1 | 10.2 | J-692 |
| J-637 | 3,850 | TRUE | Passed | 500 | 3,851 | 24 | 21.6 | J-692 |
| J-638 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.1 | 10.3 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-639 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.5 | 9.5 | J-692 |
| J-640 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.2 | 9.6 | J-692 |
| J-641 | 5,686 | TRUE | Passed | 500 | 5,687 | 24 | 19 | J-692 |
| J-642 | 4,134 | TRUE | Passed | 500 | 4,135 | 24 | 21.4 | J-692 |
| J-643 | 3,178 | TRUE | Passed | 500 | 3,179 | 24 | 22.7 | J-692 |
| J-644 | 5,436 | TRUE | Passed | 500 | 5,437 | 24 | 20.1 | J-692 |
| J-645 | 2,774 | TRUE | Passed | 500 | 2,775 | 24 | 23.1 | J-692 |
| J-646 | 7,497 | TRUE | Passed | 500 | 7,498 | 24 | 17.1 | J-692 |
| J-647 | 4,915 | TRUE | Passed | 500 | 4,916 | 24 | 20.6 | J-692 |
| J-648 | 3,031 | TRUE | Passed | 500 | 3,032 | 24 | 22.8 | J-692 |
| J-649 | 3,751 | TRUE | Passed | 500 | 3,752 | 24 | 22.2 | J-692 |
| J-650 | 1,895 | TRUE | Passed | 500 | 1,896 | 24 | 23.8 | J-692 |
| J-651 | 7,972 | TRUE | Passed | 500 | 7,973 | 24 | 16.6 | J-692 |
| J-652 | 3,098 | TRUE | Passed | 500 | 3,099 | 24 | 22.9 | J-692 |
| J-655 | 7,441 | TRUE | Passed | 500 | 7,442 | 24 | 16.8 | J-692 |
| J-656 | 3,612 | TRUE | Passed | 500 | 3,613 | 24 | 22.2 | J-692 |
| J-657 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.2 | 8.3 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.6 | 8.3 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.1 | 7.9 | J-692 |
| J-660 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.2 | 7.9 | J-692 |
| J-661 | 833 | TRUE | Passed | 500 | 837 | 24 | 24.4 | J-692 |
| J-662 | 10,000 | TRUE | Passed | 500 | 10,001 | 52.1 | 7.6 | J-692 |
| J-663 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.4 | 8 | J-692 |
| J-664 | 10,000 | TRUE | Passed | 500 | 10,001 | 32 | 9 | J-692 |
| J-665 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.3 | 9.3 | J-692 |
| J-666 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.7 | 17.7 | J-692 |
| J-667 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.4 | 17.4 | J-692 |
| J-668 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.5 | 19.8 | J-692 |
| J-669 | 4,455 | TRUE | Passed | 500 | 4,456 | 24 | 21.6 | J-692 |
| J-670 | 5,049 | TRUE | Passed | 500 | 5,050 | 24 | 20.9 | J-692 |
| J-673 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.7 | 8.2 | J-692 |
| J-674 | 4,273 | TRUE | Passed | 500 | 4,274 | 24 | 20.6 | J-692 |
| J-675 | 3,991 | TRUE | Passed | 500 | 3,992 | 24 | 21 | J-692 |
| J-676 | 5,611 | TRUE | Passed | 500 | 5,612 | 24 | 18.4 | J-692 |
| J-677 | 2,517 | TRUE | Passed | 500 | 2,518 | 24 | 22.9 | J-692 |
| J-678 | 1,884 | TRUE | Passed | 500 | 1,885 | 24 | 23.6 | J-692 |
| J-680 | 5,894 | TRUE | Passed | 500 | 5,894 | 24 | 5.8 | J-692 |
| J-682 | 4,863 | TRUE | Passed | 500 | 4,863 | 24 | 9.6 | J-692 |
| J-685 | 1,936 | TRUE | Passed | 500 | 1,961 | 24 | 20 | J-692 |
| J-686 | 5,367 | TRUE | Passed | 500 | 5,417 | 24 | 1.5 | J-692 |
| J-687 | 5,912 | TRUE | Passed | 500 | 5,937 | 33.4 | 0 | J-692 |
| J-689 | 7,058 | TRUE | Passed | 500 | 7,083 | 31.6 | 0 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-690 | 6,211 | TRUE | Passed | 500 | 6,236 | 38.7 | 0 | J-692 |
| J-691 | 5,808 | TRUE | Passed | 500 | 5,833 | 32.6 | 0 | J-692 |
| J-692 | 535 | TRUE | Passed | 500 | 535 | 24 | 25.8 | J-695 |
| J-693 | 5,667 | TRUE | Passed | 500 | 5,692 | 24 | 7.2 | J-692 |
| J-694 | 5,418 | TRUE | Passed | 500 | 5,443 | 24 | 2.7 | J-692 |
| J-695 | 1,136 | TRUE | Passed | 500 | 1,161 | 24 | 22.8 | J-692 |
| J-696 | 5,197 | TRUE | Passed | 500 | 5,202 | 24 | 13 | J-692 |
| J-697 | 6,139 | TRUE | Passed | 500 | 6,139 | 24 | 0.7 | J-692 |
| J-698 | 5,718 | TRUE | Passed | 500 | 5,743 | 24 | 3.8 | J-692 |
| J-699 | 7,209 | TRUE | Passed | 500 | 7,234 | 59.2 | 0 | J-692 |
| J-700 | 6,524 | TRUE | Passed | 500 | 6,549 | 27.7 | 0 | J-692 |
| J-702 | 5,101 | TRUE | Passed | 500 | 5,101 | 24 | 5.3 | J-692 |
| J-719 | 4,772 | TRUE | Passed | 500 | 4,772 | 24 | 23.6 | J-692 |
| J-724 | 4,595 | TRUE | Passed | 500 | 4,595 | 24 | 23.7 | J-692 |
| J-726 | 4,329 | TRUE | Passed | 500 | 4,329 | 24 | 23.4 | J-692 |
| J-727 | 8,248 | TRUE | Passed | 500 | 8,248 | 24 | 23.4 | J-692 |
| J-731 | 6,023 | TRUE | Passed | 500 | 6,024 | 24 | 19.6 | J-692 |
| J-904 | 7,126 | TRUE | Passed | 500 | 7,127 | 24 | 14.4 | J-692 |
| J-1031 | 9,777 | TRUE | Passed | 500 | 9,778 | 24 | 8.8 | J-692 |
| J-1082 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.9 | 7.5 | J-692 |
| J-1184 | 9,694 | TRUE | Passed | 500 | 9,695 | 24 | 22.3 | J-692 |
| J-1201 | 8,471 | TRUE | Passed | 500 | 8,472 | 24 | 20.5 | J-692 |
| J-1296 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.6 | 20.7 | J-692 |
| J-1334 | 4,021 | TRUE | Passed | 500 | 4,022 | 24 | 23.5 | J-692 |
| J-1340 | 4,142 | TRUE | Passed | 500 | 4,143 | 24 | 23 | J-692 |
| J-1549 | 3,102 | TRUE | Passed | 500 | 3,103 | 24 | 22.9 | J-692 |
| J-1642 | 9,102 | TRUE | Passed | 500 | 9,103 | 24 | 11.6 | J-692 |
| J-1704 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.3 | 8.3 | J-692 |
| J-1780 | 4,681 | TRUE | Passed | 500 | 4,681 | 24 | 23.7 | J-692 |
| J-1806 | 3,657 | TRUE | Passed | 500 | 3,657 | 24 | 15.8 | J-692 |
| **Scenario 5: 12-Inch SE Expansion - Pressure Zone Addition** | | | | | | | | |
| 1-FLOW | 8,805 | TRUE | Passed | 500 | 8,806 | 30 | 30.8 | 1-RES |
| 1-RES | 3,090 | TRUE | Passed | 500 | 3,094 | 30 | 48.5 | J-692 |
| 2-FLOW | 7,437 | TRUE | Passed | 500 | 7,438 | 30 | 30 | 2-RES |
| 2-RES | 4,093 | TRUE | Passed | 500 | 4,094 | 30 | 48.5 | J-692 |
| 3-FLOW | 2,846 | TRUE | Passed | 500 | 2,847 | 30 | 30.9 | 3-RES |
| 3-RES | 2,427 | TRUE | Passed | 500 | 2,428 | 30 | 40 | 3-FLOW |
| 4-FLOW | 3,236 | TRUE | Passed | 500 | 3,237 | 30 | 30.7 | 4-RES |
| 4-RES | 2,371 | TRUE | Passed | 500 | 2,372 | 30 | 42.4 | 4-FLOW |
| 5-FLOW | 1,779 | TRUE | Passed | 500 | 1,780 | 30 | 27.3 | J-51 |
| 5-RES | 1,521 | TRUE | Passed | 500 | 1,522 | 30 | 35.8 | J-692 |
| 6-FLOW | 1,979 | TRUE | Passed | 500 | 1,980 | 30 | 30.8 | 6-RES |

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|---|---|---|---|---|---|---|---|---|
| 6-RES | 1,282 | TRUE | Passed | 500 | 1,283 | 30 | 46.9 | 6-FLOW |
| 7-FLOW | 1,610 | TRUE | Passed | 500 | 1,611 | 30 | 29 | J-196 |
| 7-RES | 1,498 | TRUE | Passed | 500 | 1,499 | 30 | 32.7 | J-196 |
| J-1 | 3,864 | TRUE | Passed | 500 | 3,865 | 30 | 32.2 | J-92 |
| J-2 | 6,189 | TRUE | Passed | 500 | 6,190 | 30 | 29.5 | J-97 |
| J-3 | 7,800 | TRUE | Passed | 500 | 7,801 | 30 | 39.6 | J-97 |
| J-11 | 7,358 | TRUE | Passed | 500 | 7,359 | 30 | 29.4 | J-13 |
| J-12 | 7,234 | TRUE | Passed | 500 | 7,235 | 30 | 32.3 | J-14 |
| J-13 | 3,508 | TRUE | Passed | 500 | 3,509 | 30 | 36.3 | J-17 |
| J-14 | 3,533 | TRUE | Passed | 500 | 3,534 | 30 | 47.1 | J-92 |
| J-15 | 6,653 | TRUE | Passed | 500 | 6,654 | 30 | 30.1 | J-14 |
| J-17 | 3,776 | TRUE | Passed | 500 | 3,777 | 30 | 30.4 | J-13 |
| J-18 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.9 | 48.4 | J-692 |
| J-19 | 7,896 | TRUE | Passed | 500 | 7,897 | 30 | 27.6 | J-25 |
| J-20 | 3,901 | TRUE | Passed | 500 | 3,902 | 30 | 33.3 | J-23 |
| J-21 | 4,011 | TRUE | Passed | 500 | 4,012 | 30 | 35.1 | J-20 |
| J-22 | 1,978 | TRUE | Passed | 500 | 1,979 | 30 | 48.1 | J-25 |
| J-23 | 3,532 | TRUE | Passed | 500 | 3,533 | 30 | 30.2 | J-22 |
| J-24 | 1,838 | TRUE | Passed | 500 | 1,839 | 30 | 46.4 | J-25 |
| J-25 | 3,104 | TRUE | Passed | 500 | 3,106 | 30 | 30.1 | J-24 |
| J-26 | 1,775 | TRUE | Passed | 500 | 1,776 | 30 | 48.5 | J-692 |
| J-27 | 3,166 | TRUE | Passed | 500 | 3,167 | 30 | 29.2 | J-26 |
| J-28 | 2,027 | TRUE | Passed | 500 | 2,028 | 30 | 48.1 | J-26 |
| J-29 | 3,361 | TRUE | Passed | 500 | 3,362 | 30 | 29.5 | J-28 |
| J-30 | 4,464 | TRUE | Passed | 500 | 4,465 | 30 | 35 | J-28 |
| J-31 | 1,670 | TRUE | Passed | 500 | 1,671 | 30 | 31.2 | J-33 |
| J-33 | 1,695 | TRUE | Passed | 500 | 1,696 | 30 | 30.6 | J-74 |
| J-34 | 1,653 | TRUE | Passed | 500 | 1,654 | 30 | 32.1 | J-74 |
| J-35 | 1,747 | TRUE | Passed | 500 | 1,748 | 30 | 28.5 | J-34 |
| J-36 | 1,822 | TRUE | Passed | 500 | 1,823 | 30 | 25.7 | J-74 |
| J-37 | 1,795 | TRUE | Passed | 500 | 1,796 | 30 | 26.7 | J-74 |
| J-38 | 1,804 | TRUE | Passed | 500 | 1,805 | 30 | 26.3 | J-74 |
| J-39 | 1,793 | TRUE | Passed | 500 | 1,794 | 30 | 26.8 | J-74 |
| J-40 | 1,800 | TRUE | Passed | 500 | 1,801 | 30 | 26.5 | J-74 |
| J-41 | 1,845 | TRUE | Passed | 500 | 1,846 | 30 | 24.9 | J-74 |
| J-42 | 1,762 | TRUE | Passed | 500 | 1,763 | 30 | 28.4 | J-51 |
| J-43 | 1,829 | TRUE | Passed | 500 | 1,830 | 30 | 25.9 | J-51 |
| J-44 | 1,565 | TRUE | Passed | 500 | 1,566 | 30 | 35.2 | J-51 |
| J-45 | 1,620 | TRUE | Passed | 500 | 1,621 | 30 | 33.3 | J-51 |
| J-46 | 1,711 | TRUE | Passed | 500 | 1,712 | 30 | 30 | J-47 |
| J-47 | 1,525 | TRUE | Passed | 500 | 1,526 | 30 | 35.8 | J-692 |
| J-48 | 1,686 | TRUE | Passed | 500 | 1,687 | 30 | 27.2 | J-47 |

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|---|---|---|---|---|---|---|---|---|
| J-49 | 1,769 | TRUE | Passed | 500 | 1,770 | 30 | 28.2 | J-51 |
| J-50 | 1,664 | TRUE | Passed | 500 | 1,665 | 30 | 31.9 | J-51 |
| J-51 | 1,131 | TRUE | Passed | 500 | 1,132 | 30 | 39.2 | J-692 |
| J-52 | 1,660 | TRUE | Passed | 500 | 1,661 | 30 | 26.6 | J-51 |
| J-53 | 1,563 | TRUE | Passed | 500 | 1,564 | 30 | 31.6 | J-54 |
| J-54 | 1,603 | TRUE | Passed | 500 | 1,604 | 30 | 29.5 | J-53 |
| J-55 | 1,492 | TRUE | Passed | 500 | 1,493 | 30 | 33.7 | J-56 |
| J-56 | 1,581 | TRUE | Passed | 500 | 1,582 | 30 | 28.7 | J-55 |
| J-57 | 1,544 | TRUE | Passed | 500 | 1,545 | 30 | 35.6 | J-51 |
| J-58 | 1,625 | TRUE | Passed | 500 | 1,626 | 30 | 30.1 | J-55 |
| J-59 | 1,680 | TRUE | Passed | 500 | 1,682 | 30 | 27.9 | J-55 |
| J-60 | 1,637 | TRUE | Passed | 500 | 1,638 | 30 | 28.3 | J-55 |
| J-61 | 1,787 | TRUE | Passed | 500 | 1,788 | 30 | 27 | J-51 |
| J-64 | 1,812 | TRUE | Passed | 500 | 1,813 | 30 | 26 | J-51 |
| J-65 | 1,765 | TRUE | Passed | 500 | 1,766 | 30 | 28 | J-51 |
| J-66 | 1,859 | TRUE | Passed | 500 | 1,860 | 30 | 24.9 | J-74 |
| J-67 | 1,759 | TRUE | Passed | 500 | 1,760 | 30 | 28.7 | J-51 |
| J-68 | 1,822 | TRUE | Passed | 500 | 1,823 | 30 | 26.2 | J-74 |
| J-69 | 1,621 | TRUE | Passed | 500 | 1,622 | 30 | 33.2 | J-74 |
| J-70 | 1,717 | TRUE | Passed | 500 | 1,718 | 30 | 29.7 | J-74 |
| J-71 | 1,711 | TRUE | Passed | 500 | 1,712 | 30 | 28.4 | J-74 |
| J-72 | 1,677 | TRUE | Passed | 500 | 1,678 | 30 | 30.3 | J-74 |
| J-73 | 1,198 | TRUE | Passed | 500 | 1,199 | 30 | 38.6 | J-692 |
| J-74 | 1,626 | TRUE | Passed | 500 | 1,627 | 30 | 31.1 | J-73 |
| J-75 | 1,810 | TRUE | Passed | 500 | 1,811 | 30 | 25.5 | J-74 |
| J-76 | 1,781 | TRUE | Passed | 500 | 1,782 | 30 | 27.2 | J-74 |
| J-77 | 1,770 | TRUE | Passed | 500 | 1,771 | 30 | 28.4 | J-74 |
| J-78 | 1,882 | TRUE | Passed | 500 | 1,883 | 30 | 23.5 | J-74 |
| J-79 | 1,738 | TRUE | Passed | 500 | 1,739 | 30 | 29.1 | J-74 |
| J-80 | 1,744 | TRUE | Passed | 500 | 1,745 | 30 | 28.7 | J-74 |
| J-81 | 1,841 | TRUE | Passed | 500 | 1,842 | 30 | 25.3 | J-74 |
| J-82 | 1,897 | TRUE | Passed | 500 | 1,898 | 30 | 22.5 | J-74 |
| J-83 | 1,868 | TRUE | Passed | 500 | 1,869 | 30 | 23.7 | J-74 |
| J-84 | 1,876 | TRUE | Passed | 500 | 1,877 | 30 | 23.4 | J-74 |
| J-85 | 1,864 | TRUE | Passed | 500 | 1,865 | 30 | 23.8 | J-74 |
| J-86 | 1,850 | TRUE | Passed | 500 | 1,851 | 30 | 24.3 | J-74 |
| J-87 | 1,820 | TRUE | Passed | 500 | 1,821 | 30 | 25.5 | J-74 |
| J-88 | 1,786 | TRUE | Passed | 500 | 1,787 | 30 | 26.7 | J-74 |
| J-89 | 1,834 | TRUE | Passed | 500 | 1,835 | 30 | 24.8 | J-74 |
| J-90 | 1,776 | TRUE | Passed | 500 | 1,777 | 30 | 27 | J-74 |
| J-91 | 1,433 | TRUE | Passed | 500 | 1,434 | 30 | 36.6 | J-692 |
| J-92 | 3,937 | TRUE | Passed | 500 | 3,938 | 30 | 30.4 | J-97 |

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|---|---|---|---|---|---|---|---|---|
| J-93 | 1,838 | TRUE | Passed | 500 | 1,839 | 30 | 25.5 | J-74 |
| J-94 | 3,963 | TRUE | Passed | 500 | 3,964 | 30 | 29.9 | J-92 |
| J-95 | 5,664 | TRUE | Passed | 500 | 5,665 | 30 | 29.9 | J-97 |
| J-96 | 4,303 | TRUE | Passed | 500 | 4,304 | 30 | 30.3 | J-97 |
| J-97 | 3,944 | TRUE | Passed | 500 | 3,945 | 30 | 30.3 | J-92 |
| J-98 | 3,998 | TRUE | Passed | 500 | 3,999 | 30 | 29.9 | J-97 |
| J-99 | 3,250 | TRUE | Passed | 500 | 3,251 | 30 | 25.1 | J-692 |
| J-100 | 4,023 | TRUE | Passed | 500 | 4,024 | 30 | 21.2 | J-692 |
| J-101 | 3,150 | TRUE | Passed | 500 | 3,151 | 30 | 25.6 | J-692 |
| J-102 | 4,269 | TRUE | Passed | 500 | 4,270 | 30 | 19.3 | J-692 |
| J-103 | 4,962 | TRUE | Passed | 500 | 4,963 | 30 | 13.6 | J-692 |
| J-104 | 4,509 | TRUE | Passed | 500 | 4,510 | 30 | 18.1 | J-692 |
| J-105 | 5,232 | TRUE | Passed | 500 | 5,233 | 30 | 11.2 | J-692 |
| J-106 | 5,025 | TRUE | Passed | 500 | 5,026 | 30 | 13.2 | J-692 |
| J-107 | 4,713 | TRUE | Passed | 500 | 4,714 | 30 | 16.2 | J-692 |
| J-108 | 5,054 | TRUE | Passed | 500 | 5,055 | 30 | 12.9 | J-692 |
| J-109 | 5,023 | TRUE | Passed | 500 | 5,024 | 30 | 13.2 | J-692 |
| J-110 | 4,676 | TRUE | Passed | 500 | 4,677 | 30 | 16.3 | J-692 |
| J-111 | 4,306 | TRUE | Passed | 500 | 4,307 | 30 | 19.5 | J-692 |
| J-112 | 3,844 | TRUE | Passed | 500 | 3,845 | 30 | 22.6 | J-692 |
| J-113 | 3,365 | TRUE | Passed | 500 | 3,366 | 30 | 24.8 | J-692 |
| J-114 | 3,150 | TRUE | Passed | 500 | 3,151 | 30 | 26 | J-692 |
| J-115 | 3,836 | TRUE | Passed | 500 | 3,837 | 30 | 23 | J-692 |
| J-116 | 2,957 | TRUE | Passed | 500 | 2,958 | 30 | 27.1 | J-692 |
| J-117 | 3,484 | TRUE | Passed | 500 | 3,485 | 30 | 24.5 | J-692 |
| J-118 | 1,522 | TRUE | Passed | 500 | 1,523 | 30 | 35.8 | J-692 |
| J-118 | 3,111 | TRUE | Passed | 500 | 3,112 | 30 | 26.2 | J-692 |
| J-119 | 3,659 | TRUE | Passed | 500 | 3,660 | 30 | 23.9 | J-692 |
| J-121 | 2,817 | TRUE | Passed | 500 | 2,818 | 30 | 28 | J-692 |
| J-122 | 3,883 | TRUE | Passed | 500 | 3,884 | 30 | 22.8 | J-692 |
| J-123 | 4,236 | TRUE | Passed | 500 | 4,261 | 30 | 2.3 | J-692 |
| J-124 | 5,903 | TRUE | Passed | 500 | 5,904 | 30 | 3 | J-692 |
| J-125 | 4,009 | TRUE | Passed | 500 | 4,010 | 30 | 24.9 | J-692 |
| J-126 | 5,126 | TRUE | Passed | 500 | 5,127 | 30 | 13.9 | J-692 |
| J-127 | 4,248 | TRUE | Passed | 500 | 4,249 | 30 | 23.1 | J-692 |
| J-128 | 1,643 | TRUE | Passed | 500 | 1,644 | 30 | 37.8 | J-692 |
| J-129 | 3,846 | TRUE | Passed | 500 | 3,847 | 30 | 25.9 | J-692 |
| J-130 | 4,022 | TRUE | Passed | 500 | 4,023 | 30 | 25.2 | J-692 |
| J-133 | 4,071 | TRUE | Passed | 500 | 4,072 | 30 | 25.2 | J-692 |
| J-134 | 3,233 | TRUE | Passed | 500 | 3,234 | 30 | 28.5 | J-692 |
| J-135 | 3,629 | TRUE | Passed | 500 | 3,630 | 30 | 27 | J-692 |
| J-136 | 4,071 | TRUE | Passed | 500 | 4,072 | 30 | 25.4 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-137 | 4,363 | TRUE | Passed | 500 | 4,364 | 30 | 23.9 | J-692 |
| J-138 | 4,990 | TRUE | Passed | 500 | 4,991 | 30 | 20 | J-692 |
| J-139 | 4,349 | TRUE | Passed | 500 | 4,350 | 30 | 17.3 | J-692 |
| J-140 | 3,282 | TRUE | Passed | 500 | 3,283 | 30 | 24.9 | J-692 |
| J-141 | 3,575 | TRUE | Passed | 500 | 3,576 | 30 | 23.7 | J-692 |
| J-142 | 4,839 | TRUE | Passed | 500 | 4,840 | 30 | 15.1 | J-692 |
| J-143 | 5,425 | TRUE | Passed | 500 | 5,426 | 30 | 9.1 | J-692 |
| J-144 | 5,934 | TRUE | Passed | 500 | 5,935 | 30 | 3.7 | J-692 |
| J-145 | 4,135 | TRUE | Passed | 500 | 4,136 | 30 | 21.4 | J-692 |
| J-146 | 5,717 | TRUE | Passed | 500 | 5,718 | 30 | 5.9 | J-692 |
| J-147 | 5,496 | TRUE | Passed | 500 | 5,497 | 30 | 8.3 | J-692 |
| J-148 | 5,403 | TRUE | Passed | 500 | 5,405 | 30 | 9.2 | J-692 |
| J-149 | 4,577 | TRUE | Passed | 500 | 4,578 | 30 | 16.7 | J-692 |
| J-150 | 3,920 | TRUE | Passed | 500 | 3,921 | 30 | 21.9 | J-692 |
| J-151 | 4,575 | TRUE | Passed | 500 | 4,576 | 30 | 16.4 | J-692 |
| J-152 | 2,580 | TRUE | Passed | 500 | 2,581 | 30 | 29.2 | J-692 |
| J-153 | 3,790 | TRUE | Passed | 500 | 3,791 | 30 | 22.7 | J-692 |
| J-154 | 3,701 | TRUE | Passed | 500 | 3,702 | 30 | 23.2 | J-692 |
| J-155 | 1,861 | TRUE | Passed | 500 | 1,862 | 30 | 31.1 | J-196 |
| J-156 | 2,183 | TRUE | Passed | 500 | 2,184 | 30 | 32.8 | J-196 |
| J-157 | 2,123 | TRUE | Passed | 500 | 2,124 | 30 | 28.4 | J-237 |
| J-158 | 1,169 | TRUE | Passed | 500 | 1,170 | 30 | 33 | J-159 |
| J-159 | 1,230 | TRUE | Passed | 500 | 1,231 | 30 | 30.1 | J-158 |
| J-160 | 3,187 | TRUE | Passed | 500 | 3,188 | 30 | 25.5 | J-692 |
| J-161 | 3,230 | TRUE | Passed | 500 | 3,231 | 30 | 25.3 | J-692 |
| J-162 | 3,229 | TRUE | Passed | 500 | 3,230 | 30 | 25.3 | J-692 |
| J-163 | 3,068 | TRUE | Passed | 500 | 3,069 | 30 | 26.2 | J-692 |
| J-164 | 3,241 | TRUE | Passed | 500 | 3,242 | 30 | 25.2 | J-692 |
| J-165 | 3,391 | TRUE | Passed | 500 | 3,392 | 30 | 24.5 | J-692 |
| J-166 | 4,874 | TRUE | Passed | 500 | 4,875 | 30 | 14.2 | J-692 |
| J-167 | 2,438 | TRUE | Passed | 500 | 2,439 | 30 | 30.2 | J-692 |
| J-168 | 2,776 | TRUE | Passed | 500 | 2,777 | 30 | 27.9 | J-692 |
| J-169 | 3,127 | TRUE | Passed | 500 | 3,128 | 30 | 25.8 | J-692 |
| J-170 | 4,579 | TRUE | Passed | 500 | 4,580 | 30 | 16.3 | J-692 |
| J-171 | 2,642 | TRUE | Passed | 500 | 2,643 | 30 | 28.6 | J-692 |
| J-172 | 6,648 | TRUE | Passed | 500 | 6,649 | 30.7 | 0 | J-692 |
| J-173 | 5,154 | TRUE | Passed | 500 | 5,155 | 30 | 17.8 | J-692 |
| J-174 | 5,291 | TRUE | Passed | 500 | 5,292 | 30 | 17.4 | J-692 |
| J-175 | 7,232 | TRUE | Passed | 500 | 7,233 | 32.6 | 0 | J-692 |
| J-176 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.8 | 2.2 | J-692 |
| J-177 | 4,064 | TRUE | Passed | 500 | 4,065 | 30 | 34.1 | J-692 |
| J-178 | 6,326 | TRUE | Passed | 500 | 6,327 | 30 | 24.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-179 | 1,717 | TRUE | Passed | 500 | 1,718 | 30 | 43.7 | J-692 |
| J-180 | 1,806 | TRUE | Passed | 500 | 1,807 | 30 | 36.6 | J-692 |
| J-181 | 10,000 | TRUE | Passed | 500 | 10,001 | 87.7 | 44.3 | J-692 |
| J-183 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.7 | 22.1 | J-237 |
| J-184 | 750 | TRUE | Passed | 500 | 751 | 30.1 | 48.5 | J-692 |
| J-185 | 7,310 | TRUE | Passed | 500 | 7,311 | 30 | 23.6 | J-186 |
| J-186 | 5,098 | TRUE | Passed | 500 | 5,099 | 30 | 46 | J-156 |
| J-187 | 5,166 | TRUE | Passed | 500 | 5,167 | 30 | 23.7 | J-188 |
| J-188 | 3,936 | TRUE | Passed | 500 | 3,937 | 30 | 46.4 | J-237 |
| J-189 | 4,124 | TRUE | Passed | 500 | 4,125 | 30 | 28.7 | J-237 |
| J-190 | 4,259 | TRUE | Passed | 500 | 4,260 | 30 | 31.9 | J-237 |
| J-191 | 3,461 | TRUE | Passed | 500 | 3,462 | 30 | 26.7 | J-196 |
| J-192 | 2,848 | TRUE | Passed | 500 | 2,849 | 30 | 28.6 | J-196 |
| J-193 | 2,447 | TRUE | Passed | 500 | 2,448 | 30 | 26.5 | J-196 |
| J-194 | 1,954 | TRUE | Passed | 500 | 1,955 | 30 | 26.7 | J-196 |
| J-195 | 1,706 | TRUE | Passed | 500 | 1,707 | 30 | 28 | J-196 |
| J-196 | 1,502 | TRUE | Passed | 500 | 1,503 | 30 | 32.9 | J-197 |
| J-197 | 1,588 | TRUE | Passed | 500 | 1,589 | 30 | 29.1 | J-196 |
| J-200 | 3,690 | TRUE | Passed | 500 | 3,691 | 30 | 30 | J-201 |
| J-201 | 3,400 | TRUE | Passed | 500 | 3,401 | 30 | 33.9 | J-200 |
| J-202 | 3,625 | TRUE | Passed | 500 | 3,626 | 30 | 31.1 | J-206 |
| J-203 | 3,626 | TRUE | Passed | 500 | 3,627 | 30 | 32.4 | J-202 |
| J-204 | 3,044 | TRUE | Passed | 500 | 3,045 | 30 | 30.5 | J-205 |
| J-205 | 2,593 | TRUE | Passed | 500 | 2,594 | 30 | 37.4 | J-204 |
| J-206 | 3,237 | TRUE | Passed | 500 | 3,238 | 30 | 31.9 | J-207 |
| J-207 | 2,828 | TRUE | Passed | 500 | 2,829 | 30 | 36.3 | J-206 |
| J-208 | 4,020 | TRUE | Passed | 500 | 4,021 | 30 | 29.9 | J-209 |
| J-209 | 3,332 | TRUE | Passed | 500 | 3,333 | 30 | 38.3 | J-208 |
| J-210 | 5,578 | TRUE | Passed | 500 | 5,579 | 30 | 29.9 | J-97 |
| J-211 | 5,606 | TRUE | Passed | 500 | 5,607 | 30 | 32.5 | J-212 |
| J-212 | 4,549 | TRUE | Passed | 500 | 4,550 | 30 | 30.5 | J-213 |
| J-213 | 3,518 | TRUE | Passed | 500 | 3,519 | 30 | 40.1 | J-215 |
| J-214 | 2,755 | TRUE | Passed | 500 | 2,756 | 30 | 29.5 | J-215 |
| J-215 | 2,296 | TRUE | Passed | 500 | 2,297 | 30 | 38.4 | J-214 |
| J-216 | 803 | TRUE | Passed | 500 | 804 | 30 | 48.5 | J-692 |
| J-217 | 3,322 | TRUE | Passed | 500 | 3,323 | 30 | 29.5 | J-215 |
| J-218 | 1,853 | TRUE | Passed | 500 | 1,854 | 30 | 48.5 | J-692 |
| J-219 | 4,044 | TRUE | Passed | 500 | 4,045 | 30 | 30 | J-215 |
| J-220 | 1,935 | TRUE | Passed | 500 | 1,936 | 30 | 48.5 | J-692 |
| J-221 | 2,332 | TRUE | Passed | 500 | 2,333 | 30 | 48.4 | J-692 |
| J-222 | 4,495 | TRUE | Passed | 500 | 4,496 | 30 | 33 | J-221 |
| J-223 | 4,956 | TRUE | Passed | 500 | 4,957 | 30 | 32 | J-222 |

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|---|---|---|---|---|---|---|---|---|
| J-224 | 5,826 | TRUE | Passed | 500 | 5,827 | 30 | 37.1 | J-223 |
| J-225 | 6,061 | TRUE | Passed | 500 | 6,062 | 30 | 39 | J-224 |
| J-226 | 7,734 | TRUE | Passed | 500 | 7,735 | 30 | 32.9 | J-334 |
| J-227 | 5,756 | TRUE | Passed | 500 | 5,758 | 30 | 12.7 | J-196 |
| J-228 | 4,538 | TRUE | Passed | 500 | 4,539 | 30 | 32.9 | J-229 |
| J-229 | 4,548 | TRUE | Passed | 500 | 4,549 | 30 | 31.9 | J-228 |
| J-230 | 2,912 | TRUE | Passed | 500 | 2,913 | 30 | 48.1 | J-692 |
| J-231 | 4,380 | TRUE | Passed | 500 | 4,381 | 30 | 31 | J-230 |
| J-232 | 4,958 | TRUE | Passed | 500 | 4,959 | 30 | 33.6 | J-231 |
| J-233 | 6,701 | TRUE | Passed | 500 | 6,702 | 30 | 26.6 | J-232 |
| J-234 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.5 | 24 | J-237 |
| J-235 | 10,000 | TRUE | Passed | 500 | 10,001 | 52.7 | 26.4 | J-156 |
| J-236 | 1,774 | TRUE | Passed | 500 | 1,775 | 30 | 28.7 | J-237 |
| J-237 | 1,568 | TRUE | Passed | 500 | 1,569 | 30 | 36.6 | J-236 |
| J-238 | 1,021 | TRUE | Passed | 500 | 1,022 | 30 | 48.5 | J-692 |
| J-239 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.1 | 31.4 | J-240 |
| J-240 | 9,903 | TRUE | Passed | 500 | 9,904 | 30 | 32.6 | J-239 |
| J-241 | 8,213 | TRUE | Passed | 500 | 8,214 | 30 | 42.5 | J-14 |
| J-242 | 7,537 | TRUE | Passed | 500 | 7,538 | 30 | 37.9 | J-13 |
| J-243 | 9,636 | TRUE | Passed | 500 | 9,637 | 30 | 35.4 | J-244 |
| J-244 | 5,315 | TRUE | Passed | 500 | 5,316 | 30 | 46.5 | J-317 |
| J-245 | 9,907 | TRUE | Passed | 500 | 9,908 | 30 | 40.4 | J-243 |
| J-246 | 8,788 | TRUE | Passed | 500 | 8,789 | 30 | 40.2 | J-242 |
| J-247 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.9 | 44.8 | J-323 |
| J-248 | 7,277 | TRUE | Passed | 500 | 7,278 | 30 | 33.5 | J-318 |
| J-249 | 2,447 | TRUE | Passed | 500 | 2,448 | 30 | 29.1 | J-250 |
| J-250 | 1,334 | TRUE | Passed | 500 | 1,335 | 30 | 48.5 | J-692 |
| J-251 | 7,386 | TRUE | Passed | 500 | 7,387 | 30 | 38.1 | J-253 |
| J-252 | 7,406 | TRUE | Passed | 500 | 7,407 | 30 | 45.1 | J-253 |
| J-253 | 3,164 | TRUE | Passed | 500 | 3,165 | 30 | 48.5 | J-692 |
| J-254 | 7,635 | TRUE | Passed | 500 | 7,636 | 30 | 26.5 | J-324 |
| J-255 | 6,900 | TRUE | Passed | 500 | 6,901 | 30 | 35.9 | J-262 |
| J-256 | 4,134 | TRUE | Passed | 500 | 4,135 | 30 | 48.4 | J-692 |
| J-257 | 6,958 | TRUE | Passed | 500 | 6,959 | 30 | 36.6 | J-258 |
| J-258 | 6,913 | TRUE | Passed | 500 | 6,914 | 30 | 37.3 | J-257 |
| J-259 | 4,388 | TRUE | Passed | 500 | 4,389 | 30 | 47.5 | J-256 |
| J-260 | 6,142 | TRUE | Passed | 500 | 6,143 | 30 | 33.5 | J-731 |
| J-262 | 6,815 | TRUE | Passed | 500 | 6,816 | 30 | 37.4 | J-255 |
| J-263 | 4,182 | TRUE | Passed | 500 | 4,183 | 30 | 39.8 | J-266 |
| J-264 | 7,111 | TRUE | Passed | 500 | 7,112 | 30 | 35 | J-25 |
| J-265 | 3,933 | TRUE | Passed | 500 | 3,934 | 30 | 29.5 | J-266 |
| J-266 | 2,782 | TRUE | Passed | 500 | 2,783 | 30 | 45.7 | J-265 |

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|---|---|---|---|---|---|---|---|---|
| J-267 | 5,861 | TRUE | Passed | 500 | 5,862 | 30 | 32.1 | J-268 |
| J-268 | 5,140 | TRUE | Passed | 500 | 5,141 | 30 | 31.8 | 4-FLOW |
| J-269 | 6,021 | TRUE | Passed | 500 | 6,022 | 30 | 31.6 | J-267 |
| J-270 | 7,360 | TRUE | Passed | 500 | 7,361 | 30 | 33.4 | J-272 |
| J-271 | 6,324 | TRUE | Passed | 500 | 6,325 | 30 | 35 | J-260 |
| J-272 | 6,464 | TRUE | Passed | 500 | 6,466 | 30 | 30.6 | J-276 |
| J-273 | 4,965 | TRUE | Passed | 500 | 4,966 | 30 | 30.1 | J-274 |
| J-274 | 4,583 | TRUE | Passed | 500 | 4,585 | 30 | 34.3 | J-273 |
| J-275 | 6,176 | TRUE | Passed | 500 | 6,177 | 30 | 32.7 | J-273 |
| J-276 | 5,929 | TRUE | Passed | 500 | 5,930 | 30 | 35.4 | J-275 |
| J-277 | 6,048 | TRUE | Passed | 500 | 6,049 | 30 | 28.5 | J-278 |
| J-278 | 4,402 | TRUE | Passed | 500 | 4,403 | 30 | 38.6 | J-283 |
| J-279 | 3,953 | TRUE | Passed | 500 | 3,954 | 30 | 34.1 | J-281 |
| J-280 | 1,451 | TRUE | Passed | 500 | 1,452 | 30 | 48.5 | J-692 |
| J-281 | 3,226 | TRUE | Passed | 500 | 3,227 | 30 | 32.8 | J-280 |
| J-282 | 3,068 | TRUE | Passed | 500 | 3,069 | 30 | 29.9 | J-283 |
| J-283 | 2,427 | TRUE | Passed | 500 | 2,428 | 30 | 30.2 | J-285 |
| J-284 | 1,391 | TRUE | Passed | 500 | 1,392 | 30 | 48.5 | J-692 |
| J-285 | 2,050 | TRUE | Passed | 500 | 2,051 | 30 | 37.9 | J-283 |
| J-286 | 4,394 | TRUE | Passed | 500 | 4,395 | 30 | 27.1 | J-292 |
| J-287 | 3,562 | TRUE | Passed | 500 | 3,564 | 30 | 27.4 | J-292 |
| J-288 | 2,069 | TRUE | Passed | 500 | 2,070 | 30 | 35.5 | J-290 |
| J-289 | 2,338 | TRUE | Passed | 500 | 2,339 | 30 | 29.1 | J-290 |
| J-290 | 2,150 | TRUE | Passed | 500 | 2,151 | 30 | 34.5 | J-289 |
| J-291 | 1,156 | TRUE | Passed | 500 | 1,157 | 30 | 48.5 | J-692 |
| J-292 | 2,530 | TRUE | Passed | 500 | 2,531 | 30 | 34 | 6-FLOW |
| J-294 | 1,396 | TRUE | Passed | 500 | 1,397 | 30 | 44.6 | 6-FLOW |
| J-296 | 6,290 | TRUE | Passed | 500 | 6,291 | 30 | 30.3 | J-292 |
| J-297 | 6,445 | TRUE | Passed | 500 | 6,446 | 30 | 40.3 | J-292 |
| J-298 | 8,609 | TRUE | Passed | 500 | 8,610 | 30 | 40.5 | J-292 |
| J-299 | 9,670 | TRUE | Passed | 500 | 9,671 | 30 | 37.5 | J-292 |
| J-300 | 4,157 | TRUE | Passed | 500 | 4,158 | 30 | 29.9 | J-301 |
| J-301 | 3,339 | TRUE | Passed | 500 | 3,340 | 30 | 40.3 | J-300 |
| J-302 | 3,769 | TRUE | Passed | 500 | 3,770 | 30 | 30.6 | J-303 |
| J-303 | 3,092 | TRUE | Passed | 500 | 3,093 | 30 | 39.2 | J-302 |
| J-304 | 5,586 | TRUE | Passed | 500 | 5,587 | 30 | 36.5 | J-302 |
| J-305 | 5,798 | TRUE | Passed | 500 | 5,800 | 30 | 25.1 | J-306 |
| J-306 | 2,408 | TRUE | Passed | 500 | 2,410 | 30 | 48.5 | J-692 |
| J-307 | 7,874 | TRUE | Passed | 500 | 7,875 | 30 | 30.5 | J-306 |
| J-308 | 6,924 | TRUE | Passed | 500 | 6,925 | 30 | 40 | J-320 |
| J-309 | 3,637 | TRUE | Passed | 500 | 3,638 | 30 | 45.9 | J-311 |
| J-310 | 3,460 | TRUE | Passed | 500 | 3,461 | 30 | 46.2 | J-314 |

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|---|---|---|---|---|---|---|---|---|
| J-311 | 3,944 | TRUE | Passed | 500 | 3,945 | 30 | 40.5 | J-309 |
| J-312 | 3,877 | TRUE | Passed | 500 | 3,878 | 30 | 48.3 | J-692 |
| J-313 | 4,392 | TRUE | Passed | 500 | 4,393 | 30 | 48.1 | J-692 |
| J-314 | 3,251 | TRUE | Passed | 500 | 3,252 | 30 | 48.3 | J-692 |
| J-315 | 2,620 | TRUE | Passed | 500 | 2,621 | 30 | 48.4 | J-692 |
| J-316 | 4,492 | TRUE | Passed | 500 | 4,493 | 30 | 44.2 | J-317 |
| J-317 | 3,315 | TRUE | Passed | 500 | 3,316 | 30 | 46.7 | J-315 |
| J-318 | 6,617 | TRUE | Passed | 500 | 6,618 | 30 | 34.3 | J-319 |
| J-319 | 6,322 | TRUE | Passed | 500 | 6,323 | 30 | 35 | J-321 |
| J-320 | 6,363 | TRUE | Passed | 500 | 6,364 | 30 | 34.5 | J-319 |
| J-321 | 3,272 | TRUE | Passed | 500 | 3,273 | 30 | 47.4 | J-322 |
| J-322 | 3,483 | TRUE | Passed | 500 | 3,484 | 30 | 42.1 | J-323 |
| J-323 | 3,072 | TRUE | Passed | 500 | 3,073 | 30 | 42.4 | J-250 |
| J-324 | 4,152 | TRUE | Passed | 500 | 4,153 | 30 | 48.4 | J-692 |
| J-325 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.5 | 33.6 | J-97 |
| J-326 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.7 | 35 | J-97 |
| J-327 | 6,957 | TRUE | Passed | 500 | 6,958 | 30 | 45.4 | J-97 |
| J-328 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.7 | 35.7 | J-97 |
| J-329 | 10,000 | TRUE | Passed | 500 | 10,001 | 32 | 35.1 | J-215 |
| J-330 | 1,724 | TRUE | Passed | 500 | 1,725 | 30 | 48.5 | J-692 |
| J-331 | 6,002 | TRUE | Passed | 500 | 6,003 | 30 | 31.6 | J-330 |
| J-332 | 6,307 | TRUE | Passed | 500 | 6,308 | 30 | 42.9 | J-331 |
| J-333 | 4,534 | TRUE | Passed | 500 | 4,535 | 30 | 48 | J-692 |
| J-334 | 7,792 | TRUE | Passed | 500 | 7,793 | 30 | 33.4 | J-226 |
| J-336 | 6,589 | TRUE | Passed | 500 | 6,590 | 30 | 40.4 | J-215 |
| J-338 | 7,229 | TRUE | Passed | 500 | 7,230 | 30 | 35.9 | J-339 |
| J-339 | 6,205 | TRUE | Passed | 500 | 6,206 | 30 | 35.7 | J-215 |
| J-340 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.4 | 33 | J-97 |
| J-341 | 7,559 | TRUE | Passed | 500 | 7,560 | 30 | 36.8 | J-306 |
| J-342 | 4,011 | TRUE | Passed | 500 | 4,012 | 30 | 48.2 | J-692 |
| J-343 | 7,286 | TRUE | Passed | 500 | 7,287 | 30 | 45.3 | J-278 |
| J-345 | 4,857 | TRUE | Passed | 500 | 4,858 | 30 | 48 | J-692 |
| J-346 | 3,627 | TRUE | Passed | 500 | 3,628 | 30 | 48.3 | J-692 |
| J-347 | 10,000 | TRUE | Passed | 500 | 10,001 | 49.9 | 38.5 | J-97 |
| J-348 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.7 | 39.4 | J-97 |
| J-349 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.9 | 39.7 | J-97 |
| J-350 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.1 | 40 | J-97 |
| J-351 | 8,630 | TRUE | Passed | 500 | 8,631 | 30 | 40.1 | J-365 |
| J-352 | 8,916 | TRUE | Passed | 500 | 8,917 | 30 | 38.8 | J-365 |
| J-353 | 9,490 | TRUE | Passed | 500 | 9,491 | 30 | 38 | J-352 |
| J-354 | 10,000 | TRUE | Passed | 500 | 10,001 | 35 | 38.5 | J-358 |
| J-355 | 8,868 | TRUE | Passed | 500 | 8,869 | 30 | 42.8 | J-361 |

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|---|---|---|---|---|---|---|---|---|
| J-356 | 8,318 | TRUE | Passed | 500 | 8,319 | 30 | 35.6 | J-365 |
| J-357 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.5 | 36.6 | J-97 |
| J-358 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.1 | 35.4 | J-360 |
| J-359 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.3 | 28 | J-360 |
| J-360 | 1,510 | TRUE | Passed | 500 | 1,511 | 30 | 48.5 | J-692 |
| J-361 | 8,485 | TRUE | Passed | 500 | 8,486 | 30 | 43.4 | J-355 |
| J-362 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.3 | 40.5 | J-97 |
| J-363 | 8,021 | TRUE | Passed | 500 | 8,022 | 30 | 38 | J-364 |
| J-364 | 7,142 | TRUE | Passed | 500 | 7,143 | 30 | 38.9 | J-366 |
| J-365 | 7,551 | TRUE | Passed | 500 | 7,552 | 30 | 40.5 | J-364 |
| J-366 | 6,977 | TRUE | Passed | 500 | 6,978 | 30 | 38.7 | J-364 |
| J-367 | 8,643 | TRUE | Passed | 500 | 8,644 | 30 | 36.9 | J-398 |
| J-368 | 5,913 | TRUE | Passed | 500 | 5,914 | 30 | 43.8 | J-389 |
| J-369 | 8,725 | TRUE | Passed | 500 | 8,726 | 30 | 41.1 | J-368 |
| J-370 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.6 | 34.7 | J-360 |
| J-371 | 4,004 | TRUE | Passed | 500 | 4,005 | 30 | 22 | J-692 |
| J-371 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.1 | 38.5 | J-292 |
| J-372 | 7,001 | TRUE | Passed | 500 | 7,002 | 30 | 47.3 | J-692 |
| J-373 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.9 | 40.9 | J-97 |
| J-374 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.1 | 41 | J-97 |
| J-375 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.6 | 41.2 | J-97 |
| J-376 | 8,015 | TRUE | Passed | 500 | 8,016 | 30 | 45.8 | J-97 |
| J-377 | 10,000 | TRUE | Passed | 500 | 10,001 | 55.3 | 41.4 | J-97 |
| J-378 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.5 | 41.3 | J-97 |
| J-379 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.7 | 41.2 | J-97 |
| J-380 | 6,684 | TRUE | Passed | 500 | 6,685 | 30 | 47.3 | J-692 |
| J-382 | 7,229 | TRUE | Passed | 500 | 7,230 | 30 | 44 | J-383 |
| J-383 | 6,625 | TRUE | Passed | 500 | 6,626 | 30 | 41.7 | J-388 |
| J-384 | 6,926 | TRUE | Passed | 500 | 6,927 | 30 | 44.8 | J-431 |
| J-385 | 9,247 | TRUE | Passed | 500 | 9,248 | 30 | 38.4 | J-429 |
| J-386 | 9,979 | TRUE | Passed | 500 | 9,980 | 30 | 36.7 | J-1031 |
| J-387 | 8,489 | TRUE | Passed | 500 | 8,490 | 30 | 36.4 | J-388 |
| J-388 | 6,341 | TRUE | Passed | 500 | 6,342 | 30 | 41.7 | J-389 |
| J-389 | 4,973 | TRUE | Passed | 500 | 4,974 | 30 | 33.8 | J-390 |
| J-390 | 1,844 | TRUE | Passed | 500 | 1,845 | 30 | 48.5 | J-692 |
| J-391 | 6,745 | TRUE | Passed | 500 | 6,746 | 30 | 47.3 | J-692 |
| J-392 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.2 | 41.4 | J-97 |
| J-393 | 7,590 | TRUE | Passed | 500 | 7,591 | 30 | 38.7 | J-430 |
| J-394 | 8,959 | TRUE | Passed | 500 | 8,960 | 30 | 29.3 | J-424 |
| J-395 | 9,136 | TRUE | Passed | 500 | 9,137 | 30 | 26.8 | J-425 |
| J-396 | 10,000 | TRUE | Passed | 500 | 10,001 | 44 | 41.5 | J-97 |
| J-397 | 6,151 | TRUE | Passed | 500 | 6,152 | 30 | 27.8 | J-398 |

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|---|---|---|---|---|---|---|---|---|
| J-398 | 1,635 | TRUE | Passed | 500 | 1,636 | 30 | 48.5 | J-692 |
| J-399 | 10,000 | TRUE | Passed | 500 | 10,001 | 68.8 | 39.7 | J-156 |
| J-401 | 4,391 | TRUE | Passed | 500 | 4,392 | 30 | 22 | J-692 |
| J-401 | 10,000 | TRUE | Passed | 500 | 10,001 | 65.9 | 42.4 | J-156 |
| J-402 | 10,000 | TRUE | Passed | 500 | 10,001 | 66.5 | 42.3 | J-156 |
| J-403 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.3 | 42.7 | J-156 |
| J-404 | 10,000 | TRUE | Passed | 500 | 10,001 | 30 | 43 | J-660 |
| J-405 | 4,574 | TRUE | Passed | 500 | 4,575 | 30 | 47.9 | J-692 |
| J-406 | 10,000 | TRUE | Passed | 500 | 10,001 | 62.1 | 41.9 | J-156 |
| J-407 | 10,000 | TRUE | Passed | 500 | 10,001 | 68.5 | 41.8 | J-156 |
| J-408 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.8 | 41.8 | J-156 |
| J-409 | 3,384 | TRUE | Passed | 500 | 3,385 | 30 | 48.2 | J-692 |
| J-410 | 10,000 | TRUE | Passed | 500 | 10,001 | 55.2 | 41.9 | J-97 |
| J-411 | 3,452 | TRUE | Passed | 500 | 3,453 | 30 | 48.2 | J-692 |
| J-412 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.9 | 41.9 | J-97 |
| J-413 | 10,000 | TRUE | Passed | 500 | 10,001 | 66.2 | 41.1 | J-156 |
| J-414 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.5 | 34.1 | J-156 |
| J-415 | 1,940 | TRUE | Passed | 500 | 1,941 | 30 | 48.4 | J-692 |
| J-416 | 10,000 | TRUE | Passed | 500 | 10,001 | 62.7 | 41.5 | J-97 |
| J-417 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.9 | 41.7 | J-97 |
| J-418 | 5,366 | TRUE | Passed | 500 | 5,367 | 30 | 29.9 | J-419 |
| J-419 | 3,390 | TRUE | Passed | 500 | 3,391 | 30 | 48.2 | J-692 |
| J-420 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.3 | 35.9 | J-421 |
| J-421 | 9,204 | TRUE | Passed | 500 | 9,205 | 30 | 32.2 | J-423 |
| J-422 | 6,693 | TRUE | Passed | 500 | 6,694 | 30 | 45.8 | J-431 |
| J-423 | 9,080 | TRUE | Passed | 500 | 9,081 | 30 | 33.1 | J-422 |
| J-424 | 4,657 | TRUE | Passed | 500 | 4,658 | 30 | 44.9 | J-678 |
| J-425 | 3,988 | TRUE | Passed | 500 | 3,989 | 30 | 48.1 | J-692 |
| J-426 | 9,247 | TRUE | Passed | 500 | 9,248 | 30 | 24.5 | J-425 |
| J-427 | 7,704 | TRUE | Passed | 500 | 7,705 | 30 | 34.5 | J-424 |
| J-428 | 9,193 | TRUE | Passed | 500 | 9,194 | 30 | 35.1 | J-423 |
| J-429 | 9,165 | TRUE | Passed | 500 | 9,166 | 30 | 35.3 | J-428 |
| J-430 | 3,834 | TRUE | Passed | 500 | 3,835 | 30 | 48.1 | J-692 |
| J-431 | 7,127 | TRUE | Passed | 500 | 7,129 | 30 | 30.9 | J-432 |
| J-432 | 2,216 | TRUE | Passed | 500 | 2,217 | 30 | 48.4 | J-692 |
| J-433 | 2,411 | TRUE | Passed | 500 | 2,412 | 30 | 28.4 | J-237 |
| J-434 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.9 | 48.5 | J-692 |
| J-435 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.2 | 48.5 | J-692 |
| J-436 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.9 | 48.5 | J-692 |
| J-437 | 8,363 | TRUE | Passed | 500 | 8,364 | 30 | 48.4 | J-692 |
| J-439 | 6,622 | TRUE | Passed | 500 | 6,623 | 30 | 31.7 | J-719 |
| J-440 | 6,514 | TRUE | Passed | 500 | 6,515 | 30 | 32.1 | J-1780 |

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|---|---|---|---|---|---|---|---|---|
| J-442 | 7,597 | TRUE | Passed | 500 | 7,598 | 30 | 27.5 | J-443 |
| J-443 | 2,068 | TRUE | Passed | 500 | 2,069 | 30 | 48.5 | J-692 |
| J-445 | 8,833 | TRUE | Passed | 500 | 8,834 | 30 | 31.2 | J-455 |
| J-447 | 6,049 | TRUE | Passed | 500 | 6,050 | 30 | 27.3 | J-450 |
| J-448 | 4,818 | TRUE | Passed | 500 | 4,819 | 30 | 40.1 | J-450 |
| J-449 | 5,739 | TRUE | Passed | 500 | 5,740 | 30 | 23.5 | J-450 |
| J-450 | 3,911 | TRUE | Passed | 500 | 3,912 | 30 | 48.4 | J-692 |
| J-451 | 5,547 | TRUE | Passed | 500 | 5,548 | 30 | 35.3 | J-452 |
| J-452 | 5,056 | TRUE | Passed | 500 | 5,057 | 30 | 31.8 | J-458 |
| J-453 | 4,689 | TRUE | Passed | 500 | 4,690 | 30 | 40 | J-454 |
| J-454 | 4,512 | TRUE | Passed | 500 | 4,513 | 30 | 43.1 | J-453 |
| J-455 | 6,036 | TRUE | Passed | 500 | 6,037 | 30 | 38.2 | J-454 |
| J-456 | 6,080 | TRUE | Passed | 500 | 6,081 | 30 | 37.4 | J-455 |
| J-457 | 4,842 | TRUE | Passed | 500 | 4,843 | 30 | 40.2 | J-452 |
| J-458 | 2,803 | TRUE | Passed | 500 | 2,804 | 30 | 48.5 | J-692 |
| J-459 | 2,731 | TRUE | Passed | 500 | 2,732 | 30 | 33.4 | J-463 |
| J-460 | 3,756 | TRUE | Passed | 500 | 3,757 | 30 | 33.6 | J-459 |
| J-461 | 1,543 | TRUE | Passed | 500 | 1,544 | 30 | 29.4 | J-463 |
| J-462 | 1,356 | TRUE | Passed | 500 | 1,357 | 30 | 37.4 | J-463 |
| J-463 | 1,241 | TRUE | Passed | 500 | 1,242 | 30 | 42.6 | J-461 |
| J-464 | 4,902 | TRUE | Passed | 500 | 4,903 | 30 | 38.4 | J-457 |
| J-465 | 5,057 | TRUE | Passed | 500 | 5,058 | 30 | 36.6 | J-464 |
| J-466 | 5,359 | TRUE | Passed | 500 | 5,360 | 30 | 37.8 | J-465 |
| J-467 | 6,048 | TRUE | Passed | 500 | 6,049 | 30 | 29 | J-460 |
| J-468 | 5,974 | TRUE | Passed | 500 | 5,975 | 30 | 33.8 | J-459 |
| J-469 | 6,542 | TRUE | Passed | 500 | 6,543 | 30 | 35.5 | J-474 |
| J-470 | 7,885 | TRUE | Passed | 500 | 7,886 | 30 | 47.1 | J-556 |
| J-471 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.3 | 37.1 | J-556 |
| J-472 | 6,692 | TRUE | Passed | 500 | 6,693 | 30 | 41.3 | J-473 |
| J-473 | 6,127 | TRUE | Passed | 500 | 6,128 | 30 | 36.8 | J-475 |
| J-474 | 5,676 | TRUE | Passed | 500 | 5,677 | 30 | 46.3 | J-475 |
| J-475 | 5,249 | TRUE | Passed | 500 | 5,250 | 30 | 41.1 | J-478 |
| J-476 | 2,216 | TRUE | Passed | 500 | 2,217 | 30 | 41.4 | J-477 |
| J-477 | 2,246 | TRUE | Passed | 500 | 2,247 | 30 | 39.2 | J-476 |
| J-478 | 5,190 | TRUE | Passed | 500 | 5,191 | 30 | 39.9 | J-475 |
| J-479 | 5,326 | TRUE | Passed | 500 | 5,327 | 30 | 40 | J-478 |
| J-480 | 5,655 | TRUE | Passed | 500 | 5,656 | 30 | 37.9 | J-479 |
| J-481 | 6,002 | TRUE | Passed | 500 | 6,003 | 30 | 35.9 | J-480 |
| J-482 | 3,101 | TRUE | Passed | 500 | 3,102 | 30 | 25.8 | J-485 |
| J-483 | 1,905 | TRUE | Passed | 500 | 1,906 | 30 | 28.8 | J-485 |
| J-484 | 1,751 | TRUE | Passed | 500 | 1,752 | 30 | 34.1 | J-485 |
| J-485 | 1,421 | TRUE | Passed | 500 | 1,422 | 30 | 45.3 | J-484 |

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|---|---|---|---|---|---|---|---|---|
| J-486 | 9,043 | TRUE | Passed | 500 | 9,044 | 30 | 41.6 | 1-FLOW |
| J-487 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.5 | 45.4 | J-455 |
| J-489 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.2 | 48.3 | J-692 |
| J-490 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.4 | 38.9 | J-437 |
| J-491 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 48.5 | J-692 |
| J-492 | 10,000 | TRUE | Passed | 500 | 10,001 | 49.1 | 48 | J-692 |
| J-493 | 9,581 | TRUE | Passed | 500 | 9,582 | 30 | 36.6 | J-494 |
| J-494 | 9,701 | TRUE | Passed | 500 | 9,702 | 30 | 35.3 | J-493 |
| J-497 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.8 | 47.2 | J-692 |
| J-498 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.2 | 47.8 | J-692 |
| J-499 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.1 | 40.2 | J-500 |
| J-500 | 6,497 | TRUE | Passed | 500 | 6,498 | 30 | 48.3 | J-692 |
| J-501 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.5 | 38.7 | J-502 |
| J-502 | 4,773 | TRUE | Passed | 500 | 4,774 | 30 | 31.3 | J-726 |
| J-504 | 3,038 | TRUE | Passed | 500 | 3,039 | 30 | 40.5 | J-1334 |
| J-505 | 3,749 | TRUE | Passed | 500 | 3,750 | 30 | 42.4 | J-554 |
| J-507 | 4,184 | TRUE | Passed | 500 | 4,185 | 30 | 33.1 | J-508 |
| J-508 | 4,185 | TRUE | Passed | 500 | 4,186 | 30 | 34.1 | J-507 |
| J-509 | 4,923 | TRUE | Passed | 500 | 4,924 | 30 | 30.9 | J-508 |
| J-510 | 5,545 | TRUE | Passed | 500 | 5,546 | 30 | 32.6 | J-513 |
| J-511 | 2,218 | TRUE | Passed | 500 | 2,219 | 30 | 37.9 | J-513 |
| J-513 | 2,261 | TRUE | Passed | 500 | 2,262 | 30 | 37.5 | J-514 |
| J-514 | 2,554 | TRUE | Passed | 500 | 2,555 | 30 | 29.3 | J-513 |
| J-516 | 4,881 | TRUE | Passed | 500 | 4,882 | 30 | 38.4 | J-508 |
| J-517 | 5,335 | TRUE | Passed | 500 | 5,336 | 30 | 30.4 | J-549 |
| J-518 | 4,844 | TRUE | Passed | 500 | 4,845 | 30 | 26.2 | J-549 |
| J-519 | 5,220 | TRUE | Passed | 500 | 5,221 | 30 | 29.8 | J-508 |
| J-520 | 4,410 | TRUE | Passed | 500 | 4,411 | 30 | 32.7 | J-521 |
| J-521 | 3,627 | TRUE | Passed | 500 | 3,628 | 30 | 37.2 | J-603 |
| J-522 | 3,796 | TRUE | Passed | 500 | 3,797 | 30 | 27.5 | J-603 |
| J-523 | 4,145 | TRUE | Passed | 500 | 4,146 | 30 | 27.8 | J-603 |
| J-524 | 4,003 | TRUE | Passed | 500 | 4,004 | 30 | 29.9 | J-521 |
| J-525 | 4,455 | TRUE | Passed | 500 | 4,456 | 30 | 31.6 | J-521 |
| J-526 | 4,301 | TRUE | Passed | 500 | 4,302 | 30 | 33.8 | J-521 |
| J-527 | 4,386 | TRUE | Passed | 500 | 4,387 | 30 | 32.8 | J-528 |
| J-528 | 4,056 | TRUE | Passed | 500 | 4,057 | 30 | 35.7 | J-610 |
| J-529 | 4,278 | TRUE | Passed | 500 | 4,279 | 30 | 37.2 | J-613 |
| J-530 | 4,305 | TRUE | Passed | 500 | 4,306 | 30 | 38.6 | J-596 |
| J-531 | 2,744 | TRUE | Passed | 500 | 2,745 | 30 | 48.4 | J-692 |
| J-532 | 2,960 | TRUE | Passed | 500 | 2,961 | 30 | 48.4 | J-692 |
| J-533 | 7,908 | TRUE | Passed | 500 | 7,909 | 30 | 32.3 | J-532 |
| J-534 | 8,811 | TRUE | Passed | 500 | 8,812 | 30 | 29.7 | J-535 |

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|---|---|---|---|---|---|---|---|---|
| J-535 | 8,182 | TRUE | Passed | 500 | 8,183 | 30 | 30.9 | J-536 |
| J-536 | 7,346 | TRUE | Passed | 500 | 7,347 | 30 | 36.9 | J-535 |
| J-537 | 8,404 | TRUE | Passed | 500 | 8,405 | 30 | 36 | J-647 |
| J-538 | 8,987 | TRUE | Passed | 500 | 8,988 | 30 | 37.4 | J-648 |
| J-539 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.7 | 32.7 | J-538 |
| J-540 | 2,952 | TRUE | Passed | 500 | 2,953 | 30 | 42.9 | J-648 |
| J-541 | 3,192 | TRUE | Passed | 500 | 3,193 | 30 | 46.6 | J-648 |
| J-542 | 6,442 | TRUE | Passed | 500 | 6,443 | 30 | 41.7 | J-644 |
| J-543 | 8,742 | TRUE | Passed | 500 | 8,743 | 30 | 35.3 | J-542 |
| J-544 | 9,802 | TRUE | Passed | 500 | 9,804 | 30 | 34.1 | J-546 |
| J-545 | 5,322 | TRUE | Passed | 500 | 5,323 | 30 | 29.6 | J-546 |
| J-546 | 2,037 | TRUE | Passed | 500 | 2,038 | 30 | 48.5 | J-692 |
| J-547 | 4,971 | TRUE | Passed | 500 | 4,972 | 30 | 30.7 | J-548 |
| J-548 | 1,765 | TRUE | Passed | 500 | 1,766 | 30 | 48.5 | J-692 |
| J-549 | 1,613 | TRUE | Passed | 500 | 1,614 | 30 | 48.5 | J-692 |
| J-550 | 4,293 | TRUE | Passed | 500 | 4,294 | 30 | 29.7 | J-552 |
| J-551 | 2,852 | TRUE | Passed | 500 | 2,853 | 30 | 46.4 | J-552 |
| J-552 | 2,295 | TRUE | Passed | 500 | 2,296 | 30 | 48.5 | J-692 |
| J-553 | 3,783 | TRUE | Passed | 500 | 3,784 | 30 | 29.9 | J-554 |
| J-554 | 2,463 | TRUE | Passed | 500 | 2,465 | 30 | 48 | J-553 |
| J-555 | 10,000 | TRUE | Passed | 500 | 10,001 | 34 | 35.5 | J-556 |
| J-556 | 3,936 | TRUE | Passed | 500 | 3,937 | 30 | 48.3 | J-692 |
| J-557 | 3,478 | TRUE | Passed | 500 | 3,479 | 30 | 30.9 | J-558 |
| J-558 | 1,761 | TRUE | Passed | 500 | 1,762 | 30 | 48.5 | J-692 |
| J-559 | 10,000 | TRUE | Passed | 500 | 10,001 | 38 | 39.8 | J-557 |
| J-560 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.2 | 47.1 | J-692 |
| J-561 | 3,612 | TRUE | Passed | 500 | 3,613 | 30 | 48.3 | J-692 |
| J-562 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.7 | 37.6 | J-556 |
| J-563 | 2,779 | TRUE | Passed | 500 | 2,780 | 30 | 48.4 | J-692 |
| J-564 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.2 | 38.8 | J-563 |
| J-565 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.9 | 40.8 | J-556 |
| J-566 | 8,188 | TRUE | Passed | 500 | 8,189 | 30 | 46.5 | J-692 |
| J-567 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.2 | 39.8 | J-578 |
| J-568 | 9,994 | TRUE | Passed | 500 | 9,995 | 30 | 39.2 | J-569 |
| J-569 | 7,898 | TRUE | Passed | 500 | 7,899 | 30 | 38.2 | J-570 |
| J-570 | 6,934 | TRUE | Passed | 500 | 6,935 | 30 | 46.4 | J-569 |
| J-571 | 8,094 | TRUE | Passed | 500 | 8,095 | 30 | 43.8 | J-574 |
| J-572 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.4 | 25.1 | J-574 |
| J-573 | 7,812 | TRUE | Passed | 500 | 7,813 | 30 | 41.2 | J-692 |
| J-574 | 9,115 | TRUE | Passed | 500 | 9,116 | 30 | 33.5 | J-571 |
| J-576 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.5 | 41.7 | J-578 |
| J-577 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.9 | 38.8 | J-578 |

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|---|---|---|---|---|---|---|---|---|
| J-578 | 3,112 | TRUE | Passed | 500 | 3,113 | 30 | 48.3 | J-692 |
| J-579 | 4,146 | TRUE | Passed | 500 | 4,147 | 30 | 48.1 | J-578 |
| J-580 | 4,214 | TRUE | Passed | 500 | 4,215 | 30 | 47.8 | J-644 |
| J-581 | 3,983 | TRUE | Passed | 500 | 3,984 | 30 | 48.1 | J-692 |
| J-582 | 6,312 | TRUE | Passed | 500 | 6,313 | 30 | 39.3 | J-581 |
| J-583 | 6,831 | TRUE | Passed | 500 | 6,832 | 30 | 45.3 | J-584 |
| J-584 | 7,732 | TRUE | Passed | 500 | 7,733 | 30 | 36.9 | J-585 |
| J-585 | 5,925 | TRUE | Passed | 500 | 5,926 | 30 | 38.8 | J-587 |
| J-587 | 5,493 | TRUE | Passed | 500 | 5,494 | 30 | 38.3 | J-588 |
| J-588 | 5,129 | TRUE | Passed | 500 | 5,131 | 30 | 43.2 | J-587 |
| J-589 | 5,293 | TRUE | Passed | 500 | 5,294 | 30 | 38.9 | J-588 |
| J-590 | 6,720 | TRUE | Passed | 500 | 6,721 | 30 | 28.6 | J-591 |
| J-591 | 6,153 | TRUE | Passed | 500 | 6,154 | 30 | 36.1 | J-590 |
| J-592 | 5,879 | TRUE | Passed | 500 | 5,880 | 30 | 36 | J-596 |
| J-593 | 4,302 | TRUE | Passed | 500 | 4,303 | 30 | 36.1 | J-596 |
| J-594 | 4,182 | TRUE | Passed | 500 | 4,183 | 30 | 26.1 | J-596 |
| J-595 | 3,388 | TRUE | Passed | 500 | 3,389 | 30 | 27.1 | J-596 |
| J-596 | 2,843 | TRUE | Passed | 500 | 2,844 | 30 | 35 | J-597 |
| J-597 | 2,955 | TRUE | Passed | 500 | 2,956 | 30 | 31.4 | J-596 |
| J-598 | 3,040 | TRUE | Passed | 500 | 3,041 | 30 | 32 | J-597 |
| J-599 | 3,231 | TRUE | Passed | 500 | 3,232 | 30 | 31.3 | J-1549 |
| J-601 | 2,842 | TRUE | Passed | 500 | 2,843 | 30 | 34.6 | J-1549 |
| J-602 | 4,098 | TRUE | Passed | 500 | 4,099 | 30 | 31.8 | J-1549 |
| J-603 | 2,161 | TRUE | Passed | 500 | 2,162 | 30 | 48.5 | J-692 |
| J-604 | 4,111 | TRUE | Passed | 500 | 4,112 | 30 | 30.5 | J-596 |
| J-605 | 3,019 | TRUE | Passed | 500 | 3,020 | 30 | 31 | J-596 |
| J-606 | 3,127 | TRUE | Passed | 500 | 3,128 | 30 | 29.6 | J-596 |
| J-607 | 3,958 | TRUE | Passed | 500 | 3,959 | 30 | 31.3 | J-596 |
| J-608 | 4,086 | TRUE | Passed | 500 | 4,087 | 30 | 31.4 | J-596 |
| J-609 | 4,160 | TRUE | Passed | 500 | 4,161 | 30 | 31.4 | J-596 |
| J-610 | 4,067 | TRUE | Passed | 500 | 4,068 | 30 | 34.3 | J-596 |
| J-611 | 4,374 | TRUE | Passed | 500 | 4,375 | 30 | 28.6 | J-596 |
| J-612 | 3,859 | TRUE | Passed | 500 | 3,860 | 30 | 35.9 | J-596 |
| J-613 | 3,988 | TRUE | Passed | 500 | 3,989 | 30 | 38.9 | J-596 |
| J-614 | 6,086 | TRUE | Passed | 500 | 6,087 | 30 | 34.6 | J-596 |
| J-615 | 6,376 | TRUE | Passed | 500 | 6,377 | 30 | 30.5 | J-614 |
| J-616 | 6,521 | TRUE | Passed | 500 | 6,522 | 30 | 32.3 | J-615 |
| J-617 | 6,447 | TRUE | Passed | 500 | 6,448 | 30 | 40.8 | 3-FLOW |
| J-620 | 7,419 | TRUE | Passed | 500 | 7,420 | 30 | 28.9 | J-617 |
| J-621 | 9,104 | TRUE | Passed | 500 | 9,105 | 30 | 28.9 | J-617 |
| J-622 | 8,701 | TRUE | Passed | 500 | 8,702 | 30 | 33.3 | J-626 |
| J-623 | 8,865 | TRUE | Passed | 500 | 8,866 | 30 | 35.2 | J-617 |

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|---|---|---|---|---|---|---|---|---|
| J-625 | 9,805 | TRUE | Passed | 500 | 9,806 | 30 | 28.8 | J-623 |
| J-626 | 8,517 | TRUE | Passed | 500 | 8,518 | 30 | 33.6 | J-627 |
| J-627 | 8,447 | TRUE | Passed | 500 | 8,448 | 30 | 35.2 | J-628 |
| J-628 | 8,661 | TRUE | Passed | 500 | 8,662 | 30 | 33.7 | J-627 |
| J-629 | 9,148 | TRUE | Passed | 500 | 9,149 | 30 | 31.7 | J-628 |
| J-630 | 9,359 | TRUE | Passed | 500 | 9,360 | 30 | 32.2 | J-629 |
| J-631 | 9,414 | TRUE | Passed | 500 | 9,415 | 30 | 36.4 | J-630 |
| J-632 | 5,016 | TRUE | Passed | 500 | 5,017 | 30 | 30 | J-633 |
| J-633 | 2,981 | TRUE | Passed | 500 | 2,982 | 30 | 48.3 | J-692 |
| J-634 | 7,810 | TRUE | Passed | 500 | 7,811 | 30 | 30.5 | J-633 |
| J-636 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.4 | 34.1 | J-631 |
| J-637 | 3,632 | TRUE | Passed | 500 | 3,633 | 30 | 48.2 | J-692 |
| J-638 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.3 | 36.6 | J-539 |
| J-639 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.9 | 41.5 | J-665 |
| J-640 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.4 | 40 | J-641 |
| J-641 | 5,376 | TRUE | Passed | 500 | 5,377 | 30 | 44.7 | J-642 |
| J-642 | 3,887 | TRUE | Passed | 500 | 3,888 | 30 | 48.2 | J-692 |
| J-643 | 2,961 | TRUE | Passed | 500 | 2,962 | 30 | 48.1 | J-645 |
| J-644 | 5,124 | TRUE | Passed | 500 | 5,125 | 30 | 37.8 | J-645 |
| J-645 | 2,570 | TRUE | Passed | 500 | 2,571 | 30 | 48.4 | J-692 |
| J-646 | 7,122 | TRUE | Passed | 500 | 7,123 | 30 | 39.8 | J-648 |
| J-647 | 4,631 | TRUE | Passed | 500 | 4,632 | 30 | 45.2 | J-648 |
| J-648 | 2,803 | TRUE | Passed | 500 | 2,804 | 30 | 48.4 | J-692 |
| J-649 | 3,531 | TRUE | Passed | 500 | 3,532 | 30 | 29.8 | J-650 |
| J-650 | 1,771 | TRUE | Passed | 500 | 1,772 | 30 | 48.5 | J-692 |
| J-651 | 7,586 | TRUE | Passed | 500 | 7,587 | 30 | 29.4 | J-652 |
| J-652 | 2,904 | TRUE | Passed | 500 | 2,905 | 30 | 48.4 | J-692 |
| J-655 | 7,084 | TRUE | Passed | 500 | 7,085 | 30 | 31.6 | J-656 |
| J-656 | 3,404 | TRUE | Passed | 500 | 3,405 | 30 | 48.3 | J-692 |
| J-657 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.9 | 44.4 | J-578 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.5 | 41.5 | J-568 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.8 | 44.6 | J-578 |
| J-660 | 10,000 | TRUE | Passed | 500 | 10,001 | 43 | 42 | J-404 |
| J-661 | 801 | TRUE | Passed | 500 | 805 | 30 | 48.5 | J-692 |
| J-662 | 10,000 | TRUE | Passed | 500 | 10,001 | 56.1 | 44.6 | J-156 |
| J-663 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.3 | 44.3 | J-633 |
| J-664 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.5 | 43.1 | J-578 |
| J-665 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.7 | 41.6 | J-639 |
| J-666 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.1 | 47.9 | J-692 |
| J-667 | 8,696 | TRUE | Passed | 500 | 8,697 | 30 | 34.8 | J-25 |
| J-668 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.4 | 48.2 | J-692 |
| J-669 | 3,933 | TRUE | Passed | 500 | 3,934 | 30 | 40.2 | J-21 |

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|---|---|---|---|---|---|---|---|---|
| J-670 | 4,456 | TRUE | Passed | 500 | 4,457 | 30 | 33.3 | J-21 |
| J-673 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.2 | 43.6 | J-674 |
| J-674 | 4,141 | TRUE | Passed | 500 | 4,143 | 30 | 48 | J-692 |
| J-675 | 3,849 | TRUE | Passed | 500 | 3,850 | 30 | 48.1 | J-692 |
| J-676 | 5,436 | TRUE | Passed | 500 | 5,437 | 30 | 31 | J-675 |
| J-677 | 2,357 | TRUE | Passed | 500 | 2,358 | 30 | 29.3 | J-678 |
| J-678 | 1,755 | TRUE | Passed | 500 | 1,756 | 30 | 45.2 | J-677 |
| J-680 | 4,644 | TRUE | Passed | 500 | 4,644 | 30 | 15.6 | J-692 |
| J-682 | 4,728 | TRUE | Passed | 500 | 4,728 | 30 | 16 | J-692 |
| J-685 | 1,972 | TRUE | Passed | 500 | 1,997 | 30 | 28.1 | J-692 |
| J-686 | 3,347 | TRUE | Passed | 500 | 3,397 | 30 | 17.1 | J-692 |
| J-687 | 3,015 | TRUE | Passed | 500 | 3,040 | 30 | 43.2 | J-692 |
| J-689 | 5,948 | TRUE | Passed | 500 | 5,973 | 30 | 39.7 | J-692 |
| J-690 | 5,122 | TRUE | Passed | 500 | 5,147 | 30 | 29.6 | J-687 |
| J-691 | 5,062 | TRUE | Passed | 500 | 5,087 | 30 | 16.8 | J-692 |
| J-692 | 1,595 | TRUE | Passed | 500 | 1,595 | 30 | 34.2 | J-695 |
| J-693 | 3,316 | TRUE | Passed | 500 | 3,341 | 30 | 22.2 | J-692 |
| J-694 | 3,609 | TRUE | Passed | 500 | 3,634 | 30 | 12.5 | J-695 |
| J-695 | 1,643 | TRUE | Passed | 500 | 1,668 | 30 | 32.3 | J-692 |
| J-696 | 1,880 | TRUE | Passed | 500 | 1,885 | 30 | 26.1 | J-51 |
| J-697 | 6,301 | TRUE | Passed | 500 | 6,301 | 30.9 | 0 | J-692 |
| J-698 | 3,008 | TRUE | Passed | 500 | 3,033 | 30 | 43.9 | J-692 |
| J-699 | 7,424 | TRUE | Passed | 500 | 7,449 | 30 | 29 | J-689 |
| J-700 | 3,985 | TRUE | Passed | 500 | 4,010 | 30 | 41.7 | J-692 |
| J-702 | 4,738 | TRUE | Passed | 500 | 4,738 | 30 | 19.1 | J-692 |
| J-719 | 4,447 | TRUE | Passed | 500 | 4,447 | 30 | 39.8 | J-724 |
| J-724 | 4,283 | TRUE | Passed | 500 | 4,283 | 30 | 34.2 | J-1780 |
| J-726 | 3,988 | TRUE | Passed | 500 | 3,988 | 30 | 31.6 | J-504 |
| J-727 | 7,612 | TRUE | Passed | 500 | 7,612 | 30 | 48.5 | J-692 |
| J-731 | 5,421 | TRUE | Passed | 500 | 5,422 | 30 | 41.2 | J-260 |
| J-904 | 6,696 | TRUE | Passed | 500 | 6,697 | 30 | 41.9 | J-336 |
| J-1031 | 9,440 | TRUE | Passed | 500 | 9,441 | 30 | 38.1 | J-385 |
| J-1082 | 10,000 | TRUE | Passed | 500 | 10,001 | 62 | 44.1 | J-156 |
| J-1184 | 9,055 | TRUE | Passed | 500 | 9,056 | 30 | 37.7 | J-439 |
| J-1201 | 7,959 | TRUE | Passed | 500 | 7,960 | 30 | 26.3 | J-455 |
| J-1296 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.4 | 48 | J-692 |
| J-1334 | 3,709 | TRUE | Passed | 500 | 3,710 | 30 | 29.9 | J-504 |
| J-1340 | 3,828 | TRUE | Passed | 500 | 3,829 | 30 | 39.8 | J-508 |
| J-1549 | 2,871 | TRUE | Passed | 500 | 2,872 | 30 | 35.4 | J-601 |
| J-1642 | 8,783 | TRUE | Passed | 500 | 8,784 | 30 | 41.9 | J-633 |
| J-1704 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.5 | 42.6 | J-659 |
| J-1780 | 4,364 | TRUE | Passed | 500 | 4,364 | 30 | 32.5 | J-724 |

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|---|---|---|---|---|---|---|---|---|
| J-1806 | 3,526 | TRUE | Passed | 500 | 3,526 | 30 | 23.5 | J-692 |
| **Scenario 6: 16-Inch SE Expansion - Pressure Zone Addition** | | | | | | | | |
| 1-FLOW | 8,889 | TRUE | Passed | 500 | 8,890 | 30 | 30.8 | 1-RES |
| 1-RES | 3,097 | TRUE | Passed | 500 | 3,100 | 30 | 43.1 | J-692 |
| 2-FLOW | 7,466 | TRUE | Passed | 500 | 7,467 | 30 | 30 | 2-RES |
| 2-RES | 4,099 | TRUE | Passed | 500 | 4,100 | 30 | 43.1 | J-692 |
| 3-FLOW | 2,863 | TRUE | Passed | 500 | 2,864 | 30 | 30.9 | 3-RES |
| 3-RES | 2,438 | TRUE | Passed | 500 | 2,439 | 30 | 40.1 | 3-FLOW |
| 4-FLOW | 3,242 | TRUE | Passed | 500 | 3,243 | 30 | 30.7 | 4-RES |
| 4-RES | 2,375 | TRUE | Passed | 500 | 2,376 | 30 | 42.4 | 4-FLOW |
| 5-FLOW | 2,500 | TRUE | Passed | 500 | 2,501 | 30 | 27.1 | J-692 |
| 5-RES | 1,822 | TRUE | Passed | 500 | 1,823 | 30 | 30.7 | J-692 |
| 6-FLOW | 1,984 | TRUE | Passed | 500 | 1,985 | 30 | 30.8 | 6-RES |
| 6-RES | 1,285 | TRUE | Passed | 500 | 1,286 | 30 | 43.2 | J-692 |
| 7-FLOW | 1,618 | TRUE | Passed | 500 | 1,619 | 30 | 29 | J-196 |
| 7-RES | 1,505 | TRUE | Passed | 500 | 1,506 | 30 | 32.8 | J-196 |
| J-1 | 3,892 | TRUE | Passed | 500 | 3,893 | 30 | 32.2 | J-92 |
| J-2 | 6,263 | TRUE | Passed | 500 | 6,264 | 30 | 29.6 | J-97 |
| J-3 | 7,920 | TRUE | Passed | 500 | 7,921 | 30 | 40.1 | J-97 |
| J-11 | 7,427 | TRUE | Passed | 500 | 7,428 | 30 | 29.5 | J-13 |
| J-12 | 7,317 | TRUE | Passed | 500 | 7,318 | 30 | 32.5 | J-14 |
| J-13 | 3,526 | TRUE | Passed | 500 | 3,527 | 30 | 36.3 | J-17 |
| J-14 | 3,554 | TRUE | Passed | 500 | 3,555 | 30 | 43 | J-692 |
| J-15 | 6,730 | TRUE | Passed | 500 | 6,731 | 30 | 30.3 | J-14 |
| J-17 | 3,795 | TRUE | Passed | 500 | 3,796 | 30 | 30.4 | J-13 |
| J-18 | 10,000 | TRUE | Passed | 500 | 10,001 | 59 | 43 | J-692 |
| J-19 | 7,931 | TRUE | Passed | 500 | 7,932 | 30 | 27.6 | J-30 |
| J-20 | 3,910 | TRUE | Passed | 500 | 3,911 | 30 | 33.3 | J-23 |
| J-21 | 4,021 | TRUE | Passed | 500 | 4,022 | 30 | 35.2 | J-20 |
| J-22 | 1,982 | TRUE | Passed | 500 | 1,983 | 30 | 43.3 | J-692 |
| J-23 | 3,539 | TRUE | Passed | 500 | 3,540 | 30 | 30.2 | J-22 |
| J-24 | 1,842 | TRUE | Passed | 500 | 1,843 | 30 | 43.3 | J-692 |
| J-25 | 3,110 | TRUE | Passed | 500 | 3,111 | 30 | 30.1 | J-24 |
| J-26 | 1,778 | TRUE | Passed | 500 | 1,779 | 30 | 43.3 | J-692 |
| J-27 | 3,172 | TRUE | Passed | 500 | 3,173 | 30 | 29.2 | J-26 |
| J-28 | 2,030 | TRUE | Passed | 500 | 2,031 | 30 | 43.3 | J-692 |
| J-29 | 3,367 | TRUE | Passed | 500 | 3,368 | 30 | 29.5 | J-28 |
| J-30 | 4,473 | TRUE | Passed | 500 | 4,474 | 30 | 35 | J-28 |
| J-31 | 2,030 | TRUE | Passed | 500 | 2,031 | 30 | 29.5 | J-692 |
| J-33 | 2,097 | TRUE | Passed | 500 | 2,098 | 30 | 29.1 | J-692 |
| J-34 | 2,039 | TRUE | Passed | 500 | 2,040 | 30 | 29.4 | J-692 |
| J-35 | 2,230 | TRUE | Passed | 500 | 2,231 | 30 | 28.4 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-36 | 2,422 | TRUE | Passed | 500 | 2,423 | 30 | 27.5 | J-692 |
| J-37 | 2,350 | TRUE | Passed | 500 | 2,351 | 30 | 27.8 | J-692 |
| J-38 | 2,453 | TRUE | Passed | 500 | 2,454 | 30 | 27.3 | J-692 |
| J-39 | 2,340 | TRUE | Passed | 500 | 2,341 | 30 | 27.9 | J-692 |
| J-40 | 2,359 | TRUE | Passed | 500 | 2,360 | 30 | 27.8 | J-692 |
| J-41 | 2,523 | TRUE | Passed | 500 | 2,524 | 30 | 26.3 | J-74 |
| J-42 | 2,303 | TRUE | Passed | 500 | 2,304 | 30 | 28.1 | J-692 |
| J-43 | 2,559 | TRUE | Passed | 500 | 2,560 | 30 | 26.8 | J-692 |
| J-44 | 1,930 | TRUE | Passed | 500 | 1,931 | 30 | 30 | J-692 |
| J-45 | 2,034 | TRUE | Passed | 500 | 2,035 | 30 | 29.5 | J-692 |
| J-46 | 2,278 | TRUE | Passed | 500 | 2,279 | 30 | 28.2 | J-692 |
| J-47 | 1,840 | TRUE | Passed | 500 | 1,841 | 30 | 30.6 | J-692 |
| J-48 | 2,157 | TRUE | Passed | 500 | 2,158 | 30 | 27.2 | J-47 |
| J-49 | 2,326 | TRUE | Passed | 500 | 2,327 | 30 | 28 | J-692 |
| J-50 | 2,061 | TRUE | Passed | 500 | 2,062 | 30 | 29.3 | J-692 |
| J-51 | 1,200 | TRUE | Passed | 500 | 1,201 | 30 | 34.8 | J-692 |
| J-52 | 2,155 | TRUE | Passed | 500 | 2,156 | 30 | 26.7 | J-51 |
| J-53 | 1,949 | TRUE | Passed | 500 | 1,950 | 30 | 29.9 | J-692 |
| J-54 | 2,033 | TRUE | Passed | 500 | 2,034 | 30 | 29.5 | J-692 |
| J-55 | 1,800 | TRUE | Passed | 500 | 1,801 | 30 | 30.8 | J-692 |
| J-56 | 1,974 | TRUE | Passed | 500 | 1,975 | 30 | 28.7 | J-55 |
| J-57 | 1,906 | TRUE | Passed | 500 | 1,907 | 30 | 30.2 | J-692 |
| J-58 | 2,052 | TRUE | Passed | 500 | 2,053 | 30 | 29.4 | J-692 |
| J-59 | 2,189 | TRUE | Passed | 500 | 2,190 | 30 | 28.5 | J-55 |
| J-60 | 2,092 | TRUE | Passed | 500 | 2,093 | 30 | 28.6 | J-55 |
| J-61 | 2,516 | TRUE | Passed | 500 | 2,517 | 30 | 27 | J-692 |
| J-64 | 2,594 | TRUE | Passed | 500 | 2,595 | 30 | 26.1 | J-51 |
| J-65 | 2,470 | TRUE | Passed | 500 | 2,471 | 30 | 27.2 | J-692 |
| J-66 | 2,617 | TRUE | Passed | 500 | 2,618 | 30 | 25.2 | J-74 |
| J-67 | 2,438 | TRUE | Passed | 500 | 2,439 | 30 | 27.4 | J-692 |
| J-68 | 2,547 | TRUE | Passed | 500 | 2,548 | 30 | 26.7 | J-74 |
| J-69 | 2,026 | TRUE | Passed | 500 | 2,027 | 30 | 29.5 | J-692 |
| J-70 | 2,309 | TRUE | Passed | 500 | 2,310 | 30 | 28 | J-692 |
| J-71 | 2,224 | TRUE | Passed | 500 | 2,225 | 30 | 28.5 | J-692 |
| J-72 | 2,182 | TRUE | Passed | 500 | 2,183 | 30 | 28.7 | J-692 |
| J-73 | 1,287 | TRUE | Passed | 500 | 1,288 | 30 | 34.2 | J-692 |
| J-74 | 2,104 | TRUE | Passed | 500 | 2,105 | 30 | 29.1 | J-692 |
| J-75 | 2,487 | TRUE | Passed | 500 | 2,488 | 30 | 25.8 | J-74 |
| J-76 | 2,443 | TRUE | Passed | 500 | 2,444 | 30 | 27.4 | J-692 |
| J-77 | 2,470 | TRUE | Passed | 500 | 2,471 | 30 | 27.2 | J-692 |
| J-78 | 2,597 | TRUE | Passed | 500 | 2,598 | 30 | 24.8 | J-74 |
| J-79 | 2,331 | TRUE | Passed | 500 | 2,332 | 30 | 27.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-80 | 2,355 | TRUE | Passed | 500 | 2,356 | 30 | 27.8 | J-692 |
| J-81 | 2,552 | TRUE | Passed | 500 | 2,553 | 30 | 26.1 | J-74 |
| J-82 | 2,587 | TRUE | Passed | 500 | 2,588 | 30 | 24.4 | J-74 |
| J-83 | 2,538 | TRUE | Passed | 500 | 2,539 | 30 | 25.5 | J-74 |
| J-84 | 2,556 | TRUE | Passed | 500 | 2,557 | 30 | 25.1 | J-74 |
| J-85 | 2,556 | TRUE | Passed | 500 | 2,557 | 30 | 25 | J-74 |
| J-86 | 2,529 | TRUE | Passed | 500 | 2,530 | 30 | 25.4 | J-74 |
| J-87 | 2,428 | TRUE | Passed | 500 | 2,429 | 30 | 27.5 | J-692 |
| J-88 | 2,348 | TRUE | Passed | 500 | 2,349 | 30 | 27.8 | J-692 |
| J-89 | 2,509 | TRUE | Passed | 500 | 2,510 | 30 | 25.6 | J-74 |
| J-90 | 2,332 | TRUE | Passed | 500 | 2,333 | 30 | 27.9 | J-692 |
| J-91 | 1,628 | TRUE | Passed | 500 | 1,629 | 30 | 31.9 | J-692 |
| J-92 | 3,967 | TRUE | Passed | 500 | 3,968 | 30 | 30.4 | J-97 |
| J-93 | 2,565 | TRUE | Passed | 500 | 2,566 | 30 | 26 | J-74 |
| J-94 | 3,994 | TRUE | Passed | 500 | 3,995 | 30 | 29.9 | J-92 |
| J-95 | 5,729 | TRUE | Passed | 500 | 5,730 | 30 | 30 | J-97 |
| J-96 | 4,338 | TRUE | Passed | 500 | 4,339 | 30 | 30.3 | J-97 |
| J-97 | 3,975 | TRUE | Passed | 500 | 3,976 | 30 | 30.3 | J-92 |
| J-98 | 4,026 | TRUE | Passed | 500 | 4,027 | 30 | 29.9 | J-97 |
| J-99 | 3,279 | TRUE | Passed | 500 | 3,280 | 30 | 25 | J-692 |
| J-100 | 4,206 | TRUE | Passed | 500 | 4,207 | 30 | 22.1 | J-692 |
| J-101 | 3,162 | TRUE | Passed | 500 | 3,163 | 30 | 25.4 | J-692 |
| J-102 | 4,509 | TRUE | Passed | 500 | 4,510 | 30 | 20.5 | J-692 |
| J-103 | 5,304 | TRUE | Passed | 500 | 5,305 | 30 | 15.4 | J-692 |
| J-104 | 4,705 | TRUE | Passed | 500 | 4,706 | 30 | 19.6 | J-692 |
| J-105 | 5,680 | TRUE | Passed | 500 | 5,681 | 30 | 12.6 | J-692 |
| J-106 | 5,419 | TRUE | Passed | 500 | 5,420 | 30 | 14.6 | J-692 |
| J-107 | 4,963 | TRUE | Passed | 500 | 4,964 | 30 | 17.9 | J-692 |
| J-108 | 5,442 | TRUE | Passed | 500 | 5,443 | 30 | 14.4 | J-692 |
| J-109 | 5,380 | TRUE | Passed | 500 | 5,381 | 30 | 14.9 | J-692 |
| J-110 | 4,942 | TRUE | Passed | 500 | 4,943 | 30 | 18 | J-692 |
| J-111 | 4,499 | TRUE | Passed | 500 | 4,500 | 30 | 20.7 | J-692 |
| J-112 | 3,957 | TRUE | Passed | 500 | 3,958 | 30 | 23.3 | J-692 |
| J-113 | 3,389 | TRUE | Passed | 500 | 3,390 | 30 | 24.9 | J-692 |
| J-114 | 3,126 | TRUE | Passed | 500 | 3,127 | 30 | 25.6 | J-692 |
| J-115 | 3,903 | TRUE | Passed | 500 | 3,904 | 30 | 23.6 | J-692 |
| J-116 | 2,910 | TRUE | Passed | 500 | 2,911 | 30 | 26.3 | J-692 |
| J-117 | 3,503 | TRUE | Passed | 500 | 3,504 | 30 | 24.7 | J-692 |
| J-118 | 1,748 | TRUE | Passed | 500 | 1,749 | 30 | 31.1 | J-692 |
| J-118 | 3,077 | TRUE | Passed | 500 | 3,078 | 30 | 25.7 | J-692 |
| J-119 | 3,690 | TRUE | Passed | 500 | 3,691 | 30 | 24.3 | J-692 |
| J-121 | 2,751 | TRUE | Passed | 500 | 2,752 | 30 | 26.8 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-122 | 3,942 | TRUE | Passed | 500 | 3,943 | 30 | 23.4 | J-692 |
| J-123 | 5,983 | TRUE | Passed | 500 | 6,008 | 30 | 0.4 | J-692 |
| J-124 | 6,666 | TRUE | Passed | 500 | 6,667 | 30 | 3.1 | J-692 |
| J-125 | 4,216 | TRUE | Passed | 500 | 4,217 | 30 | 24.8 | J-692 |
| J-126 | 5,672 | TRUE | Passed | 500 | 5,673 | 30 | 14.2 | J-692 |
| J-127 | 4,475 | TRUE | Passed | 500 | 4,476 | 30 | 23.5 | J-692 |
| J-128 | 1,550 | TRUE | Passed | 500 | 1,551 | 30 | 34.4 | J-692 |
| J-129 | 3,941 | TRUE | Passed | 500 | 3,942 | 30 | 25.9 | J-692 |
| J-130 | 4,109 | TRUE | Passed | 500 | 4,110 | 30 | 25.3 | J-692 |
| J-133 | 4,117 | TRUE | Passed | 500 | 4,118 | 30 | 25.4 | J-692 |
| J-134 | 3,181 | TRUE | Passed | 500 | 3,183 | 30 | 27.5 | J-692 |
| J-135 | 3,603 | TRUE | Passed | 500 | 3,604 | 30 | 26.5 | J-692 |
| J-136 | 4,088 | TRUE | Passed | 500 | 4,089 | 30 | 25.5 | J-692 |
| J-137 | 4,419 | TRUE | Passed | 500 | 4,420 | 30 | 24.4 | J-692 |
| J-138 | 5,138 | TRUE | Passed | 500 | 5,139 | 30 | 21.4 | J-692 |
| J-139 | 4,897 | TRUE | Passed | 500 | 4,898 | 30 | 17.3 | J-692 |
| J-140 | 3,312 | TRUE | Passed | 500 | 3,313 | 30 | 25 | J-692 |
| J-141 | 3,657 | TRUE | Passed | 500 | 3,658 | 30 | 24.2 | J-692 |
| J-142 | 5,120 | TRUE | Passed | 500 | 5,121 | 30 | 16.9 | J-692 |
| J-143 | 5,902 | TRUE | Passed | 500 | 5,903 | 30 | 10.8 | J-692 |
| J-144 | 6,585 | TRUE | Passed | 500 | 6,586 | 30 | 4.9 | J-692 |
| J-145 | 4,229 | TRUE | Passed | 500 | 4,230 | 30 | 22.4 | J-692 |
| J-146 | 6,308 | TRUE | Passed | 500 | 6,309 | 30 | 7.3 | J-692 |
| J-147 | 6,017 | TRUE | Passed | 500 | 6,018 | 30 | 9.8 | J-692 |
| J-148 | 5,874 | TRUE | Passed | 500 | 5,875 | 30 | 11 | J-692 |
| J-149 | 4,901 | TRUE | Passed | 500 | 4,903 | 30 | 18 | J-692 |
| J-150 | 4,080 | TRUE | Passed | 500 | 4,081 | 30 | 22.7 | J-692 |
| J-151 | 4,947 | TRUE | Passed | 500 | 4,948 | 30 | 17.6 | J-692 |
| J-152 | 2,518 | TRUE | Passed | 500 | 2,519 | 30 | 27.7 | J-692 |
| J-153 | 3,917 | TRUE | Passed | 500 | 3,918 | 30 | 23.4 | J-692 |
| J-154 | 3,810 | TRUE | Passed | 500 | 3,811 | 30 | 23.8 | J-692 |
| J-155 | 1,872 | TRUE | Passed | 500 | 1,873 | 30 | 31.1 | J-196 |
| J-156 | 2,200 | TRUE | Passed | 500 | 2,201 | 30 | 32.9 | J-196 |
| J-157 | 2,137 | TRUE | Passed | 500 | 2,138 | 30 | 28.4 | J-237 |
| J-158 | 1,173 | TRUE | Passed | 500 | 1,174 | 30 | 33 | J-159 |
| J-159 | 1,234 | TRUE | Passed | 500 | 1,236 | 30 | 30.1 | J-158 |
| J-160 | 3,196 | TRUE | Passed | 500 | 3,197 | 30 | 25.3 | J-692 |
| J-161 | 3,247 | TRUE | Passed | 500 | 3,248 | 30 | 25.2 | J-692 |
| J-162 | 3,245 | TRUE | Passed | 500 | 3,246 | 30 | 25.2 | J-692 |
| J-163 | 3,057 | TRUE | Passed | 500 | 3,058 | 30 | 25.7 | J-692 |
| J-164 | 3,260 | TRUE | Passed | 500 | 3,261 | 30 | 25.1 | J-692 |
| J-165 | 3,438 | TRUE | Passed | 500 | 3,439 | 30 | 24.7 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-166 | 5,218 | TRUE | Passed | 500 | 5,219 | 30 | 16 | J-692 |
| J-167 | 2,360 | TRUE | Passed | 500 | 2,361 | 30 | 28.5 | J-692 |
| J-168 | 2,724 | TRUE | Passed | 500 | 2,725 | 30 | 26.9 | J-692 |
| J-169 | 3,128 | TRUE | Passed | 500 | 3,129 | 30 | 25.5 | J-692 |
| J-170 | 4,963 | TRUE | Passed | 500 | 4,964 | 30 | 17.5 | J-692 |
| J-171 | 2,600 | TRUE | Passed | 500 | 2,601 | 30 | 27.3 | J-692 |
| J-172 | 7,466 | TRUE | Passed | 500 | 7,467 | 30 | 1 | J-692 |
| J-173 | 5,333 | TRUE | Passed | 500 | 5,334 | 30 | 19.5 | J-692 |
| J-174 | 5,478 | TRUE | Passed | 500 | 5,479 | 30 | 19.2 | J-692 |
| J-175 | 8,219 | TRUE | Passed | 500 | 8,220 | 30.9 | 0 | J-692 |
| J-176 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.1 | 9 | J-692 |
| J-177 | 3,967 | TRUE | Passed | 500 | 3,968 | 30 | 31.3 | J-692 |
| J-178 | 6,326 | TRUE | Passed | 500 | 6,327 | 30 | 25 | J-692 |
| J-179 | 1,671 | TRUE | Passed | 500 | 1,672 | 30 | 38.9 | J-692 |
| J-180 | 1,737 | TRUE | Passed | 500 | 1,738 | 30 | 33.6 | J-692 |
| J-181 | 10,000 | TRUE | Passed | 500 | 10,001 | 87.2 | 39.7 | J-692 |
| J-183 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.8 | 25.5 | J-237 |
| J-184 | 751 | TRUE | Passed | 500 | 752 | 30 | 43.1 | J-692 |
| J-185 | 7,462 | TRUE | Passed | 500 | 7,463 | 30 | 23.6 | J-186 |
| J-186 | 5,172 | TRUE | Passed | 500 | 5,173 | 30 | 40.6 | J-692 |
| J-187 | 5,238 | TRUE | Passed | 500 | 5,239 | 30 | 23.7 | J-188 |
| J-188 | 3,983 | TRUE | Passed | 500 | 3,984 | 30 | 41.8 | J-692 |
| J-189 | 4,185 | TRUE | Passed | 500 | 4,186 | 30 | 28.7 | J-237 |
| J-190 | 4,323 | TRUE | Passed | 500 | 4,324 | 30 | 32.1 | J-237 |
| J-191 | 3,497 | TRUE | Passed | 500 | 3,498 | 30 | 26.8 | J-196 |
| J-192 | 2,874 | TRUE | Passed | 500 | 2,875 | 30 | 28.7 | J-196 |
| J-193 | 2,466 | TRUE | Passed | 500 | 2,467 | 30 | 26.5 | J-196 |
| J-194 | 1,965 | TRUE | Passed | 500 | 1,966 | 30 | 26.7 | J-196 |
| J-195 | 1,715 | TRUE | Passed | 500 | 1,716 | 30 | 28 | J-196 |
| J-196 | 1,509 | TRUE | Passed | 500 | 1,510 | 30 | 32.9 | J-197 |
| J-197 | 1,596 | TRUE | Passed | 500 | 1,597 | 30 | 29.1 | J-196 |
| J-200 | 3,713 | TRUE | Passed | 500 | 3,714 | 30 | 30 | J-201 |
| J-201 | 3,419 | TRUE | Passed | 500 | 3,420 | 30 | 34 | J-200 |
| J-202 | 3,648 | TRUE | Passed | 500 | 3,649 | 30 | 31.1 | J-206 |
| J-203 | 3,649 | TRUE | Passed | 500 | 3,650 | 30 | 32.4 | J-202 |
| J-204 | 3,058 | TRUE | Passed | 500 | 3,059 | 30 | 30.5 | J-205 |
| J-205 | 2,602 | TRUE | Passed | 500 | 2,603 | 30 | 37.5 | J-204 |
| J-206 | 3,254 | TRUE | Passed | 500 | 3,255 | 30 | 31.9 | J-207 |
| J-207 | 2,839 | TRUE | Passed | 500 | 2,840 | 30 | 36.3 | J-206 |
| J-208 | 4,049 | TRUE | Passed | 500 | 4,050 | 30 | 29.9 | J-209 |
| J-209 | 3,351 | TRUE | Passed | 500 | 3,352 | 30 | 38.3 | J-208 |
| J-210 | 5,642 | TRUE | Passed | 500 | 5,643 | 30 | 30 | J-97 |

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|---|---|---|---|---|---|---|---|---|
| J-211 | 5,669 | TRUE | Passed | 500 | 5,670 | 30 | 32.6 | J-212 |
| J-212 | 4,590 | TRUE | Passed | 500 | 4,591 | 30 | 30.5 | J-213 |
| J-213 | 3,540 | TRUE | Passed | 500 | 3,541 | 30 | 40.2 | J-215 |
| J-214 | 2,769 | TRUE | Passed | 500 | 2,770 | 30 | 29.5 | J-215 |
| J-215 | 2,306 | TRUE | Passed | 500 | 2,307 | 30 | 38.5 | J-214 |
| J-216 | 804 | TRUE | Passed | 500 | 805 | 30 | 43.3 | J-692 |
| J-217 | 3,343 | TRUE | Passed | 500 | 3,344 | 30 | 29.5 | J-215 |
| J-218 | 1,858 | TRUE | Passed | 500 | 1,859 | 30 | 43.2 | J-692 |
| J-219 | 4,077 | TRUE | Passed | 500 | 4,078 | 30 | 30 | J-215 |
| J-220 | 1,941 | TRUE | Passed | 500 | 1,942 | 30 | 43.2 | J-692 |
| J-221 | 2,340 | TRUE | Passed | 500 | 2,341 | 30 | 43.1 | J-692 |
| J-222 | 4,537 | TRUE | Passed | 500 | 4,538 | 30 | 33 | J-221 |
| J-223 | 5,009 | TRUE | Passed | 500 | 5,010 | 30 | 32.1 | J-222 |
| J-224 | 5,897 | TRUE | Passed | 500 | 5,898 | 30 | 37.3 | J-223 |
| J-225 | 6,138 | TRUE | Passed | 500 | 6,139 | 30 | 39.3 | J-224 |
| J-226 | 7,870 | TRUE | Passed | 500 | 7,871 | 30 | 33 | J-334 |
| J-227 | 5,819 | TRUE | Passed | 500 | 5,820 | 30 | 13.1 | J-196 |
| J-228 | 4,612 | TRUE | Passed | 500 | 4,613 | 30 | 33 | J-229 |
| J-229 | 4,621 | TRUE | Passed | 500 | 4,622 | 30 | 32 | J-228 |
| J-230 | 2,939 | TRUE | Passed | 500 | 2,940 | 30 | 42.7 | J-692 |
| J-231 | 4,445 | TRUE | Passed | 500 | 4,446 | 30 | 31 | J-230 |
| J-232 | 5,039 | TRUE | Passed | 500 | 5,040 | 30 | 33.8 | J-231 |
| J-233 | 6,820 | TRUE | Passed | 500 | 6,821 | 30 | 26.9 | J-232 |
| J-234 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.9 | 27 | J-237 |
| J-235 | 10,000 | TRUE | Passed | 500 | 10,001 | 55.5 | 29.1 | J-156 |
| J-236 | 1,784 | TRUE | Passed | 500 | 1,785 | 30 | 28.7 | J-237 |
| J-237 | 1,576 | TRUE | Passed | 500 | 1,577 | 30 | 36.6 | J-236 |
| J-238 | 1,024 | TRUE | Passed | 500 | 1,025 | 30 | 43.1 | J-692 |
| J-239 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.3 | 32.6 | J-240 |
| J-240 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.7 | 33.3 | J-239 |
| J-241 | 8,320 | TRUE | Passed | 500 | 8,321 | 30 | 41.6 | J-692 |
| J-242 | 7,589 | TRUE | Passed | 500 | 7,590 | 30 | 38.2 | J-13 |
| J-243 | 9,761 | TRUE | Passed | 500 | 9,763 | 30 | 35.6 | J-244 |
| J-244 | 5,355 | TRUE | Passed | 500 | 5,356 | 30 | 42.7 | J-692 |
| J-245 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.1 | 40.8 | J-243 |
| J-246 | 8,831 | TRUE | Passed | 500 | 8,832 | 30 | 40.4 | J-242 |
| J-247 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.5 | 41.9 | J-692 |
| J-248 | 7,335 | TRUE | Passed | 500 | 7,336 | 30 | 33.6 | J-318 |
| J-249 | 2,451 | TRUE | Passed | 500 | 2,452 | 30 | 29.1 | J-250 |
| J-250 | 1,335 | TRUE | Passed | 500 | 1,336 | 30 | 43.3 | J-692 |
| J-251 | 7,432 | TRUE | Passed | 500 | 7,433 | 30 | 38.2 | J-253 |
| J-252 | 7,454 | TRUE | Passed | 500 | 7,455 | 30 | 42.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-253 | 3,169 | TRUE | Passed | 500 | 3,170 | 30 | 43.2 | J-692 |
| J-254 | 7,681 | TRUE | Passed | 500 | 7,682 | 30 | 26.5 | J-324 |
| J-255 | 6,935 | TRUE | Passed | 500 | 6,936 | 30 | 35.9 | J-262 |
| J-256 | 4,144 | TRUE | Passed | 500 | 4,145 | 30 | 43.1 | J-692 |
| J-257 | 6,995 | TRUE | Passed | 500 | 6,996 | 30 | 36.7 | J-258 |
| J-258 | 6,951 | TRUE | Passed | 500 | 6,952 | 30 | 37.3 | J-257 |
| J-259 | 4,400 | TRUE | Passed | 500 | 4,401 | 30 | 43.1 | J-692 |
| J-260 | 6,171 | TRUE | Passed | 500 | 6,172 | 30 | 33.5 | J-731 |
| J-262 | 6,848 | TRUE | Passed | 500 | 6,849 | 30 | 37.4 | J-255 |
| J-263 | 4,192 | TRUE | Passed | 500 | 4,193 | 30 | 39.8 | J-266 |
| J-264 | 7,145 | TRUE | Passed | 500 | 7,146 | 30 | 35.1 | J-25 |
| J-265 | 3,942 | TRUE | Passed | 500 | 3,943 | 30 | 29.5 | J-266 |
| J-266 | 2,786 | TRUE | Passed | 500 | 2,787 | 30 | 43.2 | J-692 |
| J-267 | 5,887 | TRUE | Passed | 500 | 5,888 | 30 | 32.1 | J-268 |
| J-268 | 5,158 | TRUE | Passed | 500 | 5,159 | 30 | 31.8 | 4-FLOW |
| J-269 | 6,048 | TRUE | Passed | 500 | 6,049 | 30 | 31.6 | J-267 |
| J-270 | 7,409 | TRUE | Passed | 500 | 7,410 | 30 | 33.5 | J-272 |
| J-271 | 6,356 | TRUE | Passed | 500 | 6,357 | 30 | 35 | J-260 |
| J-272 | 6,510 | TRUE | Passed | 500 | 6,511 | 30 | 30.6 | J-276 |
| J-273 | 4,991 | TRUE | Passed | 500 | 4,992 | 30 | 30.1 | J-274 |
| J-274 | 4,604 | TRUE | Passed | 500 | 4,605 | 30 | 34.3 | J-273 |
| J-275 | 6,222 | TRUE | Passed | 500 | 6,224 | 30 | 32.7 | J-273 |
| J-276 | 5,970 | TRUE | Passed | 500 | 5,971 | 30 | 35.4 | J-275 |
| J-277 | 6,102 | TRUE | Passed | 500 | 6,103 | 30 | 28.5 | J-278 |
| J-278 | 4,434 | TRUE | Passed | 500 | 4,435 | 30 | 38.7 | J-283 |
| J-279 | 3,977 | TRUE | Passed | 500 | 3,978 | 30 | 34.2 | J-281 |
| J-280 | 1,453 | TRUE | Passed | 500 | 1,454 | 30 | 43.2 | J-692 |
| J-281 | 3,241 | TRUE | Passed | 500 | 3,242 | 30 | 32.8 | J-280 |
| J-282 | 3,080 | TRUE | Passed | 500 | 3,081 | 30 | 29.9 | J-283 |
| J-283 | 2,434 | TRUE | Passed | 500 | 2,435 | 30 | 30.2 | J-285 |
| J-284 | 1,394 | TRUE | Passed | 500 | 1,395 | 30 | 43.2 | J-692 |
| J-285 | 2,055 | TRUE | Passed | 500 | 2,056 | 30 | 37.9 | J-283 |
| J-286 | 4,428 | TRUE | Passed | 500 | 4,429 | 30 | 27.1 | J-292 |
| J-287 | 3,582 | TRUE | Passed | 500 | 3,583 | 30 | 27.4 | J-292 |
| J-288 | 2,074 | TRUE | Passed | 500 | 2,075 | 30 | 35.5 | J-290 |
| J-289 | 2,344 | TRUE | Passed | 500 | 2,345 | 30 | 29.1 | J-290 |
| J-290 | 2,156 | TRUE | Passed | 500 | 2,157 | 30 | 34.5 | J-289 |
| J-291 | 1,158 | TRUE | Passed | 500 | 1,159 | 30 | 43.2 | J-692 |
| J-292 | 2,540 | TRUE | Passed | 500 | 2,541 | 30 | 33.9 | 6-FLOW |
| J-294 | 1,399 | TRUE | Passed | 500 | 1,400 | 30 | 43.2 | J-692 |
| J-296 | 6,369 | TRUE | Passed | 500 | 6,370 | 30 | 30.4 | J-292 |
| J-297 | 6,530 | TRUE | Passed | 500 | 6,531 | 30 | 40.6 | J-292 |

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|---|---|---|---|---|---|---|---|---|
| J-298 | 8,780 | TRUE | Passed | 500 | 8,781 | 30 | 40.6 | J-692 |
| J-299 | 9,893 | TRUE | Passed | 500 | 9,894 | 30 | 37.7 | J-343 |
| J-300 | 4,185 | TRUE | Passed | 500 | 4,186 | 30 | 29.9 | J-301 |
| J-301 | 3,356 | TRUE | Passed | 500 | 3,357 | 30 | 40.4 | J-300 |
| J-302 | 3,790 | TRUE | Passed | 500 | 3,791 | 30 | 30.6 | J-303 |
| J-303 | 3,104 | TRUE | Passed | 500 | 3,105 | 30 | 39.3 | J-302 |
| J-304 | 5,637 | TRUE | Passed | 500 | 5,638 | 30 | 36.6 | J-302 |
| J-305 | 5,849 | TRUE | Passed | 500 | 5,850 | 30 | 25.1 | J-306 |
| J-306 | 2,416 | TRUE | Passed | 500 | 2,417 | 30 | 43.1 | J-692 |
| J-307 | 7,969 | TRUE | Passed | 500 | 7,970 | 30 | 30.7 | J-306 |
| J-308 | 6,996 | TRUE | Passed | 500 | 6,997 | 30 | 40.2 | J-320 |
| J-309 | 3,655 | TRUE | Passed | 500 | 3,656 | 30 | 43 | J-692 |
| J-310 | 3,476 | TRUE | Passed | 500 | 3,477 | 30 | 43 | J-692 |
| J-311 | 3,966 | TRUE | Passed | 500 | 3,967 | 30 | 40.6 | J-309 |
| J-312 | 3,899 | TRUE | Passed | 500 | 3,900 | 30 | 42.9 | J-692 |
| J-313 | 4,422 | TRUE | Passed | 500 | 4,423 | 30 | 42.7 | J-692 |
| J-314 | 3,266 | TRUE | Passed | 500 | 3,267 | 30 | 43 | J-692 |
| J-315 | 2,629 | TRUE | Passed | 500 | 2,630 | 30 | 43.1 | J-692 |
| J-316 | 4,524 | TRUE | Passed | 500 | 4,526 | 30 | 42.8 | J-692 |
| J-317 | 3,331 | TRUE | Passed | 500 | 3,332 | 30 | 43 | J-692 |
| J-318 | 6,669 | TRUE | Passed | 500 | 6,670 | 30 | 34.4 | J-319 |
| J-319 | 6,373 | TRUE | Passed | 500 | 6,374 | 30 | 35.1 | J-321 |
| J-320 | 6,416 | TRUE | Passed | 500 | 6,417 | 30 | 34.6 | J-319 |
| J-321 | 3,282 | TRUE | Passed | 500 | 3,283 | 30 | 43.1 | J-692 |
| J-322 | 3,494 | TRUE | Passed | 500 | 3,495 | 30 | 42.1 | J-323 |
| J-323 | 3,079 | TRUE | Passed | 500 | 3,081 | 30 | 42.5 | J-250 |
| J-324 | 4,164 | TRUE | Passed | 500 | 4,165 | 30 | 43.1 | J-692 |
| J-325 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.8 | 34.8 | J-97 |
| J-326 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.1 | 36.2 | J-97 |
| J-327 | 7,053 | TRUE | Passed | 500 | 7,054 | 30 | 41.6 | J-692 |
| J-328 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.2 | 36.9 | J-97 |
| J-329 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.5 | 36.4 | J-97 |
| J-330 | 1,728 | TRUE | Passed | 500 | 1,729 | 30 | 43.2 | J-692 |
| J-331 | 6,077 | TRUE | Passed | 500 | 6,078 | 30 | 31.6 | J-330 |
| J-332 | 6,390 | TRUE | Passed | 500 | 6,391 | 30 | 41.8 | J-692 |
| J-333 | 4,572 | TRUE | Passed | 500 | 4,573 | 30 | 42.5 | J-692 |
| J-334 | 7,933 | TRUE | Passed | 500 | 7,934 | 30 | 33.5 | J-226 |
| J-336 | 6,674 | TRUE | Passed | 500 | 6,675 | 30 | 40.8 | J-215 |
| J-338 | 7,334 | TRUE | Passed | 500 | 7,335 | 30 | 36 | J-339 |
| J-339 | 6,280 | TRUE | Passed | 500 | 6,281 | 30 | 36 | J-215 |
| J-340 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.6 | 34.2 | J-97 |
| J-341 | 7,650 | TRUE | Passed | 500 | 7,651 | 30 | 37.1 | J-306 |

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|---|---|---|---|---|---|---|---|---|
| J-342 | 4,037 | TRUE | Passed | 500 | 4,038 | 30 | 42.9 | J-692 |
| J-343 | 7,392 | TRUE | Passed | 500 | 7,393 | 30 | 41.7 | J-692 |
| J-345 | 4,901 | TRUE | Passed | 500 | 4,902 | 30 | 42.6 | J-692 |
| J-346 | 3,650 | TRUE | Passed | 500 | 3,651 | 30 | 42.9 | J-692 |
| J-347 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.4 | 39.6 | J-692 |
| J-348 | 10,000 | TRUE | Passed | 500 | 10,001 | 53.3 | 39.5 | J-692 |
| J-349 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.5 | 39.4 | J-692 |
| J-350 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.7 | 39.4 | J-692 |
| J-351 | 8,801 | TRUE | Passed | 500 | 8,802 | 30 | 40.3 | J-692 |
| J-352 | 9,101 | TRUE | Passed | 500 | 9,102 | 30 | 39.2 | J-365 |
| J-353 | 9,692 | TRUE | Passed | 500 | 9,693 | 30 | 38.4 | J-352 |
| J-354 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.6 | 39.6 | J-692 |
| J-355 | 9,044 | TRUE | Passed | 500 | 9,045 | 30 | 40.3 | J-692 |
| J-356 | 8,480 | TRUE | Passed | 500 | 8,481 | 30 | 35.9 | J-365 |
| J-357 | 10,000 | TRUE | Passed | 500 | 10,001 | 48 | 37.8 | J-97 |
| J-358 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.6 | 37 | J-360 |
| J-359 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.9 | 29.6 | J-360 |
| J-360 | 1,514 | TRUE | Passed | 500 | 1,515 | 30 | 43.2 | J-692 |
| J-361 | 8,636 | TRUE | Passed | 500 | 8,637 | 30 | 40.5 | J-692 |
| J-362 | 10,000 | TRUE | Passed | 500 | 10,001 | 50 | 39.3 | J-692 |
| J-363 | 8,171 | TRUE | Passed | 500 | 8,172 | 30 | 38.4 | J-364 |
| J-364 | 7,268 | TRUE | Passed | 500 | 7,269 | 30 | 39.1 | J-366 |
| J-365 | 7,687 | TRUE | Passed | 500 | 7,688 | 30 | 40.8 | J-364 |
| J-366 | 7,090 | TRUE | Passed | 500 | 7,091 | 30 | 39 | J-364 |
| J-367 | 8,818 | TRUE | Passed | 500 | 8,820 | 30 | 37.3 | J-398 |
| J-368 | 5,988 | TRUE | Passed | 500 | 5,989 | 30 | 42.1 | J-692 |
| J-369 | 8,893 | TRUE | Passed | 500 | 8,894 | 30 | 40.4 | J-692 |
| J-370 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.1 | 36.3 | J-360 |
| J-371 | 4,088 | TRUE | Passed | 500 | 4,089 | 30 | 22.8 | J-692 |
| J-371 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.7 | 39.5 | J-692 |
| J-372 | 7,104 | TRUE | Passed | 500 | 7,105 | 30 | 41.4 | J-692 |
| J-373 | 10,000 | TRUE | Passed | 500 | 10,001 | 52.6 | 39.2 | J-692 |
| J-374 | 10,000 | TRUE | Passed | 500 | 10,001 | 52.9 | 39.1 | J-692 |
| J-375 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.4 | 39 | J-692 |
| J-376 | 8,161 | TRUE | Passed | 500 | 8,162 | 30 | 40.5 | J-692 |
| J-377 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.2 | 39 | J-692 |
| J-378 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.3 | 39.1 | J-692 |
| J-379 | 10,000 | TRUE | Passed | 500 | 10,001 | 49.5 | 39.1 | J-692 |
| J-380 | 6,790 | TRUE | Passed | 500 | 6,791 | 30 | 41.4 | J-692 |
| J-382 | 7,349 | TRUE | Passed | 500 | 7,350 | 30 | 41.2 | J-692 |
| J-383 | 6,726 | TRUE | Passed | 500 | 6,727 | 30 | 41.6 | J-692 |
| J-384 | 7,044 | TRUE | Passed | 500 | 7,045 | 30 | 41.3 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-385 | 9,483 | TRUE | Passed | 500 | 9,484 | 30 | 38.8 | J-429 |
| J-386 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.5 | 38.3 | J-1031 |
| J-387 | 8,655 | TRUE | Passed | 500 | 8,656 | 30 | 36.7 | J-388 |
| J-388 | 6,437 | TRUE | Passed | 500 | 6,438 | 30 | 41.8 | J-692 |
| J-389 | 5,024 | TRUE | Passed | 500 | 5,025 | 30 | 33.8 | J-390 |
| J-390 | 1,849 | TRUE | Passed | 500 | 1,850 | 30 | 43.2 | J-692 |
| J-391 | 6,848 | TRUE | Passed | 500 | 6,849 | 30 | 41.5 | J-692 |
| J-392 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.1 | 39 | J-692 |
| J-393 | 7,708 | TRUE | Passed | 500 | 7,709 | 30 | 39.2 | J-430 |
| J-394 | 9,122 | TRUE | Passed | 500 | 9,123 | 30 | 29.7 | J-424 |
| J-395 | 9,300 | TRUE | Passed | 500 | 9,301 | 30 | 27.1 | J-425 |
| J-396 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.9 | 39 | J-692 |
| J-397 | 6,237 | TRUE | Passed | 500 | 6,238 | 30 | 27.8 | J-398 |
| J-398 | 1,639 | TRUE | Passed | 500 | 1,640 | 30 | 43.2 | J-692 |
| J-399 | 10,000 | TRUE | Passed | 500 | 10,001 | 70.9 | 38.4 | J-692 |
| J-401 | 4,657 | TRUE | Passed | 500 | 4,658 | 30 | 22.4 | J-692 |
| J-401 | 10,000 | TRUE | Passed | 500 | 10,001 | 68.1 | 38.4 | J-692 |
| J-402 | 10,000 | TRUE | Passed | 500 | 10,001 | 68.8 | 38.4 | J-692 |
| J-403 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.5 | 38.4 | J-692 |
| J-404 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.6 | 38 | J-692 |
| J-405 | 4,609 | TRUE | Passed | 500 | 4,610 | 30 | 42.3 | J-692 |
| J-406 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.2 | 38.5 | J-692 |
| J-407 | 10,000 | TRUE | Passed | 500 | 10,001 | 70.7 | 38.4 | J-692 |
| J-408 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.8 | 38.8 | J-692 |
| J-409 | 3,401 | TRUE | Passed | 500 | 3,402 | 30 | 42.8 | J-692 |
| J-410 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.2 | 38.8 | J-692 |
| J-411 | 3,469 | TRUE | Passed | 500 | 3,470 | 30 | 42.8 | J-692 |
| J-412 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 38.9 | J-692 |
| J-413 | 10,000 | TRUE | Passed | 500 | 10,001 | 68.2 | 38.7 | J-692 |
| J-414 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.9 | 36.6 | J-156 |
| J-415 | 1,946 | TRUE | Passed | 500 | 1,947 | 30 | 43 | J-692 |
| J-416 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.6 | 38.9 | J-692 |
| J-417 | 10,000 | TRUE | Passed | 500 | 10,001 | 60.8 | 39 | J-692 |
| J-418 | 5,412 | TRUE | Passed | 500 | 5,413 | 30 | 29.9 | J-419 |
| J-419 | 3,407 | TRUE | Passed | 500 | 3,408 | 30 | 42.8 | J-692 |
| J-420 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.1 | 37.7 | J-421 |
| J-421 | 9,428 | TRUE | Passed | 500 | 9,429 | 30 | 32.4 | J-423 |
| J-422 | 6,812 | TRUE | Passed | 500 | 6,813 | 30 | 41.4 | J-692 |
| J-423 | 9,310 | TRUE | Passed | 500 | 9,311 | 30 | 33.2 | J-422 |
| J-424 | 4,710 | TRUE | Passed | 500 | 4,712 | 30 | 42.4 | J-692 |
| J-425 | 4,025 | TRUE | Passed | 500 | 4,026 | 30 | 42.7 | J-692 |
| J-426 | 9,394 | TRUE | Passed | 500 | 9,395 | 30 | 24.9 | J-425 |

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|---|---|---|---|---|---|---|---|---|
| J-427 | 7,858 | TRUE | Passed | 500 | 7,859 | 30 | 34.7 | J-424 |
| J-428 | 9,432 | TRUE | Passed | 500 | 9,433 | 30 | 35.3 | J-423 |
| J-429 | 9,397 | TRUE | Passed | 500 | 9,398 | 30 | 35.6 | J-428 |
| J-430 | 3,867 | TRUE | Passed | 500 | 3,868 | 30 | 42.7 | J-692 |
| J-431 | 7,257 | TRUE | Passed | 500 | 7,258 | 30 | 30.9 | J-432 |
| J-432 | 2,225 | TRUE | Passed | 500 | 2,226 | 30 | 43.1 | J-692 |
| J-433 | 2,430 | TRUE | Passed | 500 | 2,431 | 30 | 28.4 | J-237 |
| J-434 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.9 | 43.2 | J-692 |
| J-435 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.2 | 43.2 | J-692 |
| J-436 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.9 | 43.2 | J-692 |
| J-437 | 8,378 | TRUE | Passed | 500 | 8,379 | 30 | 43.1 | J-692 |
| J-439 | 6,637 | TRUE | Passed | 500 | 6,638 | 30 | 31.7 | J-719 |
| J-440 | 6,529 | TRUE | Passed | 500 | 6,530 | 30 | 32.1 | J-1780 |
| J-442 | 7,627 | TRUE | Passed | 500 | 7,629 | 30 | 27.5 | J-443 |
| J-443 | 2,071 | TRUE | Passed | 500 | 2,072 | 30 | 43.3 | J-692 |
| J-445 | 8,888 | TRUE | Passed | 500 | 8,889 | 30 | 31.4 | J-455 |
| J-447 | 6,078 | TRUE | Passed | 500 | 6,079 | 30 | 27.3 | J-450 |
| J-448 | 4,834 | TRUE | Passed | 500 | 4,835 | 30 | 40.2 | J-450 |
| J-449 | 5,767 | TRUE | Passed | 500 | 5,768 | 30 | 23.5 | J-450 |
| J-450 | 3,923 | TRUE | Passed | 500 | 3,924 | 30 | 43.1 | J-692 |
| J-451 | 5,579 | TRUE | Passed | 500 | 5,580 | 30 | 35.4 | J-452 |
| J-452 | 5,086 | TRUE | Passed | 500 | 5,087 | 30 | 31.8 | J-458 |
| J-453 | 4,709 | TRUE | Passed | 500 | 4,710 | 30 | 40.1 | J-454 |
| J-454 | 4,531 | TRUE | Passed | 500 | 4,532 | 30 | 43 | J-692 |
| J-455 | 6,076 | TRUE | Passed | 500 | 6,077 | 30 | 38.3 | J-454 |
| J-456 | 6,117 | TRUE | Passed | 500 | 6,118 | 30 | 37.5 | J-455 |
| J-457 | 4,870 | TRUE | Passed | 500 | 4,871 | 30 | 40.3 | J-452 |
| J-458 | 2,809 | TRUE | Passed | 500 | 2,810 | 30 | 43.2 | J-692 |
| J-459 | 2,738 | TRUE | Passed | 500 | 2,739 | 30 | 33.4 | J-463 |
| J-460 | 3,771 | TRUE | Passed | 500 | 3,772 | 30 | 33.7 | J-459 |
| J-461 | 1,546 | TRUE | Passed | 500 | 1,547 | 30 | 29.4 | J-463 |
| J-462 | 1,359 | TRUE | Passed | 500 | 1,360 | 30 | 37.5 | J-463 |
| J-463 | 1,243 | TRUE | Passed | 500 | 1,244 | 30 | 42.6 | J-461 |
| J-464 | 4,929 | TRUE | Passed | 500 | 4,930 | 30 | 38.5 | J-457 |
| J-465 | 5,085 | TRUE | Passed | 500 | 5,086 | 30 | 36.7 | J-464 |
| J-466 | 5,391 | TRUE | Passed | 500 | 5,393 | 30 | 37.9 | J-465 |
| J-467 | 6,091 | TRUE | Passed | 500 | 6,092 | 30 | 29.1 | J-460 |
| J-468 | 6,016 | TRUE | Passed | 500 | 6,017 | 30 | 33.9 | J-459 |
| J-469 | 6,599 | TRUE | Passed | 500 | 6,600 | 30 | 35.6 | J-474 |
| J-470 | 8,004 | TRUE | Passed | 500 | 8,005 | 30 | 41.3 | J-692 |
| J-471 | 10,000 | TRUE | Passed | 500 | 10,001 | 42 | 38.7 | J-556 |
| J-472 | 6,774 | TRUE | Passed | 500 | 6,775 | 30 | 41.5 | J-473 |

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|---|---|---|---|---|---|---|---|---|
| J-473 | 6,190 | TRUE | Passed | 500 | 6,192 | 30 | 36.9 | J-475 |
| J-474 | 5,717 | TRUE | Passed | 500 | 5,718 | 30 | 42.6 | J-692 |
| J-475 | 5,292 | TRUE | Passed | 500 | 5,293 | 30 | 41.2 | J-478 |
| J-476 | 2,220 | TRUE | Passed | 500 | 2,221 | 30 | 41.4 | J-477 |
| J-477 | 2,249 | TRUE | Passed | 500 | 2,250 | 30 | 39.3 | J-476 |
| J-478 | 5,225 | TRUE | Passed | 500 | 5,226 | 30 | 40 | J-475 |
| J-479 | 5,358 | TRUE | Passed | 500 | 5,359 | 30 | 40.1 | J-478 |
| J-480 | 5,689 | TRUE | Passed | 500 | 5,690 | 30 | 38.1 | J-479 |
| J-481 | 6,039 | TRUE | Passed | 500 | 6,040 | 30 | 36 | J-480 |
| J-482 | 3,107 | TRUE | Passed | 500 | 3,108 | 30 | 25.8 | J-485 |
| J-483 | 1,908 | TRUE | Passed | 500 | 1,909 | 30 | 28.8 | J-485 |
| J-484 | 1,754 | TRUE | Passed | 500 | 1,755 | 30 | 34.1 | J-485 |
| J-485 | 1,423 | TRUE | Passed | 500 | 1,424 | 30 | 43.3 | J-692 |
| J-486 | 9,119 | TRUE | Passed | 500 | 9,120 | 30 | 41.9 | 1-FLOW |
| J-487 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.9 | 42.3 | J-692 |
| J-489 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.3 | 43 | J-692 |
| J-490 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.6 | 39.1 | J-437 |
| J-491 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 43.3 | J-692 |
| J-492 | 10,000 | TRUE | Passed | 500 | 10,001 | 49.4 | 42.6 | J-692 |
| J-493 | 9,636 | TRUE | Passed | 500 | 9,637 | 30 | 36.7 | J-494 |
| J-494 | 9,755 | TRUE | Passed | 500 | 9,756 | 30 | 35.4 | J-493 |
| J-497 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.8 | 41.2 | J-692 |
| J-498 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.8 | 42.1 | J-692 |
| J-499 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.6 | 40.7 | J-500 |
| J-500 | 6,525 | TRUE | Passed | 500 | 6,526 | 30 | 42.9 | J-692 |
| J-501 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.9 | 39.1 | J-502 |
| J-502 | 4,787 | TRUE | Passed | 500 | 4,788 | 30 | 31.3 | J-726 |
| J-504 | 3,043 | TRUE | Passed | 500 | 3,044 | 30 | 40.5 | J-1334 |
| J-505 | 3,757 | TRUE | Passed | 500 | 3,758 | 30 | 42.5 | J-554 |
| J-507 | 4,209 | TRUE | Passed | 500 | 4,210 | 30 | 33.1 | J-508 |
| J-508 | 4,211 | TRUE | Passed | 500 | 4,212 | 30 | 34.1 | J-507 |
| J-509 | 4,958 | TRUE | Passed | 500 | 4,959 | 30 | 31 | J-508 |
| J-510 | 5,566 | TRUE | Passed | 500 | 5,567 | 30 | 32.6 | J-513 |
| J-511 | 2,221 | TRUE | Passed | 500 | 2,222 | 30 | 37.9 | J-513 |
| J-513 | 2,264 | TRUE | Passed | 500 | 2,265 | 30 | 37.6 | J-514 |
| J-514 | 2,558 | TRUE | Passed | 500 | 2,559 | 30 | 29.3 | J-513 |
| J-516 | 4,912 | TRUE | Passed | 500 | 4,913 | 30 | 38.5 | J-508 |
| J-517 | 5,372 | TRUE | Passed | 500 | 5,373 | 30 | 30.4 | J-549 |
| J-518 | 4,873 | TRUE | Passed | 500 | 4,874 | 30 | 26.2 | J-549 |
| J-519 | 5,261 | TRUE | Passed | 500 | 5,262 | 30 | 29.8 | J-508 |
| J-520 | 4,451 | TRUE | Passed | 500 | 4,452 | 30 | 32.9 | J-521 |
| J-521 | 3,658 | TRUE | Passed | 500 | 3,659 | 30 | 37.2 | J-603 |

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|---|---|---|---|---|---|---|---|---|
| J-522 | 3,826 | TRUE | Passed | 500 | 3,827 | 30 | 27.5 | J-603 |
| J-523 | 4,180 | TRUE | Passed | 500 | 4,181 | 30 | 27.8 | J-603 |
| J-524 | 4,038 | TRUE | Passed | 500 | 4,039 | 30 | 29.9 | J-521 |
| J-525 | 4,496 | TRUE | Passed | 500 | 4,497 | 30 | 31.8 | J-521 |
| J-526 | 4,343 | TRUE | Passed | 500 | 4,344 | 30 | 33.9 | J-521 |
| J-527 | 4,426 | TRUE | Passed | 500 | 4,427 | 30 | 32.9 | J-528 |
| J-528 | 4,093 | TRUE | Passed | 500 | 4,094 | 30 | 35.8 | J-610 |
| J-529 | 4,319 | TRUE | Passed | 500 | 4,320 | 30 | 37.3 | J-613 |
| J-530 | 4,347 | TRUE | Passed | 500 | 4,348 | 30 | 38.8 | J-596 |
| J-531 | 2,759 | TRUE | Passed | 500 | 2,760 | 30 | 43.1 | J-692 |
| J-532 | 2,980 | TRUE | Passed | 500 | 2,981 | 30 | 43 | J-692 |
| J-533 | 8,066 | TRUE | Passed | 500 | 8,067 | 30 | 32.5 | J-532 |
| J-534 | 9,000 | TRUE | Passed | 500 | 9,001 | 30 | 29.7 | J-535 |
| J-535 | 8,345 | TRUE | Passed | 500 | 8,346 | 30 | 30.9 | J-536 |
| J-536 | 7,472 | TRUE | Passed | 500 | 7,473 | 30 | 37.2 | J-535 |
| J-537 | 8,589 | TRUE | Passed | 500 | 8,590 | 30 | 36.3 | J-647 |
| J-538 | 9,225 | TRUE | Passed | 500 | 9,226 | 30 | 37.8 | J-648 |
| J-539 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.7 | 34.7 | J-538 |
| J-540 | 2,971 | TRUE | Passed | 500 | 2,972 | 30 | 43 | J-692 |
| J-541 | 3,212 | TRUE | Passed | 500 | 3,213 | 30 | 43 | J-692 |
| J-542 | 6,533 | TRUE | Passed | 500 | 6,534 | 30 | 41.9 | J-692 |
| J-543 | 8,905 | TRUE | Passed | 500 | 8,906 | 30 | 35.6 | J-542 |
| J-544 | 9,989 | TRUE | Passed | 500 | 9,990 | 30 | 34.2 | J-546 |
| J-545 | 5,368 | TRUE | Passed | 500 | 5,369 | 30 | 29.6 | J-546 |
| J-546 | 2,041 | TRUE | Passed | 500 | 2,042 | 30 | 43.2 | J-692 |
| J-547 | 5,003 | TRUE | Passed | 500 | 5,004 | 30 | 30.7 | J-548 |
| J-548 | 1,768 | TRUE | Passed | 500 | 1,769 | 30 | 43.2 | J-692 |
| J-549 | 1,616 | TRUE | Passed | 500 | 1,617 | 30 | 43.2 | J-692 |
| J-550 | 4,318 | TRUE | Passed | 500 | 4,319 | 30 | 29.7 | J-552 |
| J-551 | 2,861 | TRUE | Passed | 500 | 2,862 | 30 | 43.1 | J-692 |
| J-552 | 2,300 | TRUE | Passed | 500 | 2,301 | 30 | 43.2 | J-692 |
| J-553 | 3,790 | TRUE | Passed | 500 | 3,791 | 30 | 29.9 | J-554 |
| J-554 | 2,467 | TRUE | Passed | 500 | 2,469 | 30 | 43.2 | J-692 |
| J-555 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.5 | 37 | J-556 |
| J-556 | 3,967 | TRUE | Passed | 500 | 3,968 | 30 | 42.9 | J-692 |
| J-557 | 3,500 | TRUE | Passed | 500 | 3,501 | 30 | 30.9 | J-558 |
| J-558 | 1,765 | TRUE | Passed | 500 | 1,766 | 30 | 43.2 | J-692 |
| J-559 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.3 | 40.6 | J-692 |
| J-560 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.3 | 41 | J-692 |
| J-561 | 3,638 | TRUE | Passed | 500 | 3,639 | 30 | 42.9 | J-692 |
| J-562 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.2 | 39.1 | J-556 |
| J-563 | 2,799 | TRUE | Passed | 500 | 2,800 | 30 | 43 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-564 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.6 | 38.7 | J-692 |
| J-565 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.9 | 39.5 | J-692 |
| J-566 | 8,408 | TRUE | Passed | 500 | 8,409 | 30 | 39.7 | J-692 |
| J-567 | 10,000 | TRUE | Passed | 500 | 10,001 | 36 | 38.2 | J-692 |
| J-568 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.7 | 36.2 | J-692 |
| J-569 | 8,256 | TRUE | Passed | 500 | 8,257 | 30 | 38.3 | J-692 |
| J-570 | 7,149 | TRUE | Passed | 500 | 7,150 | 30 | 39.9 | J-692 |
| J-571 | 8,622 | TRUE | Passed | 500 | 8,623 | 30 | 37.1 | J-692 |
| J-572 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.3 | 33.8 | J-574 |
| J-573 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.6 | 20.1 | J-692 |
| J-574 | 9,946 | TRUE | Passed | 500 | 9,947 | 30 | 34 | J-571 |
| J-576 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.6 | 37.6 | J-692 |
| J-577 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.7 | 38.1 | J-692 |
| J-578 | 3,142 | TRUE | Passed | 500 | 3,143 | 30 | 42.9 | J-692 |
| J-579 | 4,194 | TRUE | Passed | 500 | 4,195 | 30 | 42.6 | J-692 |
| J-580 | 4,256 | TRUE | Passed | 500 | 4,257 | 30 | 42.7 | J-692 |
| J-581 | 4,022 | TRUE | Passed | 500 | 4,023 | 30 | 42.7 | J-692 |
| J-582 | 6,420 | TRUE | Passed | 500 | 6,422 | 30 | 39.6 | J-581 |
| J-583 | 6,953 | TRUE | Passed | 500 | 6,954 | 30 | 41.4 | J-692 |
| J-584 | 7,903 | TRUE | Passed | 500 | 7,904 | 30 | 37.2 | J-585 |
| J-585 | 6,021 | TRUE | Passed | 500 | 6,022 | 30 | 39 | J-587 |
| J-587 | 5,574 | TRUE | Passed | 500 | 5,575 | 30 | 38.6 | J-588 |
| J-588 | 5,203 | TRUE | Passed | 500 | 5,204 | 30 | 42.3 | J-692 |
| J-589 | 5,364 | TRUE | Passed | 500 | 5,365 | 30 | 39.2 | J-588 |
| J-590 | 6,824 | TRUE | Passed | 500 | 6,825 | 30 | 28.6 | J-591 |
| J-591 | 6,243 | TRUE | Passed | 500 | 6,244 | 30 | 36.2 | J-590 |
| J-592 | 5,965 | TRUE | Passed | 500 | 5,966 | 30 | 36.3 | J-596 |
| J-593 | 4,345 | TRUE | Passed | 500 | 4,346 | 30 | 36.3 | J-596 |
| J-594 | 4,218 | TRUE | Passed | 500 | 4,219 | 30 | 26.1 | J-596 |
| J-595 | 3,411 | TRUE | Passed | 500 | 3,412 | 30 | 27.1 | J-596 |
| J-596 | 2,861 | TRUE | Passed | 500 | 2,862 | 30 | 35.1 | J-597 |
| J-597 | 2,973 | TRUE | Passed | 500 | 2,974 | 30 | 31.5 | J-596 |
| J-598 | 3,059 | TRUE | Passed | 500 | 3,060 | 30 | 32 | J-597 |
| J-599 | 3,252 | TRUE | Passed | 500 | 3,253 | 30 | 31.3 | J-1549 |
| J-601 | 2,857 | TRUE | Passed | 500 | 2,858 | 30 | 34.6 | J-1549 |
| J-602 | 4,132 | TRUE | Passed | 500 | 4,133 | 30 | 31.9 | J-1549 |
| J-603 | 2,169 | TRUE | Passed | 500 | 2,170 | 30 | 43.1 | J-692 |
| J-604 | 4,145 | TRUE | Passed | 500 | 4,146 | 30 | 30.6 | J-596 |
| J-605 | 3,037 | TRUE | Passed | 500 | 3,039 | 30 | 31 | J-596 |
| J-606 | 3,147 | TRUE | Passed | 500 | 3,148 | 30 | 29.7 | J-596 |
| J-607 | 3,990 | TRUE | Passed | 500 | 3,991 | 30 | 31.4 | J-596 |
| J-608 | 4,120 | TRUE | Passed | 500 | 4,121 | 30 | 31.5 | J-596 |

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|---|---|---|---|---|---|---|---|---|
| J-609 | 4,196 | TRUE | Passed | 500 | 4,197 | 30 | 31.5 | J-596 |
| J-610 | 4,105 | TRUE | Passed | 500 | 4,106 | 30 | 34.4 | J-596 |
| J-611 | 4,415 | TRUE | Passed | 500 | 4,416 | 30 | 28.6 | J-596 |
| J-612 | 3,892 | TRUE | Passed | 500 | 3,893 | 30 | 36 | J-596 |
| J-613 | 4,023 | TRUE | Passed | 500 | 4,024 | 30 | 39.1 | J-596 |
| J-614 | 6,181 | TRUE | Passed | 500 | 6,182 | 30 | 34.8 | J-596 |
| J-615 | 6,477 | TRUE | Passed | 500 | 6,478 | 30 | 30.5 | J-614 |
| J-616 | 6,629 | TRUE | Passed | 500 | 6,630 | 30 | 32.3 | J-615 |
| J-617 | 6,557 | TRUE | Passed | 500 | 6,558 | 30 | 41 | 3-FLOW |
| J-620 | 7,553 | TRUE | Passed | 500 | 7,554 | 30 | 29 | J-617 |
| J-621 | 9,315 | TRUE | Passed | 500 | 9,316 | 30 | 29 | J-617 |
| J-622 | 8,902 | TRUE | Passed | 500 | 8,903 | 30 | 33.5 | J-626 |
| J-623 | 9,025 | TRUE | Passed | 500 | 9,026 | 30 | 35.8 | J-617 |
| J-625 | 10,000 | TRUE | Passed | 500 | 10,001 | 30 | 28.8 | J-623 |
| J-626 | 8,719 | TRUE | Passed | 500 | 8,720 | 30 | 33.8 | J-627 |
| J-627 | 8,655 | TRUE | Passed | 500 | 8,656 | 30 | 35.4 | J-628 |
| J-628 | 8,886 | TRUE | Passed | 500 | 8,887 | 30 | 33.9 | J-627 |
| J-629 | 9,380 | TRUE | Passed | 500 | 9,381 | 30 | 32 | J-628 |
| J-630 | 9,600 | TRUE | Passed | 500 | 9,601 | 30 | 32.4 | J-629 |
| J-631 | 9,680 | TRUE | Passed | 500 | 9,681 | 30 | 36.5 | J-630 |
| J-632 | 5,092 | TRUE | Passed | 500 | 5,093 | 30 | 30 | J-633 |
| J-633 | 3,005 | TRUE | Passed | 500 | 3,006 | 30 | 42.9 | J-692 |
| J-634 | 7,986 | TRUE | Passed | 500 | 7,987 | 30 | 30.8 | J-633 |
| J-636 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.5 | 36.1 | J-631 |
| J-637 | 3,663 | TRUE | Passed | 500 | 3,664 | 30 | 42.8 | J-692 |
| J-638 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.4 | 38.6 | J-539 |
| J-639 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.3 | 38.5 | J-692 |
| J-640 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.9 | 38.4 | J-692 |
| J-641 | 5,466 | TRUE | Passed | 500 | 5,467 | 30 | 42 | J-692 |
| J-642 | 3,928 | TRUE | Passed | 500 | 3,929 | 30 | 42.7 | J-692 |
| J-643 | 2,982 | TRUE | Passed | 500 | 2,983 | 30 | 43 | J-692 |
| J-644 | 5,187 | TRUE | Passed | 500 | 5,188 | 30 | 38.1 | J-645 |
| J-645 | 2,585 | TRUE | Passed | 500 | 2,586 | 30 | 43.1 | J-692 |
| J-646 | 7,240 | TRUE | Passed | 500 | 7,241 | 30 | 40.3 | J-648 |
| J-647 | 4,681 | TRUE | Passed | 500 | 4,682 | 30 | 42.6 | J-692 |
| J-648 | 2,822 | TRUE | Passed | 500 | 2,823 | 30 | 43 | J-692 |
| J-649 | 3,555 | TRUE | Passed | 500 | 3,556 | 30 | 29.8 | J-650 |
| J-650 | 1,776 | TRUE | Passed | 500 | 1,777 | 30 | 43.2 | J-692 |
| J-651 | 7,713 | TRUE | Passed | 500 | 7,714 | 30 | 29.4 | J-652 |
| J-652 | 2,919 | TRUE | Passed | 500 | 2,921 | 30 | 43 | J-692 |
| J-655 | 7,203 | TRUE | Passed | 500 | 7,204 | 30 | 31.6 | J-656 |
| J-656 | 3,427 | TRUE | Passed | 500 | 3,428 | 30 | 42.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-657 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.4 | 38.3 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.9 | 37.3 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.5 | 38 | J-692 |
| J-660 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.7 | 38 | J-692 |
| J-661 | 802 | TRUE | Passed | 500 | 806 | 30 | 43.2 | J-692 |
| J-662 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.5 | 38.3 | J-692 |
| J-663 | 10,000 | TRUE | Passed | 500 | 10,001 | 49.7 | 38.3 | J-692 |
| J-664 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.9 | 38.3 | J-692 |
| J-665 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.1 | 38.4 | J-692 |
| J-666 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.4 | 42.5 | J-692 |
| J-667 | 8,726 | TRUE | Passed | 500 | 8,727 | 30 | 34.9 | J-25 |
| J-668 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.6 | 42.8 | J-692 |
| J-669 | 3,942 | TRUE | Passed | 500 | 3,943 | 30 | 40.2 | J-21 |
| J-670 | 4,467 | TRUE | Passed | 500 | 4,468 | 30 | 33.3 | J-21 |
| J-673 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.1 | 37.8 | J-692 |
| J-674 | 4,175 | TRUE | Passed | 500 | 4,176 | 30 | 42.4 | J-692 |
| J-675 | 3,871 | TRUE | Passed | 500 | 3,872 | 30 | 42.7 | J-692 |
| J-676 | 5,483 | TRUE | Passed | 500 | 5,484 | 30 | 31 | J-675 |
| J-677 | 2,368 | TRUE | Passed | 500 | 2,369 | 30 | 29.3 | J-678 |
| J-678 | 1,760 | TRUE | Passed | 500 | 1,761 | 30 | 43.2 | J-692 |
| J-680 | 5,073 | TRUE | Passed | 500 | 5,073 | 30 | 16.6 | J-692 |
| J-682 | 4,998 | TRUE | Passed | 500 | 4,998 | 30 | 17.7 | J-692 |
| J-685 | 2,437 | TRUE | Passed | 500 | 2,462 | 30 | 26.7 | J-692 |
| J-686 | 5,174 | TRUE | Passed | 500 | 5,224 | 30 | 10.7 | J-692 |
| J-687 | 5,426 | TRUE | Passed | 500 | 5,451 | 30 | 29.4 | J-692 |
| J-689 | 8,003 | TRUE | Passed | 500 | 8,028 | 30 | 22.6 | J-692 |
| J-690 | 7,731 | TRUE | Passed | 500 | 7,756 | 30 | 16 | J-692 |
| J-691 | 6,929 | TRUE | Passed | 500 | 6,954 | 30 | 7 | J-692 |
| J-692 | 1,718 | TRUE | Passed | 500 | 1,718 | 30 | 32.4 | J-695 |
| J-693 | 4,258 | TRUE | Passed | 500 | 4,283 | 30 | 19.5 | J-692 |
| J-694 | 5,160 | TRUE | Passed | 500 | 5,185 | 30 | 9.8 | J-692 |
| J-695 | 1,922 | TRUE | Passed | 500 | 1,947 | 30 | 29.7 | J-692 |
| J-696 | 2,870 | TRUE | Passed | 500 | 2,875 | 30 | 25.4 | J-692 |
| J-697 | 7,151 | TRUE | Passed | 500 | 7,151 | 30 | 0.3 | J-692 |
| J-698 | 5,593 | TRUE | Passed | 500 | 5,618 | 30 | 29.6 | J-692 |
| J-699 | 10,000 | TRUE | Passed | 500 | 10,025 | 33.7 | 13.4 | J-692 |
| J-700 | 6,795 | TRUE | Passed | 500 | 6,820 | 30 | 24.8 | J-692 |
| J-702 | 5,800 | TRUE | Passed | 500 | 5,800 | 30 | 15.3 | J-692 |
| J-719 | 4,452 | TRUE | Passed | 500 | 4,452 | 30 | 39.8 | J-724 |
| J-724 | 4,288 | TRUE | Passed | 500 | 4,288 | 30 | 34.2 | J-1780 |
| J-726 | 3,996 | TRUE | Passed | 500 | 3,996 | 30 | 31.6 | J-504 |
| J-727 | 7,621 | TRUE | Passed | 500 | 7,621 | 30 | 43.1 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-731 | 5,442 | TRUE | Passed | 500 | 5,443 | 30 | 41.3 | J-260 |
| J-904 | 6,788 | TRUE | Passed | 500 | 6,789 | 30 | 41.8 | J-692 |
| J-1031 | 9,683 | TRUE | Passed | 500 | 9,684 | 30 | 38.5 | J-385 |
| J-1082 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.3 | 38.3 | J-692 |
| J-1184 | 9,077 | TRUE | Passed | 500 | 9,078 | 30 | 37.8 | J-439 |
| J-1201 | 8,009 | TRUE | Passed | 500 | 8,010 | 30 | 26.4 | J-455 |
| J-1296 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.8 | 42.5 | J-692 |
| J-1334 | 3,715 | TRUE | Passed | 500 | 3,716 | 30 | 29.9 | J-504 |
| J-1340 | 3,843 | TRUE | Passed | 500 | 3,844 | 30 | 39.9 | J-508 |
| J-1549 | 2,888 | TRUE | Passed | 500 | 2,889 | 30 | 35.5 | J-601 |
| J-1642 | 9,022 | TRUE | Passed | 500 | 9,023 | 30 | 39.4 | J-692 |
| J-1704 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.6 | 37.5 | J-692 |
| J-1780 | 4,369 | TRUE | Passed | 500 | 4,369 | 30 | 32.5 | J-724 |
| J-1806 | 3,664 | TRUE | Passed | 500 | 3,664 | 30 | 24 | J-692 |
| **Scenario 7: 12-Inch North Expansion** | | | | | | | | |
| Note: Minimum residual pressure was lowered to 24 psi so that fire flow scenarios could be run. | | | | | | | | |
| 1-FLOW | 9,379 | TRUE | Passed | 500 | 9,380 | 24 | 19.2 | J-692 |
| 1-RES | 3,308 | TRUE | Passed | 500 | 3,311 | 24 | 23.6 | J-692 |
| 2-FLOW | 8,636 | TRUE | Passed | 500 | 8,637 | 24 | 20.3 | J-692 |
| 2-RES | 4,485 | TRUE | Passed | 500 | 4,486 | 24 | 23.1 | J-692 |
| 3-FLOW | 3,029 | TRUE | Passed | 500 | 3,030 | 24 | 22.9 | J-692 |
| 3-RES | 2,584 | TRUE | Passed | 500 | 2,585 | 24 | 23.3 | J-692 |
| 4-FLOW | 3,658 | TRUE | Passed | 500 | 3,659 | 24 | 22.7 | J-692 |
| 4-RES | 2,644 | TRUE | Passed | 500 | 2,645 | 24 | 23.5 | J-692 |
| 5-FLOW | 4,038 | TRUE | Passed | 500 | 4,039 | 24 | 19.2 | J-692 |
| 5-RES | 2,084 | TRUE | Passed | 500 | 2,085 | 24 | 22.7 | J-692 |
| 6-FLOW | 2,153 | TRUE | Passed | 500 | 2,154 | 24 | 23.7 | J-692 |
| 6-RES | 1,397 | TRUE | Passed | 500 | 1,398 | 24 | 24.2 | J-692 |
| 7-FLOW | 2,364 | TRUE | Passed | 500 | 2,365 | 24 | 21.8 | J-692 |
| 7-RES | 2,122 | TRUE | Passed | 500 | 2,123 | 24 | 22.3 | J-692 |
| J-1 | 5,785 | TRUE | Passed | 500 | 5,786 | 24 | 15.7 | J-692 |
| J-2 | 7,960 | TRUE | Passed | 500 | 7,961 | 24 | 12 | J-692 |
| J-3 | 8,588 | TRUE | Passed | 500 | 8,589 | 24 | 12.7 | J-692 |
| J-11 | 9,116 | TRUE | Passed | 500 | 9,117 | 24 | 12.6 | J-692 |
| J-12 | 8,801 | TRUE | Passed | 500 | 8,802 | 24 | 11.6 | J-692 |
| J-13 | 5,196 | TRUE | Passed | 500 | 5,197 | 24 | 18.4 | J-692 |
| J-14 | 4,179 | TRUE | Passed | 500 | 4,180 | 24 | 20.2 | J-692 |
| J-15 | 8,177 | TRUE | Passed | 500 | 8,178 | 24 | 12 | J-692 |
| J-17 | 6,433 | TRUE | Passed | 500 | 6,434 | 24 | 15.8 | J-692 |
| J-18 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.5 | 22.2 | J-692 |
| J-19 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.1 | 15.8 | J-692 |
| J-20 | 4,521 | TRUE | Passed | 500 | 4,522 | 24 | 21.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-21 | 4,625 | TRUE | Passed | 500 | 4,626 | 24 | 21.9 | J-692 |
| J-22 | 2,213 | TRUE | Passed | 500 | 2,214 | 24 | 23.8 | J-692 |
| J-23 | 4,078 | TRUE | Passed | 500 | 4,079 | 24 | 22.3 | J-692 |
| J-24 | 2,078 | TRUE | Passed | 500 | 2,079 | 24 | 23.8 | J-692 |
| J-25 | 3,630 | TRUE | Passed | 500 | 3,631 | 24 | 22.7 | J-692 |
| J-26 | 2,006 | TRUE | Passed | 500 | 2,007 | 24 | 23.8 | J-692 |
| J-27 | 3,735 | TRUE | Passed | 500 | 3,736 | 24 | 22.5 | J-692 |
| J-28 | 2,308 | TRUE | Passed | 500 | 2,309 | 24 | 23.6 | J-692 |
| J-29 | 4,061 | TRUE | Passed | 500 | 4,062 | 24 | 22.1 | J-692 |
| J-30 | 7,080 | TRUE | Passed | 500 | 7,081 | 24 | 17.9 | J-692 |
| J-31 | 2,855 | TRUE | Passed | 500 | 2,856 | 24 | 22.1 | J-692 |
| J-33 | 3,132 | TRUE | Passed | 500 | 3,133 | 24 | 21.7 | J-692 |
| J-34 | 3,059 | TRUE | Passed | 500 | 3,060 | 24 | 21.8 | J-692 |
| J-35 | 3,784 | TRUE | Passed | 500 | 3,785 | 24 | 20.7 | J-692 |
| J-36 | 5,145 | TRUE | Passed | 500 | 5,146 | 24 | 18.1 | J-692 |
| J-37 | 5,742 | TRUE | Passed | 500 | 5,743 | 24 | 17.5 | J-692 |
| J-38 | 5,380 | TRUE | Passed | 500 | 5,381 | 24 | 17.1 | J-692 |
| J-39 | 4,717 | TRUE | Passed | 500 | 4,718 | 24 | 19.1 | J-692 |
| J-40 | 4,641 | TRUE | Passed | 500 | 4,642 | 24 | 19.1 | J-692 |
| J-41 | 5,441 | TRUE | Passed | 500 | 5,442 | 24 | 17 | J-692 |
| J-42 | 3,297 | TRUE | Passed | 500 | 3,298 | 24 | 20.9 | J-692 |
| J-43 | 4,649 | TRUE | Passed | 500 | 4,651 | 24 | 18.1 | J-692 |
| J-44 | 2,461 | TRUE | Passed | 500 | 2,462 | 24 | 22.3 | J-692 |
| J-45 | 2,621 | TRUE | Passed | 500 | 2,622 | 24 | 22 | J-692 |
| J-46 | 3,375 | TRUE | Passed | 500 | 3,376 | 24 | 20.7 | J-692 |
| J-47 | 2,219 | TRUE | Passed | 500 | 2,220 | 24 | 22.6 | J-692 |
| J-48 | 2,913 | TRUE | Passed | 500 | 2,914 | 24 | 21.2 | J-47 |
| J-49 | 3,415 | TRUE | Passed | 500 | 3,416 | 24 | 20.7 | J-692 |
| J-50 | 2,634 | TRUE | Passed | 500 | 2,635 | 24 | 22 | J-692 |
| J-51 | 1,144 | TRUE | Passed | 500 | 1,145 | 24 | 23.9 | J-692 |
| J-52 | 2,807 | TRUE | Passed | 500 | 2,808 | 24 | 20.7 | J-51 |
| J-53 | 2,370 | TRUE | Passed | 500 | 2,371 | 24 | 22.3 | J-692 |
| J-54 | 2,552 | TRUE | Passed | 500 | 2,553 | 24 | 22 | J-692 |
| J-55 | 2,076 | TRUE | Passed | 500 | 2,077 | 24 | 22.7 | J-692 |
| J-56 | 2,413 | TRUE | Passed | 500 | 2,414 | 24 | 22.2 | J-692 |
| J-57 | 2,329 | TRUE | Passed | 500 | 2,330 | 24 | 22.4 | J-692 |
| J-58 | 2,560 | TRUE | Passed | 500 | 2,561 | 24 | 22 | J-692 |
| J-59 | 2,895 | TRUE | Passed | 500 | 2,896 | 24 | 21.4 | J-692 |
| J-60 | 2,659 | TRUE | Passed | 500 | 2,660 | 24 | 21.8 | J-692 |
| J-61 | 4,215 | TRUE | Passed | 500 | 4,216 | 24 | 18.9 | J-692 |
| J-64 | 4,144 | TRUE | Passed | 500 | 4,145 | 24 | 18.8 | J-692 |
| J-65 | 4,215 | TRUE | Passed | 500 | 4,216 | 24 | 18.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-66 | 5,248 | TRUE | Passed | 500 | 5,249 | 24 | 16.9 | J-692 |
| J-67 | 4,698 | TRUE | Passed | 500 | 4,699 | 24 | 18 | J-692 |
| J-68 | 5,016 | TRUE | Passed | 500 | 5,017 | 24 | 17.4 | J-692 |
| J-69 | 2,769 | TRUE | Passed | 500 | 2,770 | 24 | 21.9 | J-692 |
| J-70 | 4,076 | TRUE | Passed | 500 | 4,077 | 24 | 19.5 | J-692 |
| J-71 | 3,428 | TRUE | Passed | 500 | 3,429 | 24 | 20.8 | J-692 |
| J-72 | 3,412 | TRUE | Passed | 500 | 3,413 | 24 | 20.8 | J-692 |
| J-73 | 1,314 | TRUE | Passed | 500 | 1,315 | 24 | 23.8 | J-692 |
| J-74 | 3,384 | TRUE | Passed | 500 | 3,385 | 24 | 20.9 | J-692 |
| J-75 | 5,227 | TRUE | Passed | 500 | 5,228 | 24 | 17.2 | J-692 |
| J-76 | 4,935 | TRUE | Passed | 500 | 4,936 | 24 | 17.7 | J-692 |
| J-77 | 4,794 | TRUE | Passed | 500 | 4,795 | 24 | 17.8 | J-692 |
| J-78 | 5,434 | TRUE | Passed | 500 | 5,435 | 24 | 16.9 | J-692 |
| J-79 | 4,478 | TRUE | Passed | 500 | 4,479 | 24 | 19 | J-692 |
| J-80 | 5,015 | TRUE | Passed | 500 | 5,016 | 24 | 17.9 | J-692 |
| J-81 | 5,273 | TRUE | Passed | 500 | 5,274 | 24 | 17.1 | J-692 |
| J-82 | 6,054 | TRUE | Passed | 500 | 6,055 | 24 | 15.8 | J-692 |
| J-83 | 6,199 | TRUE | Passed | 500 | 6,200 | 24 | 15.4 | J-692 |
| J-84 | 6,200 | TRUE | Passed | 500 | 6,201 | 24 | 15.4 | J-692 |
| J-85 | 5,708 | TRUE | Passed | 500 | 5,709 | 24 | 16.4 | J-692 |
| J-86 | 5,390 | TRUE | Passed | 500 | 5,391 | 24 | 17 | J-692 |
| J-87 | 4,718 | TRUE | Passed | 500 | 4,719 | 24 | 18.6 | J-692 |
| J-88 | 4,119 | TRUE | Passed | 500 | 4,120 | 24 | 19.8 | J-692 |
| J-89 | 5,242 | TRUE | Passed | 500 | 5,243 | 24 | 17.3 | J-692 |
| J-90 | 3,909 | TRUE | Passed | 500 | 3,910 | 24 | 20.1 | J-692 |
| J-91 | 1,863 | TRUE | Passed | 500 | 1,864 | 24 | 23.2 | J-692 |
| J-92 | 6,443 | TRUE | Passed | 500 | 6,444 | 24 | 13.7 | J-692 |
| J-93 | 5,234 | TRUE | Passed | 500 | 5,235 | 24 | 17 | J-692 |
| J-94 | 6,409 | TRUE | Passed | 500 | 6,410 | 24 | 13.9 | J-692 |
| J-95 | 7,511 | TRUE | Passed | 500 | 7,512 | 24 | 12.8 | J-692 |
| J-96 | 6,296 | TRUE | Passed | 500 | 6,297 | 24 | 14.7 | J-692 |
| J-97 | 6,506 | TRUE | Passed | 500 | 6,507 | 24 | 13.5 | J-692 |
| J-98 | 6,673 | TRUE | Passed | 500 | 6,674 | 24 | 12.6 | J-692 |
| J-99 | 3,725 | TRUE | Passed | 500 | 3,726 | 24 | 15.8 | J-692 |
| J-100 | 5,392 | TRUE | Passed | 500 | 5,393 | 24 | 8.2 | J-692 |
| J-101 | 3,425 | TRUE | Passed | 500 | 3,426 | 24 | 16.7 | J-692 |
| J-102 | 5,513 | TRUE | Passed | 500 | 5,514 | 24 | 7 | J-692 |
| J-103 | 5,003 | TRUE | Passed | 500 | 5,004 | 24 | 6.5 | J-692 |
| J-104 | 4,306 | TRUE | Passed | 500 | 4,307 | 24 | 10.3 | J-692 |
| J-105 | 5,117 | TRUE | Passed | 500 | 5,118 | 24 | 5.2 | J-692 |
| J-106 | 4,877 | TRUE | Passed | 500 | 4,878 | 24 | 6.8 | J-692 |
| J-107 | 4,589 | TRUE | Passed | 500 | 4,590 | 24 | 8.8 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-108 | 4,932 | TRUE | Passed | 500 | 4,933 | 24 | 6.5 | J-692 |
| J-109 | 4,916 | TRUE | Passed | 500 | 4,917 | 24 | 6.6 | J-692 |
| J-110 | 4,620 | TRUE | Passed | 500 | 4,621 | 24 | 8.8 | J-692 |
| J-111 | 4,182 | TRUE | Passed | 500 | 4,183 | 24 | 11.3 | J-692 |
| J-112 | 3,702 | TRUE | Passed | 500 | 3,703 | 24 | 13.9 | J-692 |
| J-113 | 3,181 | TRUE | Passed | 500 | 3,182 | 24 | 16.2 | J-692 |
| J-114 | 2,915 | TRUE | Passed | 500 | 2,916 | 24 | 17.1 | J-692 |
| J-115 | 3,533 | TRUE | Passed | 500 | 3,534 | 24 | 14.2 | J-692 |
| J-116 | 2,713 | TRUE | Passed | 500 | 2,715 | 24 | 17.9 | J-692 |
| J-117 | 3,201 | TRUE | Passed | 500 | 3,202 | 24 | 15.7 | J-692 |
| J-118 | 2,126 | TRUE | Passed | 500 | 2,127 | 24 | 23 | J-692 |
| J-118 | 2,842 | TRUE | Passed | 500 | 2,843 | 24 | 17.2 | J-692 |
| J-119 | 3,322 | TRUE | Passed | 500 | 3,323 | 24 | 15.1 | J-692 |
| J-121 | 2,529 | TRUE | Passed | 500 | 2,530 | 24 | 18.4 | J-692 |
| J-122 | 3,415 | TRUE | Passed | 500 | 3,416 | 24 | 14.4 | J-692 |
| J-123 | 4,505 | TRUE | Passed | 500 | 4,530 | 29.1 | 0 | J-692 |
| J-124 | 5,124 | TRUE | Passed | 500 | 5,125 | 24 | 2.8 | J-692 |
| J-125 | 3,342 | TRUE | Passed | 500 | 3,343 | 24 | 13.4 | J-692 |
| J-126 | 4,272 | TRUE | Passed | 500 | 4,273 | 24 | 7.9 | J-692 |
| J-127 | 3,379 | TRUE | Passed | 500 | 3,381 | 24 | 13.4 | J-692 |
| J-128 | 1,340 | TRUE | Passed | 500 | 1,341 | 24 | 22.2 | J-692 |
| J-129 | 3,079 | TRUE | Passed | 500 | 3,080 | 24 | 15.1 | J-692 |
| J-130 | 3,119 | TRUE | Passed | 500 | 3,120 | 24 | 15 | J-692 |
| J-133 | 3,125 | TRUE | Passed | 500 | 3,126 | 24 | 15.1 | J-692 |
| J-134 | 2,569 | TRUE | Passed | 500 | 2,570 | 24 | 17.8 | J-692 |
| J-135 | 2,844 | TRUE | Passed | 500 | 2,845 | 24 | 16.6 | J-692 |
| J-136 | 3,188 | TRUE | Passed | 500 | 3,189 | 24 | 14.9 | J-692 |
| J-137 | 3,388 | TRUE | Passed | 500 | 3,389 | 24 | 13.9 | J-692 |
| J-138 | 3,755 | TRUE | Passed | 500 | 3,756 | 24 | 11.9 | J-692 |
| J-139 | 5,095 | TRUE | Passed | 500 | 5,096 | 24 | 6.8 | J-692 |
| J-140 | 3,180 | TRUE | Passed | 500 | 3,181 | 24 | 16.4 | J-692 |
| J-141 | 3,485 | TRUE | Passed | 500 | 3,486 | 24 | 15 | J-692 |
| J-142 | 4,712 | TRUE | Passed | 500 | 4,713 | 24 | 7.9 | J-692 |
| J-143 | 5,530 | TRUE | Passed | 500 | 5,531 | 24 | 2.7 | J-692 |
| J-144 | 5,457 | TRUE | Passed | 500 | 5,458 | 24 | 2.1 | J-692 |
| J-145 | 3,647 | TRUE | Passed | 500 | 3,648 | 24 | 13.3 | J-692 |
| J-146 | 5,539 | TRUE | Passed | 500 | 5,540 | 24 | 2 | J-692 |
| J-147 | 5,398 | TRUE | Passed | 500 | 5,399 | 24 | 3.1 | J-692 |
| J-148 | 5,653 | TRUE | Passed | 500 | 5,654 | 24 | 2.3 | J-692 |
| J-149 | 5,895 | TRUE | Passed | 500 | 5,896 | 24 | 4.1 | J-692 |
| J-150 | 5,638 | TRUE | Passed | 500 | 5,639 | 24 | 7.6 | J-692 |
| J-151 | 5,618 | TRUE | Passed | 500 | 5,619 | 24 | 4.8 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-152 | 2,820 | TRUE | Passed | 500 | 2,821 | 24 | 19.6 | J-692 |
| J-153 | 5,956 | TRUE | Passed | 500 | 5,957 | 24 | 7.1 | J-692 |
| J-154 | 5,663 | TRUE | Passed | 500 | 5,664 | 24 | 8.7 | J-692 |
| J-155 | 3,486 | TRUE | Passed | 500 | 3,487 | 24 | 19.3 | J-692 |
| J-156 | 3,461 | TRUE | Passed | 500 | 3,462 | 24 | 19.7 | J-692 |
| J-157 | 3,700 | TRUE | Passed | 500 | 3,701 | 24 | 18.8 | J-692 |
| J-158 | 2,977 | TRUE | Passed | 500 | 2,978 | 24 | 19.4 | J-692 |
| J-159 | 4,115 | TRUE | Passed | 500 | 4,116 | 24 | 15.7 | J-692 |
| J-160 | 4,314 | TRUE | Passed | 500 | 4,315 | 24 | 14.6 | J-692 |
| J-161 | 4,298 | TRUE | Passed | 500 | 4,299 | 24 | 14.5 | J-692 |
| J-162 | 4,343 | TRUE | Passed | 500 | 4,344 | 24 | 14.4 | J-692 |
| J-163 | 3,799 | TRUE | Passed | 500 | 3,800 | 24 | 16.2 | J-692 |
| J-164 | 4,120 | TRUE | Passed | 500 | 4,121 | 24 | 15 | J-692 |
| J-165 | 4,482 | TRUE | Passed | 500 | 4,483 | 24 | 13.5 | J-692 |
| J-166 | 5,950 | TRUE | Passed | 500 | 5,951 | 24 | 3.1 | J-692 |
| J-167 | 2,542 | TRUE | Passed | 500 | 2,543 | 24 | 20.2 | J-692 |
| J-168 | 3,146 | TRUE | Passed | 500 | 3,147 | 24 | 18.4 | J-692 |
| J-169 | 3,945 | TRUE | Passed | 500 | 3,946 | 24 | 15.7 | J-692 |
| J-170 | 5,568 | TRUE | Passed | 500 | 5,569 | 24 | 4.9 | J-692 |
| J-171 | 2,583 | TRUE | Passed | 500 | 2,584 | 24 | 19.2 | J-692 |
| J-172 | 4,959 | TRUE | Passed | 500 | 4,960 | 24 | 4.8 | J-692 |
| J-173 | 3,783 | TRUE | Passed | 500 | 3,784 | 24 | 12.1 | J-692 |
| J-174 | 3,857 | TRUE | Passed | 500 | 3,858 | 24 | 11.7 | J-692 |
| J-175 | 4,630 | TRUE | Passed | 500 | 4,631 | 24 | 6.9 | J-692 |
| J-176 | 3,695 | TRUE | Passed | 500 | 3,696 | 24 | 12.5 | J-692 |
| J-177 | 2,496 | TRUE | Passed | 500 | 2,497 | 24 | 18.3 | J-692 |
| J-178 | 3,140 | TRUE | Passed | 500 | 3,141 | 24 | 15.4 | J-692 |
| J-179 | 1,231 | TRUE | Passed | 500 | 1,232 | 24 | 22.6 | J-692 |
| J-180 | 1,562 | TRUE | Passed | 500 | 1,563 | 24 | 21.4 | J-692 |
| J-181 | 3,376 | TRUE | Passed | 500 | 3,377 | 24 | 14.2 | J-692 |
| J-183 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.8 | 3.9 | J-692 |
| J-184 | 779 | TRUE | Passed | 500 | 780 | 24 | 24.3 | J-692 |
| J-185 | 7,695 | TRUE | Passed | 500 | 7,696 | 24 | 11.1 | J-692 |
| J-186 | 5,330 | TRUE | Passed | 500 | 5,331 | 24 | 17.3 | J-692 |
| J-187 | 5,569 | TRUE | Passed | 500 | 5,570 | 24 | 16.4 | J-692 |
| J-188 | 4,208 | TRUE | Passed | 500 | 4,209 | 24 | 19.4 | J-692 |
| J-189 | 5,331 | TRUE | Passed | 500 | 5,332 | 24 | 16.4 | J-692 |
| J-190 | 5,372 | TRUE | Passed | 500 | 5,373 | 24 | 16.5 | J-692 |
| J-191 | 4,586 | TRUE | Passed | 500 | 4,587 | 24 | 18.2 | J-692 |
| J-192 | 3,993 | TRUE | Passed | 500 | 3,994 | 24 | 19.2 | J-692 |
| J-193 | 3,933 | TRUE | Passed | 500 | 3,934 | 24 | 18.7 | J-692 |
| J-194 | 3,327 | TRUE | Passed | 500 | 3,328 | 24 | 19.8 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-195 | 2,587 | TRUE | Passed | 500 | 2,588 | 24 | 21.4 | J-692 |
| J-196 | 2,141 | TRUE | Passed | 500 | 2,142 | 24 | 22.2 | J-692 |
| J-197 | 2,317 | TRUE | Passed | 500 | 2,318 | 24 | 21.9 | J-692 |
| J-200 | 5,269 | TRUE | Passed | 500 | 5,270 | 24 | 16.8 | J-692 |
| J-201 | 4,634 | TRUE | Passed | 500 | 4,635 | 24 | 18.3 | J-692 |
| J-202 | 5,102 | TRUE | Passed | 500 | 5,103 | 24 | 17.2 | J-692 |
| J-203 | 5,074 | TRUE | Passed | 500 | 5,075 | 24 | 17.4 | J-692 |
| J-204 | 3,889 | TRUE | Passed | 500 | 3,890 | 24 | 19.9 | J-692 |
| J-205 | 3,158 | TRUE | Passed | 500 | 3,159 | 24 | 21.2 | J-692 |
| J-206 | 4,257 | TRUE | Passed | 500 | 4,258 | 24 | 19.1 | J-692 |
| J-207 | 3,499 | TRUE | Passed | 500 | 3,500 | 24 | 20.6 | J-692 |
| J-208 | 5,716 | TRUE | Passed | 500 | 5,717 | 24 | 16.1 | J-692 |
| J-209 | 4,325 | TRUE | Passed | 500 | 4,326 | 24 | 19.2 | J-692 |
| J-210 | 7,445 | TRUE | Passed | 500 | 7,446 | 24 | 12.9 | J-692 |
| J-211 | 6,269 | TRUE | Passed | 500 | 6,270 | 24 | 16.9 | J-692 |
| J-212 | 5,001 | TRUE | Passed | 500 | 5,002 | 24 | 19.3 | J-692 |
| J-213 | 3,844 | TRUE | Passed | 500 | 3,845 | 24 | 21.2 | J-692 |
| J-214 | 3,019 | TRUE | Passed | 500 | 3,020 | 24 | 22.3 | J-692 |
| J-215 | 2,519 | TRUE | Passed | 500 | 2,520 | 24 | 22.9 | J-692 |
| J-216 | 882 | TRUE | Passed | 500 | 883 | 24 | 24.4 | J-692 |
| J-217 | 3,638 | TRUE | Passed | 500 | 3,640 | 24 | 21.5 | J-692 |
| J-218 | 2,018 | TRUE | Passed | 500 | 2,019 | 24 | 23.4 | J-692 |
| J-219 | 4,432 | TRUE | Passed | 500 | 4,433 | 24 | 20.3 | J-692 |
| J-220 | 2,105 | TRUE | Passed | 500 | 2,106 | 24 | 23.3 | J-692 |
| J-221 | 2,523 | TRUE | Passed | 500 | 2,524 | 24 | 22.9 | J-692 |
| J-222 | 4,913 | TRUE | Passed | 500 | 4,914 | 24 | 19.6 | J-692 |
| J-223 | 5,424 | TRUE | Passed | 500 | 5,425 | 24 | 18.7 | J-692 |
| J-224 | 6,312 | TRUE | Passed | 500 | 6,313 | 24 | 17.1 | J-692 |
| J-225 | 6,541 | TRUE | Passed | 500 | 6,542 | 24 | 16.7 | J-692 |
| J-226 | 8,378 | TRUE | Passed | 500 | 8,379 | 24 | 12.5 | J-692 |
| J-227 | 6,861 | TRUE | Passed | 500 | 6,862 | 24 | 13.6 | J-692 |
| J-228 | 5,475 | TRUE | Passed | 500 | 5,476 | 24 | 16.8 | J-692 |
| J-229 | 5,379 | TRUE | Passed | 500 | 5,380 | 24 | 17.1 | J-692 |
| J-230 | 3,183 | TRUE | Passed | 500 | 3,184 | 24 | 21.5 | J-692 |
| J-231 | 4,965 | TRUE | Passed | 500 | 4,966 | 24 | 18.1 | J-692 |
| J-232 | 5,525 | TRUE | Passed | 500 | 5,526 | 24 | 17.1 | J-692 |
| J-233 | 7,214 | TRUE | Passed | 500 | 7,215 | 24 | 13.4 | J-692 |
| J-234 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.7 | 5.6 | J-692 |
| J-235 | 10,000 | TRUE | Passed | 500 | 10,001 | 52.7 | 6.7 | J-692 |
| J-236 | 2,589 | TRUE | Passed | 500 | 2,590 | 24 | 21.3 | J-692 |
| J-237 | 2,154 | TRUE | Passed | 500 | 2,155 | 24 | 22.2 | J-692 |
| J-238 | 1,181 | TRUE | Passed | 500 | 1,182 | 24 | 23.7 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-239 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.4 | 9.6 | J-692 |
| J-240 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.9 | 9.7 | J-692 |
| J-241 | 8,900 | TRUE | Passed | 500 | 8,901 | 24 | 13.7 | J-692 |
| J-242 | 8,663 | TRUE | Passed | 500 | 8,664 | 24 | 16.4 | J-692 |
| J-243 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.2 | 13.1 | J-692 |
| J-244 | 5,705 | TRUE | Passed | 500 | 5,706 | 24 | 19.8 | J-692 |
| J-245 | 10,000 | TRUE | Passed | 500 | 10,001 | 28 | 14.4 | J-692 |
| J-246 | 9,757 | TRUE | Passed | 500 | 9,758 | 24 | 18.1 | J-692 |
| J-247 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.5 | 15.8 | J-692 |
| J-248 | 7,764 | TRUE | Passed | 500 | 7,765 | 24 | 18 | J-692 |
| J-249 | 2,654 | TRUE | Passed | 500 | 2,655 | 24 | 23.1 | J-250 |
| J-250 | 1,454 | TRUE | Passed | 500 | 1,455 | 24 | 24.3 | J-692 |
| J-251 | 8,025 | TRUE | Passed | 500 | 8,026 | 24 | 17.7 | J-692 |
| J-252 | 7,947 | TRUE | Passed | 500 | 7,948 | 24 | 18.1 | J-692 |
| J-253 | 3,429 | TRUE | Passed | 500 | 3,430 | 24 | 23.1 | J-692 |
| J-254 | 8,587 | TRUE | Passed | 500 | 8,588 | 24 | 16.8 | J-692 |
| J-255 | 7,887 | TRUE | Passed | 500 | 7,888 | 24 | 17.9 | J-692 |
| J-256 | 4,545 | TRUE | Passed | 500 | 4,546 | 24 | 21.9 | J-692 |
| J-257 | 7,834 | TRUE | Passed | 500 | 7,835 | 24 | 17.9 | J-692 |
| J-258 | 7,799 | TRUE | Passed | 500 | 7,800 | 24 | 17.8 | J-692 |
| J-259 | 4,835 | TRUE | Passed | 500 | 4,836 | 24 | 21.6 | J-692 |
| J-260 | 6,887 | TRUE | Passed | 500 | 6,888 | 24 | 19.1 | J-692 |
| J-262 | 7,946 | TRUE | Passed | 500 | 7,947 | 24 | 18 | J-692 |
| J-263 | 4,645 | TRUE | Passed | 500 | 4,646 | 24 | 21.8 | J-692 |
| J-264 | 8,479 | TRUE | Passed | 500 | 8,480 | 24 | 17.5 | J-692 |
| J-265 | 4,354 | TRUE | Passed | 500 | 4,355 | 24 | 22.1 | J-692 |
| J-266 | 3,057 | TRUE | Passed | 500 | 3,058 | 24 | 23.2 | J-692 |
| J-267 | 6,703 | TRUE | Passed | 500 | 6,704 | 24 | 19.4 | J-692 |
| J-268 | 5,889 | TRUE | Passed | 500 | 5,890 | 24 | 20.5 | J-692 |
| J-269 | 6,855 | TRUE | Passed | 500 | 6,856 | 24 | 19.2 | J-692 |
| J-270 | 8,365 | TRUE | Passed | 500 | 8,366 | 24 | 16.9 | J-692 |
| J-271 | 7,115 | TRUE | Passed | 500 | 7,116 | 24 | 18.8 | J-692 |
| J-272 | 7,159 | TRUE | Passed | 500 | 7,160 | 24 | 18.4 | J-692 |
| J-273 | 5,431 | TRUE | Passed | 500 | 5,432 | 24 | 20.6 | J-692 |
| J-274 | 5,009 | TRUE | Passed | 500 | 5,010 | 24 | 21.1 | J-692 |
| J-275 | 6,776 | TRUE | Passed | 500 | 6,777 | 24 | 18.7 | J-692 |
| J-276 | 6,548 | TRUE | Passed | 500 | 6,549 | 24 | 19.2 | J-692 |
| J-277 | 6,600 | TRUE | Passed | 500 | 6,601 | 24 | 18.8 | J-692 |
| J-278 | 4,849 | TRUE | Passed | 500 | 4,850 | 24 | 21.1 | J-692 |
| J-279 | 4,294 | TRUE | Passed | 500 | 4,295 | 24 | 21.7 | J-692 |
| J-280 | 1,579 | TRUE | Passed | 500 | 1,580 | 24 | 24.1 | J-692 |
| J-281 | 3,512 | TRUE | Passed | 500 | 3,513 | 24 | 22.5 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-282 | 3,340 | TRUE | Passed | 500 | 3,341 | 24 | 22.7 | J-692 |
| J-283 | 2,649 | TRUE | Passed | 500 | 2,650 | 24 | 23.3 | J-692 |
| J-284 | 1,516 | TRUE | Passed | 500 | 1,517 | 24 | 24.2 | J-692 |
| J-285 | 2,239 | TRUE | Passed | 500 | 2,240 | 24 | 23.7 | J-692 |
| J-286 | 4,748 | TRUE | Passed | 500 | 4,749 | 24 | 21.1 | J-692 |
| J-287 | 3,864 | TRUE | Passed | 500 | 3,865 | 24 | 21.4 | J-292 |
| J-288 | 2,245 | TRUE | Passed | 500 | 2,246 | 24 | 23.6 | J-692 |
| J-289 | 2,535 | TRUE | Passed | 500 | 2,536 | 24 | 23.1 | J-290 |
| J-290 | 2,339 | TRUE | Passed | 500 | 2,340 | 24 | 23.5 | J-692 |
| J-291 | 1,259 | TRUE | Passed | 500 | 1,260 | 24 | 24.3 | J-692 |
| J-292 | 2,778 | TRUE | Passed | 500 | 2,779 | 24 | 23.2 | J-692 |
| J-294 | 1,516 | TRUE | Passed | 500 | 1,517 | 24 | 24.1 | J-692 |
| J-296 | 6,734 | TRUE | Passed | 500 | 6,735 | 24 | 18.1 | J-692 |
| J-297 | 6,851 | TRUE | Passed | 500 | 6,852 | 24 | 17.6 | J-692 |
| J-298 | 9,108 | TRUE | Passed | 500 | 9,109 | 24 | 12.9 | J-692 |
| J-299 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.7 | 11.1 | J-692 |
| J-300 | 4,481 | TRUE | Passed | 500 | 4,482 | 24 | 21.4 | J-692 |
| J-301 | 3,612 | TRUE | Passed | 500 | 3,613 | 24 | 22.3 | J-692 |
| J-302 | 4,081 | TRUE | Passed | 500 | 4,082 | 24 | 21.9 | J-692 |
| J-303 | 3,351 | TRUE | Passed | 500 | 3,352 | 24 | 22.7 | J-692 |
| J-304 | 6,029 | TRUE | Passed | 500 | 6,030 | 24 | 19.4 | J-692 |
| J-305 | 6,179 | TRUE | Passed | 500 | 6,180 | 24 | 19.1 | J-306 |
| J-306 | 2,622 | TRUE | Passed | 500 | 2,623 | 24 | 23.3 | J-692 |
| J-307 | 8,331 | TRUE | Passed | 500 | 8,332 | 24 | 15.8 | J-692 |
| J-308 | 7,371 | TRUE | Passed | 500 | 7,372 | 24 | 17.6 | J-692 |
| J-309 | 3,877 | TRUE | Passed | 500 | 3,878 | 24 | 22 | J-692 |
| J-310 | 3,683 | TRUE | Passed | 500 | 3,684 | 24 | 22.1 | J-692 |
| J-311 | 4,196 | TRUE | Passed | 500 | 4,197 | 24 | 21.6 | J-692 |
| J-312 | 4,125 | TRUE | Passed | 500 | 4,126 | 24 | 21.6 | J-692 |
| J-313 | 4,657 | TRUE | Passed | 500 | 4,658 | 24 | 20.9 | J-692 |
| J-314 | 3,470 | TRUE | Passed | 500 | 3,471 | 24 | 22.4 | J-692 |
| J-315 | 2,819 | TRUE | Passed | 500 | 2,820 | 24 | 23 | J-692 |
| J-316 | 4,814 | TRUE | Passed | 500 | 4,815 | 24 | 20.5 | J-692 |
| J-317 | 3,572 | TRUE | Passed | 500 | 3,573 | 24 | 22.2 | J-692 |
| J-318 | 7,080 | TRUE | Passed | 500 | 7,081 | 24 | 18.7 | J-692 |
| J-319 | 6,771 | TRUE | Passed | 500 | 6,772 | 24 | 19 | J-692 |
| J-320 | 6,803 | TRUE | Passed | 500 | 6,804 | 24 | 18.8 | J-692 |
| J-321 | 3,532 | TRUE | Passed | 500 | 3,533 | 24 | 22.7 | J-692 |
| J-322 | 3,760 | TRUE | Passed | 500 | 3,761 | 24 | 22.6 | J-692 |
| J-323 | 3,331 | TRUE | Passed | 500 | 3,332 | 24 | 23 | J-692 |
| J-324 | 4,592 | TRUE | Passed | 500 | 4,593 | 24 | 21.8 | J-692 |
| J-325 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.3 | 9.5 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-326 | 10,000 | TRUE | Passed | 500 | 10,001 | 41 | 9.5 | J-692 |
| J-327 | 7,423 | TRUE | Passed | 500 | 7,424 | 24 | 15.5 | J-692 |
| J-328 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.8 | 9.5 | J-692 |
| J-329 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.3 | 9.1 | J-692 |
| J-330 | 1,846 | TRUE | Passed | 500 | 1,848 | 24 | 23.7 | J-692 |
| J-331 | 6,396 | TRUE | Passed | 500 | 6,398 | 24 | 17.3 | J-692 |
| J-332 | 6,700 | TRUE | Passed | 500 | 6,701 | 24 | 16.8 | J-692 |
| J-333 | 4,819 | TRUE | Passed | 500 | 4,820 | 24 | 20 | J-692 |
| J-334 | 8,441 | TRUE | Passed | 500 | 8,442 | 24 | 12.4 | J-692 |
| J-336 | 7,110 | TRUE | Passed | 500 | 7,111 | 24 | 15.6 | J-692 |
| J-338 | 7,875 | TRUE | Passed | 500 | 7,876 | 24 | 13.9 | J-692 |
| J-339 | 6,784 | TRUE | Passed | 500 | 6,785 | 24 | 16.1 | J-692 |
| J-340 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.6 | 9.6 | J-692 |
| J-341 | 7,999 | TRUE | Passed | 500 | 8,000 | 24 | 16.2 | J-692 |
| J-342 | 4,282 | TRUE | Passed | 500 | 4,283 | 24 | 21.4 | J-692 |
| J-343 | 7,748 | TRUE | Passed | 500 | 7,749 | 24 | 16.2 | J-692 |
| J-345 | 5,182 | TRUE | Passed | 500 | 5,183 | 24 | 20.2 | J-692 |
| J-346 | 3,880 | TRUE | Passed | 500 | 3,881 | 24 | 21.8 | J-692 |
| J-347 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.2 | 9.8 | J-692 |
| J-348 | 10,000 | TRUE | Passed | 500 | 10,001 | 49.9 | 9.9 | J-692 |
| J-349 | 10,000 | TRUE | Passed | 500 | 10,001 | 45 | 10 | J-692 |
| J-350 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.1 | 10 | J-692 |
| J-351 | 9,115 | TRUE | Passed | 500 | 9,116 | 24 | 12 | J-692 |
| J-352 | 9,426 | TRUE | Passed | 500 | 9,427 | 24 | 11.3 | J-692 |
| J-353 | 10,000 | TRUE | Passed | 500 | 10,001 | 24.1 | 9.8 | J-692 |
| J-354 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.9 | 10.6 | J-692 |
| J-355 | 9,356 | TRUE | Passed | 500 | 9,357 | 24 | 12 | J-692 |
| J-356 | 8,793 | TRUE | Passed | 500 | 8,794 | 24 | 12.7 | J-692 |
| J-357 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.3 | 9.6 | J-692 |
| J-358 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.9 | 10.8 | J-692 |
| J-359 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.2 | 10.7 | J-692 |
| J-360 | 1,639 | TRUE | Passed | 500 | 1,640 | 24 | 23.9 | J-692 |
| J-361 | 8,930 | TRUE | Passed | 500 | 8,931 | 24 | 13 | J-692 |
| J-362 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.3 | 10.1 | J-692 |
| J-363 | 8,457 | TRUE | Passed | 500 | 8,458 | 24 | 13.6 | J-692 |
| J-364 | 7,574 | TRUE | Passed | 500 | 7,575 | 24 | 15.4 | J-692 |
| J-365 | 7,999 | TRUE | Passed | 500 | 8,000 | 24 | 14.5 | J-692 |
| J-366 | 7,380 | TRUE | Passed | 500 | 7,381 | 24 | 15.8 | J-692 |
| J-367 | 9,082 | TRUE | Passed | 500 | 9,083 | 24 | 12.2 | J-692 |
| J-368 | 6,292 | TRUE | Passed | 500 | 6,293 | 24 | 18.4 | J-692 |
| J-369 | 9,192 | TRUE | Passed | 500 | 9,193 | 24 | 12.6 | J-692 |
| J-370 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.4 | 10.7 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-371 | 3,575 | TRUE | Passed | 500 | 3,576 | 24 | 13.7 | J-692 |
| J-371 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.9 | 10.6 | J-692 |
| J-372 | 7,369 | TRUE | Passed | 500 | 7,370 | 24 | 16.1 | J-692 |
| J-373 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.8 | 10.1 | J-692 |
| J-374 | 10,000 | TRUE | Passed | 500 | 10,001 | 49 | 10.1 | J-692 |
| J-375 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.4 | 10.1 | J-692 |
| J-376 | 8,423 | TRUE | Passed | 500 | 8,424 | 24 | 13.7 | J-692 |
| J-377 | 10,000 | TRUE | Passed | 500 | 10,001 | 53.2 | 10.1 | J-692 |
| J-378 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.3 | 10.2 | J-692 |
| J-379 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.6 | 10.2 | J-692 |
| J-380 | 7,060 | TRUE | Passed | 500 | 7,061 | 24 | 16.7 | J-692 |
| J-382 | 7,638 | TRUE | Passed | 500 | 7,639 | 24 | 15.7 | J-692 |
| J-383 | 7,012 | TRUE | Passed | 500 | 7,013 | 24 | 16.9 | J-692 |
| J-384 | 7,321 | TRUE | Passed | 500 | 7,322 | 24 | 16.4 | J-692 |
| J-385 | 9,780 | TRUE | Passed | 500 | 9,781 | 24 | 11.2 | J-692 |
| J-386 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.7 | 10.6 | J-692 |
| J-387 | 8,951 | TRUE | Passed | 500 | 8,952 | 24 | 13.1 | J-692 |
| J-388 | 6,738 | TRUE | Passed | 500 | 6,739 | 24 | 17.5 | J-692 |
| J-389 | 5,282 | TRUE | Passed | 500 | 5,283 | 24 | 19.9 | J-692 |
| J-390 | 1,968 | TRUE | Passed | 500 | 1,969 | 24 | 23.7 | J-692 |
| J-391 | 7,126 | TRUE | Passed | 500 | 7,127 | 24 | 16.6 | J-692 |
| J-392 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.1 | 10.2 | J-692 |
| J-393 | 7,928 | TRUE | Passed | 500 | 7,929 | 24 | 15.1 | J-692 |
| J-394 | 9,331 | TRUE | Passed | 500 | 9,332 | 24 | 12 | J-692 |
| J-395 | 9,500 | TRUE | Passed | 500 | 9,501 | 24 | 11.6 | J-692 |
| J-396 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.8 | 10.2 | J-692 |
| J-397 | 6,482 | TRUE | Passed | 500 | 6,483 | 24 | 17.6 | J-692 |
| J-398 | 1,751 | TRUE | Passed | 500 | 1,752 | 24 | 23.8 | J-692 |
| J-399 | 10,000 | TRUE | Passed | 500 | 10,001 | 66.7 | 9.7 | J-692 |
| J-401 | 3,497 | TRUE | Passed | 500 | 3,498 | 24 | 12.8 | J-692 |
| J-401 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.3 | 10.4 | J-692 |
| J-402 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.1 | 10.3 | J-692 |
| J-403 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.7 | 10.4 | J-692 |
| J-404 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.3 | 11.4 | J-692 |
| J-405 | 4,732 | TRUE | Passed | 500 | 4,733 | 24 | 20.6 | J-692 |
| J-406 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.7 | 10.3 | J-692 |
| J-407 | 10,000 | TRUE | Passed | 500 | 10,001 | 66.1 | 10.2 | J-692 |
| J-408 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.6 | 10.2 | J-692 |
| J-409 | 3,527 | TRUE | Passed | 500 | 3,528 | 24 | 22.1 | J-692 |
| J-410 | 10,000 | TRUE | Passed | 500 | 10,001 | 53 | 10.2 | J-692 |
| J-411 | 3,593 | TRUE | Passed | 500 | 3,594 | 24 | 22 | J-692 |
| J-412 | 10,000 | TRUE | Passed | 500 | 10,001 | 57.6 | 10.2 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-413 | 10,000 | TRUE | Passed | 500 | 10,001 | 64 | 10 | J-692 |
| J-414 | 10,000 | TRUE | Passed | 500 | 10,001 | 60.1 | 8.4 | J-692 |
| J-415 | 2,020 | TRUE | Passed | 500 | 2,021 | 24 | 23.4 | J-692 |
| J-416 | 10,000 | TRUE | Passed | 500 | 10,001 | 60.6 | 10 | J-692 |
| J-417 | 10,000 | TRUE | Passed | 500 | 10,001 | 56.7 | 10.2 | J-692 |
| J-418 | 5,569 | TRUE | Passed | 500 | 5,570 | 24 | 19.5 | J-692 |
| J-419 | 3,532 | TRUE | Passed | 500 | 3,533 | 24 | 22.2 | J-692 |
| J-420 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.8 | 11.4 | J-692 |
| J-421 | 9,670 | TRUE | Passed | 500 | 9,671 | 24 | 11.8 | J-692 |
| J-422 | 7,093 | TRUE | Passed | 500 | 7,094 | 24 | 16.9 | J-692 |
| J-423 | 9,574 | TRUE | Passed | 500 | 9,575 | 24 | 11.9 | J-692 |
| J-424 | 4,952 | TRUE | Passed | 500 | 4,953 | 24 | 20.3 | J-692 |
| J-425 | 4,238 | TRUE | Passed | 500 | 4,239 | 24 | 21.2 | J-692 |
| J-426 | 9,569 | TRUE | Passed | 500 | 9,570 | 24 | 11.5 | J-692 |
| J-427 | 8,133 | TRUE | Passed | 500 | 8,134 | 24 | 14.7 | J-692 |
| J-428 | 9,705 | TRUE | Passed | 500 | 9,706 | 24 | 11.5 | J-692 |
| J-429 | 9,675 | TRUE | Passed | 500 | 9,676 | 24 | 11.5 | J-692 |
| J-430 | 4,074 | TRUE | Passed | 500 | 4,075 | 24 | 21.5 | J-692 |
| J-431 | 7,536 | TRUE | Passed | 500 | 7,537 | 24 | 16 | J-692 |
| J-432 | 2,373 | TRUE | Passed | 500 | 2,374 | 24 | 23.3 | J-692 |
| J-433 | 4,001 | TRUE | Passed | 500 | 4,002 | 24 | 18.3 | J-692 |
| J-434 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 24.2 | J-692 |
| J-435 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 24.2 | J-692 |
| J-436 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.9 | 23.5 | J-692 |
| J-437 | 9,481 | TRUE | Passed | 500 | 9,482 | 24 | 21.7 | J-692 |
| J-439 | 9,834 | TRUE | Passed | 500 | 9,835 | 24 | 20.1 | J-692 |
| J-440 | 9,385 | TRUE | Passed | 500 | 9,386 | 24 | 20.1 | J-692 |
| J-442 | 8,766 | TRUE | Passed | 500 | 8,767 | 24 | 20.2 | J-692 |
| J-443 | 2,234 | TRUE | Passed | 500 | 2,235 | 24 | 24.2 | J-692 |
| J-445 | 9,910 | TRUE | Passed | 500 | 9,911 | 24 | 19.1 | J-692 |
| J-447 | 6,520 | TRUE | Passed | 500 | 6,521 | 24 | 21.5 | J-692 |
| J-448 | 5,174 | TRUE | Passed | 500 | 5,175 | 24 | 22.5 | J-692 |
| J-449 | 6,184 | TRUE | Passed | 500 | 6,185 | 24 | 17.5 | J-450 |
| J-450 | 4,252 | TRUE | Passed | 500 | 4,253 | 24 | 23.1 | J-692 |
| J-451 | 6,030 | TRUE | Passed | 500 | 6,031 | 24 | 21.8 | J-692 |
| J-452 | 5,506 | TRUE | Passed | 500 | 5,507 | 24 | 22.1 | J-692 |
| J-453 | 5,072 | TRUE | Passed | 500 | 5,073 | 24 | 22.5 | J-692 |
| J-454 | 4,893 | TRUE | Passed | 500 | 4,894 | 24 | 22.6 | J-692 |
| J-455 | 6,643 | TRUE | Passed | 500 | 6,644 | 24 | 21.4 | J-692 |
| J-456 | 6,565 | TRUE | Passed | 500 | 6,566 | 24 | 21.4 | J-692 |
| J-457 | 5,253 | TRUE | Passed | 500 | 5,254 | 24 | 22.3 | J-692 |
| J-458 | 3,037 | TRUE | Passed | 500 | 3,038 | 24 | 23.7 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-459 | 2,960 | TRUE | Passed | 500 | 2,961 | 24 | 23.7 | J-692 |
| J-460 | 4,021 | TRUE | Passed | 500 | 4,022 | 24 | 23 | J-692 |
| J-461 | 1,663 | TRUE | Passed | 500 | 1,664 | 24 | 23.4 | J-463 |
| J-462 | 1,456 | TRUE | Passed | 500 | 1,457 | 24 | 24.4 | J-692 |
| J-463 | 1,339 | TRUE | Passed | 500 | 1,340 | 24 | 24.4 | J-692 |
| J-464 | 5,276 | TRUE | Passed | 500 | 5,277 | 24 | 22.2 | J-692 |
| J-465 | 5,421 | TRUE | Passed | 500 | 5,422 | 24 | 22.1 | J-692 |
| J-466 | 5,721 | TRUE | Passed | 500 | 5,722 | 24 | 21.8 | J-692 |
| J-467 | 6,423 | TRUE | Passed | 500 | 6,424 | 24 | 21.2 | J-692 |
| J-468 | 6,333 | TRUE | Passed | 500 | 6,334 | 24 | 21.2 | J-692 |
| J-469 | 6,909 | TRUE | Passed | 500 | 6,910 | 24 | 20.6 | J-692 |
| J-470 | 8,298 | TRUE | Passed | 500 | 8,299 | 24 | 18.5 | J-692 |
| J-471 | 10,000 | TRUE | Passed | 500 | 10,001 | 38.3 | 16 | J-692 |
| J-472 | 7,103 | TRUE | Passed | 500 | 7,104 | 24 | 20.1 | J-692 |
| J-473 | 6,561 | TRUE | Passed | 500 | 6,562 | 24 | 20.9 | J-692 |
| J-474 | 6,000 | TRUE | Passed | 500 | 6,001 | 24 | 21.4 | J-692 |
| J-475 | 5,650 | TRUE | Passed | 500 | 5,651 | 24 | 21.8 | J-692 |
| J-476 | 2,363 | TRUE | Passed | 500 | 2,364 | 24 | 24 | J-692 |
| J-477 | 2,390 | TRUE | Passed | 500 | 2,391 | 24 | 23.9 | J-692 |
| J-478 | 5,572 | TRUE | Passed | 500 | 5,573 | 24 | 21.9 | J-692 |
| J-479 | 5,715 | TRUE | Passed | 500 | 5,717 | 24 | 21.9 | J-692 |
| J-480 | 6,074 | TRUE | Passed | 500 | 6,075 | 24 | 21.7 | J-692 |
| J-481 | 6,460 | TRUE | Passed | 500 | 6,461 | 24 | 21.4 | J-692 |
| J-482 | 3,327 | TRUE | Passed | 500 | 3,328 | 24 | 19.8 | J-485 |
| J-483 | 2,058 | TRUE | Passed | 500 | 2,059 | 24 | 22.8 | J-485 |
| J-484 | 1,892 | TRUE | Passed | 500 | 1,893 | 24 | 24.3 | J-692 |
| J-485 | 1,539 | TRUE | Passed | 500 | 1,540 | 24 | 24.4 | J-692 |
| J-486 | 9,665 | TRUE | Passed | 500 | 9,666 | 24 | 19.2 | J-692 |
| J-487 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.5 | 19.8 | J-692 |
| J-489 | 10,000 | TRUE | Passed | 500 | 10,001 | 52.1 | 22 | J-692 |
| J-490 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.4 | 21.4 | J-692 |
| J-491 | 10,000 | TRUE | Passed | 500 | 10,001 | 63 | 24.3 | J-692 |
| J-492 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.5 | 21.1 | J-692 |
| J-493 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.2 | 20.4 | J-692 |
| J-494 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.1 | 20.5 | J-692 |
| J-497 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.4 | 17.9 | J-692 |
| J-498 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.7 | 19.7 | J-692 |
| J-499 | 10,000 | TRUE | Passed | 500 | 10,001 | 41 | 19.8 | J-692 |
| J-500 | 6,989 | TRUE | Passed | 500 | 6,990 | 24 | 21.9 | J-692 |
| J-501 | 10,000 | TRUE | Passed | 500 | 10,001 | 43 | 20.6 | J-692 |
| J-502 | 7,271 | TRUE | Passed | 500 | 7,272 | 24 | 21.5 | J-692 |
| J-504 | 5,239 | TRUE | Passed | 500 | 5,240 | 24 | 22.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-505 | 4,735 | TRUE | Passed | 500 | 4,736 | 24 | 22.9 | J-692 |
| J-507 | 4,666 | TRUE | Passed | 500 | 4,667 | 24 | 22.6 | J-692 |
| J-508 | 4,688 | TRUE | Passed | 500 | 4,689 | 24 | 22.6 | J-692 |
| J-509 | 5,428 | TRUE | Passed | 500 | 5,429 | 24 | 22.1 | J-692 |
| J-510 | 6,129 | TRUE | Passed | 500 | 6,130 | 24 | 22.4 | J-692 |
| J-511 | 2,401 | TRUE | Passed | 500 | 2,402 | 24 | 24.2 | J-692 |
| J-513 | 2,452 | TRUE | Passed | 500 | 2,453 | 24 | 24.2 | J-692 |
| J-514 | 2,767 | TRUE | Passed | 500 | 2,768 | 24 | 23.3 | J-513 |
| J-516 | 5,372 | TRUE | Passed | 500 | 5,373 | 24 | 22.3 | J-692 |
| J-517 | 5,757 | TRUE | Passed | 500 | 5,758 | 24 | 21.8 | J-692 |
| J-518 | 5,233 | TRUE | Passed | 500 | 5,234 | 24 | 20.2 | J-549 |
| J-519 | 5,742 | TRUE | Passed | 500 | 5,743 | 24 | 21.8 | J-692 |
| J-520 | 4,770 | TRUE | Passed | 500 | 4,771 | 24 | 21.9 | J-692 |
| J-521 | 3,954 | TRUE | Passed | 500 | 3,955 | 24 | 22.5 | J-692 |
| J-522 | 4,084 | TRUE | Passed | 500 | 4,085 | 24 | 21.5 | J-603 |
| J-523 | 4,451 | TRUE | Passed | 500 | 4,452 | 24 | 21.9 | J-603 |
| J-524 | 4,322 | TRUE | Passed | 500 | 4,323 | 24 | 22.2 | J-692 |
| J-525 | 4,782 | TRUE | Passed | 500 | 4,783 | 24 | 21.8 | J-692 |
| J-526 | 4,659 | TRUE | Passed | 500 | 4,660 | 24 | 22 | J-692 |
| J-527 | 4,704 | TRUE | Passed | 500 | 4,705 | 24 | 21.8 | J-692 |
| J-528 | 4,377 | TRUE | Passed | 500 | 4,378 | 24 | 22.1 | J-692 |
| J-529 | 4,593 | TRUE | Passed | 500 | 4,594 | 24 | 21.8 | J-692 |
| J-530 | 4,632 | TRUE | Passed | 500 | 4,633 | 24 | 21.8 | J-692 |
| J-531 | 2,974 | TRUE | Passed | 500 | 2,975 | 24 | 23.2 | J-692 |
| J-532 | 3,215 | TRUE | Passed | 500 | 3,216 | 24 | 23.1 | J-692 |
| J-533 | 8,362 | TRUE | Passed | 500 | 8,363 | 24 | 16.7 | J-692 |
| J-534 | 9,267 | TRUE | Passed | 500 | 9,268 | 24 | 15.4 | J-692 |
| J-535 | 8,623 | TRUE | Passed | 500 | 8,624 | 24 | 16.4 | J-692 |
| J-536 | 7,744 | TRUE | Passed | 500 | 7,745 | 24 | 17.8 | J-692 |
| J-537 | 8,875 | TRUE | Passed | 500 | 8,876 | 24 | 15.9 | J-692 |
| J-538 | 9,483 | TRUE | Passed | 500 | 9,484 | 24 | 14.5 | J-692 |
| J-539 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.3 | 13.3 | J-692 |
| J-540 | 3,162 | TRUE | Passed | 500 | 3,163 | 24 | 23 | J-692 |
| J-541 | 3,405 | TRUE | Passed | 500 | 3,406 | 24 | 22.9 | J-692 |
| J-542 | 6,825 | TRUE | Passed | 500 | 6,826 | 24 | 19.6 | J-692 |
| J-543 | 9,228 | TRUE | Passed | 500 | 9,229 | 24 | 16.7 | J-692 |
| J-544 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.8 | 16.4 | J-692 |
| J-545 | 5,692 | TRUE | Passed | 500 | 5,693 | 24 | 21.5 | J-692 |
| J-546 | 2,193 | TRUE | Passed | 500 | 2,194 | 24 | 24 | J-692 |
| J-547 | 5,318 | TRUE | Passed | 500 | 5,320 | 24 | 22 | J-692 |
| J-548 | 1,891 | TRUE | Passed | 500 | 1,892 | 24 | 24.2 | J-692 |
| J-549 | 1,755 | TRUE | Passed | 500 | 1,756 | 24 | 24.3 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-550 | 4,723 | TRUE | Passed | 500 | 4,724 | 24 | 22.6 | J-692 |
| J-551 | 3,123 | TRUE | Passed | 500 | 3,124 | 24 | 23.6 | J-692 |
| J-552 | 2,514 | TRUE | Passed | 500 | 2,515 | 24 | 23.9 | J-692 |
| J-553 | 4,964 | TRUE | Passed | 500 | 4,965 | 24 | 22.9 | J-692 |
| J-554 | 2,900 | TRUE | Passed | 500 | 2,901 | 24 | 23.9 | J-692 |
| J-555 | 10,000 | TRUE | Passed | 500 | 10,001 | 32 | 16.2 | J-692 |
| J-556 | 4,237 | TRUE | Passed | 500 | 4,238 | 24 | 22.5 | J-692 |
| J-557 | 3,738 | TRUE | Passed | 500 | 3,739 | 24 | 22.9 | J-692 |
| J-558 | 1,900 | TRUE | Passed | 500 | 1,901 | 24 | 24.1 | J-692 |
| J-559 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.2 | 16.8 | J-692 |
| J-560 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.7 | 17.6 | J-692 |
| J-561 | 3,849 | TRUE | Passed | 500 | 3,850 | 24 | 22.7 | J-692 |
| J-562 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.8 | 16.5 | J-692 |
| J-563 | 2,988 | TRUE | Passed | 500 | 2,989 | 24 | 23.2 | J-692 |
| J-564 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.8 | 14.2 | J-692 |
| J-565 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.8 | 15.3 | J-692 |
| J-566 | 8,554 | TRUE | Passed | 500 | 8,555 | 24 | 16.3 | J-692 |
| J-567 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.7 | 13.3 | J-692 |
| J-568 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.2 | 11.7 | J-692 |
| J-569 | 8,230 | TRUE | Passed | 500 | 8,231 | 24 | 15.5 | J-692 |
| J-570 | 7,234 | TRUE | Passed | 500 | 7,235 | 24 | 17.5 | J-692 |
| J-571 | 8,398 | TRUE | Passed | 500 | 8,399 | 24 | 14.4 | J-692 |
| J-572 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.5 | 9.9 | J-692 |
| J-573 | 8,046 | TRUE | Passed | 500 | 8,047 | 24 | 10.1 | J-692 |
| J-574 | 9,438 | TRUE | Passed | 500 | 9,439 | 24 | 11.9 | J-692 |
| J-576 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.8 | 12.3 | J-692 |
| J-577 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.3 | 12.9 | J-692 |
| J-578 | 3,358 | TRUE | Passed | 500 | 3,359 | 24 | 22.8 | J-692 |
| J-579 | 4,432 | TRUE | Passed | 500 | 4,433 | 24 | 21.8 | J-692 |
| J-580 | 4,483 | TRUE | Passed | 500 | 4,484 | 24 | 21.9 | J-692 |
| J-581 | 4,226 | TRUE | Passed | 500 | 4,227 | 24 | 21.9 | J-692 |
| J-582 | 6,664 | TRUE | Passed | 500 | 6,665 | 24 | 18.9 | J-692 |
| J-583 | 7,210 | TRUE | Passed | 500 | 7,211 | 24 | 18 | J-692 |
| J-584 | 8,184 | TRUE | Passed | 500 | 8,185 | 24 | 16.5 | J-692 |
| J-585 | 6,294 | TRUE | Passed | 500 | 6,295 | 24 | 19.2 | J-692 |
| J-587 | 5,841 | TRUE | Passed | 500 | 5,842 | 24 | 19.8 | J-692 |
| J-588 | 5,476 | TRUE | Passed | 500 | 5,477 | 24 | 20.3 | J-692 |
| J-589 | 5,618 | TRUE | Passed | 500 | 5,619 | 24 | 20.1 | J-692 |
| J-590 | 7,068 | TRUE | Passed | 500 | 7,069 | 24 | 18.1 | J-692 |
| J-591 | 6,491 | TRUE | Passed | 500 | 6,492 | 24 | 18.9 | J-692 |
| J-592 | 6,268 | TRUE | Passed | 500 | 6,269 | 24 | 19.7 | J-692 |
| J-593 | 4,630 | TRUE | Passed | 500 | 4,631 | 24 | 21.8 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-594 | 4,483 | TRUE | Passed | 500 | 4,484 | 24 | 20.3 | J-596 |
| J-595 | 3,650 | TRUE | Passed | 500 | 3,651 | 24 | 21.3 | J-596 |
| J-596 | 3,100 | TRUE | Passed | 500 | 3,101 | 24 | 23.2 | J-692 |
| J-597 | 3,207 | TRUE | Passed | 500 | 3,208 | 24 | 23.1 | J-692 |
| J-598 | 3,291 | TRUE | Passed | 500 | 3,292 | 24 | 23 | J-692 |
| J-599 | 3,486 | TRUE | Passed | 500 | 3,487 | 24 | 22.9 | J-692 |
| J-601 | 3,064 | TRUE | Passed | 500 | 3,066 | 24 | 23.2 | J-692 |
| J-602 | 4,396 | TRUE | Passed | 500 | 4,397 | 24 | 22.1 | J-692 |
| J-603 | 2,350 | TRUE | Passed | 500 | 2,351 | 24 | 23.7 | J-692 |
| J-604 | 4,409 | TRUE | Passed | 500 | 4,410 | 24 | 22.1 | J-692 |
| J-605 | 3,259 | TRUE | Passed | 500 | 3,260 | 24 | 23.1 | J-692 |
| J-606 | 3,377 | TRUE | Passed | 500 | 3,378 | 24 | 23 | J-692 |
| J-607 | 4,246 | TRUE | Passed | 500 | 4,247 | 24 | 22.2 | J-692 |
| J-608 | 4,375 | TRUE | Passed | 500 | 4,376 | 24 | 22.1 | J-692 |
| J-609 | 4,464 | TRUE | Passed | 500 | 4,465 | 24 | 22 | J-692 |
| J-610 | 4,390 | TRUE | Passed | 500 | 4,391 | 24 | 22.1 | J-692 |
| J-611 | 4,690 | TRUE | Passed | 500 | 4,691 | 24 | 21.8 | J-692 |
| J-612 | 4,161 | TRUE | Passed | 500 | 4,162 | 24 | 22.3 | J-692 |
| J-613 | 4,289 | TRUE | Passed | 500 | 4,290 | 24 | 22.1 | J-692 |
| J-614 | 6,497 | TRUE | Passed | 500 | 6,498 | 24 | 19.5 | J-692 |
| J-615 | 6,786 | TRUE | Passed | 500 | 6,787 | 24 | 19.1 | J-692 |
| J-616 | 6,940 | TRUE | Passed | 500 | 6,941 | 24 | 18.9 | J-692 |
| J-617 | 6,825 | TRUE | Passed | 500 | 6,826 | 24 | 18.3 | J-692 |
| J-620 | 7,796 | TRUE | Passed | 500 | 7,797 | 24 | 16.7 | J-692 |
| J-621 | 9,536 | TRUE | Passed | 500 | 9,537 | 24 | 13.5 | J-692 |
| J-622 | 9,141 | TRUE | Passed | 500 | 9,142 | 24 | 14.4 | J-692 |
| J-623 | 9,209 | TRUE | Passed | 500 | 9,210 | 24 | 13.8 | J-692 |
| J-625 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.6 | 12.2 | J-692 |
| J-626 | 8,970 | TRUE | Passed | 500 | 8,971 | 24 | 14.8 | J-692 |
| J-627 | 8,919 | TRUE | Passed | 500 | 8,920 | 24 | 15 | J-692 |
| J-628 | 9,147 | TRUE | Passed | 500 | 9,148 | 24 | 14.6 | J-692 |
| J-629 | 9,605 | TRUE | Passed | 500 | 9,606 | 24 | 13.8 | J-692 |
| J-630 | 9,811 | TRUE | Passed | 500 | 9,812 | 24 | 13.4 | J-692 |
| J-631 | 9,896 | TRUE | Passed | 500 | 9,897 | 24 | 13.3 | J-692 |
| J-632 | 5,317 | TRUE | Passed | 500 | 5,318 | 24 | 20.3 | J-692 |
| J-633 | 3,182 | TRUE | Passed | 500 | 3,183 | 24 | 22.7 | J-692 |
| J-634 | 8,166 | TRUE | Passed | 500 | 8,167 | 24 | 15.9 | J-692 |
| J-636 | 10,000 | TRUE | Passed | 500 | 10,001 | 28 | 13.1 | J-692 |
| J-637 | 3,862 | TRUE | Passed | 500 | 3,863 | 24 | 22.2 | J-692 |
| J-638 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.9 | 13.2 | J-692 |
| J-639 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.3 | 12.7 | J-692 |
| J-640 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.8 | 12.8 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-641 | 5,712 | TRUE | Passed | 500 | 5,713 | 24 | 20.1 | J-692 |
| J-642 | 4,145 | TRUE | Passed | 500 | 4,146 | 24 | 22 | J-692 |
| J-643 | 3,184 | TRUE | Passed | 500 | 3,185 | 24 | 23 | J-692 |
| J-644 | 5,453 | TRUE | Passed | 500 | 5,454 | 24 | 21 | J-692 |
| J-645 | 2,778 | TRUE | Passed | 500 | 2,779 | 24 | 23.4 | J-692 |
| J-646 | 7,538 | TRUE | Passed | 500 | 7,539 | 24 | 18.4 | J-692 |
| J-647 | 4,933 | TRUE | Passed | 500 | 4,934 | 24 | 21.4 | J-692 |
| J-648 | 3,037 | TRUE | Passed | 500 | 3,038 | 24 | 23.1 | J-692 |
| J-649 | 3,759 | TRUE | Passed | 500 | 3,760 | 24 | 22.6 | J-692 |
| J-650 | 1,897 | TRUE | Passed | 500 | 1,898 | 24 | 24 | J-692 |
| J-651 | 8,014 | TRUE | Passed | 500 | 8,015 | 24 | 18 | J-692 |
| J-652 | 3,103 | TRUE | Passed | 500 | 3,104 | 24 | 23.2 | J-692 |
| J-655 | 7,486 | TRUE | Passed | 500 | 7,487 | 24 | 18.2 | J-692 |
| J-656 | 3,620 | TRUE | Passed | 500 | 3,621 | 24 | 22.6 | J-692 |
| J-657 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.2 | 11.7 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.8 | 12.1 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.1 | 11.5 | J-692 |
| J-660 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.3 | 11.4 | J-692 |
| J-661 | 833 | TRUE | Passed | 500 | 837 | 24 | 24.5 | J-692 |
| J-662 | 10,000 | TRUE | Passed | 500 | 10,001 | 53.4 | 11 | J-692 |
| J-663 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.6 | 11.5 | J-692 |
| J-664 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.8 | 12.3 | J-692 |
| J-665 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.1 | 12.6 | J-692 |
| J-666 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.1 | 18.6 | J-692 |
| J-667 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.7 | 18.4 | J-692 |
| J-668 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.7 | 20.4 | J-692 |
| J-669 | 4,466 | TRUE | Passed | 500 | 4,467 | 24 | 22 | J-692 |
| J-670 | 5,065 | TRUE | Passed | 500 | 5,066 | 24 | 21.4 | J-692 |
| J-673 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.5 | 11.8 | J-692 |
| J-674 | 4,282 | TRUE | Passed | 500 | 4,283 | 24 | 21.4 | J-692 |
| J-675 | 4,003 | TRUE | Passed | 500 | 4,004 | 24 | 21.6 | J-692 |
| J-676 | 5,641 | TRUE | Passed | 500 | 5,642 | 24 | 19.3 | J-692 |
| J-677 | 2,524 | TRUE | Passed | 500 | 2,525 | 24 | 23.2 | J-692 |
| J-678 | 1,887 | TRUE | Passed | 500 | 1,888 | 24 | 23.7 | J-692 |
| J-680 | 5,568 | TRUE | Passed | 500 | 5,568 | 24 | 4.5 | J-692 |
| J-682 | 4,561 | TRUE | Passed | 500 | 4,561 | 24 | 8.8 | J-692 |
| J-685 | 1,368 | TRUE | Passed | 500 | 1,393 | 24 | 20.4 | J-692 |
| J-686 | 3,840 | TRUE | Passed | 500 | 3,890 | 24 | 5.6 | J-692 |
| J-687 | 4,833 | TRUE | Passed | 500 | 4,858 | 24 | 3.9 | J-692 |
| J-689 | 6,414 | TRUE | Passed | 500 | 6,439 | 24 | 9.4 | J-692 |
| J-690 | 6,025 | TRUE | Passed | 500 | 6,050 | 25.3 | 0 | J-692 |
| J-691 | 4,983 | TRUE | Passed | 500 | 5,008 | 28.8 | 0 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-692 | 382 | FALSE | dual Pressure F | 500 | 382 | 24 | 25.9 | J-695 |
| J-693 | 4,504 | TRUE | Passed | 500 | 4,529 | 24 | 11.2 | J-692 |
| J-694 | 3,776 | TRUE | Passed | 500 | 3,801 | 24 | 7.1 | J-695 |
| J-695 | 752 | TRUE | Passed | 500 | 777 | 24 | 23.2 | J-692 |
| J-696 | 4,466 | TRUE | Passed | 500 | 4,471 | 24 | 17.5 | J-692 |
| J-697 | 5,418 | TRUE | Passed | 500 | 5,418 | 24 | 1.7 | J-692 |
| J-698 | 5,147 | TRUE | Passed | 500 | 5,172 | 24 | 13.1 | J-692 |
| J-699 | 8,033 | TRUE | Passed | 500 | 8,058 | 24 | 4.2 | J-692 |
| J-700 | 4,849 | TRUE | Passed | 500 | 4,874 | 24 | 12.4 | J-692 |
| J-702 | 4,040 | TRUE | Passed | 500 | 4,040 | 24 | 8.7 | J-692 |
| J-714 | 4,933 | TRUE | Passed | 500 | 4,933 | 24 | 22.7 | J-692 |
| J-715 | 2,506 | TRUE | Passed | 500 | 2,506 | 24 | 23.3 | J-692 |
| J-716 | 3,407 | TRUE | Passed | 500 | 3,407 | 24 | 21.6 | J-692 |
| J-717 | 3,354 | TRUE | Passed | 500 | 3,354 | 24 | 21.6 | J-692 |
| J-718 | 3,469 | TRUE | Passed | 500 | 3,469 | 24 | 21.2 | J-692 |
| J-719 | 8,222 | TRUE | Passed | 500 | 8,222 | 24 | 20.8 | J-692 |
| J-720 | 4,003 | TRUE | Passed | 500 | 4,003 | 24 | 22.4 | J-692 |
| J-721 | 4,848 | TRUE | Passed | 500 | 4,848 | 24 | 17.7 | J-692 |
| J-722 | 3,084 | TRUE | Passed | 500 | 3,084 | 24 | 22.5 | J-692 |
| J-723 | 5,279 | TRUE | Passed | 500 | 5,279 | 24 | 20.3 | J-692 |
| J-724 | 7,349 | TRUE | Passed | 500 | 7,349 | 24 | 20.7 | J-692 |
| J-725 | 6,257 | TRUE | Passed | 500 | 6,257 | 24 | 21.7 | J-692 |
| J-726 | 6,762 | TRUE | Passed | 500 | 6,762 | 24 | 21.7 | J-692 |
| J-727 | 10,000 | TRUE | Passed | 500 | 10,000 | 25.5 | 22 | J-692 |
| J-729 | 7,151 | TRUE | Passed | 500 | 7,151 | 24 | 21.8 | J-692 |
| J-731 | 6,051 | TRUE | Passed | 500 | 6,052 | 24 | 20.2 | J-692 |
| J-904 | 7,222 | TRUE | Passed | 500 | 7,223 | 24 | 15.4 | J-692 |
| J-1031 | 9,995 | TRUE | Passed | 500 | 9,996 | 24 | 10.6 | J-692 |
| J-1082 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.3 | 10.9 | J-692 |
| J-1184 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.7 | 21.1 | J-692 |
| J-1201 | 8,707 | TRUE | Passed | 500 | 8,708 | 24 | 19.8 | J-692 |
| J-1296 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.4 | 20.3 | J-692 |
| J-1334 | 6,158 | TRUE | Passed | 500 | 6,159 | 24 | 22 | J-692 |
| J-1340 | 4,261 | TRUE | Passed | 500 | 4,262 | 24 | 23 | J-692 |
| J-1549 | 3,109 | TRUE | Passed | 500 | 3,110 | 24 | 23.2 | J-692 |
| J-1642 | 9,188 | TRUE | Passed | 500 | 9,189 | 24 | 14.1 | J-692 |
| J-1704 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.8 | 12 | J-692 |
| J-1780 | 6,896 | TRUE | Passed | 500 | 6,896 | 24 | 21.2 | J-692 |
| J-1806 | 3,552 | TRUE | Passed | 500 | 3,552 | 24 | 14.8 | J-692 |
| **Scenario 8: 16-Inch North Expansion** | | | | | | | | |
| Note: Minimum residual pressure was lowered to 24 psi so that fire flow scenarios could be run. | | | | | | | | |
| 1-FLOW | 9,414 | TRUE | Passed | 500 | 9,415 | 24 | 19.5 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| 1-RES | 3,310 | TRUE | Passed | 500 | 3,314 | 24 | 23.8 | J-692 |
| 2-FLOW | 8,789 | TRUE | Passed | 500 | 8,790 | 24 | 20.1 | J-692 |
| 2-RES | 4,508 | TRUE | Passed | 500 | 4,509 | 24 | 23.1 | J-692 |
| 3-FLOW | 3,036 | TRUE | Passed | 500 | 3,037 | 24 | 23.2 | J-692 |
| 3-RES | 2,588 | TRUE | Passed | 500 | 2,589 | 24 | 23.6 | J-692 |
| 4-FLOW | 3,670 | TRUE | Passed | 500 | 3,671 | 24 | 23.1 | J-692 |
| 4-RES | 2,649 | TRUE | Passed | 500 | 2,650 | 24 | 23.8 | J-692 |
| 5-FLOW | 4,505 | TRUE | Passed | 500 | 4,506 | 24 | 19.1 | J-692 |
| 5-RES | 2,148 | TRUE | Passed | 500 | 2,149 | 24 | 23 | J-692 |
| 6-FLOW | 2,157 | TRUE | Passed | 500 | 2,158 | 24 | 23.9 | J-692 |
| 6-RES | 1,398 | TRUE | Passed | 500 | 1,399 | 24 | 24.3 | J-692 |
| 7-FLOW | 2,385 | TRUE | Passed | 500 | 2,386 | 24 | 22.8 | J-692 |
| 7-RES | 2,139 | TRUE | Passed | 500 | 2,140 | 24 | 23.1 | J-692 |
| J-1 | 5,914 | TRUE | Passed | 500 | 5,915 | 24 | 17.8 | J-692 |
| J-2 | 8,151 | TRUE | Passed | 500 | 8,152 | 24 | 14.3 | J-692 |
| J-3 | 8,735 | TRUE | Passed | 500 | 8,736 | 24 | 14.6 | J-692 |
| J-11 | 9,299 | TRUE | Passed | 500 | 9,300 | 24 | 14.7 | J-692 |
| J-12 | 9,003 | TRUE | Passed | 500 | 9,004 | 24 | 13.8 | J-692 |
| J-13 | 5,301 | TRUE | Passed | 500 | 5,303 | 24 | 19.6 | J-692 |
| J-14 | 4,224 | TRUE | Passed | 500 | 4,225 | 24 | 21.2 | J-692 |
| J-15 | 8,365 | TRUE | Passed | 500 | 8,366 | 24 | 14.3 | J-692 |
| J-17 | 6,637 | TRUE | Passed | 500 | 6,638 | 24 | 17.1 | J-692 |
| J-18 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.6 | 22.5 | J-692 |
| J-19 | 10,000 | TRUE | Passed | 500 | 10,001 | 26 | 17.2 | J-692 |
| J-20 | 4,544 | TRUE | Passed | 500 | 4,545 | 24 | 22.4 | J-692 |
| J-21 | 4,648 | TRUE | Passed | 500 | 4,649 | 24 | 22.3 | J-692 |
| J-22 | 2,217 | TRUE | Passed | 500 | 2,218 | 24 | 24 | J-692 |
| J-23 | 4,096 | TRUE | Passed | 500 | 4,097 | 24 | 22.7 | J-692 |
| J-24 | 2,082 | TRUE | Passed | 500 | 2,083 | 24 | 24 | J-692 |
| J-25 | 3,645 | TRUE | Passed | 500 | 3,646 | 24 | 23 | J-692 |
| J-26 | 2,010 | TRUE | Passed | 500 | 2,011 | 24 | 24.1 | J-692 |
| J-27 | 3,751 | TRUE | Passed | 500 | 3,752 | 24 | 22.9 | J-692 |
| J-28 | 2,314 | TRUE | Passed | 500 | 2,315 | 24 | 23.9 | J-692 |
| J-29 | 4,083 | TRUE | Passed | 500 | 4,084 | 24 | 22.6 | J-692 |
| J-30 | 7,221 | TRUE | Passed | 500 | 7,222 | 24 | 18.9 | J-692 |
| J-31 | 2,909 | TRUE | Passed | 500 | 2,910 | 24 | 22.5 | J-692 |
| J-33 | 3,205 | TRUE | Passed | 500 | 3,206 | 24 | 22.2 | J-692 |
| J-34 | 3,133 | TRUE | Passed | 500 | 3,134 | 24 | 22.3 | J-692 |
| J-35 | 3,911 | TRUE | Passed | 500 | 3,912 | 24 | 21.2 | J-692 |
| J-36 | 5,454 | TRUE | Passed | 500 | 5,456 | 24 | 18.6 | J-692 |
| J-37 | 6,056 | TRUE | Passed | 500 | 6,057 | 24 | 18.2 | J-692 |
| J-38 | 5,861 | TRUE | Passed | 500 | 5,862 | 24 | 17.4 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-39 | 4,932 | TRUE | Passed | 500 | 4,933 | 24 | 19.7 | J-692 |
| J-40 | 4,858 | TRUE | Passed | 500 | 4,859 | 24 | 19.7 | J-692 |
| J-41 | 5,918 | TRUE | Passed | 500 | 5,919 | 24 | 17.3 | J-692 |
| J-42 | 3,471 | TRUE | Passed | 500 | 3,472 | 24 | 21.2 | J-692 |
| J-43 | 5,182 | TRUE | Passed | 500 | 5,183 | 24 | 18 | J-692 |
| J-44 | 2,553 | TRUE | Passed | 500 | 2,554 | 24 | 22.6 | J-692 |
| J-45 | 2,732 | TRUE | Passed | 500 | 2,733 | 24 | 22.3 | J-692 |
| J-46 | 3,612 | TRUE | Passed | 500 | 3,613 | 24 | 20.9 | J-692 |
| J-47 | 2,290 | TRUE | Passed | 500 | 2,291 | 24 | 22.9 | J-692 |
| J-48 | 3,050 | TRUE | Passed | 500 | 3,051 | 24 | 21.2 | J-47 |
| J-49 | 3,603 | TRUE | Passed | 500 | 3,604 | 24 | 21 | J-692 |
| J-50 | 2,721 | TRUE | Passed | 500 | 2,722 | 24 | 22.4 | J-692 |
| J-51 | 1,160 | TRUE | Passed | 500 | 1,161 | 24 | 24.1 | J-692 |
| J-52 | 2,969 | TRUE | Passed | 500 | 2,970 | 24 | 20.7 | J-51 |
| J-53 | 2,474 | TRUE | Passed | 500 | 2,475 | 24 | 22.6 | J-692 |
| J-54 | 2,679 | TRUE | Passed | 500 | 2,680 | 24 | 22.3 | J-692 |
| J-55 | 2,149 | TRUE | Passed | 500 | 2,150 | 24 | 23 | J-692 |
| J-56 | 2,518 | TRUE | Passed | 500 | 2,519 | 24 | 22.5 | J-692 |
| J-57 | 2,422 | TRUE | Passed | 500 | 2,423 | 24 | 22.7 | J-692 |
| J-58 | 2,676 | TRUE | Passed | 500 | 2,677 | 24 | 22.3 | J-692 |
| J-59 | 3,061 | TRUE | Passed | 500 | 3,062 | 24 | 21.7 | J-692 |
| J-60 | 2,793 | TRUE | Passed | 500 | 2,794 | 24 | 22.1 | J-692 |
| J-61 | 4,713 | TRUE | Passed | 500 | 4,714 | 24 | 18.7 | J-692 |
| J-64 | 4,696 | TRUE | Passed | 500 | 4,697 | 24 | 18.5 | J-692 |
| J-65 | 4,712 | TRUE | Passed | 500 | 4,713 | 24 | 18.8 | J-692 |
| J-66 | 5,900 | TRUE | Passed | 500 | 5,901 | 24 | 16.6 | J-692 |
| J-67 | 5,283 | TRUE | Passed | 500 | 5,284 | 24 | 17.8 | J-692 |
| J-68 | 5,629 | TRUE | Passed | 500 | 5,630 | 24 | 17.2 | J-692 |
| J-69 | 2,870 | TRUE | Passed | 500 | 2,871 | 24 | 22.3 | J-692 |
| J-70 | 4,411 | TRUE | Passed | 500 | 4,412 | 24 | 19.8 | J-692 |
| J-71 | 3,601 | TRUE | Passed | 500 | 3,602 | 24 | 21.2 | J-692 |
| J-72 | 3,598 | TRUE | Passed | 500 | 3,599 | 24 | 21.2 | J-692 |
| J-73 | 1,327 | TRUE | Passed | 500 | 1,328 | 24 | 24 | J-692 |
| J-74 | 3,573 | TRUE | Passed | 500 | 3,574 | 24 | 21.3 | J-692 |
| J-75 | 5,742 | TRUE | Passed | 500 | 5,743 | 24 | 17.3 | J-692 |
| J-76 | 5,443 | TRUE | Passed | 500 | 5,444 | 24 | 17.7 | J-692 |
| J-77 | 5,419 | TRUE | Passed | 500 | 5,420 | 24 | 17.5 | J-692 |
| J-78 | 5,929 | TRUE | Passed | 500 | 5,930 | 24 | 17.1 | J-692 |
| J-79 | 4,819 | TRUE | Passed | 500 | 4,820 | 24 | 19.3 | J-692 |
| J-80 | 5,467 | TRUE | Passed | 500 | 5,468 | 24 | 18.1 | J-692 |
| J-81 | 5,827 | TRUE | Passed | 500 | 5,828 | 24 | 17.1 | J-692 |
| J-82 | 6,530 | TRUE | Passed | 500 | 6,531 | 24 | 16.3 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-83 | 6,712 | TRUE | Passed | 500 | 6,713 | 24 | 15.9 | J-692 |
| J-84 | 6,726 | TRUE | Passed | 500 | 6,727 | 24 | 15.8 | J-692 |
| J-85 | 6,219 | TRUE | Passed | 500 | 6,220 | 24 | 16.6 | J-692 |
| J-86 | 5,844 | TRUE | Passed | 500 | 5,845 | 24 | 17.4 | J-692 |
| J-87 | 4,988 | TRUE | Passed | 500 | 4,989 | 24 | 19.2 | J-692 |
| J-88 | 4,313 | TRUE | Passed | 500 | 4,314 | 24 | 20.3 | J-692 |
| J-89 | 5,697 | TRUE | Passed | 500 | 5,698 | 24 | 17.6 | J-692 |
| J-90 | 4,095 | TRUE | Passed | 500 | 4,096 | 24 | 20.6 | J-692 |
| J-91 | 1,887 | TRUE | Passed | 500 | 1,888 | 24 | 23.5 | J-692 |
| J-92 | 6,628 | TRUE | Passed | 500 | 6,629 | 24 | 16.2 | J-692 |
| J-93 | 5,840 | TRUE | Passed | 500 | 5,841 | 24 | 16.9 | J-692 |
| J-94 | 6,588 | TRUE | Passed | 500 | 6,589 | 24 | 16.3 | J-692 |
| J-95 | 7,691 | TRUE | Passed | 500 | 7,692 | 24 | 15 | J-692 |
| J-96 | 6,438 | TRUE | Passed | 500 | 6,440 | 24 | 16.9 | J-692 |
| J-97 | 6,698 | TRUE | Passed | 500 | 6,699 | 24 | 16 | J-692 |
| J-98 | 6,875 | TRUE | Passed | 500 | 6,876 | 24 | 15.4 | J-692 |
| J-99 | 3,924 | TRUE | Passed | 500 | 3,925 | 24 | 18.8 | J-692 |
| J-100 | 5,978 | TRUE | Passed | 500 | 5,979 | 24 | 12.7 | J-692 |
| J-101 | 3,600 | TRUE | Passed | 500 | 3,601 | 24 | 19.4 | J-692 |
| J-102 | 6,161 | TRUE | Passed | 500 | 6,162 | 24 | 11.7 | J-692 |
| J-103 | 5,736 | TRUE | Passed | 500 | 5,737 | 24 | 11.1 | J-692 |
| J-104 | 4,810 | TRUE | Passed | 500 | 4,811 | 24 | 14.4 | J-692 |
| J-105 | 6,173 | TRUE | Passed | 500 | 6,174 | 24 | 8.8 | J-692 |
| J-106 | 5,830 | TRUE | Passed | 500 | 5,831 | 24 | 10.3 | J-692 |
| J-107 | 5,175 | TRUE | Passed | 500 | 5,176 | 24 | 13.1 | J-692 |
| J-108 | 5,851 | TRUE | Passed | 500 | 5,852 | 24 | 10.2 | J-692 |
| J-109 | 5,742 | TRUE | Passed | 500 | 5,743 | 24 | 10.7 | J-692 |
| J-110 | 5,210 | TRUE | Passed | 500 | 5,211 | 24 | 13.1 | J-692 |
| J-111 | 4,654 | TRUE | Passed | 500 | 4,655 | 24 | 15.2 | J-692 |
| J-112 | 4,035 | TRUE | Passed | 500 | 4,036 | 24 | 17.3 | J-692 |
| J-113 | 3,409 | TRUE | Passed | 500 | 3,410 | 24 | 19.1 | J-692 |
| J-114 | 3,091 | TRUE | Passed | 500 | 3,092 | 24 | 19.8 | J-692 |
| J-115 | 3,858 | TRUE | Passed | 500 | 3,859 | 24 | 17.5 | J-692 |
| J-116 | 2,860 | TRUE | Passed | 500 | 2,861 | 24 | 20.3 | J-692 |
| J-117 | 3,448 | TRUE | Passed | 500 | 3,449 | 24 | 18.7 | J-692 |
| J-118 | 2,150 | TRUE | Passed | 500 | 2,151 | 24 | 23.4 | J-692 |
| J-118 | 3,016 | TRUE | Passed | 500 | 3,017 | 24 | 19.9 | J-692 |
| J-119 | 3,596 | TRUE | Passed | 500 | 3,597 | 24 | 18.2 | J-692 |
| J-121 | 2,667 | TRUE | Passed | 500 | 2,668 | 24 | 20.7 | J-692 |
| J-122 | 3,770 | TRUE | Passed | 500 | 3,771 | 24 | 17.5 | J-692 |
| J-123 | 6,770 | TRUE | Passed | 500 | 6,795 | 30.1 | 0 | J-692 |
| J-124 | 6,854 | TRUE | Passed | 500 | 6,855 | 24 | 3.3 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-125 | 3,878 | TRUE | Passed | 500 | 3,879 | 24 | 16.4 | J-692 |
| J-126 | 5,399 | TRUE | Passed | 500 | 5,400 | 24 | 10.2 | J-692 |
| J-127 | 3,986 | TRUE | Passed | 500 | 3,987 | 24 | 16.1 | J-692 |
| J-128 | 1,385 | TRUE | Passed | 500 | 1,386 | 24 | 23.2 | J-692 |
| J-129 | 3,516 | TRUE | Passed | 500 | 3,517 | 24 | 17.7 | J-692 |
| J-130 | 3,554 | TRUE | Passed | 500 | 3,555 | 24 | 17.7 | J-692 |
| J-133 | 3,511 | TRUE | Passed | 500 | 3,512 | 24 | 17.9 | J-692 |
| J-134 | 2,783 | TRUE | Passed | 500 | 2,784 | 24 | 20.2 | J-692 |
| J-135 | 3,121 | TRUE | Passed | 500 | 3,122 | 24 | 19.2 | J-692 |
| J-136 | 3,515 | TRUE | Passed | 500 | 3,516 | 24 | 18 | J-692 |
| J-137 | 3,765 | TRUE | Passed | 500 | 3,766 | 24 | 17.2 | J-692 |
| J-138 | 4,246 | TRUE | Passed | 500 | 4,247 | 24 | 15.5 | J-692 |
| J-139 | 5,887 | TRUE | Passed | 500 | 5,888 | 24 | 10.8 | J-692 |
| J-140 | 3,366 | TRUE | Passed | 500 | 3,367 | 24 | 19.3 | J-692 |
| J-141 | 3,730 | TRUE | Passed | 500 | 3,731 | 24 | 18.2 | J-692 |
| J-142 | 5,375 | TRUE | Passed | 500 | 5,376 | 24 | 12.3 | J-692 |
| J-143 | 6,656 | TRUE | Passed | 500 | 6,657 | 24 | 6.9 | J-692 |
| J-144 | 6,853 | TRUE | Passed | 500 | 6,854 | 24 | 4.9 | J-692 |
| J-145 | 4,035 | TRUE | Passed | 500 | 4,036 | 24 | 16.7 | J-692 |
| J-146 | 6,867 | TRUE | Passed | 500 | 6,868 | 24 | 5.3 | J-692 |
| J-147 | 6,588 | TRUE | Passed | 500 | 6,589 | 24 | 6.8 | J-692 |
| J-148 | 6,772 | TRUE | Passed | 500 | 6,773 | 24 | 6.7 | J-692 |
| J-149 | 6,715 | TRUE | Passed | 500 | 6,716 | 24 | 9.3 | J-692 |
| J-150 | 6,254 | TRUE | Passed | 500 | 6,255 | 24 | 12.2 | J-692 |
| J-151 | 6,425 | TRUE | Passed | 500 | 6,426 | 24 | 9.7 | J-692 |
| J-152 | 2,894 | TRUE | Passed | 500 | 2,895 | 24 | 21.5 | J-692 |
| J-153 | 6,559 | TRUE | Passed | 500 | 6,560 | 24 | 12 | J-692 |
| J-154 | 6,174 | TRUE | Passed | 500 | 6,175 | 24 | 13.3 | J-692 |
| J-155 | 3,544 | TRUE | Passed | 500 | 3,545 | 24 | 21.1 | J-692 |
| J-156 | 3,514 | TRUE | Passed | 500 | 3,515 | 24 | 21.3 | J-692 |
| J-157 | 3,764 | TRUE | Passed | 500 | 3,765 | 24 | 20.7 | J-692 |
| J-158 | 3,041 | TRUE | Passed | 500 | 3,042 | 24 | 21.3 | J-692 |
| J-159 | 4,267 | TRUE | Passed | 500 | 4,268 | 24 | 18.7 | J-692 |
| J-160 | 4,533 | TRUE | Passed | 500 | 4,534 | 24 | 17.8 | J-692 |
| J-161 | 4,540 | TRUE | Passed | 500 | 4,541 | 24 | 17.7 | J-692 |
| J-162 | 4,576 | TRUE | Passed | 500 | 4,577 | 24 | 17.7 | J-692 |
| J-163 | 3,996 | TRUE | Passed | 500 | 3,997 | 24 | 19 | J-692 |
| J-164 | 4,346 | TRUE | Passed | 500 | 4,347 | 24 | 18.2 | J-692 |
| J-165 | 4,763 | TRUE | Passed | 500 | 4,764 | 24 | 17.1 | J-692 |
| J-166 | 6,809 | TRUE | Passed | 500 | 6,810 | 24 | 8.4 | J-692 |
| J-167 | 2,610 | TRUE | Passed | 500 | 2,611 | 24 | 21.9 | J-692 |
| J-168 | 3,268 | TRUE | Passed | 500 | 3,269 | 24 | 20.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-169 | 4,179 | TRUE | Passed | 500 | 4,180 | 24 | 18.6 | J-692 |
| J-170 | 6,374 | TRUE | Passed | 500 | 6,375 | 24 | 9.7 | J-692 |
| J-171 | 2,670 | TRUE | Passed | 500 | 2,671 | 24 | 21.2 | J-692 |
| J-172 | 6,077 | TRUE | Passed | 500 | 6,078 | 24 | 8.1 | J-692 |
| J-173 | 4,269 | TRUE | Passed | 500 | 4,270 | 24 | 15.6 | J-692 |
| J-174 | 4,347 | TRUE | Passed | 500 | 4,348 | 24 | 15.4 | J-692 |
| J-175 | 5,515 | TRUE | Passed | 500 | 5,516 | 24 | 10.6 | J-692 |
| J-176 | 4,136 | TRUE | Passed | 500 | 4,137 | 24 | 16.1 | J-692 |
| J-177 | 2,642 | TRUE | Passed | 500 | 2,644 | 24 | 20.6 | J-692 |
| J-178 | 3,421 | TRUE | Passed | 500 | 3,422 | 24 | 18.5 | J-692 |
| J-179 | 1,254 | TRUE | Passed | 500 | 1,255 | 24 | 23.5 | J-692 |
| J-180 | 1,621 | TRUE | Passed | 500 | 1,622 | 24 | 22.8 | J-692 |
| J-181 | 3,679 | TRUE | Passed | 500 | 3,680 | 24 | 17.6 | J-692 |
| J-183 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.5 | 8.6 | J-692 |
| J-184 | 780 | TRUE | Passed | 500 | 781 | 24 | 24.5 | J-692 |
| J-185 | 7,852 | TRUE | Passed | 500 | 7,853 | 24 | 14 | J-692 |
| J-186 | 5,393 | TRUE | Passed | 500 | 5,394 | 24 | 19 | J-692 |
| J-187 | 5,636 | TRUE | Passed | 500 | 5,637 | 24 | 17.7 | J-188 |
| J-188 | 4,244 | TRUE | Passed | 500 | 4,245 | 24 | 20.8 | J-692 |
| J-189 | 5,422 | TRUE | Passed | 500 | 5,423 | 24 | 18.6 | J-692 |
| J-190 | 5,458 | TRUE | Passed | 500 | 5,459 | 24 | 18.7 | J-692 |
| J-191 | 4,644 | TRUE | Passed | 500 | 4,645 | 24 | 20 | J-692 |
| J-192 | 4,043 | TRUE | Passed | 500 | 4,044 | 24 | 20.8 | J-692 |
| J-193 | 3,993 | TRUE | Passed | 500 | 3,994 | 24 | 20.6 | J-692 |
| J-194 | 3,374 | TRUE | Passed | 500 | 3,375 | 24 | 20.7 | J-196 |
| J-195 | 2,613 | TRUE | Passed | 500 | 2,614 | 24 | 22 | J-196 |
| J-196 | 2,159 | TRUE | Passed | 500 | 2,160 | 24 | 23.1 | J-692 |
| J-197 | 2,338 | TRUE | Passed | 500 | 2,339 | 24 | 22.9 | J-692 |
| J-200 | 5,367 | TRUE | Passed | 500 | 5,368 | 24 | 18.7 | J-692 |
| J-201 | 4,703 | TRUE | Passed | 500 | 4,704 | 24 | 19.9 | J-692 |
| J-202 | 5,192 | TRUE | Passed | 500 | 5,193 | 24 | 19.1 | J-692 |
| J-203 | 5,161 | TRUE | Passed | 500 | 5,162 | 24 | 19.2 | J-692 |
| J-204 | 3,931 | TRUE | Passed | 500 | 3,932 | 24 | 21.2 | J-692 |
| J-205 | 3,183 | TRUE | Passed | 500 | 3,184 | 24 | 22.2 | J-692 |
| J-206 | 4,312 | TRUE | Passed | 500 | 4,313 | 24 | 20.6 | J-692 |
| J-207 | 3,530 | TRUE | Passed | 500 | 3,531 | 24 | 21.7 | J-692 |
| J-208 | 5,826 | TRUE | Passed | 500 | 5,827 | 24 | 18 | J-692 |
| J-209 | 4,379 | TRUE | Passed | 500 | 4,380 | 24 | 20.6 | J-692 |
| J-210 | 7,624 | TRUE | Passed | 500 | 7,625 | 24 | 15.1 | J-692 |
| J-211 | 6,344 | TRUE | Passed | 500 | 6,345 | 24 | 18.3 | J-692 |
| J-212 | 5,042 | TRUE | Passed | 500 | 5,043 | 24 | 20.4 | J-692 |
| J-213 | 3,865 | TRUE | Passed | 500 | 3,866 | 24 | 21.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-214 | 3,031 | TRUE | Passed | 500 | 3,032 | 24 | 22.8 | J-692 |
| J-215 | 2,527 | TRUE | Passed | 500 | 2,528 | 24 | 23.3 | J-692 |
| J-216 | 882 | TRUE | Passed | 500 | 883 | 24 | 24.5 | J-692 |
| J-217 | 3,658 | TRUE | Passed | 500 | 3,659 | 24 | 22.2 | J-692 |
| J-218 | 2,023 | TRUE | Passed | 500 | 2,024 | 24 | 23.7 | J-692 |
| J-219 | 4,463 | TRUE | Passed | 500 | 4,464 | 24 | 21.2 | J-692 |
| J-220 | 2,110 | TRUE | Passed | 500 | 2,111 | 24 | 23.7 | J-692 |
| J-221 | 2,530 | TRUE | Passed | 500 | 2,531 | 24 | 23.3 | J-692 |
| J-222 | 4,953 | TRUE | Passed | 500 | 4,954 | 24 | 20.6 | J-692 |
| J-223 | 5,475 | TRUE | Passed | 500 | 5,476 | 24 | 19.9 | J-692 |
| J-224 | 6,379 | TRUE | Passed | 500 | 6,380 | 24 | 18.5 | J-692 |
| J-225 | 6,613 | TRUE | Passed | 500 | 6,615 | 24 | 18.1 | J-692 |
| J-226 | 8,514 | TRUE | Passed | 500 | 8,515 | 24 | 14.6 | J-692 |
| J-227 | 6,944 | TRUE | Passed | 500 | 6,945 | 24 | 16.3 | J-692 |
| J-228 | 5,560 | TRUE | Passed | 500 | 5,561 | 24 | 18.8 | J-692 |
| J-229 | 5,456 | TRUE | Passed | 500 | 5,457 | 24 | 19 | J-692 |
| J-230 | 3,202 | TRUE | Passed | 500 | 3,203 | 24 | 22.3 | J-692 |
| J-231 | 5,023 | TRUE | Passed | 500 | 5,024 | 24 | 19.8 | J-692 |
| J-232 | 5,595 | TRUE | Passed | 500 | 5,596 | 24 | 18.9 | J-692 |
| J-233 | 7,320 | TRUE | Passed | 500 | 7,321 | 24 | 15.9 | J-692 |
| J-234 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.9 | 9.7 | J-692 |
| J-235 | 10,000 | TRUE | Passed | 500 | 10,001 | 55.1 | 10.5 | J-692 |
| J-236 | 2,615 | TRUE | Passed | 500 | 2,616 | 24 | 22.5 | J-692 |
| J-237 | 2,172 | TRUE | Passed | 500 | 2,173 | 24 | 23 | J-692 |
| J-238 | 1,184 | TRUE | Passed | 500 | 1,185 | 24 | 24.1 | J-692 |
| J-239 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.9 | 12.3 | J-692 |
| J-240 | 10,000 | TRUE | Passed | 500 | 10,001 | 31.3 | 12.3 | J-692 |
| J-241 | 9,025 | TRUE | Passed | 500 | 9,026 | 24 | 15.4 | J-692 |
| J-242 | 8,755 | TRUE | Passed | 500 | 8,756 | 24 | 18 | J-692 |
| J-243 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.2 | 15 | J-692 |
| J-244 | 5,739 | TRUE | Passed | 500 | 5,740 | 24 | 20.6 | J-692 |
| J-245 | 10,000 | TRUE | Passed | 500 | 10,001 | 28.8 | 16.1 | J-692 |
| J-246 | 9,818 | TRUE | Passed | 500 | 9,819 | 24 | 19.4 | J-692 |
| J-247 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.2 | 17.2 | J-692 |
| J-248 | 7,818 | TRUE | Passed | 500 | 7,819 | 24 | 19 | J-692 |
| J-249 | 2,659 | TRUE | Passed | 500 | 2,660 | 24 | 23.1 | J-250 |
| J-250 | 1,456 | TRUE | Passed | 500 | 1,457 | 24 | 24.4 | J-692 |
| J-251 | 8,086 | TRUE | Passed | 500 | 8,087 | 24 | 18.8 | J-692 |
| J-252 | 8,000 | TRUE | Passed | 500 | 8,001 | 24 | 19.1 | J-692 |
| J-253 | 3,436 | TRUE | Passed | 500 | 3,437 | 24 | 23.4 | J-692 |
| J-254 | 8,669 | TRUE | Passed | 500 | 8,671 | 24 | 17.9 | J-692 |
| J-255 | 7,957 | TRUE | Passed | 500 | 7,958 | 24 | 18.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-256 | 4,561 | TRUE | Passed | 500 | 4,562 | 24 | 22.3 | J-692 |
| J-257 | 7,901 | TRUE | Passed | 500 | 7,902 | 24 | 18.8 | J-692 |
| J-258 | 7,868 | TRUE | Passed | 500 | 7,869 | 24 | 18.8 | J-692 |
| J-259 | 4,855 | TRUE | Passed | 500 | 4,856 | 24 | 22.1 | J-692 |
| J-260 | 6,936 | TRUE | Passed | 500 | 6,937 | 24 | 19.9 | J-692 |
| J-262 | 8,020 | TRUE | Passed | 500 | 8,021 | 24 | 19 | J-692 |
| J-263 | 4,664 | TRUE | Passed | 500 | 4,665 | 24 | 22.3 | J-692 |
| J-264 | 8,566 | TRUE | Passed | 500 | 8,567 | 24 | 18.5 | J-692 |
| J-265 | 4,369 | TRUE | Passed | 500 | 4,370 | 24 | 22.5 | J-692 |
| J-266 | 3,064 | TRUE | Passed | 500 | 3,065 | 24 | 23.5 | J-692 |
| J-267 | 6,753 | TRUE | Passed | 500 | 6,754 | 24 | 20.2 | J-692 |
| J-268 | 5,926 | TRUE | Passed | 500 | 5,927 | 24 | 21.1 | J-692 |
| J-269 | 6,907 | TRUE | Passed | 500 | 6,908 | 24 | 20 | J-692 |
| J-270 | 8,453 | TRUE | Passed | 500 | 8,454 | 24 | 17.9 | J-692 |
| J-271 | 7,170 | TRUE | Passed | 500 | 7,171 | 24 | 19.6 | J-692 |
| J-272 | 7,220 | TRUE | Passed | 500 | 7,221 | 24 | 19.2 | J-692 |
| J-273 | 5,461 | TRUE | Passed | 500 | 5,462 | 24 | 21.2 | J-692 |
| J-274 | 5,033 | TRUE | Passed | 500 | 5,034 | 24 | 21.6 | J-692 |
| J-275 | 6,832 | TRUE | Passed | 500 | 6,833 | 24 | 19.6 | J-692 |
| J-276 | 6,598 | TRUE | Passed | 500 | 6,599 | 24 | 19.9 | J-692 |
| J-277 | 6,655 | TRUE | Passed | 500 | 6,656 | 24 | 19.6 | J-692 |
| J-278 | 4,878 | TRUE | Passed | 500 | 4,879 | 24 | 21.6 | J-692 |
| J-279 | 4,313 | TRUE | Passed | 500 | 4,314 | 24 | 22.1 | J-692 |
| J-280 | 1,580 | TRUE | Passed | 500 | 1,581 | 24 | 24.3 | J-692 |
| J-281 | 3,523 | TRUE | Passed | 500 | 3,524 | 24 | 22.9 | J-692 |
| J-282 | 3,350 | TRUE | Passed | 500 | 3,351 | 24 | 23 | J-692 |
| J-283 | 2,655 | TRUE | Passed | 500 | 2,656 | 24 | 23.6 | J-692 |
| J-284 | 1,518 | TRUE | Passed | 500 | 1,519 | 24 | 24.3 | J-692 |
| J-285 | 2,243 | TRUE | Passed | 500 | 2,244 | 24 | 23.9 | J-692 |
| J-286 | 4,772 | TRUE | Passed | 500 | 4,773 | 24 | 21.1 | J-292 |
| J-287 | 3,878 | TRUE | Passed | 500 | 3,879 | 24 | 21.4 | J-292 |
| J-288 | 2,249 | TRUE | Passed | 500 | 2,250 | 24 | 23.8 | J-692 |
| J-289 | 2,540 | TRUE | Passed | 500 | 2,541 | 24 | 23.1 | J-290 |
| J-290 | 2,343 | TRUE | Passed | 500 | 2,344 | 24 | 23.8 | J-692 |
| J-291 | 1,260 | TRUE | Passed | 500 | 1,261 | 24 | 24.4 | J-692 |
| J-292 | 2,785 | TRUE | Passed | 500 | 2,786 | 24 | 23.5 | J-692 |
| J-294 | 1,517 | TRUE | Passed | 500 | 1,518 | 24 | 24.3 | J-692 |
| J-296 | 6,792 | TRUE | Passed | 500 | 6,793 | 24 | 19.1 | J-692 |
| J-297 | 6,909 | TRUE | Passed | 500 | 6,910 | 24 | 18.8 | J-692 |
| J-298 | 9,236 | TRUE | Passed | 500 | 9,237 | 24 | 14.7 | J-692 |
| J-299 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.8 | 13.4 | J-692 |
| J-300 | 4,501 | TRUE | Passed | 500 | 4,502 | 24 | 21.9 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-301 | 3,624 | TRUE | Passed | 500 | 3,625 | 24 | 22.8 | J-692 |
| J-302 | 4,097 | TRUE | Passed | 500 | 4,098 | 24 | 22.3 | J-692 |
| J-303 | 3,361 | TRUE | Passed | 500 | 3,362 | 24 | 23 | J-692 |
| J-304 | 6,072 | TRUE | Passed | 500 | 6,073 | 24 | 20.2 | J-692 |
| J-305 | 6,218 | TRUE | Passed | 500 | 6,219 | 24 | 19.1 | J-306 |
| J-306 | 2,628 | TRUE | Passed | 500 | 2,629 | 24 | 23.6 | J-692 |
| J-307 | 8,410 | TRUE | Passed | 500 | 8,411 | 24 | 17.1 | J-692 |
| J-308 | 7,430 | TRUE | Passed | 500 | 7,431 | 24 | 18.7 | J-692 |
| J-309 | 3,889 | TRUE | Passed | 500 | 3,890 | 24 | 22.5 | J-692 |
| J-310 | 3,694 | TRUE | Passed | 500 | 3,695 | 24 | 22.6 | J-692 |
| J-311 | 4,211 | TRUE | Passed | 500 | 4,212 | 24 | 22.2 | J-692 |
| J-312 | 4,139 | TRUE | Passed | 500 | 4,140 | 24 | 22.2 | J-692 |
| J-313 | 4,676 | TRUE | Passed | 500 | 4,677 | 24 | 21.6 | J-692 |
| J-314 | 3,480 | TRUE | Passed | 500 | 3,481 | 24 | 22.8 | J-692 |
| J-315 | 2,825 | TRUE | Passed | 500 | 2,826 | 24 | 23.3 | J-692 |
| J-316 | 4,839 | TRUE | Passed | 500 | 4,840 | 24 | 21.2 | J-692 |
| J-317 | 3,584 | TRUE | Passed | 500 | 3,585 | 24 | 22.7 | J-692 |
| J-318 | 7,126 | TRUE | Passed | 500 | 7,127 | 24 | 19.6 | J-692 |
| J-319 | 6,815 | TRUE | Passed | 500 | 6,816 | 24 | 19.9 | J-692 |
| J-320 | 6,848 | TRUE | Passed | 500 | 6,849 | 24 | 19.7 | J-692 |
| J-321 | 3,541 | TRUE | Passed | 500 | 3,542 | 24 | 23.1 | J-692 |
| J-322 | 3,770 | TRUE | Passed | 500 | 3,771 | 24 | 22.9 | J-692 |
| J-323 | 3,339 | TRUE | Passed | 500 | 3,340 | 24 | 23.3 | J-692 |
| J-324 | 4,610 | TRUE | Passed | 500 | 4,611 | 24 | 22.3 | J-692 |
| J-325 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.7 | 12.2 | J-692 |
| J-326 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.4 | 12.2 | J-692 |
| J-327 | 7,506 | TRUE | Passed | 500 | 7,507 | 24 | 17 | J-692 |
| J-328 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.2 | 12.2 | J-692 |
| J-329 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.8 | 12 | J-692 |
| J-330 | 1,849 | TRUE | Passed | 500 | 1,851 | 24 | 23.9 | J-692 |
| J-331 | 6,455 | TRUE | Passed | 500 | 6,456 | 24 | 18.7 | J-692 |
| J-332 | 6,763 | TRUE | Passed | 500 | 6,764 | 24 | 18.2 | J-692 |
| J-333 | 4,846 | TRUE | Passed | 500 | 4,847 | 24 | 20.9 | J-692 |
| J-334 | 8,583 | TRUE | Passed | 500 | 8,584 | 24 | 14.5 | J-692 |
| J-336 | 7,195 | TRUE | Passed | 500 | 7,196 | 24 | 17.2 | J-692 |
| J-338 | 7,990 | TRUE | Passed | 500 | 7,991 | 24 | 15.8 | J-692 |
| J-339 | 6,866 | TRUE | Passed | 500 | 6,867 | 24 | 17.7 | J-692 |
| J-340 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.1 | 12.2 | J-692 |
| J-341 | 8,072 | TRUE | Passed | 500 | 8,073 | 24 | 17.5 | J-692 |
| J-342 | 4,298 | TRUE | Passed | 500 | 4,299 | 24 | 22 | J-692 |
| J-343 | 7,828 | TRUE | Passed | 500 | 7,829 | 24 | 17.5 | J-692 |
| J-345 | 5,210 | TRUE | Passed | 500 | 5,211 | 24 | 21 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-346 | 3,895 | TRUE | Passed | 500 | 3,896 | 24 | 22.4 | J-692 |
| J-347 | 10,000 | TRUE | Passed | 500 | 10,001 | 49.6 | 12.5 | J-692 |
| J-348 | 10,000 | TRUE | Passed | 500 | 10,001 | 51.2 | 12.5 | J-692 |
| J-349 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.3 | 12.5 | J-692 |
| J-350 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.4 | 12.5 | J-692 |
| J-351 | 9,249 | TRUE | Passed | 500 | 9,250 | 24 | 14 | J-692 |
| J-352 | 9,574 | TRUE | Passed | 500 | 9,575 | 24 | 13.3 | J-692 |
| J-353 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.5 | 12.4 | J-692 |
| J-354 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.2 | 13 | J-692 |
| J-355 | 9,491 | TRUE | Passed | 500 | 9,492 | 24 | 13.9 | J-692 |
| J-356 | 8,917 | TRUE | Passed | 500 | 8,918 | 24 | 14.6 | J-692 |
| J-357 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.7 | 12.3 | J-692 |
| J-358 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.1 | 13.1 | J-692 |
| J-359 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.4 | 13.1 | J-692 |
| J-360 | 1,642 | TRUE | Passed | 500 | 1,643 | 24 | 24.1 | J-692 |
| J-361 | 9,045 | TRUE | Passed | 500 | 9,046 | 24 | 14.8 | J-692 |
| J-362 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.6 | 12.6 | J-692 |
| J-363 | 8,565 | TRUE | Passed | 500 | 8,566 | 24 | 15.3 | J-692 |
| J-364 | 7,662 | TRUE | Passed | 500 | 7,663 | 24 | 16.9 | J-692 |
| J-365 | 8,098 | TRUE | Passed | 500 | 8,099 | 24 | 16.1 | J-692 |
| J-366 | 7,458 | TRUE | Passed | 500 | 7,459 | 24 | 17.2 | J-692 |
| J-367 | 9,209 | TRUE | Passed | 500 | 9,210 | 24 | 14 | J-692 |
| J-368 | 6,341 | TRUE | Passed | 500 | 6,342 | 24 | 19.4 | J-692 |
| J-369 | 9,316 | TRUE | Passed | 500 | 9,317 | 24 | 14.4 | J-692 |
| J-370 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.6 | 13.1 | J-692 |
| J-371 | 3,960 | TRUE | Passed | 500 | 3,961 | 24 | 17 | J-692 |
| J-371 | 10,000 | TRUE | Passed | 500 | 10,001 | 33.1 | 13 | J-692 |
| J-372 | 7,437 | TRUE | Passed | 500 | 7,438 | 24 | 17.5 | J-692 |
| J-373 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.1 | 12.5 | J-692 |
| J-374 | 10,000 | TRUE | Passed | 500 | 10,001 | 50.3 | 12.5 | J-692 |
| J-375 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.8 | 12.5 | J-692 |
| J-376 | 8,525 | TRUE | Passed | 500 | 8,526 | 24 | 15.4 | J-692 |
| J-377 | 10,000 | TRUE | Passed | 500 | 10,001 | 54.5 | 12.5 | J-692 |
| J-378 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.7 | 12.5 | J-692 |
| J-379 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.9 | 12.5 | J-692 |
| J-380 | 7,126 | TRUE | Passed | 500 | 7,127 | 24 | 17.9 | J-692 |
| J-382 | 7,718 | TRUE | Passed | 500 | 7,719 | 24 | 17.1 | J-692 |
| J-383 | 7,077 | TRUE | Passed | 500 | 7,078 | 24 | 18.1 | J-692 |
| J-384 | 7,394 | TRUE | Passed | 500 | 7,395 | 24 | 17.6 | J-692 |
| J-385 | 9,948 | TRUE | Passed | 500 | 9,949 | 24 | 12.9 | J-692 |
| J-386 | 10,000 | TRUE | Passed | 500 | 10,001 | 28.9 | 12.9 | J-692 |
| J-387 | 9,071 | TRUE | Passed | 500 | 9,072 | 24 | 14.8 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-388 | 6,799 | TRUE | Passed | 500 | 6,800 | 24 | 18.6 | J-692 |
| J-389 | 5,312 | TRUE | Passed | 500 | 5,313 | 24 | 20.7 | J-692 |
| J-390 | 1,971 | TRUE | Passed | 500 | 1,972 | 24 | 23.9 | J-692 |
| J-391 | 7,193 | TRUE | Passed | 500 | 7,194 | 24 | 17.9 | J-692 |
| J-392 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.4 | 12.5 | J-692 |
| J-393 | 8,004 | TRUE | Passed | 500 | 8,005 | 24 | 16.4 | J-692 |
| J-394 | 9,443 | TRUE | Passed | 500 | 9,444 | 24 | 13.8 | J-692 |
| J-395 | 9,614 | TRUE | Passed | 500 | 9,615 | 24 | 13.4 | J-692 |
| J-396 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.1 | 12.5 | J-692 |
| J-397 | 6,535 | TRUE | Passed | 500 | 6,536 | 24 | 18.7 | J-692 |
| J-398 | 1,753 | TRUE | Passed | 500 | 1,754 | 24 | 24 | J-692 |
| J-399 | 10,000 | TRUE | Passed | 500 | 10,001 | 68.2 | 12.1 | J-692 |
| J-401 | 4,151 | TRUE | Passed | 500 | 4,152 | 24 | 15.5 | J-692 |
| J-401 | 10,000 | TRUE | Passed | 500 | 10,001 | 64.8 | 12.4 | J-692 |
| J-402 | 10,000 | TRUE | Passed | 500 | 10,001 | 65.5 | 12.4 | J-692 |
| J-403 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.2 | 12.5 | J-692 |
| J-404 | 10,000 | TRUE | Passed | 500 | 10,001 | 29 | 13.2 | J-692 |
| J-405 | 4,749 | TRUE | Passed | 500 | 4,750 | 24 | 21.2 | J-692 |
| J-406 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.1 | 12.3 | J-692 |
| J-407 | 10,000 | TRUE | Passed | 500 | 10,001 | 67.6 | 12.3 | J-692 |
| J-408 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.9 | 12.4 | J-692 |
| J-409 | 3,535 | TRUE | Passed | 500 | 3,536 | 24 | 22.5 | J-692 |
| J-410 | 10,000 | TRUE | Passed | 500 | 10,001 | 54.3 | 12.5 | J-692 |
| J-411 | 3,601 | TRUE | Passed | 500 | 3,602 | 24 | 22.5 | J-692 |
| J-412 | 10,000 | TRUE | Passed | 500 | 10,001 | 59 | 12.5 | J-692 |
| J-413 | 10,000 | TRUE | Passed | 500 | 10,001 | 65.4 | 12.3 | J-692 |
| J-414 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.9 | 11.5 | J-692 |
| J-415 | 2,023 | TRUE | Passed | 500 | 2,024 | 24 | 23.8 | J-692 |
| J-416 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.9 | 12.4 | J-692 |
| J-417 | 10,000 | TRUE | Passed | 500 | 10,001 | 58.1 | 12.5 | J-692 |
| J-418 | 5,592 | TRUE | Passed | 500 | 5,594 | 24 | 20.2 | J-692 |
| J-419 | 3,540 | TRUE | Passed | 500 | 3,541 | 24 | 22.6 | J-692 |
| J-420 | 10,000 | TRUE | Passed | 500 | 10,001 | 37 | 13.3 | J-692 |
| J-421 | 9,820 | TRUE | Passed | 500 | 9,821 | 24 | 13.3 | J-692 |
| J-422 | 7,164 | TRUE | Passed | 500 | 7,165 | 24 | 18 | J-692 |
| J-423 | 9,728 | TRUE | Passed | 500 | 9,729 | 24 | 13.5 | J-692 |
| J-424 | 4,980 | TRUE | Passed | 500 | 4,981 | 24 | 21 | J-692 |
| J-425 | 4,257 | TRUE | Passed | 500 | 4,258 | 24 | 21.8 | J-692 |
| J-426 | 9,672 | TRUE | Passed | 500 | 9,673 | 24 | 13.3 | J-692 |
| J-427 | 8,233 | TRUE | Passed | 500 | 8,234 | 24 | 16.1 | J-692 |
| J-428 | 9,869 | TRUE | Passed | 500 | 9,870 | 24 | 13.1 | J-692 |
| J-429 | 9,836 | TRUE | Passed | 500 | 9,837 | 24 | 13.2 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-430 | 4,091 | TRUE | Passed | 500 | 4,092 | 24 | 22 | J-692 |
| J-431 | 7,616 | TRUE | Passed | 500 | 7,617 | 24 | 17.2 | J-692 |
| J-432 | 2,378 | TRUE | Passed | 500 | 2,379 | 24 | 23.6 | J-692 |
| J-433 | 4,072 | TRUE | Passed | 500 | 4,073 | 24 | 20.2 | J-692 |
| J-434 | 10,000 | TRUE | Passed | 500 | 10,001 | 61.8 | 24.2 | J-692 |
| J-435 | 10,000 | TRUE | Passed | 500 | 10,001 | 63.1 | 24.2 | J-692 |
| J-436 | 10,000 | TRUE | Passed | 500 | 10,001 | 59.9 | 23.4 | J-692 |
| J-437 | 9,691 | TRUE | Passed | 500 | 9,692 | 24 | 21 | J-692 |
| J-439 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.1 | 19.6 | J-692 |
| J-440 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.9 | 19.2 | J-692 |
| J-442 | 8,911 | TRUE | Passed | 500 | 8,912 | 24 | 20 | J-692 |
| J-443 | 2,237 | TRUE | Passed | 500 | 2,238 | 24 | 24.3 | J-692 |
| J-445 | 10,000 | TRUE | Passed | 500 | 10,001 | 24.1 | 19 | J-692 |
| J-447 | 6,542 | TRUE | Passed | 500 | 6,543 | 24 | 21.7 | J-692 |
| J-448 | 5,185 | TRUE | Passed | 500 | 5,186 | 24 | 22.7 | J-692 |
| J-449 | 6,202 | TRUE | Passed | 500 | 6,204 | 24 | 17.5 | J-450 |
| J-450 | 4,260 | TRUE | Passed | 500 | 4,261 | 24 | 23.2 | J-692 |
| J-451 | 6,049 | TRUE | Passed | 500 | 6,050 | 24 | 22 | J-692 |
| J-452 | 5,521 | TRUE | Passed | 500 | 5,522 | 24 | 22.4 | J-692 |
| J-453 | 5,084 | TRUE | Passed | 500 | 5,085 | 24 | 22.7 | J-692 |
| J-454 | 4,904 | TRUE | Passed | 500 | 4,905 | 24 | 22.8 | J-692 |
| J-455 | 6,671 | TRUE | Passed | 500 | 6,672 | 24 | 21.6 | J-692 |
| J-456 | 6,586 | TRUE | Passed | 500 | 6,587 | 24 | 21.6 | J-692 |
| J-457 | 5,265 | TRUE | Passed | 500 | 5,266 | 24 | 22.5 | J-692 |
| J-458 | 3,040 | TRUE | Passed | 500 | 3,041 | 24 | 23.8 | J-692 |
| J-459 | 2,963 | TRUE | Passed | 500 | 2,964 | 24 | 23.8 | J-692 |
| J-460 | 4,026 | TRUE | Passed | 500 | 4,027 | 24 | 23.2 | J-692 |
| J-461 | 1,663 | TRUE | Passed | 500 | 1,664 | 24 | 23.4 | J-463 |
| J-462 | 1,457 | TRUE | Passed | 500 | 1,458 | 24 | 24.5 | J-692 |
| J-463 | 1,339 | TRUE | Passed | 500 | 1,340 | 24 | 24.5 | J-692 |
| J-464 | 5,288 | TRUE | Passed | 500 | 5,289 | 24 | 22.5 | J-692 |
| J-465 | 5,433 | TRUE | Passed | 500 | 5,434 | 24 | 22.4 | J-692 |
| J-466 | 5,735 | TRUE | Passed | 500 | 5,736 | 24 | 22.1 | J-692 |
| J-467 | 6,441 | TRUE | Passed | 500 | 6,442 | 24 | 21.5 | J-692 |
| J-468 | 6,350 | TRUE | Passed | 500 | 6,351 | 24 | 21.5 | J-692 |
| J-469 | 6,932 | TRUE | Passed | 500 | 6,933 | 24 | 20.9 | J-692 |
| J-470 | 8,351 | TRUE | Passed | 500 | 8,352 | 24 | 19 | J-692 |
| J-471 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.2 | 16.7 | J-692 |
| J-472 | 7,137 | TRUE | Passed | 500 | 7,138 | 24 | 20.5 | J-692 |
| J-473 | 6,586 | TRUE | Passed | 500 | 6,587 | 24 | 21.2 | J-692 |
| J-474 | 6,015 | TRUE | Passed | 500 | 6,016 | 24 | 21.7 | J-692 |
| J-475 | 5,666 | TRUE | Passed | 500 | 5,667 | 24 | 22.1 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-476 | 2,364 | TRUE | Passed | 500 | 2,365 | 24 | 24.1 | J-692 |
| J-477 | 2,391 | TRUE | Passed | 500 | 2,392 | 24 | 24.1 | J-692 |
| J-478 | 5,586 | TRUE | Passed | 500 | 5,587 | 24 | 22.2 | J-692 |
| J-479 | 5,729 | TRUE | Passed | 500 | 5,730 | 24 | 22.2 | J-692 |
| J-480 | 6,089 | TRUE | Passed | 500 | 6,091 | 24 | 22 | J-692 |
| J-481 | 6,479 | TRUE | Passed | 500 | 6,480 | 24 | 21.7 | J-692 |
| J-482 | 3,329 | TRUE | Passed | 500 | 3,330 | 24 | 19.8 | J-485 |
| J-483 | 2,058 | TRUE | Passed | 500 | 2,059 | 24 | 22.8 | J-485 |
| J-484 | 1,892 | TRUE | Passed | 500 | 1,893 | 24 | 24.4 | J-692 |
| J-485 | 1,540 | TRUE | Passed | 500 | 1,541 | 24 | 24.5 | J-692 |
| J-486 | 9,698 | TRUE | Passed | 500 | 9,699 | 24 | 19.5 | J-692 |
| J-487 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.8 | 19.8 | J-692 |
| J-489 | 10,000 | TRUE | Passed | 500 | 10,001 | 52.5 | 21.9 | J-692 |
| J-490 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.6 | 21 | J-692 |
| J-491 | 10,000 | TRUE | Passed | 500 | 10,001 | 63 | 24.4 | J-692 |
| J-492 | 10,000 | TRUE | Passed | 500 | 10,001 | 48.6 | 21.3 | J-692 |
| J-493 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.4 | 20.6 | J-692 |
| J-494 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.3 | 20.7 | J-692 |
| J-497 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.8 | 18.4 | J-692 |
| J-498 | 10,000 | TRUE | Passed | 500 | 10,001 | 48 | 20 | J-692 |
| J-499 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.6 | 20 | J-692 |
| J-500 | 7,012 | TRUE | Passed | 500 | 7,013 | 24 | 22.1 | J-692 |
| J-501 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.4 | 20.7 | J-692 |
| J-502 | 8,501 | TRUE | Passed | 500 | 8,503 | 24 | 20.5 | J-692 |
| J-504 | 7,048 | TRUE | Passed | 500 | 7,049 | 24 | 21.3 | J-692 |
| J-505 | 4,985 | TRUE | Passed | 500 | 4,986 | 24 | 22.8 | J-692 |
| J-507 | 4,696 | TRUE | Passed | 500 | 4,698 | 24 | 22.8 | J-692 |
| J-508 | 4,720 | TRUE | Passed | 500 | 4,721 | 24 | 22.8 | J-692 |
| J-509 | 5,463 | TRUE | Passed | 500 | 5,464 | 24 | 22.3 | J-692 |
| J-510 | 6,185 | TRUE | Passed | 500 | 6,186 | 24 | 22.5 | J-692 |
| J-511 | 2,404 | TRUE | Passed | 500 | 2,405 | 24 | 24.3 | J-692 |
| J-513 | 2,456 | TRUE | Passed | 500 | 2,457 | 24 | 24.3 | J-692 |
| J-514 | 2,773 | TRUE | Passed | 500 | 2,774 | 24 | 23.3 | J-513 |
| J-516 | 5,403 | TRUE | Passed | 500 | 5,404 | 24 | 22.5 | J-692 |
| J-517 | 5,784 | TRUE | Passed | 500 | 5,785 | 24 | 22 | J-692 |
| J-518 | 5,256 | TRUE | Passed | 500 | 5,257 | 24 | 20.2 | J-549 |
| J-519 | 5,781 | TRUE | Passed | 500 | 5,782 | 24 | 22 | J-692 |
| J-520 | 4,787 | TRUE | Passed | 500 | 4,788 | 24 | 22.3 | J-692 |
| J-521 | 3,966 | TRUE | Passed | 500 | 3,967 | 24 | 22.9 | J-692 |
| J-522 | 4,096 | TRUE | Passed | 500 | 4,097 | 24 | 21.5 | J-603 |
| J-523 | 4,465 | TRUE | Passed | 500 | 4,466 | 24 | 21.9 | J-603 |
| J-524 | 4,335 | TRUE | Passed | 500 | 4,336 | 24 | 22.6 | J-692 |

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|---|---|---|---|---|---|---|---|---|
| J-525 | 4,798 | TRUE | Passed | 500 | 4,799 | 24 | 22.2 | J-692 |
| J-526 | 4,676 | TRUE | Passed | 500 | 4,677 | 24 | 22.3 | J-692 |
| J-527 | 4,720 | TRUE | Passed | 500 | 4,721 | 24 | 22.2 | J-692 |
| J-528 | 4,391 | TRUE | Passed | 500 | 4,392 | 24 | 22.5 | J-692 |
| J-529 | 4,609 | TRUE | Passed | 500 | 4,610 | 24 | 22.2 | J-692 |
| J-530 | 4,649 | TRUE | Passed | 500 | 4,650 | 24 | 22.2 | J-692 |
| J-531 | 2,979 | TRUE | Passed | 500 | 2,980 | 24 | 23.5 | J-692 |
| J-532 | 3,222 | TRUE | Passed | 500 | 3,223 | 24 | 23.3 | J-692 |
| J-533 | 8,443 | TRUE | Passed | 500 | 8,444 | 24 | 17.6 | J-692 |
| J-534 | 9,367 | TRUE | Passed | 500 | 9,368 | 24 | 16.3 | J-692 |
| J-535 | 8,707 | TRUE | Passed | 500 | 8,708 | 24 | 17.3 | J-692 |
| J-536 | 7,806 | TRUE | Passed | 500 | 7,807 | 24 | 18.5 | J-692 |
| J-537 | 8,972 | TRUE | Passed | 500 | 8,973 | 24 | 16.9 | J-692 |
| J-538 | 9,615 | TRUE | Passed | 500 | 9,616 | 24 | 15.5 | J-692 |
| J-539 | 10,000 | TRUE | Passed | 500 | 10,001 | 30.4 | 14.7 | J-692 |
| J-540 | 3,168 | TRUE | Passed | 500 | 3,169 | 24 | 23.3 | J-692 |
| J-541 | 3,412 | TRUE | Passed | 500 | 3,413 | 24 | 23.2 | J-692 |
| J-542 | 6,864 | TRUE | Passed | 500 | 6,865 | 24 | 20.2 | J-692 |
| J-543 | 9,308 | TRUE | Passed | 500 | 9,309 | 24 | 17.4 | J-692 |
| J-544 | 10,000 | TRUE | Passed | 500 | 10,001 | 27.5 | 17.1 | J-692 |
| J-545 | 5,712 | TRUE | Passed | 500 | 5,713 | 24 | 21.8 | J-692 |
| J-546 | 2,195 | TRUE | Passed | 500 | 2,196 | 24 | 24.1 | J-692 |
| J-547 | 5,336 | TRUE | Passed | 500 | 5,337 | 24 | 22.3 | J-692 |
| J-548 | 1,892 | TRUE | Passed | 500 | 1,893 | 24 | 24.3 | J-692 |
| J-549 | 1,757 | TRUE | Passed | 500 | 1,758 | 24 | 24.4 | J-692 |
| J-550 | 4,749 | TRUE | Passed | 500 | 4,750 | 24 | 22.8 | J-692 |
| J-551 | 3,131 | TRUE | Passed | 500 | 3,132 | 24 | 23.8 | J-692 |
| J-552 | 2,519 | TRUE | Passed | 500 | 2,520 | 24 | 24.1 | J-692 |
| J-553 | 5,329 | TRUE | Passed | 500 | 5,330 | 24 | 22.7 | J-692 |
| J-554 | 2,974 | TRUE | Passed | 500 | 2,975 | 24 | 23.9 | J-692 |
| J-555 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.8 | 17 | J-692 |
| J-556 | 4,247 | TRUE | Passed | 500 | 4,248 | 24 | 22.8 | J-692 |
| J-557 | 3,745 | TRUE | Passed | 500 | 3,746 | 24 | 23.2 | J-692 |
| J-558 | 1,901 | TRUE | Passed | 500 | 1,902 | 24 | 24.2 | J-692 |
| J-559 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.9 | 17.5 | J-692 |
| J-560 | 10,000 | TRUE | Passed | 500 | 10,001 | 45.2 | 18.1 | J-692 |
| J-561 | 3,858 | TRUE | Passed | 500 | 3,859 | 24 | 23 | J-692 |
| J-562 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.5 | 17.2 | J-692 |
| J-563 | 2,995 | TRUE | Passed | 500 | 2,996 | 24 | 23.4 | J-692 |
| J-564 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.3 | 15.3 | J-692 |
| J-565 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.8 | 16.2 | J-692 |
| J-566 | 8,688 | TRUE | Passed | 500 | 8,689 | 24 | 17 | J-692 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| J-567 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.5 | 14.6 | J-692 |
| J-568 | 10,000 | TRUE | Passed | 500 | 10,001 | 31 | 13.1 | J-692 |
| J-569 | 8,504 | TRUE | Passed | 500 | 8,505 | 24 | 16 | J-692 |
| J-570 | 7,376 | TRUE | Passed | 500 | 7,377 | 24 | 18.2 | J-692 |
| J-571 | 8,856 | TRUE | Passed | 500 | 8,857 | 24 | 14.6 | J-692 |
| J-572 | 10,000 | TRUE | Passed | 500 | 10,001 | 44.5 | 11.2 | J-692 |
| J-573 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.3 | 4 | J-692 |
| J-574 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.7 | 12 | J-692 |
| J-576 | 10,000 | TRUE | Passed | 500 | 10,001 | 38 | 13.7 | J-692 |
| J-577 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.1 | 14.2 | J-692 |
| J-578 | 3,369 | TRUE | Passed | 500 | 3,370 | 24 | 23.1 | J-692 |
| J-579 | 4,450 | TRUE | Passed | 500 | 4,451 | 24 | 22.2 | J-692 |
| J-580 | 4,499 | TRUE | Passed | 500 | 4,500 | 24 | 22.2 | J-692 |
| J-581 | 4,241 | TRUE | Passed | 500 | 4,242 | 24 | 22.3 | J-692 |
| J-582 | 6,716 | TRUE | Passed | 500 | 6,717 | 24 | 19.6 | J-692 |
| J-583 | 7,271 | TRUE | Passed | 500 | 7,272 | 24 | 18.8 | J-692 |
| J-584 | 8,274 | TRUE | Passed | 500 | 8,275 | 24 | 17.4 | J-692 |
| J-585 | 6,339 | TRUE | Passed | 500 | 6,340 | 24 | 19.9 | J-692 |
| J-587 | 5,878 | TRUE | Passed | 500 | 5,879 | 24 | 20.5 | J-692 |
| J-588 | 5,508 | TRUE | Passed | 500 | 5,509 | 24 | 20.9 | J-692 |
| J-589 | 5,650 | TRUE | Passed | 500 | 5,651 | 24 | 20.7 | J-692 |
| J-590 | 7,120 | TRUE | Passed | 500 | 7,121 | 24 | 18.9 | J-692 |
| J-591 | 6,534 | TRUE | Passed | 500 | 6,535 | 24 | 19.7 | J-692 |
| J-592 | 6,307 | TRUE | Passed | 500 | 6,308 | 24 | 20.4 | J-692 |
| J-593 | 4,647 | TRUE | Passed | 500 | 4,648 | 24 | 22.2 | J-692 |
| J-594 | 4,497 | TRUE | Passed | 500 | 4,498 | 24 | 20.3 | J-596 |
| J-595 | 3,659 | TRUE | Passed | 500 | 3,660 | 24 | 21.3 | J-596 |
| J-596 | 3,107 | TRUE | Passed | 500 | 3,108 | 24 | 23.4 | J-692 |
| J-597 | 3,214 | TRUE | Passed | 500 | 3,215 | 24 | 23.4 | J-692 |
| J-598 | 3,299 | TRUE | Passed | 500 | 3,300 | 24 | 23.3 | J-692 |
| J-599 | 3,494 | TRUE | Passed | 500 | 3,495 | 24 | 23.2 | J-692 |
| J-601 | 3,070 | TRUE | Passed | 500 | 3,071 | 24 | 23.5 | J-692 |
| J-602 | 4,410 | TRUE | Passed | 500 | 4,411 | 24 | 22.5 | J-692 |
| J-603 | 2,353 | TRUE | Passed | 500 | 2,354 | 24 | 23.9 | J-692 |
| J-604 | 4,422 | TRUE | Passed | 500 | 4,423 | 24 | 22.5 | J-692 |
| J-605 | 3,266 | TRUE | Passed | 500 | 3,267 | 24 | 23.3 | J-692 |
| J-606 | 3,385 | TRUE | Passed | 500 | 3,386 | 24 | 23.2 | J-692 |
| J-607 | 4,258 | TRUE | Passed | 500 | 4,259 | 24 | 22.6 | J-692 |
| J-608 | 4,388 | TRUE | Passed | 500 | 4,389 | 24 | 22.5 | J-692 |
| J-609 | 4,478 | TRUE | Passed | 500 | 4,479 | 24 | 22.4 | J-692 |
| J-610 | 4,405 | TRUE | Passed | 500 | 4,406 | 24 | 22.4 | J-692 |
| J-611 | 4,707 | TRUE | Passed | 500 | 4,708 | 24 | 22.2 | J-692 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| J-612 | 4,173 | TRUE | Passed | 500 | 4,174 | 24 | 22.6 | J-692 |
| J-613 | 4,303 | TRUE | Passed | 500 | 4,304 | 24 | 22.5 | J-692 |
| J-614 | 6,540 | TRUE | Passed | 500 | 6,541 | 24 | 20.1 | J-692 |
| J-615 | 6,833 | TRUE | Passed | 500 | 6,834 | 24 | 19.8 | J-692 |
| J-616 | 6,990 | TRUE | Passed | 500 | 6,991 | 24 | 19.6 | J-692 |
| J-617 | 6,879 | TRUE | Passed | 500 | 6,880 | 24 | 19.1 | J-692 |
| J-620 | 7,866 | TRUE | Passed | 500 | 7,867 | 24 | 17.7 | J-692 |
| J-621 | 9,659 | TRUE | Passed | 500 | 9,660 | 24 | 14.7 | J-692 |
| J-622 | 9,254 | TRUE | Passed | 500 | 9,255 | 24 | 15.5 | J-692 |
| J-623 | 9,302 | TRUE | Passed | 500 | 9,303 | 24 | 15.1 | J-692 |
| J-625 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.8 | 13.9 | J-692 |
| J-626 | 9,082 | TRUE | Passed | 500 | 9,084 | 24 | 15.9 | J-692 |
| J-627 | 9,034 | TRUE | Passed | 500 | 9,035 | 24 | 16 | J-692 |
| J-628 | 9,273 | TRUE | Passed | 500 | 9,274 | 24 | 15.7 | J-692 |
| J-629 | 9,738 | TRUE | Passed | 500 | 9,739 | 24 | 14.9 | J-692 |
| J-630 | 9,951 | TRUE | Passed | 500 | 9,952 | 24 | 14.6 | J-692 |
| J-631 | 10,000 | TRUE | Passed | 500 | 10,001 | 24.4 | 14.5 | J-692 |
| J-632 | 5,351 | TRUE | Passed | 500 | 5,352 | 24 | 20.9 | J-692 |
| J-633 | 3,191 | TRUE | Passed | 500 | 3,192 | 24 | 23.1 | J-692 |
| J-634 | 8,265 | TRUE | Passed | 500 | 8,266 | 24 | 16.9 | J-692 |
| J-636 | 10,000 | TRUE | Passed | 500 | 10,001 | 29.2 | 14.5 | J-692 |
| J-637 | 3,874 | TRUE | Passed | 500 | 3,875 | 24 | 22.6 | J-692 |
| J-638 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.1 | 14.6 | J-692 |
| J-639 | 10,000 | TRUE | Passed | 500 | 10,001 | 37.8 | 14.1 | J-692 |
| J-640 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.4 | 14.2 | J-692 |
| J-641 | 5,753 | TRUE | Passed | 500 | 5,754 | 24 | 20.7 | J-692 |
| J-642 | 4,161 | TRUE | Passed | 500 | 4,162 | 24 | 22.4 | J-692 |
| J-643 | 3,192 | TRUE | Passed | 500 | 3,193 | 24 | 23.3 | J-692 |
| J-644 | 5,478 | TRUE | Passed | 500 | 5,479 | 24 | 21.4 | J-692 |
| J-645 | 2,783 | TRUE | Passed | 500 | 2,784 | 24 | 23.6 | J-692 |
| J-646 | 7,593 | TRUE | Passed | 500 | 7,594 | 24 | 19.1 | J-692 |
| J-647 | 4,953 | TRUE | Passed | 500 | 4,954 | 24 | 21.8 | J-692 |
| J-648 | 3,044 | TRUE | Passed | 500 | 3,045 | 24 | 23.4 | J-692 |
| J-649 | 3,767 | TRUE | Passed | 500 | 3,768 | 24 | 22.9 | J-692 |
| J-650 | 1,899 | TRUE | Passed | 500 | 1,900 | 24 | 24.1 | J-692 |
| J-651 | 8,073 | TRUE | Passed | 500 | 8,074 | 24 | 18.7 | J-692 |
| J-652 | 3,108 | TRUE | Passed | 500 | 3,109 | 24 | 23.4 | J-692 |
| J-655 | 7,542 | TRUE | Passed | 500 | 7,543 | 24 | 19 | J-692 |
| J-656 | 3,629 | TRUE | Passed | 500 | 3,630 | 24 | 22.9 | J-692 |
| J-657 | 10,000 | TRUE | Passed | 500 | 10,001 | 35.8 | 13.4 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 39.1 | 13.5 | J-692 |
| J-659 | 10,000 | TRUE | Passed | 500 | 10,001 | 40.8 | 13.2 | J-692 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| J-660 | 10,000 | TRUE | Passed | 500 | 10,001 | 42 | 13.2 | J-692 |
| J-661 | 833 | TRUE | Passed | 500 | 838 | 24 | 24.6 | J-692 |
| J-662 | 10,000 | TRUE | Passed | 500 | 10,001 | 54.9 | 12.9 | J-692 |
| J-663 | 10,000 | TRUE | Passed | 500 | 10,001 | 46.1 | 13.2 | J-692 |
| J-664 | 10,000 | TRUE | Passed | 500 | 10,001 | 34.4 | 13.8 | J-692 |
| J-665 | 10,000 | TRUE | Passed | 500 | 10,001 | 36.6 | 14 | J-692 |
| J-666 | 10,000 | TRUE | Passed | 500 | 10,001 | 41.5 | 19.6 | J-692 |
| J-667 | 10,000 | TRUE | Passed | 500 | 10,001 | 26.2 | 19.4 | J-692 |
| J-668 | 10,000 | TRUE | Passed | 500 | 10,001 | 47.9 | 21.1 | J-692 |
| J-669 | 4,485 | TRUE | Passed | 500 | 4,486 | 24 | 22.5 | J-692 |
| J-670 | 5,090 | TRUE | Passed | 500 | 5,091 | 24 | 22 | J-692 |
| J-673 | 10,000 | TRUE | Passed | 500 | 10,001 | 42.4 | 13.3 | J-692 |
| J-674 | 4,297 | TRUE | Passed | 500 | 4,298 | 24 | 21.9 | J-692 |
| J-675 | 4,014 | TRUE | Passed | 500 | 4,015 | 24 | 22.1 | J-692 |
| J-676 | 5,666 | TRUE | Passed | 500 | 5,667 | 24 | 20.1 | J-692 |
| J-677 | 2,529 | TRUE | Passed | 500 | 2,530 | 24 | 23.3 | J-678 |
| J-678 | 1,890 | TRUE | Passed | 500 | 1,891 | 24 | 24 | J-692 |
| J-680 | 6,399 | TRUE | Passed | 500 | 6,399 | 24 | 9.3 | J-692 |
| J-682 | 5,212 | TRUE | Passed | 500 | 5,212 | 24 | 12.9 | J-692 |
| J-685 | 2,335 | TRUE | Passed | 500 | 2,360 | 24 | 20.1 | J-692 |
| J-686 | 6,419 | TRUE | Passed | 500 | 6,469 | 24 | 2.5 | J-692 |
| J-687 | 7,697 | TRUE | Passed | 500 | 7,722 | 30 | 0 | J-692 |
| J-689 | 9,136 | TRUE | Passed | 500 | 9,161 | 24 | 2.7 | J-692 |
| J-690 | 8,133 | TRUE | Passed | 500 | 8,158 | 36.7 | 0 | J-692 |
| J-691 | 7,165 | TRUE | Passed | 500 | 7,190 | 31.4 | 0 | J-692 |
| J-692 | 708 | TRUE | Passed | 500 | 708 | 24 | 25.9 | J-695 |
| J-693 | 6,202 | TRUE | Passed | 500 | 6,227 | 24 | 10.4 | J-692 |
| J-694 | 6,225 | TRUE | Passed | 500 | 6,250 | 24 | 4.6 | J-692 |
| J-695 | 1,361 | TRUE | Passed | 500 | 1,386 | 24 | 23 | J-692 |
| J-696 | 5,499 | TRUE | Passed | 500 | 5,504 | 24 | 15.9 | J-692 |
| J-697 | 6,908 | TRUE | Passed | 500 | 6,908 | 24 | 4.1 | J-692 |
| J-698 | 9,546 | TRUE | Passed | 500 | 9,571 | 24 | 2.6 | J-692 |
| J-699 | 10,000 | TRUE | Passed | 500 | 10,025 | 44.2 | 0.2 | J-692 |
| J-700 | 8,631 | TRUE | Passed | 500 | 8,656 | 24 | 2.4 | J-692 |
| J-702 | 5,760 | TRUE | Passed | 500 | 5,760 | 24 | 7.9 | J-692 |
| J-714 | 7,727 | TRUE | Passed | 500 | 7,727 | 24 | 20.7 | J-692 |
| J-715 | 4,847 | TRUE | Passed | 500 | 4,847 | 24 | 21.7 | J-692 |
| J-716 | 6,694 | TRUE | Passed | 500 | 6,694 | 24 | 18.1 | J-692 |
| J-717 | 6,895 | TRUE | Passed | 500 | 6,895 | 24 | 17.5 | J-692 |
| J-718 | 6,814 | TRUE | Passed | 500 | 6,814 | 24 | 17.3 | J-692 |
| J-719 | 10,000 | TRUE | Passed | 500 | 10,000 | 30.1 | 19 | J-692 |
| J-720 | 7,350 | TRUE | Passed | 500 | 7,350 | 24 | 19.6 | J-692 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| J-721 | 9,066 | TRUE | Passed | 500 | 9,066 | 24 | 10.7 | J-692 |
| J-722 | 7,049 | TRUE | Passed | 500 | 7,049 | 24 | 18.5 | J-692 |
| J-723 | 9,570 | TRUE | Passed | 500 | 9,570 | 24 | 15.2 | J-692 |
| J-724 | 9,354 | TRUE | Passed | 500 | 9,354 | 24 | 18 | J-692 |
| J-725 | 9,798 | TRUE | Passed | 500 | 9,798 | 24 | 18.6 | J-692 |
| J-726 | 8,788 | TRUE | Passed | 500 | 8,788 | 24 | 19.9 | J-692 |
| J-727 | 10,000 | TRUE | Passed | 500 | 10,000 | 35.4 | 21.1 | J-692 |
| J-729 | 10,000 | TRUE | Passed | 500 | 10,000 | 35 | 19.3 | J-692 |
| J-731 | 6,086 | TRUE | Passed | 500 | 6,087 | 24 | 20.9 | J-692 |
| J-904 | 7,312 | TRUE | Passed | 500 | 7,313 | 24 | 17 | J-692 |
| J-1031 | 10,000 | TRUE | Passed | 500 | 10,001 | 25.2 | 12.8 | J-692 |
| J-1082 | 10,000 | TRUE | Passed | 500 | 10,001 | 60.9 | 12.8 | J-692 |
| J-1184 | 10,000 | TRUE | Passed | 500 | 10,001 | 32.6 | 20.7 | J-692 |
| J-1201 | 8,763 | TRUE | Passed | 500 | 8,764 | 24 | 19.9 | J-692 |
| J-1296 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.7 | 20.3 | J-692 |
| J-1334 | 7,779 | TRUE | Passed | 500 | 7,780 | 24 | 20.7 | J-692 |
| J-1340 | 4,298 | TRUE | Passed | 500 | 4,299 | 24 | 23.1 | J-692 |
| J-1549 | 3,115 | TRUE | Passed | 500 | 3,116 | 24 | 23.4 | J-692 |
| J-1642 | 9,330 | TRUE | Passed | 500 | 9,331 | 24 | 15.2 | J-692 |
| J-1704 | 10,000 | TRUE | Passed | 500 | 10,001 | 43.9 | 13.4 | J-692 |
| J-1780 | 8,058 | TRUE | Passed | 500 | 8,058 | 24 | 19.8 | J-692 |
| J-1806 | 3,807 | TRUE | Passed | 500 | 3,807 | 24 | 18 | J-692 |

# APPENDIX L

# 2003 Water Study

VACLAVIK

# EVALUATION OF WATER SUPPLY SYSTEM

Prepared For The

KAUKAUNA UTILITIES

McMAHON ASSOCIATES INC.
ENGINEERS ■ ARCHITECTS
PROJ. MGRS. ■ SURVEYORS

**June 2003**
McM. No. K0004-920857
AJV:smdt

# EVALUATION OF WATER SUPPLY SYSTEM

Prepared For The

KAUKAUNA UTILITIES

Prepared By
**McMahon Associates, Inc.**
Neenah, Wisconsin
June 2003
McM. No. K0004-920857

## Table Of Contents

**From:** Don Voogt
**To:** kobiala@wppisys.org
**Date:** 12/18/2006 4:36:44 PM
**Subject:** air binding

Kevin:

I looked up the inspection report we wrote on your round reservoir back in 2003. We had a lot of pictures from inside the tank, and one of the suction line to the high lift pumps, but we did not take a picture of the line to/from the iron filter. The suction line to the high lift pumps did have a downturned elbow in the reservoir. If the line to/from the iron filter was built the same way, it would also have a downturned elbow. If that is the case, or even if the line from the reservoir was flat, then I think your theory of an air pocket at the top of that line is very feasible.

So, if there was an air pocket that had formed in the crown of the buried pipe, it would not reach your backwash pump until a quantity of water had already been pumped. That would explain why you see the vacuum pump get the air out of the pump inlet, then some flow happens, then the large air pocket from the pipe reaches the pump and it loses its prime.

I know you are frustrated with the system as it currently operates. The theory of what was installed was good. However, everything happens too fast The vacuum pump shuts off before the second pocket of air gets to it. So if there was some way to make the vacuum system work in such a way that it would evacuate or bleed off any air that gets up to the pump, then you might have something. As it is right now the probes that control the vacuum pump probably get wet, and there is always enough water in that area that it does not come back on even though another air pocket comes along. Can you verify in the PLC program that WOULD, IN FACT come on at that time if another pocket of air came along? Or is the PLC set to only have one run cycle when the pump is called for, and not come on again? In other words, is the vacuum pump set up to run whenever the backwash pump is called for provided the probers are dry?

Let me know what you find out, and we'll keep thinking about this problem.

Don Voogt

McMahon Associates, Inc.
dvoogt@mcmgrp.com
ph 920-751-4200

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# EVALUATION OF WATER SUPPLY SYSTEM

Prepared For The

KAUKAUNA UTILITIES

Prepared By
**McMahon Associates, Inc.**
Neenah, Wisconsin

June 2003
McM. No. K0004-920857

## I. DESCRIPTION OF EXISTING WATER SUPPLY & TREATMENT FACILITIES

### A. General

The Kaukauna Utilities currently have five water supply wells. The raw water supply from Well #4, Well #5 and Well #10 is pumped to the Main Treatment Plant for removal of iron. Well #9 is also treated for iron through an iron filter at the Well #9 pumphouse. Well #8 is currently not in operation. This facility, which consists of an iron filter and small reservoir, is currently being used for pilot testing of different radium reduction treatment options. The general location of the system facilities is highlighted on Figure #1. A schematic of the Kaukauna water system is provided on Figure #2.

There are two ground storage reservoirs at the Main Treatment Plant, having a total capacity of 579,000-gallons. The system also includes two 500,000-gallon elevated storage tanks, for a total elevated storage capacity of 1,000,000-gallons. The Kaukauna water system is currently operated as a single pressure zone. A summary of the system storage facilities is provided on Table #1.

The distribution system consists of approximately 80-miles of water main, ranging from 4-inches to 16-inches in diameter. An analysis of the distribution system was conducted in April 1997. A Master Water Distribution System Plan was developed at that time. This Plan illustrates how water service can be extended to future development areas. Therefore, further evaluation of the distribution system is not needed at this time. A copy of the Master Plan is provided in Appendix A.

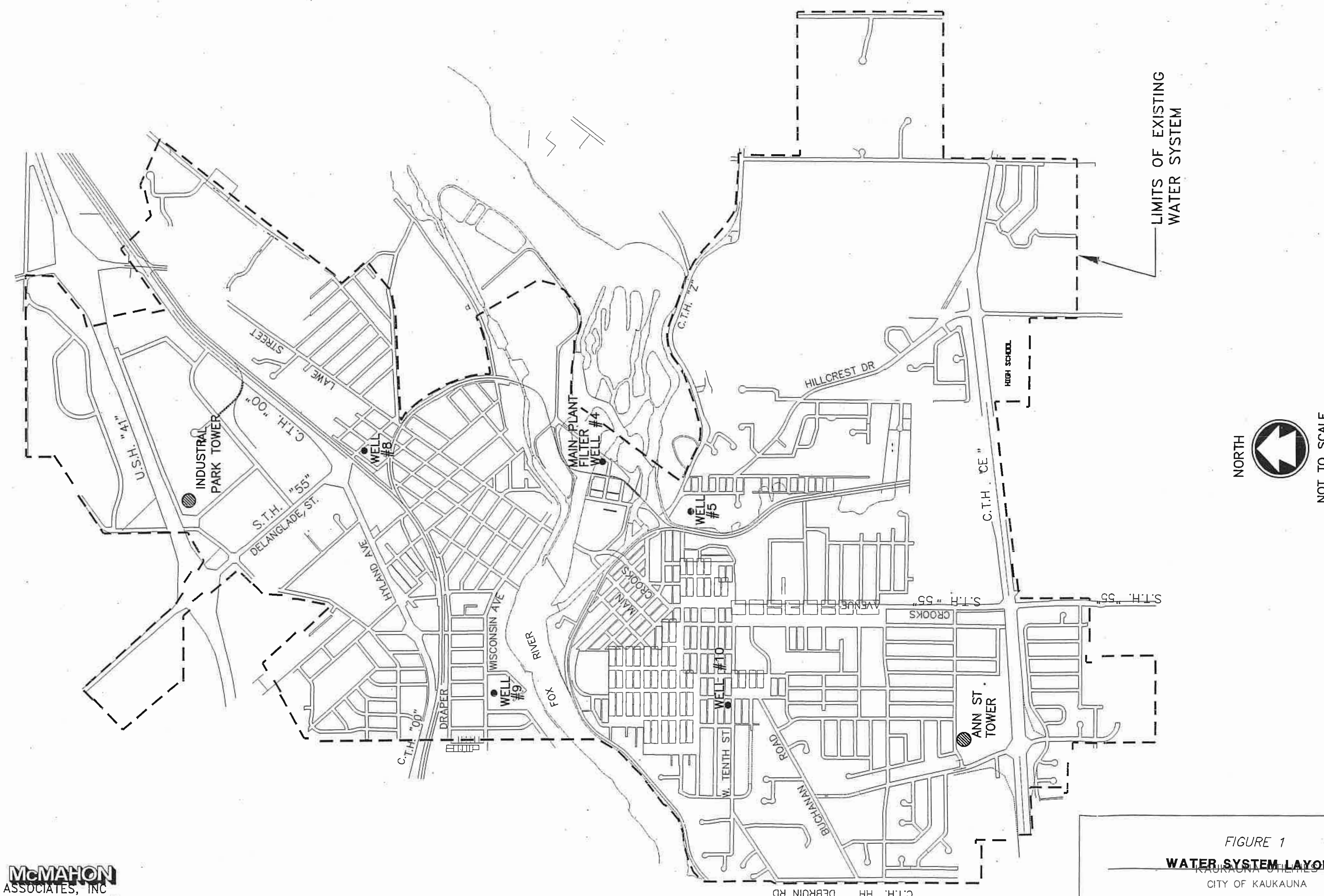



*FIGURE 1*

**WATER SYSTEM LAYOUT**

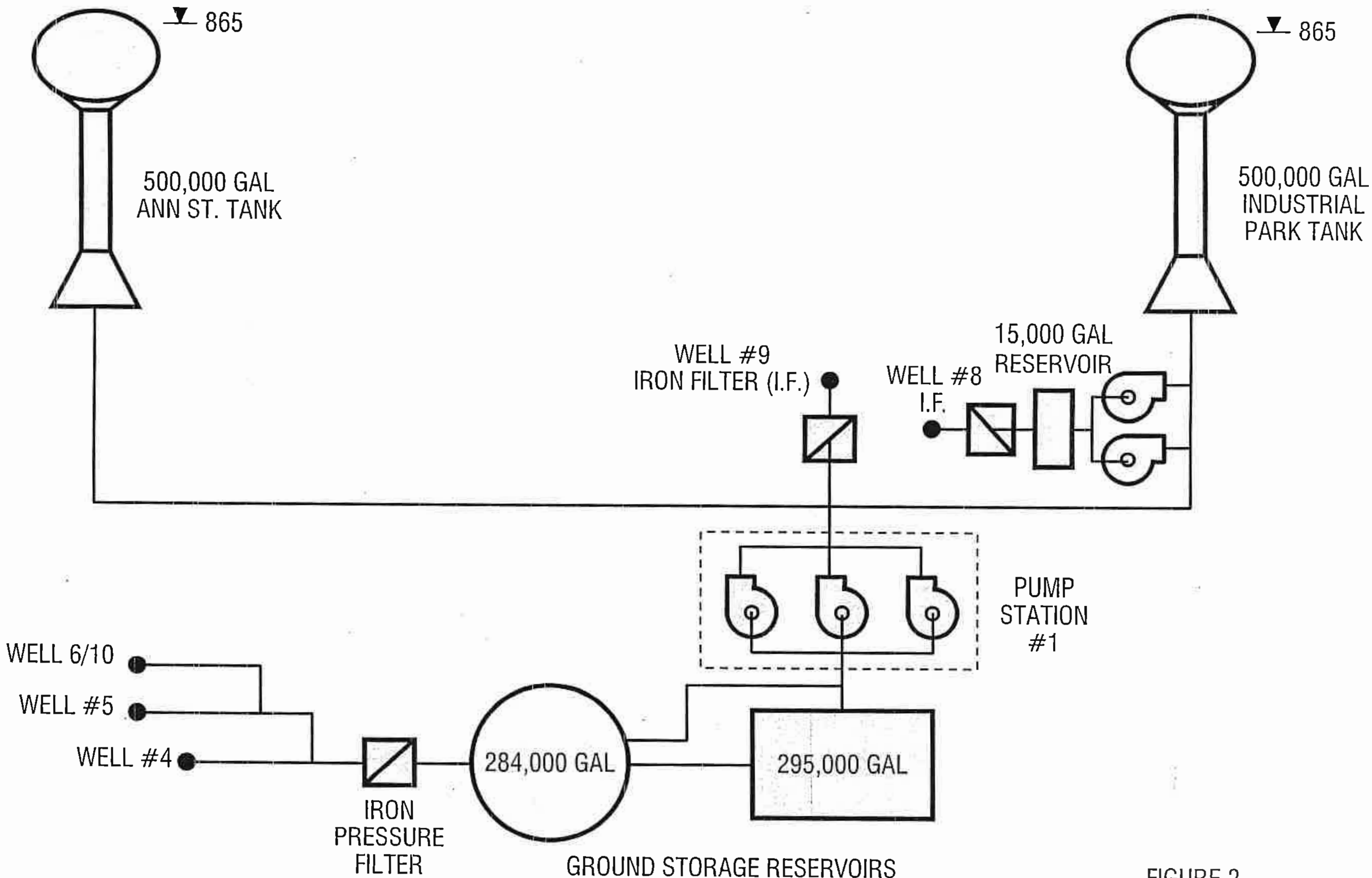
KAUKAUNA UTILITIES

CITY OF KAUKAUNA

McM# K0004-920857.00 FEBRUARY 2003

McMAHON ASSOCIATES, INC

ENGINEERS ARCHITECTS
SCIENTISTS SURVEYORS




McMAHON ASSOCIATES, INC.
ENGINEERS ■ ARCHITECTS
PROJ. MGRS. ■ SURVEYORS

FIGURE 2

**WATER SYSTEM SCHEMATIC**

KAUKAUNA UTILITIES - KAUKAUNA, WISCONSIN

McM #K0004-920857.00 2/3/03

ID: PPT\2003\MCM WIS\KAUKAUNA WATER SYS.PPT AJV:jmk

# Table #1

## WATER SYSTEM STORAGE FACILITIES
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| Name Or Number | #1 | #2 | Ann Street | Industrial Park |
|---|---|---|---|---|
| Location | At Main Treatment Plant | | | |
| Type | Reservoir | Reservoir | Elevated Tank - Sheroid | Elevated Tank - Fluted Pedestal |
| Year Constructed | 1901 | 1940 | 1999 | 1974 |
| Construction Material | Concrete | Concrete | Steel | Steel |
| Capacity | 284,000-gallons | 295,000-gallons | 500,000-gallons | 500,000-gallons |
| Last Painted | | | --- | 1996 |
| Height Of Water Level | | | 141.5-feet | 146-feet |
| Overflow Elevation | | | 865-feet | 865-feet |

## B. Water Supply & Treatment Systems

The water supply for the City of Kaukauna is obtained from deep wells, which penetrate and are open to the Sinnippee dolomite, the St. Peter sandstones, the Prairie du Chien group and the Cambrian sandstones. Engineers from McMahon Associates, Inc. conducted a site visit of each well and pumphouse on December 12, 2002. The visits were conducted to determine the physical condition and to provide an engineering assessment of the mechanical, treatment, and electrical and building systems of the facilities. A description of each well and pumphouse, and the physical condition of each, is provided in the following paragraphs. Summary tables of the system facilities are provided on Tables #2 and #3. A copy of the 2002 Wisconsin Department of Natural Resources (DNR) Sanitary Survey is provided in Appendix B.

Well logs are provided in Appendix C. In an attempt to improve the quality of the water supply, some of the wells have been filled to shallower depths to block off the portions of the aquifer that produce water with a high iron content.

### 1. Well #4

Kaukauna Well #4 Piping

Well #4 is located at the Main Treatment Plant site on Schultheis Street, between Elm and Oak Streets. The well was originally constructed in 1921. The well consists of a 15½-inch casing to a depth of 34-feet and a 12-inch casing extended to a depth of 120-eet. A 12-inch open hole was drilled from a depth of 120-feet to a total depth of 726-feet. A 10-inch liner was placed from the surface to a depth of 120-feet. The annular space between the 10-inch liner and the larger diameter casings was sealed with grout to a depth of 120-feet.

Well #4 Wellhead

Well #4 is located in a building connected to Pump Station #1. Pump Station #1 is constructed of concrete block and wood. The building also houses the Water Department operations shop. The existing well pump was installed in 1994 and consists of a Simmons submersible pump. The design capacity of the well pump is 700 gpm. Well #4 is currently operated at 560 gpm. Auxiliary power is not provided for Well #4. Raw

# Table #2

**WATER SUPPLY SYSTEM COMPONENTS**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| **Component** | **Well & Pumphouse Facilities** | | | | |
|---|---|---|---|---|---|
| **Well** | Well #4 | Well #5 | Well #10 | Well #8 | Well #9 |
| Location | Elm Street | Dodge @ Island Street | Kenneth Avenue @ 10th Street. | DeLanglade Street | Riverside Park |
| Year Drilled | 1921 | 1935 | 1945 | 1959 | 1974 |
| Well Depth | 726 | 524 | 660 | 700 | 620 |
| Casing Diameter | 15½ -inches | 16-inch | 10-inch | 16-inch | 18-inch |
| Casing Depth | 0-34-feet | 121-feet | 159-feet | 151-feet | 230 |
| Casing Diameter | 10-inch | --- | --- | --- | --- |
| Casing Depth | 0-120-feet | --- | --- | --- | --- |
| Open Hole Diameter | 12-inch | 15-inch, 121-350-feet | 10-inch | 15-inch, 151-600-feet | 17¼-inch |
| Open Hole Diameter | | 12-inch, 350-524-feet | --- | 14-inch, 600-700-feet | --- |
| | | | | | |
| Aquifer Type | Sandstone/Limestone | St. Peter Sandstone | Sandstone/Dolomite | Sandstone/Dolomite | Sandstone/Limestone |
| Original Static Water Level | 19-feet (1957) | 36-feet (1957) | 84-feet (1957) | 75-feet (1957) | 72-feet (19.77) |
| Current Static Water Level | 116-feet | 106-feet | 184-feet | 163-feet | 146-feet |
| Pumping Level | 220-feet @ 594 gpm | 146-feet @ 210 gpm | 244-feet @ 538 gpm | 236-feet @ 440 gpm | 225-feet @ 1070 gpm |
| Specific Capacity | 5.7 gpm/foot | 5.3 gpm/foot | 9.0 gpm/foot | 6.0 gpm/foot | 13.54 gpm/foot |
| | Well discharges to iron filter at the Main Treatment Plant | Well discharges to iron filter at the Main Treatment Plant<br>1935-Drilled to 570<br>1942-Drilled to 733.5<br>1947-Filled to 524 | Well originally constructed as Well #6 in 1945. Well discharges to iron filter at the Main Treatment Plant.<br>1945 - Drilled to 568<br>1995 - Drilled to 841<br>2000 - Filled to 660 | Well discharges to iron filter at Well #8<br>1959 - Drilled to 602<br>~1995 - Drilled to 800<br>2000 - Filled to 700 | 1974 - Drilled to 806<br>1989 - Filled to 620 |

**Table #2**
(continued)
**WATER SUPPLY SYSTEM COMPONENTS**

| **Well Pumping Equipment** | Well #4 | Well #5 | Well #10 | Well #8 | Well #9 |
|---|---|---|---|---|---|
| Year Installed | 1994 | 1953 | 1995 | 1996 | |
| Operating Rate | 560 gpm | 200 gpm | 540 gpm | 500 gpm | 960 gpm |
| Design Capacity | 700 gpm | 216 gpm | 650 gpm | 600 gpm | 1,160 gpm |
| Manufacturer | Simmons | Layne Northwest | Jacuzzi | Simmons | Layne Northwest |
| Type | Submersible | Vertical Turbine | Submersible | Submersible | Vertical Turbine |
| Discharge Pressure | 12 psi | 56 psi | Not Operational | 80 psi | 78 psi |
| Pump Setting Depth | 302-feet | 190-feet | 411-feet | 290-feet | 380-feet |
| (top of bowls) | | | | | |
| Latest Pump Inspection Date | 1994 | 1995 | 1996 | 1997 | 2002 |

| **Well Pump Power Equipment** | Well #4 | Well #5 | Well #8 | Well #9 | Well #10 |
|---|---|---|---|---|---|
| Year Installed | 1994 | 1979 | 1997 | 1996 | 1989 |
| Manufacturer | Franklin | U.S. | Hitachi | U.S. | Hitachi |
| Type | Electric | Electric | Electric | Electric | Electric |
| Rated Horsepower | 60 | 30 | 100 | 100 | 100 |
| Stand-By Equipment | No | No | No | Yes | No |

| **Booster Pumping Equipment** | #1 Booster | #2 Booster | #3 Booster | #6 Booster | #7 Booster |
|---|---|---|---|---|---|
| Location | Pump Station #1 Main Filter Plant | Pump Station #1 Main Filter Plant | Pump Station #1 Main Filter Plant | Pump Station #2 Well #8 Reservoir | Pump Station #2 Well #8 Reservoir |
| Pump Manufacturer | Layne | Layne | Layne Northwest | Goulds | Peerless |
| Year Installed | 1998 | 1998 | 1967 | 1991 | 1999 |
| Type | Vertical Turbine | Vertical Turbine | Vertical Turbine | Centrifugal | Centrifugal |
| Actual Capacity, gpm | 1,200 gpm | 1,200 gpm | 2,000 | 700 | 550 |
| Pump Motor Manufacturer | U.S. Electrical | U.S. Electrical | Continental | Marathon | U.S. Electrical |
| Year Installed | 1998 | 1998 | 1967 | 1985 | 1985 |
| Type | Electric | | Engine - Stand-By | Electric | Electric |
| Horsepower | 100 | 100 | 150 | 20 | 20 |

## Table #3

**WATER TREATMENT FACILITIES**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| **Location** | Elm Street | Well #8 | Well #9 |
|---|---|---|---|
| Filter Type | Pressure, Iron Removal (Main Plant) | Pressure, Iron Removal | Pressure, Iron Removal |
| Manufacturer | General Filter Company | General Filter Company | Tonka Horizontal |
| Number Of Tanks/Cells | 1 Tank / 4 Cells | 1 Tank / 4 Cells | 2 Tanks / 2 Cells Each |
| Dimensions | 10-feet Dia. x 50-feet long (Filter Area = 473 sq.ft.) | 10-feet Dia. x 24-feet long (Filter Area = 438 sq.ft.) | 8-feet Dia. x 30-feet long (Filter Area = 452 sq.ft.) |
| Filtration Rate | 2.78 gpm/sq.ft. | 2.28 gpm/sq.ft. | 2.54 gpm/sq.ft. |
| Capacity | 1,313 gpm | 500 gpm | 1,220 gpm |
| Backwash Rate | | 15 gpm/sq.ft. | 12 gpm/sq.ft. |
| Backwash Duration | 10-minutes | 10-minutes | 10-minutes/cell |
| Backwash Frequency | Weekly | 2-Times/Week | 2-Times/Week |
| Raw Water Iron Content | 0.4 mg/l | 0.5 mg/l | 0.56 mg/l |
| Finished Water Iron Content | 0.1 mg/l | 0.1 mg/l | 0.1 mg/l |
| Finished Water Discharge | 2 Ground Level Reservoirs | Distribution System | Distribution System |

Chemical Addition At All Wells: Permanganate, Sodium Silicate, Sodium Hypochlorite.

water is pumped through the iron pressure filter at the Main Filter Plant and discharged to the ground storage reservoirs. Well #4, Well #5 and Well #10 are always operated to run at the same time.

In January 2003, observations were conducted at each well to identify air entrainment conditions. A summary of the results are provided on Table #4. The results of the two observations are as follows:

Pumping Rate: 630 gpm / Well Started Operation - 9:00 a.m.

Observation #1 - 10:00 a.m.

a. Water sample clear at time zero, then air bubbles start to form.
b. Sample cleared of air in less than a minute.

Observation #2 - 1:10 p.m.

a. Water sample clear at time zero, then air bubbles start to form.
b. Sample cleared of air in less than 2-minutes.

The wellhead, discharge piping, valves, electrical system and building facility all appear to be in good functional condition. With routine maintenance and service. Well #4 should continue to provide reliable water production for the City.

### 2. Well #5

Kaukauna Well #5

Well #5 is located on Dodge Street, south of the intersection of Dodge and Island streets. The well was originally constructed in 1935 to a depth of 570-feet. In 1942, the depth of the well was extended to 733.5-feet and was then backfilled to a depth of 524-feet in 1947 to improve water quality. The well consists of a 16-inch grouted casing extended to a depth of 121-feet. A 15-inch open hole extends from the bottom of the casing to a depth of 350-feet and a 12-inch open hole extends from 350-feet to a total depth of 524 feet.

The Well #5 pumphouse was constructed in 1975. The existing block building is in good condition. The well pumping equipment consists of a Layne vertical turbine pump with a design capacity of 216 gpm. The pumping equipment

# Table #4

## AIR ENTRAINMENT OBSERVATIONS

KAUKAUNA UTILITIES

Evaluation Of Water Supply System

| Well | Pumping Rate | Well Started Operation | Air In Sample | Sample Time | Time To Clear | Air In Sample | Sample Time | Time To Clear |
|---|---|---|---|---|---|---|---|---|
| #4 | 630 gpm | 9:00 a.m. | #1 | 10:00 a.m. | A | #1 | 1:10 p.m. | B |
| #5 | 210 gpm | 9:00 a.m. | #3 | 10:15 a.m. | B | #3 | 1:25 p.m. | B |
| #10 | 540 gpm | 9:00 a.m. | #2 | 10:30 a.m. | C | #3 | 1:30 p.m. | B |
| MFP - Influent | 1,380 gpm | 9:00 a.m. | #1 | 10:05 a.m. | A | #4 | 1:20 p.m. | A |
| MFP - Effluent | 1,380 gpm | 9:00 a.m. | #1 | 10:10 a.m. | A | #4 | 1:25 p.m. | A |
| #9 | 1,100 gpm | 10:45 a.m. | #1 | 11:00 a.m. | B | #1 | 1:45 p.m. | B |
| #9 F.P. Effluent | 1,100 gpm | 10:45 a.m. | | N/A | | #1 | 1:50 p.m. | B |
| Distribution System | | | #2 | 10:00 a.m. | C | #1 | 1:30 p.m. | C |
| #8 | 300 gpm | 9:00 a.m. | #1 | 9:30 a.m. | B | | N/A | |
| #8 Reservoir Discharge | 300 gpm | 9:00 a.m. | #4 | 9:45 a.m. | B | | N/A | |

Time To Clear
A < 1-Minute
B < 2-Minutes
C < 3-Minutes

Air In Sample Code
#1 Clear at time zero, and then air bubbles start to form.
#2 Cloudy with small bubbles, turns milky white within 15-seconds.
#3 Very cloudy, milky white with air and gets cloudier.
#4 Clear, very little formation of air bubbles.

MFP = Main Filter Plant
FP = Filter Plant

was last inspected in 1995. The pump is currently operated at a rate of 200 gpm. Auxiliary power is not provided for Well #5. Sodium hypochlorite is added to the raw water for disinfection, prior to filtration at the Main Treatment Plant. Raw water is conveyed from Well #5 to the Main Treatment Plant through 2,100-feet of 8-inch transmission main.

Well #5 Pumphouse

The results of observations conducted in January 2003 to document air entrainment are summarized on Table #4. The observations made at Well #5 were as follows:

Pumping Rate:
210 gpm / Well Started Operation - 9:00 a.m.

Observation #1 - 10:15 a.m.

a. Water sample very cloudy, milky white with air, and gets cloudier.
b. Sample cleared of air in less than 2-minutes.

Observation #2 - 1:25 p.m.

a. Water sample very cloudy, milky white with air, and gets cloudier.
b. Sample cleared of air in less than 2-minutes.

The entire Well #5 facility appears to be in excellent condition. The building is well maintained, and the well motor, piping, valves, meters and electrical system are in good working order.

### 3. Well #10


Well #10 Discharge Piping

Well #10 was originally constructed as Well #6 in 1945. The well was originally constructed with a 10-inch casing grouted to a depth of 159-feet with a 10-inch open hole drilled to a depth of 568-feet. In 1995, the 10-inch open hole was extended to 841-feet and the well was renamed as Well #10. In 2000, the well was filled to a depth of 660-feet in an attempt to reduce the radium and gross alpha levels. This was somewhat effective as the radium levels were reduced. A summary of radium analysis results is provided on Table #5. This well is located on Tenth Street near Kenneth Street. There is a gas station with

**Table #5**

**SUMMARY OF RADIONUCLIDES ANALYSIS OF WATER SUPPLY**

KAUKAUNA UTILITIES

Evaluation Of Water Suppy System

| Item | Primary Standard | Well #4 | | | | | Well 5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12/83 | 8/7/2000 | 2/5/2002 | 3/21/2002 | 2/27/2003 | 12/83 | 5/5/1987 | 5/5/1987 | 5/5/1987 | 2/27/2003 |
| | pCi/l | Raw | Raw | Raw | Raw | Raw | Raw | Raw | After Filters | After Filters 300 gpm | Raw |
| Gross Alpha, pCi/l | 15 | 16.7 | 26.0 | | 23 | 16 | 14.1 | 12.2 | 17.1 | 15.2 | 15 |
| Remainder of Alpha, pCi/l | | | 23.8 | | 20.9 | 14.2 | | | | | 12.8 |
| Uranium, Total, pCi/l | | | 2.2 | | 2.1 | 1.8 | | | | | 2.2 |
| Gross Beta, pCi/l | | | 16.3 | | 11.5 | 11 | | | | | 9.4 |
| Radium-226, pCi/l | | | 3.0 | 3.2 | 3.1 | 3.3 | | | | | 3.1 |
| Radiu-228, pCi/l | | | 5.6 | 4.1 | 5.6 | 4.2 | | | | | 3.9 |
| Radium-226/228 | 5 | 11.3 | 8.6 | 7.3 | 8.7 | 7.5 | 8.6 | 4.9 | 4.9 | 5 | 7.0 |
| Well Depth | | Deep 726 | | Deep 726 | | | Shallow 524 | Shallow 524 | Shallow 524 | Shallow 524 | |

| Item | Well #10 | | | | Main Filter Plant | | | |
|---|---|---|---|---|---|---|---|---|
| | 5/5/1987 | 1/22/1999 | 4/10/2000 | 2/27/2003 | 1/22/1999 | 10/8/2002 | 2/27/2003 | 2/27/2003 |
| | Raw | Raw | Raw | Raw | After Filters Prior Resv. | After Filters Prior Resv. | Combination Raw | After Filters Prior Resv. |
| Gross Alpha, pCi/l | 12.6 | 38 | 27.4 | 17 | 39 | 16 | 18 | 10 |
| Remainder of Alpha, pCi/l | | | 20.5 | 15.6 | 31.5 | | 16.1 | 8.4 |
| Uranium, Total, pCi/l | | | 6.9 | 1.4 | 7.5 | | 1.9 | 1.6 |
| Gross Beta, pCi/l | | | 13.4 | 9.2 | | 9.3 | 9.9 | 7.1 |
| Radium-226, pCi/l | | 3.2 | 3.1 | 3.4 | 3.1 | 3 | 3.2 | 2.2 |
| Radiu-228, pCi/l | | 5.6 | 3.8 | 2.4 | 4.4 | 2.4 | 3.6 | 2.1 |
| Radium-226/228 | 5.6 | 8.8 | 6.9 | 5.8 | 7.5 | 5.4 | 6.8 | 4.3 |
| Well Depth | | | | | | | | |

| Item | Primary Standard | Well #8 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12/83 | 5/5/1987 | 5/5/1987 | 5/5/1987 | 4/15/1999 | 4/10/2000 | 2/5/2002 | 3/21/2002 | 9/30/2002 | 10/8/2002 | 3/3/2003 | 3/3/2003 |
| | pCi/l | Raw | Raw | After Filters | After Filters 400 gpm | Raw | Raw | Raw | Raw | After Filters | After Filters | Raw | After Filters |
| Gross Alpha, pCi/l | 15 | 28.4 | 22.3 | 17.2 | 19.6 | 30 | 36 | | 26.1 | 12 | 12 | 26 | 6 |
| Remainder of Alpha, pCi/l | | | | | | | | | 21.2 | | | 24.6 | 4.6 |
| Uranium, Total, pCi/l | | | | | | | | | 4.9 | | | 1.4 | 1.4 |
| Gross Beta, pCi/l | | | | | | 14.5 | 15 | | 14.8 | 5.5 | 9.3 | 13 | 4.9 |
| Radium-226, pCi/l | | | | | | 2.9 | 4.1 | 3.6 | 3.7 | 2.4 | 1.8 | 4.1 | 0.15 |
| Radiu-228, pCi/l | | | | | | 4.6 | 3 | 2.1 | 2.9 | 1.7 | 1.3 | 2.5 | -0.1 |
| Radium-226/228 | 5 | 13.7 | 8.5 | 6.5 | 7.7 | 7.5 | 7.1 | 5.7 | 6.6 | 4.1 | 3.1 | 6.6 | 0.05 |
| Well Depth | | Shallow 590 | Shallow 590 | Shallow 590 | Shallow 590 | | | | | | | | |

| Item | Primary Standard | Well #9 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 12/83 | 5/5/1987 | 4/20/1988 | 4/28/1988 | | 1/22/1999 | 2/5/2002 | 3/21 /2002 | 10/8/2002 | 2/27/2003 | 2/27/2003 |
| | pCi/l | Raw | Raw | Raw | Raw | | Finished | Raw | Raw | Finished | Raw | Finished |
| Gross Alpha, pCi/l | 15 | 15.6 | 20 | 14.4 | 14 | | 14 | | 17.4 | 13 | 15 | 14 |
| Remainder of Alpha, pCi/l | | | | | | | | | 15.2 | | 13.7 | 12.3 |
| Uranium, Total, pCi/l | | | | | | | | | 2.2 | | 1.3 | 1.7 |
| Gross Beta, pCi/l | | | | | | | | | 8 | 6.6 | 7.7 | 6.2 |
| Radium-226, pCi/l | | | | | | | 1.5 | 2.8 | 2.46 | 1.8 | 2.5 | 1.6 |
| Radium-228, pCi/l | | | | | | | 1.5 | 1.6 | 2.2 | 1.8 | 2.3 | 0.7 |
| Radium-226/228 | 5 | 7.7 | 6.2 | 5.1 | 3 | | 3 | 4.4 | 4.66 | 3.6 | 4.8 | 2.3 |
| Well Depth | | Deep 795 | Deep 795 | Shallow 620 | Shallow 620 | | | | | | | |

| Item | Primary Standard | Distribution System at Utility Office | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pCi/l | 6/28/1999 | 8/17/1999 | 11 /16/1999 | 5/11/2000 | | 8/7/2000 | 10/1 0/2000 | 3/5/2001 | 6/45/01 | | 12/1 0/2001 |
| Gross Alpha, pCi/l | 15 | 29 | 29 | 27 | 21 | | 20 | 64 | 17 | 16.9 | | 19 |
| Remainder of Alpha, pCi/l | | | 26.3 | 24.5 | | | 17.7 | | | | | 17.0 |
| Uranium, Total, pCi/l | | | 2.7 | 2.5 | | | 2.3 | | | | | 2 |
| Gross Beta, pCi/l | | 14 | 16 | 14.9 | 13.2 | | 13 | 29.1 | 11 | 11.8 | | 12 |
| Radium-226, pCi/l | | 2.4 | 3.1 | 3.1 | 1.72 | | 1.96 | 8.2 | 1.88 | 2 | | 2.46 |
| Radium-228, pCi/l | | 3.3 | 3.3 | 3.8 | 2.6 | | 2.7 | 12 | 2.8 | 2.9 | | 2.8 |
| Radium-226/228 | 5 | 5.7 | 6.4 | 6.9 | 4.32 | | 4.66 | 20.2 | 4.68 | 4.9 | | 5.26 |

underground fuel tanks immediately adjacent to this well. Observations were also conducted at Well #10 in January 2003 to record the conditions of entrainment air. The observations made are as follows:

Pumping Rate: 540 gpm / Well Started Operation - 9:00 a.m.

Observation #1 - 10:30 a.m.

a. Water sample initially cloudy with small bubbles, turns milky white within 15-seconds.
b. Sample cleared of air in less than 3-minutes.

Observation #2 - 1:30 p.m.

a. Water sample very cloudy, milky white with air, and gets cloudier.
b. Sample cleared of air in less than 2-minutes.

Well #10 Pumphouse

The Well #10 pumphouse was constructed in 1945. It is a brick and concrete structure. The discharge piping has rusted completely through and must be replaced. There is a humidity problem within the well house that needs to be addressed. Chlorine is not added to the raw water at this location. The existing well pump equipment, consisting of a Jacuzzi submersible pump was installed in 1995. The pump has a design capacity of 650 gpm. Currently, the pump operates at a rate of approximately 540 gpm. There is no standby power at this facility. Raw water is conveyed from Well #10 to the iron pressure filter at the Main Treatment Plant via a 6,100-foot 8-inch main. Well #5 is also connected to this transmission main.

### 4. Main Treatment Plant

A 1,300-gallon per minute iron pressure filter is located at the Main Plant, located on Schutheis Street. This filter treats water from Well #4, Well #5 and Well #10. A schematic of the Main Plant is provided on Figure #3. The Main Treatment Plant building is in good condition, inside and out. Potassium permanganate is added to the raw water supply prior to filtration to facilitate iron filtration. Although it was originally added to enhance radium removal

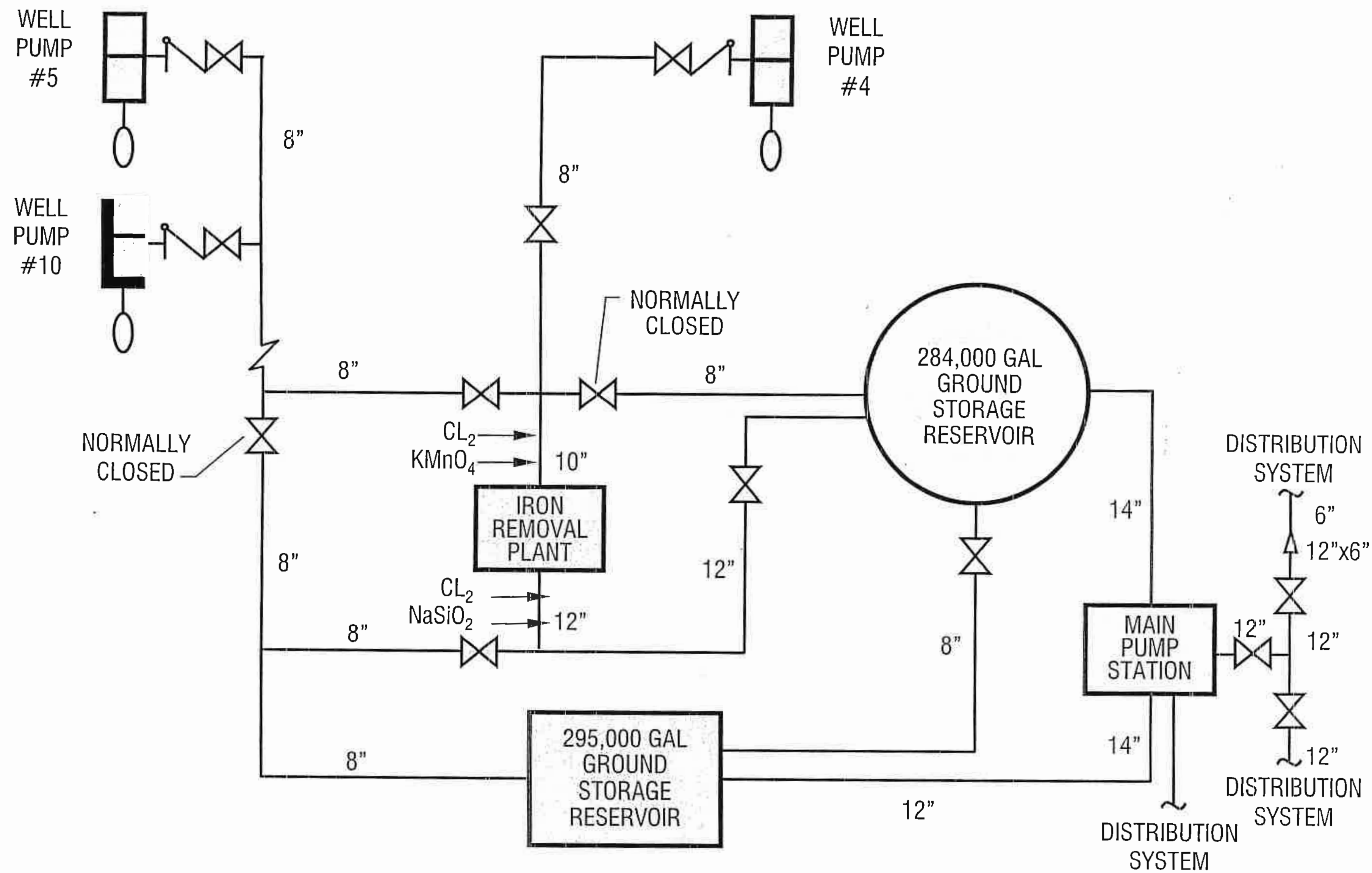



FIGURE 3

**SCHEMATIC OF WATER SUPPLY, STORAGE, PUMPAGE & TREATMENT SYSTEMS AT MAIN PLANT**

KAUKAUNA UTILITIES - KAUKAUNA, WISCONSIN

McM #K0004-920857.00 2/3/03

ID: PPT\2003\MCM WIS\KAUKAUNA WATER SYS PPT AJV:jmk

McMAHON ASSOCIATES, INC.

ENGINEERS ■ ARCHITECTS
PROJ ■ SURV

with the adsorption of radium onto hydrous manganese, oxides precipitated on the filter media. Liquid sodium hypochlorite is also added prior to filtration for disinfection. Treated water discharges to the 284,000-gallon and 295,000-gallon ground storage reservoirs, which are located on the plant site. After iron filtration, the water is treated with sodium silicate for corrosion control and sodium hypochlorite as a disinfectant prior to being discharged to the ground reservoirs. A condition assessment of the reservoirs is provided in Appendix D. A summary of the assessment is provided in a later section of this report.. Filter backwash water is discharged to the sanitary sewer.

Pump Station 1# With Well 4#
(White Building) & Reservoir

Samples were taken of the influent and effluent at the Main Filter Plant to observe entrained air. The observation results are summarized on Table #4 and are described as follows:

Main Filter Plant - Influent
Pumping Rate: 1,300 gpm / Well Started Operation - 9:00 a.m.

Observation #1 - 10:05 a.m.

a. Water sample clear at time zero, then air bubbles start to form.
b. Sample cleared of air in less than 1-minute.

Main Filter Building

Observation #2 - 1:20 p.m.

a. Water sample clear, very little formation of air bubbles.
b. Sample cleared of air in less than 1-minute.

Main Filter Plant - Effluent
Pumping Rate: 1,300 gpm / Well Started Operation - 9:00 a.m.

Observation #1 - 10:10 a.m.

a. Water sample clear at time zero, then air bubbles start to form.
b. Sample cleared of air in less than 1-minute.

Observation #2 - 1:25 p.m.

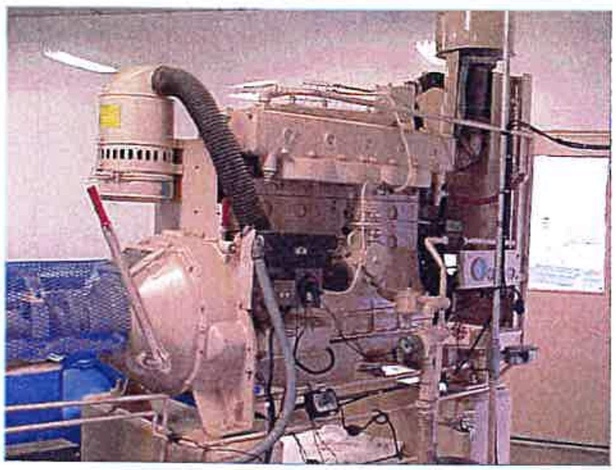
a. Water sample clear, very little formation of air bubbles.
b. Sample cleared of air in less than 1-minute.

Pump Station #1 is located on Schultheis Street, between Elm and Oak Streets, at the same site as the Main Treatment Plant and the two ground level reservoirs. The station was constructed in 1961. The station is in excellent condition. Two high lift pumps, Booster Pump #1 and Booster Pump #2, are equipped with soft starters. Each of these pumps can operate at 1,200 gpm. These two pumps are always operated individually. Generally, one is used for 6-months, and then the second pump is used for 6-months. The third high lift pump, Booster Pump #3, is an engine driven pump that is normally used for emergency purposes only. Booster pump data is summarized on Table #2.

Main Plant - Iron Filter

The Autocon telemetry system at the Main Plant that is used for monitoring and control of remote sites is in working order. However, it is understood that this system is scheduled for complete replacement in the near future.

Pump Station #1 Booster Pumps



Pump Station #1 Engine

## 5. Well #8

Well #8 is located at the intersection of Blackwell Street and Delanglade Street. The well was originally constructed in 1959. Currently, the well is not being used to supply water to the system customers. The well is being used to pilot test radium reduction treatment options. This well has an extensive history of high levels of dissolved gases in this water supply, resulting in cloudy

Well #8 Well House

water. The well consists of a 16-inch grouted casing placed to a depth of 151-feet. The 15-inch original open hole was constructed to a depth of 600-feet. In 1995, a 14-inch open hole was extended to a depth of 800-feet in an attempt to increase the capacity of the well. In 2000, the well was filled to 700-feet in an attempt to reduce the radium levels in the water supply (refer to Table #5).

Well #8 Ground Reservoir

Observations were conducted in January 2003 to observe air entrainment in the Well #8 water. One observation was made at the wellhead and at the reservoir discharge, each. The observations are summarized, with the observations from the other wells, on Table #4. Based upon the results of the observations, the 15-minutes of detention time in the storage reservoir is not sufficient for the air to dissipate. The results are as follows:

Well #8 - Raw Water
Pumping Rate: 300 gpm / Well Started Operation - 9:00 a.m.

Observation #1 - 9:30 a.m.

a. Water sample clear at time zero, then air bubbles start to form.
b. Sample cleared of air in less than 2-minutes.

Well #8 - Reservoir Discharge
Pumping Rate: 300 gpm / Well Started Operation - 9:00 a.m.

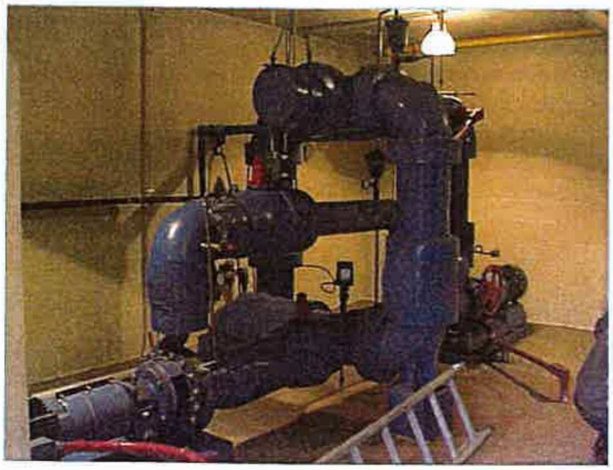
Observation #2 -

a. Sample cleared of air in less than 2-minutes.

The Well #8 pumping equipment was installed in 1997 and consists of a Simmons submersible pump. The design capacity of the pump is 600 gpm. There is no provision for standby power at this facility. The Well #8 well house is constructed of brick and concrete block. The building appears to be in good condition.

Well #8

If Well #8 were used to provide water to the community, raw water would discharge directly to the iron pressure filter housed in the Well #8 pumphouse. The filter is in very poor condition. There is a significant amount of deep corrosion on the tank, and the piping is severely corroded. Treated water discharges to a 15,000-gallon



Well #8 Booster Piping

baffled reservoir. This reservoir was constructed in 1999 to allow pressure to be released from the water to remove the dissolved gases from the water. It was hoped that this would reduce or eliminate the cloudy water problem encountered with this supply; however, this has not been as effective as hoped. This relatively small reservoir was not intended to provide system storage capacity. This reservoir appears to be in excellent condition as viewed from the exterior. Water is pumped from the reservoir into the distribution system via high lift pumps.

### 6. Well #9

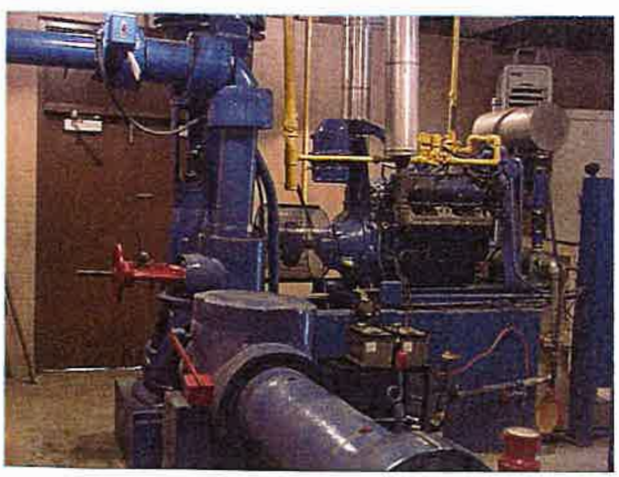
Well #8 Pumphouse

Well #9 is located in Riverside Park, north of the Fox River on the west side of Kaukauna. The well was originally constructed in 1974. The well consists of an 18-inch casing grouted to a depth of 239-feet. A 17¼-inch diameter open hole was originally extended to a depth of 806-feet. In 1989, the well was filled to a depth of 620-feet in an attempt to improve the quality of the water supply to reduce the radium levels.

The Well #9 pumping equipment consists of a Layne vertical turbine pump. The design capacity of the pump is 1160 gpm. The pumping equipment is operated at a rate of 960 gpm. A natural gas engine provides a backup power supply at this location.

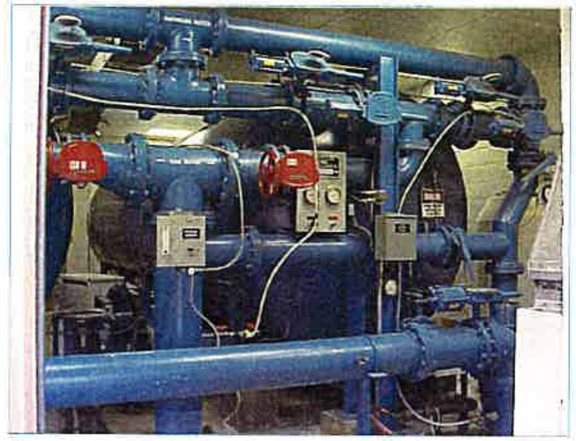
Well #9 Pumphouse

To control the iron and sulfur bacteria in the raw water in this well, 75-gallons of sodium hypochlorite is introduced into the well once a month. The well is then pumped to waste via a sanitary sewer to remove the chlorine from the well. The backwash pit does not have sufficient capacity to hold the volume of water when the well is pumped to waste. The sanitary sewer serving this plant also does not have sufficient capacity to handle the high rate of discharge.



Well #9 Piping

Therefore, an orifice plate is used on the backwash pit to control the discharge rate, so the sewer does not become surcharged. Therefore, the discharge process to remove the chlorinated water from the well takes a considerable amount of time.


Well #9 Iron Pressure Filter

The results of observations conducted in January 2003 to document entrained air in the water at Well #9 are summarized in Table #4. Observations were made of the raw water and the filter plant effluent. The results are as follows:

<u>Well #9 - Raw Water</u>
<u>Pumping Rate: 1,100 gpm / Well</u>
<u>Started Operation - 10:45 a.m.</u>

Observation #1 - 11:00 a.m.

a. Water sample clear at time zero, then air bubbles start to form.
b. Sample cleared of air in less than 2-minutes.

Observation #2 - 1:45 p.m.

a. Water sample clear at time zero, then air bubbles start to form.
b. Sample cleared of air in less than 2-minutes.

<u>Well #9 - Filter Plant Effluent</u>

Observation - 1:50 p.m.

a. Water sample clear at time zero, then air bubbles start to form.
b. Sample cleared of air in less than 2-minutes.


Well House (Left) & Filter Plant (Right)

The Well #9 pumphouse is constructed of stone and concrete block. The building is in very good condition. The iron filtration system was added to this facility in 1990. Raw water from Well #9 is treated with liquid sodium hypochlorite for disinfection, and potassium permanganate as an oxidant prior to iron filtration treatment. At start up, the well is pumped to waste for 10-minutes to reduce the sulfur content of the raw water. The start-up wastewater is discharged to a storm sewer. Sodium silicate is added to the water after filtration for corrosion control. The treatment plant at this location, located in a separate concrete block building, is in good condition. The filter backwash water discharges to the sanitary sewer.

## C. Main Plant Ground Storage Water Reservoirs

A Condition Assessment of both ground water reservoirs located at the main treatment plant was conducted on April 16, 2003. A copy of the Assessment is provided in Appendix D. A summary of the Condition Assessment is provided in the following paragraphs.

### 1. Rectangular 295,000-Gallon Reservoir

The 295,000-gallon concrete reservoir was constructed in 1940. The reservoir is approximately 13-feet deep. The tank appears to be in good structural condition. The previous repairs made to cracks in the walls and ceilings are intact. There are no new cracks and no leaks were observed.

There is a brick masonry baffle wall that runs across the tank. The wall has an opening at the west end. The baffle is in poor condition. It is recommended that the wall be repaired.

### 2. Round 284,000-Gallon Reservoir

The 284,000-gallon concrete reservoir was constructed in 1901. The reservoir is approximately 18-feet deep. In general, the reservoir is in good condition. Previous repairs made to cracks in the walls and ceilings are intact. There are no new cracks and no leaks were observed.

There is a brick masonry baffle wall extending from the east side of the tank to approximately two-thirds across the center of the tank. The wall is approximately 6-feet high. The top of the wall is very weak, and the top several courses of brick are loose. The walls are in very poor condition. Funds should be budgeted to repair the baffle wall.

On the interior of the tank, there are nine interior columns and six columns built into the wall of the tank. Three beams run across the tank columns. There are cracks and areas of spalled concrete just below the beam in all of the wall columns. These cracks should be repaired, preferably by epoxy injection. There are also areas on the north beam and the center beam where reinforcing steel is exposed. These areas should be cleaned and coated to prevent further oxidation and corrosion of the steel.

## II. WATER SUPPLY SYSTEM CAPACITY ANALYSIS

### A. Water Demand History

Historical water system demand is presented on Table #6. The average day demand and maximum day demands have decreased slightly over the last 6-years, even though the number of customers has increased. The ratio of maximum day demand to average day demand has averaged 1.61 to 1 over the previous 6-years. This ratio, commonly referred to as the Maximum Day ratio, is relatively low compared to other communities. Generally, this ratio ranges from 1.5 to 4.

Historical metered usage is also summarized on Table #6. Water pumped from the system wells should be accounted for through customer metering or documentation of un-metered use. Un-metered use may include water used for main flushing, street sweeping, construction and fighting fires. The difference between water delivered to the system and unaccounted for water (including metered and documented un-metered use) should be monitored on an annual basis. If the difference is greater than 15% the system operation should be reviewed. The historical unaccounted for amount is provided on Table #6. The percentage has ranged from 9% to 21%.

### B. Projected Future Demand

Future water system demands were developed from information that was originally provided by Robert Jakel, Director of Planning & Community Development, for the Heart Of The Valley Metropolitan Sewerage District (HOVMSD)'s Wastewater Interceptor Study, which was conducted by Earth Tech in 2002. A copy of the information provided by the City is included in Appendix E. Earth Tech projected that wastewater flows would increase approximately 13% each decade. The projected water system demands are as follows (refer to Figure #4):

| | Current Average | 2010 Projected | 2020 Projected |
|---|---|---|---|
| Average Day Demand, mgd | 1.38 mgd | 1.58 mgd | 1.76 mgd |
| Maximum Day Demand, mgd | 2.24 mgd | 2.54 mgd | 2.83 mgd |
| Maximum Day Ratio | 1.61 to 1 | | |

### C. Water System Capacity Analysis

#### 1. Description

The current total capacity of the Kaukauna Utilities' treated water supply system is 3.83 mgd. This is with all five wells operational. The adequacy of a water supply is evaluated on the basis of the maximum day demand

## Table #6

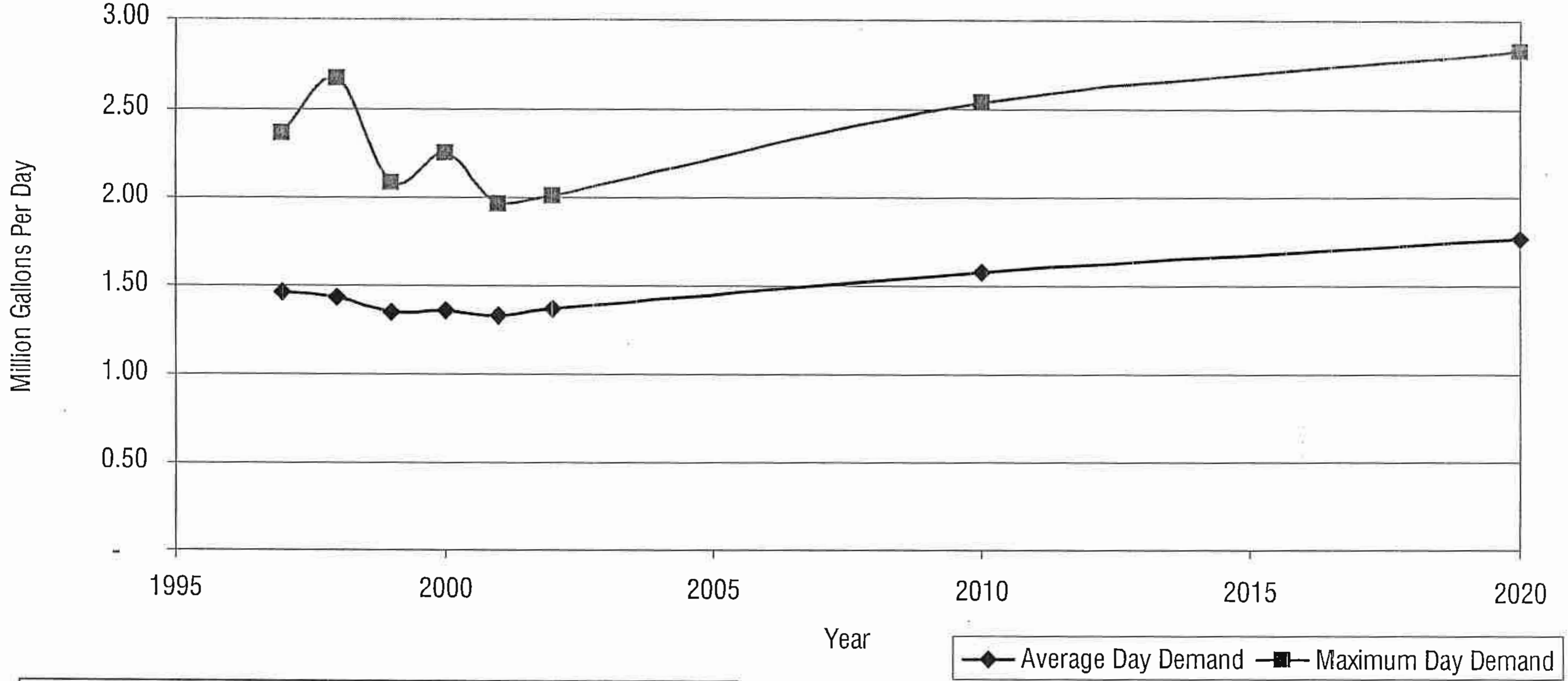
**HISTORICAL WATER SYSTEM DEMAND**

KAUKAUNA UTILITIES

Evaluation Of Water Supply System

| Customer Classification | 1997 No. of Custmrs | 1997 Metered Water Use (Gal) | 1997 % of Total Flow | 1998 No. of Custmrs | 1998 Metered Water Use (Gal) | 1998 % of Total Flow | 1999 No. of Custmrs | 1999 Metered Water Use (Gal) | 1999 % of Total Flow | 2000 No. of Custmrs | 2000 Metered Water Use (Gal) | 2000 % of Total Flow | 2001 No. of Custmrs | 2001 Metered Water Use (Gal) | 2001 % of Total Flow | 2002 Metered Water Use (Gal) | Average Metered Water Use (Gal) | Average % of Total Flow |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Residential | 4,178 | 241,435,000 | 66% | 4,243 | 247,210,000 | 66% | 4,317 | 244,264,000 | 68% | 4,397 | 236,403,000 | 64% | 4,528 | 236,399,000 | 65% | Data Not Available At This Time | 241,142,200 | 66% |
| Commercial | 296 | 52,544,000 | 14% | 304 | 54,280,000 | 14% | 310 | 50,129,000 | 14% | 322 | 57,455,000 | 16% | 338 | 57,011,000 | 16% | | 54,283,800 | 16% |
| Industrial | 13 | 59,108,000 | 16% | 13 | 59,677,000 | 16% | 16 | 52,514,000 | 15% | 19 | 61,[illegible] | 17% | 19 | 56,606,000 | 16% | | 57,831,600 | 16% |
| Public | 16 | 9,482,000 | 3% | 16 | 8,896,000 | 2% | 18 | 9,631,000 | 3% | 17 | 9,732,000 | 3% | 20 | 9,544,000 | 3% | | 9,457,000 | 3% |
| Interdepartmental Sales | 3 | 3,390,000 | 1% | 3 | 4,887,000 | 1% | 3 | 4,069,000 | 1% | 3 | 4,423,000 | 1% | 3 | 3,884,000 | 1% | | 4,130,600 | 1% |
| Total | 4,506 | 365,959,000 | | 4,579 | 374,950,000 | | 4,664 | 360,607,000 | | 4,758 | 369,266,000 | | 4,908 | 363,444,000 | | | 366,845,200 | |

| | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | Average |
|---|---|---|---|---|---|---|---|
| Total Gallons Pumped | 534,240,000 | 521,995,000 | 490,893,000 | 494,305,000 | 484,189,000 | 501,160,000 | 504,464,000 |
| Average Day Demand ,gpd | 1,463,671 | 1,430,123 | 1,344,912 | 1,354,260 | 1,326,545 | 1,373,041 | 1,382,000 |
| Total pumped into Dist. Syst | 462,776,000 | 439,443,000 | 421,738,000 | 419,540,000 | 407,749,000 | | |
| Unaccounted For Water | 21% | 15% | 14% | 12% | 9% | 10% | 14% |
| Maximum Day Demand,gpd | 2,366,000 | 2,667,000 | 2,087,000 | 2,252,000 | 1,961,000 | 2,011,000 | 2,224,000 |
| Date of Max Day Demand | Oct 29,1997 | April 27 ,1998 | April 16 ,1999 | May 29,2000 | July 17 ,2001 | October 9 , 2002 | |
| Reason for Max Day | | Hyd. Flushing/Main Break | Hyd. Flushing/Main Break | New Main Flushing | New Main Flushing | Hydrant Flushing | |
| Max Day Ratio | 1.62 | 1.86 | 1.55 | 1.66 | 1.48 | 1.46 | 1.61 |
| Population | 12,325 | 12,517 | 12,735 | 12,983 | 13,358 | | |
| Average Person Per Hsehold | 2.95 | 2.95 | 2.95 | 2.95 | 2.95 | | |
| Residential gpcd | 54 | 54 | 53 | 50 | 48 | | 52 |
| Total gpcd | 119 | 114 | 106 | 104 | 99 | | 108 |




**Water System Demands**

| | Current Average | 2010 Projected | 2010 Projected |
|---|---|---|---|
| • Average Day Demand | 1.38 mgd | 1.58 mgd | 1.76 mgd |
| • Maximum Day Demand | 2.24 mgd | 2.54 mgd | 2.83 mgd |
| • Maximum Day Ratio | 1.61 to 1 | | |

McMAHON ASSOCIATES, INC.
ENGINEERS ■ ARCHITECTS
PROJ. MGRS. ■ SURVEYORS

FIGURE 4

**PROJECTED WATER DEMANDS**

KAUKAUNA UTILITIES - KAUKAUNA, WISCONSIN

McM #K0004-920857.00 2/3/03

ID: PPT\2003\MCM WIS\KAUKAUNA WATER SYS.PPT AJV:jmk requirements. As a minimum, the supply required to maintain the maximum day or peak day demand would need to be supplied from the entire water supply over a 24-hour period. The reliability of the supply system can be analyzed under a variety of conditions. The following conditions have been analyzed. The conditions are summarized on Table #7.

a. Condition A – This condition assumes that all systems are operational. This condition would provide a supply of 2,560 gpm or 3,686,000 gpd.

b. Condition B – This condition assumes that the largest source of raw water supply, Well No. 9, is out of operation. A supply of 1,600 gpm or 2,304,000 would be provided.

c. Condition C – This condition assumes that the largest treatment facility, the Main Filter Plant, is out of operation. A supply of 1,460 gpm or 2,102,000 gpd would be provided.

d. Condition D – This condition assumes that the largest pumping equipment, the booster pumps at Pump Station #1, are out of operation. This condition would provide 1,460 gpm or 2,102,000 gpd; the same rate as Condition C.

e. Condition E – This condition assumes that the booster pumps at Pump Station #1 are out of service and the engine driven booster pump (BS #3) is used to pump treated water from the ground level reservoirs into the distribution system. Booster Pump #3 has a rated capacity of 2,000 gpm. However, for this condition, it was assumed that the plant discharge rate would be restricted to the capacity of the treatment plant.

## 2. Determination Of Reliable Capacity Of Existing System

The results of the supply capacity analysis are summarized on Table #7. This analysis illustrates that if one of the largest water supply components was out of service during a period of maximum demand, the supply system cannot meet the design criteria to supply maximum day demand. The safe, reliable, water supply capacity of the existing system with provision for pumping units out of service is 2.1 mgd. The current maximum day demand is approximately 2.22 mgd, and the projected year 2020 demand is 2.8 mgd.

## Table #7

### KAUKAUNA WATER SUPPLY SYSTEM CAPACITY ANALYSIS

KAUKAUNA UTILITIES

Evaluation Of Water Supply System

| Well # | Well Pumping Capacity | Treatment System Capacity | Booster Pump or Plant Discharge Capacity | **Condition A** All Systems Operational | **Condition B** Largest Well Out Of Service | **Condition C** Largest Treatment System Out Of Service | **Condition D** Largest Pumping Equipment Out Of Service | **Condition E** Use Engine Driven Pump At Pump Station #1 |
|---|---|---|---|---|---|---|---|---|
| Well #4 | 560 gpm | | | | | | | |
| Well #5 | 200 gpm | 1,300 gpm | 1,100 gpm | 1,100 gpm | 1,100 gpm | --- | --- | 1,300 gpm |
| Well #10 | 540 gpm | | | | | | | |
| (all three wells are operated at the same time) | | | | | | | | |
| Well #8 | 500 gpm | 600 gpm | 500 gpm | 500 gpm | 500 gpm | 500 gpm | 500 gpm | 500 gpm |
| Well #9 | 960 gpm | 1,300 gpm | 960 gpm | 960 gpm | --- | 960 gpm | 960 gpm | 960 gpm |
| Totals | 2,760 gpm<br>3,974,000 gpd | 3,200 gpm<br>4,608,000 gpd | 2,560 gpm<br>3,686,400 gpd | 2,560 gpm<br>3,686,400 gpd | 1,600 gpm<br>2,304,000 gpd | 1,460 gpm<br>2,102,000 gpd | 1,460 gpm<br>2,102,000 gpd | 2,760 gpm<br>3,974,000 gpd |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Meet Design Criteria | N/A | N/A | Yes | Yes | No, System Deficient | No, System Deficient | No, System Deficient | Yes |

Design Criteria:

Available supply should meet maximum day demand, with largest source of supply out of service.
Projected Year 2020 Maximum Day Demand = 2,830,000 gpd
Current Maximum Day Demand = 2,224,000 gpd

## 3. Determine Needs For Additional Supply

The supply capacity analysis indicates that the safe, reliable, water supply capacity of the existing system is 2.1 mgd. With a projected maximum day demand of 2.8 mgd in the year 2020, there is a supply system short fall of approximately 700,000 gpd or 500 gpm. The supply shortfall should not have to be provided from storage. The storage system can be relied upon to meet short-term high water demands that occur throughout the day. However, when high system demands continue for an extended period of days or if there is a fire demand in combination with high system demands, the supply system would not have sufficient capacity to replace the quantity of water removed from storage. Therefore, it is critical that a system not be required to rely on storage capacity for an extended period of time.

The capacity of the supply system should be increased by a minimum of 500 gpm (700,000 gpd) to provide a safe, reliable water supply of 2.8 mgd. Therefore, there is a need for Kaukauna Utilities to develop an additional water supply.

## 4. Options To Provide Additional Supply

Two options to provide additional water supply will be evaluated. One will be to expand and maximize the capacity of the systems in the existing infrastructure and the second will be to add additional groundwater supply wells to supplement the existing system.

### a. Option #1 - Expand Existing Supply System

The capacity of the existing water supply could be expanded with the following modifications:

1) Well #9

Add an additional pump stage to return the pumping system to the original capacity of 1,300 gpm. This will require installation of a larger motor (200-horsepower) and new switchgear. The estimated cost for these modifications is as follows:

| | |
|---|---|
| Existing Pump Modifications | $15,000 |
| New 200-Horsepower & Motor Starter | 40,000 |
| Engineering & Contingencies | 10,000 |
| Total | $65,000 |

2) Well #8

To operate the well at 500 gpm, it would be advisable to remove the dissolved air from the supply. This issue is described in detail in another section of this report. The use of membrane technology, as described elsewhere in this report, would be used to remove the dissolve air.

The City has also requested that a backwash holding tank be provided to restrict the discharged flow rate into the sanitary sewer system. This system would then be similar to the concept used at Well #9.

The estimated cost for these improvements is summarized as follows:

| | |
|---|---|
| Air Removal Membranes | $30,000 |
| Vacuum Pump / Mechanical | 20,000 |
| Building Modifications | 10,000 |
| Electrical | 5,000 |
| Engineering & Contingencies | 15,000 |
| Total | $80,000 |

3) Well #5

The original depth of this well was 733-feet. The well was filled in 1947 to 524-feet to provide a better water quality. The majority of the Cambrian Sandstone, however, was filled significantly; impacting the capacity of the well. As there is no reason to suspect the water quality in this well would be much different than Well #4 or Well #10, it is recommended to remove the fill to a depth of 630-feet to expose the upper 120-feet of the Cambrian Sandstone. A well capacity of 600 gpm would be expected.

The estimated cost for these improvements is summarized as follows:

| | |
|---|---|
| Deepen Well (From 524-feet to 630-feet) | $40,000 |
| New 600 gpm Well Pump & Motor | 30,000 |
| New Switchgear | 15,000 |
| Engineering & Contingencies | 20,000 |
| Total | $105,000 |

4) Main Filter Plant

With the additional 400 gpm expected from Well #5, the capacity of the iron filtration system at the Main Filter Plant would need to be expanded. The total supply capacity at this location from Wells #4, #5 and #10 would be 1,700 gpm with the proposed modifications to Well #5. The size of the existing 4-cell filter is 473 square feet, with a rated capacity of 1,300 gpm. The expansion of the existing system should be provided in size increments equal to the existing filter cell size of 118 square feet/cell to simplify backwash operation.

The additional filtration capacity would be provided with the addition of two 12-foot diameter tanks, or a single, 2-cell, 10-foot diameter x 26-foot long, horizontal tank.

The booster pump capacity would also need to be expanded to 1,700 gpm, requiring larger horsepower motors for each of the two booster pumps.

The estimated cost for these improvements is summarized as follows:

| | |
|---|---|
| Iron Filtration System (236 square feet) | $80,000 |
| Installation | 30,000 |
| Building Additions | 100,000 |
| Piping / Mechanical | 45,000 |
| Booster Pump Modifications | 70,000 |
| Engineering & Contingencies | 75,000 |
| Total | $400,000 |

It should be additionally noted that the existing masonry baffle walls in the two ground storage reservoirs are severely deteriorated and should be either removed or removed and replaced. An estimated cost for replacement of these baffle wells is $40,000. The following discussion relates to the need for replacement of the baffle walls.

a) From an operational standpoint, the baffle walls are not required. No chemicals are added to the water entering the reservoir, so detention time should not be an issue.

b) From a settlement standpoint, there is very little sand or particulates in the water. Detention time for settling should not be an issue.

c) The inlet and outlets of the tanks are across the tanks from each other. Short-circuiting should not be a concern. Some areas of the tanks, particularly the corners of the rectangular reservoir, will not have, however, much water movement.

d) The short height of the baffle wall in the round reservoir would have minimal effect on the water flow as it is.

5) Cost Summary

The above noted system improvements would increase the system supply to sufficiently meet the year 2020 maximum day demand under all five conditions referenced on Page 13 and Table #7. A summary of the system supply capacity relative to meeting these five operating conditions is presented in Table #8.

A summary of the capacity costs to implement this option is as follows:

| | |
|---|---|
| Well #9 | $65,000 |
| Well #8 | 80,000 |
| Well #5 | 105,000 |
| Main Filter Plant | 400,000 |
| Total | $650,000 |

6) Analysis Of Increased Pumpage On Aquifer

If the existing groundwater supply system were to be continued and increased in the future to meet future demands, the impact on the groundwater system should be evaluated. The ominous trend of declining groundwater levels at a rate of nearly 1-foot per year could result in serious problems, if the pumping levels were to drop sufficiently to fall below the top of the Cambrian Sandstone. To determine this impact, the hydrologists at the United States Geological Society (USGS) conducted groundwater flow model simulations using the Fox Cities groundwater model developed as part of the 1997 groundwater

## Table #8

**KAUKAUNA WATER SUPPLY SYSTEM CAPACITY ANALYSIS UNDER OPTION #1**
**UPGRADE EXISTING SUPPLY SYSTEM**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| Well # | Well Pumping Capacity | Treatment System Capacity | Booster Pump or Plant Discharge Capacity | **Condition A** All Systems Operational | **Condition B** Largest Well Out Of Service | **Condition C** Largest Treatment System Out Of Service | **Condition D** Largest Pumping Equipment Out Of Service | **Condition E** Use Engine Driven Pump At Pump Station #1 |
|---|---|---|---|---|---|---|---|---|
| Well #4 | 560 gpm | | | | | | | |
| Well #5 | 600 gpm | 1,700 gpm | 1,700 gpm | 1,700 gpm | 1,700 gpm | 700 gpm | 1,700 gpm | 1,300 gpm |
| Well #10 | 540 gpm | | | | | | | |
| (all three wells are operated at the same time) | | | | | | | | |
| Well #8 | 500 gpm | 600 gpm | 500 gpm | 500 gpm | 500 gpm | 500 gpm | 500 gpm | 500 gpm |
| Well #9 | 1,300 gpm | 1,300 gpm | 1,300 gpm | 1,300 gpm | --- | 1,300 gpm | 1,300 gpm | 1,300 gpm |
| Totals | 3,500 gpm<br>5,040,000 gpd | 3,600 gpm<br>5,184,000 gpd | 3,500 gpm<br>5,040,000 gpd | 3,500 gpm<br>5,040,000 gpd | 2,200 gpm<br>3,168,000 gpd | 2,500 gpm<br>3,600,000 gpd | 2,500 gpm<br>3,600,000 gpd | 3,100 gpm<br>4,464,000 gpd |
| Meet Design Criteria | N/A | N/A | Yes | Yes | Yes | Yes | Yes | Yes |

Design Criteria:

Available supply should meet maximum day demand, with largest source of supply out of service.
Projected Year 2020 Maximum Day Demand = 2,830,000 gpd
Current Maximum Day Demand = 2,224,000 gpd

study. This study, entitled "Hydrogeology & Simulation Of The Groundwater Flow In The Sandstone Aquifer, Northeastern Wisconsin", included the development of a groundwater flow model, which would be utilized to simulate water levels in the principle aquifer utilized for the groundwater supply in the Fox Valley region.

Several model simulations were developed, and they are documented and provided for referenced in Appendix F. The modeled scenario most likely to occur compared the water pumping levels under the current water pumpage volumes in both the Fox Cities and the 11 communities using groundwater in the Green Bay area to the water pumping levels under future water pumpage volumes for the Fox Cities communities and with the 11 communities in the Green Bay area no longer using groundwater. While the groundwater levels will continue to drop, the modeled future pumping levels will be positively impacted by the aquifer rebound effect resulting from the reduced pumpage in the Green Bay area. As such, the future pumping levels are projected to decline another 66-feet, which would be above the top of the Cambrian Sandstone. This modeling summary is provided in the May 21, 2003 communication, located in Appendix F. This modeling concludes that the decline in groundwater levels will continue for another 66-feet before it stabilizes to equilibrium. There is, however, no projection for the impact to groundwater quality.

b. <u>Option #2 - Construction Of Additional Wells</u>

Based upon the analysis of supply capacity under the five operating conditions, summarized in Table #7, the existing supply is deficient to meet the year 2020 maximum day demand by approximately 700,000 gpd. The construction of a new well of, at least, 500 gpm would be required to provide the required additional supply.

The most likely location for siting a new well would be approximately 3-miles to the northwest of Kaukauna, where a groundwater source of better quality could, most likely, be developed. This area would also provide better well siting options under the State's current wellhead protection requirements. The greater spacing from the existing wells afforded under this location would also reduce the impact on the pumping levels resulting from well interference in all the wells.

While there are high capital costs associated with a new well siting up to 3-miles from the existing distribution system, due to the long connecting transmission main, the long-term benefits of this concept would be to provide the opportunity to construct additional wells in the same area in the future to either replace existing wells or to provide additional capacity in the future. Additionally, the concept of replacing the entire existing supply from the five existing wells is a feasible alternative, especially if a water supply of better water quality is desired. Water hardness, for example, would, most likely, be 20 to 25-grain, as compared to the hardness of 50-grain in the existing supply.

A groundwater study is proposed to identify potential well sites, should this alternative be considered. It is assumed, however, that the iron levels will be sufficiently high to require treatment using conventional iron filtration systems.

The capital cost of adding an additional well with iron filtration located in this area to the existing system is summarized, as follows:

| | |
|---|---|
| Well | $200,000 |
| Pumphouse | 200,000 |
| Iron Treatment System | 300,000 |
| Connecting Water Main | 750,000 |
| Pumping Equipment | 75,000 |
| Electrical | 100,000 |
| Engineering & Contingencies | 375,000 |
| Total | $2,000,000 |

C. Conclusion

The most cost-effective solution, at this time, to meet the water demands for the next 20-years would be to expand the existing system to provide maximum production capacity. Should a water supply of a better water quality be required or when additional supply beyond 2.8 mgd be required, the construction of additional wells will be required.

## III. DRINKING WATER QUALITY STANDARDS COMPLIANCE

### A. Drinking Water Quality Standards

Wisconsin Administrative Code NR 809 and the United States Environmental Protection Agency (EPA) Safe Drinking Water Act establish drinking water quality standards. The standards are established to protect the public health, safety and welfare. Maximum contaminant levels, or MCL's are the maximum permissible level of a contaminant in water, which is delivered to any user of a public water system. The MCL's established for various inorganic contaminants, which may be applicable to the Kaukauna Utilities water supply, are listed on Table #9. Secondary standards are also listed. Secondary standards have been established for parameters that are not hazardous to health, but may be objectionable when present in quantities above the secondary standards. The MCL's for radionuclides are also presented on Table #9.

## B. Kaukauna Drinking Water Quality

The results of various water sample analyses are summarized on Table #5 and Table #10.

### 1. Primary Drinking Water Standards

#### a. Radionuclides

The levels of Gross Alpha and Radium 226/228 in the Kaukauna Utilities raw water supply exceed the primary drinking water standards. A summary of Gross Alpha/Radium analysis is provided on Table #5.

The DNR has advised the Utility that a violation of the radioactivity standard for alpha radiation (15 pCi/l) exists for the water system. The alpha radiation level in the water supply has ranged between 15 and 30 pCi/l over the years, depending upon sample location. The Utility is required to provide quarterly notices to the served public regarding this violation. In 2000, a composite radioactivity sample was taken from the distribution system that showed a gross alpha level at 64 pCi/l and a combined radium level of 20.2 pCi/l. The combined radium standard is 5 pCi/l. These results were waived as they were such a marked increase from previous results that it was thought that results were in error, however, the Utility was asked to conduct quarterly composite samples during 2001. These results came back at a level of gross alpha of 15 pCi/l, right at the standard, and combined radium at 3.51 pCi/l, which is below the standard. To calculate the alpha radiation content, the uranium concentration is deducted from the gross alpha level. During 2002, the Department has asked the Utility to conduct radioactivity sampling at each of the entry points to the distribution system.

# Table #9

## DRINKING WATER QUALITY STANDARDS

KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| Contaminants | Primary Drinking Water Standards Max. Contaminant Level (MCL) (mg/l, Unless Noted) | Secondary Standards (mg/l) |
|---|---|---|
| Alkalinity, Total as $CaCO_3$ | | |
| Aluminum, Total | | 0.05 - 0.2 |
| Arsenic | .05 | |
| Calcium, Total | | |
| Chloride | | 250 |
| Conductivity | | |
| Fluoride | 4.0 | 2.0 |
| Hardness, Total as $CaCO_3$ | | |
| Iron, Total | | 0.3 |
| Lead, Total | 0.015 * | |
| Magnesium, Total | | |
| Manganese, Total | | 0.05 |
| Nitrate/Nitrite Nitrogen | 10/1 | |
| pH - Lab | | |
| pH - Field | | |
| Potassium, Total | | |
| Silicon, Total | | |
| Sodium, Total | | |
| Sulfate | | 250 |
| Total Dissolved Solids | | |
| Temperature (Degree F) | | |
| Carbon Dioxide | | |
| Gross Alpha | 15 pCi/l | |
| Radium 226/228 | 5 pCi/l | |

* Treatment Technique Action Level at 0.015 mg/l for Lead.

Primary Drinking Water Standards: Maximum permissible level of a contaminant in water, which is delivered by any user of a public water system.

Secondary Standards: Waters containing parameters in quantities above the limits indicated are not hazardous to health, but may be objectionable to an appreciable number of persons.

Primary and Secondary Standards have only been established for contaminants as listed.

*Blank lines indicate there are no standards.*

## Table #10

### INORGANIC CHEMICAL ANALYSIS
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| Item | Well #9 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1975 | 1985 | 1988 | 1990 | 1990 | 1991 | 1996 | 1997 | 1997 | 1999 | 2000 |
| 1. Alkalinity, Total As $CACO_3$ | 184 | 200 | Filled | 196 | 210 | 196 | 198 | 180 | 199 / 200 | 220 | |
| 2. Aluminum, Total | --- | --- | --- | --- | --- | <0.3 | <0.20 | --- | --- | --- | |
| 3. Arsenic | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 0 |
| 4. Calcium, Total | 224 | 226 | --- | 210 | 200 | 220 | 204 | 232 | --- | 210 | |
| 5. Chloride | 6 | 5 | --- | 5 | 14 | 18 | 4.60 | --- | --- | 4.30 | |
| 6. Conductivity | --- | 1,020 | --- | 1,030 | --- | 1100 | 1,010 | 1,023 | --- | --- | |
| 7. Fluoride | 2 | 160 | --- | --- | --- | 1.80 | 1.80 | --- | --- | 1.80 | |
| 8. Hardness, Total As $CACO_3$ | 656 | 633 | 516 | 604 | 596 | 635 | 640 | 632 | --- | 620 | |
| 9. Iron, Total | 0.56 | 0.45 | 0.56 | 0.43 | 0.29 | 0.27 | 0.20 | 1.30 | --- | 0.50 | |
| 10. Lead, Total | --- | --- | --- | --- | 0.23 | <0.06 | <0.70 | --- | --- | --- | |
| 11. Magnesium, Total | 24 | 22 — | | --- | <.01 | 24 | 26 | 52 | --- | 24 | |
| 12. Manganese, Total | <.04 | 0.020 | 0.03 | <.02 | --- | <0.02 | <0.02 | --- | --- | 0.016 | |
| 13. Nitrate/Nitriate Nitrogen | <.50 | --- | --- | --- | 7.20 | <0.16 | <0.10 | --- | --- | --- | |
| 14. pH - Lab | 7.50 | 7.90 | --- | 7.10 | --- | 7.20 | 6.90 | 7.80 | 7.1 / 7.1 | 7.20 | |
| 15. pH - Field | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |
| 16. Potassium, Total | --- | 4.40 | --- | --- | --- | 4.20 | 4.40 | --- | --- | --- | |
| 17. Silicon, Total | --- | 7.00 | --- | 13 | --- | 3.10 | 3.20 | 8 | --- | --- | |
| 18. Sodium, Total | 9 80 | 11 | --- | 417 | --- | 9.80 | 9.70 | --- | --- | 11 | |
| 19. Sulfate | 425 | 417 | 288 | 830 | 470 | 435 | 322 | 467 | --- | 450 | |
| 20. Total Dissolved Solids | 928 | 946 | 696 | --- | --- | 846 | 880 | 1,280 | --- | 880 | |
| 21. Temperature (Degree F) | --- | 53 | --- | --- | 40 | --- | --- | --- | --- | --- | |
| 22. Carbon Dioxide | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |

Well constructed in 1974 to a depth of 806.
1989 - Filled to 620.

| Item | Well #10 / #6 | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1970 | 1985 | 1991 | 1996 | 1997 | 1999 | 2000 |
| 1. Alkalinity, Total As $CACO_3$ | 178 | 204 | 199 | 184 | 189 | 200 | |
| 2. Aluminum, Total | --- | --- | <0.3 | <0.20 | --- | --- | |
| 3. Arsenic | --- | --- | --- | --- | --- | --- | 0 |
| 4. Calcium, Total | 234 | 170 | 188 | 253 | --- | 200 | |
| 5. Chloride | 8 | 7 | 19 | 12 | --- | 9 | |
| 6. Conductivity | --- | 820 | 950 | 1,110 | --- | --- | |
| 7. Fluoride | 2 | 1.50 | 3.60 | 1.80 | --- | 1.80 | |
| 8. Hardness, Total As $CACO_3$ | 662 | 505 | 440 | 680 | --- | 590 | |
| 9. Iron, Total | 4.09 | 0.47 | 0.48 | 0.35 | --- | 0.60 | |
| 10. Lead, Total | --- | --- | <0.06 | <0.07 | --- | --- | |
| 11. Magnesium, Total | 18 | 23 | 24 | 22 | --- | 22 | |
| 12. Manganese, Total | <.04 | 0.028 | <0.02 | <0.02 | --- | 0.020 | |
| 13. Nitrate/Nitriate Nitrogen | --- | --- | <0.13 | 0.19 | --- | <.10 | |
| 14. pH - Lab | 7.40 | 7.60 | 7.20 | 6.90 | 7.20 | 7.30 | |
| 15. pH - Field | 7.10 | --- | --- | --- | --- | --- | |
| 16. Potassium, Total | --- | 4.70 | 4.30 | 4.70 | --- | --- | |
| 17. Silicon, Total | --- | 7.20 | 3.50 | 3.30 | --- | --- | |
| 18. Sodium, Total | 12 | 13 | 12 | 13 | --- | --- | |
| 19. Sulfate | 465 | 265 | 376 | 484 | --- | 460 | |
| 20. Total Dissolved Solids | 942 | 689 | 746 | 980 | --- | 880 | |
| 21. Temperature (Degree F) | --- | 54 | --- | --- | --- | --- | |
| 22. Carbon Dioxide | --- | --- | --- | --- | --- | --- | |

1995 - Drilled from original depth of 568 to 841.
2000 - Filled to 660.

# Table #10

**INORGANIC CHEMICAL ANALYSIS**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| Item | Well #4 1970 | 1985 | 1991 | 1996 | 1997 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|
| 1. Alkalinity, Total As $CACO_3$ | 186 | 190 | 180 | 189 | 174 | 180 | |
| 2. Aluminum, Total | --- | --- | <0.3 | <0.20 | --- | 0.0007 | |
| 3. Arsenic | --- | --- | --- | --- | --- --- | | 0 |
| 4. Calcium, Total | 257 | 269 | 298 | 309 | --- | 260 | |
| 5. Chloride | 7 | 7 | 6 | 8.10 | --- | 7.80 | |
| 6. Conductivity | --- | 1,140 | 1,370 | 1,280 | --- | --- | |
| 7. Fluoride | 2 | 1.50 | 2 | 1.80 | --- | 1.90 | |
| 8. Hardness, Total As $CACO_3$ | 722 | 768 | 780 | 840 | --- | 710 | |
| 9. Iron, Total | 1 | 0.52 | 0.39 | 0.82 | --- | 0.51 | |
| 10. Lead, Total | --- | <.04 | <0.06 | <0.07 | --- | --- | |
| 11. Magnesium, Total | 19 | 19 | 21 | 22 | --- | 18 | |
| 12. Manganese, Total | <.04 | 0.031 | <0.02 | <0.02 | --- | 0.022 | |
| 13. Nitrate/Nitriate Nitrogen | <.10 | <.1 | <0.01 | <0.10 | --- | <.1 | |
| 14. pH - Lab | 7.4 | 7.50 | 7 | 6.90 | 7.30 | 7.60 | |
| 15. pH - Field | 7 | --- | --- | --- | --- | --- | |
| 16. Potassium, Total | --- | 5.70 | 5 | 4.90 | --- | --- | |
| 17. Silicon, Total | --- | 6.70 | 4 | 3.20 | --- | --- | |
| 18. Sodium, Total | 12 | 9 | 12 | 13 | --- | 13 | |
| 19. Sulfate | 500 | 538 | 718 | 676 | --- | 680 | |
| 20. Total Dissolved Solids | 998 | 1052 | 1208 | 1196 | --- | 1,100 | |
| 21. Temperature (Degree F) | --- | 54 | --- | --- | --- | --- | |
| 22. Carbon Dioxide | --- | --- | --- | --- | --- | --- | |

Depth = 726.

| Item | Well #5 1970 | 1972 | 1985 | 1991 | 1996 | 1997 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|
| 1. Alkalinity, Total As $CACO_3$ | 180 | 178 | 188 | 172 | 173 | 177 | 180 | |
| 2. Aluminum, Total | --- | --- | --- | <0.3 | <0.02 | --- | 0.0012 | |
| 3. Arsenic | --- | --- | --- | --- | --- | --- | --- | 0 |
| 4. Calcium, Total | 308 | 219 | 321 | 337 | 301 | --- | 270 | |
| 5. Chloride | 10 | 5 | 9 | 7 | 12 | --- | 11 | |
| 6. Conductivity | --- | --- | 1,300 | 1,450 | 1,310 | --- | --- | |
| 7. Fluoride | 2 | 1.90 | 1.5 | 3.40 | 1.80 | --- | 1.90 | |
| 8. Hardness, Total As $CACO_3$ | 837 | 617 | 867 | 900 | 880 | --- | 770 | |
| 9. Iron, Total | 0.64 | 0.73 | 0.54 | 0.43 | 0.50 | --- | 0.06 | |
| 10. Lead, Total | --- | --- | <40 | <0.06 | <0.07 | --- | --- | |
| 11. Magnesium, Total | 16 | 17 | 20 | 22 | 24 | --- | 20 | |
| 12. Manganese, Total | <.04 | <.04 | 0.033 | <0.02 | <0.20 | --- | 0.025 | |
| 13. Nitrate/Nitriate Nitrogen | <.10 | --- | <.10 | <0.11 | <0.10 | --- | <.1 | |
| 14. pH - Lab | 7.30 | 7.40 | 7.60 | 7.10 | 7 | --- | 7.20 | |
| 15. pH - Field | 7.10 | 7.20 | --- | --- | --- | --- | --- | |
| 16. Potassium, Total | --- | --- | 5.50 | 4.60 | 5 | --- | --- | |
| 17. Silicon, Total | --- | --- | 7.40 | 3.50 | 3.20 | --- | 14 | |
| 18. Sodium, Total | 12 | 10 | 10 | 14 | 14 | --- | 750 | |
| 19. Sulfate | 620 | 420 | 650 | 825 | 689 | --- | 1,200 | |
| 20. Total Dissolved Solids | 1,206 | 876 | 1,307 | 1,208 | 1,224 | --- | --- | |
| 21. Temperature (Degree F) | --- | --- | 52 | --- | --- | --- | --- | |
| 22. Carbon Dioxide | --- | --- | --- | --- | --- | --- | --- | |

Depth = 524.

| Item | Well #8 1985 | 1991 | 1991 | 1996 | 1997 | 1997 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|
| 1. Alkalinity, Total As $CACO_3$ | 178 | 167 | 176 | 171 | 171 / 169 | 148 | 180 | |
| 2. Aluminum, Total | --- | --- | <0.3 | <0.20 | --- | --- | --- | |
| 3. Arsenic | --- | --- | --- | --- | --- | --- | --- | 0 |
| 4. Calcium, Total | 223 | 226 | 228 | 212 | --- | 272 | 210 | |
| 5. Chloride | 4 | 2 | 4 | 4.60 | --- | --- | 3.30 | |
| 6. Conductivity | 1,030 | 668 | 675 | 990 | --- | 1,135 | --- | |
| 7. Fluoride | 2 | 1.60 | 1.70 | 1.80 | --- | --- | 1.90 | |
| 8. Hardness, Total As $CACO_3$ | 613 | 680 | 590 | 640 | --- | 708 | 610 | |
| 9. Iron, Total | 0.66 | <.03 | 0.50 | 0.35 | --- | 0.70 | 0.90 | |
| 10. Lead, Total | --- | <.70 | <0.07 | <0.07 | --- | --- | --- | |
| 11. Magnesium, Total | 20 | 21 | 23 | 23 | --- | 28 | 20 | |
| 12. Manganese, Total | 0.039 | 0.030 | <0.30 | 0.03 | --- | --- | 0.021 | |
| 13. Nitrate/Nitriate Nitrogen | <.10 | <.10 | <0.01 | <0.10 | --- | --- | <.10 | |
| 14. pH - Lab | 7.50 | 7 | 7.40 | 7 | 7.1 / 6.9 | 7.50 | 7.30 | |
| 15. pH - Field | --- | --- | --- | --- | --- | --- | --- | |
| 16. Potassium, Total | 4.70 | 4.30 | 4.30 | 4.50 | --- | --- | --- | |
| 17. Silicon, Total | 7.40 | 3.40 | 2.60 | 3.20 | --- | 8 | --- | |
| 18. Sodium, Total | 10 | 10 | 10 | 9.80 | --- | --- | 8.80 | |
| 19. Sulfate | 450 | 427 | 460 | 438 | --- | 582 | 500 | |
| 20. Total Dissolved Solids | 956 | 846 | 842 | 852 | --- | 1,430 | 890 | |
| 21. Temperature (Degree F) | 53 | --- | --- | --- | --- | --- | --- | |
| 22. Carbon Dioxide | --- | --- | --- | --- | --- | --- | --- | |

1995 - Drilled from original depth of 602 to 800.
2000 - Filled to 700.

| | Primary Drinking Water Standards Max. Contaminant Level (MCL) (mg/l, Unless Noted) | Secondary Standards (mg/l) |
|---|---|---|
| 1. Aluminum, Total | | 0.05- 0.2 |
| 2. Arsenic | 0.05 | |
| 3. Chloride | | 250.00 |
| 4. Fluoride | 4 | 2.00 |
| 5. Iron, Total | | 0.30 |
| 6. Lead, Total | 0.015 * | |
| 7. Manganese, Total | | 0.05 |
| 8. Sulfate | | 250.00 |

* Treatment Technique Action Level at 0.015 mg/l for Lead.

Primary Drinking Water Standards: Maximum permissible level of a contaminant in water, which is delivered by any user of a public water system.

Secondary Standards: Waters containing parameters in quantities above the limits indicated are not hazardous to health, but may be objectionable to an appreciable number of persons.

Primary and Secondary Standards have only been established for contaminants as listed.

The Utility still has a violation of the gross alpha standard and will be required to bring this level into compliance by December 2003; or to enter into a Consent Order, a legally binding agreement, with the DNR. The Consent Order will include a schedule that must be met to bring the system into compliance.

Previous sample results from the individual wells indicate that the water supply may not consistently meet the compliance standards for alpha radiation and combined radium level at the distribution system entry points. Compliance with the radium standard after December 2003 will be enforced at each entry point.

Additional samples were taken February 27, 2003. The information obtained from those samples is listed in Table #5. This data reinforces the need to have treatment at each system entry point.

The following sections will identify alternatives to address the radionuclide issue and bring the water supply system into compliance with the Standard.

b. Review Of Alternatives To Address The Radium Issue

The following alternatives were reviewed as options to address the radium issue for the City of Kaukauna. The alternatives have been identified by the United States Environmental Protection Agency (EPA) as best available technologies in the Radium Compliance Guidance Manual. Only those feasible alternatives will be evaluated in further detail.

1) Synthetic Zeolite Ion Exchange

a) System Description

In ion exchange, sodium ions are exchanged primarily for calcium and magnesium ions. As radium is chemically similar to calcium and magnesium, it is also exchanged for sodium. The media upon which this exchange takes place loses its capacity over time and has to be regenerated by backwashing with sodium chloride. Radium is removed during regeneration as a waste product, along with calcium and chloride ions. The backwash water is then discharged to the sanitary sewer. The Department Of Health & Family Services

(DHFS), Radiation Protection Section, is responsible for the establishment and enforcement of the disposal requirement for wastewater discharges containing naturally occurring radionuclides. A copy of the current Disposal Guidelines & Criteria is provided in Appendix G. A schematic of this treatment process is provided on Figure #5.

Raw water filtering is performed until a predetermined hardness breakthrough occurs. The softened water is blended with some un-softened water to reduce aggressiveness, which raises the hardness and radium level of the blended water.

b) Efficiency & Costs

The process is effective in removing between 70% and 98% of the radium in the source water. Ion exchange does produce finished water with an elevated sodium content, however, usually the taste of water is not affected if sodium concentrations are below 200 ppm. In general, the process is cost effective for communities with average daily demands of less than 10 mgd.

c) Waste Disposal

Waste disposal from ion exchange requires the discharge to a sanitary sewer with compliance to HFS 157. Discharge to surface waters is not acceptable, due to the high chloride levels in the discharge.

d) Application

The resultant water quality, while having removed 90% of the radium, would not be advantageous for Kaukauna. Ion exchange softening would provide a finished water with low hardness and a high total dissolved solids, which would be a very aggressive water in the distribution system. Consequently, some blend of raw water with softened water would appear to be the solution. Due to the high hardness levels in the raw water, it would not be possible to achieve a 5 to 6-grain hardness for the finished treated water, which is normally the objective of this treatment process.

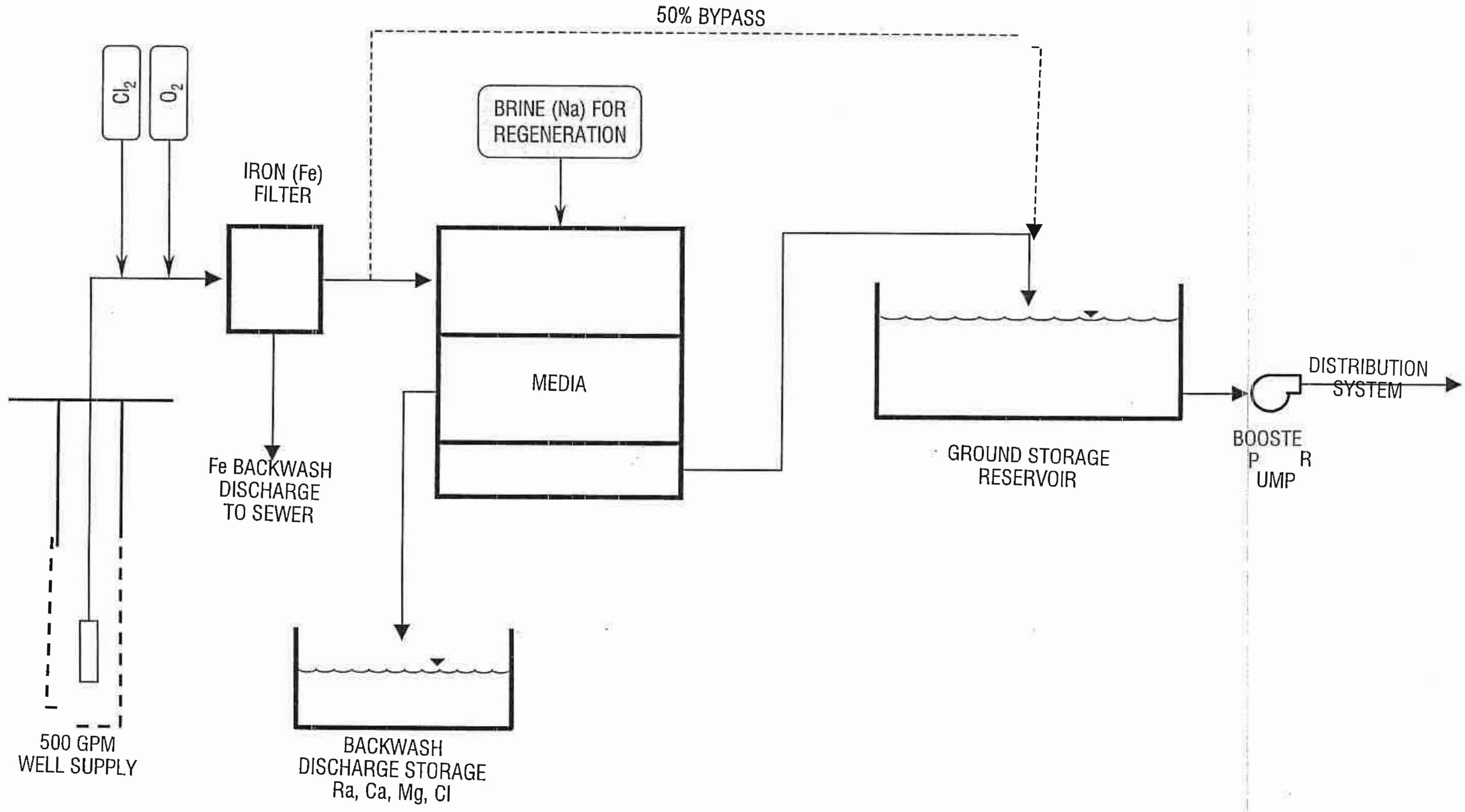



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FIGURE 5
**PROPOSED PROCESS / FLOW SCHEMATIC FOR ION EXCHANGE (CONVENTIONAL)**
KAUKAUNA UTILITIES
McM#K0004-820857.00 4/30/03
ID: PPT\2003\MCM WIS\KAUKAUNA WELL 8.PPT GLR:jmk

Although the radium levels would be approximately 1 pCi/l, the sodium in the finished water could be approximately 325 mg/l, which would be at a level to impact an objective taste to the water.

As an alternative, this treatment process could be utilized to reduce the radium levels to slightly below the 5 pCi/l standard. For example, a 37% blending ratio would result in a water having 4 pCi/l radium and 18-grain hardness, along with a slightly elevated sodium concentration of 269 mg/l. A summary of the amount of blending required at each well to achieve a radium level of 4 pCi/l is presented in Table #11, which also indicates the resultant sodium levels. Since each well has varying calcium and magnesium levels, the resultant water hardness to achieve a radium level of 4 pCi/l varies significantly from well to well. This would be difficult to control at a central treatment plant and would result in varying water qualities delivered to the water distribution system, if individual treatment plants were developed. The resultant water would also have a hardness of 15 to 18-grains, a level which would require the continued use of point of use softening treatment for domestic use.

2) Lime & Lime Soda Ash Softening

a) Process Description

In this process, calcium and magnesium are complexed by lime or in waters with a high level of non-carbonate hardness, it is necessary to also use soda ash. The complexed materials floc and are filtered out. Radium is also precipitated out with the precipitated sludge. The efficiency of radium removal is dependent upon the quality of chemicals used, process, pH, amount of magnesium removal, non-carbonate hardness removal and filter efficiency.

b) Efficiency & Costs

Radium removal efficiencies can be as high as 90%, provided the calcium and magnesium removal rates are also high enough to reduce the total hardness to less

## Table #11

**WATER QUALITY ION EXCHANGE TREATMENT**

KAUKAUNA UTILITIES

Evaluation Of Water Supply System

| Langelier Indiex * | | | | Treated Water Quality | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Well # | Raw | Treated | % Blending | Ra (pCi/l) | Fe (mg/l) | Na (mg/l) | TDS (mg/l) | $SO_4$ (mg/l) | Hardness (grains) |
| 4 | +.5 | - .15 | 25 | 4 | 0 | 286 | 1052 | 538 | 11.3 |
| 5 | +.6 | -.05 | 37 | 4 | 0 | 269 | 1307 | 650 | 18.3 |
| 10 | +.45 | -.2 | 51 | 4 | 0 | 241 | 689 | 265 | 15 |
| 8 | +.45 | -.6 | 20 | 4 | 0 | 298 | 956 | 450 | 7 |
| 9 | + .85 | +.25 | 42 | 4 | 0 | 262 | 946 | 633 | 15.5 |

* Using raw water pH.

than 100 ppm. Capital and operation and maintenance costs are dependent upon the amount of soda ash required to treat the water, since it has a much higher cost than lime. The finished product is usually stabilized with carbon dioxide to the saturation pH, so that no further treatment is needed. Since it is a steady flow process, the chances of breakthrough (as in ion exchange) are non-existent. The sodium levels in finished water are dependent upon the amount of soda ash required in the treatment process. Due to the high capital costs, this type of system is usually considered cost effective for communities having average water quality characteristics with average daily demands of greater than 10 mgd.

c) Waste Disposal

Disposal issues with lime softening are:

(1) All clarifier and settled backwash sludge has to be landfilled or land applied.
(2) Supernatant of backwash can be re-routed to head of treatment plant or discharged subject to the WPDES permit limitations.

d) Application

Since there are high levels of non-carbonate hardness in the water supply (mostly in the form of calcium sulfate and magnesium sulfate), it would be necessary to utilize a combination of lime and soda ash in the treatment process. Adding lime alone would result in only a 30% reduction in hardness and would, most likely, not reduce the radium to below 5 pCi/l. Treatment to a hardness of 100 ppm, or approximately 6-grains, should result in radium removal efficiencies of up to 90%; although the use of soda ash in the process would raise the sodium level in the finished water to approximately 175 mg/l. The finished water would also have a reduced level of total dissolved solids, although there would not be a significant decrease in the sulfate level. The finished water would need to have a pH of approximately 9.0 to be stabilized. This treatment process would be applicable for the removal of radium and provides the only process for complete treatment of the water supply for the City.

Due to the high capital and operating costs associated with this process, this option will not be considered in further detail.

3) Reverse Osmosis / Nanofiltration

a) System Description

Nanofiltration, which is a lower pressure Reverse Osmosis (RO) system, is a process by which water containing soluble minerals is pumped through a semi-permeable membrane using a high driving pressure. A schematic of this process is provided on Figure #6. Divalent ions, like radium, calcium and magnesium, do not pass through the membrane with as high efficiency as the single valent ions. The amount of product water in relation to reject water resulting from this process depends upon the amount of dissolved solids present in the source water, the type of membrane and the operating pressure utilized.

Raw water entering the plant is filtered for removal of any suspended solids, which could foul the membrane. Raw water pH is lowered to convert bicarbonate to carbon dioxide, thus, reducing the potential for precipitation of calcium carbonate on the membrane. The water is then pumped through the membranes producing treated water. Post-treatment consists of decarbonation by aeration, upward pH adjustment and addition of chlorine for disinfection.

b) Efficiency & Costs

The efficiency of radium removal ranges from 87% to 98%. In general, a well maintained plant could operate at a greater than 90% removal efficiency. The system can remove divalent ions, produces better quality finished water and is adaptable to small scale facilities. The capital and operating costs for this system are generally high.

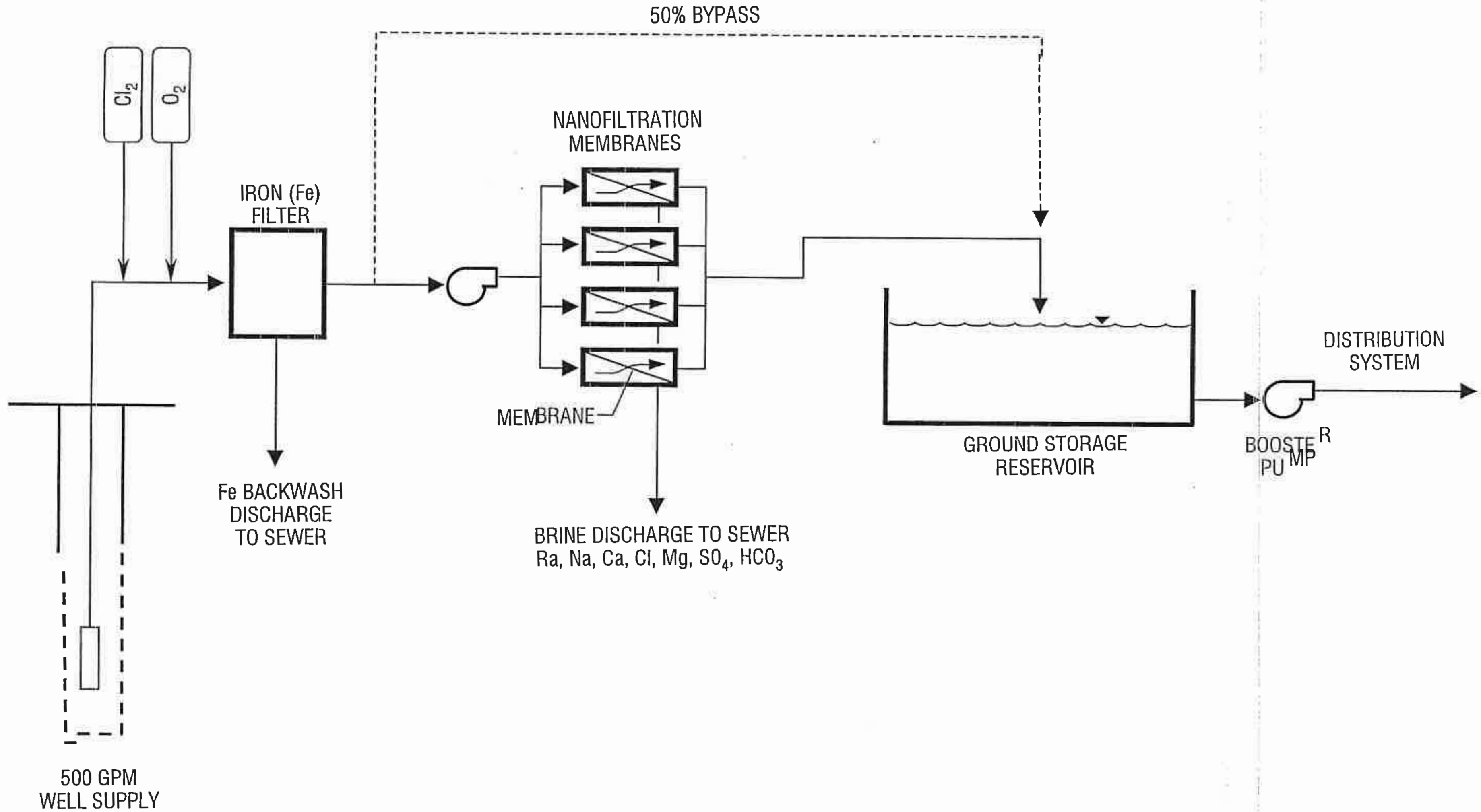



FIGURE 6

**PROPOSED PROCESS / FLOW SCHEMATIC FOR NANOFILTRATION MEMBRANE**

KAUKAUNA UTILITIES

ID: PPT2 MCM#K0004-82085 7.00 4/30/03 GLR:jmk
003\MCM WIS\KAUKAUNA WELL 8.PPT

McMAHON ASSOCIATES, INC.
ENGINEERS ARCHITECTS
PROJ. MGRS. SURVEYORS

c) Waste Disposal

Disposal of waste from RO is similar to that of ion exchange. Discharge to a sanitary sewer would require Department Of Health & Family Services Code compliance. Membrane disposal, due to fouling or end of useful life, could be regulated by the DNR. Permanent rules for membrane disposal have not been developed beyond a set of interim guidelines (refer to Appendix G).

d) Application

The use of an nanofiltration membrane operating at pressures of approximately 100 psi would remove approximately 88% of the total dissolved solids, as compared to a 95% to 98% removal rate for a RO membrane operating at pressures in excess of 250 psi. The characteristics of the treated water would, however, require adjustment of the pH and blending to stabilize and minimize corrosiveness. As in the case of the ion exchange treatment process, a blending of approximately 50% of the raw water and treated water to provide a finished water having a radium level just slightly below the standard would be the most likely design objective. This approach would minimize the capital cost to install the necessary treatment equipment and help to reduce the overall operating costs, but would provide a finished water having a hardness of approximately 18 to 20-grains of hardness, a level at which further treatment at the point of use would be required.

4) Pre-Formed Hydrous Manganese Oxide

a) System Description

It is recognized that a limited amount of radium may be removed as a consequence of iron and manganese treatment processes, presumably a result of adsorption. Radium removal resulting from permanganate-greensand treatment has been observed to vary greatly from 0% to nearly 50%. Removals have been generally observed to increase when the manganous ion is increased and have been attributed primarily to the adsorption of radium to hydrous manganese oxides (HMO's), not to iron oxides, which apparently have a much lower radium adsorption potential under typical water treatment conditions.

Hydrous manganese oxides, also referred to as amorphous manganese dioxide, may be formed by the rapid oxidation of manganous ion, such as accomplished by reduction of permanganate ion or from the reduction of permanganate by other substances, such as ferrous iron. The exact composition of the product is not fixed, but depends upon the reaction conditions. However, the product ($MnO_2$(s), sometimes referred to as manganese dioxide, has usually been found to be the closest to what is observed and is usually assumed to represent what is produced.

Adsorption of cations to hydrous manganese oxides has been extensively studied. The adsorption capacity of HMO's is generally much greater than other oxides, such as those of iron, owing to their relatively large surface area per unit mass.

The adsorption capacity per unit mass is, however, expected to depend upon the conditions under which the HMO is formed, the chemicals used to form it, and the constituents in the water. For example, available surface area of metal oxides generally increases with the rate of formation and may be affected by the presence of other constituents, such as silica. HMO's produced by strong oxidants that rapidly oxidize manganous ions, such as permanganate, are expected to have greater surface areas and adsorption capacities than HMO's produced by slow oxidation by oxygen.

b) Efficiency & Costs

Recent pilot-scale studies and full-scale operations have shown that addition of pre-formed HMO's could be used to significantly lower radium levels in drinking water using reasonably low HMO dosages in the range of 0.2 to 1.0 mg/l as Mn applied ahead of a sand filter.

Radium removal rates of 75% to 85% were demonstrated in the treatment of water containing about 3.0 pCi/l of Ra-226 and well-oxidized and well flocculated iron using an HMO dosage of 1.0 mg/l applied ahead of a pilot-scale sand filter in Iowa.

Other studies demonstrated that HMO's formed by chlorine oxidation of manganous sulfate or permanganate oxidation of ferrous sulfate were nearly equally effective for radium removal. Although the presence of well-oxidized and well-flocculated iron did not appear to interfere with radium removal in the pilot studies, batch studies suggested that the presence of soluble iron might reduce radium adsorption to the HMO's if oxidized in the presence of the HMO's.

c) Waste Disposal

Disposal of the backwash water and any radium adsorbed on to the manganese dioxide, which would be removed from the media during backwash would be discharged to the sanitary sewer. The limitation of discharge would be those limits as currently established under the Draft Guidelines for radionuclide disposal, prepared by HFS and provided in Appendix G.

d) Application

The application of HMO's in the Kaukauna system would only require the addition of a manganese sulfate chemical system as there are iron filters and permanganate chemical systems at each of the well stations. It would also be proposed to replace the anthracite media in the existing iron filters with either small effective size silica sand or greensand for the physical removal of any precipitated manganese.

The current full-scale pilot application of this process at Well Station #8 appears to be effective in both radium removal and control of manganese levels in the filtered water. This process appears to be easily adaptable to the Kaukauna system.

5) Radium Selective Media

a) System Description

The selective media process for radium removal utilizes multiple vessels filled with Water Remediation Technology, LLC (WRT)'s Z-88™ chemically modified natural treatment media. Water is passed through the media in each successive stage. When media for radium removal in the first stage becomes loaded with radium, water is routed to the next stage and the media is replaced with new Z-88™.

b) Efficiency & Costs

The levels of radium removal percent efficiency are a function of the number of contactors the water passes through in series flow. The radium can be reduced to nearly zero or to a level just below the standard. The level of treatment can, therefore, be selective.

All costs associated with the initial installation of the treatment equipment and media, as well as spent media removal and disposal, are included in a unit charge per thousand gallons of water treated, similar to a lease.

c) Waste Disposal

The license fee paid to WRT for this process includes the removal and ultimate disposal of the exhausted media, which is loaded with the radium, by WRT personnel. There are no additional costs to the Owner / Operator for system backwashing or media replacement.

d) Application

The application of this technology and approach is a viable solution in Kaukauna because the process selectively removes the radium and specifically addresses this single water quality issue to a pre-selected level to ensure compliance with the water quality standard. There is a reduced capital cost associated with this option, as the treatment equipment and media are not purchased, but leased from the equipment owner, WRT.

6) Blending

a) System Description

Blending would consist of mixing water with a high radium content with water of a low radium content. The purpose would be to achieve a final product below the 5 pCi/l radium standard. This could be achieved by discharging two or more wells into a common reservoir. Baffles may be needed to ensure proper mixing. High lift pumps are then used to pump blended water into the distribution system.

b) Efficiency & Costs

The quality of water produced is not constant and can vary considerably over time. While an initial cost may be relatively low, long-term monitoring would increase.

c) Application

As a solution to the situation in Kaukauna, blending is not feasible because there are no wells producing water low enough in radium to dilute the concentration significantly enough to provide a blended water below the required standards.

7) Well Reconstruction

Well reconstruction consists of "casing or sealing off" the high radium producing sections of a well. This alternative does not often appear to be feasible because:

a) The formations providing the water with high radium content are likely to be those producing the most water. Casing, sealing or the backfilling of these areas will usually reduce production capacity significantly.

b) Unreliability of using packer tests in existing wells.

c) Results of packer tests may be likely "well specific".

Wells #8, #9 and #10 have been filled to obtain water from the upper 120-feet of the Cambrian Sandstone in an effort to determine if sealing off water from the lower sections of the Cambrian Sandstone would provide a resultant water, which would meet the radionuclide standard. The results from the sealing of Well #9 in 1989 were effective in reducing the radium levels, however, the gross alpha levels remained over the standard. A similar effort in 1998 at Wells #8 and #10 produced mixed results. Well #4 is the only well open to the entire depth of the Cambrian Sandstone.

The relationship of well depth and water quality is summarized in Table #5. From the data in this table, it does not appear that there is a definite relationship between well depth and water quality. Therefore, further efforts to obtain water from the existing wells meeting the radionuclides standard are not warranted.

8) Point Of Use / Point Of Entry

a) System Description

Point of use treatment is another way to remove impurities from drinking water by providing the required treatment at a decentralized level. It can be accomplished by either treating the entire supply for a home or facility (point of entry) or at individual taps within a home or facility (point of use).

The process of treatment varies according to type of unit. The most common processes are Reverse Osmosis (RO) and cation ion exchange.

b) Efficiency & Costs

The level of efficiency is dependent upon the type of unit, its configuration and the source of water. Costs of individual units vary too, but other costs need to be considered. Costs of administration, maintenance, monitoring and others would have to be weighed carefully.

c) Institutional Framework

An institutional framework in the form of a Water Quality District would need to be instituted to mange point of use/point of entry systems.

Institutional issues that should be considered when establishing a Water Quality District to ensure that adequate treatment is being provided also include:

(1) Determining whether the purpose of the District is for compliance with drinking water regulations or for reduction of non-regulated and/or secondary contaminants.
(2) Establishing a legal entity to obtain funding, incur costs and assume responsibility for point of use treatment systems.
(3) Granting the right of access to all sites serviced by the water supply.
(4) Including clearly defined provisions for equipment ownership, installation, monitoring and maintenance.

d) Application

Point of use treatment has the following associated advantages, when compared to central treatment:

(1) Only water intended for consumption may need to be treated.
(2) Costs per customer may be significantly lower for small communities.
(3) Provides a means for private well owners to treat their water to assure continual supply.
(4) Some forms of treatment may provide greater contaminant reduction than with central treatment.

The disadvantages of point of use treatment include:

(1) Greater complexity associated with control of treatment, monitoring, routine maintenance and regulatory oversight.

(2) Life and efficiency of treatment units are dependent upon source water quality.

(3) Monitoring costs will be higher than with central treatment.

(4) Media beds may be susceptible to microbial growth.

The implementation of a point of use treatment concept in the City of Kaukauna would depend upon the acceptability of the public for creation of an institutional framework within which such treatment concepts could reasonably function. Additionally, the acceptability of this concept by the Wisconsin DNR as a means of compliance with the Water Quality Standards remains an issue. These and several other institutional factors suggest that this concept be removed from further detailed consideration.

9) Development Of Alternate Supply

a) General

Development of an alternate water supply having either a better water quality (less radium) or a supply not having a radium contamination problem is an alternative warranting evaluation. The obvious alternatives include development of an alternate groundwater supply either having less radium or a better water quality and the use of Lake Winnebago as a surface water source, which does not have a radium contamination problem.

The use of the Fox River as a surface water source has been determined by the DNR to not be an acceptable source of municipal drinking water supply. Purchase of water from another municipality supply should be explored.

b) Alternate Groundwater Supply

It would be necessary to locate an alternate groundwater supply approximately 3-miles to the northwest of Kaukauna in order to obtain water having significantly better quality, as measured by the parameters of total dissolved solids, hardness and sulfates.

In general, the water quality would be similar to the quality of the water supply in the Little Chute area. It is expected, however, that there would be no appreciable change in the amount of gross alpha or combined radium in the supply than is experienced in the Kaukauna wells. With an alternate raw water supply having a hardness of approximately 25-grains, the most logical treatment process to remove the radium would be ion exchange softening.

While this alternate source of water would result in a water quality more desirous than the existing supply, it still would require treatment for removal of radium. As such, unless there were a stated objective of the Utility to increase the water quality of the supply or a need to significantly increase the capacity of the water supply system, there would appear to be no advantage to obtaining water from an alternate groundwater source. This option will be removed from further consideration for the analysis of options to address the radium issue. This option should be considered, however, if additional wells are needed to either provide additional supply or if a water source of better water quality is desired.

c) Surface Water Supply

The only surface water supply source reasonably available to Kaukauna would be Lake Winnebago, since the Fox River is not considered as an acceptable source and a Lake Michigan supply would not be economically feasible to develop for a single municipality in the Fox Valley region. The treatment process would be similar to that which is currently being utilized by the City of Appleton.

A preliminary cost estimate for such a facility, including the connecting pipe line, would be approximately $15 million; making this option economically unfeasible. As such, this option will not be evaluated further.

d) Connection To The City Of Appleton

The City of Appleton currently has sufficient capacity to accommodate an additional average daily demand of 1.6 mgd and a maximum day demand of 2.1 mgd. There is also sufficient capacity within the Appleton distribution systems to deliver the flow rate required of the maximum day demand.

A connection to the Appleton system on the south side of the City of Kaukauna would require a 24,300-foot, 20-inch diameter, transmission main. This interconnection could require a pressure reducing valve to provide the required supply at the desired pressure in Kaukauna.

## C. Detailed Evaluation Of Treatment Alternatives To Address The Radium Issue

### 1) Design Conditions

a) Water Quality

Due to the observed decline in water quality of the existing water supply, it will be necessary to estimate the future water quality parameters of the existing groundwater supply for the purposes of developing and evaluating alternate water treatment processes for removal of radium.

Due to the nature of some treatment processes, it may be necessary to evaluate each alternative in a very preliminary screening process to determine if resultant water quality would meet desired water quality objectives. Although some treatment processes could be implemented to only reduce the radium levels, the overall objective for total treatment of the water supply would be to remove the radium to minimum levels, reduce the hardness and the sulfates of the water, remove iron in the water and to reduce the total dissolved solids in the finished water. Elevated sodium levels above 250 mg/l resulting from any treatment process would be considered objectionable.

Generally speaking, for the purpose of evaluating water treatment processes, it will be assumed that the water quality parameters of hardness, total dissolved solids and sulfate of the raw water will increase by an additional 10%, over and above the existing levels measured in milligrams per liter or parts per million, over a 20-year design period.

b) Water Quantity

The static water levels in the Sandstone Aquifer in the Kaukauna area have been observed to have declined approximately 80-feet since the mid 1930's. The United State Geological Society conducted a groundwater flow model simulation of the region in an effort to estimate the future impact to water pumping levels in the region under the scenario of increased groundwater pumping in the Fox Valley region and with the existing groundwater users in the metropolitan Green Bay area no longer using groundwater for their water supply. The graphic results of those model simulations are provided in Appendix F, which illustrates that there would be a projected decline in water pumping levels in the Kaukauna area of an additional 66-feet over the current pumping levels, even with the Brown County communities connected to a surface water supply. Continued use of groundwater in that region of Brown County would have a more significant impact on the pumping water levels in the Fox Valley area.

For the purpose of evaluating and estimating capital and operating costs for various treatment processes utilizing the existing groundwater supply, the static water levels will be assumed to have stabilized with an additional decline of 40-feet in static water levels over the next 20-years. The yield of the well will not, however, be projected to decrease with the lower static and pumping levels.

For the purpose of developing preliminary treatment system sizes and costs, a plant having an average day demand capacity of 1.4 mgd and a maximum day demand capacity of 2.2 mgd will be utilized. For the purposes of developing annual operating costs, an annual average daily demand of 1.4 mgd will be utilized.

For the purpose of developing a treatment system at the individual well, the following wells will be provided with treatment systems to provide the required treated water volume.

(1) Wells #4, #5 and #10 pumping to the Main Filter Plant for single treatment system (1.87 mgd).
(2) Well #9 provided with a treatment system for pumping into the distribution system (1.75 mgd).
(3) Well #8 provided with a treatment system for pumping into the distribution system (.57 mgd).
(4) Total available supply capacity = 4.2mgd.
(5) Total available treated capacity = 4.0 mgd.

2) Treatment Alternatives & Costs

a) General

Of the water treatment concepts presented in the previous section, the following have been considered for a detailed evaluation for the treatment of the existing groundwater supply, at the individual well sites. A cursory review of utilizing a central treatment system concluded that there would be a higher capital cost due to the significant piping costs associated with the interconnecting all the wells to a central site.

(1) Synthetic Zeolite Ion Exchange
(2) Nanofiltration (Reverse Osmosis)
(3) Pre-Formed Hydrous Manganese Oxides
(4) Radium Selective Media
(5) Connection To Appleton Water System

b) Alternative #1 - Synthetic Zeolite Ion Exchange

The development of zeolite ion exchange system for effective radium removal while providing a non-aggressive water and maintaining a sodium level below 250 mg/l would require blending raw water at Well #9, Well #8 and at the Main Filter Plant to a 50% level of total water supply, which would yield a hardness of approximately 24-grains and a radium level of less than 4 pCi/l.

A schematic of this treatment process is provided in Figure #5. A detailed capital cost summary for this alternative is provided in Table #12 and a detailed annual operating summary is provided in Table #13.

c) Alternative #2 - Nanofiltration
(Low Pressure Reverse Osmosis)

The use of low pressure RO membranes have been documented to effectively remove radium, as well as the majority of all cations and anions in water. The recovery of feed water is approximately 75%, so that 25% of all feed water is discharged to the sanitary sewer as a waste. This waste normally contains approximately four times the level of radium in the feed water to the membrane. Since there is such a high percentage removal of all cations and anions in the water, the resultant water discharged from the membrane is low in calcium, alkalinity and pH. The treated water is unstabilized, aggressive and would be corrosive in the distribution system. In an effort to stabilize the water delivery to the system and to reduce the capital costs and operating costs of the treatment system, a bypass flow rate of approximately 50% around the membrane would combine with the treated water to produce a finished water having a radium level of below 4 pCi/l or 20% below the standard. In general, the water quality characteristics would be as follows:

| | Permeate (mg/l) | Raw Water (mg/l) | Blended Finish Water (mg/l) |
|---|---|---|---|
| Total Dissolved Solids | 118 | 946 | 530 |
| Calcium | 6.5 | 226 | 115 |
| Magnesium | 1.0 | 22 | 12 |
| Alkalinity | 25.4 | 200 | 110 |
| Sulfates | 10.4 | 417 | 215 |

A schematic of this treatment process is provided on Figure #6.

## Table #12

**ALTERNATIVE #1**
**ION EXCHANGE SOFTENING OF 50% OF SUPPLY**
**Summary Of Capital Costs**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| MAIN FILTER PLANT | | |
|---|---|---|
| Treatment Equipment | $325,000 | |
| Building | 270,000 | |
| Piping / Mechanical | 125,000 | |
| Site Piping | 70,000 | |
| Electrical / Controls | 70,000 | |
| Backwash & Brine Tank | 80,000 | |
| Pump Modifications | 30,000 | |
| Engineering & Contingency | 230,000 | |
| TOTAL | | $1,200,000 |

| WELL #9 | | |
|---|---|---|
| Treatment Equipment | $200,000 | |
| Building | 210,000 | |
| Piping / Mechanical | 115,000 | |
| Site Piping | 45,000 | |
| Electrical / Controls | 50,000 | |
| Backwash & Brine Tank | 80,000 | |
| Pump Modifications | 25,000 | |
| Engineering & Contingency | 175,000 | |
| TOTAL | | $900,000 |

| WELL #8 | | |
|---|---|---|
| Treatment Equipment | $170,000 | |
| Building | 155,000 | |
| Piping / Mechanical | 80,000 | |
| Site Piping | 45,000 | |
| Electrical / Controls | 25,000 | |
| Backwash & Brine Tank | 65,000 | |
| Pump Modifications | 10,000 | |
| Engineering & Contingency | 150,000 | |
| TOTAL | | $700,000 |

| | |
|---|---|
| **TOTAL** | **$2,800,000** |

## Table #13

**PROJECTED OPERATION & MAINTENANCE (O&M) COSTS**
**For Water Treatment Alternatives**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| | Existing Facility | Alternative #1 Ion Exchange | Alternative #2 Reverse Osmosis | Alternative #3 HMO's | Alternative #4 Radium Selective Media (WRT) | Alternative #5 Purchase Water From Appleton |
|---|---|---|---|---|---|---|
| **SOURCE OF SUPPLY** | | | | | | |
| Operations | $25,573 | $25,600 | $25,600 | $25,600 | $25,600 | $25,600 |
| Expenses | 6,269 | 6,300 | 6,300 | 6,300 | 6,300 | 6,300 |
| Maintenance | 4,942 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 |
| SUBTOTAL | $36,784 | $36,900 | $36,900 | $36,900 | $36,900 | $36,900 |
| **PUMPING EXPENSES** | | | | | | |
| Operations | $29,540 | $30,000 | $30,000 | $30,000 | $30,000 | $0 |
| Electric | 69,303 | 75,000 | 90,000 | 70,000 | 70,000 | 0 |
| Expenses | 4,270 | 4,300 | 4,300 | 4,300 | 4,300 | 0 |
| Maintenance | 24,186 | 24,200 | 24,200 | 24,200 | 24,200 | 0 |
| SUBTOTAL | $127,299 | $133,500 | $148,500 | $128,500 | $128,500 | |
| **WATER TREATMENT** | | | | | | |
| Operations | $20,760 | $60,000 | $80,000 | $25,000 | $25,000 | $0 |
| Chemicals | 39,708 | 83,600 | 65,000 | 47,000 | 40,000 | 0 |
| Maintenance | 27,401 | 50,000 | 45,000 | 30,000 | 30,000 | 0 |
| Membranes | | | 30,000 | | | 0 |
| Purchase | | | | | 225,000 | $1,375,000 |
| SUBTOTAL | $87,869 | $193,600 | $220,000 | $102,000 | $320,000 | $1,375,000 |
| **TOTAL** | **$251,952** | **$364,000** | **$405,400** | **$267,400** | **$485,400** | **$1,411,900** |
| Net Increase from Existing | | $112,048 | $153,448 | $15,448 | $233,448 | $1,159,948 |

A detailed capital cost summary for this alternative is provided in Table #14, and a detailed annual operating cost summary is provided in Table #13.

d) Alternative #3 - Hydrous Manganese Oxide

The existing iron filters and current practice of permanganate addition prior to the filters for iron oxidiation provides a unique opportunity to modify the current operational practices to add a source of manganese to pre-form manganese dioxide on which the radium would be absorbed for eventual removal by the filter media. Replacement of the existing .8 mm to 1.0 mm anthracite with .35 mm greensand provides a more effective media for removal of the small particle size of the manganese dioxide and to prevent the passing of unoxidized permanganate through the filter. The backwashing frequency of the filter media, based upon the operating results from Well #8, may need to be increased from the current one backwash per week per site to every 32 to 40-hours of operation. There is potential for manganese breakthrough of the filter media should the filter operate beyond this schedule. It is, therefore, recommended that the burden and time required for the operation of the filter backwashing process at Well #8 and the Main Filter Plant be automated to accommodate the additional backwashing operations, which is now viewed as a critical operating condition to ensure both compliance with the radium standard but also to keep the manganese levels in the filtered water to below .030 ppm.

The City has requested that a holding tank be provided at Well #8 to relieve the high flow rate discharged to the sanitary sewer during the filter backwash operation.

A schematic of this proposed operation as applicable at Well #8 is provided on Figure #7. This same process would be applied at Well #9 and the Main Filter Plant.

A detailed capital cost summary for this alternative is provided on Table #15, and a detailed operating cost analysis of this alternative is provided on Table #13.

## Table #14

**ALTERNATIVE #2**
**REVERSE OSMOSIS TREATMENT OF 50% OF SUPPLY**
**Summary Of Capital Costs**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| | | |
|---|---|---|
| **MAIN FILTER PLANT** | | |
| Treatment Equipment | $360,000 | |
| Equipment Installation | 145,000 | |
| Piping / Mechanical | 150,000 | |
| Building | 100,000 | |
| Site Work | 60,000 | |
| Electrical / Controls | 75,000 | |
| Engineering & Contingency | 220,000 | |
| TOTAL | | $1,110,000 |
| **WELL #9** | | |
| Treatment Equipment | $330,000 | |
| Equipment Installation | 140,000 | |
| Piping / Mechanical | 150,000 | |
| Building | 120,000 | |
| Site Work | 60,000 | |
| Electrical / Controls | 90,000 | |
| Below Grade Reservoir | 100,000 | |
| Booster Pumps | 60,000 | |
| Engineering & Contingency | 260,000 | |
| TOTAL | | $1,310,000 |
| **WELL #8** | | |
| Treatment Equipment | $250,000 | |
| Equipment Installation | 100,000 | |
| Piping / Mechanical | 90,000 | |
| Building | 80,000 | |
| Site Work | 50,000 | |
| Electrical / Controls | 65,000 | |
| Engineering & Contingency | 165,000 | |
| TOTAL | | $800,000 |
| **TOTAL** | | **$3,220,000** |

## Table #15

### ALTERNATIVE #3
### HYDROUS MANGANESE OXIDE IN EXISTING FILTERS
### Summary Of Capital Costs

KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| | | |
|---|---|---|
| **MAIN FILTER PLANT** | | |
| Automation Of Filter Backwash System | $45,000 | |
| Media Replacement | 33,000 | |
| Chemical Feed Systems | 15,000 | |
| TOTAL | | $93,000 |
| **WELL #9** | | |
| Media Replacement | $32,000 | |
| Chemical Feed System | 15,000 | |
| TOTAL | | $47,000 |
| **WELL #8** | | |
| Automation Of Filter Backwash System | $30,000 | |
| Replace Filter Piping | 10,000 | |
| Chemical Feed System | 5,000 | |
| Backwash Holding Tank | 75,000 | |
| TOTAL | | $120,000 |
| **TOTAL** | | **$260,000** |

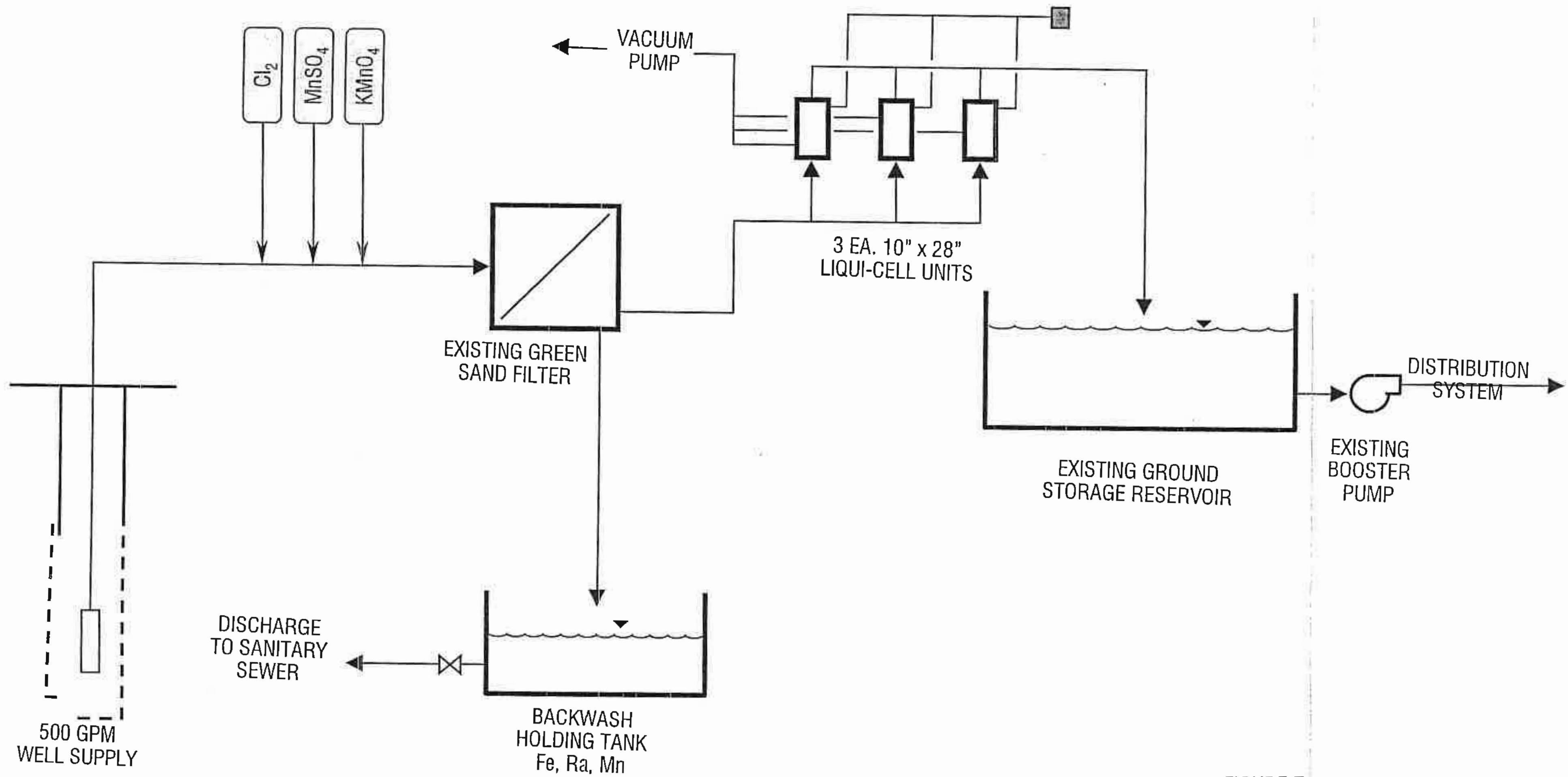



FIGURE 7

**PROPOSED PROCESS / FLOW SCHEMATI C FOR WELL #8 AIR REMOVAL SYSTEM & USE OF HMO's FOR RADIUM REMOVA L**

KAUKAUNA UTILITIES

McM#K0004-820857.00 4/30/03

ID: PPT\2003\MCM WIS\KAUKAUNA WELL 8.PPT GLR:jmk

McMAHON ASSOCIATES, INC.

ENGI NEERS ARCH ITECTS
PROJ. MGRS. SURV EYORS

e) Alternative #4 - Radium Selective Media

The use of a media specifically designed to remove only radium does not impact other water quality issues, which would impact the water quality of the existing water supply. The absorption of radium onto this selective media does result in a low level radioactive waste, which must be properly disposed of. As such, the implementation of this alternative is viable only under a loan/lease arrangement where all treatment equipment and media and media disposal are leased from Water Remediation Technology, LLC (WRT) for a unit cost per thousand gallons of water treated. This concept removes liability from the Utility and provides a guarantee to meet the water quality standard for radium.

Facilities to house the equipment and piping to and from the treatment equipment would be provide by the Utility. Additional detail on this proposal is provided in a proposal from WRT in Appendix H.

A detailed capital cost summary for this alternative is provided in Table #16, and a detailed operating cost analysis is provided in Table #13.

f) Alternative #5 - Connection To Appleton

A direct connection to the Appleton system would eliminate the need for pre-pumping of the water as the hydraulic grade line in the Appleton system is greater than the grade line in the Kaukauna system. Since the water supply from Appleton is softened, a benefit of this option is the delivery of a 100% softened water supply to the residents.

A detailed capital cost analysis for this alternative is provide in Table #17, and a detailed operating cost analysis is provided in Table #13.

g) Summary & Analysis Of Results

The operating costs associated with each of the five evaluated alternatives are presented and compared on

## Table #16

**ALTERNATIVE #4**
**RADIUM SELECTIVE MEDIAL (WRT)**
**Summary Of Capital Costs**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| MAIN FILTER PLANT | | |
|---|---|---|
| Building | $125,000 | |
| Piping / Mechanical | 75,000 | |
| Site Piping | 40,000 | |
| Electrical / Controls | 40,000 | |
| Engineering & Contingency | 70,000 | |
| TOTAL | | $350,000 |

| WELL #9 | | |
|---|---|---|
| Building | $100,000 | |
| Piping / Mechanical | 75,000 | |
| Site Piping | 30,000 | |
| Electrical / Controls | 30,000 | |
| Engineering & Contingency | 60,000 | |
| TOTAL | | $295,000 |

| WELL #8 | | |
|---|---|---|
| Building | $80,000 | |
| Piping / Mechanical | 65,000 | |
| Site Piping | 30,000 | |
| Electrical / Controls | 30,000 | |
| Engineering & Contingency | 50,000 | |
| TOTAL | | $255,000 |

| | |
|---|---|
| **TOTAL** | **$900,000** |

<u>**Table #17**</u>

**ALTERNATIVE #5**
**CONNECTION TO CITY OF APPLETON**
**Summary Of Capital Costs**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| | | |
|---|---|---|
| 20-Inch Water Main (22,000 feet) | $1,760,000 | |
| Pressure Reducing Valve & Metering | 80,000 | |
| Engineering & Contingency | 460,000 | |
| TOTAL | | $2,300,000 |

Table #18 to the year 2001 operating costs required to support the existing water supply and treatment system. The net increase in annual operating costs for each alternative over current costs is also provided on Table #18.

The initial capital cost to implement each of the five alternatives are also summarized in Table #18, together with the annual debt service cost required to support that capital cost over 20-years at 4½% interest rate and with an additional 30% added for bond service coverage. The additional increase in annual operating costs for each alternative is added to determine the total increase in annual revenue required to support each alternative, together with the percentage increase of total annual revenue over the year 2001 annual water sales of $1,895,636.

The use of pre-formed hydrous manganese oxides in the existing iron filtration system has a significantly lower capital and operating cost impact to current operations. The promising operating results demonstrated at Well #8 in removing the radium and controlling the manganese in the filtered water suggests that this process can effectively be utilized at all of the other wells. It is recommended that this treatment process be implemented at each of the well sites, together with upgrades to the filtration process to automate the filter backwash operations.

## 2. Secondary Drinking Water Standards

The secondary standard for fluoride in drinking water is 2.0 mg/l. Analysis results presented on Table #9 indicate that in 1999 the Kaukauna raw water supply did not exceed the fluoride secondary standard. However, the level of fluoride in both Well #4 and Well #5 was measured at 1.90 mg/l in 1999. In the past, the level of fluoride has exceeded 2.0 mg/l in both of these wells.

The secondary standard for iron in drinking water is 0.3 mg/l. Iron levels found in all wells, except Well #5, are greater than 0.3 mg/l. In the past the iron level in Well #5 water has also exceeded the limit. The raw water supply is treated and the iron level in the water delivered to the customer is less than 0.1 mg/l.

**Table #18**

**SUMMARY & COMPARISON OF WATER TREATMENT ALTERNATIVES**
**Water Revenue Impact Analysis**
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| | **Alternative #1** Ion Exchange | **Alternative #2** Reverse Osmosis | **Alternative #3** HMO's | **Alternative #4** Radium Selective Media (WRT) | **Alternative #5** Purchase Water From Appleton |
|---|---|---|---|---|---|
| Initial Capital Cost | $2,800,000 | $3,220,000 | $260,000 | $900,000 | $2,300,000 |
| Debt Service Cost | | | | | |
| Principle & Interest With 30% Coverage [1] | 285,000 | 322,000 | 26,000 | 90,000 | 230,000 |
| Net Increase In O&M Costs (2001) From Existing | 112,048 | 153,448 | 15,448 | 233,438 | 1,159,948 |
| TOTAL INCREASE IN ANNUAL COST | $397,048 | $475,448 | $41,448 | $323,448 | $1,389,948 |
| **TOTAL INCREASE IN ANNUAL REVENUE REQUIRED** [2] | 20.7% | 25% | 2.2% | 17.0% | 73.3% |

[1] Annual debt service cost for 20-year amortization at 4½% per annum.
[2] Year 2001 annual water sales: $1,895,636

The secondary standard for sulfate is 250 mg/l. The raw water obtained from all of the wells has sulfate levels in excess of 250 mg/l. It is not feasible to reduce the sulfate levels in the existing water supply.

### 3. Air Entrainment

As described previously, observations were conducted in January 2003 to document air entrainment conditions at each of the wells. The results are summarized on Table #4. From these observations, it is evident that all the wells have air entrainment resulting in a milky white coloration as the air comes out of solution and is released. Wells #4, #5 and #10, combined, pump through an iron filter to a large ground storage reservoir for re-pumping. There is a slight trace of remaining dissolved air in the supply to the booster pumps and in the pump discharge. As Well #9 pumps through an iron filter, air remains in the water and is evident in the filter effluent. Entrained air was also observed in a distribution system sample taken at Well #10. The results of that observation are summarized in Table #4 and included the following:

<u>Distribution System Sample</u>

Observation #1 - 10:00 a.m.
a. Water sample cloudy with small bubbles, turns milky white within 15-seconds.
b. Sample cleared of air in less than 3-minutes.

Observation #2 - 1:30 a.m.
a. Water sample clear at time zero, then air bubbles start to form.
b. Sample cleared of air in less than 3-minutes.

In an effort to determine the nature and source of the entrained gases in the water supply from each of the five wells, a detailed analysis of this condition was completed by Dr. Tim Grundl. Dr. Grundl's complete report is provided in Appendix I. In summary, the analysis of entrained gases collected at each well site have determined that excess nitrogen is present in concentrations of 28 to 30 ppm. Carbon dioxide is also present at levels of 22 to 25 ppm, which is causing the low pH levels in the wells. The purging or removal of the carbon dioxide will have the beneficial effect of increasing the pH of the water entering the distribution system.

Dr. Grundl proposes a theory as to the source and cause for these high nitrogen levels. The concepts contained in that theory are contrary to widely held opinions formulated in the Fox Cities Groundwater Study, where the upper geological bedrock units were considered as confining layers, preventing the vertical movement of surface water to the Cambrian Sandstone aquifer used for the groundwater supply in the Kaukauna area.

The cause for this occurrence is under continued study by the United States Geologic Survey (USGS) and graduate students from the University of Wisconsin - Milwaukee. Reference Appendix J.

The presence of these entrained gases are most evident in the distribution system when Well #8 is in operation. It is at this well site that treatment to remove this air is required to allow continued use of this well.

The majority of the visible entrained gases escape upon release to atmospheric pressure within 30-seconds. The sampling conducted at Well #8 at the wellhead found the nitrogen to be 28.8 ppm and had reduced to 25.2 ppm after the 15-minute detention tank. This level was still greater than the concentration of one atmosphere partial pressure.

Complete removal or to a non-objectionable level requires several hours of detention time, as can be provided at the Main Filter Plant. The 15-minutes of detention time provided at Well #8 is not sufficient for all the gas to escape. There are several alternatives to remove these dissolved gases:

a. Long detention ground storage reservoir.
b. High efficiency air stripping towers.
c. Membrane contactors.

Of these options, the use of the membrane contactor is the option most likely to effectively remove the dissolved gases as removal efficiencies of greater than 98% can be achieved with a multiple pass system. It is unlikely, however, that the removal of more than 85% of the dissolved nitrogen that can be obtained with a single pass system would be required. A completed proposal and projected removal efficiencies of single, double and triple pass systems provided by membrane Liqui-Cel membrane contactors is provided in Appendix K.

For Well #8, the use of three 14-inch diameter membrane modules operating at 200 gpm each would provide 600 gpm of treatment capacity. The membranes would operate under vacuum to create the driving force to cause the dissolved nitrogen and carbon dioxide to pass from the water through the membrane to release to the atmosphere. The estimated cost to implement this technology at Well #8 was documented in an earlier section of this report and that part of the cost specifically related to removing the air is detailed as follows:

| | |
|---|---|
| Membranes | $30,000 |
| Vacuum Pump / Mechanical | 20,000 |
| Building Modifications | 10,000 |
| Electrical | 5,000 |
| Engineering & Contingencies | 15,000 |
| Total | $80,000 |

Should the high levels of nitrogen, which are also evident at Well #9, result in customer complaints, a similar system could be implemented at Well #9. Prior to installation, it is proposed to operate a 50 gpm pilot study at Well #8 using a 6-inch diameter membrane module to verify the adequacy of a single pass system to provide the desired nitrogen removal levels.

## IV. SUMMARY

### A. Water Supply

Two alternatives were evaluated to provide an additional 700,000-gallons per day of supply that will be required, in addition to the supply from the existing water supply system, in order to meet the year 2020 maximum day demand. Improvements at each of the existing wells, pumphouses and treatment plants are recommended to increase the water supply and treatment capacity to meet this requirement at a cost of $650,000. A more costly alternative would be to construct a new well and treatment system in a location north of the City, where a better quality can be obtained. While construction of an additional well is not warranted at this time, it may be advantageous to the Utility to identify and secure an area to the north for future siting of a well when additional capacity will be needed.

### B. Water Quality Compliance

A total of five alternatives were investigated to address the non-compliance issue relating to the elevated gross alpha and Radium 226/228 levels in each of the wells. Clearly, the most cost effective alternative will be to implement the use of pre-formed hydrous manganese oxides, as is currently under a detailed and full-scale pilot operation at Well #8. The current operation at the Main Filter Plant and Well #9 would be modified to add a source of manganese and to replace the filter media with Greensand. Automation of the filter backwashing operations at Well #8 and the Main Filter Plant are recommended to implement a more vigorous filter backwash schedule, and a holding tank at Well #8 is recommended for controlled release of the backwash water to the sanitary sewer. The estimated cost to implement these system changes is $260,000.

## C. Entrained Air Issue

A detailed study of the entrained air problem, most evident at Well #8, was conducted by Dr. Tim Grundl. The entrained air is nitrogen, present at levels of 28 to 30 ppm, well above the saturation levels at atmospheric pressure. High levels of carbon dioxide are also present, which is depressing the pH in the water supply. While the source of the nitrogen and carbon dioxide is not known and under continued study, it would be necessary to remove these gases for aesthetic purposes. The most effective technology to remove this air is with an ultrafiltration membrane operating under a vacuum to pull the dissolved gases from the water. As this is a new application of this technology, it is recommended that a pilot study be conducted to determine the number of passes through the membrane reactor that would be required to remove the gases to an acceptable aesthetic level.

A 50 gpm pilot study would be implemented at Well #8 using a 6-inch membrane and a rented vacuum pump over the period of several weeks to verify the feasibility of this technology.

## D. Implementation Schedule

The following schedule, provided in Table #19, is recommended for implementation of the water system improvements required to address the radium non-compliance issue, to increase the capacity of the water supply system and to address the entrained air issue at Well #8.

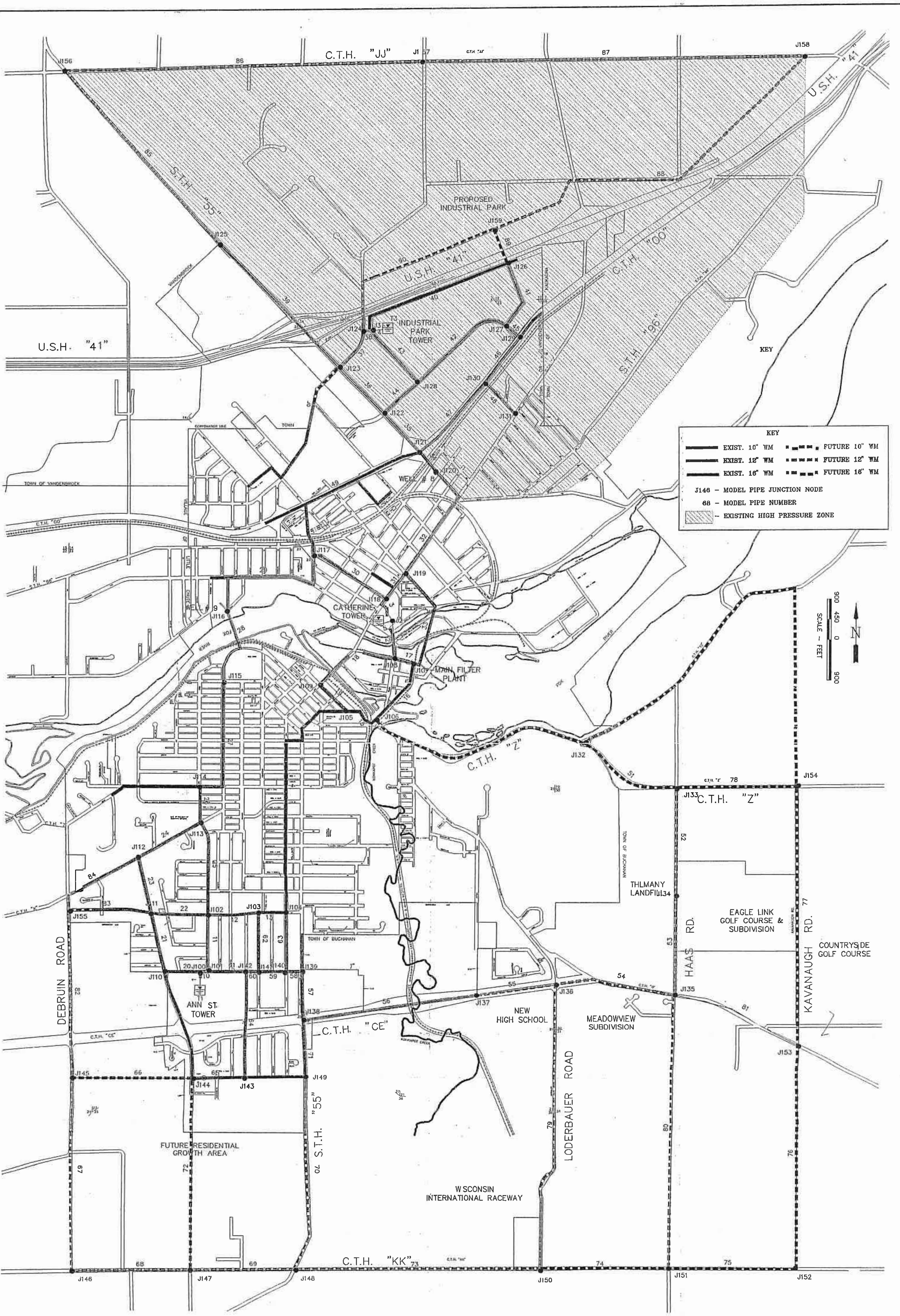
# Table #19

## IMPLEMENTATION SCHEDULE
## Capital Improvement Plan - Water Supply System
KAUKAUNA UTILITIES
Evaluation Of Water Supply System

| Event | Schedule | Cost |
|---|---|---|
| Pilot Testing Of Air Removal System At Well #8 | Summary 2003 | $3,500 |
| Pre-Purchase Of Greensand Filter Media | Summary 2003 | $45,000 |
| Air Removal System At Well #8 & Replace Piping & Automate Backwash System | Fall 2003 | $125,000 |
| Change Media At Well #9 & Replace Pump/Motor | Fall 2003 | $90,000 |
| Change Media At Main Filter Plant & Automate Backwash System | Fall 2003 | $70,000 |
| Holding Tank At Well #8 | 2004 | $75,000 |
| Deepen Well, New Pump/Motor At Well #5 | 2006 | $105,000 |
| Add New Filters At Main Filter Plant | 2007 | $400,000 |
| **TOTAL** | | **$913,500** |

# APPENDIX A

WATER DISTRIBUTION MASTER PLAN




| SCALE | 1" = 900' |
|---|---|
| DATE | APRIL, 1997 |
| PROJECT NO | 1104-97242 |

**KAUKAUNA WATER DISTRIBUTION MASTER PLAN**
**WATER MAINS 10-INCH AND LARGER**

| DESIGNED | BDW |
|---|---|
| DRAWN | KRH |
| CHECKED | |

McM

McMAHON ASSOCIATES, INC.
ENGINEERS ARCHITECTS SCIENTISTS SURVEYORS
1445 McMahon Drive Neenah, WI 54956
Mailing Address:
P.O. Box 1025 Neenah, WI 54957-1025
TEL: 414-751-4200 FAX: 414-751-4284

| NO. | DATE | REVISION |
|---|---|---|

# APPENDIX B

2002 WISCONSIN DEPARTMENT OF NATURAL RESOURCES (DNR)
SANITARY SURVEY

WISCONSIN
DEPT. OF NATURAL RESOURCES

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Scott McCallum, Governor
Darrell Bazzell, Secretary
Ronald W. Kazmierczak, Regional Director

Northeast Region Headquarters
1125 N. Military Ave., P.O. Box 10448
Green Bay, Wisconsin 54307-0448
Telephone 920-492-5800
FAX 920-492-5913
TDD 920-492-5912

July 3, 2002

Mr. James Jellish
Superintendent
Kaukauna Electric and Water Department
777 Island Street Street
Kaukauna, Wisconsin 54130

FID# 445033600
MC Outagamie Co.

Subject: 2002 Sanitary Survey

Dear Mr. Jellish:

Attached is a report on the investigation of the Kaukauna public water supply system, conducted on June 20, 2002. The fine cooperation of Mr. Kevin Obiala and yourself was appreciated during this investigation. The report evaluates the water system, in relation to current construction requirements, reviews operating procedures and water quality, and concludes with recommendations concerning conditions observed.

On the basis of this investigation, it is concluded that the operation and maintenance of the Kaukauna water supply is excellent. However, there are corrections/changes necessary to bring the system into compliance with current Wisconsin Administrative Codes. So to improve the water system, and to provide the best possible service to the consumer, the Utility is strongly urged to implement the recommendations in this report in a timely manner. Please provide a written response, regarding the recommendations in this report, by October 1, 2002.

Thank you for your cooperation.

Sincerely,

Robert P. Barnum
Water Supply Engineer

Cc: Mr. Jeff Feldt, General Manager
Mr. Kevin Obiala, Kaukauna Water Utility Operator
Le Clerc
DG/2
Khatri

**Report on the Investigation of the Public Water Supply System At the City of Kaukauna, And Operated by the Kaukauna Electric and Water Utility**

The City of Kaukauna water supply system consists of five wells, and two 500,000 gallon elevated storage reservoirs. Also, present are a 15,000 gallon ground storage reservoir on Blackwell Street used to strip air from the water provided from Well # 8, and two adjacent ground storage reservoirs at the Elm Street plant that have a combined capacity of 598,000 gallons.

Wells #4, 5, and 10 pump directly to the iron filters at the Elm Street treatment plant, with only the water from Well #5 disinfected prior to the plant. However, the water from all three wells is treated with potassium permanganate prior to the filters as an oxidant. After iron filtration, the water is treated with sodium silicate for corrosion control, and sodium hypochlorite as a disinfectant prior to being discharged into the adjacent ground storage reservoirs.

Well #8, located on Blackwell Street, would be treated much the same way with the addition of potassium permanganate, sodium silicate, and sodium hypochlorite, and iron filtration, however, this well is not being used for the distribution system, because it produces cloudy water, caused by entrained gases. A 15,000 gallon ground storage reservoir and repumping system was installed to try and eliminate this problem, but it has not been as effective as hoped.

Well #9 pumps directly to the iron filtration plant in Riverside Park. Sodium hypochlorite, as a disinfectant, and potassium permanganate as an oxidant, are added prior to the iron filtration, and sodium silicate is added after the iron filters. This well is shock-chlorinated monthly to prevent iron bacteria growth.

The Kaukauna water system was initially constructed in 1898, and over the years saw the construction and eventual abandonment of numerous wells, and storage facilities. It is interesting to note that the original wells drilled for the City operated under artesian head, and now the static water levels in the current wells average between 110 and 200' below ground. As the population of Fox River Valley area continues to increase, it will place an even larger burden on the groundwater resources of the area and the Utility should expect continued dropping of the static and pumping water levels of the wells, and a continued decline in water quality characteristics. The City should be proactive in the promotion of water conservation, and in planning for the future growth and needs of the City, as well as, the growth and needs of the Valley area as a whole.

As the Utility is aware, a violation of the radioactivity standard for alpha radiation (15 pCi/l) exists for the water system. The level in the City water supply has been over

the years between 15 and 30 pCi/l, depending on sample location. The City is required to provide quarterly notices to the served public regarding this violation.
In 2000, a composite radioactivity sample was taken from the distribution system that showed an alpha level at 64 pCi/l, and a combined radium level of 20.2 pCi/l. The combined radium standard is 5 pCi/l. These results were waived as they were such a marked increase from previous results that it was thought that results were in error, however the Utility was asked to conduct quarterly composite samples during 2001. These results came back at a level of alpha of 15 pCi/l, right at the standard, and combined radium at 3.51 pCi/l, which is below the standard. During 2002, the Department has asked the Utility to conduct radioactivity sampling at each of the entry points to the distribution system.

The Utility still has a violation of the alpha standard and will be required to bring this level into compliance by December 2003, or to enter into a consent order, a legally binding agreement, with the Department on a timetable to bring the system into compliance.

Previous sample results from the individual wells appear to indicate that some of the wells will exceed the radium standard at the entry point to the distribution system. However, the Utility is being proactive in resolving this and has been approved to conduct a year pilot study at Well #8 to perform enhanced oxidation to determine if the utilization of hydrous manganese oxides will allow a higher percentage removal of radium 226/228.

I reviewed the City's Consumer Confidence Report (CCR) for 2000, during this survey, and found it to be a very well done report. On future CCR reports, the City might want to include information on water conservation, as this will be an issue for all water suppliers in the future, and on what the City is doing on the radioactivity issue. An informed public can be a very valuable asset in supporting water system improvements.

Security issues pertaining to drinking water supplies have long been a concern in the assurance of a safe supply of water. All public water supply systems are at risk. The Department recommends that the City perform a security analysis of its facilities to insure that all reasonable measures are being taken to minimize the possibility of the drinking water being compromised. This analysis should include, but not be limited to, the installation of security lighting; the installation of motion detectors; the installation of security alarms; the maintenance of locks; the assurance of daily distribution system chlorine residual; the performance of daily inspections of water system facilities; restricting those with access to water system facilities; increasing police surveillance around water system facilities and restricting parking adjacent to water system facilities. The City is encouraged to address this issue as soon as practical. Listed below are the "top 10" things you can do to protect your water system from contamination and other harm:

1. **Prepare** (or update) a written emergency response plan. Make sure all employees help to create it and receive training on the plan;

2. **Post** updated emergency 24 - hour numbers at your facilities in highly visible areas (pumphouse door, vehicles, office) and give them to key personnel and local response officials;
3. **Get to know** your local police and ask them to add your facilities to their routine rounds. Practice emergency response procedures with local police, emergency response and public health officials;
4. **Fence and lock** your drinking water facilities and vulnerable areas (e.g. wellhead, hydrants, manholes, pumphouse, and storage tanks);
5. **Lock** all entry gates and doors and set alarms to indicate illegal entry Do not leave keys in equipment or vehicles at any time;
6. **Install good lighting** around your pumphouse, treatment facility and parking lot;
7. **Identify** existing and alternate water supplies and maximize use of backflow prevention devices and interconnections;
8. **Use** your Source Water Assessment information to work with any businesses and homeowners that are listed as potential sources of contamination and lessen their threat to your source;
9. **Lock** monitoring wells to prevent vandals or terrorists from pouring contaminants directly into ground water near your source. Prevent pouring or siphoning contaminants through vent pipes by moving them inside the pumphouse or treatment plant, or if that isn't possible, fencing or screening them; and
10. **In case of an emergency**, first call "911", then follow your emergency response plan.

In my review of the well vulnerability maps (attached), it was apparent that many potential contaminant source sites are not reflected on the maps. The Department will be conducting a survey to update these maps in the near future, and you may be contacted for assistance. These vulnerability surveys are used to determine sampling requirements for the City.

Attached are data sheets regarding the investigation of the Kaukauna water system conducted June 20, 2002. Basically, the system is well operated and in very good condition. However, to improve the water system and protect the health and welfare of the consumer, the City Utility is urged to implement the following recommendations:

1. The City Utility is reminded that public notification of the alpha radiation maximum contaminant level exceedance is required quarterly with a copy to be sent to this office.

2. According to the Department records, a current system map is not on file with the Department. It is our understanding that the system map is currently being updated. Please provide this office with a copy of the updated system map when it becomes available.

3. Overflow points of reservoirs, both ground and elevated, are very difficult to seal from the entrance of insects and such. Most times an overflow incident will blow out the required screen at the terminus of the overflow, or the screen is such a mesh size that the entrance of insects and other small creatures is very difficult to prevent. Counter-balanced flaps with neoprene gaskets are being used very successfully by the City, however, the City should make sure that they open at a low pressure range, 2-4 psi., so that during freezing conditions ice plugs are not formed. City will attempt to adjust tension on the counter-weight flaps to open at a pressure range of 2-4psi.

(+) assume done

4. During the survey, it was noted that the City has an adequate program for cross-connection control, however, inspections are not currently being documented. In our discussions, it was apparent that documentation could be provided on the computer system in the future, please make sure that this is done.

5. It was noted that valve exercising occurs only once every three years. To prevent future system maintenance problems, it is urged that this program be increased to at least every two years.

6. An examination of the inspection history of the ground storage reservoirs at the Elm street plant shows that they have not had an interior inspection since 1991. Wisconsin Administrative Code states, "Water storage facilities shall be emptied and inspected at least once every 5 years". In addition, the elevated storage reservoirs need to meet this requirement. Please put together and implement a plan to conduct interior and exterior inspections of your ground and elevated storage reservoirs by October 1, 2002, as required by Wis. Adm. Code NR 811.08(5). The City is reminded that when conducting these inspections that an inspection form (found on the Department web site) needs to be completed and submitted to the Department.

7. During 2001, the City experienced a waterloss of only 9%. In 1995, the loss was 17%. The City is to be commended for the steps they have taken to achieve this reduction.

8. The City is reminded that the Consumer Confidence Report is required to be provided to your customers by July 1, 2001, and by that date every year after. Also, a certification form is to be submitted to the Department by October 1, 2001. If you need additional help on this, please contact me.

9. Attached you will find the vulnerability maps for your wells showing potential contaminant sources. You'll note a buried bulk fuel tank adjacent to Well # 10. As a City, you might want to look critically at these sources, and develop well-head protection plans for future protection of your drinking water supply.

10. At Well #5, the water prelube line for the well pump bypasses the solenoid and is in a constant feed mode. This is a considerable loss of water and should be corrected.

(*) assume done

assume done

11. The screen on the vent of the Blackwell Street reservoir needs to be replaced to preclude the entrance of animals and insects, as required in Wisconsin Administrative NR 811.58(8).

12. The addition of sodium hypochlorite to the water discharged from Well #9, prior to the iron filters at the Riverside Plant, seems to be unnecessary at this addition point, and probably is added in excessive amounts to counter the chlorine demand through the filter process. The City should investigate chlorine addition after the iron filter.

13. There has been some confusion regarding sampling point locations for the yearly monitoring requirements associated with the Safe Drinking Water Act. Following is a listing of the sample points, and their designation:

| **Source** | **Designation** | **Number** |
|---|---|---|
| Well #4 (BG 574) | Source | 4 |
| Well #5 (BG 575) | Source | 5 |
| Well #8 (HJ 196) | Source | 8 |
| Well #9 (BG 578) | Source | 9 |
| Well #10 (BG576) | Source | 10 |
| Blackwell Street Plant* | Entry Point | 200 |
| Riverside Plant* | Entry Point | 300 |
| Elm Street Plant* | Entry Point | 400 |

* These samples are all after treatment, prior to entering the distribution system.

14. The City shall include daily results of chemical residuals at each entry point into the distribution system, and chlorine residuals in the distribution system at least twice per week on the monthly reports. In addition, monthly water levels should be entered on the reports.

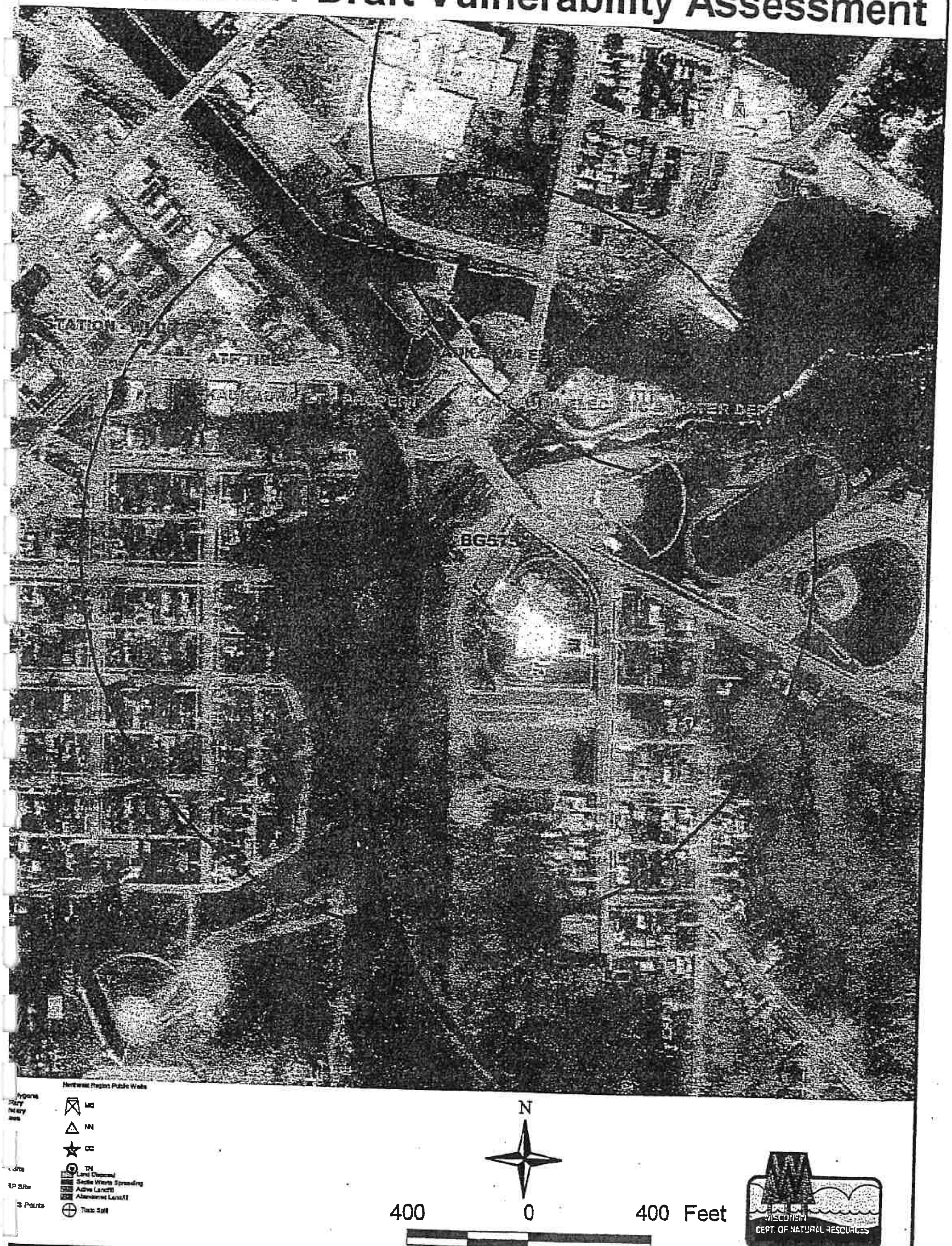
15. Please be reminded that, in accordance with Wisconsin Statutes, plans and specifications for all modifications or additions to the water system should be prepared by a registered engineer and approved by the Department prior to installation or construction.

If you have any questions regarding this report, please contact me at 920-492-5888.

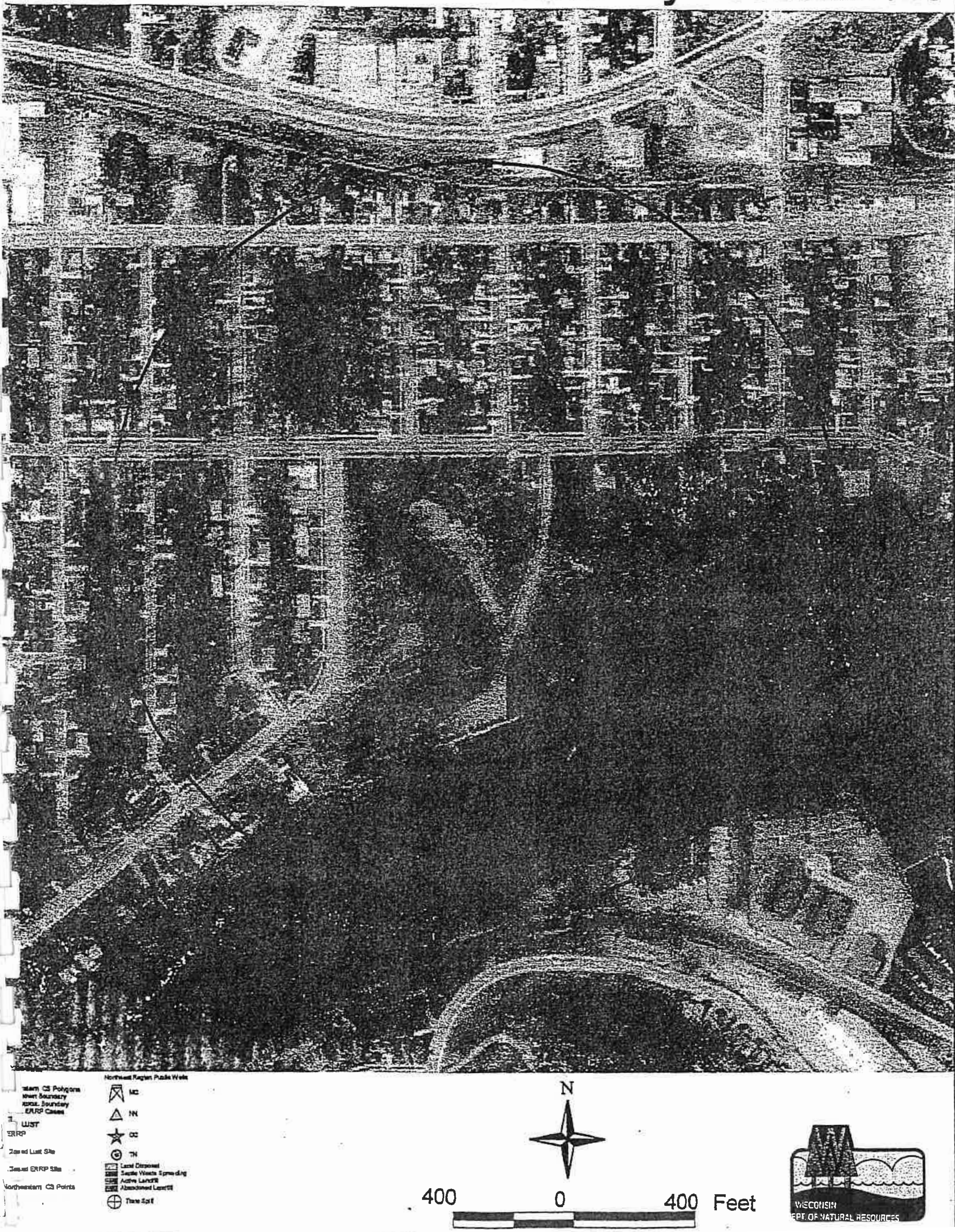
# Well Location / Draft Vulnerability Assessment

# Well Location /Draft Vulnerability Assessment

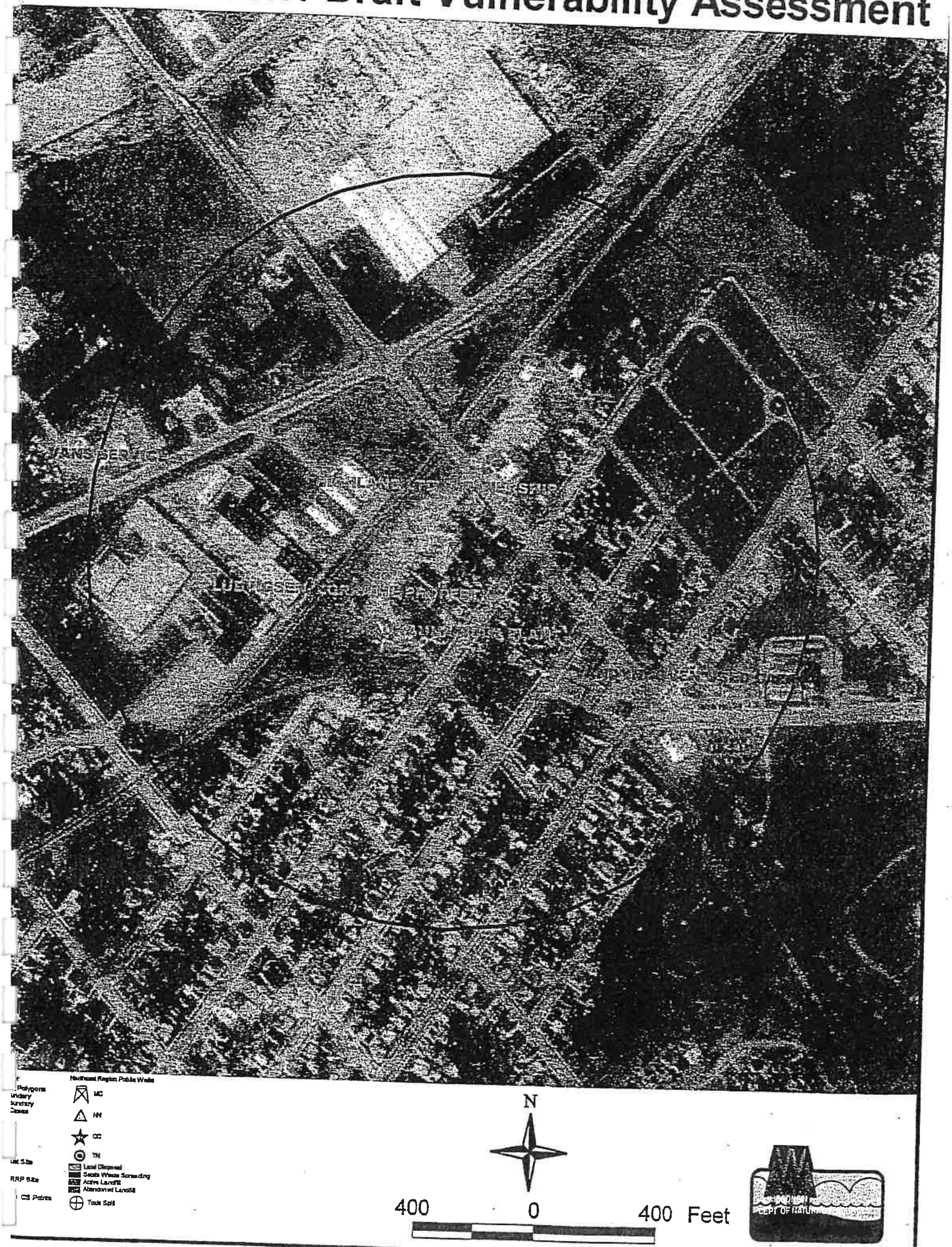
# Well Location / Draft Vulnerability Assessment



# Well Location /Draft Vulnerability Assessment



# Well Location / Draft Vulnerability Assessment



## GENERAL INFORMATION

SYSTEM NAME: **Kaukauna Electric & Water Department**

SURVEY DATE: **June 20,2002**

SYSTEM OWNER: **City of Kaukauna**

PWS I.D.: **445033600**

INSPECTOR'S NAME: **Bob Barnum**

OFFICAL'S NAME: **Jeff Feldt**

TITLE: **General Manager**

OPERATOR'S NAME: **Kevin Obiala**

PHONE: **920-462-0233**

ADDRESS: **777 Island Street**

SUPERINTENDENT'S NAME: **James Jellish**

PHONE: **920-462-0216**

ADDRESS: **777 Island Street**

CLERKS NAME: **Sue Duda**

PHONE: **920-766-6300**

UTILITY ADDRESS: **777 Island Street**

ZIP CODE: **54130**

COUNTY: **Outagamie**

DISTRICT: **NER**

OTHER PHONE NUMBER (S): **920-766-5988**

FAX NUMBER: **920-766-7698**

TOTAL STORAGE: **1,579,000** GALLONS

BOOSTED STORAGE: **579,000** GALLONS

GAVITY STORAGE: **1,000,000** GALLONS

PRESSURE TANK STORAGE: N/A GALLONS

DESIGN PUMPING CAPACITY: **4,608,000** GPD

EMERGENCY POWER PRODUCTION: **2,783,520 GPD**

TOTAL NUMBER OF WELLS: **5**

NUMBER OF PRESSURE ZONES: **1**

SURFACE WATER SOURCE: **--**

NAME: **--**

CHEMICAL ADDITION: **Permanganate, Sodium Silicate, Sodium Hypochlorite**

TREATMENT: **Iron removal**

SYSTEM CLASSIFICATION: **G.D.I.**

# POPULATION / COMSUMPTION

WATERWORKS: **Kaukauna**

PWS I.D.: **445033600**

CURRENT POPULATION: **12,983**

YEAR: **2001**

POPULATION AT PREVIOUS SANITARY SURVEY: **12,505**

DATE: **1995**

NUMBER OF SERVICES:

TOTAL: **5,003**

METERED: **5,003**

RESIDENTIAL: **4,620**

INDUSTRIAL: **14**

COMMERCIAL: **344**

OTHER: **25 Public Use**

CONSUMPTION:

| YEAR | AVERAGE DAY | MAXIMUM DAY | PER CAPITA/DAY |
|---|---|---|---|
| **2001** | **1,207,450** | **1,961,000** | **92.88** |

| YEAR | TOTAL PUMPED FROM WELLS | TOTAL PUMPED TO MAINS | TOTAL METERED | PERCENT LOSS |
|---|---|---|---|---|
| **2001** | **434,189,000** | **407,749,000** | **363,444,000** | **9.00%** |

HOURS WELLS PUMP: AVERAGE DAY: **18 hrs** MAXIMUM DAY: **21 hrs**

## ORDINANCES / PROGRAMS

WATERWORKS: **Kaukauna**

PWS I.D.: **445033600**

CROSS CONNECTION CONTROL PROGRAM: **Yes**

EFFECTIVE DATE OF ORDINANCE: **February 18, 1981**

FREQUENCY OF INSPECTIONS: **At Meter Change**

INSPECTION RECORDS ON FILE: **No**

ADEQUATE PROTECTION AT WASTEWATER PLANT: **Yes (RPBP) Tested Yearly**

CONNECTIONS BETWEEN WATER MAINS AND SEWERS: **None**

WATER MAINS PASS THROUGH SEWER MANHOLES: **None**

PRIVATE WELL ABANDONMENT ORDINANCE: **Yes**

EFFECTIVE DATE OF ORDINANCE: **September 18, 1990**

OPERATION PERMITS AND ABANDONMENT FORMS ON FILE: **None**

ESTIMATED NUMBER OF WELLS IN WATER SERVICE AREA: **0**

WELL HEAD PROTECTION PROGRAM: **None**

ORDINANCE AVAILABLE: **--**

RECHARGE AREAS DELINEATED: **--**

WELL INFLUENCE AREAS DELINEATED: **--**

GROUNDWATER FLOW DIRECTION(S) DELINEATED: **--**

EQUIPMENT RELACEMENT FUND AVAILABLE: **Yes**

## CERTIFICATION

OPERATOR IN CHARGE: **Jim Jellish**

CERTIFIED: **Yes**

CLASS: **G.D.Z.I.L.S.**

OTHERS: **Keven Obiala**

CONTINUING EDUCATION REQUIREMENTS FULFILLED: **Yes**

## DISTRIBUTION SYSTEM

WATERWORKS: Kaukauna

PWS I.D.: 445033600

WATER MAIN MATERIALS LENGTH (FT) TOTAL

| SIZE (IN) | 4" | 6 " | 8" | 10" | 12" | 14" | 16" | TOTAL |
|---|---|---|---|---|---|---|---|---|
| DUCTILE | | 29,995 | 26,359' | 22,579 | 22,524 | | 11,574' | 113,031' |
| CAST | 7,060 | 134,607' | 15,466' | 11,193' | 4,813' | 120' | | 173,259' |
| PVC | | 2,525' | 47,675' | 19,525' | 63,248' | | | 132,973' |
| OTHER | | | | | | | | |
| TOTAL | 7,060' | 167,127' | 89,500' | 53,297' | 90,585' | 120' | 11,574' | 419,263' |

TOTAL LENGTH OF MAIN EXISTING IN SYSTEM: 419,263'

PERCENT OF MAINS LESS THAN 6 INCHES IN DIAMETER: 1.68%

STATIC PRESSURE RANGE THROUGHOUT SYSTEM: 65 psig

CURRENT SYSTEM MAP ON FILE WITH DNR: No

LATEST REVISION DATE: 2001

INTERCONNECTIONS WITH OTHER WATERWORKS: None

ISOLATED SERVICE AREAS: 2 MAINS OR BACKUP PROVIDED: Yes (3 River Crossings)

FLUSHING DEVICES ON DEAD END MAINS: Hydrants

FREQUENCY FOR FLUSHING DEAD ENDS: 2 X Yearly & with complaints

FREQUENCY FOR FLUSHING SYSTEM: 2 X Yearly

IS 500 GPM AT 20 PSI AVILABLE AT ALL HYDRANTS: Yes

LATEST FIRE FLOW STUDY PERFORMED: 1978

FREQUENCY FOR EXCERCISING VALVES: Once Every 3 Years

ADEQUATE MAINTENANCE AND LOCATION RECORDS: Yes

OTHER MAINTENANCE RECORDS ADEQUATE: Yes

## SAMPLING / REPORTING

WATERWORKS: **Kaukauna**

PWS I.D.: **445033600**

SAMPLING:

BACTERIOLOGICAL

| | |
|---|---|
| NUMBER OF MONTHLY BACTERIOLOGICAL SAMPLES REQUIRED: | **15** |
| CORRECT NUMBER COLLECTED EACH MONTH: | **Yes** |
| SITE PLAN ON FILE WITH DEPARTMENT: | **Yes** |
| ADEQUATE BACTI, SAMPLING DATE SELECTION: | **Yes** |

CHLORINE

| | |
|---|---|
| TESTING FREQUENCY AT ENTRY POINTS: | **No** <br> **Needs to be recorded on MR** |
| TESTING FREQUENCY IN SYSTEM: | **No,** <br> **Needs to be recorded on MR** |
| RESIDUALS TESTED AND RECORDED AT TIME OF BACTI SAMPLING: | **Yes,** |
| FREE CHLORINE RESIDUAL AT SYSTEM EXTREMITIES: | **Yes** |

FLUORIDE

| | |
|---|---|
| AVERAGE NATURAL FLUORIDE IN WELLS: | **1.8 ppm** |
| SPLIT SAMPLING CONDUCTED: | N/A |
| DAILY RESIDUALS FROM SYSTEM: | N/A |
| RESIDUALS WITHIN ACCEPTABLE LIMITS: | N/A |

| | |
|---|---|
| OTHER SAMPLING REQUIRED: | N/A |
| SDWA CERTIFIED LAB: | **Environmental Health Lab** |
| ANALYSIS SUBMITTED TO DEPARTMENT: | **Yes** |
| SAMPLES COLLECTED WITHIN MONITORING PERIOD: | **Yes** |

REPORTING:

MONTHLY OPERATING REPORTS:

| | | |
|---|---|---|
| TOTALS AND AVERAGES: | **Yes** | PUMPAGE: **Yes** |
| AMOUNT OF CHEMICAL USED: | **Yes** | WATER LEVELS: **No, need static water levels** |
| DAILY FLUORIDE: | **N/A** | THEORETICAL RESIDUALS: **N/A** |
| BIWEEKLY CHLORINE: | **No** | THEORETICAL RESIDUALS: **Yes** |
| OTHER TESTING NECESSARY: | **Permanganate level in distributi on system** | |

## WATER QUALITY

WATERWORKS: **Kaukauna**

PWS I.D.: **445033600**

BACTERIOLOGICAL QUALITY:

| YEAR | SAFE | POSITIVE | MISSED | O.S. | O.G. | RAW | POSITIVE |
|---|---|---|---|---|---|---|---|
| 2001 | 130 | 0 | 0 | 0 | 0 | 5 | 0 |
| 2000 | 120 | 0 | 0 | 0 | 0 | 16 | 0 |
| 1999 | 120 | 1 | 0 | 0 | 0 | 15 | 0 |
| 1998 | 120 | 0 | 0 | 0 | 0 | 15 | 0 |
| 1997 | 122 | 0 | 0 | 0 | 0 | 13 | 0 |

CHEMICAL QUALITY:

CONSUMER COMPLIANTS:

LATEST SAMPLE DATES:

| | |
|---|---|
| INORGANIC: | **January 21, 2002** |
| RADIOLOGICAL: | **December 10, 2001** |
| VOC: | **January 21, 2002** |
| SOC: | **Never completely sampled, will be in 2005** |
| THM: | **August 6, 2001** |

### PARAMETERS EXCEEDING STANDARDS
### (INORGANICS / ORGANICA / RADIOACTIVITY)

| WELL#/LOCATION | PARAMETER | CONCENTRATION | HEALTH STANDARD | AESTHETIC STANDARD |
|---|---|---|---|---|
| **Distriubtion** | Gross | 15 + or-5 | 15 | - |

WELL INFORMATION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **4**

UNIQUE WELL NUMBER: **BG 574**

STATUS:

WELL LOCATION: **NE¼, NE¼, SECTION 22, T 21 N, R 18 E**
STREET ADDRESS: **Elm Street**

IS WELL LOCATED IN A FLOOD PLAIN: **No**

WELL ADEQUATELY PROTECTED: **Yes**

DATE CONSTRUCTED: **1921**

WELL DRILLER: **Louis Faust**

LATEST RECONSTRUCTION DATE: **--**

CONSTRUCTION REPORT AVAILABLE: **Yes**

WELL DEPTH: **726'**

AQUIFER TYPE: **Limestone and Sandstone**

| GEOLOGIC DATA: | FORMATIONS | DEPTH FROM | DEPTH TO |
|---|---|---|---|
| | **Droft** | **0'** | **4'** |
| | **Limestone** | **4'** | **380'** |
| | **Sandstone** | **380'** | **726'** |
| **CASING DATA** | **DIAMETER** | | |
| **Inner** | **12"** | **0'** | **120'** |
| **Outer** | **18"** | **0'** | **120'** |
| **SCREEN/BOREHOLE** | **DIAMETER** | | |
| **NONE** | | | |

GROUT DEPTH **120'**

| | ORIGINAL | CURRENT |
|---|---|---|
| STATIC WATER LEVEL: | **117'** | **125'** |
| PUMPING WATER LEVEL: | **243' @ 697 GPM** | **243' @ 685GPM** |
| SPECIFIC CAPACITY: | **-- GPM/FT** | **5.8 GPM/FT** |

MEANS FOR MEASURING WATER LEVELS: **Yes**

AIRLINE LENGTH: **302'**

AIRLINE SEAL: **Yes**

WELL SEAL: **Yes**

WELL VENT: **Yes**

U-BEND: **Yes**

SCREENED: **Yes**

HEIGHT ABOVE FLOOR: **36"**

GRAVEL REFILL PIPES: **--**

CAPPED: **--**

HEIGHT ABOVE FLOOR: **--**

PUMP BASE HEIGHT: **12"**

REHABILITATION PERFORMED: **---**

DATE: **--**

## WELL PUMP / PIPING / PUMPHOUSE

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **4**

### WELL PUMP

MAKE: **Simmons**

TYPE: **Submersile**

DESIGN CAPACITY: **700 GPM @ 72 FT. HD**

SETTING: **302**
(TOP OF THE BOWLS)

OPERATIONAL CAPACITY: **697 GPM @ 157 FT. HD.**
(WELL DISCHARGE PRESSURE + PUMPING WATER LEVEL)

LUBRICATION: **N/A**

PRELUBE: **N/A**

PRELUBE METERED: **N/A**

PRELUBE EQUIPPED WITH SOLENOID: **N/A**

MOTOR HP: **75**

AUXILIARY POWER: **--**

BACKSPIN PROTECTION: **Time Delay**

LATEST PUMP INSPECTION DATE: **1994**

WELL DISCHARGES TO: **Iron Filter @ Elm Street Reservior Entry Point 200**

### DISCHARGE PIPING

AIR RELIEF: **Yes**

U-BEND: **Yes**

SCREENED: **Yes**

HEIGHT ABOVE FLOOR: **24"**

CHECK VALVE: **Yes**

METER: **Yes**

SHUT OFF VALVE: **Yes**

RAW WATER SAMPLE TAP: **Yes**

PRESSURE GAUGE: **Yes**

CHEMICAL ADDITION TAP: **No**

PIPING CONDITION: **Good**

ENTRY POINT SAMPLE TAP:

### PUMP STATION

DESCRIPTION: **Concrete Block & Wood**

DOOR OPENS OUT: **Yes**

ROOF HATCH: **Yes**

HEATER: **Yes**

DEHUMIDIFIER: **No**

FLOOR DRAIN: **Yes**

DISTANCE FROM WELL: **2'**

DISCHARGES TO: **Dry Well**

DISTANCE TO SANITARY SEWER: **150'**

BACK-SIPHONAGE PROTECTION ON HOSE BIBS: **No Hose Bibs**

GENERAL CONDITION OF PUMPHOUSE: **Good**

WELL INFORMATION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **5**

UNIQUE WELL NUMBER: **BG 575**

STATUS: **--**

WELL LOCATION: **SE¼, NE¼, SECTION 22 T 21 N, R 18 E**
STREET ADDRESS: **Dodge & Island Streets**

IS WELL LOCATED IN A FLOOD PLAIN: **No**

WELL ADEQUATELY PROTECTED: **Yes**

DATE CONSTRUCTED: **1935**

WELL DRILLER: **Louis Faucet**

LATEST RECONSTRUCTION DATE: **--**

CONSTRUCTION REPORT AVAILABLE: **Yes**

WELL DEPTH: **534'**

AQUIFER TYPE: **Dolimite & Sandstone**

| GEOLOGIC DATA: | FORMATIONS | DEPTH FROM | DEPTH TO |
|---|---|---|---|
| | **Glacial Drift** | **0'** | **8'** |
| | **Dolomite** | **8'** | **175'** |
| | **Sandstone** | **172'** | **534'** |

| CASING DATA | DIAMETER | | |
|---|---|---|---|
| **Inner** | **16"** | **0'** | **121'** |

| SCREEN/BOREHOLE | DIAMETER |
|---|---|
| **NONE** | |

GROUT DEPTH **121'**

| | ORIGINAL | CURRENT |
|---|---|---|
| STATIC WATER LEVEL: | **112'** | **110'** |
| PUMPING WATER LEVEL: | **155' @ 216 GPM** | **154' @ 210GPM** |
| SPECIFIC CAPACITY: | **5.02 GPM/FT** | **4.77 GPM/FT** |

MEANS FOR MEASURING WATER LEVELS: **Yes**

AIRLINE LENGTH: **190'**

AIRLINE SEAL: **Yes**

WELL SEAL: **Yes**

WELL VENT: **Yes**

U-BEND: **Yes**

SCREENED: **Yes**

HEIGHT ABOVE FLOOR: **30"**

GRAVEL REFILL PIPES: **--**

CAPPED: **--**

HEIGHT ABOVE FLOOR: **--**

PUMP BASE HEIGHT: **12"**

REHABILITATION PERFORMED: **--**
DATE: **--**

## WELL PUMP / PIPING / PUMPHOUSE

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **5**

### WELL PUMP

MAKE: **Layne**

TYPE: **Vertical Turbine**

DESIGN CAPACITY: **216 GPM @ 72 FT. HD**

SETTING: **190**
(TOP OF THE BOWLS)

OPERATIONAL CAPACITY: **380 GPM @ 157 FT. HD.**
(WELL DISCHARGE PRESSURE + PUMPING WATER LEVEL)

LUBRICATION: **Water**

PRELUBE: **Water**

PRELUBE METERED: **Yes**

PRELUBE EQUIPPED WITH SOLENOID: **Yes, bypassing solenoid**

MOTOR HP: **30**

AUXILIARY POWER: **--**

BACKSPIN PROTECTION: **Ratchet**

LATEST PUMP INSPECTION DATE: **1995**

WELL DISCHARGES TO: **Iron Filter @ Elm Street Reservoir, Entry Point 200**

### DISCHARGE PIPING

AIR RELIEF: **Yes**

U-BEND: **Yes**

SCREENED: **Yes**

HEIGHT ABOVE FLOOR: **24"**

CHECK VALVE: **Yes**

METER: **Yes**

SHUT OFF VALVE: **Yes**

RAW WATER SAMPLE TAP: **Yes**

PRESSURE GAUGE: **Yes**

CHEMICAL ADDITION TAP: **Yes**

PIPING CONDITION: **Good**

ENTRY POINT SAMPLE TAP:

### PUMP STATION

DESCRIPTION: **Brick Building**

DOOR OPENS OUT: **Yes**

ROOF HATCH: **Yes**

HEATER: **Yes**

DEHUMIDIFIER: **No**

FLOOR DRAIN: **Yes (2)**

DISTANCE FROM WELL: **2' & 5'**

DISCHARGES TO: **Dry Well**

DISTANCE TO SANITARY SEWER: **3'**

BACK-SIPHONAGE PROTECTION ON HOSE BIBS: **No**

GENERAL CONDITION OF PUMPHOUSE: **Good**

## CHEMICAL ADDITION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **5**

SURFACE PLANT LOCATION: **--**

CHEMICAL:

CHEMICAL NAME: **Hawkins Sodium Hypochlorite**

NSF APPROVED: **Yes**

CONCENTRATION: **Liquid (12.5%)**

FEEDER TYPE: **Pulsatron**

STROKES PERMINUTE: **52**

CAPACITY: **0 to 24 GPD**

ROTAMETER SETTING: **N/A**

FEEDER CONTROL: **Well Pump**

SPEED SETTING: **30%**

STROKE SETTING: **50%**

POINT OF APPLICATION: **After check valve, prior to Iron Filter**

FLUORIDE INJECTION ANGLE: **--**

ANTI SIPHONE DEVICE: **Yes**

SECONDARY CONTROL: **--**

SOLUTION LINE MATERIAL: **Plastic**

RESIDUAL TESTER TYPE: **Hach**

SOLUTION TANK MATERIAL: **Poly**

SIZE: **55 gallon**

OVERLAPPING COVER: **Yes**

VENTED: **Ok**

USAGE DETERMINATION: **Scale**

CHEMICAL DILUTION: **None**

CHEMICAL ROOM:

DOOR OPENS OUT: **Yes**

PANIC HARDWARE ON DOOR: **No**

SWITCH LOCATIONS: **Outside**

DOOR ACTIVATED: **Yes**

OBSERVATION WINDOW: **Yes**

FRESH AIR INTAKE LOCATION: **Ceiling**

EXHAUST INTAKE LOCATION: **Floor**

GAS CHLORINE INJECTOR PROPERLY LOCATED AND PROTECTED: **N/A**

CHLORINATOR VENT: **N/A**

AIRPACK AVAILABLE: **N/A**

CYLINDER SIZE: **N/A**

CYLINDER (S) SECURED: **N/A**

# WELL INFORMATION

WATERWORKS: Kaukauna

PWS I.D.: 44503360

WELL NUMBER: 10 *

UNIQUE WELL NUMBER: BG 576

STATUS: --

WELL LOCATION: SW¼, NE¼ SECTION 23, T 21 N, R 18 E
STREET ADDRESS: 10th Street

IS WELL LOCATED IN A FLOOD PLAIN: No

WELL ADEQUATELY PROTECTED: Yes

DATE CONSTRUCTED: 1945

WELL DRILLER: Joseph Egerer

LATEST RECONSTRUCTION DATE: --

CONSTRUCTION REPORT AVAILABLE: 841'

WELL DEPTH: Yes

AQUIFER TYPE: Dolomite & Sandstone

| GEOLOGIC DATA: | FORMATIONS | DEPTH FROM | DEPTH TO |
|---|---|---|---|
| | Till | 0' | 10' |
| | Clay | 10' | 60' |
| | Dolomite | 60' | 455' |
| | Sandstone | 455' | 841' |
| **CASING DATA** | **DIAMETER** | | |
| Outer | 16" | 0' | 71' |
| Inner | 10" | 0' | 159' |
| **SCREEN/BOREHOLE** | **DIAMETER** | | |
| NONE | | | |

GROUT DEPTH 159'

| | 1994 | CURRENT |
|---|---|---|
| STATIC WATER LEVEL: | 176' | 188' |
| PUMPING WATER LEVEL: | 220' @ 526 GPM | 250' @ 39GPM |
| SPECIFIC CAPACITY: | 11.95 GPM/FT | 8.69 GPM/FT |

540gpm

250'

MEANS FOR MEASURING WATER LEVELS: Yes

AIRLINE LENGTH: 260'

AIRLINE SEAL: Yes

WELL SEAL: Yes

WELL VENT: Yes

U-BEND: No

SCREENED: Yes

HEIGHT ABOVE FLOOR: 2'

GRAVEL REFILL PIPES: --

CAPPED: --

HEIGHT ABOVE FLOOR: --

PUMP BASE HEIGHT: 24"

REHABILITATION PERFORMED: Yes, well deepened to 841
DATE: 1995

* Service to keep line to filter plant pressurized controlled by solenoid.

# WELL PUMP / PIPING / PUMPHOUSE

WATERWORKS: **Kaukauna**

PWS I.D.: 44503360

WELL NUMBER: **10**

## WELL PUMP

MAKE: **Jacuzzi**

TYPE: **Submersible**

DESIGN CAPACITY: **600 GPM @ -- FT. HD**

SETTING: 260
(TOP OF THE BOWLS)

OPERATIONAL CAPACITY: **526 GPM @ 157** FT. HD.
(WELL DISCHARGE PRESSURE + PUMPING WATER LEVEL)

LUBRICATION: **Yes**

PRELUBE: **N/A**

PRELUBE METERED: **N/A**

PRELUBE EQUIPPED WITH SOLENOID: **N/A**

MOTOR HP: **50**

AUXILIARY POWER: **--**

BACKSPIN PROTECTION: **Submersible/Check Valve**

LATEST PUMP INSPECTION DATE: **1996**

WELL DISCHARGES TO: **Iron Filter & GSR @ Elm Street Entry Point 200**

## DISCHARGE PIPING

AIR RELIEF: **Yes**

U-BEND: **Yes**

SCREENED: **Yes**

HEIGHT ABOVE FLOOR: **24"**

CHECK VALVE: **Yes**

METER: **Yes**

SHUT OFF VALVE: **Yes**

RAW WATER SAMPLE TAP: **Yes**

PRESSURE GAUGE: **Yes**

CHEMICAL ADDITION TAP: **None**

PIPING CONDITION: **Good**

ENTRY POINT SAMPLE TAP:

## PUMP STATION

DESCRIPTION: **Brick & Concrete**

DOOR OPENS OUT: **Yes**

ROOF HATCH: **Yes**

HEATER: **Yes**

DEHUMIDIFIER: **No**

FLOOR DRAIN: **Yes**

DISTANCE FROM WELL: **2'**

DISCHARGES TO: **Sanitary Sewer**

DISTANCE TO SANITARY SEWER: **70'**

BACK-SIPHONAGE PROTECTION ON HOSE BIBS: **No**

GENERAL CONDITION OF PUMPHOUSE: **Good**

## CHEMICAL ADDITION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **#4, #5, and #10 Filter Plant**

SURFACE PLANT LOCATION: **--**

CHEMICAL:

CHEMICAL NAME: **Potassium Permanganate (Cairox)**

NSF APPROVED: **Yes**

CONCENTRATION: **100% Liquid**

FEEDER TYPE: **Pulsatron**

STROKES PERMINUTE: **54**

CAPACITY: **75 GPD**

ROTAMETER SETTING: **N/A**

FEEDER CONTROL: **Well Pumps #4, #5, or #10**

SPEED SETTING: **40%**

STROKE SETTING: **39%**

POINT OF APPLICATION: **Before Iron Filter**

FLUORIDE INJECTION ANGLE: **N/A**

ANTI SIPHONE DEVICE: **Yes**

SECONDARY CONTROL: **N/A**

SOLUTION TANK MATERIAL: **Plastic**

RESIDUAL TESTER TYPE: **Hach**

SOLUTION TANK MATERIAL: **Plastic**

SIZE: **140 gallons**

OVERLAPPING COVER: **Yes.**

VENTED: **Yes**

USAGE DETERMINATION: **Graduated Tank**

CHEMICAL DILUTION: **1 lb. permanganate per 10 gallons of water**

CHEMICAL ROOM: **Inside Iron Filter Room**

DOOR OPENS OUT: **Yes**

PANIC HARDWARE ON DOOR: **No**

SWITCH LOCATIONS: **--**

DOOR ACTIVATED: **--**

OBSERVATION WINDOW: **Yes**

FRESH AIR INTAKE LOCATION: **--**

EXHAUST INTAKE LOCATION: **--**

GAS CHLORINE INJECTOR PROPERLY LOCATED AND PROTECTED: **--**

CHLORINATOR VENT: **--**

AIRPACK AVAILABLE: **--**

CYLINDER SIZE: **--**

CYLINDER (S) SECURED: **--**

## CHEMICAL ADDITION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **#4. #5, & #10 Filter Plant**

SURFACE PLANT LOCATION: **--**

CHEMICAL:

CHEMICAL NAME: **Sodium Hypochlorite (Hawkins)**

NSF APPROVED: **Yes**

CONCENTRATION: **12.5% Liquid**

FEEDER TYPE: **Pulsatron**

STROKES PERMINUTE: **--**

CAPACITY: **44 GPD**

ROTAMETER SETTING: **N/A**

FEEDER CONTROL: **Wells #4, #5, & #10**

SPEED SETTING: **70%**

STROKE SETTING: **70%**

POINT OF APPLICATION: **After Iron Filter**

FLUORIDE INJECTION ANGLE: **--**

ANTI SIPHONE DEVICE: **Yes**

SECONDARY CONTROL: **--**

SOLUTION TANK MATERIAL: **Plastic**

RESIDUAL TESTER TYPE: **Hach**

SOLUTION TANK MATERIAL: **Poly**

SIZE: **30 gal**

OVERLAPPING COVER: **Ok**

VENTED: **Ok**

USAGE DETERMINATION: **Graduated tank**

CHEMICAL DILUTION: **No**

CHEMICAL ROOM:

DOOR OPENS OUT: **N/A**

PANIC HARDWARE ON DOOR: **N/A**

SWITCH LOCATIONS: **N/A**

DOOR ACTIVATED: **N/A**

OBSERVATION WINDOW: **N/A**

FRESH AIR INTAKE LOCATION: **N/A**

EXHAUST INTAKE LOCATION: **N/A**

GAS CHLORINE INJECTOR PROPERLY LOCATED AND PROTECTED: **N/A**

CHLORINATOR VENT: **N/A**

AIRPACK AVAILABLE: **N/A**

CYLINDER SIZE: **N/A**

CYLINDER (S) SECURED: **N/A**

## CHEMICAL ADDITION

WATERWORKS: Kaukauna

PWS I.D.: 44503360

WELL NUMBER: #4, #5, & #10

SURFACE PLANT LOCATION: --

CHEMICAL:

CHEMICAL NAME: PQ - Hawkins

NSF APPROVED: Yes

CONCENTRATION: Sodium Silicate (Hawkins)

FEEDER TYPE: Pulsatron

STROKES PER MINUTE: 64

CAPACITY: 120 gpd/day

ROTAMETER SETTING: N/A

FEEDER CONTROL: Well pump

SPEED SETTING: 40%

STROKE SETTING: 60%

POINT OF APPLICATION: After Iron Filtration

FLUORIDE INJECTION ANGLE: N/A

ANTI-SIPHONE DEVICE: Yes

SECONDARY CONTROL: --

SOLUTION TANK MATERIAL: Plastic

RESIDUAL TESTER TYPE: Hach

SOLUTION TANK MATERIAL: Plastic

SIZE: 250 gallon

OVERLAPPING COVER: Ok

VENTED: Yes

USAGE DETERMINATION: Graduated site tube

CHEMICAL DILUTION: No

CHEMICAL ROOM: NONE

DOOR OPENS OUT:

PANIC HARDWARE ON DOOR:

SWITCH LOCATIONS:

DOOR ACTIVATED:

OBSERVATION WINDOW:

FRESH AIR INTAKE LOCATION:

EXHAUST INTAKE LOCATION:

GAS CHLORINE INJECTOR PROPERLY LOCATED AND PROTECTED:

CHLORINATOR VENT:

AIRPACK AVAILABLE:

CYLINDER SIZE:

CYLINDER (S) SECURED:

## IRON FILTRATION

LOCATION: **Kaukauna Wells #4, #5, & #10**

STREET ADDRESS: **Elm Street**

TYPE: **General Filter Co. Ames, Iowa**

NUMBER OF TANKS / CELLS: **4**

DIMENSIONS:

BYPASS LINE: **Yes**

ACCESS MANHOLE: **Yes (6 manholes)**

PRESSURE OR LOSS OF HEAD GAUGES: **Yes**

| MEDIA TYPE | DIAMETER | DEPTH |
|---|---|---|
| **Anthracite** | -- | -- |
| **Gravel** | -- | -- |

AIR RELIEF: **Yes**

SURFACE WASH: **Yes**

RAW AND FINISHED WATER SAMPLE TAPS: **Yes**

RATE CONTROLLER: **Manual**

OXIDATION METHOD:

AERATION FORCED DRAFT:

PH CONTROL:

GRAVITY:

PERMANGANATE: **X**

AIR COMPRESSOR: **X**

CHLORINE:

DIFFUSOR INSPECTED: **Once Per Year**

DESCRIPTION OF OXIDATION PROCESS: **Air and Permanganate**

FILTRATION RATE: **2.78** GPM / FT2

CAPACITY: **1,313** GPM

SOURCE OF BACKWASH: **Treated Water from GSRW/booster**

HOLDING TANK: **None**

BACKWASH FREQUENCY: **Weekly**

BACKWASH RATE: **800** GPM / FT2

BACKWASH DURATION: **10** MIN.

DISCHARGES TO: **Sanitary Sewer**

BACKWASH LINE TERMINATES 24" ABOVE FLOOR: **6 Ft Above Bottom of Pit**

DISCHARGE PERMIT: **No - Discharge goes to sanitary sewer**

SUITABLE AIR GAPAVAILABLE ON BACKWASH LINE: **12 in. above floor**

RAW IRON: **.4**

FINISHED IRON: **.1**

TESTING FREQUENCY: **Weekly**

LATEST INTERIOR INSPECTION DATE: **1998**

# WELL INFORMATION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **8** *

UNIQUE WELL NUMBER: **HJ 196**

STATUS: **--**

WELL LOCATION: **NE¼, SW¼, SECTION 13, T 21 N, R 18 E**
STREET ADDRESS: **DeLanglade Street**

IS WELL LOCATED IN A FLOOD PLAIN: **No**

WELL ADEQUATELY PROTECTED: **Yes**

DATE CONSTRUCTED: **1959**

WELL DRILLER: **Layne-Northwest Co.**

LATEST RECONSTRUCTION DATE: **--**

CONSTRUCTION REPORT AVAILABLE: **Yes**

WELL DEPTH: **800'**

AQUIFER TYPE: **Dolomite & Sandstone**

| GEOLOGIC DATA: | FORMATIONS | DEPTH FROM | DEPTH TO |
|---|---|---|---|
| | Clay | 0' | 70' |
| | Dolomite | 70' | 455' |
| | Sandstone | 455' | 800' |

| CASING DATA | DIAMETER | FROM | TO |
|---|---|---|---|
| Inner | 16" | 0' | 151' |
| Outer | 20" | 0' | 73' |

| SCREEN/BOREHOLE | DIAMETER |
|---|---|
| NONE | |

GROUT DEPTH **151'**

| | 1994 | CURRENT |
|---|---|---|
| STATIC WATER LEVEL: | 192' | 163' |
| PUMPING WATER LEVEL: | 380' @ 320 GPM | 238' @ 608GPM |
| SPECIFIC CAPACITY: | 1.7 GPM/FT | 8.11 GPM/FT |

MEANS FOR MEASURING WATER LEVELS: **Yes**

AIRLINE LENGTH: **290'**

AIRLINE SEAL: **Yes**

WELL SEAL: **Yes**

WELL VENT: **Yes**

U-BEND: **Yes**

SCREENED: **Yes**

HEIGHT ABOVE FLOOR: **24"**

GRAVEL REFILL PIPES: **--**

CAPPED: **--**

HEIGHT ABOVE FLOOR: **--**

PUMP BASE HEIGHT: **12"**

REHABILITATION PERFORMED: **--**
DATE: **--**

* **Well not run because of white water, well will be used for trial radium reduction.**

## WELL PUMP / PIPING / PUMPHOUSE

WATERWORKS: **Kaukauna**

PWS I.D.: 44503360

WELL NUMBER: **#8**

### WELL PUMP

MAKE: **Simmons**

TYPE: **Submersible**

DESIGN CAPACITY: **610 GPM @ 170 FT. HD**

SETTING: 290
(TOP OF THE BOWLS)

OPERATIONAL CAPACITY: **400 GPM @ 157 FT. HD.**
(WELL DISCHARGE PRESSURE + PUMPING WATER LEVEL)

LUBRICATION: **Water**

PRELUBE: **N/A**

PRELUBE METERED: **N/A**

PRELUBE EQUIPPED WITH SOLENOID: **N/A**

MOTOR HP: **100**

AUXILIARY POWER: --

BACKSPIN PROTECTION: **N/A**

LATEST PUMP INSPECTION DATE: **1997**

WELL DISCHARGES TO: **Iron Filter @ Blackwell Street Reservoir - Entry Point 300**

### DISCHARGE PIPING

AIR RELIEF: **Yes**

U-BEND: **Yes**

SCREENED: **Yes**

HEIGHT ABOVE FLOOR: **42"**

CHECK VALVE: **Yes**

METER: **Yes**

SHUT OFF VALVE: **Yes**

RAW WATER SAMPLE TAP: **Yes**

PRESSURE GAUGE: **Yes**

CHEMICAL ADDITION TAP: **Yes**

PIPING CONDITION: **Good**

ENTRY POINT SAMPLE TAP:

### PUMP STATION

DESCRIPTION: **Brick & Concrete Block**

DOOR OPENS OUT: **Yes**

ROOF HATCH: **Yes**

HEATER: **Yes**

DEHUMIDIFIER: **No**

FLOOR DRAIN: **Yes**

DISTANCE FROM WELL: **4'**

DISCHARGES TO: **Sanitary Sewer**

DISTANCE TO SANITARY SEWER: **200'**

BACK-SIPHONAGE PROTECTION ON HOSE BIBS: **No**

GENERAL CONDITION OF PUMPHOUSE: **Good**

## CHEMICAL ADDITION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **8** *

SURFACE PLANT LOCATION: **--**

CHEMICAL:

CHEMICAL NAME: **Hawkins Sodium Hypochlorite**

NSF APPROVED: **Yes**

CONCENTRATION: **12.5% liquid**

FEEDER TYPE: **--**

STROKES PER MINUTE: **--**

CAPACITY: **0-75 gpd**

ROTAMETER SETTING: **N/A**

FEEDER CONTROL: **Well Pump**

SPEED SETTING: **32%**

STROKE SETTING: **30%**

POINT OF APPLICATION: **Before and After Iron Filter**

FLUORIDE INJECTION ANGLE: **N/A**

ANTI SIPHONE DEVICE: **Yes**

SECONDARY CONTROL: **N/A**

SOLUTION LINE MATERIAL: **Plastic**

RESIDUAL TESTER TYPE: **Hach**

SOLUTION TANK MATERIAL: **Poly**

SIZE: **15 gal**

OVERLAPPING COVER: **Ok**

VENTED: **Ok**

USAGE DETERMINATION: **Scale**

CHEMICAL DILUTION: **--**

CHEMICAL ROOM:

DOOR OPENS OUT: **Yes**

PANIC HARDWARE ON DOOR: **No**

SWITCH LOCATIONS: **Yes**

DOOR ACTIVATED: **Yes**

OBSERVATION WINDOW: **Yes**

FRESH AIR INTAKE LOCATION: **Ceiling**

EXHAUST INTAKE LOCATION: **Floor**

GAS CHLORINE INJECTOR PROPERLY LOCATED AND PROTECTED: **N/A**

CHLORINATOR VENT: **N/A**

AIRPACK AVAILABLE: **N/A**

CYLINDER SIZE: **N/A**

CYLINDER (S) SECURED: N/A

* **Not Presently Used**

CHEMICAL ADDITION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **#8** *

SURFACE PLANT LOCATION: **--**

CHEMICAL:

CHEMICAL NAME: **Sodium Silicate**

NSF APPROVED: **Yes**

CONCENTRATION: **Liquid**

FEEDER TYPE: **Pulsatron**

STROKES PER MINUTE: **--**

CAPACITY: **42 gpd/day**

ROTAMETER SETTING: **N/A**

FEEDER CONTROL: **Well Pump**

SPEED SETTING: **--**

STROKE SETTING: **--**

POINT OF APPLICATION: **After Iron Filtration**

FLUORIDE INJECTION ANGLE: **N/A**

ANTI SIPHONE DEVICE: **Yes**

SECONDARY CONTROL: **N/A**

SOLUTION TANK MATERIAL: **Plastic**

RESIDUAL TESTER TYPE: **Hach**

SOLUTION TANK MATERIAL: **Plastic**

SIZE: **250 gallons**

OVERLAPPING COVER: **Yes**

VENTED: **Yes**

USAGE DETERMINATION: **Graduated site tube**

CHEMICAL DILUTION: **As Is**

CHEMICAL ROOM:

DOOR OPENS OUT: **--**

PANIC HARDWARE ON DOOR: **--**

SWITCH LOCATIONS: **--**

DOOR ACTIVATED: **--**

OBSERVATION WINDOW: **--**

FRESH AIR INTAKE LOCATION: **--**

EXHAUST INTAKE LOCATION: **--**

GAS CHLORINE INJECTOR PROPERLY LOCATED AND PROTECTED: **--**

CHLORINATOR VENT: **N/A**

AIRPACK AVAILABLE: **N/A**

CYLINDER SIZE: **N/A**

CYLINDER (S) SECURED: **N/A**

* **Not Being Used**

## IRON FILTRATION

LOCATION: **Kaukauna Well #8**

STREET ADDRESS: **Blackwell Street**

TYPE: **General Filter Company**

NUMBER OF TANKS / CELLS: **4**

DIMENSIONS: **10' Dia - 24' Long**

BYPASS LINE: **Yes**

ACCESS MANHOLE: **Yes (6 Access Manhole)**

PRESSURE OR LOSS OF HEAD GAUGES: **Yes**

| MEDIA TYPE | DIAMETER | DEPTH |
|---|---|---|
| Anthrafilt | -- | 24" |
| Gravel | -- | 15" |

AIR RELIEF: **Yes**

SURFACE WASH: **--**

RAW AND FINISHED WATER SAMPLE TAPS: **Yes**

RATE CONTROLLER: **Manual**

OXIDATION METHOD:

AERATION FORCED DRAFT:

PH CONTROL:

GRAVITY:

PERMANGANATE:

AIR COMPRESSOR: **X**

CHLORINE: **X**

DIFFUSOR INSPECTED: **Once Per Year**

DESCRIPTION OF OXIDATION PROCESS: **Air**

FILTRATION RATE: **2.28** GPM / FT2

CAPACITY: **500**

SOURCE OF BACKWASH: **Well Water**

HOLDING TANK: **None**

BACKWASH FREQUENCY: **2 X Weekly**

BACKWASH RATE: **15** GPM / FT2

BACKWASH DURATION: **10 MIN.**

DISCHARGES TO: **Sanitary Sewer**

BACKWASH LINE TERMINATES 12" ABOVE FLOOR: **6 ft Above Bottom of a Pit**

DISCHARGE PERMIT: **No, Discharge to Sanitary Sewer**

SUITABLE AIR GAPAVAILABLE ON BACKWASH LINE: **12" Above Floor**

RAW IRON: **.5**

FINISHED IRON; **.1**

TESTING FREQUENCY: **Weekly**

LATEST INTERIOR INSPECTION DATE: **April 1992**

## WELL INFORMATION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **#9**

UNIQUE WELL NUMBER: **BG 578**

STATUS: **--**

WELL LOCATION: **NW¼, NE¼, SECTION 23, T 21 N, R 18 E**
STREET ADDRESS: **Riverside Park**

IS WELL LOCATED IN A FLOOD PLAIN: **No**

WELL ADEQUATELY PROTECTED: **Yes**

DATE CONSTRUCTED: **1976**

WELL DRILLER: **Egerer-Galloway Well Corp**

LATEST RECONSTRUCTION DATE: **July 19, 1989**

CONSTRUCTION REPORT AVAILABLE: **Yes**

WELL DEPTH: **806'**

AQUIFER TYPE: **Limestone & Sandstone**

| GEOLOGIC DATA: | FORMATIONS | DEPTH FROM | DEPTH TO |
|---|---|---|---|
| | Clay & Stone | 0' | 26' |
| | Limestone | 26' | 353' |
| | Red Shale | 353' | 355' |
| | Limestone | 395' | 795' |

| CASING DATA | DIAMETER | FROM | TO |
|---|---|---|---|
| Inner | 18" | 0' | 239' |
| Outer | 24" | 0' | 36' |

| SCREEN/BOREHOLE | DIAMETER |
|---|---|
| No Screen | |

GROUT DEPTH 239'

| | 1994 | CURRENT |
|---|---|---|
| STATIC WATER LEVEL: | 151' | 156' |
| PUMPING WATER LEVEL: | 234' @ 1157 GPM | 232' @ 1157GPM |
| SPECIFIC CAPACITY: | 14.81 GPM/FT | 13.94 GPM/FT |

MEANS FOR MEASURING WATER LEVELS: **Yes**

AIRLINE LENGTH: **280'**

AIRLINE SEAL: **Yes**

WELL SEAL: **Yes**

WELL VENT: **Yes**

U-BEND: **Yes**

SCREENED: **Yes**

HEIGHT ABOVE FLOOR: **30"**

GRAVEL REFILL PIPES: **--**

CAPPED: **--**

HEIGHT ABOVE FLOOR: **--**

PUMP BASE HEIGHT: **13"**

REHABILITATION PERFORMED: **Yes**

DATE: **Yes**

## WELL PUMP / PIPING / PUMPHOUSE

WATERWORKS: Kaukauna

PWS I.D.: 45503360

WELL NUMBER: #9

### WELL PUMP

MAKE: Layne

TYPE: Vertical Turbine

DESIGN CAPACITY: 1,157 GPM @ 764 FT. HD

SETTING: 380
(TOP OF THE BOWLS)

OPERATIONAL CAPACITY: 1,220 GPM @ 157 FT. HD.
(WELL DISCHARGE PRESSURE + PUMPING WATER LEVEL)

LUBRICATION: Water

PRELUBE: Water

PRELUBE METERED: Not directly

PRELUBE EQUIPPED WITH SOLENOID: Yes

MOTOR HP: 150

AUXILIARY POWER: Yes (Natural Gas Engine)

BACKSPIN PROTECTION: Time Delay

LATEST PUMP INSPECTION DATE: 2002

WELL DISCHARGES TO: Iron Filter prior to GSR - Entry Point 400

### DISCHARGE PIPING

AIR RELIEF: Yes

U-BEND: Yes

SCREENED: Yes

HEIGHT ABOVE FLOOR: 1.5'

CHECK VALVE: Yes

METER: Yes

SHUT OFF VALVE: Yes

RAW WATER SAMPLE TAP: Yes

PRESSURE GAUGE: Yes

CHEMICAL ADDITION TAP: Yes

PIPING CONDITION: Good

ENTRY POINT SAMPLE TAP:

### PUMP STATION

DESCRIPTION: Stone & Concrete Block

DOOR OPENS OUT: Yes

ROOF HATCH: Yes

HEATER: Yes

DEHUMIDIFIER: No

FLOOR DRAIN: Yes

DISTANCE FROM WELL: 6"

DISCHARGES TO: Sanitary Sewer

DISTANCE TO SANITARY SEWER: 75'

BACK-SIPHONAGE PROTECTION ON HOSE BIBS: No

GENERAL CONDITION OF PUMPHOUSE: Good

* Adds 75 gallons of Sodium Hypochlorite directly to well once a month for iron bacteria control & sulfur smell. Plastic tube terminates at pump. Also, pump pumps 10 min to waste prior to filter.

## CHEMICAL ADDITION

WATERWORKS: **Kaukauna**

P.WS I.D.: **44503360**

WELL NUMBER: **#9**

SURFACE PLANT LOCATION: **--**

CHEMICAL:

CHEMICAL NAME: **Potassium Permanganate**

NSF APPROVED: **Yes**

CONCENTRATION: **100%**

FEEDER TYPE: **Milton Roy Pump LMI 8121-91**

STROKES PERMINUTE: **--**

CAPACITY: **60 gal/day**

ROTAMETER SETTING: **--**

FEEDER CONTROL: **Well Pump**

SPEED SETTING: **55%**

STROKE SETTING: **72%**

POINT OF APPLICATION: **Before Iron Filter/After Well Gate Valve**

FLUORIDE INJECTION ANGLE: **N/A**

ANTI SIPHONE DEVICE: **Yes**

SECONDARY CONTROL: **N/A**

SOLUTION LINE MATERIAL: **Plastic**

RESIDUAL TESTER TYPE: **Hach**

SOLUTION TANK MATERIAL: **Plastic**

SIZE: **140 gallons**

OVERLAPPING COVER: **Yes**

VENTED: **No**

USAGE DETERMINATION: **Graduated Tank**

CHEMICAL DILUTION: **1 lb. permanganate per 10 gallons of water**

CHEMICAL ROOM: **Permanganate Room**

DOOR OPENS OUT: **Yes**

PANIC HARDWARE ON DOOR: **Yes**

SWITCH LOCATIONS: **Outside**

DOOR ACTIVATED: **No**

OBSERVATION WINDOW: **Yes**

FRESH AIR INTAKE LOCATION: **3 ft Above Floor**

EXHAUST INTAKE LOCATION: **Floor**

GAS CHLORINE INJECTOR PROPERLY LOCATED AND PROTECTED: **--**

CHLORINATOR VENT: **--**

AIRPACK AVAILABLE: **--**

CYLINDER SIZE: **--**

CYLINDER (S) SECURED: **--**

## CHEMICAL ADDITION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **#9**

SURFACE PLANT LOCATION: **--**

CHEMICAL:

CHEMICAL NAME: **Sodium Hypochloride (Hawkins)**

NSF APPROVED: **Yes**

CONCENTRATION: **12.5% Liquid**

FEEDER TYPE: **Milton Roy LMI**

STROKES PERMINUTE: **--**

CAPACITY: **0 - 60 GPD**

ROTAMETER SETTING: **N/A**

FEEDER CONTROL: **Well Pump**

SPEED SETTING: **59%**

STROKE SETTING: **67%**

POINT OF APPLICATION: **Before Iron Filter**

FLUORIDE INJECTION ANGLE: **N/A**

ANTI SIPHONE DEVICE: **Yes**

SECONDARY CONTROL: **--**

SOLUTION LINE MATERIAL: **Plastic**

RESIDUAL TESTER TYPE: **Hach**

SOLUTION TANK MATERIAL: **Poly**

SIZE: **250 gal**

OVERLAPPING COVER: **Ok**

VENTED: **Ok**

USAGE DETERMINATION: **Sonar Measuring**

CHEMICAL DILUTION: **No**

CHEMICAL ROOM:

DOOR OPENS OUT: **Out**

PANIC HARDWARE ON DOOR: **Yes**

SWITCH LOCATIONS: **Yes**

DOOR ACTIVATED: **Yes**

OBSERVATION WINDOW: **Yes**

FRESH AIR INTAKE LOCATION: **Ceiling**

EXHAUST INTAKE LOCATION: **Floor**

GAS CHLORINE INJECTOR PROPERLY LOCATED AND PROTECTED: **N/A**

CHLORINATOR VENT: **N/A**

AIRPACK AVAILABLE: **N/A**

CYLINDER SIZE: **N/A**

CYLINDER (S) SECURED: **N/A**

## CHEMICAL ADDITION

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

WELL NUMBER: **#9**

SURFACE PLANT LOCATION: **--**

CHEMICAL:

CHEMICAL NAME: **Sodium Silicate (Hawkins)**

NSF APPROVED: Yes

CONCENTRATION: **29.9% Liquid**

FEEDER TYPE: Pulsatron

STROKES PER MINUTE: **--**

CAPACITY: **120 gpd/day**

ROTAMETER SETTING: **N/A**

FEEDER CONTROL: **Well Pump**

SPEED SETTING: **60%**

STROKE SETTING: **60%**

POINT OF APPLICATION: **After Iron Filtration**

FLUORIDE INJECTION ANGLE: **N/A**

ANTI SIPHONE DEVICE: **Yes**

SECONDARY CONTROL: **N/A**

SOLUTION LINE MATERIAL: **Plastic**

RESIDUAL TESTER TYPE: **Hach**

SOLUTION TANK MATERIAL: **Poly**

SIZE: **250 gallons**

OVERLAPPING COVER: **Yes**

VENTED: **Yes**

USAGE DETERMINATION: **Graduated Site Tube**

CHEMICAL DILUTION: **As Is**

CHEMICAL ROOM: **NONE**

DOOR OPENS OUT: **--**

PANIC HARDWARE ON DOOR: **--**

SWITCH LOCATIONS: **--**

DOOR ACTIVATED: **--**

OBSERVATION WINDOW: **--**

FRESH AIR INTAKE LOCATION: **--**

EXHAUST INTAKE LOCATION: **--**

GAS CHLORINE INJECTOR PROPERLY LOCATED AND PROTECTED: **--**

CHLORINATOR VENT: **--**

AIRPACK AVAILABLE: **--**

CYLINDER SIZE: **--**

CYLINDER (S) SECURED: **--**

# IRON FILTRATION

LOCATION: **Kaukauna Well #9**

STREET ADDRESS: **Riverside Park**

TYPE: **Tonka Horizontal Pressure Filter**

NUMBER OF TANKS / CELLS: **4**

DIMENSIONS: **8' Dia. - 30' Long (2 tanks)**

BYPASS LINE: **Yes**

ACCESS MANHOLE: **Yes (access manhole)**

PRESSURE OR LOSS OF HEAD GAUGES: **Yes**

| MEDIA TYPE | DIAMETER | DEPTH |
|---|---|---|
| Anthacite | 07 to .8 | 24" |
| Gravel | -- | 12" |

AIR RELIEF: **Yes**

SURFACE WASH: **--**

RAW AND FINISHED WATER SAMPLE TAPS: **Yes**

RATE CONTROLLER: **Automatic Dezurik Valves (Butterfly)**

OXIDATION METHOD:

AERATION FORCED DRAFT:

PH CONTROL:

GRAVITY:

PERMANGANATE: **X**

AIR COMPRESSOR: **X**

CHLORINE: **X**

DIFFUSOR INSPECTED:

DESCRIPTION OF OXIDATION PROCESS: **Air - Permanganate**

FILTRATION RATE: **2.54** GPM / FT2

CAPACITY: **1,220**

SOURCE OF BACKWASH: **Well**

HOLDING TANK: **13,500 gal**

BACKWASH FREQUENCY: **2 X Weekly**

BACKWASH RATE: **12** GPM / FT2

BACKWASH DURATION: **10 MIN.\CELL**

DISCHARGES TO: **Sanitary Sewer**

BACKWASH LINE TERMINATES 36" ABOVE FLOOR: **42"**

DISCHARGE PERMIT: **No, Discharge to Sanitary**

SUITABLE AIR GAPAVAILABLE ON BACKWASH LINE: **Yes**

RAW IRON: **.56**

FINISHED IRON; **.1**

TESTING FREQUENCY: **Weekly**

LATEST INTERIOR INSPECTION DATE: **1991**

## STORAGE FACILITIES

(ELEVATED STORAGE)

WATERWORKS: **Kaukauna**

PWS I.D.: **44503360**

LOCATION: **Industrial Park**

CAPACITY: **500,000**

TYPE: **Steel Fluted Pedestal**

OVERFLOR ELEVATION: **--**

HEIGHT: **146'**

LOW WATER LEVEL: **--**

HIGH WATER LEVEL: **--**

SCREENED: **Yes**

VENT: **Yes**

SAFETY CLIMB DEVICE: **Yes**

ACCESS LADDER: **Yes**

LOCKING ACCESS DOOR/GATE/LADDER: **Yes**

SAMPLING AND DISINFECTION TAPS: **Yes**

INSULATED RISER: **No**

OVERFLOW DIAMETER: **8"**

HEIGHT ABOVE GRADE: **36"**

SCREENED: **Cantilevered Flap**

SPLASH PAD: **Yes**

RAISED ACCESS MANHOLE: **Yes**

OVERLAPPING COVER: **Yes**

FREEZING PROBLEMS: **No**

RECIRCULATION PUMP: **No**

LAST INTERIOR INSECTION DATE: **1996**

LAST PAINTED: **1996**

CONDITION OF EXTERIOR PAINT: **Good**

LAST PAINTED: **1996**

MEANS FOR DRAINAGE: **Hydrant**

DATE OF CONSTRUCTION: **1974**

STORAGE FACILITIES

(ELEVATED STORAGE)

WATERWORKS: **Kaukauna**

PWS I.D.: **445033660**

LOCATION: **Ann Street**

CAPACITY: **500,000 gallons**

TYPE: **Steel Spheroid**

OVERFLOR ELEVATION: **141.5'**

HEIGHT: **146'**

LOW WATER LEVEL: **--**

HIGH WATER LEVEL: **--**

SCREENED: **Yes**

VENT: **Yes**

SAFETY CLIMB DEVICE: **Yes**

ACCESS LADDER: **Yes**

LOCKING ACCESS DO OR/GATE/LADDER: **Yes**

SAMPLING AND DISINFECTION TAPS: **Yes**

INSULATED RISER: **Yes**

OVERFLOW DIAMETER: **12"**

HEIGHT ABOVE GRADE: **12"**

SCREENED: **Cantilevered Flap**

SPLASH PAD: **Concrete**

RAISED ACCESS MANHOLE: **Yes**

OVERLAPPING COVER: **Yes**

FREEZING PROBLEMS: **No**

RECIRCULATION PUMP: **No**

LAST INTERIOR INSECTION DATE: **1998**

LAST PAINTED: **1998**

CONDITION OF EXTERIOR PAINT: **Good**

LAST PAINTED: **1998**

MEANS FOR DRAINAGE: **Hydrant**

DATE OF CONSTRUCTION: **1998**

## STORAGE FACILITIES

* (GROUND) CLEARWELL

WATERWORKS: **Kaukauna**

CONSTRUCTION DATE: --

DIMENSIONS: 12'x8'x21'8"

CONSTRUCTION: **concrete**

TYPE: --

HIGH WATER LEVELS: --

VENT: **Yes**

OVERFLOW ELEVATION: --

OVERFLOW DIAMETER: **10"**

SPLASH PAD: **Yes**

RAISED ACCESS MANHOLE: **Yes**

INFLOW AND OUTFLOW LINES PRESSUREIZED: --

LAST INTERIOR INSPECTION DATE: --

PWS I.D.: **44503360**

LOCATION: **Blackwell Street**

CAPACITY: **15,000 gal**

PERCENT BELOW GRADE: **60%**

NUMBER OF CELLS: --

LOW WATER LEVEL: --

SCREENED: **No**

OVERFLOW SUBJECT TO FLOODING: **No**

SCREENED: **OK – Weighted Cantilever**

HEIGHT ABOVE SPLASH PAD: **3'**

OVERLAPPING COVER: **Yes**

BYPASS: --

MEANS FOR DRAINAGE: --

HIGHT LIFT PUMPS

| NUMBER | CAPACITY | TOTAL HEAD | MOTOR HP | AUX. POWER |
|---|---|---|---|---|

PUMP DISCHARGE PIPING:

CHECK VALVE: --

AIR RELIEF: --

PRESSURE GAUGE: --

CHEMICAL INJECTION TAPS: --

WATER METER: **Yes**

SHUT OFF VALVE: **Yes**

SMOOTH ENDED SAMPLE TAP: **Yes**

* **Used to Strip Air From Well #8**

# APPENDIX C

WELL LOGS

Well Construction Report For WISCONSIN UNIQUE WELL NUMBER **BG574**

Property Owner: KAUKAUNA, CITY OF — Telephone Number: 44 – 766 – 5721

Mailing Address: 777 ISLAND ST

City: KAUKAUNA — State: WI — Zip Code: 54130

County of Well Location: OUTAGAMIE — Co. Well Permit No.: — Well Completion Date: May 1, 1921

Cnty 45 — Well Constructor (Business Name): LUISER WELL DRILLING INC — License # 157

Dist 4 — Address: 7391 S PORCUPINE LAK

City: LENA — State: WI — Zip Code: 54139

M — M=Munic.O=OTM N=NonCom P=Priv Z=Other X=Non-Pot. A=Anode L-Loop H=Drillhole

2. Dates — Rc'd — Create — 11/19/98 Last FM

1. Well Location — Flag

C — T=Town C=City Village — Fire # (If avail.)

of KAUKAUNA

Grid or Street Address or Road Name and Number: ELM ST #4

Subdivision Name — Lot # — Block #

Gov't Lot # ______ or NE 1/4 of NE 1/4 of

Section 22 T 21 N R 18 E (E/W)

3. Well Type — Flag: 1 — 1 = New 2 = Replacement 3 = Reconstruction

of previous unique well # ______ constructed in 19 0

Reason for new, replaced or reconstructed well?

1 — 1 = Drilled 2 = Driven Point 3 = Jetted 4 = Other

4. Well serves # of homes and or (Ex: barn, restaurant, church, school, industry, etc.) — Flag

High Capacity: Well? Property?

5. Well located on highest point of property, consistent with the general layout and surroundings? Well located in floodplain?

Distance in Feet From Well To Nearest:

1. Landfill
2. Building Overhang
3. Septic or Holding Tank (circle one)
4. Sewage Absorption Unit
5. Nonconforming Pit
6. Buried Home Heating Oil Tank
7. Buried Petroleum Tank
8. Shoreline/Swimming Pool
9. Downspout/Yard Hydrant
10. Privy
11. Foundation Drain to Clearwater
12. Foundation Drain to Sewer
13. Building Drain — 1 = Cast Iron or Plastic 2 = Other
14. Building Sewer 1=Gravity 2=Pressure — 1 = Cast Iron or Plastic 2 = Other
15. Collector or Street Sewer
16. Clearwater Sump
17. Wastewater Sump
18. Paved Animal Barn Pen — Flag
19. Animal Yard or Shelter
20. Silo - Type
21. Barn Gutter
22. Manure Pipe 1=Gravity 2=Pressure — 1 = Cast Iron or Plastic 2 = Other
23. Other Manure Storage — Other NR 112 Waste Source
24.

6. Drillhole Dimensions

| Dia. (in.) | From (ft.) | To (ft.) |
|---|---|---|
| 18.0 | surface | 34 |
| 15.5 | 34 | 75 |
| 12.0 | 75 | 726 |

Method of constructing upper enlarged drillhole only.

1. Rotary - Mud Circulation
2. Rotary - Air
3. Rotary - Foam
4. Reverse Rotary
5. Cable-tool Bit ________ in. dia.
6. Temp. Outer Casing ______ in. dia. Removed?
7. Other

9. Geology — Flag

| DNR USE ONLY | Type, Caving/Noncaving, Color, Hardness, Etc. | From (ft.) | To (ft.) |
|---|---|---|---|
| D | DRIFT | Surface | 4 |
| L | LIMESTONE GAL PLAT | 4 | 170 |
| GNL | SANDSTONE STP | 170 | 185 |
| H | SHALE STP | 185 | 210 |
| NN | SANDSTONE STP | 210 | 220 |
| L | LIMESTONE LMAGN | 220 | 340 |
| LH | LIMESTONE TREMP | 340 | 380 |
| N | SANDSTONE FRANCO | 380 | 510 |
| N | SANDSTONE DRESB | 510 | 726 |

7. Flag — Casing, Liner, Screen

| Dia. (in.) | Material, Weight, Specification Manufacturer & Method of Assembly | From (ft.) | To (ft.) |
|---|---|---|---|
| 15.5 | | surface | 34 |
| 12.0 | | 34 | 120 |

| Dia. (in.) | Screen type, material & slot size | From | To |
|---|---|---|---|
| | | | |

8. Grout or Other Sealing Material — Flag

| Method | Kind of Sealing Material | From (ft.) | To (ft.) | # Sacks Cement |
|---|---|---|---|---|
| | | surface | | |

10. Static Water Level — Flag: 117.0 ft. B ground surface — A=Above B=Below

11. Pump Test — Flag: Pumping Level 245.0 ft. below ground surface — Pumping at 697.0 GPM M hrs

12. Well Is: — Flag: 0 in Grade — A=Above B=Below

Developed? Disinfected? Capped? Depth (feet)

13. Did you permanently seal all unused, noncomplying, or unsafe wells? If no, explain — Flag

14. Signature of Point Driver or Licensed Supervisory Driller — Date Signed — Flag

Signature of Drill Rig Operator (Mandatory unless same as above) — Date Signed

Additional Comments? — More Geo? — Owner Sent Label? Y

# KAUKAUNA CITY WELL NO. 4

Oa-44

J. J. Faust & Sons Co. Drillers
Completed, May, 1921
Samples examined by F. T. Thwaites, U.W. Nos. 53064-53185, 53505-53530
Elevation 645
NE¼ SW¼ Sec 24
T21N R18E

1" = 100'

| Formation | Thickness | Depth | Description |
| --- | --- | --- | --- |
| DRIFT | 4 | 0-4 | Drift, no samples |
| GALENA-PLATTEVILLE | | 4-20 | Limestone, magnesian, no samples |
| | | 20-90 | Limestone, magnesian, gray |
| | | 90-110 | Limestone, magnesian, gray; layers of blue limy shale |
| | | 110-120 | Limestone magnesian gray & blue mixed |
| | | 120-125 | Limestone, magnesian, gray |
| | | 125-130 | Limestone magnesian blue & gray mixed |
| | | 130-140 | Limestone, magnesian, mottled gray & blue |
| | | 140-165 | Limestone magnesian, gray with blue spots |
| | 166 | 165-170 | Limestone magnesian, light bluish gray. |
| ST. PETER | | 170-185 | Sandstone, medium, gray, limy |
| | | 185-200 | Shale, mixed gray & red, caves |
| | | 200-210 | Shale, mixed gray & red with white flint |
| | 50 | 210-220 | Sandstone fine, med., gray & pink, red, gray, [illegible] |
| LOWER MAGNESIAN | | 220-245 | Limestone, magnesian, gray, blue spots |
| | | 245-250 | Limestone, magnesian, gray, fine lime sand grains |
| | | 250-255 | Limestone, magnesian, gray; green shale |
| | 120 | 255-340 | Limestone, magnesian, gray |
| TRE. | 40 | 340-380 | Limestone, magnesian, sandy, [illegible] and red layers shale, red, pink, & green - gray |
| FRANCONIA | | 380-415 | Sandstone, very fine, pink and brownish red, very limy, greensand, green shale |
| | | 415-430 | Sandstone, fine, greenish gray, red, limy, greensand |
| | | 430-435 | Sandstone, coarse to fine, pinkish gray, [illegible] |
| | | 435-455 | Sandstone, medium to coarse, white [illegible] |
| | | 455-460 | Sandstone fine, medium to coarse, [illegible] pink & gray, limy |
| | | 460-485 | Sandstone, medium to coarse, white |
| | | 485-495 | Sandstone, medium to fine, white, hard, limy |
| | | 495-500 | S.S. very fine, gray, limy; gray shale |
| | | 500-505 | Marl, gray |
| | 130 | 505-510 | Sandstone, fine, gray, limy; gray marl |
| DRESBACH | | 510-700 | Sandstone, medium to fine, gray to white |
| | | 700-710 | S.S. medium to fine, gray; [illegible] |
| | | 710-715 | Sandstone very fine to medium; white. |
| | 216 | 715-726 | Sandstone very fine to medium; white |

10" hole
15½" pipe
34
15½" hole
75
10" Liner
120'
12" hole

12:08 FROM KAUKAUNA ELECTRIC + WATER TO 7514284 P:05

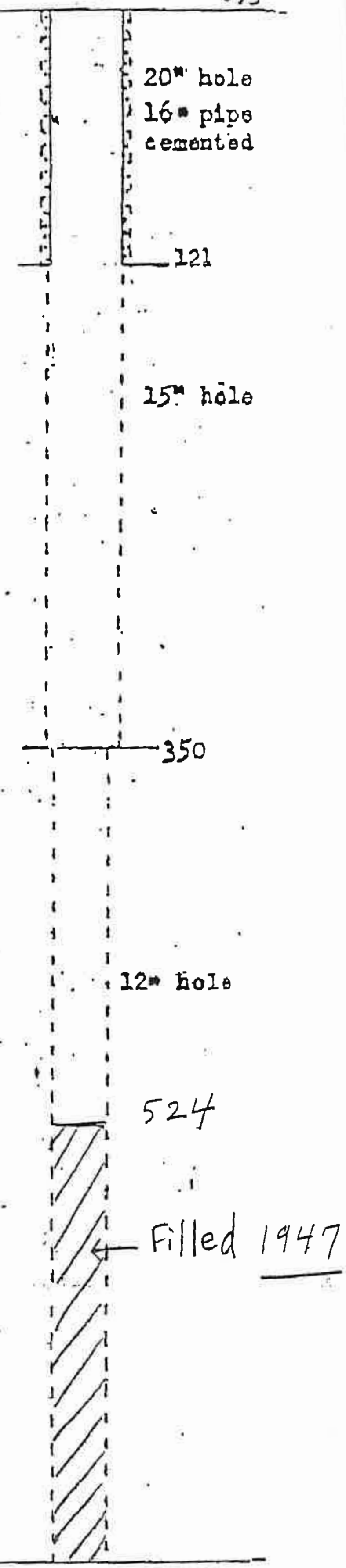
1998

#5

1070' S. of waterworks
Drilled to 570 by Louis Faust, 1935; deepened to 733½ by Jos. Egerer, 1942
Samples 570-733 examined by F. T. Thwaites, Nos. 114061-114093
SW1/4, SW1/4, Sec 24, T21N, R18E

ALt 642'

| | | | |
|---|---|---|---|
| 0-8 | 8 | Drift |
| 8-172 | 164 | Dolomite, gray and blue-gray |
| 172-228 | 56 | Sandstone, medium, light gray; some shale |
| 228-370 | 142 | Dolomite, light gray |
| 370-403 | 33 | Dolomite, sandy, shaly, gray, red |
| 403-510 | 107 | Sandstone, fine to coarse, light gray, dolomitic |
| 510-570 | 60 | Sandstone, medium to fine, light gray |
| 570-620 | 50 | Sandstone, fine to medium, light gray, dolomitic |
| 620-625 | 5 | Sandstone, medium to fine, light gray, dol. |
| 625-640 | 15 | Sandstone, fine, light gray, dolomitic |
| 640-665 | 25 | Sandstone, fine, light gray |
| 665-705 | 40 | Sandstone, fine to medium, light gray |
| 705-733½ | 28½ | Sandstone, fine, white |




Drift; Galena-Platteville (includes Decorah); St. Peter; Lower ...

Well Construction Report For
WISCONSIN UNIQUE WELL NUMBER **BG575**

| | |
|---|---|
| Property Owner KAUKAUNA, CITY OF | Telephone Number 414 — 766 — 5721 |
| Mailing Address 777 ISLAND ST | |
| City KAUKAUNA | State WI / Zip Code 54130 |
| County of Well Location OUTAGAMIE | Co. Well Permit No. / Well Completion Date January 1, 1935 |

Cnty 45

Dist 4

| Well Constructor (Business Name) | License # |
|---|---|
| LUISIER WELL DRILLING INC | 157 |
| Address 7391 S PORCUPINE LAK | |
| City LENA / State WI / Zip Code 54139 | |

M — M=Munic. O=OTM N=NonCom P=Priv Z=Other X=Non-Pot. A=Anode L-Loop H=Drillhole

2. Dates
Rc'd
Create
11/19/98 Last FM

1. Well Location
C T=Town C=City V=Village Fire # (If avail.)
of KAUKAUNA
Grid or Street Address or Road Name and Number
DODGE @ ISLAND ST #5
Subdivision Name Lot # Block #

Gov't Lot # ______ or SE 1/4 of NE 1/4 of
Section 22 T 21 N;R 18 E (E/W)

3. Well Type 1 1 = New 2 = Replacement 3 = Reconstruction
of previous unique well # ______ constructed in 19 0
Reason for new, replaced or reconstructed well?

1 1 = Drilled 2 = Driven Point 3 = Jetted 4 = Other

4. Well serves # of homes and or
(Ex: barn, restaurant, church, school, industry, etc .)
High Capacity: Well? Property?

5. Well located on highest point of property, consistent with the general layout and surroundings?
Well located in floodplain?
Distance in Feet From Well To Nearest:
1. Landfill
2. Building Overhang
3. Septic or Holding Tank (circle one)
4. Sewage Absorption Unit
5. Nonconforming Pit
6. Buried Home Heating Oil Tank
7. Buried Petroleum Tank
8. Shoreline/Swimming Pool
9. Downspout/Yard Hydrant
10. Privy
11. Foundation Drain to Clearwater
12. Foundation Drain to Sewer
13. Building Drain
1 = Cast Iron or Plastic 2 = Other
14. Building Sewer 1=Gravity 2=Pressure
1 = Cast Iron or Plastic 2 = Other
15. Collector or Street Sewer
16. Clearwater Sump
17. Wastewater Sump
18. Paved Animal Barn Pen
19. Animal Yard or Shelter
20. Silo - Type
21. Barn Gutter
22. Manure Pipe 1=Gravity 2=Pressure
1 = Cast Iron or Plastic 2 = Other
23. Other Manure Storage
Other NR 112 Waste Source
24.

6. Drillhole Dimensions

| Dia. (in.) | From (ft.) | To (ft.) |
|---|---|---|
| | surface | |

Method of constructing upper enlarged drillhole only.
1. Rotary - Mud Circulation
2. Rotary - Air
3. Rotary - Foam
4. Reverse Rotary
5. Cable-tool Bit ______ in. dia.
6. Temp. Outer Casing ______ in. dia.
Removed?
7. Other

9. Geology

| DNR USE ONLY | Type, Caving/Noncaving, Color, Hardness, Etc. | From (ft.) | To (ft.) |
|---|---|---|---|
| D | GLACIAL DRIFT | Surface | 8 |
| L | DOLOMITE GAL PLAT | 8 | 172 |
| N | SANDSTONE STP | 172 | 534 |

7. Casing, Liner, Screen

| Dia. (in.) | Material, Weight, Specification Manufacturer & Method of Assembly | From (ft.) | To (ft.) |
|---|---|---|---|
| 16.0 | | surface | 121 |

| Dia. (in.) | screen type, material & slot size | From | To |
|---|---|---|---|

8. Grout or Other Sealing Material

| Method / Kind of Sealing Material | From (ft.) | To (ft.) | # Sacks Cement |
|---|---|---|---|
| | surface | | |

10. Static Water Level
112.0 ft. B ground surface
A=Above B=Below

12. Well Is:
0 in Grade
A=Above B=Below

11. Pump Test
Pumping Level 155.0 ft. below ground surface
Pumping at 216.0 GPM M hrs

Developed?
Disinfected?
Capped?
Depth (feet)

13. Did you permanently seal all unused, noncomplying, or unsafe wells?
If no, explain

14. Signature of Point Driver or Licensed Supervisory Driller — Date Signed

Signature of Drill Rig Operator (Mandatory unless same as above) — Date Signed

Additional Comments? More Geo? Owner Sent Label? Y

[WISC]ONSIN GEOLOGICAL SURVEY, Science Hall, Madison, Wisconsin    Log No. Ou-299

KAUKAUNA CITY WELL : NO. 8, KAUKAUNA, WISCONSIN
(NE¼) (SW¼) Sec. 13, T 21N, R 18E
Jerry Donohue Engineering Co., Engineer
Layne-Northwest Co., Driller, January 1959
Sample Nos. 205892-206011 - Examined by J. B. Steuerwald

7091

| Formation | Depth | Thickness | Description | Well |
|---|---|---|---|---|
| DRIFT | 0 - 35 | 35 | Clay, pale red, non dolomitic | 20" pipe |
| | 35 - 45 | 10 | Clay (till?), pale red-gray, few stones, dolomitic | |
| 70 | 45 - 70 | 25 | Clay, pale red, non dolomitic | |
| GALENA-PLATTEVILLE | 70 - 190 | 120 | Dolomite, light tan-gray, little blue-gray mottling, pyritic 100-110, 130-135 | 73' 75' water; 19" hole; 16" pipe; 151' |
| | 190 - 210 | 20 | Dolomite, blue-gray & tan | 15" hole |
| | 210 - 225 | 15 | Dolomite, medium gray, little blue-gray | |
| 175 | 225 - 245 | 20 | Dolomite, tan, much blue-gray, some green shale & sandstone 235-245 | |
| | 245 - 270 | 25 | Dolomite, bl-gy & tan-gy, sandy, pyritic, some ss, trace of oolitic ch., oolitic dol, 260-270 | |
| | 270 - 275 | 5 | Sandstone, med grained & dolomite, lt gy, sandy | |
| | 275 - 285 | 10 | Dolomite, light medium gray, sandy, pyritic | |
| | 285 - 310 | 25 | Dolomite, light medium gray | |
| | 310 - 315 | 5 | Dolomite, light brown-gray, little oolitic chert | |
| | 315 - 340 | 25 | Dolomite, light medium gray, sandy, some fine sandstone, some oolitic white chert | |
| | 340 - 410 | 70 | Dolomite, light medium gray | |
| | 410 - 425 | 15 | Dolomite, tan & purplish-gray | |
| 210 | 425 - 455 | 30 | Dolomite, tan & pale red-gray, very sandy | |
| | 455 - 465 | 10 | Sandstone, fine gr., vy dolo., glauc., red, micaceous | 460 shot with |
| | 465 - 480 | 15 | Dolomite, pale red, & sandstone, glauconitic | 470 25# shots |
| 40 | 480 - 495 | 15 | Siltstone, & shale, dk red, sandy, glauc., dolo. | |
| | 495 - 505 | 10 | Sandstone, cr., & vy fine gr., pinkish gy, dolo. | 505 |
| | 505 - 525 | 20 | Sandstone, fine grained, light gray, very dolomitic, much drift | shot with 35# shots every 10' from 505-590 |
| | 525 - 565 | 40 | Sandstone, fine grained, light gray & light pale red-gray, pyritic, glauconitic, very dolomitic (breaks in chips) | |
| 15 | 565 - 600 | 35 | Sandstone, medium & coarse grained, light cream-gray, dolomitic | 590' |
| | 602 | | Total depth | |

[Fo]rmations: Drift, Galena-Platteville, Prairie du Chien, Trempealeau, Franconia.
[Bef]ore shooting: Tested at 433 gpm for 14½ hrs., specific capacity = 1.70 gpm/ft. of drawdown.
[Aft]er shooting: Tested for 9½ hrs. @ rates varying from 240-751 gpm, last 25 min. @ 751 gpm, [s]pecific capacity at end of test = 4 gpm/ft.
[Whe]n hole was 73' deep water level was 52'. Before shooting water level was 83', after shoot[in]g 75'.

DRILLED to 770 in ±1995

Well Construction Report For
*WISCONSIN UNIQUE WELL NUMBER* **HJ196**

Property Owner: KAUKAUNA ELECTRIC @ WATER
Telephone Number: 414 – 766 – 5721
Mailing Address: 777 ISLAND ST
City: KAUKAUNA State: WI Zip Code: 54130
County of Well Location: OUTAGAMIE
Co. Well Permit No.:
Well Completion Date: July 14, 1997

Cnty 45 Dist 4
Well Constructor (Business Name): MUNICIPAL WELL @ PUMP INC License #: 13
Address: 20950 ENTERPRISE AVE
City: BROOKFIELD State: WI Zip Code: 53045
M — M=Munic. O=OTM N=NonCom P=Priv Z=Other X=Non-Pot. A=Anode L-Loop H=Drillhole

2. Dates: 10/08/97 Rc'd; 11/25/97 Create; Last FM

1. Well Location (Flag)
C — T=Town C=City V=Village; Fire # (If avail.)
of KAUKAUNA
Grid or Street Address or Road Name and Number: HWY 55
Subdivision Name: WELL #8 Lot #: Block #:
Gov't Lot # ______ or NE 1/4 of SW 1/4 of
Section 13, T 21 N; R 18 E (E/W)

3. Well Type (Flag): 3 — 1 = New 2 = Replacement 3 = Reconstruction
of previous unique well # ______ constructed in 19 0
Reason for new, replaced or reconstructed well? INCREASE CAPACITY
1 — 1 = Drilled 2 = Driven Point 3 = Jetted 4 = Other

4. Well serves (Flag) # of homes and or MUNICIPALITY
(Ex: barn, restaurant, church, school, industry, etc.)
High Capacity: Well? Y Property?

5. Well located on highest point of property, consistent with the general layout and surroundings? Y
Well located in floodplain? N

Distance in Feet From Well To Nearest:

1. Landfill
2. Building Overhang
3. Septic or Holding Tank (circle one)
4. Sewage Absorption Unit
5. Nonconforming Pit
6. Buried Home Heating Oil Tank
7. Buried Petroleum Tank
8. Shoreline/Swimming Pool
9. Downspout/Yard Hydrant
10. Privy
11. Foundation Drain to Clearwater
12. Foundation Drain to Sewer
13. Building Drain — 1 = Cast Iron or Plastic 2 = Other
14. Building Sewer — 1=Gravity 2=Pressure; 1 = Cast Iron or Plastic 2 = Other
15. Collector or Street Sewer
16. Clearwater Sump
17. Wastewater Sump
18. Paved Animal Barn Pen (Flag)
19. Animal Yard or Shelter
20. Silo - Type
21. Barn Gutter
22. Manure Pipe — 1=Gravity 2=Pressure; 1 = Cast Iron or Plastic 2 = Other
23. Other Manure Storage
Other NR 112 Waste Source
24.

6. Drillhole Dimensions

| Dia. (in.) | From (ft.) | To (ft.) |
|---|---|---|
| 20.0 | surface | 73 |
| 19.0 | 73 | 151 |
| 15.0 | 151 | 600 |
| 14.0 | 600 | 800 |

Method of constructing upper enlarged drillhole only.
1. Rotary - Mud Circulation
2. Rotary - Air
3. Rotary - Foam
4. Reverse Rotary
X 5. Cable-tool Bit 14 in. dia.
6. Temp. Outer Casing ______ in. dia. Removed?
7. Other

9. Geology

| DNR USE ONLY | Geology Type, Caving/Noncaving, Color, Hardness, Etc. | Flag | From (ft.) | To (ft.) |
|---|---|---|---|---|
| | | | Surface | 600 |
| N | SANDSTONE | | 600 | 800 |

7. (Flag) Casing, Liner, Screen

| Dia. (in.) | Material, Weight, Specification Manufacturer & Method of Assembly | From (ft.) | To (ft.) |
|---|---|---|---|
| 20.0 | CASING PIPE | surface | 73 |
| 16.0 | LINER | 1 | 151 |
| | | | |
| | | | |

| Dia. (in.) | screen type, material & slot size | From | To |
|---|---|---|---|
| | | | |

8. Grout or Other Sealing Material

| Method | Kind of Sealing Material | From (ft.) | To (ft.) (Flag) | # Sacks Cement |
|---|---|---|---|---|
| | GROUT | surface | 151.0 | |
| | | | | |

10. Static Water Level (Flag): 150.0 ft. B ground surface (A=Above B=Below)

11. Pump Test (Flag): Pumping Level 280.0 ft. below ground surface; Pumping at 845.0 GPM M 48.00 hrs

12. Well Is (Flag): 13 in. A Grade (A=Above B=Below)
Developed? Y
Disinfected? Y
Capped? Y
Depth (feet)

13. Did you permanently seal all unused, noncomplying, or unsafe wells? Y (Flag)
If no, explain

14. Signature of Point Driver or Licensed Supervisory Driller (Flag): TG Date Signed: 9/29/97
Signature of Drill Rig Operator (Mandatory unless same as above): CK Date Signed:

Additional Comments? More Geo? Owner Sent Label? Y

UN
IVERSITY OF WISCONSIN GEOLOGICAL & NATURAL HISTORY SURVEY — Log No. E95-Ou-3
1815 University Avenue, Madison Wisconsin 53706

Well name Kaukauna City Well #9 — County: Outagamie

Owner.... City of Kaukauna
Address.. 200 W. 2nd St.
Kaukauna, WI 54130
Driller.. Egerer-Galloway Well Corp.
Engineer. Donohue & Associates, Inc.
Sheboygan, Wisconsin

Completed... 5/7/74
Field check.
Altitude.... 685' ETM (672)
Use......... Municipal
Static w.l.. 72'
Spec. cap... 15 GPM/ft

R. 18 E.
T. 21 N.
Sec. 23

Quad. Kaukauna 7½'

| Drill Hole | | | | | | Casing & Liner Pipe or Curbing | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dia. | from | to | Dia. | from | to | Dia. | Wgt.& Kind | from | to | Dia. | Wgt.& Kind | from | to |
| 24" | 0 | 239' | | | | 24" | A-53 .375 Wall Welded | 0 | 36' | | | | |
| $17\frac{1}{4}$" | 239' | 806' | | | | 18" | A-53 .375 Wall Welded | +3' | 239' | | | | |

Drilling method: Cable Tool
Samples from 0 to 806' Rec'd: 4/16/74

| Grout | from | to |
|---|---|---|
| Pure Cement Grout | 0 | 239' |

Studied by: Mary J. Hartman (0-185', 225'-806')
Kathleen Massie (185'-225')

Issued: 3/22/84

Formations: Drift, Sinnipee Gp, St. Peter Ss, Prairie du Chien Gp, Jordan Fm (Coon Valley, Van Oser & Norwalk Mbrs), St. Lawrence Fm, Tunnel City Gp, Elk Mound Gp, Precambri

Remarks: Well tested 24 hours at 1560 GPM with 106 feet of drawdown.

FILLED to 620 in 1989

LOG OF WELL:

| | Depths | Graphic Section | Rock Type | Color | Grain Size Mode | Grain Size Range | Miscellaneous Characteristics |
|---|---|---|---|---|---|---|---|
| DRIFT | 0-5 | | Clay | Red brown | — | — | Dolomitic. Little sand, si lt. Trace gravel. |
| | 5-10 | | " | " | — | — | Dolomitic. Trace silt. |
| | 110-15 | | " | " | — | — | Dolomitic. Trace gravel, sand, silt. |
| 25 | 5-20 | | " | " | — | — | Same. |
| | 20-25 | | " | Rd bn & lt gy | — | — | Dolic. Samp is 25% lt gry w/mch gvl, snd, st; 75% rd bn w/tr snd, st, gran, |
| SINNIPEE GROUP | 25-30 | | Dolomite | Lt bn gray | M | Fn/M | Trace calcite crystals, pyrite, gravel from above. |
| | 30-35 | | " | Brown | " | " | Slgtly sugary. Tr pyrite, gry stng from pyrite. |
| | 35-40 | | " | Pale brown | " | " | Slgtly sug. Tr pyrtzd fos frags, gry stng from pyr, bn sh, cvd |
| | 40-45 | | " | Lt bn gray | " | " | Slgtly sug, limy. Tr pyrtzd fos frags (more than abv), gry stng, bk spklg, cvd grans, |
| | 45-50 | | " | " | " | " | Same. |
| | 50-55 | | " | Gray brown | " | " | Slgtly sug. Few pyrtzd fos frags. Ltl gry stng from pyr. Tr wh mot, cvd grans, |
| | 55-60 | | " | " | " | " | Same but no caved granules. |
| | 60-65 | | " | " | " | " | Same. |
| | 65-70 | | " | " | " | " | " |
| | 70-75 | | " | " | " | " | Same but many pyritized fossil fragments. |
| | 75-80 | | " | " | " | " | Slgtly sug. Tr pyrtzd fos frags, wh mot, gn gry & wh sh, gry stng |
| | 80-85 | | " | " | " | " | Same but no white shale. |
| | 85-90 | | " | " | " | " | Sugary. Ltl gry stng from pyr. Tr pyrtzd fos frags, cvd grans. |
| | 90-95 | | " | Lt bn gray | " | " | Sugary. Few pyrtzd fossil fragments. Tr gry stng from pyrite. |
| | 95-100 | | " | " | " | " | Sug. Mny pyrtzd fos frags. Ltl gry stng from pyr. Tr bn & gn gry sh, wh mot, wh cht. |
| | 100-105 | | " | " | " | " | Same but few fossil fragments. |
| | 105-110 | | " | " | " | " | Slgtly sug. Few pyrtzd fos frags. Tr gry stng from pyr, wh cht, pyr xls, bn sh. |
| | 110-115 | | " | " | " | " | Same. |
| | 115-120 | | " | " | " | " | Sug. Mny pyrtzd fos frags. Ltl gry stng from pyr. Tr gn gry & bn sh. |
| | 120-125 | | " | Gray | " | " | Sug. Mny pyrtzd fos frags. Ltl pl bn mot. Tr wh cht. |
| | 125-130 | | " | " | " | " | Sug. Mny pyrtzd fos frags. Ltl pl bn mot. Tr gn gn gry sh. |
| | 130-135 | | " | Pale brown | " | " | Sug. Mch gry stng. Mny pyrtzd fos frags. gry sh, calc xls, pyr xls. |
| | 135-140 | | " | " | " | " | Same. Tr gn gry shale, pyr xls. |
| | 140-145 | | " | Lt bn gray | " | " | Limy. Ltl gry stng. Tr pyrtzd fossil frags, wh mot, pyrite xls. |
| | 145-150 | | " | " | " | " | Same. |
| | 150-155 | | " | Brown | " | " | Little gray staining. Trace pyrite, sugary texture, brown shale. |
| 155-160 | | | " | " | " | " | Same plus trace green gray shale. |

..ITY OF WISCONSIN GEOLOGICAL & NATURAL HISTORY SURVEY
.815 University Avenue, Madison, Wisconsin 53706

Log No. E95-Ou-33

Well name: Kaukauna City Well #9

| | Depths | Graphic Section | Rock Type | Color | Grain Size Mode | Grain Size Range | Miscellaneous Characteristics |
|---|---|---|---|---|---|---|---|
| S | 160-165 | | Dolomite | Pale brown | M | Fn/M | Slgtly sugary. Trace gry staining, wh mottling, pyrite, bn shale. |
| I | 165-170 | | " | Brown | " | " | Same. |
| N. | 170-175 | | " | " | " | " | " |
| | 175-180 | | " | Gray brown | " | " | Slgtly sugary. Ltl gry stng. Tr rd speckling, pyrite, le. |
| 60' | 180-185 | | " | " | " | " | Slgtly sugary. Ltl gry stng, T C ss, fltg qtz snd, pyr, wh sha bn sh, rd |
| St. | 185-190 | | Shale | Light gray | — | — | Sil. Mch fnly dis pyr(st/M xls), qtz Vfn/VC snd, st, Tr spklg, |
| P | 190-195 | | " | Green gray | — | — | See end of log. agg of pyr xls(Fn/M), pyr & sil cem ss, wh cht, |
| E | 195-200 | | " | Rd yl&rd br | — | — | See end of log. lt gr lyred cht. |
| T | 200-205 | | " | Lt rd yl | — | — | See end of log. |
| E | 205-210 | | " | Pl bl gn | — | — | Sil. Mch fnly dis pyr(most Vfn st, st/Fn), st, pnk feld sft sh, |
| R | 210-215 | | " | Pl bl gn & pk | — | — | See end of log. qtz snd, sh as main rock type as in 185'-190'. |
| | 215-220 | | " | Pl bl gn to bl gn | — | — | See end of log. Ltl sft hemic sh, G sil cem feld M ss. |
| 10' | 220-225 | | " | Gray to wh | — | — | Dolic, Mch gry dol, qtz snd, st, Ltl bl gn sil sh, sil cem M/C ss |
| P | 225-230 | | Dolomite | Light gray | M | Fn/M | See end of log. Tr pyr, hemic sh, pnk sil sh, |
| | 230-235 | | " | " | " | " | Slgtly sug. Ltl gn gry sil sh. Tr hemic & dk gry sh, lt gry sh |
| R | 235-240 | | " | " | " | " | See end of log. w/mch dis pyr, fltg qtz sand, pyr xls agg, sil |
| A | 240-245 | | " | Lt bn gray | " | " | Slgtly limy, sug. Tr fltg qtz snd, gn gry & rd bn sh cem ss, |
| I | 245-250 | | " | Bn to pl bn | Fn | " | Slgtly limy. Tr fltg qtz sand, w/pyr, mssv mal, pnk cht, pyr, |
| R | 250-255 | | " | Gy bn to pl bn | M | " | See end of log. mssv malachite, pyrite, gn gry & rd bn shale, |
| I | 255-260 | | " | " | " | " | V limy, Mch fltg qtz snd. Mny ool. Tr dk rd bn sh, gn stng from |
| E | 260-265 | | " | Pale brown | " | " | Same plus tr wh sh. mal, gn gry sh w/mch dis pyr, pnk cht, dol |
| | 265-270 | | " | " | " | " | V limy, Slgtly sug, Tr pyr, ool, qtz snd, wh cht, drsy cem ss |
| | 270-275 | | " | " | " | " | See end of log. qtz, calc xls, gn gry sh w/dis pyr, mssv mal, |
| du | 275-280 | | " | " | " | " | Slgtly limy, Sug, Tr wh cht(some ool), qtz snd, drsy ool cht, |
| | 280-285 | | " | Lt bn gray | " | " | See end of log. qtz, mssv mal, chalc, pyr, gn gry sh, |
| C | 285-290 | | " | " | " | " | Slgtly sug, limy, Trace quartz sand, wh chert, gry staining, vugs, |
| H | 290-295 | | " | " | " | " | Slgtly sug, limy, Tr qtz snd & pebs, wh cht, pyr, chalc, gry stng. |
| I | 295-300 | | " | " | " | " | Slgtly limy. Tr quartz sand, gray staining, very sugary texture. |
| I | 300-305 | | " | " | " | " | Slgtly limy. Tr qtz sand & pebbles, gry stng, pyrite, v sug text. |
| E | 305-310 | | " | Light gray | " | " | Slgtly limy. Tr quartz sand, pyrite, zircon xls(?), bk speckling. |
| N | 310-315 | | " | Pale brown | " | " | Limy. Tr calcite xls, vugs, sugary texture, quartz sand, pyrite. |
| | 315-320 | | " | " | " | " | Limy. Slightly sugary. Trace pyrite, quartz sand, vugs. |
| Gp. | 320-325 | | " | " | " | " | Limy. Slgtly sugary, Trace pyrite, quartz sand, oolitic chert. |
| | 325-330 | | " | Lt bn gray | " | " | Slightly sugary, Trace pyrite, brown staining, white mottling. |
| | 330-335 | | " | Light gray | " | " | Slightly sugary, Trace pyrite, green gray shale with dis pyrite |
| | 335-340 | | " | Lt bn gray | " | " | Slgtly limy, Sugary, Trace pyrite, zircon crystals, bn speckling |
| | 340-345 | | " | " | " | " | Limy, Sugary, Trace quartz crystals w/pyrite inclusions, vugs, |
| | 345-350 | | " | Gray brown | " | " | Limy, Sugary, Trace pyrite, |
| | 350-355 | | " | " | " | " | Same. & lt rd bn sh. |
| 35' | 355-360 | | " | Brown | " | " | Limy, V sug, Ltl dol cem ss w/tr Fn glauc, rd bn mot, Tr gn gry |
| | 360-365 | | " | " | " | " | Limy. Sug. Mch fltg qtz snd, dol cem ss, Ltl rd bn mot, Tr gn |
| .V. | 365-370 / 370-375 | | " | " | " | " | Same but no drsy qtz. stng, wh cht, drsy qtz, bn spklg, lt rd bn |
| | | | " | " | " | " | Limy. Sug. Mch fltg qtz snd. Ltl dol cem ss. Tr gn gry & sh. |
| | 375-380 | | " | Gray brown | " | " | See end of log. lt rd bn sh, rd bn mot, ool(occur singley & cem |
| 5' | 380-385 | | " | Brown | " | " | Limy. Mny snd cored ool(samp is 85% by dol), gn stng, pyr. |
| O. | 385-390 | | Sandstone | Light brown | " | Vfn/VC | See end of log. ool dol ). Tr pyr fl tg qtz snd, rd bn mot, bn dol |
| D' | 390-395 | | " | Lt rd bn | " | " | Srnd. Mch v G dol cem. Mny sec qtz grwths. Ltl ool cem ss. |
| or. | 395-400 | | " | Yellow red | Fn | Vfn/C | See end of log. d ol. Tr bn dol w/fltg snd & rd bn mot. Tr gn |
| t. | 400-405 / 405-410 | | Siltstone | Red brown | — | — | Dolic. Mch fltg snd, dolic sh. Tr Fn glauc. gry sh w/dis pyr, |
| | 410-415 | | " | " | — | — | Dolic, Mch fltg sand, dolic shale. Ltl Fn wh sh, mfc incl, |
| | 415-420 | | " | " | — | — | Dolic. Mch fltg snd, dolic sh, Ltl glauconite. Tr pyrite. |
| A | | | Shale | " | — | — | See end of log. Fn/M glauc. Tr gn gry sh w/dis pyr. |
| V. | 420-425 | | " | " | — | — | Hemic, Mch fltg sand, dolic silt, Fn/M glauc, Tr wh & bn shale, |
| | 425-430 | | " | " | — | — | Hemic, Mch fltg snd, dolic st, Fn/M glauc, Ltl lt gry dol w/fltg |
| | 430-435 | | Siltstone | " | — | — | Dolic. Mch fltg snd, hemic sh, Fn/M snd & glauc. Tr ool, pyr. |
| 10' | 435-440 | | " | Dark brown | — | — | See end of log. glauc, Tr gn gry & wh sh, lt gry dol as abv, pyr. |
| | 440-445 | | Sandstone | Brown | Fn | Vfn/VC | Srnd, Mch P dolic sh cem, Fn/M glauc st. Tr v G dol cem, gn gry |
| | 445-450 | | " | " | M | " | See end of log. sh, pyr, sec qtz grwths, mfc incl. |
| | 450-455 | | " | " | " | " | Srnd. Mch P dolic sh cem, st. Ltl Fn/M glauc. Few sec qtz grwths. |
| | 455-460 | | " | " | " | " | Same but no wh shale. Tr v G dol cem, fros, pyr(some in fils on |
| | 460-465 | | " | " | " | " | See end of log. grns), wh sh, mfc incl, |
| C | 465-470 | | " | " | " | " | Srnd. Mch P dolic sh cem, st. Ltl Fn/M glauc. Few sec qtz grwths. |
| I | 470-475 | | " | " | C | " | See end of log. Tr fros, pyr fils on grns, gn gry & wh sh, lt gry |
| T | 475-480 | | " | " | " | " | Srnd, Ltl P dolic sh cem, st. Mny pyr fils on dol, mfc incl, |
| Y | 480-485 | | " | Light brown | M | " | See end of log. grns, sec qtz grwths. Tr wh dol, fros, Fn glauc, |
| | 485-490 | | " | " | " | " | Srnd, Tr P dolic sh cem, v G dol cem, mfc incl, gn gry & wh sh, |
| | | | | | | | wh sh, fros, Fn glauc, Mny sec qtz grwths, pyr fils on grns. |
| | | | | | | | Wh st |

…RSITY OF WISCONSIN GEOLOGICAL & NATURAL HISTORY SURVEY
…15 University Avenue, Madison, Wisconsin 53706

Log No. E95-Ou-33

Well name: Kaukauna City Well #9

| Depths | Graphic Section | Rock Type | Color | Grain Size Mode | Grain Size Range | Miscellaneous Characteristics |
|---|---|---|---|---|---|---|
| 490-495 | G P | Sandstone | Lt ~~brown~~ | M | Vfn/VC | Srnd. Tr P dolic sh cem, v G dol cem, mfc incl, gn gry & wh sh, st, grns. Mch fros, Fn glauc, cvd mfc grns, Mny sec qtz grwths, pyr fils on |
| 495-500 | G | " | " | " | " | Srnd. Tr P dolic sh cem, v G dol cem, zircon grns, mfc incl, fros, |
| 500-505 | G | " | " | Fn | " | See end of log. Fn glauc, gn gry sh. Mny sec qtz grwths. Mch |
| 505-510 | | " | " | " | " | See end of log. st. Few pyr fils on grns. |
| 510-515 | G | " | Brown | M | " | Srnd. Ltl v G dol cem. Tr p dolic sh cem, pyr(some in fils on |
| 515-520 | G | " | Gray brown | Fn/M | " | See end of log. grns), Fn glauc, fros, mfc incl, wh shly pnk dol |
| 520-525 | | " | Pale brown | Fn | " | See end of log. w/pyr, hemic sh w/M glauc. Mny sec qtz grwths. |
| 525-530 | G | " | " | " | " | Srnd. Tr v G calc cem, v G pyr cem, Fn glauc, gry Few calc xls. |
| 530-535 | G | " | Light gray | C | " | See end of log. bn & wh sh, mfc incl, fros. Mny sec qtz grwths. |
| 535-540 | | " | V pl brown | " | " | Rnd. Mch fros. Mny sec qtz grwths. Tr pyr xls, mfc incl, pl yl |
| 540-545 | | " | " | " | " | Same but no dolomite. dol. |
| 545-550 | | " | " | " | " | Rnd. Tr v G calc cem, pyr xls, mfc incl. Mch fros. Mny sec qtz |
| 550-555 | | " | " | " | " | Rnd. Mch fros. Mny sec qtz grwths. Tr pyr xls, mfc grwths. |
| 555-560 | | " | " | " | " | Same but no dolomite. incl, rd bn dol w/glauc. |
| 560-565 | | " | White | " | " | Rnd. Tr v G sil cem, mfc incl, pyr. Mch fros. Mny sec qtz grwths |
| 565-570 | | " | " | " | " | Rnd. Tr v G calcite cem, pyrite. Mch fros. Mny sec qtz grwths. |
| 570-575 | | " | V pl brown | " | " | Rnd. Mch fros. Mny sec qtz grwths. Tr wh & rd bn. sh, mfc incl. |
| 575-580 | | " | " | M | " | Same. Mch fros. Mny sec qtz grwths. |
| 580-585 | | " | White | C | " | Rnd. Tr v G calc cem, pl yl dol, mfc incl, pyr cotg grns, wh sh. |
| 585-590 | | " | " | " | " | Same. pyr cotg grns. |
| 590-595 | | " | " | M/C | " | Rnd. Mch fros. Mny sec qtz grwths. Tr rd bn & wh sh, mfc incl. |
| 595-600 | | " | " | " | " | Same plus trace zircon grains. cotg grns. |
| 600-605 | G | " | " | C | " | Rnd. Mch fros. Mny sec qtz grwths. Tr Fn glauc, mfc incl, pyr |
| 605-610 | | " | V pl brown | " | " | Rnd. Mch fros. Mny sec qtz grwths. Tr pl bn dol, mfc incl. Fn |
| 610-615 | | " | White | " | " | Rnd. Tr v G calc cem, wh sh, mfc incl. Mch fros. Mny sec glauc. |
| 615-620 | G | " | V pl brown | " | " | Rnd. Mch fros. Mny sec quartz grwths. Tr pl bn qtz grwths. |
| 620-625 | | " | White | M | " | Srnd. Tr P to v G dol cem, pyr, mfc incl. dol, pyrite, M glauc. |
| 625-630 | | " | " | C | " | Same. Mch fros. Mny sec qtz grwths. |
| 630-635 | G | " | V pl brown | M | " | Same plus trace white shale. Fn glauconite. |
| 635-640 | | " | " | C | " | Rnd. Mch frosting. Mny sec quartz grwths. Tr mafic inclusions. |
| 640-645 | G | " | White | M | " | Srnd. Tr P to v G dol & calc cem, mafic incl, pyrite. Fn glauc. |
| 645-650 | | " | V pl brown | C | " | Rnd. Mch fros. Mny sec qtz grwths. Tr pyr, mfc incl, rutile incl |
| 650-655 | G | " | " | " | " | Rnd. Mch fros. Mny sec qtz grwths. Tr pyr, mfc incl. Fn glauc. |
| 655-660 | | " | White | M | " | Same. |
| 660-665 | G | " | " | " | " | " gry & wh sh. |
| 665-670 | | " | " | C | " | Rnd. Mny sec qtz grwths. Ltl fros. Tr wh dol, mfc incl, pyr, gn |
| 670-675 | | " | " | M/C | " | Rnd. Mny sec quartz growths. Ltl frosting. Tr pyrite, mfc incl. |
| 675-680 | G | " | " | " | " | Rnd. Mny sec qtz grwths. Ltl fros. Tr Fn glauc, wh sh, gn gry sh |
| 680-685 | G | " | " | C | " | Same but no green gray shale. w/rd mot. |
| 685-690 | | " | V pl brown | " | " | Rnd. Mny sec qtz grwths. Ltl fros. Tr pyr, mfc incl, bn sh, cvd |
| 690-695 | | " | White | " | " | Rnd. Mny sec qtz grwths. Ltl fros. Tr mfc bk cotd snd grns. |
| 695-700 | | " | " | " | " | Same plus tr pyrite, bn shale. incl, cvd grains as abv. |
| 700-705 | G | " | " | " | " | Rnd. Mny sec qtz grwths. Ltl fros. Tr pyr, mfc incl, M glauc, cvd |
| 705-710 | | " | " | " | " | Rnd. Tr v G calc cem, pyr, mfc incl, cvd grns as grns as abv. |
| 710-715 | G | " | V pl brown | M | " | Same plus tr bn sh, Fn glauc. abv. Mny sec qtz grwths. Ltl fros. |
| 715-720 | | " | Red brown | " | " | Srnd. Tr v G sil sh cem(rd) v G calc cem, pyr, fros, mfc incl. Mny |
| 720-725 | | " | " | " | " | Rnd. Tr v G sil sh cem(rd), v G calc cem, pyr. sec qtz grwths. |
| 725-730 | | " | Lt rd bn | " | " | Same. fros. Tr gry dol, mfc incl. Mny sec qtz grwths. |
| 730-735 | | " | Pink | C | " | Rnd. Tr v G sil sh cem(rd), v G calc cem, pyr, wh sh, mfc incl, lt |
| 735-740 | | " | " | M | " | Srnd. Tr v G sil sh gry dol. Ltl fros. Few sec qtz grwths. |
| 740-745 | | " | " | " | " | Same. cem(rd), pyr, zircon grns, mfc incl, wh sh. Mny sec qtz |
| 745-750 | | " | Lt brown | Fn | " | Sand. Tr P sil cem, v G calc cem, wh sh, pyr. grwths. Ltl fros. |
| 750-755 | | " | " | " | " | Sand. Tr v G sil cem, gn gry sil mfc incl. Mny sec qtz grwths. |
| 755-760 | | " | Pink | M | " | Same but srnd. sh w/mch st sized dis pyr wh sh, pyr, fros, mfc |
| 760-765 | | " | " | " | " | Srnd. Tr P to v G sil cem, gn gry sh incl. Mny sec qtz grwths. |
| 765-770 | | " | " | Fn | " | Same. as abv, wh sh, pyr, mfc incl. Mny sec qtz grwths. Mch fros. |
| 770-775 | | " | " | M | " | " |
| 775-780 | | " | Lt brown | " | " | " fros. Mny sec qtz grwths. |
| 780-785 | | " | Pink | " | " | Srnd. Ltl P to v G sil cem. Tr gn gry & wh sh, wh cht, mfc incl. |
| 785-790 | | " | V pl ~~brown~~ | " | " | Srnd. Tr P to v G sil cem, wh sh, mfc incl, zircon grns. Mny sec |
| 790-795 | | " | Red brown | " | " | See end of log. qtz grwths. Ltl fros. |
| 795-800 | | Granite | Dk rd bn | " | Fn/M | Orthoc 50%, plag 40%, qtz 5%, mfc 5%. Mch sap. Tr qtz snd. V wea. |
| 800-805 | | " | " | " | " | See end of log. Perthitic feld. |
| 805-806 | | " | Red brown | " | " | Plagioclase 50%, orthoclase 35%, mafics (mostly biotite) 10%, quartz 5%. Little saprolite. Trace quartz sand. Weathered. Slightly perthitic feldspar. |

END OF LOG

p. 34

WELL CONSTRUCTOR'S REPORT
FORM 3300–15

NOTE
WHITE COPY – DIVISION'S COPY
GREEN COPY – DRILLER'S COPY
YELLOW COPY – OWNER'S COPY

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESO
Box 450
Madison, Wisconsin 53701

COUNTY: Outagamie
CHECK ONE: ☐ Town ☐ Village ☒ City
NAME: Kaukauna

2. LOCATION – ¼ Section, Section, Township, Range: NW¼ of NE¼-23 T21N R18E

OR – Grid or street no. / Street name

AND – If available subdivision name, lot & block no.

3. OWNER AT TIME OF DRILLING: City of Kaukauna
ADDRESS: Electric and Water Utility, Municipal Building
POST OFFICE: Kaukauna, Wis. 54130

4. Distance in feet from well to nearest: (Record answer in appropriate block) – BUILDING | SANITARY SEWER C.I. / TILE | FLOOR DRAIN C.I. / TILE | FOUNDATION DRAIN SEWER CONNECTED / INDEPENDENT | WASTE WATE C.I.

CLEAR WATER DRAIN C.I. / TILE | SEPTIC TANK | PRIVY | SEEPAGE PIT | ABSORPTION FIELD | BARN | SILO | ABANDONED WELL | SINK HOLE

OTHER POLLUTION SOURCES (Give description such as dump, quarry, drainage well, stream, pond, lake, etc.)

5. Well is intended to supply water for: City of Kaukauna, Wis. WELL #9

6. DRILLHOLE

| Dia. (in.) | From (ft.) | To (ft.) | Dia. (in.) | From (ft.) | To (ft.) |
|---|---|---|---|---|---|
| 24" | Surface | 239' | | | |
| 17½ | 239 | 806 | | | |

7. CASING, LINER, CURBING, AND SCREEN

| Dia. (in.) | Kind and Weight | From (ft.) | To (ft.) |
|---|---|---|---|
| 24" | A-53 .375 Wall | Surface | 36' |
| | Welded | | |
| 18" | A-53 .375 Wall | +3' | 239' |
| | Welded | | |

9. FORMATIONS

| Kind | From (ft.) | To (ft.) |
|---|---|---|
| Clay with stone | Surface | |
| Limestone | 26' | 3 |
| Red Shale | 353' | 3 |
| Limestone | 355' | 3 |
| Sandstone | 395' | 7 |
| Broken Granite | 795' | 80 |

8. GROUT OR OTHER SEALING MATERIAL

| Kind | From (ft.) | To (ft.) |
|---|---|---|
| Pure Cement Grout | Surface | 239' |

10. TYPE OF DRILLING MACHINE USED
☒ Cable Tool ☐ Direct Rotary ☐ Reverse Rot
☐ Rotary – air w/drilling mud ☐ Rotary – hammer with drilling mud & air ☐ Jetting with ☐ Air ☐ W

Well construction completed on May 7 19 7

Well is terminated 24 inches ☒ above ☐ below final g

Well disinfected upon completion ☒ Yes ☐

Well sealed watertight upon completion ☒ Yes ☐

11. MISCELLANEOUS DATA
Yield test: 24 Hrs. at 1560 GPM
Depth from surface to normal water level 72 ft.
Depth to water level when pumping 178 ft.

Water sample sent to State Laboratory of Hygiene, Madison, WI laboratory on: May 7 19

Your opinion concerning other pollution hazards, information concerning difficulties encountered, and data relating to nearby wells, screens, type of casing joints, method of finishing the well, amount of cement used in grouting, blasting, sub-surface pumprooms, access pits, etc. should be given on reverse side.

SIGNATURE: EGERER-GALLOWAY WELL CORP.
G. G. Elliott
G. G. Elliott, Registered Well Driller

COMPLETE MAIL ADDRESS: P. O Box 7296, Milwaukee, Wisconsin 53213

OLI FORM

Please do not write in space below

TEST RESULT | GAS - 24 HRS | GAS - 48 HRS

Well Construction Report For
*WISCONSIN UNIQUE WELL NUMBER* **AY326**

Reconstruction

| | |
|---|---|
| Property Owner: KAUKAUNA WATER | Telephone Number: 414 - 766 - 5721 |
| Mailing Address: 777 ISLAND ST | |
| City: KAUKAUNA | State: WI  Zip Code: 54130 |
| County of Well Location: OUTAGAMIE | Co. Well Permit No. |
| Well Completion Date: April 19, 1988 | |

Cnty 45 — Dist 4

| | |
|---|---|
| Well Constructor (Business Name): MUNICIPAL WELL @ PUMP INC | License #: 13 |
| Address: 2201 BADGER CT | |
| City: WAUKESHA | State: WI  Zip Code: 53188 |

2. Dates: 07/21/89 Rc'd — Create 04/13/99 Last FM

OZ — M=Munic. O=OTM N=NonCom P=Priv Z=Other X=Non-Pot. A=Anode L-Loop H=Drillhole

1. Well Location Flag: C — T=Town C=City V=Village — Fire # (If avail.)
of KAUKAUNA
Grid or Street Address or Road Name and Number
Subdivision Name: WELL NO 9 — Lot # — Block #
Gov't Lot # ____ or NW 1/4 of NE 1/4 of
Section 23 T 21 N; R 18 E (E/W)

3. Well Type Flag: 3 — 1 = New 2 = Replacement 3 = Reconstruction
of previous unique well # ____ constructed in 19 76
Reason for new, replaced or reconstructed well? WATER QUALITY
1 — 1 = Drilled 2 = Driven Point 3 = Jetted 4 = Other

4. Well serves # of homes and or MUNICIPAL
Flag
(Ex: barn, restaurant, church, school, industry, etc.)
High Capacity: Well? Y Property? Y

5. Well located on highest point of property, consistent with the general layout and surroundings?
Well located in floodplain?
Distance in Feet From Well To Nearest:

1. Landfill
2. Building Overhang
3. Septic or Holding Tank (circle one)
4. Sewage Absorption Unit
5. Nonconforming Pit
6. Buried Home Heating Oil Tank
7. Buried Petroleum Tank
8. Shoreline/Swimming Pool
9. Downspout/Yard Hydrant
10. Privy
11. Foundation Drain to Clearwater
12. Foundation Drain to Sewer
13. Building Drain — 1 = Cast Iron or Plastic 2 = Other
14. Building Sewer 1=Gravity 2=Pressure — 1 = Cast Iron or Plastic 2 = Other
15. Collector or Street Sewer
16. Clearwater Sump
17. Wastewater Sump
18. Paved Animal Barn Pen Flag
19. Animal Yard or Shelter
20. Silo - Type
21. Barn Gutter
22. Manure Pipe 1=Gravity 2=Pressure — 1 = Cast Iron or Plastic 2 = Other
23. Other Manure Storage — Other NR 112 Waste Source
24.

6. Drillhole Dimensions

| Dia. (in.) | From (ft.) | To (ft.) |
|---|---|---|
| 24.0 | surface | 239 |
| 17.3 | 239 | 806 |

Method of constructing upper enlarged drillhole only.
1. Rotary - Mud Circulation
2. Rotary - Air
3. Rotary - Foam
4. Reverse Rotary
X 5. Cable-tool Bit 24 in. dia.
6. Temp. Outer Casing ____ in. dia. Removed?
7. Other

7. Flag

| Dia. (in.) | Casing, Liner, Screen Material, Weight, Specification Manufacturer & Method of Assembly | From (ft.) | To (ft.) |
|---|---|---|---|
| 24.0 | A53 P.E. .375 WALL | surface | 36 |
| 18.0 | A-53 P.E. .375 WALL | 3 | 239 |

| Dia. (in.) | screen type, material & slot size | From | To |
|---|---|---|---|

8. Grout or Other Sealing Material

| Method / Kind of Sealing Material | From (ft.) | To (ft.) | # Sacks Cement |
|---|---|---|---|
| NEAT CEMENT GRO | surface | 239.0 | |
| BENTONITE PELLE | 600.0 | 806.0 | |

| DNR USE ONLY | 9. Geology Flag — Type, Caving/Noncaving, Color, Hardness, Etc. | From (ft.) | To (ft.) |
|---|---|---|---|
| | | Surface | |

10. Static Water Level Flag: 129.0 ft. B ground surface — A=Above B=Below

11. Pump Test: Pumping Level 210.0 ft. below ground surface Flag — Pumping at 1200. GPM 10.00 hrs

12. Well Is: Flag — 13 in. A Grade — A=Above B=Below
Developed? Y
Disinfected? Y
Capped? Y
Depth (feet)

13. Did you permanently seal all unused, noncomplying, or unsafe wells? Y
If no, explain Flag

14. Signature of Point Driver or Licensed Supervisory Driller Flag: TG — Date Signed 7/19/89
Signature of Drill Rig Operator (Mandatory unless same as above): CJK — Date Signed 7/19/89

Additional Comments? — More Geo? — Owner Sent Label? Y

Ou-46

(810)

CITY WELL NO. 6, KAUKAUNA, WIS. T21N R18E SE,SE SEC 23

Kenneth Ave. and 10th St. ; about 65' above Well No. 5

Mead, Ward and Hunt, Engineers H. F. Weckwerth, Supt. Water

Jos. Egerer, Contractor, 1945 SURF EL = 720

7187

Samples examined by F. T. Thwaites Nos. 122160-122265

| | Depth | Thick. | Description | Well |
|---|---|---|---|---|
| | 0-10 | 10 | Till, pink, dolomitic | |
| | 10-60 | 50 | Clay, pink, dolomitic | 16" pipe |
| 70 | 60-70 | 10 | No sample | 61 water |
| | 70-125 | 55 | Dolomite, light gray | 71; 15" hole; 10" pipe cemented |
| | 125-155 | 30 | Dolomite, light gray, blue specks | |
| | 155-165 | 10 | Dolomite, light gray | 159 |
| | 165-180 | 15 | Dolomite, light blue-gray | |
| | 180-190 | 10 | Dolomite, blue-gray and light gray | |
| | 190-225 | 35 | Dolomite, light gray | |
| | 225-230 | 5 | Dolomite, light gray, green-gray | |
| | 230-235 | 5 | Dolomite, blue-gray and light gray | |
| 175 | 235-245 | 10 | Dolomite, light gray, sandy, pyritic | |
| | 245-255 | 10 | Dolomite, light gray; some green shale | |
| | 255-265 | 10 | Sandstone, medium to fine, light gray, dol. | 10" hole |
| | 265-305 | 40 | Dolomite, light gray | |
| | 305-310 | 5 | Dolomite, light gray; chert, white | |
| | 310-315 | 5 | Dolomite, light gray, some sand | |
| | 315-400 | 85 | Dolomite, light gray | |
| | 400-415 | 15 | Dolomite, gray and pink, glauconitic | |
| 200 | 415-445 | 30 | Dolomite, sandy, pink-gray; chert, oolitic at bottom | |
| | 445-455 | 10 | Dolomite, sandy, red and pink | |
| | 455-465 | 10 | Siltstone, red, very dolomitic | |
| 35 | 465-470 | 5 | Dolomite, sandy, red to light gray | |
| | 470-480 | 10 | Siltstone, red, dolomitic, glauconitic | |
| | 480-490 | 10 | Sandstone, very fine to silty, gr-gy, d, gl. | |
| | 490-500 | 10 | Sandstone, fine to medium, pink, dol, glauc. | |
| | 500-510 | 10 | Sandstone, fine to medium, light gray | |
| | 510-520 | 10 | Sandstone, fine, gray, dolomitic | |
| | 520-550 | 30 | Sandstone, medium to fine, light gray | |
| | 550-555 | 5 | Sandstone, fine, light gray, dolomitic | |
| | 555-560 | 5 | Siltstone, light gray, dolomitic | |
| 90 | 560-565 | 5 | Sandstone, fine to silty, lt. gray, dol. | |
| | 565-570 | 5 | Siltstone, light gray, dolomitic | |

rr ted total depth 568

ec
rmat ions: Drift; Galena-Platteville; Lower Magnesian (Prairie du Chien); Tremp ealeau; ranconia.

ot with 300 lbs, 3 of 50 lbs, 2 of 75 lbs. Tested 30½ hours Specific capacity = 5 g.p.m. at end of test; rate 340 g.p.m.

DRILLED to 841 in 1995

Filled to 660 in 2000

Well Construction Report For
*WISCONSIN UNIQUE WELL NUMBER* **BG576**

Property Owner KAUKAUNA ELECTRIC @ WATER UTIL
Telephone Number 414 - 766 - 5721

Mailing Address 777 ISLAND DR

City KAUKAUNA State WI Zip Code 54130

County of Well Location OUTAGAMIE
Co. Well Permit No.
Well Completion Date May 5, 1995

Cnty 45 Well Constructor (Business Name) MUNICIPAL WELL @ PUMP INC
License # 13

Dist 4 Address 20950 ENTERPRISE AVE

City BROOKFIELD State WI Zip Code 53045

M M=Munic. O=OTM N=NonCom P=Priv Z=Other X=Non-Pot. A=Anode L-Loop H=Drillhole

2. Dates Rc'd
Create 03/14/97 Last FM

1. Well Location Flag
C T=Town C=City V=Village Fire # (If avail.)
of KAUKAUNA
Grid or Street Address or Road Name and Number
KENNETH AVE @ 10TH ST
Subdivision Name WELL #10 Lot # Block #
Gov't Lot # ______ or SW 1/4 of NE 1/4 of
Section 23 T 21 N; R 18 E (E/W)

3. Well Type Flag
1 1 = New 2 = Replacement 3 = Reconstruction
of previous unique well # ______ constructed in 19 0
Reason for new, replaced or reconstructed well?

1 1 = Drilled 2 = Driven Point 3 = Jetted 4 = Other

4. Well serves # of homes and or CITY
Flag
(Ex: barn, restaurant, church, school, industry, etc.)
High Capacity: Well? Y
Property? Y

5. Well located on highest point of property, consistent with the general layout and surroundings?
Well located in floodplain?

Distance in Feet From Well To Nearest:

1. Landfill
2. Building Overhang
3. Septic or Holding Tank (circle one)
4. Sewage Absorption Unit
5. Nonconforming Pit
6. Buried Home Heating Oil Tank
7. Buried Petroleum Tank
8. Shoreline/Swimming Pool
9. Downspout/Yard Hydrant
10. Privy
11. Foundation Drain to Clearwater
12. Foundation Drain to Sewer
13. Building Drain
 1 = Cast Iron or Plastic 2 = Other
14. Building Sewer 1=Gravity 2=Pressure
 1 = Cast Iron or Plastic 2 = Other
15. Collector or Street Sewer
16. Clearwater Sump
17. Wastewater Sump
18. Paved Animal Barn Pen Flag
19. Animal Yard or Shelter
20. Silo - Type
21. Barn Gutter
22. Manure Pipe 1=Gravity 2=Pressure
 1 = Cast Iron or Plastic 2 = Other
23. Other Manure Storage
 Other NR 112 Waste Source
24.

6. Drillhole Dimensions

| Dia. (in.) | From (ft.) | To (ft.) |
|---|---|---|
| 16.0 | surface | 159 |
| 10.0 | 159 | 568 |
| 10.0 | 568 | 841 |

Method of constructing upper enlarged drillhole only.

1. Rotary - Mud Circulation
2. Rotary - Air
3. Rotary - Foam
4. Reverse Rotary
X 5. Cable-tool Bit 10 in. dia.
6. Temp. Outer Casing ______ in. dia. Removed?
7. Other

9. Geology Flag

| DNR USE ONLY | Type, Caving/Noncaving, Color, Hardness, Etc. | From (ft.) | To (ft.) |
|---|---|---|---|
| NH | SANDSTONE WITH SHALE | Surface | 841 |

7. Flag Casing, Liner, Screen

| Dia. (in.) | Material, Weight, Specification Manufacturer & Method of Assembly | From (ft.) | To (ft.) |
|---|---|---|---|
| 10.0 | EXISTING CASING | surface | 159 |

Dia. (in.) screen type, material & slot size From To

8. Grout or Other Sealing Material

| Method | Kind of Sealing Material | From (ft.) | To (ft.) | # Sacks Cement |
|---|---|---|---|---|
| | EXISTING | surface | 159.0 | |

10. Static Water Level Flag
180.0 ft. B ground surface
A=Above B=Below

11. Pump Test Flag
Pumping Level 242.0 ft. below ground surface
Pumping at 726.0 GPM M 12.00 hrs

12. Well Is: Flag
13 in. A Grade
A=Above B=Below
Developed? Y
Disinfected? Y
Capped? Y
Depth (feet)

13. Did you permanently seal all unused, noncomplying, or unsafe wells? Flag
If no, explain NA

14. Signature of Point Driver or Licensed Supervisory Driller Flag TRG Date Signed 5/30/95

Signature of Drill Rig Operator (Mandatory unless same as above) AEK Date Signed 5/30/95

Additional Comments? More Geo? Owner Sent Label? Y

06/23/99 08:24 MUNI CIPAL WELL → 1 920 751 4200 NO.588 P004

WISCONSIN UNIQUE WELL NUMBER 86 576

Department of Natural Resources MECONSTRUCT, Box 7921, Madison, WI 53707 (Please type or print using a black pen.) WELL #10 (FORMERLY #6)

Property Owner: KAUKAUNA ELECTRIC AND WATER UTILITY — Telephone Number: (414) 766-5721

Mailing Address: 777 ISLAND DR.

City: KAUKAUNA — State: WI — Zip Code: 54130

County of Well Location: OUTAGAMIE — Co. Well Permit No. W —

Well Completion Date (mm-dd-yy): 05-05-95

Well Constructor (Business Name): MUNICIPAL WELL & PUMP — License #

Address: 20950 ENTERPRISE AVE.

City: BROOKFIELD — State: WI — Zip Code: 53045

1. Well Location (Please use decimals instead of fractions.)

☐ Town ☒ City ☐ Village of KAUKAUNA — Fire # (If avail.)

Grid or Street Address or Road Name and Number (If avail.): KENNETH AVE. & 10TH ST.

Subdivision Name ____ Lot # ____ Block # —

Gov't Lot # ____ or ____ 1/4 of ____ 1/4 of Section ____ T ____ N; R ____ ☐ E ☐ W

2. Mark well location with a dot in correct 40-acre parcel of section. N / W / E / S

3. Well Type ☒ New ☐ Replacement ☒ Reconstruction of previous unique well # ____ constructed in 19 ____

Reason for new, replaced or reconstructed well?

Well serves — # of homes and or CITY (Ex: barn, restaurant, church, school, industry, etc.)

High Capacity: Well? ☒ Yes ☐ No — Property? ☒ Yes ☐ No

☒ Drilled ☐ Driven Point ☐ Jetted ☐ Other ____

Well located on highest point of property, consistent with the general layout and surroundings? ☐ Yes ☐ No If no, explain on back side.

Well located in floodplain? ☐ Yes ☐ No

Distance in Feet From Well To Nearest:

1. Landfill
2. Building Overhang
3. Septic or Holding Tank (circle one)
4. Sewage Absorption Unit
5. Nonconforming Pit
6. Buried Home Heating Oil Tank
7. Buried Petroleum Tank
8. Shoreline/Swimming Pool
9. Downspout/Yard Hydrant
10. Privy
11. Foundation Drain to Clearwater
12. Foundation Drain to Sewer
13. Building Drain ☐ Cast Iron or Plastic ☐ Other
14. Building Sewer ☐ Gravity ☐ Pressure ☐ Cast Iron or Plastic ☐ Other
15. Collector or Street Sewer
16. Clearwater Sump
17. Wastewater Sump
18. Paved Animal Barn Pen
19. Animal Yard or Shelter
20. Silo - Type ____
21. Barn Gutter
22. Manure Pipe ☐ Gravity ☐ Pressure ☐ Cast Iron or Plastic ☐ Other
23. Other Manure Storage; Other NR 112 Waste Source
24. ____

4. Drillhole Dimensions

| Dia. (in.) | From (ft.) | To (ft.) |
|---|---|---|
| 26 | surface | 159 |
| 22" | 159 | 568 |
| NEW HOLE | | |
| 10" | 568 | 841 |

Method of constructing upper enlarged drillhole only.

☐ 1. Rotary - Mud Circulation
☐ 2. Rotary - Air
☐ 3. Rotary - Foam
☐ 4. Reverse Rotary
☒ 5. Cable-tool Bit 9 3/4 in. dia.
☐ 6. Temp. Outer Casing ____ in. dia. Removed? ☐ Yes ☐ No If no, explain ____
☐ 7. Other

9. Geology

| DNR USE ONLY | Type, Caving/Noncaving, Color, Hardness, Etc. | From (ft.) | To (ft.) |
|---|---|---|---|
| | | Surface | |
| | SANDSTONE WITH SHALE STREAKS | 568 | 841 |
| | WELL SHOT WITH 1# OF DYNAMITE PER FOOT (407 LBS) | | |

Casing, Liner, Screen

| Dia. (in.) | Material, Weight, Specification, Manufacturer & Method of Assembly | From (ft.) | To (ft.) |
|---|---|---|---|
| | | surface | |
| | EXISTING | | |

| Dia. (in.) | Screen type, material & slot size | From | To |
|---|---|---|---|
| | | | |

10. Static Water Level: — ft. above ground surface; 180 ft. below ground surface

11. Pump Test: Pumping Level 242 ft. below surface; Pumping at 726 GPM for 12 hours

12. Well Is: 13 in. ☒ Above ☐ Below Grade

Developed? ☒ Yes ☐ No
Disinfected? ☒ Yes ☐ No
Capped? ☒ Yes ☐ No

Grout or Other Sealing Material

Method —

| Kind of Sealing Material | From (ft.) | To (ft.) | # Sacks Cement |
|---|---|---|---|
| EXISTING | surface | | |

13. Did you permanently seal all unused, noncomplying, or unsafe wells? ☐ Yes ☐ No If no, explain N.A.

14. Signature of Point Driver or Licensed Supervisory Driller: [signature] — Date Signed 5/30/95

Signature of Drill Rig Operator (Mandatory unless same as above) Date Signed

# APPENDIX D

MAIN PLANT GROUND STORAGE WATER RESERVOIR OBSERVATIONS
April 16, 2003

McMAHON
ASSOCIATES, INC.
ENGINEERS ■ ARCHITECTS
PROJ. MGRS. ■ SURVEYORS

1445 McMahon Drive Neenah, WI 54956
Mailing Address: P.O Box 1025 Neenah, WI 54957-1025
Tel: (920) 751-4200 Fax: (920) 751-4284
e-mail: mcm@mcmgrp.com

# MAIN PLANT
# GROUND STORAGE WATER RESERVOIR OBSERVATIONS
## Kaukauna Electric & Water Utility

April 16, 2003
McM. No. K0004-920857.00

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## Rectangular Reservoir

1. Suction pipe in southeast corner of tank covered with rust blisters. Scraping away rust shows the pipe is in good condition with only minor pitting.

2. East wall in southern half of the tank is in good condition. Cracks in the wall were previously repaired and the repairs are still intact.

3. Cracks in the ceiling were previously repaired with a mastic material and the repairs are still intact. No new cracking was observed in the ceiling. The ceiling appears damp from condensation, not roof leaks.

4. Some rust spotting on the ceiling is from supports used to keep the reinforcing steel off of the bottom of the formwork. This condition does not appear to have worsened over time.

5. Overflow pipe near southeast corner of tank appears in good condition.

6. South wall of tank appears in good condition. Cracks in the wall were previously sealed and the repairs are intact. The walls are very hard and no voids detected when tapped with a hammer.

7. The tank floor appears in good condition. There was less than ½-inch of silt/sediment on the floor. The floor is sloped from the walls down to the center of the tank approximately 14-inches. Several areas of the floor have a rough finish, which occurred during the original floor pour.

8. West wall of tank appears in good condition with no visible leads. Cracks in the wall were previously repaired and the repairs are intact. Overflow pipe near southwest corner is covered with a stainless steel screen.

# GROUND STORAGE WATER RESERVOIR OBSERVATIONS

## Rectangular Reservoir (continued)

9. There is a brick masonry baffle wall running east-west across the tank with an opening at the west end. The east and middle sections at the baffle wall appear in fair condition. There is a vertical crack in the concrete column in the west section of the baffle wall, approximately 4-feet above the floor. The west section of the baffle is in poor condition. This masonry wall section has a large diagonal crack that is approximately 2-inches wide. The brick masonry column at the west end of the baffle wall is cracked and bulging outward. The brick masonry is very soft and hollow sounding when tapped with a hammer. The masonry joints are separating. The baffle wall goes up to within 2-feet of the ceiling. The tank is approximately 13-feet deep.

10. The west wall in the north half of the tank appears in good condition. Cracks in the wall were previously sealed and the repairs are intact.

11. The north wall of the tank is in good condition. Cracks in the wall were previously sealed and the repairs are intact.

12. The east wall in the north half of the tank appears in good condition. There is a square bump out in the east tank wall which is in good condition. The transfer pipe through the east wall is in good condition.

13. There is a 4-inch deep sump in the floor directly below the hatch.

14. There is a pipe penetrating the ceiling near the northeast corner of the tank that is capped.

15. The 12 concrete columns in the tank appear in good structural condition.

16. The roof on the tank appears water tight and in good condition.

17. The roof hatches are raised approximately 24-inches above the roof level. The hatch lid overlaps the access hatch. The hatch is locked.

18. There are two 3-inch diameter pipe vents through the roof. Both vents are screened.

19. The tank has a 6-inch overflow pipe located on the west side of the tank. The overflow pipe has a flapper gate on the end of the pipe. The overflow is approximately 16-inches above grade and discharges to the ground.

20. The exterior concrete walls of the tank are in good condition, with some previously repaired cracks visible.

# GROUND STORAGE WATER RESERVOIR OBSERVATIONS

## Summary - Rectangular Reservoir

The tank appears in good structural condition. The previous repairs to cracks in the walls and ceiling are intact. No leaks were observed.

The brick masonry baffle wall in the tank is in poor condition. The Owner should consider budgeting funds for repairs to the baffle wall.

Since the round and rectangular reservoirs are direct connected by piping, all the vents serve both tanks and hence should be of adequate size.

## Round Reservoir

1. The tank is approximately 18-feet deep. The floor is sloped approximately 12-inches down toward the middle of the tank.

2. The tank has nine interior columns and six columns built into the wall of the tank. Three beams run across the tank columns in an east-west direction.

3. Some rust spotting on the ceiling is from supports used to keep the reinforcing steel off of the bottom of the formwork.

4. The vent pipes through ceiling appear in good condition. No leaks were observed around the vents.

5. Roof on reservoir appears watertight. No leaks were observed in the roof or along the top of the wall at the ceiling.

6. A small piece of reinforcing steel was exposed in the ceiling in the southeast corner, 1-foot south of southeast wall column.

7. All columns cast into the wall have cracks just below the beam which extends across the top of the columns. The beam is approximately 12-inches below the ceiling of the tank. Some of the column cracks have areas of spalled concrete.

8. All interior columns appear in good condition with no cracking. The beams in the tank are in good condition with no cracking observed.

# GROUND STORAGE WATER RESERVOIR EVALUATIONS

## Round Reservoir (continued)

9. There are approximately 22 areas along the north and south sides of the north beam where the steel reinforcing is exposed in the ceiling. There are approximately 9 areas along the south side of the center beam where the reinforcing steel is exposed in the ceiling. The amount of reinforcing steel exposed ranged in length from less than 1-inch to approximately 12-inches. See attached sketch for areas of exposed reinforcing steel.

10. The inlet pipe in the north wall appears in good condition as well as its two concrete support piers.

11. Cracks in the ceiling have been previously patched with a mastic type sealant. The repairs appear to be intact.

12. The tank walls are in good condition, with a hard, sound surface. No new cracks were observed. Old cracks previously repaired with a mastic type sealer showed no leaks.

13. There is a brick masonry wall extending from the east side of the tank to 2/3 across the center of the tank. The wall is approximately 6-feet high. The top of the wall is very weak and the top several courses of brick are loose.

14. The floor of the tank is in good condition. Less than ½-inch of sediment is on the tank floor.

15. The suction pipe in the southwest corner of the tank is in good condition. No leakage was observed around the pipe penetrations through the wall.

16. The fill pipe in the southeast corner of the tank is in good condition.

17. The tank has two 4-inch vent pipes that are screened.

18. The tank has a 6-inch overflow pipe located on the north side. The overflow pipe has a flapper gate on the end of the pipe. The overflow is approximately 3-feet above grade and discharges onto the gravel drive.

19. The access hatch is raised 24-inches above the top of the roof. The hatch lid overlaps the access hatch. The hatch is locked.

20. The exterior wall of the tank has some previously repaired cracking. No new cracks were observed.

# GROUND STORAGE WATER RESERVOIR EVALUATIONS

## Summary - Round Reservoir

Overall, the round reservoir is in good condition. The previous repairs to cracks in the walls and ceiling are intact. No leaks were observed.

The brick masonry baffle wall is in poor condition. The Owner should consider budgeting funds for repairs to the baffle wall.

The cracks near the top of the wall columns should be repaired, preferably by epoxy injection. The areas of exposed reinforcing steel should be cleaned and coated to prevent further oxidation and corrosion of the steel.

JAK:car
I.D.\CORR\K0004\920857.DOC

MILLER WAGNER COENEN McMAHON
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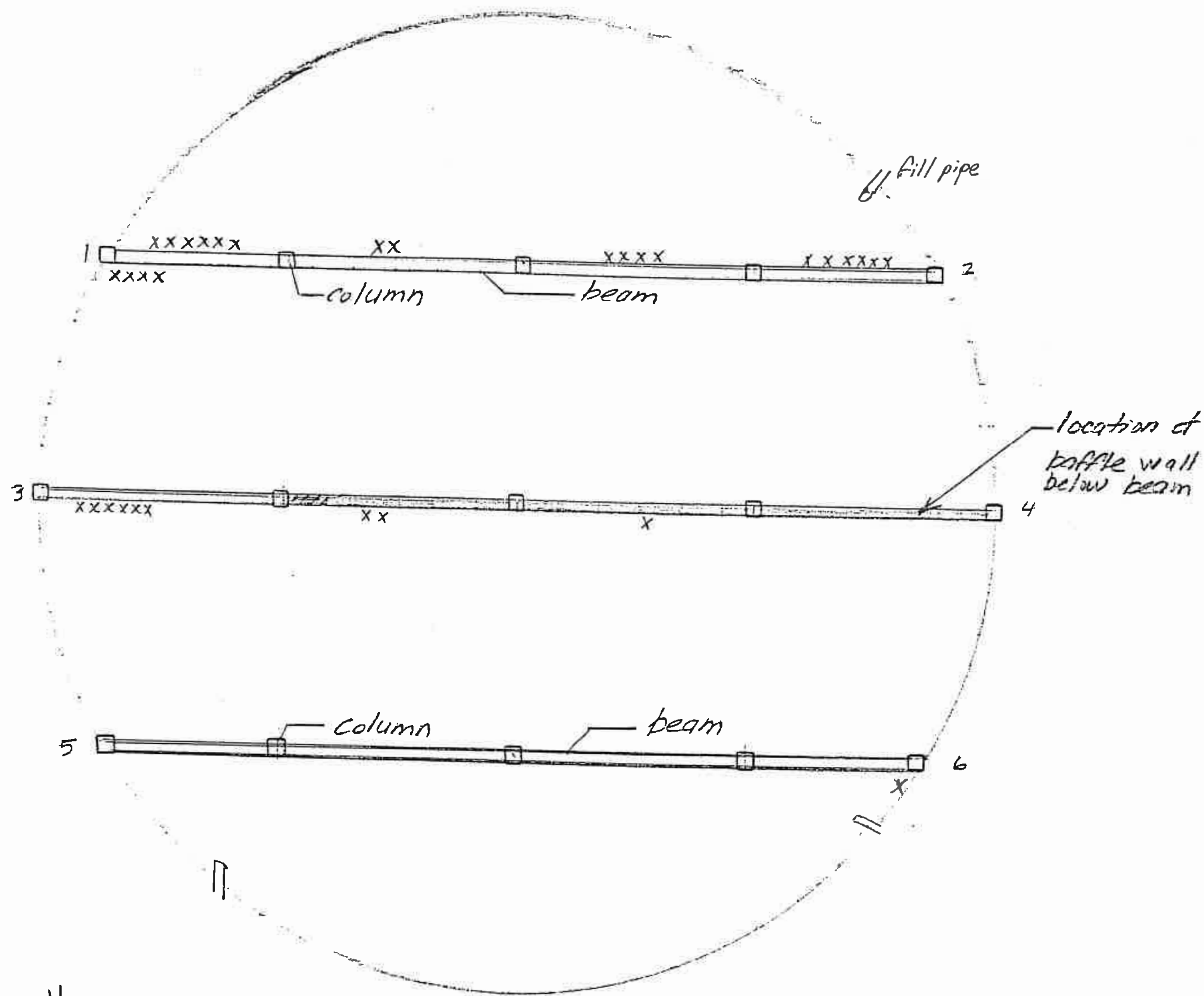
1445 McMahon Drive Neenah, WI 54956
Mailing Address: P.O. Box 1025 Neenah, WI 54957-1025
TEL: 920-725-6346 FAX 920-751-4284
e-mail: mcm@mcmgrp.com
An Affiliate of McMahon Associates, Inc.

DATE 4/16/03
CLIENT Kaukauna Util.
PROJECT Reservoir Evaluation
PROJECT No. K0004-920857
BY Kollmer


305 Elm St.

Round Reservoir




N
S

x - exposed reinforcing steel (4" to 10" exposed)

MILLER
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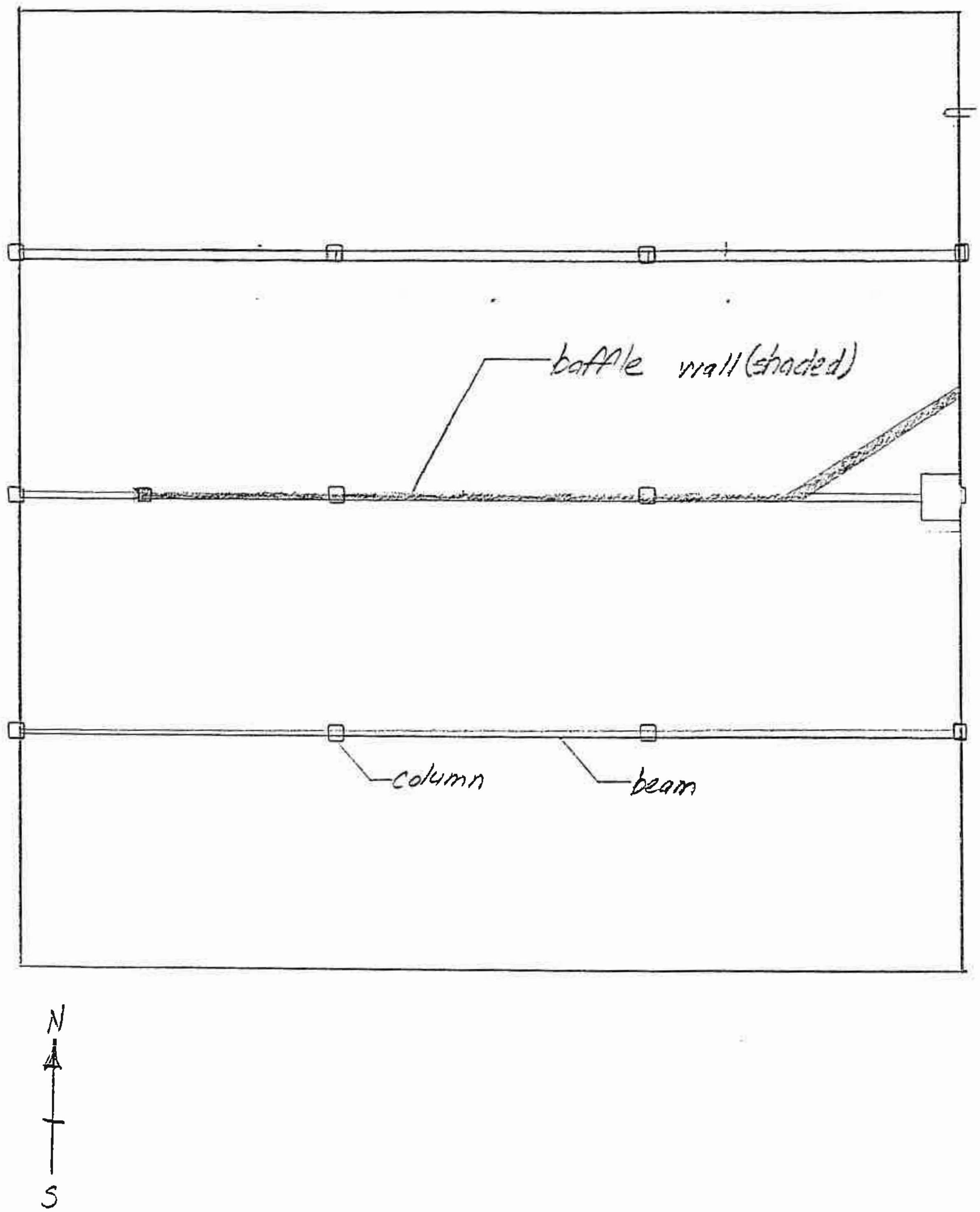
e-mail: mcm@mcmgrp.com
An Affiliate of McMahon Associates, Inc.

DATE 4/16/03
CLIENT Kaukauna Utilities
PROJECT Reservoir Evaluation
PROJECT No. K000 4 020857
BY Kellner


305 Elm St.

Rectangular Reservoir



# PHOTOGRAPHS

## Rectangular Tank

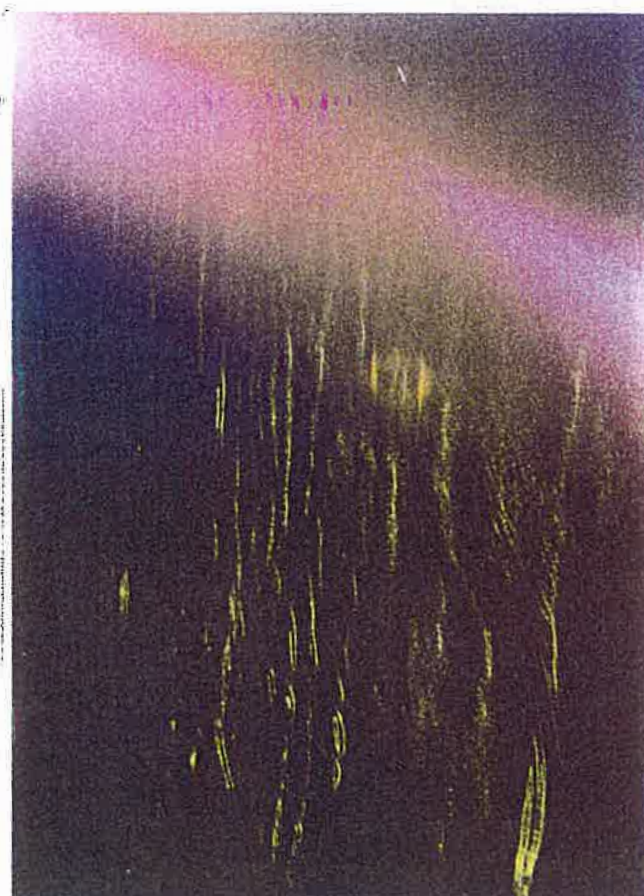
1. Inlet Pipe
2. South Vent Through Roof
3. Inlet Pipe
4. Light Sediment on Floor Underwater
5. Small Rust Area in Previously Repaired Crack
6. Small Piece of Exposed Reinforcing Steel Near Column
7. Brick Masonry Baffle Wall Crack
8. Capped Pipe Through Ceiling; Fill Pipe from Round Reservoir
9. Screened Overflow Pipe; Patched Ceiling Cracks
10. Wood Scrap from Original Column Forming
11. West End of Baffle Wall
12. West End of Baffle Wall
13. Corner Column
14. Ceiling Wall Intersection
15. Top of Column
16. Inlet Pipe
17. North Vent Pipe
18. South Vent Pipe
19. Access Hatch
20. Fill Pipe
21. South End of Tank
22. North End of Tank

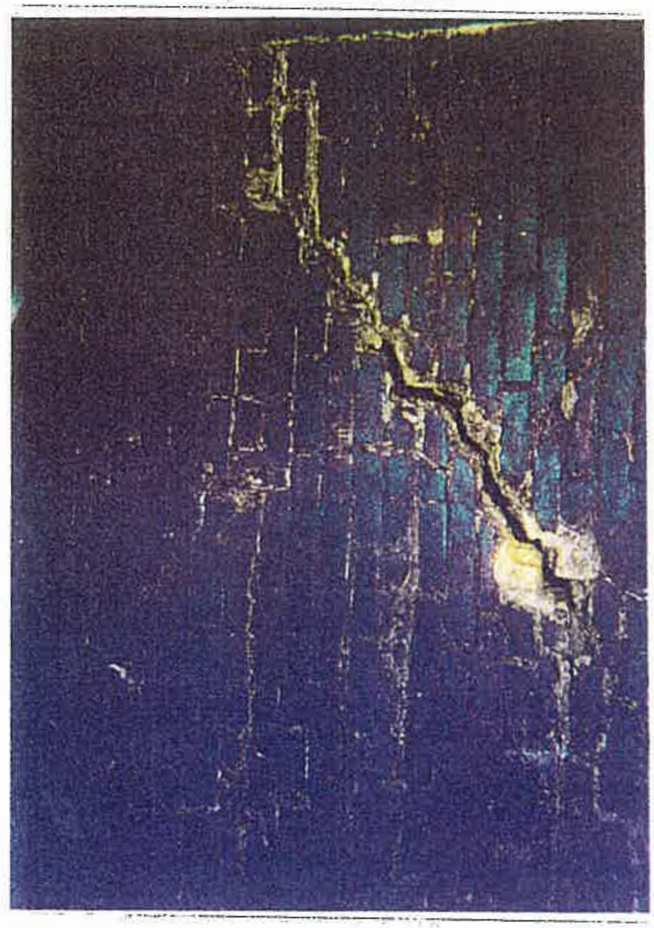
## Round Tank

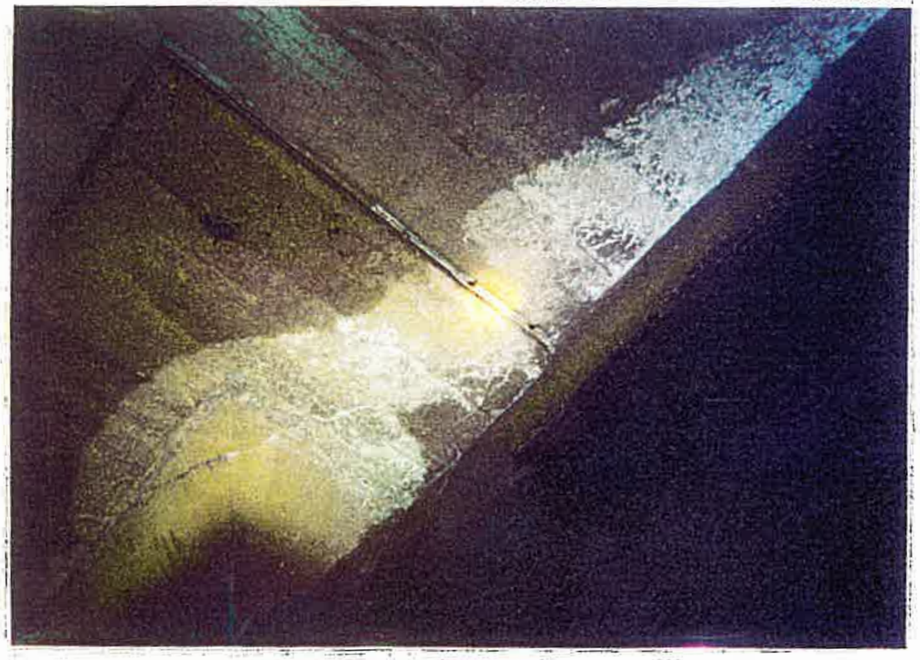
23. Rust Due to Reinforcing Supports
24. Exposed Reinforcing Steel on North Side of North Beam
25. Exposed Reinforcing Steel on South Side of North Beam
26. Intersection of Ceiling, Beam, Column and Wall
27. Access Hatch
28. Intersection of Ceiling, Beam and Wall
29. Suction Pipe
30. Fill Pipe
31. Small Areas of Corrosion in Ceiling
32. Capped Roof Hatch
33. Intersection of Ceiling, Beam, Wall and Column
34. Pipe Near Top of Wall
35. Capped Pipe in Ceiling
36. Top of Brick Masonry Baffle Wall
37. Top of Column
38. Capped Pipe through Ceiling Near Column
39. Thin Layer of Sediment on Floor Underwater
40. Bottom of Column
41. Sump in Floor
42. Top of Wall Column

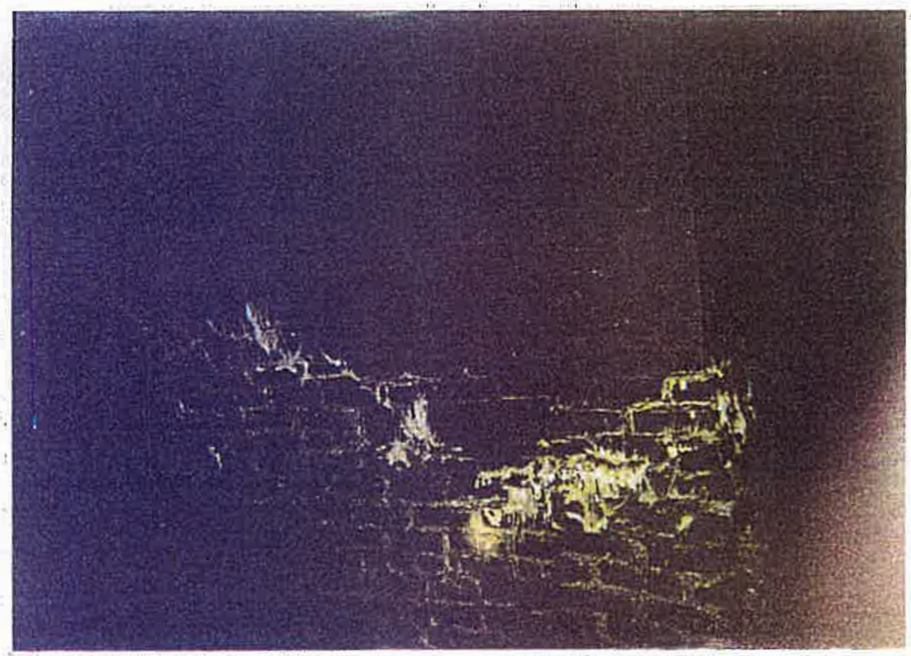
1

3







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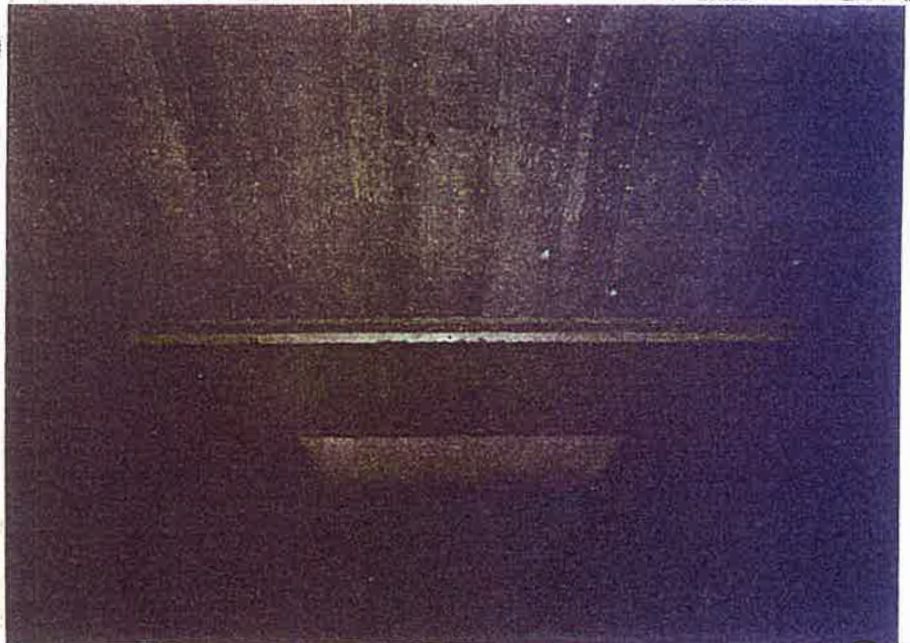

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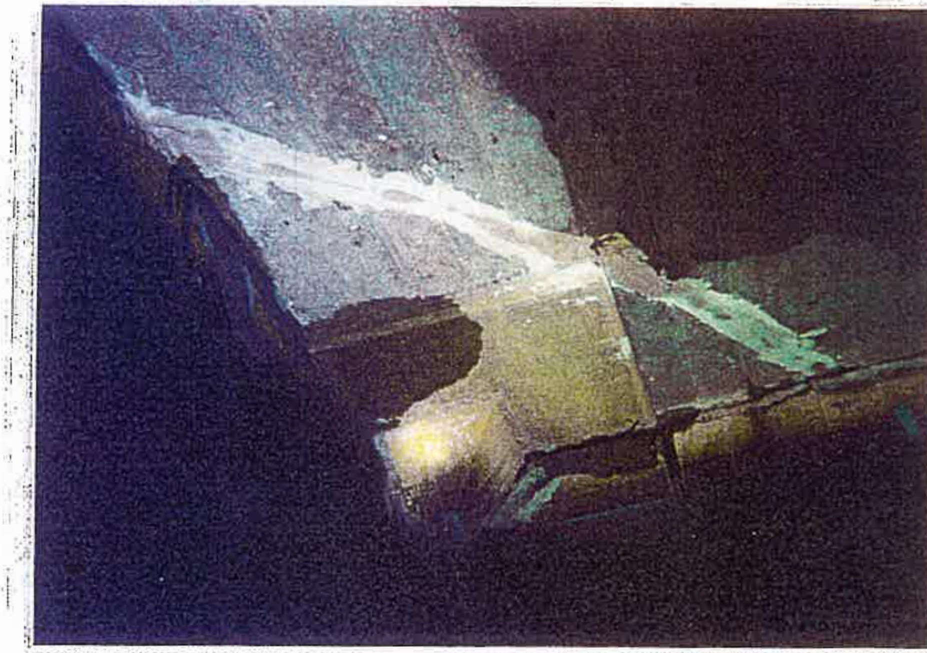

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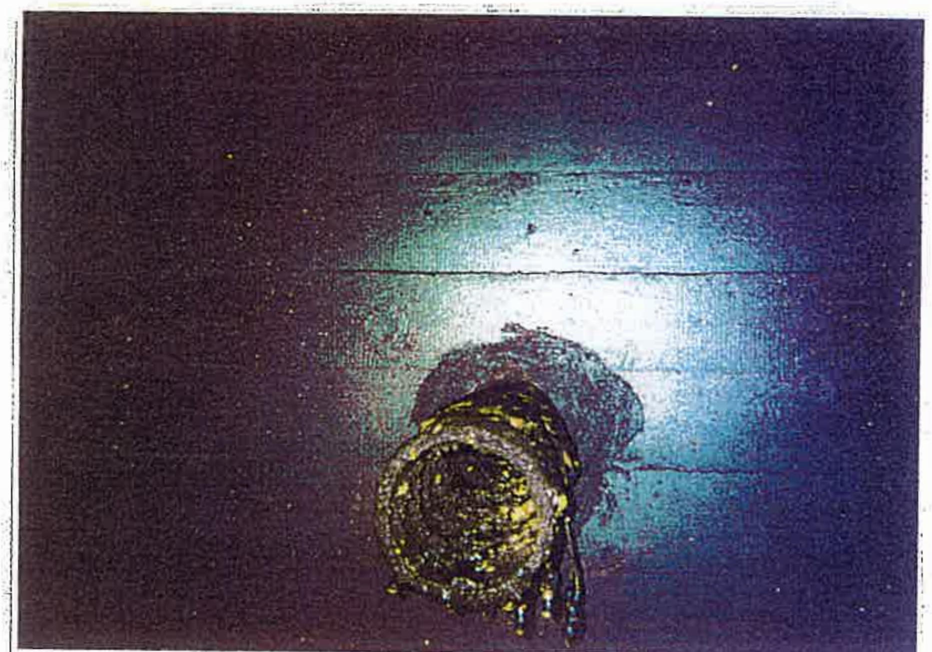

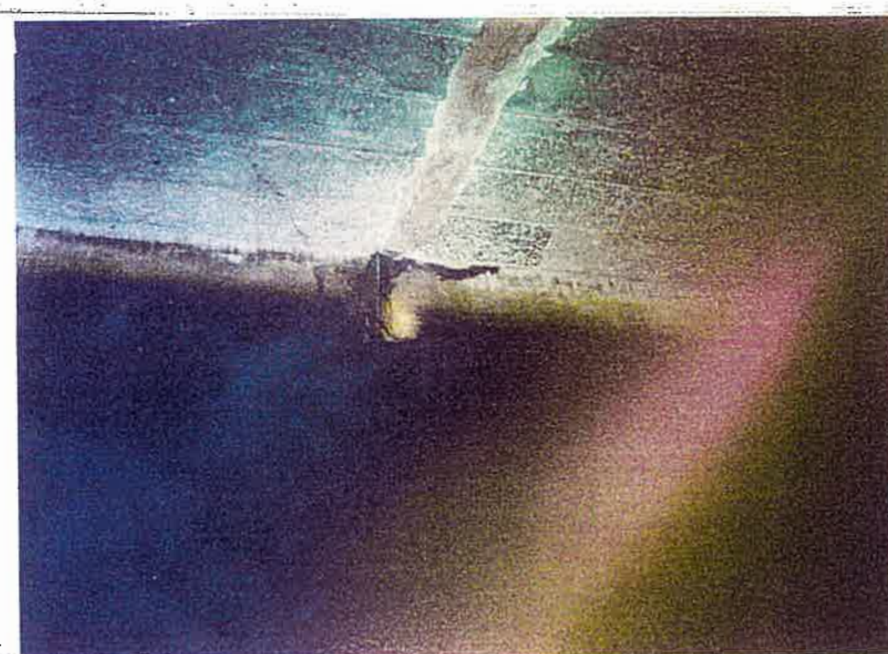

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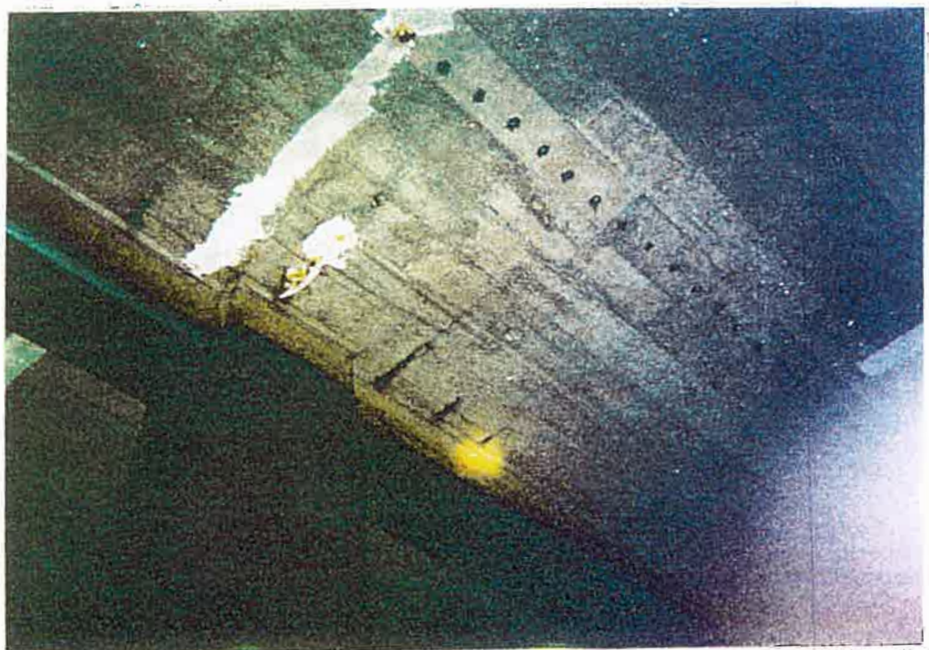

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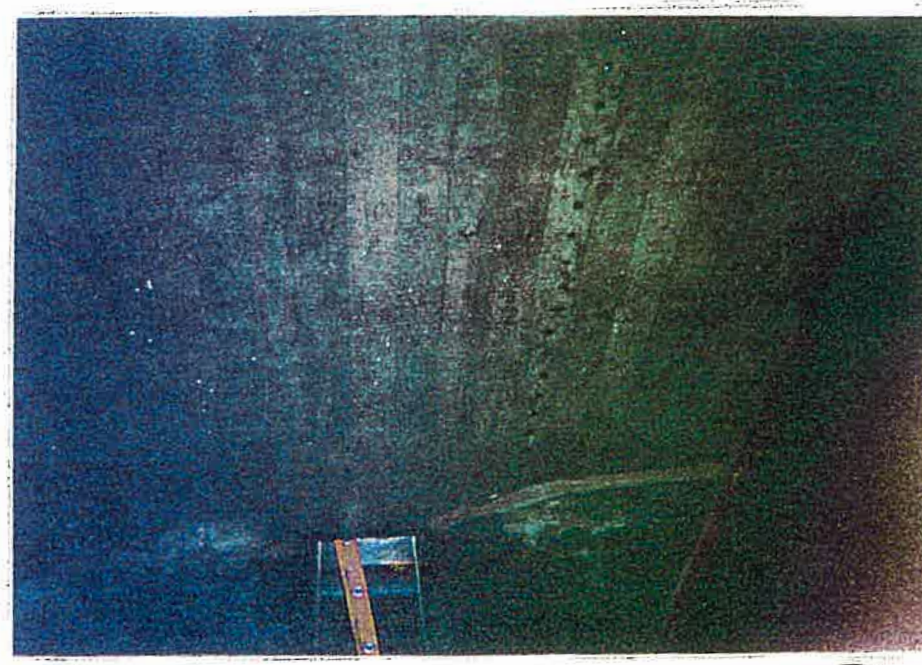

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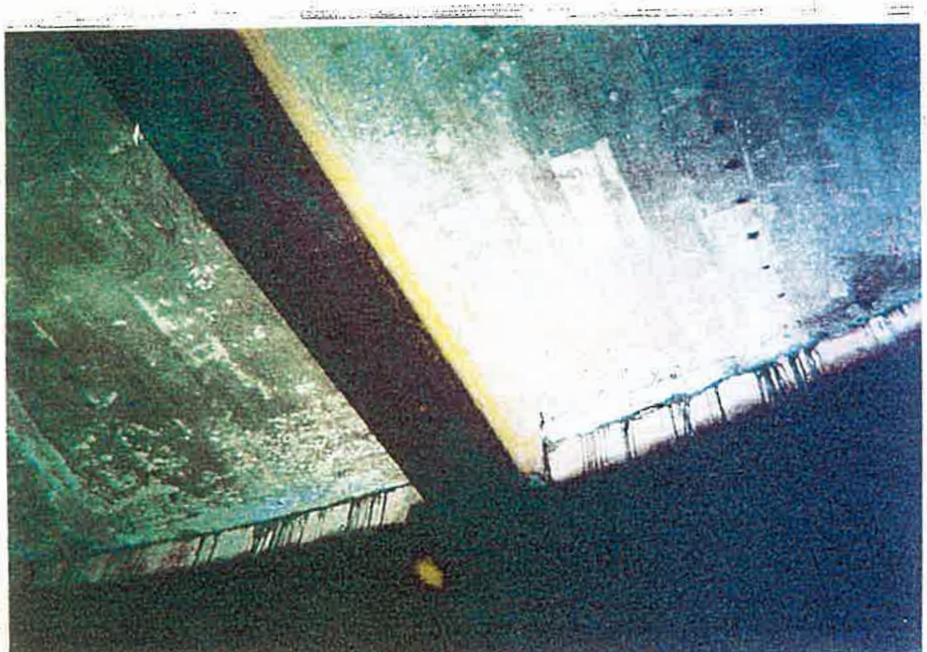

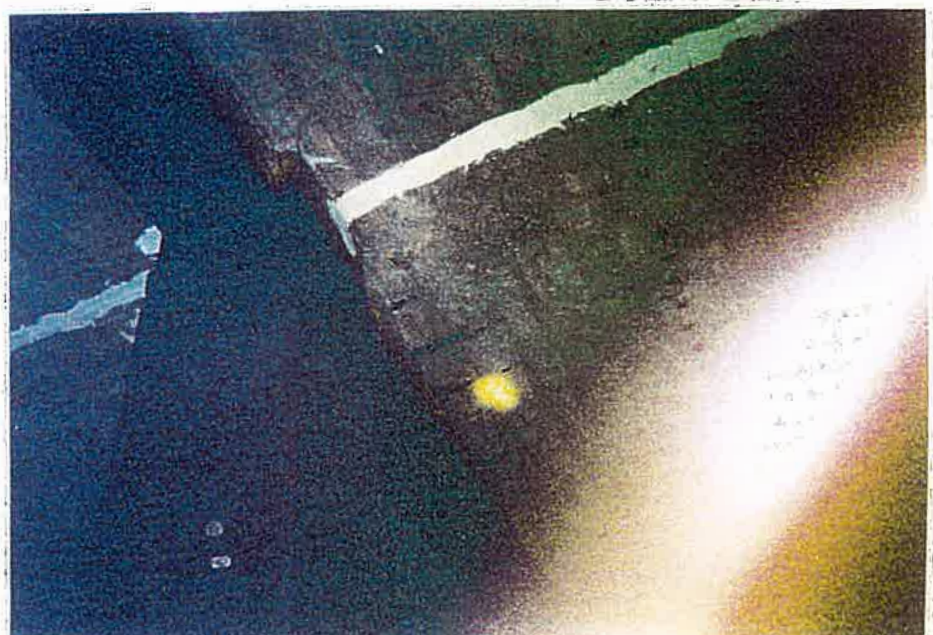

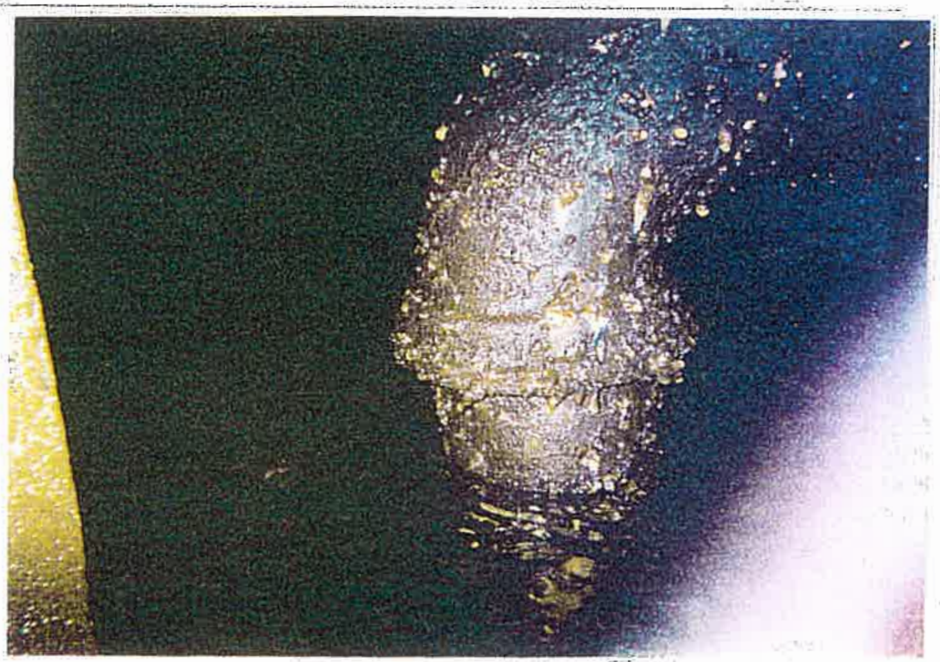

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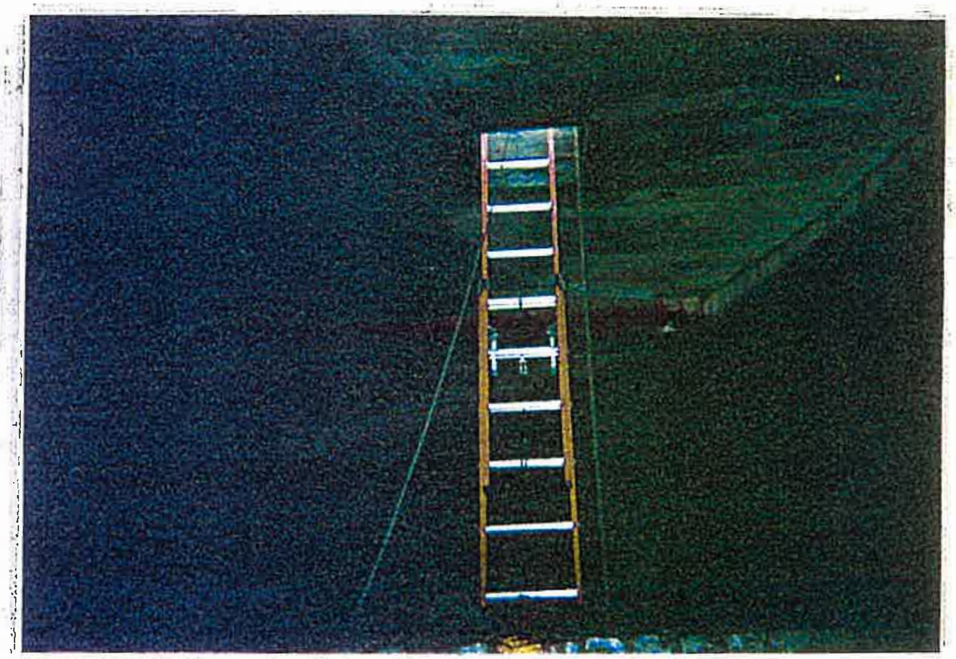

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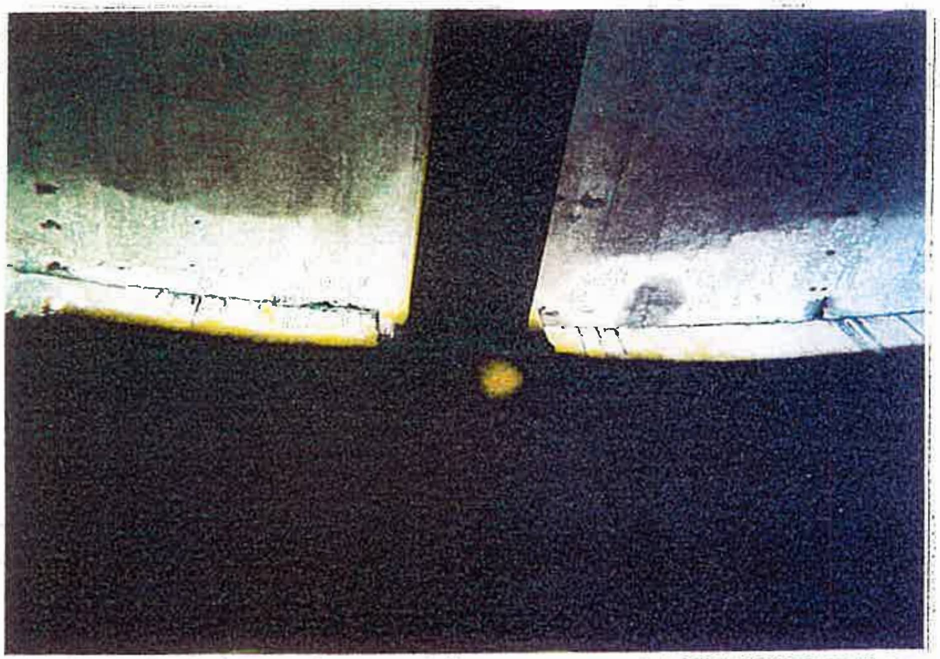

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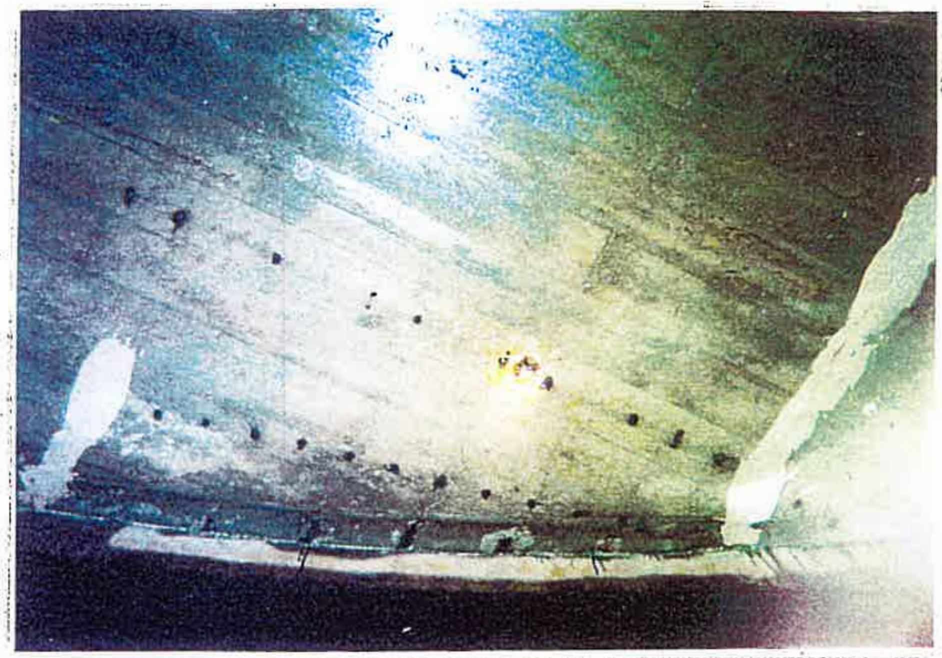

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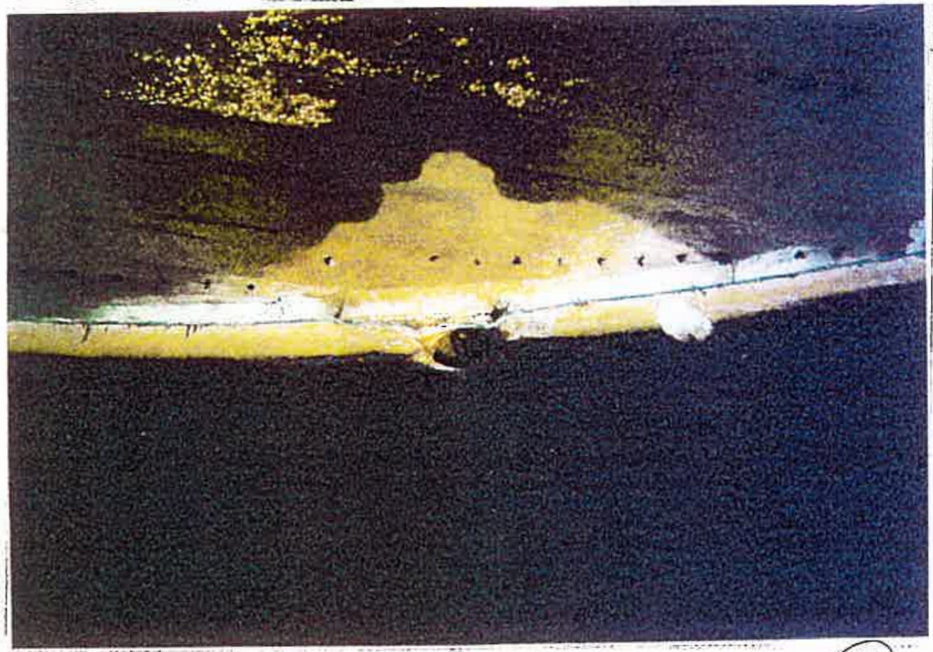

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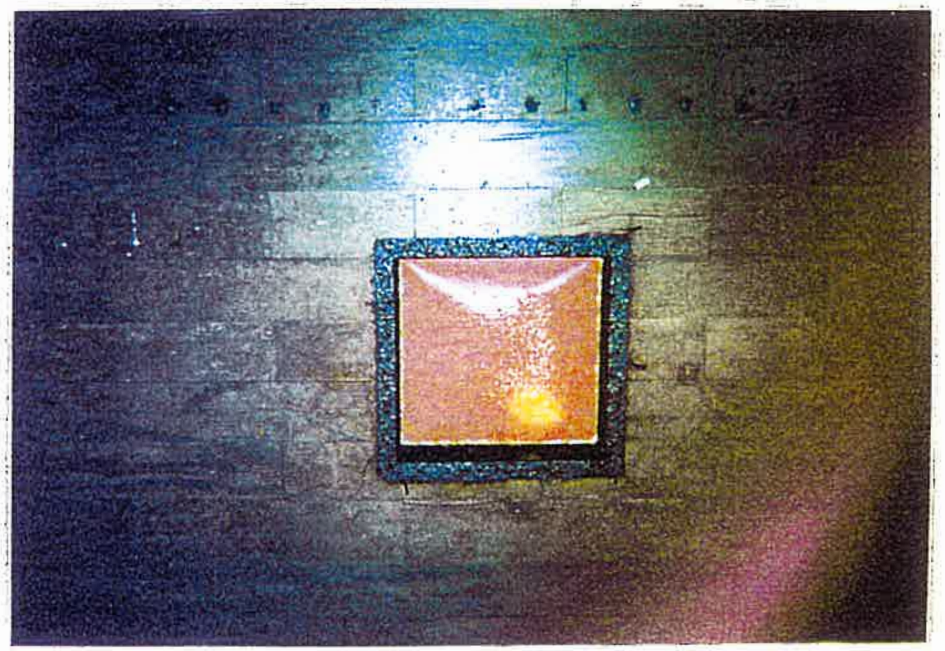

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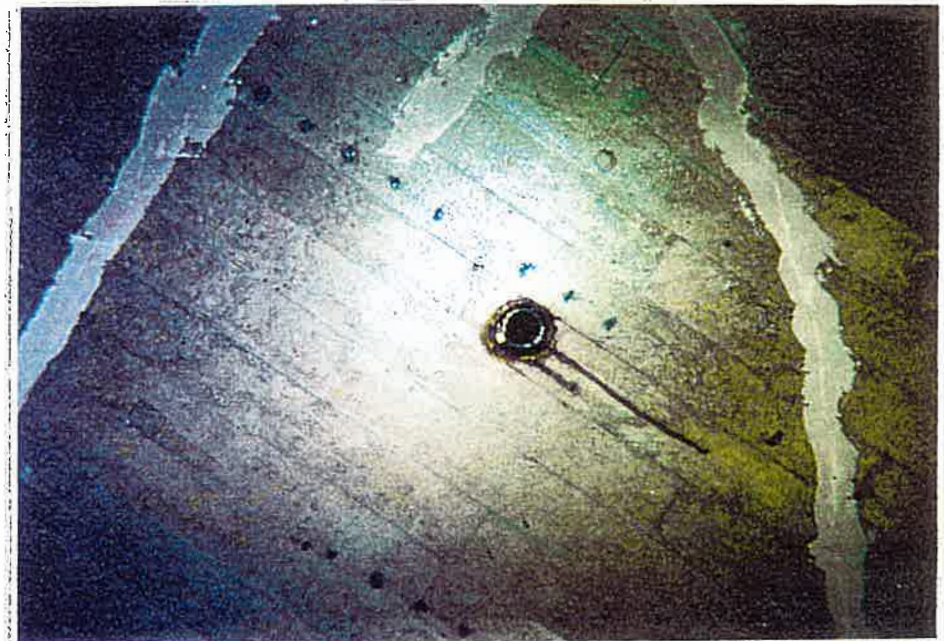

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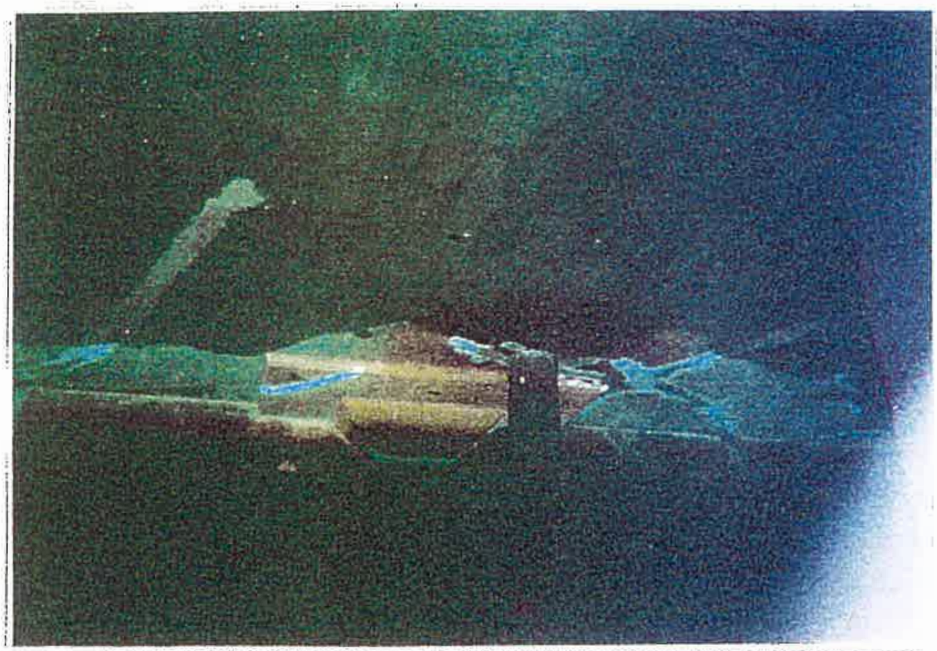

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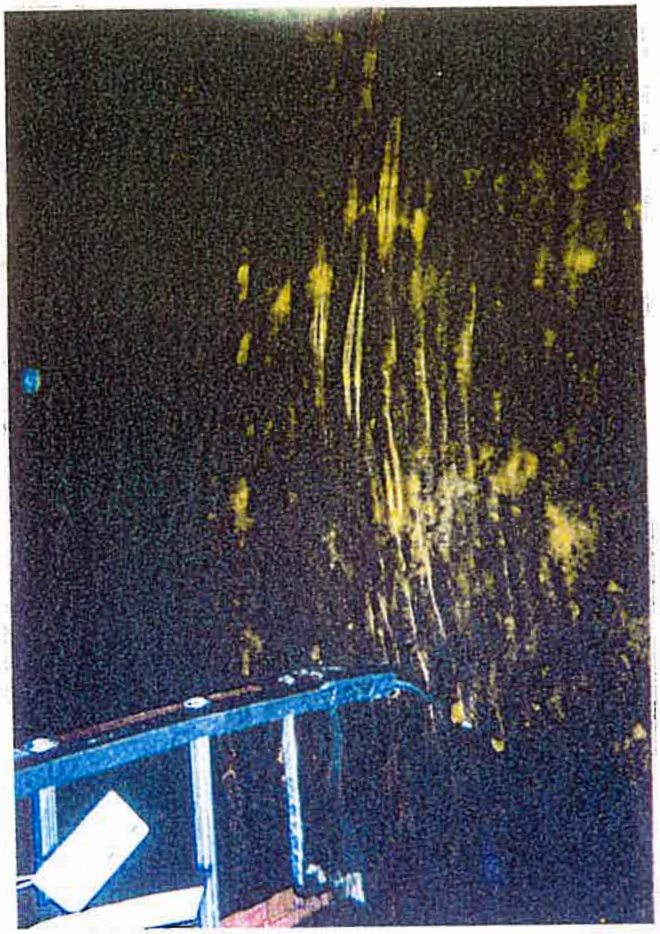

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State of Wisconsin
Department of Natural Resources
Box 7921, Madison, WI 53707-7921

# Reservoir Inspection Report



Notice: Under NR 811.08 (5), Wis. Adm. Code, municipalities are required to empty and inspect water storage facilities at least once every 5 years and perform maintenance as necessary. Use this form as a checklist of inspection requirements, and provide a copy of the completed form to the DNR Area Engineer within 30 days of completing the inspection. Personal information collected is unlikely to be used for other purposes.

## Tank Information

Tank Owner (Municipality) Name: City of Kaukauna
Facility Identifier FID #:

Tank Location: Address: 305 Elm Street | City: Kaukauna | State: WI | ZIP Code: 54130

Type of Tank (check one): [X] Ground (below grade) [ ] Elevated (above grade) [ ] Other Round Tank

Constructed By (Company Name): Unknown | Construction Date: ± 1930

## Inspection Information

Inspection Company: McMahon Associates, Inc | Inspector Name: Jeffrey A. Kellner | Inspection Date: 4-16-03

Company Address: 1445 McMahon Drive Neenah, WI 54956 | Telephone Number: (920) 751-4200

Current Certifications (check all that apply)
[ ] National Assoc. of Corrosion Engineers (NACE) [ ] American Welders Society (AWS)
[X] Steel Structures Painting Council (SSPC) [X] Other Wisconsin Professional Engineer

Type of Inspection Performed (check all that apply)
[X] Completely Drain [ ] Float-down [ ] Dive [ ] Other drained to 16" of water remaining at wall

## Ground Reservoir -- Exterior Information

Number of Vents: [ ] 0 [ ] 1 [X] 2 [ ] 3 | Are vents screened? [X] Yes [ ] No | Is venting adequately sized? [X] Yes [ ] No

Size of Overflow: 6 inch | Subject to flooding? [ ] Yes [X] No | Screened? flapper gate [ ] Yes [ ] No | Splash pad below? [ ] Yes [X] No | How high above the splash pad is the overflow? 36"

Raised access manhole? [X] Yes [ ] No | If yes, does cover overlap? [X] Yes [ ] No | Is cover airtight? [X] Yes [ ] No | Is cover locked securely? [X] Yes [ ] No

Condition of Exposed Concrete: [ ] Excellent [X] Good [ ] Fair [ ] Poor | Cracking or spalling? [X] Yes [ ] No minor cracks | Efflorescence present? [ ] Yes [X] No

Comments

Foundation (if visible) Not Visible

Settling? [ ] Yes [X] No | Cracks? [ ] Yes [X] No | Deterioration? [ ] Yes [X] No

Comments

## Ground Reservoir -- Interior Information

Ladders? [ ] Yes [X] No | If yes, how many present? [ ] 1 [ ] 2 | Ladder Type ( e.g., steel rungs poured in-place in concrete)

Sump present? [X] Yes [ ] No | If yes, condition: [X] Excellent [ ] Good [ ] Fair [ ] Poor

Amount of Sediment: < 1/2" | Sediment Deposit Locations: [X] Distributed Evenly [ ] Center [ ] Near Overflow [ ] Edges | Removed as part of the inspection? [ ] Yes [X] No

Baffle wall present? [X] Yes [ ] No | If yes, evidence of spalling or cracking? [X] Yes [ ] No | Walls/floor cracking? [X] Yes [ ] No | Other Problems: Wall cracks were previously repaired. No new cracks.

Piping inside of tank? [X] Yes [ ] No | If yes, condition (check all that apply): [X] Good [ ] Pitting [ ] Corrosion [ ] Need Repainting

## Elevated Reservoir -- Exterior Information

Type of Reservoir: [ ] Single Pedestal Spheroid [ ] Ellipsoidal [ ] Fluted Pillar [ ] Glass-lined

Foundation Condition (check all that apply): [ ] Signs of Settlement [ ] Shrubs or Trees Encroaching on Foundation [ ] Anchor Bolts/Chairs Deteriorating [ ] Concrete Spalled, Cracked or Deteriorating [ ] Grout Deteriorating

## Base Section

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

## Bowl/Conical Section

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

## Equator/Sidewall Section

No. of Sections

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

## Roof

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

## Elevated Reservoir -- Interior Information

Ladders? ☐ Yes ☐ No

If yes, how many present? ☐ 1 ☐ 2

Ladder Type

Amount of Sediment

Sediment Deposit Locations: ☐ Distributed Evenly ☐ Center ☐ Near Overflow ☐ Edges

Removed as part of the inspection? ☐ Yes ☐ No

Piping inside of tank? ☐ Yes ☐ No

If yes, condition (check all that apply): ☐ Good ☐ Pitting ☐ Corrosion ☐ Need Repainting

## Other Information

### Samples and Testing

Were any coating samples taken? ☐ Yes ☐ No

Was an adhesion test performed? ☐ Yes ☐ No

Were any coating samples test for lead? ☐ Yes ☐ No

Valve Pit General Condition: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Thickness samples? ☐ Yes ☐ No

Condition of Pipes in the Pit: ☐ Excellent ☐ Good ☐ Fair ☐ Poor

Type of Controls Present: ☐ Pressure Valve ☐ Pressure Gage ☐ SCADA

Is the pit insulated? ☐ Yes ☐ No

### Riser/Access Area

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

### Access Ladder

Access ladder present? ☐ Yes ☐ No

Safety climb device? ☐ Yes ☐ No

Locking access door/hatch? ☐ Yes ☐ No

### Platforms

Is condensate drained properly? ☐ Yes ☐ No

### Lighting

Explosion proof housings? ☐ Yes ☐ No

Enough light for safety? ☐ Yes ☐ No

Are items stored in pedestal base? ☐ Yes ☐ No

If yes, identify.

### Accessories

Cathodic protection? ☐ Yes ☐ No

Cathodic Type: ☐ Hanging ☐ Rod ☐ Net

Date Last Evaluated

Condition at Time: ☐ Excellent ☐ Good ☐ Fair ☐ Poor

Aviation lights? ☐ Yes ☐ No

Antennae? ☐ Yes ☐ No

Antennae interfering with tank operation? ☐ Yes ☐ No

## Tank Maintenance Information

Were any photos or videos taken of the tank during the inspection? ☒ Yes ☐ No

Did the inspection reveal any problem that requires additional work to complete? ☒ Yes ☐ No See attached report.

## Signatures

| Inspector Signature | | Date |
|---|---|---|
| [signature] | | 4/30/03 |
| Municipal Official Signature | Title | Date |
| | | |

State of Wisconsin
Department of Natural Resources
Box 7921, Madison, WI 53707-7921

# Reservoir Inspection Report

Form 3300-248 (10/99)



**Notice:** Under NR 811.08 (5), Wis. Adm. Code, municipalities are required to empty and inspect water storage facilities at least once every 5 years and perform maintenance as necessary. Use this form as a checklist of inspection requirements, and provide a copy of the completed form to the DNR Area Engineer within 30 days of completing the inspection. Personal information collected is unlikely to be used for other purposes.

## Tank Information

Tank Owner (Municipality) Name: City of Kaukauna

Facility Identifier FID #:

Tank Location: Address: 305 Elm St.

City: Kaukauna | State: WI | ZIP Code: 54130

Type of Tank (check one):
[X] Ground (below grade) [ ] Elevated (above grade) [ ] Other Rectangular

Constructed By (Company Name): Unknown

Construction Date: ± 1930

## Inspection Information

Inspection Company: McMahon Associates, Inc.

Inspector Name: Jeffrey A. Kellner

Inspection Date: 4-16-03

Company Address: 1445 McMahon Drive, Neenah, WI 54956

Telephone Number: (920) 751-4200

Current Certifications (check all that apply)
[ ] National Assoc. of Corrosion Engineers (NACE) [ ] American Welders Society (AWS)
[X] Steel Structures Painting Council (SSPC) [X] Other Wisconsin Professional Engineer

Type of Inspection Performed (check all that apply)
[X] Completely Drain [ ] Float-down [ ] Dive [ ] Other drained to 4" of water remaining at wall.

## Ground Reservoir -- Exterior Information

Number of Vents: [ ] 0 [ ] 1 [X] 2 [ ] 3

Are vents screened? [X] Yes [ ] No

Is venting adequately sized? [X] Yes [ ] No

Size of Overflow: 6 inch

Subject to flooding? [ ] Yes [X] No

Screened? [X] Yes [ ] No

Splash pad below? [ ] Yes [X] No

How high above the splash pad is the overflow? 16"

Raised access manhole? [X] Yes [ ] No

If yes, does cover overlap? [X] Yes [ ] No

Is cover airtight? [X] Yes [ ] No

Is cover locked securely? [X] Yes [ ] No

Condition of Exposed Concrete: [ ] Excellent [X] Good [ ] Fair [ ] Poor

Cracking or spalling? [X] Yes [ ] No minor cracks

Efflorescence present? [ ] Yes [X] No

Comments: Tank is in good condition.

Foundation (if visible)

Settling? [ ] Yes [X] No Not visible

Cracks? [ ] Yes [X] No

Deterioration? [ ] Yes [X] No

Comments

## Ground Reservoir -- Interior Information

Ladders? [ ] Yes [X] No

If yes, how many present? [ ] 1 [ ] 2

Ladder Type ( e.g., steel rungs poured in-place in concrete)

Sump present? [X] Yes [ ] No

If yes, condition: [X] Excellent [ ] Good [ ] Fair [ ] Poor

Amount of Sediment: < 1/2"

Sediment Deposit Locations: [X] Distributed Evenly [ ] Center [ ] Near Overflow [ ] Edges

Removed as part of the inspection? [ ] Yes [X] No

Baffle wall present? [X] Yes [ ] No

If yes, evidence of spalling or cracking? [X] Yes [ ] No

Walls/floor cracking? [X] Yes [ ] No

Other Problems: Walls were previously repaired. No new cracks.

Piping inside of tank? [X] Yes [ ] No

If yes, condition (check all that apply): [X] Good [ ] Pitting [ ] Corrosion [ ] Need Repainting

## Elevated Reservoir -- Exterior Information

Type of Reservoir
[ ] Single Pedestal Spheroid [ ] Ellipsoidal
[ ] Fluted Pillar [ ] Glass-lined

Foundation Condition (check all that apply)
[ ] Signs of Settlement [ ] Shrubs or Trees Encroaching on Foundation
[ ] Anchor Bolts/Chairs Deteriorating [ ] Concrete Spalled, Cracked or Deteriorating
[ ] Grout Deteriorating

**Base Section**

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

**Bowl/Conical Section**

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

**Equator/Sidewall Section**

No. of Sections

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

**Roof**

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

**Elevated Reservoir – Interior Information**

Ladders? ☐ Yes ☐ No

If yes, how many present? ☐ 1 ☐ 2

Ladder Type

Amount of Sediment

Sediment Deposit Locations: ☐ Distributed Evenly ☐ Center ☐ Near Overflow ☐ Edges

Removed as part of the inspection? ☐ Yes ☐ No

Piping inside of tank? ☐ Yes ☐ No

If yes, condition (check all that apply): ☐ Good ☐ Pitting ☐ Corrosion ☐ Need Repainting

**Other Information**

**Samples and Testing**

Were any coating samples taken? ☐ Yes ☐ No

Was an adhesion test performed? ☐ Yes ☐ No

Were any coating samples test for lead? ☐ Yes ☐ No

Valve Pit General Condition: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Thickness samples? ☐ Yes ☐ No

Condition of Pipes in the Pit: ☐ Excellent ☐ Good ☐ Fair ☐ Poor

Type of Controls Present: ☐ Pressure Valve ☐ Pressure Gage ☐ SCADA

Is the pit insulated? ☐ Yes ☐ No

**Riser/Access Area**

General Condition of Paint: ☐ Excellent ☐ Fair ☐ Good ☐ Poor

Describe any failings of coating.

**Access Ladder**

Access ladder present? ☐ Yes ☐ No

Safety climb device? ☐ Yes ☐ No

Locking access door/hatch? ☐ Yes ☐ No

**Platforms**

Is condensate drained properly? ☐ Yes ☐ No

**Lighting**

Explosion proof housings? ☐ Yes ☐ No

Enough light for safety? ☐ Yes ☐ No

Are items stored in pedestal base? ☐ Yes ☐ No

If yes, identify.

**Accessories**

Cathodic protection? ☐ Yes ☐ No

Cathodic Type: ☐ Hanging ☐ Rod ☐ Net

Date Last Evaluated

Condition at Time: ☐ Excellent ☐ Good ☐ Fair ☐ Poor

Aviation lights? ☐ Yes ☐ No

Antennae? ☐ Yes ☐ No

Antennae interfering with tank operation? ☐ Yes ☐ No

**Tank Maintenance Information**

Were any photos or videos taken of the tank during the inspection? ☒ Yes ☐ No

Did the inspection reveal any problem that requires additional work to complete? ☐ Yes ☒ No See attached report.

**Signatures**

Inspector Signature: Jeffrey A. Kallner

Date: 4-30-03

Municipal Official Signature

Title

Date

# APPENDIX E

## PROJECTED FLOW INFORMATION

Kaukauna ON THE FOX

March 20, 2002

Terry Johnson, P.E.
4135 Technology Parkway
Sheboygan, WI 53083

RE: Projected Sanitary Flows – Kaukauna

Dear Terry:

Attached please find the sanitary sewer flow projections for the City of Kaukauna. These flows are based on the City's ability to treat requested subdivisions, the ability to provide water and other essential municipal services and that the area would be contained in the political subdivision.

The territory in which flows are projected are contained within the enclosed map. As with all developments, the location and extent of development is a function of several factors including economic, transportation and market wants.

Should you have any questions or comments on this matter, please feel free to contact this office at (920) 766-6315 or via e-mail at planning@kaukauna-wi.org.

Sincerely,

JAKEL

Robert L. Jakel, AICP
Director of Planning and Community Development

Enclosure

201 WEST SECOND STREET · PO BOX 890 · KAUKAUNA, WISCONSIN 54130-0890

JAN-02-03 10:18 From:CIVIL 9204583644 T-538 P.02/04 Job-079

| | | | Acres | Population |
|---|---|---|---|---|
| 2020 Projection | North | Residential | 280 | 1,000 |
| | | Commercial | 60 | - |
| | | Industrial | 160 | - |
| | South | Residential | 1,900 | 3,800 |
| | | Commercial | 150 | - |
| | | Industrial | 40 | - |
| 2040 Projection | North | Residential | 700 | 3,000 |
| | | Commercial | 140 | - |
| | | Industrial | 210 | - |
| | South | Residential | 4,500 | 9,000 |
| | | Commercial | 310 | - |
| | | Industrial | 110 | - |

The above acreages do not include open space, wetlands, parks or environmental corridors. The acreage does include road right of way, neighborhood parks (less than two acres) and storm water detention facilities.

It should be noted that the 2040 projections are a copulation of the 2020 projections plus the projected growth from 2020 to 2040.

KA= 4,190 AC
EA= 13,624 AC
NA= 2,208 AC
SA= 7,226 AC

# FAX

To: AMY VACLAVIK
Company: McMAHON

From: TERRY JOHNSON

Address: **Sheboygan, WI**
4135 Technology Parkway
Sheboygan, WI 53083

Project #:
Subject: KAUKAUNA

Date: 1/2/03
Fax #: 920-751-4287

Ext. #:

Sending From Fax #:
_ (920) 458-0537
_ (920) 458-0550
_ (920) 458-8771
_ (920) 458-0948
_ (920) 458-3644

Comments: ATTACHED IS LETTER OF 3/20/02 FROM KAUKAUNA

If you do not receive 4 Pages (including cover page), please call us as soon as possible at (920) 458-8711

EARTH TECH
A tyco INTERNATIONAL LTD. COMPANY

9204583644 I-538 P.01/04 Job-079

# APPENDIX F

GROUNDWATER FLOW MODEL SIMULATIONS BY USGS

Mr. Gary Rosenbeck
McMahon and Associates Inc.
1445 McMahon Drive
Neenah WI 54957-1025

May 21, 2003

Dear Gary,

Enclosed are the results of the additional groundwater flow model simulation for the city of Kaukauna that you requested in our recent phone conversation. Plot 6 shown below represents the difference between **Foxss1997** and **Foxss1997_25nogbkau.** Please let me know if more explanation or simulations are needed.

Sincerely,

Jim

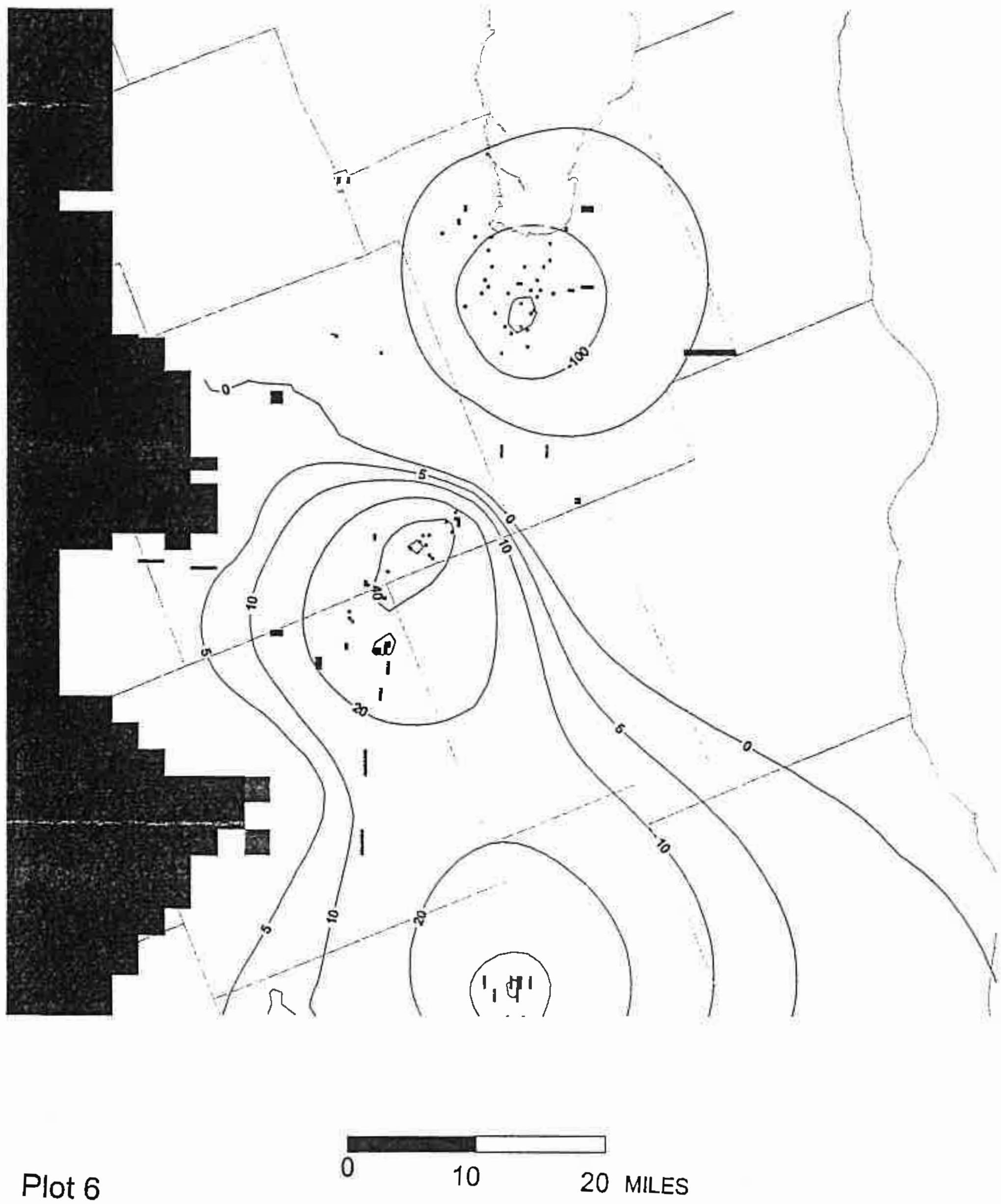
Jim Krohelski
Hydrologist

## Simulations

1. **Foxss1997** has updated 1997 pumpages for the Green Bay metropolitan area municipal wells. All other wells pump at rates as reported in Conlon (1998), which represent 1990 conditions.

2. **Foxss1997_25nogbkau** has all Green Bay metro wells turned off, a 25 percent increase in pumping rates for all other wells except pumping rates as follows: Kimberly wells - well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells - well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD.

Drawdown and drawup (recovery) due to changing pumping rates as follows: Kimberly wells: well 1 from 257200 to 600000 GPD; well 2 from 548700 to 00000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells: well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD. All Green Bay metro wells are turned off rates and all other wells have a 25 percent increase in pumping of 1990 rates as reported by Conlon (1998). Maximum drawdown is 66 feet and the maximum drawup is -215 feet determined by subtracting simulated heads in Foxss1997_25nogbkau from simulated heads in Foxss1997. Contour intervals are -200, -100, -50, 0, 5, 10, 20, 40, and 60 feet.




Plot 6

May 21, 2003

USGS
science for a changing world

Mr. Gary Rosenbeck
McMahon and Associates Inc.
1445 McMahon Drive
Neenah WI 54957-1025

May 13, 2003

Dear Gary,

Enclosed are the results of the groundwater flow model simulations for the city of Kaukauna that you requested in your letter of April 28, 2003. The Fox Cities groundwater model documented in Conlon (1998) was used for the simulations. I have followed the same format to present results for the city of Kaukauna as was used for the Kimberly request that was done last October. The objective of the simulations was to show the amount of drawdown due to changes in the pumping rates of Kimberly wells 1, 2, and 3 and Kaukauna wells 4, 5, 8, 9, and 10(6). Three base case simulations were run: 1) Foxss1997, 2) Foxss1997_25, and 3) Foxss1997_25nogb. These simulations are described below. The drawdown or drawup (recovery) caused by two of the base cases (Foxss1997_25, and Foxss1997_25nogb) are shown in plots 2 and 3. The drawdown due to changes in the pumping rates of the Kimberly and Kaukauna wells are also simulated in three simulations 1) Foxsskau 2) Foxss1997_25kau, and 3) Foxss1997_25nogbkau. These simulations are compared to the base cases to determine drawdown as shown in plots 1, 4, and 5. Please let me know if you need more information or want to discuss the results.

Sincerely,

Jim Krohelski
Hydrologist

## Simulations

1. **Foxss1997** has updated 1997 pumpages for the Green Bay metropolitan area municipal wells. All other wells pump at rates as reported in Conlon (1998), which represent 1990 conditions.

2. **Foxsskau** is the same as **Foxss1997** but with pumping rates as follows: Kimberly wells - well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells - well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD.

3. **Foxss1997_25** is the same as **Foxss1997** but all well pumping rates have been increased by 25 percent

4. **Foxss1997_25nogb** is the same as **Foxss1997_25** but all Green Bay metropolitan municipal wells have been turned off (deleted) (see table).

5. **Foxss1997_25kau** is the same as **Foxss1997_25** but with pumping rates as follows: Kimberly wells - well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells - well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD.

6. **Foxss1997_25nogbkau** is the same as **Foxss1997_25nogb** but with pumping rates as follows: Kimberly wells - well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells - well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD.

## Plots

1. **Drawdown** due to pumping rates as follows: Kimberly wells - well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells - well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD. Green Bay metro wells are pumping at 1997 rates and all other wells are pumping at 1990 rates as reported by Conlon (1998). Maximum drawdown is 56 feet determined by subtracting simulated heads in **Foxsskau** from simulated heads in **Foxss1997.**

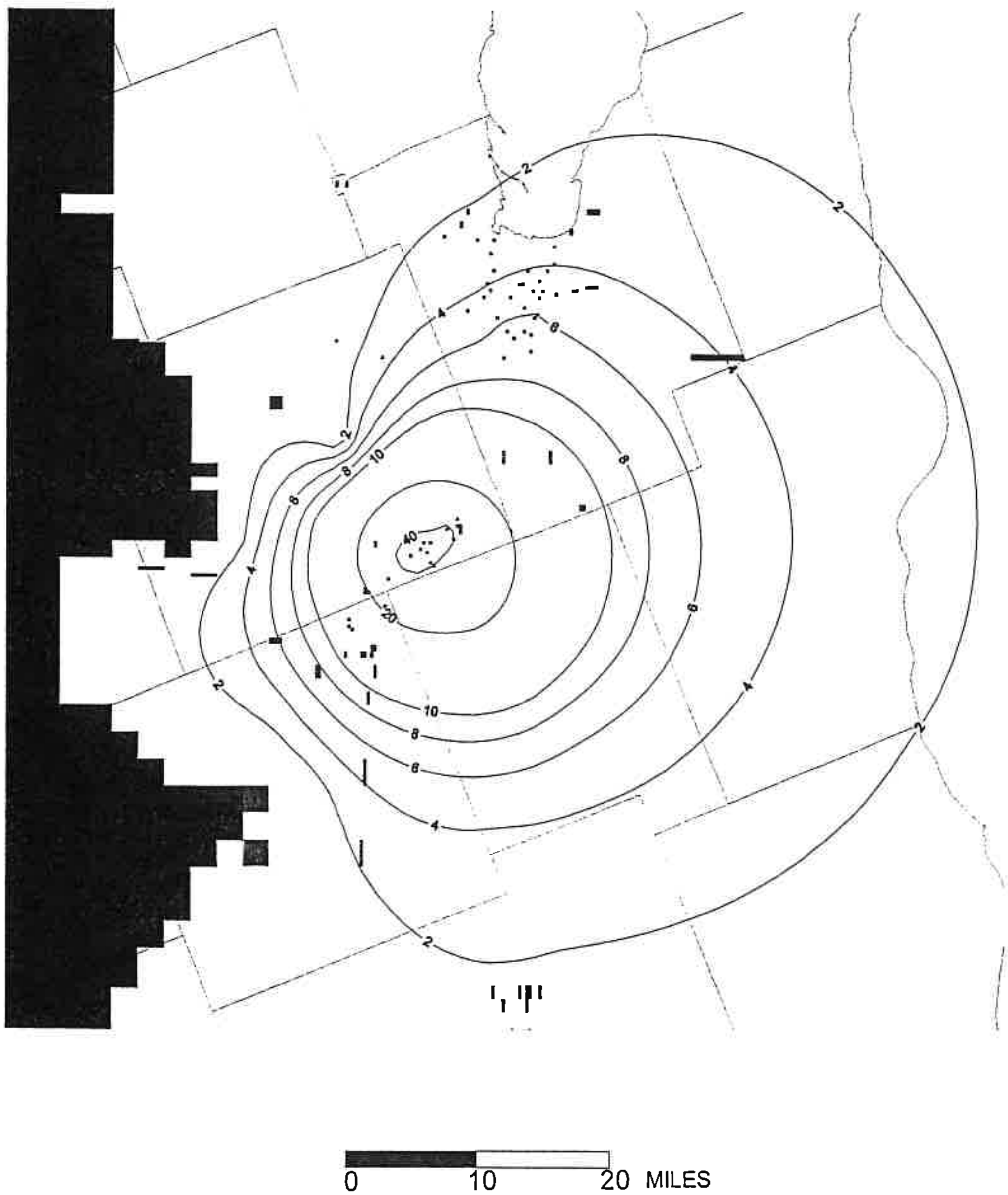
2. **Drawdown** due to increasing pumping rates for all wells by 25 percent over Green Bay metro wells 1997 rates and all other wells over 1990 rates as reported by Conlon (1998). Maximum drawdown is 100 feet in the Green Bay metropolitan area and 70 feet in the Fox Cities area determined by subtracting simulated heads in **Foxss1997_25** from simulated heads in **Foxss1997**.

3. **Drawup** (recovery) due to turning off all Green Bay metropolitan municipal wells (see table). Pumping rates for all other wells are increased by 25 percent over 1990 rates as reported by Conlon (1998). Maximum drawup is 316 feet (note the drawup is negative on plot contours) determined by subtracting simulated heads in **Foxss1997_25nogb** from simulated heads in **Foxss1997_25**.

4. **Drawdown** due to pumping rates as follows: Kimberly wells - well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells - well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD. Pumping rates for all other wells are increased by 25 percent over Green Bay metropolitan municipal wells 1997 rates and other wells over 1990 rates as reported by Conlon (1998). Maximum drawdown is 39 feet determined by subtracting simulated heads in **Foxss1997_25kau** from simulated heads in **Foxss1997_25**

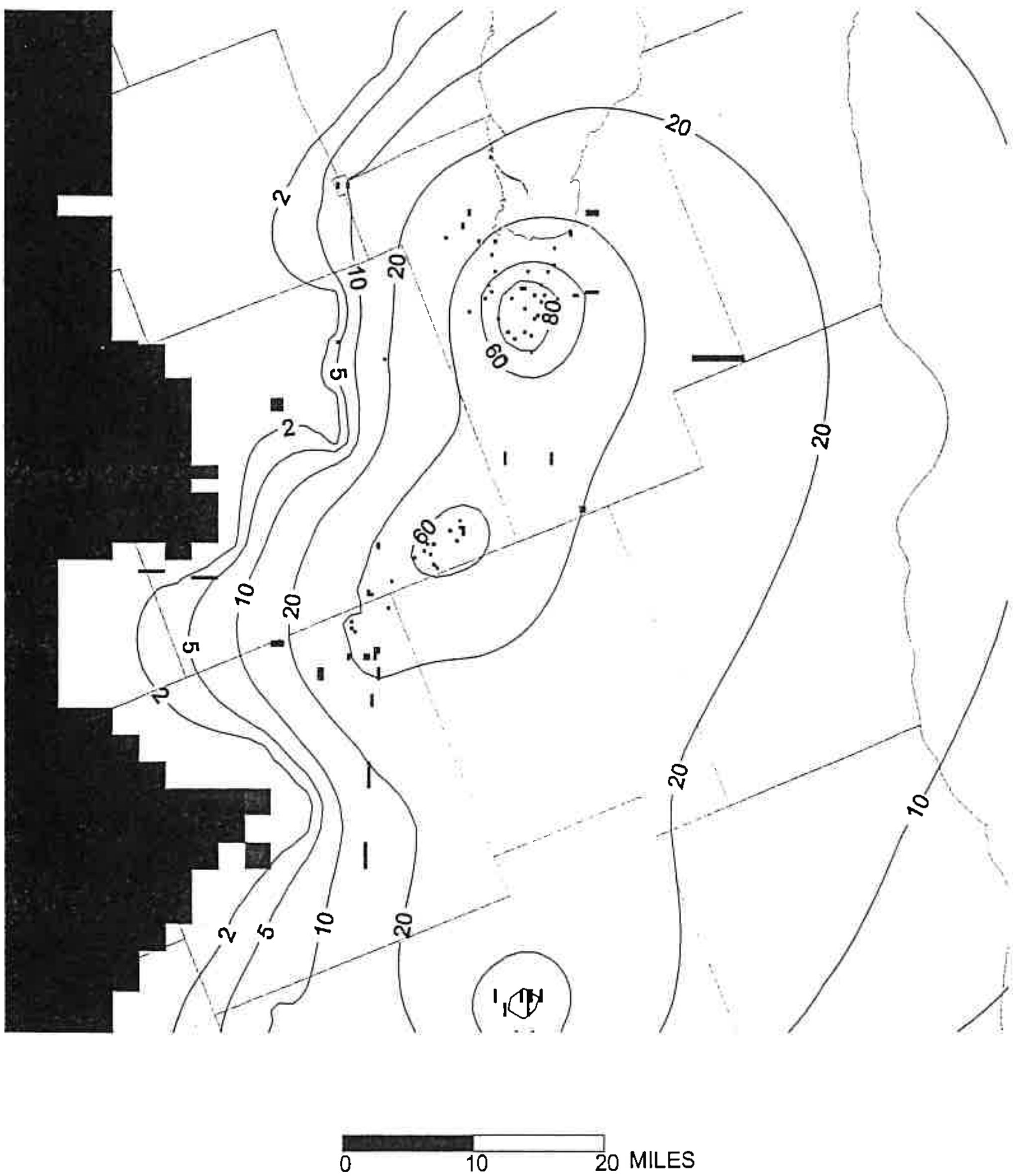
5. **Drawdown** due to pumping rates as follows: Kimberly wells - well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells - well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD. All Green Bay metropolitan municipal wells are turned off and all other wells are pumping at a 25 percent increase over1990 rates as reported by Conlon (1998). Maximum drawdown is 34 feet determined by subtracting simulated heads in **Foxss1997_25nogbkau** from simulated heads in **Foxss1997_25nogb**.

Drawdown due to changing pumping rates as follows: Kimberly wells: well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells: well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD. Green Bay metro wells are pumping at 1997 rates and all other wells are pumping at 1990 rates as reported by Conlon (1998). Maximum drawdown is 56 feet determined by subtracting simulated heads in Foxsskau from simulated heads in Foxss1997. Contour intervals are 2, 4, 6, 8, 10, 20, and 40 feet.



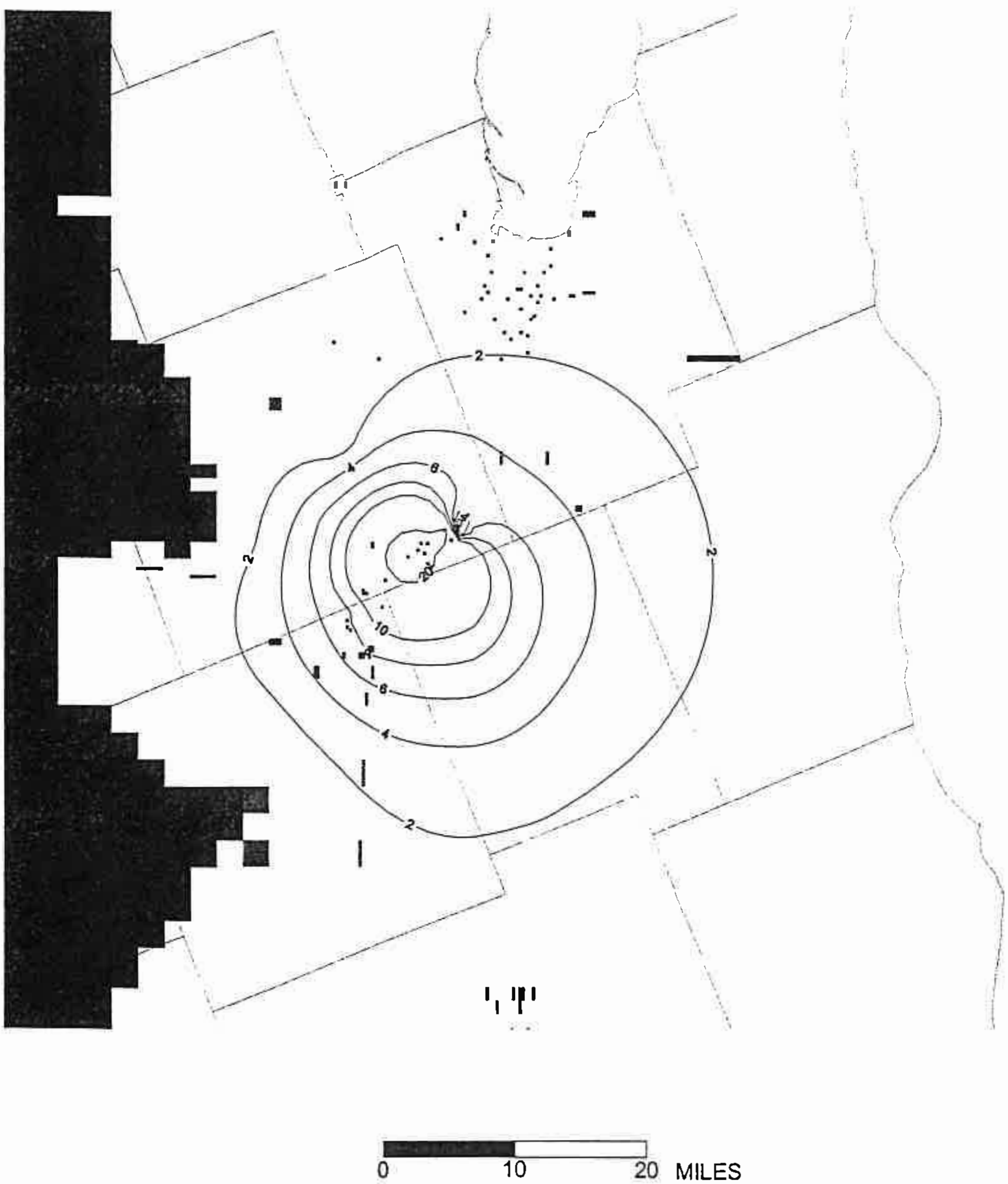

Plot 1

Drawdown due to increasing pumping rates for all wells by 25 percent over Green Bay metro wells 1997 rates and all other wells over 1990 rates as reported by Conlon (1998). Maximum drawdown is 100 feet in the Green Bay metropolitan area and 70 feet in the Fox Cities area determined by subtracting simulated heads in Foxss1997_25 from simulated heads in Foxss1997. Contour intervals are 2, 5, 10, 20, 40, 60, and 80 feet.



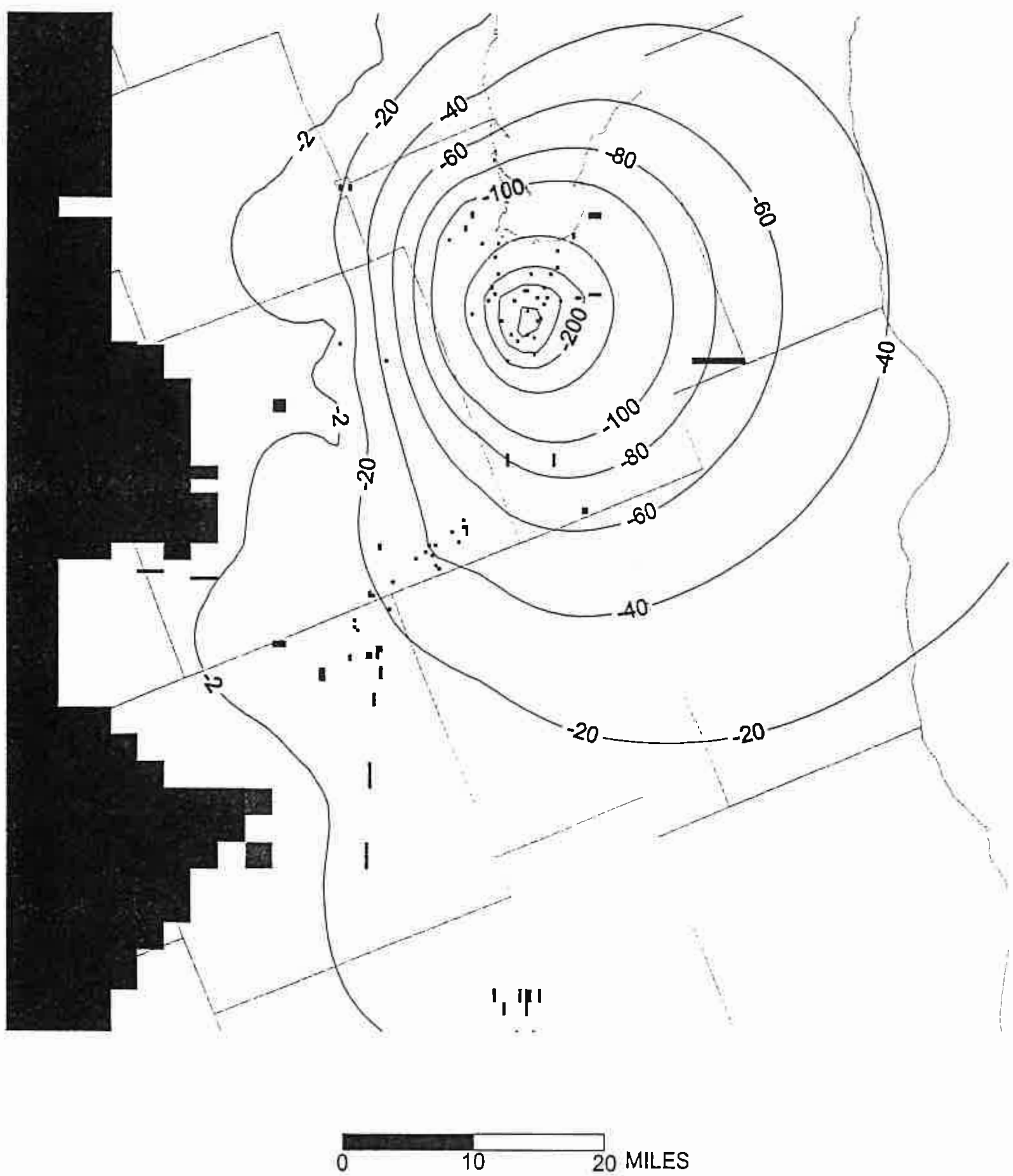

Plot 2

Drawdown due to changing pumping rates as follows: Kimberly wells: well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells: well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD. All Green Bay metro wells are turned off and all other wells are pumping at 1990 rates as reported by Conlon (1998). Maximum drawdown is 34 feet determined by subtracting simulated heads in Foxss1997_25nogbkau from simulated heads in Foxss1997_25nogb. Contour intervals are 2, 4, 6, 8, 10, and 20 feet.



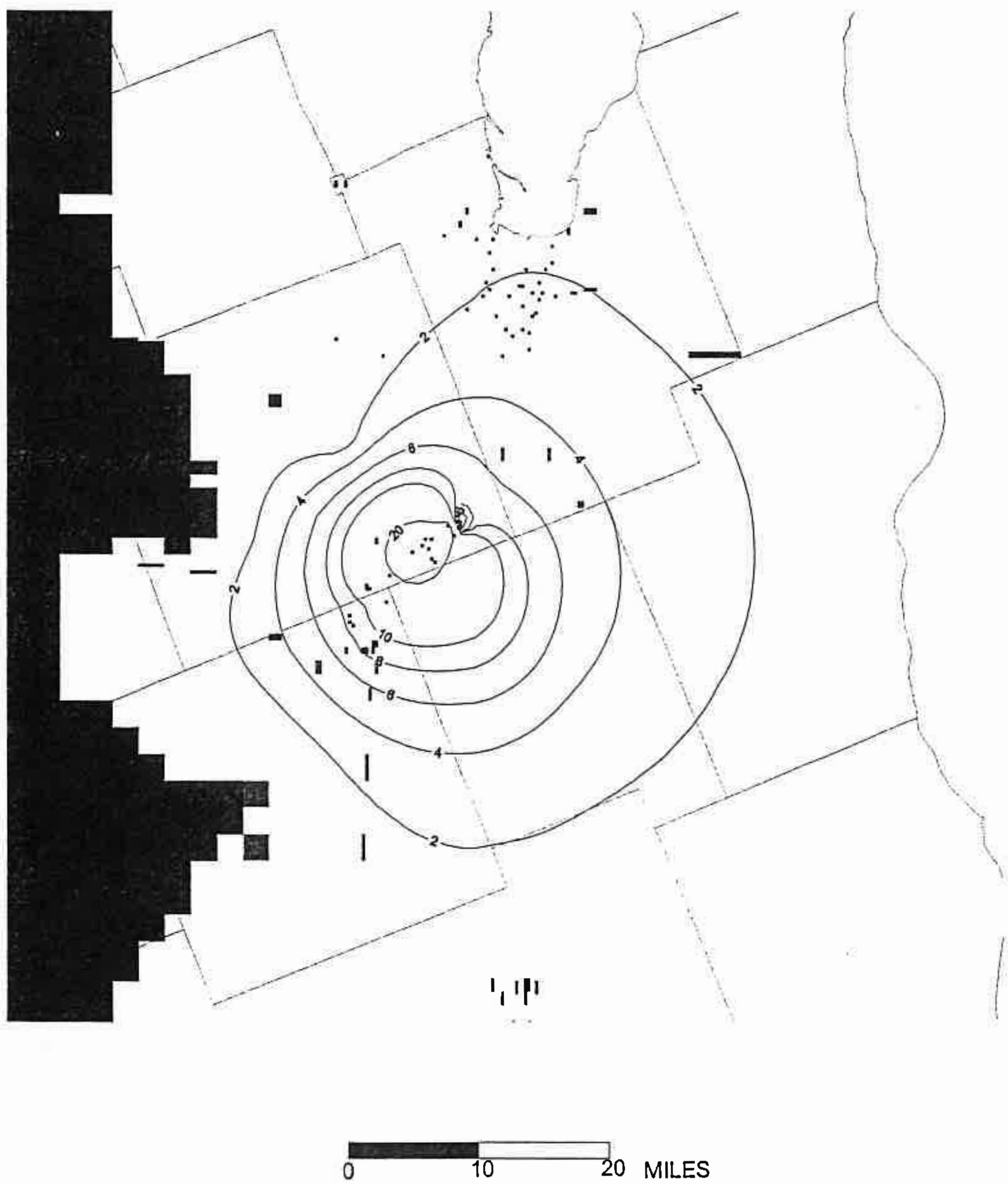

Plot 5

Drawup (recovery) due to turning off all Green Bay metropolitan municipal wells (see table). Pumping rates for all other wells are increased by 25 percent over 1990 rates as reported by Conlon (1998). Maximum drawup is 316 feet (note the drawup is negative on plot contours) determined by subtracting simulated heads in Foxss1997_25nogb from simulated heads in Foxss1997_25. Contour intervals are -2, -20, -40, -60, -80, -100, -150, -200, -250, and -300 feet.




Plot 3

Drawdown due to changing pumping rates as follows: Kimberly wells: well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells: well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD ; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD. Pumping rates for all other wells are increased by 25 percent over Green Bay metropolitan municipal wells 1997 rates and other wells over 1990 rates as reported by Conlon (1998). Maximum drawdown is 39 feet determined by subtracting simulated heads in Foxss1997_25kau from simulated heads in Foxss1997_25. Contour intervals are 2, 4, 6, 8, 10, 20, and 40 feet.




Plot 4

Table 1. - Green Bay metropolitan municipal wells

| Layer | Row | Column | Local Well Number | Owner |
|---|---|---|---|---|
| 2 | 38 | 77 | BN-23/20E/12-0024 | Allouez Well # 1 |
| 2 | 40 | 79 | BN-23/20E/13-0023 | Allouez Well # 2 |
| 2 | 45 | 77 | BN-23/20E/23-0113 | Allouez Well # 3 |
| 2 | 44 | 78 | BN-23/20E/13-0144 | Allouez Well # 4 |
| 2 | 42 | 74 | BN-23/20E/14-0166 | Allouez Well # 5 |
| 2 | 38 | 80 | BN-23/20E/12-0285 | Allouez Well # 6 |
| 2 | 35 | 79 | BN-23/20E/PC-0770 | Allouez Well # 7 |
| 2 | 36 | 73 | BN-23/20E/02-0084 | Ashwaubenon Well # 1 |
| 2 | 39 | 70 | BN-23/20E/10-0130 | Ashwaubenon Well # 2 |
| 2 | 39 | 62 | BN-23/20E/05-0146 | Ashwaubenon Well # 3 |
| 2 | 45 | 66 | BN-23/20E/16-0147 | Ashwaubenon Well # 4 |
| 2 | 37 | 64 | BN-23/20E/04-0295 | Ashwaubenon Well # 5 |
| 2 | 43 | 57 | BN | Ashwaubenon Well # 6 |
| 2 | 37 | 91 | BN-23/21E/22-0138 | Bellevue Well # 1 |
| 2 | 38 | 89 | BN-23/21E/17-0291 | Bellevue Well # 2 |
| 2 | 39 | 84 | BN | Bellevue Well # 3 |
| 2 | 49 | 74 | BN-23/20E/PC-0067 | De Pere Well # 1 |
| 2 | 51 | 71 | BN-23/20E/28-0128 | De Pere Well # 2 |
| 2 | 49 | 69 | BN-23/20E/21-0132 | De Pere Well # 3 |
| 2 | 50 | 76 | BN-23/20E/27-0107 | De Pere Well # 4 |
| 2 | 55 | 76 | BN-23/20E/34-0139 | De Pere Well # 5 |
| 2 | 57 | 68 | BN | De Pere Well 6 Shuering |
| 2 | 20 | 88 | BN-24/21E/26-0129 | GB # 2 Highway 54 & 57 |
| 2 | 24 | 83 | BN-24/21E/28-0145 | GB # 3 Eastman & Danz |
| 2 | 29 | 83 | BN-23/21E/32-0021 | GB # 4 Deckner and Henry |
| 2 | 31 | 81 | BN-24/21E/06-0005 | GB # 5 Cass and Goodell |
| 2 | 31 | 75 | BN-24/20E/36-0006 | GB # 6 Mason and Adams |
| 2 | 31 | 65 | BN-24/20E/27-0007 | GB # 7 7th and Military |
| 2 | 35 | 63 | BN-24/20E/33-0099 | GB # 8 Highland |
| 2 | 26 | 64 | BN-24/20E/22-0017 | GB # 9 Bond and Military |
| 2 | 22 | 65 | BN-24/20E/14-0100 | GB #10 Military & Tower |
| 2 | 22 | 60 | BN-24/20E/16-0127 | Howard Well # 1 |
| 2 | 21 | 50 | BN-24/20E/07-0161 | Howard Well # 2 |
| 2 | 17 | 57 | BN-24/20E/03-0299 | Howard Well # 3 |
| 2 | 17 | 91 | BN | Scott S.D. |

Mr. Gary Rosenbeck
McMahon and Associates Inc.
1445 McMahon Drive
Neenah WI 54957-1025

May 21, 2003

Dear Gary,

Enclosed are the results of the additional groundwater flow model simulation for the city of Kaukauna that you requested in our recent phone conversation. Plot 6 shown below represents the difference between **Foxss1997** and **Foxss1997_25nogbkau.** Please let me know if more explanation or simulations are needed.

Sincerely,

Jim

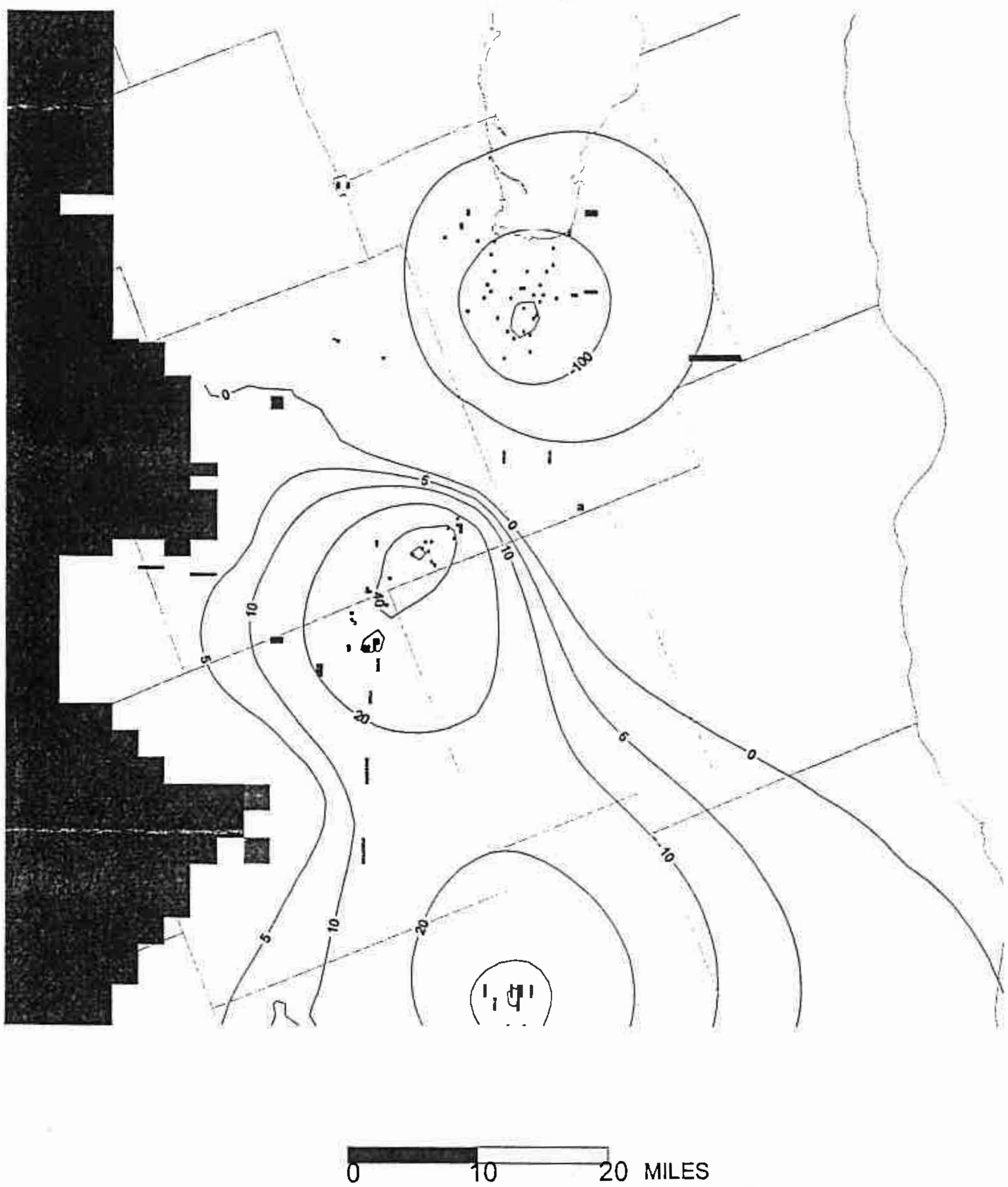
Jim Krohelski
Hydrologist

## Simulations

1. **Foxss1997** has updated 1997 pumpages for the Green Bay metropolitan area municipal wells. All other wells pump at rates as reported in Conlon (1998), which represent 1990 conditions.

2. **Foxss1997_25nogbkau** has all Green Bay metro wells turned off, a 25 percent increase in pumping rates for all other wells except pumping rates as follows: Kimberly wells - well 1 from 257200 to 600000 GPD; well 2 from 548700 to 400000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells - well 4 from 458800 to 440000 GPD; well 5 from 340960 to 176000 GPD; well 8 from 479500 to 176000 GPD; well 9 from 82000 to 192720 GPD; well 10 (6) from 129300 to 440000 GPD.

Drawdown and drawup (recovery) due to changing pumping rates as follows: Kimberly wells: well 1 from 257200 to 600000 GPD; well 2 from 548700 to 00000 GPD; well 3 from 454000 to 1300000 GPD and Kaukauna wells: well 4 from 458800 to 440000 GPD; well 5 from 340960 to 17600 0 GPD well 8 from 479500 to 176000 GPD; well 9 from 82 000 to 1 92720 GPD; well 10 (6) from 129300 to 440000 GPD All Green Bay metro wells are turned off rates and all other wells have a 25 percent increase in pumping of 1990 rates as reported by Conlon (1998). Maximum drawdown is 66 feet and the maximum drawup is -215 feet determined by subtracting simulated heads in Foxss1997_25nogbkau from simulated heads in Foxss1997. Contour intervals are -200, -100, -50, 0, 5, 10, 20, 40, and 60 feet.




Plot 6

# APPENDIX G

WISCONSIN DNR APPLICATION FOR
DHFS RADIONUCLIDE WASTEWATER DISPOSAL CRITERIA

# DNR Application of DHFS Radionuclide Wastewater Disposal Criteria

## For Cation and Anion Exchange Unit & Other Water Treatment Plant Wastewater Discharges Containing Radionuclides

# DRAFT

**Intent**: This document is solely intended to be used as an information guide for explaining and applying HFS 157 wastewater disposal criteria for wastewater containing naturally occurring radionuclides removed from well water that will be discharged to a sanitary sewer or directly to a publicly operated treatment works (POTW). Examples of applicable wastewater types include regeneration wastewater from cation and anion exchange units, backwash wastewater from filter units and wastewaster from membrane and electrodialysis reversal (EDR) units.

**Wastewater Description**: Regeneration wastewater from cation exchange softeners used to remove radium and water hardness (including backwash, brining and rinse wastewater) will contain high concentrations of chlorides. Regeneration wastewater from anion exchange units used to remove nitrates and uranium will contain high concentrations of sodium. The majority of the chlorides and/or sodium will be contained in the wastewater generated during the brining stage of regeneration. The wastewater chloride and/or sodium concentrations will likely exceed the allowable discharge limits for discharge to the ground surface or to a surface water body. Therefore, when conducting a review of cation or anion exchange units that regenerate using sodium chloride reviewers should ensure that the cation or anion exchange wastewater discharges to a sanitary sewer system. Discharge to a sanitary sewer system will also apply to the disposal of brackish wastewater from membrane and EDR units. Economics normally dictate that filter backwash wastewater be disposed of to a sanitary sewer although WPDES permits are occasionally granted for wastewater discharges to a detention pond or to surface water after pretreatment where sanitary sewers are not available. In almost all of the above cases the elevated radium and/or uranium content of the wastewater will dictate that the wastewater be discharged to a sanitary sewer. In some cases wastewater will need to be discharged to a holding tank. The wastewater will then need to be periodically hauled directly to the POTW for disposal.

**Unity Equation**: Acceptable levels of radium and uranium for discharge to sanitary sewer systems are calculated based upon the Unity Equation (see below) found in Appendix E of HFS 157. The average radium-226, radium-228 and total uranium (all as applicable) present in the wastewater will need to be calculated and inserted into the equation. Where the resultant number is less than or equal to one the proposed discharge to the sanitary sewer will be acceptable. Although most of the radionuclides will be released from cation and anion resins during the brining period of regeneration the total amount of radium and/or uranium calculated to be removed between each regeneration can be averaged over the total volume of wastewater collected for each regeneration. In the same way the amount of radium and/or uranium removed by other water treatment processes can be averaged into the total amount of filter backwash wastewater, etc. Additionally, if needed, s. HFS157.30 (3), Wis. Adm. Code, allows the radionuclide content to be averaged over a 30 day period over all the process wastewater produced. Also, the other building/site wastewater released into the sanitary sewer over the 30 days can be added. Alternatives if the result of the calculations is greater than one include adding additional low radionuclide content dilution water to the wastewater, regenerating/backwashing more frequently, nonapproval of the water treatment process as proposed or granting a variance if applicable based upon the dilution capabilities of the sanitary sewers-POTW. DNR will consult with staff of the Radiation Protection

Section (RPS) of the Department of Health and Family Services (DHFS) before proceeding further if the Unity Equation cannot be successfully met. The installation of a wastewater holding tank will not normally be required unless necessary to allow additional low radionuclide water to be added for blending down the average radionuclide content to acceptable levels or to prevent hydraulic overloading of the sanitary sewer. Until such time as we obtain better data, these calculations only need to be performed for wells with combined radium-226 and radium-228 and/or uranium exceeding the drinking water standards.

## UNITY EQUATION:

(Avg. R-226 ÷ 600) + (Avg. R-228 ÷ 600) + (Avg. Total Uranium ÷ 3,000) ≤ 1

## DETERMINING AVERAGE RADIONUCLIDE CONCENTRATIONS FOR INSERTION INTO THE EQUATION:

All radium and uranium can be assumed to be contained in the total volume of regeneration/backwashing wastewater (total volume of backwash + brining + rinse wastewater). Also, the process radium removal efficiency for a cation exchange water softener can be assumed to be 99% (0.99).

Avg. R-226 (pCi/l) = [Vol. of well water treated between regeneration/backwashing (gal.) x raw water R-226 (pCi/l) x % process radium removal efficiency] ÷ [Total volume of regeneration/backwashing wastewater (gal.)]

Avg. R-228 (pCi/l) = [Vol. of well water treated between regeneration/backwashing (gal.) x raw water R-228 (pCi/l) x % process radium removal efficiency] ÷ [Total volume of regeneration/backwashing wastewater (gal.)]

Average Total Uranium (pCi/l) = [Vol. of water treated between anion exchange unit regenerations (gal.) x raw water total uranium (pCi/l) x % process uranium removal efficiency] ÷ [Total volume of regeneration wastewater (gal.)]

**Other Water Treatment Plant Radionuclide Concerns**: There may be worker radiation and radon gas safety concerns involved when treatment vessels removing radionuclides are installed within buildings. Concerns include gamma radiation being given off from radionuclides building up on the treatment media and high levels of radon gas given off when vessel hatches are opened or regeneration/backwash wastewater is discharged with a free air break into a wastewater collection sump. Only metal vessels should be allowed for radionuclide removal treatment units, as they will provide better shielding from radioactivity than plastic. Staff of the Radiation Protection Section indicate that in some cases it may be necessary to take precautions to minimize exposures to waterworks operators especially from resins that continuously concentrate radionuclides and are then removed for disposal and from radon gas when released into the air. Also, it is possible that in some cases the spent media may need to be handled, shipped and disposed of as a low-level radioactive waste. The RPS will need to be contacted early in the plan review process for any proposed water treatment process that may generate a low-level radioactivate waste. DHFS licensing will likely then be required. Department approval letters for the installation of radionuclide water treatment equipment should condition that the Department be contacted as to how to proceed before removing and disposing of any spent media that has been used to remove radionuclides. The same Department approval letters should also recommend that precautions such as providing enhanced room air ventilation and minimizing the amount of time operators spend in rooms while units are being regenerated/backwashed be taken. Norman Hahn, Bureau of Drinking Water and Groundwater (608-267-7661) and Paul Schmidt (608-267-4792), Chief, Radiation Protection Section, can be contacted to discuss all of the above issues as necessary.

# APPENDIX H

WRT PROPOSAL FOR RADIUM SELECTIVE REMOVAL PROCESS

May 14, 2003

Mr. Gary Rosenbeck, P.E
McMahon Associates, Inc.
1445 McMahon Drive
Neenah, Wisconsin 54957

Subject: City of Kaukauna, Wisconsin – Budget Proposal for Radium Removal

Dear Mr. Rosenbeck:

It was a pleasure speaking to you regarding radium removal for the City of Kaukauna. We appreciate the opportunity to provide you with preliminary budget pricing for WRT's Z-88™ Radium Removal System.

WRT designs, builds and maintains this proprietary, patent pending system to reduce radium levels to less than 5 pCi/L.

WRT's Z-88™ Radium Removal System is designed to be added to any new or existing potable water system. Water passes through treatment columns where Radium 226 and Radium 228 are removed. After the media is loaded with radium, it is removed from the circuit and permanently disposed of in a licensed facility. This complete process is handled by WRT, who is responsible for the safe, long term disposal of the media.

Advantages of the WRT Z-88™ Radium Removal System include:

- Nothing is added to the water. No chemicals are added in the treatment process, and nothing is imparted into the water during the treatment process.
- No liquid waste stream is generated by this process.
- Disposal of material to licensed low level radioactive waste facilities by WRT.
- Minimal Maintenance and Operation required, only routine sampling and monitoring. No handling of radioactive materials, media or chemicals by Utility personnel.
- Z-88™ Radium Removal Media is NSF, Standard 61 certified for use in drinking water applications.
- Guaranteed process performance.



5460 Ward Road, Suite 100, Arvada, Colorado 80002 • tel 303.424.5355 • fax 303.425.7497
email: info@wrtnet.com • web: www.wrtnet.com

This preliminary proposal is based upon WRT providing a complete WRT Z-88™ Radium Removal System under a long term contract, including equipment, media, exchange of media when required and proper handling and disposal of used media. The equipment is comprised of one or two treatment vessels which contain the treatment media, in addition to connection piping, valves, controls and instrumentation. This equipment is provided to each treatment site by WRT and remains the property and liability of WRT. WRT delivers and installs media as required directly into the treatment vessels at each site. WRT removes used media directly out of the treatment vessels, into a service vehicle at each site. All handling of media is done by WRT. Analytical fees for laboratory analysis of samples taken for operational purposes are paid by WRT. Used treatment media remains the property and liability of WRT. WRT is licensed and permitted to dispose of used media in an approved facility. All of these items are provided for a single fee, eliminating the capital equipment investment by the Utility.

In summary, WRT will provide the following:

- Design and provide WRT Z-88™treatment system at each treatment site.
- Supervise installation of system.
- Provide Operator training and Operation and Maintenance Manuals.
- Maintain system during period of contract.
- Handling of all media.
- Installation and replacement of media.
- Transport and disposal of media.
- Operating analytical fees (analysis of samples required by WRT for operational monitoring).
- Meeting the current MCL for Radium.

The Utility will provide the following:

- Provide water at current water quality and specified pressure.
- Site for each treatment system.
- Building to house each system.
- Site access for media loading and unloading.
- All permitting and approvals.
- Maintain each site, excluding WRT treatment system.
- Provide utilities to operate system.
- Property taxes, use fees.
- Sign confidentiality agreement.
- Sampling and daily monitoring.

- Compliance analytical fees (analysis of samples required for regulatory compliance).

Terms of Contract

- Term of contract is typically 20 years.
- Cost will be a price per month, based on agreed minimum usage amount.
- Additional usage will be billed on a cost/1,000 gallons treated basis.
- Price will be adjusted annually, tied to an agreed upon index and any increase in disposal costs.

This proposal is based upon providing a WRT Z-88™ Radium Removal System at each well site, thus eliminating the need for piping water to a central location, and providing flexibility for well site location in the future. An additional treatment system could be added with each new well site that required treatment in the future.

Based on the water quality information you provided, we have prepared a budget estimate for the treatment of radium to meet the 5 pCi/L standard, subject to conducting a pilot study at your facility to verify our anticipated test results. Upon completion of the Z-88™ field pilot study, a firm proposal will be provided.

Provided below is budgetary pricing, based on the following design criteria :

| City of Kaukauna, Wisconsin | |
|---|---|
| Hydraulic capacity of WRT systems per site | 1,300/600/1,200 GPM (gallons per minute) |
| Average annual usage | 500 MGY (million gallons per year) |
| Radium level in the water to be treated | 5.5/6.5/5.5 pCi/L avg. |
| Number of sites/treatment locations in this system | 3 sites |
| Required Radium level of treated water | 5.0 pCi/L (MCL) |
| Budget Cost | |
| Budgetary annual cost for treated water including capital equipment, operating media, exchange and proper disposal of media as detailed herein. * | \$0.35 to \$0.50/1,000 gallons treated |

* This budget estimate is based on today's costs, and may increase in future years based on a predetermined index. This price is based on a minimum annual usage of 500,000,000 gallons. This price is based upon the water quality information provided, and is subject to verification during a field pilot study. The Utility would be required to provide a site and housing for the equipment as required for weather and security protection, installation, electrical service and

power, connection piping into and out of the system, and any site engineering, bonding and permitting. Note that taxes are not included.

We look forward to the opportunity to discuss this proposal with you in detail.

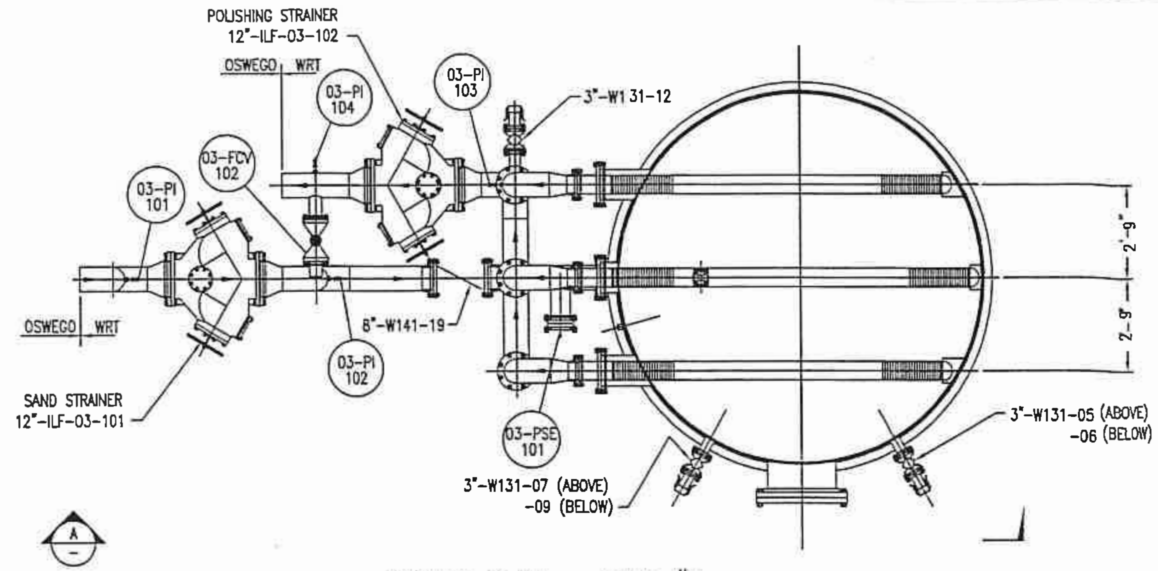
Please feel free to contact me with any questions or comments.

Thank you for your interest in our technology.

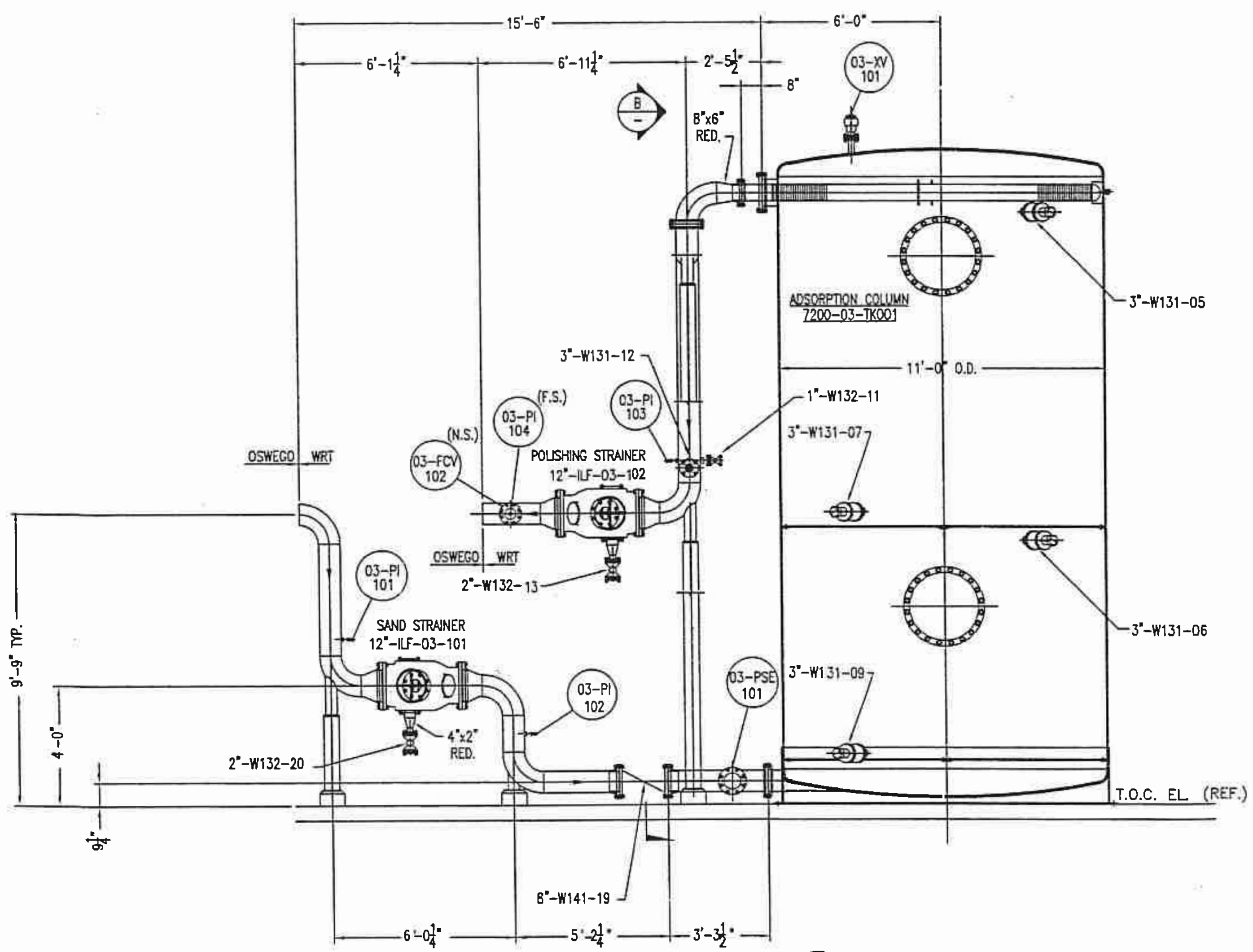
Best Regards,

Ron Dollar

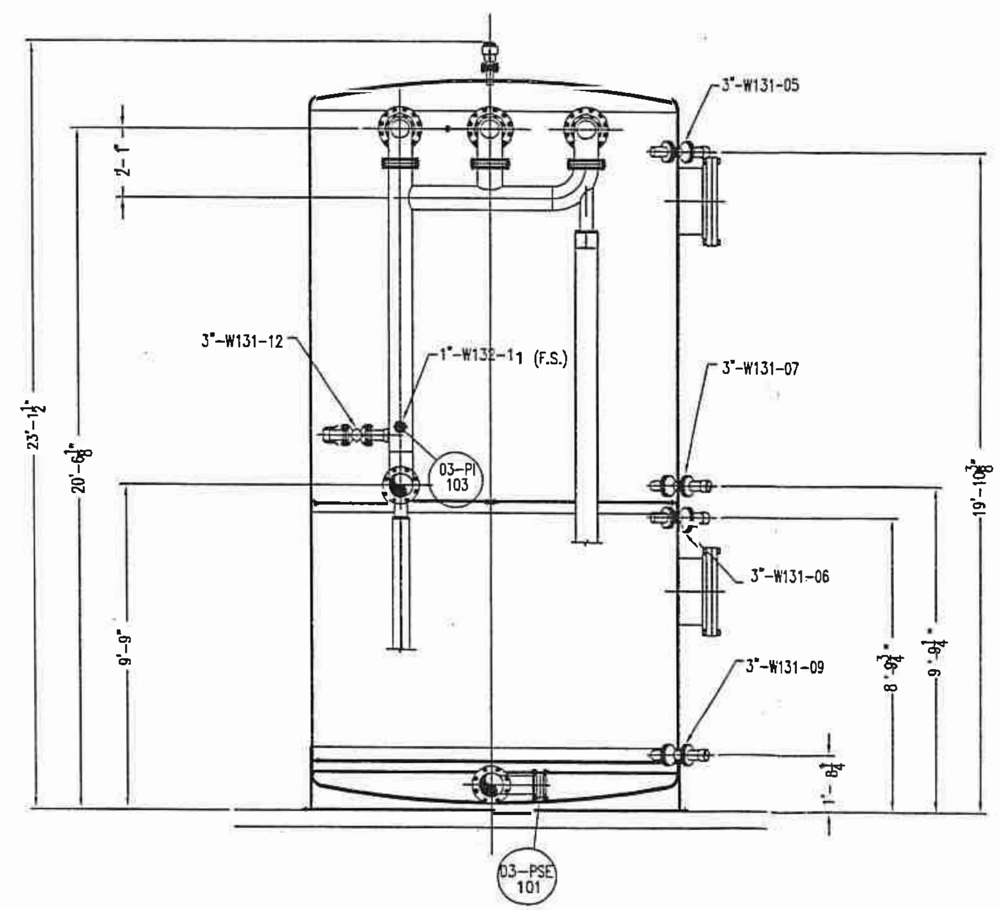
Ron Dollar, V P Marketing
Water Remediation Technology, LLC




PIPING PLAN - SITE #3




VIEW A




SECTION B

NOTES:

1. PIPE AND FITTINGS SHALL BE SCH 10, TYPE 304L S.S.
2. PIPE MATERIAL, FABRICATION, INSTALLATION AND SUPPORTS SHALL CONFORM TO STANDARDS AND PRACTICES SPECIFIED BY ASME AND AWWA.



| JOB REFERENCE NUMBERS | REFERENCE DRAWINGS | NO. | REVISIONS | BY | DATE | CHK'D | APP'D | NO. | REVISIONS | BY | DATE | CHK'D | APP'D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7200 | | A | PRELIMINARY | SJD | 02/05/03 | | | E | RELOCATED SAND STRAINER 12"-ILF-03-102 | JJ | 04-07-03 | | |
| | | B | REVISED PER CLIENT | SJD | 01/12/03 | | | | | | | | |
| | | C | REVISED INSTRUMENT & VALVE NUMBERS | SJD | 02/25/03 | | | | | | | | |
| | | D | GENERAL REVISION | SJD | 03/28/03 | | | | | | | | |

| | ENGINEERING | DATE |
|---|---|---|
| DRWN | | 02/05/03 |
| CHK'D | | |
| APP'D | | |
| APP'D | | |

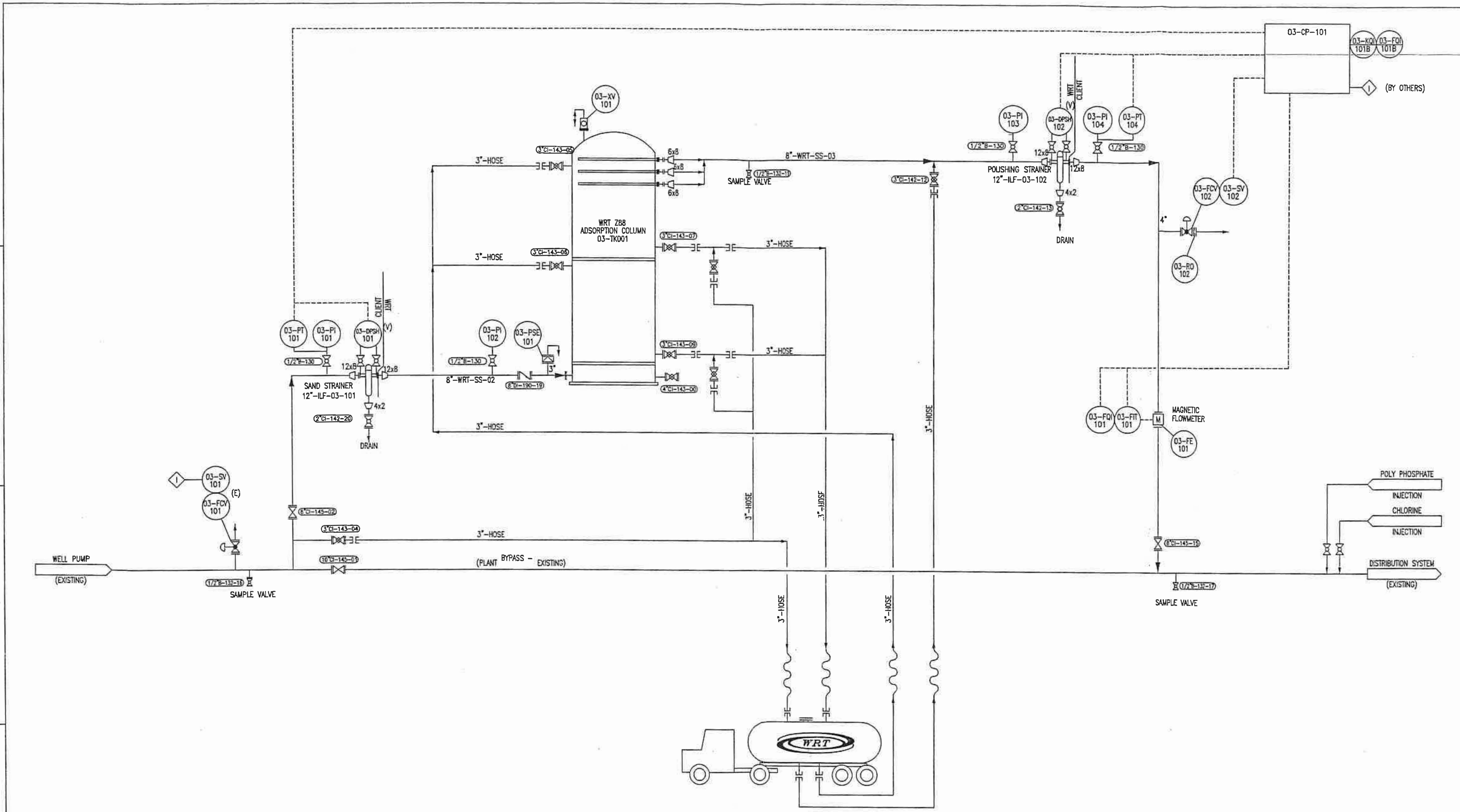
WRT
OSWEGO

RADIUM REMOVAL SYSTEM
11'-0" DIA. WRT ADSORP. COLUMN
PIPING ARRANGEMENT SITE #3

SCALE: 3/8"=1'-0"

7200-P-03

REV. E

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NOTE: THIS IS A DRAWING OF THE REPRESENTATIVE PROCESS.

PROJECT: 0388-0101
WRT OSWEGO

RADIUM REMOVAL SYSTEM
11'-0" DIA. PRESSURE VESSEL
P&ID - SITE #3

SCALE: N/A

7200-I-03

REV. A

| JOB REFERENCE NUMBERS | REFERENCE DRAWINGS | NO. | REVISIONS | BY | DATE | CHK'D | APP'D |
|---|---|---|---|---|---|---|---|
| 7200 | | A | ISSUED FOR APPROVAL - IFA | RKY | 05/05/03 | MGD | |

| | ENGINEERING | DATE |
|---|---|---|
| DRWN | SJD | 05/05/03 |
| CHK'D | MGD/JRD | 05/05/03 |
| APP'D | | |
| APP'D | | |

8 7 6 5 4 3 2 1

# APPENDIX I

REPORT ON DISSOLVED GAS INVESTIGATION IN THE MUNICIPAL WELLS
OF KAUKAUNA, WISCONSIN; May 1, 2003

TIMOTHY J. GRUNDL, PHD
GEOCHEMICAL AND HYDROGEOLOGIC CONSULTING

# Report on Dissolved Gas Investigation in the Municipal wells of Kaukauna, Wisconsin
## May 1, 2003

***Introduction:***

This document is a report of the findings of my investigation into the geochemical conditions in the groundwater being pumped from the municipal wells within the City of Kaukauna. The particular question to be investigated is to determine what gas is evolving from these wells and to deduce the underlying cause. The specific tasks of this investigation are as follows:

a) Collect water samples at the well head while pumping and conduct in-the-field measurements of pH over time during sampling.

b) Analyze water samples for major ions plus barium and the dissolved gases.

c) Conduct geochemical modeling to deduce the underlying cause of gas evolution in these wells.

A considerable amount of study had already been completed by other workers on this problem. Previous gas sampling had been performed and the most likely gas (carbon dioxide) was not found in concentrations sufficient to cause degassing. Hydrogen sulfide gas is not present because there is no sulfide smell evident in any of the wells. However none of the previous studies directly ascertained the particular gas that was evolving. The current study analyzed the full suite of dissolved gases in an effort to identify the actual composition of the evolving gas and come to some understanding of the underlying cause of gas evolution in these waters.

***Methods:***

A variety of data was collected and analyzed for the current study. Gary Rosenbeck of McMahon Associates provided a wealth of background data including:

- Detailed description of the behavior of the evolving gases at each well in the system.
- Well stratigraphy and construction details for all five wells.

- Previous gas sampling results.
- Previous water chemistry results.

In addition to this background data, a round of sampling was performed on February 18, 2003. Careful sampling for the dissolved gases ($CO_2$, $CH_4$, $N_2$, Ar and $O_2$), field pH, the major ions ($Ca^{2+}$, $Mg^{2+}$, $Na^+$, $K^+$, $HCO_3^-$, $Cl^-$, $SO_4^{2-}$) and barium was made. All wells had been pumped for a minimum of 1.5 hours prior to sampling; a sufficient time to have cleared the well bore of standing water. Samples were taken directly from the sample tap at the wellhead. One additional dissolved gas sample was taken from the overflow basin attached to well #8. This was done to check on the condition of well #8 water after standing open to the atmosphere for a period of 3.5 hours. Dissolved gas samples were taken by filling the bottle with a sample tube while submerged in a bucket of well water. All bottles were sealed before removal from the bucket of well water. Duplicate samples were taken at each site. Sample bottles were stored on ice and shipped by overnight delivery to the United States Geological Survey laboratory in Reston VA for analysis. Major ion and barium samples were collected by McMahon Associates personnel, preserved and sent to Badger Laboratories for analysis. Alkalinity measurements were not made in the field. In the field pH measurements were made over time at each well to see if any changes occurred as the degassing proceeded. Some gases, notably $CO_2$, are acid gases and will affect the pH as they evolve out of the water.

All data collected (field and laboratory) collected during the course of the February 18, 2003 sampling round are given in Appendix A. Appendix A is attached to the end of this report.

***Results:***

Inspection of the well logs and construction reports show that all the wells except well #9 are open to the entire stratigraphic section from the Sinnipee Dolomite through the Saint Peter (sandstone), the Prairie du Chien (dolomite) and the Elk Mound (sandstone). Well #9 is open only to the Prairie du Chien and the Elk Mound. Wells #10, #8 and #5 have been backfilled partially through the Elk Mound. From a geochemical point of view, the overall chemistry and the extent of gas evolution is also relatively constant. The primary difference is that wells #4 and #5 exhibit higher salinity and correspondingly high sulfate values in comparison to the other wells. The generic similarity of the wells and the water produced from them indicates that the gas evolution problem is not specific to a particular well, but is due to some process that is in operation across the entire well field.

The results of the gas analyses are given in Appendix A. The five dissolved gases are given in terms of concentration (mg/L), molar concentration (mMol/L) and partial pressures (atm). In general the waters are low in dissolved oxygen (less than 0.5 mg/L) and methane (less than 0.03 mg/L). They contain a reasonable amount of carbon dioxide (20-25 mg/L) and large amounts of both nitrogen and argon. The most pertinent fact is that nitrogen is the only gas that exceeds atmospheric pressure (nitrogen partial pressures of 1.21 to 1.39 atmospheres). The gas that is evolving from these waters is nitrogen. This high nitrogen, in combination with correspondingly high argon levels is indicative of "excess" air being entrained into the groundwater. The phenomenon of "excess" air being entrained into natural waters is a common occurrence, however the amounts seen in these waters are unusually high. A probable cause for this phenomenon is discussed in the following section.

Another line of evidence that agrees with the presence of nitrogen is the slightly basic pH levels seen in these waters. A geochemical speciation model (PHREEQC 2.71) was run to see what the expected pH would be if 1.2 atmospheres of an acid gas (carbon dioxide) were present. Modeled results indicate that a pH of 4.8 is expected. Since nitrogen is not an acid gas it has no effect on the pH and more basic pH levels are possible.

Major ion sampling was performed in order to check on the overall chemistry of the water as well as to see if any hints exist as to why radium levels are high in some wells – particularly well #8. In some parts of Wisconsin where the Makoqueta Shale does not confine the sandstone, the radium content varies with barium content. This does not appear to be the case in Kaukauna. The barium content is below the limit of detection in all five Kaukauna wells. The interpretation of major ion analyses was complicated by the fact that 4 of the 5 analyses did not achieve charge balance (ie. the reported level of cations exceeds the reported amount of anions and the water is not electrically balanced). Comparison to previous sampling rounds indicates that the sulfate content is anomalously low in the current round of sampling.

***Discussion:***

Although excess air could be a function of a leaky riser pipe or some other engineering artifact, this seem unlikely especially in the light of the fact that all five Kaukauna wells are evolving nitrogen in a similar manner. In addition, the dissolved gas data is very good, with excellent reproducibility between duplicates and freedom from any indication of unusual error. A more probable explanation is given below.

The solubilities of nitrogen and argon in water are both a function of temperature and pressure. For Kaukauna, where the wells are all at approximately the same elevation, pressure can be considered constant and the solubility is controlled solely by temperature. The solubility-temperature relationship for nitrogen differs from that of argon therefore the ratio of nitrogen to argon in a given water can be related to the temperature at which it equilibrated with the atmosphere. All this is embodied in the line labeled WEA (Water in Equilibrium with Air) in figure 1. This line depicts the equilibrium amounts of nitrogen and argon present in water at any temperature between 0° and 30° C. Waters that contain air in excess of equilibrium fall along the diagonal lines extending to the right of the WEA line. What is notable about Kaukauna wells is that 1) the amount of excess air is quite high – up to 10 cc/L water and 2) the indicated temperature is quite low - approximately 1°-2° C.

High levels of excess air are indicative of aquifers where the groundwater is recharged in a rapid, episodic manner. This kind of behavior is most commonly seen in karstic or fractured aquifers. The physical process is that of small air bubbles being physically entrained in the rapidly recharging water and subsequently dissolving in the groundwater. The low equilibration temperatures (1°-2° C) are in stark contrast to both the average groundwater temperature of nearly 11° C and the average climatic temperature for the Appleton area (7° C). The low equilibration temperatures seen in this data imply that when recharged, the groundwater exists at a much lower temperature than the average. These two facets of the data point to the conclusion that groundwater in the Kaukauna area is being recharged in rapid episodic events at a time of year when temperatures are near freezing. This is probably in the early spring immediately after the ground unfreezes and before vegetation begins to intercept much of the percolating surface water. Preferential recharge in the early spring is the normal behavior in many groundwater systems, however peculiarities of the aquifer system in the Kaukauna area are such that the level of excess air is high enough to form gas bubbles upon it's return to the surface. It is certainly possible that the upper stratigraphic unit (the Sinippee Dolomite) is more highly fractured in this area causing the recharge to entrain large amounts of excess air.

From a practical point of view this situation unfortunate in that there is nothing that can be done to change the manner in which the aquifer is being recharged. However, it is important to note that nitrogen is an inert gas that is of no danger to anyone, nor is it an indication of bacterial processing of some unknown contaminant in the aquifer.

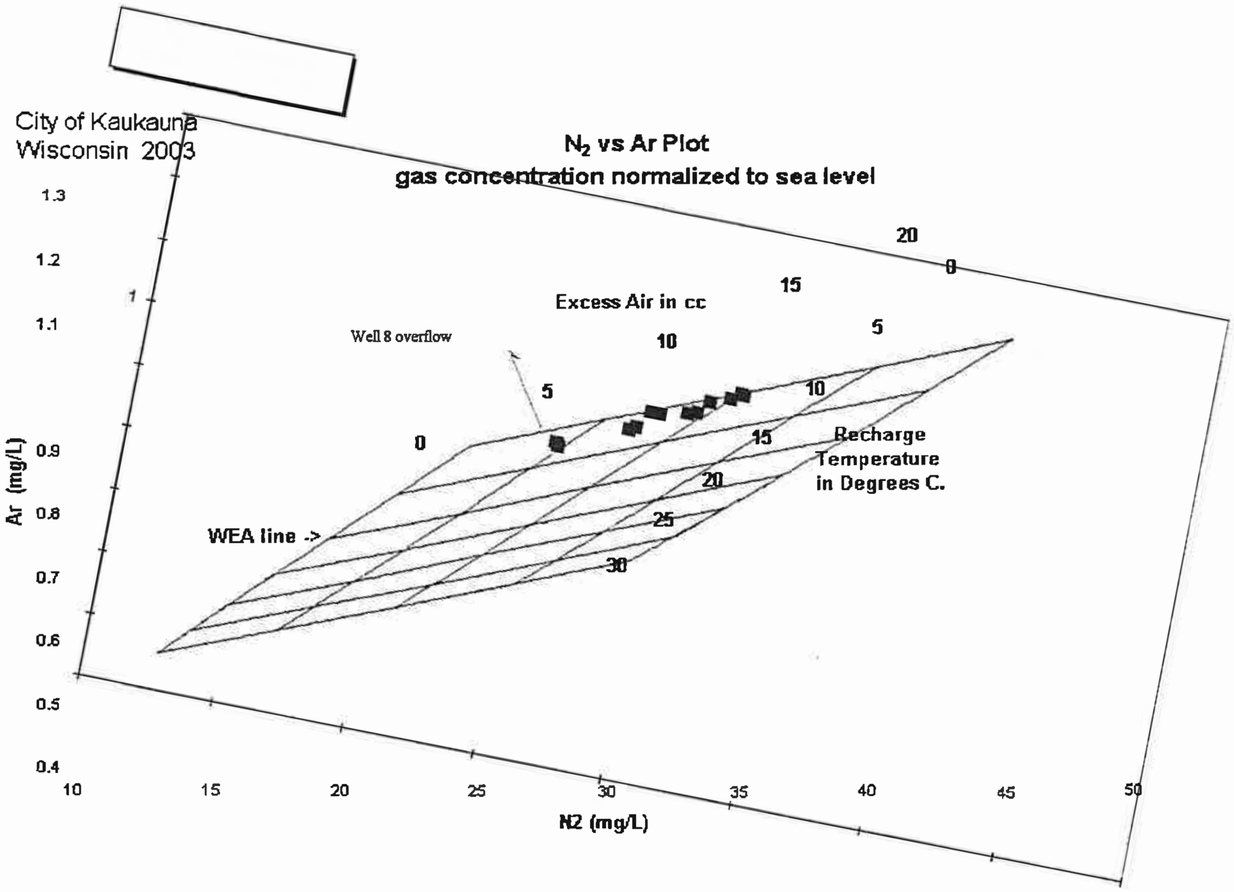


Figure 1: Excess air plot for the five Kaukauna wells and the well #8 overflow basin.

# APPENDIX A

Data collected during the course of this study, including the February 18, 2003 sampling trip.

A1: Dissolved gas data (analyses performed by the United States Geological Survey Dissolved Gas Laboratory)

Samples submitted by: James Krohelski
District:
Geographic location: City of Kaukauna, WI
Date received: 2/19/03
Dated analyzed: 3/11/03
Analyzed by: PW
Worksheet Name: WI JK 2003

| ***** SAMPLES ***** | Date | Time | Field | Recharge | | | Concentration in mg/L | | | | | Concentration in mmol/L | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well Name | Collected | Collected | Temp | Elevation | Lab ID # | Bottle # | CH4 | CO2 | N2 | O2 | Ar | CH4 | CO2 | N2 | O2 | Ar | Comments |
| 08 overflow-1 | 2/18/2003 | 0105 | | 709.0 | D-11884 | 2A1246 | 0.006 | 19.929 | 25.316 | 0.117 | 0.8780 | 0.00038 | 0.4528 | 0.9037 | 0.0036 | 0.02198 | |
| 08 overflow-2 | 2/18/2003 | 0150 | | 709.0 | D-11883 | 1A1057 | 0.007 | 19.397 | 25.227 | 0.090 | 0.8819 | 0.00042 | 0.4407 | 0.9005 | 0.0028 | 0.02208 | |
| Well 04-1 | 2/18/2003 | 1110 | 11.5 | 645.0 | D-11893 | 2A0892 | 0.024 | 21.910 | 30.664 | 0.102 | 0.9916 | 0.00147 | 0.4978 | 10946 | 0.0032 | 0.02482 | |
| Well 04-2 | 2/18/2003 | 1115 | 11.5 | 645.0 | D-11894 | 2A1232 | 0.005 | 22.045 | 31.844 | 0.189 | 1.0132 | 0.00032 | 0.5009 | 1.1368 | 0.0059 | 0.02536 | |
| Well 05-1 | 2/18/2003 | 1140 | 11.0 | 648.0 | D-11892 | 2A1252 | 0.018 | 22.659 | 31.711 | 0.095 | 1.0156 | 0.00114 | 0.5149 | 1.1320 | 0.0030 | 0.02542 | |
| Well 05-2 | 2/18/2003 | 1148 | 11.0 | 648.0 | D-11891 | 2A1253 | 0.017 | 22.662 | 31.393 | 0.122 | 1.0046 | 0.00104 | 0.5149 | 1.1207 | 0.0038 | 0.02515 | |
| Well 08-1 | 2/18/2003 | 0930 | 10.9 | 709.0 | D-11888 | 1A1051 | 0.009 | 20.274 | 28.472 | 0.097 | 0.9577 | 0.00055 | 0.4607 | 1.0164 | 0.0030 | 0.02397 | |
| Well 08-2 | 2/18/2003 | 0933 | 10.9 | 709.0 | D-11887 | 2A1244 | 0.008 | 21.374 | 28.813 | 0.159 | 0.9577 | 0.00049 | 0.4857 | 1.0286 | 0.0050 | 0.02397 | |
| Well 09-1 | 2/18/2003 | 1030 | 10.8 | 672.0 | D-11890 | 2A1266 | 0.007 | 25.956 | 28.086 | 0.092 | 0.9328 | 0.00045 | 0.5898 | 1.0026 | 0.0029 | 0.02335 | |
| Well 09-2 | 2/18/2003 | 1025 | 10.9 | 672.0 | D-11889 | 2A1281 | 0.007 | 25.376 | 27.879 | 0.091 | 0.9261 | 0.00044 | 0.5766 | 0.9952 | 0.0028 | 0.02318 | |
| Well 10-1 | 2/18/2003 | 1230 | 12.0 | 718.0 | D-11886 | 2A1255 | 0.007 | 22.701 | 30.181 | 0.407 | 0.9712 | 0.00046 | 0.5158 | 1.0774 | 0.0127 | 0.02431 | |
| Well 10-2 | 2/18/2003 | 1235 | 12.0 | 718.0 | D-11885 | 2A1265 | 0.007 | 22.570 | 29.853 | 0.385 | 0.9659 | 0.00044 | 0.5128 | 1.0657 | 0.0120 | 0.02418 | |

| | Date | Time | Field | Recharge | | | Partial pressures at Field Temperatures in atm | | | | | Measured | Tot Pressure | | Barometric | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well Name | Collected | Collected | Temp | Elevation | Lab ID # | Bottle # | CH4 | CO2 | N2 | O2 | Ar | Pressure | Corrected | Elevation | Pressure | |
| 08 overflow-1 | 2/18/2003 | 0105 | | 709.0 | D-11884 | 2A1246 | | | | | | 0.000000 | 0.000000 | 709.0 | 0.97430 | |
| 08 overflow-2 | 2/18/2003 | 0150 | | 709.0 | D-11883 | 1A1057 | | | | | | 0.000000 | 0.000000 | 709.0 | 0.97430 | |
| Well 04-1 | 2/18/2003 | 1110 | 11.5 | 645.0 | D-11893 | 2A0892 | 0.000789 | 0.009822 | 1.3389 | 0.0019 | 0.01374 | 1.365175 | 1.397897 | 645.0 | 0.97659 | |
| Well 04-2 | 2/18/2003 | 1115 | 11.5 | 645.0 | D-11894 | 2A1232 | 0.000171 | 0.009882 | 1.3904 | 0.0036 | 0.01404 | 1.418094 | 1.452084 | 645.0 | 0.97659 | |
| Well 05-1 | 2/18/2003 | 1140 | 11.0 | 648.0 | D-11892 | 2A1252 | 0.000606 | 0.009991 | 1.3707 | 0.0018 | 0.01392 | 1.397024 | 1.430666 | 648.0 | 0.97648 | |
| Well 05-2 | 2/18/2003 | 1148 | 11.0 | 648.0 | D-11891 | 2A1253 | 0.000554 | 0.009992 | 1.3570 | 0.0023 | 0.01377 | 1.383575 | 1.418894 | 648.0 | 0.97648 | |
| Well 08-1 | 2/18/2003 | 0930 | 10.9 | 709.0 | D-11888 | 1A1051 | 0.000289 | 0.008910 | 1.2283 | 0.0018 | 0.01310 | 1.252360 | 1.285395 | 709.0 | 0.97430 | |
| Well 08-2 | 2/18/2003 | 0933 | 10.9 | 709.0 | D-11887 | 2A1244 | 0.000262 | 0.009393 | 1.2429 | 0.0030 | 0.01310 | 1.268668 | 1.302133 | 709.0 | 0.97430 | |
| Well 09-1 | 2/18/2003 | 1030 | 10.8 | 672.0 | D-11890 | 2A1266 | 0.000235 | 0.011369 | 1.2091 | 0.0017 | 0.01273 | 1.235166 | 1.266026 | 672.0 | 0.97562 | |
| Well 09-2 | 2/18/2003 | 1025 | 10.9 | 672.0 | D-11889 | 2A1281 | 0.000233 | 0.011152 | 1.2026 | 0.0017 | 0.01266 | 1.228393 | 1.259084 | 672.0 | 0.97562 | |
| Well 10-1 | 2/18/2003 | 1230 | 12.0 | 718.0 | D-11886 | 2A1255 | 0.000250 | 0.010345 | 1.3310 | 0.0078 | 0.01360 | 1.362965 | 1.399380 | 718.0 | 0.97398 | |
| Well 10-2 | 2/18/2003 | 1235 | 12.0 | 718.0 | D-11885 | 2A1265 | 0.000239 | 0.010286 | 1.3165 | 0.0074 | 0.01353 | 1.347923 | 1.383936 | 718.0 | 0.97398 | |
| | | | | | | | | | | | | 0.000000 | 0.000000 | | 1.00000 | |
| | | | | | | | | | | | | 0.000000 | 0.000000 | | 1.00000 | |
| | | | | | | | | | | | | 0.000000 | 0.000000 | | 1.00000 | |
| | | | | | | | | | | | | 0.000000 | 0.000000 | | 1.00000 | |

Dissolved Gas Spread Sheet. Dissolved Gas Laboratory, Reston, VA. See Instructions at bottom of Column A

| Sample Name | Date Collected | Time Collected | LAB ID | Bottle # | Field Temp | mg/L N2 | mg/L Ar | mg/L O2 | mg/L CO2 | mg/L CH4 | Estimate mg/L Excess N2 | Recharge Elev. Ft. | mm Hg BP | Recharge T oC | Ex Air cc STP/L | Air - Water Equilibrium N2 mg/L | Air - Water Equilibrium Ar mg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 08 overflow-1 | 2/18/2003 | 0105 | D-11884 | 2A1246 | 0.0 | 25.316 | 0.8780 | 0.12 | 19.93 | 0.006 | | 709.0 | 740.5 | 2.6 | 4.4 | 21.045 | 0.8051 |
| 08 overflow-2 | 2/18/2003 | 0150 | D-11883 | 1A1057 | 0.0 | 25.227 | 0.8819 | 0.09 | 19.40 | 0.007 | | 709.0 | 740.5 | 2.2 | 4.1 | 21.274 | 0.8144 |
| Well 04-1 | 2/18/2003 | 1110 | D-11893 | 2A0892 | 11.5 | 30.664 | 0.9916 | 0.10 | 21.91 | 0.024 | 0 | 645.0 | 742.2 | 0.9 | 8.9 | 22.006 | 0.8439 |
| Well 04-2 | 2/18/2003 | 1115 | D-11894 | 2A1232 | 11.5 | 31.844 | 1.0132 | 0.19 | 22.05 | 0.005 | 0 | 645.0 | 742.2 | 0.8 | 10.0 | 22.068 | 0.8464 |
| Well 05-1 | 2/18/2003 | 1140 | D-11892 | 2A1252 | 11.0 | 31.711 | 1.0156 | 0.10 | 22.66 | 0.018 | 0 | 648.0 | 742.1 | 0.5 | 9.7 | 22.269 | 0.8545 |
| Well 05-2 | 2/18/2003 | 1148 | D-11891 | 2A1253 | 11.0 | 31.393 | 1.0046 | 0.12 | 22.66 | 0.017 | 0 | 648.0 | 742.1 | 0.9 | 9.6 | 22.029 | 0.8449 |
| Well 08-1 | 2/18/2003 | 0930 | D-11888 | 1A1051 | 10.9 | 28.472 | 0.9577 | 0.10 | 20.27 | 0.009 | 0 | 709.0 | 740.5 | 0.6 | 6.5 | 22.150 | 0.8499 |
| Well 08-2 | 2/18/2003 | 0933 | D-11887 | 2A1244 | 10.9 | 28.813 | 0.9577 | 0.16 | 21.37 | 0.008 | 0 | 709.0 | 740.5 | 1.0 | 7.1 | 21.901 | 0.8398 |
| Well 09-1 | 2/18/2003 | 1030 | D-11890 | 2A1266 | 10.8 | 28.086 | 0.9328 | 0.09 | 25.96 | 0.007 | 0 | 672.0 | 741.5 | 2.1 | 6.9 | 21.370 | 0.8183 |
| Well 09-2 | 2/18/2003 | 1025 | D-11889 | 2A1281 | 10.9 | 27.879 | 0.9261 | 0.09 | 25.38 | 0.007 | 0 | 672.0 | 741.5 | 2.3 | 6.8 | 21.234 | 0.8128 |
| Well 10-1 | 2/18/2003 | 1230 | D-11886 | 2A1255 | 12.0 | 30.181 | 0.9712 | 0.41 | 22.70 | 0.007 | 0 | 718.0 | 740.2 | 1.8 | 8.9 | 21.478 | 0.8227 |
| Well 10-2 | 2/18/2003 | 1235 | D-11885 | 2A1265 | 12.0 | 29.853 | 0.9659 | 0.38 | 22.57 | 0.007 | 0 | 718.0 | 740.2 | 1.8 | 8.6 | 21.492 | 0.8233 |
| 0 | 1/0/1900 | 0 | 0 | 0 | 0.0 | 0.000 | 0.0000 | 0.00 | 0.00 | 0.000 | | 0.0 | 760.0 | 100.0 | 0.0 | 0.000 | 0.0000 |
| 0 | 1/0/1900 | 0 | 0 | 0 | 0.0 | 0.000 | 0.0000 | 0.00 | 0.00 | 0.000 | | 0.0 | 760.0 | 100.0 | 0.0 | 0.000 | 0.0000 |
| 0 | 1/0/1900 | 0 | 0 | 0 | 0.0 | 0.000 | 0.0000 | 0.00 | 0.00 | 0.000 | | 0.0 | 760.0 | 100.0 | 0.0 | 0.000 | 0.0000 |

is spread sheet finds the recharge temperature and cc's (STP) of excess air from an analysis of
ssolved nitrogen and argon (in mg/L) for an assumed amount of excess nitrogen
mg/L) at assumed elevation (in feet, col M) for recharge of the sample.
back solving routine (Calc button) interates on recharge temperature until the amount of excess air calculated from N2 and Ar are the same.
s assumed that the sample contains argon from air-water equilibrium and dissolution of excess air. The source of N2 is assumed to be that of argon plus excess N2 from another source such as denitrification.
r samples that have not undergone denitrification, Column L values should be zero (no excess N2 from denitrification),
is spread sheet does not account for other processes such as gas stripping during sampling or in the environment.
e spread sheet is intended to be used primarily to estimate recharge temperature (and excess air for estimates of recharge elevation, and in some cases, denitrification.
t the calc button to recalculate the spreadsheet every time you change a value (such as elevation or excess N2 from denitrification).
timating Denitrification: Criteria-- Should be low DO, Check CFC results for N2O; if present, active denitrification is occurring.
ter an estimate of the amount of N2 (in mg/L) in column L that may have been produced by denitrification. This value will be subtracted from the measured total N2 (mg/L) in the sample. The remaining N2 should not be lower than the expected N2 solubility
e column AD for calculated solubility of N2 and compare with residual N2 after removing denitrified N2 from measured value.
other constraint on estimating amount of denitrification is obtaining positive (but "reasonable" values of excess air). Values of 0 to 3 cc/L excess are are normal, but up to 10 or more cc/L have been observed in water from some fractured rock or and areas
cognizing cases of denitrification: Calculated recharge temperature will be unrealistically high and high excess air.
tural (microbial) processes can produce high concentrations of methane, CO2 and N2 that can lead to gas stripping of samples (if the total pressure of the gases exceeds the hydrostatic pressure)
cognizing cases of degassing: Calculated recharge temperature will be unrealistically high with negative excess air.
rmally, recharge temperatures will be near the mean annual temperature and the temperature of shallow ground water.
careful with denitrification estimation; it is easy to produce erroneous results.

Constant in columnO: Converts mg of N2/L to cc (STP) of air. [28013 (mg N2/mol)/22414.4 (cc N2/mol N2)] * 0.78080 (fraction of N2 in air)= cc air STP
) Constant in column P: Converts mg of Ar/L to cc (STP) of air. [39948 (mg Ar/mol)/22414.4 (cc Ar/mol Ar)] * 0.00934 (fraction of Ar in air)= cc air STP

A2: Major ion data (analyses performed by Badger Laboratories)

CHEMISTS
ENGINEERS
BADGER LABORATORIES & ENGINEERING INC.
501 WEST BELL STREET • NEENAH, WISCONSIN 54956-4868 • EST. 1966
(920) 729-1100 • FAX (920) 729-4945 • 1-800-776-7196

KAUKAUNA ELECTRIC AND WATER DEPARTMENT
777 ISLAND STREET
P.O. BOX 1777
KAUKAUNA, WI 54130

REPORT NUMBER: 99501923
REPORT DATE: 03/14/03
SAMPLED BY: CLIENT

ATTN: MR. JIM JELLISH

6 GROUNDWATERS

SAMPLE NUMBER: 33004030
DESCRIPTION: WELL #4
SAMPLE DATE: 02/18/03
DATE RECEIVED: 02/18/03

| TEST | RESULT/FLAGS | UNITS | LOD | LOQ | METHOD | ANALYZED | ANALYST |
|---|---|---|---|---|---|---|---|
| ALKALINITY, TOTAL AS | 186/E | mg/l | 8.000 | 12.000 | 310.2 | 02/25/03 | BW |
| CHLORIDE | 8.1 | mg/l | 1.400 | 4.600 | 325.2 | 02/21/03 | BW |
| SULFATE | 360/E | mg/l | 8.000 | 24.000 | 375.2 | 03/06/03 | BW |

SAMPLE NUMBER: 33004031
DESCRIPTION: WELL #5
SAMPLE DATE: 02/18/03
DATE RECEIVED: 02/18/03

| TEST | RESULT/FLAGS | UNITS | LOD | LOQ | METHOD | ANALYZED | ANALYST |
|---|---|---|---|---|---|---|---|
| ALKALINITY, TOTAL AS | 178/E | mg/l | 8.000 | 12.000 | 310.2 | 02/25/03 | BW |
| BARIUM, TOTAL | <70 | ug/l | 70.000 | 240.000 | 7080A | 02/20/03 | LP |
| CALCIUM, TOTAL | 321 | mg/l | 1.300 | 4.300 | 3500D | 02/20/03 | CB |
| CHLORIDE | 12 | mg/l | 1.400 | 4.600 | 325.2 | 02/21/03 | BW |
| MAGNESIUM, TOTAL | 22 | mg/l | 0.030 | 0.090 | 7450 | 03/05/03 | TS |
| POTASSIUM, TOTAL | 4.7 | mg/l | 0.010 | 0.010 | 7610 | 03/10/03 | TS |
| SODIUM, TOTAL | 15 | mg/l | 0.010 | 0.010 | 7770 | 02/27/03 | TS |
| SULFATE | 389/E | mg/l | 8.000 | 24.000 | 375.2 | 03/06/03 | BW |
| TURBIDITY | 0.3 | NTU | 0.000 | 0.000 | 180.1 | 02/18/03 | LP |

REPORT NUMBER: 99501923
PAGE: 2

SAMPLE NUMBER: 33004032
DESCRIPTION: WELL #8
SAMPLE DATE: 02/18/03
DATE RECEIVED: 02/18/03

| TEST | RESULT/FLAGS | UNITS | LOD | LOQ | METHOD | ANALYZED | ANALYST |
|---|---|---|---|---|---|---|---|
| ALKALINITY, TOTAL AS | 182/E | mg/l | 8.000 | 12.000 | 310.2 | 02/25/03 | BW |
| BARIUM, TOTAL | <70 | ug/l | 70.000 | 240.000 | 7080A | 02/20/03 | LP |
| CALCIUM, TOTAL | 200 | mg/l | 1.300 | 4.300 | 3500D | 02/20/03 | CB |
| CHLORIDE | 2.6 | mg/l | 1.400 | 4.600 | 325.2 | 02/21/03 | BW |
| MAGNESIUM, TOTAL | 21 | mg/l | 0.030 | 0.090 | 7450 | 03/05/03 | TS |
| POTASSIUM, TOTAL | 4.2 | mg/l | 0.010 | 0.010 | 7610 | 03/10/03 | TS |
| SODIUM, TOTAL | 8.8 | mg/l | 0.010 | 0.010 | 7770 | 02/27/03 | TS |
| SULFATE | 299/E | mg/l | 8.000 | 24.000 | 375.2 | 03/06/03 | BW |
| TURBIDITY | 0.4 | NTU | 0.000 | 0.000 | 180.1 | 02/18/03 | LP |

SAMPLE NUMBER: 33004033
DESCRIPTION: WELL #9
SAMPLE DATE: 02/18/03
DATE RECEIVED: 02/18/03

| TEST | RESULT/FLAGS | UNITS | LOD | LOQ | METHOD | ANALYZED | ANALYST |
|---|---|---|---|---|---|---|---|
| ALKALINITY, TOTAL AS | 206/E | mg/l | 8.000 | 12.000 | 310.2 | 02/25/03 | BW |
| BARIUM, TOTAL | <70 | ug/l | 70.000 | 240.000 | 7080A | 02/20/03 | LP |
| CALCIUM, TOTAL | 224 | mg/l | 1.300 | 4.300 | 3500D | 02/20/03 | CB |
| CHLORIDE | 4.9 | mg/l | 1.400 | 4.600 | 325.2 | 02/21/03 | BW |
| MAGNESIUM, TOTAL | 25 | mg/l | 0.030 | 0.090 | 7450 | 03/05/03 | TS |
| POTASSIUM, TOTAL | 4.3 | mg/l | 0.010 | 0.010 | 7610 | 03/10/03 | TS |
| SODIUM, TOTAL | 9.8 | mg/l | 0.010 | 0.010 | 7770 | 02/27/03 | TS |
| SULFATE | 640/E | mg/l | 2.500 | 7.500 | 300.0 | 03/13/03 | JW |
| TURBIDITY | 0.4 | NTU | 0.000 | 0.000 | 180.1 | 02/18/03 | LP |

SAMPLE NUMBER: 33004034
DESCRIPTION: WELL #10
SAMPLE DATE: 02/18/03
DATE RECEIVED: 02/18/03

| TEST | RESULT/FLAGS | UNITS | LOD | LOQ | METHOD | ANALYZED | ANALYST |
|---|---|---|---|---|---|---|---|
| ALKALINITY, TOTAL AS | 206/E | mg/l | 8.000 | 12.000 | 310.2 | 02/25/03 | BW |
| BARIUM, TOTAL | <70 | ug/l | 70.000 | 240.000 | 7080A | 02/20/03 | LP |
| CALCIUM, TOTAL | 192 | mg/l | 1.300 | 4.300 | 3500D | 02/20/03 | CB |
| CHLORIDE | 8.6 | mg/l | 1.400 | 4.600 | 325.2 | 02/21/03 | BW |
| MAGNESIUM, TOTAL | 24 | mg/l | 0.030 | 0.090 | 7450 | 03/05/03 | TS |
| POTASSIUM, TOTAL | 4.5 | mg/l | 0.010 | 0.010 | 7610 | 03/10/03 | TS |
| SODIUM, TOTAL | 13 | mg/l | 0.010 | 0.010 | 7770 | 02/27/03 | TS |
| SULFATE | 290/E | mg/l | 8.000 | 24.000 | 375.2 | 03/06/03 | BW |
| TURBIDITY | 0.4 | NTU | 0.000 | 0.000 | 180.1 | 02/18/03 | LP |

REPORT NUMBER: 99501923
PAGE: 3

SAMPLE NUMBER: 33004035
DESCRIPTION: WELL #4-METALS
SAMPLE DATE: 02/20/03
DATE RECEIVED: 02/18/03

| TEST | RESULT/FLAGS | UNITS | LOD | LOQ | METHOD | ANALYZED | ANALYST |
|---|---|---|---|---|---|---|---|
| BARIUM, TOTAL | <0.07 | mg/l | 0.070 | 0.240 | 7080A | 03/04/03 | LP |
| CALCIUM, TOTAL | 305 | mg/l | 1.300 | 4.300 | 3500D | 02/26/03 | CB |
| MAGNESIUM, TOTAL | 21 | mg/l | 0.030 | 0.090 | 7450 | 03/05/03 | TS |
| POTASSIUM, TOTAL | 4.7 | mg/l | 0.010 | 0.010 | 7610 | 03/10/03 | TS |
| SODIUM, TOTAL | 13 | mg/l | 0.010 | 0.010 | 7770 | 02/27/03 | TS |
| TURBIDITY | 0.2 | NTU | 0.000 | 0.000 | 180.1 | 02/20/03 | LP |

BADGER LABORATORIES & ENGINEERING
WDNR Certified Lab #445023150

Approved By:

Jeffrey M. Wagner

SCT:rt

cc: Mr. Gary Rosenbeck
McMahon Associates Inc.
PO Box 1025
Neenah WI 54956

A3: Description of gas evolution at each well (provided by Gary Rosenbeck of McMahon Associates).

**McMAHON**
**ASSOCIATES, INC.**

ENGINEERS ■ ARCHITECTS
PROJ. MGRS. ■ SURVEYORS

January 13, 2003

**E-MAIL MEMO**

To: Tim Grundl
grundl@csd.uwm.edu

From: Gary Rosenbeck
grosenbeck@mcmgrp.com

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I made the following observations at each well in the Kaukauna water system.

| Well | Pumping Rate | Well Started Operation | Inspection Report #1 | | | Inspection Report #2 | | |
|---|---|---|---|---|---|---|---|---|
| | | | Air In Sample | Sample Time | Time to Clear | Air In Sample | Sample Time | Time to Clear |
| #4 | 630 gpm | 9:00 a.m. | #1 | 10:00 a.m. | A | #1 | 1:10 p.m. | B |
| #5 | 210 gpm | 9:00 a.m. | #3 | 10:15 a.m. | B | #3 | 1:25 p.m. | B |
| #10 | 540 gpm | 9:00 a.m. | #2 | 10:30 a.m. | C | #3 | 1:30 p.m. | B |
| MFP-Influent | 1,300 gpm | 9:00 a.m. | #1 | 10:05 a.m. | A | #4 | 1:20 p.m. | A |
| MFP-Effluent | 1,300 gpm | 9:00 a.m. | #1 | 10:10 a.m. | A | #4 | 1:25 p.m. | A |
| #9 | 1,100 gpm | 10:45 a.m. | #1 | 11:00 a.m. | B | #1 | 1:45 p.m. | B |
| #9 F.P. Effluent | 1,100 gpm | 10:45 a.m. | | N/A | | #1 | 1:50 p.m. | B |
| Distribution System | | | #2 | 10:00 a.m. | C | #1 | 1:30 p.m. | C |
| #8 | 300 gpm | 9:00 a.m. | #1 | 9:30 a.m. | B | | N/A | |
| #8 Reservoir Discharge | 300gpm | 9:00 a.m. | | 9:45 a.m. | B | | N/A | |

Time To Clear Code

A < 1 Min
B < 2 Min
C < 3 Min

Air In Sample Code

#1 Clear at time 0 and then air bubble start to form.
#2 Cloudy with small bubbles, turns milky white within 15 seconds.
#3 Very cloudy, milky white with air and gets cloudier.
#4 Clear, very little formation of air bubbles.

MFP = Main Filter Plant
FP = Filter Plant

What is evident is that all wells have air entrainment resulting in a milky white coloration as the air comes out of solution and is released. Wells #4, 5, and 10 each pump through an iron filter to a large ground storage reservoir for re-pumping. While there is a slight trace of remaining dissolved air in the supply to the booster pumps and in the pump discharge, it is very slight. As Well #9 pumps through an iron filter, air remains in the water and is evident at the filter effluent and in a distribution system sample, which was collected at well #10 station. Well #8 really is no different than any of the other wells in this regard; however, the 15 minute of detention time in ground storage reservoir is not sufficient time for the air to dissipate. Well #8 is the only well not currently in operation.

ID\CORR\K0004\920857\GLR:sbk

A4: February 18, 2003 field parameters.

| | |
|---|---|
| DATE: | 2/18/03 |
| TIME: | 11:00 AM |
| AIR TEMPERATURE: | |
| PURGE VOLUME: | since 6 AM at ~600 gpm |

| WELL# | 4 |
|---|---|

| time (min) | pH | water temp (°C) | qualitative remarks |
|---|---|---|---|
| 0.3 | 7.20 | 12.0 | slightly cloudy/some bubbles effervescing/cleared up |
| 1.5 | 7.21 | 11.7 | tiny bubbles on side |
| 2.5 | 7.22 | 11.6 | |
| 4.5 | 7.23 | 11.5 | more tiny bubbles |
| 5.5 | 7.24 | | |
| 6.5 | 7.24 | 11.5 | more tiny bubbles |
| 8.0 | 7.24 | 11.5 | |
| 9.0 | 7.26 | 11.5 | |
| 10.0 | 7.23 | 11.5 | bubble getting larger on bottom |
| 12.5 | 7.23 | 11.5 | bubble getting larger on bottom |
| 14.0 | 7.23 | 11.5 | bubbles releasing from bottom |
| 16.0 | 7.22 | | |
| 17.0 | 7.22 | 11.5 | |
| 19.0 | 7.22 | 11.5 | bubbles on side getting larger |
| 21.0 | 7.23 | 11.5 | bubbles releasing |
| 23.0 | 7.23 | 11.6 | |
| 25.0 | 7.23 | 11.6 | |
| 27.0 | 7.24 | 11.6 | |
| 28.5 | 7.23 | 11.6 | |
| 29.0 | 7.23 | 11.6 | |

| | |
|---|---|
| DATE: | 2/18/03 |
| TIME: | 11:40 AM |
| AIR TEMPERATURE: | |
| PURGE VOLUME: | since 8 am at 200gpm |

well 5

| time (min) | pH | water temp (°C) | qualitative remarks |
|---|---|---|---|
| 0.8 | 7.31 | 11.3 | bubbles/cloudy - cleared within 30 sec. |
| 1.8 | 7.31 | 11.1 | very tiny bubbles forming on sides |
| 2.5 | 7.31 | 11.0 | more bubbles forming on sides |
| 3.0 | 7.30 | 11.0 | |
| 4.0 | 7.31 | 11.0 | more forming and larger sizes |
| 5.0 | 7.31 | 11.0 | |
| 6.0 | 7.32 | 11.0 | |
| 7.0 | 7.33 | 11.1 | |
| 8.0 | 7.34 | 11.1 | more bubbles on sides and larger sizes |
| 9.0 | 7.34 | 11.1 | bubbles - some releasing |
| 10.0 | 7.35 | 11.1 | |
| 11.0 | 7.35 | 11.1 | |
| 12.0 | 7.36 | 11.2 | |
| 13.5 | 7.36 | 11.2 | more bubbles forming on sides |
| 15.0 | 7.37 | 11.3 | |
| 16.0 | 7.38 | 11.3 | bubbles releasing |
| 17.5 | 7.39 | 11.4 | |
| 19.5 | 7.39 | 11.4 | |
| 21.0 | 7.38 | 11.5 | bigger bubbles |
| 23.0 | 7.37 | 11.6 | |
| 24.5 | 7.37 | | |
| 26.0 | 7.36 | 11.7 | |
| 28.0 | 7.36 | 11.8 | |
| 29.0 | 7.36 | 11.8 | |
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|---|---|
| DATE: | 2/18/03 |
| TIME: | 9:30 AM |
| AIR TEMPERATURE: | |
| PURGE VOLUME: | since 8 AM 310 gpm |

| | |
|---|---|
| WELL# | 8 |

| time (min) | pH | water temp (°C) | qualitative remarks |
|---|---|---|---|
| 0.3 | 6.96 | 11.1 | no bubbles |
| 0.5 | 6.94 | | water looks clear - not cloudy |
| 0.8 | 6.93 | | |
| 1.0 | 6.95 | | |
| 1.5 | 6.98 | | |
| 2.0 | 7.01 | | |
| 2.5 | 7.03 | | |
| 3.0 | 7.03 | | tiny bubbles on sides |
| 4.0 | 7.05 | | |
| 5.0 | 7.08 | 11.0 | |
| 5.5 | 7.10 | | |
| 6.5 | 7.14 | | bubbles forming on bottom |
| 7.5 | 7.17 | 10.9 | |
| 9.0 | 7.19 | | more tiny bubbles on sides |
| 10.5 | 7.23 | 10.9 | bubbles on bottom getting larger |
| 11.5 | 7.26 | | |
| 12.5 | 7.30 | 10.9 | |
| 15.0 | 7.32 | 10.9 | |
| 18.5 | 7.34 | 10.9 | |
| 19.5 | 7.34 | | more tiny bubbles |
| 20.5 | 7.35 | 10.9 | shook it and pH rose |
| 22.0 | 7.36 | 10.9 | shook it and pH rose |
| 22.5 | 7.37 | 10.9 | tiny bubbles releasing from bottom to top |
| 24.0 | 7.36 | | |
| 25.0 | 7.37 | 10.9 | |
| 26.0 | 7.38 | 10.9 | bubbles appear to be getting larger |
| 27.5 | 7.38 | 10.9 | |
| 30.0 | 7.39 | 10.9 | |
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| | |
|---|---|
| DATE: | 2/18/03 |
| TIME: | 10:10 AM |
| AIR TEMPERATURE : | |
| PURGE VOLUME: | 1000 gpm "since all night" |

well 9

| time (min ) | pH | water temp (°C) | qualitative remarks |
|---|---|---|---|
| 0.5 | 7.16 | 11.2 | very cloudy |
| 1.5 | 7.17 | 11.2 | upper half cloudy (bubbles) lower more clear |
| 2.0 | 7.17 | 11.1 | cloudiness is gone; verry few bubbles on side |
| 3.0 | 7.17 | 11.0 | very tiny bubbles on bottom forming |
| 4.0 | 7.17 | 10.9 | |
| 5.0 | 7.17 | 10.8 | shook container |
| 6.0 | 7.18 | 10.8 | more tiny bubbles forming on sides |
| 7.0 | 7.18 | 10.8 | more tiny bubbles forming on sides |
| 8.0 | 7.18 | 10.8 | more tiny bubbles forming on sides |
| 9.5 | 7.18 | 10.8 | more tiny bubbles forming on sides |
| 11.5 | 7.19 | 10.9 | more tiny bubbles forming on sides |
| 13.5 | 7.19 | 10.9 | |
| 16.0 | 7.21 | 11.0 | |
| 17.0 | 7.22 | 11.0 | |
| 18.0 | 7.22 | 11.1 | |
| 19.0 | 7.22 | | lots of tiny bubbles on sides |
| 20.0 | 7.22 | 11.2 | |
| 21.0 | 7.22 | 11.2 | |
| 23.0 | 7.22 | 11.3 | |
| 25.5 | 7.22 | 11.4 | |
| 27.0 | 7.22 | 11.4 | |
| 28.0 | 7.22 | 11.5 | |

| | |
|---|---|
| DATE: | 2/18/03 |
| TIME: | 12:10 PM |
| AIR TEMPERATURE: | |
| PURGE VOLUME: | 540 gpm since 8 am |

| WELL# | 10 |
|---|---|

| time (min) | pH | water temp (°C) | qualitative remarks |
|---|---|---|---|
| 0.8 | 7.05 | 12.2 | very cloudy bubbly/most of any well |
| 1.0 | 7.11 | 11.9 | cleared ~50 sec. |
| 1.5 | 7.18 | 11.8 | tiny bubbles on sides |
| 2.3 | 7.25 | 11.9 | |
| 3.0 | 7.28 | 11.9 | more forming-- getting larger |
| 4.0 | 7.30 | 11.9 | |
| 5.0 | 7.32 | 11.9 | |
| 6.0 | 7.30 | 11.9 | many bubbles on sides - more than other wells |
| 8.0 | 7.31 | 12.1 | |
| 9.5 | 7.32 | 12.2 | |
| 10.5 | 7.32 | 12.2 | |
| 11.0 | 7.33 | 12.3 | |
| 12.5 | 7.33 | 12.4 | |
| 14.0 | 7.34 | | |
| 16.0 | 7.36 | 12.6 | |
| 18.0 | 7.35 | 12.7 | sides of container covered with many bubbles |
| 21.0 | 7.36 | 12.9 | |
| 23.0 | 7.36 | 13.0 | |
| 24.0 | 7.36 | 13.2 | |
| 25.0 | 7.36 | 13.3 | |
| 26.0 | 7.36 | 13.3 | |
| 27.0 | 7.36 | 13.4 | |
| 28.0 | 7.37 | 13.5 | |
| 29.0 | 7.37 | 13.5 | |
| 30.0 | 7.37 | 13.6 | |
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DATE: 2/18/03
TIME : 1:00 PM
AIR TEMPERATURE:
PURGE VOLUME: samples taken from overflow bsin

well 8 overflow basin

| time (min) | pH | water temp (°C) | qualitative remarks |
|---|---|---|---|
| | 7.13 | 10.7 | well 8 pump was turned off at about 10 am and sat until 1 pm |
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# APPENDIX J

LETTER FROM USGS
May 14, 2003

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Water Resources Division
8505 Research Way
Middleton, Wisconsin 53562-3586
phone: (608) 828-9901
fax: (608) 821-3817
http://wi.water.usgs.gov

Mr. Gary Rosenbeck
McMahon and Associates Inc.
1445 McMahon Drive
Neenah WI 54957-1025

May 14, 2003

Dear Gary,

The laboratory analyses and the interpretation of the analyses for dissolved gas from the Kaukauna wells are very interesting. The results of the analyses have determined that the gas is $N_2$, which is not a human health concern. The hydrologic conceptual model for the Lower Fox River Valley that we have used requires that the Sinnipee Group be a confining unit, which would preclude recent rapid recharge to the sandstone aquifer. Based on previous discussion that Randy Hunt, from our office, has had with Tim Grundl, we would like to analyze water samples from the Kaukauna wells for oxygen isotopes. These analyses would help determine if the recharge water is recent or perhaps recharged under a colder climate, for example, during the Pleistocene. The oxygen isotope analyses will contribute to the understanding of how recharge occurs to the sandstone aquifer in the Kaukauna area. I assume Tim will be in touch with you sometime this summer to discuss sampling.

Sincerely,

Jim

Jim Krohelski
Hydrologist

cc Tim Grundl
Randy Hunt

# APPENDIX K

PROPOSAL FROM MEMBRANE LIQUI-CEL MEMBRANE CONTRACTORS

**From:** <PMCMURRA@celgard.net>
**To:** <grosenbeck@mcmgrp.com>
**Date:** 2/25/03 1:10PM
**Subject:** Membrana Quotation

Gary,
I have attached a quotation for the application we discussed, including a performance estimate.
I included 3 cases: 1 pass, 2 pass, and 3 pass. In each case, everything is the same except the number of contactors.
I also included the vacuum pump size for each case.
The pump I quoted is the larger of the 2 sizes.

I also have attached some literature about the pumps.

I hope we can work with you on this project. Please don't hesitate to give me a call if you have questions.

Regards,
Patrick McMurray
Technical Service / Inside Sales
Membrana - Charlotte
A Division of Celgard, Inc.
13800 South Lakes Drive
Charlotte, NC USA 28273
PH: 704-587-8455
FX: 704-587-8736
e-mail: patrickmcmurray@celgard.com
Web - www.liqui-cel.com
www.membrana.com

<<jpm03-050 McMahon Assoc.dot>> <<XBA 101 to 107.pdf>> <<LEM 110-170.pdf>>

MEMBRANA
Underlining Performance

# Quotation

**Date:** Feb. 25, 2003 **Quotation Number:** **JPM03-050**

**To:** Gary Rosenbeck
McMahon Associates

**Phone:** 920-751-4200
**Fax:**

**From:** *Patrick McMurray*
*Membrana - Charlotte*

**Phone:** *(704) 587-8455*
**e-mail :** patrickmcmurray@celgard.com

**Re:** *Liqui-Cel® Membrane Contactor Quotation*

**Number of pages: 3**
(Including cover sheet)

Gary,

Thank you for your interest in Liqui-Cel Membrane Contactors. You will find pricing and a product description for your application below.

| Description | Unit Price | | Part Number |
|---|---|---|---|
| **10 x 28 Liqui-Cel® Industrial Membrane Contactor**<br>X-IND fiber, Epoxy potting, FRP housing<br>3" ANSI RF water connections<br>1" ANSI RF gas connections | Qty: 1-5: $10,000 ea<br>Qty. 6-10: $9,600 ea | | G700H |
| **SIHI Liquid Ring Vacuum Pump**<br>XBA-106 Vacuum Pump System<br>• LEM 170 Pump Motor, 7.5 Hp, 1750 rpm<br>• Max Capacity – 105 ACFM @ 27" Hg (100 torr) | ***Standard**** | $4,100 | XBA-106 |
| | ***OE**** | $4,625 | |
| | ***4B**** | $9,450 | |

**Note** – *If 10x28 contactors will be mounted horizontally, place an "R" after the part number.*

***Availability** – Contactor – 1 week from receipt of PO; Vacuum Pump 4-6 weeks from receipt of PO.*
***Terms** - FCA Charlotte, NC USA Price valid for 90 days.*
** Reference materials of construction as listed on the vacuum pump data sheet.*

If you have any questions please contact me at the numbers listed above. ***To place an order, please fax the PO to our customer service department (704-587-8585). When placing an order, please reference the quote number listed on this quote.***

Thanks again and we look forward to working with you in the future.

Regards,

**Membrana-Charlotte**
A Division of Celgard, Inc.
13800 South Lakes Drive
Charlotte, NC 28273 USA
Phone: (704) 588-5310
(800) 235-4273
fax: (704) 587-8585
www membrana.com
www.liqui-cel.com

MEMBRANA
Underlining Performance

| Design Criteria | 1 Pass | 2 Pass | 3 Pass | |
|---|---|---|---|---|
| Contactor Size<br>Membrane Type | 10-inch<br>XIN-Industrial | 10-inch<br>XIN-Industrial | 10-inch<br>XIN-Industrial | |
| Feed Flow (gpm) | 500.0 | 500.0 | 500.0 | |
| Temperature (F)<br>(C) | 50<br>10 | 50<br>10 | 50<br>10 | |
| pH | 6.0 | 6.0 | 6.0 | |
| Component Concentrations (ppb) | | | | |
| *"Inlet"* O2 | 11,235 | 11,235 | 11,235 | |
| N2 | 18,151 | 18,151 | 18,151 | |
| CO2 *(free)* | 50,000 | 50,000 | 50,000 | |
| *"Average Outlet"* O2 | 2,531 | 532 | 64 | |
| N2 | 5,893 | 3,608 | 3,125 | |
| CO2 *(free)* - ***ppm*** | 22.88 | 11.54 | 8.70 | |
| *"Maximum Outlet"* O2 | 2,884 | 759 | 102 | |
| CO2 *(free)* - ***ppm*** | 28.15 | 14.62 | 10.77 | |
| Minimum Gas Removal O2<br>CO2 (free) | 74.33%<br>43.69% | 93.24%<br>70.75% | 99.09%<br>78.46% | |
| No. of Contactors Required | 3 | 6 | 9 | |
| No. Parallel Trains | 3 | 3 | 3 | |
| No. in Series | 1 | 2 | 3 | |
| Approximate Pressure Drop<br>Thru Train Less Pipe Loss (psi) | 5.14 | 10.28 | 15.42 | |
| Maximum Allowable<br>Feed Pressure (psig) | 62.24 | 62.24 | 62.24 | |
| Operating Mode | Combo w/ N2 | Combo w/ N2 | Combo w/ N2 | |
| Estimated Sweep Rate<br>(scfm @ 60 F, 14.7 psi.) | 3.00 | 6.00 | 9.00 | |
| Sweep Composition<br>Oxygen<br>Nitrogen<br>Carbon Dioxide | <br>0.005%<br>99.995%<br>0.000% | <br>0.005%<br>99.995%<br>0.000% | <br>0.005%<br>99.995%<br>0.000% | |
| Approximate Vapor Load<br>(lb-mole/hr) | 0.866 | 1.495 | 2.063 | |
| Approx. Vapor Molar Comp.<br>Oxygen<br>Nitrogen<br>Water<br>Carbon Dioxide | <br>7.87%<br>67.51%<br>9.10%<br>15.53% | <br>5.60%<br>72.24%<br>9.10%<br>13.07% | <br>4.24%<br>75.55%<br>9.10%<br>11.12% | |
| Vacuum Volume Flow (acfm) | 40.8 | 70.4 | 97.2 | |
| Vacuum Pump Type | Liquid Ring | Liquid Ring | Liquid Ring | |

**Membrana-Charlotte**
A Division of Celgard, Inc.
13800 South Lakes Drive
Charlotte, NC 28273 USA
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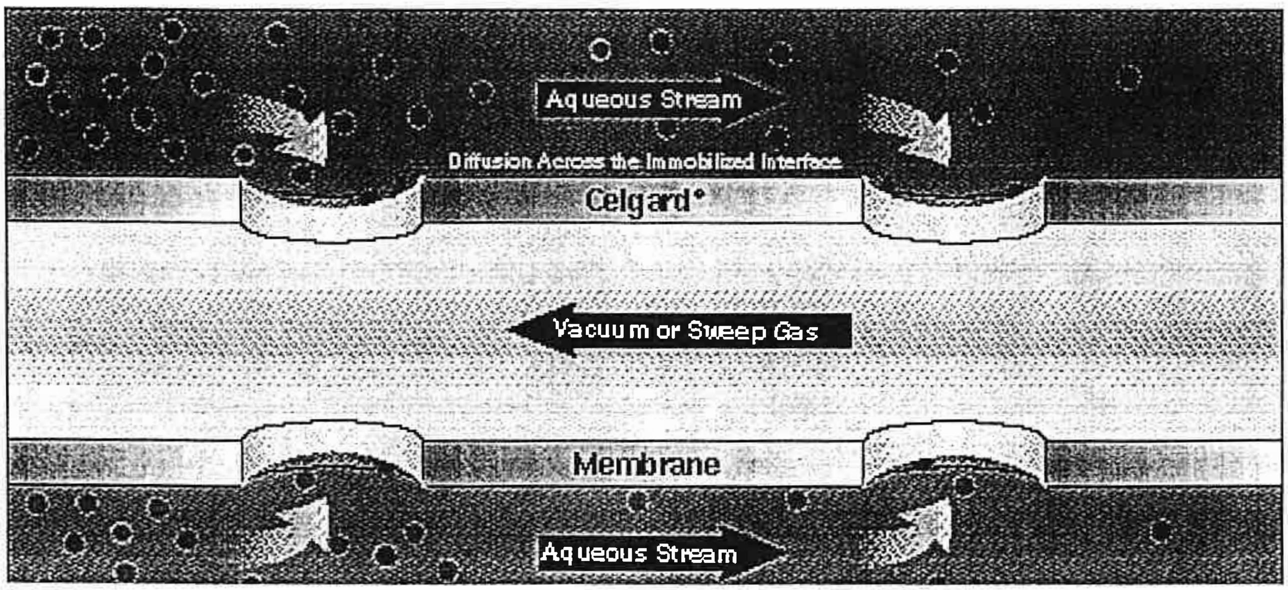
www.membrana.com
www.liqui-cel.com

This example calculates how much oxygen will dissolve into water exposed to air at 1.0 atmosphere. By lowering the partial pressure of oxygen in contact with the water, we can create a driving force to remove the dissolved oxygen from the water. This can be achieved by creating a vacuum in the air exposed to the water, lowering the concentration of oxygen in contact with the water or a combination of the two.

These two operating conditions govern the operation of membrane contactors, vacuum degasifiers and force draft decarbonators.

The Liqui-Cel® Membrane Contactor is a unique membrane device that can be used to alter the partial pressure of gases in contact with a liquid for the purpose of dissolved gas removal. It's compact size, ease of use and versatility offer many benefits over conventional degasification equipment.

## Stripping of Dissolved Gases from and Aqueous Stream



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Shinjuku-ku, Tokyo 163-0427
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Phone: 81 3 5324 3369

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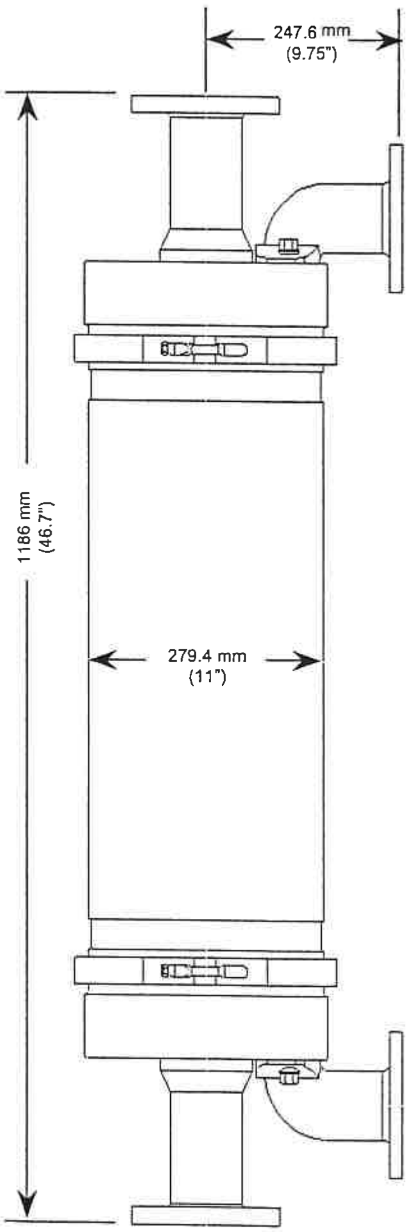
www.membrana.com
www.liqui-cel.com

PRODUCT DATA SHEET

Liqui-Cel®

Membrane Contactors

# INDUSTRIAL 10x28




| Cartridge Characteristics | |
|---|---|
| **Cartridge Configuration** | Industrial Use Extra-Flow with Center Baffle |
| **Liquid Flow Guidelines** | 10 – 48 $m^3$/hr (44 – 210 gpm) |
| **Membrane Type** | **X-IND Fiber** |
| Membrane/Potting Material | Polyolefin / Epoxy |
| Maximum Shellside Working Temperature/Pressure* *[Using 50 mm vacuum on Lumenside. Add 1.05 kg/cm² (15 psig) when vacuum is not used.]* | 50°C, 4.6 kg/cm² or 4.5 bar In European Union Countries<br>50°C, 5.3 kg/cm² or 5.2 bar In Rest of World<br>(122°F, 65 psig) In European Union Countries<br>(122°F, 75 psig) In Rest of World |

| Housing Options and Characteristics | |
|---|---|
| **Material** | ▪ **Fiber Reinforced Plastic (FRP) for Industrial Use**<br>▪ **Color is Gray** |
| **Flange Connections** | |
| Shellside (Liquid Inlet/Outlet) | • 3 inch class 150 raised face flange per ANSI B16.5<br>• 80A at 10K flat face flange per JIS B2238 |
| Lumenside | • 1 inch class 150 raised face flange per ANSI B16.5<br>• 50A at 10K flat face flange per JIS B2238 |
| Max. Allowable Working Pressure* | • 4.6 Kg/cm² (4.5 bar or 65 psi) In European Union Countries<br>• 5.3 Kg/cm² (5.2 bar or 75 psi) Rest of World |

## Seal Options

| Material | Applications |
|---|---|
| EPDM (ANSI / NSF 61) | General Purpose |

| Weight | | |
|---|---|---|
| Dry | 33 kg. | (73 lbs.) |
| Liquid full (shellside) | 57 kg. | (125 lbs.) |
| Cartridge only – dry | 10 kg. | (23 lbs.) |
| Shipping weight | 44 kg. | (98 lbs.) |

*Pressures are based on nondangerous liquids and nondangerous gasses per the European Union Pressure Equipment Directive /97/23/EC

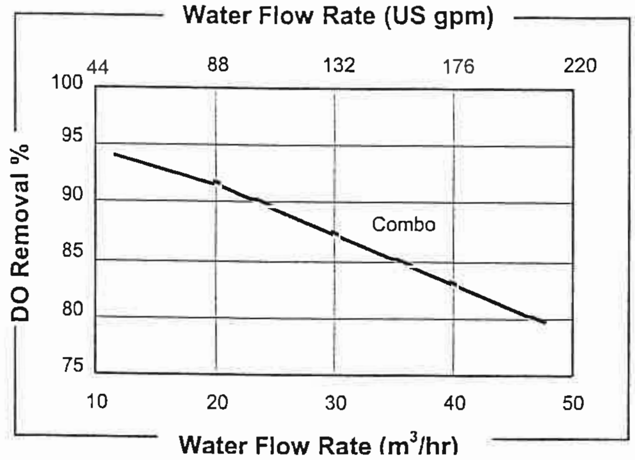
ADDITIONAL NOTES:

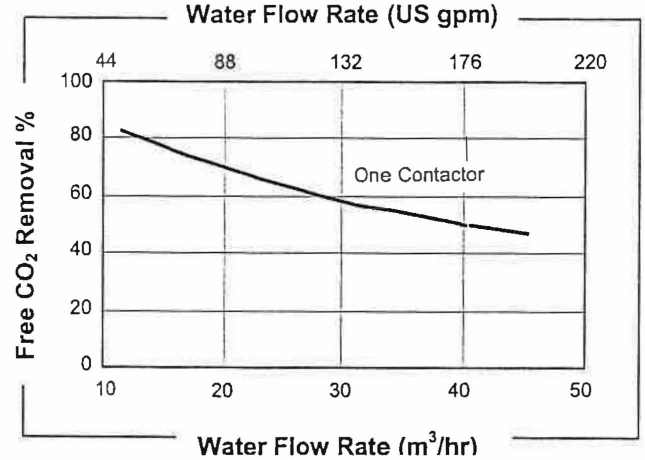
- This Contactor Complies with the PED. The pressures and volumes of liquid processed do not require a CE Mark. This device is Manufactured with Sound Engineering Practice.
- This Industrial Contactor is **NOT** manufactured with FDA Compliant materials.

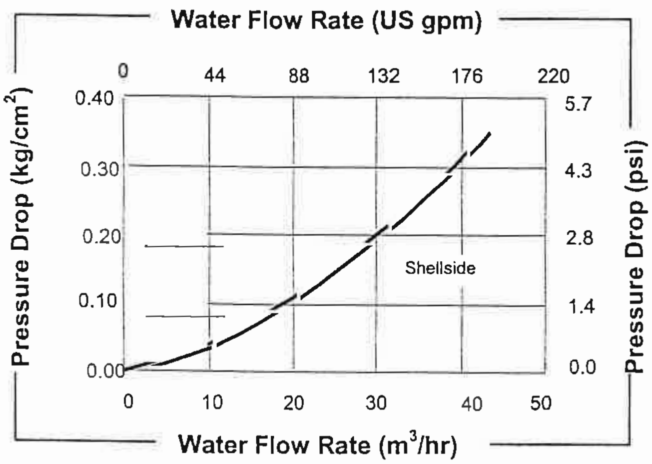
# Liqui-Cel®

Membrane Contactors

## INDUSTRIAL 10x28 PRODUCT DATA SHEET




| Cartridge Specifications | | |
|---|---|---|
| **Characteristics** | **Test Conditions** | **Specifications** |
| Performance<br>$O_2$ Removal | Shellside water flow:<br>160 gpm, 20°C (68°F)<br>Lumenside $N_2$ Flow:<br>3.5 $ft^3$/min, 1.0 atm at 20°C | 80.1%<br>minimum |
| Pressure Drop | Shellside water flow:<br>160 gpm, 20°C (68°F) | 6.0 psi<br>maximum |

Curves represent nominal values, generated using water at 20°C. Characteristics may change under different operating conditions.



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Shinjuku Mitsui Building, 27F
1-1, Nishishinjuku 2-chome
Shinjuku-ku, Tokyo 163-0427
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www.membrana.com
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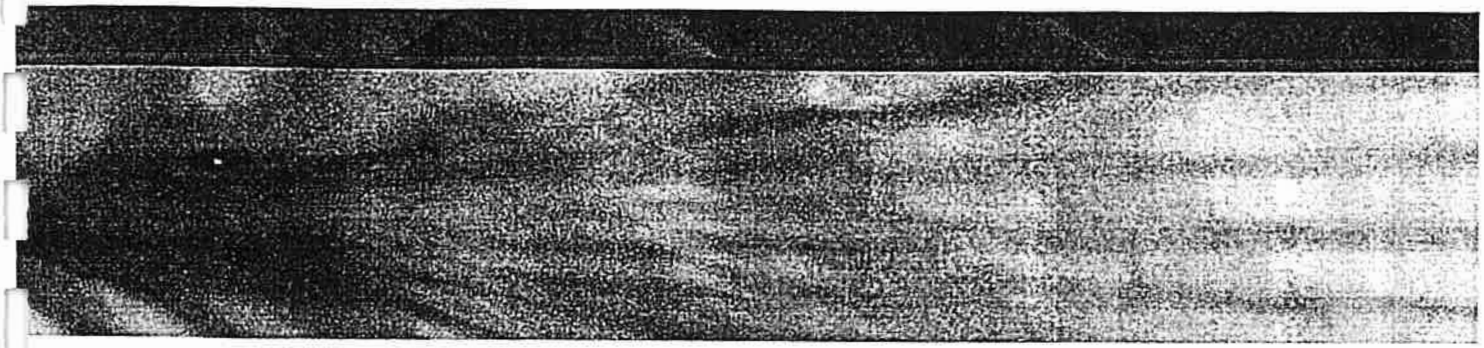


# SuperPhobic®

## Membrane Contactors


Bubble Removal for Enhanced Processing and Yield Improvement

Developers

Emulsions

Inks

Oils

Membrane Technologies For All Your Gas Transfer Needs

# Bubble Removal for Enhanced Processing and Yield Improvement

**SuperPhobic®**
Membrane Contactors

A mechanical pump or a pressurized gas, such as nitrogen, is often used to move liquids from one process to the next. When moving solutions by these methods, microbubbles have a tendency to form. The actual formation of the microbubbles occurs when the liquid pressure is reduced below the saturation pressure of all dissolved gasses within the liquid. Bubbles usually surface at the liquid discharge and can be disruptive to the process and quality of the solution.

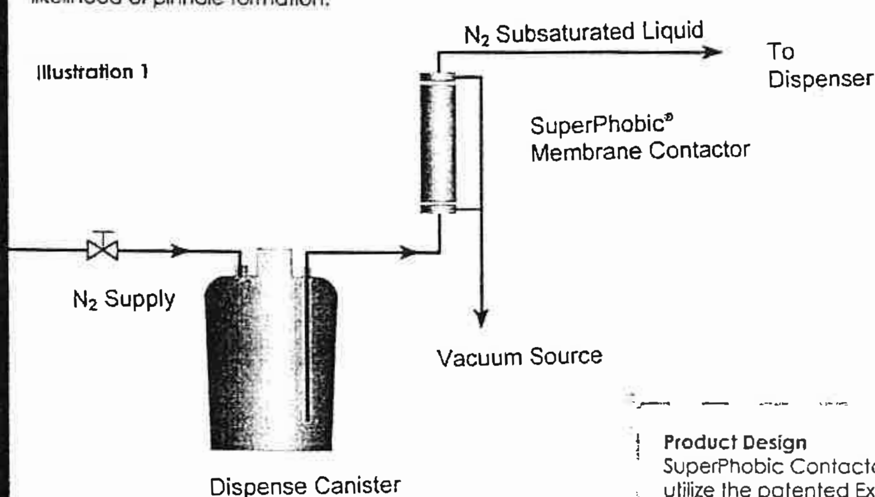
**Preventing Microbubbles**
Microbubbles can be prevented by reducing the dissolved gas concentration below the atmospheric equilibrium levels. SuperPhobic® Membrane Contactors are ideal for removing these microbubbles from the process. The membrane acts as a support medium that keeps the liquid on the outside of the membrane while allowing the gases in the liquid to permeate through the membrane into the vacuum phase.

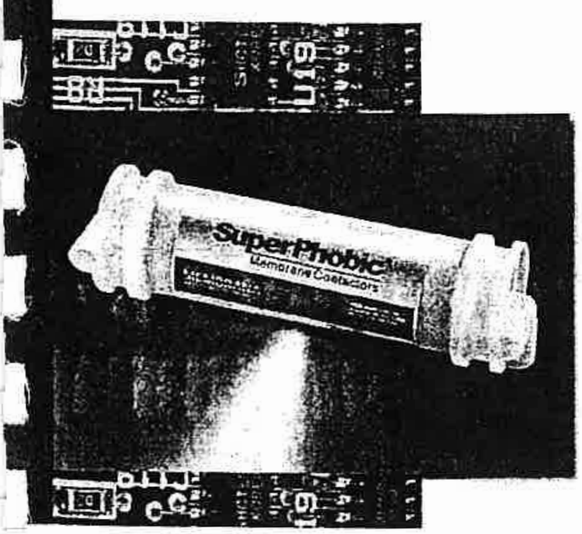
The contactor is placed in-line and connected to a vacuum source (see Illustration 1). The vacuum lowers the partial pressure of the gas phase in the lumens (inside) of the Hollow Fiber. The gasses in the liquid solution want to reach equilibrium with the gases in the vacuum phase and they permeate out of the solution through the membrane wall leaving the liquid bubble free.

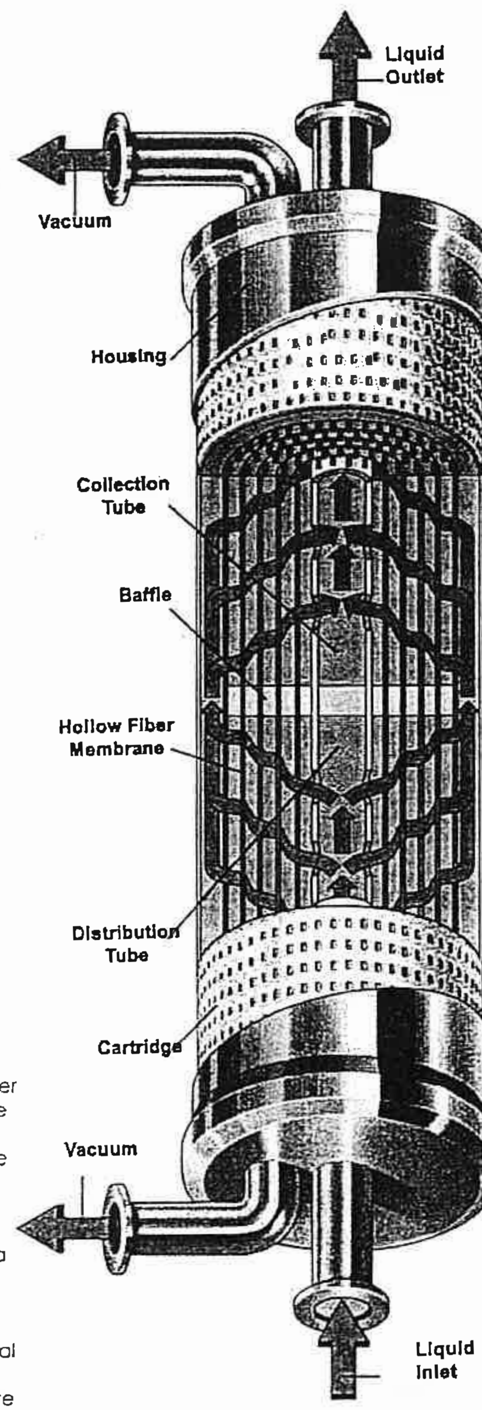
Bubble formation is a problem where coatings are applied to substrates in the semiconductor, photographic film and lithographic plate industries. In the semiconductor industry the application of photo resist and developer solutions is critical and bubbles negatively impact wafer yields.

The lithographic plating, film and paper industries can experience coating defects as well. Entrapped gasses cause pinholes to form and thereby reduce the quality of the printing films, plates and coating solutions. SuperPhobic contactors will remove dissolved gasses and reduce the likelihood of pinhole formation.

Illustration 1




**Product Design**
SuperPhobic Contactors utilize the patented Extra-Flow design where a flow-directing baffle in the center of the contactor directs the liquid radially across the membrane to maximize the mass transfer and surface contact area.

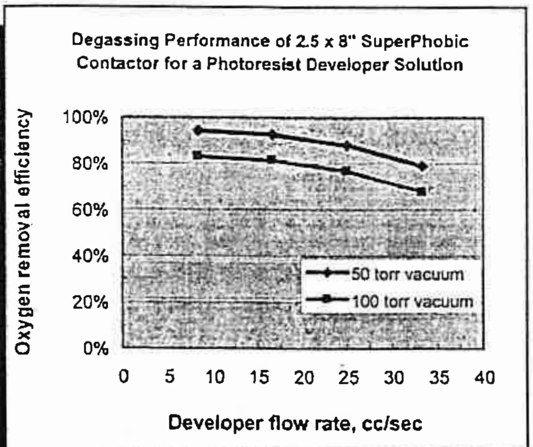
The time it takes to degas a solution is greatly reduced due to the large suface area available for gas transfer versus the traditional vacuum degassing tank. SuperPhobic Contactors are used in-line and degassing is immediate.

# SuperPhobic®

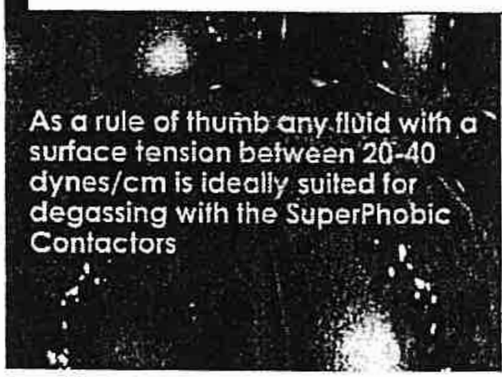
## Membrane Contactors

SuperPhobic® Membrane Contactor Product Family

**Illustration 2** shows the oxygen removal performance of a SuperPhobic Contactor used to degas a developer solution.



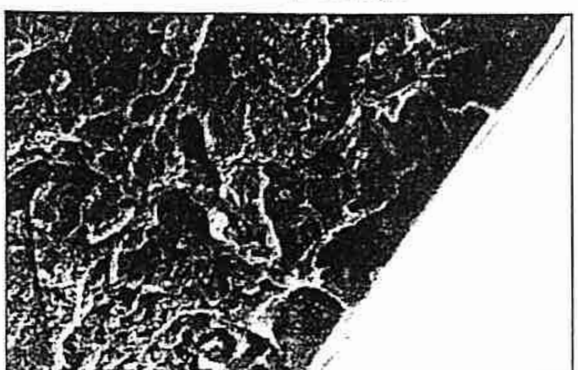

**Developer Solution Characteristics:**
Alkaline liquid containing TMAH (Tetra Methyl Ammonium Hydroxide) and proprietary surfactants




### Applications

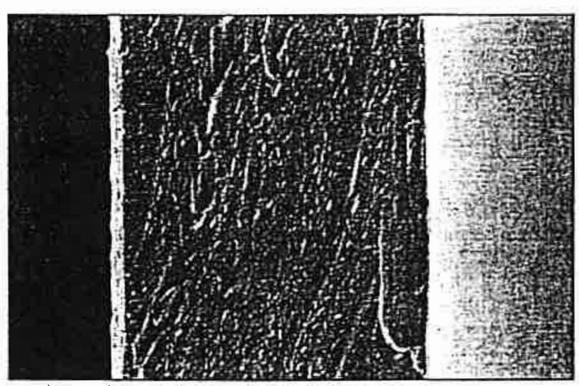
- Developer Solution debubbling
- Emulsion degassing
- Debubbling Inks
- Debubbling photographic coating solutions for papers, films, and printing plates
- Degassing oily solutions

**The Membrane**
The Hollow Fiber Membrane used in SuperPhobic Contactors is a proprietary semi-permeable porous membrane with a non-porous but gas-permeable layer on the outer surface. The process liquid comes in contact with this outer membrane surface, which allows gas diffusion but no liquid flow across the membrane. This membrane introduces a barrier near the liquid phase that allows the liquid and gas phases to remain independent of each other.



20,000X Magnification

Membrane | Outer wall | Liquid side/ Shellside



2,000X Magnification

Liquid side | Outer Wall | Membrane | Gas side/ Lumenside

Liqui-Cel®

Membrane Contactors

# TechBrief

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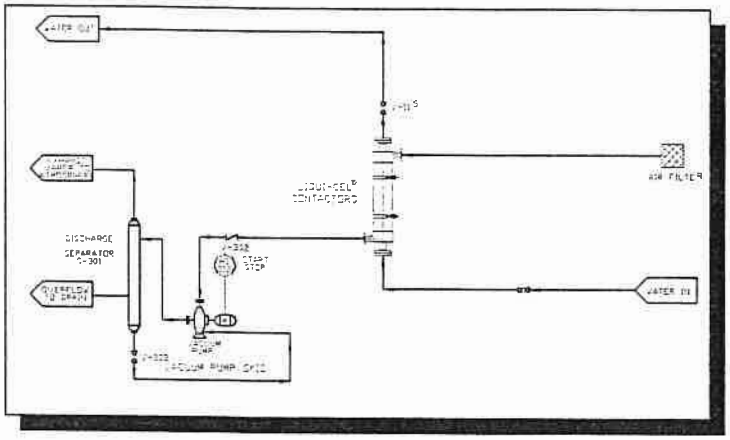

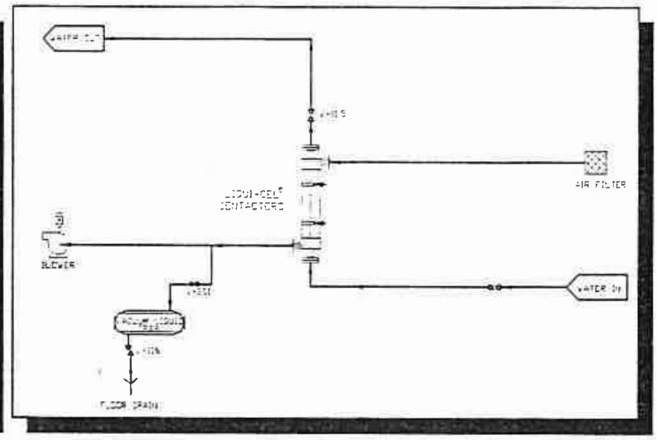

## System Configuration

The Liqui-Cel system configuration is so simple that the only requirement is to connect your water line and either a liquid ring vacuum pump or a regenerative air blower. You can see the simplicity of the system by reviewing the sample P&ID's above.

## Cleaner System

When using a forced draft tower, high purity RO effluent water comes in direct contact with air, which has the potential of adding particles and dissolving other substances like organic matter into your water.

Liqui-Cel Membrane Contactors, however, use Celgard® microporous hollow fiber membrane, which separates the gas phase from the liquid phase. Gas transfer occurs through a 0.03 micron pore making it virtually impossible to re-contaminate the high purity water. This high standard of purity has allowed Liqui-Cel Membrane Contactors to become the degas technology of choice in the pharmaceutical, power and semiconductor industries.

## System Performance

The table to the right is meant to give you an understanding of system performance. You can see the $CO_2$ removal percentage at different water flow rates.

These calculations are based on 20° C water temperature. For a large systems we would recommend multiple 6-inch contactors in parallel or we would suggest moving up to our 10 x 28 INDUSTRIAL Contactor.

| Flow rate (m3/h) | CO2 removal % | 6 x 28 units | Vacuum pump capacity | Vacuum level (mmHg) |
|---|---|---|---|---|
| 2 | 90 | 1 | 15 m3/h | 125 |
| 5 | 97 | 2 | 34 m3/h | 250 |
| 10 | 94 | 2 | 65 m3/h | 250 |

To estimate the remaining amount of CO2 in the water, you can multiply your inlet CO2 in ppm by (1-% removal). For example, if the CO2 inlet is 100 ppm at a flow rate of 5 $m^3$/h, you would have 100*(1-0.97) = 3 ppm CO2 left in the water. As an added benefit, the contactors are non selective to gasses and they will also remove any dissolved oxygen in the water that could negatively impact your process.

In summary, Liqui-Cel Contactors are clean, small, modular, efficient, and proven in the field. We hope you agree that Liqui-Cel contactors are the best choice for your $CO_2$ removal application. Please call us to learn more or to let us size your specific system. You can also visit our website at www.liqui-cel.com for more information.



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Liqui-Cel® Membrane Contactors

# $CO_2$ Removal— Comparison of Liqui-Cel® Membrane Contactors to Forced Draft Degasifiers

Liqui-Cel Membrane Contactors have been used for over 10 years and they are clearly proven in the field. In effort to help further educate customers on the benefits of Liqui-Cel Membrane Contactors over conventional forced draft degasifiers for CO2 removal, we have prepared the following technical comparison.

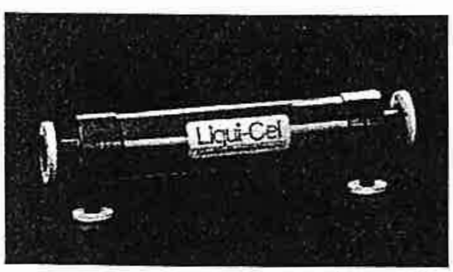
The table below lists the system design requirements that must be thought through at the beginning of the project. You will see that the Liqui-Cel System has fewer restraints.

## Design Requirements

| Forced Draft | Liqui-Cel® Contactors |
|---|---|
| Influent water flow rate | Influent water flow rate |
| Influent CO2 | Influent CO2 |
| Influent water temp. | Influent water temp. |
| Influent water pH | Influent water pH |
| CO2 Outlet | CO2 Outlet |
| Influent suspended solids | **Not applicable** |
| Physical site limitations | **Not applicable** |
| Seismic Zone | **Not applicable** |
| Wind Loading | **Not applicable** |
| Sump retention | **Not applicable** |

## System Size and Placement

The size of a Liqui-Cel Contactor is comparable to a reverse osmosis (RO) membrane, which makes it possible to design your RO unit and easily accommodate your degassing system in the same system skid/frame. This is impossible when using a forced draft tower. The advantages here are saving space and lowering installation costs. Additionally, no special foundation is needed for your Liqui-Cel System. These points are very important to consider when comparing a Liqui-Cel system to a forced draft tower because the foundation, support structure, and installation of a tower can be a big expense.



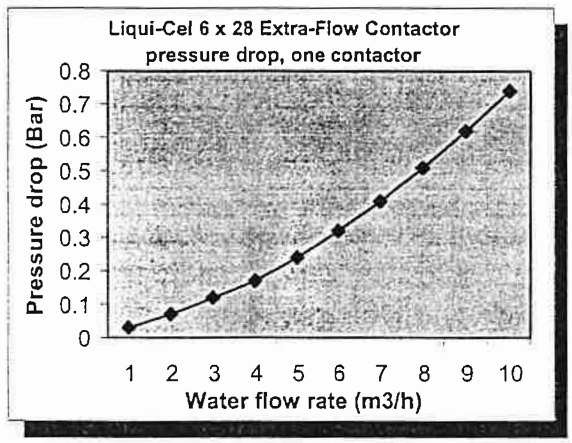

6 x 28 Inch Contactor

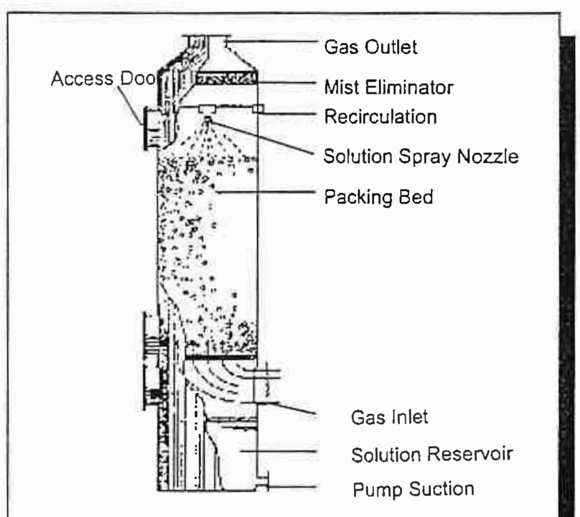
**Foot print comparison**
20 m3/hr (89gpm) system:
Forced Draft: 2′ ft x 20′ ft high
2 Liqui-Cel Contactors on skid with pump: 3′x 2′ x 5′ ft high

## System Pressure Drop

Because the pressure drop in the Liqui-Cel Contactors is so small compared to a forced draft tower, you have a huge benefit of sending your RO permeate water through the Liqui-Cel System and then directly into the storage tank. Similarly, RO permeate can be sent directly through the Liqui-Cel System then through the ion exchange, mixed bed, or EDI and into the storage tank without the need to re-pump. This represents a big cost savings that must be taken into consideration when comparing a Liqui-Cel Contactor system to a forced draft tower.

**The following graph shows the pressure drop for one 6x28 Liqui-Cel Contactor.**




FORCED DRAFT TOWER

Membrana - Charlotte volume: 17 August 2000

# Liqui-Cel® TechBrief

Membrane Contactors

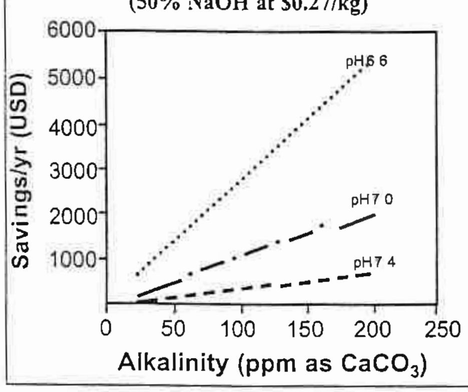
## Carbon Dioxide

In a typical small flow water system, that contains an RO membrane and Ion Exchange Resin, Liqui-Cel® Membrane Contactors may be able to save the customer thousands of dollars a year in chemical regeneration costs.

Carbon Dioxide can be removed from the water using Liqui-Cel Membrane Contactors. When the $CO_2$ is removed, the load on the anion exchange equipment is reduced. This will reduce the frequency of anion exchange regeneration.

By reducing the frequency of regeneration, a reduction in NaOH costs can be realized. This is shown in the attached graph for a 6 m³/hr system. This graph shows the savings realized through NaOH costs as a function of alkalinity. This data is based on a NaOH cost of $0.27 USD/kg (50%). It is shown for three pH levels using a single 4-inch Liqui-Cel Membrane Contactor. The largest savings are realized when the pH is below 7. This is because more $CO_2$ is available for removal. At higher pH more of the $CO_2$ is in an ionic form that is not easily removed using this technology. Air is blown through the inside of the hollow fiber membrane. The air source can be from a compressor, blower or drawn through the fibers from a vacuum source.

NaOH Cost Savings on a 6m³/hr Water System (50% NaOH at $0.27/kg)




As an example, air can be blown through the contactor using a small blower. The electrical consumption of this size blower is about 0.5 kW. This translates to a yearly electrical consumption of about $300.00 USD per year.

During regeneration, the resin must be rinsed with water. The savings in raw water and waste-water will typically be between $750.00 and $1000.00 USD per year. This savings can easily offset the yearly electrical consumption of a small blower.

If the regeneration is done by an outside source, the savings will be even more dramatic. The outside source must also pay transportation costs, labor and overhead. If the NaOH savings alone are reviewed, a small Liqui-Cel system can be paid off in 2-3 years! If the additional cost of labor, chemical storage, waste water treatment and ion exchange resin replacement are included, the savings are even greater.

If the pH of the water is lowered to prevent scaling of the RO membrane, these cost savings are significantly increased. The increased savings are due to the shift in equilibrium from $HCO_3$ to $CO_2$ at lower pH conditions. Under lower pH conditions, more $CO_2$ is available for removal.

The membrane contactors are a very clean, safe way to remove carbon dioxide from water. They will not allow bacteria or other airborne contaminants to come in contact with the water during operation.

If the membranes are placed downstream of an RO membrane, little to no maintenance should be required during their operation.

There are currently hundreds of membranes that have been in operation for 3-5 years without service issues. The Liqui-Cel Membrane Contactors are compact and can easily be installed on existing water systems.

To find out more about this cost savings, please contact your Membrana representative or call 704-587-8511. Also visit our web site **liqui-cel.com**.

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