NORTHWEST METRO AREA REGIONAL WATER SUPPLY SYSTEM STUDY

Draft

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COUNCIL

October 2020

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The Metropolitan Council is the regional planning organization for the seven-county Twin Cities area. The Council operates the regional bus and rail system, collects and treats wastewater, coordinates regional water resources, plans and helps fund regional parks, and administers federal funds that provide housing opportunities for low- and moderate-income individuals and families. The 17-member Council board is appointed by and serves at the pleasure of the governor.

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About this Report

The 2005 Minnesota Legislature directed the Metropolitan Council to “carry out planning activities addressing the water supply needs of the metropolitan area,” including the development of a Twin Cities Metropolitan Area Master Water Supply Plan (Minn. Stat., Sec. 473.1565). After completing that plan, the Council took on many technical and outreach projects that strengthen local and regional water supply planning efforts. These projects have also elevated the importance of water supply in local comprehensive planning, which is carried out by local communities.

This study is one of several being led by the Metropolitan Council to support activities identified by the Minnesota Legislature to address the water supply needs of the seven-county metropolitan area. This study is funded from the Clean Water Legacy Fund (Minn. Laws 2013 Ch. 137, Art. 2, Sec. 9).

The Metropolitan Council retained Short Elliott Hendrickson Inc. (SEH), in partnership with workgroup communities, to complete this technical assessment of different approaches to a regional water supply in the Northwest Metro regional area.

CLEAN
WATER
LAND &
LEGACY
AMENDMENT

Recommended Citation

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Executive Summary

The primary source of drinking water in the Northwest Metro is the Tunnel City-Wonewoc (TCW) aquifer. Concerns with groundwater use in the region include naturally occurring manganese, a potential health concern, and aquifer drawdown due to increased future demands. It is possible that groundwater may not be able to meet all of the future drinking water demands.

The primary objective of this study is to understand the relative costs and implementation considerations of different approaches to long term water supply within the study area. The study area includes the Northwest Metro cities of Corcoran, Dayton, Ramsey and Rogers.

The study will be referenced to support future planning of metro area water supplies and water sustainability practices. As cities face increased demands on their water supplies in the future, this report provides concept level options for consideration.

This report meets the requirements of Minnesota Statutes, section 473, subdivision 1565, which calls for the Council to "carry out planning activities addressing the water supply needs of the metropolitan area". Special funding for this project was provided through the Clean Water Fund.

This study evaluates four approaches to meet future water demands in the study area:

- Approach 1: Regional Surface Water Treatment Plant
- Approach 2: Regional Groundwater Treatment Plant
- Approach 3: Conjunctive Use of Surface Water and Groundwater
- Approach 4: Status Quo – Individual Lime Softening Water Treatment Plants

This study provides communities concept level costs and considerations for various water supply approaches. It is not meant to prescribe specific solutions for implementation. Rather these approaches serve as examples to stimulate future planning that could involve a hybrid of the alternatives identified in this study or in combination with water conservation measures and other sustainability approaches.

Study Area Community Information

The communities in the study area represent different levels of development. All the communities have significant growth forecasted for 2040, with the study area population estimated to grow by 250%. The average day water demand for the study area is expected to increase from 3.3 million gallons per day (MGD) to 7.8 MGD in 2040. The maximum day demand for the four communities is estimated to increase from 7.4 MGD to 21.8 MGD. Community projections for ultimate buildout conditions for the study area predict an average day demand of 29 MGD and maximum day demand of 73 MGD.

Regional Water System Capacity

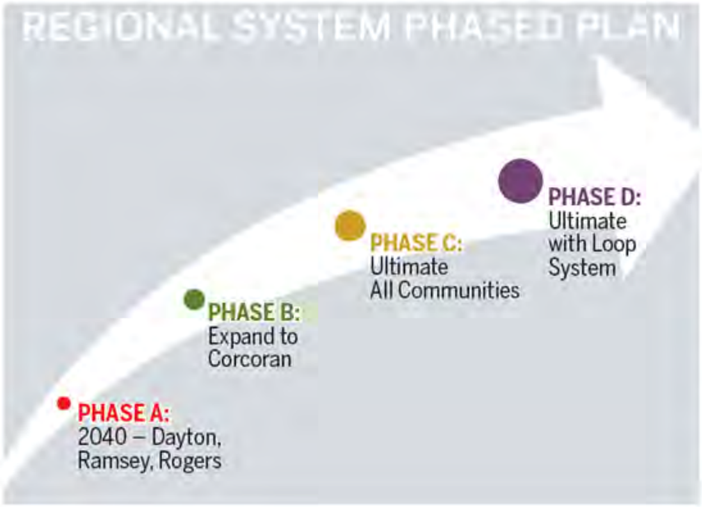
In planning for a regional water system with a single, centrally treated supply, the maximum day demand is the criteria used to establish the capacity of most system components. For approaches 1 and 2 with a central water treatment plant, the design capacity is assumed to be 25 MGD for 2040 and 75 MGD for ultimate conditions. For Approach 3, the central water treatment system capacity is based on the average day demand and peak day demands are served by each community's well system. The 2040 water treatment plant (WTP) capacity is assumed to be 12 MGD and the capacity serving ultimate demands would be 40 MGD.

Phased Approach

For water distribution systems, the trunk watermain is typically sized for the ultimate system capacity. To provide reliability of service, typically there is a "loop" trunk system. Given the different levels of development for the four communities and the distances involved, a looped trunk watermain sized for the ultimate capacity is a significant investment that would be underutilized for a long time.

The concept plan for the distribution system and WTPs is segmented into four phases for two different WTP location sites as demonstrated on Figure ES-1. The phased watermain and water treatment plant locations are shown on Figures ES-2 and ES-3.

Figure ES-1. Phased Approach to Trunk Watermain Construction



PHASE A1 (WTP in Ramsey): A backbone 36" watermain is constructed connecting Ramsey, Dayton, and Rogers. Serves water demands through 2040.

PHASE A2 (WTP in Dayton): A backbone 36" watermain is constructed connecting Ramsey, Dayton, and Rogers. Serves water demands through 2040.

PHASE B: Extend 16" watermain to Corcoran, meets 2 MGD demands.

PHASE C: Extend 36" watermain to Corcoran; meets Corcoran ultimate demands.

PHASE D1 (WTP in Ramsey): Complete 36" watermain loop; meets ultimate demands.

PHASE D2 (WTP in Dayton): Complete 36" watermain loop; meets ultimate demands.

Approach 1 – Regional Surface Water Treatment Plant

Several Minnesota communities have the Mississippi River as their source of drinking water, including St. Cloud, St. Paul Regional Water Services, and Minneapolis. It was determined that the Mississippi River in the vicinity of the Northwest Metro has sufficient capacity and water quality to serve the ultimate water demands of the communities. Two locations were considered for a potential regional surface water treatment plant, including a location in Ramsey and a location in Dayton.

To protect public health from pathogens, surface water used for drinking water is required to follow the US EPA's Surface Water Treatment Rule. To meet maximum day demands, the 2040 capacity of the water treatment plant is 25 MGD and the ultimate capacity is 75 MGD.

Approach 2 – Regional Groundwater Treatment Plant

A regional groundwater treatment plant would utilize wells in a central wellfield for its source water. To reduce chlorides in wastewater from home softeners and compare the groundwater WTP against a lime softening surface WTP, it is assumed that the potential regional groundwater WTP is a lime softening WTP. The groundwater treatment plant is proposed to be located in Dayton because it is centrally located, less developed than Rogers or Ramsey, and the Tunnel City Wonewoc aquifer is available throughout the entire City.

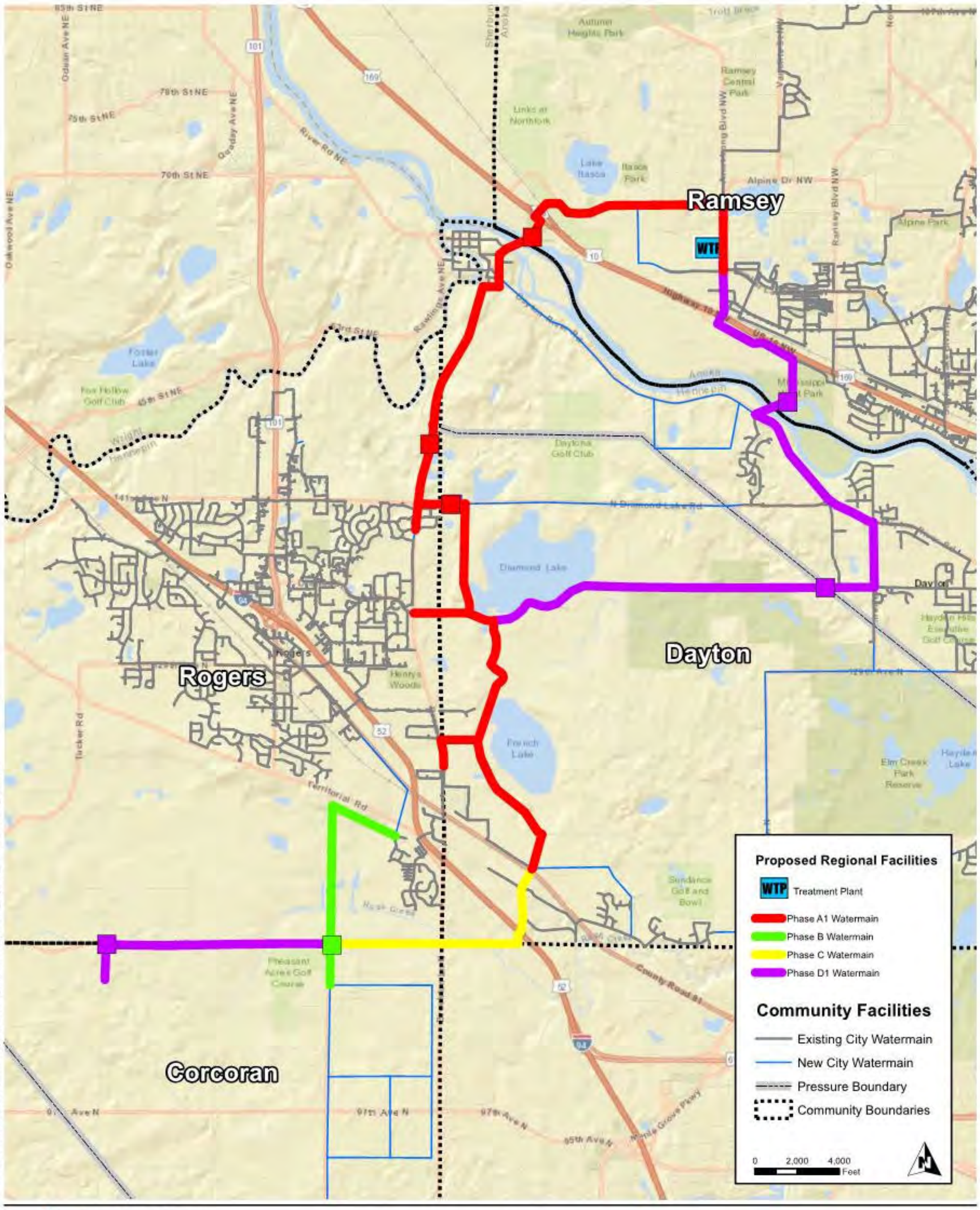
The concept regional groundwater WTP is proposed to provide a capacity of 25 MGD and would serve the maximum day demands for the Northwest Metro communities through 2040. After 2040, the groundwater WTP will be expanded to 75 MGD to meet ultimate water demands.

Approach 3 – Conjunctive Use

A hybrid option for the Northwest Metro to utilize some of its groundwater infrastructure is to build a new water treatment facility with a surface water source for conjunctive use with the existing groundwater systems. Conjunctive use is using treated surface water to meet average day demands and peaking with existing groundwater wells.

Approach 3 consists of constructing a 12 MGD surface WTP to meet 2040 demands and a 28 MGD expansion (total of 40 MGD) to meet ultimate demands. The 2040 average day demand for the Northwest Metro is 7.8 MGD and the ultimate average day demand is 29 MGD. The WTP capacities are designed to be larger than the average day demands so that the water treatment plant does not need to be operated 24 hours per day.

Figure ES-2. Phased Regional Water System with a WTP in Ramsey.



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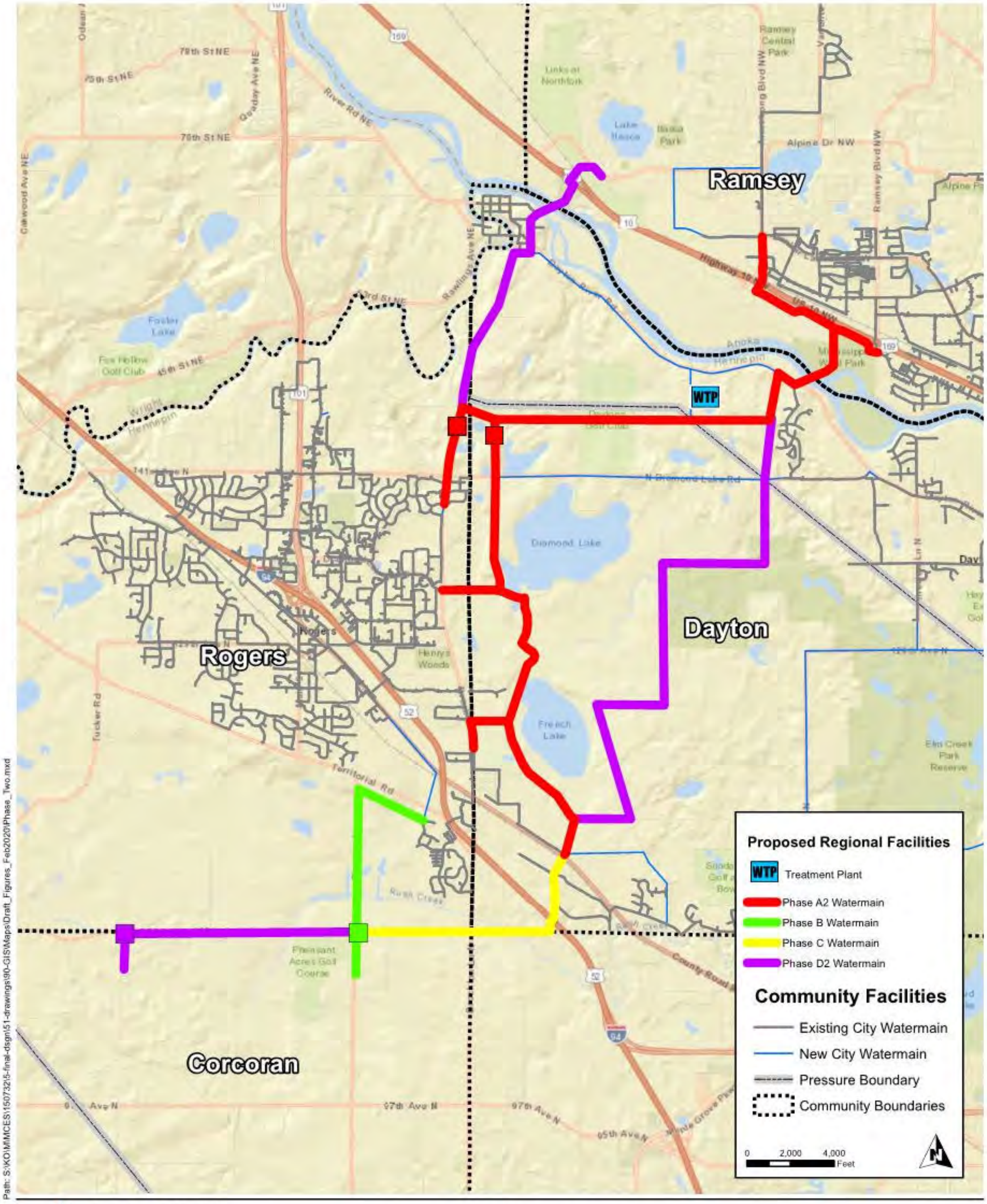
Scenario 1 - WTP in Ramsey
Phased Regional Water System
Northwest Metro Regional Water Supply Study

FIGURE ES-2

Figure ES-3. Phased Regional Water System with a WTP in Dayton.



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Scenario 2 - WTP in Dayton
Phased Regional Water System
Northwest Metro Regional Water Supply Study

FIGURE ES-3

Approach 4 – Status Quo – Individual Lime Softening Water Treatment Plants

In the absence of a project driver or an incentive to do something different, the Northwest Metro cities will most likely continue to utilize groundwater in separate water systems.

To provide an equivalent comparison to Approaches 1-3, it is assumed that the Northwest Metro cities will continue to drill wells as needed and construct lime softening WTPs. A potential driver for selecting a lime softening treatment process for community drinking water systems is a future wastewater discharge limit for chlorides in the Twin Cities metro area receiving waters. The majority of the chloride in wastewater comes from the regeneration process of home water softeners.

The number of new wells and the capacities of the lime softening water treatment plants in Approach 4 is based on the 2040 and ultimate water demands of the individual Northwest Metro cities. To meet ultimate demands using only groundwater, it is estimated that an additional 54 wells will be needed.

Approach Comparison

The four approaches are compared through an analysis using 20-year and 60-year planning horizons. The 2040 Regional System Plan is based on meeting the 2040 demands for Dayton, Ramsey and Rogers and assumes that the ultimate water trunk main is extended to Corcoran by 2040. For the 60-year planning period, the system capacity is expanded from 2040 to accommodate the ultimate or buildout conditions of all four communities.

Table ES-1 summarize the lifecycle costs for water system facilities to meet 2040 demands. The three regional drinking water system approaches and continuing with the ‘status quo’ of separate community systems are compared.

Table ES-1. Concept Level Capital and O&M Costs for 2040 Demand

Item	Approach 1 Regional Surface Water	Approach 2 Regional Groundwater Lime Softening	Approach 3 Conjunctive Use	Approach 4 Status Quo Lime Softening
Capital Costs				
Distribution System (Watermain/Booster Stations)				
Phase A, Scenario 1	$61,000,000		$61,000,000	
Phase A, Scenario 2		$59,300,000		
Phase B	$5,800,000	$5,800,000	$5,800,000	
Phase C	$18,600,000	$18,600,000	$18,600,000	
WTP and Wells	$132,000,000	$176,000,000	$102,000,000	$197,000,000
Capital Cost Total[1]	**$217,000,000**	**$260,000,000**	**$187,000,000**	**$190,000,000**
Annualized Capital Cost (20 year)	**$14,600,000**	**$17,500,000**	**$12,500,000**	**$12,700,000**
O&M Annual Costs				
WTP/Well O&M	$5,900,000	$5,500,000	$5,250,000	$6,100,000
Booster Station O&M	$100,000	$100,000	$100,000	
WTP/Well Repair & Replacement (2%)	$2,600,000	$3,500,000	$2,000,000	$3,900,000
Distribution Repair and Replacement (1%)	$900,000	$800,000	$900,000	
O&M Cost Total[1]	**$9,500,000**	**$9,900,000**	**$8,250,000**	**$10,000,000**
Total Annualized Cost[1]	**$24,100,000**	**$27,400,000**	**$20,750,000**	**$22,700,000**

[1] Costs based on 2020 dollars; no escalation to date of construction.

Table ES-2 summarizes the lifecycle costs for water system facilities to meet ultimate demands. The three regional drinking water system approaches and continuing with the ‘status quo’ of separate community systems are compared.

Table ES-2. Concept Level Capital and O&M Costs for Ultimate Demand

Item	Approach 1 Regional Surface Water	Approach 2 Regional Groundwater Lime Softening	Approach 3 Conjunctive Use	Approach 4 Status Quo Lime Softening
Capital Costs				
2040 Capital Costs	**$217,000,000**	**$260,000,000**	**$187,000,000**	**$190,000,000**
Distribution System				
Phase D, Scenario 1	$67,000,000		$67,000,000	
Phase D2, Scenario 2		$62,000,000		
WTP and Wells	$164,000,000	$272,000,000	$202,000,000	$410,000,000
Capital Cost Total[1]	**$448,000,000**	**$594,000,000**	**$456,000,000**	**$600,000,000**
Annualized Capital Cost (60 year)	**$16,100,000**	**$21,500,000**	**$16,400,000**	**$21,700,000**
O&M Annual Costs				
WTP O&M	$17,500,000	$16,400,000	$15,600,000	$18,100,000
Booster Station O&M	$440,000	$440,000	$440,000	
WTP Repair & Replacement (2%)	$5,900,000	$8,900,000	$6,000,000	$12,100,000
Distribution Repair and Replacement (1%)	$1,600,000	$1,300,000	$1,600,000	
O&M Cost Total[1]	**$25,000,000**	**$27,000,000**	**$24,000,000**	**$30,000,000**
Total Annualized Cost[1]	**$41,300,000**	**$48,500,000**	**$40,400,000**	**$51,700,000**

[1] Costs based on 2020 dollars; no escalation to date of construction.

Summary of Findings and Implementation Considerations

Key takeaways from this concept level study of alternative approaches to a Northwest Metro area regional drinking water supply system include:

- The average day water demand in the Northwest Metro is projected to increase from 3.3 MGD in 2015 to 7.8 MGD in 2040 (140% increase).
- The ultimate average day water demand in the Northwest Metro is 29 MGD (approximately 800% increase from 2015).
- If the Northwest Metro cities continue to utilize only groundwater to meet water demands, an additional 54 wells will likely be needed to meet ultimate demands. A 2016 MCES report indicated drawdown in the Tunnel City-Wonewoc aquifer in 2040 when demands are only 27% of the ultimate demands. It is possible that the aquifer cannot sustain the ultimate demands of the Northwest Metro.
- The Mississippi River has sufficient water quantity to serve the Northwest Metro communities. The water quality in the Mississippi River appears to be acceptable for a conventional surface water treatment plant. St. Could, St. Paul, and Minneapolis utilize the Mississippi River as their source of drinking water.
- A regional surface WTP has the advantages of being a cost effective approach, eliminates the need for numerous addition wells, increases groundwater sustainability, provides fully softened water, and reduces chloride discharges to the Mississippi River. The disadvantages of a regional surface WTP is that it changes water taste and odor and relies heavily on one water source.
- A regional lime-softening groundwater WTP has the advantages of providing fully softened water and reduces chloride discharges to the Mississippi River. The disadvantages of a regional lime softening groundwater WTP is that it is one of the most expensive approaches evaluated, may not be feasible due to groundwater drawdown, and relies heavily on one water source.

- A regional conjunctive use WTP has the advantages of being a cost effective approach, increases groundwater sustainability, provides mostly softened water, reduces chloride discharges to the Mississippi River, and does not rely on one water source. The disadvantages of a regional conjunctive use WTP is that it changes water taste and odor and does not provide fully softened water in the summer.
- Constructing individual lime softening groundwater WTPs (Status Quo) has the advantages of providing fully softened water and reduces chloride discharges to the Mississippi River. The disadvantages of individual lime softening WTPs is that it is the most expensive approach and relies on one water source.
- A cost of service example indicates that grant funding will be an integral part of implementing a regional surface water supply system to make the project viable.
- In the absence of a project driver, Northwest Metro cities are likely to continue to utilize groundwater and construct iron and manganese removal water treatment plants. At this point, none of the Northwest Metro cities have water treatment plants, although 2 are in the planning stages (Ramsey and Corcoran).
- The Northwest Metro communities are embarking on this study at an optimal time. The water systems are not fully developed and significant growth is planned.

Chapter 1 - Introduction

Metropolitan Council Environmental Services (MCES) has partnered with communities to study regional water supply sustainability initiatives in the Twin Cities metropolitan area. One of these initiatives is the Northwest Metropolitan Area Regional Surface Water Supply System Study (Study). This study is a collaborative and cooperative effort between MCES and the Cities or Corcoran, Dayton, Ramsey, and Rogers (Northwest Metro). The scope of this study was developed in conjunction with the Northwest Metro communities.

The approaches evaluated in the study are not meant to be prescriptive, but serve as examples to stimulate future planning that could involve a hybrid of alternatives identified in the study, or in combination with water conservation measures and other sustainability approaches.

1.1 Study Objectives

The primary objective of this study is to understand the relative costs and implementation considerations of different approaches to a regional water supply in the Northwest Metro regional area.

This study evaluates four approaches to water supply:

- Approach 1: Regional Surface Water Treatment Plant
- Approach 2: Regional Groundwater Treatment Plant
- Approach 3: Regional Conjunctive Use System (Surface Water Augmented with Groundwater)
- Approach 4: Status Quo

The approaches were selected in consultation with the study partner communities. The project components developed for each approach should be viewed as examples. The best option for moving forward may be a hybrid of the examples considered in this study and could involve approaches that were not considered in this study. The “status quo” approach assumes that all communities continue with separate water supply systems and provides a comparison to the three regional water supply approaches evaluated.

This study does not provide a “shovel-ready” project for implementation. The projects defined by each approach are at a concept-level, with the intent to compare relative differences in costs between approaches, and more importantly to explore the implementation issues associated with each approach.

Joint water system governance and cost sharing options are also explored as part of the implementation considerations evaluation.

1.2 Evaluation Process

This study defines concept level water infrastructure systems to deliver the approaches identified in the study objectives. The basic elements of the evaluation include:

- Description of concept system alternatives
- Concept level costs
- Considerations for implementation
- Comparison of potential benefits of alternative / approach combinations to the sustainability of water resources and system reliability in the Northwest Metro area

1.3 Study Area

The Northwest Metro study area is delineated in Figure 1-1. The communities in the study area include the cities of Corcoran, Dayton, Ramsey and Rogers.

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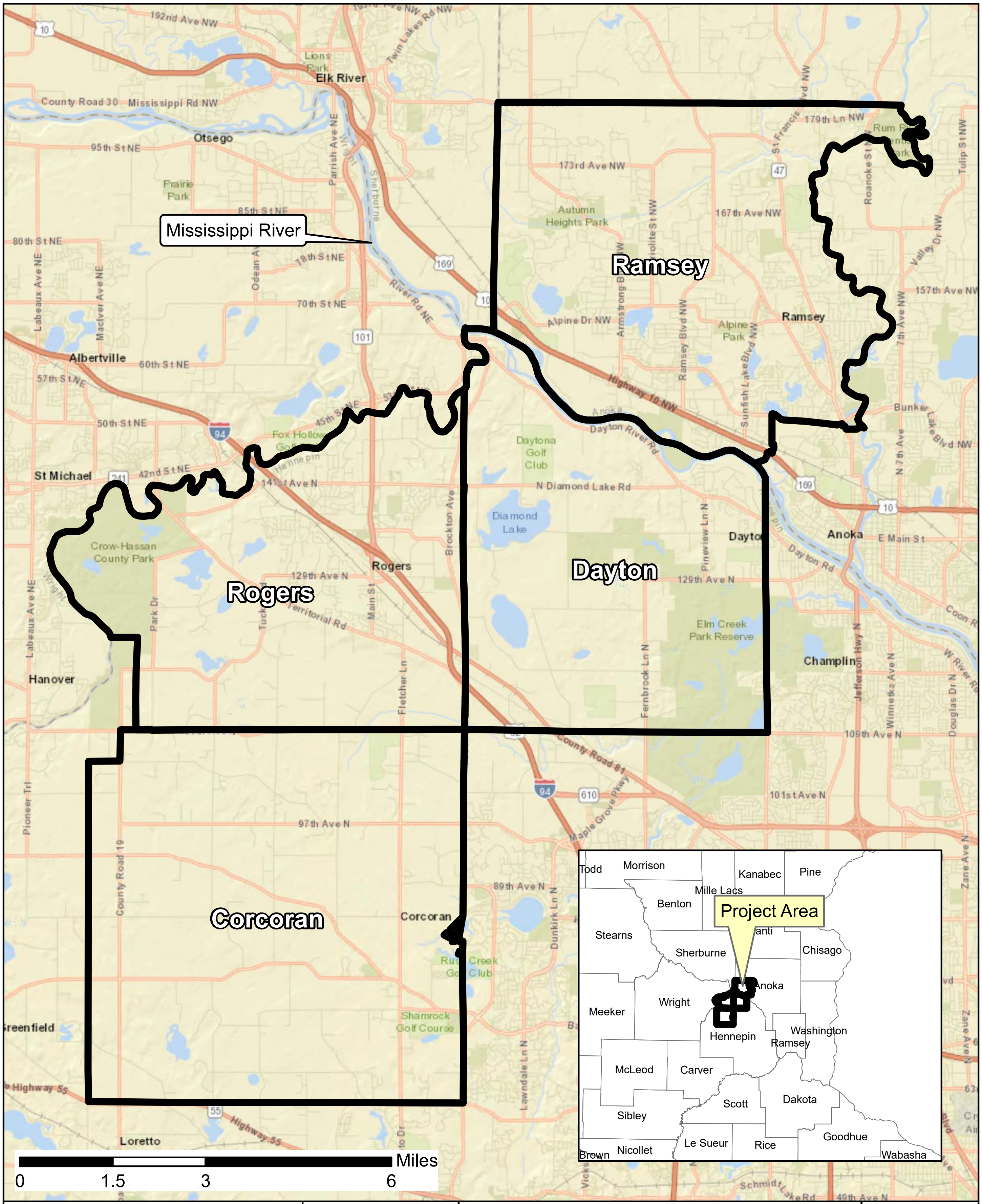

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STUDY AREA

Ramsey, Dayton, Corcoran,
and Rogers, Minnesota

Figure
1-1

1.4 Water Demand

Existing water and projected 2040 water demands for each of the study area communities is presented in Table 1-1. In 2040, projected average daily water use by the entire study area is estimated to be 8 million gallons per day (MGD), while maximum day water demand is expected to be 22 MGD.

The total study area population is expected to grow by about 250% by 2040. The 2040 projected water demands for Rogers are within their permitted well appropriation but Ramsey will exceed their current appropriation. Dayton and Corcoran are supplied water by Maple Grove and have water contracts through 2036 and 2038, respectively. Dayton has a current appropriation of 35 MGY and Corcoran currently has no permitted community drinking water wells.

Table 1-1. Historic and Projected Population and Drinking Water Demand for Northwest Metro Communities.

City	2015 Population[1]	2040 Population[1]	2015 Avg Day Demand (MGD)[2]	2040 Avg Day Demand (MGD) [3]	2015 Max Day Demand (MGD) [3]	2040 Max Day Demand (MGD) [3]
Rogers	9,400	20,050	1.3	2.5	2.9	6.2
Ramsey	13,774	26,988	1.8	3.5	4.5	10.3
Dayton	1,667	7,317	0.2	0.7	0.4	1.9
Corcoran	48	7,650	0.01	1.1	NA	3.4
Total	**24,899**	**62,005**	**3.3**	**7.8**	**7.4**	**21.8**

[1] Served by Municipal Water System (estimated) - [2] DNR Water Appropriations database – [3] Community comprehensive plans.

This concept level study requires projecting beyond the typical 20-year planning horizon. Communities provided their projections for buildout conditions and the potential “ultimate” water demand. The ultimate average annual demand is estimated to be around 30 MGD and the ultimate maximum day demand could be greater than 70 MGD. Table 1-2 provides the estimated ultimate demand provided by each community.

Table 1-2. Ultimate Water Demand for Northwest Metro Communities.

Year	Ultimate Avg Day Demand (MGD)	Ultimate Max Day Demand (MGD)
Rogers	4.8	12
Ramsey	8.0	20
Dayton	7.7	19.3
Corcoran	8.8	22
Total	**29**	**73**

Sources: Community provided based on ultimate growth projections.

An important water infrastructure planning criteria is the ratio of maximum day water use to average day use. Peak demands occur during warmer months, and are mainly attributed to irrigation and outdoor water use needs. This ratio provides one method of assessing a community’s water use efficiency. Table 1-3 summarizes the projected 2040 water demand and peak ratios.

Table 1-3. 2040 Average and Maximum Day Demands by Community.

City	Avg Day[1] 2040 Demand (MGD)	Max Day[2] 2040 Demand (MGD)	Peak Ratio[3]	% Total Study Area Avg Day Demand
Rogers	2.5	6.2	2.5	32%
Ramsey	3.5	10.3	2.9	45%
Dayton	0.7	1.9	2.7	9%
Corcoran	1.1	3.4	3.1	14%
Total	**7.8**	**21.8**	2.8	

[1] Average day demand is defined as the total annual water use for a system divided by 365 days, thus the annual average demand.

[2] Maximum day demand is defined as the largest daily water use over the course of a calendar year. This is an important criterion for the sizing of infrastructure systems for reliable service.

[3] Peak Ratio is the maximum day demand divided by the average day demand.

1.5 Existing Water Infrastructure

There are 17 municipal wells listed within the study area. All of these wells draw from the Tunnel City-Wonewoc (TCW) aquifer. The sum appropriation for these wells is 1,635 MGY. Table 1-4 provides a summary of well information, along with storage capacity and distribution system interconnects for each community. Well locations and other water infrastructure are shown in Figure 1-2.

Table 1-4. Northwest Metro Municipal Wells and Supply System Features

City	No. of Wells	Aquifers	Total Capacity	Firm Capacity (MGD)	Storage (MG)	Interconnects
Rogers	7	TCW	7.8	6.3	3.15	Dayton
Ramsey	8	TCW	11	9	4	Anoka
Dayton	2	TCW	2.1	0	0.5	Rogers, Champlin, Maple Grove
Corcoran	0	-	-	-	-	Maple Grove, Medina

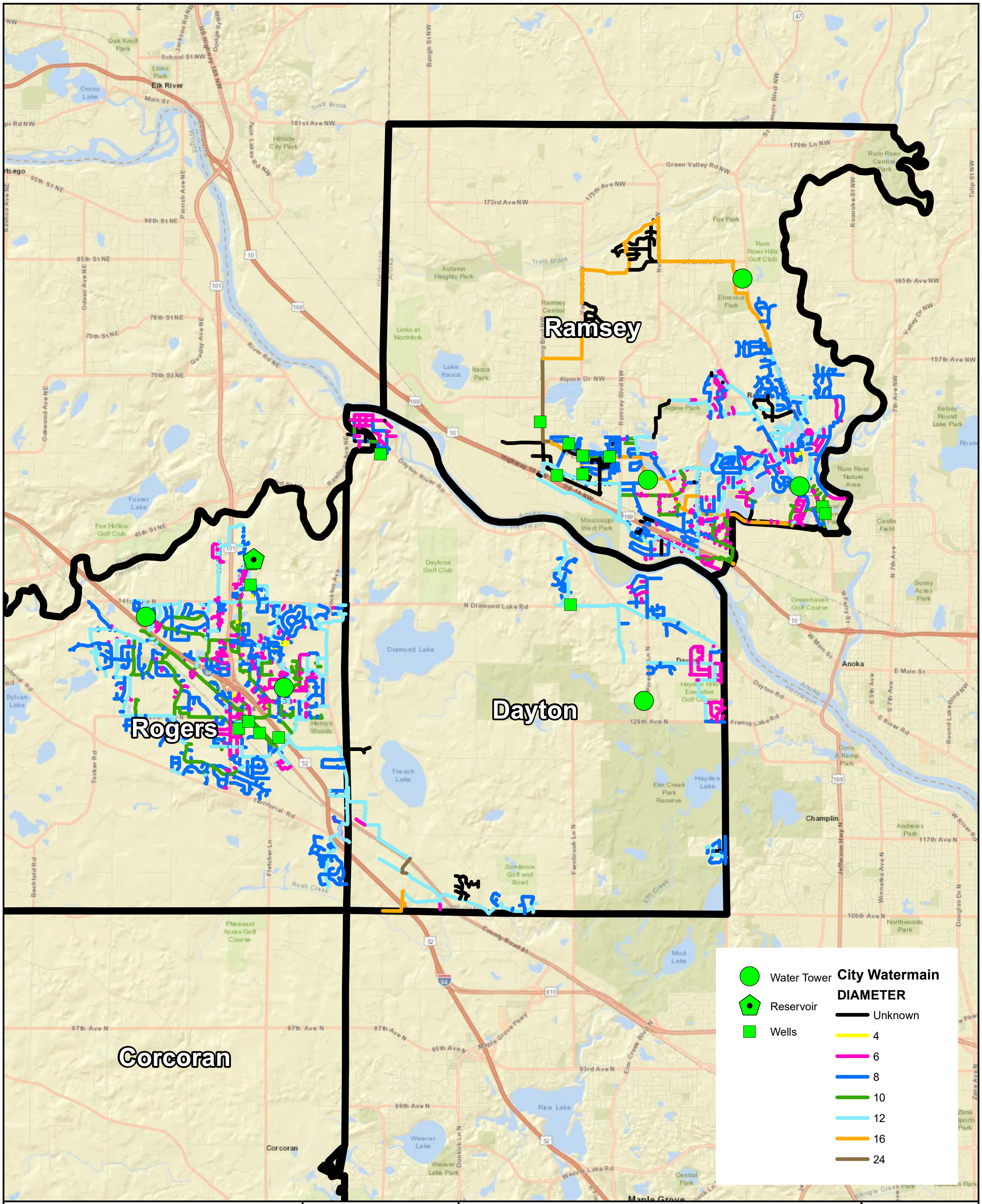
TCW = Tunnel City Wonewoc

Pressure zones across the communities range from a low of 1030 in Ramsey to a high of 1170 in a small high pressure zone in Rogers. New pressure zones are anticipated in the southern portion of Dayton and the City of Corcoran which are not currently served by those cities. Portions of Dayton and Corcoran are currently served by Maple Grove.

1.6 Community Development and System Capacity

The communities in this study represent different stages of development, as summarized in Figure 1-3. Using maximum day demand as an equivalent to drinking water system capacity, the capacity requirements of the communities can be compared. Rogers and Ramsey currently have community drinking water systems serving large portions of their population. It is estimated that the existing maximum day demand (based on 2015 data) for Rogers and Ramsey is approximately 25% of their projected ultimate demand. Dayton and Corcoran represent less developed communities. Dayton has a community water supply system serving a small portion of the city and Corcoran has none. Both currently purchase drinking water from Maple Grove. The existing maximum day demand for Dayton is estimated to be only 2% of the ultimate maximum day demand, and for Corcoran it is less than 0.2%.

Another way to look at it: the capacity of a regional drinking water system in operation today (based on 2015 data) would be based on Rogers and Ramsey at 95% of the capacity. In 2040, this decreases to 75%, and to less than 45% for buildout conditions represented by an ultimate study area demand.



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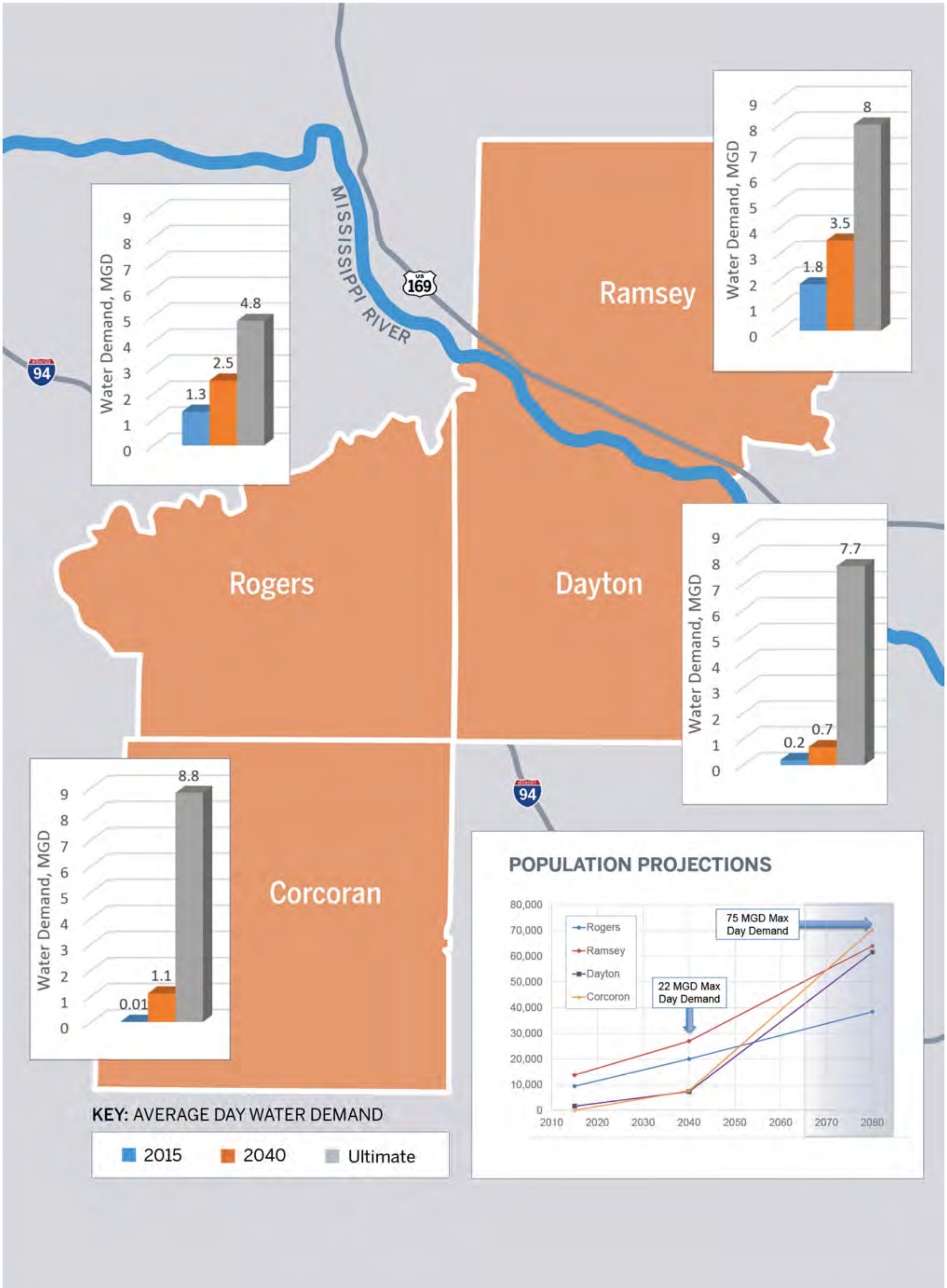
EXISTING WATER INFRASTRUCTURE

Northwest Metro Area Regional
Water Supply Study

Figure
1-2

Figure 1-3. Growth and Water Demand Projections for the Study Area.



Chapter 2 – Water Supply Quality and Quantity

The regional water supply approaches evaluate two sources of water: the Mississippi River and groundwater, focusing on the Tunnel City-Wonewoc aquifer. This section provides information about the water quality and quantity of each supply in the study area vicinity of relevance to designing a drinking water system.

2.1 Mississippi River

The following sections discuss Mississippi River water quality, constituents of concern, and regulated constituents.

2.1a Water Quality

In the Twin Cities metro area, the Mississippi River serves as the primary drinking water source for Minneapolis and St. Paul and the communities they serve with wholesale or retail water. These long-serving drinking water systems provide a historic record of water quality and treatment practices as a reference to define system components for a Northwest Metro area regional surface water treatment system. It is common practice to treat Mississippi River water using a lime softening process with various filtration methods.

The closest water quality monitoring site to a potential intake for a new regional water treatment plant is located in Anoka, less than 2 miles downstream of the Dayton/Ramsey border. MCES has been collecting field and laboratory analyzed samples at this site for over 45 years. The Anoka monitoring site is the primary reference source for water quality characterization in this study. Other data sources reviewed include data maintained by the Minnesota Department of Health (MDH) at Fridley, MCES' monitoring at Fridley and MDH data for St. Cloud, to provide a reference point upstream of the Crow River confluence.

This study focused on a subset of constituents important when considering surface water as a source for drinking water. Constituents of interest in planning for conventional drinking water treatment processes are categorized in this study as primary constituents of interest. This list is expanded to summarize the full list of constituents regulated for public drinking water supplies. Historic data is also reviewed for other monitored constituents not currently regulated for drinking water supplies to identify any constituents that may have been detected. Appendix A provides information on the data sources, monitoring site locations, data analysis methods, and a more comprehensive compilation of water quality data.

Surface water sources, including the Mississippi River, have a wider range of potential contaminants than groundwater due to intentional and unintentional discharges to the river. This could include runoff, wastewater treatment discharges, and accidental releases. A discussion of regulated contaminants and potential future regulations is presented in Section 2.1c.

2.1b Primary Constituents of Interest

Historic data for constituents of interest in selecting and designing drinking water treatment processes are listed in Table 2-1. The average concentrations and variability are generally similar to what is observed for other surface WTPs along this upper stretch of the Mississippi River. Conventional treatment processes with accepted best practices are able to treat these constituent concentration ranges.

Table 2-1. Primary Constituent Summary

Constituent	Unit	Avg	St Dev	Min	95th Percentile	Max	No. Samples
Alkalinity	mg/L CaCO3	178	31	90	227	374	296
Hardness	mg/L	208	37	86	274	332	145
Iron	mg/L	0.51	0.26	0.17	1.2	1.3	27
Manganese	mg/L	0.0001	0.00005	0.000045	NA	0.0002	12
Total Dissolved Solids	mg/L	269	48.3	119	348	720	972
Total Organic Carbon	mg/L	9.4	2.5	5.1	NA	14.5	20
Nitrate	mg/L	0.90	0.78	0	2.4	5.4	1313
Nitrite	mg/L	0.011	0.04	0	0.05	1	1314
Total Kjeldahl Nitrogen	mg/L	0.93	0.34	0	1.5	3.6	1109
Phosphorus, Total	mg/L	0.11	0.08	0	0.24	1	1349
Turbidity	NTU	6.6	7.2	1.3	15	200	1086
Total Suspended Solids	mg/L	16.7	14.2	0	40	165	1320
E. Coli	#/100mL	117	283	0	419	2420	572/4ND
Giardia*	cysts/L	0.24	0.30	0	0.90	1.1	43/16 ND
Cryptosporidium*	cysts/L	0.06	0.10	0	0.30	0.30	48/33 ND

Sources:

Metropolitan Council Environmental Services, Conventional River Water Monitoring Program, Anoka site, data downloaded 8/29/2019.

*Minnesota Department of Health, Fridley site, water quality data request received 11/22/2019.

Notes:

NA=Not available/calculated given limited data set.

ND=no detection; example entry for E. Coli - 572/4ND of 572 samples analyzed, 4 had no E. Coli detected.

Laboratory analysis: Use of unfiltered samples, except for TOC which included filtered samples.

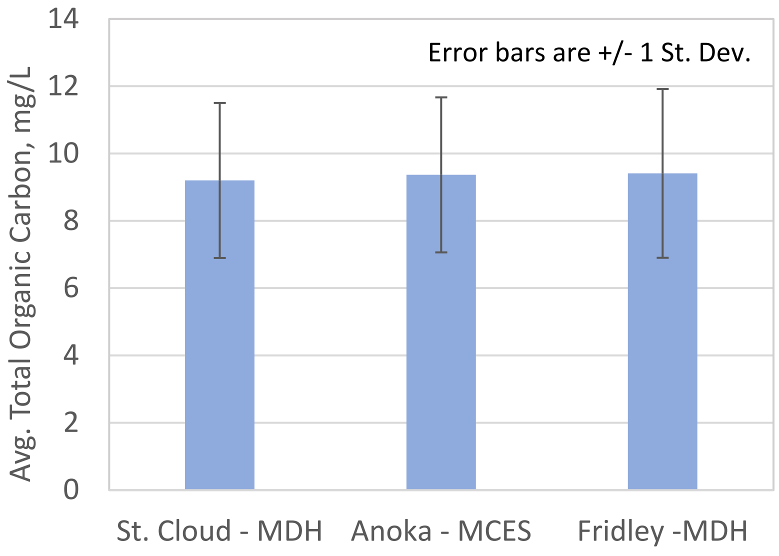
Refer to Appendix A for more detailed information.

Total organic carbon (TOC) is an key surface water treatment parameter because it can impact treatment processes, taste and odor, and disinfection byproducts. TOC measurement at the Anoka site has not had the frequency of sampling as at the intakes of the St. Cloud and Minneapolis WTPs. Table 2-2 and Figure 2-2 summarize the TOC along the Mississippi River, indicating the number of samples and range of dates characterizing the summary statistics. This set of data indicates the average TOC concentrations at the three sites are very similar, from 9.2 to 9.4 mg/L, and can range from 5 to 18 mg/L.

Table 2-2. Total Organic Carbon Summary at Multiple Sites

	St. Cloud - MDH	Anoka - MCES	Fridley - MDH
Avg, mg/L	9.20	9.37	9.41
St Dev	2.3	2.3	2.51
Min, mg/L	5.6	5.1	5.6
Max, mg/L	18	14.5	18
Num. Samples	122	20	115
95th Percentile	13.9	NA	14.0
Sample Start Date	1/6/2010	4/29/1996	1/5/2010
Sample End Date	11/4/2019	4/15/2019	11/5/2019

Figure 2-2. Average Total Organic Carbon at Multiple Sites



2.1c Drinking Water Regulated Constituents

None of the constituents measured in the Mississippi River at Anoka, except those treated by conventional treatment for solids and pathogens, exceed the Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL). MCES also analyzed the Mississippi River for other constituents as part of their priority pollutant monitoring requirements. There were no organic compounds or metals (not already reported for the SDWA list) present at levels that exceed the SDWA MCLs. Appendix A provides the summary statistics for the complete set of constituents analyzed at each of the MCES and MDH monitoring stations.

The US EPA maintains a Contaminant Candidate List (CCL) for contaminants that may need to be regulated, which is published every five years. The current CCL includes 97 chemicals or chemical groups and 12 microbiological contaminants. The list includes chemicals used in commerce, pesticides, biological toxins, disinfection byproducts, and waterborne pathogens. The contaminants on the list are not currently regulated by existing Primary drinking water standards. The CCL should be reviewed when considering a surface water source for drinking water.

2.1d Water Quantity

The Mississippi River flow in the Northwest Metro study area averages 7,000 cfs and typically ranges between 4,800 cubic feet per second (cfs) and 8,700 cfs. The average WTP flow in 2040 is 12 cfs (7.8 MGD) and 45 cfs (29 MGD) at ultimate buildout. The proposed withdrawals for a regional surface WTP would be less than 1% of the seasonal flow. DNR begins to restrict water usage from the Mississippi River at 2,000 cfs near Ramsey.

2.2 Groundwater

The Northwest Metro communities currently gets the majority of its drinking water from 17 wells drilled in the Tunnel City-Wonewoc (TCW) aquifer. The remainder of the water is purchased from the City of Maple Grove.

2.2a Regional Aquifers

Several groundwater aquifers exist in the Northwest Metro study area including from shallowest to deepest; Quaternary aquifers, St. Peter, Prairie du Chien-Jordan, Tunnel City-Wonewoc, and the Mt. Simon-Hinckley. Only the TCW and Mt. Simon-Hinckley aquifers exist over the majority of the Northwest Metro area and can relied upon for municipal scale drinking water wells. The Mt. Simon-Hinckley aquifer is a protected resource in the Metro area and new high capacity wells are generally not permitted by Minnesota Law. If a communities does not have other viable options, a variance can be granted by the Minnesota Department of Natural Resources for Mt. Simon-Hinckley wells.

New wells in this report are assumed to be drilled in the TCW aquifer because it is the aquifer that is consistently available and legally allowed.

2.2b Regional Groundwater Supply

In 2016, the Metropolitan Council along with the support of HDR completed a study on the groundwater supply within the Northwest Metro regional area (*Regional Water Supply, Enhanced Groundwater Recharge, and Stormwater Capture and Reuse Study (Northwest Metro Study Area) Report*, December 2016). The study was one of several studies to support an update to the Twin Cities Metropolitan Area Master Water Supply Plan (Minn. Stat., Sec. 473.1565) and other activities identified by the 2005 Minnesota Legislature to address water supply needs of the seven-county metro area. As part of these activities, the Metropolitan Council modeled the existing source water aquifers to evaluate current and future drawdown of the aquifers and discussed the potential for using alternative water sources or increasing water recharge to the source water aquifers.

The 2016 study concluded that the existing source water aquifers are expected to see an increase in drawdown at existing municipal well sites under the predicted 2040 water demand. Areas within the Northwest Metro area could see drawdown in their bedrock aquifers between 10 - 40 feet. To compensate for the excessive drawdown, the report discusses the use of alternative water supplies such as surface water, stormwater reuse, and the potential for enhanced groundwater recharge.

Chapter 3 – Concept Regional Drinking Water Distribution System

Creating one overall water system from the four individual community systems will require a network of trunk watermain and booster stations to connect the systems and accommodate the different pressure zone elevations (hydraulic grade lines). Figure 1-2 in Section 1-5 shows the existing water infrastructure for the Northwest Metro communities.

The basis for the regional water system assumes that a regional system utility will own and operate the following infrastructure:

- Water supply and treatment plant
- Trunk watermain constructed to connect the member communities
- Booster stations

It is assumed the individual communities will continue to own and operate their water towers and water distribution systems (watermain, hydrants, services, etc.).

3.1 Assessment Methods

The following sections describe assessment methods for water modeling and cost estimating used in this report.

3.1.a Hydraulic Water Model

To determine the layout and sizes of trunk watermain and booster stations, a hydraulic water model was constructed using WaterCAD®. The existing water systems were imported into the water model and a future water supply, trunk watermain, and booster stations were added to create a functioning water system. Steady state scenarios were run to verify that system pressures and pipe velocities remained within acceptable limits.

3.1.b Basis for Concept Level Costs

The concept level costs for the water treatment plants were developed using the book *Cost Estimating Manual for Water Treatment Facilities, McGiveney and Kawamura, Wiley 2016.* The concept level watermain costs were developed based on bid tabs and experience with similar types of projects. All costs are based on 2020 dollars and no escalation is included for date of construction.

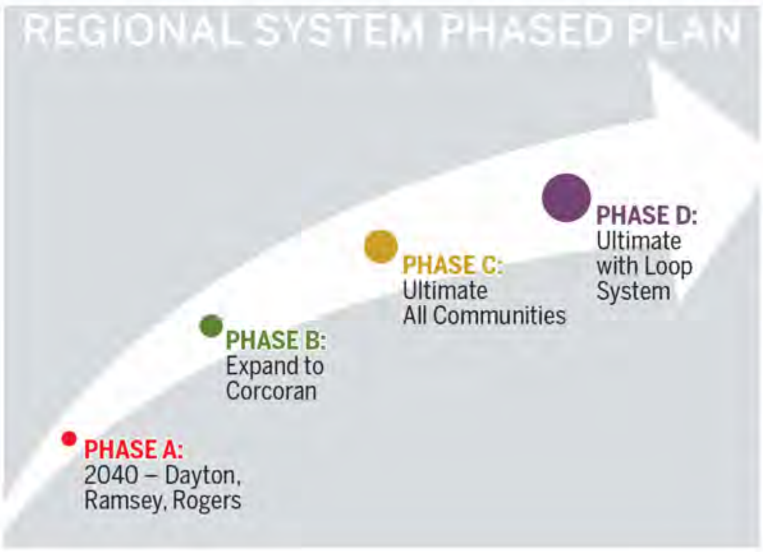
3.2 Phased Watermain Approach

Constructing the entire network of trunk watermain to meet ultimate demands for the Northwest Metro communities before it is needed would be very expensive and make a potential project not feasible. To spread the costs out so that the infrastructure is being constructed when it is needed, a phased approach was developed.

Four different phases (Phases A-D) were identified as summarized in Figure 3-1 for two different water treatment plant (WTP) location sites. In Scenario 1, the WTP is located in Ramsey and is only a surface WTP. The WTP in Scenario 1 can only be a surface WTP because it is assumed that the TCW aquifer in Ramsey cannot support enough wells for a regional groundwater WTP.

In Scenario 2, the WTP is located in Dayton and can either be a surface or a groundwater WTP. In Scenario 2 it is assumed that the TCW aquifer in Dayton could support a regional groundwater WTP through 2040. The phased plan developed for the regional trunk watermain is shown in Figure 3-2 for a WTP located in Ramsey and in Figure 3-3 for a WTP located in Dayton.

Figure 3-1. Phased Approach to Trunk Watermain Construction



PHASE A1 (WTP in Ramsey): A backbone 36" watermain is constructed connecting Ramsey, Dayton, and Rogers. Serves water demands through 2040.

PHASE A2 (WTP in Dayton): A backbone 36" watermain is constructed connecting Ramsey, Dayton, and Rogers. Serves water demands through 2040.

PHASE B: Extend 16" watermain to Corcoran, meets 2 MGD demands.

PHASE C: Extend 36" watermain to Corcoran; meets Corcoran ultimate demands.

PHASE D1 (WTP in Ramsey): Complete 36" watermain loop; meets ultimate demands.

PHASE D2 (WTP in Dayton): Complete 36" watermain loop; meets ultimate demands.

The following sections present components and estimated capital costs of the various watermain phases.

3.3 Lateral Benefit

When cities construct new trunk watermain in an area that was previously not served by municipal water, they often assess the cost of the trunk watermain to properties in the area. The assessments are legal because the new trunk watermain increases the value of the property in the area. This assessment is sometimes referred to as "*lateral benefit*."

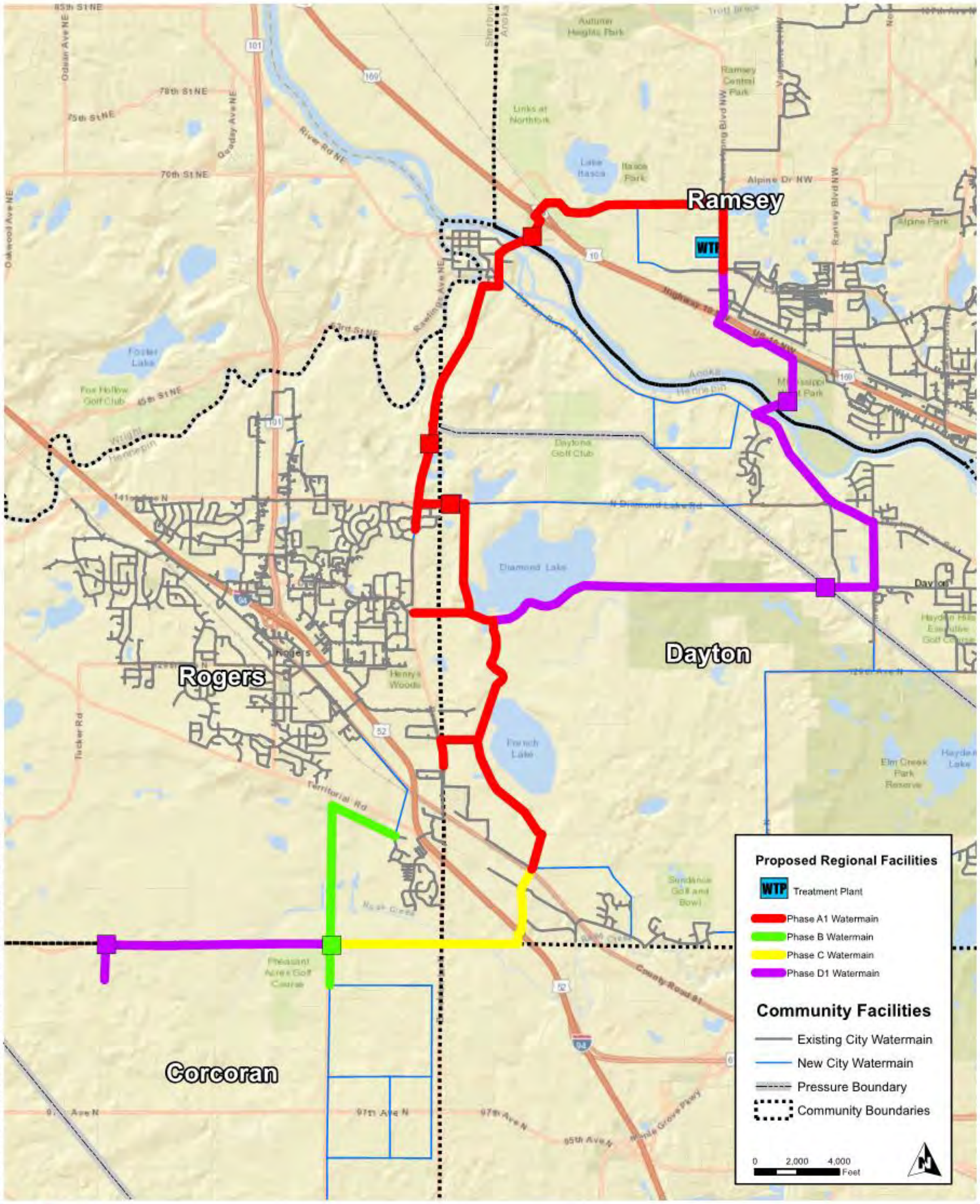
The cost tables in this section assume that a portion of the new trunk watermain would be eligible for lateral benefit. The cost of the lateral benefit is assumed to be 12" watermain at a cost of $200 per foot.

3.4 Phase A – Scenario 1 Watermain – WTP in Ramsey

Phase A – Scenario 1 (Phase A1) watermain with the WTP in Ramsey consists of a 36" backbone watermain connecting the Ramsey, Dayton, and Rogers water systems. The WTP would provide water directly to the Ramsey system at an HGL of 1030 and the 36" watermain would be at an HGL of 1060 to match the northern Dayton pressure zone. Booster stations would be constructed to serve Rogers at an HGL of 1080 and Dayton's southern pressure zone at an HGL of 1110. The Phase A1 watermain and infrastructure is shown on Figure 1 in Appendix C. The trunk watermain is sized to meet ultimate demands, but the Phase A WTP is sized for 2040 demands. The booster stations are sized to meet 2040 demands.

Table 3-1 provides a concept level cost for Phase A1.

Figure 3-2. Phased Regional Water System with a WTP in Ramsey.



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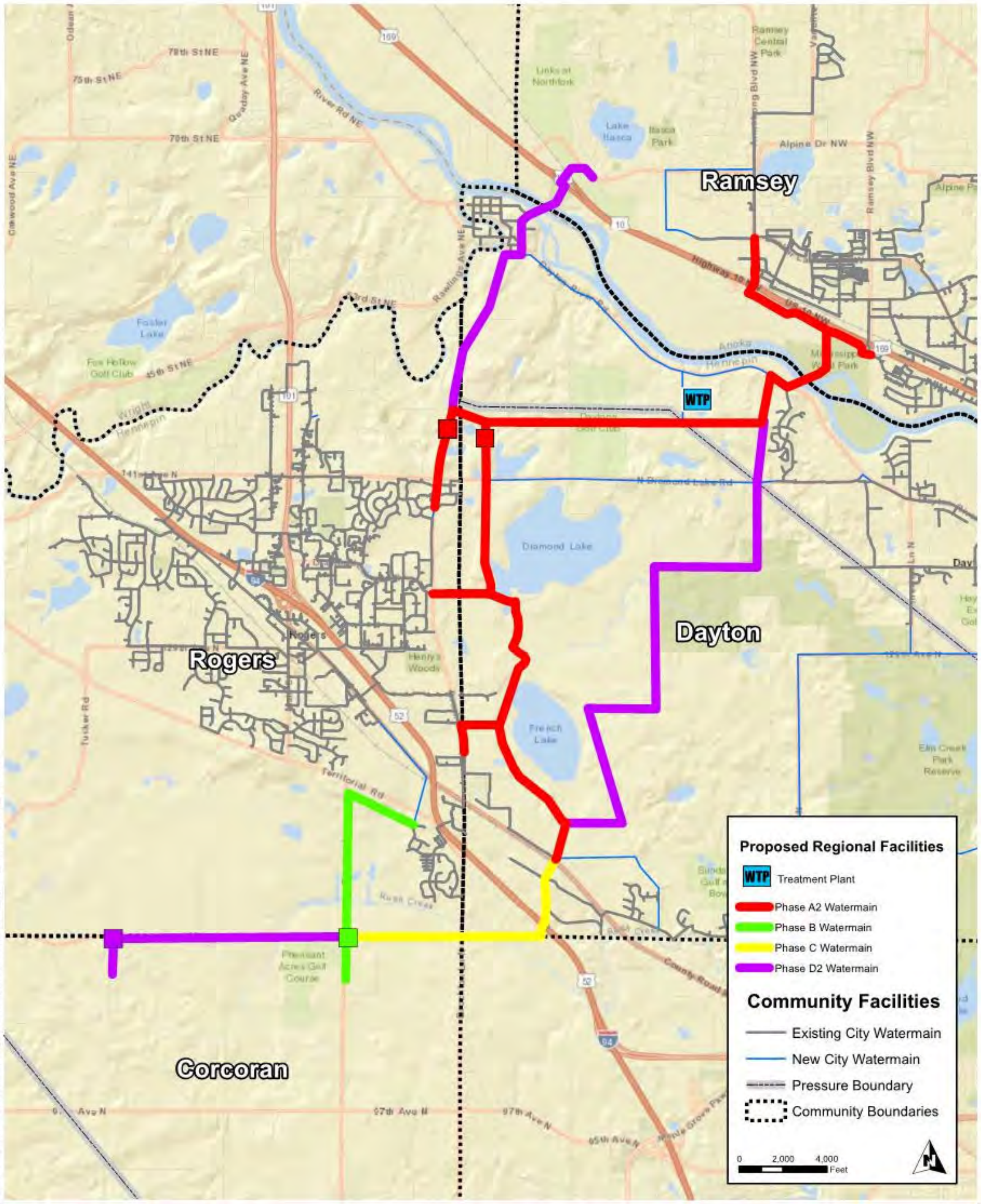
Project Number: MCES 150732
Print Date: 3/12/2020

Scenario 1 - WTP in Ramsey
Phased Regional Water System
Northwest Metro Regional Water Supply Study

FIGURE 3-2

Figure 3-3. Phased Regional Water System with a WTP in Dayton.



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Project Number: MCES 150732
Print Date: 2/27/2020

Scenario 2 - WTP in Dayton
Phased Regional Water System
Northwest Metro Regional Water Supply Study

FIGURE 3-3

Table 3-1. Concept Level Cost for Phase A1 Watermain and Booster Stations with WTP in Ramsey.

Item	Quantity	Units	Unit Cost	Total Cost
New Water Main				
36" Open Cut DIP	51,000	Feet	$500	$25,500,000
Lateral Benefit	25,000	Feet	($200)	($5,000,000)
36" Jacked Road/River Crossing	2,000	Feet	$4,000	$8,000,000
24" Open Cut DIP	6,900	Feet	$400	$2,760,000
Booster Stations				
15 MGD (Rogers, Dayton)	1	Each	$2,500,000	$2,500,000
10 MGD (Rogers, Dayton High Zone)	1	Each	$2,000,000	$2,000,000
2 MGD (Dayton High Zone)	1	Each	$800,000	$800,000
Easements/Land Acquisition	300,000	Square Feet	$6	$1,800,000
Environmental	11	Miles	$50,000	$550,000
			Subtotal	**$38,910,000**
			Contingency (30%)	$11,700,000
			Eng/Admin/Legal (20%)	$10,100,000
			Total Phase A1	**$61,000,000**

3.5 Phase A - Scenario 2 Watermain – WTP in Dayton

Phase A, Scenario 2 (Phase A2) watermain with the WTP in Dayton consists of a 36" backbone watermain connecting the Ramsey, Dayton, and Rogers water systems. The WTP would provide water directly to the Dayton northern pressure zone at HGL 1060 and the southern pressure zone at HGL 1110. The WTP would also provide water directly to Ramsey at an HGL of 1030. Booster stations would be provided on the 36" watermain to the west to provide water to the Dayton southern zone at HGL 1110 and Rogers at HGL 1080. The Phase A2 watermain and infrastructure is shown on Figure 2 in Appendix C.

Table 3-2 provides a concept level cost for Phase A2.

Table 3-2. Concept Level Cost for Phase A2 Watermain and Booster Stations with WTP in Dayton.

Item	Quantity	Units	Unit Cost	Total Cost
New Water Main				
36” Open Cut DIP	53,500	Feet	$500	$26,750,000
Lateral Benefit	26,000	Feet	($200)	($5,200,000)
36” Jacked Road/River Crossing	1,450	Feet	$4,000	$5,800,000
24” Open Cut DIP	10,200	Feet	$400	$4,080,000
Booster Stations				
10 MGD (Rogers)	1	Each	$2,000,000	$2,000,000
10 MGD (Dayton High Zone, Rogers)	1	Each	$2,000,000	$2,000,000
Easements/Land Acquisition	325,000	Square Feet	$6	$1,950,000
Environmental	12	Miles	$50,000	$600,000
			Subtotal	**$37,980,000**
			Contingency (30%)	$11,400,000
			Eng/Admin/Legal (20%)	$9,900,000
			Total Phase A2	**$59,300,000**

3.6 Phase B – Extend Watermain to Corcoran

Phase B consists of extending a 16” watermain from Rogers to serve Corcoran. The 16” watermain would provide up to 2 MGD of water to Corcoran which is the total amount of water that the Rogers system can provide without adverse pressure effects. A booster station is required to take the water from Rogers at an HGL of 1080 and provide it to Corcoran at an HGL of approximately 1130. The Phase B watermain and booster station are shown on Figure 3 in Appendix C using the Ramsey WTP configuration.

The timing of the Phase B watermain is dependent upon the need for water in northern Corcoran. The watermain could be constructed before or after the Phase A1 or A2 watermain. If the Phase B watermain and booster station were constructed ahead of Phase A1 or A2, Corcoran could receive water from Rogers’ existing wells until the regional treatment plant was constructed.

Table 3-3 provides a concept level cost for Phase B.

Table 3-3. Concept Level Cost for Phase B Watermain and Booster Stations.

Item	Quantity	Units	Unit Cost	Total Cost
New Water Main				
16” Open Cut DIP	9,900	Feet	$250	$2,475,000
Lateral Benefit	5,000	Feet	($200)	($1,000,000)
16” Jacked Road	100	Feet	$800	$80,000
Booster Stations				
5 MGD Expansion (Rogers)	1	Each	$1,000,000	$1,000,000
5 Expansion MGD (Corcoran)	1	Each	$1,000,000	$1,000,000
Easements/Land Acquisition	10,000	Square Feet	$6	$60,000
Environmental	2	Miles	$50,000	$100,000
			Subtotal	**$3,715,000**
			Contingency (30%)	$1,100,000
			Eng/Admin/Legal (20%)	$960,000
			Total Phase B	**$5,800,000**

3.7 Phase C – Extend 36” Watermain to Corcoran

Phase C consists of extending the 36” watermain from Dayton to Corcoran. The 36” watermain would serve Corcoran’s ultimate water demand of 22 MGD. A booster station is required to take the water from Dayton at an HGL of 1110 and provide it to Corcoran at an HGL of approximately 1130. The Phase C watermain and booster station are shown on Figure 4 in Appendix C. The Phase C watermain would be constructed when Corcoran’s demands exceed the 2 MGD being provided by the Phase B watermain. The ultimate demands for the remaining communities would be met by the Phase D Scenario 1 or Scenario 2 watermain discussed in Sections 3.8 and 3.9.

Table 3-4 provides a concept level cost for Phase C.

Table 3-4. Concept Level Cost for Phase C Watermain and Booster Station.

Item	Quantity	Units	Unit Cost	Total Cost
New Water Main				
36” Open Cut DIP	14,800	Feet	$500	$7,400,000
Lateral Benefit	7,500	Feet	($200)	($1,500,000)
36” Jacked Road/River Crossing	450	Feet	$4,000	$1,800,000
Booster Stations				
10 MGD Expansion (Dayton High Zone, Corcoran)	1	Each	$2,000,000	$2,000,000
10 MGD Expansion (Corcoran)	1	Each	$2,000,000	$2,000,000
Easements/Land Acquisition	15,300	Square Feet	$6	$92,000
Environmental	3	Miles	$50,000	$150,000
			Subtotal	**$11,900,000**
			Contingency (30%)	$3,600,000
			Eng/Admin/Legal (20%)	$3,100,000
			Total Phase C	**$18,600,000**

3.8 Phase D – Scenario 1 – Complete 36” Watermain Loop - WTP in Ramsey

Phase D – Scenario 1 (Phase D1) consists of completing the 36” watermain loop with additional watermain in Dayton and Ramsey, which also includes a second Mississippi River crossing. The Phase D watermain is hydraulically necessary to supply ultimate water demands. The Phase D watermain also provides redundancy and reliability because it completes a loop and can supply water from two directions. A booster station from Ramsey to Dayton would be required. The Phase D1 watermain and booster station are shown on Figure 5 in Appendix C. The Phase D1 watermain would be constructed after 2040 and would meet the ultimate demands of the Northwest Metro communities.

Table 3-5 provides a concept level cost for Phase D1.

Table 3-5. Concept Level Costs for Phase D1 Watermain and Booster Station.

Item	Quantity	Units	Unit Cost	Total Cost
New Water Main				
36" Open Cut DIP	52,200	Feet	$500	$26,100,000
Lateral Benefit	26,000	Feet	($200)	($5,200,000)
36" Jacked Road/River Crossing	1,450	Feet	$4,000	$5,800,000
Booster Stations				
New 30 MGD (Dayton, Rogers, Corcoran)	1	Each	$5,000,000	$5,000,000
New 25 MGD (Rogers, Dayton High Zone, Corcoran)	1	Each	$4,500,000	$4,500,000
Expansion 10 MGD (Dayton High Zone, Corcoran)	1	Each	$2,000,000	$2,000,000
New 15 MGD (Corcoran)	1	Each	$2,500,000	$2,500,000
Easements/Land Acquisition	270,000	Square Feet	$6	$1,600,000
Environmental	10	Mile	$50,000	$500,000
			Subtotal	**$42,800,000**
			Contingency (30%)	$12,800,000
			Eng/Admin/Legal (20%)	$11,100,000
			Total Phase D1	**$67,000,000**

3.9 Phase D – Scenario 2 – Complete 36" Watermain Loop - WTP in Dayton

Phase D – Scenario 2 (Phase D2) consists of completing the 36" watermain loop with additional watermain in Dayton and Ramsey, which also includes a second Mississippi River crossing. The Phase D2 watermain and booster station are shown on Figure 6 in Appendix C. The Phase D watermain is hydraulically necessary to supply ultimate water demands. The Phase D watermain also provides redundancy and reliability because it completes a loop and can supply water from two directions. The Phase D2 watermain would be constructed after 2040 and would meet the ultimate demands of the Northwest Metro communities.

Table 3-6 provides a concept level cost for Phase D2.

Table 3-6. Concept Level Cost for Phase D2 Watermain and Booster Station.

Item	Quantity	Units	Unit Cost	Total Cost
New Water Main				
36" Open Cut DIP	59,700	Feet	$500/ft	$29,850,000
Lateral Benefit	30,000	Feet	($200/ft)	($6,000,000)
36" Jacked Road/River Crossing	2,000	Feet	$4,000/ft	$8,000,000
Booster Stations				
20 MGD Expansion (Dayton High Zone, Rogers, Corcoran)	1	Each	$3,000,000	$3,000,000
New 15 MGD (Corcoran)	1	Each	$2,500,000	$2,500,000
Easements/Land Acquisition	310,000	Sf	$6/sf	$1,860,000
Environmental	12	Miles	$50,000/mile pipe	$600,000
			Subtotal	**$39,800,000**
			Contingency (30%)	$11,900,000
			Eng/Admin/Legal (20%)	$10,300,000
			Total Phase D1	**$62,000,000**

3.10 Operation and Maintenance Costs

Booster station O&M was estimated by calculating the annual pumping power required and estimated labor. The repair and replacement costs are assumed to be 1% of the pipeline capital cost, with the costs accounted for in the total O&M costs when comparing the different approaches in Chapter 8.

Table 3-7. 2040 Booster Station O&M Costs.

Item	Quantity	Units	Unit Cost ($)	Total Cost ($)
Electrical Power				
Booster Stations	950,000	kWh	$0.075	$71,000
Labor	0.25	FTE	$100,000	$25,000
			Total	**$97,000**

Table 3-8. Ultimate Booster Station O&M Costs.

Item	Quantity	Units	Unit Cost ($)	Total Cost ($)
Electrical Power				
Booster Stations	5,200,000	kWh	$0.075	$390,000
Labor	0.5	FTE	$100,000	$50,000
			Total	**$440,000**

Chapter 4 – Regional Surface Water Treatment Plant (Approach 1)

4.1 Overview

Several Minnesota communities have the Mississippi River as their source of drinking water, including St. Cloud, St. Paul Regional Water Services (SPRWS), and Minneapolis. An advantage to using the Mississippi River is that a large quantity of water can be accessed from one spot (versus numerous wells).

4.2 Surface WTP Locations

Two locations are being considered for a potential surface water treatment plant, including a location in Ramsey and a location in Dayton. These WTP locations are meant to serve as examples only and specific parcels and/or property owners were not identified. Figure 4-1 identifies the potential WTP locations.

The City of Ramsey is in the feasibility stage of constructing a water treatment plant to remove manganese (See Section 5.3a). The proposed location of the Ramsey water treatment plant is the same location shown on Figure 4-1.

4.3 River Withdrawal Options

Two options were considered for withdrawal from the river including collector wells and a direct withdrawal from the river through an intake structure.

4.3a Collector Wells

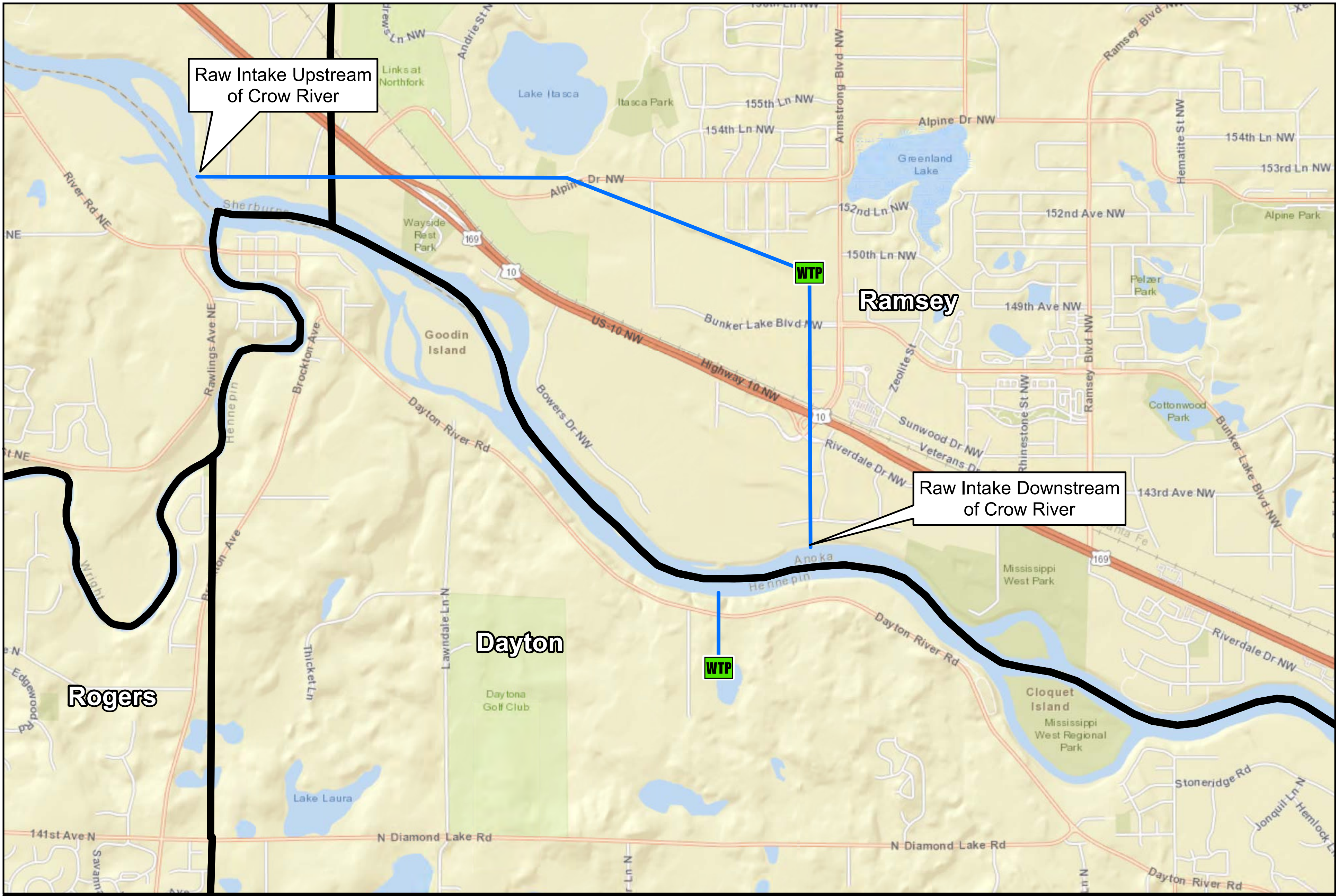
Collector wells are large capacity horizontal wells that take water from a shallow sand layer in the vicinity of the river. Because the water from a collector well has travelled through the surrounding sand, the water quality is often better than water taken directly from a surface water source.

This requires a significant thickness of sand and gravel with limited clay or silt. A previous MCES report (*Regional Water Supply, Enhanced Groundwater Recharge, and Stormwater Capture and Reuse Study, Northwest Metro Area, MCES, 2016)* reviewed the geology along the Mississippi River in Dayton and Ramsey. It was determined that relatively few locations in the area would be suitable for horizontal collector wells. It is assumed that horizontal collector wells are not a suitable option for this study.

4.3b Direct River Withdrawal Location

The selection of a river withdrawal location will depend on several factors, including: type of withdrawal system, river profile and geology, and proximity of known dischargers to the withdrawal location. The river depths along a portion of the study area is generally 9 feet to 12 feet deep.

This stretch of the river in the study area has no permitted dischargers, but there are several WWTPs on the Crow River and upstream on the Mississippi River (refer to Figure A in Appendix A). The water quality was compared for sites upstream and downstream of the Crow River confluence. The preliminary analysis did not identify significant differences to suggest locating the intake upstream of the Crow River. However, with the ever growing concern for emerging contaminants that are not routinely tested or not yet identified, there may be merit in further evaluation of an intake location.



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POTENTIAL SURFACE WTP LOCATIONS

Northwest Metro Area Regional Water Supply Study

Figure 4-1

4.4 Surface Water Treatment

To protect public health from pathogens, surface water used for drinking water is required to follow the Surface Water Treatment Rule. The Surface Water Treatment Rule and recommended treatment processes for a Northwest Metro surface WTP are included in Appendix D.

4.5 Estimate of Probable Capital Costs

The following tables provide concept level capital costs for surface WTPs that would meet 2040 demands (25 MGD) and ultimate demands (75 MGD). The capital costs for a surface WTP that would meet ultimate demands is included to provide a planning horizon beyond 20 years.

Table 4-2 provides a concept level cost estimate for a 25 MGD surface WTP. A layout for a 25 MGD lime softening surface WTP is included in Appendix E. It is assumed that 20 acres of land would be required to construct a 25 MGD surface WTP (includes room for expansion) plus easements for the raw water line and that the WTP is constructed in Ramsey. The difference in cost to construct the water treatment plant in Dayton would be negligible. Table 4-2 presents costs in 2020 dollars.

Table 4-2. Concept Level Cost for 25 MGD Surface Water Treatment Plant.

Item	Quantity	Units	Unit Cost	Total Cost
25 MGD Surface WTP	1	Lump Sum	$73,000,000	$73,000,000
River Intake	1	Lump Sum	$2,000,000	$2,000,000
48” Raw Watermain	7,500	Feet	$700	$5,250,000
Road Crossing	400	Feet	$5,000	$2,000,000
Easements/ Land Acquisitions	20	Acres	$100,000	$2,000,000
Environmental	2	Miles	$50,000	$100,000
			Subtotal	**$84,350,000**
			Contingency (30%)	$25,000,000
			Eng/Admin/Legal (20%)	$22,700,000
			Total	**$132,000,000**

Table 4-3 provides a concept level cost estimate for a 50 MGD expansion of the 25 MGD surface WTP to bring the capacity to 75 MGD. Although it is presented as one large expansion, it is likely that the expansion would take place over multiple steps. It is assumed that a second raw water line and road crossing would be required. Table 4-3 presents costs in 2020 dollars.

Table 4-3. Concept Level Cost for 50 MGD Surface Water Treatment Plant Expansion.

Item	Quantity	Units	Unit Cost	Total Cost
50 MGD Surface WTP Expansion	1	Lump Sum	$98,000,000	$98,000,000
48” Raw Watermain (2nd)	7,500	Feet	$700	$5,250,000
Road Crossing (2nd)	400	Feet	$5,000	$2,000,000
Environmental	2	Miles	$50,000	$100,000
			Subtotal	**$105,350,000**
			Contingency (30%)	$31,600,000
			Eng/Admin/Legal (20%)	$27,400,000
			Total	**$164,000,000**

4.6 Estimated Operation and Maintenance Costs

Operation and maintenance (O&M) costs for major surface WTPs vary considerably with the types of unit processes and water quality characteristics. To develop O&M costs for a surface WTP, O&M costs from Moorhead, Minnesota (a 10 MGD lime softening surface WTP), were used as the basis for this study and proportioned based on the size of the new surface WTPs. The costs include labor, chemicals, electricity, building costs, residual byproduct disposal, and administrative costs.

Table 4-4. Annual Operation and Maintenance Costs for Surface WTPs.

Alternative	Treatment Plant O&M
Approach 1 – 2040 Demands (7.8 MGD Water Provided)	$5,900,000
Approach 1 – Ultimate Demands (29 MGD Water Provided)	$17,500,000

Chapter 5 – Regional Groundwater Treatment Plant (Approach 2)

5.1 Overview

Groundwater is the most common source of drinking water in Minnesota, including the Northwest Metro communities. To reduce chlorides in wastewater from home softeners and compare the groundwater WTP against a lime softening surface WTP, it is assumed that the potential regional groundwater WTP is a lime softening WTP.

The concept regional groundwater WTP is proposed to provide capacity of 25 MGD and would serve the maximum day demands for the Northwest Metro communities through 2040. After 2040, the groundwater WTP will be expanded to 75 MGD to meet ultimate water demands.

5.2 Groundwater Treatment Plant Location

A potential groundwater treatment plant location is the same as the surface water treatment plant location in Dayton (Figure 4-1). The water treatment is proposed to be located in Dayton because it is centrally located, less developed than Rogers or Ramsey, and the Tunnel City Wonewoc aquifer is available throughout the entire City.

5.3 Constituents of Interest

The primary constituents of interest in groundwater are iron, manganese, and hardness. The following sections describe the potential health and aesthetic effects of these constituents.

5.3.a Manganese

Manganese occurs naturally in rocks and soil across Minnesota and is often found in Minnesota groundwater. Your body needs some manganese to stay healthy, but too much can be harmful.

The Minnesota Department of Health (MDH) has set a Health Based Guidance Value (HBV) for manganese of 0.1 milligrams per liter (mg/L, equivalent to parts per million). Children and adults who drink water with high levels of manganese for a long time may have problems with memory, attention, and motor skills. Infants (babies under one year old) may develop learning and behavior problems if they drink water with too much manganese in it.

The City of Ramsey has manganese in its drinking water above the MDH HBV of 0.1 mg/L. To reduce the level of manganese, Ramsey is currently evaluating the construction of a WTP (separate from this report).

5.3.b Aesthetic Standards

Iron and manganese cause red and black staining in toilets and on fixtures and hardness causes scaling. Table 5-1 identifies the secondary (aesthetic) standards for iron, manganese, and hardness. It is very common to have iron, manganese, or hardness above the secondary standards in groundwater wells in Minnesota.

Table 5-1. Secondary Standards for Iron, Manganese, and Hardness.

Constituent	Secondary Standard (mg/L)
Iron	0.3
Manganese	0.05
Hardness	80

5.4 Treatment Processes

Iron and manganese are removed from water by adding oxidants, typically chlorine and sodium permanganate, which convert the iron and manganese from soluble compounds to filterable solids. The iron and manganese are subsequently removed in the filtration process.

The lime softening, recarbonation, and filtration processes are the same as surface water treatment described in Section 4.4. A chlorine contact tank is not necessary for groundwater treatment due to the lack of pathogens.

5.5 Wells

The average Tunnel City-Wonewoc well in the Northwest Metro communities produces about 800 gpm, except Rogers where the assumed well capacity is 500 gpm. This production rate will be used in establishing the supply for a regional groundwater treatment plant. It is assumed that the wells will be spaced at least 0.25 miles apart. It is assumed that the permitting, testing, drilling, and building costs for each new well is $1,500,000.

5.6 Estimate of Probable Capital Cost

The following tables provide capital costs for a lime softening groundwater treatment plant that would meet 2040 demands (25 MGD) and ultimate demands (75 MGD).

Table 5-2 provides a concept level cost estimate for a 25 MGD lime softening groundwater treatment plant. A layout for a 25 MGD lime softening groundwater WTP is included in Appendix D. It is assumed that 20 acres of land would be required to construct a 25 MGD surface WTP (including room for future expansion) plus easements for the raw water line (total of 23 acres). To meet 2040 demands, 22 new wells in Dayton would be required. Table 5-2 presents costs in 2020 dollars.

Table 5-2. Concept Level Cost for 25 MGD Lime Softening Groundwater Treatment Plant.

Item	Quantity	Units	Unit Cost	Total Cost
25 MGD Lime Softening Groundwater Treatment Plant	1	Lump Sum	$68,000,000	$68,000,000
New Wells	22	Each	$1,500,000	$33,000,000
Raw Watermain	30,000	Feet	$300	$9,000,000
Easements/ Land Acquisitions	23	Acres	$100,000	$2,300,000
Environmental	6	Miles	$50,000	$300,000
			Subtotal	**$112,600,000**
			Contingency (30%)	$33,800,000
			Eng/Admin/Legal (20%)	$29,300,000
			Total	**$176,000,000**

Table 5-3 provides a concept level cost estimate for a 50 MGD expansion of the 25 MGD lime softening groundwater treatment plant to bring the capacity to 75 MGD. Although it is presented as one large expansion, it is likely that the expansion would take place over multiple steps. Table 5-3 presents costs in 2020 dollars.

Table 5-3. Concept Level Cost for 50 MGD Lime Softening Groundwater Treatment Plant Expansion.

Item	Quantity	Units	Unit Cost	Total Cost
50 MGD Lime Softening Groundwater WTP Expansion	1	Lump Sum	$90,000,000	$90,000,000
New Wells	44	Each	$1,500,000	$66,000,000
Raw Watermain	58,000	Feet	$300	$17,400,000
Easements/ Land Acquisitions	7	Acres	$100,000	$700,000
Environmental	11	Miles	$50,000	$550,000
			Subtotal	**$174,650,000**
			Contingency (30%)	$52,400,000
			Eng/Admin/Legal (20%)	$45,400,000
			Total	**$272,000,000**

5.7 *Estimated Operation and Maintenance Costs*

O&M costs for the lime softening groundwater treatment plants were estimated based on pumping costs, chemicals, labor, residuals handling and disposal, and maintenance expenses.

Table 5-4. Annual O&M Costs for Lime Softening Groundwater Treatment Plants.

Alternative	Treatment Plant O&M
2040 Demands (7.8 MGD WaterAnnual Average)	$5,500,000
Ultimate Demands (29 MGD Water Annual Average)	$16,400,000

5.8 *Implementation Considerations*

To provide the groundwater necessary to supply the four Northwest Metro communities would require approximately 66 wells. Having 66 wells in one community could cause unsustainable aquifer drawdown. This would need to be evaluated further before constructing a regional groundwater treatment plant.

Chapter 6 – Conjunctive Use System (Surface Water Augmented with Groundwater – Approach 3)

A hybrid option for the Northwest Metro to utilize some of its groundwater infrastructure is to build a new water treatment facility with a surface water source for conjunctive use with the existing groundwater systems.

6.1 Conjunctive Use Overview

All of the Northwest Metro communities utilize groundwater as their source of drinking water. The intent with Approach 3 is that there is conjunctive use of surface water and groundwater. Conjunctive use is using groundwater and treated surface water in the distribution system at the same time. Approach 3 evaluates options for converting a portion of the drinking water for various communities in the study area from groundwater to treated surface water.

The surface water treatment plant capacity for the conjunctive use system will be based on the average day demands for the Northwest Metro communities. Groundwater wells will be utilized for peaking. Communities typically only exceed average day demands in the summer (since the annual average takes into account summer months).

6.2 Conjunctive Use Water Quality

A previous desktop study was conducted to identify water quality impacts associated with delivering treated surface water to groundwater communities and the possibility of conjunctive use of surface water and groundwater (*Feasibility Assessment of Water Sustainability Approaches in the Northeast Metro Area,* Metropolitan Council Environmental Services, 2014). The analysis was qualitative in nature. Preliminary conjunctive use water quality findings are as follows:

- Communities may need to switch disinfection methods from chlorine to chloramines with a conversion to conjunctive use with surface water.
- Mixing groundwater and surface water is predicted to be feasible.
- Customers can expect taste and odor properties to be different with conjunctive use of surface water. A public education program would be recommended.
- Lead, copper, and iron solution chemistry will be different with a conversion to conjunctive use of surface water. These constituents will need to be monitored closely and practices to control levels may need to be modified, including corrosion control.

6.3 Conjunctive Use Water Treatment Plant

The surface WTP for a conjunctive use system is assumed to be located in Ramsey at the location shown on Figure 4-1. The Ramsey location provides a suitable surface water treatment plant location, along with close proximity to 6 of Ramsey's wells that could be used for conjunctive use blending.

Approach 3 consists of constructing a 12 MGD surface WTP to meet 2040 demands and a 28 MGD expansion (total of 40 MGD) to meet ultimate demands. The 2040 average day demand for the Northwest Metro is 7.8 MGD and the ultimate average day demand is 29 MGD. The WTP capacities are designed to be larger than the average day demands because filter backwashing and plant downtime needs to be considered over the course of a year. In addition, most unit processes must consider standby capacity with the largest unit out of service.

6.4 Wells

Additional wells will be necessary to meet 2040 and ultimate peaking demands in some of the communities. Table 6-1 identifies additional wells that will be needed in each community.

Table 6-1. Additional Wells Necessary for the Conjunctive Use System.

Community	Additional Wells needed for 2040 Conjunctive Use Approach	Additional Wells needed after 2040 for Ultimate Conjunctive Use Approach
Rogers	0	1
Ramsey	0	5
Dayton	2	10
Corcoran	2	12

6.5 *Blending*

Blending stations located in each distribution system would allow for suitable mixing of treated surface water with groundwater from municipal wells into the distribution systems. This applies to Rogers and Ramsey where several wells exist in close proximity to each other.

New wells would also be located in the vicinity of the water treatment plant. The groundwater wells could be blended into the surface water ahead of the water treatment plant during periods of lower demand, or bypassed around the water treatment plant during periods of high demand.

6.6 *Estimate of Probable Capital Cost*

The following tables provide capital costs for conjunctive use surface WTPs that would meet 2040 demands (12 MGD) and ultimate demands (40 MGD). The tables also include wells that would be needed to meet peak demands.

Table 6-2. Concept Level Costs for a 12 MGD Conjunctive Use Surface WTP.

Item	Quantity	Units	Unit Cost	Total Cost
12 MGD Surface WTP	1	Lump Sum	$45,000,000	$45,000,000
River Intake	1	Lump Sum	$2,000,000	$2,000,000
30" Raw Watermain	7,500	Feet	$450	$3,375,000
Road Crossing	400	Feet	$4,000	$1,600,000
Additional Wells	4	Each	$1,500,000	$6,000,000
Blending Stations	4	Each	$1,500,000	$6,000,000
Easements/ Land Acquisitions	10	Acres	$100,000	$1,000,000
Environmental	2	Miles	$50,000	$100,000
			Subtotal	**$65,100,000**
			Contingency (30%)	$19,500,000
			Eng/Admin/Legal (20%)	$16,900,000
			Total	**$102,000,000**

Table 6-3 provides a concept level cost estimate for a 28 MGD expansion of the 12 MGD surface WTP to bring the capacity to 40 MGD. Although it is presented as one large expansion, it is likely that the expansion would take place over multiple steps. Table 6-3 presents costs in 2020 dollars.

Table 6-3. Concept Level Costs for 28 MGD Conjunctive Use Surface WTP Expansion.

Item	Quantity	Units	Unit Cost	Total Cost
28 MGD Surface WTP Expansion	1	Lump Sum	$78,000,000	$78,000,000
30" Raw Watermain (2nd)	7,500	Feet	$450	$3,375,000
Road Crossing (2nd)	400	Feet	$4,000	$1,600,000
Additional Wells	24	Each	$1,500,000	$36,000,000
Raw Watermain for Wells	32,000	Feet	$300	$9,600,000
Easements/ Land Acquisitions	4	Acres	$100,000	$400,000
Environmental	6	Miles	$50,000	$300,000
			Subtotal	**$129,300,000**
			Contingency (30%)	$38,800,000
			Eng/Admin/Legal (20%)	$33,600,000
			Total	**$202,000,000**

6.7 Estimated Operation and Maintenance Costs

Operation and maintenance (O&M) costs for major surface WTPs vary considerably with the types of unit processes and water quality characteristics. To develop O&M costs for Approach 3, O&M costs from Moorhead, Minnesota (a lime softening surface WTP), were used as the basis for this study and proportioned based on the size of the new surface WTPs. The costs include labor, chemicals, electricity, building costs, residuals handling and disposal, and administrative costs.

Table 6-4. Annual Operation and Maintenance Costs for Conjunctive Use WTPs for Approach 3.

Alternative	Treatment Plant O&M
Approach 3 – 2040 Demands (7.8 MGD Water Provided)[1]	$5,250,000
Approach 3 – Ultimate Demands (29 MGD Water Provided)[1]	$15,600,000

[1] – Assumes that 80% of the water annually is provided from surface WTP.

Chapter 7 – Status Quo – Approach 4 - Individual Lime Softening Water Treatment Plants

In the absence of a project driver or an incentive to do something different, the Northwest Metro cities will most likely continue to utilize groundwater as their source of drinking water. This section identifies infrastructure that may be necessary in the future with individual community continued reliance on groundwater.

7.1 Lime Softening

To provide an equivalent comparison to Approaches 1-3, it is assumed that the Northwest Metro cities will construct lime softening WTPs. A potential driver for selecting a lime softening treatment process for community drinking water systems is a future wastewater discharge limit for chlorides in the Twin Cities metro area receiving waters.

The majority of the chloride in wastewater comes from the regeneration process of home water softeners. A sodium chloride solution (salt brine) is used to displace calcium and magnesium (hardness compounds) from ion-exchange softening resin. The waste product is discharged to the sanitary sewer.

The only practical way to eliminate chloride from wastewater is to eliminate home water softeners and provide a water supply that is softened at a municipal lime softening water treatment plant. The lime softening process does not add chloride to wastewater. This follows best practices currently recommended by the state to reduce chlorides in wastewater treatment plant discharge.

In addition to hardness, the lime softening process and subsequent filtration process would also remove iron and manganese.

7.2 2040 Water Infrastructure

The Northwest Metro communities will need to add additional wells to meet 2040 demands. It is also assumed that lime softening water treatment plants are also added. Table 7-1 identifies the water infrastructure needed to meet 2040 demands and estimated costs.

Table 7-1. Water Infrastructure Needed to Meet 2040 Demands and Estimated Costs.

Item	Quantity	Units	Unit Cost	Total Cost
Rogers				
7 MGD Lime Softening WTP	1	Lump Sum	$30,000,000	$30,000,000
Wells	1	Each	$1,500,000	$1,500,000
Raw Watermain	10,000	Feet	$300	$3,000,000
Ramsey				
12 MGD Lime Softening WTP	1	Lump Sum	$40,000,000	$40,000,000
Wells	2	Each	$1,500,000	$3,000,000
Raw Watermain	5,000	Feet	$300	$1,500,000
Dayton				
2 MGD Lime Softening WTP	1	Lump Sum	$15,000,000	$15,000,000
Wells	1	Each	$1,500,000	$1,500,000
Raw Watermain	1,000	Feet	$300	$3,000,000
Corcoran				
4 MGD Lime Softening WTP	1	Lump Sum	$20,000,000	$20,000,000
Wells	4	Each	$1,500,000	$6,000,000
Raw Watermain	5,000	Feet	$300	$1,500,000
Easements/ Land Acquisitions	12	Acres	$100,000	$1,200,000
Environmental	4	Miles	$50,000	$200,000
			Subtotal	**$126,300,000**
			Contingency (30%)	$37,900,000
			Eng/Admin/Legal (20%)	$32,800,000
			Total	**$197,000,000**

7.3 Ultimate Water Infrastructure

The Northwest Metro communities will need to add additional infrastructure after 2040 to meet ultimate demands. Table 7-2 identifies the water infrastructure and estimated costs needed to meet ultimate demands. It should be noted that this infrastructure is in addition to what was included in Table 7-1.

Table 7-2. Water Infrastructure Needed to Meet Ultimate Demands and Estimated Costs.

Item	Quantity	Units	Unit Cost	Total Cost
Rogers				
5 MGD Lime Softening WTP Expansion	1	Lump Sum	$25,000,000	$25,000,000
Wells	7	Each	$1,500,000	$10,500,000
Raw Watermain	5,300	Feet	$300	$1,590,000
Ramsey				
8 MGD Lime Softening WTP Expansion	1	Lump Sum	$32,000,000	$32,000,000
Wells	8	Each	$1,500,000	$12,000,000
Raw Watermain	10,600	Feet	$300	$3,180,000
Dayton				
8 MGD Lime Softening WTP Expansion (north zone)	1	Lump Sum	$32,000,000	$32,000,000
10 MGD Lime Softening WTP (south zone)	1	Lump Sum	$36,000,000	$36,000,000
Wells	15	Each	$1,500,000	$22,500,000
Raw Watermain	20,000	Feet	$300	$6,000,000
Corcoran				
18 MGD Lime Softening WTP Expansion	1	Lump Sum	$53,000,000	$53,000,000
Wells	16	Each	$1,500,000	$24,000,000
Raw Watermain	22,000	Feet	$300	$6,600,000
Easements/ Land Acquisitions	35	Acres	$100,000	$3,500,000
Environmental	11	Miles	$50,000	$550,000
			Subtotal	**$268,400,000**
			Contingency (30%)	$80,500,000
			Eng/Admin/Legal (20%)	$69,800,000
			Total	**$419,000,000**

7.4 Estimated Operation and Maintenance Costs

O&M costs for the lime softening groundwater WTPs were estimated based on pumping costs, chemicals, labor, residuals handling and disposal, and maintenance expenses.

Table 7-3. Total Annual O&M Costs for Lime Softening Groundwater WTPs for Each Community (Status Quo).

Alternative	Treatment Plant O&M
Approach 4 – 2040 Demands (7.8 MGD Water Provided)	$6,100,000
Approach 4 – Ultimate Demands (29 MGD Water Provided)	$18,100,000

Chapter 8 – Approach Comparison

The four approaches are compared through an analysis using 20-year and 60-year planning horizons. The 2040 Regional System Plan is based on meeting the 2040 demands for Dayton, Ramsey and Rogers and assumes that the ultimate water trunk main is extended to Corcoran by 2040. For the 60-year planning period, the system capacity is expanded from 2040 to accommodate the ultimate or buildout conditions of all four communities.

The concept regional water supply distribution system features are defined in Chapter 3. The treatment facilities for regional surface water, groundwater, and conjunctive use systems are described in Chapters 4-6. Chapter 7 defines the future water supply systems for each community assuming continued reliance on groundwater. Complete regional water systems are formulated for each of the four approaches for 2040 and Ultimate Plans.

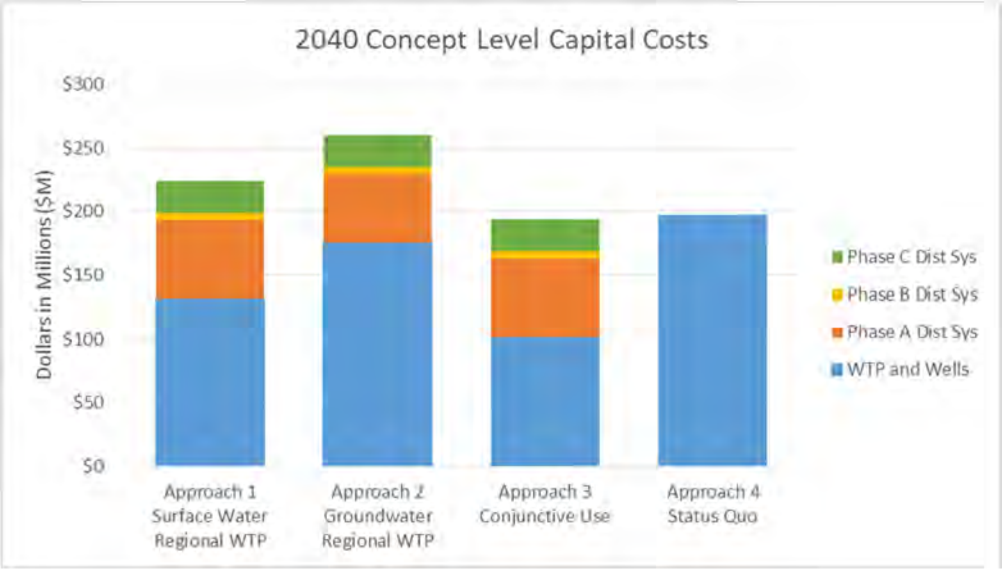
Table 8-1 and Figure 8-1 summarize the lifecycle costs for water system facilities to meet 2040 demands. The three regional drinking water system approaches and continuing with the ‘status quo’ of separate community systems are compared.

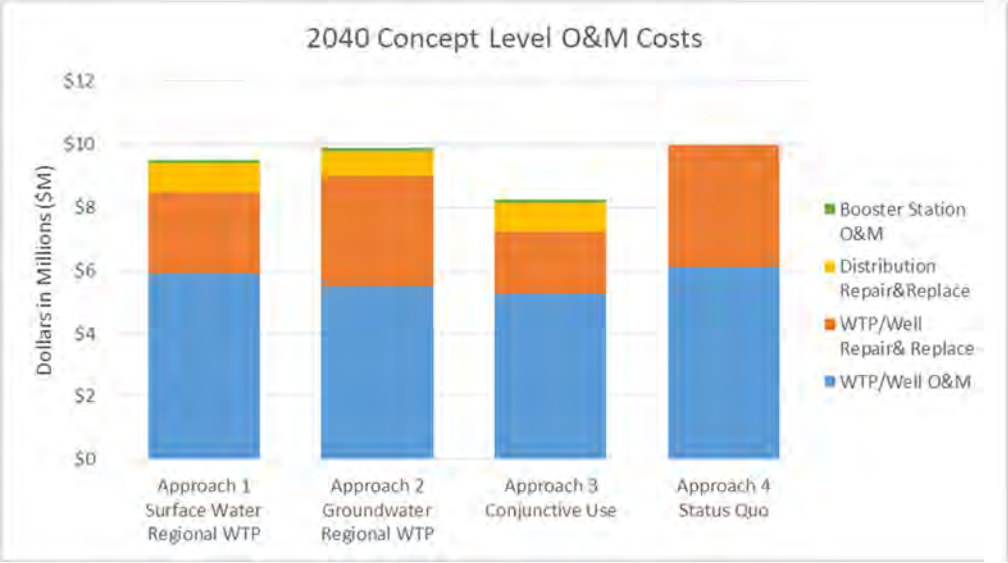
Table 8-1. Concept Level Capital and O&M Costs for 2040 Demand

Item	Approach 1 Regional Surface Water	Approach 2 Regional Groundwater Lime Softening	Approach 3 Conjunctive Use	Approach 4 Status Quo Lime Softening
Capital Costs				
Distribution System (Watermain/Booster Stations)				
Phase A, Scenario 1	$61,000,000		$61,000,000	
Phase A, Scenario 2		$59,300,000		
Phase B	$5,800,000	$5,800,000	$5,800,000	
Phase C	$18,600,000	$18,600,000	$18,600,000	
WTP and Wells	$132,000,000	$176,000,000	$102,000,000	$197,000,000
Capital Cost Total[1]	**$217,000,000**	**$260,000,000**	**$187,000,000**	**$190,000,000**
Annualized Capital Cost (20 year)	**$14,600,000**	**$17,500,000**	**$12,500,000**	**$12,700,000**
O&M Annual Costs				
WTP/Well O&M	$5,900,000	$5,500,000	$5,250,000	$6,100,000
Booster Station O&M	$100,000	$100,000	$100,000	
WTP/Well Repair & Replacement (2%)	$2,600,000	$3,500,000	$2,000,000	$3,900,000
Distribution Repair and Replacement (1%)	$900,000	$800,000	$900,000	
O&M Cost Total[1]	**$9,500,000**	**$9,900,000**	**$8,250,000**	**$10,000,000**
Total Annualized Cost[1]	**$24,100,000**	**$27,400,000**	**$20,750,000**	**$22,700,000**

[1] Costs based on 2020 dollars; no escalation to date of construction.

Figure 8-1. 2040 Concept Level Capital, O&M, and Lifecycle Annualized Costs





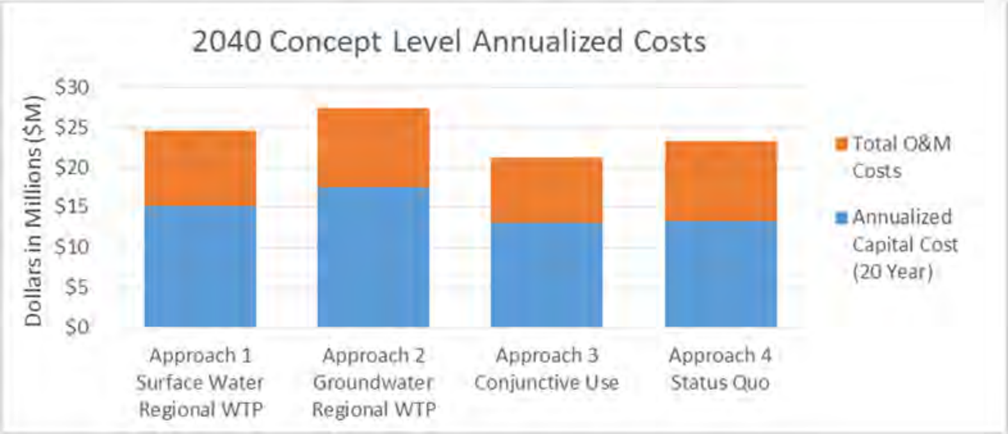


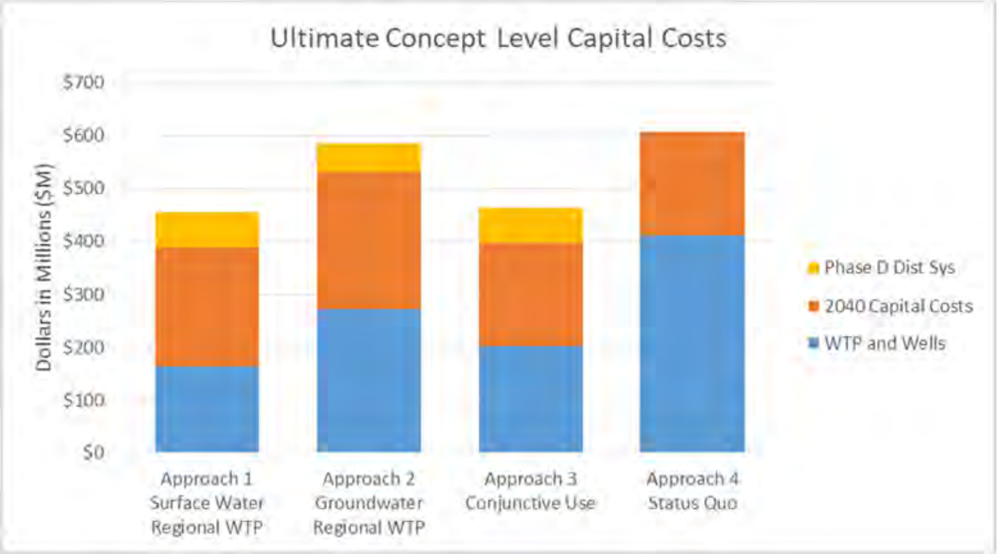
Table 8-2 and Figures 8-1 and 8-2 summarize the lifecycle costs for water system facilities to meet ultimate demands. The three regional drinking water system approaches and continuing with the ‘status quo’ of separate community systems are compared.

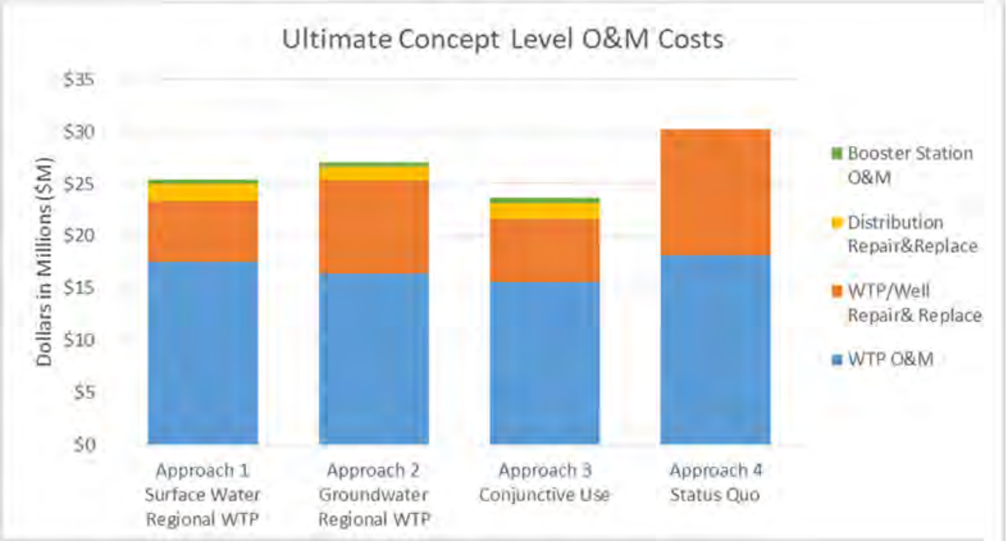
Table 8-2. Concept Level Capital and O&M Costs for Ultimate Demand

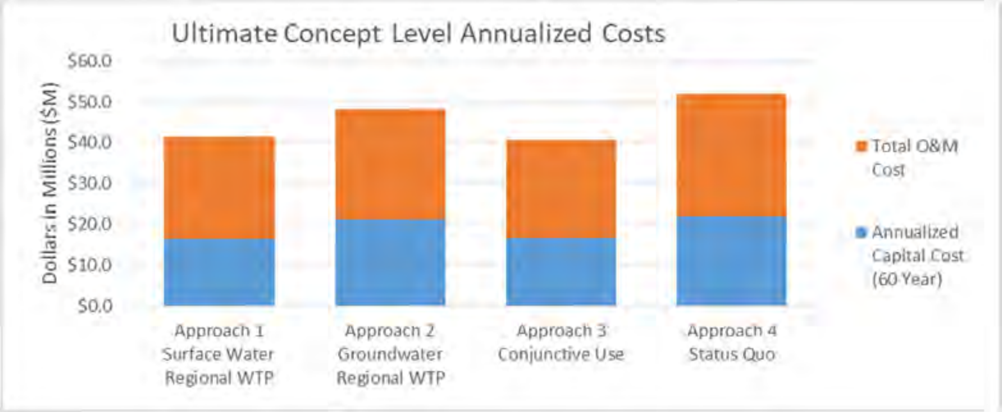
Item	Approach 1 Regional Surface Water	Approach 2 Regional Groundwater Lime Softening	Approach 3 Conjunctive Use	Approach 4 Status Quo Lime Softening
Capital Costs				
2040 Capital Costs	**$217,000,000**	**$260,000,000**	**$187,000,000**	**$190,000,000**
Distribution System				
Phase D, Scenario 1	$67,000,000		$67,000,000	
Phase D2, Scenario 2		$62,000,000		
WTP and Wells	$164,000,000	$272,000,000	$202,000,000	$410,000,000
Capital Cost Total[1]	**$448,000,000**	**$594,000,000**	**$456,000,000**	**$600,000,000**
Annualized Capital Cost (60 year)	**$16,100,000**	**$21,500,000**	**$16,400,000**	**$21,700,000**
O&M Annual Costs				
WTP O&M	$17,500,000	$16,400,000	$15,600,000	$18,100,000
Booster Station O&M	$440,000	$440,000	$440,000	
WTP Repair & Replacement (2%)	$5,900,000	$8,900,000	$6,000,000	$12,100,000
Distribution Repair and Replacement (1%)	$1,600,000	$1,300,000	$1,600,000	
O&M Cost Total[1]	**$25,000,000**	**$27,000,000**	**$24,000,000**	**$30,000,000**
Total Annualized Cost[1]	**$41,300,000**	**$48,500,000**	**$40,400,000**	**$51,700,000**

[1] Costs based on 2020 dollars; no escalation to date of construction.

Figure 8-2. 2040 Concept Level Capital, O&M, and Lifecycle Annualized Costs







Chapter 9 – Regional Water System Governance and Cost Sharing

The practice of shared utility services across municipal boundaries has been increasing as municipalities face pressures of increasing costs, and in the case of drinking water, look to address reliability concerns because of supply limitations and to provide backup sources as part of their resiliency plan. This chapter provides an overview of governance structure options and applies concept cost sharing strategies to fund a Northwest Metro regional water system.

9.1 Governance

The drivers influencing the type of governance structure selected for a shared utility system are many but center around the following items each municipality must consider:

- Degree of community autonomy
- Extent of legal and formal institutional structure
- Cost sharing and financing

There are four general models to consider in the governance of a regional water treatment system:

- Regional Utility
- Inter-Municipal Agreements
  - Cooperative agreement for joint investment
  - Smaller agreements as needed
- Public – Private Partnership
- Privatization

9.1a Regional Utility

A new or expanded utility is formed that owns and operates the water treatment and infrastructure system. The decision-making authority for the regional utility is a board or commission. The term Joint Water Utility, Joint Powers, Water Commission are typical titles for regional water utilities. Board members are nominated by the municipalities served by the water system and the representation can vary as decided upon with the founding of the regional utility. A regional water utility can own all or a portion of the assets related to a water system. Typically a regional water utility owns the treatment plant, wells (if supplying groundwater), trunk water main and water towers. In this case, individual municipalities served by the utility own the distribution system infrastructure that serves their community members. However, some regional utilities may own all the water infrastructure, or may provide wholesale water to a portion of their customers that own and maintain their own distribution system.

One example of a regional water utility in close proximity to the Northwest Metro study area is the Joint Powers Water Board of Albertville, Hanover and St. Michael (Joint Powers). Founded in 1977, Joint Powers owns and operates the water treatment plant, wells, water towers, and trunk water main that supplies water to the three communities. Each community owns and maintains the distribution system within its city boundaries. The Board consists of the mayor and one council member from each city. This provides for equal representation from each community and is not based on the community size or water use. Joint Powers bills each city and the cities bill their customers. Joint Powers also receives a portion of the connection fees assessed through the water availability charge (WAC).

9.1b Inter-Municipal Agreements

Another model is for municipal utilities to remain separate but jointly fund new infrastructure and/or operations and maintenance and have rights to a certain share of the water through cooperative agreements. These agreements can vary in complexity and have flexibility in establishing coordination among partners. Inter-municipal agreements have been used to share drinking water infrastructure assets and services in numerous ways. The agreements may be as simple as sharing a contract for bulk supply of chemicals for smaller, more remote communities to large metropolitan-area water supply agreements.

9.1c Public – Private Partnership

A public-private partnership, also called a P3, is a cooperative agreement between a private company and a unit of government to provide a service. There are community water and wastewater facilities across the U.S. that are based on a public-private partnership, ranging from large design-build-operate projects to shared functions such as administration and billing. There is flexibility in the roles and responsibilities of the public and private partners.

9.1d Privatization

In a completely privatized model, a corporation owns and operates the utility and in context of this study, is the water service provider for a municipality or group of municipalities. Privatization of drinking water service transfers all ownership, operations, and management responsibilities to a private entity. Municipalities may sell their existing water utility to a private entity, or elect to fund the construction of a new utility owned by a private entity. In this model, the role of the municipal government(s) is to establish policies and provide oversight in addition to the oversight and regulation administered by the state.

9.1e Application for Northwest Metro Communities

For the purposes of evaluating cost sharing strategies, this study assumes that the governance structure for a Northwest Metro regional water system will be an independent Joint Utility. At this concept level, a Joint Utility structure provides a clear demarcation of shared facilities and associated costs for the member communities. With continued planning and development of regional system features, the questions associated with governance structure and the related funding of the system will evolve and can be explored in more detail.

9.2 Cost Sharing

A simple cost sharing strategy was applied to the concept level system developed for a Northwest Area regional surface water supply system (Approach 1). This is meant to serve as an example and only extends through 2040.

9.2a Funding

The funding sources available include:

- WAC (the joint utility receives a portion of WAC for each new connection)
- Lateral Benefit (assessment already considered in the capital costs)
- Trunk Charges
- State/Federal Grants
- PFA Loan
- Water Rates

9.2b Concept System Features

The features of the concept regional surface water system for this cost sharing example include:

- Phase A1, B, C Trunk Watermain
  - 36” pipeline meeting 2040 demands for all communities
  - Pump stations/storage to meet 2040 demand for all communities
- 25 MGD surface WTP – meeting 2040 demand

9.2c Cost of Service

To estimate the water rates that a regional utility would charge for the concept system defined in this example, the following assumptions apply:

- WAC
  - 20,100 additional WAC by 2040

  - $3,500 fee to Joint Utility per WAC
  - Total WAC of $70,350,000
- Bonding at 3% interest rate over 20 years, $61,650,000 amortized
- Grant – assume a grant provided to fund trunk watermain and booster stations (approximately $90 million)
- Capital and O&M costs as summarized in Chapter 8 of this report

The concept level cost of service estimate assuming a grant of $80M are presented in Table 9-1.

Table 9-1. Concept Level Cost of Service Estimate.

2040 Cost of Service - Preliminary			
Item	**Annual Cost**	**Water Used (thousand gallons)**	**Cost per 1,000 gallons**
Annualized Payment	$2,250,000	2,847,000	$0.79
Joint Utility O&M	$6,000,000	2,847,000	$2.10
Repair and Replacement	$3,500,000	2,847,000	$1.22
Cities Existing O&M	$1.00/1,000 gal	2,847,000	$1.00
		Total:	**$5.13**

The impact of the up-front grant funding on cost of service was evaluated. The cost of service would be $6.13 per 1,000 gallons without any grant funding. To achieve a cost of service in line with water systems treating a Mississippi River supply ($4 per 1,000 gallons), grant funding of approximately $200M would be required.

Existing water rates in the Northwest Metro range from $2.08 to $4.58 per 1,000 gallons based on 8,000 gallons of water used per month.

Chapter 10 – Summary of Findings and Implementation Considerations

Key takeaways from this concept level study of alternative approaches to a Northwest Metro area regional drinking water supply system include:

- The average day water demand in the Northwest Metro is projected to increase from 3.3 MGD in 2015 to 7.8 MGD in 2040 (140% increase).
- The ultimate average day water demand in the Northwest Metro is 29 MGD (approximately 800% increase from 2015).
- If the Northwest Metro cities continue to utilize only groundwater to meet water demands, an additional 54 wells will likely be needed to meet ultimate demands. A 2016 MCES report indicated drawdown in the Tunnel City-Wonewoc aquifer in 2040 when demands are only 27% of the ultimate demands. It is possible that the aquifer cannot sustain the ultimate demands of the Northwest Metro.
- The Mississippi River has sufficient water quantity to serve the Northwest Metro communities. The water quality in the Mississippi River appears to be acceptable for a conventional surface water treatment plant. St. Could, St. Paul, and Minneapolis utilize the Mississippi River as their source of drinking water.
- A regional surface WTP has the advantages of being a cost effective approach, eliminates the need for numerous addition wells, increases groundwater sustainability, provides fully softened water, and reduces chloride discharges to the Mississippi River. The disadvantages of a regional surface WTP is that it changes water taste and odor and relies heavily on one water source.
- A regional lime-softening groundwater WTP has the advantages of providing fully softened water and reduces chloride discharges to the Mississippi River. The disadvantages of a regional lime softening groundwater WTP is that it is one of the most expensive approaches evaluated, may not be feasible due to groundwater drawdown, and relies heavily on one water source.
- A regional conjunctive use WTP has the advantages of being a cost effective approach, increases groundwater sustainability, provides mostly softened water, reduces chloride discharges to the Mississippi River, and does not rely on one water source. The disadvantages of a regional conjunctive use WTP is that it changes water taste and odor and does not provide fully softened water in the summer.
- Constructing individual lime softening groundwater WTPs (Status Quo) has the advantages of providing fully softened water and reduces chloride discharges to the Mississippi River. The disadvantages of individual lime softening WTPs is that it is the most expensive approach and relies on one water source.
- A cost of service example indicates that grant funding will be an integral part of implementing a regional surface water supply system to make the project viable.
- In the absence of a project driver, Northwest Metro cities are likely to continue to utilize groundwater and construct iron and manganese removal water treatment plants. At this point, none of the Northwest Metro cities have water treatment plants, although 2 are in the planning stages (Ramsey and Corcoran).
- The Northwest Metro communities are embarking on this study at an optimal time. The water systems are not fully developed and significant growth is planned.

Appendix A: Mississippi River Water Quality

SEH
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MEMORANDUM

TO: Ali Elhassan, MCES

FROM: Amy Prok, Patti Craddock

DATE: March 12, 2020

RE: Mississippi River Water Quality Summary
MCES Contract No. 16P135E, PO 19006941
SEH No. MCES 150732 14.00

A. Introduction

The primary objective of this analysis is to characterize the water quality of the Mississippi River as a potential drinking water source for the Northwest metro area communities of Corcoran, Dayton, Ramsey, and Rogers. In addition, the analysis includes a preliminary comparison of water quality upstream and downstream of the Crow River in consideration of the location of the water supply intake structure.

B. Database Sources

The primary source of data utilized in this analysis was collected by Metropolitan Council Environmental Services as part of their Conventional River Water Monitoring Program. The data were obtained from the MCES' Environmental Information Management Systems (EIMS) database. This online resource provides water quality data for waterbodies in the region. The MCES database for the Anoka site (river mile 871.6) is very complete and covers a wide range of constituents starting in 1976 for some constituents.

Data from other monitoring sites are also included in the analysis to compare water quality at several points along the Mississippi River, including upstream and downstream of the Crow River confluence. The downstream sites reviewed are the MCES' Conventional River Water Monitoring Program in Fridley (river mile 862.8) and the Fridley site in the Minnesota Department of Health's database. The upstream site is represented by the St. Cloud site from the MDH's database. The MDH database is not as comprehensive as the data available from the MCES monitoring program, but provides a larger dataset for some constituents of interest for drinking water, such as TOC, Cryptosporidium, and Giardia.

Figure 1 presents the location of the sampling sites and Table 1 summarizes the databases and sites used in this analysis.

Table 1 – Water Quality Source Information by Site

Monitoring Site	Agency	Source	Site ID	Location	Data Collection Dates
St. Cloud	MDH	Email Transfer	1730027	St. Cloud Treatment Plant Intake	01/06/2010 to 11/04/2019
Anoka	MCES	EIMS Portal	UM8716	River Mile 871.6	01/07/1976 to 8/26/2019
Fridley	MCES	EIMS Portal	UM8628	River Mile 862.8	08/19/1976 to 04/29/2019
Fridley	MDH	Email Transfer	1270024	Fridley Treatment Plant Intake	01/05/2010 to 11/05/2019

C. Methods

Statistics were performed on each of the water quality constituents measured at the monitoring sites. For each parameter, the minimum, maximum, 95th percentile, average, standard deviation, total sample count, number of non-detects were calculated, and the sampling date range were identified. In the MCES and MDH databases, values less than the detection limit were demarked by a “less than” (<) sign. Data such as this was treated as a non-detect and the value was represented as zero (0). These statistics were then summarized by constituent in tabular form. The statistical summary information is based on all individual data reported by MCES and MDH. There has been no deletion of data to account for statistically significant outliers. Time series plots were also created in review of conventional constituents.

D. Results

Anoka, MCES

MCES has been sampling at the Anoka site since the mid-1970s and the list of constituents analyzed has grown over the years. Table A located in the appendix provides the full list of constituents analyzed and available in the MCES’ EIMS for the Anoka and Fridley sites. The data analysis and subsequent results for this study focused on a sub-set of constituents important to surface water treatment. These constituents are characterized in Tables 2 and 3.

Table 2 summarizes water quality constituents of concern in planning and design of drinking water treatment facilities. Table 3 broadens the list to include all those parameters regulated under the Safe Drinking Water Act (SDWA) and also lists the regulatory maximum contaminant limit (MCL) and public health goals for each constituent.

MCES also monitors for other priority pollutants beyond those found in the Safe Drinking Water Act. Some of these monitored constituents are emerging pollutants of concern. A full list of pollutants with and the number of samples with detections can be found in Table A in the Appendix.

Multiple Site Water Quality Comparison

Sites upstream and downstream of the confluence of the Crow River with the Mississippi River were evaluated to assess the optimum location for a northwest metro area regional surface water treatment plant (WTP) intake. This preliminary assessment is based on limited data from the MDH databases and additional evaluation is necessary to fully assess water quality variations along the river. The preliminary assessment compared conventional constituents at the four sites including: total organic carbon, alkalinity, suspended solids, and turbidity. The following Figures 2 through Figure 5 demonstrate the results of these water quality constituents compared between monitoring sites.

The selection of a river withdrawal location will depend on several factors, including: type of withdrawal system, river profile and geology, and proximity of known dischargers to the withdrawal location. The river depths along a portion of the study area is generally 9 feet to 12 feet deep.

This stretch of the river in the study area has no permitted dischargers, but there are several WWTPs on the Crow River and upstream on the Mississippi River (refer to Figure A in the Appendix). The water quality was compared for sites upstream and downstream of the Crow River confluence. The preliminary analysis did not identify significant differences to suggest locating the intake upstream of the Crow River. However, with the ever growing concern for emerging contaminants that are not routinely tested or not yet identified, there may be merit in further evaluation of an intake location.

E. Gap Analysis

For future water supply characterization, additional historic data can be reviewed to better assess the optimum location for a water supply intake. The impact of the Crow River on the water supply intake location could be evaluated more closely by analyzing the water quality of the Mississippi River in a location more directly upstream of the Crow River confluence than the St. Cloud monitoring station. Pathogens of interest in planning a drinking water supply that are not monitored in the MCES program are *Cryptosporidium* and *Giardia*. Since these our routinely monitored for the WTPs treating Mississippi River water and are readily available in the MDH database, future data reviews should coordinate use of both databases. Additional information on the sample collection and analysis methods for the different monitoring programs is recommended and should be considered when comparing and utilizing multiple databases. For the purposes of this concept level study, this effort was not expended.

F. Conclusion

The water quality of the Mississippi River as a source for a northwest metro area regional WTP was characterized using the MCES Anoka site. The MCES database provided sampling data over a wide period of time and a large range of constituents, making it very comprehensive. The data for several constituents related to drinking water quality were analyzed statistically and, in some cases, compared with data from other monitoring sites. The analysis characterized water quality constituents of interest in determining treatment requirements and adherence to regulatory requirements. With the more than 45,800 samples analyzed, constituents with concentrations exceeding SDWA limits were limited to those that are removed through conventional treatment processes. Additional assessment is needed to better define the optimum intake location for a WTP, but general indications are that conventional constituents are not expected to have statistically significant variation along that reach of the Mississippi River, assuming best practices are used in the location of a site and method of water withdrawal from the river.

Table 2 – Primary Constituent Summary

Constituent	Unit	Avg	St Dev	Min	95th Percentile	Max	No. Samples
Alkalinity	mg/L CaCO3	178	31	90	227	374	296
Hardness	mg/L	208	37	86	274	332	145
Iron	mg/L	0.51	0.26	0.17	1.2	1.3	27
Manganese	mg/L	0.0001	0.00005	0.000045	NA	0.0002	12
Total Dissolved Solids	mg/L	269	48.3	119	348	720	972
Total Organic Carbon	mg/L	9.4	2.5	5.1	NA	14.5	20
Nitrate	mg/L	0.90	0.78	0	2.4	5.4	1313
Nitrite	mg/L	0.011	0.04	0	0.05	1	1314
Total Kjeldahl Nitrogen	mg/L	0.93	0.34	0	1.5	3.6	1109
Phosphorus, Total	mg/L	0.11	0.08	0	0.24	1	1349
Turbidity	NTU	6.6	7.2	1.3	15	200	1086
Total Suspended Solids	mg/L	16.7	14.2	0	40	165	1320
E. Coli	#/100mL	117	283	0	419	2420	572/4ND
Giardia*	cysts/L	0.24	0.30	0	0.90	1.1	43/16 ND
Cryptosporidium*	cysts/L	0.06	0.10	0	0.30	0.30	48/33 ND

Sources:

Metropolitan Council Environmental Services, Conventional River Water Monitoring Program, Anoka site, data downloaded 8/29/2019.

*Minnesota Department of Health, Fridley site, water quality data request received 11/22/2019.

Notes:

NA=Not available/calculated given limited data set.

ND=no detection; example entry for E. Coli - 572/4ND of 572 samples analyzed, 4 had no E. Coli detected.

Laboratory analysis: Use of unfiltered samples, except for TOC which included filtered samples.

Refer to Appendix for more detailed information.

Table 3 - SDWA Constituent Summary

Constituent	Unit	MCL or TT (mg/L)	Public Health Goal	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects
1,1,1-Trichloroethane	mg/L	0.2	0.2	0	0	0	0	0	27	27
1,1,2-Trichloroethane	mg/L	0.005	0.003	0	0	0	0	0	27	27
1,2,4-Trichlorobenzene	mg/L	0.07	0.07	0	0	0	0	0	26	26
1,2-Dichloroethane	mg/L	0.005	0	0	0	0	0	0	27	27
1,2-Dichloropropane	mg/L	0.005	0	0	0	0	0	0	27	27
Antimony	mg/L	0.006	0.006	5.67E-06	3.54E-05	0	0	0.0003	194	189
Arsenic	mg/L	0.01	0	1.45	0.85	0	3	4.70	222	26
Barium	mg/L	2	2	75.50	24.89	41	NA	100	8	0
Benzo(a)pyrene	mg/L	0.0002	0	0	0	0	0	0	26	26
Beryllium	mg/L	0.004	0.004	0.000051	0.000695	0	0	0.01	206	198
Cadmium	mg/L	0.005	0.005	0.000053	0.00017	0	0.0003	0.001	222	181
Carbon Tetrachloride	mg/L	0.005	0	0	0	0	0	0	27	27
Chlordane	mg/L	0.002	0	0	0	0	0	0	26	26
Chlorine Residual	mg/L	MRDL = 4.0[1]	MRDLG = 4[1]	0.042	0.1	0	0.14	0.64	46	0
Chlorobenzene	mg/L	0.1	0.1	0	0	0	0	0	27	27
Chromium	mg/L	0.1	0.1	0.00078	0.0017	0	0.002	0.013	222	85
Copper	mg/L	TT[2]; Action Level = 1.3	1.3	0.00186	0.0033	0	0.0043	0.05	222	25
Cryptosporidium*	cysts/L	TT[4]	0	0.0598	0.10	0	0.30	0.30	48	33
Cyanide	mg/L	0.2	0.2	0.00041	0.0036	0	0	0.04	220	217
E. Coli	#/100mL			117.46	282.78	0	419.40	2420	572	4
Endrin	mg/L	0.002	0.002	0	0	0	0	0	26	26
Ethyl Benzene	mg/L	0.7	0.7	0	0	0	0	0	27	27
Fecal Coliform Bacteria	#/100mL	MCL[3]	0[3]	150.75	402.44	0	537.60	10400	1811	4
Fecal Strep Bacteria	#/100mL	MCL[3]	0[3]	433	864.89	0	3580	3900	49	1
Fluoride*	mg/L	4.0	4.0	0	0	0	NA	0	1	1
Giardia*	cysts/L	TT[4]	0	0.243	0.295	0	0.90	1.10	43	16
Heptachlor Epoxide	mg/L	0.0002	0	0	0	0	0	0	26	26
Heptachlor	mg/L	0.0004	0	0	0	0	0	0	26	26
Hexachlorobenzene	mg/L	0.001	0	0	0	0	0	0	26	26
Hexachlorocylopentadiene	mg/L	0.05	0.05	0	0	0	NA	0.00	25	25
Lead	mg/L	TT[2]; Action Level=0.015	0	0.0010	0.0033	0	0.0045	0.043	221	85
Mercury	mg/L	0.002	0.002	0.0000076	0.000045	0	0.00001	0.0004	220	196
Nitrate N	mg/L	10	10	0.90	0.78	0	2.44	5.42	1313	47
Nitrite N	mg/L	1	1	0.011	0.041	0	0.05	1.00	1314	873
Pentachlorophenol	mg/L	0.001	0	0	0	0	0	0	26	25
Selenium	mg/L	0.05	0.05	0.00043	0.0021	0	0.0012	0.023	207	154
Thallium	mg/L	0.002	0.0005	0.000014	0.000066	0	0.000115	0.00077	209	194
Toluene	mg/L	1	1	0	0	0	0	0	27	27
Toxaphene	mg/L	0.003	0	0	0	0	0	0	26	26
Turbidity (NTU)	NTU	TT[4]	n/a	6.55	7.24	1.30	14.97	200	1086	0
Vinyl Chloride	mg/L	0.002	0	0	0	0	0	0	27	27

Sources:
Metropolitan Council Environmental Services. Conventional River Water Monitoring Program, data downloaded 8/29/2019.
*Minnesota Department of Health. Water quality data request received 11/22/2019.
Refer to Table A for the different analytical methods used to characterize these constituents

Table 3 - SDWA Constituent Summary (cont.)

Footnotes

1. Definitions

   Maximum Contaminant Level Goal (MCLG): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals

   Maximum Contaminant Level (MCL): The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards

   Maximum Residual Disinfectant Level Goal (MRDLG): The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

   Maximum Residual Disinfectant Level (MRDL): The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants

   Treatment Technique (TT): A required process intended to reduce the level of a contaminant in drinking water.

2. Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L
3. A routine sample that is fecal coliform-positive or E. coli-positive triggers repeat samples - if any repeat sample is total coliform-positive, the system has an acute MCL violation. A routine sample that is total coliform-positive and fecal coliform-negative or E. coli-negative triggers repeat samples - if any repeat sample is fecal coliform-positive or E. coli-positive, the system has an acute MCL violation. See also Total Coliforms.
4. EPA's surface water treatment rules require systems using surface water or ground water under the direct ifnluence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the followign contaminants are controlled a tht efollowing levels:

   Cryptosporidium: 99 percent removal for systems that filter. Unfiltered systems are required to include Cryptosporidium in their existing watershed control provisions.

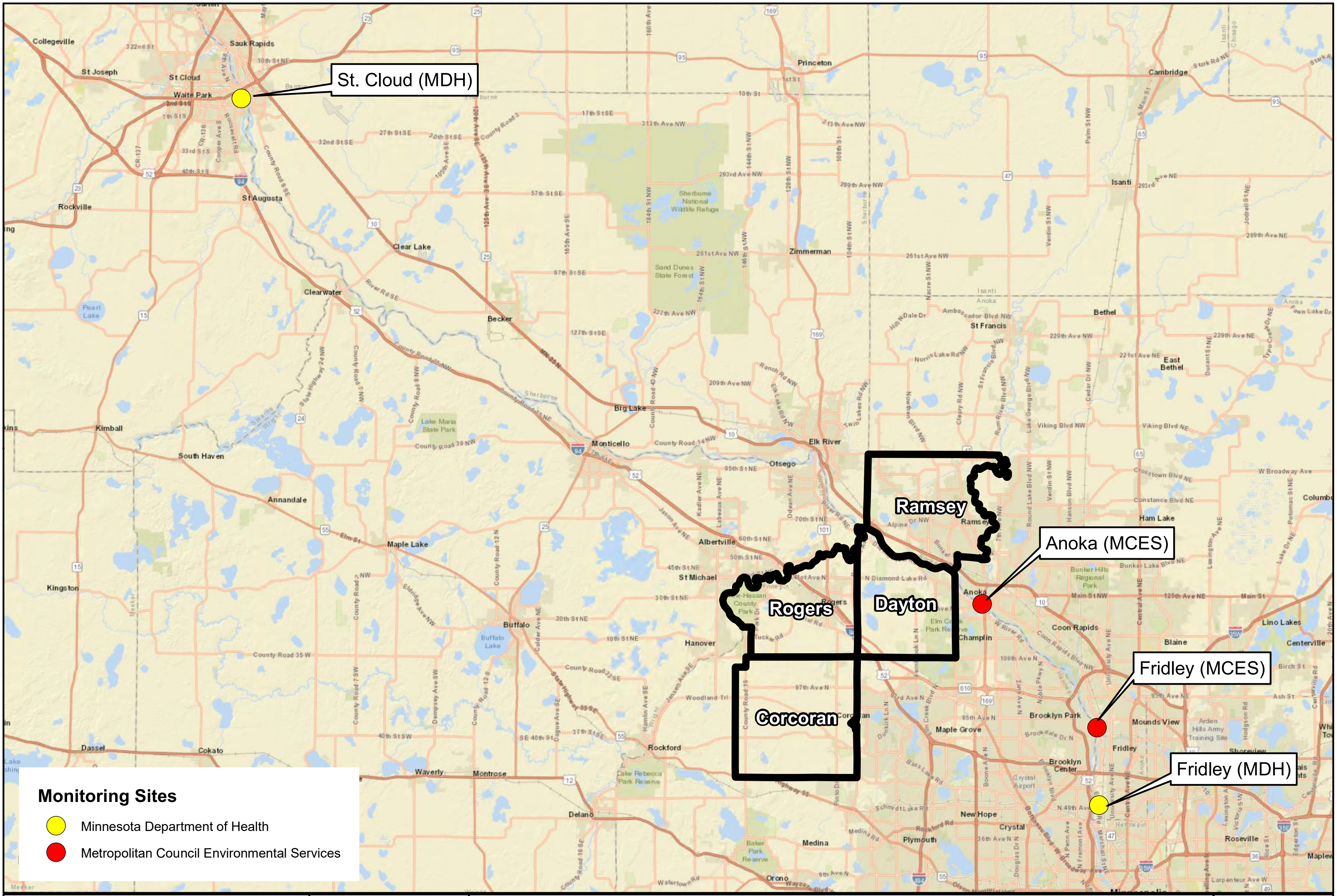
   Giardia lamblia: 99.9 percent removal/inactivation

   Viruses: 99.9 percent removal/inactivation

   Legionella: No limit, but EPA believes that if Giardia and viruses are removed/inactivated, according to the treatment techniques in the surface water treatment rule, *Legionella* will also be controlled.

   Turbidity: For systems that use conventional or direct filtration, at no time can turbidity (cloudiness of water) go higher than 1 nephelometric turbidity unit (NTU), and samples for turbidity must be less than or equal to 0.3 NTU in at least 95 percent of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU.

5. All data retreived from: Anoka MCES (2019), except Cryptosporidium, Flouride, Giardia, which were retreived from: Fridley MDH (2019)



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Print Date: 1/17/2020

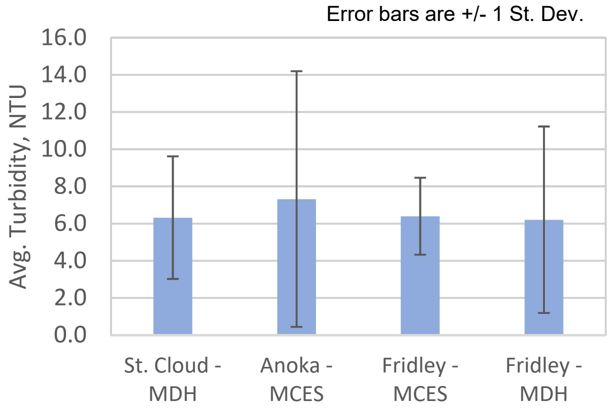
WATER QUALITY MONITORING SITES

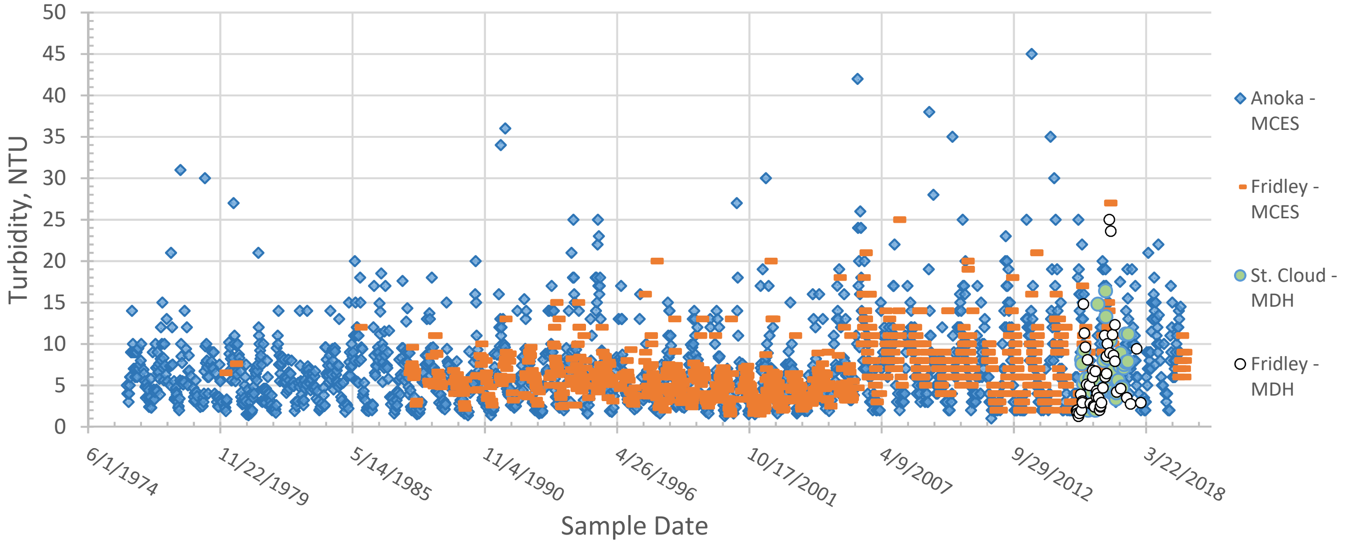
Northwest Metro Area Regional Water Supply Study

Figure
1

Figure 2 - Turbidity

	Units	St. Cloud - MDH	Anoka - MCES	Fridley - MCES	Fridley - MDH
Avg	NTU	6.3	7.3	6.4	6.2
St Dev	NTU	3.3	6.9	2.1	5.0
Min	NTU	2.0	1.0	6.0	1.3
Max	NTU	16.4	200.0	27.0	25.0
95th Percentile	NTU	14.0	17.0	12	19.6
Num. Samples		50	1767	1365	48
Sample Start Date		7/21/2015	9/4/1909	5/30/1978	1/6/2015
Sample End Date		6/26/2017	1/7/1976	8/26/2019	12/20/2016





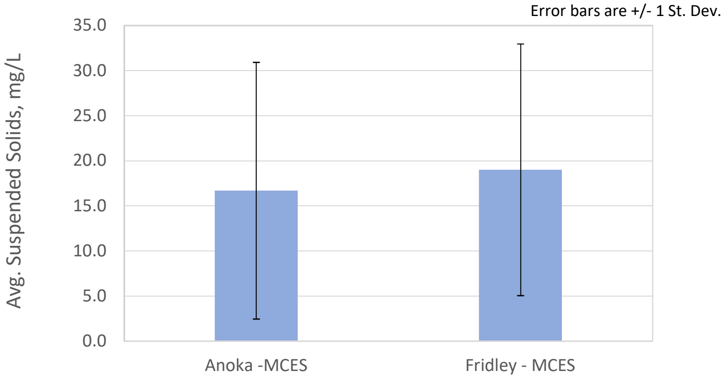
Note:
1) Two points fall above plot, 1) 12/19/1994, 200 mg/L, Anoka-MCES, and 2) 5/26/2015, 65 mg/L, Anoka-MCES
2) Refer to Table A for the different analytical methods used to characterize turbidity at Anoka

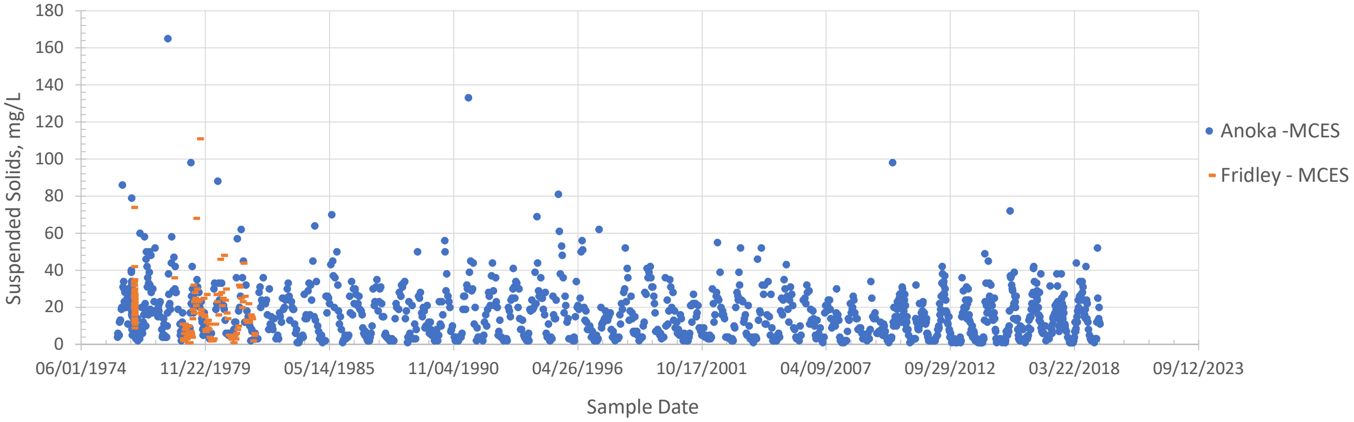
Metropolitan Council Environmental Services, August 2019. Conventional River Water Monitoring Program, data downloaded 8/29/2019.

Minnesota Department of Health, August 2010. Water quality data request received 11/22/2019.

Figure 3 - Total Suspended Solids

	Units	Anoka - MCES	Fridley - MCES
Avg, mg/L	mg/L	16.7	19.0
St Dev	mg/L	14.2	14.0
Min, mg/L	mg/L	1.0	1.0
Max, mg/L	mg/L	165.0	111.0
95th Percentile	mg/L	40.0	36.6
Num. Samples		1320	157
Sample Start Date		1/7/1976	8/19/1976
Sample End Date		5/6/2019	12/14/1981





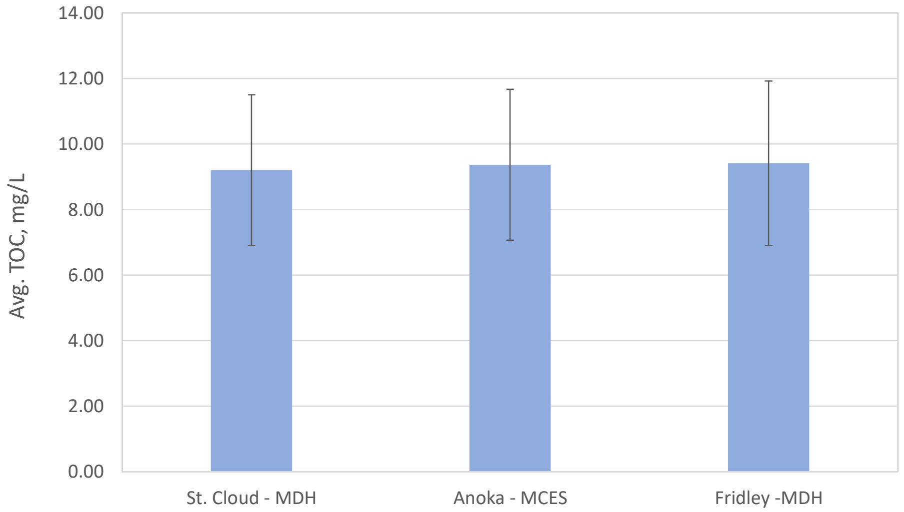
Metropolitan Council Environmental Services, August 2019. Conventional River Water Monitoring Program, data downloaded 8/29/2019.

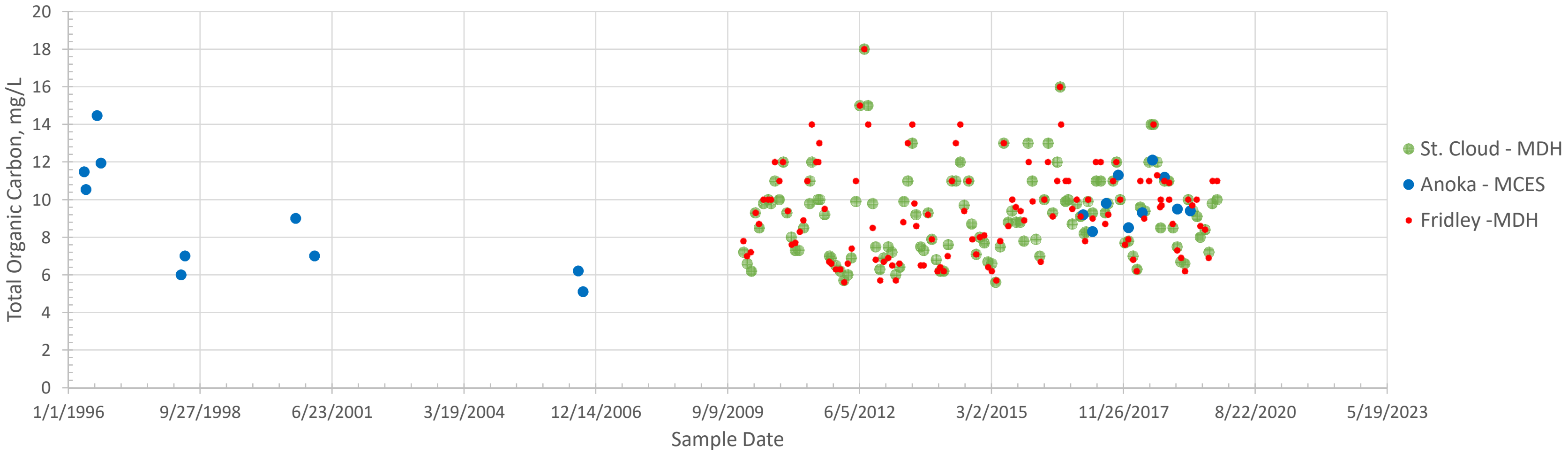
Minnesota Department of Health, August 2010. Water quality data request received 11/22/2019.

Figure 4 - Total Organic Carbon

	Units	St. Cloud - MDH	Anoka - MCES	Fridley - MDH
Avg	mg/L	9.20	9.37	9.41
St Dev	mg/L	2.3	2.3	2.51
Min	mg/L	5.6	5.1	5.6
Max	mg/L	18	14.5	18
95th Percentile	mg/L	13.9	NA	14.0
Num. Samples		122	20	115
Sample Start Date		1/6/2010	4/29/1996	1/5/2010
Sample End Date		11/4/2019	4/15/2019	11/5/2019

Error bars are +/- 1 St. Dev.

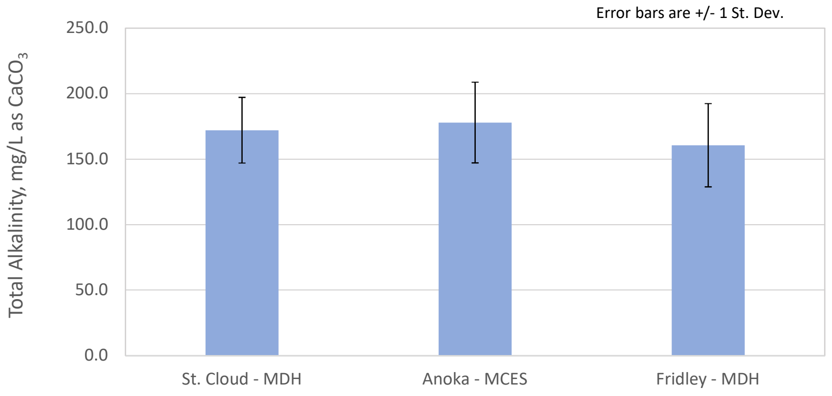


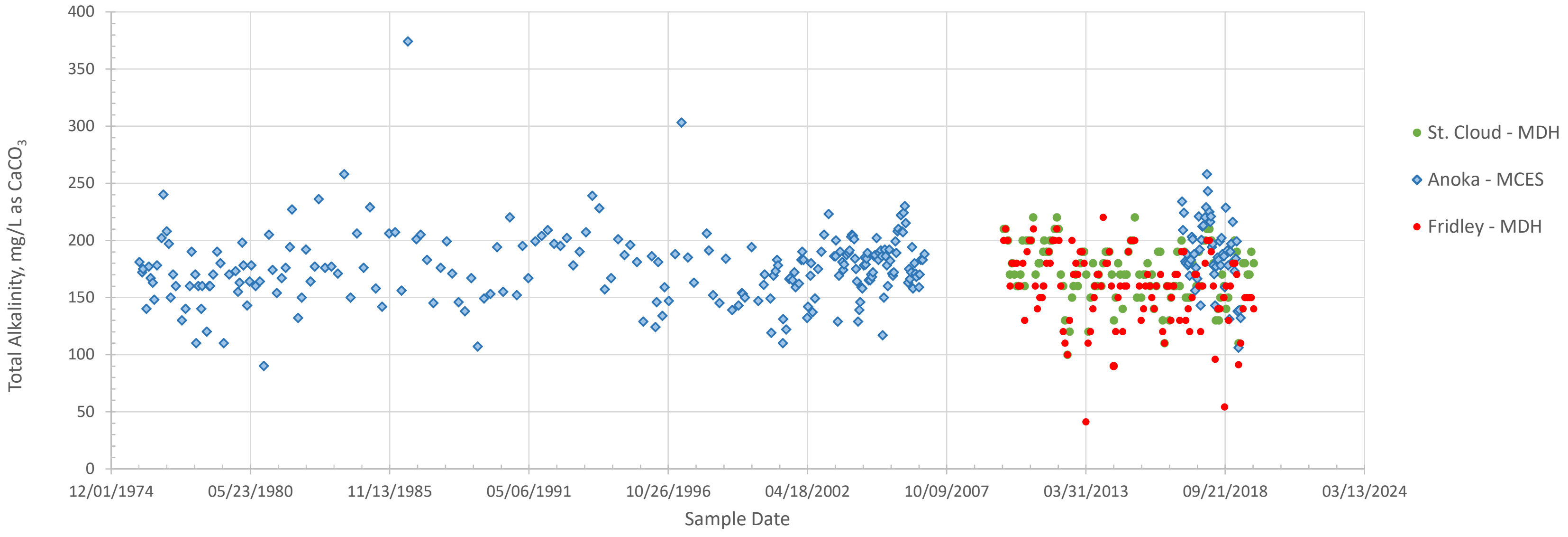


Metropolitan Council Environmental Services. Conventional River Water Monitoring Program, data downloaded 8/29/2019.
Minnesota Department of Health. Water quality data request received 11/22/2019.

Figure 5 - Alkalinity

	Units	St. Cloud - MDH	Anoka - MCES	Fridley - MDH
Avg	mg/L as CaCO3	172.1	177.9	160.6
St Dev	mg/L as CaCO3	25.0	30.8	31.7
Min	mg/L as CaCO3	100.0	90.0	41.0
Max	mg/L as CaCO3	220.0	374.0	220.0
95th Percentile	mg/L as CaCO3	210.0	227.2	200.0
Num. Samples		121	296	112
Sample Start Date		1/6/2010	1/14/1976	1/5/2010
Sample End Date		11/4/2019	4/29/2019	2/6/2019





Metropolitan Council Environmental Services. Conventional River Water Monitoring Program, data downloaded 8/29/2019.
Minnesota Department of Health. Water quality data request received 11/22/2019.

Appendix

Supporting Information for Mississippi River Water Quality Summary Memorandum

Table A - Mississippi River Water Quality Summary by Station

Constituent	Unit	Anoka, MCES							Fridley, MCES							Fridley, MDH							St Cloud, MDH						
		Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects
% Chlorophyll-a, Particulate	%	27.38	8.21	11	41.2	46	55	0	22.82	6.60	9	36.3	39	56	0														
1,1,1-Trichloroethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
1,1,2,2-Tetrachloroethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
1,1,2-Trichloroethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
1,1-Dichloroethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
1,1-Dichloroethene, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
1,2,4-Trichlorobenzene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
1,2-Dichlorobenzene, Unfiltered	mg/L	0.00	0.00	0	0	0	29	29																					
1,2-Dichloroethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
1,2-Dichloropropane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
1,2-Diphenylhydrazine, Unfiltered	mg/L	0.00	0.00	0	NA	0	25	25																					
1,3-Dichlorobenzene, Unfiltered	mg/L	0.00	0.00	0	0	0	29	29																					
1,4-Dichlorobenzene, Unfiltered	mg/L	0.00	0.00	0	0	0	29	29																					
2,4,6-Trichlorophenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
2,4-Dichlorophenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
2,4-Dimethylphenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
2,4-Dinitrophenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
2,4-Dinitrotoluene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
2,6-Dinitrotoluene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
2-Chloroethylvinylether, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
2-Chloronapthalene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
2-Chlorophenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
2-Methyl-4,6-Dinitrophenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
2-Nitrophenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
3,3'-Dichlorobenzidine, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
4,4'-DDD, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
4,4'-DDE, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
4,4'-DDT, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
4-Bromophenyl Phenyl Ether, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
4-Chloro-3-Methylphenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
4-Chlorophenyl Phenyl Ether, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
4-Nitrophenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
a-BHC, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Acenaphthylene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Acenapthene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Aldrin, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Alkalinity, Bicarbonate	mg/L															150.00	0	150	NA	150	1	0	180.00	0	180	NA	180	1	0
Alkalinity, Carbonate	mg/L																						1.60	0	1.6	NA	1.6	1	0
Alkalinity, Total	mg/L															160.63	31.74	41	200	220	112	0	172.07	25.0262	100	210	220	121	0
Aluminum, Unfiltered	mg/L	0.17	0.13	0.038	NA	0.495	15	0																					
Ammonia Nitrogen, Filtered	mg/L	0.04	0.07	0	0.156	0.37	107	63																					
Ammonia Nitrogen, Total	mg/L															0.00	0	0	NA	0	2	2	0.00	0	0	NA	0	1	1
Ammonia Nitrogen, Unfiltered	mg/L	0.08	0.16	0	0.34	3	1808	733	0.07	0.12	0	0.3	2.33	1504	635														
Anthracene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Antimony, Filtered	mg/L	0.00	0.00	0	NA	0	1	1																					
Antimony, Unfiltered	mg/L	5.6701E-06	3.54E-05	0	0	3.00E-04	194	189																					
Arsenic	ug/L															1.41	0	1.41	NA	1.41	1	0	0.00	0	0	NA	0	1	1
Arsenic, Filtered	mg/L	0.0020	0.00	0.00060	0.0037	0.0039	48	0																					
Arsenic, Unfiltered	mg/L	0.00	0.00	0	0.003	0.0047	222	26																					
Barium	ug/L															52.30	0	52.3	NA	52.3	1	0	54.50	0	54.5	NA	54.5	1	0
Barium, Unfiltered	mg/L	0.08	0.02	0.041	NA	0.1	8	0																					
b-BHC, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Benzine, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Benzidine, Unfiltered	mg/L	0.00	0.00	0	NA	0	25	25																					
Benzo(a)anthracene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Benzo(a)pyrene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Benzo(b)fluoranthene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Benzo(g,h,i)perylene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Benzo(k)fluoranthene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Beryllium, Filtered	mg/L	0.00	0.00	0	NA	0	2	2																					
Beryllium, Unfiltered	mg/L	0.00	0.00	0	0	0.01	206	198																					
Bicarbonate, Unfiltered	mg/L	244.93	282.72	110	284.95	2880	90	0																					
Bis (2-chloroethoxy) Methane, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Bis (2-chloroethyl) Ether, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Bis (2-chloro-Isopropyl) Ether, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Bis(2-ethylhexyl)phthalate, Unfiltered	mg/L	0.00	0.01	0	0.02393	0.03329	26	19																					

Table A - Mississippi River Water Quality Summary by Station

Constituent	Unit	Anoka, MCES							Fridley, MCES							Fridley, MDH							St Cloud, MDH						
		Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects
BOD 5-day, Filtered	mg/L	2.01	1.60	0	5.15	5.5	54	8	1.87	1.13	0.2	4.18	4.5	27	0														
BOD 5-day, Unfiltered	mg/L	2.47	1.65	0	5.3	18.2	1111	76	3.81	2.00	0.9	7.46	14	101	0														
BOD K-rate, Filtered	/day	0.01	0.00	0.006	0.0150667	0.0156667	28	0																					
BOD K-rate, Unfiltered	/day	0.02	0.00	0.009	0.02495	0.026	28	0																					
BOD Ultimate K-rate, Filtered	/day	0.01	0.00	0.004	NA	0.009	8	0																					
BOD Ultimate K-rate, Unfiltered	/day	0.02	0.00	0.012	NA	0.017	8	0																					
BOD Ultimate, Filtered	mg/L	6.71	2.17	3.9	11.405	13.7	36	0																					
BOD Ultimate, Unfiltered	mg/L	11.08	3.56	5.4	19.535	20.3	36	0																					
Boron, Unfiltered	mg/L	0.08	0.03	0.05	NA	0.13	4	0																					
Bromide	mg/L															8.08	11.81	0	NA	30.4	5	3	10.00	0	10	NA	10	1	0
Bromodichloromethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Bromoform, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Bromomethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Butylbenzylphthalate, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Ca as CaCO3	mg/L as CaCO3															110.00	0	110	NA	110	1	0							
Cadmium, Filtered	mg/L	0.00	0.00	0	0.00021	0.00046	48	43																					
Cadmium, Unfiltered	mg/L	0.00	0.00	0	0.0003	0.001	222	181																					
Calcium	mg/L																						53.00	0	53	NA	53	1	0
Calcium, Filtered	mg/L	53.19	20.05	4	70.115	425	496	0																					
Carbon Tetrachloride, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Carbonate, Unfiltered	mg/L CO3	0.18	0.80	0	2	6	73	0																					
CBOD 5-day, Filtered	mg/L	0.32	0.42	0	NA	1.2	15	9																					
CBOD 5-day, Unfiltered	mg/L	1.73	1.58	0	4.8	18	968	180	4.99	1.54	2.35	7.505	12	58	0														
CBOD K-rate, Filtered	/day	0.01	0.01	0.006	0.016775	0.017	28	0																					
CBOD K-rate, Unfiltered	/day	0.02	0.00	0.008	0.025875	0.027	28	0																					
CBOD Ultimate K-rate, Filtered	/day	0.01	0.00	0.007	NA	0.018	4	0																					
CBOD Ultimate K-rate, Unfiltered	/day	0.02	0.00	0.018	NA	0.022	3	0																					
CBOD Ultimate, Filtered	mg/L	5.06	1.24	3.2	8	7.766667	32	0																					
CBOD Ultimate, Unfiltered	mg/L	8.30	2.02	4.65	12.8	14	31	0																					
Chlordane, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Chloride	mg/L															16.70	0	16.7	NA	16.7	1	0	14.50	0	14.5	NA	14.5	1	0
Chloride, Filtered	mg/L	14.93	4.84	0	22	36	373	1	8.95	0.95	6.75	11.15	12	53	0														
Chloride, Unfiltered	mg/L	16.23	4.58	4	23.41	37.4	318	0	10.38	6.38	5.5	NA	22.9	5	0														
Chlorine Residual, Lab	mg/L	0.04	0.10	0	0.14	0.64	46	0	0.02	0.04	0.00	NA	0.12	11	0														
Chlorobenzene, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Chloroethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Chloroform, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Chloromethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Chlorophyll-a Trichromatic Uncorrected	mg/L	0.03	0.02	0	0.072	0.15	1280	3	0.04	0.02	0.003	0.077	0.103	183	0														
Chlorophyll-a, % Pheo-Corrected	%	79.64	14.87	0	99	110	1222	1	79.67	13.52	33	99	100	127	0														
Chlorophyll-a, Pheo-Corrected	mg/L	0.02	0.02	0	0.05405	0.12	598	1																					
Chlorophyll-a/Pheophytin-a Abs. Ratio	Ratio	1.62	0.23	1.2	2.0205	3.66	598	0																					
Chlorophyll-b	mg/L	0.003252926	0.01	0	0.011	0.14	598	184																					
Chlorophyll-c	mg/L	0.01	0.01	0	0.018	0.044	598	20																					
Chromium, Filtered	mg/L	0.000294271	0.00	0	0.0010043	0.0054	48	25																					
Chromium, Unfiltered	mg/L	0.00	0.00	0	0.002	0.013	222	85																					
Chrysene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Cis-1,3-Dichloropropene, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Conductivity, Field	umho/cm	431.17	70.77	165	543.2	789	857	0	370.07	60.22	0.000	455.05	540	578	0														
Conductivity, Lab	umho/cm	374.82	71.07	159	517.7	600	288	0	328.55	68.71	180	511.5	600	76	0														
Copper, Filtered	mg/L	0.00	0.00	0	0.00312	0.0036	48	5																					
Copper, Unfiltered	mg/L	0.00	0.00	0	0.00427	0.047	222	25																					
Cryptosporidium	cysts/L															0.06	0.1	0	0.3	0.3	48	33	0.01	0.03312	0	0.081	0.17	48	40
Cyanide, Unfiltered	mg/L	0.00	0.00	0	0	0.04	220	217																					
d-BHC, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Dibenzo(a,h)anthracene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Dibromochloromethane, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Dieldrin, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Diethylphthalate, Unfiltered	mg/L	0.00	0.00	0	0.000728	0.00112	26	25																					
Dimethylphthalate, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Di-N-butyl-phthalate, Unfiltered	mg/L	0.00	0.00	0	0.0033365	0.00341	26	18																					
Di-N-octylphthalate, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Dissolved Organic Carbon	mg/L															12.10	2.7	9.4	NA	14.8	2	0	13.90	0	13.9	NA	13.9	1	0
Dissolved Oxygen, Field	mg/L	9.28	1.94	5.31	13	17.03	887	0	9.80	1.98	5.93	13.795	19.94	789	0														

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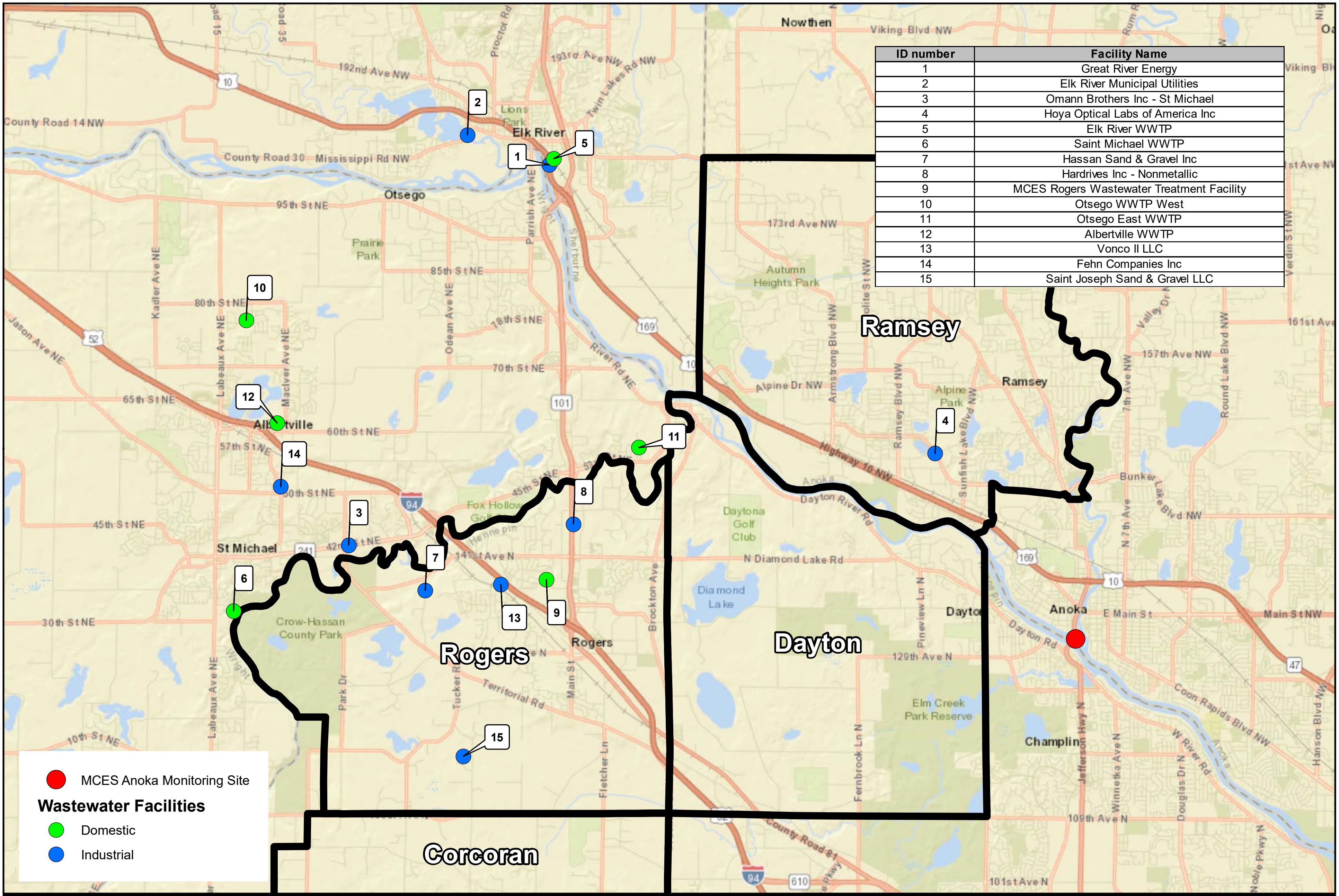
Constituent	Unit	Anoka, MCES							Fridley, MCES							Fridley, MDH							St Cloud, MDH						
		Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects
Dissolved Oxygen, Lab	mg/L	10.90	2.22	5.2	14.1	15.6	959	0	11.19	2.28	6.2	14.4	16.6	693	0														
Dissolved Oxygen	mg/L															7.72	0	7.72	NA	7.72	2	0							
E. Coli Bacteria Count	#/100mL	117.46	282.78	0	419.4	2420	572	4	98.65	210.08	0	365	1986	475	4	116.40	315.3	0	699.195	1986	48	1	72.64	77.7484	6.3	286.9	365.4	47	0
Endosulfan I, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Endosulfan II, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Endosulfan Sulfate, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Endrin Aldehyde, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Endrin, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Ethyl Benzene, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Fecal Coliform Bacteria Count	#/100mL	150.75	402.44	0	537.6	10400	1811	4	134.24	276.27	2	512.8	4400	1503	0														
Fecal Strep Bacteria Count	#/100mL	433.00	864.89	0	3580	3900	49	1	748.33	827.60	0	NA	2040	15	1														
Fluoranthene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Fluorene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Fluoride, Total	mg/L															0.00	0	0	NA	0	1	1	0.00	0	0	NA	0	1	1
g-BHC, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Giardia	cysts/L															0.24	0.295	0	0.9	1.1	43	16	0.12	0.15987	0	0.467	0.83	48	17
Hardness, Unfiltered	mg/L	208.28	37.41	86	274	332	145	0																					
Heptachlor Epoxide, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Heptachlor, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Hexachlorobenzene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Hexachlorobutadiene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Hexachlorocylopentadiene, Unfiltered	mg/L	0.00	0.00	0	NA	0	25	25																					
Hexachloroethane, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Hex-chromium, Filtered	mg/L	0.00	0.00	0	0	0	30	30																					
Indeno (1,2,3-c-d)pyrene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Iron	ug/L															569.00	0	569	NA	569	1	0	302.00	0	302	NA	302	1	0
Iron, Filtered	mg/L	0.01	0.01	0	NA	0.025	2	1																					
Iron, Unfiltered	mg/L	0.51	0.26	0.17	1.212	1.3	27	0																					
Isophorone, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Lead, Filtered	mg/L	0.00	0.00	0	0.000676	0.003	48	40																					
Lead, Unfiltered	mg/L	0.00	0.00	0	0.00452	0.0428	221	85																					
m&p-Xylenes, Unfiltered	mg/L	0.00	0.00	0	NA	0	23	23																					
Magnesium	mg/L																						18.50	0	18.5	NA	18.5	1	0
Magnesium	mg/L as CaCO3															62.00	0	62	NA	62	1	0							
Magnesium, Filtered	mg/L	19.39	4.49	8.64	26.83	61.4	496	0																					
Manganese	ug/L															130.00	0	130	NA	130	1	0	48.70	0	48.7	NA	48.7	1	0
Manganese, Filtered	mg/L	0.00	0.00	0.002	NA	0.005	2	0																					
Manganese, Unfiltered	mg/L	0.10	0.05	0.045	NA	0.21	12	0																					
Mercury, Filtered	mg/L	0.00	0.00	0	9.773E-05	0.0002	46	33																					
Mercury, Unfiltered	mg/L	0.00	0.00	0	1.395E-05	0.0004	220	196																					
Methylene Chloride, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Molybdenum	mg/L	0.00	0.00	0	NA	0	6	6																					
m-Xylenes, Unfiltered	mg/L	0.00	0.00	0	NA	0	3	3																					
Naphthalene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Nickel, Filtered	mg/L	0.00	0.00	0	0.00271	0.0044	48	4																					
Nickel, Unfiltered	mg/L	0.00	0.00	0	0.00456	0.0097	221	27																					
Nitrate + Nitrite Nitrogen, Total	mg/L															0.24	0	0.24	NA	0.24	1	0	0.23	0	0.23	NA	0.23	1	0
Nitrate N, Unfiltered	mg/L	0.90	0.78	0	2.436	5.42	1313	47	0.28	0.38	0	0.98	2.54	157	30														
Nitrite N, Unfiltered	mg/L	0.01	0.04	0	0.05	1	1314	873	0.01	0.03	0	0.052	0.21	157	76														
Nitrite Nitrogen, Total	mg/L															0.02	0	0.02	NA	0.02	2	0	0.04	0	0.04	NA	0.04	1	0
Nitrobenzene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
N-Nitrosodimethyl Amine, Unfiltered	mg/L	0.00	0.00	0	NA	0	25	25																					
N-Nitrosodi-N-Propylamine, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
N-Nitroso-Diphenylamine, Unfiltered	mg/L	0.00	0.00	0	NA	0	25	25																					
Oil and Grease	mg/L	1.53	3.52	0	NA	14	15	10																					
Ortho Phosphate as P, Filtered	mg/L	0.05	0.05	0	0.139	0.464	1123	87	0.06	0.06	0	0.16605	0.354	140	6														
Ortho Phosphate as P, Unfiltered	mg/L	0.05	0.05	0	0.1499	0.313	641	17	0.09	0.06	0.01	NA	0.25	18															
Oxidation Reduction Potential	mV															30.30	0	30.3	NA	30.3	2	0	192.60	0	192.6	NA	192.6	1	0
Oxygen Demand, Particulate	mg/L	12.82	2.89	7	17.503	20.9	57	0	11.25	2.14	7.33	14.7525	16.6	58	0														
o-Xylenes, Unfiltered	mg/L	0.00	0.00	0	NA	0	23	23																					
p&o-Xylenes, Unfiltered	mg/L	0.00	0.00	0	NA	0	3	3																					
PCB: 1016, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
PCB: 1221, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
PCB: 1232, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
PCB: 1242, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					

Table A - Mississippi River Water Quality Summary by Station

Constituent	Unit	Anoka, MCES							Fridley, MCES							Fridley, MDH							St Cloud, MDH						
		Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects	Avg	St Dev	Min	95th Percentile	Max	Count	# of Non-Detects
PCB: 1248, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
PCB: 1254, Unfiltered	mg/L	0.00	0.00	0	3.185E-05	0.000049	26	24																					
PCB: 1260, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Pentachlorophenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
pH	units															8.30	0	8.3	NA	8.3	1	0	8.00	0	8	NA	8	1	0
pH, Field	units	8.06	0.32	7.02	8.6	9.2	1176	0	8.02	0.31	6	8.494	8.79	931	0														
pH, Lab	units	8.08	0.35	6.8	8.7	9.12	654	0	8.04	0.36	6.8	8.64	9.1	532	0														
Phenanthrene, Unfiltered	mg/L	0.00	0.00	0	0.001365	0.0021	26	25																					
Phenol, Unfiltered	mg/L	0.00	0.00	0	0	0	26	25																					
Pheophytin-a	mg/L	0.00	0.00	0	0.011	0.034	600	190																					
Phosphate, Total	mg/L															0.22	0	0.22	NA	0.22	1	0	0.17	0	0.17	NA	0.17	1	0
Potassium	mg/L															2.14	0	2.14	NA	2.14	1	0	2.46	0	2.46	NA	2.46	1	0
Potassium, Filtered	mg/L	2.96	0.79	0.8	4.505	8	494	0																					
Pyrene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Selenium, Filtered	mg/L	0.00	0.00	0	NA	0	2	2																					
Selenium, Unfiltered	mg/L	0.00	0.00	0	0.0012	0.023	207	154																					
Silica, Filtered	mg/L	12.13	4.14	1	20	26	221	0																					
Silver, Filtered	mg/L	0.00	0.00	0	NA	0	4	4																					
Silver, Unfiltered	mg/L	0.00	0.00	0	0	0.00036	217	211																					
Sodium	mg/L															10.00	0	10	NA	10	1	0	7.87	0	7.87	NA	7.87	1	0
Sodium, Filtered	mg/L	10.56	5.88	3.99	16.5	95	494	0																					
Specific Conductance	uS/cm															363.00	0	363	NA	363	2	0	354.00	0	354	NA	354	1	0
Strontium	ug/L															94.10	0	94.1	NA	94.1	1	0	103.00	0	103	NA	103	1	0
Sulfate	mg/L															9.96	0	9.96	NA	9.96	1	0	11.20	0	11.2	NA	11.2	1	0
Sulfate, Filtered	mg/L	21.80	9.04	3	37.79	96	493	0																					
Suspended Solids	mg/L	16.68	14.22	0	39.95	165	1320	9	19.00	13.96	1	36.6	111	157	0														
Temperature	deg C	12.99	9.22	-0.2	25.7725	30	1830	0	13.92	8.68	-0.21	25.44	28.9	1463	0	24.16	0	24.16	NA	24.2	2	0	18.20	0	18.2	NA	18.2	1	0
Tetrachloroethene, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Thallium, Filtered	mg/L	0.00	0.00	0	NA	0	4	4																					
Thallium, Unfiltered	mg/L	0.00	0.00	0	0.000115	0.00077	209	194																					
Toluene, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Total Alkalinity, Filtered	mg/L CaCO3	177.39	31.40	25	228.9	245	213	0																					
Total Alkalinity, Unfiltered	mg/L CaCO3	177.90	30.81	90	227.15	374	296	0																					
Total Dissolved Solids	mg/L	268.97	48.28	119	348	720	972	0	240.09	35.43	138	NA	309	22	0														
Total Kjeldahl Nitrogen, Filtered	mg/L	0.87	0.32	0.25	1.5	2.3	579	0																					
Total Kjeldahl Nitrogen, Particulate	mg/L	0.22	0.21	0	0.534	3.56	951	81	0.31	0.21	0.03	0.7	0.7	39	0														
Total Kjeldahl Nitrogen, Unfiltered	mg/L	0.93	0.34	0	1.5	3.55	1109	4	0.91	0.30	0.24	1.448	2	123	0														
Total Kjeldahl Nitrogen, Unfiltered, Low Level Detection	mg/L	0.93	0.22	0.67	NA	1.3	9	0																					
Total Nitrate/Nitrite N, Unfiltered	mg/L	1.07	0.56	0.21	2.383	2.68	37	0																					
Total Organic Carbon	mg/L															9.41	2.508	5.6	14	18	115	0	9.20	2.3042	5.6	13.85	18	122	0
Total Organic Carbon, Filtered	mg/L	9.37	2.30	5.1	NA	14.47	20	0																					
Total Organic Carbon, Unfiltered	mg/L	11.50	0.66	10.74	NA	12.44	4	0																					
Total Phenolics, Unfiltered	mg/L	0.00	0.00	0	0.003415	0.0086	218	123																					
Total Phosphorus, Filtered	mg/L	0.06	0.06	0	0.1606	0.59	895	151	0.07	0.08	0	0.282	0.34	66	10														
Total Phosphorus, Particulate	mg/L	0.05	0.04	0	0.10645	0.83	1030	7	0.06	0.04	0	0.12	0.17	104	1														
Total Phosphorus, Unfiltered	mg/L	0.11	0.08	0	0.24	1	1349	34	0.13	0.09	0.02	0.302	0.63	227	0														
Total Phosphorus, Unfiltered, Low Level Detection	mg/L	0.08	0.07	0.013	NA	0.259	9	0																					
Toxaphene, Unfiltered	mg/L	0.00	0.00	0	0	0	26	26																					
Trans-1,2-Dichloroethene, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Trans-1,3-Dichloropropene, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Trichloroethene, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Trichlorofluoromethane, Unfiltered	mg/L	0.00	0.00	0	0.000876	0.00146	27	26																					
Turbidity	NTU															6.21	5.016	1.26	19.64	25	48	0	6.32	3.29828	2	13.975	16.4	50	0
Turbidity (JTU)	JTU	6.62	3.78	2	12.95	31	120	0	4.12	1.09	2.7	NA	7.1	13	0														
Turbidity (NTRU)	NTRU	8.91	6.45	1	19	65	546	0	7.74	3.82	2	14	27	459	0														
Turbidity (NTU), Field	NTU	9.68	5.71	1	21.8	29	121	0	8.46	6.43	0	18	59	119	0														
Turbidity (NTU), Lab	NTU	6.55	7.24	1.3	14.965	200	1086	0	5.65	2.63	1.2	10.675	20	972	0														
UV Absorbance, 254 nm	units/cm															0.44	0.15	0.29	NA	0.59	2	0	0.53	0	0.53	NA	0.53	1	0
UV Absorbance, specific	L/mg-m															3.57	0.435	3.13	NA	4	2	0	3.83	0	3.83	NA	3.83	1	0
Vinyl Chloride, Unfiltered	mg/L	0.00	0.00	0	0	0	27	27																					
Volatile Suspended Solids	mg/L	5.05	3.96	0	12	31	1255	74	8.55	5.19	0	17.45	25	110	1														
Zinc, Filtered	mg/L	0.01	0.01	0	0.03325	0.06	48	15																					
Zinc, Unfiltered	mg/L	0.01	0.03	0	0.03925	0.32	222	50																					



ID number	Facility Name
1	Great River Energy
2	Elk River Municipal Utilities
3	Omann Brothers Inc - St Michael
4	Hoya Optical Labs of America Inc
5	Elk River WWTP
6	Saint Michael WWTP
7	Hassan Sand & Gravel Inc
8	Hardrives Inc - Nonmetallic
9	MCES Rogers Wastewater Treatment Facility
10	Otsego WWTP West
11	Otsego East WWTP
12	Albertville WWTP
13	Vonco II LLC
14	Fehn Companies Inc
15	Saint Joseph Sand & Gravel LLC

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PERMITTED DISCHARGERS IN STUDY AREA VICINITY

Northwest Metro Area Regional Water Supply Study

Figure
A

Appendix B: Groundwater Aquifer Information

SEH

Building a Better World
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MEMORANDUM

TO: Chris Larson, PE

FROM: Mark Sherrill

DATE: March 12, 2020

RE: Northwest Metro Aquifers
SEH No. 150732 14.00

This memo presents a summary of the regional groundwater aquifers in the Northwest Metro area including the Cities of Corcoran, Dayton, Ramsey, and Rogers.

While variation and extent of bedrock aquifers occur, in general five regional aquifers support much of the potable water for the Twin Cities region, from oldest to youngest: (1) Mt Simon-Hinckley (2) Tunnel City-Wonewoc (3) Prairie du Chien-Jordan (4) St. Peter, and (5) Quaternary aquifers. These aquifers are hydrologically disconnected by a variety of interbedded confining layers.

In the Northwest Metro area, Quaternary deposits are highly variable in the types of materials present. Large areas of sand and gravel are required for high production municipal wells. For purposes of this report, Quaternary deposits will not be relied upon for drinking water wells.

Based upon the geologic bedrock map represented in Figure 1, the St. Peter aquifer only exists in a small portion of Corcoran and is largely not available as a bedrock aquifer.

Jordan Aquifer

The Jordan Aquifer is generally considered to be hydrologically connected to the Prairie Du Chien Unit. However, as evident from the geologic bedrock map (Figure 1) the Prairie Du Chien Unit was either not deposited or has been eroded through much of this area. The thickness and presence of this aquifer through this area is scarce and laterally disconnected. Where present, the thickness of the Jordan aquifer is generally around 70 feet, with some areas within the Cities of Corcoran and Dayton as thick as 170 feet. Within the City of Ramsey, the Jordan Sandstone thickness is minimal at around 20-30 feet and appears heavily eroded. Quaternary deposits directly overlay this unit and the Jordan Sandstone is likely recharged by these deposits.

Based on the geologic bedrock map and lack of existing Jordan wells, it assumed that the Jordan aquifer is not available for municipal wells throughout most of the study area.

Tunnel City – Wonewoc Aquifer

The Tunnel City Group and underlying Wonewoc Sandstone supply water for much of the Northwest Metro region. Presence and thickness of the Tunnel City is depicted on Figure 2 and for the Wonewoc on Figure 3. These units appear laterally continuous through much of this area and greater Twin Cities region aside from where it has been eroded away. Areas where the Aquifer is not present primarily occur within bedrock valleys where previous streams and surface water features carved away the bedrock unit.

The productivity of the Tunnel City – Wonewoc Aquifer is generally regarded as variable. Yields tend to be moderate to low with some of the highest yields reported where bedrock units are highly fractured.

The geologic maps (Figures 2 and 3) indicate that the Tunnel City – Wonewoc is present in most of the study area, with the exception of bedrock valleys in Ramsey and Rogers. This report assumes that all of the new wells will be in the Tunnel City – Wonewoc aquifer.

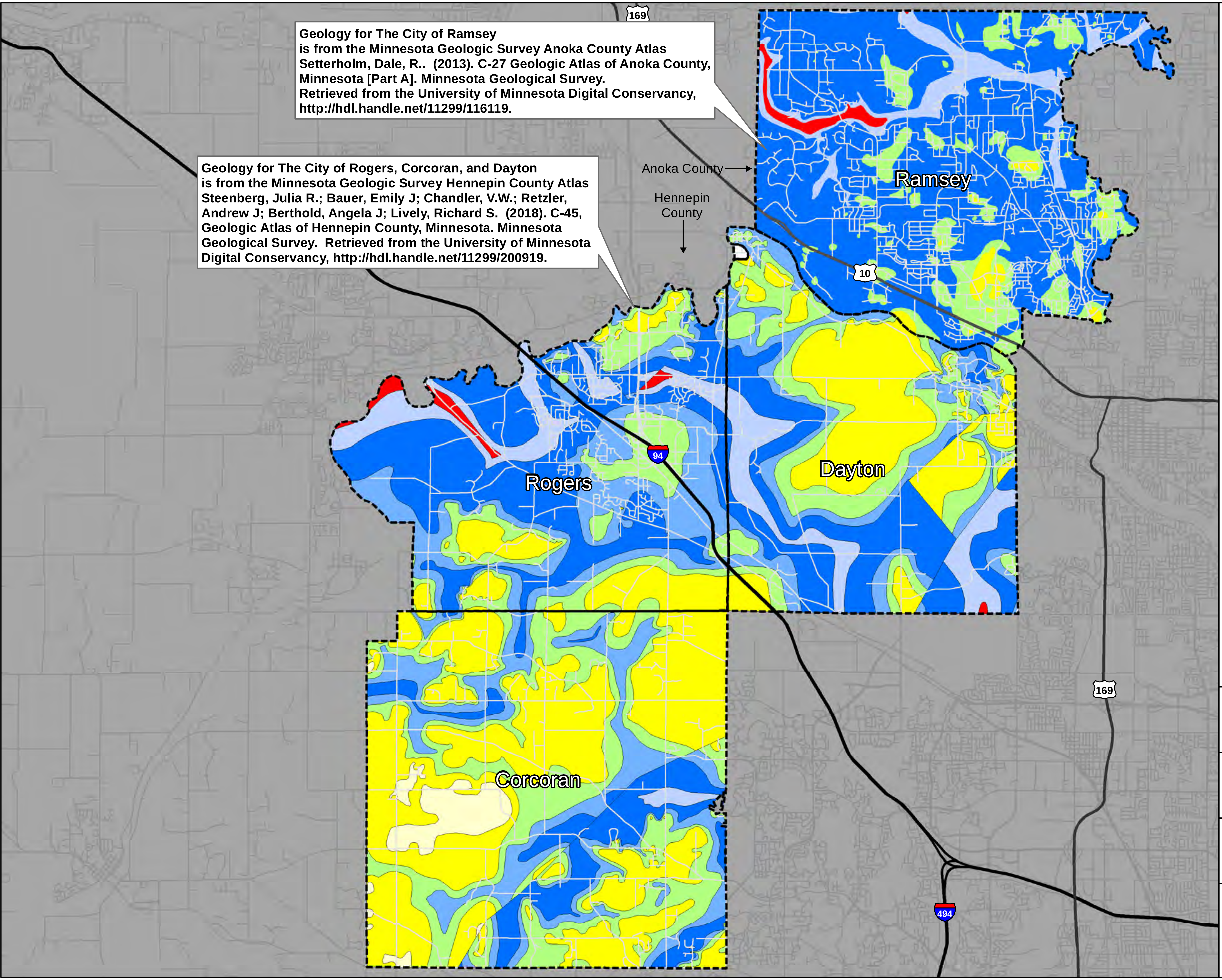
Mt. Simon-Hinckley Aquifer

The Mount Simon-Hinckley Aquifer is generally described as a high to moderate yield aquifer. New high capacity wells are generally not permitted by the Minnesota Department of Natural Resources as use has been restricted by Minnesota Law, therefore it is not discussed in this report in greater detail.

Regional Groundwater Supply

In 2016, the Metropolitan Council along with the support of HDR completed a study on the groundwater supply within the Northwest Metro regional area (*Regional Water Supply, Enhanced Groundwater Recharge, and Stormwater Capture and Reuse Study (Northwest Metro Study Area) Report*, December 2016). The study was one of several studies to support an update to the Twin Cities Metropolitan Area Master Water Supply Plan (Minn. Stat., Sec. 473.1565) and other activities identified by the 2005 Minnesota Legislature to address water supply needs of the seven-county metro area. As part of these activities, the Metropolitan Council modeled the existing source water aquifers to evaluate current and future drawdown of the aquifers and discussed the potential for using alternative water sources or increasing water recharge to the source water aquifers.

The 2016 study concluded that the existing source water aquifers are expected to see an increase in drawdown at existing municipal well sites under the predicted 2040 water demand. Areas within the Northwest Metro area could see drawdown in their bedrock aquifers between 10 - 40 feet. To compensate for the excessive drawdown, the report discusses the use of alternative water supplies such as surface water, stormwater reuse, and the potential for enhanced groundwater recharge.



Geology for The City of Ramsey is from the Minnesota Geologic Survey Anoka County Atlas Setterholm, Dale, R.. (2013). C-27 Geologic Atlas of Anoka County, Minnesota [Part A]. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/116119.

Geology for The City of Rogers, Corcoran, and Dayton is from the Minnesota Geologic Survey Hennepin County Atlas Steenberg, Julia R.; Bauer, Emily J; Chandler, V.W.; Retzler, Andrew J; Berthold, Angela J; Lively, Richard S. (2018). C-45, Geologic Atlas of Hennepin County, Minnesota. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/200919.

Legend

⬚ Municipality Boundary

Anoka County Bedrock Geology

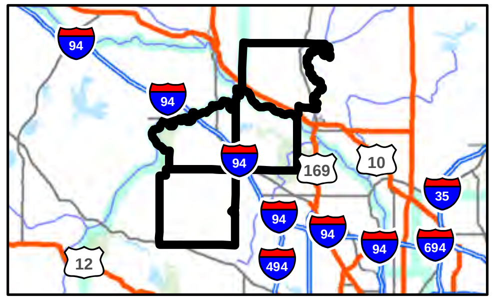
- 🟨 Jordan Sandstone, Up. Camb.
- 🟩 St. Lawrence Formation, Up. Camb.
- 🟦 Tunnel City group,Up. Camb.
- ▨ Wonewoc Sandstone, Up. Camb.
- 🟥 Eau Claire Formation, Mid. to Up. Camb.

Hennepin County Bedrock Geology

- ▢ Os, St. Peter Sandstone
- 🟨 Cj, Jordan Sandstone
- 🟩 Cs, St. Lawrence Fm
- 🟦 Ctm, Tunnel City Grp, Mazomanie Fm
- 🟦 Ctl, Tunnel City Grp, Lone Rock Fm
- ▨ Cw, Tunnel City Grp, Wonewoc Sandstone
- 🟥 Ce, Eau Claire Fm

0 3,000 6,000 12,000
Feet

N



Bedrock Geology

Water Distribution Systems
Ramsey, Dayton, Rogers, and Corcoran

SEH

Project: MCES 150732
Print Date: 12/30/2019

Map by: Msherrill
Projection: UTM Zone 15N
Source: ESRI, SEH Digi MnDOT, Minnesota Geologic Survey (MGS)

Figure
1

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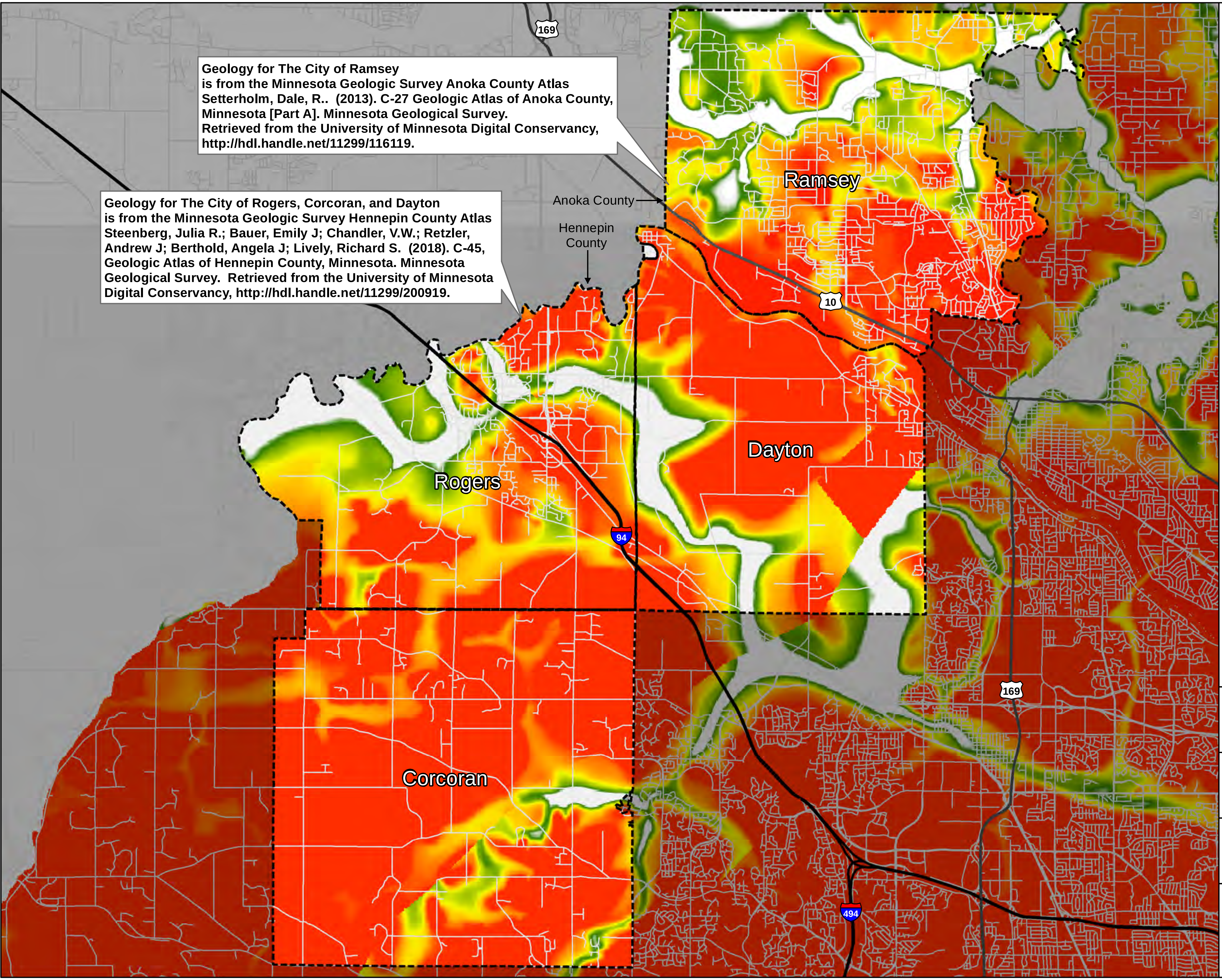

Geology for The City of Ramsey
is from the Minnesota Geologic Survey Anoka County Atlas
Setterholm, Dale, R.. (2013). C-27 Geologic Atlas of Anoka County,
Minnesota [Part A]. Minnesota Geological Survey.
Retrieved from the University of Minnesota Digital Conservancy,
http://hdl.handle.net/11299/116119.

Geology for The City of Rogers, Corcoran, and Dayton
is from the Minnesota Geologic Survey Hennepin County Atlas
Steenberg, Julia R.; Bauer, Emily J; Chandler, V.W.; Retzler,
Andrew J; Berthold, Angela J; Lively, Richard S. (2018). C-45,
Geologic Atlas of Hennepin County, Minnesota. Minnesota
Geological Survey. Retrieved from the University of Minnesota
Digital Conservancy, http://hdl.handle.net/11299/200919.

Thickness of Tunnel City

Water Distribution Systems
Ramsey, Dayton, Rogers, and Corcoran

SEH

Project: MCES 150732
Print Date: 12/30/2019

Map by: Msherrill
Projection: UTM Zone 15N
Source: ESRI, SEH Digi MnDOT,
Minnesota Geologic Survey (MGS)

Figure
2

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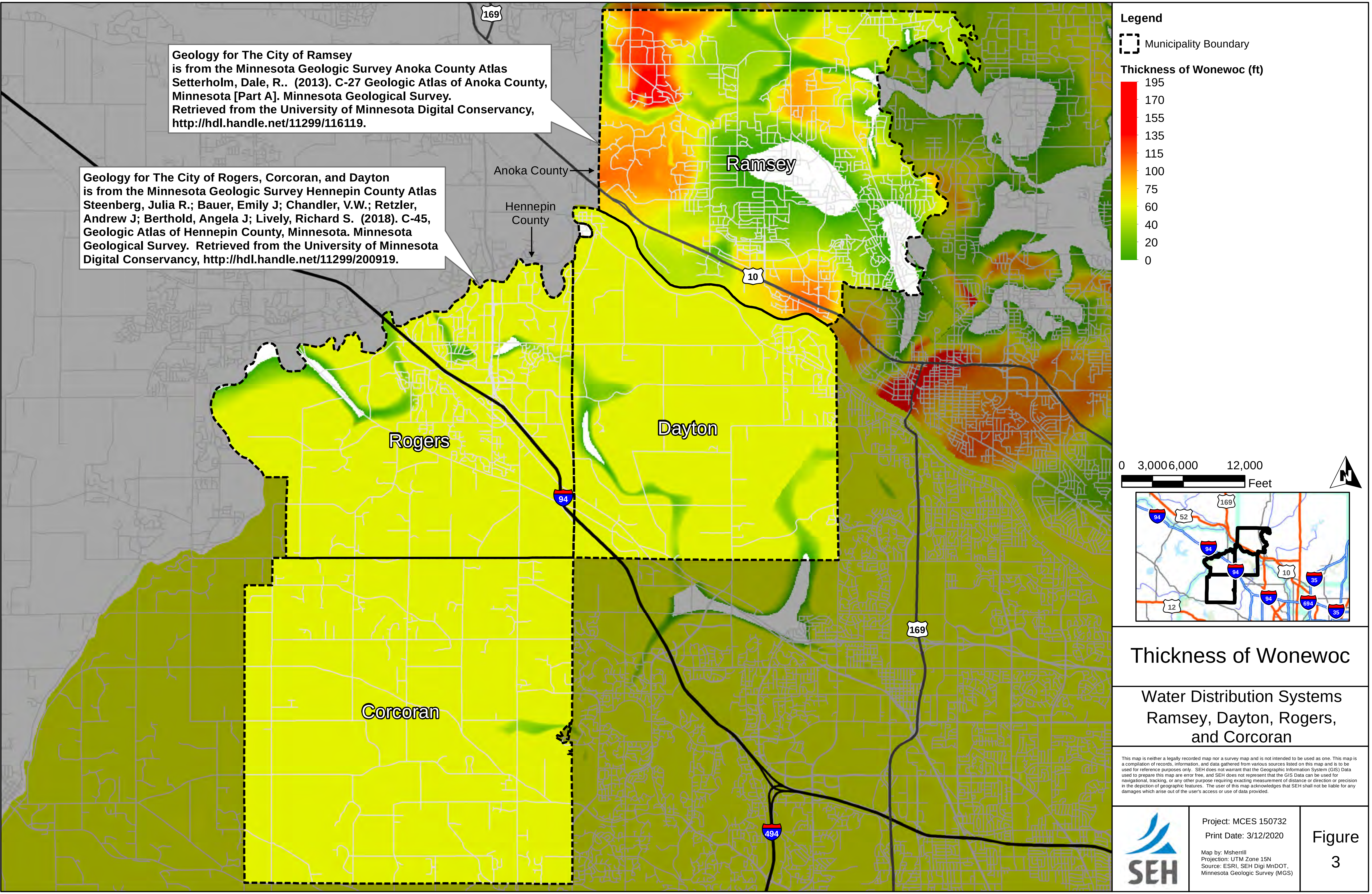

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Geology for The City of Rogers, Corcoran, and Dayton is from the Minnesota Geologic Survey Hennepin County Atlas Steenberg, Julia R.; Bauer, Emily J; Chandler, V.W.; Retzler, Andrew J; Berthold, Angela J; Lively, Richard S. (2018). C-45, Geologic Atlas of Hennepin County, Minnesota. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/200919.

Thickness of Wonewoc

Water Distribution Systems
Ramsey, Dayton, Rogers, and Corcoran

SEH

Project: MCES 150732
Print Date: 3/12/2020

Map by: Msherrill
Projection: UTM Zone 15N
Source: ESRI, SEH Digi MnDOT, Minnesota Geologic Survey (MGS)

Figure
3

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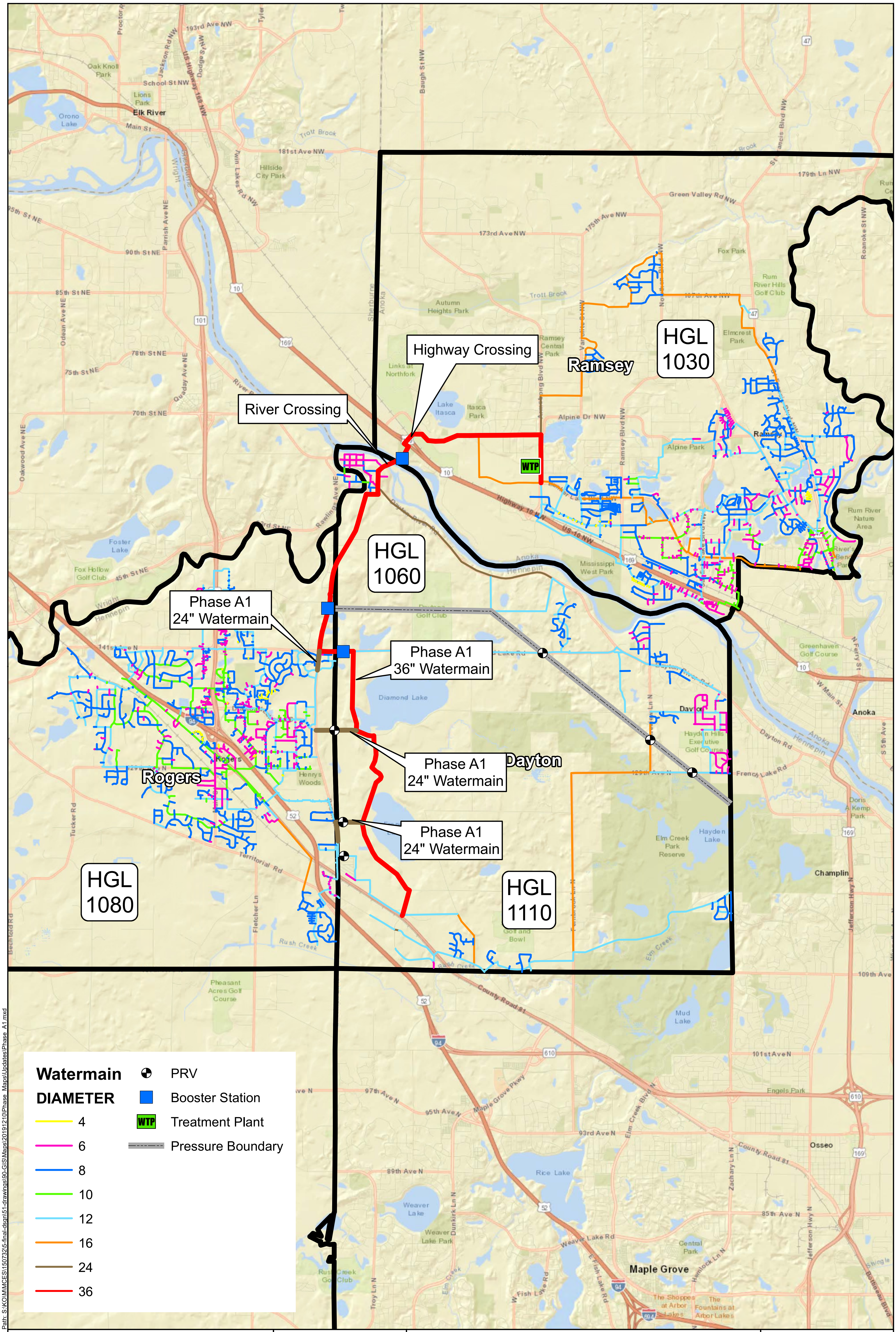
Appendix C: Phased Regional Trunk Watermain Maps



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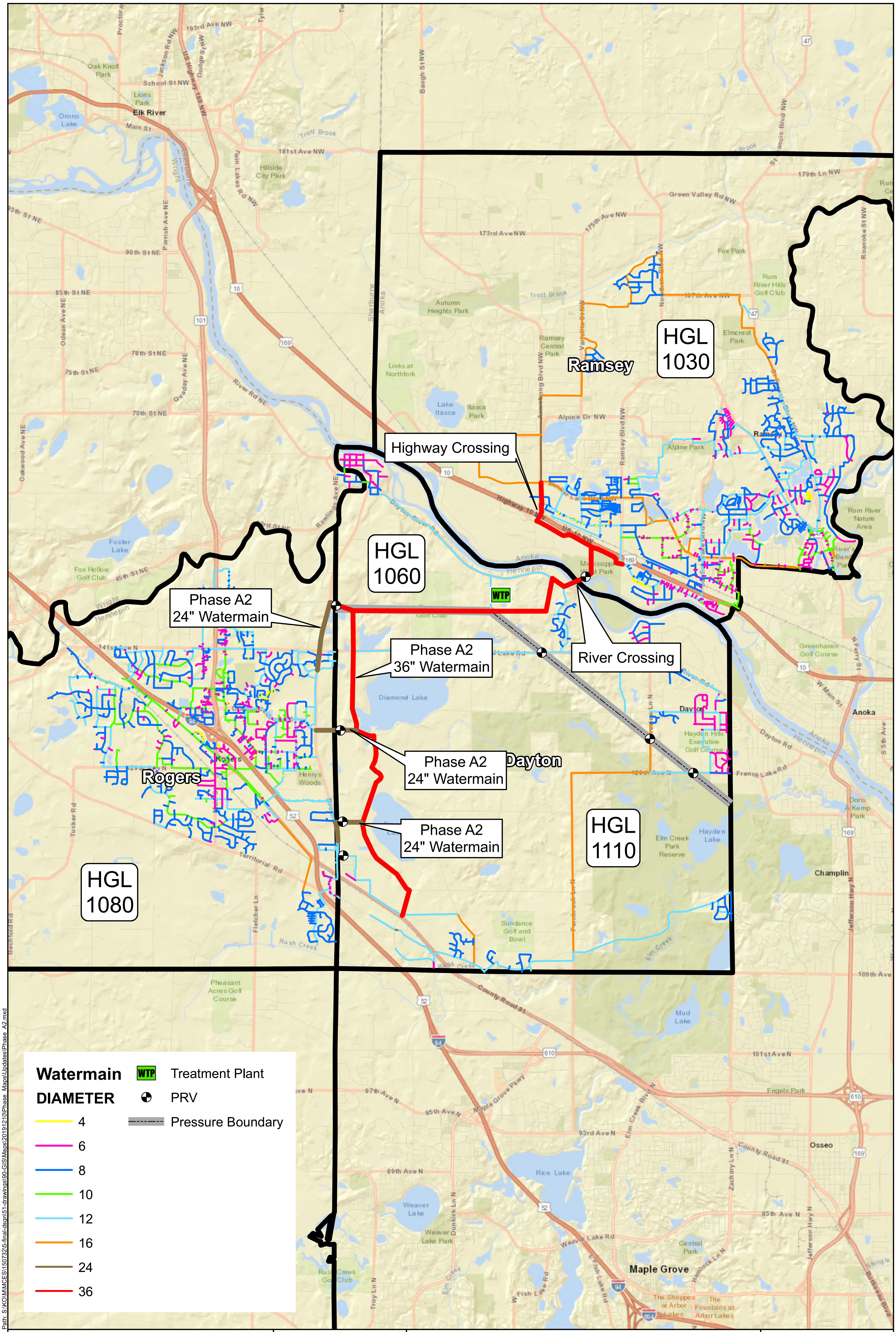
PHASE A1

Northwest Metro Area Regional
Water Supply Study

Figure
1



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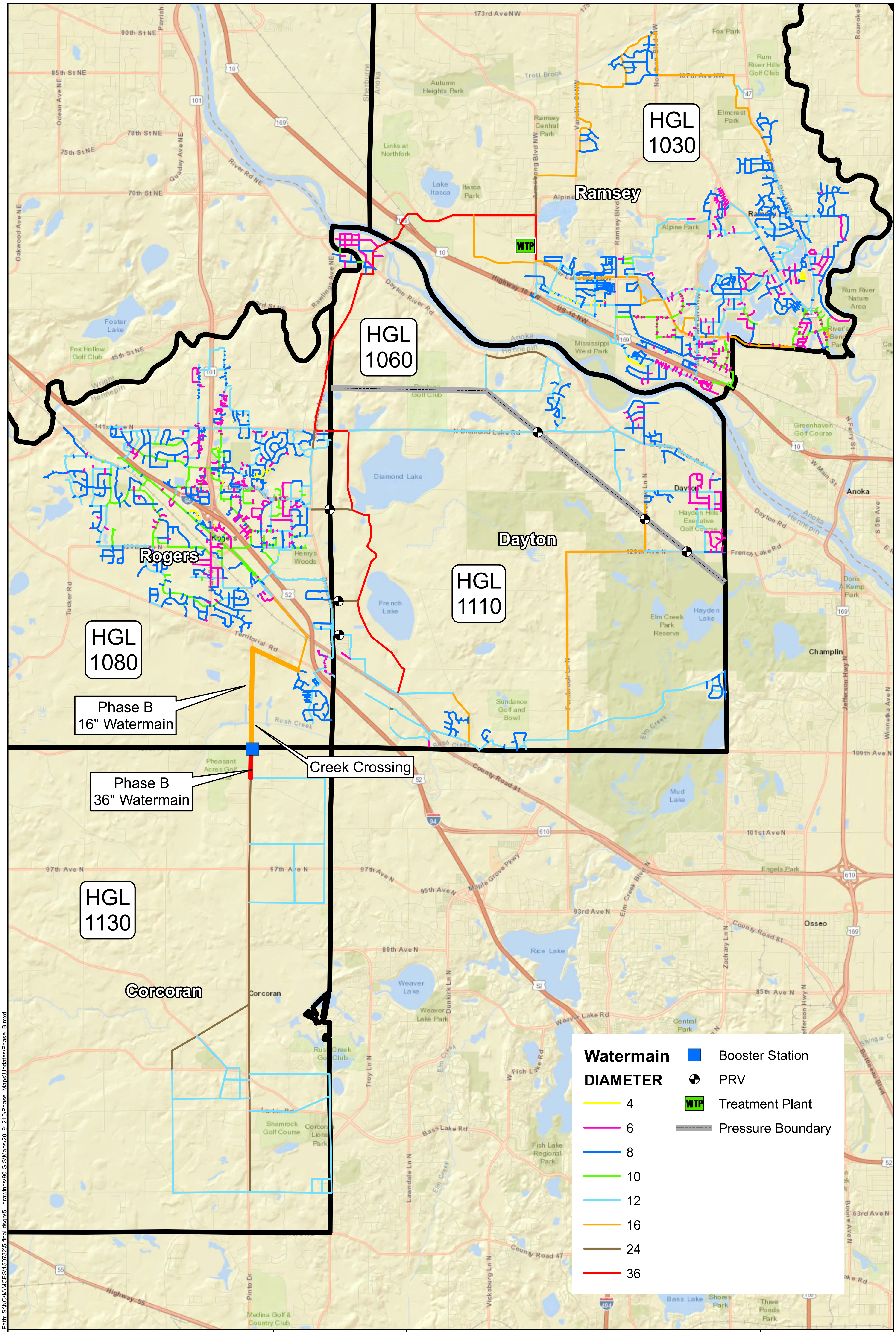
PHASE A2

Northwest Metro Area Regional Water Supply Study

Figure 2



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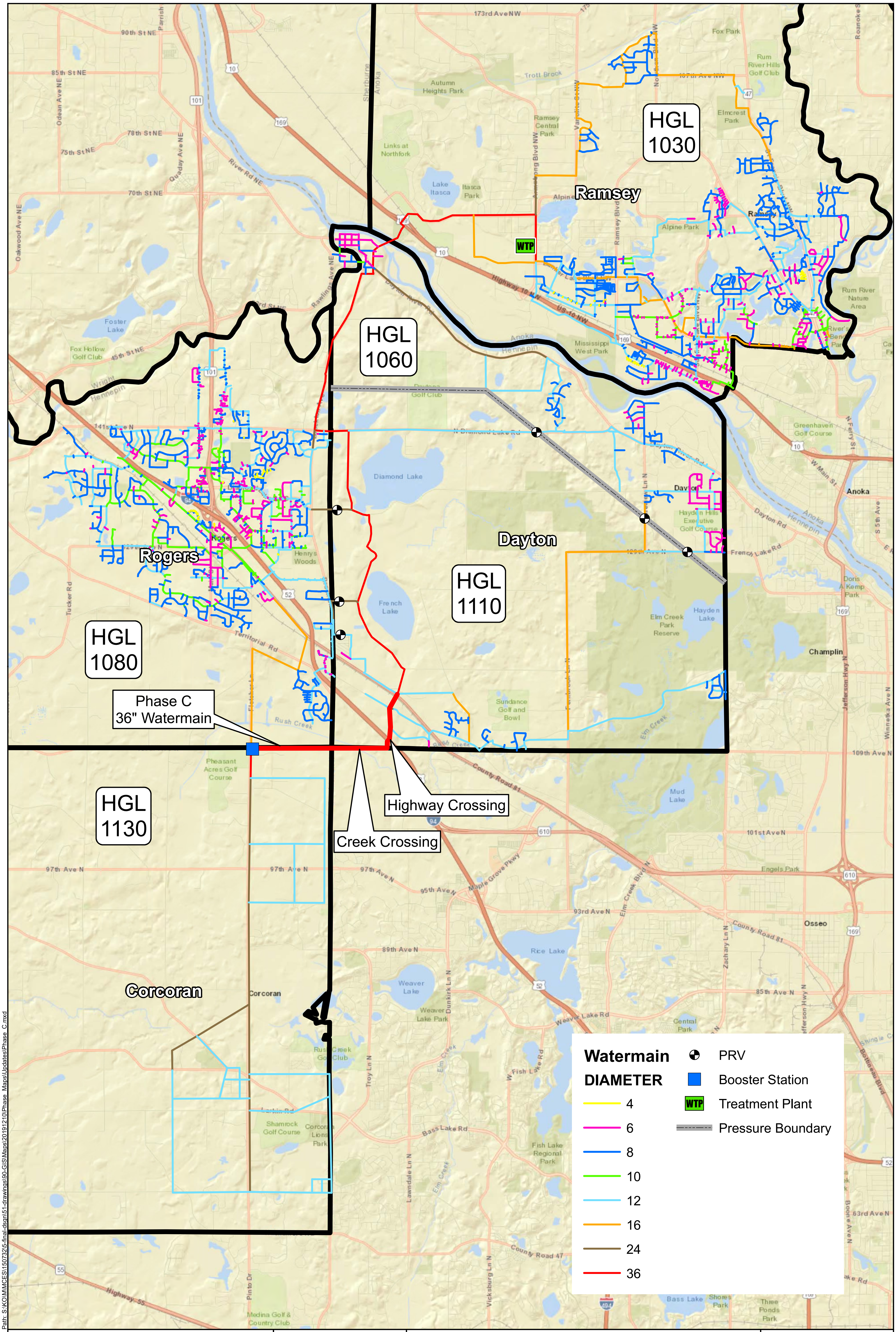
PHASE B

Northwest Metro Area Regional
Water Supply Study

Figure
3



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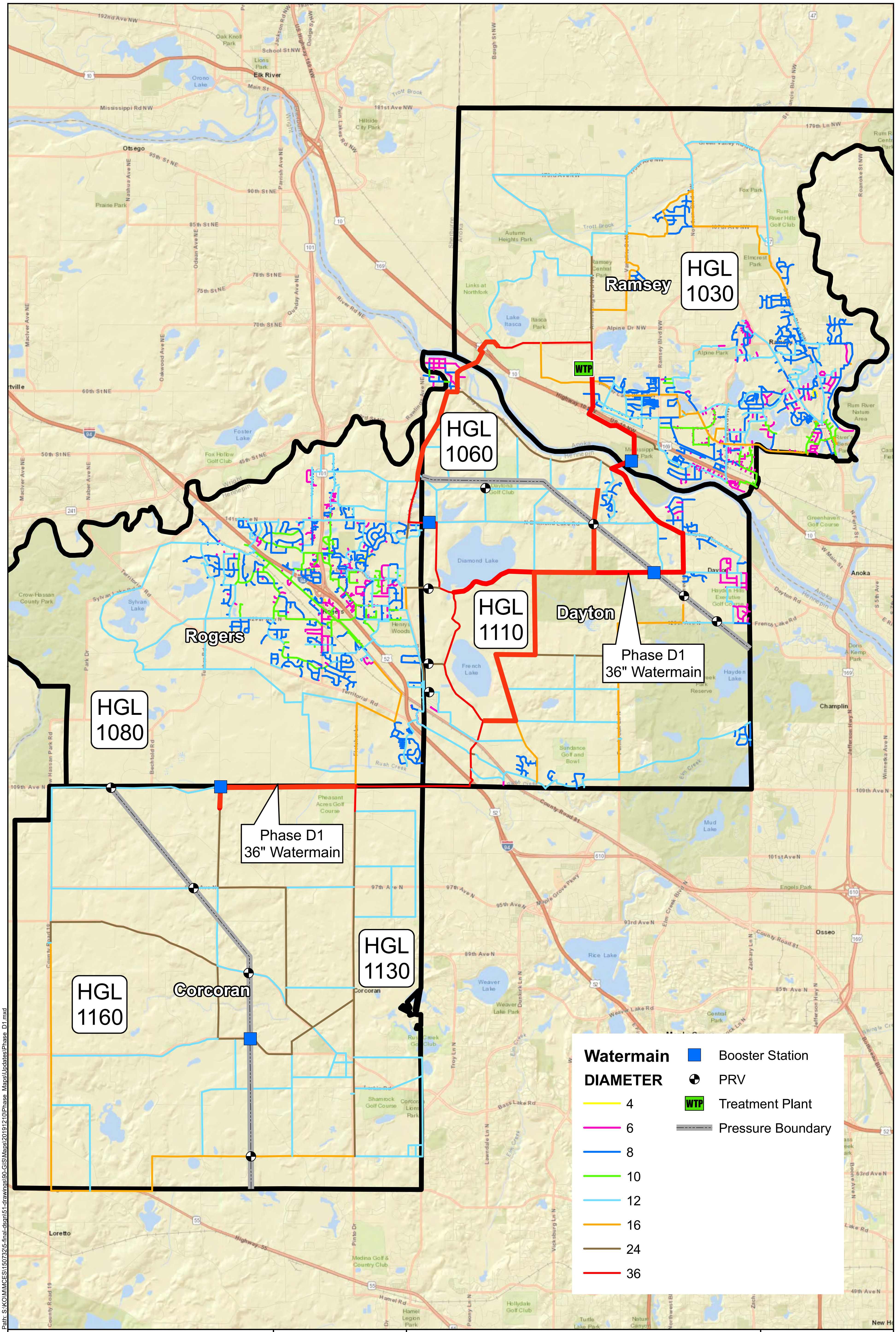
PHASE C

Northwest Metro Area Regional Water Supply Study

Figure
4



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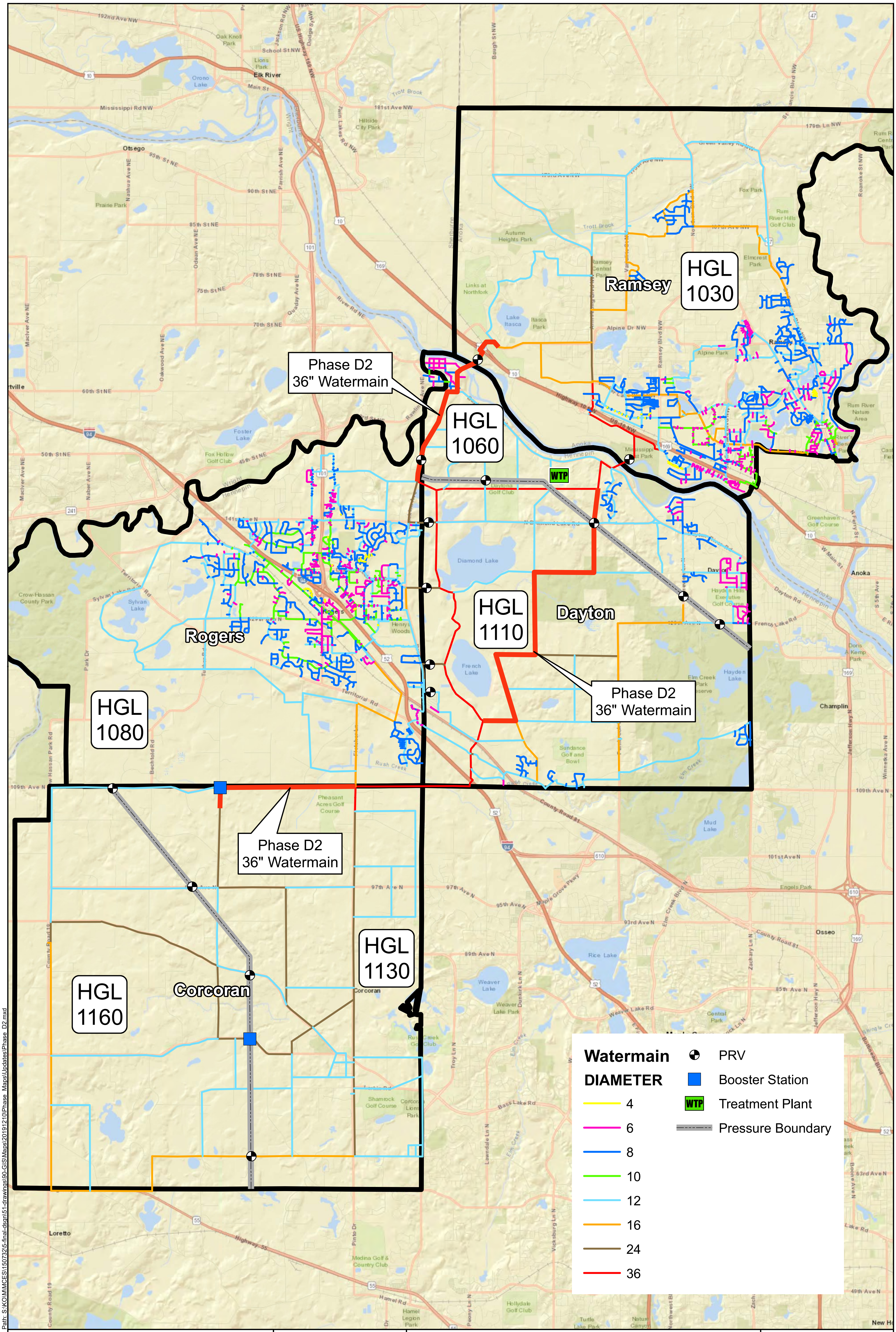
Print Date: 3/12/2020

PHASE D1

Northwest Metro Area Regional
Water Supply Study

Figure
5



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SEH

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PHASE D2

Northwest Metro Area Regional Water Supply Study

Figure 6

Appendix D: Surface Water Treatment

SEH

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MEMORANDUM

TO: Chris Larson, PE

FROM: Simon McCormack

DATE: March 12, 2020

RE: Surface Water Treatment
SEH No. 150732 14.00

The Surface Water Treatment Rule was established in 1989 to protect public health from the pathogens Giardia lamblia and viruses. Following the original rule, additional rules have been established to further protect public health by addressing the pathogen Cryptosporidium, addressing risk trade-offs with disinfection and disinfection byproducts, and enhancing water system processes.

The rules apply to all water systems using surface water and together they act to limit the levels of pathogens (viruses, Giardia lamblia, and Cryptosporidium) and turbidity in the water, as well as ensure adequate disinfection of the water throughout the treatment process. Adequate disinfection throughout the treatment process is determined by conducting disinfection profiling where a system's microbial inactivation is calculated over 12 consecutive months.

The three pathogens targeted by the surface water treatment rules are regulated by required removal efficiencies called log removal. Surface water treatment processes must remove 99.99% (4-log) of viruses, 99.9% (3-log) of Giardia lamblia, and 99% (2-log) of Cryptosporidium. Further Cryptosporidium removal may be required if high concentrations are found through source water monitoring. Source water monitoring, which can be waived if the treatment processes achieve 5.5-log removal, requires 24 months of Cryptosporidium monitoring where the average Cryptosporidium concentration determines the bin classification and the additional removal requirements (see Table 4-1). Additional Cryptosporidium removal can be achieved through additional disinfection (e.g. UV), improved treatment processes, and other measures.

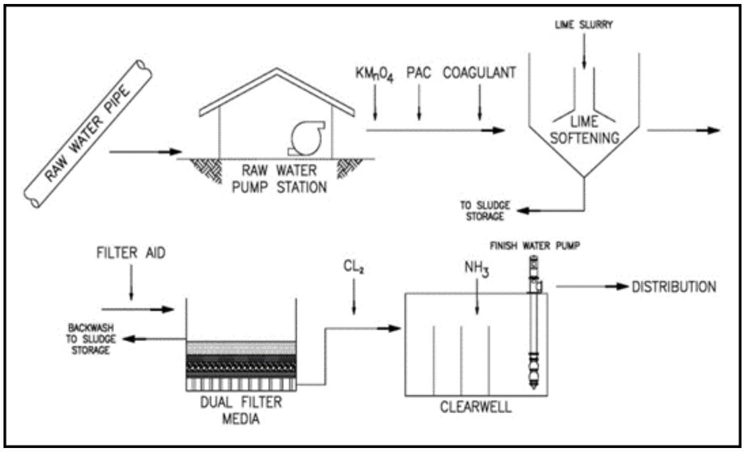
Along with those three pathogens, turbidity, a measure of the cloudiness of the water, is regulated as it serves as an indicator of the overall water quality and filter effectiveness, and because high turbidity levels are often associated with high pathogen levels. Turbidity must be reported each month from each individual filter's effluent (IFE), as well as the combined filter effluent (CFE). The CFE turbidity must be monitored and recorded every four hours and at least 95% of the turbidity measurements must be less than or equal to 0.3 NTU. MDH must be contacted if any measurement exceeds 1 NTU. The IFE turbidity must be monitored and recorded every 15 minutes and measurements exceeding 0.5 NTU must be investigated.

Table 1. Surface Water Treatment Rule Bin Classification

Bin Classification	Crypto Concentration (oocysts/L)	Additional Treatment Requirements for Systems with Conventional Treatment
1	< 0.075	No Additional Treatment
2	From 0.075 - < 1.0	1 log of Additional Treatment (90%)
3	From 1.0 - < 3.0	2 log of Additional Treatment (99%)
4	≥ 3.0	2.5 log of Additional Treatment (99.7%)

Treatment Processes

The preliminary treatment process proposed for a Northwest Metro surface WTP assumes that the surface water supply will be classified as Bin 1. If additional treatment is required, a future UV or chlorine dioxide addition process can be implemented to assist in meeting additional treatment requirements.



Process Train

As depicted in the process diagram, a potential process train to treat raw surface water from the Mississippi River includes raw water pumping, chemical addition, lime softening, filtration, chlorine contact, and finished water pumping. This process is very similar to other major surface water treatment plants in Minnesota including SPRWS, the City of Minneapolis, and the City of St. Cloud. The chemical addition includes potassium permanganate (KMnO4) for oxidation, powdered activated carbon (PAC) for taste and odor, and coagulant to help with floc production. SPRWS uses granular activated carbon (GAC) in their filters rather than PAC.

Coagulation/Flocculation and Lime Softening

In coagulation, a chemical such as alum is added to the water to encourage larger particles to form in the flocculation process. The flocculation and settling occur in the clarifier.

Hardness in water is primarily caused by calcium and magnesium ions (Ca^{2+} and Mg^{2+}). Hardness causes scaling on water fixtures, dishes, and appliances. Lime (Ca(OH)$_2$) is added to the raw water to raise the pH. When the pH is raised sufficiently, calcium and magnesium precipitates (solids) form and they are settled out of the water in clarifiers.

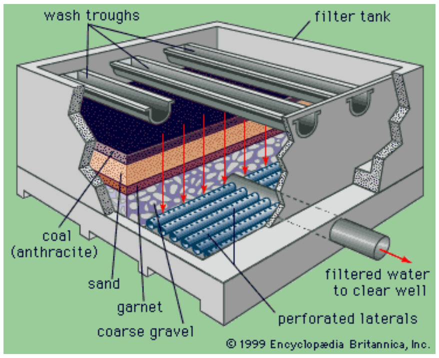
Lime from a silo or other storage method is fed into slakers which add water to the lime and the slurry is then fed into the raw water. The raw water and lime enter one of the clarifiers at the WTP where the softening process occurs and the sludge is removed from the water.

Recarbonation

The water from the clarifiers enters a recarbonation basin where carbon dioxide is bubbled into the water to lower the pH. This process stabilizes the water and prevents additional precipitation. The pH of the water in this process is lowered from approximately 11 to 9.

Conventional Filtration (Conv)

Conventional filtration is considered for its benefits in reduction of suspended particulates. Typical conventional filters used in water treatment are rapid, deep bed, dual media, gravity filters that utilize layers of both sand and anthracite for media. Typical depths are 12" sand and 12"-24" anthracite. The particulates removed in conventional filtration include microbial contaminants, turbidity, trihalomethane (THM) precursors, as well as those precipitates formed in pretreatment processes.



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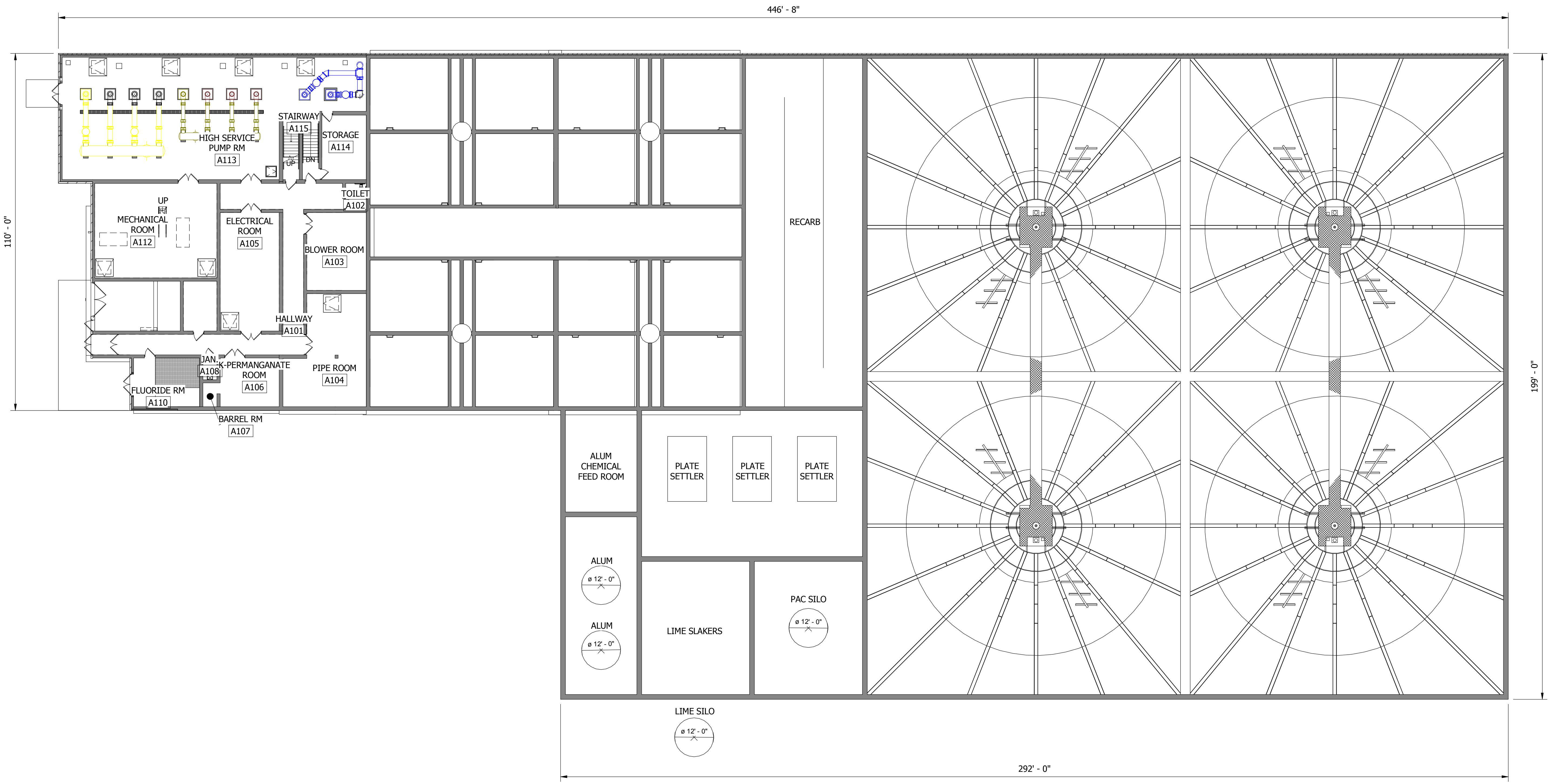
Chlorine Contact

After filtration, chlorine is added and the water enters a chlorine contact basin. The chlorine contact basin is provided to allow time for the chlorine to inactivate Giardia and viruses. The amount of time and chlorine concentrations are dictated by the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR).

In addition to chlorine, fluoride is added to the water for dental health, and corrosion inhibitor is added to the water for corrosion control. After the chlorine contact basin, the treated water is pumped into the drinking water distribution system.

Appendix E: Water Treatment Plant Layouts



A MAIN LEVEL PLAN

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NW METRO REGIONAL WATER SUPPLY STUDY

MARK	DATE	DESCRIPTION
	10/19/2015	RECORD PLAN

REVISIONS

FILE NO.	**MCES150732**
CITY PROJECT NO.	**2012-108**
ISSUE DATE	**10-08-2019**
DESIGNED BY	**XXX**
DRAWN BY	**XXX**

SHEET TITLE
25 MGD SURFACE WATER TREATMENT PLANT

SHEET
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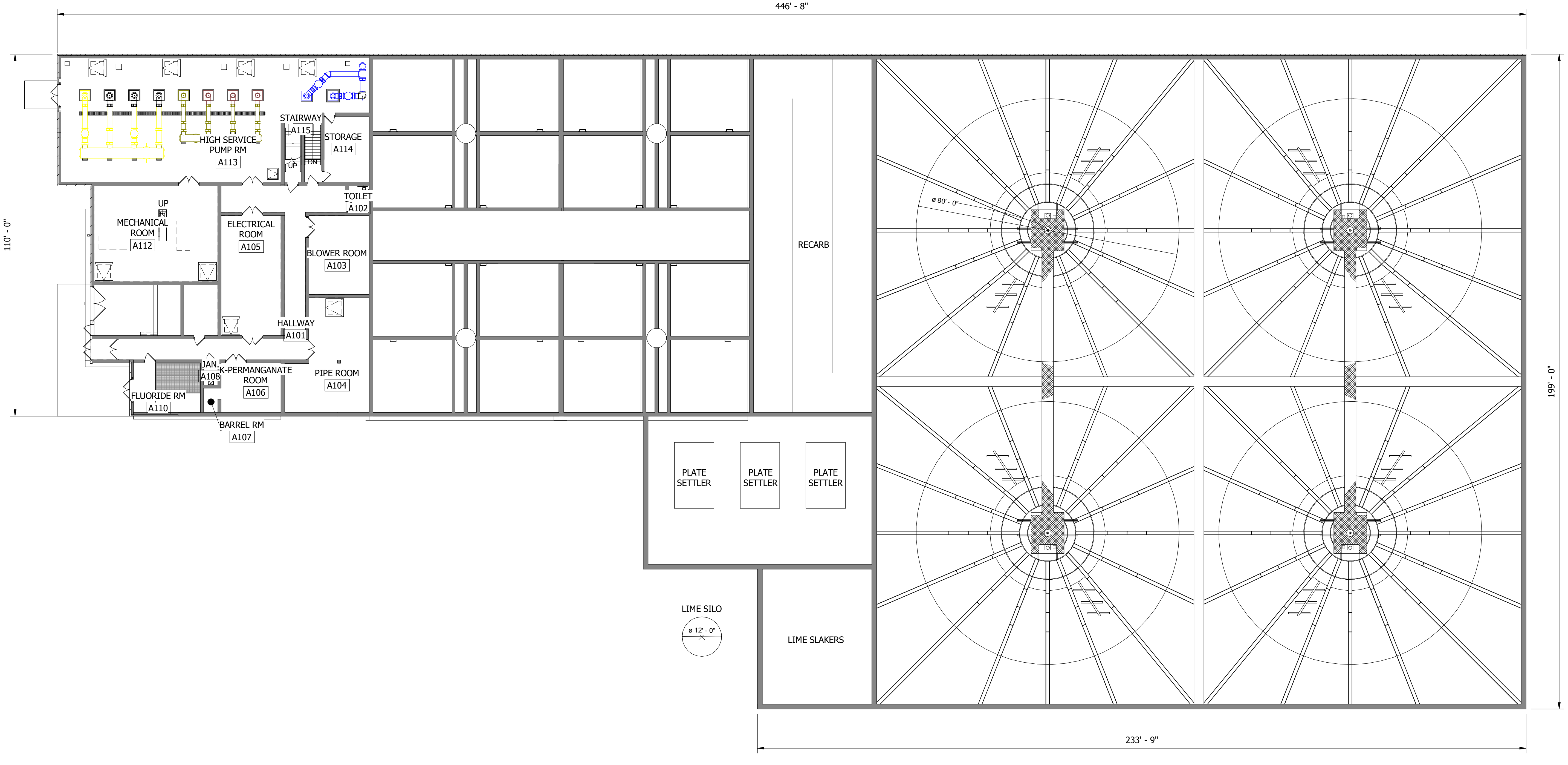

A MAIN LEVEL PLAN

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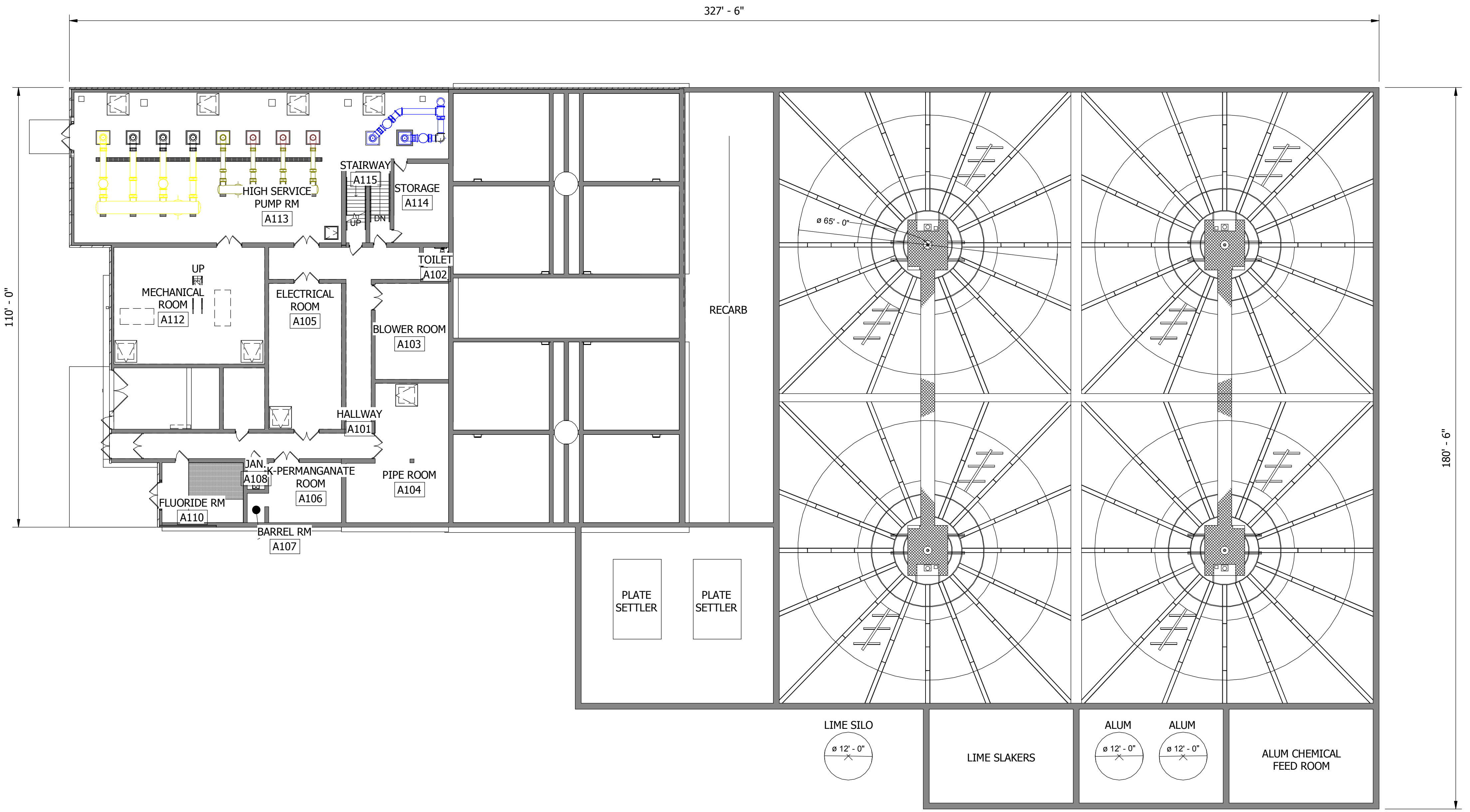

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12 MGD CONJUNCTIVE USE WTP

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