FEASIBILITY ASSESSMENT OF APPROACHES TO WATER SUSTAINABILITY IN THE NORTHEAST METRO

JUNE 2014

FINAL DRAFT

METROPOLITAN COUNCIL

The Council's mission is to foster efficient and economic growth for a prosperous metropolitan region.

Metropolitan Council Members

Susan Haigh	Chair	Edward Reynoso	District 9
Katie Rodriguez	District 1	Marie McCarthy	District 10
Lona Schreiber	District 2	Sandy Rummel	District 11
Jennifer Munt	District 3	Harry Melander	District 12
Gary Van Eyll	District 4	Richard Kramer	District 13
Steve Elkins	District 5	Jon Commers	District 14
James Brimeyer	District 6	Steven T. Chávez	District 15
Gary L. Cunningham	District 7	Wendy Wulff	District 16
Adam Duininck	District 8		

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.

This publication printed on recycled paper.

About this Report

The Metropolitan Council recognizes that water supply planning is an integral component of long-term regional and local comprehensive planning. The Council has implemented a number of projects to provide a base of technical information needed to make sound water supply decision.

This report summarizes the result of work to ___________, which meets the requirements of Minnesota Statutes, section ____, subdivision ___, which calls for the Council to "____________".

The report is organized into __ major sections. The introduction provides an overview of the Council and the need for the project. The next ___ sections discuss methods and results. The last section is the appendix, which includes maps and supporting data.

Special funding for this project was provided through the Clean Water Fund.

Acknowledgements

The Council would like to acknowledge the following people who assisted with this study and its resulting recommendations:

First Last, Committee Name

First Last, Agency Name

First Last, City Name

First Last, County Name

First Last, Consulting Company Name

Recommended Citation

Metropolitan Council. [date]. [*Report Title italicized*]. Prepared by [consultant name]. Metropolitan Council: Saint Paul.

Table of Contents

Metropolitan Council Members ... *2*

CHAPTER 1 - INTRODUCTION ... **7**

1.1 Objectives ... **7**
1.2 Background ... **7**
1.2a Metropolitan Council Planning Activities ... *7*
1.2b North & East Groundwater Management Area ... *7*
1.3 Feasibility Assessment Process ... **8**
1.4 Feasibility Assessment Alternatives Overview ... **8**
1.4a Approach 1 and 2 – Groundwater to Surface Water Drinking Water Supplies ... *8*
1.4b Approach 3 - Lake Augmentation ... *14*
1.5 Report Contents ... **14**

CHAPTER 2 - STUDY AREA COMMUNITY CHARACTERISTICS ... **15**

2.1 General ... **15**
2.2 Water Demand ... **15**
2.3 Existing Water Infrastructure ... **17**
2.4. Water Rates ... **18**

CHAPTER 3 - APPROACH 1 - CONNECTION TO SAINT PAUL REGIONAL WATER SERVICES TO SUPPLY DRINKING WATER (SPRWS EXPANSION) ... **19**

3.1 SPRWS Existing System ... **19**
3.2 Conjunctive Use Water Quality ... **20**
3.3 Development of Concept System to Serve Northeast Metro ... **20**
3.4 Altervative 1A - SPRWS Service Expanded to North Saint Paul ... **21**
3.5 Alternative 1B - SPRWS Service Expanded to Select Northeast Metro Communities ... **21**
3.5a Alternative 1B - Trunk Water Main and Booster Stations ... *23*
3.5b Alternative 1B – Estimated Costs ... *23*
3.6 Alternative 1C - SPRWS Service Expanded to All Northeast Metro Communities ... **25**
3.6a Alternative 1C Trunk Water Main ... *25*
3.6b Alternative 1C – Booster Stations ... *25*
3.6c Alternative 1C – Estimated Costs ... *25*
3.7 Cost Summary - Alternatives 1A, 1B and 1C ... **28**
3.8 Operation and Maintenance Costs ... **28**
3.9 Booster Station O&M Costs ... **29**
3.10 Annual Costs ... **29**

CHAPTER 4 - APPROACH 2 - DEVELOPMENT OF A SURFACE WATER CONNECTION TO A NEW SUBREGIONAL WATER TREATMENT PLANT (NEW SURFACE WATER TREATMENT PLANT) ... **30**

4.1 New Water Treatment Plant Location ... **30**
4.1a TCAAP Site ... *30*
4.1b Vadnais Lake Site ... *30*
4.2 New Water Treatment Plant ... **30**
4.3 Conjunctive Use Water Quality ... **30**
4.4 Development of Concept System to Serve Northeast Metro ... **30**
4.5 Alternative 2B - New Surface WTP for Select Northeast Metro Communities ... **31**
4.5a Alternative 2B - Trunk Water Main and Booster Stations ... *31*
4.5b Alternative 2B – Estimated Costs ... *31*
4.6 Alternative 2C - New Surface WTP for All Northeast Metro Communities ... **34**
4.6a Alternative 2C Trunk Water Main ... *34*
4.6b Alternative 2C – Booster Stations ... *34*
4.6c Alternative 2C – Estimated Costs ... *34*
4.7 Cost Summary – Alternatives 2B and 2C ... **37**
4.8 Operations and Maintenance Cost ... **37**
4.9 Booster Station O&M Costs ... **37**
4.10 Annual Costs ... **37**

CHAPTER 5 - APPROACH 3 - LAKE AUGMENTATION ALTERNATIVE ... **39**

5.1 Development of Concept System ... **39**

5.2 Study Area Characteristics 40
5.3 Environmental Considerations 40
5.4 Water Quality Considerations 40
5.5 Permitting Requirements 41
5.6 Augmentation Pumping Rate 41
5.7 White Bear Lake Water Budget 41
5.8 Concept 1 – Mississippi River Water via Vadnais Lake 42
5.9 Route 1A – Vadnais Lake to White Bear Lake via BNSF Railroad Right-of-Way and County Road F (Cty 95) 43
5.10 Route 1B – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and County Road F (Cty 95) 45
5.11 Route 1C – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and Goose Lake ... 45
5.12 Operations and Maintenance 46
5.13 Estimated Costs 46
5.14 St. Croix River 46
5.15 Summary 49

CHAPTER 6 – SUMMARY OF FINDINGS AND IMPLEMENTATION CONSIDERATIONS 50

6.1 Connecting Northeast Metro to SPRWS (Approach 1) 50
6.2 New Surface Water Treatment Plant (Approach 2) 51
6.3 Direct Augmentation of White Bear Lake (Approach 3) 51
6.4 No Change Approach 52
6.5 Conjunctive Use of Groundwater and Surface Water 53
6.6 Cost Sharing, Financing, and Ownership Models 53

CHAPTER 7 - EVALUATION OF ALTERNATIVES 56

Appendix A: Study Area Existing Water Infrastructure
Appendix B: Conjunctive Use Water Quality Memo
Appendix C: Cost Estimating Methodology
Appendix D: Pipe Segment Descriptions
Appendix E: Surface Water Treatment Rule & Process Train Description
Appendix F: Study Area Characteristics
Appendix G: Environmental Considerations
Appendix H: Water Quality
Appendix I: Water Budget
Appendix J: System Components
Appendix K: Route Characteristics

List of Figures

Figure 1-1. Alternative 1A - SRRWS Expansion to North St. Paul Concept System. 9
Figure 1-2. Alternative 1B - SRRWS Expansion to Select Northeast Metro Communities Concept System. 10
Figure 1-3. Alternative 1C - SRRWS Expansion to All Northeast Metro Communities Concept System. 11
Figure 1-4. Alternative 2B - New Surface WTP for Select Northeast Metro Communities Concept System. 12
Figure 1-5. Alternative 2C - New Surface WTP for All Northeast Metro Communities Concept System. 13
Figure 1-6. Approach 3 - Lake Augmentation Concept System Options. 14
Figure 2-1. Study Area Communities. 15
Figure 3-1. Schematic of SRRWS Raw Water and Treatment Infrastructure. 19
Figure 3-2. Alternative 1A - SPRWS Service Expanded to North St. Paul Concept System Plan. 22
Figure 3-3. Alternative 1B - SPRWS Service Expanded to Select NE Metro Communities Concept System Plan. 24
Figure 3-4. Alternative 1C - SPRWS Service Expanded to All NE Metro Communities Concept System Plan. 26
Figure 4-1. Alternative 2B - New Surface WTP For Select NE Metro Communities Concept System Layout.. 33
Figure 4-2. Alternate 2C - New Surface WTP for All NE Metro Communities Concept System Layout. 36
Figure 5-2. Augmentation Alternative Routes from Vadnais Lake to White Bear Lake. 44

Figure 5-3. Augmentation Alternative Raw Water Source: St. Croix River. 48
Figure A-1. Centerville's Existing Water Infrastructure. 59
Figure A-2. Circle Pines' Existing Water Infrastructure. 61
Figure A-3. Columbus' Existing Water Infrastructure. 63
Figure A-4. Forest Lake's Existing Water Infrastructure. 66
Figure A-5. Hugo's Existing Water Infrastructure 68
Figure A-6. Lexington's Existing Water Infrastructure 70
Figure A-7. Lino Lakes' Existing Water Infrastructure 72
Figure A-8. Mahtomedi's Existing Water Infrastructure. 74
Figure A-9. North St. Paul's Existing Water Infrastructure. 76
Figure A-10. Shoreview's Existing Water Infrastructure. 79
Figure A-11. Vadnais Heights' Existing Water Infrastructure. 81
Figure A-12. White Bear Lake's Existing Water Infrastructure. 83
Figure A-13. White Bear Township's Existing Water Infrastructure. 86

List of Tables

table 1-1. Approach 1: SPRWS Expansion Alternatives Description Summary. 9
Table 1-2. Approach 2: New Surface WTP Alternatives Description Summary. 12
Table 2-1. Historic and Projected Population and Drinking Water Demand for Northeast Metro Communities. 16
Table 2-2. Historic and Projected Total Population and Water Demand for the Northeast Metro. 16
Table 2-3. 2040 Average and Maximum Day Demands by Community. 17
Table 2-4. Number of Northeast Metro Municipal Wells in Area Aquifers. 18
Table 2-5. Calculated Annual Residential Household Water Bills for Northeast Metro Communities. 18
Table 3-1. SPRWS Retail Water Rates. 20
Table 3-2. Alternative 1A – SPRWS Service Expanded to North Saint Paul Capital Costs. 21
Table 3-3. Alternative 1B – SPRWS Service Expanded to Select NE Metro Communities Capital Costs. 23
Table 3-4. Alternative 1C – Phase 1 – SPRWS Connection to North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, And Shoreview Capital Costs. 27
Table 3-5. Alternative 1C – Phase 2 – SPRWS Connection to Hugo, Lino Lakes & Centerville Capital Costs 27
Table 3-6. Alternative 1C – Phase 3 – SPRWS Connection to Forest Lake, Columbus, Circle Pines and Lexington Capital Costs. 28
Table 3-7 Capital Costs to Connect Northeast Metro Communities to SPRWS 28
Table 3-8. Annual Costs for Approach 1 - Connection to SPRWS to Supply Drinking Water (SPRWS Expansion). 29
Table 4-1. Alternative 2B – New Surface WTP for Select Northeast Metro Communities Capital Costs. 32
Table 4-2. Alternate 2C – Phase 1 – New Surface WTP for Vadnais Heights, White Bear Lake, White Bear Township and Shoreview (North St. Paul to SPRWS) Capital Costs. 34
Table 4-3. Alternate 2C – Phase 2 – New Surface WTP for Hugo, Lino Lakes & Centerville Capital Costs. 35
Table 4-4. Alternate 2C – Phase 3 – New Surface WTP for Forest Lake, Columbus, Circle Pines and Lexington Capital Costs. 35
Table 4-5. Costs to Connect Northeast Metro to New Surface WTP. 37

Table 4-6. Annual Operation and Maintenance Costs. 37
Table 4-7. Annual Costs for Alternatives to Connect Northeast Metro to a New Surface WTP.......... 38
Table 5-1. White Bear Lake Augmentation Water Budget. 42
Table 5-2. Railroad and County Road F Cost Breakdown. 43
Table 5-3. Goose Lake Road and County Road F Cost Breakdown. 45
Table 5-4. Goose Lake Road and Goose Lake Cost Breakdown. 45
Table 5-5. Estimated Augmentation Operation Costs. 46
Table 5-6. White Bear Lake Augmentation Cost Estimate Summary – Mississippi River. 46
Table 5-7. White Bear Lake Augmentation Cost Estimate Summary - St. Croix River. 47
Table 6-1. Costs to Connect Northeast Metro Communities to SPRWS. 50
Table 6-2. Costs to Connect Northeast Metro to New Surface WTP 51
Table 6-3. Costs for Augmenting White Bear Lake 52
Table A-1. Summary of Water Demand Data for Centerville. 58
Table A-2. High-Capacity Well Summary Data for Centerville. 58
Table A-3. Summary of Water Demand Data for Circle Pines. 60
Table A-4. High-Capacity Well Summary Data for Circle Pines. 60
Table A-5. Summary of Water Demand Data for Columbus. 62
Table A-6. High-Capacity Well Summary Data for Columbus. 62
Table A-7. Summary of Water Demand Data for Forest Lake. 64
Table A-8. High-Capacity Well Summary Data for Forest Lake. 64
Table A-9. Summary of Water Demand Data for Hugo. 67
Table A-10. High-Capacity Well Summary Data for Hugo. 67
Table A-11. Summary of Water Demand Data for Lexington. 69
Table A-13. Summary of Water Demand Data for Lino Lakes. 71
Table A-14. High-Capacity Well Summary Data for Lino Lakes. 71
Table A-15. Summary of Water Demand Data for Mahtomedi. 73
Table A-16. High-Capacity Well Summary Data for Mahtomedi. 73
Table A-17. Summary of Water Demand Data for North St. Paul. 75
Table A-18. High-Capacity Well Summary Data for North St. Paul. 75
Table A-19. Summary of Water Demand Data for Shoreview. 77
Table A-20. High-Capacity Well Summary Data for Shoreview. 77
Table A-21. Summary of Water Demand Data for Vadnais Heights. 80
Table A-22. High-Capacity Well Summary Data for Vadnais Heights. 80
Table A-23. Summary of Water Demand Data for White Bear Lake. 82
Table A-24. High-Capacity Well Summary Data for White Bear Lake. 82
Table A-25. Summary of Water Demand Data for White Bear Township. 84
Table A-26. High-Capacity Well Summary Data for White Bear Township. 84
Table A-27. Summary of Fee Schedules for All Cities in the Northeast Metro. 87

Chapter 1 - Introduction

The State Fiscal Year 2014-2015 Clean Water Fund appropriation identified the Twin Cities northeast metropolitan area (northeast metro) as an area where potential solutions are needed to address emerging water supply issues. A groundwater workgroup, consisting of interested area community stakeholders, was formed to address the long-term sustainability of area water supplies. Metropolitan Council, working with communities in the northeast metro area, is leading a study to examine the feasibility of approaches to address water sustainability in the region.

1.1 Objectives

The feasibility assessment is directed at evaluation of three base approaches to address water sustainability in the region:

- Connection to Saint Paul Regional Water Services to supply drinking water (SPRWS Expansion)
- Development of a surface water connection to a new subregional water treatment plant (New Surface Water Treatment Plant)
- Direct augmentation of White Bear Lake with river water (Lake Augmentation)

These approaches were selected based on their potential to achieve water supply reliability and sustainability goals for the Twin Cities metropolitan area. In particular, the approaches either produce a sustainable balance of surface water and groundwater or offset potential environmental impacts of current groundwater use. The base approaches are not intended to be mutually exclusive and the best possible outcome may be a combination of the approaches.

1.2 Background

1.2a Metropolitan Council Planning Activities

This study is one of several being led by Metropolitan Council to support an update to the Twin Cities Metropolitan Area Master Water Supply Plan (Master Plan) and other activities identified by the 2005 Minnesota Legislature (Minn. Stat., Sec. 473.1565) to address the water supply needs of the metropolitan area. This study is funded from the Clean Water Legacy Fund (Minn. Laws 2013 Ch. 137, Art. 2, Sec. 9).

Concurrent studies in the northeast metro area include:

- Characterizing Groundwater and Surface Water Interaction in Northeast Metro Area Lakes, MN – in conjunction with the United States Geological Survey (USGS); scheduled for completion in 2016.
- Feasibility Study of Joint Water Utility – Cities of Centerville, Circle Pines, Columbus, Hugo, Lexington, and Lino Lakes – in conjunction with Barr Engineering Company, Inc.; scheduled for completion in Fall 2014.

In addition to these studies, a metro-wide based study, *Regional Feasibility of Alternative Approaches to Water Sustainability*, performed in conjunction with HDR Engineering, Inc., has work activities that are being coordinated with this study.

This version of the report, submitted as the *Draft Report,* June 30, 2014, provides project findings based on coordination with other studies limited to use of standard planning criteria and cost estimating metrics. The draft report findings will be coordinated to provide a cohesive approach and metrics to establish conclusions and develop recommendations for future planning and implementation activities in the *Final Report* submitted Fall 2014.

1.2b North & East Groundwater Management Area

To address the long term groundwater sustainability and resources that depend upon it, the Minnesota Department of Natural Resources (DNR) is creating a Groundwater Management Area (GWMA) in the North and East Metro. The DNR is the agency responsible for managing the state's water to ensure its use is sustainable. Issues to be addressed by the North & East GWMA include:

- Growth in groundwater use

- Declining aquifer levels in some areas
- Impact to surface water features
- Projected increase in future groundwater use
- Contaminated groundwater
- Water conservation

The boundaries of the proposed North & East GWMA include all of Washington and Ramsey counties, and eight cities in southern Anoka County. All of the northeast metro communities in this study reside in the North & East GWMA. Refer to http://www.dnr.state.mn.us/gwmp/area-ne.html for more information on the GWMA. The activities of DNR associated with the North & East GWMA will provide additional information to coordinate with future water sustainability planning for the northeast metro communities.

1.3 Feasibility Assessment Process

This assessment defines concept level water infrastructure systems to deliver the three approaches to water sustainability identified in the study objectives. The basic outcomes of the assessment include:

- Definition of system components
- Concept level system costs
- Considerations for implementation

The assessment for each approach followed a similar method: preliminary screening of options and then a secondary evaluation of options with a more detailed analysis. For Approaches 1 and 2 related to drinking water supplies, different alternatives were developed for sets of communities. For Approach 3 – Lake Augmentation, the source of river water and conveyance routes presented different system component options. Each approach is evaluated independently and considered in separate chapters as a stand-alone option to address water sustainability in the region.

1.4 Feasibility Assessment Alternatives Overview

1.4a Approach 1 and 2 – Groundwater to Surface Water Drinking Water Supplies

In Approach 1, northeast metro communities would be served through SPRWS as wholesale customers. The preliminary screening process identified the Hazel Park pressure zone, in proximity to North Saint Paul, as the easiest connection point for service to northeast metro communities from SPRWS' existing distribution system. However, the Hazel Park pressure zone has capacity to serve only North Saint Paul. Rather than make improvements to serve additional northeast metro communities from the Hazel Park pressure zone it is more cost-effective to provide service through a new connection. This constraint provided the basis for identifying a project with the least capital investment, defined as Alternative 1A – SPRWS Expansion to North Saint Paul. Figure 1-1 presents the concept system components for Alternative 1A.

The screening process identified a subset of study area communities for service based on capital investment in new infrastructure and upgrades to the existing SPRWS infrastructure. Alternative 1B – SPRWS Expansion to Select Northeast Metro Communities provides service to Vadnais Heights, White Bear Lake, White Bear Lake Township, Mahtomedi, and Shoreview through new water main connected to the core of the SPRWS system. Alternative 1B also includes service to North Saint Paul as defined in Alternative 1A. Figure 1-2 presents this concept system alternative.

Alternative 1C represents a system serving all the northeast metro communities as SPRWS wholesale customers. For this alternative, the trunk water main is sized to serve all northeast metro communities and is proposed for development in phases based on existing infrastructure capacity expansion needs to meet the demand for communities considering their growth projections. In Phase 1, the communities identified for Alternatives 1A and 1B are served. In Phase 2, the communities of Lino Lakes, Centerville, and Hugo are added. In Phase 3, the system is expanded to serve Forest Lake, Columbus, Circle Pines and Lexington. Figure 1-3 presents the Alternative 1C concept system.

Table 1-1. Approach 1: SPRWS Expansion Alternatives Description Summary.

Alternative	Communities Served	Significant Features
1A SPRWS Expansion to North Saint Paul	North Saint Paul	SPRWS connection to Hazel Park pressure zone
1B SPRWS Expansion to Select Northeast Metro Communities	North Saint Paul	SPRWS connection to Hazel Park pressure zone
	Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	SPRWS connection near McCarrons WTP; system sized for only these communities
1C SPRWS Expansion to All Northeast Metro Communities		
Phase 1	North Saint Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	Same connections as for Alternative 1B: system sized for all northeast metro communities
Phase 2	Lino Lakes, Centerville, Hugo	Water main extensions at Shoreview and White Bear Township; increase SPRWS raw water supply and treatment capacity
Phase 3	Forest Lake, Columbus, Circle Pines, Lexington	Water main extensions at Lino Lakes and Hugo

Figure 1-1. Alternative 1A - SPRWS Expansion to North St. Paul Concept System.

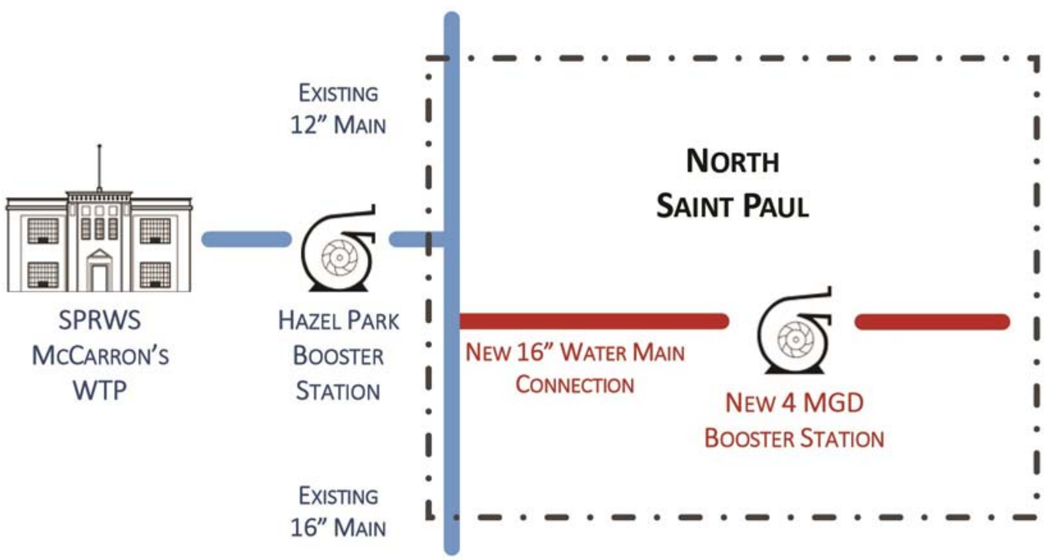


Figure 1-2. Alternative 1B - SPRWS Expansion to Select Northeast Metro Communities Concept System.

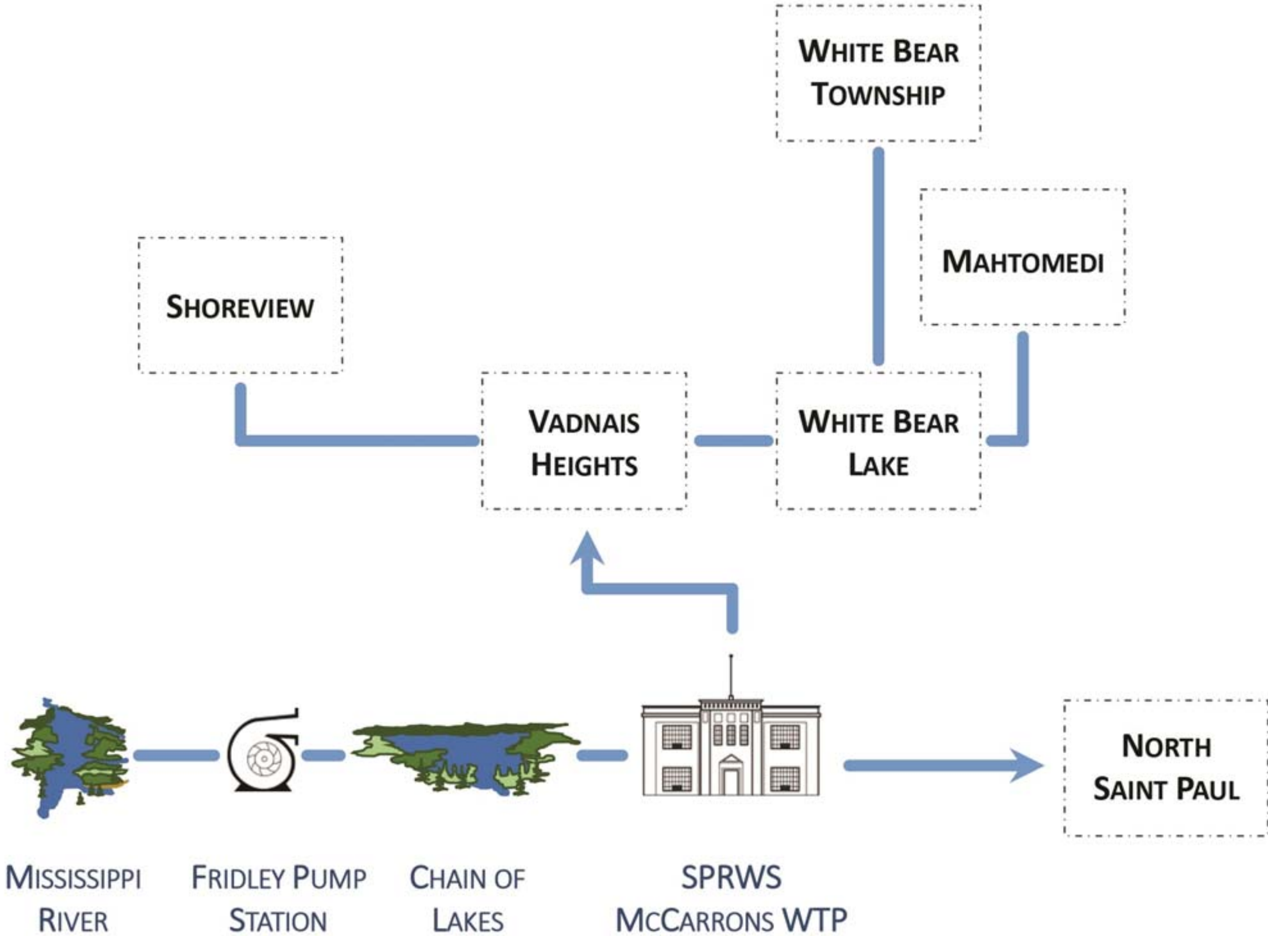
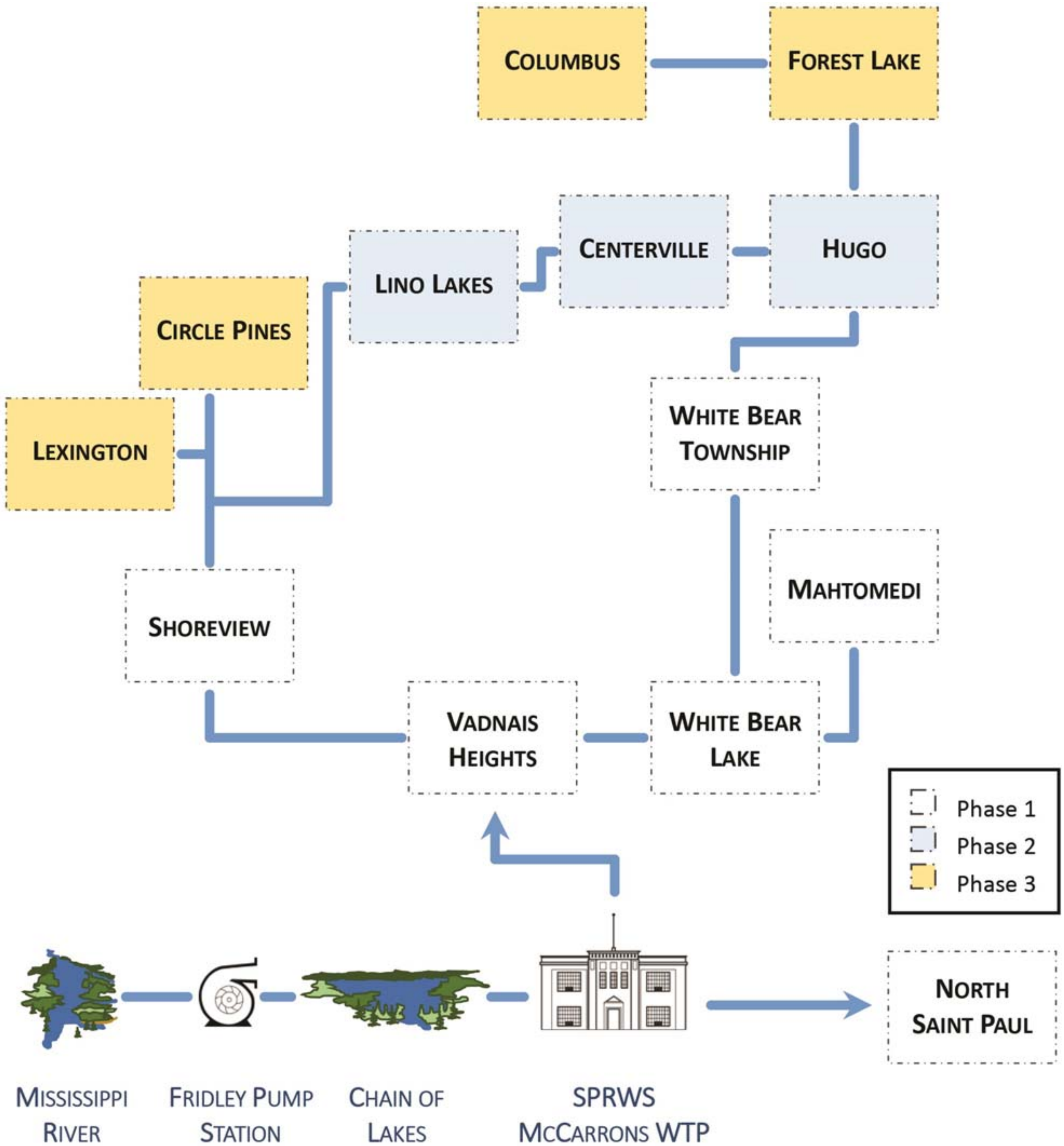


Figure 1-3. Alternative 1C - SPRWS Expansion to All Northeast Metro Communities Concept System.



In Approach 2, the water supply source is obtained through the SPRWS appropriation of Mississippi River water, with a new WTP constructed at Vadnais Lake. For this approach there are two base alternatives that correlate to Approach 1 alternatives. Alternative 2B defines a subset of northeast metro communities served by a new surface WTP that is similar to Alternative 1B: Vadnais Heights, White Bear Lake, White Bear Lake Township, Mahtomedi, and Shoreview. North Saint Paul would be served as a wholesale customer of SPRWS. Figure 1-4 presents the Alternative 2B concept system. Alternative 2C defines a water supply system served by a new surface WTP for all the study area communities through a phased approach, similar to Alternative 1C. Figure 1-5 presents the Alternative 2C concept system.

Figure 1-4. Alternative 2B - New Surface WTP for Select Northeast Metro Communities Concept System.

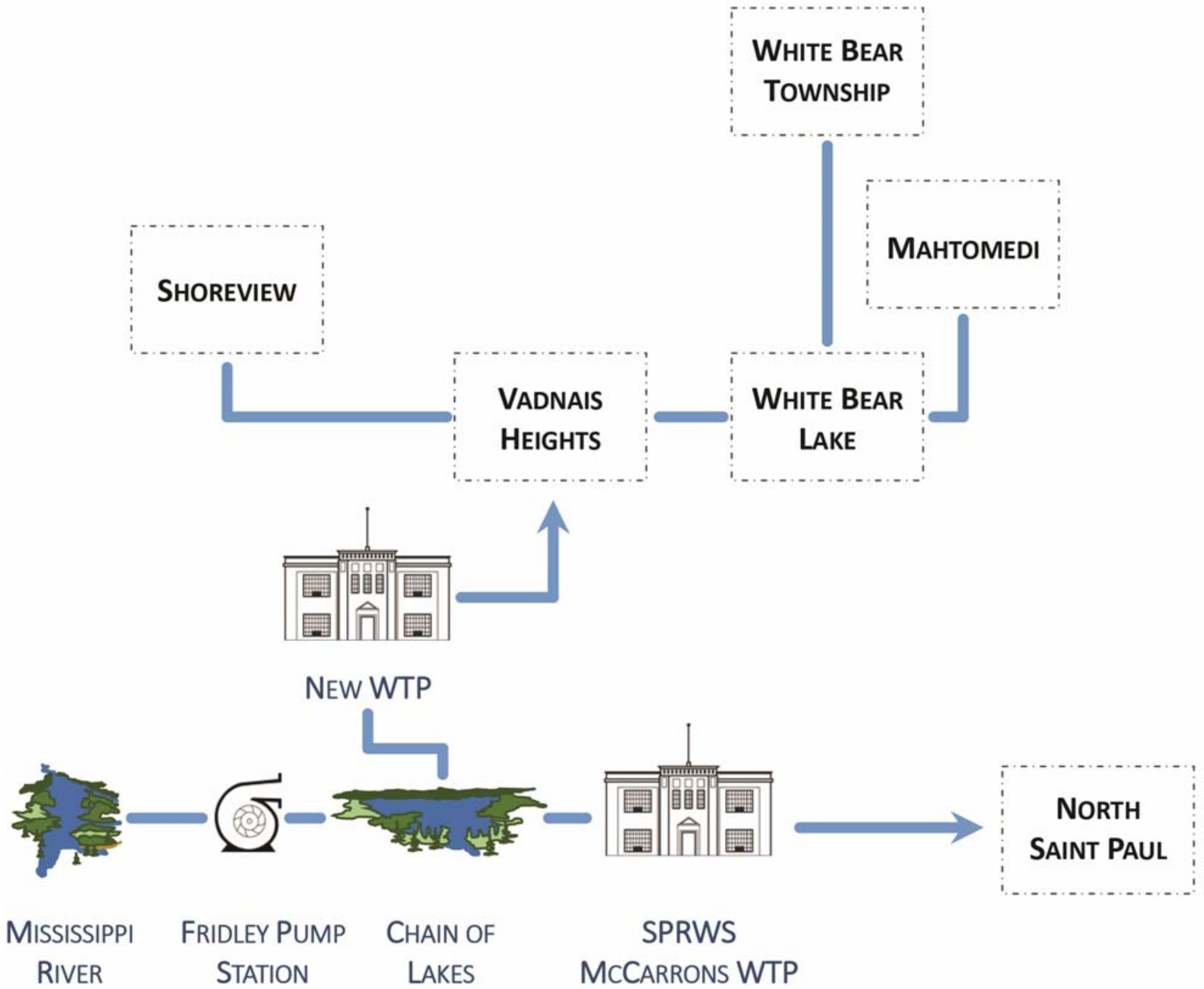
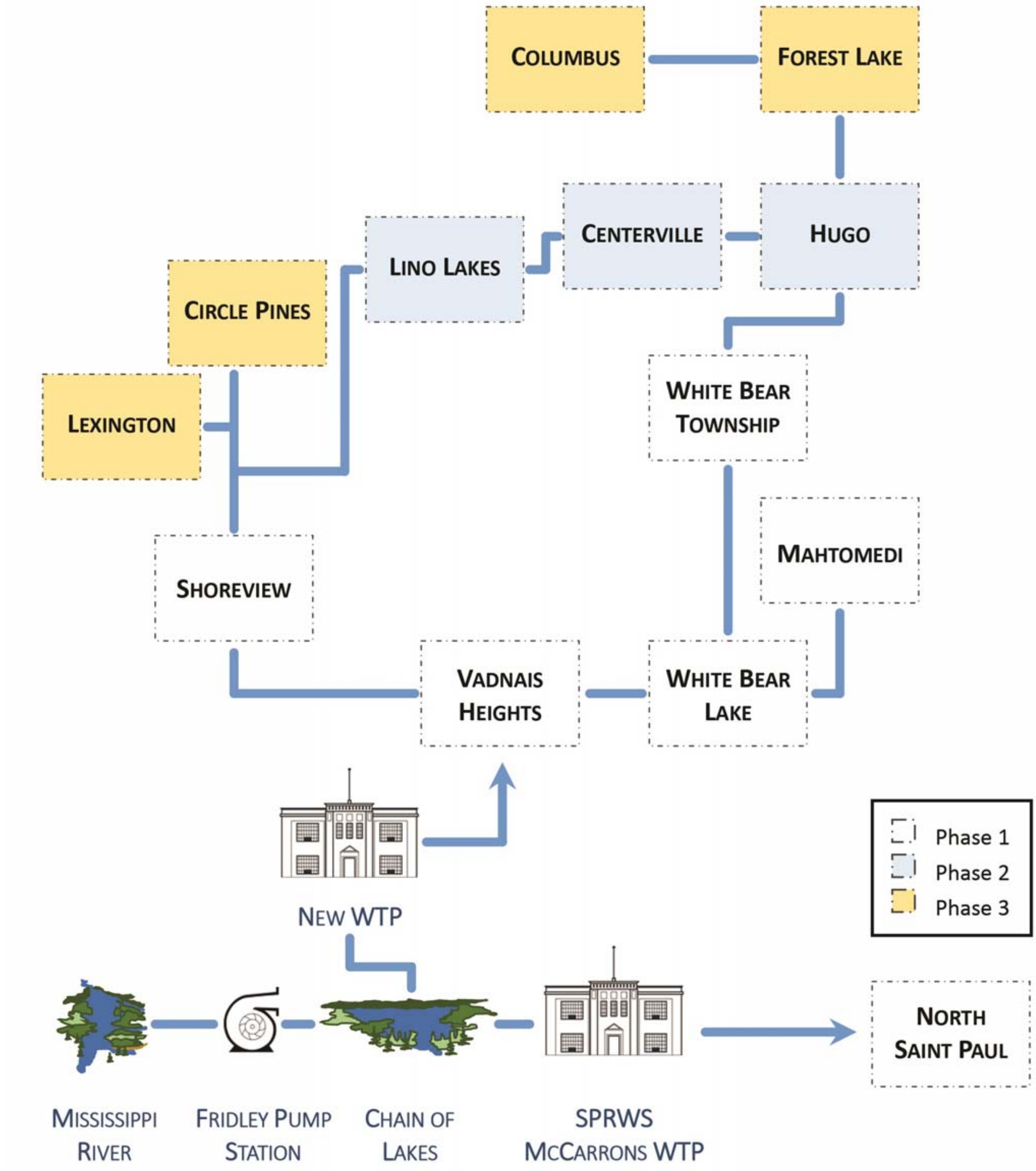


Table 1-2. Approach 2: New Surface WTP Alternatives Description Summary.

Alternative	Communities Served	Significant Features
2B New Surface WTP for Select Northeast Metro Communities	North Saint Paul	SPRWS connection to Hazel Park pressure zone
	Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	Connection to New WTP located on East Vadnais Lake
2C New Surface WTP for All Northeast Metro Communities		
Phase 1	Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, Shoreview	Same connections as for Alternative 2B; system sized for all northeast metro communities
Phase 2	Lino Lakes, Centerville, Hugo	Same as Alternative 1C-Phase 2
Phase 3	Forest Lake, Columbus, Circle Pines, Lexington	Same as Alternative 1C-Phase 3

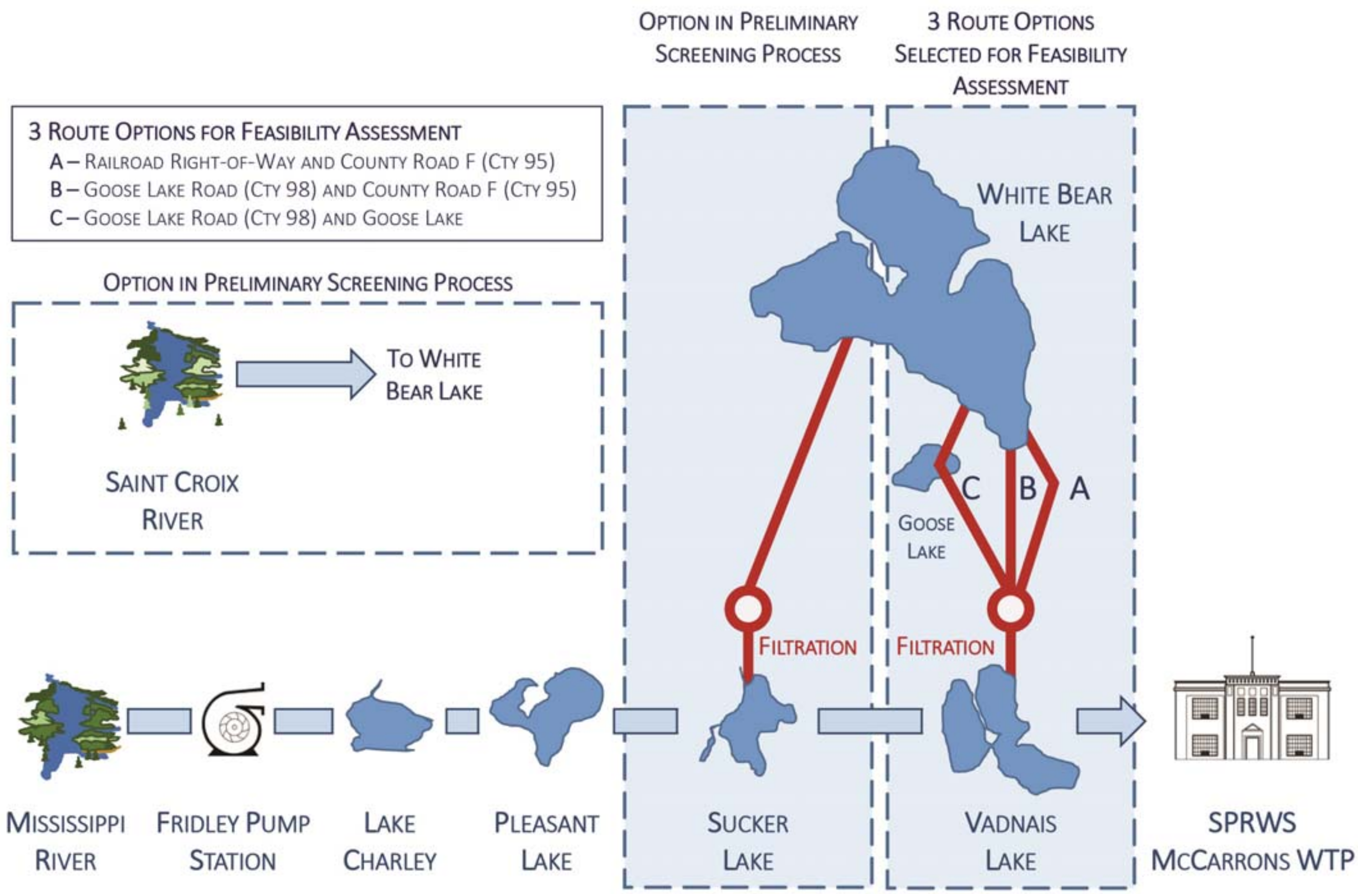
Figure 1-5. Alternative 2C - New Surface WTP for All Northeast Metro Communities Concept System.



1.4b Approach 3 - Lake Augmentation

Approach 3 evaluates options for northeast metro water sustainability by augmentation of White Bear Lake with river water. The screening process for this approach involved selection of the river water source and then options were considered for the preferred conveyance route. The Mississippi River and St. Croix were evaluated as source waters with preliminary conveyance routes. Screening criteria identified the Mississippi River with withdrawal from Vadnais Lake as the optimum source for river water. Options were evaluated for different conveyance routes from Vadnais Lake to White Bear Lake as depicted in Figure 1-6.

Figure 1-6. Approach 3 - Lake Augmentation Concept System Options.



1.5 Report Contents

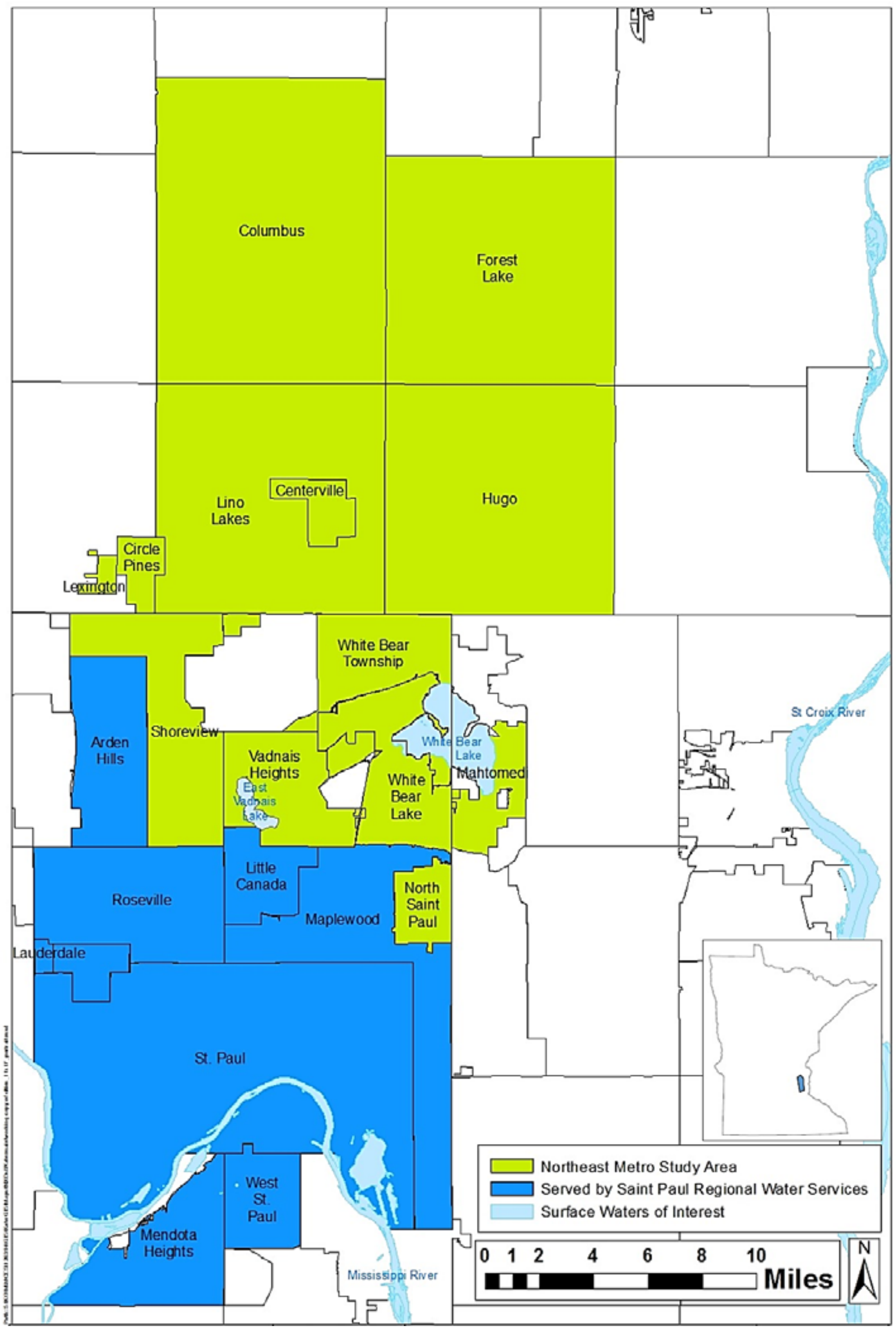
This *Draft Report* presents the study area existing conditions and feasibility assessment findings to serve as a basis for stakeholder discussions and coordination with other related studies to fine-tune the analysis and present recommendations in the *Final Report* to be submitted in Fall 2014. The body of the report provides summary information and references appendices for more detailed information and results. Separate chapters in the report present the study area community characteristics, the analysis for each of the three water sustainability approaches and a summary section that provides general conclusions about the assessment and key items for consideration in implementation of water infrastructure systems to achieve sustainability goals in the northeast metro area.

Chapter 2 - Study Area Community Characteristics

2.1 General

The northeast metro study area is delineated in Figure 2-1 in context with surface water features of interest and the St. Paul Regional Water Services (SPRWS) service area. The communities in the study area include the cities of Centerville, Circle Pines, Columbus, Forest Lake, Hugo, Lexington, Lino Lakes, Mahtomedi, North St. Paul, Shoreview, Vadnais Heights, White Bear Lake, and White Bear Township.

Figure 2-1. Study Area Communities.



All of the study area communities lie within the Minnesota Department of Natural Resources' (DNR's) proposed North and East Groundwater Management Area, and all of these communities rely on groundwater as their primary source of drinking water.

2.2 Water Demand

Current municipal well appropriations for individual cities in the study area range from 20 million gallons per year (MGY) to 1.4 billion gallons per year (BGY), and total approximately 7.1 BGY. Table 2-1 shows the relationship between groundwater withdrawals from municipal wells in each of the study cities from 2010 and associated appropriation limits.

Projected 2040 water demands for each of the study area communities are also presented in Table 2-1. Projected average daily water use by the entire study area is estimated to be 22 million gallons per day (MGD), while peak daily water demand is expected to be 64 MGD, as summarized in Table 2-2. Annual water use in 2040 is expected to be 8.1 BGY.

Total study area demand is expected to grow by about 53% from 2010 to 2040. The 2040 projected water demands for the majority of the communities exceed the 2010 permit appropriations. It is apparent that future water demands may not be met by current groundwater appropriations.

Table 2-1. Historic and Projected Population and Drinking Water Demand for Northeast Metro Communities.

City	2010 Population[1]	2040 Population[2]	2010 Municipal Water Use[3] (MGY)	2010 Municipal Well Appropriation (MGY)	2040 Demand[4] (MGY)
Centerville	3,792	4,600	96	108	187
Circle Pines	4,918	5,860	157	200	170
Columbus	3,914	1,576	16	20	121
Forest Lake	18,375	26,900	425	565.4	982
Hugo	13,332	21,798	370	650	906
Lexington	2,049	2,474	83	100	106
Lino Lakes	20,216	22,657	498	900	818
Mahtomedi	7,676	9,461	255	315	347
North St. Paul	11,460	14,800	424	584	492
Shoreview	25,043	35,000	1,062	1,400	1,445
Vadnais Heights	12,302	18,600	485	579	761
White Bear Lake	23,797	31,560	897	1,150	1,206
White Bear Township	10,949	13,294	532	515	586
Total	**157,823**	**208,580**	**5,300**	**7,086**	**8,127**

[1]US Census Bureau - [2]Served by Municipal Water System - [3]DNR - [4]Metropolitan Council

Table 2-2. Historic and Projected Total Population and Water Demand for the Northeast Metro.

Year	2010	2040
Population	157,823	208,580
Annual Water Usage (MG)	5,300	8,127
Average Day Demand (MGD)	14.5	22.3
Maximum Day Demand (MGD)	44.1	64.2

Refer to Tables 2-1, 2-3 for sources and definitions.

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. For this study, 2010 water use data from the DNR was used to find the maximum day to average day ratio. This ratio was applied to the average day demand projected for 2040. Table 2-3 summarizes the 2040 water demand and peak ratios.

Table 2-3. 2040 Average and Maximum Day Demands by Community.

City	Avg Day[1] 2040 Demand (MGD)	Max Day[2] 2040 Demand (MGD)	Peak to Avg Ratio	% Total Study Area Avg Day Demand
Centerville	0.51	1.3	2.6:1	2%
Circle Pines	0.46	1.5	3.3:1	2%
Columbus	0.33	0.8	2.5:1	1%
Forest Lake	2.69	4.7	1.7:1	12%
Hugo	2.48	8.9	3.6:1	11%
Lexington	0.29	1.7	5.9:1	1%
Lino Lakes	2.24	7.5	3.3:1	10%
Mahtomedi	0.95	2.4	2.5:1	4%
North St. Paul	1.35	4.0	3.0:1	6%
Shoreview	3.96	12.8	3.2:1	18%
Vadnais Heights	2.08	5.1	2.4:1	9%
White Bear Lake	3.30	9.2	2.8:1	15%
White Bear Township	1.61	4.2	2.6:1	7%
Total	**22**	**64.2**	**2.9:1**	**-**

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.

2.3 Existing Water Infrastructure

Water infrastructure varies little from community to community. A water tower and/or a ground storage tank are present in all cities except for Columbus, and allow for 0.5 to 3.0 MG of storage in each community.

Pressure zones across the communities range from a low of 1,054 feet in Centerville to 1,171 feet in Mahtomedi. Most communities in the study area utilize treatment at individual wells, which typically consists of chlorination for disinfection, fluoride addition to prevent tooth decay, and the addition of polyphosphates for stabilization. Forest Lake, White Bear Lake, Circle Pines, and White Bear Township all have water treatment plants that further improve water quality. Appendix A provides a summary of each community’s water supply system infrastructure.

There are 57 municipal wells listed within the study area. Of these 57 wells, 43 utilize the Prairie du Chien-Jordan aquifer, 5 in quaternary aquifers, and 9 in deeper aquifers. The sum appropriation for these wells is 7.1 BGY. Table 2-4 provides a summary of well counts and corresponding aquifers for each community.

Table 2-4. Number of Northeast Metro Municipal Wells in Area Aquifers.

City	Quaternary Wells	Prairie du Chien-Jordan Wells	Deeper Wells[1]	Total Wells
Centerville	0	2	0	2
Circle Pines	1	1	1	3
Columbus	2	0	1	3
Forest Lake	0	1	5	5
Hugo	0	6	0	6
Lexington	1	0	0	1
Lino Lakes	0	4	1	5
Mahtomedi	0	5	0	5
North St. Paul	0	5	0	5
Shoreview	1	5	0	6
Vadnais Heights	0	4	0	4
White Bear Lake	0	4	1	5
White Bear Township	0	6	0	6
Total	**5**	**43**	**9**	**57**

[1] Refers to wells utilizing aquifers that are deeper than the Prairie du Chien-Jordan aquifer, including the Franconia, Ironton, Galesville and Mt. Simon aquifers.

2.4. Water Rates

Table 2-5 summarizes annual residential water bills for each community based on per capita usage. The per capita usage assumed in these calculations is 80 gallons per day, and rates were based on a residential water meter where applicable.

Table 2-5. Calculated Annual Residential Household Water Bills for Northeast Metro Communities.

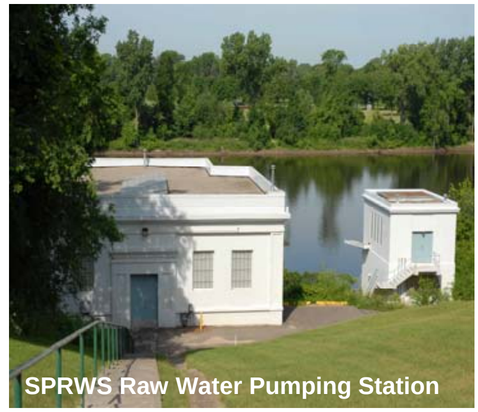
City	Current Annual Cost per Household
Centerville	$216.01
Circle Pines	$202.21
Columbus	NA
Forest Lake	$217.24
Hugo	$167.91
Lexington	$162.81
Lino Lakes	$158.81
Mahtomedi	$236.54
North St. Paul	$243.85
Shoreview	$172.67
Vadnais Heights	$113.85
White Bear Lake	$86.97
White Bear Township	$181.51
St Paul	$242.49

Note: A household was defined as a family of four, with a residential water meter and an average water usage rate of 16,456 gallons per quarter. Columbus' residential water bill was not calculated as its municipal system primarily serves commercial businesses. Source: 2013/14 individual city fee schedules. NA= Not applicable.

Chapter 3 - Approach 1 - Connection to Saint Paul Regional Water Services to Supply Drinking Water (SPRWS Expansion)

To reduce reliance on groundwater, the northeast metro communities could be connected to St. Paul Regional Water Services (SPRWS) for their drinking water supply. SPRWS operates a major water utility that gets its raw water from the Mississippi River. SPRWS has excess treatment capacity and is in close proximity to the northeast metro communities.

3.1 SPRWS Existing System


SPRWS Raw Water Pumping Station

The SPRWS raw water pumping station is located on the Mississippi River in Fridley, Minnesota (Figure 3-1). The pumping station has a capacity of 80 million gallons per day (MGD). The pumping station pumps raw water into two 60-inch cast-in-place concrete pipes. The pressure inside the concrete pipes is regulated by a surge tower located at the pumping station. The overflow elevation of the surge tower is 950-ft.

The raw water conduits are routed east approximately 9 miles and discharge into Charley Lake in the City of North Oaks. Charley Lake is the first lake in a series of lakes that also include Pleasant Lake, Sucker Lake, and Vadnais Lake. The purpose of the lakes is to act as sedimentation basins (to settle out solids) to improve the raw water quality ahead of the water treatment plant and provide storage. In addition, oxygen is added to the water in Pleasant Lake and Vadnais Lake to further improve raw water quality. The chain of lakes has an operating capacity of 3.56 billion gallons above the intakes (submerged structure where water enters pump station). A pumping station in Vadnais Lake pumps the raw water into two 90-inch conduits that deliver the water to the SPRWS McCarrons water treatment plant (WTP) located on Rice Street in St. Paul.

Figure 3-1. Schematic of SPRWS Raw Water and Treatment Infrastructure.

Along the two 90-inch conduits, SPRWS has 10 Prairie du Chien – Jordan aquifer wells with a combined capacity of 45 MGD. The wells pump directly into the 90-inch conduits. SPRWS used approximately 1.4 billion gallons of water from the wells in 2012 (3.8 MGD).


McCarrons Water Treatment Plant

The McCarrons WTP is a conventional lime softening facility. The treatment process includes chemical addition, flocculation, clarification, recarbonation, settling, filtration, and high service pumping. The lime softening process removes hardness from the water. In 2006, granular activated carbon was added to the filters at the WTP to remove objectionable taste and odor constituents from the water. The sustainable capacity of the water treatment plant is 105 MGD with a peak capacity of 130 MGD. In other words, the WTP could only sustain 130 MGD for one or two days, whereas it could sustain 105 MGD for several weeks at a time.

SPRWS serves approximately 420,000 people in 12 cities. In 2012, the average day demand for the SPRWS system was 45 MGD with a maximum day demand of 77 MGD.

SPRWS has retail customers and wholesale customers. SPRWS owns and operates the water systems of their retail customers (Maplewood, West St. Paul, Mendota Heights, Lauderdale, and Falcon Heights). SPRWS sells water to their wholesale customers, but the wholesale customers own and operate their respective water systems (Roseville and Little Canada). Table 3-1 reflects the rates charged to SPRWS retail customers.

Table 3-1. SPRWS Retail Water Rates.

Type	Retail Customer
Base Rate	$9.00/quarter
Winter Rate	$3.13/1,000 gallons
Summer Rate	$3.26/1,000 gallons

3.2 Conjunctive Use Water Quality

Gregory Harrington, PhD, P.E. was retained to identify water quality impacts associated with delivering SPRWS potable water to the suburban communities in the northeast metro and the possibility of conjunctive use of surface water and groundwater. The analysis is qualitative in nature and will be followed with a more quantitative analysis in the final report. The more in-depth analysis is not expected to change the general conclusions.

A detailed discussion of the conjunctive use water quality is included in Appendix B. Preliminary conjunctive use water quality findings are as follows:

- Communities would need to switch disinfection methods from chlorine to chloramines with a conversion to water from SPRWS.
- Mixing groundwater and surface water from SPRWS is predicted to be feasible.
- Customers in the northeast metro could expect taste and odor properties to be different with water from SPRWS. A public education program would be recommended.
- Lead, copper, and iron solution chemistry would be different with a conversion to water from SPRWS. These constituents would need to be monitored closely.

3.3 Development of Concept System to Serve Northeast Metro

Three alternatives were developed to serve portions or all of the northeast metro from SPRWS. Different scale alternatives were selected to determine the most cost effective option. A description of the alternatives is as follows:

- Alternative 1A – SPRWS Service Expanded to North Saint Paul
- Alternative 1B – SPRWS Service Expanded to Select Northeast Metro Communities (connect North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview to SPRWS; infrastructure sized to serve only these communities).
- Alternative 1C - SPRWS Service Expanded to All Northeast Metro Communities
    - Phase 1 will connect North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview to SPRWS.
    - Phase 2 will connect Hugo, Lino Lakes, and Centerville to SPRWS.
    - Phase 3 will connect Forest Lake, Columbus, Lexington, and Circle Pines to SPRWS.

Several design decisions/assumptions were made in developing the concept of bringing treated surface water to the northeast metro from SPRWS:

- For Alternative 1A, trunk water main would be constructed and connect to the SPRWS Hazel Park pressure zone with a hydraulic grade line (HGL) of 1098-ft. The HGL is equivalent to the water tower elevation. A booster station would be constructed in North St. Paul to boost water to their HGL of 1125 (i.e. tower elevation). Additional communities cannot be connected to the Hazel Park pressure zone due to hydraulic limitations.
- For Alternatives 1B and 1C, trunk water main would be constructed and operated at the same HGL as SPRWS high service zone (1019-ft). Booster stations would be constructed in the individual northeast metro communities to boost water to each city's respective HGL.

- Surface water connections in the northeast metro communities are made in the vicinity of wells or treatment facilities so that mixing of surface water and groundwater would be feasible if conjunctive use were desired. Mixing facilities are not included in the estimated costs.
- Northeast metro communities would continue to utilize their elevated storage tanks at their existing HGLs.
- New trunk water main and booster stations are sized to serve the 2040 maximum day demands identified in Chapter 2. Conjunctive use of surface and groundwater is feasible, but facilities are sized to provide maximum day demands from surface water.
- As discussed in Section 3.2, all northeast metro communities would convert disinfection methods from chlorination to chloramination.

3.4 Altervative 1A - SPRWS Service Expanded to North Saint Paul

SPRWS serves the City of Maplewood which is adjacent to the northeast metro community of North St. Paul. Connecting North St. Paul to SPRWS could be achieved via a 16-inch water main and booster station, as depicted in Figure 3-2. A description of North St. Paul's water infrastructure is included in Appendix A.

Table 3-2 summarizes the estimated construction costs to connect North St. Paul to SPRWS. A summary of the cost estimating approach for this report is included as Appendix C. A description of the pipe segments including a map and detailed cost tables are included in Appendix D.

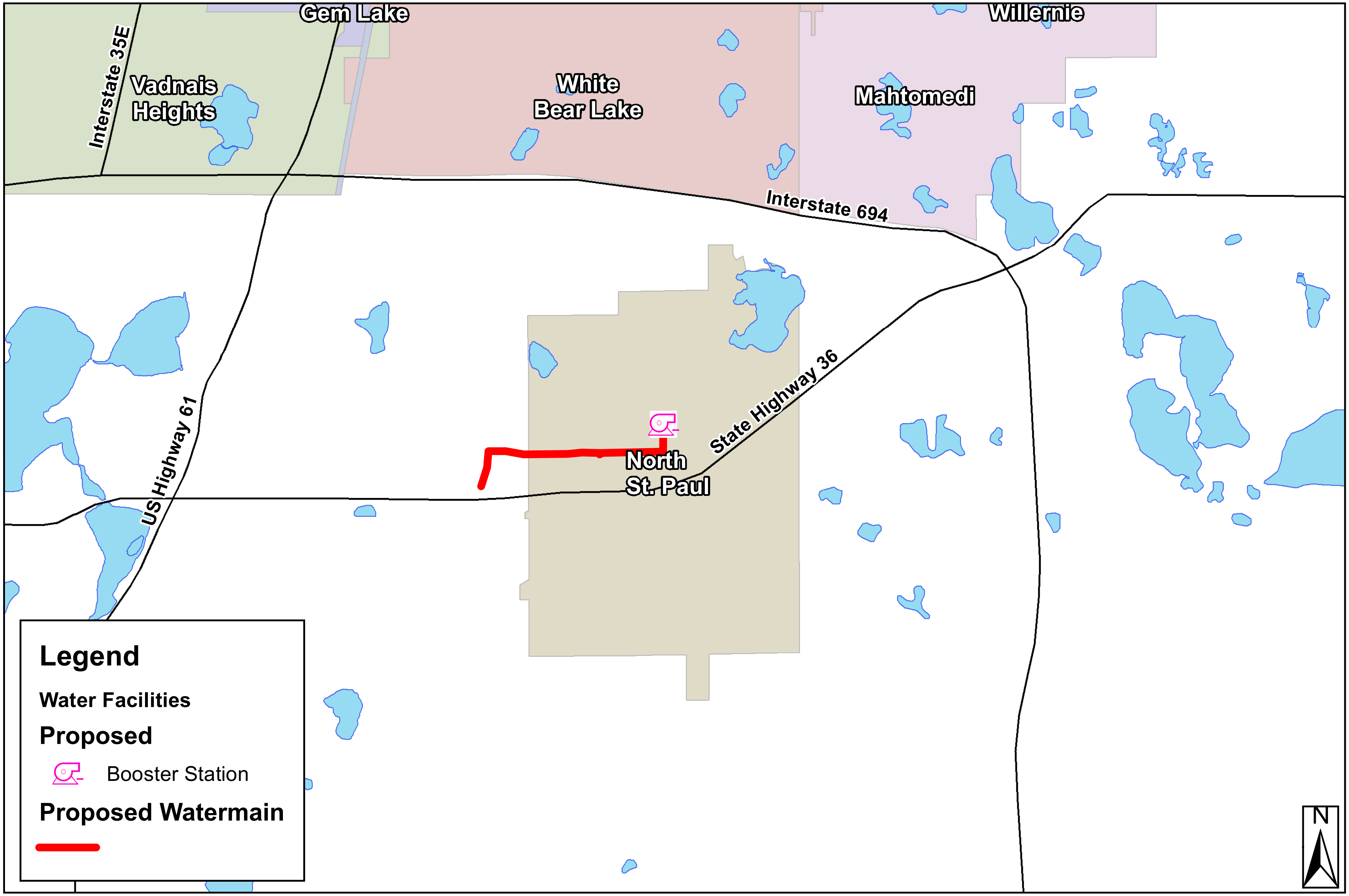
Table 3-2. Alternative 1A – SPRWS Service Expanded to North Saint Paul Capital Costs.

Item	Units	Unit Cost	Total Cost
16" Directionally Drilled HDPE	7,100 ft	$300/ft	$2,130,000
16" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	10	$15,000 ea	$150,000
Booster Stations			
North St. Paul – 4 MGD	1	$650,000 ea	$650,000
Easements/Land Acquisition	36,000 sf	$6/sf	$216,000
Environmental	1.3 miles	$50,000/mile pipe	$65,000
		Subtotal	**$3,461,000**
		Contingency (30%)	$1,038,000
		Eng/Admin/Legal (20%)	$692,000
		Total Alternative 1A	**$5,191,000**

3.5 Alternative 1B - SPRWS Service Expanded to Select Northeast Metro Communities

The northeast metro communities that would be connected to SPRWS in Alternative 1B are Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview. As part of Alternative 1B, North St. Paul would be connected to the SPRWS Hazel Park pressure zone. Because the combined 2040 maximum day water demands of the five communities (not including North St. Paul) is 33.7 MGD, it requires trunk water main to connect to the SPRWS system at the McCarrons WTP.

SPRWS has sufficient excess water treatment plant capacity to provide water for Alternative 1B. Although the SPRWS raw water conduits and Fridley pumping station do not have additional capacity beyond SPRWS' maximum day demand, the chain of lakes have sufficient storage to meet all demands of these communities. For Alternative 1B, it is assumed that the SPRWS raw water conduits and Fridley Pumping Station do not need to be upgraded.



Document Path: S:\KO\M\MCES\126394\GIS\Maps\MXDs\06252014\LetterSize\Alternative1A_8x11.mxd

SEH

3535 VADNAIS CENTER DR.
ST. PAUL, MN 55110
PHONE: (651) 490-2000
FAX: (651) 490-2150
WATTS: 800-325-2055
www.sehinc.com

Project: MCES 126394
Print Date: 07/11/2014

Map by:AK
Projection:WGS 1984
Source: SEH, MCES

Alternative 1A - SPRWS Expanded to North St. Paul

Figure 3-2

For Alternative 1B, the northeast metro communities will be connected to the SPRWS high service zone which operates at a HGL of approximately 1019-ft.

3.5a Alternative 1B - Trunk Water Main and Booster Stations

The trunk water main proposed as part of Alternative 1B is described in Appendix D and shown on Figure 3-3. The water main is sized to only serve the Alternative 1B communities and is not sized to be extended further.

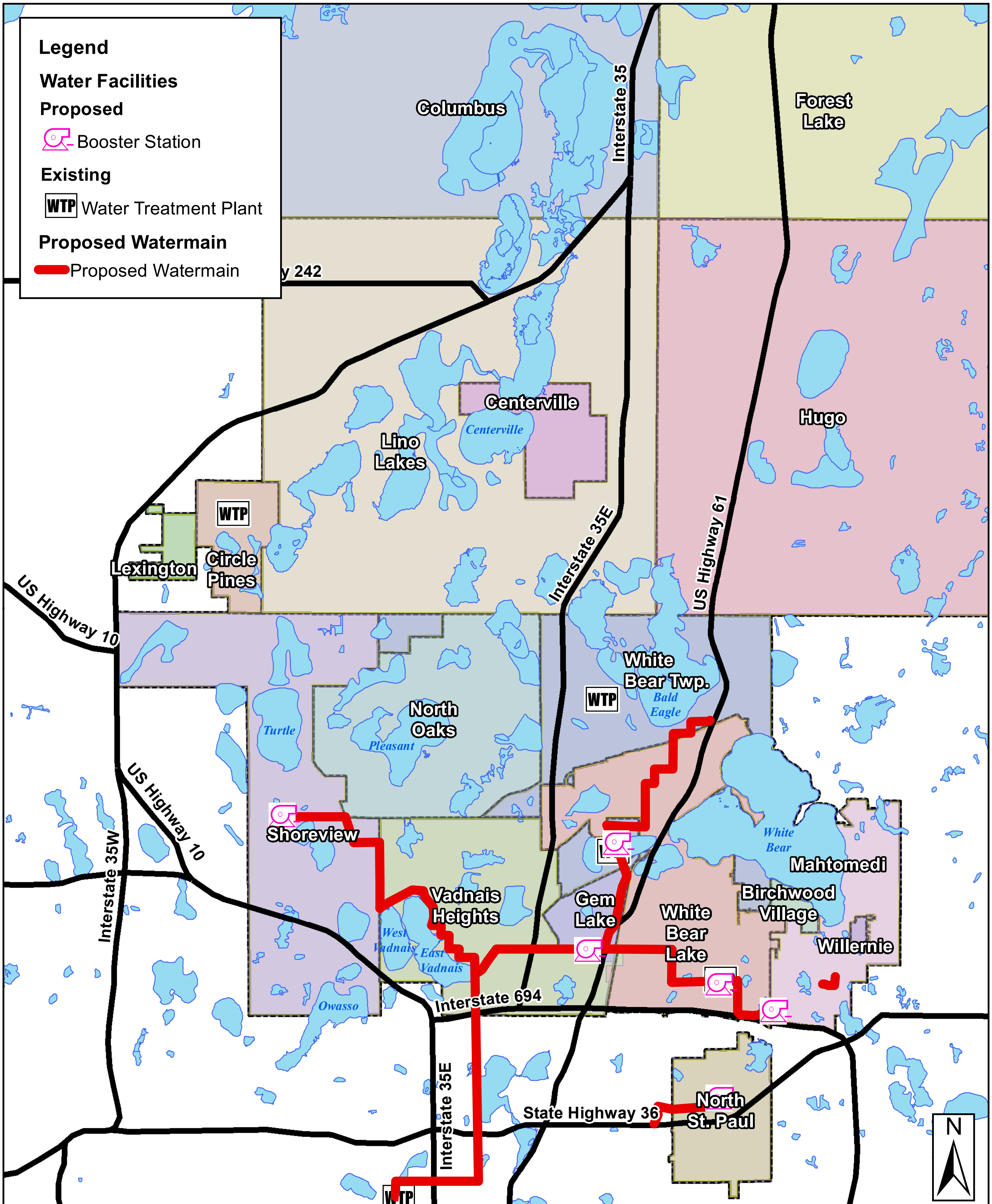
Because all of the northeast metro communities operate at higher HGLs than SPRWS, booster stations will be required for each community. A description of each community's existing infrastructure is included in Appendix A.

3.5b Alternative 1B – Estimated Costs

Table 3-3 summarizes the estimated construction costs to connect the Alternative 1B communities to SPRWS.

Table 3-3. Alternative 1B – SPRWS Service Expanded to Select Northeast Metro Communities Capital Costs.

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
New Water Main			
Open Cut 48" DIP (100% in road)	22,560 ft	$1,316/ft	$29,689,000
48" Cased, tunneled pipe	1,200 ft	$4,000/ft	$4,800,000
Open Cut 36" DIP (100% in road)	12,350 ft	$1,025	$12,659,000
36" cased, tunneled pipe	400 ft	$3,000/ft	$1,200,000
Open Cut 30" DIP (100% in road)	25,500 ft	$908/ft	$23,154,000
30" cased, tunneled pipe	500 ft	$2,500/ft	$1,250,000
Open Cut 30" (0% in road)	14,140 ft	$364/ft	$5,147,000
Directionally Drilled 18" HDPE	27,330 ft	$350/ft	$9,566,000
18" cased, tunneled pipe	250 ft	$1,250/ft	$313,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
Fusing Pits	52	$15,000 ea	$780,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$585,000 ea	$585,000
Shoreview – 13 MGD	1	$938,000 ea	$938,000
Vadnais Heights – 6 MGD	1	$731,000 ea	$731,000
White Bear Lake – 10 MGD	1	$839,000 ea	$839,000
White Bear Twp – 5 MGD	1	$605,000 ea	$605,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	675,000 sf	$6/sf	$4,050,000
Environmental	21.5 miles	$50,000/mile pipe	$1,075,000
		Subtotal	**$103,575,000**
		Contingency (30%)	$31,073,000
		Eng/Admin/Legal (20%)	$20,715,000
		Total Alternative 1B	**$155,363,000**



Path: S:\KO\M\MCES\126394\GIS\Maps\MXDs\06252014\LetterSize\Alternative1B_8x11.mxd

SEH

3535 VADNAIS CENTER DR.
ST. PAUL, MN 55110
PHONE: (651) 490-2000
FAX: (888) 908-8166
TF: (800) 325-2055
www.sehinc.com

Project: MCES 126394
Print Date: 07/22/2014

Map by: AK/SH
Projection: WGS_1984
Source: MnDOT, MnDNR, MnGEO, MCES, SEH.

Alternative 1B - SPRWS Service Expanded to Select Northeast Metro Communities

Figure 3-3

3.6 Alternative 1C - SPRWS Service Expanded to All Northeast Metro Communities

In Alternative 1C, all of the northeast metro communities would be connected to SPRWS in a phased approach. The phasing and major infrastructure improvements necessary for Alternative 1C are described below.

Phase 1 – SPRWS Connection to North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview

Phase 2 – SPRWS Connection to Hugo, Lino Lakes, and Centerville

- Upgrade SPRWS Fridley raw water pumping station
- Add third 60-inch conduit to SPRWS raw water conveyance
- Add 50 MGD capacity to SPRWS McCarrons WTP

Phase 3 – SPRWS Connection to Forest Lake, Columbus, Circle Pines, and Lexington

3.6a Alternative 1C Trunk Water Main

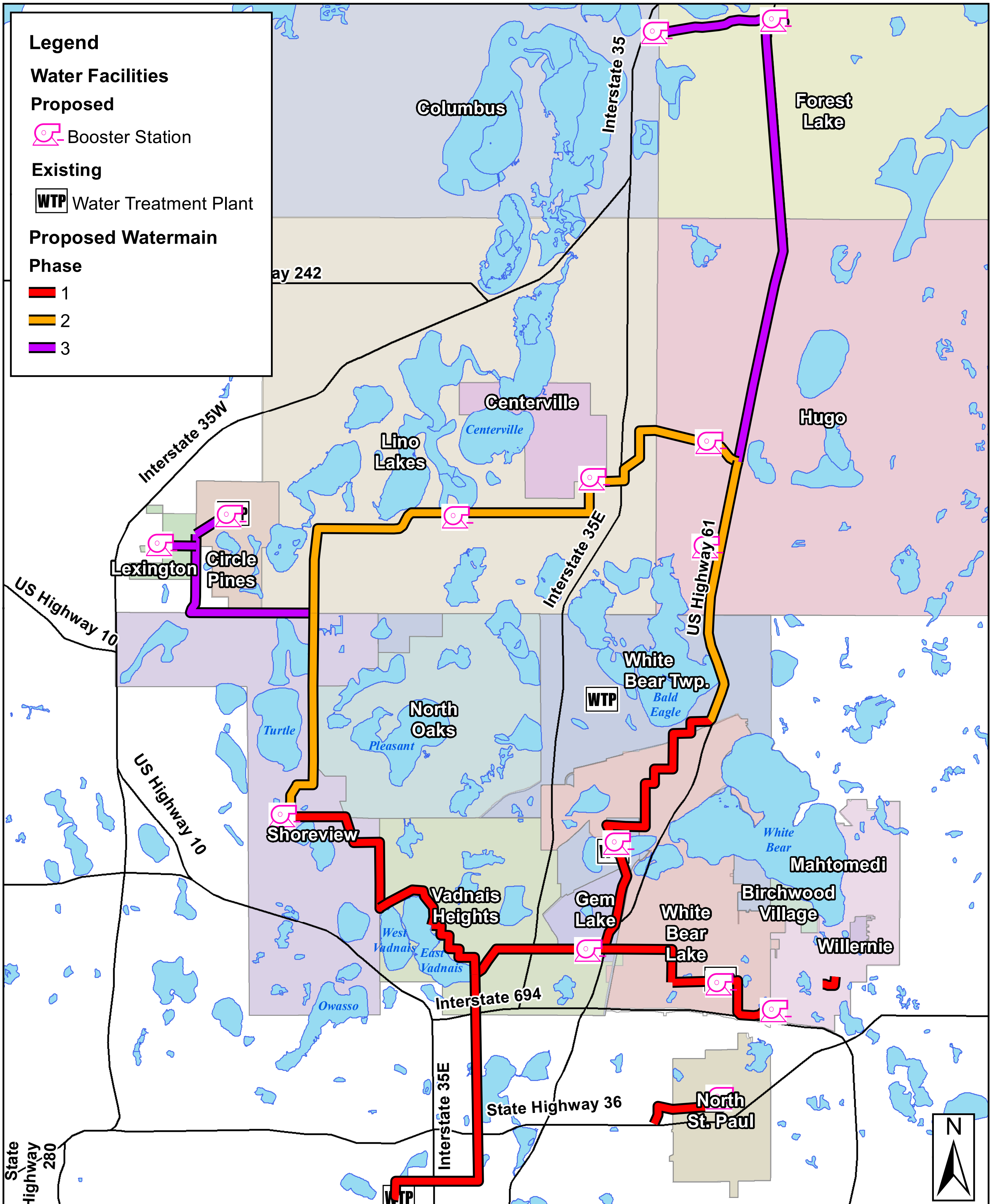
The trunk water main proposed as part of Alternative 1C, Phases 1-3, is described in Appendix D and shown on Figure 3-4. The trunk water main in Alternative 1C, Phases 1-3, is sized to serve the entire northeast metro.

3.6b Alternative 1C – Booster Stations

As previously indicated, because all of the northeast metro communities operate at higher HGLs than SPRWS, booster stations will be required for each community. A description of each community's infrastructure is included in Appendix A.

3.6c Alternative 1C – Estimated Costs

Tables 3-4, 3-5, and 3-6 summarize the estimated construction costs to connect the entire northeast metro to SPRWS in a phased approach.



Path: S:\KO\M\MCES\126394\GIS\Maps\MXDs\06252014\LetterSize\Alternative1C_8x11.mxd

SEH

3535 VADNAIS CENTER DR.
ST. PAUL, MN 55110
PHONE: (651) 490-2000
FAX: (888) 908-8166
TF: (800) 325-2055
www.sehinc.com

Project: MCES 126394
Print Date: 07/22/2014

Map by: AK/SH
Projection: WGS_1984
Source: MnDOT, MnDNR, MnGEO, MCES, SEH.

Alternative 1C - SPRWS Service Expanded to All Northeast Metro Communities

Figure 3-4

Table 3-4. Alternative 1C – Phase 1 – SPRWS Connection to North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, and Shoreview Capital Costs.

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
Water Main			
Open cut dual 48" DIP (100% in road)	22,560 ft	$1,979/ft	$44,646,000
Open Cut 48" (0% in road)	14,140 ft	$663/ft	$9,375,000
Open Cut 48" DIP (100% in road)	54,180 ft	$1,316/ft	$71,301,000
48" Cased, tunneled pipe	3300 ft	$4,000/ft	$13,200,000
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$585,000 ea	$585,000
Shoreview – 13 MGD	1	$938,000 ea	$938,000
Vadnais Heights – 6 MGD	1	$731,000 ea	$731,000
White Bear Lake – 10 MGD	1	$839,000 ea	$839,000
White Bear Twp – 5 MGD	1	$605,000 ea	$605,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	682,000 sf	$6/sf	$4,091,000
Environmental	21.7 miles	$50,000/mile pipe	$1,085,000
		Subtotal	**$164,371,000**
		Contingency (30%)	$49,311,000
		Eng/Admin/Legal (20%)	$32,874,000
		Total Alt 1C, Phase 1	**$246,556,000**

Table 3-5. Alternative 1C – Phase 2 – SPRWS Connection to Hugo, Lino Lakes, and Centerville Capital Costs.

Item	Units	Unit Cost	Total Cost
Fridley Pumping Station Upgrades	1	$10,000,000 ea	$10,000,000
Additional 60" Raw Water Conduit (50% in road)	42,000 ft	$1,196/ft	$50,232,000
50 MGD SPRWS Treatment Plant Expansion	1	$65,000,000 ea	$65,000,000
Water Main			
Open Cut 48" DIP (50% in road)	71,030 ft	$910/ft	$64,637,000
Open Cut 48" DIP (100% in road)	16,000 ft	$1,316/ft	$21,056,000
48" cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Booster Stations			
Centerville – 2 MGD	1	$551,000 ea	$551,000
Hugo – 7 MGD	1	$741,000 ea	$741,000
Hugo – 5 MGD	1	$700,000 ea	$700,000
Lino Lakes – 8 MGD	1	$724,000 ea	$724,000
Easements/Land Acquisition	524,000 sf	$6/sf	$3,144,000
Environmental	24.5 miles	$50,000/mile pipe	$1,225,000
		Subtotal	**$219,611,000**
		Contingency (30%)	$65,883,000
		Eng/Admin/Legal (20%)	$43,922,000
		Total Alt 1C, Phase 2	**$329,416,000**

Table 3-6. Alternative 1C – Phase 3 – SPRWS Connection to Forest Lake, Columbus, Circle Pines, and Lexington Capital Costs.

Item	Units	Unit Cost	Total Cost
Water Main			
20” Directionally drilled HDPE (or open cut under trail)	37,900 ft	$400/ft	$15,160,000
12” Directionally drilled HDPE	24,325 ft	$250/ft	$6,081,000
12” cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10” Directionally drilled HDPE	9,500 ft	$225/ft	$2,138,000
10” cased, tunneled pipe	250 ft	$900/ft	$225,000
Fusing Pits	121	$15,000 ea	$1,815,000
Booster Stations			
Circle Pines – 2 MGD	1	$571,000 ea	$571,000
Columbus – 1 MGD	1	$557,000 ea	$557,000
Forest Lake – 5 MGD	1	$724,000 ea	$724,000
Lexington – 2 MGD	1	$571,000 ea	$571,000
Easements/Land Acquisition	449,000 sf	$6/sf	$2,694,000
Environmental	13.7 miles	$50,000/mile pipe	$685,000
		Subtotal	**$31,471,000**
		Contingency (30%)	$9,441,000
		Eng/Admin/Legal (20%)	$6,294,000
		Total Alt 1C, Phase 3	**$47,206,000**

3.7 Cost Summary - Alternatives 1A, 1B and 1C

Table 3-7 provides a cost summary of Alternatives 1A, 1B, and 1C. These represent project cost estimates; including contingencies, engineering, administration, and legal costs in addition to construction costs. Detailed cost tables by alternative and pipe segment are included in Appendix D.

Table 3-7 Capital Costs to Connect Northeast Metro Communities to SPRWS

	Capital Cost
Alternative 1A – SPRWS Connection to North St. Paul	**$5,191,000**
Alternative 1B – SPRWS Connection to Select Northeast Metro Communities	**$155,363,000**
Alternative 1C – SPRWS Connection to All Northeast Metro Communities	
Phase 1 – SPRWS Connection to North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview	$246,556,000
Phase 2 – SPRWS Connection to Hugo, Lino Lakes, and Centerville	$329,416,000
Phase 3 – SPRWS Connection to Forest Lake, Columbus, Circle Pines, and Lexington	$47,206,000
Total Alternative 1C	**$623,178,000**

3.8 Operation and Maintenance Costs

Operation and maintenance (O&M) costs for communities connected to SPRWS are included in the water rates charged by SPRWS. To determine the rate, SPRWS would conduct a “Cost of Service” study. Roseville, a wholesale customer of SPRWS, currently pays approximately 70% of SPRWS retail rate (plus a base charge). This works out to be approximately $2.19/1,000 gallons in the winter and $2.28/1,000 gallons in the summer, plus a quarterly base rate of $9, for each connection. The total cost for Roseville customers includes this wholesale cost charged by SPRWS plus a City charge for their system infrastructure costs.

According to SPRWS, the water coming from the Hazel Park pressure zone would likely be charged more than 70% of the SPRWS retail rate because it is provided at a higher pressure and goes through more SPRWS distribution piping. For Alternative 1A, it is assumed that the wholesale rate from SPRWS would be 75% of the average retail rate ($2.40 per 1,000 gal).

Because major water infrastructure is being constructed in the SPRWS system as part of Alternatives 1B and 1C and assumes a lower delivery pressure, it is assumed that the wholesale rate from SPRWS would be 55% of the average retail rate ($1.76 per 1,000 gal). This rate is only for alternative comparison purposes in this report and has not been negotiated with SPRWS.

3.9 Booster Station O&M Costs

O&M costs for the booster stations needed to connect northeast metro communities to SPRWS were developed based on pumping energy, equipment maintenance, labor costs, building heat, and other miscellaneous costs. The booster station operation and maintenance costs are presented in detail in Appendix C.

3.10 Annual Costs

Annual costs to connect northeast metro communities to SPRWS include bond payments on capital infrastructure, repair and replacement on capital infrastructure, cost of water from SPRWS, and booster station O&M. The annual costs for each alternative are included in Table 3-8.

Cost assumptions include:

- 20 year bond, 4% interest
- 1% annual repair and replacement for new water main
- 2% annual repair and replacement for booster stations
- Repair and replacement for new SPRWS infrastructure and treatment plant is included in cost of water
- O&M and repair and replacement for existing northeast metro infrastructure is <u>not included</u>

Table 3-8. Annual Costs for Approach 1 - Connection to SPRWS to Supply Drinking Water (SPRWS Expansion).

	2040 Annual Water Demand (MG)	Bond Payment	Repair & Replacement	Cost of Water	Booster Station O&M	Total Annual Cost
Alternative 1A	492	$382,000	$36,800	$1,181,000	$40,000	$1,639,800
Alternative 1B	4,837	$11,432,000	$980,000	$8,828,000	$280,000	$21,520,000
Alternative 1C						
Phase 1	4,837	$18,142,000	$1,584,000	$8,828,000	$329,000	$28,883,000
Phase 2	1,911	$24,239,000	$927,000	$3,363,000	$132,000	$28,661,000
Phase 3	1,379	$3,474,000	$307,000	$2,427,000	$121,000	$6,329,000
Total Alternative 1C	8,127					**$63,873,000**

Chapter 4 - Approach 2 - Development of a Surface Water Connection to a New Subregional Water Treatment Plant (New Surface Water Treatment Plant)

A second option for reducing reliance on groundwater for northeast metro communities is to build a new water treatment plant (WTP) with a surface water source. Although the northeast metro communities are not in the immediate vicinity of a major river, the raw water supply for SPRWS does come through the northeast metro area.

4.1 New Water Treatment Plant Location

Two locations were identified as possible sites for a new WTP. These sites include the former Twin Cities Army Ammunition Plant (TCAAP), and a second potential site on the east side of Vadnais Lake owned by SPRWS.

4.1a TCAAP Site

The TCAAP site is currently vacant land owned by the United States Army. The SPRWS raw water conduits run adjacent to the site along County Road I. Advantages of the TCAAP site are the site is at a higher elevation than Vadnais Lake and would allow for easier elevated storage of treated water and it is adjacent to the SPRWS raw water conduits. Disadvantages of the TCAAP site are that it would require additional trunk water main to serve the northeast metro and the raw water quality at Vadnais Lake is better due to treatment in the SPRWS chain of lakes. In addition, portions of the TCAAP site have environmental contamination (TCAAP is a superfund site) which could impact construction activities.

4.1b Vadnais Lake Site

A potential Vadnais Lake water treatment plant site is on the east side of Vadnais Lake on wooded property currently owned by SPRWS. Advantages of the Vadnais Lake site are that it would require less trunk water main and the water quality is better than the TCAAP site. The disadvantage is that the site is lower in elevation and elevated storage would be more expensive.

Because the water quality is better at the Vadnais Lake site and it would be less expensive overall (due to less trunk water main), this report assumes that the treatment plant would be constructed at Vadnais Lake.

4.2 New Water Treatment Plant

A new surface WTP would need to adhere to the United States Environmental Protection Agency's Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). A discussion of the LT2ESWTR and potential treatment processes is included in Appendix E.

4.3 Conjunctive Use Water Quality

As discussed in Section 3.2, conjunctive use of surface water and groundwater is predicted to be feasible. It will require northeast metro communities to switch their disinfection method from chlorination to chloramination.

4.4 Development of Concept System to Serve Northeast Metro

Several design decisions and assumptions were made in developing the concept of bringing treated surface water to the northeast metro from a new surface water treatment plant as follows:

- Due to its proximity, the City of North St. Paul would be served by SPRWS and not from a new water treatment plant.
- A new surface water treatment plant would be constructed at Vadnais Lake.
- New trunk water main and booster stations are sized to serve the 2040 maximum day demands identified in Chapter 2. Conjunctive use of surface and groundwater is feasible, but facilities are sized to provide maximum day demands from surface water.

- A trunk water main loop and spurs would be constructed and operated at the same hydraulic grade line (approximately 1054'). A hydraulic grade line (HGL) of 1054 ft was selected because it is the lowest HGL found in the northeast metro and is common with three of the communities (Lino Lakes, Centerville, & Hugo south zone).
- Booster stations would be constructed in individual northeast metro communities as necessary to boost water from the trunk water main to each city's respective HGL.
- Northeast metro communities would continue to utilize their elevated storage tanks at their existing HGLs.
- As discussed in Section 3.2, it is assumed that all northeast metro communities would convert disinfection methods from chlorination to chloramination.

4.5 Alternative 2B - New Surface WTP for Select Northeast Metro Communities

The northeast metro communities that would be connected to a new surface WTP in Alternative 2B are Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview. As part of Alternative 2B, North St. Paul would be connected to the SPRWS Hazel Park pressure zone.

The proposed surface WTP for Alternative 2B would be constructed with a capacity of 40 MGD.

Although the SPRWS raw water conduits and Fridley pumping station do not have additional capacity beyond SPRWS' maximum day demand, the chain of lakes have sufficient storage to meet all demands of the communities. For Alternative 2B, it is assumed that the SPRWS raw water conduits and Fridley Pumping Station do not need to be upgraded.

4.5a Alternative 2B - Trunk Water Main and Booster Stations

The trunk water main proposed as part of Alternative 2B is described in Appendix D and shown on Figure 4-1. The water main is sized to only serve the Alternative 2B communities and is not sized to be extended further.

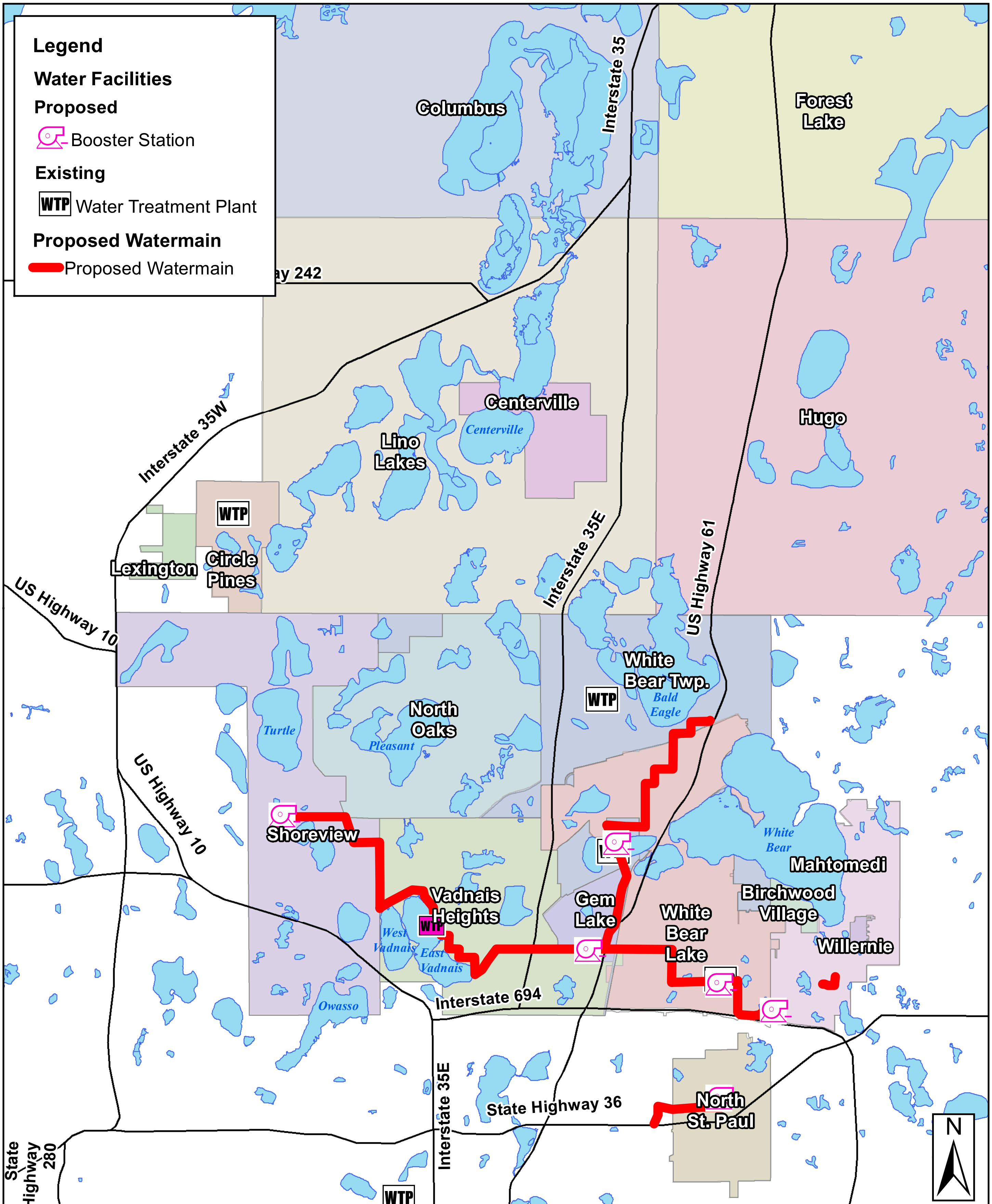
Because the new trunk distribution system is proposed to operate at a HGL of 1054', booster stations will be required for some northeast metro communities. A description of each community's existing infrastructure is included in Appendix A.

4.5b Alternative 2B – Estimated Costs

Table 4-1 summarizes the estimated construction costs to connect the Alternative 2B communities to SPRWS.

Table 4-1. Alternative 2B – New Surface WTP for Select Northeast Metro Communities Capital Costs.

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000 ea	$3,461,000
40 MGD Surface Water Treatment Plant	1	$85,000,000 ea	$85,000,000
Open Cut 36” DIP (100% in road)	12,350 ft	$1,025/ft	$12,659,000
36” cased, tunneled pipe	400 ft	$3,000/ft	$1,200,000
Open Cut 30” (0% in road)	14,140 ft	$364/ft	$5,147,000
Open Cut 30” DIP (100% in road)	25,500 ft	$908/ft	$23,154,000
30” cased, tunneled pipe	500 ft	$2,500/ft	$1,250,000
30” cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Directionally Drilled 18” HDPE	27,330 ft	$350/ft	$9,566,000
18” cased, tunneled pipe	250 ft	$1,250/ft	$313,000
12” Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12” cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10” Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
Fusing Pits	52	$15,000 ea	$780,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$585,000 ea	$585,000
Shoreview – 13 MGD	1	$938,000 ea	$938,000
Vadnais Heights – 6 MGD	1	$731,000 ea	$731,000
White Bear Lake – 10 MGD	1	$839,000 ea	$839,000
White Bear Twp – 5 MGD	1	$605,000 ea	$605,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	558,000 sf	$6/sf	$3,348,000
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$153,159,000**
		Contingency (30%)	$45,948,000
		Eng/Admin/Legal (20%)	$30,632,000
		Total Alternative 2B	**$229,739,000**



Path: S:\KO\M\MCES\126394\GIS\Maps\MXDs\06252014\LetterSize\Alternative2B_8x11.mxd

SEH

3535 VADNAIS CENTER DR.
ST. PAUL, MN 55110
PHONE: (651) 490-2000
FAX: (888) 908-8166
TF: (800) 325-2055
www.sehinc.com

Project: MCES 126394
Print Date: 07/22/2014

Map by: AK/SH
Projection: WGS_1984
Source: MnDOT, MnDNR, MnGEO, MCES, SEH.

Alternative 2B - New Surface WTP for Select Northeast Metro Communities

Figure 4-1

4.6 Alternative 2C - New Surface WTP for All Northeast Metro Communities

In Alternative 2C, all of the northeast metro communities will be connected to a new surface WTP in a phased approach. The phasing and major infrastructure improvements necessary for Alternative 2C are described below. For comparison purposes, Alternative 2C phasing is the same as Alternative 1C.

Phase 1 – New surface WTP connected to Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and Shoreview. North St. Paul connected to SPRWS.

- 40 MGD surface WTP constructed

Phase 2 – New surface WTP connected to Hugo, Lino Lakes, and Centerville

- Upgrade SPRWS Fridley raw water pumping station
- Add third 60" conduit to SPRWS raw water conveyance
- 20 MGD Expansion of surface WTP

Phase 3 – New surface WTP connected to Forest Lake, Columbus, Circle Pines, and Lexington

4.6a Alternative 2C Trunk Water Main

The trunk water main proposed as part of Alternative 2C, Phases 1-3, is described in Appendix D and shown on Figure 4-2. The trunk water main in Alternative 2C, Phases 1-3, is sized to serve the entire northeast metro.

4.6b Alternative 2C – Booster Stations

As previously indicated, some of the northeast metro communities operate at higher HGLs than the proposed trunk water main, booster stations will be required for some of the communities. A description of each community's existing infrastructure is included in Appendix A.

4.6c Alternative 2C – Estimated Costs

Tables 4-2, 4-3, and 4-4 summarize the estimated construction costs to connect the entire northeast metro to a new surface WTP in a phased approach.

Table 4-2. Alternate 2C – Phase 1 – New Surface WTP for Vadnais Heights, White Bear Lake, White Bear Township, and Shoreview (North St. Paul to SPRWS) Capital Costs.

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
New 40 MGD Surface Water Treatment Plant	1	$85,000,000	$85,000,000
Water Main			
Open Cut 48" (0% in road)	14,140 ft	$663	$9,375,000
Open Cut 48" DIP (100% in road)	54,180 ft	$1,316	$71,301,000
48" cased, tunneled pipe	900 ft	$4,000	$3,600,000
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$585,000 ea	$585,000
Shoreview – 13 MGD	1	$938,000 ea	$938,000
Vadnais Heights – 6 MGD	1	$731,000 ea	$731,000
White Bear Lake – 10 MGD	1	$839,000 ea	$839,000
White Bear Twp – 5 MGD	1	$605,000 ea	$605,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	558,000 sf	$6/sf	$3,348,000

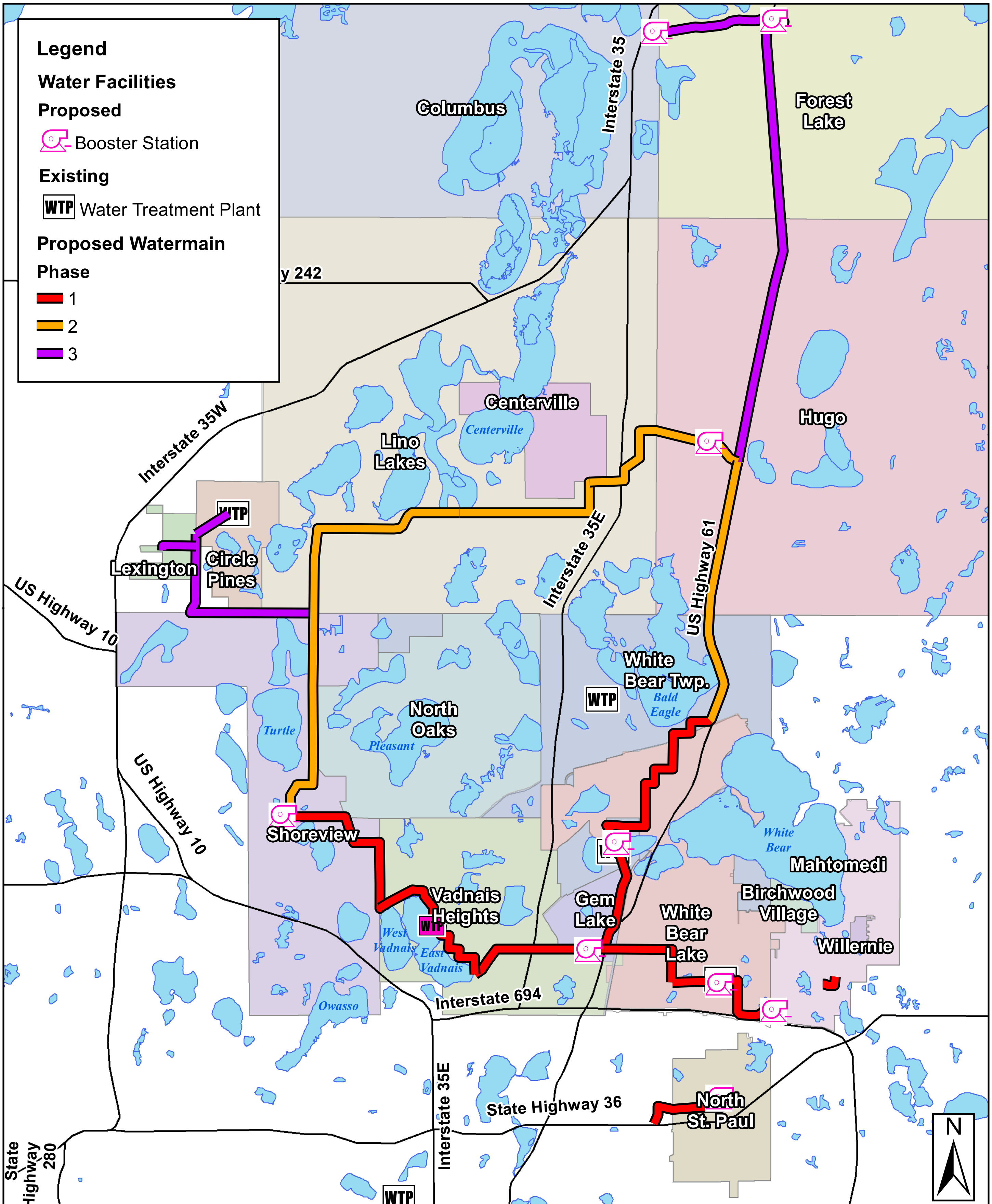
Item	Units	Unit Cost	Total Cost
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$194,174,000**
		Contingency (30%)	$58,252,000
		Eng/Admin/Legal (20%)	$38,835,000
		Total Alt 2C, Phase 1	**$291,261,000**

Table 4-3. Alternate 2C – Phase 2 – New Surface WTP for Hugo, Lino Lakes, and Centerville Capital Costs.

Item	Units	Unit Cost	Total Cost
Fridley Pumping Station Upgrades	1	$10,000,000 ea	$10,000,000
Additional 60" Raw Water Conduit (50% in road)	42,000 ft	$1,196/ft	$50,232,000
20 MGD Lime Softening Water Treatment Plant Expansion	1	$30,000,000 ea	$30,000,000
Water Main			
Open Cut 48" DIP (50% in road)	71,030 ft	$910/ft	$64,637,000
Open Cut 48" DIP (100% in road)	16,000 ft	$1,316/ft	$21,056,000
48" cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Booster Stations			
Hugo – 7 MGD	1	$741,000 ea	$741,000
Easements/Land Acquisition	458,000 sf	$6/sf	$2,748,000
Environmental	24.5 miles	$50,000/mile pipe	$1,225,000
		Subtotal	**$182,240,000**
		Contingency (30%)	$54,672,000
		Eng/Admin/Legal (20%)	$36,448,000
		Total Alt 2C, Phase 2	**$273,360,000**

Table 4-4. Alternate 2C – Phase 3 – New Surface WTP for Forest Lake, Columbus, Circle Pines, and Lexington Capital Costs.

Item	Units	Unit Cost	Total Cost
Water Main			
20" Directionally drilled HDPE (or open cut under trail)	37,900 ft	$400/ft	$15,160,000
12" Directionally drilled HDPE	24,325 ft	$250/ft	$6,081,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
10" Directionally drilled HDPE	9,500 ft	$225/ft	$2,138,000
10" cased, tunneled pipe	250 ft	$900/ft	$225,000
Fusing Pits	121	$15,000 ea	$1,815,000
Booster Stations			
Columbus – 1 MGD	1	$557,000 ea	$557,000
Forest Lake – 5 MGD	1	$724,000 ea	$724,000
Easements/Land Acquisition	403,000 sf	$6/sf	$2,418,000
Environmental	13.7 miles	$50,000/mile pipe	$685,000
		Subtotal	**$30,053,000**
		Contingency (30%)	$9,016,000
		Eng/Admin/Legal (20%)	$6,011,000
		Total Alt 2C, Phase 3	**$45,080,000**



Path: S:\KO\M\MCES\126394\GIS\Maps\MXDs\06252014\LetterSize\Alternative2C_8x11.mxd

SEH
3535 VADNAIS CENTER DR.
ST. PAUL, MN 55110
PHONE: (651) 490-2000
FAX: (888) 908-8166
TF: (800) 325-2055
www.sehinc.com

Project: MCES 126394
Print Date: 07/22/2014

Map by: AK/SH
Projection: WGS_1984
Source: MnDOT, MnDNR, MnGEO, MCES, SEH.

Alternative 2C - New Surface WTP for All Northeast Metro Communities

Figure 4-2

4.7 Cost Summary – Alternatives 2B and 2C

Table 4-5 provides a cost summary of Alternatives 2B and 2C to connect northeast metro communities to a new surface WTP. These represent project cost estimates; including contingencies, engineering, administration, and legal costs in addition to construction costs. Detailed cost tables by alternative and pipe segment are included in Appendix D.

Table 4-5. Costs to Connect Northeast Metro to New Surface WTP.

	Capital Cost
Alternative 2B – New Surface WTP for Select Northeast Metro Communities	**$229,739,000**
Alternative 2C – New Surface WTP for All Northeast Metro Communities	
Phase 1 – New Surface WTP for Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi & Shoreview (North St. Paul connection to SPRWS)	$291,261,000
Phase 2 – New Surface WTP for Hugo, Lino Lakes, and Centerville	$273,360,000
Phase 3 – New Surface WTP for Forest Lake, Columbus, Circle Pines & Lexington	$45,080,000
Total Alternative 2C	**$609,701,000**

4.8 Operations and Maintenance Cost

The O&M costs for various sized lime softening, surface water treatment facilities are included in Table 4-6. These costs do not include O&M costs for distribution systems or booster stations.

Table 4-6. Annual Operation and Maintenance Costs.

WTP Size	Annual O&M
20 MGD	In Progress
40 MGD	In Progress
60 MGD	In Progress

4.9 Booster Station O&M Costs

O&M costs for the booster stations needed to connect northeast metro communities to a new surface WTP were developed based on pumping energy, equipment maintenance, labor costs, building heat, and other miscellaneous costs. The booster station operation and maintenance costs are presented in detail in Appendix D.

4.10 Annual Costs

Annual costs to connect northeast metro communities to a new surface WTP include bond payments on capital infrastructure, repair and replacement on capital infrastructure, cost of raw water from SPRWS ($100 per million gallons), WTP O&M, and booster station O&M. The annual costs for each alternative are included in Table 4-7.

Cost assumptions include:

- 20 year bond, 4% interest
- 1% annual repair and replacement for new water main
- 2% annual repair and replacement for WTP and booster stations
- O&M and repair and replacement for existing northeast metro infrastructure is not included

Table 4-7. Annual Costs for Alternatives to Connect Northeast Metro to a New Surface WTP.

	2040 Annual Water Demand (MG)	Bond Payment	Repair and Replacement	Cost of Raw Water	WTP and Booster Station O&M	Total Annual Cost
Alternative 2B	4,837	$16,905,000	$2,387,000	$484,000	In Progress	In Progress
Alternative 2C						
Phase 1	4,837	$21,431,000	$2,755,000	$484,000	In Progress	In Progress
Phase 2	1,911	$20,114,000	$1,488,000	$191,000	In Progress	In Progress
Phase 3	1,379	$3,317,000	$283,000	$138,000	In Progress	In Progress
Total Alternative 2C	**8,127**					**In Progress**

Chapter 5 - Approach 3 - Lake Augmentation Alternative

5.1 Development of Concept System

Concept Description

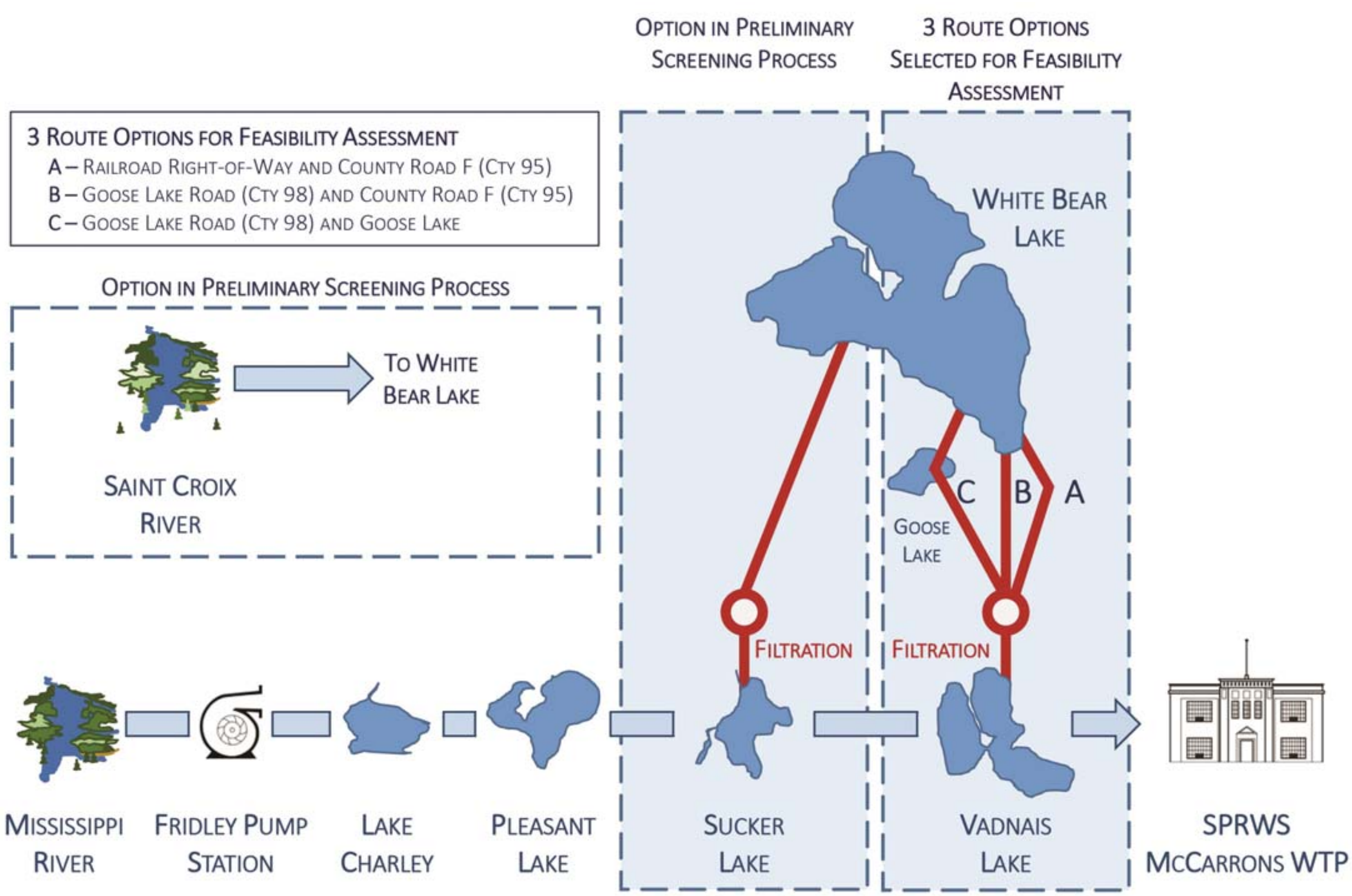
Two raw water sources have been considered for augmentation of water into White Bear Lake: the St. Croix River and the Mississippi River. The following sections of this chapter, as well as Appendices F-K, outline study area characteristics, environmental considerations, water quality considerations, flow projections, alignment characteristics and infrastructure, as well as cost estimates for multiple potential project routes.

Planning Approach

The design of an augmentation system for White Bear Lake took many factors into account. Design was performed with the goals of increasing lake levels, handling maximum flow criteria, attaining maximum efficiency, utilizing gravity flow when possible, and keeping costs at a minimum.

The concept system was developed in two phases, as depicted in Figure 5-1. The preliminary analysis included assessing three options: 1. Augmentation of White Bear Lake using Mississippi River water via Sucker Lake, 2. Augmentation of White Bear Lake using Mississippi River water via Vadnais Lake and 3. Augmentation of White Bear Lake using St. Croix River water. These options were screened to advance the most feasible options for further development.

Figure 5-1. Approach 3 - Lake Augmentation Concept System Options.



Pumping water from the St. Croix River would require construction of 121,000 linear feet of forcemain, with a total head of 324 feet to overcome. As a result, it was determined that the expense of installing such a length of forcemain, as well as purchasing and operating multiple pumps, makes this option less cost effective as well as requires an increased construction duration. In addition, the St. Croix River is a protected waterway and construction of a pump station on its shore would require extensive permitting.

Alignments that considered pumping Mississippi River water (Sucker Lake to White Bear Lake and Vadnais Lake to White Bear Lake) were more comparable in cost and feasibility. However, Vadnais Lake has a higher quality water due to its location at the end of a chain of lakes, as well as an existing lake oxygenation system.

Further analysis showed that pumping Mississippi River water via Vadnais Lake is the most feasible option. Three alignment alternatives have been developed that connect Vadnais Lake to White Bear Lake with a 30-inch High Density Polyethylene (HDPE) forcemain. Each alignment includes a lake intake and filtration structure, 30" HDPE forcemain, as well as an outlet structure for discharge of water into White Bear Lake. These alignments are described in more detail below.

5.2 Study Area Characteristics

White Bear Lake

White Bear Lake (WBL) is located in Washington County, Minnesota. WBL has an area of 2127 acres with a maximum depth of 83 feet. WBL has a record high water level of 926.7 feet as measured in 1943. The record low water level is 918 feet as measured in 2013. The ordinary high water level and outlet elevation is 924 feet. White Bear Lake is used heavily for recreation by a variety of user groups. Further detail regarding study area characteristics are included in Appendix F.

White Bear Lake is part of a chain of lakes that were created by glacial scouring of bedrock and subsequent melting. Groundwater in the water table aquifer flows toward White Bear Lake on all sides except from the northwest corner of the lake, where the flow path is routed northwest. Groundwater within the Prairie du Chien-Jordan aquifer lies at a regional elevation high northeast of White Bear Lake, centered approximately at School Section Lake. Groundwater flows outward from this point, flowing southwest past White Bear Lake. Groundwater within the Franconia Ironton Galesville and Mount Simon-Hinckley aquifers follows similar paths to that in the Prairie du Chien-Jordan aquifer.

5.3 Environmental Considerations

A search of the Minnesota Pollution Control Agency's (MPCA) "What's In My Neighborhood" (WIMN) database was conducted to identify potential environmental concerns related to White Bear Lake augmentation pipeline route alternatives. Environmental database listings indicate environmental conditions which may negatively impact the construction of augmentation pipeline for portions of several route alternatives.

The MPCA's database was searched with a ¼ mile radius from each of the augmentation routes. The descriptions for the environmental conditions, as well as the frequency of occurrence, are summarized in Appendix G.

In addition, an environmental consideration that needs to be accounted for is the presence of invasive species in the Mississippi River water. Zebra mussels of various stages of life grow and reproduce in the Mississippi River, which is considered as a raw water source for augmentation of White Bear Lake. These zebra mussels can cause damage to facilities and infrastructure. It reduces the amount of intake head and incapacitates the system. Zebra mussels will colonize on hard surfaces and are costly to eradicate once populations have been established. The Minnesota DNR restricts the transfer of infested waters from water body to water body unless treatment is provided.

5.4 Water Quality Considerations

White Bear Lake is a moderately clear lake in which nutrient levels (nitrogen and phosphorus) are low. The only indication of anthropogenic influences on WBL is a steady increase in chloride concentrations. Saint Paul Regional Water Services (SPRWS) pumps Mississippi River water to their chain of lakes. The chain of lakes acts as a clarification process for the intake at SPRWS. The turbidity and solids concentrations in the Mississippi River are significantly higher than those in White Bear Lake. Ammonia and Phosphorus levels in the Mississippi River or chain of lakes are not significantly elevated compared to White Bear Lake, and nitrite/nitrate concentrations are slightly elevated in the chain of lakes as compared to White Bear Lake.

If no filtration occurs prior to augmentation, White Bear Lake would likely experience an increase in turbidity and total suspended solids (TSS) concentrations. While the nutrient concentrations in the augmentation water are not elevated to a point of concern, the potential for an increased rate of eutrophication of White Bear Lake is possible. Water quality data for White Bear Lake indicate that the lake is a phosphorus limited system, as is common in Minnesota Lakes. Small additions of the nutrient may cause increases in plant and algae growth, phosphorus should therefore be the focus of management efforts. The effects of the additional nutrient load from augmentation have been simulated with the Wisconsin Lake Modeling Suite (WiLMS) program. The results of the WiLMS, and other water quality details are included in Appendix H. The results indicate that the augmentation water should not have a significant impact on WBL water quality, but should be closely monitored. Based on the screening analysis performed using WiLMS, treatment of the augmentation water will not be necessary. It is likely that phosphorus will be further reduced in the augmentation water during filtration.

5.5 Permitting Requirements

Multiple permits need to be considered for augmentation. They are as follows:

- DNR Invasive Species Permit
- Army Corps 404 for structures
- Wetland Conservation Act
- Public Water Work Permit (DNR)
- Saint Paul Regional Water Reservoir Permit
- MNDOT and County permits for any roadway crossings
- Vadnais Lake Area Water Management Organization (VLAWMO)
- Rice Creek Watershed District (RCWD)
- NPDES and SWPPP
- MCES Crossings permit

In addition, there is a possibility that wetlands may need to be mitigated as part of construction. Utilities are exempt from this mitigation under the Wetlands Conservation Act, however a permit is still required.

5.6 Augmentation Pumping Rate

The augmentation pumping rate was selected based upon practical limitations. As discussed in Chapter 3, SPRWS raw water conduits and Fridley Pumping Station have limited capacity (80 million gallons per day [MGD]). In addition, SPRWS only has approximately 7 billion gallons per year (BG/yr) of excess appropriation from the Mississippi River.

The augmentation flow rate selected is 2 BG/yr pumped over 8 months (approximately 6,000 gallons per minute [gpm] or 8.6 MGD). Augmentation is not anticipated to occur over the winter months due to ice plugging the filters.

If there were no losses (i.e. evaporation, groundwater exchange), a volume of 1 billion gallons would likely raise the level of White Bear Lake by approximately 1.25 feet.

If augmentation were able to raise water levels to the normal high water level (924 feet amsl), maintenance pumping would need to be performed. The rate of maintenance pumping will depend on multiple factors such as inputs and outlets to and from WBL, and will take place over a long-term duration. It is not known if augmenting White Bear Lake by 2 billion gallons per year would cause lake levels to reach 924'.

5.7 White Bear Lake Water Budget

A water budget model of White Bear Lake was created with Microsoft Excel in order to aid in selecting an augmentation flow rate and gauge its potential effects on lake levels. The development of the model's methods were pulled heavily from two previously published works, the DNR's "Lake-Ground

Water Interaction Study at White Bear Lake, Minnesota" report published in 1998, and the USGS's "Groundwater and Surface-Water Interactions Near White Bear Lake, Minnesota, through 2011" report published in 2013. The model was created based on a water balance equation provided in the DNR's 1998 report on historical augmentation of White Bear Lake:

DL = P + RO – SO – E + GWex + PA

DL = change in water level
P = direct precipitation
RO = runoff volume from drainage area
SO = volume of outflow surface outlet
E = evaporation
GWex = groundwater exchange
PA = volume of pumped augmentation

The model generated expected water levels on a monthly basis given over a three year period, starting at the 2012 and 2013 average lake level elevation of 920 feet above mean sea level (amsl) and assuming variable values based on past trends. The above equation was also assessed using the ten year averages of each of the parameters. A description of each variable's estimation, as well as more detailed information on the water budget is provided in Appendix I.

Results of the model should be interpreted with caution, and not used for any purpose other than developing a starting point for assessing the effects of lake augmentation. Table 5-1 summarizes the time required to bring current lake levels up to 924 feet amsl given the varying groundwater exchange scenarios. Assuming augmentation with surface water would result in the same groundwater exchange parameter as augmentation using groundwater in the 1930s did, augmenting by 2 BG/yr, it would take approximately 4.5 years to restore White Bear Lake water levels. If the groundwater exchange parameter is unaffected by surface water augmentation, the same pumping scenario could result in restored lake levels as quickly as 1.9 years.

Table 5-1. White Bear Lake Augmentation Water Budget.

Groundwater Exchange (inches/year)	11	18.5	33
Time to fill with no augmentation (years)	>10 years	continued decrease	continued decrease
Time to fill with 2BG/yr (years)	1.7	1.9	4.5

It should be noted that White Bear Lake was augmented with approximately 2 billion gallons per year of groundwater in the 1930's and the water level never reached an elevation of 923 feet amsl (below current outlet level). There was potential short circuiting due to a connection with the aquifer; however current groundwater pumping rates by cities adjacent to White Bear Lake equal approximately 2 billion gallons per year. It is possible that augmenting White Bear Lake with 2 billion gallons per year of water would cause water levels to rise and reach an equilibrium below the current overflow elevation of 924 feet amsl.

5.8 Concept 1 – Mississippi River Water via Vadnais Lake

Description

Raw water would be pumped from the southeastern shore of Vadnais Lake to augment White Bear Lake. A filtration system would be installed on the shoreline of Vadnais Lake and filtered water would flow through a 30-inch HDPE pipe to an outlet structure located in White Bear Lake. The filtration system will prevent the transfer of zebra mussels from the infested waters of Vadnais Lake and improve the water quality by reduction of solids and nutrients.

System Components

Augmentation of White Bear Lake from Vadnais Lake will require both an intake structure with a filtration facility located in Vadnais Lake and an outlet structure located on the bottom of White Bear Lake (Figure 5-2). The intake and outlet structures would be the same for all of the proposed routes. The intake and outlet structures are described below.

Intake

The intake structure would be constructed approximately 20 feet deep in Vadnais Lake with a filtration housing structure located on-shore. The facility would include the intake structure with intake portals, 30” HDPE intake pipe with concrete armor mat to minimize bottom disturbance, a well pump, primary filters, secondary filters, a magnetic flow meter, an overhead service crane, and a filter house. The intake structure is shown in Appendix J.

Outlet

The outlet structure would be constructed on the bottom of WBL in approximately 15 feet of water. Water will exit the structure at a velocity that ensures complete mixing and protects both fish and plant life. Components of the outlet structure include 6” diameter ports spaced 6 feet apart. There will be three ports on each side of the structure. The structure will be made of 30” capped HDPE with concrete armor mat. Appendix J shows the layout of the structure.

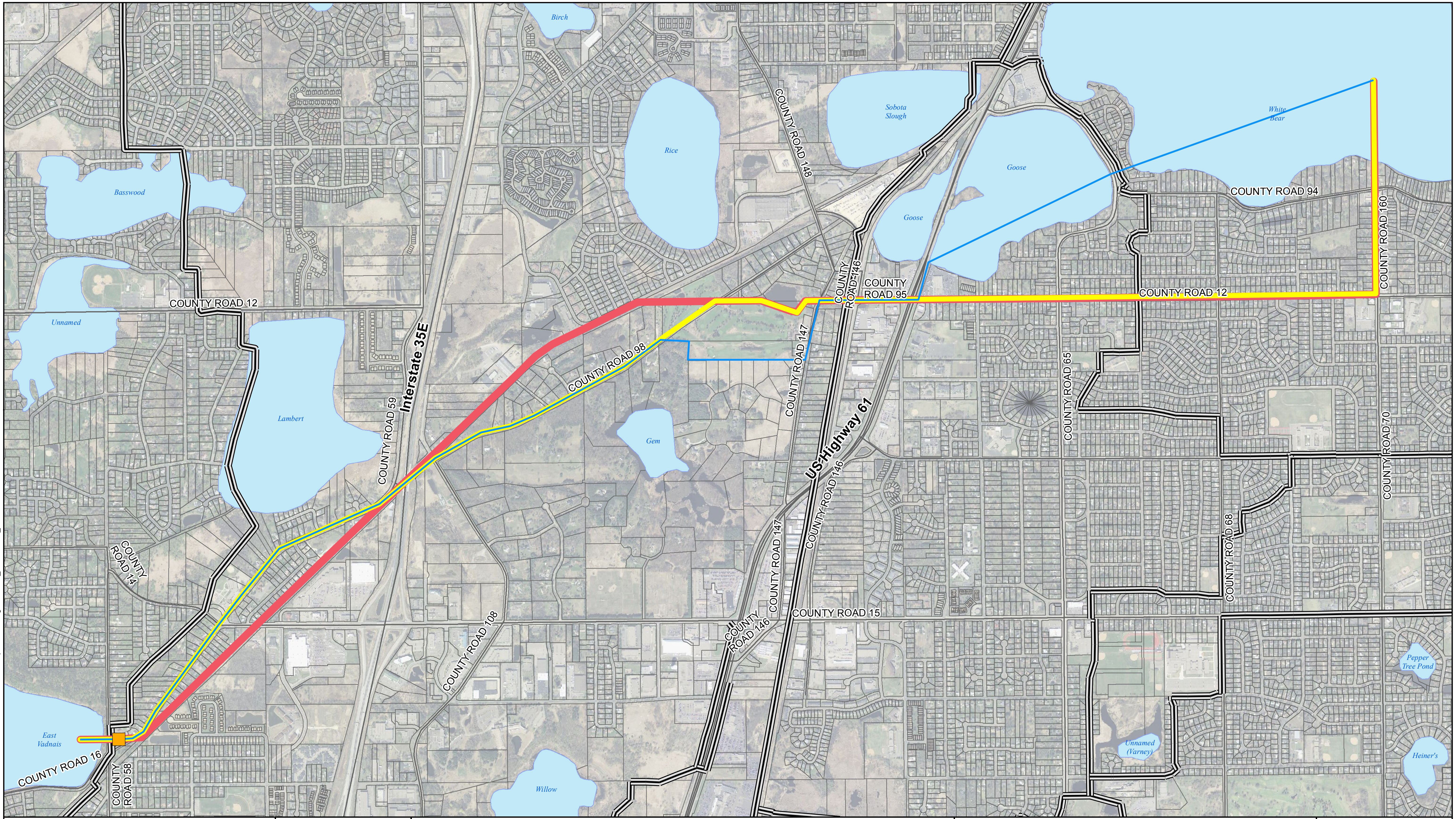
5.9 Route 1A – Vadnais Lake to White Bear Lake via BNSF Railroad Right-of-Way and County Road F (Cty 95)

This route includes pumping water from East Vadnais Lake to White Bear Lake via the Burlington Northern Santa Fe (BNSF) Railroad Right of Way and County Road F (Cty 95). Route description details are shown in Appendix K.

The preliminary costs are listed in Table 5-2.

Table 5-2. Railroad and County Road F Cost Breakdown.

Item	Unit	Unit Cost	Cost
Pumping Station, Intake, Outfall	1	$9,340,000	$9,340,000
Pumping Station Land	4 acres	$435,600/acre	$1,742,000
30” HDPE Forcemain in Road	12,242 ft	$908	$11,116,000
Tunneled Forcemain	600 ft	$2500/ft	$1,500,000
30” HDPE Forcemain in Railroad	11,158 ft	$700/ft	$7,810,000
Steel Casing	11,158 ft	$400/ft	$4,463,000
Railroad Easement	223,160 sf	$3/sf	$670,000
Private Easement	100,000 sf	$6/sf	$600,000
		Subtotal	$37,241,000
		Contingency (20%)	$7,448,000
		Eng/Legal/Adm (20%)	$7,448,000
		Total	**$52,137,000**



Document Path: S:\KO\M\MCES\126394\GIS\Maps\MXDs\Augmentation_Alternatives_11x17.mxd

SEH

3535 VADNAIS CENTER DR.
ST. PAUL, MN 55110
PHONE: (651) 490-2000
FAX: (651) 490-2150
WATTS: 800-325-2055
www.sehinc.com

Project: MCES 126394
Print Date: 04/28/2014

Map by: AK
Projection: MN State Plane South FT

Pump Station
MCES Interceptor

Augmentation Alternative
1-A
1-B
1-C

1,500 750 0 1,500 Feet

Augmentation Alternative

Vadnais Lake to White Bear Lake
1 inch = 1,500 feet

Figure
5-2

5.10 Route 1B – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and County Road F (Cty 95)

This route includes pumping water from East Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and County Road F (Cty 95). The alignment is similar to that outlined in Concept 1A, however, this alignment does not include installing forcemain in the Railroad Right-of-Way. Route description details are shown in Appendix K.

The preliminary costs are listed in Table 5-3.

Table 5-3. Goose Lake Road and County Road F Cost Breakdown.

Item	Unit	Unit Price	Cost
Pumping Facility, Intake, Outfall	1	$9,340,000	$9,340,000
Pumping Station Land	4 acres	$435,600/acre	$1,742,000
30" HDPE Forcemain in Road	24609 ft	$908	$22,345,000
Tunneled Forcemain	600 ft	$2500/ft	$1,500,000
Private Easement	100,000 sf	$6/sf	$600,000
		Subtotal	**$35,527,000**
		Contingency (20%)	$7,105,000
		Eng/Legal/Adm (20%)	$7,105,000
		Total	**$49,737,000**

5.11 Route 1C – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and Goose Lake

Description

This route includes pumping water from East Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) as described above. However, rather than the alignment running through the Gem Lake Hills Golf Course by permanent easement and meeting up with County Road F, this alignment runs south of the golf course, crosses US Highway 61, and then traverses along the bottom of Goose Lake east of US Highway 61 before discharging into White Bear Lake through an outlet structure as detailed in Appendix J. Route description details are shown in Appendix K.

The preliminary costs are listed in Table 5-4.

Table 5-4. Goose Lake Road and Goose Lake Cost Breakdown.

Item	Unit	Unit Price	Cost
Pumping Facility, Intake, Outfall	1	$9,225,000	$9,225,000
Pumping Station Land	4 acres	$435,600/acre	$1,742,000
30" HDPE Forcemain in Road	21,267 ft	$908	$19,310,000
30" HDPE Forcemain in Goose Lake	3,340 ft	$700/ft	$2,338,000
Tunneled Forcemain	300 ft	$2500/ft	$750,000
Private Easement	200,000 sf	$6/sf	$1,200,000
		Subtotal	**$34,565,000**
		Contingency (20%)	$6,913,000
		Eng/Legal/Admin (20%)	$6,913,000
		Total	**$48,391,000**

5.12 Operations and Maintenance

Equipment installed as part of the intake structure would need to be operated and maintained throughout the duration of augmentation. Preliminary costs associated with operations are listed in Table 5-5.

Vertical turbine pumps with vertical high-thrust motors were assumed for the project. Components need to be installed and routinely maintained per manufacturers' instructions.

Finally, an automatic self-cleaning strainer assembly would be used to filter water before it enters White Bear Lake. The strainer should be disassembled for internal inspection annually. The straining element should be checked for mechanical damage or binding. In addition, the straining element should be cleaned thoroughly.

As the filter system is very large and heavy, servicing of the individual components would require the use of an overhead hoisting bridge crane.

Table 5-5. Estimated Augmentation Operation Costs.

Item	Quantity	Unit Cost	Cost/Month	Cost/Year
Energy	720 Hours	$11.19/Hour	$8,056	$64,448
Water	260 MG	$100/MG	$26,000	$208,000
Operator	1 Operator	$50/hour	$2,000	$16,000
Total			$36,056	$288,448
**Yearly costs are based on an 8 month augmentation period*				
**Water use is based on a 6,000 gpm pumping rate*				

5.13 Estimated Costs

The total cost for implementation of an augmentation system from Vadnais Lake to White Bear Lake is estimated to range between $48-$52 million dollars as shown in Table 5-6.

All of the alignments contain the following components with costs that will remain consistent: sitework, screening facility structure, backwash system, and electrical controls. Discrepancies in estimates are resultant from the discrepancies in cost of various permits, linear footage of forcemain, right-of-way acquisition and forcemain casing requirements.

Table 5-6. White Bear Lake Augmentation Cost Estimate Summary – Mississippi River.

Concept	Route Description	Cost
1A	Railroad Right-of-Way and County Road F (Cty 95)	$ 52,137,000
1B	Goose Lake Road (Cty 98) and County Road F (Cty 95)	$ 49,737,000
1C	Goose Lake Road (Cty 98) and Goose Lake	$ 48,391,000

5.14 St. Croix River

The raw water would be pumped from the St. Croix River at the town of Marine on St. Croix. High Density Polyethylene Pipe (HDPE) would be laid along the route as described below. The Marine on St. Croix intake location was selected to minimize elevation differences between the St. Croix River and White Bear Lake.

Pipe would run west from the St. Croix River to meet up with Highway 95. It would bend at this location and run south along Highway 95 until it meets up with Country Road 7. The pipe would then run west on Country Road 7 until it meets up with Country Road 71 and bends south. The pipe would then cross Lake Avenue and discharge into White Bear Lake. This alignment for the pipe is shown on Figure 5-3. Route description details are shown in Appendix K.

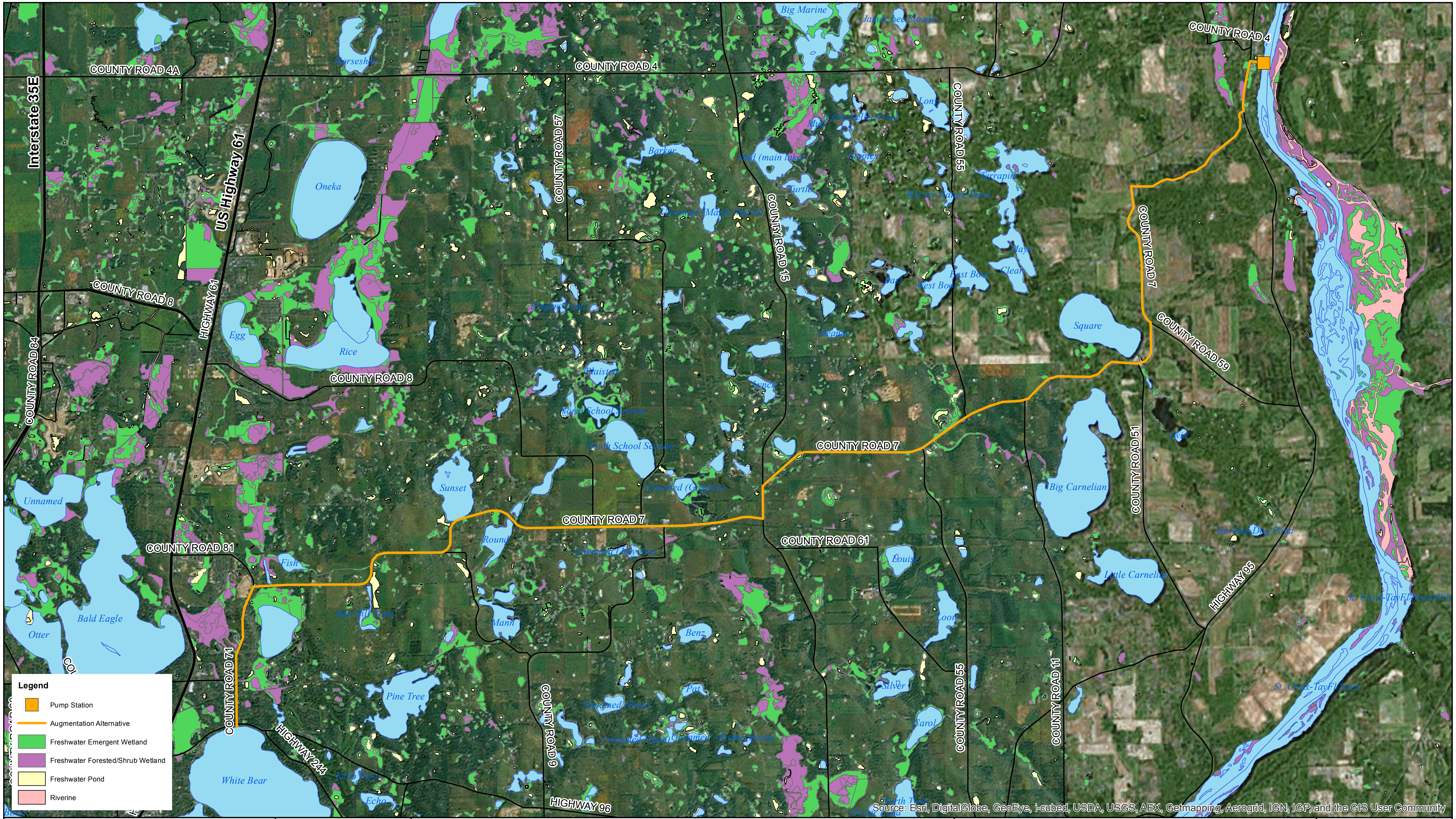
The total cost for implementation of an augmentation system from the St. Croix River to White Bear Lake is estimated to be nearly $120 million. This alternative is estimated to be significantly higher primarily due to the increase in linear footage of forcemain. Pumping water from Vadnais Lake will require approximately 23,000-25,000 LF of forcemain, while pumping water from the St. Croix River will require approximately 121,000 LF of forcemain.

There are some existing road projects that would allow for a lower per foot cost for the installation of forcemain along the Concept 2 alignment, however, it is not enough to make up for the cost difference resultant from the increased linear footage of pipe.

In addition, there is a much greater head to overcome during pumping with this alignment. The costs of pumps as well as electricity required to perform the pumping will increase costs by approximately 60 percent.

Table 5-7. White Bear Lake Augmentation Cost Estimate Summary - St. Croix River.

Item	Units	Unit Cost	Cost
Pump Station, Intake, Outfall	1	$12,500,000 ea	$12,500,000
30” HDPE Forcemain (50% in road)	121,000 ft	$575	$ 69,575,000
Private Easement	200,000 sf	$6/sf	$1,200,000
		Subtotal	**$83,275,000**
		Contingency (20%)	$16,655,000
		Eng/Legal/Adm (20%)	$16,655,000
		Total	**$116,585,000**



SEH

3535 VADNAIS CENTER DR.
ST. PAUL, MN 55110
PHONE: (651) 490-2000
FAX: (651) 490-2150
WATTS: 800-325-2055
www.sehinc.com

Project: MCES 126394
Print Date: 07/22/2014

Map by: AK
Projection: NAD_1983_HARN_StatePlane_Minnesota_South_FIPS_2203_Feet
Source: MnGeo, SEH, Ramsey County

0 3,500 7,000 14,000 21,000 28,000 Feet

N

Augmentation Alternative

Raw Water Source: St. Croix River

White Bear Lake, Minnesota

Figure 5-3

5.15 Summary

Results of the preliminary feasibility analysis show that Concept 1C, Goose Lake Road (Cty 98) and Goose Lake, is the most cost effective alignment with an estimated cost of $ 48,391,000. Special consideration will need to be taken for construction of forcemain on the bottom of Goose Lake. Necessary permits will need to be acquired from the DNR and other agencies as summarized in Section 5.5.

The augmentation pumping facilities were sized for 6,000 gpm. The intake structure would be located approximately 20 feet deep in Vadnais Lake. It would flow through a filtration system before entering White Bear Lake, and exit through an outlet structure with 6” diameter portals.

Chemical treatment of the augmentation water is not expected to be necessary. It is likely that phosphorus will be further reduced in the augmentation water during filtration. Invasive species will be eliminated from the Mississippi River water during filtration. While the temperature in the augmentation water is slightly higher than that of White Bear Lake, significant impacts are not expected.

Further investigation is required before any alignment can be selected for construction. Utility locates, geotechnical exploration, right-of-ways, easements, permitting, constructability, and community consent will all need to be considered.

Chapter 6 – Summary of Findings and Implementation Considerations

6.1 Connecting Northeast Metro to SPRWS (Approach 1)

The feasibility of connecting northeast metro communities to SPWRS was evaluated. Key findings are as follows:

- The SPRWS raw water main and pumping capacity are essentially at capacity with existing SPRWS maximum day demands (approximately 80 MGD); however, significant storage exists in the chain of lakes (3.5 BG) to provide additional water to the northeast metro.
- The SPRWS McCarrons Water Treatment Plant currently has approximately 30 MGD of excess capacity.
- The six communities nearest to the SPRWS system (Shoreview, Vadnais Heights, White Bear Lake, White Bear Township, Mahtomedi, and North Saint Paul) could be served by SPRWS without expanding its major water treatment facility or improving its raw water delivery system to the plant. To expand service beyond these six communities, additional large-scale infrastructure improvements would be needed. This would significantly increase the capital costs of the system.
- The SPRWS Hazel Park pressure zone which is adjacent to North Saint Paul and White Bear Lake has limited capacity to provide water to the northeast metro. Only North Saint Paul can be served from the Hazel Park pressure zone without large-scale infrastructure improvements.
- A new trunk water main that connects to the SPRWS McCarrons Water Treatment Plant is necessary to bring water to the majority of the northeast metro.

A cost summary to connect the northeast metro to SPRWS is included in Table 6-1.

Table 6-1. Costs to Connect Northeast Metro Communities to SPRWS.

	Annual Groundwater Offset (Millions of Gallons)	Capital Cost[1,2]	Annual Operations & Maintenance Cost for Water Service
Alternative 1A – Saint Paul Connection to North Saint Paul	**500**	**$5,191,000**	**$1,257,800**
Alternative 1B – Saint Paul Connection to Select NE Metro Communities *(Mahtomedi, North Saint Paul, Shoreview, Vadnais Heights, White Bear Lake, White Bear Township)*	**4,800**	**$155,363,000**	**$10,088,000**
Alternative 1C – Saint Paul Connection to All NE Metro Communities			
Phase 1		*$246,556,000*	
Phase 2		*$329,416,000*	
Phase 3		*$47,206,000*	
Total Alternative 1C	**8,100**	**$623,178,000**	**$18,018,000**

1 Based on April 2014; no escalation to date of construction.
2 Capital cost estimates for Approach 1 include distribution facilities. Alternative 1C also includes improvements to the McCarrons water treatment plant and the raw water delivery system from the Mississippi River.

As Table 6-1 indicates, Alternative 1A, which would bring water from SPRWS to North Saint Paul, has the lowest cost of the alternatives considered. This is due to North Saint Paul's proximity to SPRWS and relatively little infrastructure being necessary to implement the alternative.

Alternative 1B and Alternative 1C – Phase 1 connect the same select northeast metro communities to SPRWS, with the difference being that Alternative 1C infrastructure is sized to ultimately connect all northeast metro communities. The cost difference is primarily due to larger pipes in Alternative 1C requiring different construction methods (directional drilling versus open cut in roads).

The large jump in cost for a relatively small increase in system capacity between Alternative 1C – Phase 1 and Phase 2 is due in part to capacity improvements needed to the SPRWS raw water conveyance system and an expansion of capacity at the McCarrons Water Treatment Plant. The analysis assumes SPRWS will pass on the bond debt service costs similar to the costs for water infrastructure owned by others.

6.2 New Surface Water Treatment Plant (Approach 2)

The feasibility of constructing a new WTP with a surface water source was evaluated. Key findings are as follows:

- SPRWS owns land on Vadnais Lake, the final lake in the SPRWS chain of lakes, which could serve as a location for a new water treatment plant.
- The water quality in Vadnais Lake is better than the Mississippi River due to chemical treatment, oxygen being added, and settling of solids. Preliminary screening of plant sites based on water quality and location resulted in the identification of Vadnais Lake as the preferred site for a new water treatment plant at this concept level.

A cost summary to connect the northeast metro communities to a new water treatment plant (WTP) is included in Table 6-2.

Table 6-2. Costs to Connect Northeast Metro to New Surface WTP

	Annual Groundwater Offset (Millions of Gallons)	Capital Cost[1]	Annual Operations & Maintenance Cost for Water Service
Alternative 2B – New Surface WTP for Select NE Metro Communities *(Mahtomedi, North Saint Paul, Shoreview, Vadnais Heights, White Bear Lake, White Bear Township)*	**4,800**	**$229,739,000**	*In Progress*
Alternative 2C – New Surface WTP for All NE Metro Communities			
Phase 1		*$291,261,000*	
Phase 2		*$273,360,000*	
Phase 3		*$45,080,000*	
Total Alternative 2C	**8,100**	**$609,701,000**	*In Progress*

[1] Based on April 2014; no escalation to date of construction.

Alternative 2B and Alternative 2C – Phase 1 connect the same select northeast metro communities to a new water treatment plant, with the difference being that Alternative 2C infrastructure is sized to ultimately connect all northeast metro communities. The cost difference is primarily due to larger pipes in Alternative 2C requiring different construction methods (directional drilling versus open cut in roads).

The large jump in cost for a relatively small increase in system capacity between Alternative 2C – Phase 1 and Phase 2 is due in part to capacity improvements needed to the SPRWS raw water conveyance system.

6.3 Direct Augmentation of White Bear Lake (Approach 3)

The feasibility of augmenting White Bear Lake water levels with water from the Mississippi River and St. Croix River was evaluated. Key findings are as follows:

- The St. Croix River is significantly further away and has significantly higher pumping pressure required than water from the Mississippi River for augmentation. The potential route identified for the pipeline from the St. Croix River is approximately 23 miles. This compares to 4 – 5 miles for the options that evaluated service from Vadnais Lake. The pumping head needed to pump from the St. Croix River is calculated to be 324 feet, compared to 70 feet in pumping head needed to transfer water from Vadnais Lake to White Bear Lake. In addition, the St. Croix River is a National Scenic Riverway, making construction in or near the river difficult from a regulatory standpoint.

- The Mississippi River is impaired with zebra mussels, as is Vadnais Lake. Augmentation from this source will require filtration.
- With filtration, augmentation with water from Vadnais Lake is not anticipated to degrade White Bear Lake water quality. The primary concerns based on analysis of water quality differences between Vadnais Lake and White Bear Lake are increased eutrophication, turbidity, and total coliform levels. The water from Vadnais Lake has significantly higher nitrate levels than White Bear Lake. However, White Bear Lake is a phosphorous-limited lake, and modeling indicates that augmentation should not increase phosphorous levels in the lake. Turbidity and total coliform levels could both be reduced to acceptable levels through a properly-designed filtration system.
- SPRWS has sufficient capacity to draw and convey 2 billion gallons of water annually (2 BG/yr) for augmentation.
- It is not certain if augmentation of 2 BG/yr will maintain the water level of White Bear Lake to the ordinary high water level.
- It is unlikely that augmenting White Bear Lake will provide benefit to other lakes or to the regional groundwater aquifers.

Table 6-3 shows a cost summary for augmenting White Bear Lake.

Table 6-3. Costs for Augmenting White Bear Lake

	Capital Cost[1]	Annual Operations & Maintenance Cost
White Bear Lake Augmentation System (2 Billion Gallons per Year)	**$50,000,000**	**$300,000**

[1] Based on April 2014; no escalation to date of construction.

6.4 No Change Approach

The costs to convert northeast metro public water supplies from groundwater sources to a surface water source are significant. There are, however, costs and potential environmental impacts that are inherent in continuing on the current path of relying on groundwater. The costs that need to be considered include infrastructure that would need to be constructed and operated over the same planning horizon to provide drinking water sourced from groundwater. These costs include new treatment facilities and expansion of existing treatment facilities, and new groundwater supply wells.

Several northeast metro groundwater-related capital projects are known to be planned or will be needed in the future, including:

- A new groundwater treatment plant in Shoreview in 2015 (estimated cost $10,000,000)
- A new groundwater treatment plant in Lino Lakes in approximately 2020 (estimated cost $20,000,000)
- New wells in Hugo and possibly Lino Lakes
- Water treatment plant maintenance, rehabilitation, and upgrade costs in White Bear Lake, White Bear Township, Circle Pines, and Forest Lake

In addition to capital and operational costs there is potential for continued and increased groundwater use to exacerbate the impact to surface water bodies in the area (lakes and trout streams) as a result of lower aquifer water levels.

A more complete analysis of the costs and impacts to be expected with continued use of groundwater is underway at the time of this draft report. This information will be included in the final report to be completed in fall 2014.

6.5 Conjunctive Use of Groundwater and Surface Water

The potential for use of both groundwater and surface water within a single water system (conjunctive use) was evaluated as part of this study. Conjunctive use could allow for surface water facilities to be sized for only part of a communities water demand, with the remainder of the demand being taken up by local groundwater facilities. This could have several benefits, including:

- Reducing capital costs of a surface water delivery system
- Increasing reliability of supplies by actively maintaining groundwater supply and treatment systems
- Offering flexibility for utilities and regional water resource planners and regulators to limit water use from a particular source as needed to protect the resource or protect public health.

There are also potential drawbacks to conjunctive use:

- Higher operational costs of maintaining both surface water and groundwater systems (some duplication of services)
- Potential water chemistry issues if two water sources with different chemical properties are mixed in an uncontrolled environment as could occur within a water distribution system

The feasibility of utilizing treated surface water for the base drinking water supply and using groundwater for peaking or emergency use was evaluated for the northeast metro. The conjunctive use of groundwater and surface water appears to be feasible. If conjunctive use of groundwater and surface water were implemented, modifications would likely be needed to some systems' disinfection methods in order to make them compatible with the surface water disinfection system. For example, Saint Paul Regional Water Services uses a chloramine disinfectant, which is common for surface water systems. All of the groundwater systems in the northeast metro use a free chlorine disinfectant. Based on the preliminary analysis presented in Appendix B, the mixing of waters disinfected with chloramine and free chlorine is not recommended.

Because the water source could change between surface water and groundwater in a conjunctive use system, the taste and odor qualities of the water would also change. Changing taste and odor of drinking water is a common source of complaints for water utilities. This would likely require an education campaign to maintain customers' confidence in the safety of their water. In addition, the solution chemistry for lead, copper, and iron would change with a switch to surface water and these constituents would need to be monitored.

A more complete analysis of the conjunctive use of groundwater and surface water is ongoing at the time of this draft report. The results will be included in the final report to be completed in fall 2014.

6.6 Cost Sharing, Financing, and Ownership Models

Because the costs would be high to develop a surface water source for water supply to northeast metro communities, implementation is not likely to occur without incentive, and a mechanism to share the costs amongst a broad range of beneficiaries. The motivation for the reduction in groundwater use is regional in nature – to protect natural resources from the cumulative effects of groundwater use throughout the aquifer. Therefore, it is unlikely that a single community or a small subset of communities could or should bear the cost of such a change in behavior. An analysis of rate impacts to each community is underway at the time of this draft report, and will be presented with the final report in fall 2014. This analysis will consider cost sharing from two perspectives:

- A scenario where only the communities served by the hypothetical surface water system would pay for the system. This scenario will consider the cost impacts to those communities, and also the degree of outside funding that would be necessary to bring the costs to the individual communities in line with other water systems in the region.

- A scenario where the costs are shared amongst all of the communities in the DNR North and East Metro Groundwater Management Area. In this case, the model for ownership and cost sharing will include the creation of a district that would own and operate the surface water delivery system, with fees paid by all communities within the Groundwater Management Area to promote equity amongst users of the groundwater resource.

Fortunately, there are many examples of similar cost sharing arrangements for water supply across the country. The Metropolitan Council has collected information on case studies as part of our ongoing study, "Regional Feasibility of Alternative Approaches to Water Sustainability," which is also to be completed in fall 2014. This study, being conducted by HDR Engineering on behalf of the Metropolitan Council, has reviewed three regional water system cost-sharing models. The cost sharing models included the San Jacinto River Authority, Conroe, Texas; West Harris County Regional Water Authority, Houston, Texas; and Woodland-Davis Clean Water Agency, Woodland and Davis, California. The cost-sharing models are summarized below.

San Jacinto River Authority, Conroe, Texas

The San Jacinto River Authority, Conroe, Texas (SJRA) watershed includes approximately 3,200 square miles of land north of the City of Houston. In 2001, the Lone Star Groundwater Conservation District (LSGCD) was created to help Montgomery County manage its dependence on the Gulf Coast Aquifer. The LSGCD studied the aquifer and confirmed that the water levels were declining at an unsustainable rate. The LSGCD calculated the amount of water that the aquifer could yield on a sustainable basis.

To address deficit pumping, the LSGCD required all large-volume groundwater users (LVGUs) to reduce groundwater pumping by 30 percent. In response to this directive, the SJRA created the Groundwater Reduction Plan Division (GRP) to implement a county-wide program to meet the requirements of the LSGCD.

Participation in the GRP was opened to all of the LVGUs that included approximately 200 cities, utilities, and other water users. Of these, 140 water systems joined the GRP. By joining the GRP, the participants are able to achieve cost savings by utilizing a "group compliance" concept in which some of the participants are converted to surface water while other participants continued to use groundwater, while meeting the overall groundwater reduction goal of 30 percent. Cost, proximity to surface water, and demands were used to determine which participants would be converted to surface water. Any LVGUs that did not join the GRP were still required to meet the 30 percent groundwater reduction goal.

The SJRA issued approximately $552 million in bonds between 2009 and 2013 to construct Phase 1 of the project, which included building a surface water treatment plant and transmission system.

One of the challenges in implementing the groundwater reduction plan was defining a rate system that balanced costs between participants, including those that would continue to rely solely on groundwater and those that would be converted to surface water. To balance revenue between the two groups, a groundwater pumpage fee and a surface water rate were calculated. The groundwater pumpage fee and surface water rate developed are $2.25 and $2.44 per 1,000 gallons, respectively.

West Harris County Regional Water Authority, Houston, Texas

In the early 1940s, studies of the Houston/Galveston area located in southeast Texas showed increasing problems due to groundwater extraction from the Chico and Evangeline aquifers causing land subsidence (sinking). In 1975, the Harris Galveston Subsidence District (HGSD) was created to address the impacts of groundwater pumping on land subsidence. In response to the regulatory plans of the HGSD, the West Harris County Regional Water Authority (Authority) was created to transition the area to surface water within a set timeframe.

There are currently 120 municipal water providers within the boundary of the Authority which is managed by a nine-member Board of Directors. The Authority's Groundwater Reduction Plan (GRP) requirements include a 30 percent reduction in groundwater use in 2010, a 60 percent reduction by 2025, and an 80 percent reduction by 2035.

The initial phase of the plan included negotiating a long-term contract with the City of Houston and the construction of numerous transmission projects to supply treated surface water to utility districts within the GRP.

Like SJRA, the Authority has developed a similar rate structure where all water users within the area will pay a share of the costs to build and maintain water delivery infrastructure and for the supply of surface water from the City of Houston system. As of 2014, the groundwater and surface water rates charged to the water providers are $1.90/1,000 gallons and $2.30/1,000 gallons, respectively.

Woodland-Davis Clean Water Agency, Woodland and Davis, California

In September 2009, the neighboring cities of Woodland and Davis, California created the Woodland-Davis Clean Water Agency (WDCWA), a joint powers authority to implement and oversee a regional surface water supply project. Both cities have been dealing with water supply and wastewater discharge issue related to degrading groundwater quality and concluded that a jointly-owned and operated surface water system was the best overall solution.

The Cities of Woodland and Davis have depended on groundwater for water supply since the 1950's. Over time, the quality of the groundwater has declined to the point where the water supply system will not be able to meet state and federal drinking water standards, and the wastewater will not meet anticipated discharge regulations.

The cities identified two possible solutions to address the water quality issues, including developing a higher quality water supply or installing a new wastewater treatment process. It was determined that building a new surface water treatment plant was the most cost effective solution. The system, which will be put into service in 2016, will provide treated surface water from the Sacramento River to the Cities through dedicated service lines. The total capital cost estimate for the project is $228 million. According to the joint powers agreement, the costs to cover the debt service and O&M costs will be divided between the cities based on demand.

Chapter 7 - Evaluation of Alternatives

In addition to capital and annual operation and maintenance costs, each alternative has other impacts and potential benefits. The work of evaluating these alternatives is ongoing, and will be completed for the final report.

When considering the costs presented in this draft report, keep in mind the the following key points, which will be developed more fully in the evaluation process of the final report:

- The benefits of augmenting White Bear Lake with river water are uncertain. The ongoing study of lake–groundwater interaction in the northeast metro by the USGS will provide additional information that may help to evaluate the long-term benefits to the lake and the aquifer.
- Using groundwater flow modeling, we are evaluating the benefits of eliminating some groundwater pumping by connecting some community water supplies to surface water sources. Preliminary results indicate that an increase in aquifer levels around White Bear Lake can be expected as communities in the study area reduce groundwater pumping. This analysis will be important as we evaluate the alternative approaches.
- Bringing a surface water supply source to some communities in the study area would contribute to greater long-term reliability of water supplies in the region by providing greater diversity of sources in the area.

The following criteria have been developed to evaluate the alternatives in this report:

- Benefit to groundwater systems
- Benefit to surface water features
- Capital cost
- Operations and maintenance costs
- Regional reliability of water supply
- Ease of implementation (including time to implement, institutional barriers, funding availability, etc.)
- Potential impact on user rates

This study evaluates two approaches to reduce the reliance of the northeast metro communities on groundwater for their drinking water supply. These approaches include providing treated surface water from SPRWS (Approach 1), and building a new surface water treatment plant to serve the northeast metro (Approach 2). Both options utilize the Mississippi River via the SPRWS raw water source at Vadnais Lake. Various scale alternatives were evaluated in each approach to determine the most cost-effective solutions.

In addition, the feasibility of augmenting White Bear Lake with river water to restore lake water levels is evaluated (Approach 3). This approach was evaluated for its feasibility to address lower lake levels in White Bear Lake specifically. Based on the preliminary findings of the ongoing study by the USGS to assess the interaction of groundwater and surface water bodies in the northeast metro, it appears that there are other lakes in the area that exhibit a correlation between lake levels and reduced groundwater levels in the aquifers, similar to White Bear Lake. Scientific understanding of these hydraulic relationships between surface water bodies and groundwater are currently limited. Directly augmenting White Bear Lake will likely not have a significant impact on regional aquifer levels or other lakes. This needs to be accounted for in the side-by-side comparison of the three approaches considered in this study.

Appendix A: Study Area Existing Water Infrastructure

Appendix A: Study Area Existing Water Infrastructure

Information Acquisition

Several sources of information were used to compile the community existing water infrastructure summaries:

- Municipal well water usage from 2010 was provided by the MnDNR's "Water Appropriations Permits Program" website. Groundwater wells withdrawing over 10,000 gallons per day (GPD) or 1 million gallons per year (MGY) require an appropriation permit issued by the MnDNR. Multiple wells can be assigned to one permit, and their cumulative withdrawals may not exceed the volume or pumping rate limitation set by the permit. Individual well information is also included in the MnDNR's dataset, including well depth, the aquifer it is cased in, installation ID number, well usage, and in some cases well location. It is important to note that municipal wells do not serve the entire population within each of the study area communities. Many private wells exist throughout the area, therefore municipal usage is only a subset of the total water usage in the area. The 2010 population numbers that accompany the 2010 municipal water usage data are from the 2010 US Census.
- Projected demands in 2040 were provided by Metropolitan Council. These demands are based on historical per capita use for each city and projected city populations served by municipal systems. This data differs from the 2010 MnDNR data because it is the estimated water usage for the entire population within the study area communities, not just municipal water system customers.
- Information on infrastructure in each of the study area communities was taken from City Comprehensive Plans as well as GIS files when possible. Each City's Comprehensive plan dated back to 2008, and at that time detailed existing wells and water storage and treatment facilities. GIS files of existing watermain were not available for Circle Pines and Forest Lake. This information was supplemented with Minnesota Department of Health (MDH) Public Water Supply Inventory reports from 2012. Information was verified through meetings with City staff when possible.
- Water rate structure information was provided to SEH by each study area community. Information was verified through meetings with City staff when possible.

A.1 Centerville

Centerville is located in the middle of the study area, bordered on all sides by Lino Lakes. Municipal water use in 2010 accounted for approximately 2% of municipal use in the northeast metro. Centerville's projected 2040 water demand is a 96% increase from 2010 usage, and exceeds current groundwater appropriations.

Table A-1. Summary of Water Demand Data for Centerville.

Year	2010	2040
Population	3792	4600
Annual Water Usage (MG)	96	187
Average Daily Demand (MGD)	0.26	0.51
Peak Daily Demand (MGD)	0.68	1.32
% of Total Northeast Metro Demand	2%	2%

Water Supply

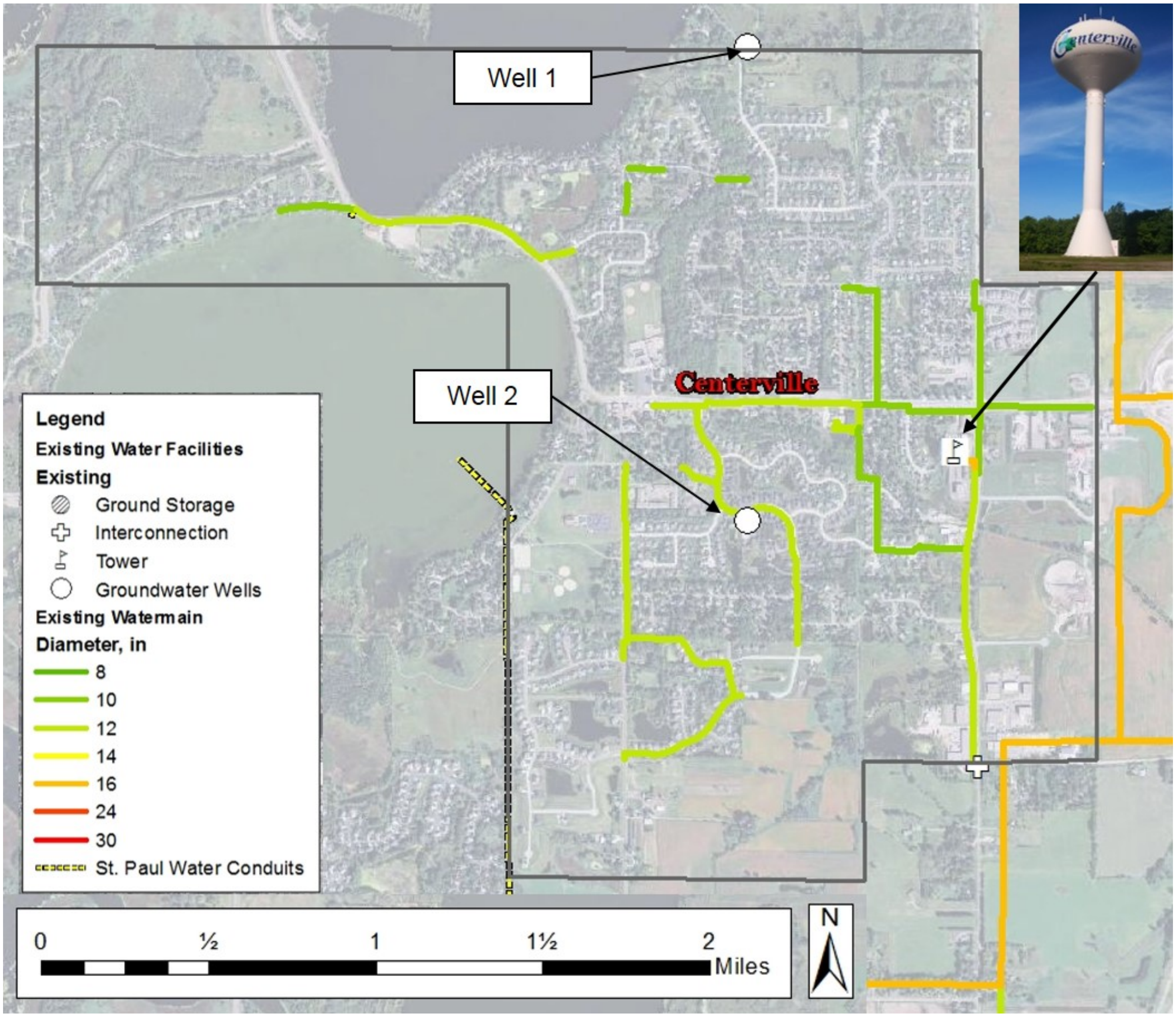
Centerville's municipal water system obtains its drinking water from two Prairie du Chien-Jordan wells (see Table 2.3). These wells have a joint MnDNR appropriation to pump up to 108 MGY. This allotted supply is exceeded by projected 2040 demands. Centerville's peak daily water demand to average demand ratio is 2.6:1, an average value indicating excessive water use for nonessential needs is not likely an issue in the community.

Table A-2. High-Capacity Well Summary Data for Centerville.

Permit No.	Well ID	Installation ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use, MG	Appropriation MGY
1991-6246	511091	1	CENTERVILLE, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	267	92.4	108
1991-6246	512748	2	CENTERVILLE, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	187	0.3	108

Water Infrastructure
Centerville has a 0.5 MG water tower, which is operated at an overflow elevation of 1,054 feet. The whole city lies within one pressure zone. One emergency connection exists tying Centerville to Lino Lakes.

Figure A-1. Centerville's Existing Water Infrastructure.



Water Treatment
Centerville's water is treated in-well with the addition of chlorine, fluoride, and polyphosphate.

Water Rates
Per capita average use currently results in an annual residential water bill of approximately $144.

A.2 Circle Pines

Circle Pines is located on the west side of the northeast metro, bordered by Lino Lakes, Shoreview, and Lexington. Similar to Centerville, Circle Pines accounts for a very small percentage of current water demand in the study area. Unlike Centerville, Circle Pines' 2040 water demand projection indicates only an 8% increase from 2010 water usage. This growth rate is the lowest in the northeast metro. 2040 demand could be met current groundwater appropriations.

Table A-3. Summary of Water Demand Data for Circle Pines.

Year	2010	2040
Population	4918	5860
Annual Water Usage (MG)	157	170
Average Daily Demand (MGD)	0.43	0.46
Peak Daily Demand (MGD)	1.40	1.52
% of Total Northeast Metro Demand	3%	2%

Water Supply

Circle Pines obtains its drinking water from two wells, for which it has a joint appropriation of 200 MGY. A third municipal well, City Well 1, was decommissioned sometime before 1988. One non-municipal high capacity well used for landscaping has an appropriation of 4 MGY. Water usage in the city has shown a slight downward trend since 2007, and 2040 demand is expected to be met by current appropriations. The peak to average ratio in Circle Pines is somewhat high at 3.3:1, indicating significant water use for nonessential needs.

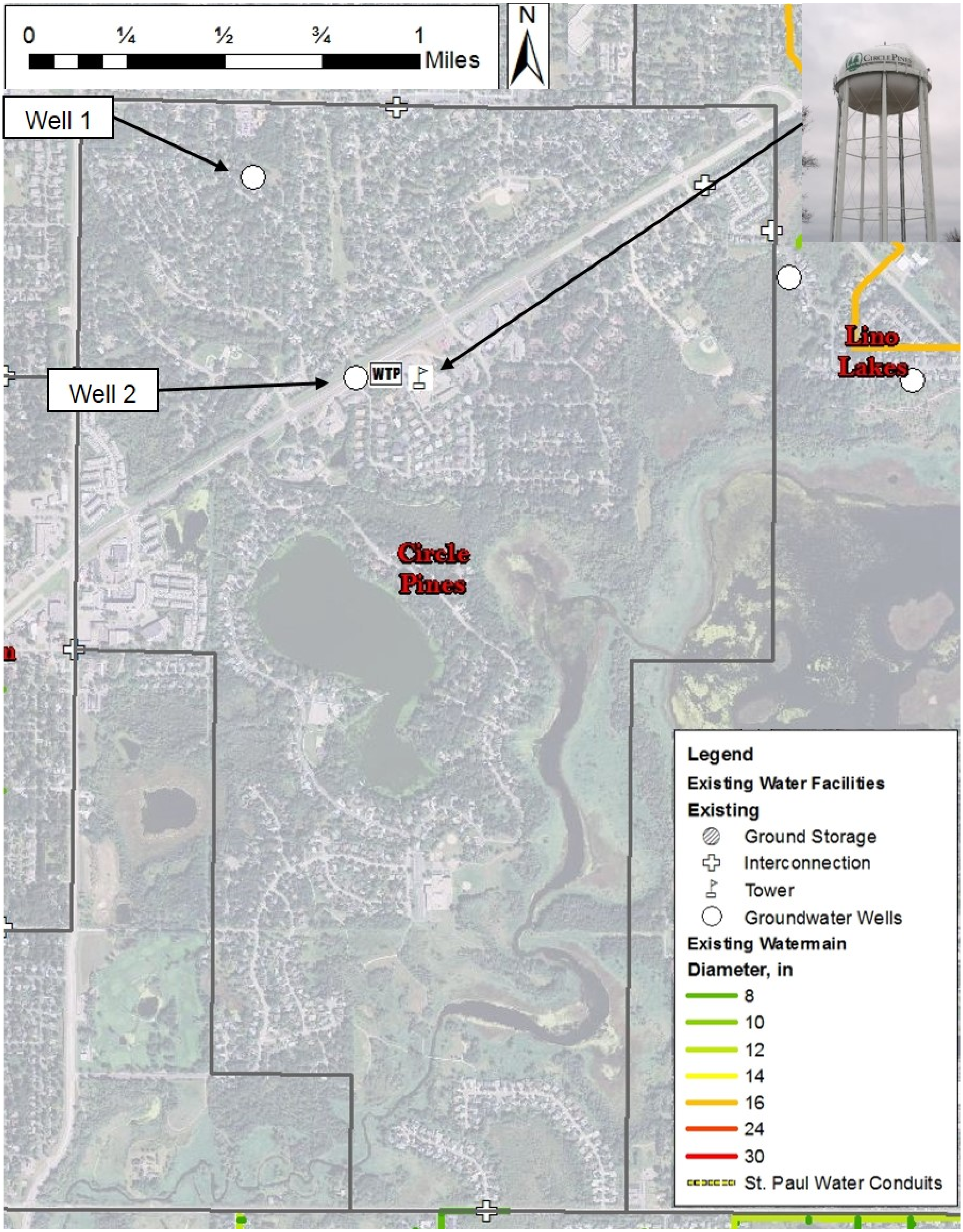
Table A-4. High-Capacity Well Summary Data for Circle Pines.

Permit No.	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
1959-0782	208995	1	CIRCLE PINES, CITY OF	Municipal Waterworks	Quaternary Buried Artesian Aquifer	321	0.0	200
1959-0782	208637	2	CIRCLE PINES, CITY OF	Municipal Waterworks	Franconia	507	66.6	200
1959-0782	208636	3	CIRCLE PINES, CITY OF	Municipal Waterworks	Jordan-St Lawrence	270	87.7	200
2010-0576	NA	1	CIRCLE PINES, CITY OF	Landscaping/ Athletic Fields	NA	NA	0.1	4

Water Infrastructure

One water tower provides Circle Pines with 0.5 MG of storage, which serves the City at 1,054 feet of overflow elevation. Emergency interconnects tie Circle Pines to Lino Lakes, Shoreview, Lexington, and Blaine.

Figure A-2. Circle Pines' Existing Water Infrastructure.



Water Treatment
Groundwater treatment is accomplished via a 1,400 GPM water treatment plant, which provides chlorination, fluoridation, and iron and manganese removal.

Water Rates
Per capita average use in Circle Pines currently results in an annual residential bill of approximately $243.

A.3 Columbus

Columbus is one of the two northernmost cities in the study area, along with Forest Lake. Columbus had the lowest 2010 water usage in the study area, at about 0.3% of the total study area demand. However, it has the highest water demand growth rate in the northeast metro between 2010 and 2040, at approximately 645%.

Table A-5. Summary of Water Demand Data for Columbus.

Year	2010	2040
Population	3914	1576
Annual Water Usage (MG)	16	121
Average Daily Demand (MGD)	0.04	0.33
Peak Daily Demand (MGD)	0.11	0.83
% of Total Northeast Metro Demand	0.3%	1%

Water Supply

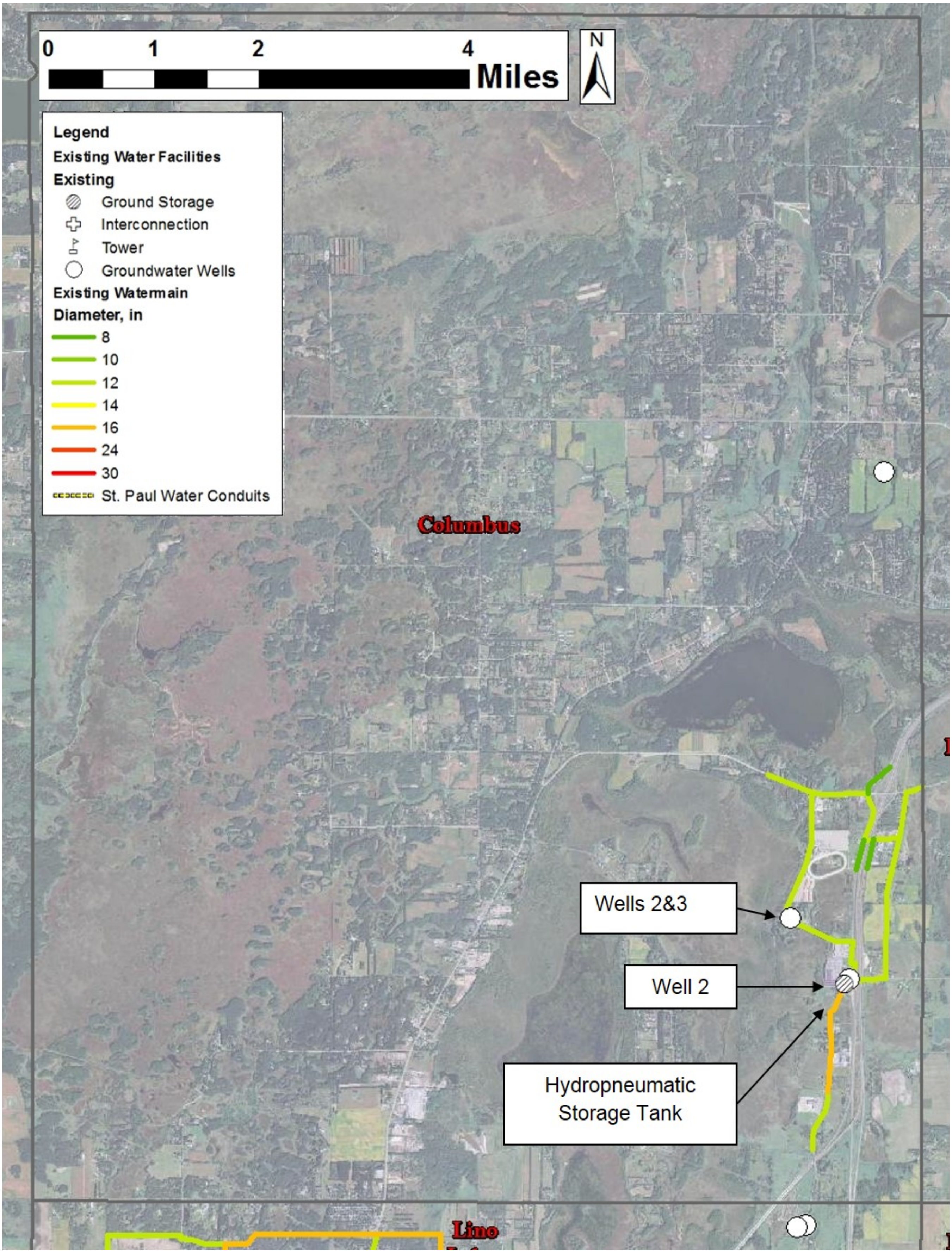
All but approximately four homes in Columbus are served by domestic wells. Columbus has three municipal wells; however, these serve a commercial district within the city. These wells have been in use since 2009, and fall under a joint appropriation of 20 MGY. If all homes were to connect to a municipal system, this appropriation limit is not high enough to meet the projected 2040 demand of 121 MGY. A fourth well previously used for an aquaculture operation has an appropriation of 340 MGD.

Table A-6. High-Capacity Well Summary Data for Columbus.

Permit No.	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
2009-0641	731131	1	COLUMBUS, CITY OF	Municipal Waterworks	Quaternary Buried Artesian Aquifer	180	3.7	20
2009-0641	749393	2	COLUMBUS, CITY OF	Municipal Waterworks	Quaternary Buried Artesian Aquifer	168	3.8	20
2009-0641	749394	3	COLUMBUS, CITY OF	Municipal Waterworks	Franconia-Ironton-Galesville	396	7.4	20
1975-6046	208989	1	TROUT AIR	Aquaculture (Hatcheries/ Fisheries)	St Lawrence-Mt Simon	569	12.3	340

Water Infrastructure
Columbus has one hydropneumatic water storage tank with 7,500 gallons of capacity. The City has no emergency connections.

Figure A-3. Columbus' Existing Water Infrastructure.



Water Treatment
Water is treated in-well with chlorine, fluoride, and polyphosphate.

Water Rates
Water rate information was not available for Columbus.

A.4 Forest Lake

Forest Lake is one of the two northernmost cities in the study area, along with Columbus. Its current water demand accounts for approximately 8% of the northeast metro's total demands. Demands are expected to increase by about 131% from 2010 to 2040.

Table A-7. Summary of Water Demand Data for Forest Lake.

Year	2010	2040
Population	18375	26900
Annual Water Usage (MG)	425	982
Average Daily Demand (MGD)	1.17	2.69
Peak Daily Demand (MGD)	2.04	4.70
% of Total Northeast Metro Demand	8%	12%

Water Supply
Forest Lake obtains its drinking water from three municipal wells, which have a joint appropriation of 565 MGY. The MnDNR lists two more municipal wells (Wells 1 and 2); however, these haven't seen use since 2002. This limit falls far below the projected 2040 demand of 982 MGY. Many other non-municipal high capacity wells exist in Forest Lake. Golf course irrigation accounts for the majority of these wells. Forest Lake's peak to average water demand ratio is a relatively low 1.7:1, indicating a reasonable use of water for nonessential needs.

Table A-8. High-Capacity Well Summary Data for Forest Lake.

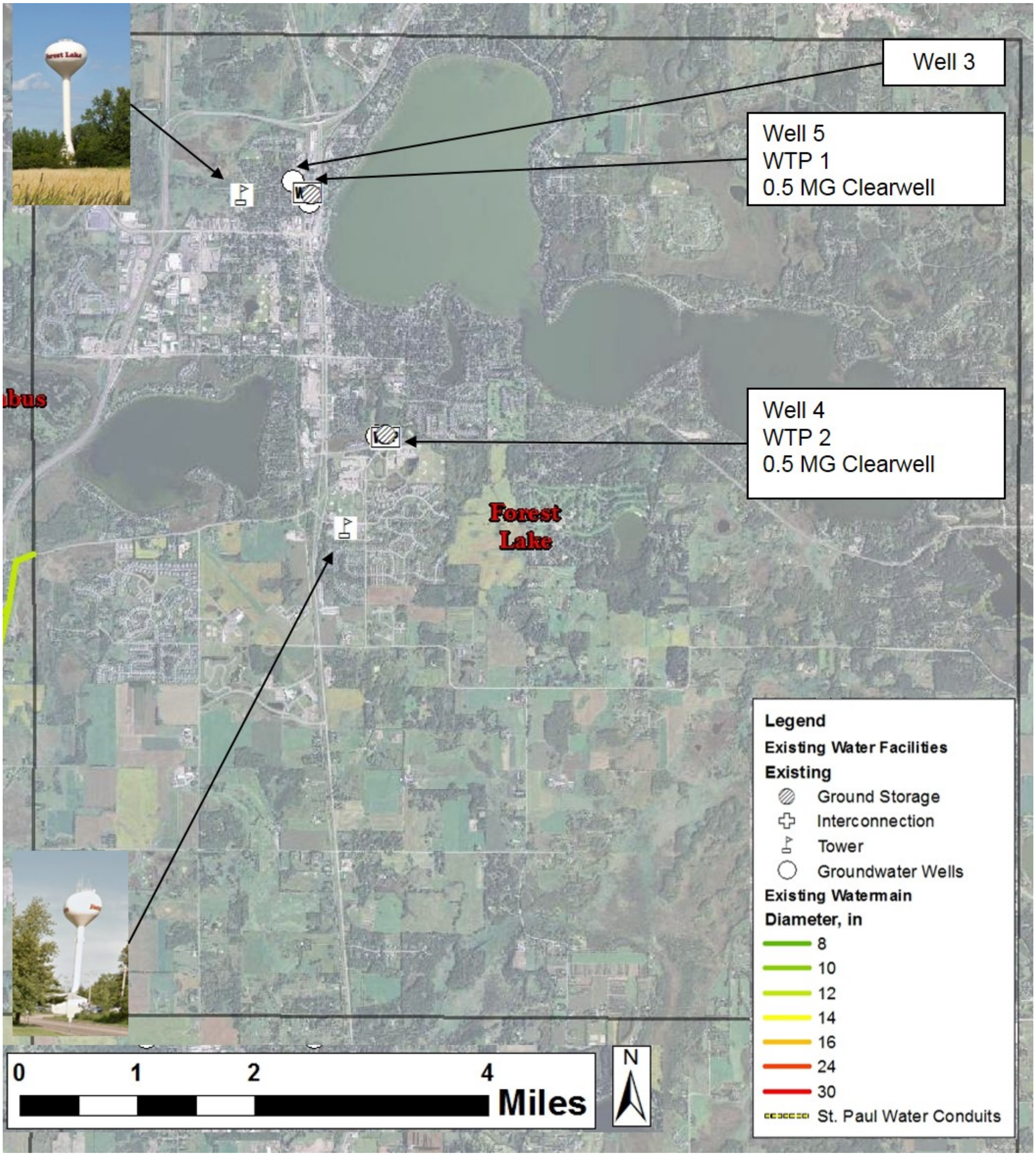
Permit Number	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use, MG	Appropriation, MGY
1965-0815	208558	1	FOREST LAKE, CITY OF	Municipal Waterworks	St Lawrence-Mt Simon	678	0.0	565.4
1965-0815	208559	2	FOREST LAKE, CITY OF	Municipal Waterworks	St Lawrence-Eau Claire	402	0.0	565.4
1965-0815	201157	3	FOREST LAKE, CITY OF	Municipal Waterworks	Ironton-Galesville-Mt Simon	630	46.9	565.4
1965-0815	559346	4	FOREST LAKE, CITY OF	Municipal Waterworks	Mt Simon	610	127.9	565.4
1965-0815	593618	5	FOREST LAKE, CITY OF	Municipal Waterworks	Mt Simon	630	261.1	565.4
1998-6103	251948	1	AGGREGATE INDUSTRIES-NCR INC	Non-Metallic Processing	NA	NA	0.4	5
1965-0276	208560	1	FOREST HILLS GOLF CLUB	Golf Course Irrigation	Franconia-Mt Simon	645	17.0	37
1987-6022	418708	1	FOREST LAKE C C	Private Waterworks	St Lawrence-Franconia	321	NA	4
1987-6022	418711	2	FOREST LAKE C C	Private Waterworks	Franconia	365	NA	4
1987-6023	418712	1	FOREST LAKE, CITY OF	Golf Course Irrigation	Jordan-Franconia	359	9.5	22.8

Permit Number	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use, MG	Appropriation, MGY
1987-6023	NA	POND	FOREST LAKE, CITY OF	Golf Course Irrigation	NA	NA	0.0	22.8
1994-6117	538095	1	FOREST LAKE, TOWN OF	Private Waterworks	Quaternary Buried Artesian Aquifer	250	0.0	21.9
2010-0372	668000	1	FOREST LAKE, CITY OF	Landscaping/ Athletic Fields	Quaternary Buried Artesian Aquifer	73	6.2	15.1
2010-0372	NA	2	FOREST LAKE, CITY OF	Landscaping/ Athletic Fields	NA	NA	0.0	15.1
2012-0902	436684	1	KNIFE RIVER CORPORATION -NORTH CENTRAL	Non-Metallic Processing	Jordan	170	0.0	3.5
1977-6301	NA	1	SALVERDA JR, W E	Major Crop Irrigation	Prairie du Chien-Jordan		0.0	14
2000-6059	627231	1	TANNERS BROOK LLP	Golf Course Irrigation	Quaternary Buried Artesian Aquifer	120	6.7	35
2000-6059	666457	2	TANNERS BROOK LLP	Golf Course Irrigation	Quaternary Buried Artesian Aquifer	130	2.6	35
1959-0696	251407	1	WLP LLC	Private Waterworks	Franconia	200	0.0	6
1959-0696	251408	2	WLP LLC	Private Waterworks	Franconia	175	3.9	6

Water Infrastructure

The City has two 0.5 MG towers, with one pressure zone at an overflow elevation of 1,090 feet, as well as 0.3 MG and 0.7 MG clearwells. Forest Lake has no emergency connections.

Figure A-4. Forest Lake's Existing Water Infrastructure.



Water Treatment

Water treatment within City Well 6 is accomplished via in-well treatment with chlorine, fluoride, and polyphosphates. Two water treatment plants, one 2,000 GPM and one 1,000 GPM, serve the rest of the wells. Both plants treat with chlorine, fluoride, filtration for iron removal, softening, and polyphosphates and caustic soda for corrosion control.

Water Rates

Per capita average use currently results in an annual residential bill of approximately $266.

A.5 Hugo

Hugo is located on the east central portion of the study area. Current water use accounts for about 7% of current total northeast metro demand. Water demand in Hugo is expected to increase by about 145% by 2040. Hugo, along with White Bear Township, has the most municipal wells in the northeast metro at a total of six.

Table A-9. Summary of Water Demand Data for Hugo.

Year	2010	2040
Population	13332	21798
Annual Water Usage (MG)	370	906
Average Daily Demand (MGD)	1.01	2.48
Peak Daily Demand (MGD)	3.65	8.94
% of Total Northeast Metro Demand	7%	11%

Water Supply

Hugo obtains its water from four municipal wells. The MnDNR lists two additional municipal wells (Wells 1 and 6); however, neither of the two have been used since 2003. All of the municipal wells have a joint appropriation of 650 MGY, which is below the 2040 demand. The peak to average ratio in Hugo is a 3.6:1, likely indicating significant water use for nonessential needs.

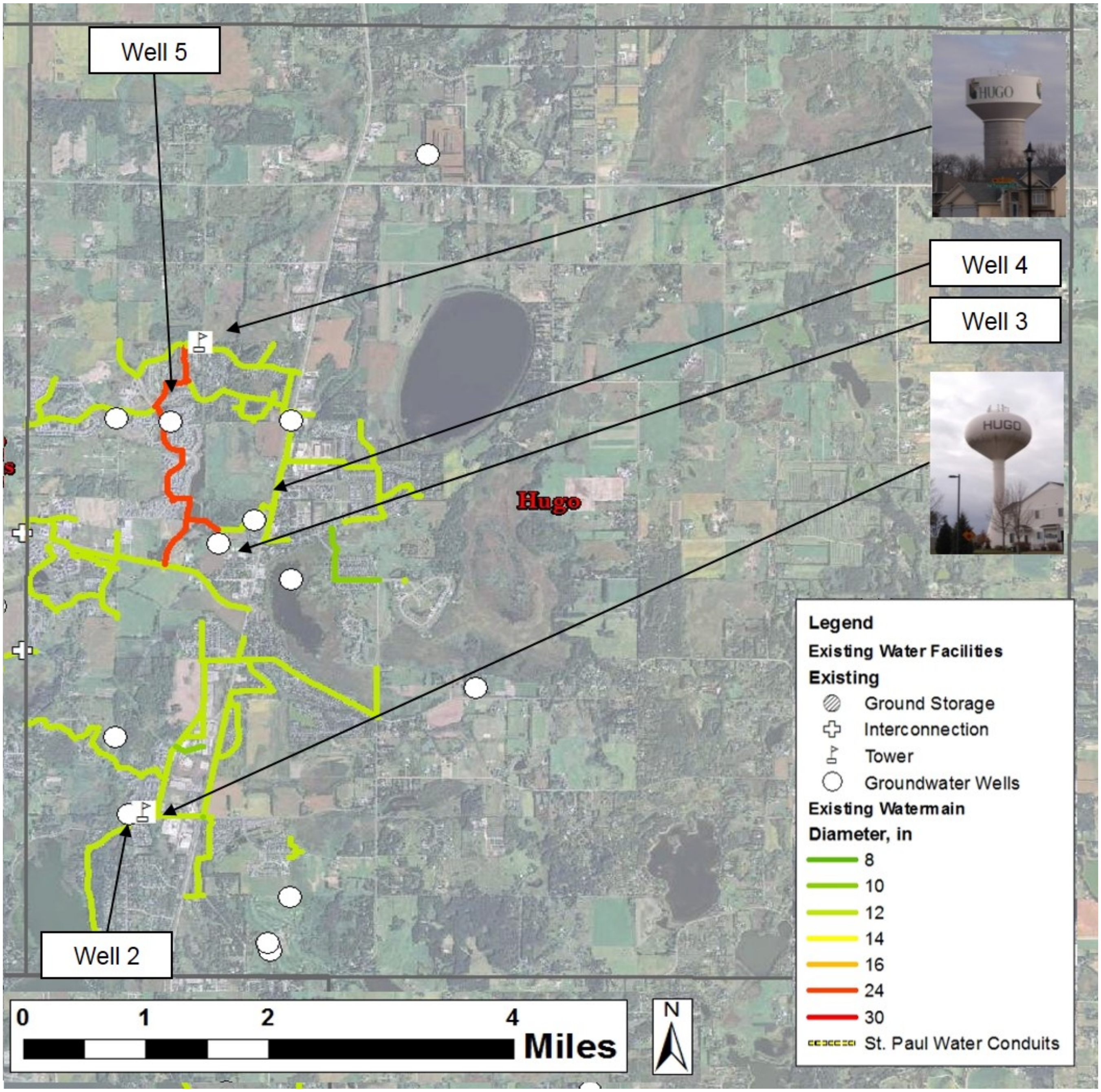
Table A-10. High-Capacity Well Summary Data for Hugo.

Permit Number	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
1975-6218	208521	1	HUGO, CITY OF	Municipal Waterworks	Jordan	320	0.0	650
1975-6218	523948	2	HUGO, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	261	122.8	650
1975-6218	654497	3	HUGO, CITY OF	Municipal Waterworks	Jordan	315	82.0	650
1975-6218	671642	4	HUGO, CITY OF	Municipal Waterworks	Jordan	219	65.6	650
1975-6218	686272	5	HUGO, CITY OF	Municipal Waterworks	Jordan	275	78.4	650
1975-6218	773400	6	HUGO, CITY OF	Municipal Waterworks	Jordan	355	0.0	650
2010-0445	713255	1	HUGO, CITY OF	Landscaping/ Athletic Fields	Prairie du Chien	201	4.0	7.1
1971-0984	271943	1	BERGMAN, LOUISE	Major Crop Irrigation		78	0.0	11.2
1995-6039	544462	1	ONEKA RIDGE GOLF COURSE	Golf Course Irrigation	Quaternary Buried Artesian Aquifer	175	9.1	61
1995-6039	544463	2	ONEKA RIDGE GOLF COURSE	Golf Course Irrigation	Quaternary Buried Artesian Aquifer	175	10.1	61
2008-0754	249300	1	TWIN PINE MOBILE HOME PARK	Private Waterworks	Prairie du Chien	185	4.5	8.7
2008-0754	249301	2	TWIN PINE MOBILE HOME PARK	Private Waterworks	Prairie du Chien	185	3.7	8.7

Water Infrastructure

Two water towers provide storage for Hugo. A 1.5 MG tower serves a northern pressure zone at 1,085 feet of overflow elevation, while a 0.5 MG tower serves a southern zone at 1,055 feet. One emergency interconnect ties the City to Lino Lakes.

Figure A-5. Hugo's Existing Water Infrastructure



Water Treatment

Hugo's water treatment needs are served in-well, with the addition of chlorine, fluoride, and polyphosphate.

Water Rates

Per capita residential water rates for average use currently result in an annual residential bill of approximately $113.

A.6 Lexington

Lexington lies on the west central portion of the study area, and geographically is the smallest city in the northeast metro. Lexington's 2010 municipal water use was the second lowest in the northeast metro following Columbus; it accounted for about 1.6% of total northeast metro municipal water usage. The City's water demand is projected to increase by about 27% by 2040.

Table A-11. Summary of Water Demand Data for Lexington.

Year	2010	2040
Population	2049	2474
Annual Water Usage (MG)	83	106
Average Daily Demand (MGD)	0.23	0.29
Peak Daily Demand (MGD)	1.35	1.71
% of Total Northeast Metro Demand	2%	1%

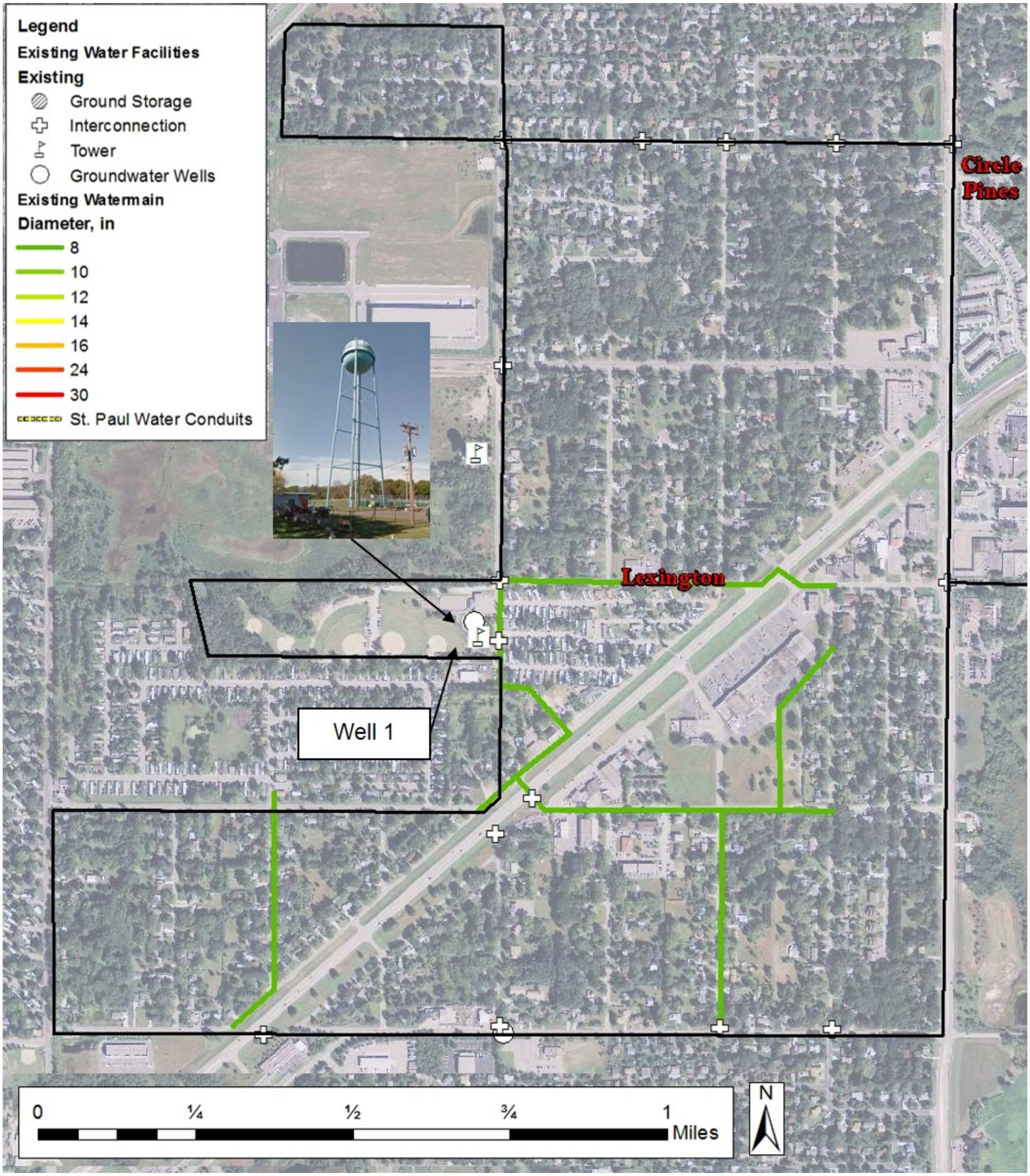
Water Supply

Lexington obtains its drinking water from one quaternary well which has an appropriation of 100 MGY, and also purchases water from the City of Blaine. Unless Lexington continues to purchase water from Blaine, the projected 2040 demand of 106 MG will be met with the current appropriation limit. Other high capacity wells in the city include three wells which are described the MnDNR as belong to a "private waterworks", and one well used for landscaping; all are cased in the quaternary aquifer. The peak to average ratio in Lexington is a very high 5.9:1, likely indicating significant water use for nonessential needs.

Water Infrastructure

A 0.1 MG tower provides storage for the town. The city has emergency connections to Blaine and Circle Pines.

Figure A-6. Lexington's Existing Water Infrastructure



Water Treatment

Water treatment is accomplished in-well with the addition of chlorine, fluoride, and polyphosphate.

Water Rates

Per capita residential water rates for average use currently result in an annual bill of approximately $97.

A.7 Lino Lakes

Lino Lakes is located in a central portion of the northeast metro, and accounted for about 10% of 2010 water demand in the study area. Water usage in the city is projected to increase by about 64% by 2040.

Table A-13. Summary of Water Demand Data for Lino Lakes.

Year	2010	2040
Population	20216	22657
Annual Water Usage (MG)	498	818
Average Daily Demand (MGD)	1.36	2.24
Peak Daily Demand (MGD)	4.55	7.47
% of Total Northeast Metro Demand	9%	10%

Water Supply

Lino Lakes obtains its water from five municipal wells, which have a joint appropriation of 900 MGY. This appropriation limit will allow for the projected 2040 demand of 818 MG to be met. The peak to average water demand ratio in Lino Lakes is 3.3:1, likely indicating significant water use for nonessential needs.

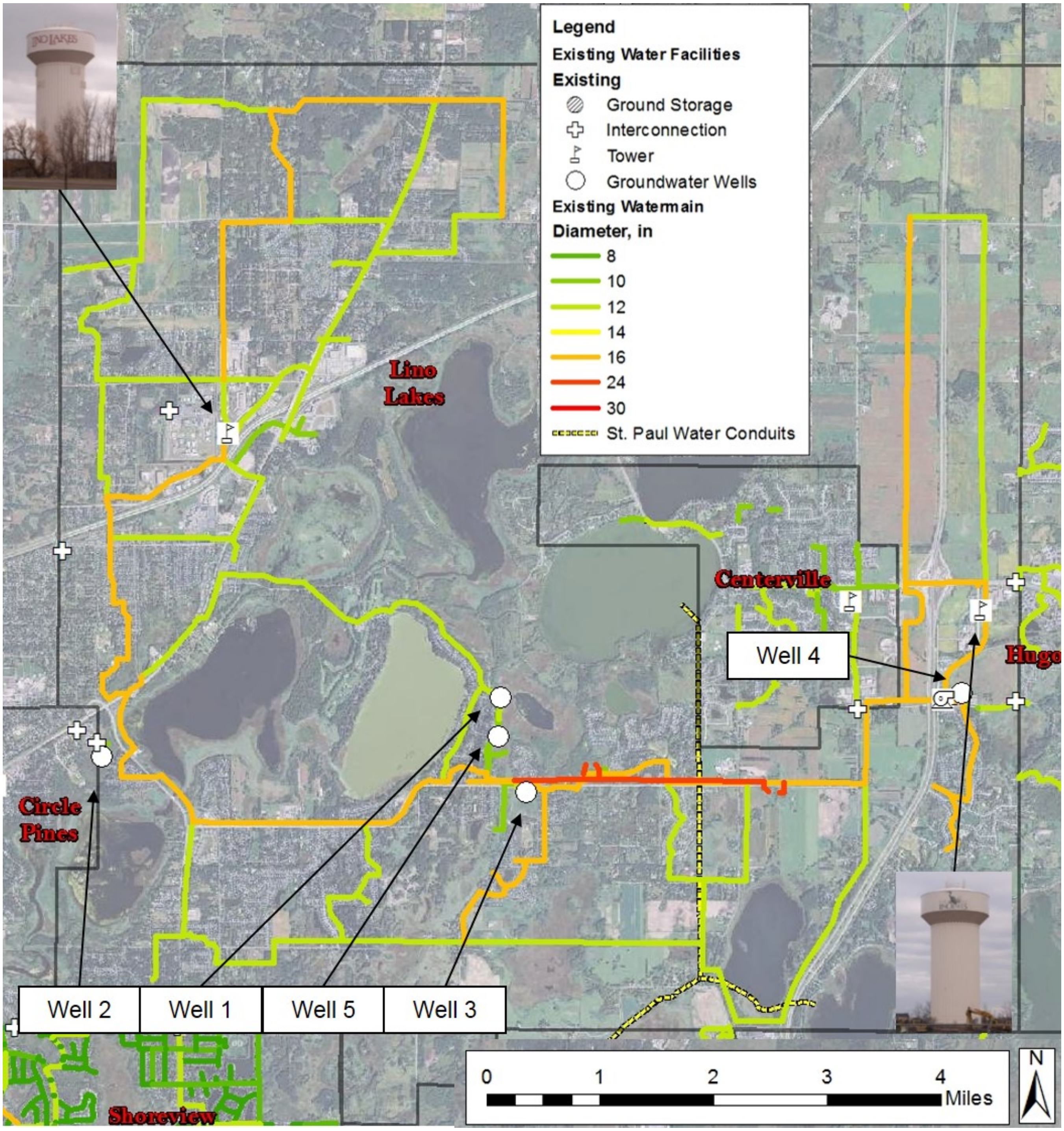
Table A-14. High-Capacity Well Summary Data for Lino Lakes.

Permit Number	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
1966-0584	208996	1	LEXINGTON, CITY OF	Municipal Waterworks	Quaternary Buried Artesian Aquifer	309	77.0	100
2011-0269	774904	1	LEXINGTON ESTATES TOWNHOME ASSOC NO 4	Landscaping/ Athletic Fields	Quaternary Buried Artesian Aquifer	180	2.2	2.5
1985-6036	249759	1	PAUL REVERE COOPERATIVE	Private Waterworks	Quaternary Buried Artesian Aquifer	196	7.6	9
1986-6138	208651	1	RESTWOOD TERRACE M H PARK	Private Waterworks	Quaternary Buried Artesian Aquifer	232	14.1	15
1986-6138	208992	2	RESTWOOD TERRACE M H PARK	Private Waterworks	Quaternary Buried Artesian Aquifer	242	0.0	15

Water Infrastructure

Two 1 MG towers provide storage for the city, and correspond to east and west pressure zones which are both at a 1,055 foot overflow elevation. Emergency connections exist between Lino Lakes and Blaine, Centerville, Circle Pines, Hugo, and Shoreview.

Figure A-7. Lino Lakes' Existing Water Infrastructure



Water Treatment

Water treatment occurs in-well with the addition of chlorine, fluoride, and polyphosphate.

Water Rates

Per capita residential water rates for average use currently result in an annual bill of approximately $94.

A.8 Mahtomedi

Mahtomedi lies on the southeast portion of the study area, and entirely encompasses the City of Willernie geographically. Mahtomedi serves Willernie's water demands, and Willernie's growth and demand information is included in Mahtomedi's. Mahtomedi's demand accounted for about 5% of the northeast metro's total water demand in 2010, and is projected to increase by about 36% by 2040.

Table A-15. Summary of Water Demand Data for Mahtomedi.

Year	2010	2040
Population	7676	9461
Annual Water Usage (MG)	255	347
Average Daily Demand (MGD)	0.70	0.95
Peak Daily Demand (MGD)	1.75	2.38
% of Total Northeast Metro Demand	5%	4%

Water Supply

Mahtomedi obtains its water from four municipal wells, which share a joint appropriation of 315 MGY. The MnDNR lists a fifth municipal well; however, Well 2 has not been used since at least 1988. Mahtomedi's appropriation will not be enough to meet 2040's projected 347 MG water demand. A non-municipal appropriation of about 150 MGY was obtained for a dewatering well that has been used since 2007, with a peak of 878 MG in 2008. The City's peak to average water demand ratio is 2.5:1, indicating reasonable water use for nonessential needs in the community.

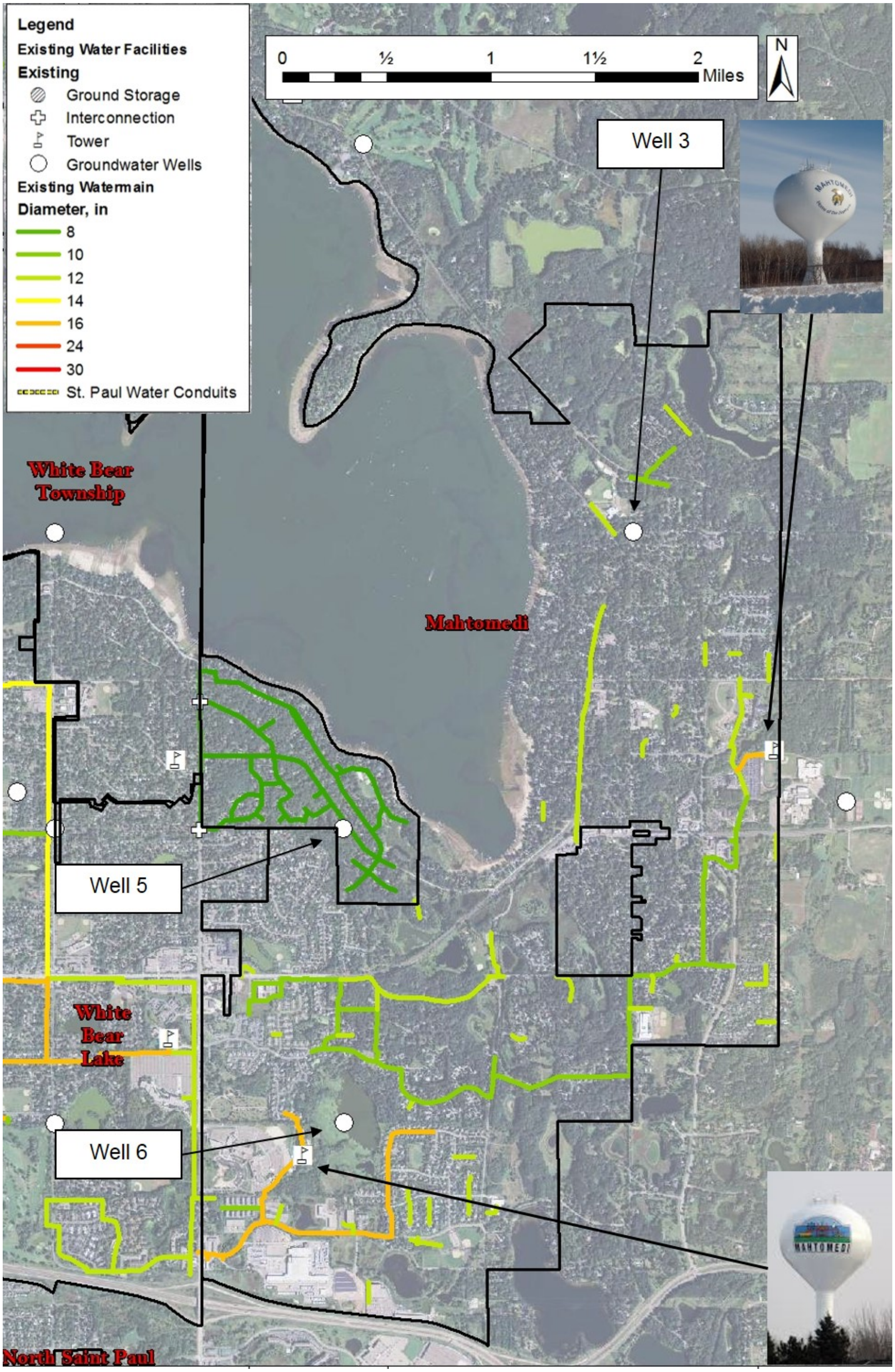
Table A-16. High-Capacity Well Summary Data for Mahtomedi.

Permit Number	Well ID	Installation ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use, MG	Appropriation, MGY
1969-0163	208505	2	MAHTOMEDI, CITY OF	Municipal Waterworks	Prairie du Chien-St Lawrence	440	0.0	315
1969-0163	208497	3	MAHTOMEDI, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	392	112.5	315
1969-0163	208506	4	MAHTOMEDI, CITY OF	Municipal Waterworks	Jordan-St Lawrence	435	47.7	315
1969-0163	433255	5	MAHTOMEDI, CITY OF	Municipal Waterworks	Prairie du Chien-St Lawrence	470	45.1	315
1969-0163	753675	6	MAHTOMEDI, CITY OF	Municipal Waterworks	Jordan	465	50.8	315
2006-0618	NA	1	MN DEPT OF TRANS	Dewatering	NA	NA	1.2	149.8

Water Infrastructure

Two towers each provide 0.5 MG of storage. The city is divided into two pressure zones served by these towers, a western zone at a 1,138 foot overflow elevation and a larger eastern zone at 1,171 feet. The city has emergency connections to White Bear Lake and Willernie.

Figure A-8. Mahtomedi's Existing Water Infrastructure.



Water Treatment
Treatment with chlorine, fluoride, and polyphosphate is provided in-well.

Water Rates
Per capita average use currently results in an annual residential water bill of approximately $136.

A.9 North St Paul

North St Paul lies at the southern extreme of the northeast metro, and doesn't directly border any other city in the study area. Neighboring communities are all wholesale water customers of St Paul Regional Water Services, except for a portion of Maplewood which lies due north of the City, which North St Paul serves. North St Paul has one of the lowest projected demand increases by 2040, at 16%. Water rates in North St Paul are the highest in the northeast metro.

Table A-17. Summary of Water Demand Data for North St. Paul.

Year	2010	2040
Population	11460	14800
Annual Water Usage (MG)	424	492
Average Daily Demand (MGD)	1.16	1.35
Peak Daily Demand (MGD)	3.48	4.04
% of Total Northeast Metro Demand	8%	6%

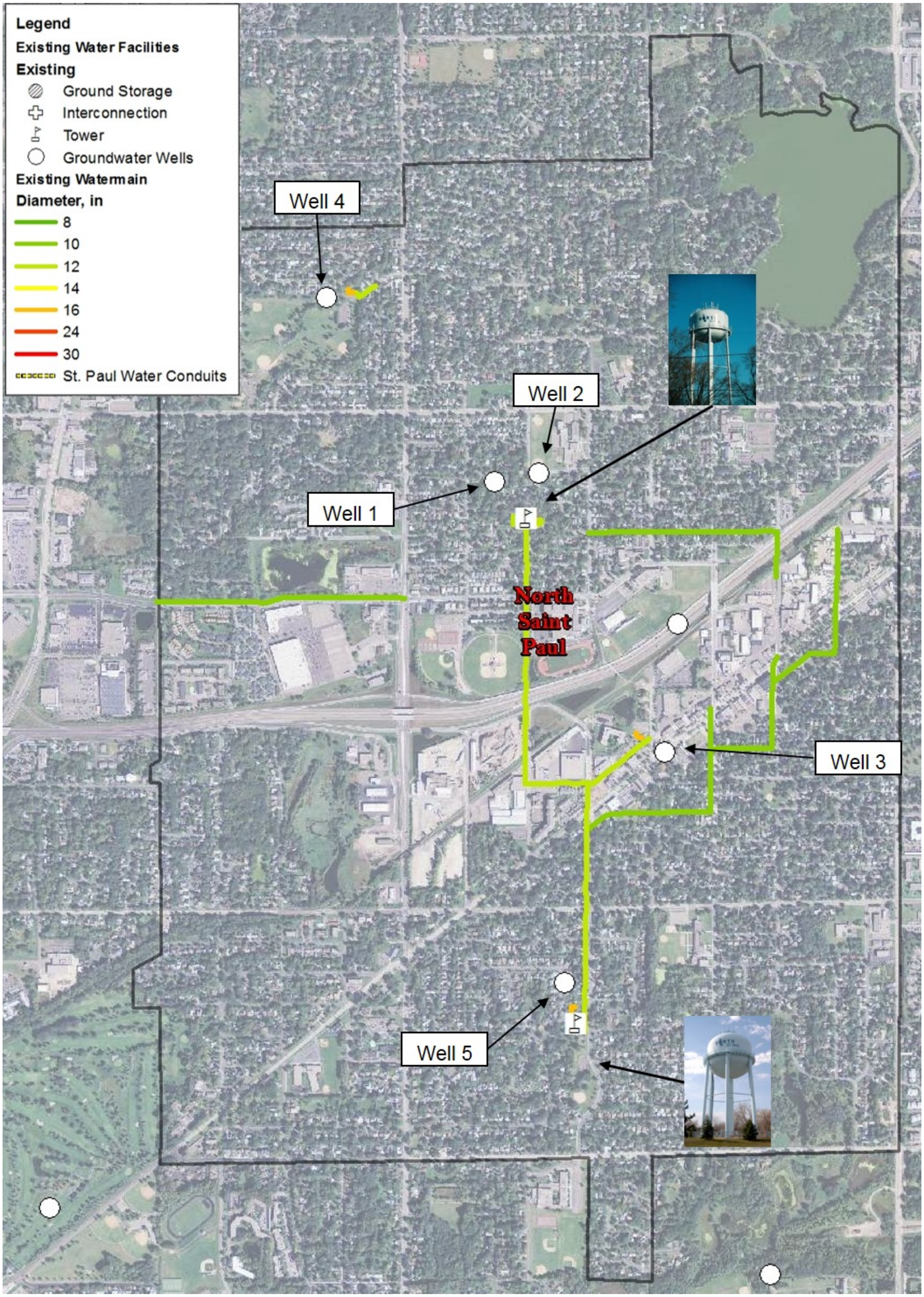
Water Supply
The only high capacity wells found in North St Paul are used for municipal water supply, and all are cased in the Prairie du Chien-Jordan aquifer. These wells' joint appropriation of 584 MGY will meets the City's projected 2040 water demand of 492 MG. The City's peak to average water demand ratio is 3:1, indicating reasonable water use for nonessential needs in the community.

Table A-18. High-Capacity Well Summary Data for North St. Paul.

Permit Number	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
1977-6176	208222	1	NORTH ST PAUL, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	470	65.6	584
1977-6176	208223	2	NORTH ST PAUL, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	470	51.6	584
1977-6176	208224	3	NORTH ST PAUL, CITY OF	Municipal Waterworks	Jordan	468	110.7	584
1977-6176	205744	4	NORTH ST PAUL, CITY OF	Municipal Waterworks	Jordan	475	131.4	584
1977-6176	112229	5	NORTH ST PAUL, CITY OF	Municipal Waterworks	Jordan	531	60.8	584

Water Infrastructure
The whole city lies within one 1,125 foot overflow elevation pressure zone which is served by two towers, one 0.3 MG and one 0.5 MG. No emergency connections exist within the city.

Figure A-9. North St. Paul's Existing Water Infrastructure.



Water Treatment
Fluoride is added in-well, otherwise no treatment is provided for the water.

Water Rates
Per capita average use currently results in an annual bill of approximately $299, the highest in the northeast metro.

A.10 Shoreview

Shoreview is located at the southwest corner of the northeast metro, and has the highest current and projected water demands in the study area, at 19% in 2010 and an expected 18% in 2040. Shoreview's demand is expected to increase by about 36% from 2010 to 2040.

Table A-19. Summary of Water Demand Data for Shoreview.

Year	2010	2040
Population	25043	35000
Annual Water Usage (MG)	1,062	1445
Average Daily Demand (MGD)	2.91	3.96
Peak Daily Demand (MGD)	9.41	12.81
% of Total Northeast Metro Demand	20%	18%

Water Supply
Shoreview is served by six municipal wells with a joint appropriation of 1,400 MGY, the highest appropriation within the northeast metro. Demand in 2040 is projected to be 1,445 MG, which will exceed this appropriation. Other high capacity wells in Shoreview are used for a private waterworks, landscaping, and golf course irrigation. The peak to average ratio in Shoreview is 3.2:1, likely indicating significant water use for nonessential needs.

Table A-20. High-Capacity Well Summary Data for Shoreview.

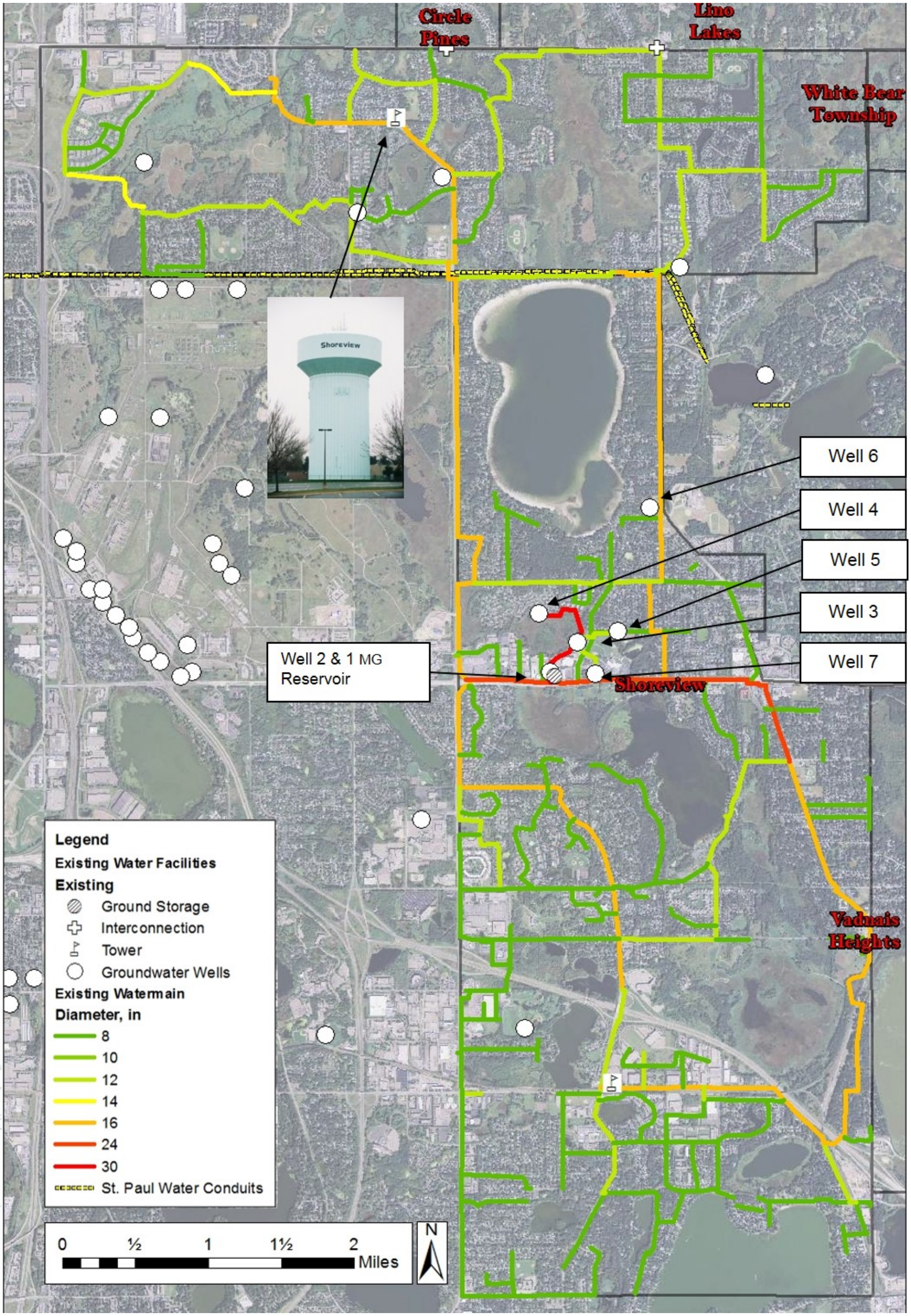
Permit No.	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
1974-5038	206752	2	SHOREVIEW, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	395	237.8	1400
1974-5038	206751	3	SHOREVIEW, CITY OF	Municipal Waterworks	Jordan-St Lawrence	413	0.2	1400
1974-5038	206750	4	SHOREVIEW, CITY OF	Municipal Waterworks	Quaternary Buried Artesian Aquifer	423	13.9	1400
1974-5038	151557	5	SHOREVIEW, CITY OF	Municipal Waterworks	Jordan-St Lawrence	408	335.7	1400
1974-5038	151576	6	SHOREVIEW, CITY OF	Municipal Waterworks	Jordan-St Lawrence	414	83.1	1400
1974-5038	432019	7	SHOREVIEW, CITY OF	Municipal Waterworks	Jordan-St Lawrence	442	312.4	1400
1996-6168	538605	1	SILVERTHORN ESTATES	Landscaping/ Athletic Fields	Prairie du Chien	185	4.3	20
1976-6181	109793	1	BROOKSIDE MOBILE HOME PRK	Private Waterworks	Quaternary Buried Artesian Aquifer	272	11.7	12
1976-6181	138928	2	BROOKSIDE MOBILE HOME PRK	Private Waterworks	Quaternary Buried Artesian Aquifer	281	0.0	12
1994-	540345	1	FORE INC	Golf Course	Prairie du Chien	330	3.7	18

Permit No.	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
6217				Irrigation				
1992-6163	476680	1	HEATHER RIDGE TOWNHOUSE ASSOC	Landscaping/ Athletic Fields	Prairie du Chien	170	7.4	7.1
2011-0269	774904	1	LEXINGTON ESTATES TOWNHOME ASSOC NO 4	Landscaping/ Athletic Fields	Quaternary Buried Artesian Aquifer	180	2.2	2.5
1994-6011		1	SHOREVIEW, CITY OF	Basin/ Lake Level Maintenance	SUCKER LAKE	0	0.0	250

Water Infrastructure

The City has a 1 MG underground storage reservoir and two 1.5 MG towers. The city all lies within one pressure zone at a 1093 foot overflow elevation. Emergency interconnections tie the city to Arden Hills, Lino Lakes, North Oaks, Vadnais Heights, Roseville, and Circle Pines.

Figure A-10. Shoreview's Existing Water Infrastructure.



Water Treatment
Chlorine and fluoride are added in-well.

Water Rates
Per capita average use currently results in an annual bill of approximately $93.

A.11 Vadnais Heights

Vadnais Heights is located at the south central portion of the northeast metro. Water demand in the city accounted for about 9% of total northeast metro demand in 2010 & is expected to grow by about 57% by 2040.

Table A-21. Summary of Water Demand Data for Vadnais Heights.

Year	2010	2040
Population	12302	18600
Annual Water Usage (MG)	485	761
Average Daily Demand (MGD)	1.33	2.08
Peak Daily Demand (MGD)	3.24	5.08
% of Total Northeast Metro Demand	9%	9%

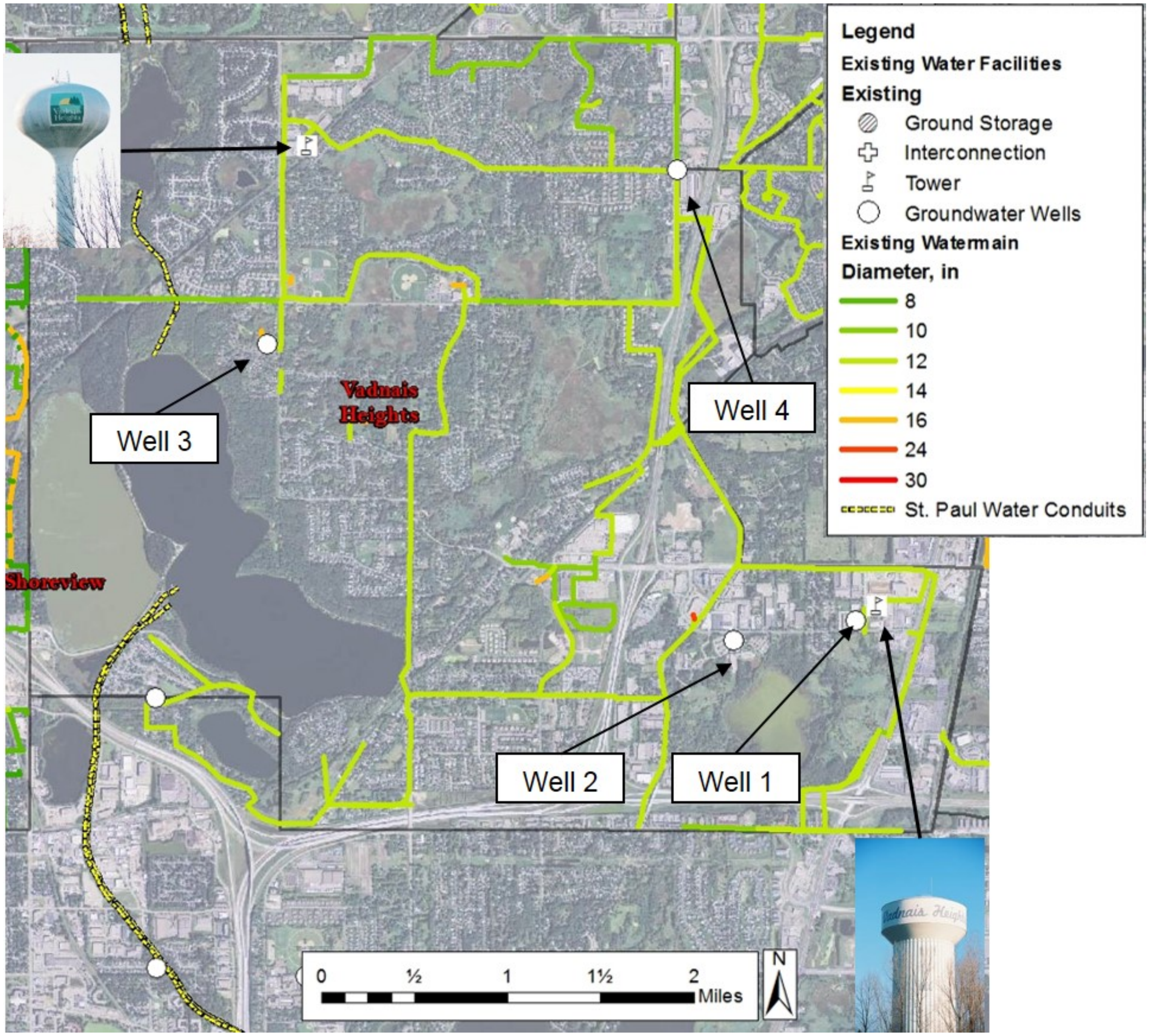
Water Supply
Vadnais Heights is served by four PDCJ well which have a joint appropriation of 579 MGY. This limit will be exceeded by the projected 2040 demand of 761 MG. One other high capacity well used for commercial heating and cooling is present in Vadnais Heights. Vadnais Heights' peak to average demand ratio is 2.6:1, indicating reasonable use of water for nonessential needs in the community.

Table A-22. High-Capacity Well Summary Data for Vadnais Heights.

Permit No.	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
1980-6153	112222	1	VADNAIS HEIGHTS, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	490	33.1	579
1980-6153	127265	2	VADNAIS HEIGHTS, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	470	160.2	579
1980-6153	224790	3	VADNAIS HEIGHTS, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	495	148.1	579
1980-6153	127271	4	VADNAIS HEIGHTS, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	476	141.0	579
1980-6214	151562	1	H B FULLER	Commercial building A/C	Jordan	481	0.0	185
1980-6214	151562	1	H B FULLER	Once-through heating or A/C	Jordan	481	11.9	185

Water Infrastructure
The city has two 1 MG towers which serve one pressure zone at a 1,100 foot overflow elevation. No emergency connections exist between Vadnais Heights and any other city.

Figure A-11. Vadnais Heights' Existing Water Infrastructure.



Water Treatment
In-well treatment with chlorine, fluoride, and polyphosphate is provided.

Water Rates
Per capita average use currently results in an annual bill of approximately $107.

A.12 White Bear Lake

White Bear Lake is located in the south central portion of the study area. The City had the second highest 2010 water demands at 17% of total northeast metro municipal water demands. This demand is expected to grow by 34% by 2040. The City's water rates are the lowest in the northeast metro, and it possesses the greatest water storage infrastructure capacity.

Table A-23. Summary of Water Demand Data for White Bear Lake.

Year	2010	2040
Population	23797	31560
Annual Water Usage (MG)	897	1206
Average Daily Demand (MGD)	2.46	3.30
Peak Daily Demand (MGD)	6.86	9.23
% of Total Northeast Metro Demand	17%	15%

Water Supply

White Bear Lake is served by five wells, which have a joint appropriation of 1,150 MGY. This is not enough to meet the projected 2040 demand of 1,206 MG. Additional high capacity wells in the city are used for agricultural processing, golf course irrigation, and landscaping. White Bear Lake's peak to average water demand ratio is 2.8:1, indicating reasonable use of water in the City for nonessential needs.

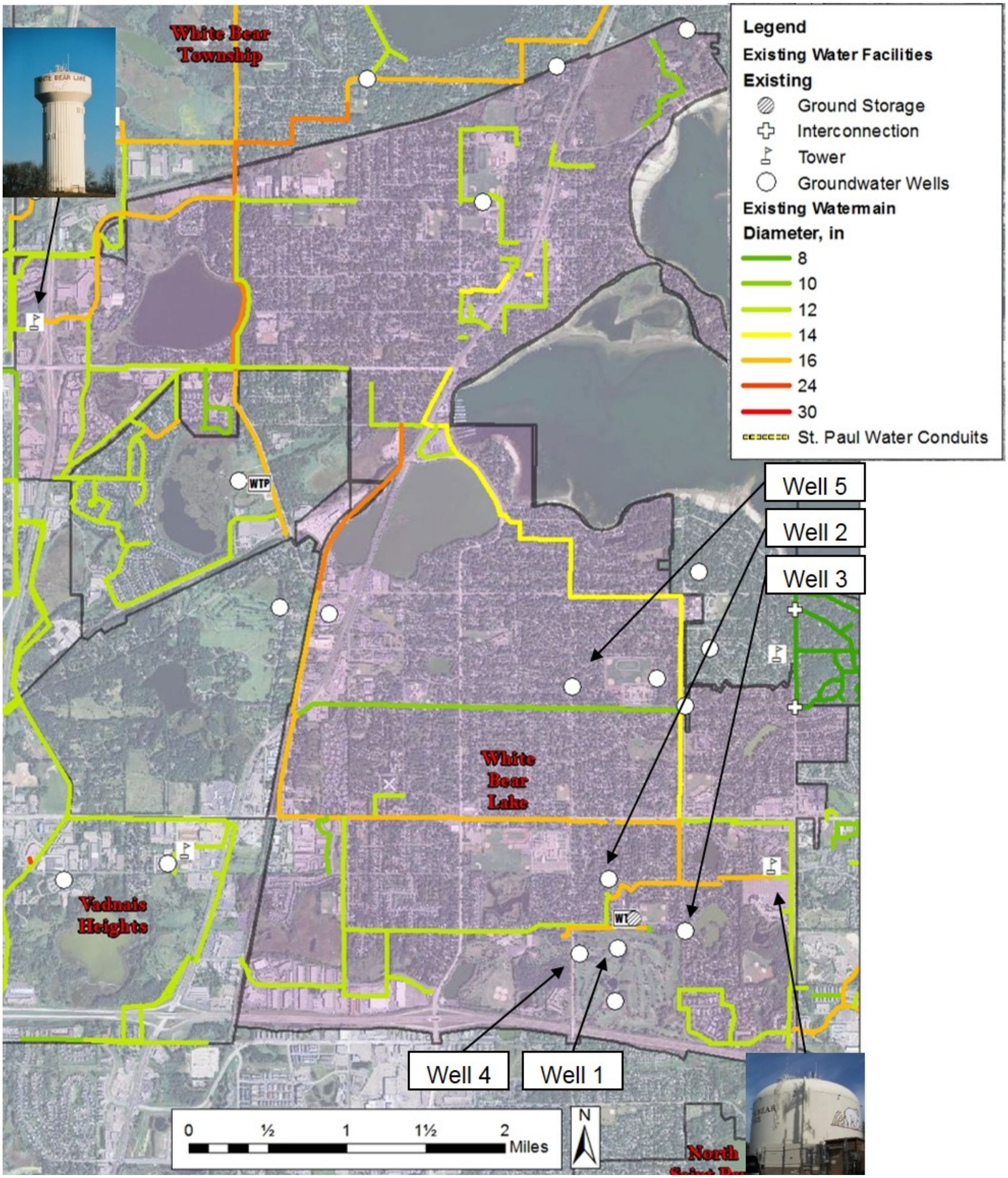
Table A-24. High-Capacity Well Summary Data for White Bear Lake.

Permit No.	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
1969-0174	014005	1	WHITE BEAR LAKE, CITY OF	Municipal Waterworks	Jordan	490	57.3	1150
1969-0174	222880	2	WHITE BEAR LAKE, CITY OF	Municipal Waterworks	Ironton-Galesville-Mt Simon	970	4.0	1150
1969-0174	205733	3	WHITE BEAR LAKE, CITY OF	Municipal Waterworks	Prairie du Chien-Jordan	513	379.5	1150
1969-0174	226566	4	WHITE BEAR LAKE, CITY OF	Municipal Waterworks	Prairie du Chien-St Lawrence	476	444.9	1150
1969-0174	226567	5	WHITE BEAR LAKE, CITY OF	Municipal Waterworks	Jordan-St Lawrence	463	0.0	1150
2002-6073	626779	1	IND SCHOOL DISTRICT 624	Landscaping/ Athletic Fields	Quaternary Buried Artesian Aquifer	183	2.0	3.5
2004-3020	655934	1	IND SCHOOL DISTRICT 624	Landscaping/ Athletic Fields	Prairie du Chien	350	2.3	5
1987-6205	127293	A	MANITOU RIDGE GOLF CLUB	Golf Course Irrigation	Prairie du Chien	397	16.1	60
1987-6205		B	MANITOU RIDGE GOLF CLUB	Golf Course Irrigation	St Peter		0.0	60
1986-6316	233149	1	M-FOODS DAIRY LLC	Agricultural Processing	Jordan	436	126.7	180

Water Infrastructure

Water storage infrastructure within the city consists of a 1 MG tower, a 1 MG clearwell, and a 3 MG standpipe tower; the most storage of any city within the study area. The tower and standpipe have overflow elevations of 1,129 feet and 1,125 feet respectively. Emergency connections tie the city to Mahtomedi and White Bear Township.

Figure A-12. White Bear Lake's Existing Water Infrastructure.



Water Treatment

Treatment is accomplished via a 5000 GPM water treatment plant, which adds chlorine and fluoride, and provides softening.

Water Rates

Per capita average use currently results in an annual residential water bill of approximately $40, the lowest in the northeast metro.

A.13 White Bear Township

White Bear Township is located on the east central portion of the northeast metro, and along with Hugo has the most municipal wells in the study area. White Bear Township has one of the lowest demand growth rates in the northeast metro, water demand is projected to increase by only 10% by 2040.

Table A-25. Summary of Water Demand Data for White Bear Township.

Year	2010	2040
Population	10949	13294
Annual Water Usage (MG)	532	586
Average Daily Demand (MGD)	1.46	1.61
Peak Daily Demand (MGD)	3.79	4.18
% of Total Northeast Metro Demand	10%	7%

Water Supply

White Bear Township has seven municipal wells listed with the MnDNR; however, Well 2 has been sealed since 2008. Wells 1 and 2A share a 65 MGY appropriation, while the remaining four are jointly limited to 450 MGY. The sum appropriation of 515 MGY will not be enough to serve the 2040 demand of 586 MG. Other high capacity wells in use within the Township are used for industrial process cooling and pollution containment. White Bear Township's peak demand to average demand ratio is 2.6:1, indicating reasonable use of water for nonessential needs.

Table A-26. High-Capacity Well Summary Data for White Bear Township.

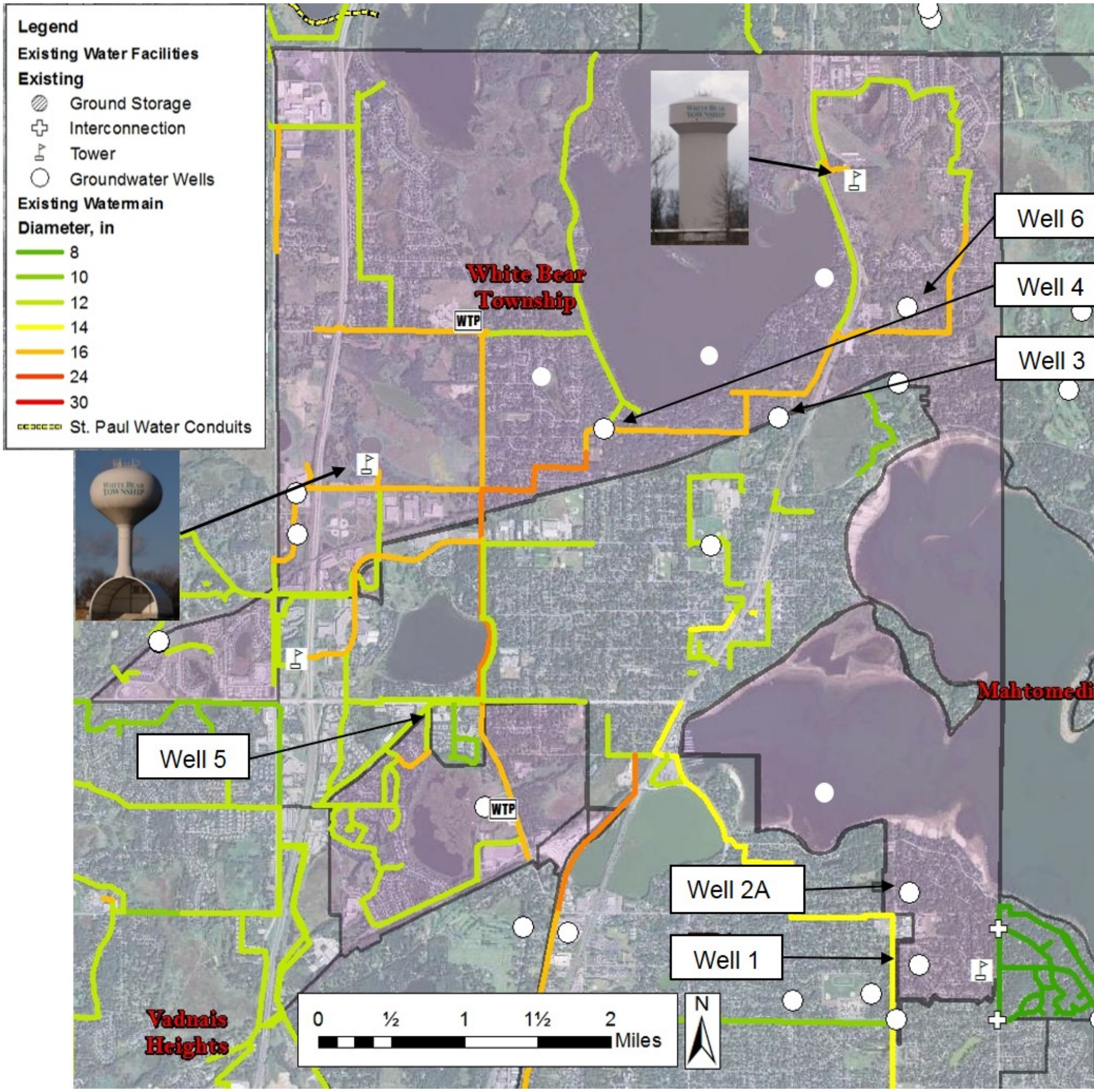
Permit No.	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
1984-6120	226570	1	WHITE BEAR TOWNSHIP	Municipal Waterworks	Jordan	442	15.0	65
1984-6120	226571	2	WHITE BEAR TOWNSHIP	Municipal Waterworks	Jordan	435	24.2	65
1984-6120	676446	2A	WHITE BEAR TOWNSHIP	Municipal Waterworks	Jordan	420	0.0	65
1984-6121	224679	3	WHITE BEAR TOWNSHIP	Municipal Waterworks	Prairie du Chien-Jordan	372	85.1	450
1984-6121	226572	4	WHITE BEAR TOWNSHIP	Municipal Waterworks	Prairie du Chien-Jordan	408	10.3	450
1984-6121	151596	5	WHITE BEAR TOWNSHIP	Municipal Waterworks	Prairie du Chien-Jordan	412	366.7	450
1984-6121	596636	6	WHITE BEAR TOWNSHIP	Municipal Waterworks	Prairie du Chien-Jordan	360	11.0	450
2003-3036	771109	2	VEECO INSTRUMENTS INC	Industrial Process Cooling Once-through	St Peter	198	14.5	40
2004-3159	656436	1	VEECO INSTRUMENTS INC	Industrial Process Cooling Once-through	St Peter	180	14.1	20
1984-6226	NA	1	WHITE BEAR TOWNSHIP	Temporary Water Level Maintenance	NA	NA	NA	3.8
1992-6156	NA	1	WHITE BEAR TOWNSHIP	Temporary Construction (dewatering)	NA	NA	0.0	54

Permit No.	Well ID	Install ID	Permittee	Use Name	Aquifer	Well Depth, ft	2011 Use MG	Appropriation MGY
1989-6037	770750	EW1B	WHIRLPOOL CORP & REYNOLDS METALS	Pollution Containment	NA	95	4.8	26
1989-6037	717789	EW2	WHIRLPOOL CORP & REYNOLDS METALS	Pollution Containment	St Peter	135	5.6	26

Water Infrastructure

White Bear Township has three towers, with storage capacities of 0.1 MG, 0.75 MG, and 1 MG. The 1 MG and 0.75 MG towers are located in a northern pressure zone with an overflow elevation of 1,090 feet, while the 0.1 MG tower feeds a southern pressure zone at 1,103 feet. An emergency connection ties the Township to White Bear Lake.

Figure A-13. White Bear Township's Existing Water Infrastructure.



Water Treatment

Water treatment is accomplished both in-well & with a water treatment plant. In-well treatment is accomplished with the use of chlorine, fluoride and polyphosphates. City Well 5 is served by a 1,700 GPM water treatment plant, which provides chlorination, fluoridation, iron removal, and iron/manganese sequestration.

Water Rates

Per capita average use currently results in an annual residential water bill of approximately $157.

Study Area Water Rate Summary

Table A-27. Summary of Fee Schedules for All Cities in the Northeast Metro.

City	Use Type	Billing Frequency	Charge Type	Cost per Unit	Cost Unit	Usage Range	Meter Size
Centerville	Residential	Quarterly	Flat Fee	$21.00	Fixed	NA	NA
Centerville	Commercial	Quarterly	Flat Fee	$21.00	Fixed	NA	NA
Centerville	Residential	Quarterly	Usage	$ 2.00	1000 gallons	0-90,000	NA
Centerville	Residential	Quarterly	Usage	$2.20	1000 gallons	90,001 - 150,000	NA
Centerville	Residential	Quarterly	Usage	$2.50	1000 gallons	150,001 - 999,999	NA
Centerville	Commercial	Quarterly	Usage	$2.00	1000 gallons	0-500,000	NA
Centerville	Commercial	Quarterly	Usage	$2.50	1000 gallons	>500,001	NA
Circle Pines	Residential	Monthly	Flat Fee	$7.50	Fixed	NA	NA
Circle Pines	Commercial	Monthly	Flat Fee	$7.50	Fixed	NA	NA
Circle Pines	Residential	Monthly	Usage	$1.70	1000 gallons	0-8,000	NA
Circle Pines	Residential	Monthly	Usage	$2.00	1000 gallons	8,001-16,000	NA
Circle Pines	Residential	Monthly	Usage	$2.35	1000 gallons	16001-35,000	NA
Circle Pines	Residential	Monthly	Usage	$3.25	1000 gallons	>35,000	NA
Circle Pines	Commercial	Monthly	Usage	$1.70	1000 gallons	0-16,000	NA
Circle Pines	Commercial	Monthly	Usage	$2.00	1000 gallons	16,001-35,000	NA
Circle Pines	Commercial	Monthly	Usage	$2.35	1000 gallons	>35,000	NA
Forest Lake	All Use	Quarterly	Flat Fee	$19.70	1000 gallons	0-5,000	3/4"
Forest Lake	All Use	Quarterly	Flat Fee	$38.00	1000 gallons	5,001-10,000	1"
Forest Lake	All Use	Quarterly	Flat Fee	$83.50	1000 gallons	10,001-22,000	1.5"
Forest Lake	All Use	Quarterly	Flat Fee	$151.80	1000 gallons	22,001-40,000	2"
Forest Lake	All Use	Quarterly	Flat Fee	$341.60	1000 gallons	40,001-90,000	3"
Forest Lake	All Use	Quarterly	Flat Fee	$607.20	1000 gallons	90,001-160,000	4"
Forest Lake	All Use	Quarterly	Flat Fee	$1,214.40	1000 gallons	160,001-320,001	5"
Forest Lake	All Use	Quarterly	Usage	$3.80	1000 gallons	>5,001	≥1"
Forest Lake	All Use	Quarterly	Usage	$3.94	1000 gallons	0-5,000	3/4"
Hugo	Residential	Quarterly	Flat Fee	$17.00	Fixed	Base	NA
Hugo	Commercial	Quarterly	Flat Fee	$8.00	Fixed	Base	NA
Hugo	Residential	Quarterly	Usage	$1.50	1000 gallons	0-15,000	NA
Hugo	Residential	Quarterly	Usage	$1.65	1000 gallons	15,001-30,000	NA
Hugo	Residential	Quarterly	Usage	$2.50	1000 gallons	>30,001	NA
Hugo	Irrigation	Quarterly	Usage	$2.65	1000 gallons	All Use	NA
Hugo	Commercial	Quarterly	Usage	$1.00	1000 gallons	0-5,000	NA
Hugo	Commercial	Quarterly	Usage	$1.65	1000 gallons	>5,000	NA
Lexington	Residential	Quarterly	Flat Fee	$11.00	Fixed	Base	NA
Lexington	Commercial	Quarterly	Flat Fee	$11.00	Fixed	Base	NA
Lexington	Residential	Quarterly	Usage	$1.76	1000 gallons	0-15,000	NA
Lexington	Residential	Quarterly	Usage	$2.20	1000 gallons	15,001-30,000	NA
Lexington	Residential	Quarterly	Usage	$2.97	1000 gallons	30,001-40,000	NA

City	Use Type	Billing Frequency	Charge Type	Cost per Unit	Cost Unit	Usage Range	Meter Size
Lexington	Residential	Quarterly	Usage	$4.15	1000 gallons	>40,000	NA
Lexington	Commercial	Quarterly	Usage	$1.54	1000 gallons	0-15,000	NA
Lexington	Commercial	Quarterly	Usage	$1.93	1000 gallons	15,001-30,000	NA
Lexington	Commercial	Quarterly	Usage	$2.61	1000 gallons	30,001-40,000	NA
Lexington	Commercial	Quarterly	Usage	$3.65	1000 gallons	>40,000	NA
Lino Lakes	Residential	Quarterly	Flat Fee	$10.00	Fixed per REU	Base	NA
Lino Lakes	Commercial	Quarterly	Flat Fee	$10.00	Fixed per REU	Base	NA
Lino Lakes	Residential	Quarterly	Usage	$1.80	1000 gallons	0-20,000	NA
Lino Lakes	Residential	Quarterly	Usage	$2.00	1000 gallons	20,001-40,000	NA
Lino Lakes	Residential	Quarterly	Usage	$2.50	1000 gallons	40,001-80,000	NA
Lino Lakes	Residential	Quarterly	Usage	$3.00	1000 gallons	80,001-120,000	NA
Lino Lakes	Residential	Quarterly	Usage	$3.50	1000 gallons	>120,001	NA
Lino Lakes	Irrigation	Quarterly	Usage	$2.50	1000 gallons	0-40,000	NA
Lino Lakes	Irrigation	Quarterly	Usage	$3.00	1000 gallons	40,001-80,000	NA
Lino Lakes	Irrigation	Quarterly	Usage	$3.50	1000 gallons	>80,001	NA
Lino Lakes	Commercial	Quarterly	Usage	$1.80	1000 gallons	0-20,000	NA
Lino Lakes	Commercial	Quarterly	Usage	$2.00	1000 gallons	20,001-40,000	NA
Lino Lakes	Commercial	Quarterly	Usage	$2.25	1000 gallons	>40,0001	NA
Mahtomedi	All Use	Quarterly	Flat Fee	$13.25	Fixed	Base	NA
Mahtomedi	All Use	Quarterly	Usage	$2.08	748 gallons	0-37,000	NA
Mahtomedi	All Use	Quarterly	Usage	$2.49	748 gallons	37,501-56,250	NA
Mahtomedi	All Use	Quarterly	Usage	$3.10	748 gallons	>56,250	NA
North St. Paul	Residential	Monthly	Flat Fee	$7.78	Fixed	Base	NA
North St. Paul	Commercial	Monthly	Flat Fee	$15.56	Fixed	Base	NA
North St. Paul	Residential	Monthly	Usage	$2.28	1000 gallons	0-7,000	NA
North St. Paul	Residential	Monthly	Usage	$2.98	1000 gallons	7,001-20,000	NA
North St. Paul	Residential	Monthly	Usage	$4.34	1000 gallons	>20,001	NA
North St. Paul	Commercial	Monthly	Usage	$2.28	1000 gallons	0-50,000	NA
North St. Paul	Commercial	Monthly	Usage	$2.98	1000 gallons	50,001-150,000	NA
North St. Paul	Commercial	Monthly	Usage	$4.34	1000 gallons	>150,001	NA
Shoreview	All Use	Quarterly	Flat Fee	$13.40	Fixed	Base	NA
Shoreview	All Use	Quarterly	Usage	$1.08	1000 gallons	Tier 1 (5,000)	NA
Shoreview	All Use	Quarterly	Usage	$1.74	1000 gallons	Tier 2 (5,000)	NA
Shoreview	All Use	Quarterly	Usage	$2.41	1000 gallons	Tier 3 (20,000)	NA
Shoreview	All Use	Quarterly	Usage	$3.96	1000 gallons	Tier 4 (>20,000)	NA
Vadnais Heights	All Use	Quarterly	Flat Fee	$9.20	Fixed per REU	Base	5/8"
Vadnais Heights	All Use	Quarterly	Flat Fee	$19.20	Fixed per REU	Base	1"
Vadnais Heights	All Use	Quarterly	Flat Fee	$38.40	Fixed per REU	Base	1.5"
Vadnais Heights	All Use	Quarterly	Flat Fee	$57.88	Fixed per REU	Base	2"
Vadnais Heights	All Use	Quarterly	Flat Fee	$189.21	Fixed per REU	Base	3"

City	Use Type	Billing Frequency	Charge Type	Cost per Unit	Cost Unit	Usage Range	Meter Size
Vadnais Heights	All Use	Quarterly	Flat Fee	$247.09	Fixed per REU	Base	4"
Vadnais Heights	All Use	Quarterly	Usage	$1.02	1000 gallons	0-12,000	NA
Vadnais Heights	All Use	Quarterly	Usage	$1.56	1000 gallons	12,001-25,000	NA
Vadnais Heights	All Use	Quarterly	Usage	$1.59	1000 gallons	MDH surcharge	NA
Vadnais Heights	All Use	Quarterly	Usage	$2.59	1000 gallons	Over 25,000	NA
Vadnais Heights	All Use	Quarterly	Usage	$3.28	1000 gallons	Over 50,000	NA
White Bear Lake	All Use	Quarterly	Usage	$8.16	Fixed	0-6,000	NA
White Bear Lake	All Use	Quarterly	Usage	$0.97	750 gallons	6,001-20,250	NA
White Bear Lake	All Use	Quarterly	Usage	$1.02	750 gallons	20,251-56,250	NA
White Bear Lake	All Use	Quarterly	Usage	$1.15	750 gallons	56,250+	NA
White Bear Township	All Use	Quarterly	Flat Fee	$16.50	1000 gallons	Base	<1"
White Bear Township	All Use	Quarterly	Flat Fee	$26.09	1000 gallons	Base	1"
White Bear Township	All Use	Quarterly	Flat Fee	$36.90	1000 gallons	Base	1.5"
White Bear Township	All Use	Quarterly	Flat Fee	$46.67	1000 gallons	Base	2"
White Bear Township	All Use	Quarterly	Flat Fee	$66.00	1000 gallons	Base	3"
White Bear Township	Residential Irrigation	Quarterly	Usage	$3.25	1000 gallons	All Use	NA
White Bear Township	Commercial Irrigation	Quarterly	Usage	$3.25	1000 gallons	All Use	NA
White Bear Township	Commercial	Quarterly	Usage	$2.45	1000 gallons	All Use	NA
White Bear Township	All Use	Quarterly	Usage	$1.75	1000 gallons	0-24,000	NA
White Bear Township	All Use	Quarterly	Usage	$1.95	1000 gallons	24-39,000	NA
White Bear Township	All Use	Quarterly	Usage	$2.25	1000 gallons	39,001-54,000	NA
White Bear Township	All Use	Quarterly	Usage	$3.25	1000 gallons	54,000+	NA

.

Appendix B: Conjunctive Use Water Quality Memo

Date: June 6, 2014

To: Chris Larson - SEH
Colin Fitzgerald - SEH

From: Greg Harrington

Re: Draft evaluation of water quality issues for the Northeast Metro Water Supply Feasibility Assessment

The purpose of this memo is to provide you with a first draft of my conclusions on the water quality aspects of delivering water from St. Paul Regional Water Services to the suburban communities in the northeast Twin Cities metro area. This draft is qualitative in nature and will be followed with a more quantitative analysis towards the end of June. The more in-depth analysis is not expected to change the general conclusions.

Water quality issues will be driven by a number of factors, including the manner in which SPRWS water is delivered to the communities. The following are possible alternatives

- Abandonment of existing wells with complete conversion to water from SPRWS, or placement of existing wells onto a status of emergency use only.
- Mixing of existing well water with water from SPRWS prior to delivering SPRWS water into the distribution system. This memo only focuses on the water quality aspects of this approach, without covering how this would be done from a hydraulics or construction perspective, and without quantifying costs.
- Retaining existing wells and their entry points while introducing SPRWS water into the distribution system at a separate entry point. This memo does not attempt to identify the most plausible entry point of SPRWS water to each community's distribution system.

As noted later, the communities are strongly encouraged to implement the same distribution system disinfection strategy as SPRWS, which is likely to be chloramination for an extended period of time. For communities that switch from chlorination to chloramination, all three of these alternatives are technically feasible for reaching acceptable water quality targets and the best approach can be decided on a community-by-community basis. For example, those communities with existing treatment facilities for their groundwater sources may find the second option more feasible because they would give up a substantial capital investment to implement the first and third of the above alternatives and they have a potential centralized location to implement the second of the above alternatives. The distance of the community treatment plant from the SPRWS system may influence the decision as well. Those communities without existing treatment facilities may find the first and third options more feasible, due to the cost of reaching a centralized location for the second option.

All of the above could be performed by purchasing treated water from SPRWS or by purchasing untreated water from SPRWS and building a new water treatment plant. For purposes of this assessment, it was assumed that a new water treatment plant would have a similar set of treatment processes as the current SPRWS facility and, therefore, would produce water of similar quality to the existing treatment plant. Thus, this memo assumes that the water quality issues will be independent of the entity providing treated water from the chain of lakes. There are some implications to this assumption. For example, it assumes that SPRWS' ten wells, which are fed into the raw water pipeline between Vadnais Lake and the McCarron WTP, are included in both scenarios.

The remainder of this memo will cover water quality issues on a parameter-specific basis, giving consideration to the three alternative approaches noted above.

Waterborne Pathogens, Disinfection Byproducts and Disinfection

For all three alternatives noted above, the northeast metro communities will transition from rules focused on enteric viruses to rules focused on *Cryptosporidium*, *Giardia*, *Legionella*, *E. coli*, and enteric viruses. Most of the effort needed to manage these water quality concerns is done at the surface water treatment plant, so it is unlikely that the northeast metro communities will be directly involved in this aspect of regulatory compliance. However, the northeast metro communities will transition to a new water supply that has significant potential to form trihalomethanes (THMs) and haloacetic acids (HAAs) when free chlorine is used as a disinfectant. The northeast metro communities will need to continue the maintenance of a disinfectant residual in the distribution system. However, SPRWS meets these standards with chloramines as their distribution system disinfectant while the northeast metro communities currently use free chlorine as their distribution system disinfectant.

The difference in disinfectant raises a number of potential issues for the northeast metro communities. The first of these to consider is breakpoint chemistry, which accounts for the interaction between free chlorine, free ammonia, and chloramines. This chemistry will be explained in more detail in a follow-up report. For the purposes of this memo, this chemistry has implications for the blending of chloraminated SPRWS water with chlorinated water and the implications depend on the approach used to incorporate SPRWS water into the water supply:

- If the wells are abandoned or placed off-line for emergency purposes only, then the northeast metro communities are committing to a conversion from free chlorine to chloramines. With respect to breakpoint chemistry, there will be a short and temporary loss of disinfectant residual at locations in the distribution system. For a location that is one day of residence time downstream of the SPRWS entry point, this loss of residual would likely occur at approximately one day after the SPRWS water is turned on.
- If chloraminated SPRWS water is blended with chlorinated well water prior to distribution system, some loss of disinfectant will occur in the blending tank. To avoid this, it is strongly recommended that well water be introduced to the blending tank with no disinfectant applied upstream of the blending tank. Chlorine and ammonia should be added to the blending tank at a ratio needed to achieve a chloramine residual sufficient to survive the entire residence time of the distribution system.
- If chloraminated SPRWS water is introduced via a separate entry point from chlorinated well water, then there will be areas of the distribution system with little to no disinfectant residual. This will be a permanent issue, unlike the temporary issue associated with the first alternative. Although there are some utilities, notably in southern California, that follow this approach while complying with regulatory standards, it is strongly recommended that the northeast metro communities avoid this by converting to chloramines at the wells. Compliance monitoring for disinfectant residuals and coliform presence does not produce a sufficient number of samples to adequately capture the nature of the problem. Conversion to chloramines would require the installation of an ammonia feed system at each entry point to the distribution system.

As noted above, the northeast metro communities are advised to switch to chloramine disinfection once SPRWS water is introduced to the distribution system, regardless of approach used to implement SPRWS water. Of the three alternatives, the first would require less monitoring, offer easier control of chloramine residuals, and require the operation and maintenance of fewer chemical feed systems. However, all three are technically feasible and the best approach can be decided on a community-by-community basis.

Conversion to chloramines raises some additional water quality issues, to include but not be limited to the following:

- **Nitrification.** Nitrification is the conversion of free ammonia to nitrite by ammonia oxidizing bacteria (AOB). Although AOB are not pathogenic, the nitrite they produce can deplete the chloramine residual. This requires careful monitoring of disinfectant residuals, free ammonia residuals, and areas of the distribution system with long residence times. Data from SPRWS suggest that residence times of 10 days or longer are a significant concern. Implementation of distribution system hydraulic models can help identify areas of concern. Minimizing thermal stratification in storage tanks is an important strategy for managing nitrification events, and the communities will want to consider alternatives for doing this.
- **Microbial counts.** Conversion to chloramines can potentially introduce relatively high disinfectant residuals to areas of the distribution system having historically low disinfectant residuals. This may produce a temporary increase in microorganism counts as the system re-equilibrates to the new disinfectant. Again, careful monitoring is needed to manage this issue.
- **Corrosion chemistry.** The pipe surfaces in the distribution system will need to re-equilibrate to the new redox potential and this could lead to changes in corrosion of lead, copper, and iron pipe materials. Changes are difficult to predict. Although Washington DC was infamous for an increase in lead concentrations after converting from chlorine to chloramines, other utilities have made the conversion without such an issue. Careful monitoring will be needed to understand what changes take place and what control strategies are best implemented, with the understanding that time to equilibration may be more than a year.

- **Toxicity to fish.** The free ammonia present in chloraminated systems is of concern for residents with aquariums containing fish that are sensitive to free ammonia. The communities will need to implement a public education campaign to manage this concern.

Chloramination can be avoided if steps are taken at the treatment plant to remove more natural organic matter (NOM) that is present in the surface water. A sufficient amount of removal would be needed to keep THMs and HAAs below regulatory limits while using free chlorine as the distribution system disinfectant. This would require technologies at a significantly higher cost than currently used to achieve THM and HAA compliance. Implementation of this alternative would require regional cooperation on expectations for water quality and willingness to pay for that water quality.

Lead, Copper and Iron from Pipe Corrosion

As noted above, conversion from free chlorine to chloramines is expected to have some impact on lead, copper, and iron release from pipe corrosion. The concentration of these metals is also dependent on pH, alkalinity, hardness, sulfate concentration, and chloride concentration. For the northeast metro communities, a switch to water from SPRWS will come with a reduction in alkalinity and hardness, but with increased pH as well as increased sulfate and chloride concentrations.

As with the change in disinfectant, changes in these parameters are likely to have site-specific effects on the concentrations of lead, copper, and iron. A study in the Tampa Bay area showed that decreased alkalinity was associated with more iron release but with less lead and copper release. The same study showed that increased sulfate concentration was associated with increased iron release but decreased lead release.

These conflicting concerns suggest that utilities serving the northeast metro communities may wish to participate in some water quality monitoring and testing projects prior to implementation of SPRWS water. This could help utilities anticipate needed changes to corrosion control programs, especially the polyphosphate approach used by ten of the communities. It is important to note that equilibration may take more than a year for precipitation/dissolution processes like those encountered in metals release from pipe surfaces.

As noted earlier, the strategy employed for implementation of SPRWS water will influence changes in water quality. For example, abandonment of existing wells or blending of groundwater with surface water at the entry point to the distribution system will produce a change in water chemistry throughout the distribution system. Using separate entry points for surface water and groundwater will mitigate the widespread nature of the change, but will make changes more difficult to monitor and predict.

Hardness, Iron and Manganese from Source

At the present time, four communities provide oxidation and filtration for iron and manganese removal from their groundwater source and two of these also provide facilities for hardness removal. Eight communities use sequestration to limit iron and manganese precipitation in the distribution system. SPRWS water contains less hardness, iron and manganese than the groundwater sources at the northeast metro communities, which should benefit from this change.

Abandonment of existing wells or blending of groundwater with surface water at the entry point to the distribution system will allow communities using sequestration to abandon or reduce the need for that treatment strategy. A similar statement can be made for those communities using oxidation and filtration, although the costs of doing so may not be practical. Using separate entry points for surface water and groundwater will also reduce the costs of treating the groundwater source by oxidation/filtration or by sequestration.

Taste and Odor

Customers in the northeast metro communities can expect taste and odor properties to change for two reasons. First, many customers will detect a change in taste and odor due to the change in disinfection strategy. Second, there is a possibility that customers will notice the naturally-occurring tastes and odors associated with the surface water supply. The primary culprits for the latter are geosmin and methylisoborneol (MIB). SPRWS has done an extensive amount of work to reduce complaints associated with geosmin and MIB, with granular activated carbon as a key component of the treatment plant. Nevertheless, the communities will likely need to invest in a public education campaign to educate their customers about the change.

Conclusions and Recommendations

At this time, the primary conclusions and recommendations for implementing SPRWS water in the northeast metro communities are as follows:

- Blending chloraminated SPRWS water with chlorinated groundwater will create loss of total chlorine residual. The northeast metro communities are strongly encouraged to switch to chloramination for distribution system disinfection. Public education programs should be implemented to manage concerns with changing taste and odor properties of the water and with aquarium owners.
- Blending SPRWS water with groundwater will change the chemistry of the bulk water in the distribution system, and is expected to change release of lead, copper, and iron from pipe materials. The northeast metro communities are encouraged to participate in treatment studies that elucidate potential changes prior to implementation of SPRWS water.
- There are several alternatives for incorporating SPRWS water at each community:
  - Complete switch to SPRWS water
  - Blending groundwater with SPRWS water prior to the distribution system entry point.
  - Introducing SPRWS water and groundwater at separate entry points to the distribution system.
- The above alternatives should be considered on a case-by-case basis for each community, taking costs into consideration. All are capable of meeting accepted water quality targets, provided that the communities convert to chloramines.

Appendix C: Cost Estimating Methodology

TECHNICAL MEMORANDUM

TO: Chris Larson

FROM: Noah Johnson

DATE: June 25, 2014

RE: Unit Cost Development for the Feasibility Assessment of Approaches to Water Sustainability in the Northeast Metro
SEH No. MCES 126394 14.00

Cost estimating for projects under an urban roadway are difficult to estimate at a study phase level. For the purpose of this study several assumptions are needed. A tool was developed to calculate these costs, titled “MCES_NE_FeasibilityStudy_UnitPrices”. The easily definable cost estimates for pavement removal, trench excavation and backfill, pipe and installing costs, and pavement replacement are quantifiable based on 2014 MNDOT published costs. These costs are developed on sheet “Piping and Pavement” of the tool. These cost typically represent 25-35% of a project. The general assumptions that were used to determine the defined costs are:

- A 40 foot wide section of roadway would be removed and replaced
- The curb, gutter and sidewalks would also be removed and replaced
- Some of the pipe would not be under the roadway and a portion of the pavement costs were not included based on the proposed alignments
- The pipe would be buried 8 feet deep and the excavation would have a side slope of 1:1
- No excavation protection was assumed

Several other undefined costs associated with working in the roadway exist and are not easily determined. These costs include watermain structures and pipe fittings, other trenching or dewatering costs, other pavement removal and replacement costs, conflicts with the proposed alignments, allowances, and construction activity costs. These costs make up the majority of the project costs and are unknown without a significant effort. In order to estimate these costs a similar project that was just bid in 2014 was reviewed, sheet “SLP” of the tool. Each item was reviewed and the prices were removed from the project if they were accounted for in the defined costs listed above. The remaining bid items were grouped based on the cost item in the following groups:

- Pipe Fittings
- Other Trenching Costs
- Watermain Structures
- Other Pavement Costs
- Allowances
- Construction Costs
- Stormwater Protection
- Utility Conflicts

These undefined costs were then divided by the total amount of roadway that was removed and replaced in the similar project. This method provided a unit price per foot for each group of undefined cost. These costs are totaled in the “Undefined Costs” sheet in the tool.

To determine the basis for the final projected unit costs, the proposed alignments were considered. Three unit costs for each pipe diameter were developed based on the percentage of the pipe alignment under the roadway. The pavement costs were adjusted based directly on the amount of pavement that would be removed and replaced, identified in the “Percent Under Road” column of the “Piping and Pavement” sheet. The undefined costs were not directly adjusted by the same amounts, these were adjusted based on the potential to encounter the undefined costs identified in the “Multiplier” cells of the “Undefined Costs” sheet. The undefined costs were further refined based on the diameter of the pipe to be installed. The undefined costs were scaled down linearly based on pipe diameter, 60” pipe assumed 100% of the undefined costs down to 24” pipe which assumed 60% of these costs. With a range of unit prices, the final proposed alignments can be evaluated and a final total cost can be calculated. The following tables outline the assumptions made to determine the unit costs and the final unit costs for each pipe diameter.

Table 1. Unit Cost Adjustments Based on the Proposed Alignments

Percentage of the alignment under the roadway	Percentage of pavement costs included in the unit cost	Percentage of undefined costs included in the unit cost
100%	100%	100%
50%	50%	50%
0%	0%	25%

Table 2. Northeast Metro Water Supply Feasibility Study Unit Cost Summary

Pipe Diameter (in)	Percent in Roadway	Defined Costs per Foot	Undefined Costs per Foot	Total Costs per Foot
24	0%	$194	$110	$304
24	50%	$283	$219	$503
24	100%	$372	$439	$811
30	0%	$242	$122	$364
30	50%	$331	$244	$575
30	100%	$420	$487	$908
36	0%	$311	$134	$445
36	50%	$400	$268	$668
36	100%	$489	$536	$1,025
42	0%	$371	$146	$518
42	50%	$460	$292	$753
42	100%	$549	$585	$1,134
48	0%	$505	$158	$663
48	50%	$594	$317	$910
48	100%	$683	$634	$1,316
54	0%	$592	$171	$762
54	50%	$681	$341	$1,022
54	100%	$770	$682	$1,452
60	0%	$741	$183	$924
60	50%	$830	$365	$1,196
60	100%	$919	$731	$1,650

Each township provided with water will utilize a booster station to provide the required system water pressure. It is more cost effective to transport water at low pressure and boost the pressure at each township. In order to estimate the costs of each of the needed booster stations a cost development tool was created titled “MCES_NE_FeasibilityStudy_BoosterStationEstimate”. Before the tool can be used, the demand and pressure zones of each township and the pressure zone at which the water will be delivered to each booster station must be known. The “Demand Summary” sheet is used for these inputs. Alternative 1B and 1C assumed the booster stations would need to boost from elevation 1019, this is the

St. Paul Regional Water Service pressure zone. North Saint Paul would be supplied by SPRWS at an elevation of 1098. With the flow and head of each booster station determined, several pump curves were evaluated. The “Motor Hp” and “# of Duty Pumps” are direct inputs based on the review of possible pump curves and horsepower that may be used for each application. These direct inputs are used for the basis of each booster station cost estimate.

It is assumed vertical turbine pumps will be used at each booster station. These costs are determined on sheet “Pumps Pipes and Valves” of the tool. Factors were applied to the pump costs for piping, valves and installation costs based on similar projects and design experience. A stand-by pump was included in order to determine the total costs for the pumps detailed in the following table.

Table 3. Alternative 1B and 1C Booster Pump Size and Costs

Community	Flow (MGD)	Head (Ft)	Total Number of Pumps	Hp	Cost per Pump	Total
Centerville	1.3	35	2	10	$74,000.00	$148,000.00
Circle Pines	1.5	35	2	10	$74,000.00	$148,000.00
Columbus	0.8	70	2	15	$77,000.00	$154,000.00
Forest Lake	4.7	71	3	30	$84,000.00	$252,000.00
Hugo	7.0	66	3	50	$89,000.00	$267,000.00
Hugo 2	5.0	36	3	20	$77,000.00	$231,000.00
Lexington	1.7	35	2	15	$77,000.00	$154,000.00
Lino Lakes	7.5	35.5	3	30	$84,000.00	$252,000.00
Mahtomedi	2.4	119	2	50	$89,000.00	$178,000.00
North St. Paul	4.0	27	2	30	$84,000.00	$168,000.00
Shoreview	12.8	73.5	3	100	$118,000.00	$354,000.00
Vadnais Heights	5.1	81	3	40	$86,000.00	$258,000.00
White Bear Lake	9.2	106	3	100	$118,000.00	$354,000.00
White Bear Township	4.2	84	2	75	$98,000.00	$196,000.00

The booster stations will range between a total of 2 or 3 pumps based on water demand. Structure costs were then developed which provided an appropriate footprint and building size for each station. General structural costs and installation multipliers are develop for the 2 or 3 pump stations in sheets “2 Pump Bldg” and “3 Pump Bldg”. Building mechanical estimated costs are based on similar projects and detailed in sheet “Mechanicals” of the tool. The “Yard Piping” sheet details costs for various diameters of pipe, these costs are based on 200 feet of pipe, and fittings needed to bring water into the booster station and to connect to the service line or water tower. The summary sheet tabulates the costs developed in the tool sheets plus electrical and generator costs. The electrical cost is an estimate based on experience and current costs. This estimate is 13% of the pump, structure and mechanical costs. The generator cost is developed based on the size and number of duty pumps needed for each station. It is assumed natural gas generators will be used. The following table outlines the total estimated cost for each booster station in year 2014 dollars, ENR 9800.

Table 4. Alternative 1B and 1C Booster Station Total Costs							
Community	**Pumps, Pipes, Valves Cost**	**Bldg**	**Mechanical**	**Electrical**	**Generator**	**Yard Piping**	**Total Cost**
Centerville	$148,000	$199,442	$45,600	$70,748	$80,000	$26,499	$570,288
Circle Pines	$148,000	$199,442	$45,600	$70,748	$80,000	$26,499	$570,288
Columbus	$154,000	$199,442	$45,600	$71,828	$80,000	$26,499	$577,368
Forest Lake	$252,000	$249,007	$45,600	$98,389	$80,000	$26,499	$751,495
Hugo	$267,000	$249,007	$45,600	$101,089	$80,000	$26,499	$769,195
Hugo 2	$231,000	$249,007	$45,600	$94,609	$80,000	$26,499	$726,715
Lexington	$154,000	$199,442	$45,600	$71,828	$80,000	$26,499	$577,368
Lino Lakes	$252,000	$249,007	$45,600	$98,389	$80,000	$26,499	$751,495
Mahtomedi	$178,000	$199,442	$45,600	$76,148	$80,000	$26,499	$605,688
North St. Paul	$168,000	$199,442	$45,600	$74,348	$80,000	$26,499	$593,888
Shoreview	$354,000	$249,007	$45,600	$116,749	$170,000	$35,251	$970,607
Vadnais Heights	$258,000	$249,007	$45,600	$99,469	$80,000	$26,499	$758,575
White Bear Lake	$354,000	$249,007	$45,600	$116,749	$80,000	$26,499	$871,855
White Bear Township	$196,000	$199,442	$45,600	$79,388	$80,000	$26,499	$626,928

Yearly operation and maintenance costs are determined on tab “O&M Costs”. Based on previous project experience, 3% of the capital costs for the pumping equipment is used to determine the costs in the “Equipment Maintenance” totals to cover items such as pump seal replacement or other typical equipment upkeep costs. A general amount of $2,000 was assumed for heating the building and another $2000 was identified for other miscellaneous building costs. The “Operator Costs” are based on an assumed 4 hours per week of time and an hourly cost of $50. The pumping energy costs assumed the pumps were 60% efficient at pumping the average daily flow and a KW-hr cost of $0.072. The following table outlines the probable costs of operation and maintenance in 2014 dollars.

Table 5. Alternative 1B and 1C Booster Station Yearly Operation and Maintenance Costs						
Community	**Equipment Maintenance**	**Operator Costs**	**Pumping Energy Costs**	**Building Heating**	**Misc Bldg Costs**	**Total**
Centerville	$4,440.00	$10,400.00	$3,049.65	$2,000.00	$2,000.00	$21,889.65
Circle Pines	$4,440.00	$10,400.00	$2,400.60	$2,000.00	$2,000.00	$21,240.60
Columbus	$4,620.00	$10,400.00	$4,705.17	$2,000.00	$2,000.00	$23,725.17
Forest Lake	$7,560.00	$10,400.00	$26,921.34	$2,000.00	$2,000.00	$48,881.34
Hugo	$8,010.00	$10,400.00	$21,776.40	$2,000.00	$2,000.00	$44,186.40
Hugo 2	$6,930.00	$10,400.00	$8,710.56	$2,000.00	$2,000.00	$30,040.56
Lexington	$4,620.00	$10,400.00	$1,985.95	$2,000.00	$2,000.00	$21,005.95
Lino Lakes	$7,560.00	$10,400.00	$14,115.51	$2,000.00	$2,000.00	$36,075.51
Mahtomedi	$5,340.00	$10,400.00	$15,683.90	$2,000.00	$2,000.00	$35,423.90
North St. Paul	$5,040.00	$10,400.00	$7,841.95	$2,000.00	$2,000.00	$27,281.95
Shoreview	$10,620.00	$10,400.00	$48,485.58	$2,000.00	$2,000.00	$73,505.58
Vadnais Heights	$7,740.00	$10,400.00	$25,737.69	$2,000.00	$2,000.00	$47,877.69
White Bear Lake	$10,620.00	$10,400.00	$56,152.25	$2,000.00	$2,000.00	$81,172.25
White Bear Township	$5,880.00	$10,400.00	$22,610.96	$2,000.00	$2,000.00	$42,890.96

Alternatives 2B and 2C assume the booster stations would boost from the trunk water main at an elevation of 1055. North Saint Paul would still be supplied by SPRWS at an elevation of 1098. The size of the pumps are reduced and stations located in Centerville, Circle Pines, Lexington, Lino Lakes and the station in the second pressure zone in Hugo would be eliminated. The following tables outline the results of the alternative 2B and 2C booster station cost analysis.

Table 6. Alternative 2B and 2C Booster Pump Size and Costs

Community	Flow (MGD)	Head (Ft)	Total Number of Pumps	Hp	Cost per Pump	Total
Centerville	--	--	--	--	--	--
Circle Pines	--	--	--	--	--	--
Columbus	0.8	35	2	8	$43,000.00	$ 86,000.00
Forest Lake	4.7	35	3	20	$77,000.00	$231,000.00
Hugo	7.0	30	3	30	$84,000.00	$252,000.00
Hugo 2	--	--	--	--	--	--
Lexington	--	--	--	--	--	--
Lino Lakes	--	--	--	--	--	--
Mahtomedi	2.4	83	2	30	$84,000.00	$168,000.00
North St. Paul	4.0	27	2	30	$84,000.00	$168,000.00
Shoreview	12.8	37.5	3	75	$98,000.00	$294,000.00
Vadnais Heights	5.1	45	3	25	$83,000.00	$249,000.00
White Bear Lake	9.2	70	3	75	$98,000.00	$294,000.00
White Bear Township	4.2	48	2	50	$89,000.00	$178,000.00

Table 7. Alternative 2B and 2C Booster Station Total Costs

Community	Pumps, Pipes, Valves Cost	Bldg	Mechanical	Electrical	Generator	Yard Piping	Total Cost
Centerville	--	--	--	--	--	--	--
Circle Pines	--	--	--	--	--	--	--
Columbus	$86,000	$199,442	$45,600	$59,588	$80,000	$26,499	$497,128
Forest Lake	$231,000	$249,007	$45,600	$94,609	$80,000	$26,499	$726,715
Hugo	$252,000	$249,007	$45,600	$98,389	$80,000	$26,499	$751,495
Hugo 2	--	--	--	--	--	--	--
Lexington	--	--	--	--	--	--	--
Lino Lakes	--	--	--	--	--	--	--
Mahtomedi	$168,000	$199,442	$45,600	$74,348	$80,000	$26,499	$593,888
North St. Paul	$168,000	$199,442	$45,600	$74,348	$80,000	$26,499	$593,888
Shoreview	$294,000	$249,007	$45,600	$105,949	$170,000	$35,251	$899,807
Vadnais Heights	$249,000	$249,007	$45,600	$97,849	$80,000	$26,499	$747,955
White Bear Lake	$294,000	$249,007	$45,600	$105,949	$80,000	$26,499	$801,055
White Bear Township	$178,000	$199,442	$45,600	$76,148	$80,000	$26,499	$605,688

Table 8. Alternative 2B and 2C Booster Station Yearly Operation and Maintenance Costs

Community	Equipment Maintenance	Operator Costs	Pumping Energy Costs	Building Heating	Misc Bldg Costs	Total
Centerville	--	--	--	--	--	--
Circle Pines	--	--	--	--	--	--
Columbus	$2,580.00	$10,400.00	$2,352.59	$2,000.00	$2,000.00	$19,332.59
Forest Lake	$6,930.00	$10,400.00	$17,947.56	$2,000.00	$2,000.00	$39,277.56
Hugo	$7,560.00	$10,400.00	$13,065.84	$2,000.00	$2,000.00	$35,025.84
Hugo 2	--	--	--	--	--	--
Lexington	--	--	--	--	--	--
Lino Lakes	--	--	--	--	--	--
Mahtomedi	$5,040.00	$10,400.00	$9,410.34	$2,000.00	$2,000.00	$28,850.34
North St. Paul	$5,040.00	$10,400.00	$7,841.95	$2,000.00	$2,000.00	$27,281.95
Shoreview	$8,820.00	$10,400.00	$36,364.19	$2,000.00	$2,000.00	$59,584.19
Vadnais Heights	$7,470.00	$10,400.00	$16,086.06	$2,000.00	$2,000.00	$37,956.06
White Bear Lake	$8,820.00	$10,400.00	$42,114.19	$2,000.00	$2,000.00	$65,334.19
White Bear Township	$5,340.00	$10,400.00	$15,073.97	$2,000.00	$2,000.00	$34,813.97

Appendix D: Pipe Segment Descriptions

Pipe Segment Descriptions

The sizes of the water mains may vary depending on alternative. Where water main sizes are not listed, refer to tables in this appendix for pipe sizes.

Segment 1 (7,420 ft) A proposed water main is connected to an existing SPRWS 16" water main in the northeast corner of State Highway 36 and White Bear Avenue. The proposed water main is routed north along the east side of White Bear Avenue to 11th Avenue, and east along 11th Avenue to 2nd Street in North St. Paul. The proposed water main is routed north on 2nd Street to the North St. Paul water tower in the City park at 13th Avenue.

Segment 2 (22,560 ft) – Water main(s) are proposed from the SPRWS McCarron's water treatment facility in St. Paul. The proposed water main(s) are routed north from the water treatment facility to Roselawn Avenue. The water mains are routed east along Roselawn Avenue, tunnel under Interstate 35, to Edgerton Street. The proposed water main(s) are routed north on Edgerton Street, tunnel under State Highway 36, continue north on Edgerton, tunnel under Interstate 694, and continue north to Centerville Road in Vadnais Heights.

Segment 3 (14,140 ft) – A proposed water main continues north along Edgerton Street to the Oak Creek Park. The proposed water main is routed west and north along Vadnais Lake in the property owned by SPRWS. At the north end of Vadnais Lake, the proposed water main is routed west, goes under the SPRWS raw water conduits, to Rice Street.

Segment 4 (14,500 ft) – A proposed water main is routed north on Rice Street to Snail Lake Road, west on Snail Lake Road to Hodgson Road, and northwest on Hodgson Road to County Road 96. The proposed water main is tunneled under Highway 96 and routed west to Victoria Street.

Segment 5 (12,350 ft) – A single water main is routed from the intersection of Edgerton Street and Centerville Road northeast along Centerville Road to County Road E. The water main is routed east along County Road E, tunnels under Interstate 35E, and continues east to State Highway 61.

Segment 6 (27,330 ft) **-** A proposed water main is routed north along the west side of State Highway 61 from County Road E to Scheuneman Road. The proposed water main is routed north on Sheuneman Road to Otter Lake Road, north on Otter Lake Road to Park Street. The proposed water main is routed east on Park Avenue, across Columbia Park, to 4th Avenue. The proposed water main is routed north on 4th Avenue, tunnels under Highway 96, and continues north to 5th Street. The proposed water main is routed east on 5th Street to Wood Avenue, north on Wood Avenue to 9th Street, east on 9th Street to Bald Eagle Avenue, and north on Bald Eagle Avenue to Stillwater Street. The proposed water main is routed east on Stillwater Street to Division Street, north on Division Street to Park Avenue, and east on Park Avenue to Highway 61.

Segment 7 (11,000 ft) – A 30" water main is routed from the water main at State Highway 61, tunnels under Highway 61, and continues along County Road E to White Bear Avenue. The 30" water main is routed south along White Bear Avenue to Orchard Lane. The 30" water main is routed east along Orchard Lane to the White Bear Lake water treatment facility.

Segment 8-1 (7,200 ft) To provide water to Mahtomedi, a proposed 12" water main is connected to the 30" water main in Orchard Lane. The proposed 12" water main is routed east on Orchard Avenue to Bellaire Avenue. The proposed 12" water main is routed along Bellaire Avenue to the south and east and crosses Century Avenue.

Segment 8-2 (1,700 ft) **-** To provide water to Mahtomedi's low pressure zone, a new section of 10" water main is proposed. The proposed 10" water main connects to existing 12" water main in Dunbar Avenue and is routed east to Lincolntown Avenue and north on Lincolntown Avenue where it connects to an existing 10" water main.

Segment 9 (21,400 ft) – A proposed 48" water main is routed south on the west side of State Highway 61 from County Road 8 to Park Avenue in White Bear Township, where the proposed 48" water main connects to the proposed 48" water main Segment 2F. This completes the trunk water main loop.

Segment 10 (16,000 ft) – A proposed 48" water main is routed east on West Cedar Street from 20th Avenue South, tunneled under Interstate Highway 35E to Otter Lake Road, and north on Otter Lake Road to County Road 14. At County Road 14, the proposed 48" water main is routed east to State Highway 61.

Segment 11 (12,880 ft) – A proposed 48" water main is routed east on Hodgson Road from Pheasant Run South to 20th Avenue South and north on 20th Avenue South to the Centerville border at West Cedar Street.

Segment 12 (18,900 ft) – A proposed 48" water main is routed north on Hodgson Road to Birch Street, east on Birch Street to Pheasant Run South.

Segment 13 (17,850 ft) – A proposed 48" water main is routed north on Victoria Street (turns into Larson Road), east on Mercury Drive West to Hodgson Connection, north on Hodgson Connection to Hodgson Road. The proposed 48" water main is routed north on Hodgson Road to County Road J.

Segment 14 (37,900 ft) – A proposed 20" water main is routed north along State Highway 61 underneath the existing trail from County Road 8 in Hugo to Highway 97 in Forest Lake.

Segment 15 (9,500 ft) – A proposed 10" water main is routed west from the intersection of Highway 97 and State Highway 61 to Hornsby Street in Columbus.

Segment 16 (16,305 ft) – A proposed 12" water main is routed west from the intersection of County Road J and Hodgson Road. The proposed 12" water main is routed west on County Road J to Lexington Avenue, north on Lexington Avenue to Woodland Road.

Segment 17 – (3,020 ft) - A proposed 12" water main is routed west on Woodland Road, jacked and cased under Lexington Avenue, jacked and cased under Lake Drive, to Hamline Avenue. The proposed 12" water main is routed north on Hamline Avenue to the Lexington water tower.

Segment 18 – (5,000 ft) - A proposed 12" water main is routed north on Lexington Avenue from Woodland Road, northeast on Lake Drive to the Circle Pines WTP.

Table 3-2
Alternative 1A – SPRWS Connection to North St. Paul

Item	**Units**	**Unit Cost**	**Total Cost**
16" Directionally Drilled HDPE	7,100 ft	$300/ft	$2,130,000
16" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	10	$15,000 ea	$150,000
Booster Stations			
North St. Paul – 4 MGD	1	$650,000 ea	$650,000
Easements/Land Acquisition	36,000 sf	$6/sf	$216,000
Environmental	1.3 miles	$50,000/mile pipe	$65,000
		Subtotal	**$3,461,000**
		Contingency (30%)	$1,038,000
		Eng/Admin/Legal (20%)	$692,000
		Total Alternative 1A	**$5,191,000**

Table 3-3 Alternative 1B – SPRWS Connection to Select NE Metro Communities			
Item	**Units**	**Unit Cost**	**Total Cost**
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
Segment 2			
Open Cut 48" DIP (100% in road)	22,560 ft	$1,316/ft	$29,689,000
48" Cased, tunneled pipe	1,200 ft	$4,000/ft	$4,800,000
Segment 3			
Open Cut 30" (0% in road)	14,140 ft	$364/ft	$5,147,000
Segment 4			
Open Cut 30" DIP (100% in road)	14,500 ft	$908/ft	$13,166,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segment 5			
Open Cut 36" DIP (100% in road)	12,350 ft	$1,025	$12,659,000
36" cased, tunneled pipe	400 ft	$3,000/ft	$1,200,000
Segment 6			
Directionally Drilled 18" HDPE	27,330 ft	$350/ft	$9,566,000
18" cased, tunneled pipe	250 ft	$1,250/ft	$313,000
Fusing Pits	39	$15,000 ea	$585,000
Segment 7			
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segments 8-1, 8-2			
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$585,000 ea	$585,000
Shoreview – 13 MGD	1	$938,000 ea	$938,000
Vadnais Heights – 6 MGD	1	$731,000 ea	$731,000
White Bear Lake – 10 MGD	1	$839,000 ea	$839,000
White Bear Twp – 5 MGD	1	$605,000 ea	$605,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	675,000 sf	$6/sf	$4,050,000
Environmental	21.5 miles	$50,000/mile pipe	$1,075,000
		Subtotal	**$103,575,000**
		Contingency (30%)	$31,073,000
		Eng/Admin/Legal (20%)	$20,715,000
		Total Alternative 1B	**$155,363,000**

Table 3-4 Alternative 1C – Phase 1 – SPRWS Connection to North St. Paul, Vadnais Heights, White Bear Lake, White Bear Township, and Shoreview			
Item	**Units**	**Unit Cost**	**Total Cost**
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
Segment 2			
Open cut dual 48" DIP (100% in road)	22,560 ft	$1,979/ft	$44,646,000
48" Cased, tunneled pipe	2,400 ft	$4,000/ft	$9,600,000
Segment 3			
Open Cut 48" (0% in road)	14,140 ft	$663/ft	$9,375,000
Segment 4			
Open Cut 48" DIP (100% in road)	14,500 ft	$1,316/ft	$19,082,000
48" cased, tunneled pipe	250 ft	$4,000/ft	$1,000,000
Segment 5			
Open Cut 48" DIP (100% in road)	12,350 ft	$1,316/ft	$16,253,000
48" cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Segment 6			
Open Cut 48" DIP (100% in road)	27,330 ft	$1,316/ft	$35,966,000
48" cased, tunneled pipe	250 ft	$4,000/ft	$1,000,000
Segment 7			
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segments 8-1, 8-2			
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$585,000 ea	$585,000
Shoreview – 13 MGD	1	$938,000 ea	$938,000
Vadnais Heights – 6 MGD	1	$731,000 ea	$731,000
White Bear Lake – 10 MGD	1	$839,000 ea	$839,000
White Bear Twp – 5 MGD	1	$605,000 ea	$605,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	682,000 sf	$6/sf	$4,091,000
Environmental	21.7 miles	$50,000/mile pipe	$1,085,000
		Subtotal	**$164,371,000**
		Contingency (30%)	$49,311,000
		Eng/Admin/Legal (20%)	$32,874,000
		Total Alt 1C, Phase 1	**$246,556,000**

Table 3-5
Alternative 1C – Phase 2 – SPRWS Connection to Hugo, Lino Lakes, and Centerville

Item	Units	Unit Cost	Total Cost
Fridley Pumping Station Upgrades	1	$10,000,000 ea	$10,000,000
Additional 60” Raw Water Conduit (50% in road)	42,000 ft	$1,196/ft	$50,232,000
50 MGD SPRWS Treatment Plant Expansion	1	$65,000,000 ea	$65,000,000
Segment 9			
Open Cut 48” DIP (50% in road)	21,400 ft	$910/ft	$19,474,000
Segment 10			
Open Cut 48” DIP (100% in road)	16,000 ft	$1,316/ft	$21,056,000
48” cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Segment 11			
Open Cut 48” DIP (50% in road)	12,880 ft	$910/ft	$11,721,000
Segment 12			
Open Cut 48” DIP (50% in road)	18,900 ft	$910/ft	$17,199,000
Segment 13			
Open Cut 48” DIP (50% in road)	17,850 ft	$910/ft	$16,244,000
Booster Stations			
Centerville – 2 MGD	1	$551,000 ea	$551,000
Hugo – 7 MGD	1	$741,000 ea	$741,000
Hugo – 5 MGD	1	$700,000 ea	$700,000
Lino Lakes – 8 MGD	1	$724,000 ea	$724,000
Easements/Land Acquisition	524,000 sf	$6/sf	$3,144,000
Environmental	24.5 miles	$50,000/mile pipe	$1,225,000
		Subtotal	**$219,611,000**
		Contingency (30%)	$65,883,000
		Eng/Admin/Legal (20%)	$43,922,000
		Total Alt 1C, Phase 2	**$329,416,000**

Table 3-6
Alternative 1C – Phase 3 – SPRWS Connection to Forest Lake, Columbus, Circle Pines, and Lexington

Item	Units	Unit Cost	Total Cost
Segment 14			
20” Directionally drilled HDPE (or open cut under trail)	37,900 ft	$400/ft	$15,160,000
Fusing Pits	54	$15,000 ea	$810,000
Segment 15			
10” Directionally drilled HDPE	9,500 ft	$225/ft	$2,138,000
Fusing Pits	14	$15,000 ea	$210,000
10” cased, tunneled pipe	250 ft	$900/ft	$225,000
Segment 16			
12” Directionally drilled HDPE	16,305 ft	$250/ft	$4,076,000
Fusing Pits	23	$15,000 ea	$345,000
Segment 17			
12” Directionally drilled HDPE	3,020 ft	$250/ft	$755,000
Fusing Pits	23	$15,000 ea	$345,000
12” cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Segment 18			
12” Directionally drilled HDPE	5,000 ft	$250/ft	$1,250,000
Fusing Pits	7	$15,000 ea	$105,000
Booster Stations			
Circle Pines – 2 MGD	1	$571,000 ea	$571,000
Columbus – 1 MGD	1	$557,000 ea	$557,000
Forest Lake – 5 MGD	1	$724,000 ea	$724,000
Lexington – 2 MGD	1	$571,000 ea	$571,000
Easements/Land Acquisition	449,000 sf	$6/sf	$2,694,000
Environmental	13.7 miles	$50,000/mile pipe	$685,000
		Subtotal	**$31,471,000**
		Contingency (30%)	$9,441,000
		Eng/Admin/Legal (20%)	$6,294,000
		Total Alt 1C, Phase 3	**$47,206,000**

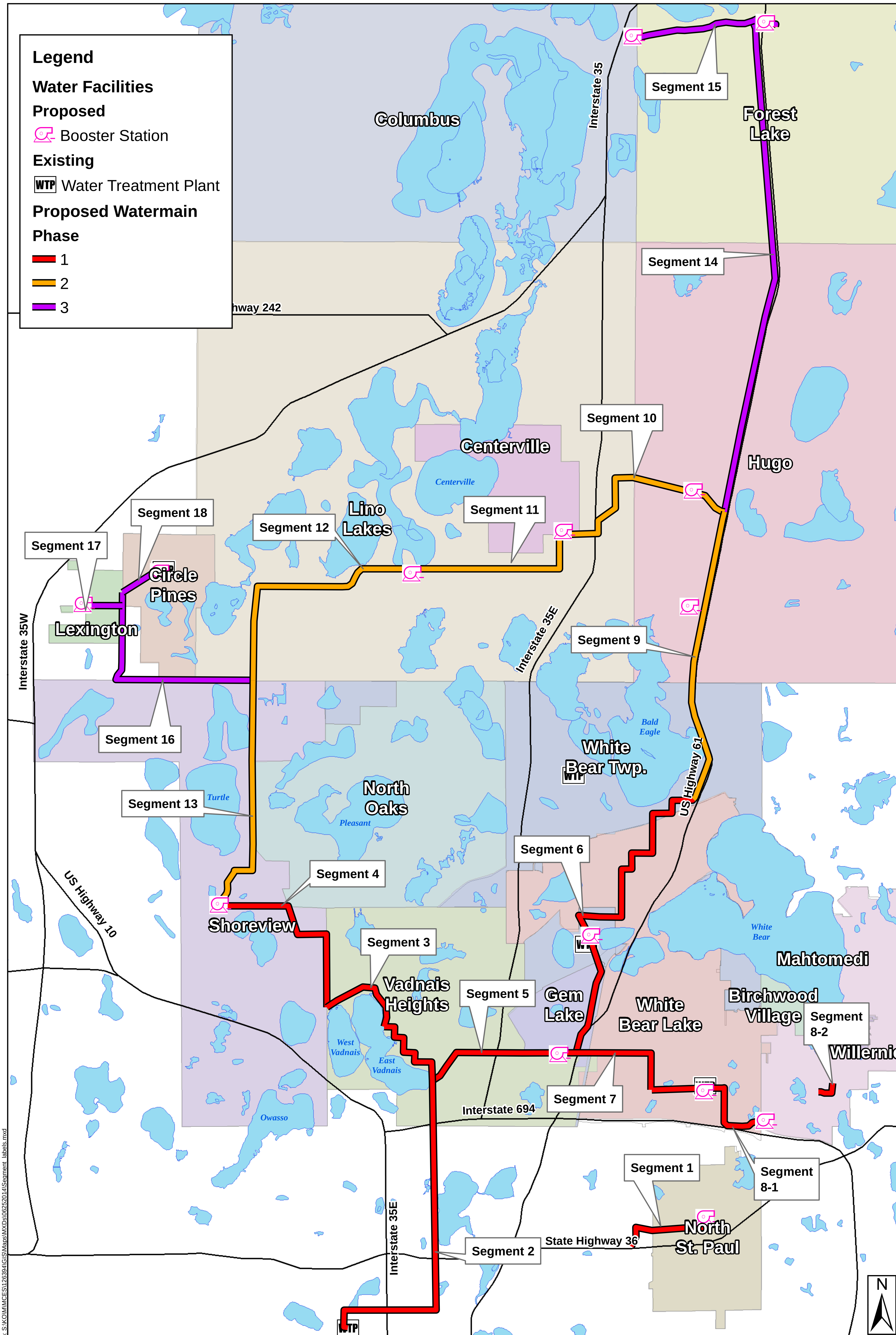
Table 4-1 Alternative 2B – New Surface WTP for Select NE Metro Communities			
Item	**Units**	**Unit Cost**	**Total Cost**
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000 ea	$3,461,000
40 MGD Surface Water Treatment Plant	1	$85,000,000 ea	$85,000,000
Segment 3			
Open Cut 30” (0% in road)	14,140 ft	$364/ft	$5,147,000
Segment 4			
Open Cut 30” DIP (100% in road)	14,500 ft	$908/ft	$13,166,000
30” cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segment 5			
Open Cut 36” DIP (100% in road)	12,350 ft	$1,025/ft	$12,659,000
36” cased, tunneled pipe	400 ft	$3,000/ft	$1,200,000
Segment 6			
Directionally Drilled 18” HDPE	27,330 ft	$350/ft	$9,566,000
18” cased, tunneled pipe	250 ft	$1,250/ft	$313,000
Fusing Pits	39	$15,000 ea	$585,000
Segment 7			
Open Cut 30” DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30” cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segments 8-1, 8-2			
10” Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
12” Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12” cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$585,000 ea	$585,000
Shoreview – 13 MGD	1	$938,000 ea	$938,000
Vadnais Heights – 6 MGD	1	$731,000 ea	$731,000
White Bear Lake – 10 MGD	1	$839,000 ea	$839,000
White Bear Twp – 5 MGD	1	$605,000 ea	$605,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	558,000 sf	$6/sf	$3,348,000
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$153,159,000**
		Contingency (30%)	$45,948,000
		Eng/Admin/Legal (20%)	$30,632,000
		Total Alternative 2B	**$229,739,000**

Table 4-2
Alternative 2C – Phase 1 – New Surface WTP for Vadnais Heights, White Bear Lake, White Bear Township, and Shoreview (North St. Paul to SPRWS)

Item	Units	Unit Cost	Total Cost
Connect North St. Paul to SPRWS (See Table 3-2)	1	$3,461,000	$3,461,000
New 40 MGD Surface Water Treatment Plant	1	$85,000,000	$85,000,000
Segment 3			
Open Cut 48" (0% in road)	14,140 ft	$663	$9,375,000
Segment 4			
Open Cut 48" DIP (100% in road)	14,500 ft	$1,316	$19,082,000
48" cased, tunneled pipe	250 ft	$4,000	$1,000,000
Segment 5			
Open Cut 48" DIP (100% in road)	12,350 ft	$1,316	$16,253,000
48" cased, tunneled pipe	400 ft	$4,000	$1,600,000
Segment 6			
Open Cut 48" DIP (100% in road)	27,330 ft	$1,316	$35,966,000
48" cased, tunneled pipe	250 ft	$4,000	$1,000,000
Segment 7			
Open Cut 30" DIP (100% in road)	11,000 ft	$908/ft	$9,988,000
30" cased, tunneled pipe	250 ft	$2,500/ft	$625,000
Segments 8-1, 8-2			
10" Directionally Drilled HDPE	1,700 ft	$225/ft	$383,000
12" Directionally Drilled HDPE	7,200 ft	$250/ft	$1,800,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Fusing Pits	13	$15,000 ea	$195,000
Booster Stations			
Mahtomedi – 2.5 MGD	1	$585,000 ea	$585,000
Shoreview – 13 MGD	1	$938,000 ea	$938,000
Vadnais Heights – 6 MGD	1	$731,000 ea	$731,000
White Bear Lake – 10 MGD	1	$839,000 ea	$839,000
White Bear Twp – 5 MGD	1	$605,000 ea	$605,000
Flow Control Structure	1	$300,000 ea	$300,000
Easements/Land Acquisition	558,000 sf	$6/sf	$3,348,000
Environmental	17 miles	$50,000/mile pipe	$850,000
		Subtotal	**$194,174,000**
		Contingency (30%)	$58,252,000
		Eng/Admin/Legal (20%)	$38,835,000
		Total Alt 2C, Phase 1	**$291,261,000**

Table 4-3 Alternative 2C – Phase 2 – New Surface WTP for Hugo, Lino Lakes, and Centerville			
Item	**Units**	**Unit Cost**	**Total Cost**
Fridley Pumping Station Upgrades	1	$10,000,000 ea	$10,000,000
Additional 60" Raw Water Conduit (50% in road)	42,000 ft	$1,196/ft	$50,232,000
20 MGD Lime Softening Water Treatment Plant Expansion	1	$30,000,000 ea	$30,000,000
Segment 9			
Open Cut 48" DIP (50% in road)	21,400 ft	$910/ft	$19,474,000
Segment 10			
Open Cut 48" DIP (100% in road)	16,000 ft	$1,316/ft	$21,056,000
48" cased, tunneled pipe	400 ft	$4,000/ft	$1,600,000
Segment 11			
Open Cut 48" DIP (50% in road)	12,880 ft	$910/ft	$11,721,000
Segment 12			
Open Cut 48" DIP (50% in road)	18,900 ft	$910/ft	$17,199,000
Segment 13			
Open Cut 48" DIP (50% in road)	17,850 ft	$910/ft	$16,244,000
Booster Stations			
Hugo – 7 MGD	1	$741,000 ea	$741,000
Easements/Land Acquisition	458,000 sf	$6/sf	$2,748,000
Environmental	24.5 miles	$50,000/mile pipe	$1,225,000
		Subtotal	**$182,240,000**
		Contingency (30%)	$54,672,000
		Eng/Admin/Legal (20%)	$36,448,000
		Total Alt 2C, Phase 2	**$273,360,000**

Table 4-4 Alternative 2C – Phase 3 – New Surface WTP for Forest Lake, Columbus, Circle Pines, and Lexington			
Item	**Units**	**Unit Cost**	**Total Cost**
Segment 14			
20" Directionally drilled HDPE (or open cut under trail)	37,900 ft	$400/ft	$15,160,000
Fusing Pits	54	$15,000 ea	$810,000
Segment 15			
10" Directionally drilled HDPE	9,500 ft	$225/ft	$2,138,000
Fusing Pits	14	$15,000 ea	$210,000
10" cased, tunneled pipe	250 ft	$900/ft	$225,000
Segment 16			
12" Directionally drilled HDPE	16,305 ft	$250/ft	$4,076,000
Fusing Pits	23	$15,000 ea	$345,000
Segment 17			
12" Directionally drilled HDPE	3,020 ft	$250/ft	$755,000
Fusing Pits	23	$15,000 ea	$345,000
12" cased, tunneled pipe	250 ft	$1,000/ft	$250,000
Segment 18			
12" Directionally drilled HDPE	5,000 ft	$250/ft	$1,250,000
Fusing Pits	7	$15,000 ea	$105,000
Booster Stations			
Columbus – 1 MGD	1	$557,000 ea	$557,000
Forest Lake – 5 MGD	1	$724,000 ea	$724,000
Easements/Land Acquisition	403,000 sf	$6/sf	$2,418,000
Environmental	13.7 miles	$50,000/mile pipe	$685,000
		Subtotal	**$30,053,000**
		Contingency (30%)	$9,016,000
		Eng/Admin/Legal (20%)	$6,011,000
		Total Alt 2C, Phase 3	**$45,080,000**



Path: S:\KO\M\MCES\126394\GIS\Maps\MXDs\06252014\Segment_labels.mxd

3535 VADNAIS CENTER DR.
ST. PAUL, MN 55110
PHONE: (651) 490-2000
FAX: (888) 908-8166
TF: (800) 325-2055
www.sehinc.com

Project: 126394
Print Date: 7/14/2014

Map by: aknorr
Projection: WGS_1984
Source: WMS Aerial Photography

Segment Labels

Figure D-1

Appendix E: Surface Water Treatment Rule & Process Train Description

Appendix E – Surface Water Treatment Rule and Process Train

The purpose of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is to reduce illness associated with the contaminant *Cryptosporidium* and other disease-causing microorganisms in drinking water. Pathogens, such as *Giardia* and *Cryptosporidium*, are often found in water, and can cause gastrointestinal illness (e.g., diarrhea, vomiting, cramps) and other health risks. In many cases, this water needs to be disinfected through the use of additives such as chlorine to inactivate (or kill) microbial pathogens.

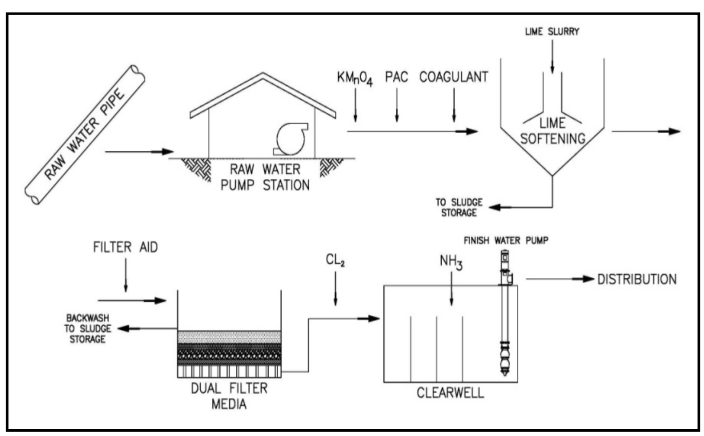
Cryptosporidium is a significant concern in drinking water because it contaminates surface waters used as drinking water sources, it is resistant to chlorine and other disinfectants, and it has caused waterborne disease outbreaks. Consuming water with *Cryptosporidium,* a contaminant in drinking water sources, can cause gastrointestinal illness, which may be severe in people with weakened immune systems (e.g., infants and the elderly) and sometimes fatal in people with severely compromised immune systems (e.g., cancer and AIDS patients).

The rule is intended to supplement existing regulations by targeting additional *Cryptosporidium* concentrations treatment requirements to higher risk systems. LT2ESWTR has the following major components:

- Source water characterization of *Cryptosporidium* concentrations based on a two-year long, monthly source water monitoring program for *Cryptosporidium,* E-Coli, and turbidity. The highest running annual average of the monitoring data will determine the bin classification for compliance.
- Bin classification for treatment requirements are shown in the Table below.
- Requirements presume that conventional treatment obtains 3.0 log removal and direct filtration obtains 2.0 log removal/inactivation of *Cryptosporidium.*
- Treatment requirements range from 0 to 2.5 log additional removal/inactivation of *Cryptosporidium* for systems utilizing conventional treatment resulting in 3.0 to 5.5 log total removal/inactivation of *Cryptosporidium.*
- Additional log removal credits may be achieved by utilizing multiple tools. The following list summarizes alternatives that may be implemented:
  - Watershed Control
  - Alternative Source
  - Pretreatment
  - Improved Treatment
  - Improved disinfection: Chlorine dioxide, ozone, UV
  - Peer review validation of system performance

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%)

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



Process Train

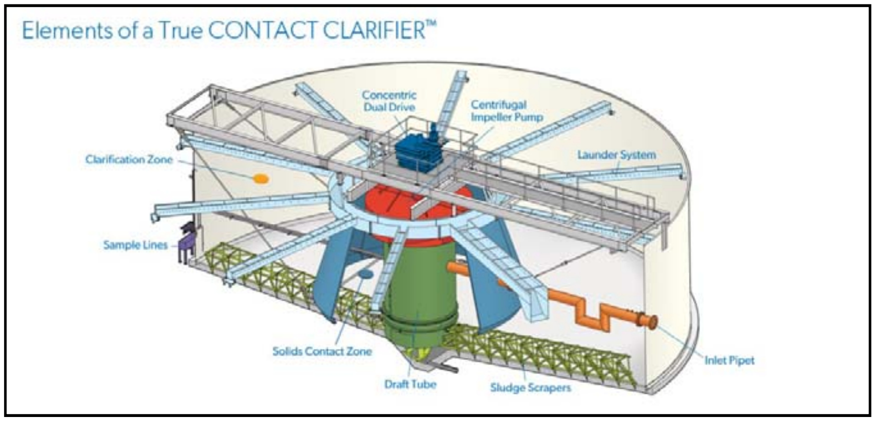
As depicted in the process diagram, a potential process train to treat raw surface water from SPRWS includes raw water pumping, chemical addition, lime softening, filtration, and finished water pumping.

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.

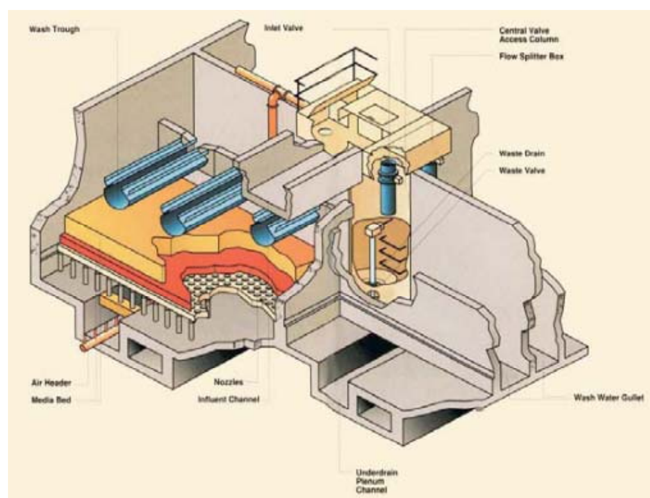
Lime Softening

Lime softening is used to reduce hardness of water prior to filtration. In addition to removal of hardness from a drinking water supply, lime softening can also remove the following constituents including arsenic, barium, beryllium, chromium III, copper, fluoride, lead, mercury, cadmium, nickel and radionuclides. The softening step includes the addition of quick lime (CaO) which combined with water forms hydrated lime slurry ($Ca(OH)_2$) typically in the 5%-10% lime slurry. Hydrated lime can also be used if desired. The lime slurry reacts with CO_2 to form a calcium carbonate ($CaCO_3$) precipitate. The optimum pH is around 10.3. Magnesium precipitation in the form of magnesium hydroxide ($Mg(OH)_2$) requires a pH of 11-11.3. The solids contact clarifiers (SCC) combine mixing, flocculation and sedimentation in a single basin and is typically used for lime softening. The rapid mix time and surface overflow rate will typically govern the sizing of the Raw water and lime is mixed with previously formed lime slurry in a centrally located draft tube with impeller. The water then passes through zones where flocculation occurs followed by clarification. Clarified water is collected in radial effluent launders which direct flow to an effluent discharge pipe. After softening, water is recarbonated to “stabilize” the water. A portion of the solids collected at the bottom of the clarifier is recirculated and serves as a seed for coagulation/precipitation process with the raw water in the contact zone.



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 24”-36” anthracite. Underdrains and or gravel provide the support necessary for the media. Some particles are removed simply by the mechanical process of interstitial straining. However, the filters are capable of removing particulates smaller than the interstices between filter particles. These particles are brought close enough to the surface of the media grains that inter-particle forces attach them to the media. The filter media arrangement allows for the larger particulates to be removed near the top of the media bed with the smaller particulates being retained deeper within the media bed. Typical loading rates range from 2 gpm/ft^2 to 4 gpm/ft^2. Gravity media filters require periodic backwashing depending on the pressure differential across the media. Typical backwash rates range from 12 gpm/ft^2 to 15 gpm/ft^2. The particulates removed in conventional filtration include microbial contaminants, turbidity, THM precursors, as well as those precipitates formed in pretreatment processes.



Appendix F: Study Area Characteristics

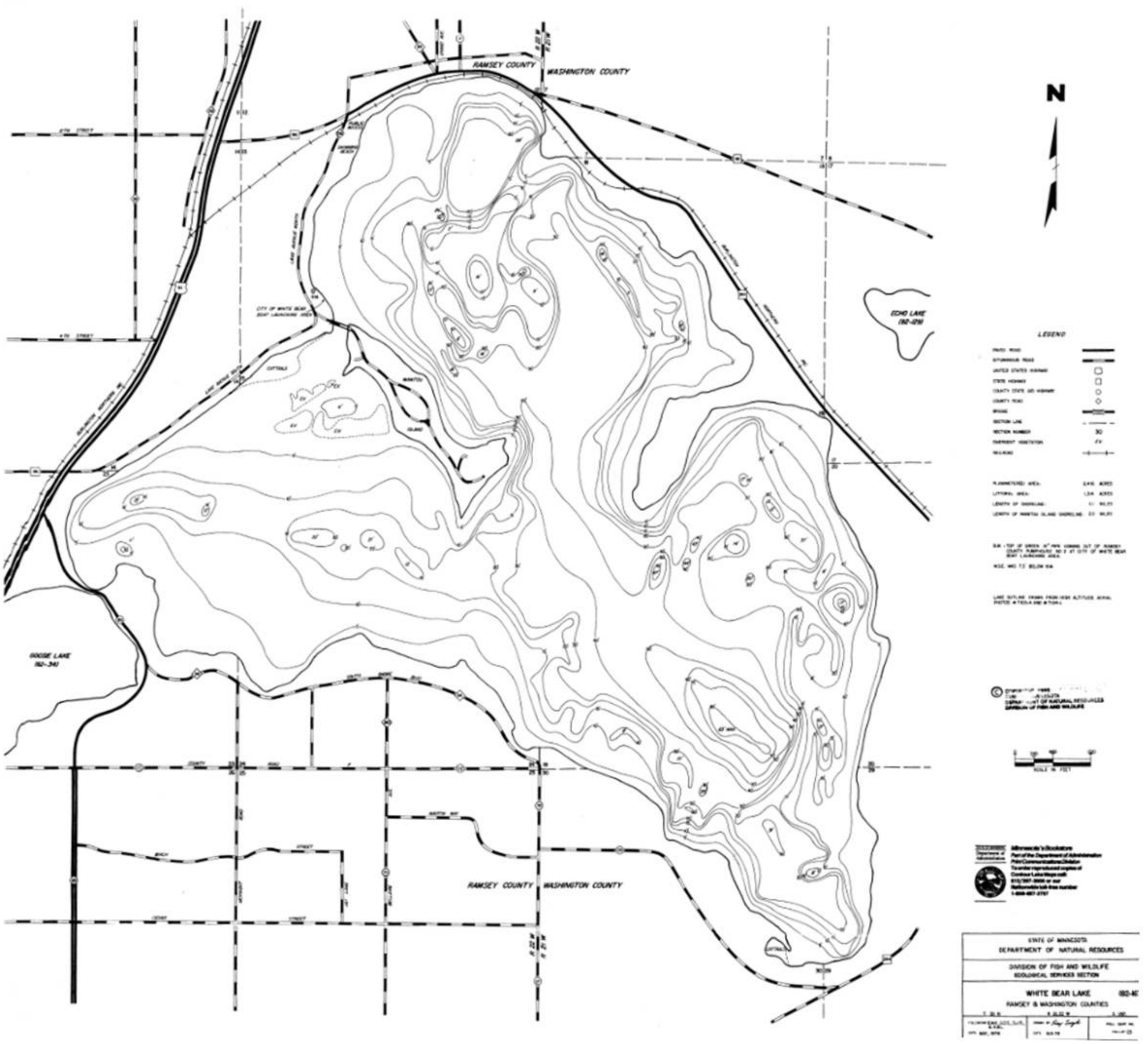
White Bear Lake Study Area Characteristics

White Bear Lake

The lake of interest, White Bear Lake (WBL), is located in Washington County, Minn. WBL has an area of 2127 acres with a maximum depth of 83 feet. An aerial map of WBL is shown below in Figure 1.

WBL has a record high water level of 926.7 feet as measured in 1943. The record low water level is 918 feet as measured in 2013. The ordinary high water level is 924 feet. The lake has a primarily sandy bottom and supports various plant and fish life.

Figure 1. White Bear Lake.



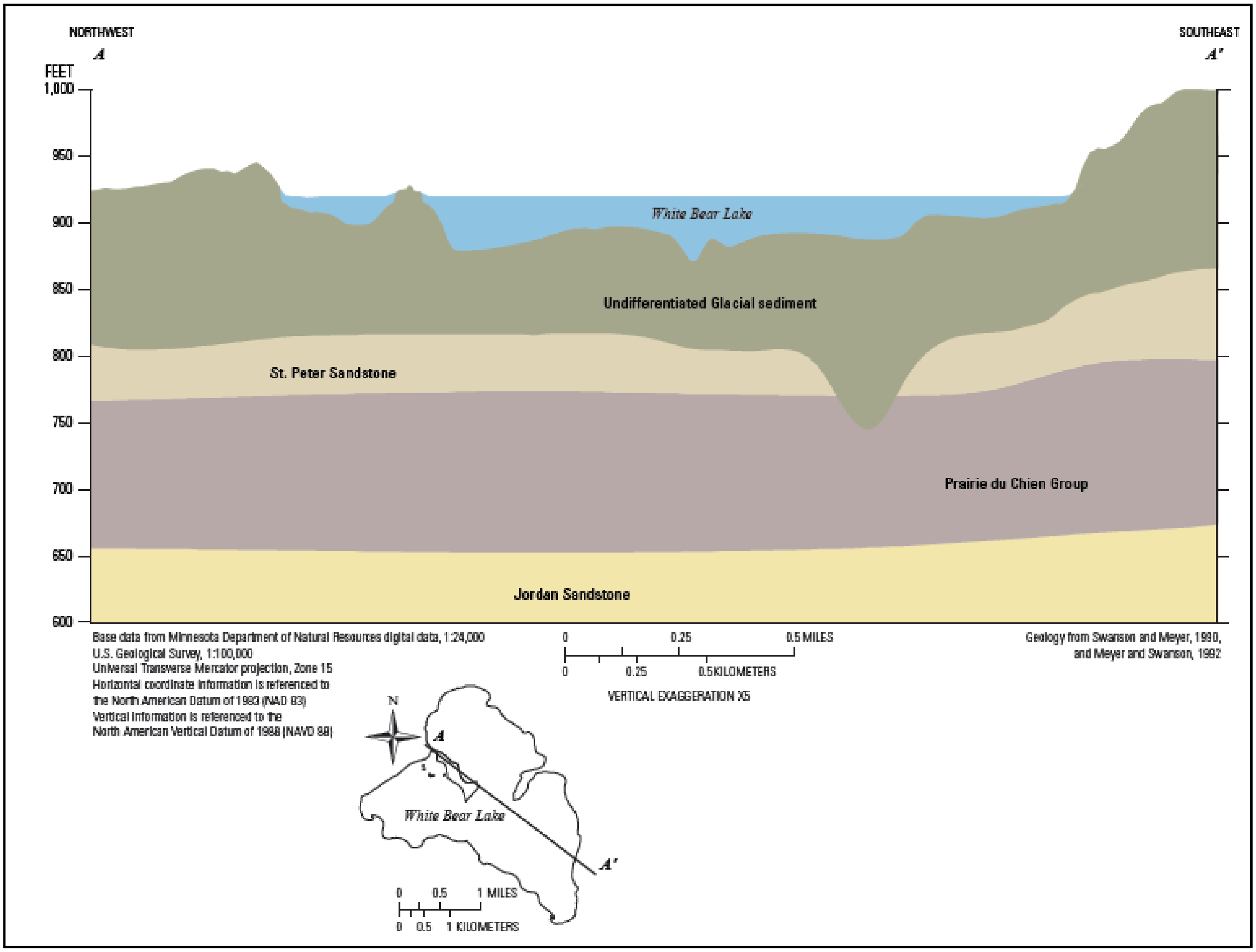
Parks and Recreation

White Bear Lake is used heavily for recreation by a variety of user groups. WBL offers opportunities for boating, fishing, paddling, swimming, and more. Multiple parks surround WBL and offer public swimming areas in the form of public beaches. These include: Memorial Beach Park, Bellaire Beach, Mahtomedi Beach, and other private beaches.

Geotechnical

White Bear Lake is part of a Chain of Lakes that were created by glacial scouring of bedrock and subsequent melting. Shallow geology about White Bear Lake consists of glacial till and outwash deposits. Regional bedrock units include the Glenwood Formation, St. Peter Sandstone, Prairie du Chien group, Jordan Sandstone, St. Lawrence Formation, Franconia Formation, Ironton and Galesville Sandstones, Eau Claire Formation, and Mt. Simon Sandstone. White Bear Lake lies in a bedrock basin that is overlain by glacial deposits. Immediately underlying the deposits are St. Peter Sandstone and the Prairie du Chien Group as shown in Figure 2.

Figure 2. Immediately underlying the deposits are St. Peter Sandstone and the Prairie du Chien Group.



Soils

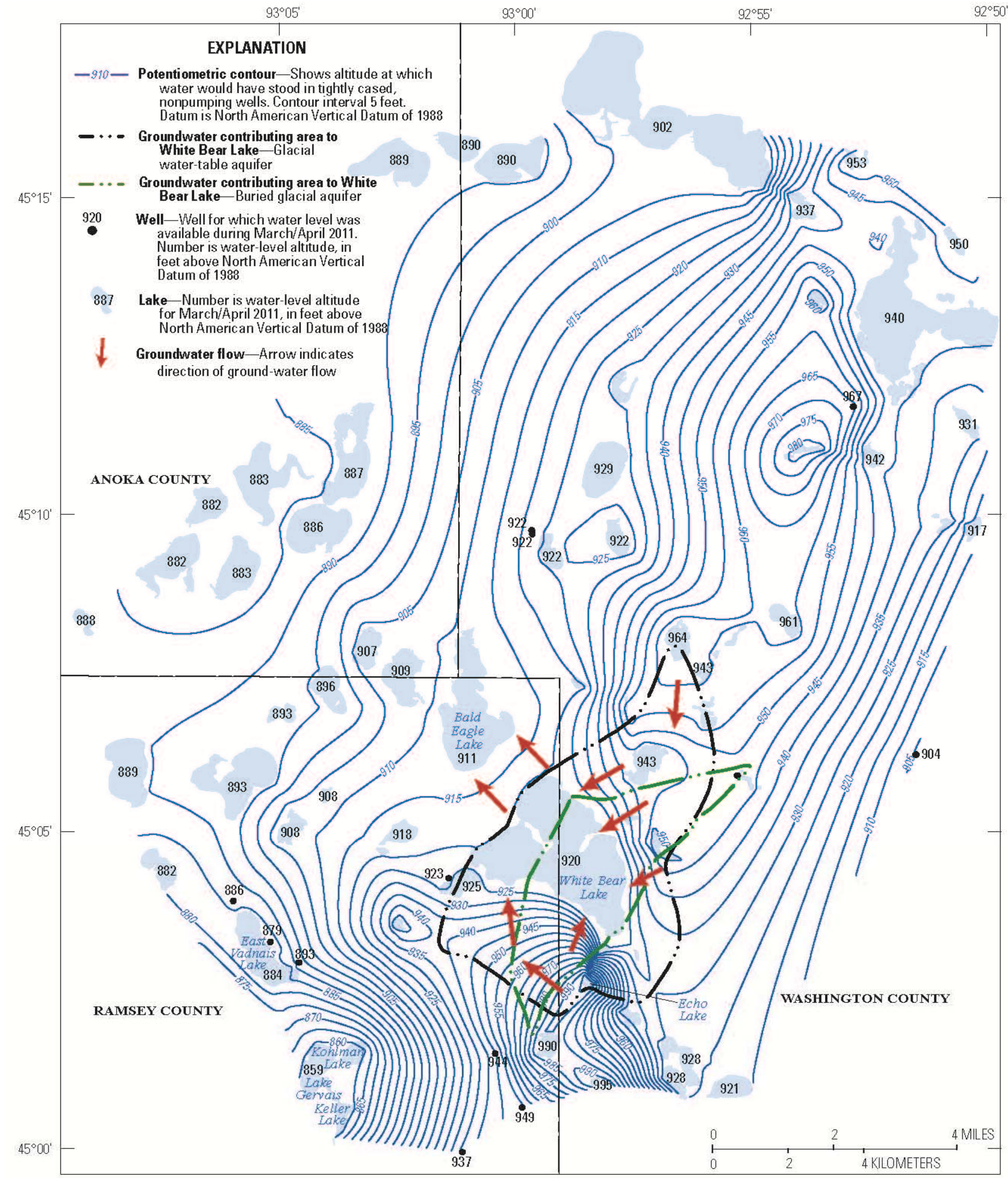
As part of construction of this project, a determination of soil types will need to be performed along the selected route. Water lines, sanitary sewer lines, railroad routes and highway routes are all affected by soil type. The following need to be performed as part of a preliminary geotechnical investigation:

1. Soil borings
2. Geotechnical laboratory testing
3. Report with foundation and other geotechnical recommendations for the facility footprint

Groundwater Resources

The St. Peter Aquifer is utilized to a minor degree for domestic water supply. Groundwater present in glacial till deposits flows toward White Bear Lake on all sides except for the northwest corner of the lake, where the flow path is routed northwest. Groundwater within the Prairie du Chien-Jordan lies at a regional elevation high northeast of White Bear Lake, centered approximately at School Section Lake. Groundwater flows outward from this point, flowing southwest past White Bear Lake. Groundwater within the Franconia Ironton Galesville and Mount Simon-Hinckley aquifers follows similar paths to that in the Prairie du Chien-Jordan aquifer. Figure 3, from the USGS Scientific Investigation report titled “Groundwater and Surface Water Interactions near White Bear Lake, Minnesota, through 2011”, shows the groundwater flow around the lake as well as local well sites.

Figure 3. Potentiometric surface of the glacial water-table aquifer and lake levels in the northeast Twin Cities Metropolitan Area, Minnesota. March/April 2011.



Base data from Minnesota Department of Natural Resources digital data, 1:24,000 and U.S. Geological Survey, 1:100,000
Universal Transverse Mercator projection, Zone 15
Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83)

Appendix G: Environmental Considerations

Environmental Considerations

A search of the Minnesota Pollution Control Agency's (MPCA) "What's In My Neighborhood" (WIMN) database was conducted to identify potential environmental concerns related to White Bear Lake augmentation pipeline route alternatives. Environmental database listings indicate environmental conditions which may negatively impact the construction of augmentation pipeline for portions of several route alternatives.

The MPCA's database was searched with a ¼ mile radius from each of the augmentation routes. The descriptions for the environmental conditions found at the sites are summarized below:

1. Petroleum Brownfield – Petroleum Brownfields are sites potentially contaminated with petroleum where the MPCA is helping buyers, sellers, developers or local governments to voluntarily investigate and clean up land for sale, financing or redevelopment.
2. Voluntary Investigation & Cleanup (VIC) – VIC sites are non-petroleum brownfields where the MPCA is helping buyers, sellers, developers or local governments to voluntarily investigate and clean up land for sale, financing or redevelopment.
3. Leak Site – Leak sites are locations where a release of petroleum products has occurred from a tank system. Leak sites can occur from above ground or underground tank systems as well as from spills at tank facilities.
4. State Assessment Site/Unpermitted Dumpsite – State Assessment sites are places the MPCA has investigated due to suspected contamination. They are assessed to determine if they pose a risk to human health or the environment. If so, they are referred to a cleanup program. Unpermitted dumps are landfills that were never permitted. Generally, they existed before the creation of the MPCA. They were not restricted to any type of waste but were often farm or municipal disposal sites that accepted household waste.
5. CERCLIS Site – A Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) site is a place suspected of being contaminated. Each site is investigated to determine if it needs to be elevated to a state/federal Superfund list.
6. RCRA Cleanup – A Resource Conservation and Recovery Act Cleanup (RCRA) site is a place where a business with a hazardous waste license or permit may have released hazardous waste to the environment. These sites are investigated to decide if cleanup is needed.

Solid Waste, Permit by Rule Landfill – A Permit-by-Rule landfill does not need to obtain a solid waste permit since it meets certain eligibility criteria. It must comply with waste management regulations. It is small and/or operates for a short time (<15,000 cubic yards/1 year).

Concept 1 – Mississippi River

All three Concept 1 alignments share a leak site in common. The leak site is located at Vadnais Heights Service, the proposed site for the intake structure.

Table 1. Concept 1-A Environmental Conditions Review.

Condition	No. of Occurrences
Leak Site	1
Multiple Activities	6
Petroleum Brownfield	0
Solid Wate, Permit By Rule	1
Voluntary Investigation & Cleanup (VIC)	2

Table 2. Concept 1-B Environmental Conditions Review.

Condition	No. of Occurrences
Leak Site	1
Multiple Activities	8
Petroleum Brownfield	0
Solid Waste, Permit By Rule	1
Voluntary Investigation & Cleanup (VIC)	4

Table 3. Concept 1-C Environmental Conditions Review.

Condition	No. of Occurrences
Leak Site	2
Multiple Activities	8
Petroleum Brownfield	1
Solid Waste, Permit By Rule	1
Voluntary Investigation & Cleanup (VIC)	4

Concept 2 – St. Croix River

There are two leak sites located along the proposed conveyance route from the St. Croix River intake at Marine on St. Croix to the outlet at White Bear Lake.

The first leak site is located just north of White Bear Lake at Bartylla Landscaping, Inc. The second is located east of Round Lake at Withrow Elementary School. Leak sites can lead to contaminated soil which increases the cost of construction for contaminated soil excavation and disposal. Further investigation of the constituents present in this soil would be required.

In addition, wetlands as described above in the “Route constraints” section need to be considered. Any wetlands that are disturbed as part of the construction of this project need to be protected during construction or mitigated.

Appendix H: Water Quality

Water Quality Considerations

The Minnesota Pollution Control Agency, Minnesota DNR, Ramsey County Public Works, the Citizen Lake Monitoring Program and MCES have monitored the water quality characteristics of White Bear Lake dating back to 1954. From the data available, the following conclusions can be made about the water quality in White Bear Lake: 1. White Bear Lake is a moderately clear lake (mesotrophic), indicating that WBL has not seen increased aging due to anthropogenic activity, 2. Nutrient levels (nitrogen and phosphorus) are low in WBL indicating there is no excess inflow of nutrients from agricultural or residential properties. This also indicates that WBL does not likely experience significant algal blooms in the summer months, and 3. The only indication of anthropogenic influences on WBL is a steady increase in chloride concentrations.

Saint Paul Regional Water Supply (SPRWS) pumps Mississippi River Water to the water supply's Chain of Lakes, which serve as raw water storage for SPRWS. Water quality characteristics of the river water through the Chain of Lakes and into the McCarron's treatment plant are monitored by SPRWS. The following conclusions can be made about the Mississippi River water, and subsequently, the water in the Chain of Lakes:

1. The Chain of Lakes acts as a clarification process for the intake at SPRWS, reducing turbidity, solids and coliform bacteria

2. The turbidity and solids concentrations in the Mississippi River are significantly higher than those in White Bear Lake, and less as the water moves through the Chain of Lakes.

3. Ammonia and Phosphorus levels in the Mississippi River or Chain of Lakes are not significantly elevated compared to White Bear Lake.

4. Nitrite/Nitrate concentrations are slightly elevated in the Chain of Lakes as compared to White Bear Lake.

Table 1. Constituent Concentrations in River & Lake Water.

Constituent	**River Water**	**Raw WTP Water**	**White Bear Lake**
Temperature °C	NA	20.11±4.38	17.88±4.71
Turbidity(NTU)	9.24±6.18	0.85±0.45	2.03±1.29
pH	8.17±0.25	8.11±0.12	8.24±0.2
Dissolved Oxygen (mg/L)	9.59±1.49	9.77±1.3	7.24±1.82
Total Phosphorus (mg-P/L)	0.06±0.04	0.02±0.01	0.03±0.02
Ammonia (mg-N/L)	0.12±0.03	0.07±0.12	0.06±0.16
Nitrate/Nitrite (mg-N/L)	0.47±0.14	0.26±0.12	0.02±0.01
Total Nitrogen (mg-N/L)	1.08±0.24	0.72±0.21	0.86±0.23
Total Coliform MPN Count/100 ml	1855.67±977.45	995.5±1154.71	211.78±341.21
E.Coli MPN Count/100 ml	42.5±20.76	0.5±0.71	46.55±229.43

If no filtration occurs prior to augmentation, White Bear Lake will likely experience an increase in turbidity and total suspended solids (TSS) concentrations due to the relatively high turbidity and TSS concentrations in the river water.

More complex interactions that could occur include the potential increased rate of eutrophication of White Bear Lake due to increased nutrient concentrations. While the nutrient concentrations in the augmentation water are not elevated to an extreme point of concern, it has been demonstrated that minor, seemingly meaningless increases in phosphorus and nitrogen or changes in the nitrogen to phosphorus ratio can lead to algal/cyanobaterial blooms (SITE). However, the relationship between nitrogen and phosphorus ratios and algal/ cyanobaterial growth is not linear and varies significantly by the lake being examined. Furthermore, while the Mississippi River does not typically experience excessive algal/cyanobacterial growth in the summer, the increased stagnation of the water in White Bear Lake may further support algal/cyanobacterial growth in White Bear Lake.

The biological diversity (both macro and micro) between the augmentation water and White Bear Lake is most likely very different. To date, little work has been done to determine the potential impacts. In this situation we can predict that Total Coliform bacteria will likely increase in White Bear Lake, as the augmentation water has a significantly higher concentration of Total Coliform counts. The filtration facility final design will consider the potential reduction of Total Coliform levels in the augmentation supply.

A screening model prepared by SEH, further demonstrated the effects of mixing augmentation water with White Bear Lake water. The total phosphorus to total nitrogen ratio (N:P) is used to determine which nutrient likely limits aquatic plant and algae growth in a water body. Phosphorus is the limiting nutrient when the ratio is greater than 16:1 and nitrogen is limiting when the ratio is less than 10:1. Water quality data for White Bear Lake indicate that the lake is a phosphorus limited system, as is common in Minnesota Lakes, with an N:P averaging about 46:1. When phosphorus is limiting production, small additions of the nutrient may cause dramatic increases in plant and algae growth and phosphorus should therefore be the focus of management efforts to control plant and algae growth.

The effects of the additional nutrient load from augmentation were simulated with the Wisconsin Lake Modeling Suite (WiLMS) program. The WiLMS is a collection of empirical lake models developed from statistical analyses of lake and reservoir systems and as such the results of the models more accurately predict the percentage of change rather than absolute values. Three of the models in WiLMS were a good fit to White Bear Lake: Canfield-Bachmann (1981) Natural Lake, Canfield-Bachmann (1981) Artificial Lake, and Rechow (1977) Water Load <50 m/yr.

Two augmentation scenarios were evaluated: the first was 2 billion gallons (Bgal) of water and the second was 4 Bgal of water, both sourced from Vadnais Lake in Ramsey County, MN. It was assumed that augmentation would occur from April through November. The growing season for phosphorus was assumed to be April through October. Results of the scenarios for both models are summarized in Table 2.

Table 2. Change in WBL Phosphorus Concentration with Addition of Augmentation Water.

Model Type	**2 Bgal**				**4 Bgal**			
	Conc. Before (ug/L)	**Conc. After (ug/L)**	**% Change**	**Net Change (ug/L)**	**Conc. Before (ug/L)**	**Conc. After (ug/L)**	**% Change**	**Net Change (ug/L)**
Canfield-Bachmann Natural Lake	24	22	6.9	2	24	21	13.8	3
Canfield-Bachmann Artificial Lake	24	21	13.8	3	24	21	13.8	3
Rechow Water Load <50 m/yr	24	25	5.7	1	24	25	5.7	1

The results of the WiLMS indicate that the augmentation water can be a net neutral impact on WBL, but should be closely monitored.

The augmentation system will include a filtration component to reduce the impact of solids and turbidity on the water quality of White Bear Lake. In addition, the filtration system will prevent the transfer of invasive species.

Based on the screening analysis performed as described above, treatment of the augmentation water will not be necessary. It is likely that phosphorus will be further reduced in the augmentation water during filtration.

While the temperature in the augmentation water is slightly higher than that of White Bear Lake, significant impacts are not expected.

Appendix I: Water Budget

White Bear Lake Water Budget

Model Development

A simple water budget model of White Bear Lake was created with Microsoft Excel in order to aid in selecting an augmentation flow rate and gauge its potential effects on lake levels. The development of the model's methods pulled heavily from two previously published works, the Minnesota DNR's "Lake-Ground Water Interaction Study at White Bear Lake, Minnesota" report published in 1998, and the USGS's "Groundwater and Surface-Water Interactions Near White Bear Lake, Minnesota, through 2011" report published in 2013. The model was created based on a water balance equation provided in the MnDNR's 1998 report on historical augmentation of White Bear Lake:

DL	**= P + RO – SO – E + GWex + PA**
DL	= change in water level
P	= direct precipitation
RO	= runoff volume from drainage area
SO	= volume of outflow surface outlet
E	= evaporation
GWex	= groundwater exchange
PA	= volume of pumped augmentation

The model generated expected water levels on a monthly basis given over a three year period, starting at the 2012 and 2013 average lake level elevation of 920 feet amsl and assuming variable values based on past trends. The above equation was also assessed using average the ten year averages of each of the parameters. A description of each variable's estimation is provided below.

<u>Direct Precipitation</u>

Monthly precipitation data recorded at the National Weather Service (NWS) station VADM5-218477 from 2003-2013 was averaged to provide an average precipitation rate for each month. Station 218477 lies approximately three miles from White Bear Lake, and is the closest station to the lake. The volume of precipitation added to the lake was calculated as the precipitation amount multiplied by the area of the lake at the current depth. Lake area was calculated as a function of lake storage, as described in the Stage Storage section below. Monthly precipitation values used are shown in Table 1. Data was obtained from the Minnesota Climatology Working Group's "Nearest Station Precipitation Data Retrieval" website (*http://climate.umn.edu/HIDradius/radius_new.asp*).

<u>Runoff</u>

Using the same method as the USGS's 2013 report, runoff was estimated based on a coefficient determined from the ratio of historical runoff to precipitation stated in the 1998 MnDNR's report. This coefficient, 0.19, was calculated based on the MnDNR's 1981-1990 runoff and precipitation data. This coefficient was multiplied by the area contributing surface water runoff to the lake, 3,087 acres, and the average monthly precipitation values.

<u>Surface Outlet</u>

A culvert with an invert elevation of 924.3 feet amsl is the only outlet from White Bear Lake. If the lake's water level were to rise above this elevation, a negative value proportional to the water level and the culvert's capacity would result; however, this variable was not included because the intention of the model was to determine the time at which augmentation would result in lake levels returning to this elevation.

Table 1. Average Monthly Evaporation Summary.

Month	Precipitation, in
January	0.71
February	1.19
March	2.06
April	3.10
May	4.62
June	4.62
July	3.70
August	3.89
September	3.24
October	2.86
November	0.99
December	1.73
Annual	**32.7**

Source: *http://climate.umn.edu/HIDradius/radius_new.asp*

Evaporation

Similar to precipitation data, pan evaporation data was obtained on a monthly basis from 2003-2013 and averaged by month. A pan evaporation coefficient of 0.75, which was provided in the USGS's 2013 report, was applied to the values. The volume of loss from the lake was taken as the pan evaporation multiplied by the pan coefficient and by the area of the lake at the current depth. Lake area was calculated as a function of lake storage, as described in the Stage Storage section below. Monthly evaporation values used are shown in Table 2. Evaporation data was obtained from the same source as the USGS's 2013 report, which was the Minnesota Climatology Working Group's St. Paul Campus Climatological Observatory (Cooperative station ID 21–8450–6) monthly pan evaporation database, located at *http://climate.umn.edu/img/wxsta/pan-evaporation.htm*.

Groundwater Exchange

Two groundwater exchange values were considered in this analysis. The MnDNR's WATBUD analysis in their 1998 report found that average groundwater loss in the 1930s when lake level augmentation was occurring was 33 inches per year. The other seepage value assessed was 19.2 inches, which was the groundwater exchange parameter calculated based on averaging White Bear Lake's water budget values over the last ten years. The volume of loss from the lake was calculated by multiplying the monthly groundwater loss rate by the area of the lake at the current depth. Lake area was calculated as a function of lake storage, as described in the Stage Storage section below.

Pumped Augmentation

Augmentation scenarios of pumping 6,000 gpm continuously for 8 months for a total of 2 BGY and 12,000 gpm for a total of 4 BGY were assessed. Pumping was not included for the four months between December and March to avoid ice issues.

Table 2. Average monthly evaporation summary.

Month	Evaporation, In
January	0.00
February	0.00
March	0.00
April	1.31
May	4.68
June	5.33
July	6.01
August	4.97
September	3.63
October	1.03
November	0.00
December	0.00
Annual	27.0

Months with "0" values did not have data provided for them; they were assumed to be zero since they represent winter months. Source: *http://www.dnr.state.mn.us/climate/wxsta/pan-evaporation.html*.

Stage Storage

Each of the variables described above was calculated as a volume contribution in acre-feet for each month. A stage storage analysis was provided in the MnDNR's 1998 report, and when fit with a second order polynomial trend line, resulted in a relationship of:

$Y= -7.6E\text{-}09*X^2 + 1.0E\text{-}2*X+892.5$

Y= lake elevation, feet

X= lake volume, acre-ft

Change in Water Level

The effect of each of the above parameters on White Bear Lake's water levels was assessed in two ways. First, a simplified water budget using the ten year averages for each of the variables was solved for the ten year average groundwater exchange parameter. This equation took the following form:

DL = P + RO – SO – E + GWex + PA

-5.3 inches/year = 32.7 inches/year + 8.2 inches/year – 0.7 inches/year – 26.97 inches/year + GWex

GWex= -18.5 inches/year

The results of the temporal water budget model are discussed in the below section.

Results of the Model

Results of the model should be interpreted with caution, and not used for any purpose other than developing a starting point for assessing the effects of lake augmentation.

Table 3 summarizes the time required to bring current lake levels up to 924 feet amsl given the varying pumping rates and seepage scenarios. Assuming augmentation with surface water would result in the same groundwater exchange parameter as augmentation using groundwater in the 1930s did, the low flow 2 BGY option would take approximately 4.5 years to restore White Bear Lake water levels. If the groundwater exchange parameter is unaffected by surface water augmentation, the same pumping scenario could result in restored lake levels as quickly as 1.9 years. A 4 BGY pumping scenario could have similar results in 1.4 years and 11 months respectively.

Table 3. Summary of White Bear Lake water budget findings.

Seepage Scenario (inches/year)	11	18.5	33
Time to fill with no augmentation (years)	>10 years	continued decrease	continued decrease
Time to fill with 4BG/yr (years)	0.8	0.9	1.4
Time to fill with 2BG/yr (years)	1.7	1.9	4.5

Appendix J: System Components

Lake Augmentation System Components

Figure 1. White Bear Lake Augmentation – Intake and Filtration at Vadnais Lake, Profile.

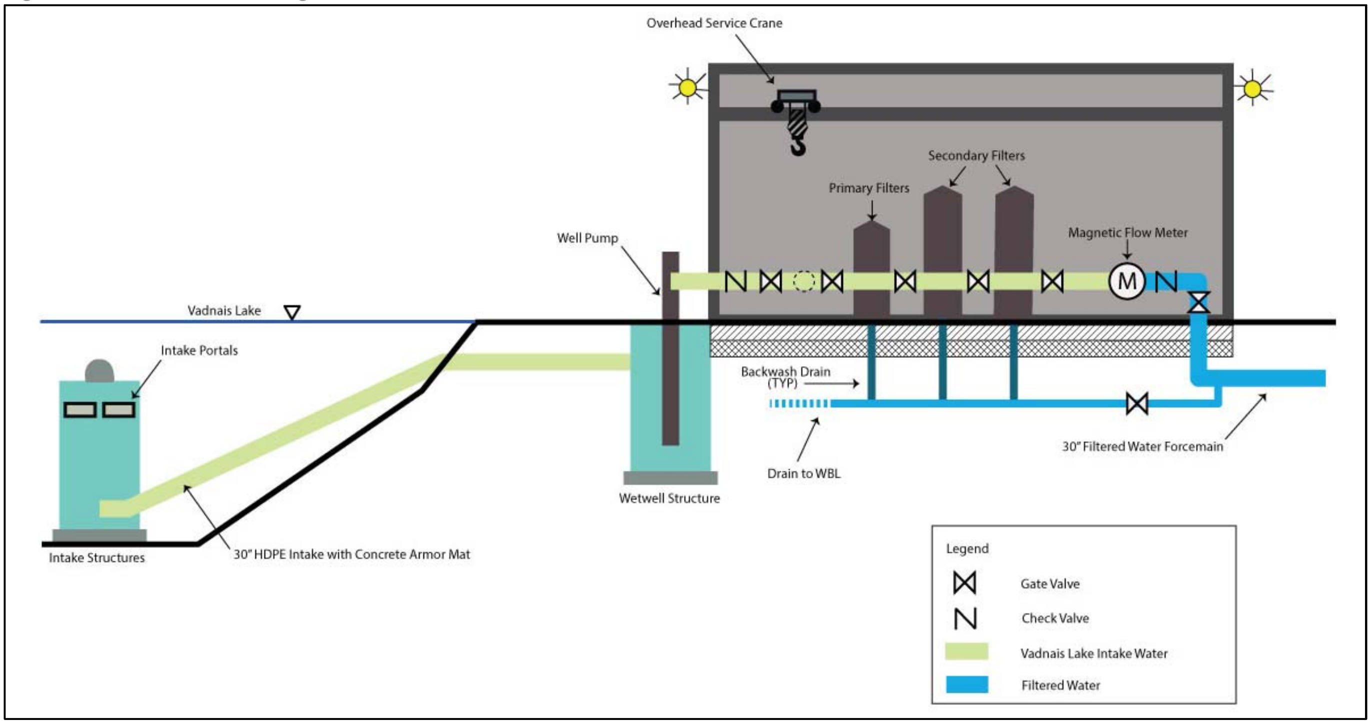


Figure 5-2. White Bear Lake Augmentation – Intake and Filtration at Vadnais Lake, Plan.

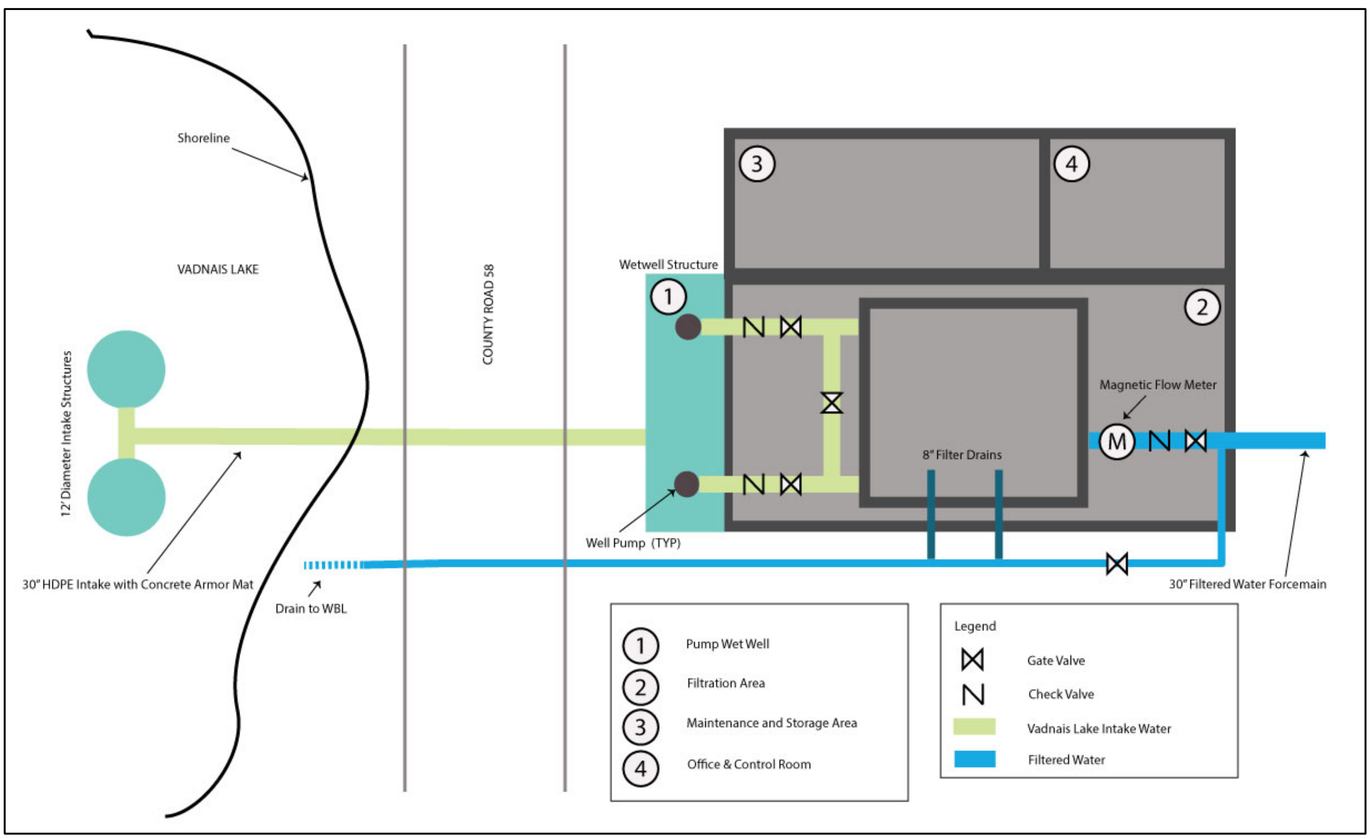
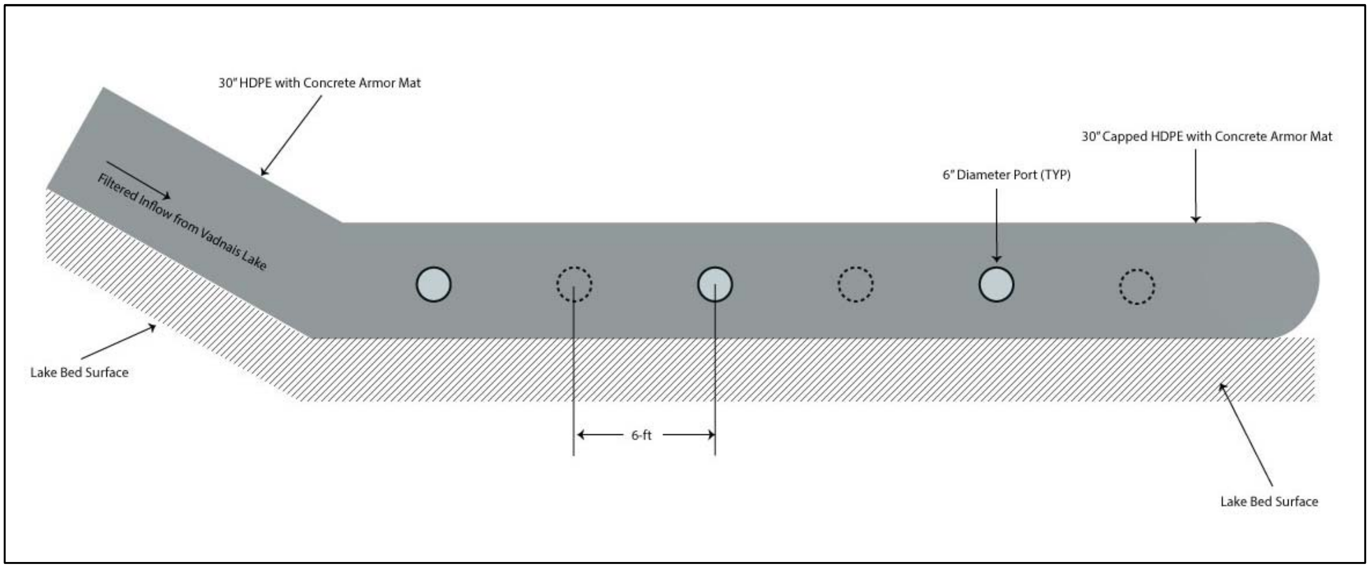


Figure 2. Outlet Structure at White Bear Lake, Profile



Appendix K: Route Characteristics

Lake Augmentation Route Characteristics and Route Constraints

Concept 1A – Vadnais Lake to White Bear Lake via BNSF Railroad Right-of-Way and County Road F (Cty 95)

Route Characteristics
This route includes pumping water from East Vadnais Lake to White Bear Lake via the Burlington Northern Santa Fe (BNSF) Railroad Right of Way and County Road F (Cty 95).

Raw water will be pumped from East Vadnais Lake using an intake structure that includes an intake, pumps, and filtration system as shown in Appendix J figures. The proposed 30-inch HDPE pipe would follow in the railroad right-of-way adjacent to Goose Lake Road (Cty 98) and cross under Interstate 35E under the existing I-35 bridge. Once it passes under the interstate, the alignment would continue in the BNSF Railroad Right-of-Way adjacent to Goose Lake Road (Cty 98).

The Route turns east to cross the Gem Lake Hills Golf Course and follows County Road F (Cty 95), crossing County Road 147, County Road 146, and US Highway 61 by means of tunneling. The alignment turns again to continue north along County Road 160, also known as Bellaire Avenue, through Bellaire Beach Park, and would discharge into White Bear Lake through the outlet structure shown in Appendix J.

Route Constraints
Permission will need to be granted by the Gem Lake Hills Golf Course by permanent easement to install pipe through the golf course. In addition, permission will need to be granted by the City of White Bear Lake to install pipe through the park at Bellaire Beach. Tunneling will need to be coordinated for the crossings of County Road 147, County Road 146 and US Highway 61.

Route constraints stem primarily from the easement use of the Railroad Right-of-Way. BNSF Rail is requiring that all forcemain installed in the Railroad Right-of-Way be installed in a steel casing. In addition, each square foot of land acquired in the right-of-way will add additional cost.

Concept 1B – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and County Road F (Cty 95)

Route Characteristics
This route includes pumping water from East Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and County Road F (Cty 95). The alignment is similar to that outlined in Concept 1A, however, this alignment does not include installing forcemain in the Railroad Right-of-Way.

Raw water will be pumped from East Vadnais Lake using an intake structure that includes pumps and a filtration system as shown in Appendix J. The proposed 30-inch HDPE pipe would follow the highway Right-of-Way of Goose Lake Road (Cty 98) and cross under Interstate 35E under the existing bridge. Once it passes under the interstate, the alignment would continue in the highway right-of-way of Goose Lake Road (Cty 98).

The Route turns east to cross the Gem Lake Hills Golf Course by permanent easement and follows County Road F (Cty 95), crossing County Road 147, County Road 146, and US Highway 61 by means of tunneling. The alignment turns again to continue north along County Road 160, also known as Bellaire Avenue, through Bellaire Beach Park, and would discharge into White Bear Lake through the outlet structure shown in Appendix J.

Route Constraints
Permission will need to be granted by the Gem Lake Hills Golf Course by permanent easement to install pipe through the golf course. In addition, permission will need to be granted by the City of White Bear Lake to install pipe through the park at Bellaire Beach. Tunneling will need to be coordinated for the crossings of County Road 147, County Road 146 and US Highway 61.

Concept 1C – Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98) and Goose Lake

Route Characteristics
This route includes pumping water from East Vadnais Lake to White Bear Lake via Goose Lake Road (Cty 98), also known as Goose Lake Road, as described above. However, rather than the alignment running through the Gem Lake Hills Golf Course by permanent easement and meeting up with Highway 95, this alignment runs south of the Golf Course, crosses US Highway 61, and

then traverses along the bottom of Goose Lake east of US Highway 61 before discharging into White Bear Lake through an outlet structure as described above.

Raw water will be pumped from East Vadnais Lake via an intake structure that includes pumps and a filtration system as shown in Appendix J. The proposed 30-inch HDPE pipe would follow the highway Right-of-Way of Goose Lake Road (Cty 98) and cross under Interstate 35E under the existing bridge. Once it passes under the interstate, the alignment would continue in the highway right-of-way of Goose Lake Road (Cty 98).

The route continues along the south side of the Gem Lake Hills Golf Course before turning north to follow County Road 147. The alignment runs north until County Road 147 meets County Road F (Cty 95), and then it runs east until it meets up with US Highway 61.

Route Constraints
This alignment offers a few constraints in addition to concept 1-B due to the construction of the alignment on the bottom of Goose Lake, as well as the US Highway 61 crossing. Construction of the forcemain pipe along the bottom of Goose Lake will require the issue of a DNR approved permit. An acceptable location will need to be determined for the pipe to be tunneled under US Highway 61 to reach White Bear Lake from Goose Lake.

Concept 2 – St. Croix River

Route Characteristics
Pipe would run west from the St. Croix River to meet up with Highway 95. It would bend at this location and run south along Highway 95 until it meets up with Country Road 7. The pipe would then run west on Country Road 7 until it meets up with Country Road 71 and bends south. The pipe would then cross Lake Avenue and discharge into White Bear Lake.

Route Constraints
This route poses many design constraints in respect to constructability. The stretch of road that runs from Highway 95 west along County Road 7 to Oak Knoll Drive has a very steep incline and contains significant curves and bends in the road. Past this stretch of road there are low-hanging electrical overhead lines that cross the road and would require relocation and coordination with Excel Energy.

Along Country Road 7 between Country Road 11 and Country Road 55, there is a large freshwater emergent wetland on the north side of the road with a freshwater pond. This wetland continues on the south side of the road but does not have standing water. Multiple freshwater emergent wetlands and ponds are within close proximity to the roadway along County Road 7. Where wetlands and standing water are not present, the topography is primarily farmland or large residential lots with multiple outbuildings. The road continues to wind and bend with very few lengths of straight road.

Power lines primarily run along the North side of County Road 7 with the exception of the stretch of road bordering Sunset Lake. The power lines cross Country Road 7 to avoid close proximity to the water body.

Where County Road 7 meets up with Country Road 71 and bends south toward White Bear Lake it is a residential area with many homes, sidewalks, power lines and other infrastructure.

Apart from the constraints offered by the route, there are also constraints due to the protection of the St. Croix River by the National Park Service. As stated on the National Park Service web page, “St. Croix National Scenic Riverway preserves, protects, restores, enhances, and interprets the riverway’s exceptional natural and cultural resources for the enjoyment of present and future generations”. The River is protected under the “Wild and Scenic Rivers Act”.

Refer to Figures 5-1 and 5-2 in the body of the report for route maps.

public.info@metc.state.mn.us
metrocouncil.org

390 Robert Street North
Saint Paul, MN 55101-1805

651.602.1000
TTY 651.291.0904