Comprehensive Water System Plan

2018 Comprehensive Water Plan

Richfield, Minnesota

RICHF 141143 | July 31, 2018

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Comprehensive Water System Plan

2018 Comprehensive Water Plan
Richfield, Minnesota

SEH No. RICHF 141143

July 31, 2018

I hereby certify that this report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

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Comprehensive Water System Plan

2018 Comprehensive Water Plan

Prepared for City of Richfield Public Works Department

1 Introduction

The Richfield municipal water system serves the City of Richfield, which is a community of approximately 37,000 persons located in the southeastern part of Hennepin County. The municipal water system provides water service to residences and businesses within the city limits of Richfield.

The City of Richfield provides water to its customers via one (1) water treatment plant in the northeastern part of the city. The water plant is sourced by seven (7) high capacity municipal wells and contains a large ground storage reservoir. The City of Richfield water system is comprised of one (1) pressure zone with two (2) elevated storage tanks. The City of Richfield maintains approximately 120 miles of transmission and distribution water mains ranging in size up to 24 inches in diameter.

The customers of the City of Richfield include several numerous industrial, public and commercial users with the primary users being residential users. Currently, approximately 69 percent of the total water consumption is attributed to residential sales and 23 percent to commercial and industrial sales.

The City of Richfield's location with respect to nearby major urban centers, principal transportation corridors, and proximity to the airport offers potential for future growth. However, the majority of the City's land is currently fully developed, and redevelopment would be required for additional users to be added to the system. Since future water needs are related to future growth proper planning is essential to coordinate the planned capital improvements of municipal water system facilities with short term as well as long term needs of the community.

This report summarizes the results of a water system evaluation completed for the City of Richfield. The primary purposes of the study were 1) to evaluate the water needs 2) Identify system deficiencies and 3) provide potential capital improvements to meet the water needs and address deficiencies.

Present and future water needs of the Richfield water system have been evaluated, and recommendations made concerning improvements necessary to maintain an adequate level of water service. Current and future water needs were evaluated over a planning period extending to the year 2040. This report will serve as a plan to guide future expansion and redevelopment of the water system.

1.1 Scope

The study began with an analysis of community development and growth including population projections and existing and expected future land uses all documented in Section 2. Section 3 covers water consumption projections, which will serve as the foundation for evaluating and identifying recommended improvements to the system. The assumptions and conclusions presented in Section 2 were used to develop projections of water requirements that are presented in Section 3. Section 4 provides a review of existing utility facilities. Section 5 summarizes the evaluation of the water system. A summary of recommended water system improvements is presented in Section 6. Section 7 includes a proposed utility capital improvements plan.

Because needs change with time, municipal water system planning is a continuous function. Therefore, the longer term projections and improvements discussed in this report should be reviewed, re-evaluated and modified as necessary, to assure the adequacy of future planning efforts. Proper future planning will help assure that system expansion is coordinated and constructed in the most effective manner.

2 Population & Community Growth

This section summarizes the planning assumptions made regarding future service area characteristics for the Richfield water service area. To maintain consistency between individual planning efforts, the results of previous planning efforts were reviewed. The input received from local officials and utility staff members was also considered and incorporated.

2.1 Population Forecast

There is generally a close relationship between a community's population and total water consumption volumes. Future water sales can be expected to generally reflect future changes in service area population. Similarly, commercial, public, and industrial water consumption will also tend to vary proportionately with the growth of the community.

Table 2-1 – Historical Population Data

Year	Population	Exponential Growth Rate (%)
1970	47,231	-
1980	37,851	-2.2%
1990	35,710	-0.6%
2000	34,439	-0.4%
2010	35,228	0.2%
2015	36,557	0.7%
2016	36,338	-0.6%

Source: State Demographer, US Census

The City of Richfield has been substantially developed for many years has not experienced a substantial increase in population over the past 20 years. The City's estimated population in 2016 was 36,338 according to the state demographer. Table 2-1 above summarizes past trends and Table 2-2 below summarizes projected future population of the City. Future population estimates are based on projection provided by Met Council through the year 2040.

Table 2-2 – Projected Population Data

Year	Population	Exponential Growth Rate (%)
2020	37,100	0.3%
2025	37,200	0.1%
2030	37,300	0.1%
2035	37,500	0.1%
2040	37,700	0.1%
Linear regression used to extrapolate/interpolate data		

Source: 2020-2040 projections based on Met council Thrive 2040 forecast

Projections noted above indicate the City's service area total population is not expected to increase significantly (if at all) by the year 2040. For this study, in calculating per capita water use, it is assumed that the total percentage of population served by the Water Utility by the year 2040 will be similar to the rates observed in drought year 2012 and the recent years surrounding 2012. With a nearly zero increase in population due to the land locked nature of Richfield, the water projections are anticipated to be similar to the current water needs.

2.2 Existing Land Use

For this study, existing City land use data was reviewed. Figure 2-1 illustrates current land uses and represents the nature and extent of existing development within Richfield, future growth and land use. Richfield's existing land use is a diverse mix of historical development patterns flanked by commercial, industrial, entertainment and residential developments.

Commercial and Industrial development exists along three main corridors within the City: Interstate I-494, 66th Street and State Highway 77. Just east of the City is the Minneapolis/St Paul International Airport which adds many height restrictions to Richfield's development. The City is effectively 100 percent developed and any future growth would come through redevelopment with higher density land uses.

2.3 Water Service Area

The extent of this water study includes the existing water service area, which is comprised of all areas in Figure 2-1. The water system will be discussed in more detail in Section 4 (see Figure 4-1 later in the report). All developed areas within the existing city limits are currently served by water main.

3 Water Requirements

Projections of customer demands serve as the basis for capital improvements planning. Several standard methods were used in this study to project water supply and storage needs based on estimates of population and community growth. This chapter summarizes the methodology used and the results of these projections.

3.1 Water Consumption History

An analysis was made of past water consumption characteristics by reviewing annual pumpage and water sales records for the period from 2007 to 2016. Average and maximum day water consumption during this period, together with the amount of water sold in each customer category, has been analyzed. Projections of future water requirements are based on the results of this analysis, coupled with estimates of population and community growth discussed in Section 2.

A summary of recent historical water sales and pumpage is provided in Table 3-1. From 2007 to 2016, average day water use varied from a low of 2.78 million gallons per day (MGD) in 2016 to a high of 3.72 MGD in 2007. Over the past decade, overall water use in proportion to population have declined significantly due to conservation efforts. With the City now settled into more steady water use patterns, after the previous rescission, a tendency to conserve water can be seen in the resulting data.

Table 3-1 – Historical Water Use

Year	Population	Average Day (AD) Water Pumped (MGD)	Maximum Day (MD) Water Pumped (MGD)	MD:AD Ratio	AD Per Capita Water Use (gpcd)	MD Per Capita Water Use (gpcd)
2007	33,107	3.72	8.49	2.28	112	256
2008	33,676	3.40	7.41	2.18	101	220
2009	33,859	3.28	6.75	2.06	97	199
2010	35,228	3.02	5.63	1.86	86	160
2011	35,376	3.08	5.90	1.92	87	167
2012	35,979	**3.20**	**6.81**	**2.13**	**89**	**189**
2013	36,041	3.03	6.25	2.06	84	173
2014	36,157	2.94	6.01	2.05	81	166
2015	36,557	2.87	4.97	1.73	78	136
2016	36,338	2.78	4.80	1.72	77	132
5 Year Average (skip 2012)		**2.94**	**5.58**	**1.90**	**81**	**155**
Maximum		*3.72*	*8.49*	*2.28*	*112*	*256*

Source: DNR Water Use Records, State demographer

3.2 Water Demands By Customer Category

A historical summary of utility customers served is provided in Table 3-2. Residential customers, over the past five years, have accounted for 75 percent of the Richfield's water sales. Non-residential customers, such as commercial and industrial have accounted for 25 percent of the water sales over the past five years. Water Supplier services account for approximately 1 percent of total sales. Unaccounted water, either by leak, meter errors, theft, breaks and/or flushing comprised approximately 8.6 percent of total water use over the past five years.

Table 3-2 – Historical Average Water Sales by Customer Class

Year	Water Sold			Water Pumped	
	Average Day Residential Water Sold (MGD)	Average Day Non-Residential Water Sold (MGD)	Total Average Day Water Sold (MGD)	Average Day Water Pumped (MGD)	Unmetered & Unaccounted Water (%)
2007	1.99	1.35	3.33	3.72	10.3%
2008	1.80	1.30	3.10	3.40	8.8%
2009	1.81	1.28	3.09	3.28	5.9%
2010	2.15	0.65	2.81	3.02	7.2%
2011	2.18	0.67	2.85	3.08	7.5%
2012	**2.28**	**0.72**	**3.00**	**3.20**	**6.3%**
2013	2.15	0.67	2.82	3.03	6.8%
2014	2.03	0.65	2.69	2.94	8.4%
2015	1.93	0.64	2.57	2.87	10.2%
2016	1.85	0.66	2.51	2.78	9.8%
5-Year Average (skip 2012)	**2.03**	**0.66**	**2.69**	**2.94**	**8.6%**
% of Total	**75%**	**25%**	**100%**		

Source: DNR Water Use Records,City Records

3.3 Unaccounted Water

There is generally a close relationship between the total gallons of water pumped, and the gallons of water metered and sold to water utility customers. Total metered water sales are always less than the amount of pumpage due to several factors, including:

- Unmetered water usage for maintenance purposes such as hydrant flushing and water main repairs.
- Unmetered water usage for firefighting.
- Inaccuracies in water metering devices.
- Unaccounted-for public water consumption.
- Leakage within the distribution system.

The difference between total pumpage and total water sales is termed "unaccounted" water. The amount of unaccounted water is an indication of the condition of the water system and is most commonly expressed as a percentage. When a distribution system is very old or poorly maintained, the percentage of water loss often increases dramatically. Unaccounted water was shown in Table 3-2. Since 2012, City of Richfield has averaged less than 10 percent unaccounted water, which is very good compared to other utilities cross the county.

For future planning purposes, the 2012 drought year unaccounted for water percentage of **6.3 percent** will be assumed for future projections maximum day projections. For conservation planning and projection purposes, the five year average around 2012 of 8.6 percent will be assumed for future unaccounted water.

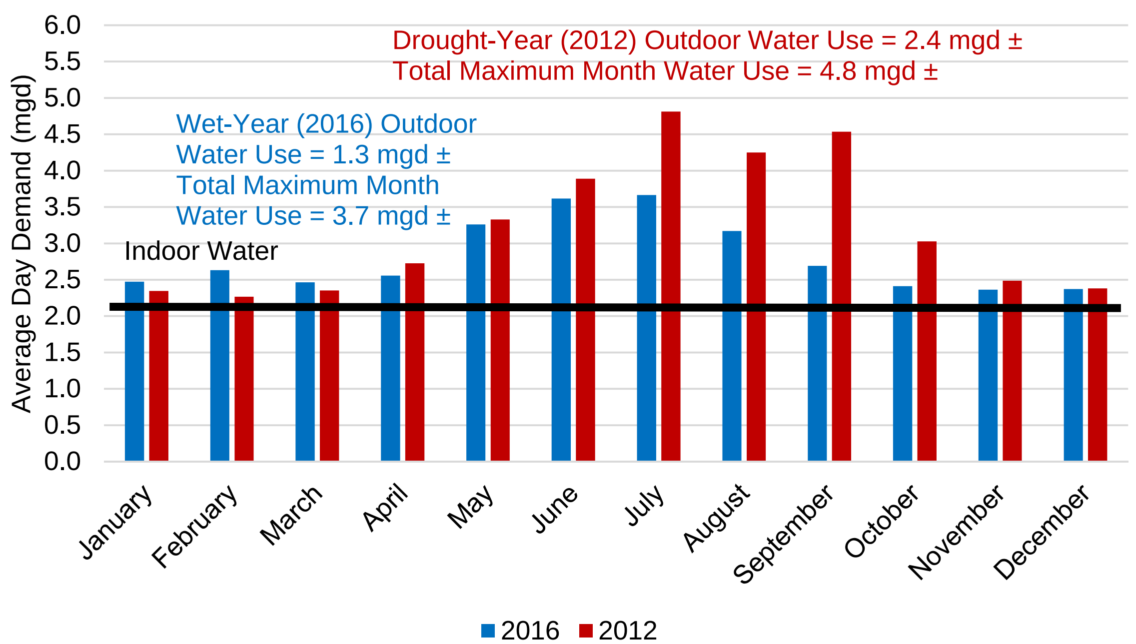
3.4 Variations in Water Use

3.4.1 Seasonal Variations

Seasonal fluctuations in water usage are important factors in the design and sizing of water supply and storage facilities. The seasonal nature of water consumption in the City of Richfield can be demonstrated by an analysis of monthly pumpage variations. The City of Richfield's monthly pumpage variations in 2016 are presented in Figure 3-1. In 2016, for instance, the maximum monthly pumpage occurred in July, while the minimum monthly pumpage occurred November through March.

Figure 3-1 revealed an interesting trend within the 2016 water use. During the cold-season months the average day pumpage was approximately constant, at an average of approximately 2.4 mgd. In a wet year, such as 2016, the maximum month (July) is increased by approximately 1.3 mgd from the baseline indoor water use. In a drought year, such as 2012, the maximum month is increased by approximately 2.4 mgd from the baseline indoor water use.

Figure 3-1: Richfield Monthly Water Use for 2012 & 2016



3.4.2 Effect of Drought

Richfield experiences high water use in the warm months due to irrigation and lawn watering. Information from Table 3-1 was compared with climate data in Table 3-3. Of the ten years in the table, year 2012 had the highest average summer daily high temperature and had the second lowest summer rainfall. Year 2012 had the highest average day and maximum day demands in the past 10 years. The combination of high temperatures and low rainfall, substantiates summer water demand, and in-turn, the maximum day demand. During a drought year, such as 2012, the maximum day demand increases to a very high value not generally observed in normal years with more typical rainfall.

Table 3-3 – Historical Water Use

Year	Summer Precipitation (inches)	Average Summer High Temperature (°F)	Average Day (AD) Water Pumped (MGD)	Maximum Day (MD) Water Pumped (MGD)	MD:AD Ratio
2007	18.7	80.2	3.72	8.49	2.28
2008	7.3	80.4	3.40	7.41	2.18
2009	9.1	77.8	3.28	6.75	2.06
2010	13.5	80.3	3.02	5.63	1.86
2011	8.6	81.0	3.08	5.90	1.92
2012	**6.6**	**82.8**	**3.20**	**6.81**	**2.13**
2013	6.9	81.8	3.03	6.25	2.06
2014	6.1	78.3	2.94	6.01	2.05
2015	15.0	79.4	2.87	4.97	1.73
2016	18.4	80.0	2.78	4.80	1.72
5 Year Average (skip 2012)			**2.94**	**5.58**	**1.90**
Maximum (2012)			*3.72*	*8.49*	*2.28*

Source: NOAA Online Data

The projections in this report include supply provisions to plan for drought conditions. However, drought conditions may be first addressed with water use controls. These approaches are briefly discussed later in the "Water Conservation" section.

3.5 Hourly Demand Fluctuations

The hour-to-hour variation of customer demands is also an important characteristic used to evaluate water supply and storage requirements. As with maximum day demands, peak hour is often expressed as a ratio to the average demand of any particular day. The peak hour demand is the hour of maximum demand that occurs on the maximum day, and is thus assumed to be the peak hour of the year.

The peak hourly rate for Richfield was estimated to be approximately 165 percent of the maximum day rate. This estimate is based on a typical AWWA diurnal curve in residential communities. This diurnal curve will be used to determine storage equalization needs of the community.

3.6 Per Capita Usage

Water use is often proportional, and is therefore correlated with a community's population. An analysis of per capita water consumption for the Richfield water system for the two customer classifications was made from the available sales records and is summarized in Table 3-4.

Table 3-4 – Historical Per Capita Water Use by Customer Class

	Sales			Water Pumped	
Year	Residential Per Capita Water Use (gpcd)	Non-Residential Per Capita Water Use (gpcd)	Total Average Day Water Sold (gpcd)	Total Average Day Water Pumped (gpcd)	Total Maximum Day Water Pumped (gpcd)
2007	60	41	101	112	256
2008	54	39	92	101	220
2009	53	38	91	97	199
2010	61	19	80	86	160
2011	62	19	81	87	167
2012	**63**	**20**	**83**	**89**	**189**
2013	60	19	78	84	173
2014	56	18	74	81	166
2015	53	18	70	78	136
2016	51	18	69	77	132
5-Year Average (skip 2012)	**56**	**18**	**75**	**81**	**155**
% of Total	**75%**	**25%**	**100%**		

Source: DNR Water Use Records, City Records

For future planning purposes, the per capita water use in 2012 will be the basis of design. If the City pursues conservation more rigorously, the recent values around 2012 may be used to estimate a projection with water conservation.

3.7 Water Conservation

Water conservation occurs in two different forms, active conservation and passive conservation. Active conservation efforts include mechanisms such as educational programs, customer incentives and conservation ordinances while passive conservation results are a product of the installation of water efficient fixtures (toilets, showerheads and washers) implemented by manufacturing standards and plumbing codes which may or may not be a result of intended conservation efforts.

Research has indicated that individual conservation efforts including educational programs, public information, school programs, retrofit programs, conservation ordinances, and/or regulations can reduce water use about 1%-4% per program. It should be also noted that indoor residential water use has decreased about 15.4 percent from 69.3 GPCD in 1999 to 58.6 GPCD in recent years nationwide. Furthermore, homes built according to EPA's water sense specification use 37 percent less water than the average home and 47 percent less water than an average home in 1999. In summary, when estimating projected water use, both active and passive water conservation should be accounted for.

As previously noted, nationwide per capita indoor water use has been trending downward. The Water Research Foundation previously published an executive report profiling the Residential End Use of Water in 1999 and followed up with a second version of the report in 2016. In Table 3-5, the report profiled water use trends across the country and found that per capita average water use has decreased from 69.3 gpcd in 1999 (REU 1999) to 58.6 gpcd in 2016 (REU 2016). The improved efficiency of clothes washers and toilets account for most of the water savings.

Table 3-5 – Indoor Conservation Potential – Per Capita Water Use

Water Use	REU 1999[1]	REU 2016[4]	2007 MWCP[3]	High Eff. [4]
Showers	11.6	11.1	8.8	8.4
Clothes Washers	15	9.6	10	4.7
Dishwashers	1	0.7	0.7	0.4
Toilets	18.5	14.2	8.2	6.1
Baths	1.2	1.5	1.2	5.8
Leaks	9.5	7.9	4	3.2
Faucets	10.9	11.1	10.8	6.5
Other Domestic Uses	1.6	2.5	1.6	1.6
Total	**69.3**	**58.6**	**45.3**	**36.7**

[1] 1999 report, Residential end use of water (REU 1999)

[2] 2016 report, Residential end use of water, Version 2 (REU 2016)

[3] 2007 Madison Water Conservation Plan (Vickers, Amy. 2002. Handbook of Water Use and Conservation: Homes, Landscapes, Industries, Businesses, Farms.

[4] High Eff from 2016 report, Residential end use of water, Version 2 (REU 2016)

Even without an intentional conservation program and or effort to switch to more efficient fixtures, reductions in total water use will be expected as old toilets and washers wear out. Per capita water use has the potential to be reduced to 36.7 gpcd in the future (REU 2016). For purposes of this report, this value will be considered the maximum water use reduction potential used in the most optimal conservation effort.

3.7.2 Residential Water Conservation

Table 3-4 showed residential water use to be approximate 63 gpcd in 2012. Table 3-5 reported that, nation-wide, communities could reduce residential demands to as low as 36.7 gpcd. However, with each step to decrease average day residential demand, the next step becomes increasingly more difficult. Challenges include 1) recruiting customer participation, 2) costs of incentive programs, 3) public relations when conservation disagrees with customer interests, and/or 4) maintaining adequate water utility revenues with decreasing sales. For the purpose of future planning, the rate of residential sales in 2012 of approximately **63 gpcd** will be projected into the future. If the utility promotes conservation, this value could potentially be reduced to a value of approximately **56 gpcd**, based on the data from recent years around 2012.

3.7.3 Non-Residential Water Conservation

Table 3-4 showed non-residential water use to be approximately 20 gpcd in 2012, with large customer pulled out. Conservation for non-residential customers can become challenging, as each non-residential customer has to be individually examined for their ability to conserve water. A waterpark, for instance, must use increased water for the summer months. Restaurants and hotels must wash dishes, cook, and clean. Seasonal drivers determine when some of these businesses are required to use water, and summer tourism amplifies the summer water needs of businesses in Richfield. It is recommended that the utility devise and initiate a public outreach program to learn what methods should be used to reduce non-residential water demand.

For the purpose of future planning, the rate of non-residential sales in 2012 of approximately **20 gpcd** will be projected into the future. If the utility promotes conservation, this value could reduce to a value of approximately **18 gpcd**, based on the data from recent years around 2012.

3.7.4 Maximum Day Water Conservation

Conservation with regards to the Maximum day demand may provide more immediate benefit to City of Richfield, and City of Richfield is required to provide sufficient supply and storage for the maximum day demand. Conserving on the maximum day is usually connected to outdoor water use, such as lawn watering. Indoor water use is usually constant throughout the year, as people generally do not change their domestic hygiene habits from summer to winter. Conservation of outdoor water use, however, is challenging to achieve because it usually requires some degree of authority action, either by increasing rates (charging higher fees for excess water use) or by enforcement (writing citations). Alternate day lawn watering is used by many utilities; however, the water reduction of alternate day lawn watering is often offset (or even reversed) by excessive watering when watering occurs.

For the purposes of future planning, the design maximum day from 2012 will be used, corresponding to a **maximum day to average day ratio** of **2.13**. If conservation increases, the utility has the potential to reduce the maximum day to average day ratio to approximately **1.90** based on the data from recent usage data from years around 2012.

3.8 Water Needs Projections

Population growth, development, customer water needs, conservation, and climate all affect future water needs. This section provides a project of water needs to year 2040 based on these factors. One projection is based on anticipated population growth and conservation. A second projection is based on buildout of all service areas.

Table 3-6 summarizes the water needs projections, first for current water use in a drought year, and then for a drought year if more aggressive conservation were pursued. Projects were solely based on the values from year 2012, as 2012 represents a hot and dry year when the system will be stressed for water. With the assumptions shown in the table, by 2040, Richfield could experience another maximum day demand of 6.8 mgd just like year 2012 if all current methods continue. If aggressive conservation were pursued, the planned drought year maximum day could be reduced, perhaps on the order of 5.5 mgd.

Table 3-6 – Future Water Needs Projections

Demand Type	Current Practices for Drought Year (Based on Drought Year 2012)			
	Assumption	**Demand (mgd)**		
	Year	*2020*	*2030*	*2040*
	Population	*37,100*	*37,300*	*37,700*
Residential	63 gpcd	2.34	2.35	2.38
Non-Residential	20 gpcd	0.74	0.75	0.75
Average Day Sales		*3.08*	*3.10*	*3.13*
Unaccounted Water	6.3%			
Projected Average Day Demand		**3.3**	**3.3**	**3.3**
Projected Maximum Day Demand	**213%**	**7.0**	**7.0**	**7.1**

For the purposes of planning, an average day demand of **3.2 mgd** with a maximum day demand of **6.8 mgd** will be the design basis of this report. These volumes are representative of recent water use trends.

3.9 Water Needs for Fire Protection

In addition to the water supply requirements for residential, public, commercial, and industrial consumption, water system planning for fire protection needs is an important consideration. In most instances, water main sizes are designed specifically to supply needed fire flow requirements.

Benefits of providing adequate fire protection for the City of Richfield include the reduction of insurance rates for residential homes and commercial business in the community. In the United States, guidelines for determining fire flow requirements are developed based on recommendations offered by the Insurance Services Office (ISO), which is responsible for evaluating and classifying municipalities for fire insurance rating purposes.

When a community evaluation is conducted by ISO, the water system is evaluated for its capacity to provide needed fire flow at a specific location and will depend on land use characteristics and the types of properties to be protected. The ISO has developed a method for design and evaluation of a municipal system which will indicate the Needed Fire Flow (NFF). For residential buildings the NFF is determined by the distance between structures as shown below:

Distance between Structures (ft)	***Fire Flow*** *(gpm)*
More than 100	500
31-100	750
11-30	1,000
Less than 11	1,500

Fire protection needs vary with the physical characteristics of each building that is to be protected. For example, needed fire flows for a specific building can vary from 500 gpm to as high as 12,000 gpm, depending on habitual classifications, separation distances between buildings, height, materials of construction, size of the building, and the presence or absence of building sprinklers. Municipal fire insurance ratings are partially based on the City's ability to provide needed fire flows up to 3,500 gpm. If a specific building has a needed fire flow greater than this amount, the community's fire insurance rating will only be based on the water system's ability to provide 3,500 gpm.

However, in high value districts containing commercial and industrial buildings, fire flow requirements of up to 3,500 gpm or more can be expected. These values can be reduced if existing buildings have sprinklers. Below is a formula that has been established for determining the NFF for commercial and industrial structures and is documented in the *Fire Protection Rating System* (1998) and AWWA M-31 (1998):

$$NFF = 18 \times F \times A^{0.5} [O \times (X+P)]$$

Where: NFF = needed fire flow (gpm)
F = class of construction coefficient
A = effective area (ft^2)
O = occupancy factor
X = exposure factor
P = communication factor

Based on current insurance classification guidelines, base fire flow requirements are not expected to change over the planning period.

Table 3-7 shows typical fire flow requirements for various land uses. These requirements were used as a basis for evaluating the Richfield water system. The requirements shown in the table are only intended as a general guideline. The actual needed fire flow for a specific building can vary considerably, as discussed above.

Table 3-7 – Typical Fire Flow Requirements

Land Use	Approximate Needed Fire Protection (gpm)
Single & Two-Family	
Over 100 feet Building Separation	500
31 to 100 feet Building Separation	750
11 to 30 feet Building Separation	1,000
10 feet or Less Building Separation	1,500
Multiple Family Residential Complexes	2,000 to 3,000+
Average Density Commercial	1,500 to 2,500+
High Value Commercial	2,500 to 3,500+
Light Industrial	2,000 to 3,500
Heavy Industrial	2,500 to 3,500+
Other Commercial, Industrial & Public Buildings	Up to 12,000

4 Water System Evaluation

Water systems are analyzed, planned, and designed primarily through the application of basic hydraulic principles. A map of the existing water system is shown in Figure 4-1. A schematic of the water system is shown in Figure 4-2. Figure 4-1 and Figure 4-2 provide the basis of understanding of the water system layout and operation. The existing water system contains multiple tanks, wells, booster stations and pressure zones. When analyzing the various components of a water system, important factors that must be considered when performing this analysis include:

- The location and capacity of supply facilities.
- The location, sizing, and design of storage facilities.
- The location, magnitude, and variability of customer demands.
- Water system geometry and geographic topography.
- Minimum and maximum pressure requirements.
- Land use characteristics with respect to fire protection needs.
- Other operational criteria which define the manner in which the system can most efficiently be operated.

For this study, an evaluation of the Richfield water system was performed to determine the adequacy of the system to supply existing and future water needs and to supply water for fire protection purposes.

The system was evaluated based on the following criteria:

- Reliable Supply Capacity of Entire System.
- Reliable Pumping Capacity into each Zone.
- Storage Volume in each Zone.
- Pressures.
- Fire Projection.
- Reliability.

The water system evaluation was based on compliance with Minnesota state code requirements and standard water industry engineering practice.

4.1 Reliable Supply Capacity

The reliable supply capacity of a water system is the total available delivery rate with the largest pumping unit(s) out of service. The reliable supply capacity is less than the total supply capacity because well and other high service pumps must be periodically taken out of service for maintenance. These water supply pumps can be off-line for periods of several days to several weeks, depending on the nature of the maintenance being performed.

4.1.1 Water Supply Wells

The current reliable well capacity is given in Table 4-1. Under present operating conditions, the existing wells have a combined total capacity of about 16.7 mgd when operating 24 hours per day. However, the reliable capacity of the supply wells is approximately 14.1 mgd with the one well out of service. The availability of this reliable supply capacity assumes that there will be no significant declines or changes in the water supply capacity over the next 20 years.

Table 4-1 – Existing Water Production Wells

Well Name	Unique Well Number	Depth (ft)	Rated Capacity (gpm)	Normal Operational Capacity (gpm)	Allowed Pumping Time per Day (Hours)	Daily Capacity (MGD)
Well No.1	206353	435	2100	1799	24	2.6
Well No.2	206354	435	1900	1789	24	2.6
Well No.3	206361	412	2000	1799	24	2.6
Well No.4	206276	405	1500	1300	24	1.9
Well No.5	206280	400	1950	1795	24	2.6
Well No.6	206279	422	2000	1800	24	2.6
Well No.7	133362	1,066	1400	1296	24	1.9
			Total	**11,578**	**--**	**16.7**
					Minus One High Yielding Well (Well No. 1)	**2.6**
					Reliable Capacity (Minus One Well)	**14.1**

Source: City Records

In addition, sustainability of the groundwater resources is an important element to be considered with the development of this plan. Six of the City's wells pull their water from either the Jordan aquifer or a combination of the Prairie du Chien and Jordan aquifers. The seventh well pulls water from multiple aquifers and is open to both the Franconia-Ironton-Galesville (FIG) aquifer and the Mt. Simon aquifer.

The Prairie du Chien and Jordan aquifers are the most commonly accessed and productive bedrock aquifers in the Twin Cities metro area. Wells completed in these aquifers are typically produce between 500 gpm to 2000 gpm, depending on well construction and pump capacity. The FIG-Mt. Simon aquifer wells typically have a lower capacityand are considered less sustainable, because they don’t recharged in the same manor as the Prairie du Chien and Jordan aquifers are. The Richfield Prairie du Chien and Jordan wells were drilled in the early 1960s. The FIG-Mt. Simon well was drilled in 1977. For over 40 years, these seven wells have met the City's water supply demands, demonstrating the ability of these aquifers to produce high capacities of water for sustained periods. Based on the observed performance of these wells, water levels appear to be stable and do not indicate that present well discharge is exceeding the capacity of the aquifer to recharge itself. Historical water level records for each well are documented in Appendix F. The results of the static and pumping water levels indicate stable levels that are not declining. It is recommended that the City continue to maintain these wells with a regular well rehabilitation program.

4.1.2 Water Treatment Plant

Raw water is pumped from the well fields to the plant where it is metered. It is then combined with the recycled water from the plant. Lime and polymer are then continuously added this mixture. From there, the water flows to a clarifier. Sodium hypochlorite and fluoride are added as the water flows out of the clarifier. Carbon dioxide is then injected, and the water passes through a series of baffles to assist in mixing. After filtration through gravity filtration cells, the water enters the clear well. The treated water is pumped from the clear well to the distribution system by four 3,500 gpm high service pumps. The pumps start and stop automatically by signals from the water levels in the Penn and Logan elevated reservoirs.

The firm capacity (1 standby) of the high service pumps is 10,500 gpm or 15.1 MGD. The current reliable water plant capacity is given in Table 4-2. Under present operating conditions, the existing high service pumps have a combined total capacity of about 16.7 mgd when operating 24 hours per day. However, the reliable capacity of the supply wells is approximately 14.0 mgd with the one well out of service. The availability of this reliable supply capacity assumes that there will be no significant declines or changes in the water supply capacity over the next 20 years.

4.1.3 Supply Versus Demand Comparison

For planning purposes, the total and reliable water supply values shall be the minimum values between Table 4-1 and Table 4-2. The basis of this assumption are 1) if the wells capacity is less than the high service pump capacity, the water plant will be limited by the well field and 2) if the high service pump capacity is less than the well field capacity, the water plant will be limited by the high service pumps.

Table 4-2 – Existing Water Treatment Facilities

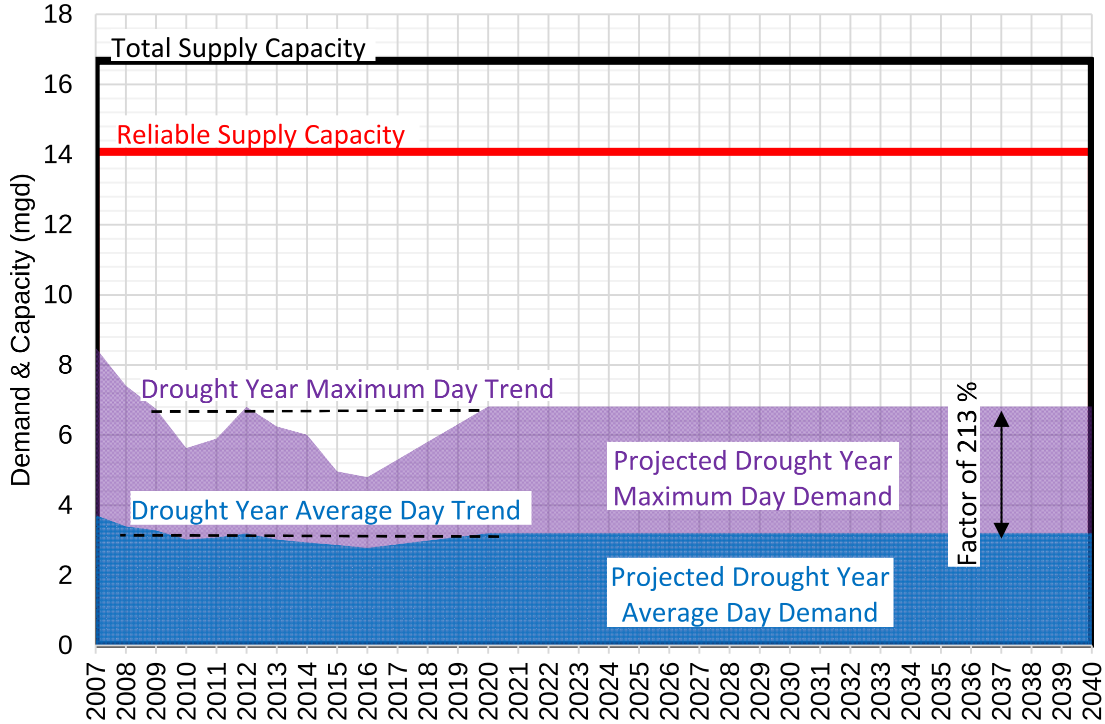
Facility Name	Operational Capacity (gpm)	Operational Capacity (MGD)*	Filter Type	Filter Media
Water Treatment Plant		**14.0**	Lime Softening	Iron & Manganese Removal
High Service Pump #1	3,500	5.0		
High Service Pump #2	3,500	5.0		
High Service Pump #3	3,500	5.0		
High Service Pump #4	3,500	5.0		
Total	**14,000**	**20.2**		
Minus One Pump	3,500	5.0		
Reliable Capacity	**10,500**	**15.1**		
*WTP operation capacity based on 24 hour operation day.				

Source: City Records

The minimum values between Table 4-1 and Table 4-2 occur with respect to the wells on Table 4-1. For this report, the supply capacity will be based on the wells, with a total capacity of 16.7 gpm and a reliable capacity of 14.1 gpm.

To determine if Richfield should plan for additional supply, the demands of the system must be compared to supply capacity. The projected drought-year average day and maximum day demands are compared to total and reliable supply capacities in Figure 4-1, assuming the growth projections discussed in Table 2-2 and Table 3-6. The results in Figure 4-1 indicated no need for more reliable supply in the future; however, future projections are not records and thus should be re-evaluated frequently (every five years ±).

Figure 4-1
Historical & Projected Demands
Versus Total & Reliable Supply Capacity



4.2 Reliable Pumping Capacity & Storage

Now that the reliable supply capacity for the whole system was established, the system must be further broken down to assess the ability of each pressure zone to deliver adequate water service to the customers within each zone.

The Richfield water system was evaluated using the following criteria:

- Reliable pumping capacity should be equal to or greater than the maximum day demand.
- Sufficient water storage capacity should meet maximum day equalization storage needs plus fire protection needs.

If both criteria are met, supply facilities will have adequate capacity to replenish storage during off peak hours, while depletion of available storage occurs during peak demand hours. Using this criteria and projections of future water supply needs, the following sections summarize minimum future pumping and storage needs of each zone.

The storage tanks of the water system are listed in Table 4-3. The volumes in Table 4-3 will be used for analysis.

Table 4-3 – Existing Water Storage Facilities

Tank Name	Capacity (MG)	Overflow Elevation	Headrange (ft)	Construction Style
Penn Elevated Tower	1.5	1006.4	35	Legged
Logan Elevated Tower	1.0	1006.4	35	Legged
Total Elevated Storage	**2.5**			
Treatment Plant Clearwell	2.5	845	15	Ground

Source: City Records

Table 4-4 – Pumping Capacity & Storage Analysis

	Design Demand Year		
Pumping Capacity Analysis	**2020**	**2030**	**2040**
Maximum Day Demand (mgd)[1]	6.8	6.8	6.8
Existing Firm Pumping Capacity (mgd)[1]	15.1	15.1	15.1
Preliminary Additional Firm Pumping Capacity Recommended (mgd)[3]	**None**	**None**	**None**
Recommended Storage Volume			
Maximum Day Equalization Volume (gallons)[4]	1,020,000	1,020,000	1,020,000
Fire Protection Volume (gallons)[5]	630,000	630,000	630,000
Reserve Volume (gallons; 15% of Total)[6]	250,000	250,000	250,000
Total Recommended Volume (gallons)	**1,900,000**	**1,900,000**	**1,900,000**
Existing Storage & Pumping Volume[2]			
Surplus Reliable Pumping Capacity (gallons)[7]	1,040,000	1,040,000	1,040,000
Penn Elevated Tower (gallons)	1,500,000	1,500,000	1,500,000
Logan Elevated Tower (gallons)	1,000,000	1,000,000	1,000,000
Total Existing Volume (gallons)	**3,540,000**	**3,540,000**	**3,540,000**
Additional Storage Volume Recommended (gallons)	**None**	**None**	**None**

1. See Table 3-6.
2. See Table 4-3.
3. Additional firm pumping capacity may be recommended if the maximum day demand exceeds the existing firm pumping capacity.
4. Maximum Day Equalization Volume is the projected maximum volume depletion during the peak hours of the maximum day assuming the pumping rate into the service zone is equal to the maximum day demand rate. Typical residential diurnal curves were assumed with a peaking factor of 1.65. This typical curve estimates 150,000 gallons of equalization storage required per MG maximum day demand, a ratio of 15 percent.
5. Fire Protection storage was calculated based on one fire of 3,500 gpm for 3 hours.
6. Reserve Volume is recommended to provide a start/stop range for well and booster pump operation and provide a basis for minimum emergency reserve storage in the system.
7. Surplus Reliable Pumping Capacity is the difference between maximum day demand and reliable Pumping Capacity which is available to supplement fire protection for 3 hours.

Table 4-4 analyzes the pumping and storage capacity of the system. With the assumptions from Table 4-4, the water system is not anticipated to require additional reliable supply capacity within the next 20 years. At this time, no additional storage requirements are anticipated.

4.3 Water Distribution System Analysis

Now that a macroscopic analysis of supply, pumping and storage capacity was performed for each pressure zone, the water distribution system can be analyzed. Two important factors in proper distribution system performance are the normal pressures and the available flow for fire protection. The following sections discuss how the system was analyzed using a computer water model.

4.3.1 Water System Computer Model

The 2017 hydraulic computer model was generated to closely match the Utility's current water distribution system using CAD and GIS information (see figure 4-1 for a map of the model). The Richfield system was modeled using WaterGEMS®, a pipe network program developed by Bentley®. Pipe roughness coefficients were based on industry standards. Field testing was performed on selected hydrants in 2017.

The Richfield water system model was calibrated using results of flow testing performed in August 2017. A summary of the flow test results is listed in Table 4-5 and the test locations are shown in Figure 4-3.

Table 4-5 – Water System Model Calibration Results

Flow Test	Location	Field Hydrant Flow (gpm)	Calculated Avail. Fire Flow @ 20 psi	Pressure Differential Field Results (psi)	Pressure Differential Model Results (psi)	Pressure Differential (psi)
1	Xerxes Ave S and Washburn Cir	1,500	2,072	22	21	-1
2	Thomas Ave S, South of W 66th St	1,500	2,072	22	23	1
3	W 62nd St and corners of Humboldt Ave S and Grand Ave S	1,826	2,837	23	23	0
4	Knox Ave S and corners of W 70th St and W 71st St	1,458	2,586	18	17	-1
5	Dupont Ave S and corners of W 74th St and W 75th St	1,582	2,509	20	21	1
6	Wentworth Ave S and corners of W 75th St and W 76th St	1,595	2,671	20	20	0
7	2nd Ave S and corners of E 72nd St and E 73rd St	1,415	1,904	30	29	-1
8	W 62nd St and W 63rd St just off Pillsbury Ave S	1,608	6,423	4	5	1
9	Grand Ave S and corners of W 68th St and W 69th St	1,582	2,450	24	23	-1
10	3rd Ave S at and North of E 64th St	1,803	7,352	4	4	0
11	Oakland Ave S and corners of E 69th St and E 70th St	1,400	1,993	26	27	1
12	Oakland Ave S and corners of E 75th St and E 76th St	1,659	2,806	17	18	1
13	16th Ave S and corners of E 75th St and E 76th St	1,708	3,412	15	14	-1
14	13th Ave S and corners of E 71st St and E 72nd St	1,528	2,154	27	28	1
15	16th Ave S and corners of E 68th St and E 69th St	1,458	2,120	25	24	-1
16	E 62nd St and corners of 15th Ave S and Bloomington Ave S	1,780	3,034	19	20	1
17	Washburn Ave S off W 62nd St	1,354	1,785	18	17	-1

During the calibration process of the Richfield water system hydraulic model, pumping rates, customer demands, and tower water levels were set to the conditions recorded during the field testing. Individual pipe roughness coefficients (C-factors) were adjusted until the calibrated system model closely simulated field test data as indicated in Table 4-5.

Once the computer water model was constructed and calibrated, the model was used to calculate the normal working pressures (static pressures) and the available flow for fire protection (fire flow) in the water distribution system.

4.3.2 Normal Pressures

Water system pressure is primarily a function of elevation with some degree of pressure loss as water flows across the system. Static pressures throughout the distribution system as determined by the water model is shown in and Figure 4-4 through 4-6 for Average Day, Maximum Day and Peak Hour demand. Low pressures generally occur in areas where the elevations are relatively high compared to the overflow elevation or hydraulic grade line of the system.

The pressures in Figure 4-4 are generally consistent across the system, except in the higher areas to the northwest. All areas of the system are within the range of 35 to 80 psi are acceptable pressures.

4.3.3 Available Flow for Fire Protection

Water system planning for fire protection is an important consideration. In most instances, water main sizes are designed specifically to supply desired fire flows. Guidelines for determining fire flow requirements are provided by the ISO. ISO is the insurance service organization responsible for evaluating and classifying municipalities for fire insurance rating purposes. Available flow for fire protection (fire flow) in this report is defined as the flow capacity at a point in the water distribution system which causes the pressure to fall to 20 psi (residual pressure). A map of the analysis of the distribution system under a maximum day demand is shown in Figure 4-7. Generally, low fire flow occurs where normal pressures are already low and in areas of small diameter and old water mains. Dead ends typically have noticeably weaker fire flows that looped mains.

To assess if the system is deficient in available fire flow, a basis for fire protection must be established. Table 3-7 provided some general fire protection recommendations according to AWWA M31 and the ISO. For planning purposes, the minimum fire protection requirement will be based on land use according to Table 4-6, with a map in Figure 4-8.

Table 4-6 – Base Fire Protection Requirement

Land Use	Flow (gpm)
Park	500
Single-Family	1,000
R-1 Low-Density Single-Family	1,000
Two-Family	1,000
Planned Multi-Family	1,500
Multi-Family	1,500
Multi-Fam & Cedar Overlay	1,500
High-Density Multi-Family	1,500
Service Office	1,500
Community Commercial	2,500
General Commercial	2,500
Planned General Commercial	2,500
Industrial	3,500
Mixed Use-Neighborhood	2,000
Mixed Use-Community	2,000
Mixed Use & Cedar Overlay	2,000
Mixed Use & Penn Overlay	2,000
Mixed Use-Regional	2,000
Planned Mixed Use	2,000

With the assumptions in Table 4-6 and Figure 4-5, the available flow for fire protection shown in Figure 4-7 can be analyzed.

Figure 5-7 illustrates the estimated available fire flow throughout the City for a typical maximum day water demand while maintaining a residual pressure of 20 psi throughout the system under typical operating conditions. In general, approximately 90 percent of the City is well protected with fire flows of 1,500 gpm or higher. Areas of low flow are primarily located in along long sections of water main that lack looping.

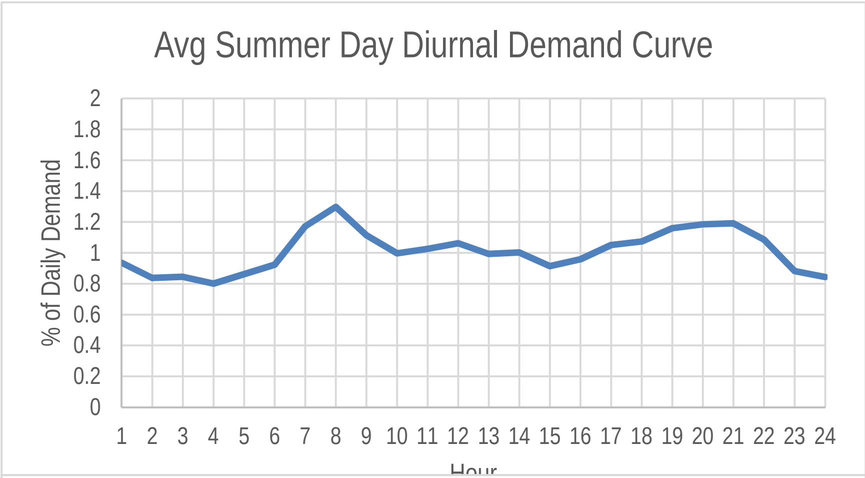
Based on a comparison of Figure 4-7 and Figure 4-8, the highlighted areas in Figure 4-9 may have be deficient for fire protection in relation to the land use types present.

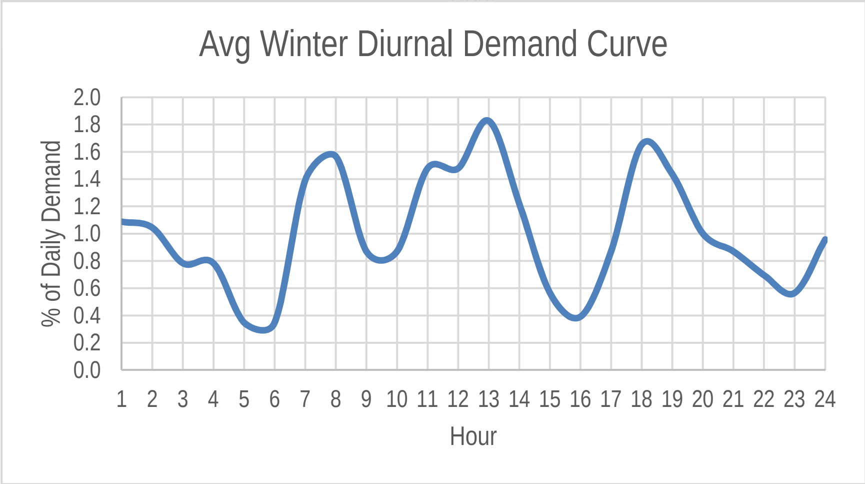
Figure 4-9 also identifies areas where fire flow deficiencies currently exist. Deficiencies were identified where the basic ISO guidelines were not met for a particular land use as determined from the City land use map. Specific fire flow deficiencies are scattered through the water system .The fire flow availabilities illustrated in Figure 4-7 are based upon the assumption that the water level within the towers is constant. In reality the level of water in each tower will generally decrease during a fire event. The rate of decline in each tower will be dependent upon the amount of fire protection, the location of the fire, high service pump operation, and other system demands. Later in this plan, recommendations will be made in relation to water main improvements which will help remediate current areas that are deficient in fire flow.

4.4 Water Age Modeling

As part of the water system analysis, a series of extended period water distributions system simulations were conducted to evaluate estimate water age through the water system. While the model predictions may not be an exact prediction of age, it does provide for a relative comparison across the system. The goal of this analysis is to identify regions of the system which may have the potential for old water to be present. These problem areas may require future flushing or operational changes.

The analysis was completed utilizing Average Summer Day (ASW) and Average Winter Day (AWS) demand and operational conditions. First, custom diurnal demand curves were developed for each season. This was done by analyzing historical SCADA operation data documenting system water tower levels and water treatment plant flow rates over a period of days and weeks. A mass balance calculation was then done to estimate the amount of water consumed during each hour of the day, on average. This then provides for a series of hourly scaling factors which can be utilized in the model to estimate demand during each hour of operation. For example, water use typically trends high in the morning hours when customers are getting ready for the day with the demand dropping off during the nighttime hours. Such is the case in Richfield for the winter demand. The resulting diurnal curves from the calculations described above are documented above. As can be seen in the figure above, the summer diurnal curve is drastically different than the winter curve with demands peaking in the morning, noon and later in the evening.





Once the model was set with the assumed system controls, diurnal demand curves and demand levels, the model was then operated for an extended period of 1,000+. Hours. Over this simulation period, the water treatment plant high service pumps cycle on and off with water tower levels as they do in real life. This simulation method allows for water age to be estimated across the system. For reasonable water age results to be produced, the model must be simulated for many hours to allow for the system to reach equilibrium.

The results of these simulations are shown in figures 4-10 and 4-11. The resulting average water ager for each is mapped. In general, the oldest water in the system can be found on the far west side of the system. With the supply source on the east, the water must travel a long distance to fill the water towers. If the level of the towers does not bounce significantly, water will tend to age in the towers and consequently in the system.

5 Recommended Water System Improvements

The purpose of this section of the report is to review and recommend facility improvement priorities for the water system moving forward. As previously discussed in this report, outward expansion of the water system is limited by the boundaries of the City. Potential increases in water demand would be the result of denser redevelopment.

Recent water use trends, combined with the developed nature of the Richfield water system revealed minimal need for new water supply in storage facilities. However, there are multiple recommended improvements to help optimize system operations, increase the redundancy and support the resiliency of the water system as a whole. In addition, specific water main upgrades and additions are recommended as street reconstruction is accomplish and funds are available.

With this in mind, future water system facilities should be sized to optimize the operations of the existing system. While existing supply, Treatment and storage faculties are adequately sized to meet future water system demands, the distribution system can be optimized to provide better service. Additionally, the way in which facilities are operate can help provide more consistent and reliable water service to the customers.

The ultimate water system planning map, presented in Figure 5-1 represents a guiding document for the redevelopment of the water distribution system systems. Sizing of future water system piping in a manner as outlined in this document will help to assure that the entire water system can perform at a manner that serves the customers well.

5.1 Distribution System Improvements

This section summarizes distribution system improvements that are recommended to strengthen the existing system, enhance supply reliability, loop major transmission mains, and improve flow capacity and fire protection to various parts of the City. The goal of these suggested improvements include:

1. Reduce system Back pressure at supply sources
2. Increase water transmission capacity
3. Increase fire flow
4. Support Redundant operation
5. Optimize WTP Operation
6. Loop Long lengths of pipe
7. Complete trunk water main grid
8. Maintain right sized piping

As discussed in the previous chapters, there are various parts of the water distribution system where needed fire flows cannot be supplied. For isolated deficiencies, it is often not economical to recommend specific improvements as these deficiencies will eventually be corrected by annual water main replacements (replacing existing older small diameter mains) and/or distribution system growth (primarily as a result of looping existing dead end mains). In locations where more widespread deficiencies are found, specific water distribution system improvements are presented in Figure 5-1. A well-developed trunk water main and distribution system helps to deliver adequate flows for various conditions including emergency fire flow.

Actual main routing will depend on a variety of local factors as individual street rehabilitation projects progress. This map should be seen as a recommendation for the general hydraulic capacity of the distribution system to optimize existing water service. These improvements are intended to support robust fire flow and increased system which lead in water service redundancy and reduce water age which benefits water quality.

Generally speaking, the existing Richfield water system has strong conductivity in the North/South direction, however, there are areas with long sections of single mains that would benefit from looping. Each of the Water main improvements recommended are documented in the table below along with project specific information related to each improvement.

Table 5-1 – Proposed Ultimate Water Main Improvements

Segment	Proposed Main Diameter (in.)	Length (ft)	Location	Function
A	8	1670	E 66th from Co. Rd. 35 to Elliot Ave S	Fire Flow, Looping
B	8	1360	18th Ave S from E 67th to E 69th	Fire Flow, Looping
C	8	650	E 68th from 17th Ave S to Cedar Ave S	Fire Flow, Looping
D	8	1300	E 69th from Bloomington Ave S to Cedar Ave S	Fire Flow, Looping
E	8	640	E 70th from 17th Ave S to 18th Ave S	Fire Flow, Looping
F	8	2650	E 72nd from 12th Ave S to Cedar Ave S	Fire Flow, Looping
G1	8	650	E 75th from 4th Ave S to Co Rd 35	Fire Flow, Looping
G2	8	660	E 75th from 17th Ave to Cedar Ave	Fire Flow, Looping
H	8	480	Bloomington Ave S fom E 78th St to E 77th St	Fire Flow, Looping
I	8	620	2nd Ave S from E 77th to E 78th	Fire Flow, Looping
J	8	560	E 75th from 4th Ave S to Co Rd 35	Fire Flow, Looping
K	12	660	4th Ave S from E 74th to E 73rd	Fire Flow, Looping, Trunk
L	8	1980	E 72nd from Co Rd 52 to 4th Ave	Fire Flow, Looping
M	8	2500	W 68th from Lyndale Ave S to Co Rd 52	Fire Flow, Looping
N	12	5300	77th St from Co Rd 35 to Lyndale Ave S	Fire Flow, Looping, Trunk
O1	8	320	Garfield Ave S to Hariet Ave S	Fire Flow, Looping
O2	8	360	Grand Ave S to Pleasant Ave S	Fire Flow, Looping
P	12	2000	W 75th St from Fremont St to Lyndale Ave S	Fire Flow, Looping, Trunk
Q	12	1060	Fremont Ave S from W 75th to W 73rd	Fire Flow, Looping, Trunk
R	12	3890	W 73rd St from Lyndale Ave to Humboldt Ave	Fire Flow, Looping, Trunk
S	12	340	Logan Ave S from Begin to W 73rd St	Fire Flow, Looping
T	12	2460	W 73rd from Penn Ave S to I- 35 W	Fire Flow, Looping, Trunk
U	8	2270	W 71st from Penn Ave S to Irving Ave S	Fire Flow, Looping
V	8	2640	W 69th St from Xerxes Ave to Penn Ave S	Fire Flow, Looping
W	8	620	W 68th St from Xerxes Ave to Vincent Ave	Fire Flow, Looping
X	8	310	W 67th St from Xerxes Ave to Washburn Ave	Fire Flow, Looping
Y	8	840	Xerxes Ave from Co Rd 53 to W 65th St	Fire Flow, Looping
Z	8	330	W 64th St. from Washburn to Vincent St	Fire Flow, Looping
Total 8-inch		**23,410**	**--**	
Total 12-Inch		**15,710**		
Total		**39,120**		

5.2 Water Main Highway Crossings

Richfield's elevated water storage tanks are both located west of Interstate 94, while the supply (Water treatment plant and wells) are located east. Water traveling to fill the water tanks must past though one of four water mains that cross the freeway. Without these crossings, the tanks could not be supplies with water, and the majority of the system would not benefit from elevated water storage tank service. As a result, these crossings are some of the most critical water mains in the entire Richfield water system. While the existing crossings have operated sufficiently, failure of a crossing would limit the flow between regions. Special care should be taken to monitor the condition of these mains and proper maintenance completed when needed. As part of this report, each of the I-35W crossings were operated in the model during an average summer day as a standalone pipe, without the others to test the resiliency and capacity of each. The Crossings modeled include:

- West 65th 16-Inch
- West 66th 8-Inch
- West 73rd 12-Inch (fed by 8-inch main)
- West 75th 8-Inch

Graphical results of this modeling effort are included in Appendix D. The results of the modeling indicate that the only crossing that is capable of sustaining normal system operations all alone is the West 65th 16-Inch crossing. If the system was to run on the other crossings individually, flow to the water towers would be constricted, elevating system back pressure, which would limit the operation of the high service pumps. With the high service pumps offline during this type of a scenario, supply flow from the towers to areas east of 35W would be limited and pressures would be low. Use of VFD's on the high service pumps would allow for the pumps to be set to sustain a fixed pressure, which would essentially provide a similar feature to that of a water tower by sustaining consistent pressure. This would allow for the system to operate and sustain system wide pressures with only one of the southern crossings open. Without VFDs, either the 16-inch or two of the other three crossings would need to remain open to sustain normal system operations.

5.3 Water System Interconnect/Redundant Supply

Richfield has been actively pursuing a source for a redundant water supply in the event of a water treatment plant or well failure. Recently, the City has narrowed the options down to three possibilities which include an Interconnect with Bloomington, Edina or modifications to existing wells to have backup power and pump directly to the distribution system. Each of these options is briefly summarized below, full memos for each options are included in Appendix C

5.3.1 Interconnect with Bloomington

Previous water system interconnect analysis have narrowed the most feasible option to a connection with an existing 42-inch water supply line running from the Minneapolis water system, through Richfield to Bloomington along Logan Ave. The City of Richfield desires to have access to an emergency backup water supply with a maximum anticipated water draw of 3.5 MGD (2,430 gpm) -- which is slightly more than recent historical Average Day Demand of approximately 3 MGD. Bloomington currently owns two (2) supply lines that obtain water from a 60-inch trunk main located along 60th Street in Minneapolis. Bloomington generally alternates use of each line on an every other day basis to keep fresh water circulating in the system. Bloomington's contract with Minneapolis requires that Bloomington draw a minimum of 2.0 MGD each day, but can draw up to 30 MGD (using both lines simultaneously). At a minimum 2.0 MGD withdrawal, operation of either line lasts for a period of 1-2 hours.

The Minneapolis/Bloomington Supply line 42-inch supply line runs along Logan Ave. and the west edge of Donaldson Park, where the Logan water tower is located. In this area, the 42-inch supply line runs only a few feet away and parallel to 12-inch and 16-inch Richfield trunk main that serve the Logan water tower. This is an ideal location to transport a large volume of supply water into the Richfield system. Connection to either the 12-inch or 16-inch lines would allow for the 2,430 gpm (3.5 MGD) flow rate to feed the Richfield system and fill the water towers. (Confirmed via EPS water modeling). With any of the interconnect options discussed above, The proposed interconnect facility would ideally consist of a 16-inch connection to the 42-inch supply line, a metering/control station, bypass line and isolation valves. For the metering/control station, it is feasible that either an above-grade or below-grade structure could be constructed to house the necessary flow control equipment

For Richfield to receive water from this line, one of five options would need to be considered. Each of these options and corresponding modeling is explored future in Appendix C

5.3.2 Interconnect with Edina

This option would provide for a direct connection to the Edina Water system. In order for the appropriate amounts of flow to pass from Edina to Richfield, two connection points would be required. Desired design flow rate of 2,430 gpm (3.5 MGD) will require water trunk mains that are sized large enough as to limit excessive velocities while conducting the desired flow rates. The ability to conduct this amount of flow will be a function of the available system piping in both Edina and Richfield as well as the difference between hydraulic grades. As part of this effort, potential interconnect locations were identified by inspection, with 10-inch and 12-inch main being the preferred water main size both from a supply (Edina) and discharge (Richfield) perspective. There will need to be sufficiently sized main to move the desired flow rates, with limited velocity and headloss. Currently, the water main piping on the Western edge of the City of Richfield is limited in size, which the largest size being 8-inch. Though the main in this part of town is well looped, conduits which flow from West to east are limited. Appendix C provides for a summary of interconnection points that have been considered for this project and the resulting modeling work

5.3.3 Emergency Well Supply

This option would complete the conversion of Wells No. 1 and No. 2 to be able to be switched to pump directly to the distribution system. For emergency service, wells would be re-fit with pumping equipment that could provide dual-service. Normal duty would continue as it does today, with these wells pumping through the raw water main to the filtration plant. In emergency situations, valves and pumping equipment would be reset, and water would be delivered directly into the distribution system. For dual service to be permissible, the existing system will need to undergo improvements to install pumps, motors and supporting facilities so that these wells can deliver water under either service setting.

The wells being considered are the two Jordan Aquifer Wells located in Nicollet Park Well Field, Wells No. 1 and No. 2. Well No 1 produces about 2,200 gpm and Well No. 2 produces 1,750 gpm. Together these wells are capable of producing 5.7MGD.

This option is further described in Appendix C

5.4 Water Treatment Plan High Service Pump Operation (VFD's)

As previously mentioned, the City's water tanks are located in the far western portions of the water system, a great distance from the system supply at the water treatment plant. Because of this, the system pressures on the East side of the City are heavily influenced by the discharge flow rate coming from the water treatment plant. When a single pump is operated at the WTP at a rate of 3,400 gpm and especially when two pumps operate for a combined 6,800, system pressure can exceed the hydraulic grade of the tank. Operating the high service pumps at a higher flow rate caused the water storage tanks to fill very quickly, which leads to shorter run times and frequent starting and stopping of the pumps. As a result, it is recommended that variable frequency drives (VFD's) be installed on the Water treatment plant high service pumps. This will allow for more system operational flexibility. For example, during the winter months, the Average demand is roughly 1,600 gpm. In an effort to limit the starting and stopping of the pumps, the high service pumps could be set with the VFD's to operate at a rate of 1,800 gpm which would extend the high service pump run times while tank bounce (level change) would be accomplished by the varying system demand. Results of this modeling along with a similar effort for the summer months is documented in Appendix D.

Setting the high service pumps to operate at a flow rate that is slightly greater than the expected daily demand helps to balance the elevated tank, limit pump cycling, reduce dynamic pressures and reduce the potential for water hammer. Additionally, the City may be able to reduce peak demand charges by limiting the amount of power drawn out over a longer period of time.

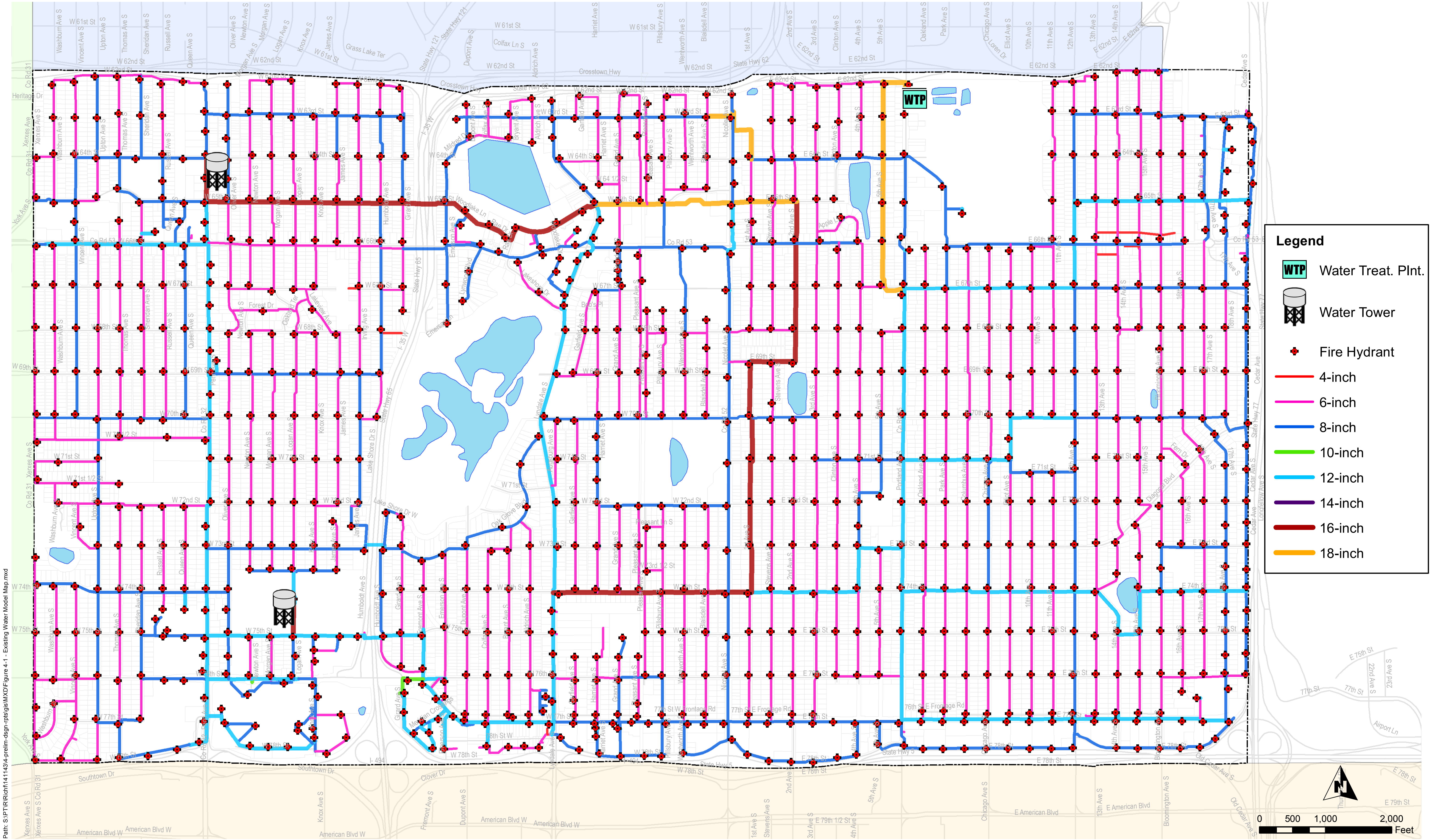
5.5 Ultimate Water System Modeling

Figure 5-1 presented the proposed preliminary water main improvement recommendations. Actual main routing will depend on a variety of local factors as individual projects progress. The modeling maps presented in figures 5-2 and 5-3 represent the estimated system pressures and fire flow after the proposed improvements documented in figure 5-1 are made.

5.6 Conclusion

The recommended improvements in this plan are intended to serve the City in making future water system improvement decisions. While the plan may represent the current planned redevelopment of the Richfield water system, future changes in land use, water demands, or customer characteristics could substantially alter the implementation of the plan. For this reason, it is recommended that the plan be periodically reviewed and updated using City planning information to reflect the most current projections of City growth and development.

Figures



Path: S:\PT\R\Richf\141143\4-prelim-dsgn-rpts\gis\MXD\Figure 4-1 - Existing Water Model Map.mxd

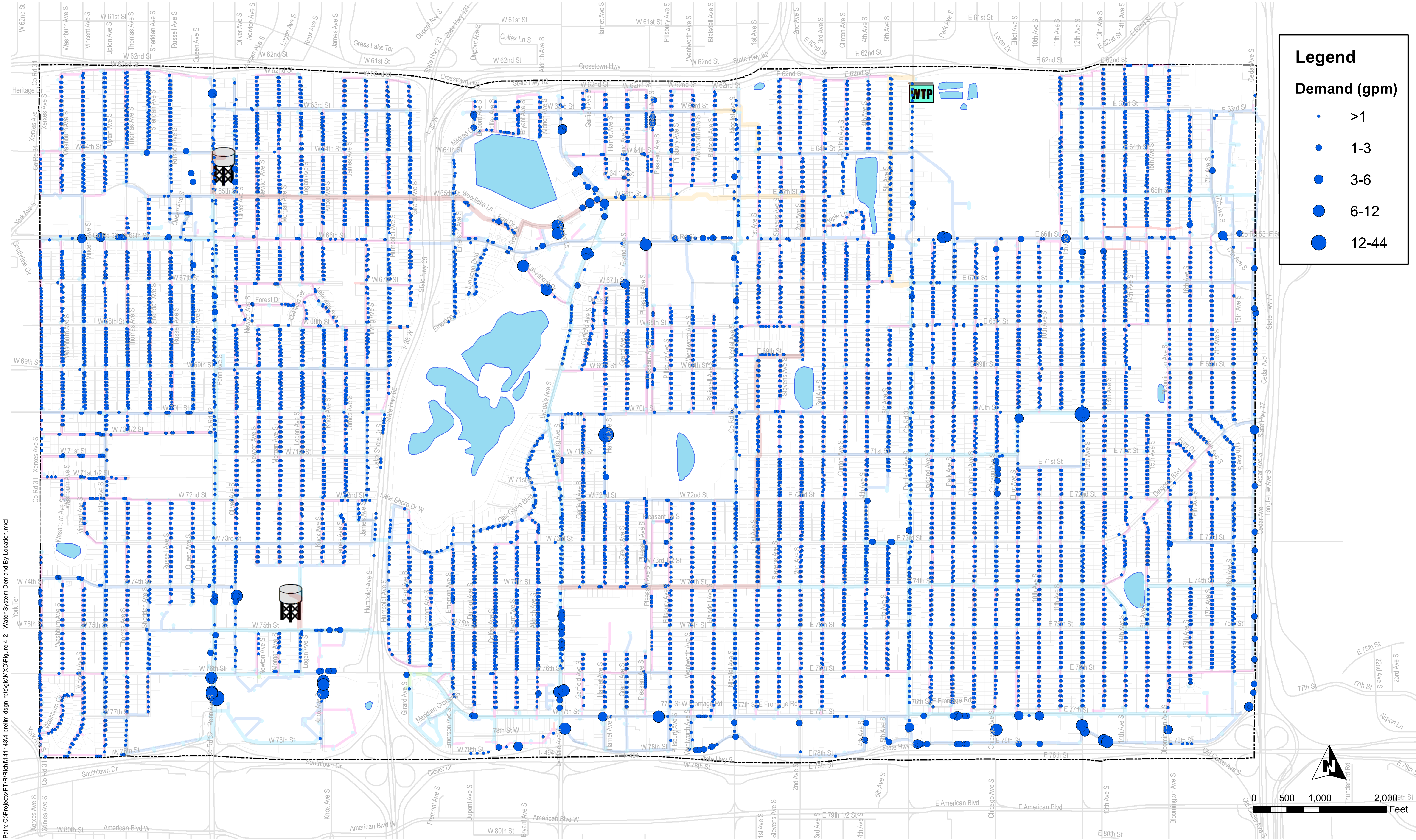
SEH

Project Number: RICHF 141143
Print Date: Print Date: 6/6/2018

Map by:
Projection:
Source:

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-1
Water Model Map



Path: C:\Projects\PT\R\Richf\141143\4-prelim-dsgn-rpts\gis\MXD\Figure 4-2 - Water System Demand By Location.mxd

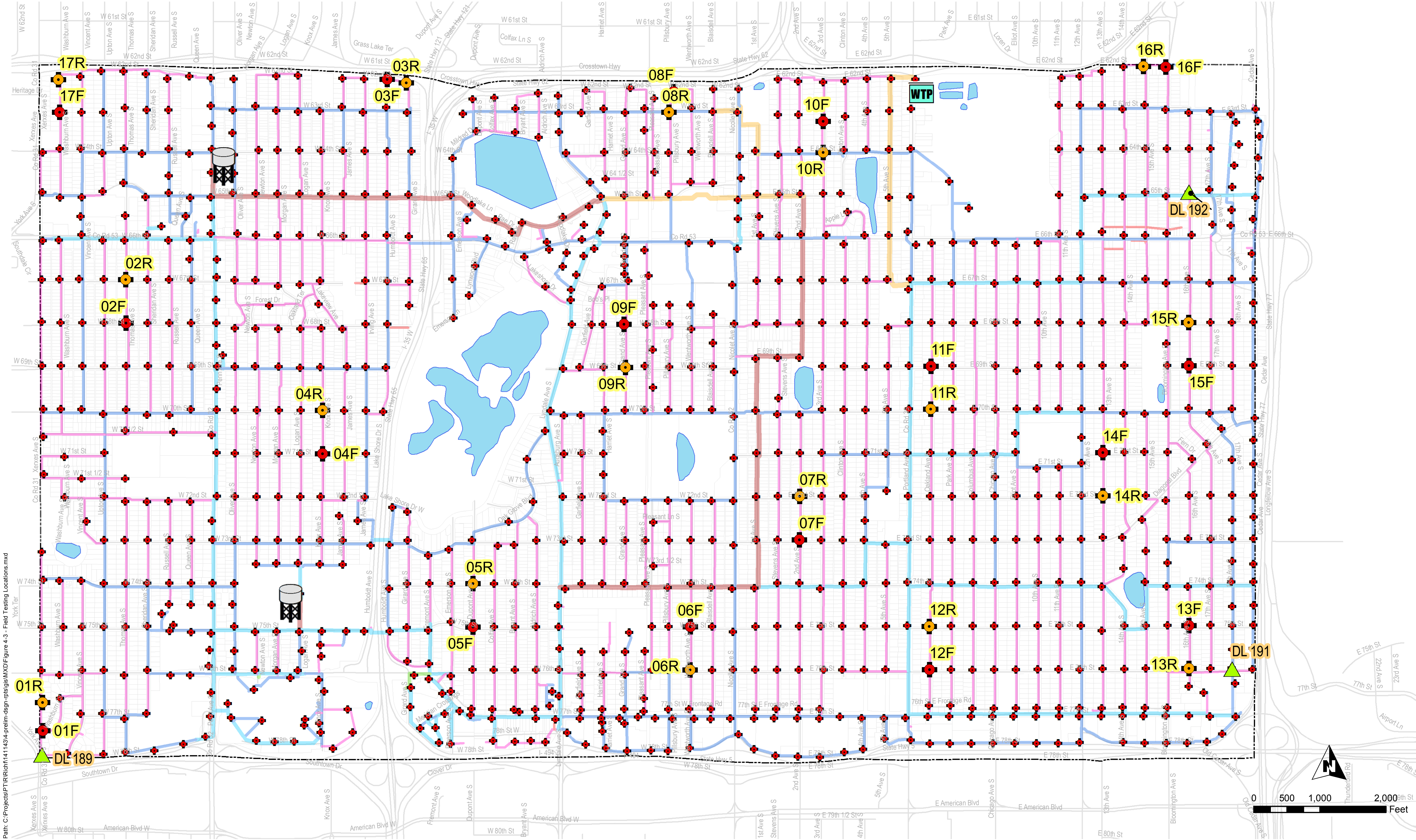
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-2
Water System Demands By Location



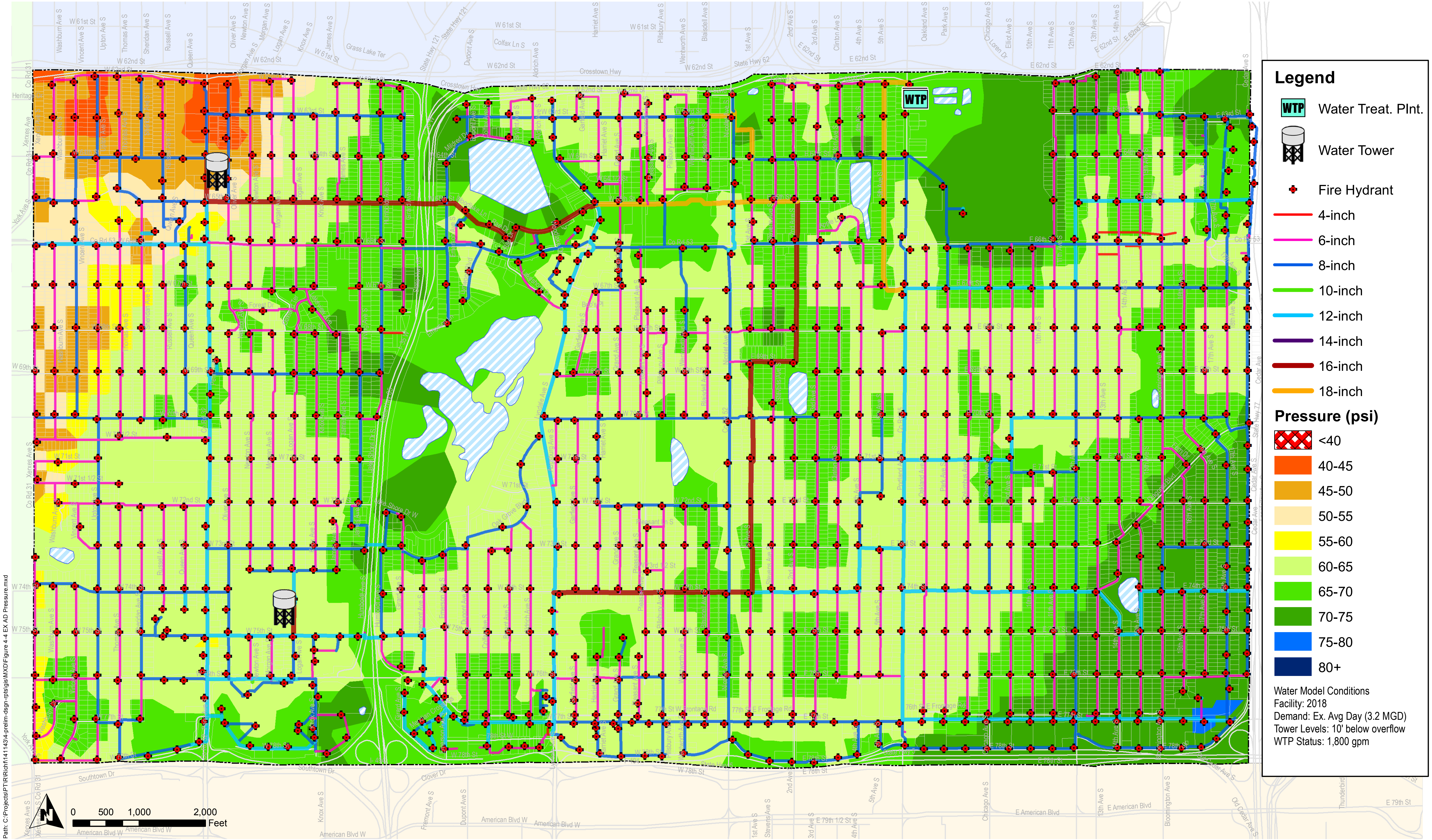
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-3
Water System Field
Flow Testing Locations



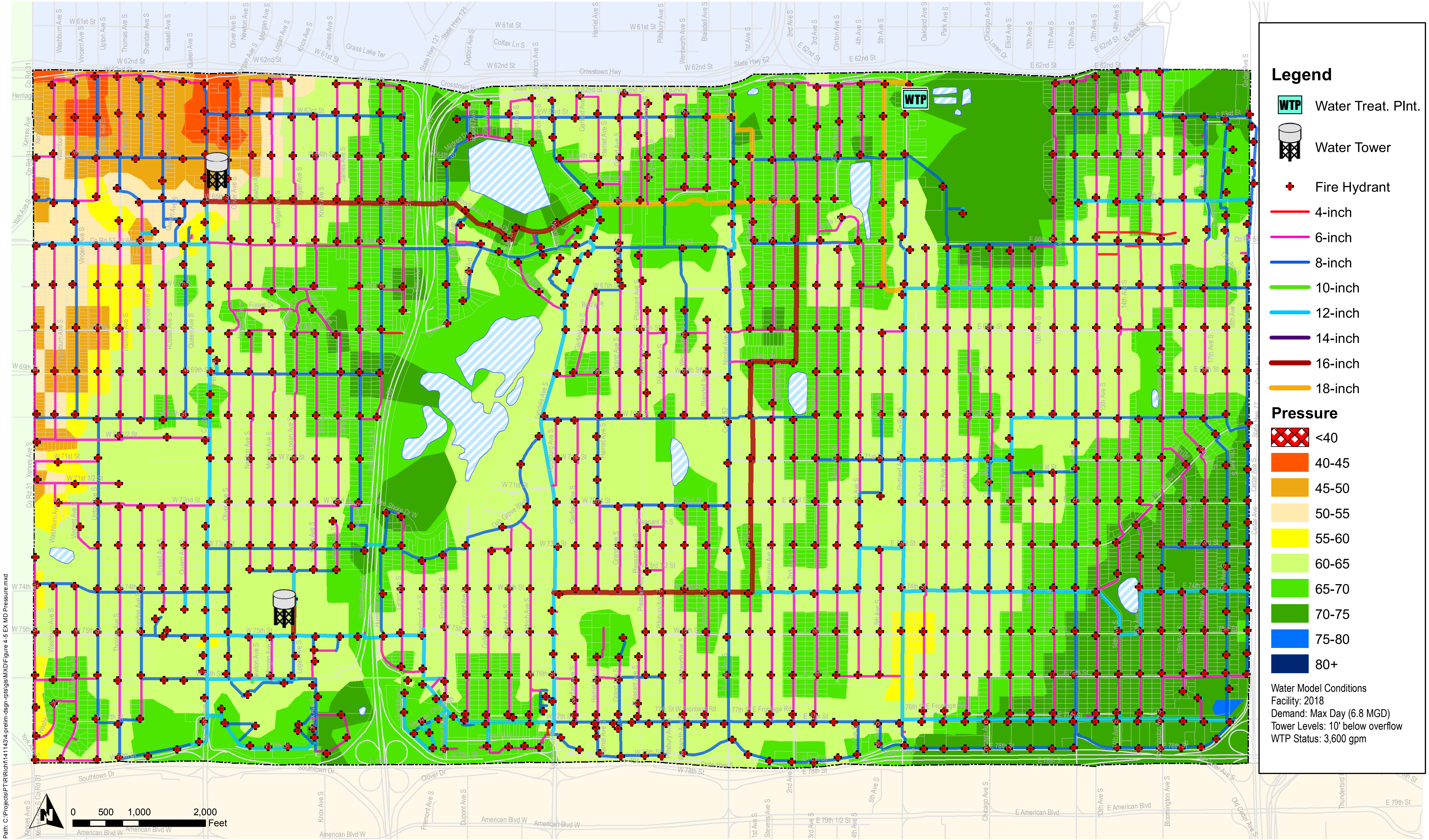
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-4
Existing Average Day Pressure



Path: C:\Projects\PT\R\Richf\141143\4-prelim-dsgn-rpts\gis\MXD\Figure 4-5 EX MD Pressure.mxd

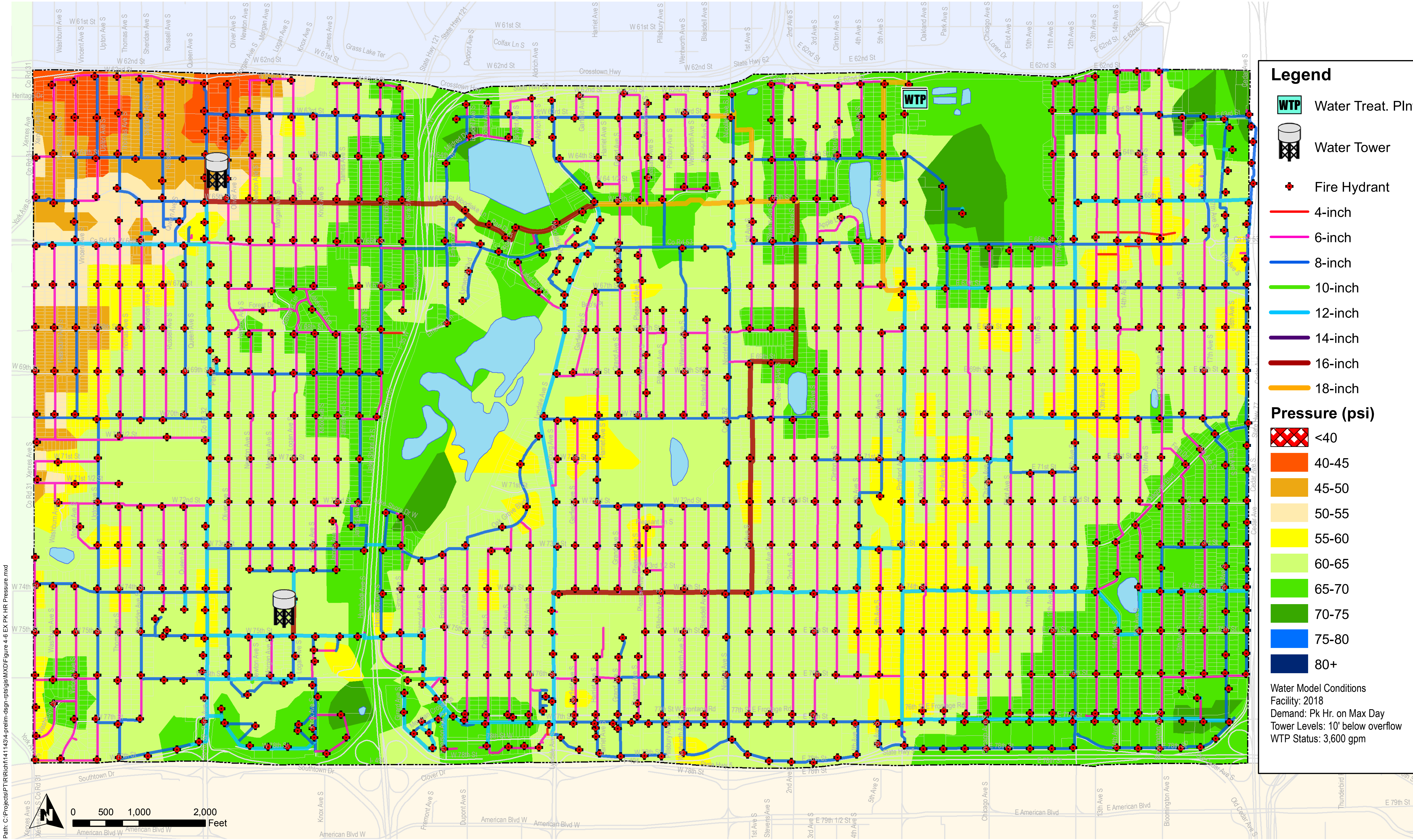
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-5
Existing Water System
Max Day Pressure



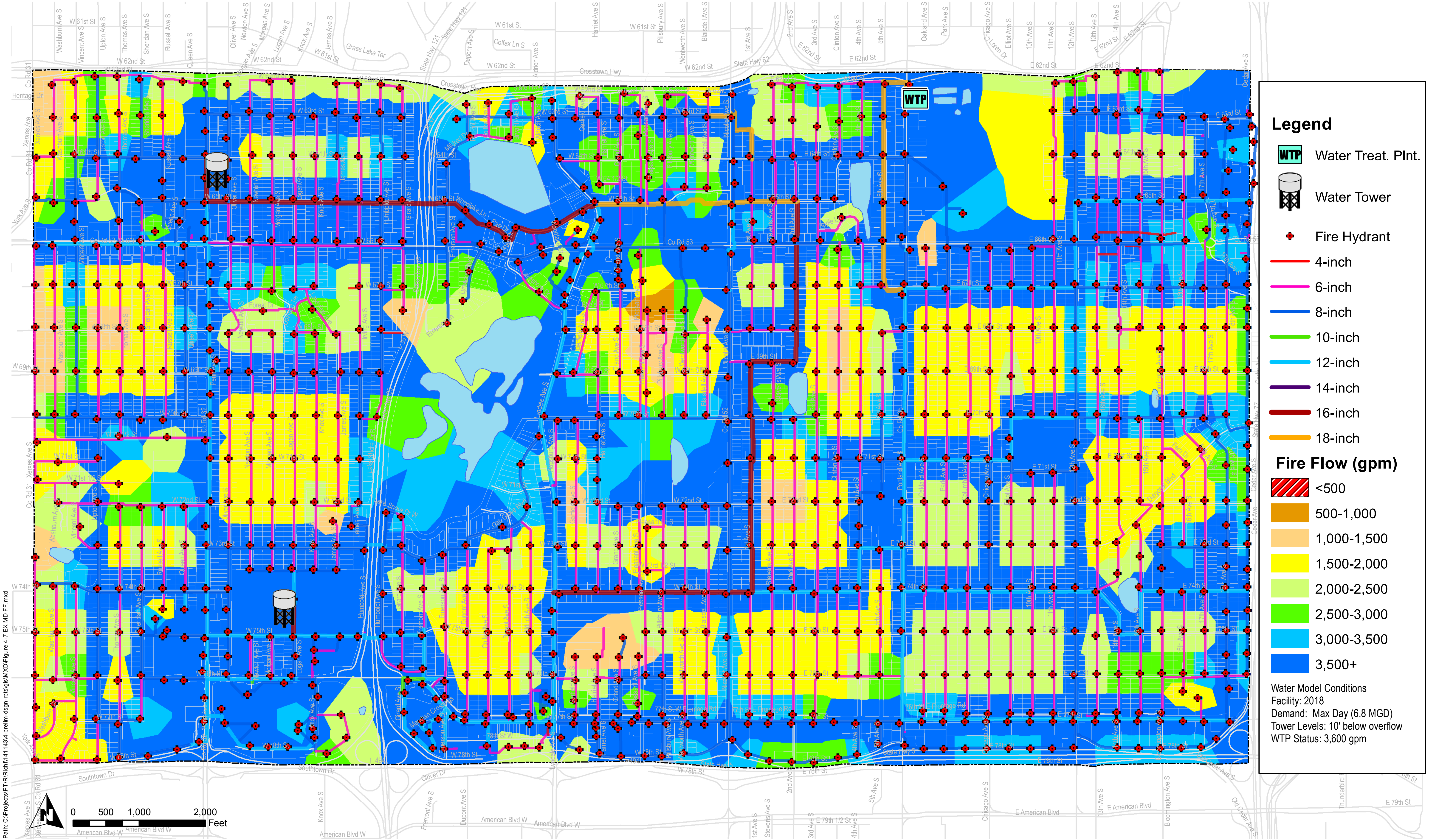
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-6
Existing Peak Hour Pressure



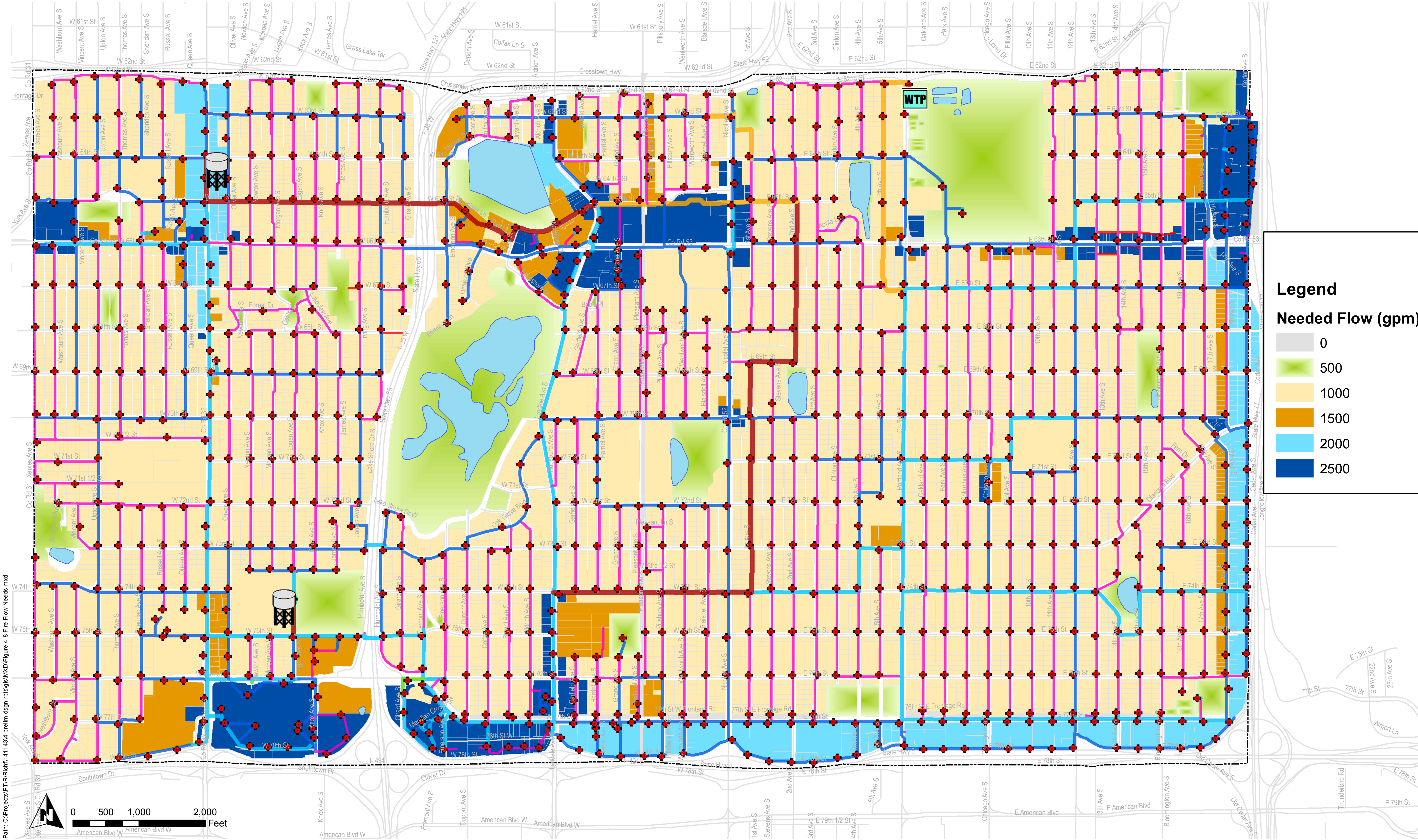
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-7
Existing Max Day Fire Flow



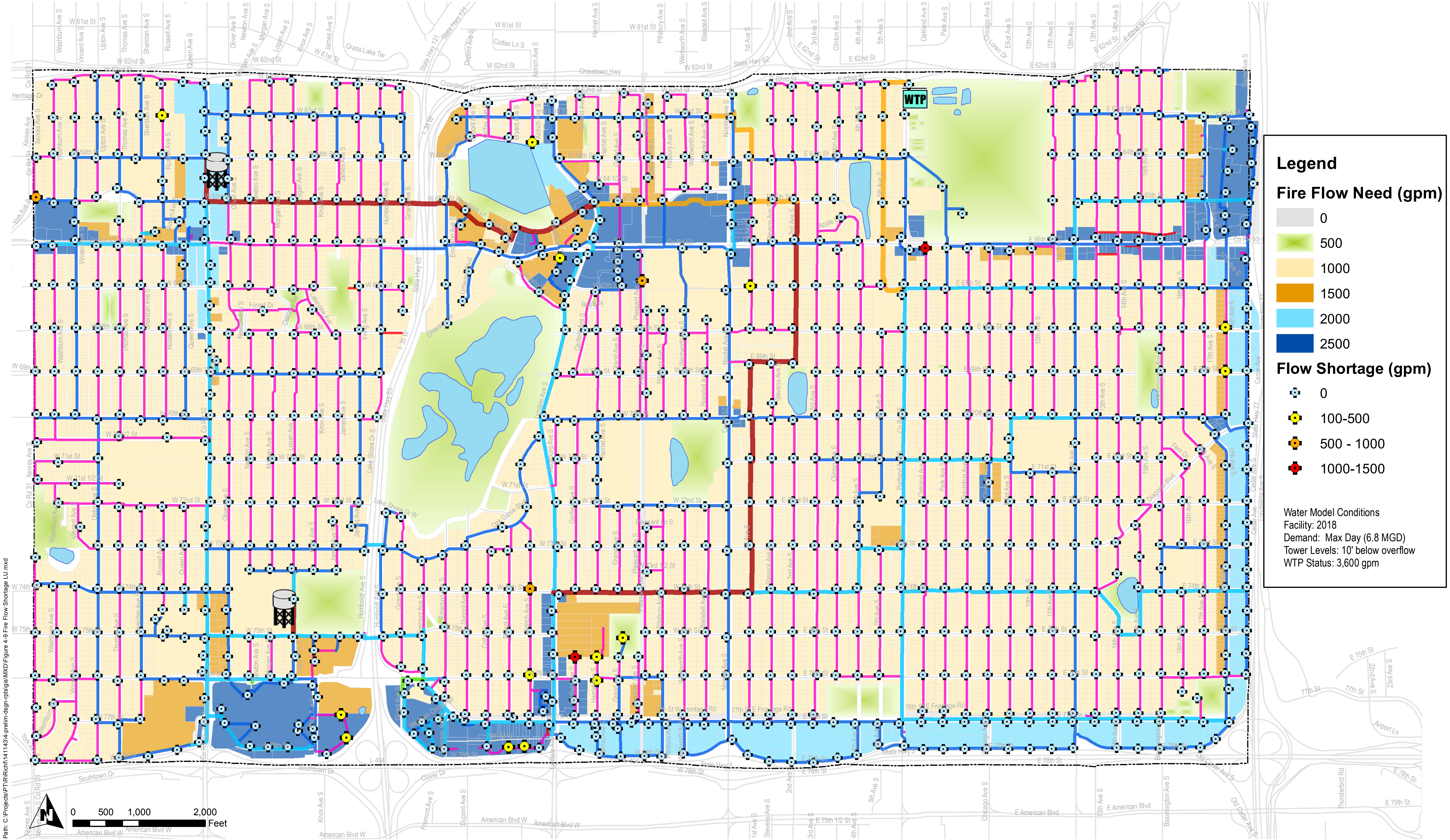
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-8
Estimated Needed Fire Flow
Based on Land Use

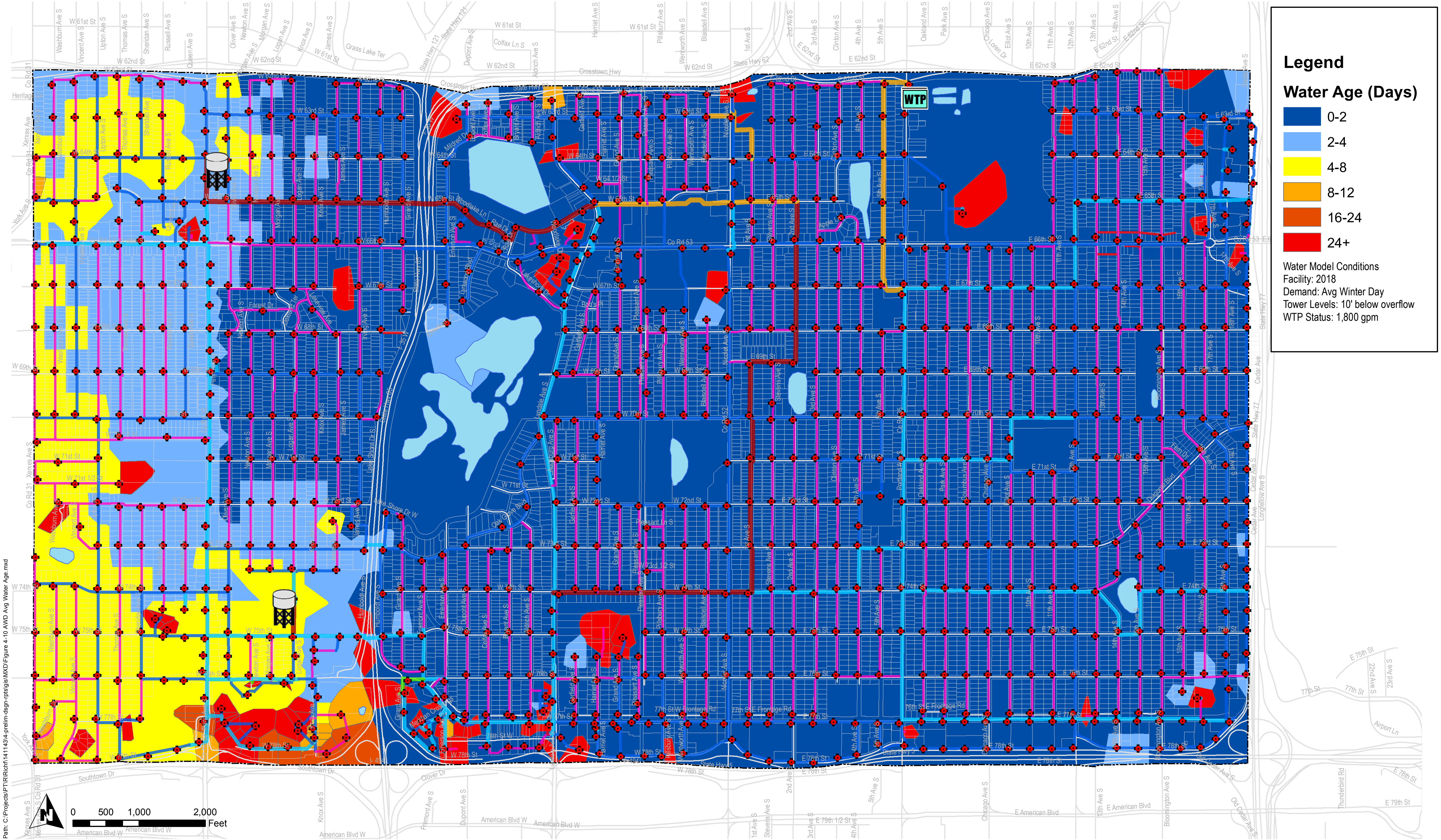


Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-9
Estimated Hydrant Fire Flow Shortage by Land Use Need



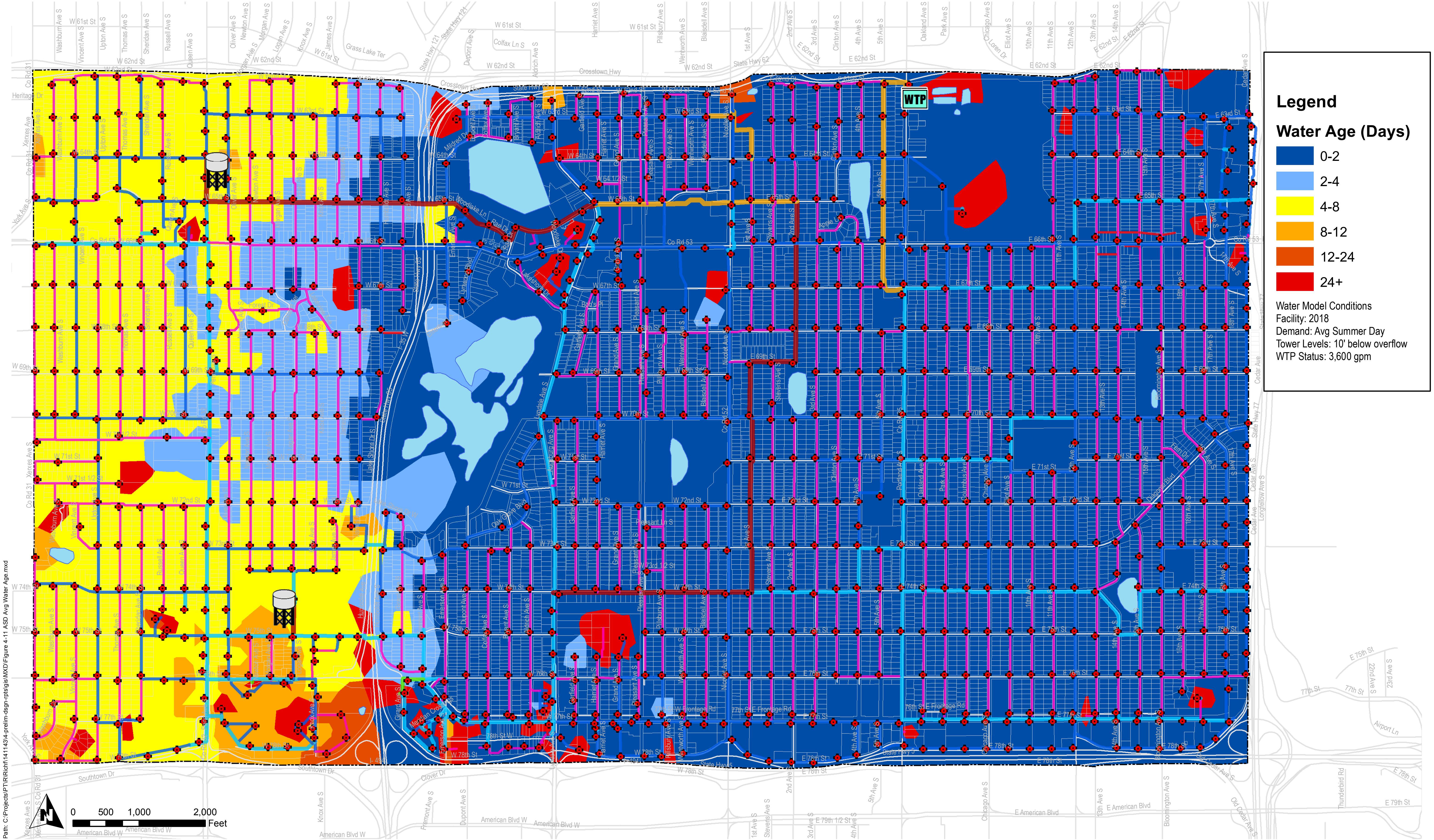
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

.2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-10
Average Water Age
Average Winter Day (AWD)



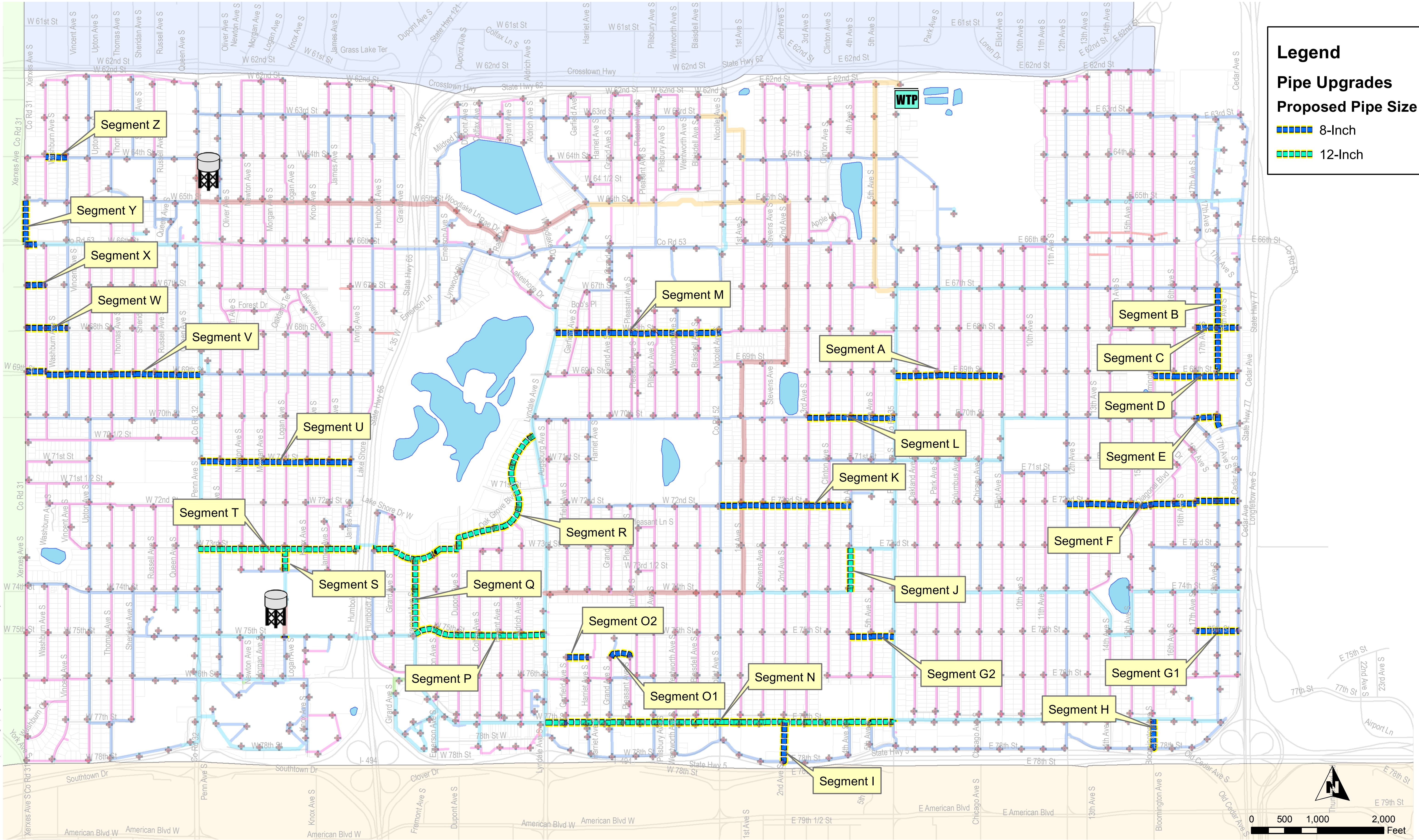
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 4-11
Average Water Age
Average Summer Day (AWD)



Path: S:\PT\R\Richf\141143\4-prelim-dsgn-rpts\gis\MXD\Figure 5-1 - Ultimate Water System.mxd

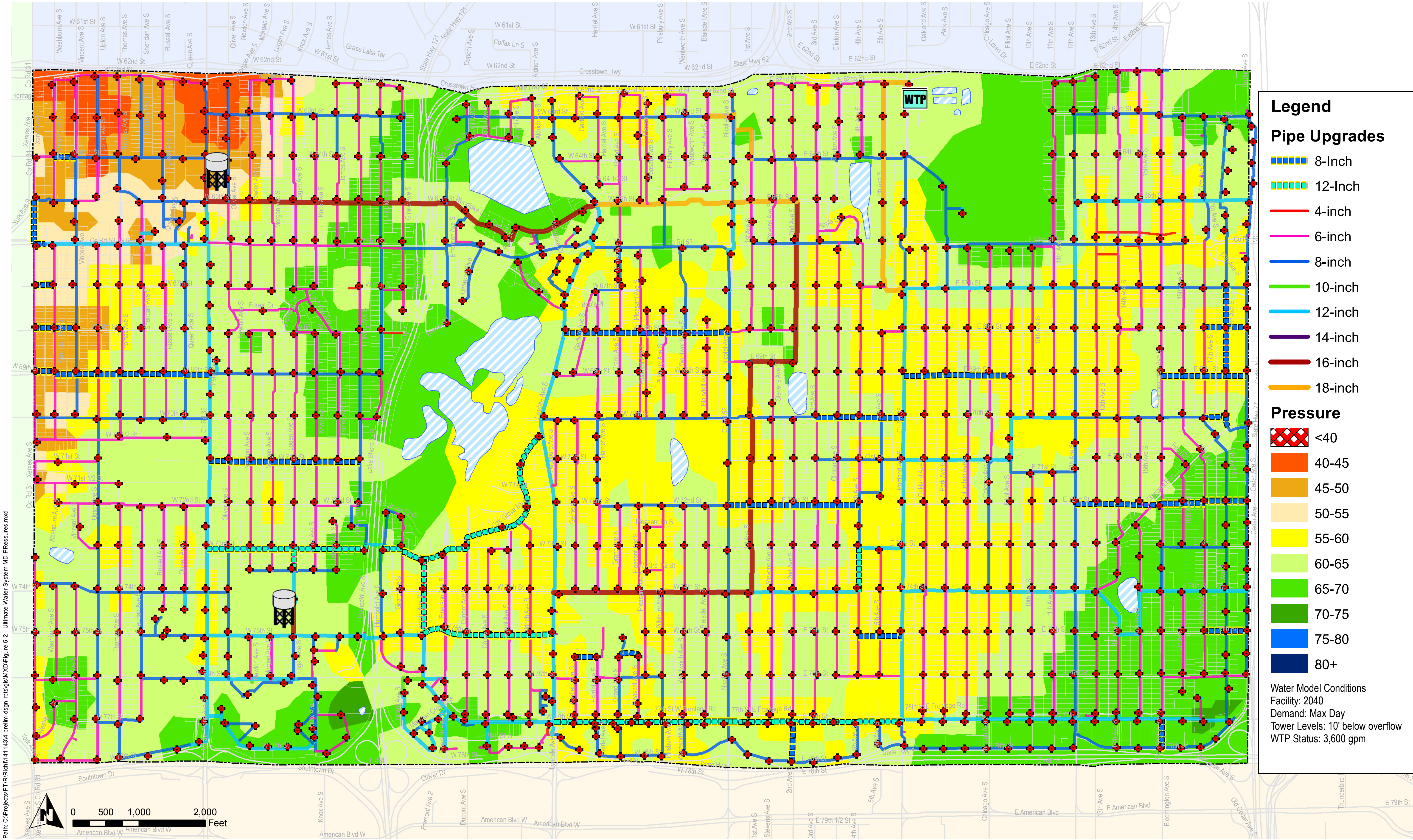
SEH

Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 5-1
Ultimate Water System
Planning Map



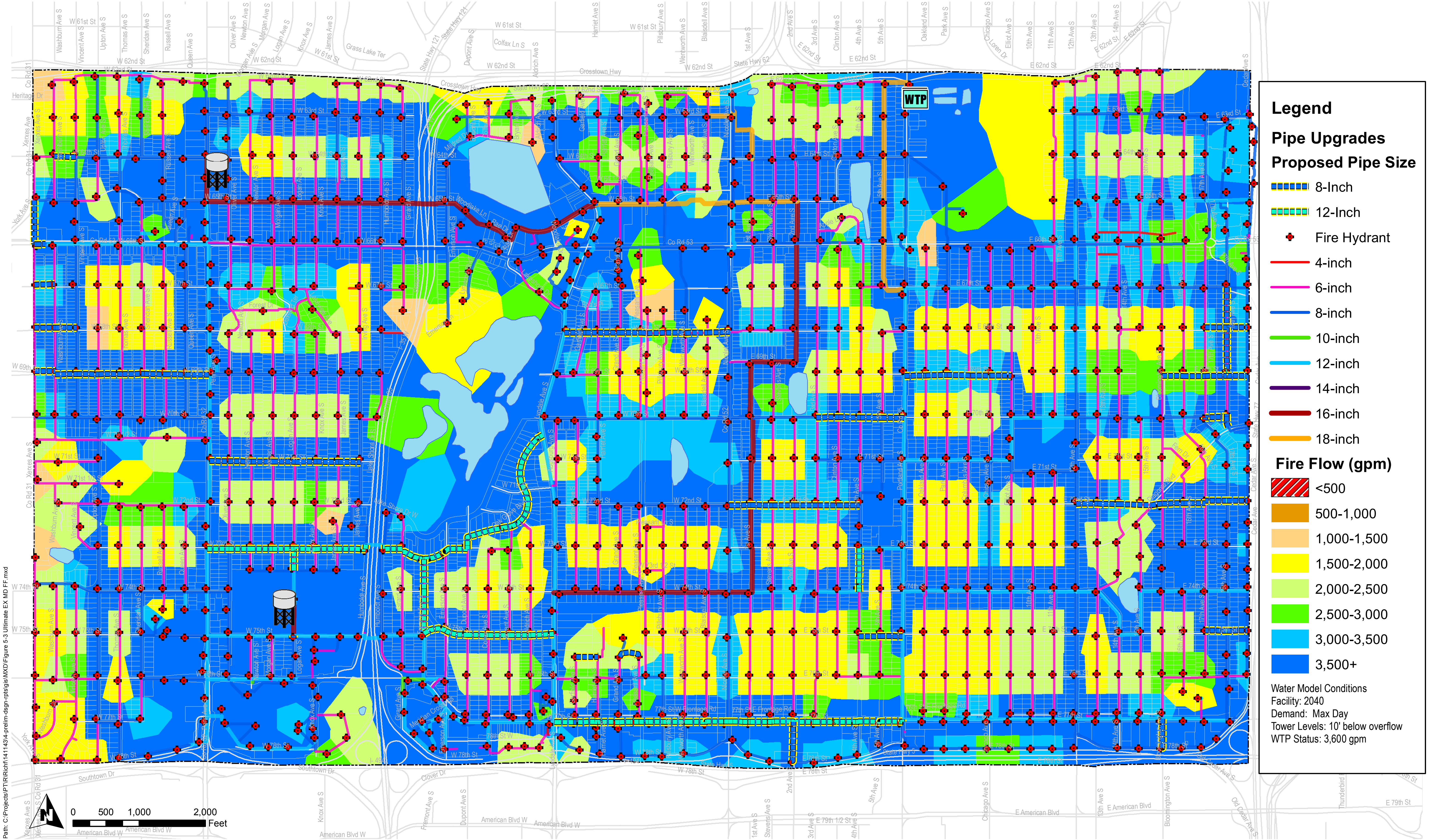
Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 5-2
Ultimate Water System
Max Day Pressure



Path: C:\Projects\PT\R\Richf\141143\4-prelim-dsgn-rpts\gis\MXD\Figure 5-3 Ultimate EX MD FF.mxd

Project Number: RICHF 141143
Print Date: Print Date: 7/30/2018

Map by:
Projection:
Source:

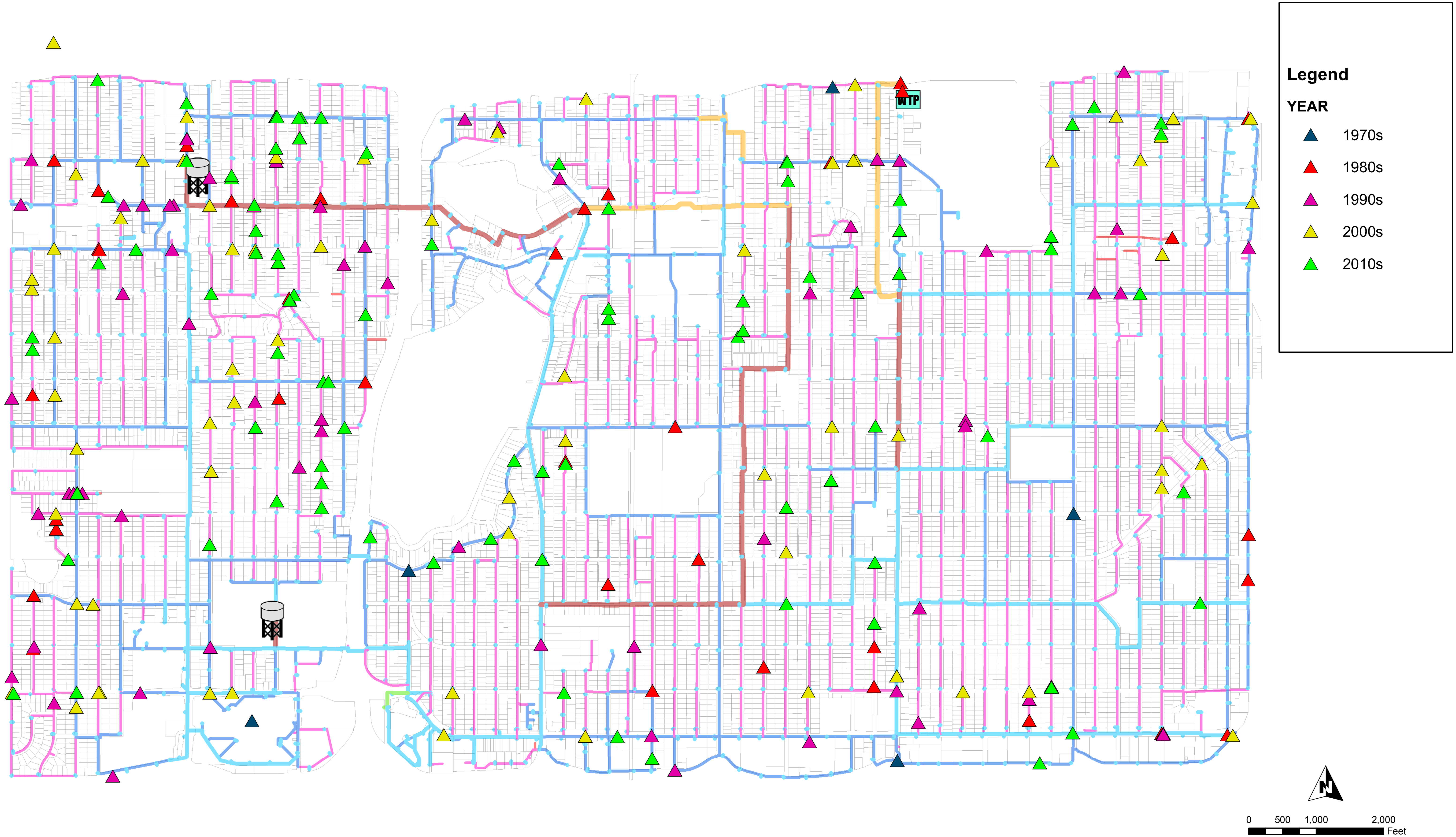
SEH

2018 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE 5-3
Ultimated Water System
Max Day Fire Flow

Appendix A

Mapping Data



Project Number: RICHF 141143
Print Date: Print Date: 12/28/2017

Map by:
Projection:
Source:

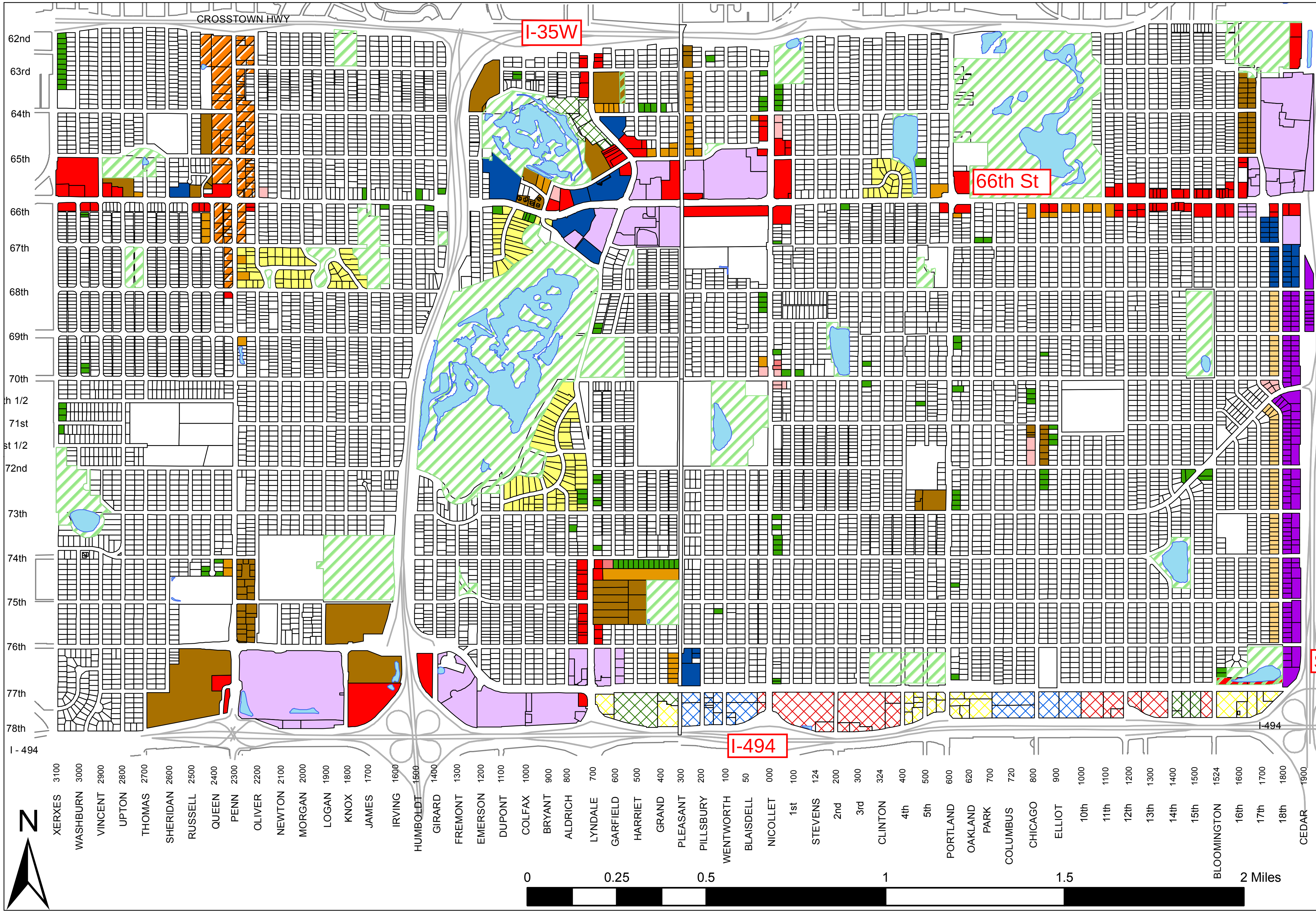
SEH

2017 Comprehensive Water System Plan
Richfield, Minnesota

FIGURE X
Water Main Break
History Location

UPDATED 9/2017

Figure 2-1: Richfield Zoning Map

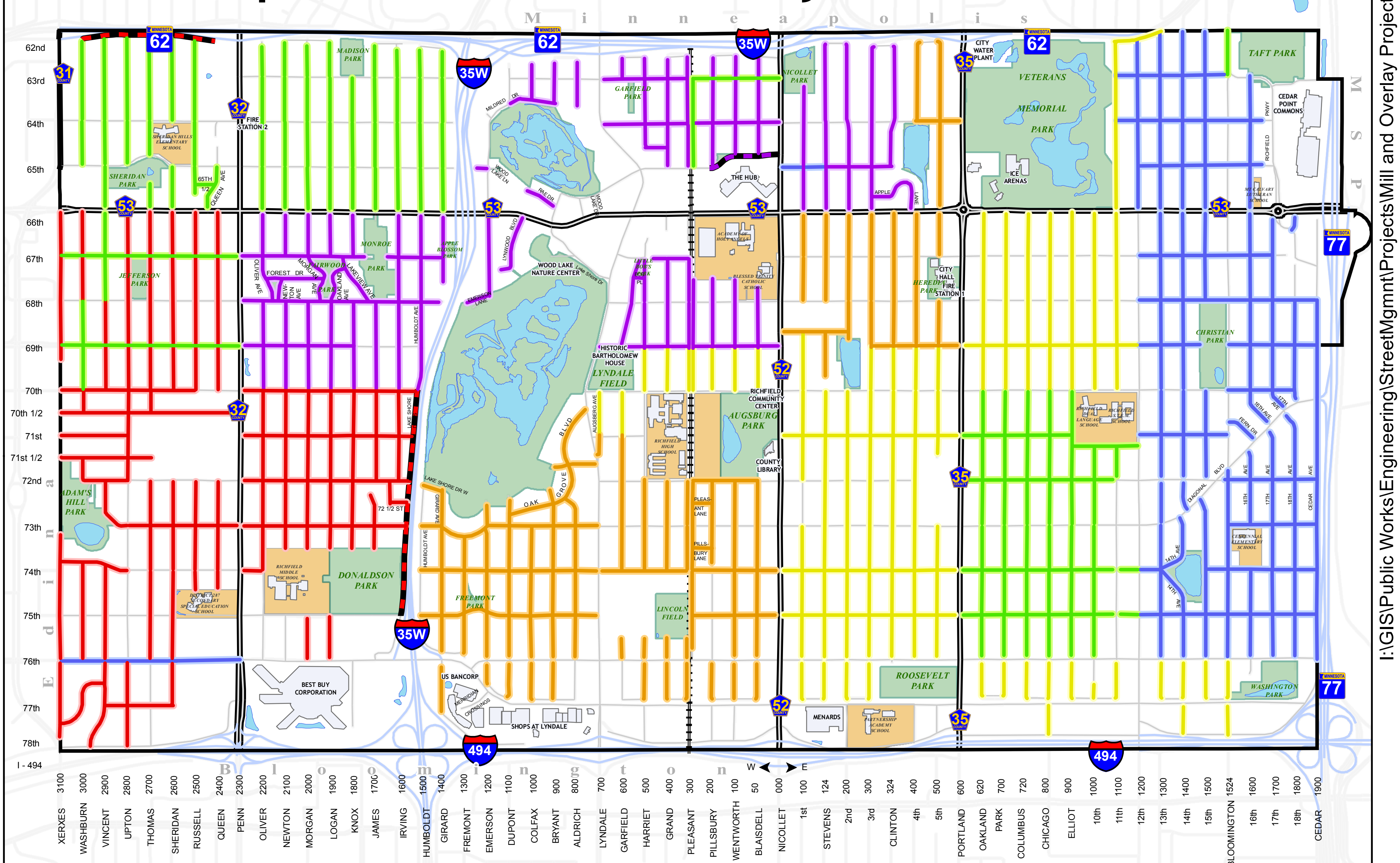


Richfield — The Urban Hometown

Zoning Designation

- Park (Zoning District is R)
- R Single-Family
- R-1 Low-Density Single-Family
- MR-1 Two-Family
- PMR Planned Multi-Family
- MR-2 Multi-Family
- MR-2/CAC Multi-Fam + Cedar Overlay
- MR-3 High-Density Multi-Family
- SO Service Office
- C-1 Community Commercial
- C-2 General Commercial
- PC-2 Planned General Commercial
- I Industrial
- MU-N Mixed Use-Neighborhood
- MU-C Mixed Use-Community
- MU-C/CAC Mixed Use + Cedar Overlay
- MU-C/PAC Mixed Use + Penn Overlay
- MU-R Mixed Use-Regional
- PMU Planned Mixed Use

Proposed Mill & Overlay Areas



1 in = 1,954 ft

N

0 | 1,000 | 2,000 | 3,000 | 4,000 feet

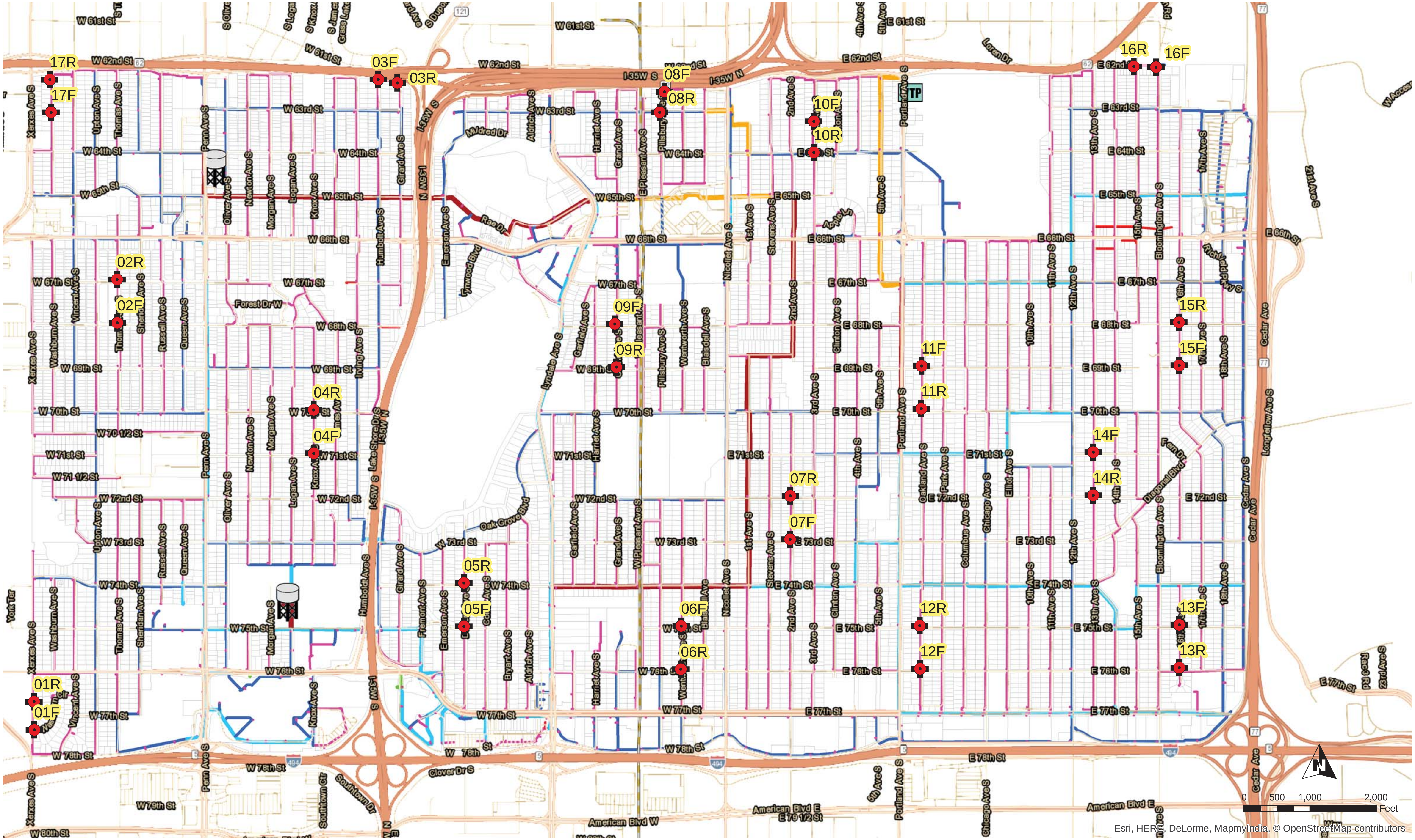
Richfield — The Urban Hometown

2015	2017	2019	2020
2016	2018	2019 M&O*	2020 M&O*

Date: 2/8/2017

Appendix B

Field Testing and Calibration



Path: C:\Projects\PT\R\Rich\141143\4-prelim-dsgn-rpts\gis\mxd\Figure 3 - Field Testing Locations.mxd

Project Number: XXXXX 000000
Print Date: Print Date: 11/14/2017

Map by:
Projection:
Source:

SEH

Water System Model
Richfield, Minnesota

FIGURE 3

Water System Field
Flow Testing Locations

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: XXXXX 000000
Print Date: 11/10/2017

Map by: jjb
Projection: NAD_1983_HARN_
Adj_MN_Hennepin_Feet
Source: 2017 Water Model

AVAILABLE FLOW FOR FIRE PROTECTION AT 20 PSI

RICHFIELD WATER MASTER PLAN
City of Richfield, Minnesota

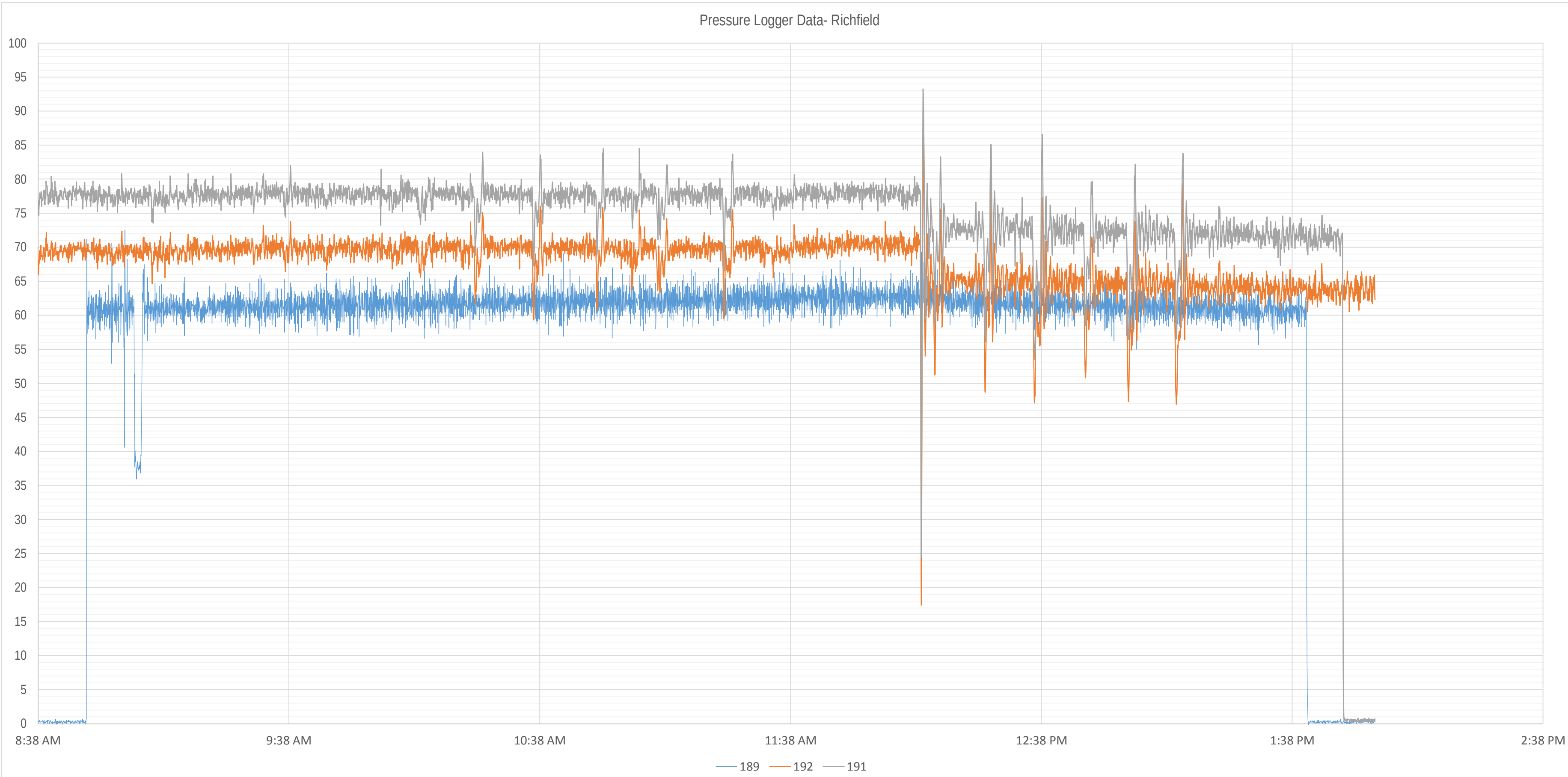
Figure
1

This map is neither a legally recorded map nor a survey map and is not intended to be used as one. This map is a compilation of records, information, and data gathered from various sources listed on this map and is to be used for reference purposes only. SEH does not warrant that the Geographic Information System (GIS) Data used to prepare this map are error free, and SEH does not represent that the GIS Data can be used for navigational, tracking, or any other purpose requiring exacting measurement of distance or direction or precision in the depiction of geographic features. The user of this map acknowledges that SEH shall not be liable for any damages which arise out of the user's access or use of data provided.

TABLE 1
RICHF - FIELD FLOW TESTING RESULTS

Test Location	Date	Time		FIELD TESTING							Boundary Conditions		
				R Static Pressure (psi)	R Residual Pressure (psi)	Pressure Difference (psi)	Flow Meter Size (inch)	Flow Meter pitot pressure (psi)	Field Flow (gpm)	Calc. Fire Flow @ 20 psi	Logan Tower Level (ft)	Penn Tower Level (ft)	WTP HSP Flow (gpm)
01F	5/24/2017	9:01	9:01	60	38	22	3.90	13.5	1,500	2,072	28.2	28.6	3500
02F	5/24/2017	9:18	9:18	60	38	22	3.90	13.5	1,500	2,072	28.5	29.0	3500
03F	5/24/2017	9:37	9:37	72	49	23	3.90	20.0	1,826	2,837	29.0	29.4	3500
04F	5/24/2017	9:53	9:53	72	54	18	3.90	12.8	1,458	2,586	29.4	29.7	3500
05F	5/24/2017	10:10	10:10	67	47	20	3.90	15.0	1,582	2,509	29.8	30.1	3500
06F	5/24/2017	10:22	10:22	72	52	20	3.90	15.3	1,595	2,671	30.1	30.3	3500
07F	5/24/2017	10:35	10:35	72	42	30	3.90	12.0	1,415	1,904	30.4	30.6	3500
08F	5/24/2017	10:51	10:51	72	68	4	3.90	15.5	1,608	6,423	31.0	31.1	3500
09F	5/24/2017	11:06	11:06	74	50	24	3.90	15.0	1,582	2,450	31.2	31.3	3500
10F	5/24/2017	11:21	11:21	74	70	4	3.90	19.5	1,803	7,352	31.6	31.6	3500
11F	5/24/2017	12:12	12:12	70	44	26	3.90	11.8	1,400	1,993	32.8	32.8	
12F	5/24/2017	12:23	12:23	65	48	17	3.90	16.5	1,659	2,806	32.3	32.4	
13F	5/24/2017	12:35	12:35	74	59	15	3.90	17.5	1,708	3,412	31.6	32.0	
14F	5/24/2017	12:48	12:48	71	44	27	3.90	14.0	1,528	2,154	31.0	31.5	
15F	5/24/2017	12:59	12:59	70	45	25	3.90	12.8	1,458	2,120	30.5	31.1	
16F	5/24/2017	13:08	13:08	71	52	19	3.90	19.0	1,780	3,034	30.1	30.8	
17F	5/24/2017	13:29	13:29	50	32	18	3.90	11.0	1,354	1,785	29.3	30.1	

* See flow testing map for locations of flow tests



Pressure Logger Data- Richfield
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
8:38 AM
9:38 AM
10:38 AM
11:38 AM
12:38 PM
1:38 PM
2:38 PM
189
192
191

Appendix C

Interconnect Options

Building a Better World for All of Us®

MEMORANDUM

TO: Butch Lupkes, Mike Peterson

FROM: Chad T. Katzenberger

DATE: December 15, 2016

RE: Interconnect - Water System Review Modeling
SEH No. RICHF 137369 14.00

The purpose of this memo is to summarize the findings of our water system review and modeling related to a proposed water system interconnect between the Cities of Richfield and Bloomington. This memo will review design assumptions related to supply system pressure, flow capacity, system control and proposed interconnect system design.

Water System Model

The City of Richfield's existing water system model was utilized to examine existing normal water system operation. The model is constructed in Bentley WaterCAD v8i and provides a virtual representation of the City's existing water distribution system including supply and storage facilities. Use of this model allows for operation of the water system to be simulated during steady state or extended period conditions. For purpose of this analysis, proposed facilities were initially designed and sized using the steady state modeling functions and then later verified with an Extended Period Simulation (EPS).

Emergency Water Supply Needs

Previous water system interconnect analysis have narrowed the most feasible option to a connection with an existing 42-inch water supply line running from the Minneapolis water system, through Richfield to Bloomington along Logan Ave. The City of Richfield desires to have access to an emergency backup water supply with a maximum anticipated water draw of 3.5 MGD (2,430 gpm) -- which is slightly more than recent historical Average Day Demand of approximately 3 MGD.

Supply Line Hydraulics

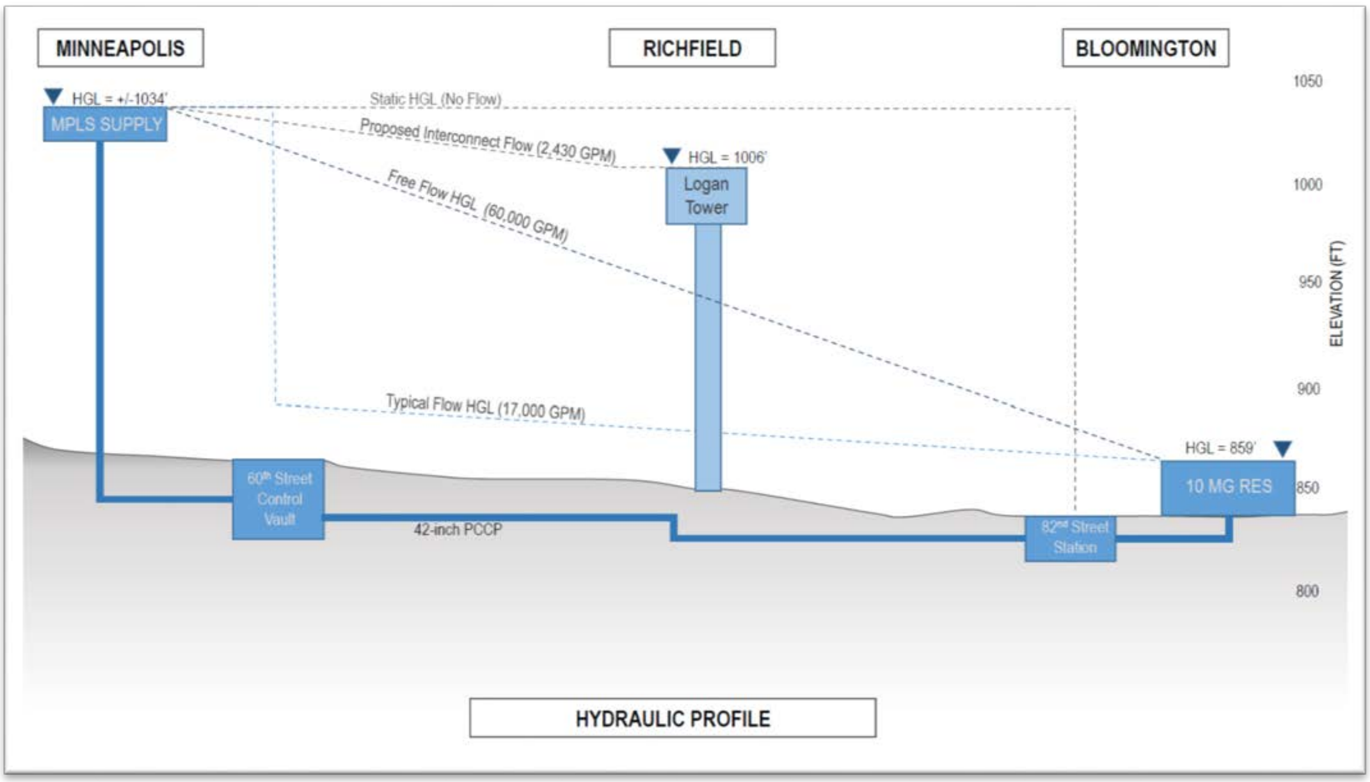
Bloomington currently owns two (2) supply lines that obtain water from a 60-inch trunk main located along 60th Street in Minneapolis. Bloomington generally alternates use of each line on an every other day basis to keep fresh water circulating in the system. Bloomington's contract with Minneapolis requires that Bloomington draw a minimum of 2.0 MGD each day, but can draw up to 30 MGD (using both lines simultaneously). At a minimum 2.0 MGD withdrawal, operation of either line lasts for a period of 1-2 hours.

When operated, water in the 42-inch Knox/Logan Line flows at a rate of 17,000 gpm. At its connection on 60th Street, the Hydraulic Grade Line (HGL) of the Minneapolis system rides at an approximate elevation of 1034 feet but, can vary up to an elevation of 1075 feet. To obtain water, Bloomington initiates flow by opening a butterfly valve located near their 10 MG storage reservoir. As water begins to flow, the rate is modulated by a control valve located in a vault at 60th Street in Minneapolis. The vault also contains a flow meter to measure and totalize the flow. Inside the vault, the valve never fully closes and sustains pressure in the supply transfer line.

When the valve opens flow passes through the partially open valve at the 60th street control vault. With flow active through the flow meter and control valve, the control valve automatically opens slowly until a max flow rate of 17,000 gpm is achieved in the supply transfer line. When the desired amount of water is supplied to Bloomington, the reservoir control valve is closed, the flow in the 60th street control vault stops, and the control valve returns to its mostly closed position. The control systems between the 60th street vault and Bloomington reservoir are locally controlled, with the only communication taking place between the two is the flow rate.

Interconnect Hydraulic Considerations

The figure below provides an illustration of the hydraulic grade lines for the water systems of Minneapolis, Richfield and Bloomington along the route of the 42" main. As shown, the normal HGL of the Minneapolis water system is approximately 1,034 feet, which is 28-feet higher than the HGL of the Richfield system. With this additional head, water could flow by gravity from the water supply line into the Richfield system. However, various system operational conditions need to be accounted for and so, the following paragraphs offer discussion of alternate solutions for Richfield to obtain water via the 42-inch Logan water line.



Gravity Feed – Option 1 – Simple Open-Close Valve Control to Richfield – Bloomington Accesses Alternate Line

Under this emergency alternative, Richfield would obtain water from the 42-inch Logan line, Bloomington would use its alternate line from Minneapolis and would keep its control valve on the 42-inch Logan line closed. This is because when the 60th street station is activated and throttles flow to Bloomington, the HGL in the 42-inch line in the vicinity of the proposed Richfield Interconnect is believed to be reduced to a level lower than the Richfield HGL, which would not permit gravity flow into the Richfield system. Therefore, in order for a gravity interconnect option to be feasible, an agreement would need to be in place such that Richfield would have sole access to the water supply line in the event of a major emergency.

Under this Option 1 design, an interconnecting water main would be constructed between the 42-inch line and the fill line to Richfield's Logan Tower. Along with this interconnecting water main, a vault, or above-grade building, would be constructed containing an open-close valve installed on Richfield's interconnecting water line would control the flow of water into the Richfield system based upon the level of water in Richfield's Logan tank. With the proposed location of the interconnect being located so close to the Logan tank, the flow control valve inside would simply operate like a pump to open and close according to tank level set points. Unless in filling mode, the interconnect line would not remain open as the HGL from Minneapolis is higher than Richfield's. This alternative is feasible unless Bloomington opens their flow control valve on the 42-inch Logan line, which would cause the HGL in that line to drop below Richfield's HGL thereby preventing water from entering the Richfield System when called for.

Gravity Feed – Option 2 – Upgraded Supply Control to Richfield – Bloomington Accesses Alternate Line
Similar to Option 1, under this emergency alternative, Richfield would obtain water from the 42-inch Logan line, Bloomington would use its alternate line from Minneapolis and would keep its control valve on the 42-inch Logan line closed. An interconnecting water main would be constructed between the 42-inch line and the fill line to Richfield's Logan Tower. Along with this interconnecting water main, a vault, or above-grade building, would be constructed containing flow control and pressure reducing valves which would control the flow of water into the Richfield system and reduce the pressure of the Minneapolis system HGL to match that of Richfield's. With the PRV in place, the flow control valve could remain open for extended periods of time and not have to open and close with each tank filling cycle. This alternative is feasible unless Bloomington opens their flow control valve on the 42-inch Logan line, which would cause the HGL in that line to drop below Richfield's HGL thereby preventing water from entering the Richfield System.

Gravity Feed – Option 3 – Simple Open-Close Valve Control to Richfield – Bloomington has Concurrent Access
This option is similar to Option 1, except that a pressure sustaining valve (PSV) would be installed downstream of the proposed Option 1 Richfield Interconnect, so that the City of Bloomington can use the 42-inch pipeline for their water supply even if Richfield has a concurrent emergency water supply need from that same line. The proposed downstream PSV would hold the Minneapolis HGL all the way to the Richfield connection and then allow the pressure downstream to have a downward gradient to the Bloomington reservoir so that the City of Bloomington can access the same line.

Gravity Feed – Option 4 – Upgraded Supply Control to Richfield – Bloomington has Concurrent Access
This option is similar to Option 2, except that a pressure sustaining valve (PSV) would be installed downstream of the proposed Option 2 Richfield Interconnect, so that the City of Bloomington can use the 42-inch pipeline for their water supply even if Richfield has a concurrent emergency water supply need from that same line. Similar to Option 3, the proposed downstream PSV would hold the Minneapolis HGL all the way to the Richfield connection and then allow the pressure downstream to have a downward gradient to the Bloomington reservoir so that the City of Bloomington can access the same line.

Pumped Feed – Option 5 – Simple Pump and Valve Control to Richfield – Bloomington has Concurrent Access
This option is similar to Option 1, except that both an open-close valve and a pump would be installed inside the flow control structure. Flow control into Richfield's system would be controlled by the valve or pump depending on available pressures in Richfield's interconnecting line. The flow control valve would be used if the available pressure (HGL) is higher, such as when Bloomington is not drawing water through the 42-inch line. The pump when the available pressure (HGL) is lower, such as when Bloomington is drawing water through the 42-inch line. This alternative appears feasible and allows the City of the option of using the 42-inch Logan line.

Proposed Interconnect Facility

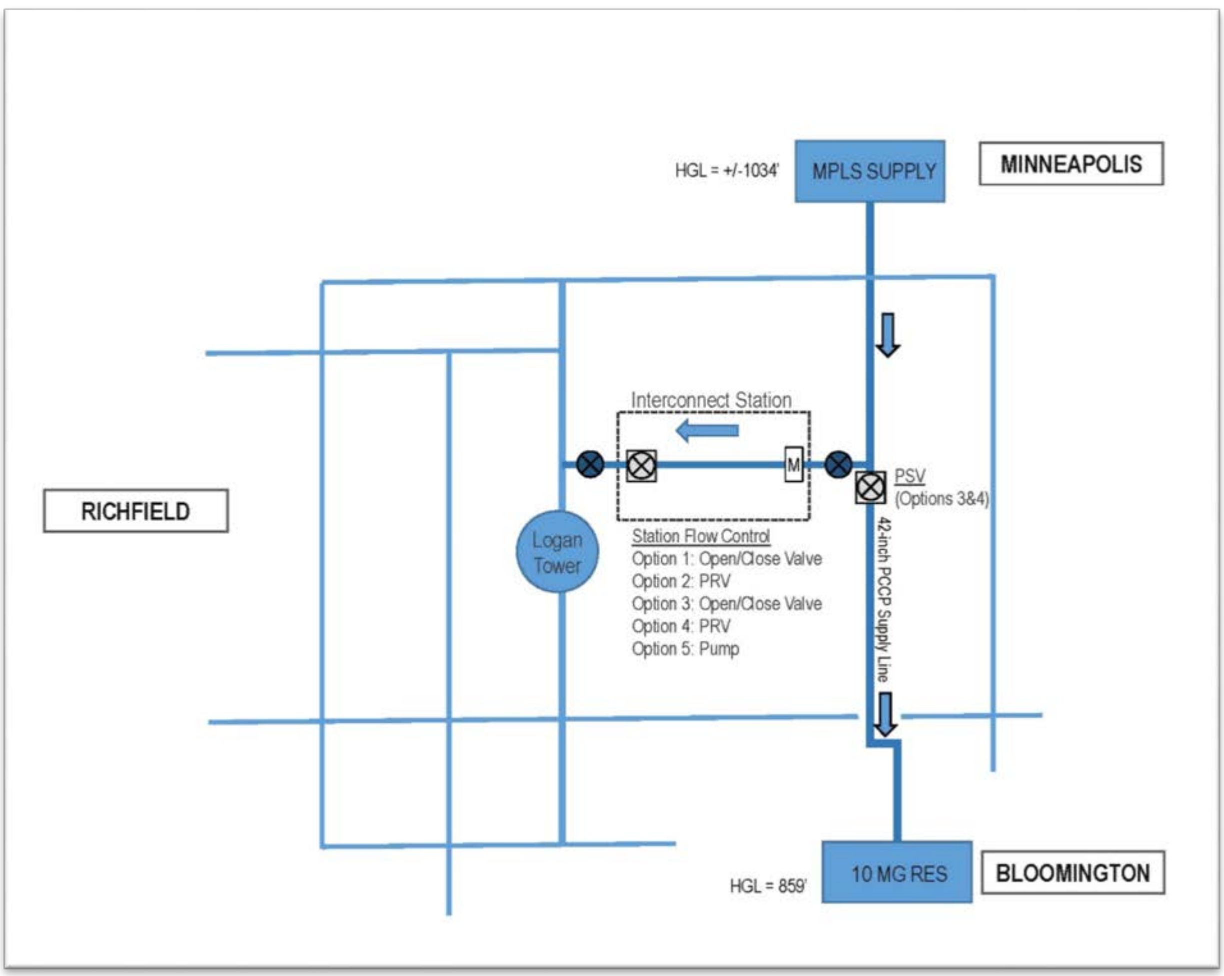
The Minneapolis/Bloomington Supply line 42-inch supply line runs along Logan Ave. and the west edge of Donaldson Park, where the Logan water tower is located. In this area, the 42-inch supply line runs only a few feet away and parallel to 12-inch and 16-inch Richfield trunk main that serve the Logan water tower. This is an ideal location to transport a large volume of supply water into the Richfield system. Connection to either the 12-inch or 16-inch lines would allow for the 2,430 gpm (3.5 MGD) flow rate to feed the Richfield system and fill the water towers. (Confirmed via EPS water modeling). With any of the interconnect options discussed above, The proposed interconnect facility would ideally consist of a 16-inch connection to the 42-inch supply line, a metering/control station, bypass line and isolation valves. For the metering/control station, it is feasible that either an above-grade or below-grade structure could be constructed to house the necessary flow control equipment.

Water Model Simulation

Steady State Simulation

The City's existing water system model was updated to include various scenarios that would simulate the operation of the proposed interconnect station options during an emergency event. First a steady state simulation was completed to determine the hydraulic capabilities for moving the desired flow rate of 2,430 gpm into the Richfield system. Assuming a 16-inch connection to the 42-inch PCCP line into the existing 12-inch Richfield line just North of the Logan water tower, average daily demand levels and Richfield towers at 5 feet below overflow, the model estimates that a maximum flow rate of 5,500 gpm (7.9 MGD) could move from the supply line (HGL=1034') into the Richfield system (HGL=1001') if needed. Since the proposed supply flow for the interconnect system is 2,430 gpm, the pipe size through the interconnect station could be reduced down to 12-inch, additionally the flow control valve would need to be throttled appropriately to restrict the flow to the desired rate.

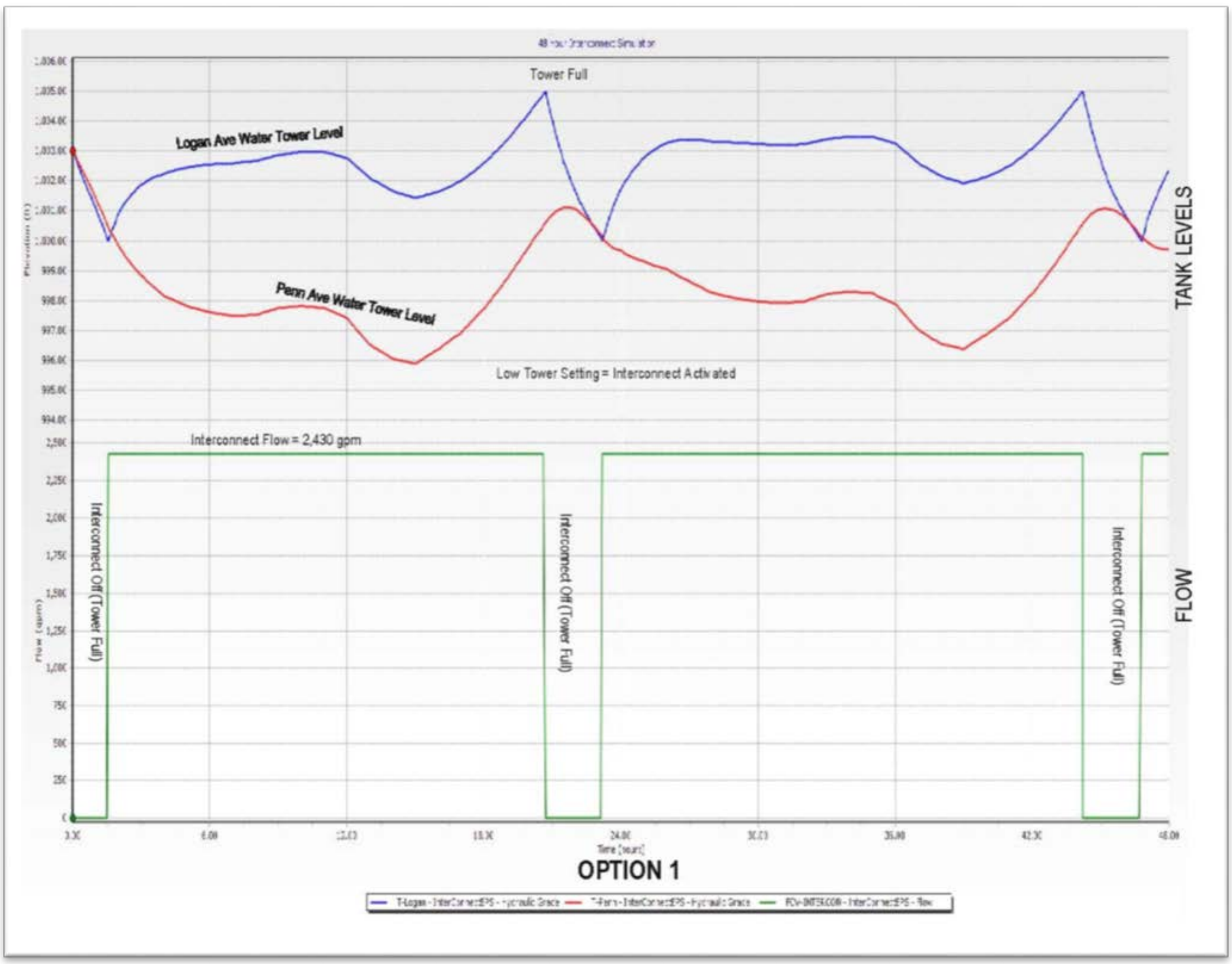
Extended Period SimulationThe model was then used to simulate the extended period operation of the five different proposed system options over the course of two days (48 hours). Controls within the model were set to



open and close the interconnect station base on water levels in the Logan water tower to prevent overflow. Current average day demand (3.0 MGD) was assumed and simulated with a diurnal demand pattern according to the hour of day within the operation. Below is a summary of the modeling results for each of the 5 options proposed earlier in the memo. For the options with

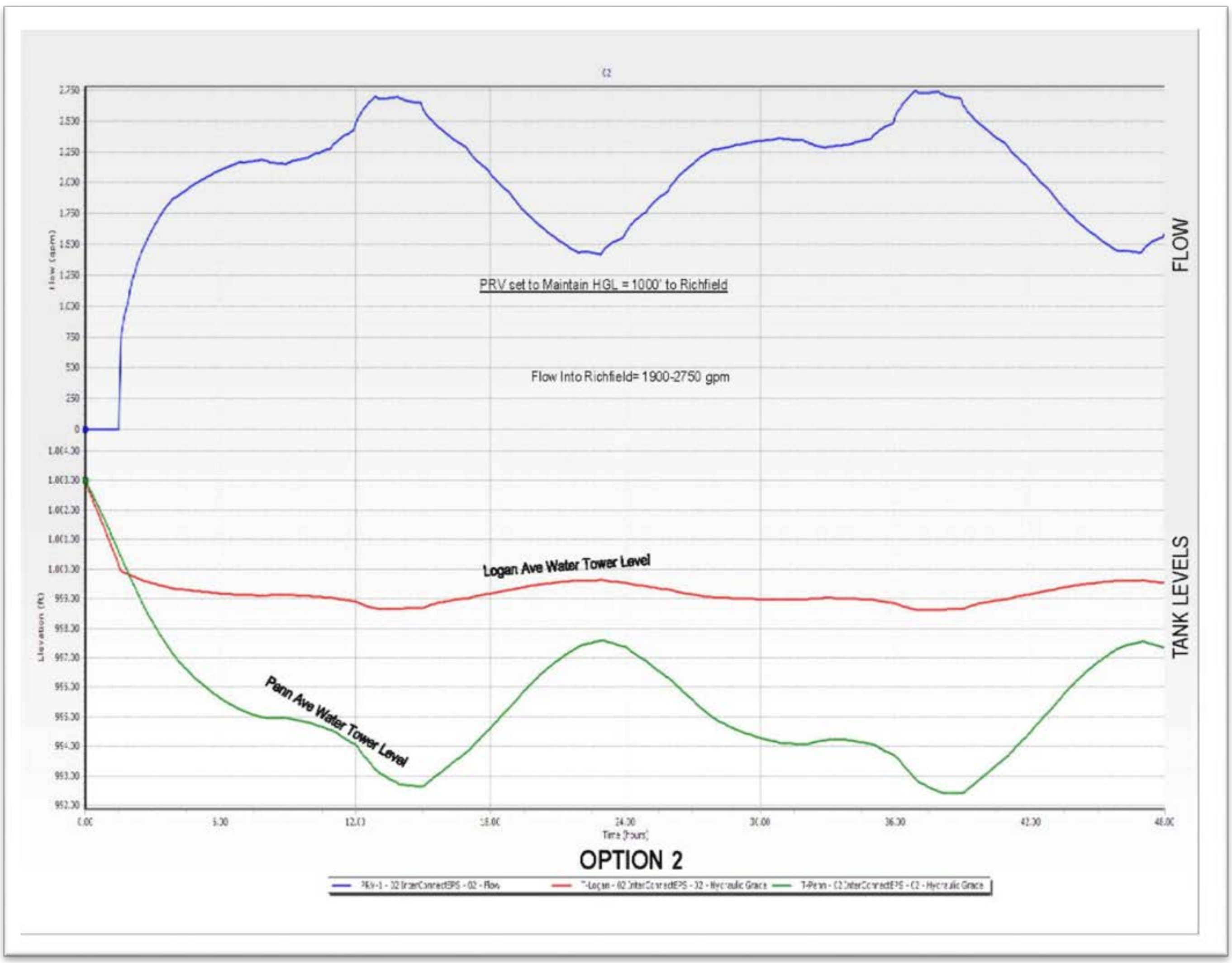
<u>Modeling of Gravity Feed – Option 1 – Simple Open-Close Valve Control to Richfield – Bloomington Accesses Alternate Line</u>

The modeled system reacted as expected with water flowing at the set rate of 2,430 gpm from the supply line into the Richfield system, maintaining working water tower levels. For purpose of analysis, both tower levels were set at 1,000 feet upon commencement of the model run. Since the Logan tower is near the proposed interconnection, as expected, the model simulation indicates that this tower will fill faster than the Penn tower. To prevent overflow of the Logan tower, this facility was used as the controlling tower for activation of the interconnect station, turning off upon filling of the tower. In general, the Penn and Logan towers float within 5-feet of one another under this scenario, which would provide more than adequate service pressure to the distribution system, on par with current non-emergency operations.



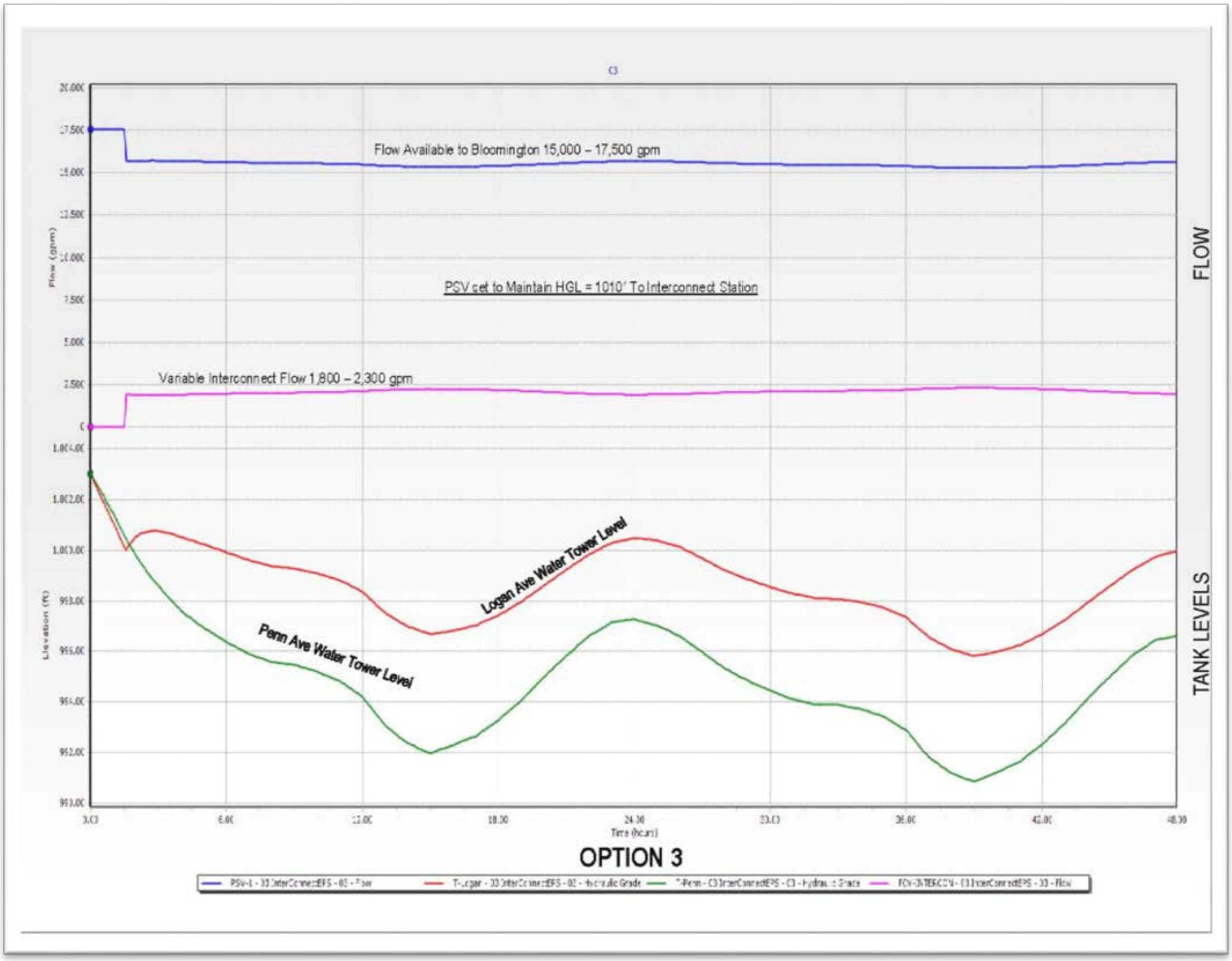
<u>Modeling of Gravity Feed – Option 2 – Upgraded Supply Control to Richfield – Bloomington Accesses Alternate Line</u>

This option was simulated similar to options 1, except it was assumed that control of water into the Richfield system would be provided by a Pressure Reducing Valve (PRV). This would essential provide a hydraulic control of the supplied flow, set to maintain a manually set pressure. Using this type of flow control would result in a variable flow through the interconnect while maintaining pressure in the Richfield system. In general, the Penn and Logan towers would float within 2-6 feet of one another under this scenario. This would provide more than adequate service pressure to the distribution system, on par with current non-emergency operations.



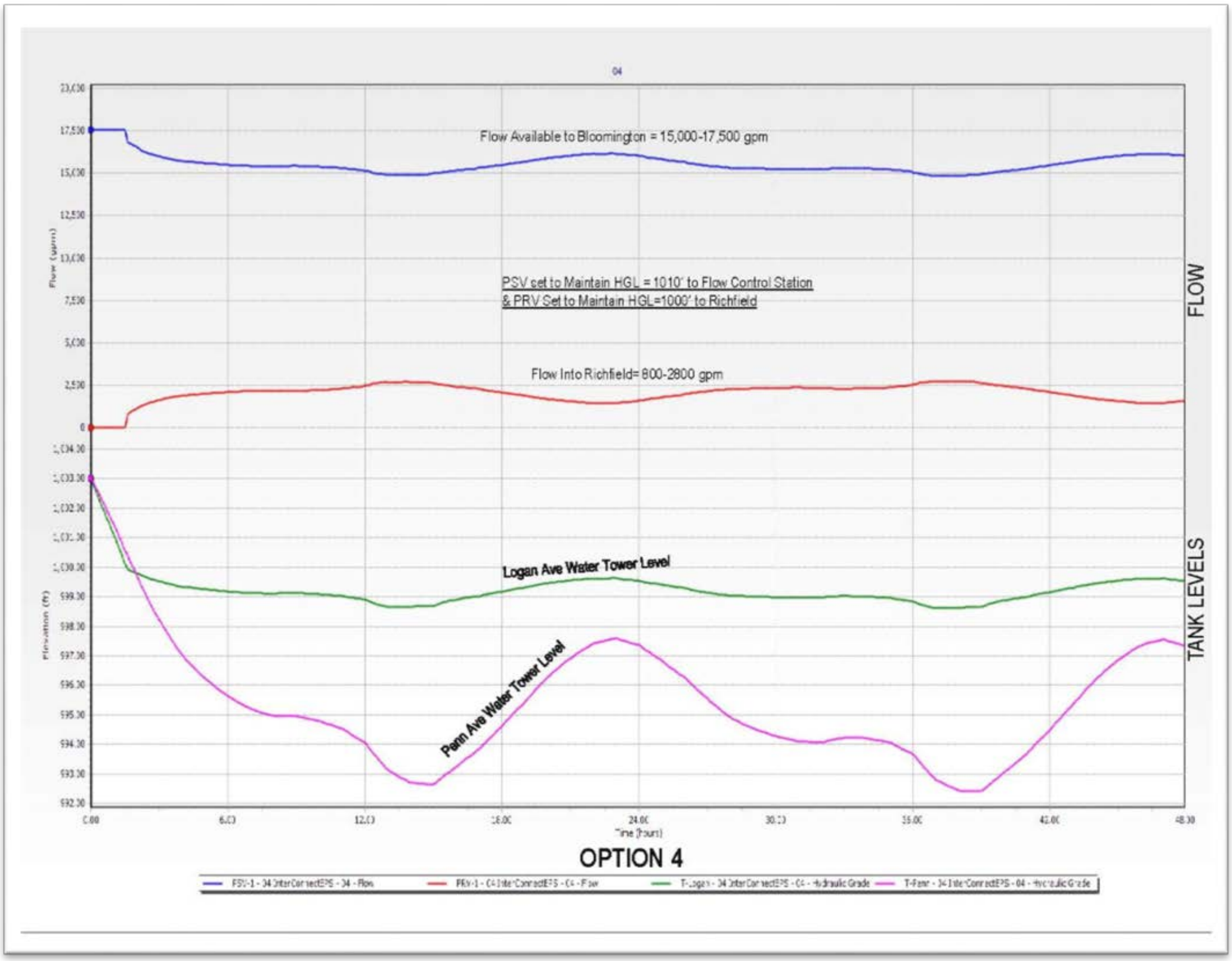
Modeling of Gravity Feed – Option 3 – Simple Open-Close Valve Control to Richfield – Bloomington has Concurrent Access

This option was simulated similar to options 1, except it was assumed that Bloomington would be drawing water at the same time with full gravity flow and a downstream PSV on the 42-inch supply line would sustain pressure. The results show that under this scenario a range of flow between 15,000-17,500 gpm would be maintained to supply Bloomington (depending on activity of the interconnection station) while providing gravity flow to Richfield at a rate of 1,800-2,300 gpm. In general, the Penn and Logan towers float within 5-feet of one another, which would provide more than adequate service pressure to the distribution system, on par with current non-emergency operations. Furthermore, this option has the added benefit of allowing Bloomington to access the line at the same time.



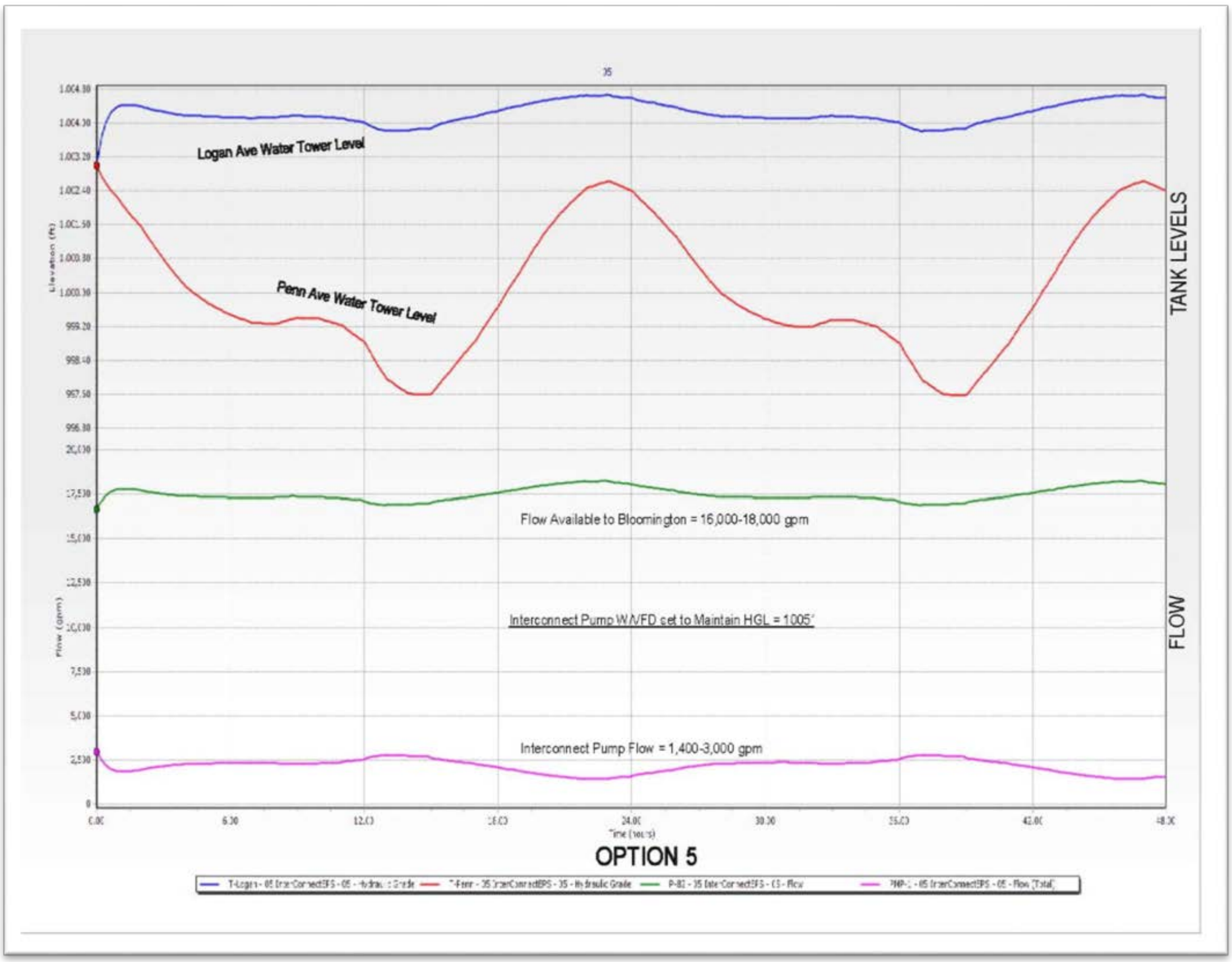
<u>Modeling of Gravity Feed – Option 4 – Upgraded Supply Control to Richfield – Bloomington has Concurrent Access</u>

This option was simulated and is similar to Option 2, except that a pressure sustaining valve (PSV) would be installed downstream of the proposed Option 2 Richfield Interconnect and a PRV would control flow into the Richfield system at a set pressure. In general, the Penn and Logan towers float within 2-6 feet of one another under this scenario, which would provide more than adequate service pressure to the distribution system, on par with current non-emergency operations. Furthermore, this option has the added benefit of allowing Bloomington to access the line at the same time.



Modeling of Pumped Feed – Option 5 – Simple Pump and Valve Control to Richfield – Bloomington has Concurrent Access

This option was modeled with an open-close valve and a pump would be installed inside the flow control structure. This option would allow for the Bloomington supply line operate in a similar fashion to current system configurations. The system was modeled with a pump pulling water from the supply line while utilizing a variable frequency drive to maintain a set discharge pressure, The resulting operation simulated flow rates of 1,400-3,000 gpm through the interconnect and would allow flow in the range of 16,000-18,000 gpm to be provided to Bloomington. The result of the simulation indicates that this would be a feasible option as tank levels would be maintained at a manageable level and a robust amount of flow capacity would still be available to Bloomington.



Summary

It appears that use of the existing 42-inch Minneapolis/Bloomington supply line would have the hydraulic capacity and ability to serve the City of Richfield on an emergency basis. Multiple options are available to modulate and control the flow. Considerations should be made as to which option provides the simplest solution in regards future operation as well as construction considerations. Also, the current controls at the Minneapolis 60th street control vault should be reviewed to assure that the system would react and open to allow appropriate levels of flow through to the Richfield interconnect when needed. Future improvements to this installation would also need to account for use of the interconnect system.

ctk

c:Miles Jensen/SEH

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SEH

Building a Better World for All of Us®

MEMORANDUM

TO: Butch Lupkes, Mike Peterson

FROM: Jeff Ledin, Chad Katzenberger

DATE: July 17, 2017

RE: Interconnect & Direct to System Well Conversion
SEH No. RICHF 137369 14.00

The purpose of this memo is to summarize the two scenarios for emergency water supply. One is conversion of Wells No. 1 and No. 2 to be able to be switched to pump directly to the distribution system, the other is an interconnect with the City of Edina. Estimated implementation cost for the well pump conversion is $1,228,800. Estimated implementation costs for the Edina interconnect has two options with estimated costs of, $654,000 and $890,000. Discussion of each alternative follows below.

DUAL SERVICE OF WELLS NO. 1 AND NO. 2

For emergency service, wells would be re-fit with pumping equipment that could provide dual-service. Normal duty would continue as it does today, with these wells pumping through the raw water main to the filtration plant. In emergency situations, valves and pumping equipment would be reset, and water would be delivered directly into the distribution system. For dual service to be permissible, the existing system will need to undergo improvements to install pumps, motors and supporting facilities so that these wells can deliver water under either service setting.

The wells being considered are the two Jordan Aquifer Wells located in Nicollet Park Well Field, Wells No. 1 and No. 2. Well No 1 produces about 2,200 gpm and Well No. 2 produces 1,750 gpm. Together these wells are capable of producing 5.7MGD.

Existing well pump and motor data is summarized as follows:

ID	Flow Rate (gpm)	TDH (ft)	Horsepower	Pump Stages
Well No. 1	1,800	189	150HP	3 stage
Well No. 2	2000	200		
Well No. 5	2000	202	125HP	3 stage

Well Pump Hydraulics

Presuming the target flow rate from the wells would be the same for either situation, static and pumping water levels would also be the same. What will change is the head conditions during pumping into the distribution system versus just pumping to the WTP. There will be additional elevation head added to the Total Dynamic Head experienced for each pump. To estimate the change, we started with the HGL of the Richfield system 1,006 feet, (working level in water towers.) Using an estimate of the upper inlet of the WTP of approximately 870 feet. Therefore there would be 136 feet of added head to the pumping system.

Pumps would need to be changed out to be able to deliver the same flow rate at higher TDH conditions. These pumps would be selected to operate at two primary design points. One condition would be at full speed, pumping into the distribution system. The second condition would use a VFD to slow the speed down, and pump at the lower TDH condition, but same flow rate, as is done today.

Well Pump Changes Needed

The pumps themselves would need to be replaced to the higher TDH units. To accomplish this, an increase in the number of stages is also needed. (From the existing 3 stage units up to 4-6 stage unit to be able to deliver the higher head). In reviewing pump curves for this dual operational point, we found that the pumps needed to have different geometric characteristics in order to have good efficiency at the normal operating point and still be somewhat efficient at the higher TDH operating point. We found that increasing the diameter of the pump (from existing 12" to 15" provided this improved performance. The horsepower requirements for these new pumps will increase from approximately 125HP to 300 HP, so a larger motor would also be needed. Finally, a VFD is needed for each pump to adjust the pump speeds for the differing head conditions.

The existing drop pipe diameter/depth, flow meter and other well head appurtenances, if in good condition, could remain unchanged. With the higher horsepower, the shaft size will need to be increased along with spiders and bearings being changed out.

Our understanding is that yard piping and valves are currently in place so that water can be directly sent to the system.

There will need to be some adjustments to the SCADA system so, these wells could be tied into tower levels to turn on and off during the water emergency.

Consideration could be given to adding a chemical feed set-up for feeding chlorine, fluoride and polyphosphate. Chemical feed would be needed in the event of a longer time frame of emergency pumping. However, the chemical feed equipment would need to be stored "dry" as the shelf life of the chemicals would soon be exceeded with inactivity.

Electrical Changes

With the significant increase in motor horsepower, there are also increased sizes needed for the electrical equipment. (A listing of upgrades is shown in the cost estimate table). The larger equipment is needed to start the larger motors, and also deliver the full speed, higher TDH flow condition. However, during normal duty pumping, with the VFD slowing down the pump, there will not be a significant increase in power consumption.

The existing generator does not have enough capacity to start the new pumps with large motors, even in the low TDH, (normal mode), so a larger generator is needed. The new generator, and automatic transfer switch, are able to provide back-up power and switching for either pumping scenario. (Pumping to WTP or pumping directly to the system).

Final Well Design Notes

During final pump selection, it will be worthwhile to conduct field pressure, flow and drawdown testing of the wells and raw water system. This will allow the City's computer model to be used to fine tune the design/selection of the revised pumping equipment.

Estimated Costs – Well Improvements

The following listing of improvements combines the summary above. These costs are taken from other well improvement projects completed in the Metro area in recent years, plus RS Means values.

Well 1 & 2 Pumping Upgrades

Item No.	Item	Unit	Est. Quantity		Unit Price	Total Price
1	MOBILIZATION	LS	1		$10,000	$10,000
2	REMOVE PUMP, MOTOR AND DOWNHOLE PIPING/EQUIPMENT	LS	2		$4,000	$8,000
3	PAINTING (DISCHARGE HEAD & WELL HOUSE PIPING)	LS	2		$500	$1,000
4	IMPROVE DISCHARGE HEAD	1	2		$2,000	$4,000
5	10-FT LENGTH OF 10-IN SCH 40 COLUMN PIPE W/ COUPLING	EA	28		$400	$11,200
6	10-FT LENGTH 10-IN SCH 40 SUCTION PIPE	EA	2		$450	$900
7	10-FT LENGTH STAINLESS STEEL LINE SHAFT	EA	28		$250	$7,000
8	LINE SHAFT BEARING RETAINER	EA	28		$100	$2,800
9	RUBBER LINE SHAFT BEARING	EA	28		$25	$700
10	STAINLESS STEEL SHAFT SLEEVE	EA	28		$25	$700
11	STILLING TUBES - INSTALL/IMPROVE/REPAIR	EA	2		$300	$600
12	SCADA Adjustments	LS	2		$10,000	$20,000
13	NEW PUMP & MOTOR	LS	2		$120,000	$240,000
14	NEW PUMP & MOTOR INSTALLATION	EA	2		$24,000	$48,000
15	ELECTRICAL UPGRADES			MATERIAL	LABOR	
	MOTOR CONTROL CENTER (1000A)	LOT	4	$2,400	$2,400	$19,200
	1000A MAIN CB	EA	1	$4,000	$900	$4,900
	600A WELL #1 FEEDER CB	EA	1	$3,500	$900	$4,400
	LP PANEL	EA	1	$2,500	$1,000	$3,500
	WELL #2 NEW SERVICE (1000AMP)	EA	1	$10,000	$5,000	$15,000
	600AMP FEED TO WELL #1 FROM WELL #2 SERVICE	LF	500	$65	$30	$47,500
	300HP VFD WITH FILTER	EA	2	$45,000	$10,000	$110,000
	WLL #1 600AMP DISCONNECT WITH TAP	EA	1	$6,000	$1,500	$7,500
	CONTROL PROGRAMMING	EA	2		$5,000	$10,000
	DEMO	EA	2		$10,000	$20,000
16	GENERATOR UPGRADES					
	LOAD SHED GEN. 500KW, 480V (DIESEL. GAS)	EA	1	$220,000	$50,000	$270,000
	1000AMP AUTOMATIC TRANSFER SWITCH	EA	1	$25,000	$5,000	$30,000

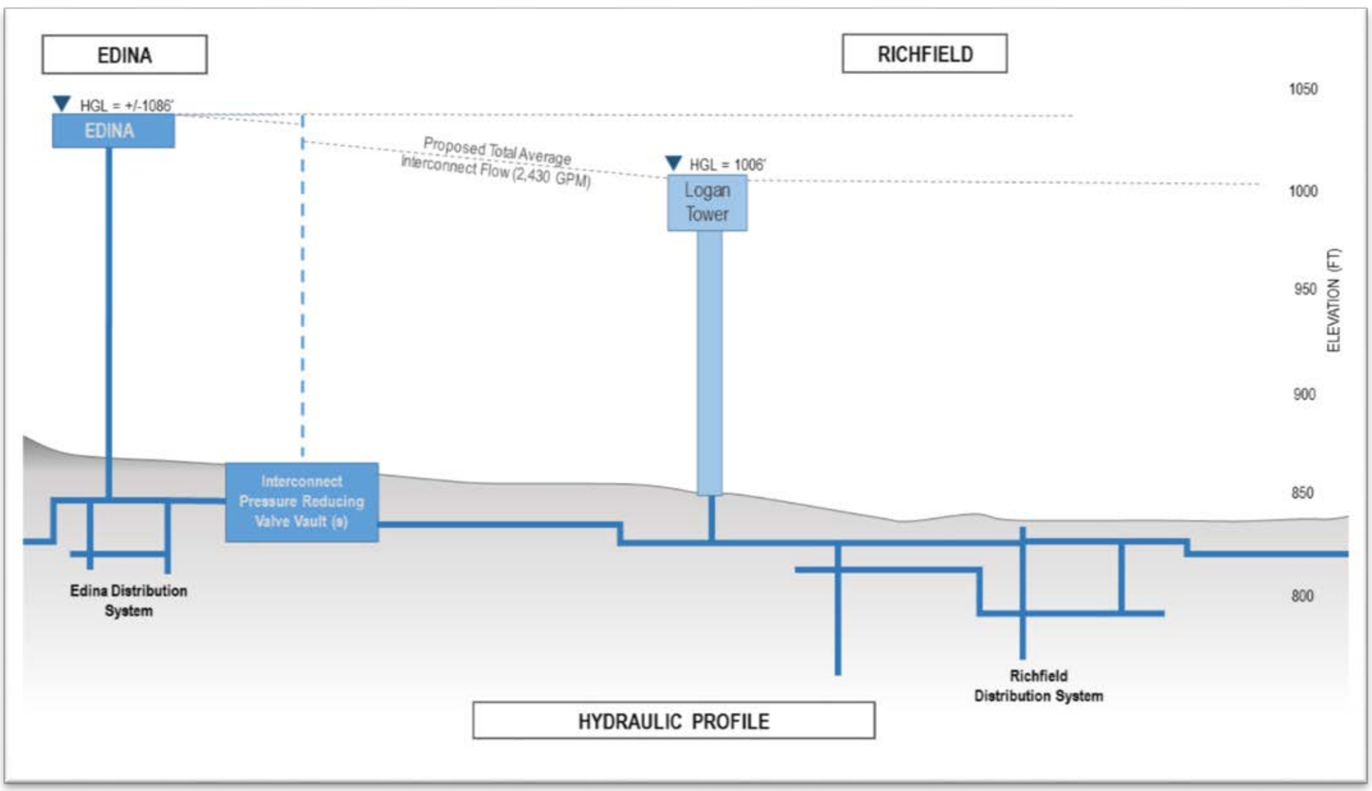
Total Construction	**$896,900**
Contingency (20%)	**$179,400**
Engineering	**$152,500**
TOTAL ESTIMATED COST	**$1,228,800**

WATER SYSTEM INTERCONNECTION – DUAL EDINA CONNECTION

In the past few years, there have been multiple efforts to identify a feasible water system interconnection so that the City of Richfield could be served on a temporary basis, by another municipality. Most recently the feasibility of a connection to 42-inch water supply line running from the Minneapolis water system, through Richfield to Bloomington. After review of the potential for this connection, it has been decided that other options should be explored. The discussion in this memo revisits the option of connecting to the City of Edina on along the City's western boundary. The City of Richfield desires to have access to an emergency backup water supply with a maximum anticipated water draw of 3.5 MGD (2,430 gpm) - which is slightly more than recent historical Average Day Demand of approximately 3 MGD.

Interconnect Hydraulic Considerations

The figure below provides an illustration of the hydraulic grade lines for the water systems of Edina and Richfield. As shown, the normal HGL of the Edina water system is approximately 1,086 feet, which is 80-feet higher than the HGL of the Richfield system. With this additional head, water could flow by gravity from the Edina system into the Richfield system. However, various system operational conditions need to be accounted for and so, the following paragraphs offer discussion of alternate solutions for Richfield to obtain water from Edina.

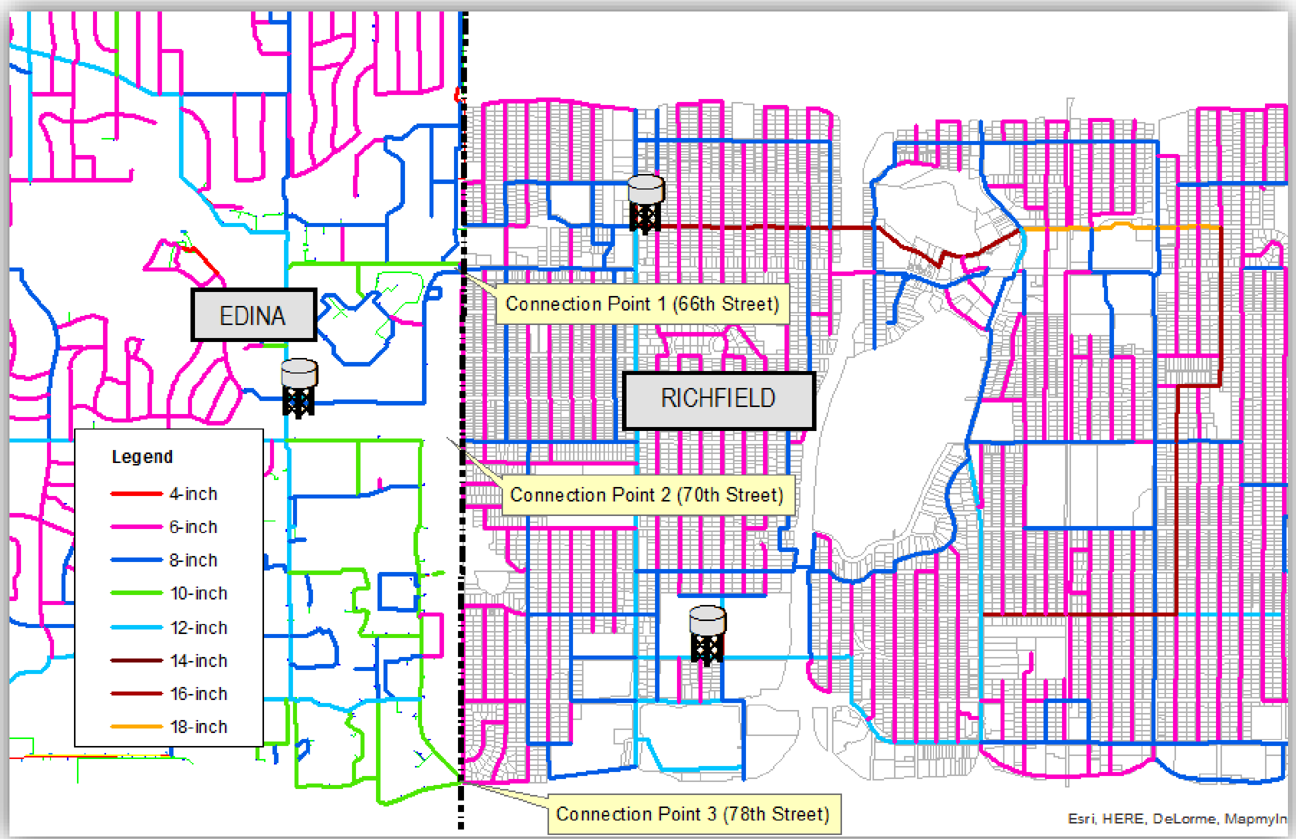


First, the desired design flow rate of 2,430 gpm (3.5 MGD) will require water trunk mains that are sized large enough as to limit excessive velocities while conducting the desired flow rates. The ability to conduct this amount of flow will be a function of the available system piping in both Edina and Richfield as well as the difference between hydraulic grades. As part of this effort, potential interconnect locations were identified by inspection, with 10-inch and 12-inch main being the preferred water main size both from a supply (Edina) and discharge (Richfield) perspective. There will need to be sufficiently sized main to move the desired flow rates, with limited velocity and headoss. Currently, the water main piping on the Western edge of the City of Richfield is limited in size, which the largest size being 8-inch. Though the main in this part of town is well looped, conduits which flow from West to east are limited. Below is a brief summary of interconnection points that have been considered for this project.

Connection Point 1 (66th Street)
Currently, the pipe along 66th Street is slated for upgrade from 8-inch to 12 inch during the summer of 2017. This well help to support future flows, however, the furthest West portion of this main, within Richfield is not scheduled for replacement (about 190' of pipe, which will remain an 8-inch pipe. Even with the short section of 8-inch pipe, this location is an especially advantageous location in that it would be supplied by a 10-inch water main on the Edina side and would eventually feed a 12" trunk main in Richfield with a trunk main path to the elevated storage tanks.

Connection Point 2 (70th Street)
This potential connection point would be fed by 10-inch water main on the Edina side and would flow into well looped 6 and 8 inch main on the Richfield side. This disadvantage of this location is that it would require about 650' of new water main to be constructed in Edina, extending to the Richfield border in order to connect the two systems.

Connection Point 3 (78th Street)
This potential connection point, again would be fed by 10-inch water main on the Edina side and flow into looped 6 inch main on the Richfield side. While the 10-inch main on the supply side is advantageous, this 6-inch pipe on the Richfield side may limit flow. This will be explored further later in this



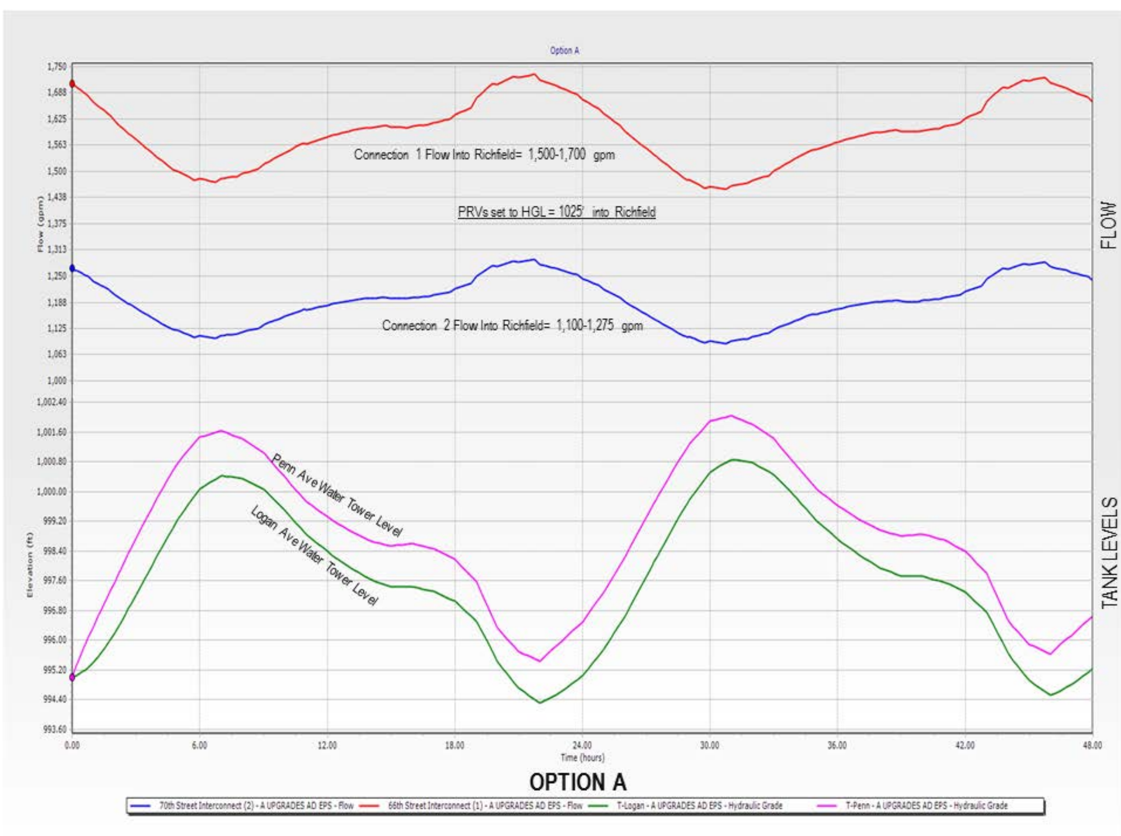
Water system Modeling

The City of Richfield's existing water system model was utilized to examine existing normal water system operation with each of the three connection points. The model is constructed in Bentley WaterCAD v8i and provides a virtual representation of the City's existing water distribution system including supply and storage facilities. Use of this model allows for operation of the water system to be simulated during steady state or extended period conditions. For purpose of this analysis, proposed facilities were initially designed and sized using the steady state modeling functions and then later verified with an Extended Period Simulation (EPS).

First, each of the three connection points was modeled alone to see if they would be able to achieve the desired flow rate on their own, while flowing by gravity through a pressure reducing valve. As expected the small available pipe size at each of these locations limited the flow to 1,000-1,500 gpm each. Because of the limited standalone flow availability, the option of utilizing two connection points was explored. **Option A** utilized the combination of connection point 1and connection point 2 while **Option B** utilizes Connection Point 1 and connection point 3. Below is a brief summary of the proposed system facilities as well as simulated water mode results.

Option A (Connection Points 1 & 2)

Under this emergency alternative, Richfield would obtain water from **connection points 1&2**
Connection point 1 (66th Street) would consist of connecting water main pipe from the existing 8-inch in Edina Just south of 66th street. This main is fed by a 10-inch. The main would ultimately connect into the 8-inch Richfield main also on the South side of 66th which will eventually feed a 12-inch. The goal with this connection is to limit the disturbance within the 66st street roadway. This facility would further consist of a Pressure Reducing Valve (PRV) located in a below grade manhole or vault. When the City wished to engage the interconnect station, an isolation valve could be opened, and the PRV could be operated hydraulically, and maintain a pre-set pressure . Additional monitoring equipment such as pressure transducers and a flow meter could also be added to the facility if needed.

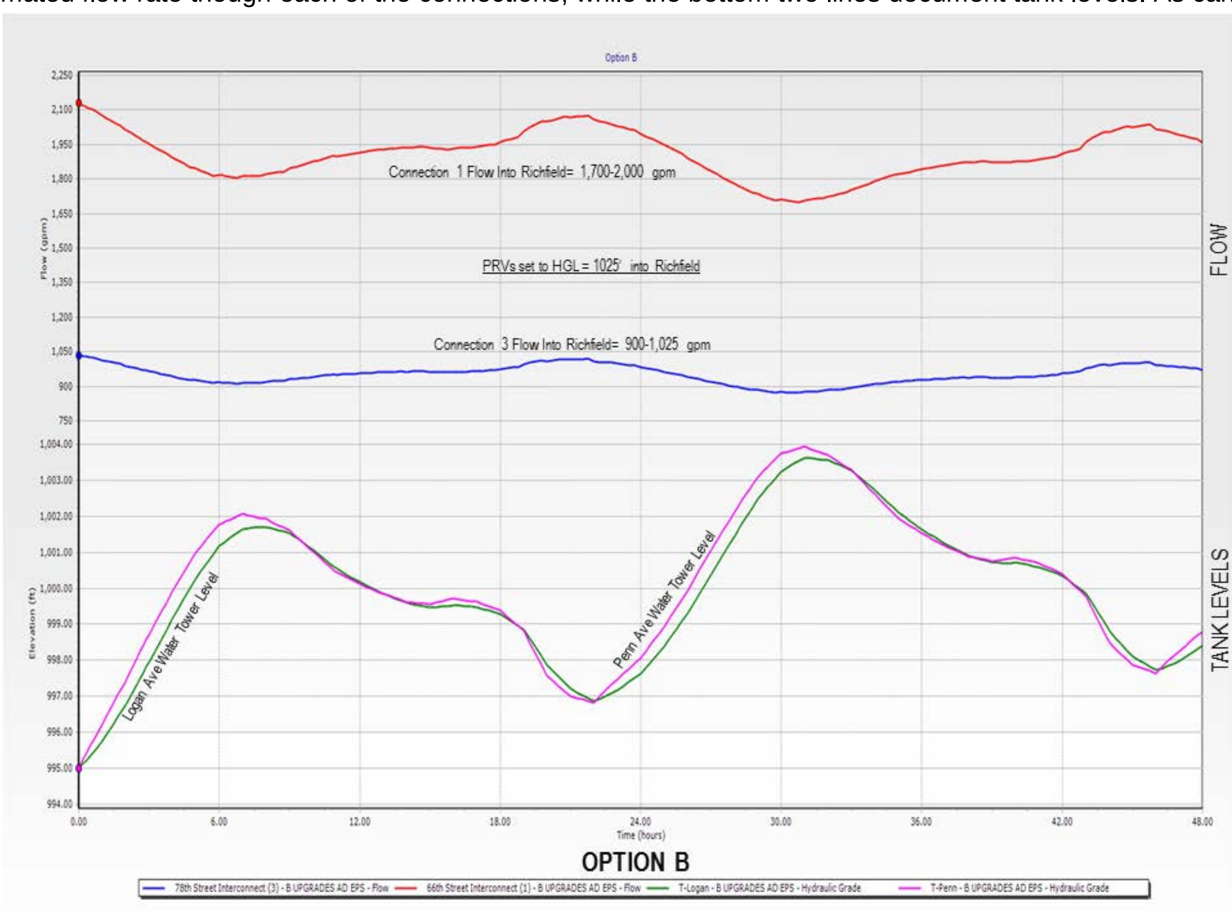


Connection point 2 would utilize an identical facility as connection point 1, except that approximately 650’ of 12” water main would need to be installed within Edina to connect the existing 10” main at the intersection of York Ave S and 70th Street to the 6 and 8-inch main at the intersection of 70th and Xerxes in Richfield.

The results of the option A modeling exercise are show in in the graph above. The top two lines represent the estimated flow rate though each of the connections, while the bottom two lines document tank levels. As can be seen in the figure, the flow rate at connection 1 would range between 1,400 gpm and 1,700 gpm while connection point 2 has a range of 1,050 – 1,275 gpm. Additionally the Richfield water tanks would fill and empty at similar rates. It should also be noted that the pipes around the interconnect points would potentially experience high velocity due to some sections of limited size main. While the majority of the mains would have velocity less 6 feet per second, the short section of 8-inch main along 66th (in Richfield) could potentially be in the 10-11 fps. While this is not a concern from a headloss perspective, it should be recognized as it relates to design and operation. All things considered, this modeling operation indicates that Option A is a feasible alternative for providing a water system interconnection.

Option B (Connection Points 1 & 3)
Under this emergency alternative, Richfield would obtain water from **connection points 1&3**
Connection point 1 would be constructed as previously discussed in Option B. Connection point 3 would utilize an identical facility as connection point 1, and would be located just east of intersection of York Ave S and 78th Street in Richfield. Connection would be made to an existing looped 10-inch main on the Edina side and would flow into looped 6-inch main on the Richfield side.

The results of the option B modeling exercise are show in in the graph above. The top two lines represent the estimated flow rate though each of the connections, while the bottom two lines document tank levels. As can be



seen in the figure, the flow rate at connection 1 would range between 1,700 gpm and 2,100 gpm which is 3,400 gpm higher than existing in option A at the same connection. Connection point 2 has a range of 900– 1,000 gpm. As before, the Richfield water tanks would fill and empty at similar rates. Again the pipes around the interconnect points would potentially experience high velocity due to some sections of limited size main. While the majority of the mains would have velocity less 6 feet per second, the short section of 8-inch main along 66th (in Richfield) could potentially be in the 11-12 fps and the nearby Edina 8-inch would be in the range of 10-11 fps . While this is not a concern from a headloss perspective, it should be recognized as it relates to design and operation. All things considered, this modeling operation indicates that Option B is a feasible alternative for providing a water system interconnection.

Interconnection Cost Estimates

Below is a high level cost estimate for each of the connection point options, with the idea that two of the three would be required to achieve the desired level of service.

Connection Point 1 (66th Street)

Item No.	Item	Unit	Est. Qty.	Unit Price	Total Price
1	MOBILIZATION	LS	1	30,000	30,000
2	INSTALL 10' DIA STRUCTURE W/ HATCH	LS	1	60,000	60,000
3	INSTALL INTERIOR PIPING & PRV	LS	1	35,000	35,000
4	SITE PIPING & VALVES	LS	1	31,200	31,200
5	POWER SERVICE, POWER METER & NEMA 4 BOX	LS	1	10,000	10,000
6	INSTALL 12" FLOW METER	LS	1	20,000	20,000
7	CONNECT TO EXISTING WATER MAIN	LS	2	2,500	5,000
11	PAVEMENT REMOVAL & RESTORATION	LS	1	20,000	20,000
12	TRAFFIC CONTROL	LS	1	5,000	5,000
13	MISC RESTORATION	LS	1	3,000	3,000
				Subtotal Connection Point 1	219,200
				Contingency (20%)	43,800
				Engineering	39,500
				Total Connection Point 1	**303,000**

Connection Point 2 (70th Street)

Item No.	Item	Unit	Est. Qty.	Unit Price	Total Price
1	MOBILIZATION	LS	1	30,000	30,000
2	12" TRUNK WATER MAIN & STREET RECONSTRUCT	LF	650	300	195,000
3	INSTALL 10' DIA STRUCTURE W/ HATCH	LS	1	60,000	60,000
4	INSTALL INTERIOR PIPING & PRV	LS	1	35,000	35,000
5	SITE PIPING & VALVES	LS	1	25,000	25,000
6	POWER SERVICE, POWER METER & NEMA 4 BOX	LS	1	10,000	10,000
7	INSTALL 12" FLOW METER	LS	1	20,000	20,000
8	CONNECT TO EXISTING WATER MAIN	LS	2	2,500	5,000
9	PAVEMENT REMOVAL & RESTORATION	LS	1	20,000	20,000
10	TRAFFIC CONTROL	LS	1	5,000	5,000
11	MISC RESTORATION	LS	1	20,000	20,000
				Subtotal Connection Point 2	$425,000
				Contingency (20%)	$85,000
				Engineering	$76,500
				Total Connection Point 2	**$587,000**

Connection Point 3 (78th Street)

Item No.	Item	Unit	Est. Qty.	Unit Price	Total Price
1	MOBILIZATION	LS	1	30,000	$30,000
2	INSTALL 10' DIA STRUCTURE W/ HATCH	LS	1	60,000	$60,000
3	INSTALL INTERIOR PIPING & PRV	LS	1	35,000	$35,000
4	SITE PIPING & VALVES	LS	1	36,000	$36,000
5	POWER SERVICE, POWER METER & NEMA 4 BOX	LS	1	10,000	$10,000
6	INSTALL 12" FLOW METER	LS	1	20,000	$20,000
7	CONNECT TO EXISTING WATER MAIN	LS	2	2,500	$5,000
8	PAVEMENT REMOVAL & RESTORATION	LS	1	20,000	$20,000
9	TRAFFIC CONTROL	LS	1	20,000	$20,000
10	MISC RESTORATION	LS	1	18,000	$18,000
				Subtotal Connection Point 3	$254,000
				Contingency (20%)	$50,800
				Engineering	$45,700
				Total Connection Point 3	**$351,000**

TOTAL OPTION A **$890,000**

TOTAL OPTION B **$654,000**

Summary

The information developed above indicates that that use of Option A or Option B above would have the hydraulic capacity and ability to serve the City of Richfield on an emergency basis. Considerations should be made as to the features that the City would like to have included in the facilities such as SCADA monitoring, automation, metering and environmental control within the facility (Heating, lights, dehumidification etc.)

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c:Miles Jensen/SEH

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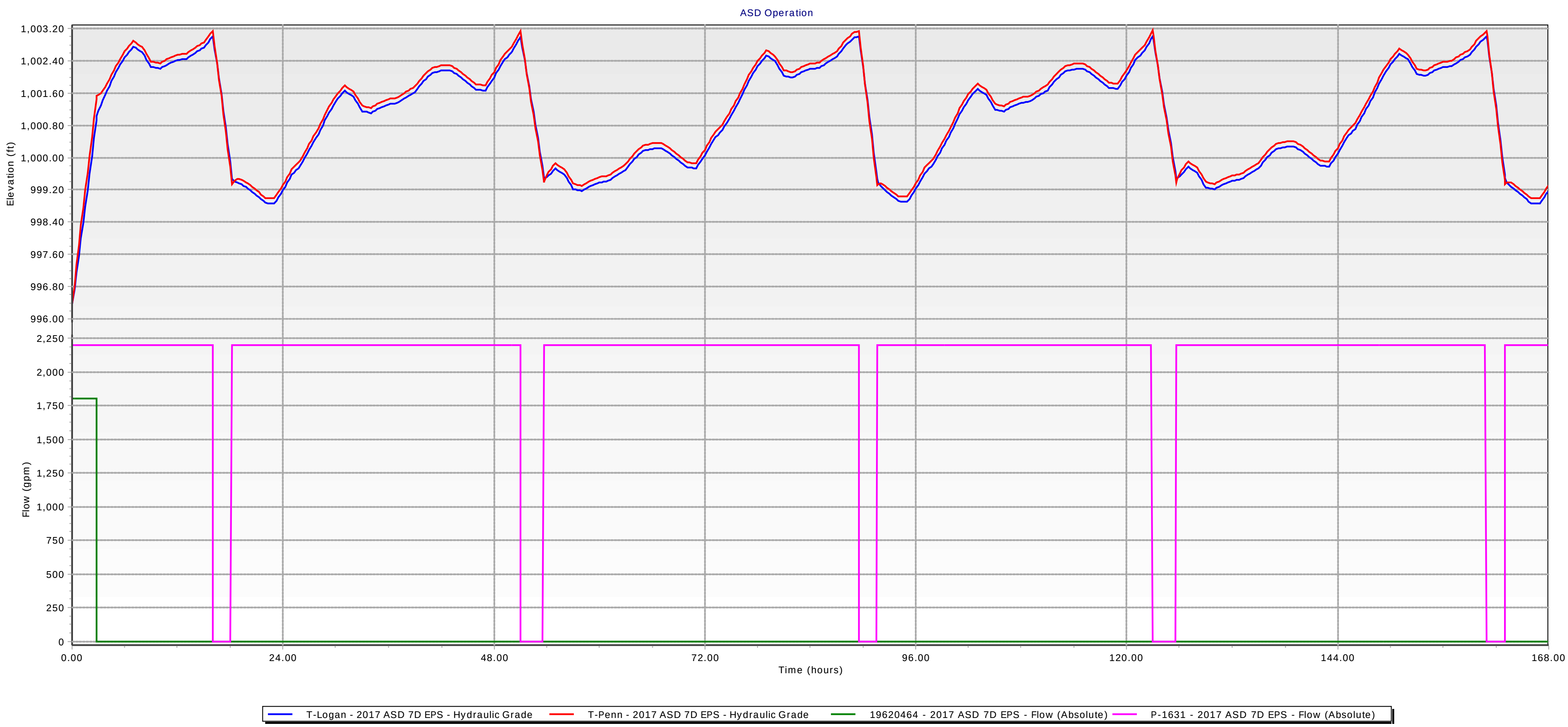
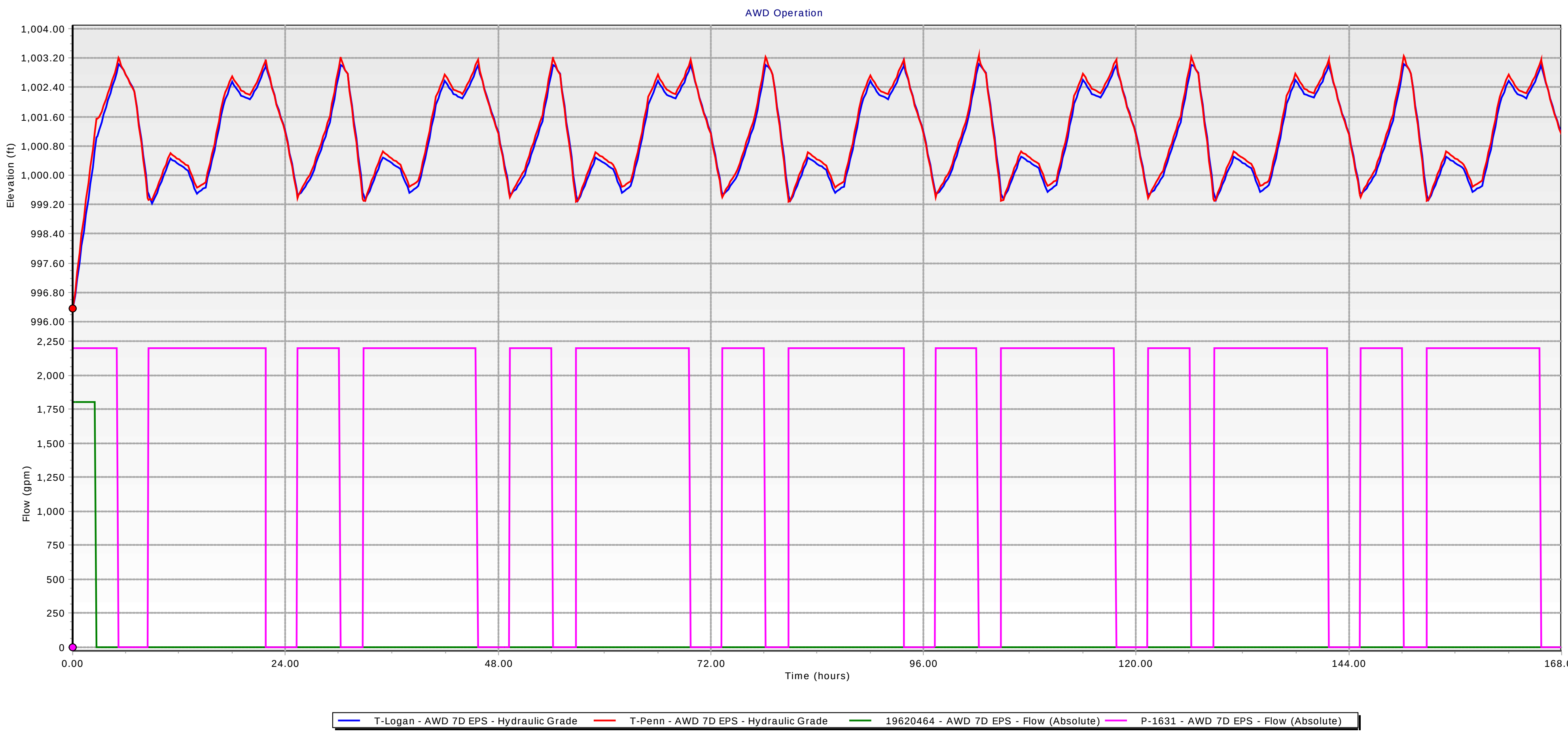
Appendix D

Additional Modeling Results

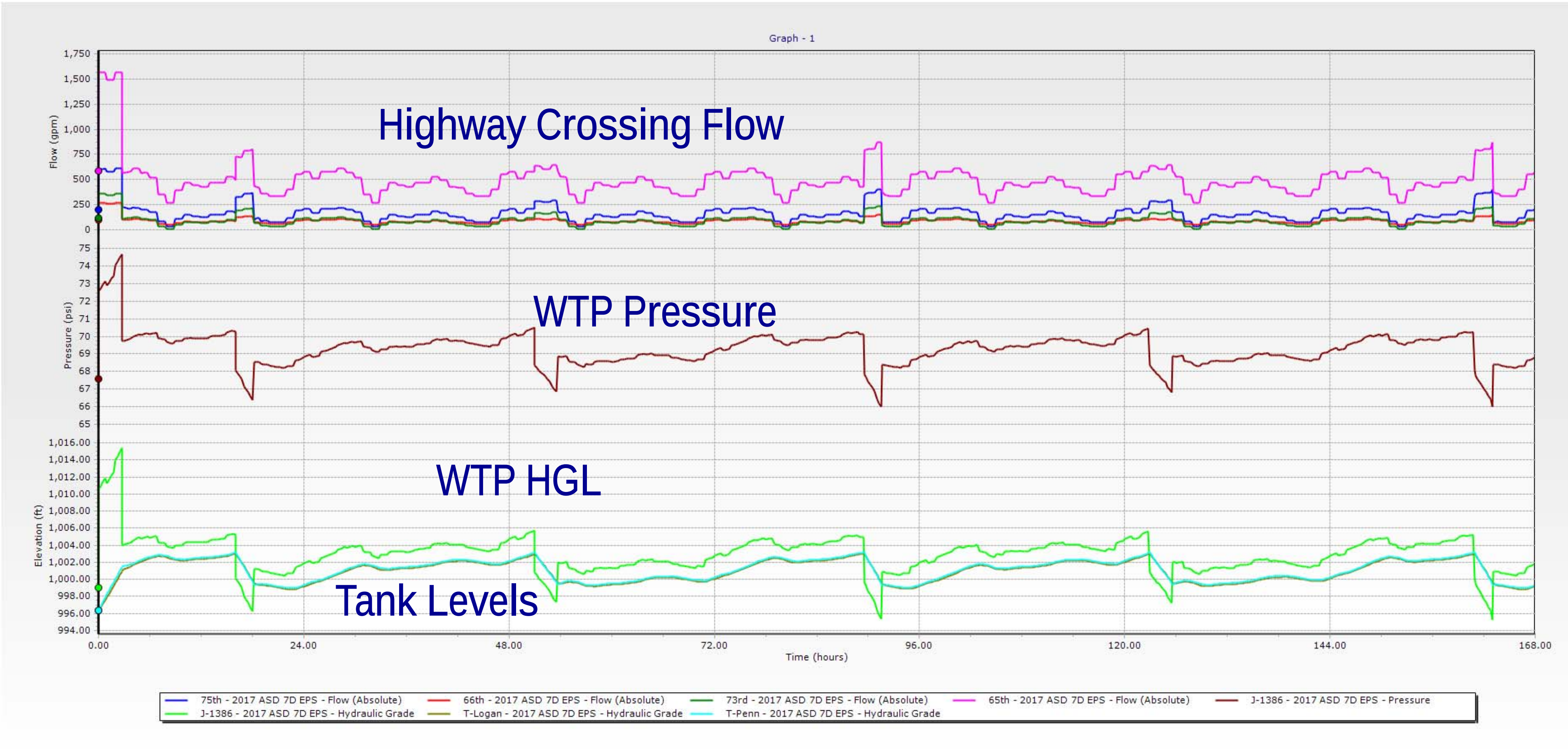
Avg. SummerDay Modeling Results - 7 Day Extended Period



Avg. Winter Day Modeling Results - 7 Day Extended Period

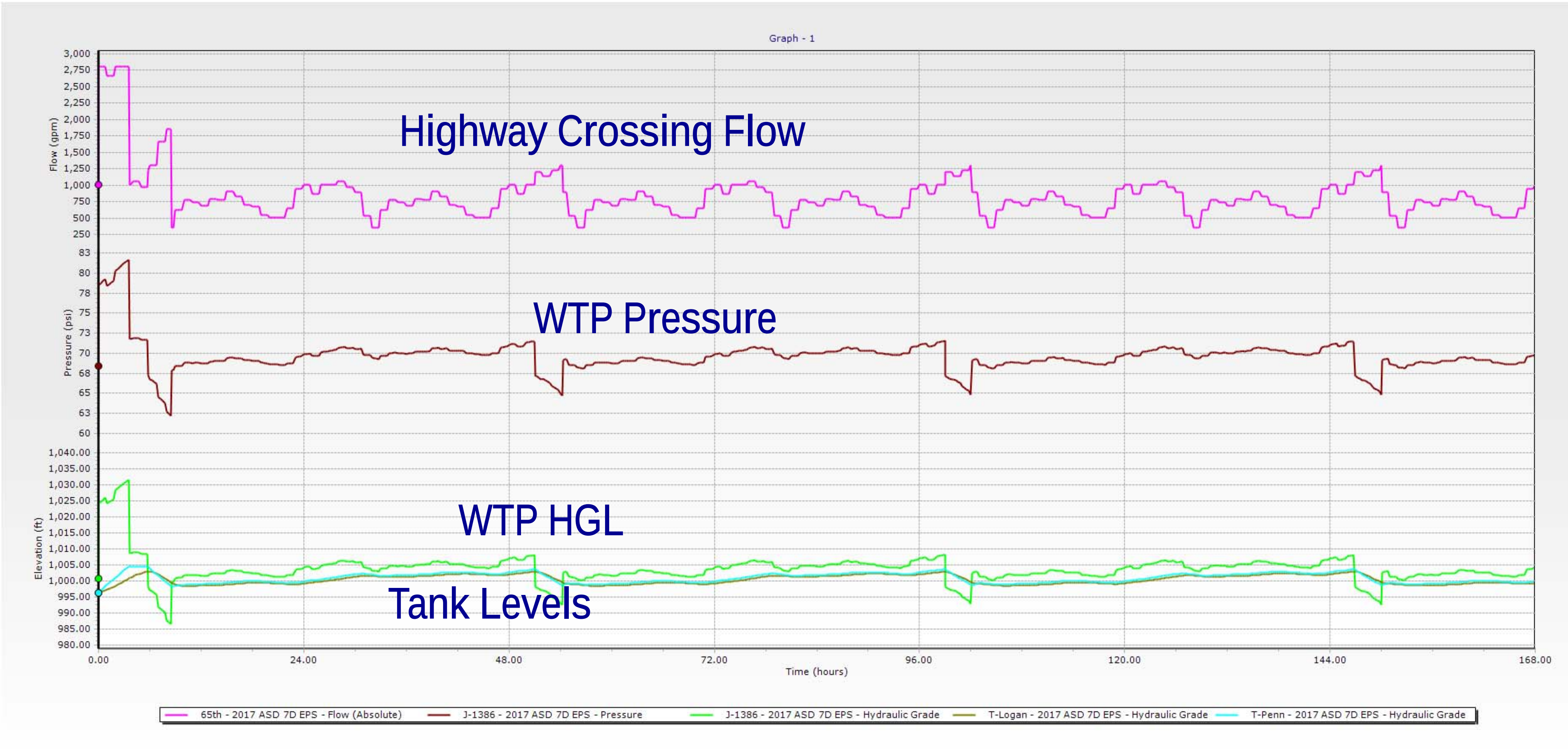


Average Summer Day Operation – All Crossings Open



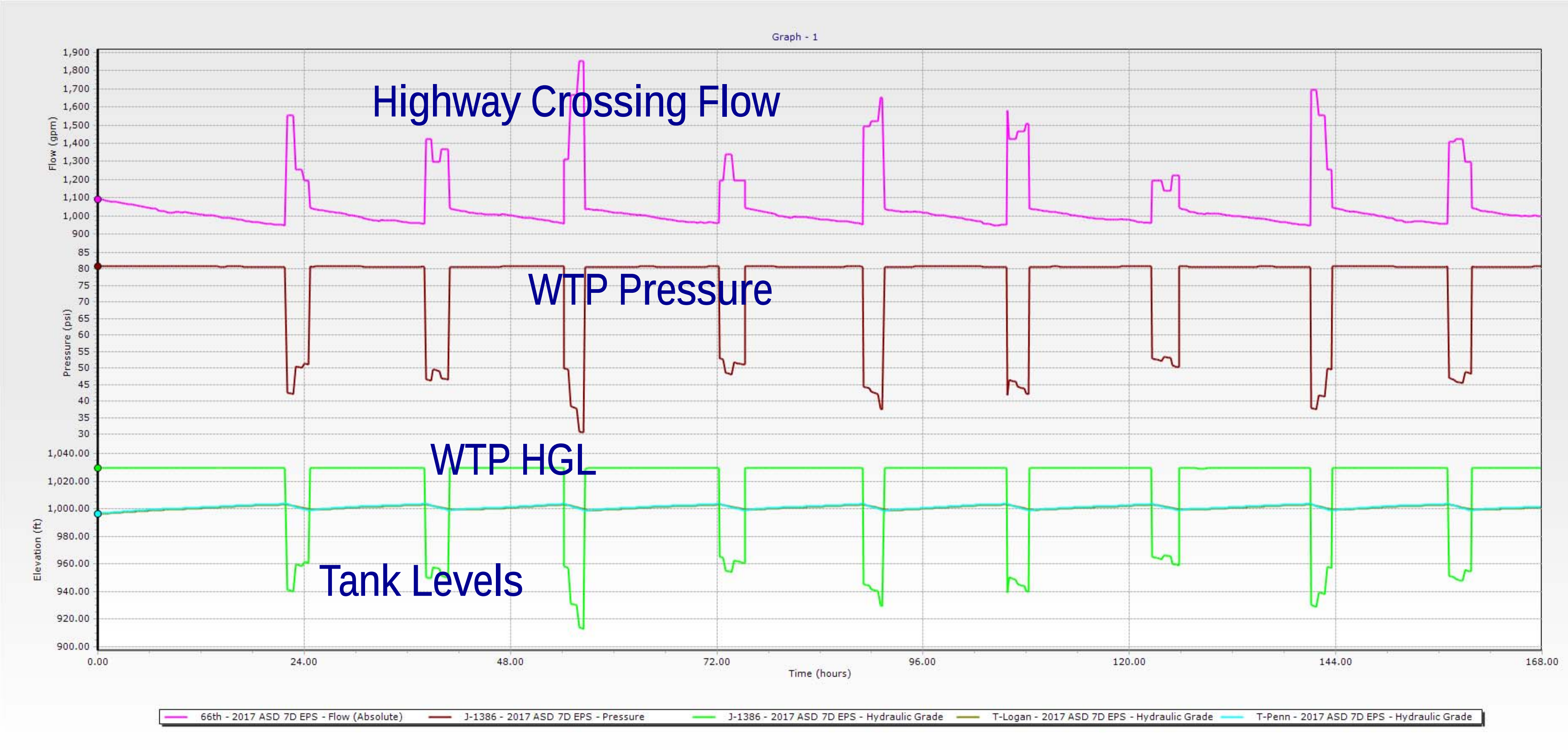
Results: This scenario represent normal operation: Tanks float together – major constrictions not present – VFDs at WTP not required

Average Summer Day Operation – 65th Open (all others closed)



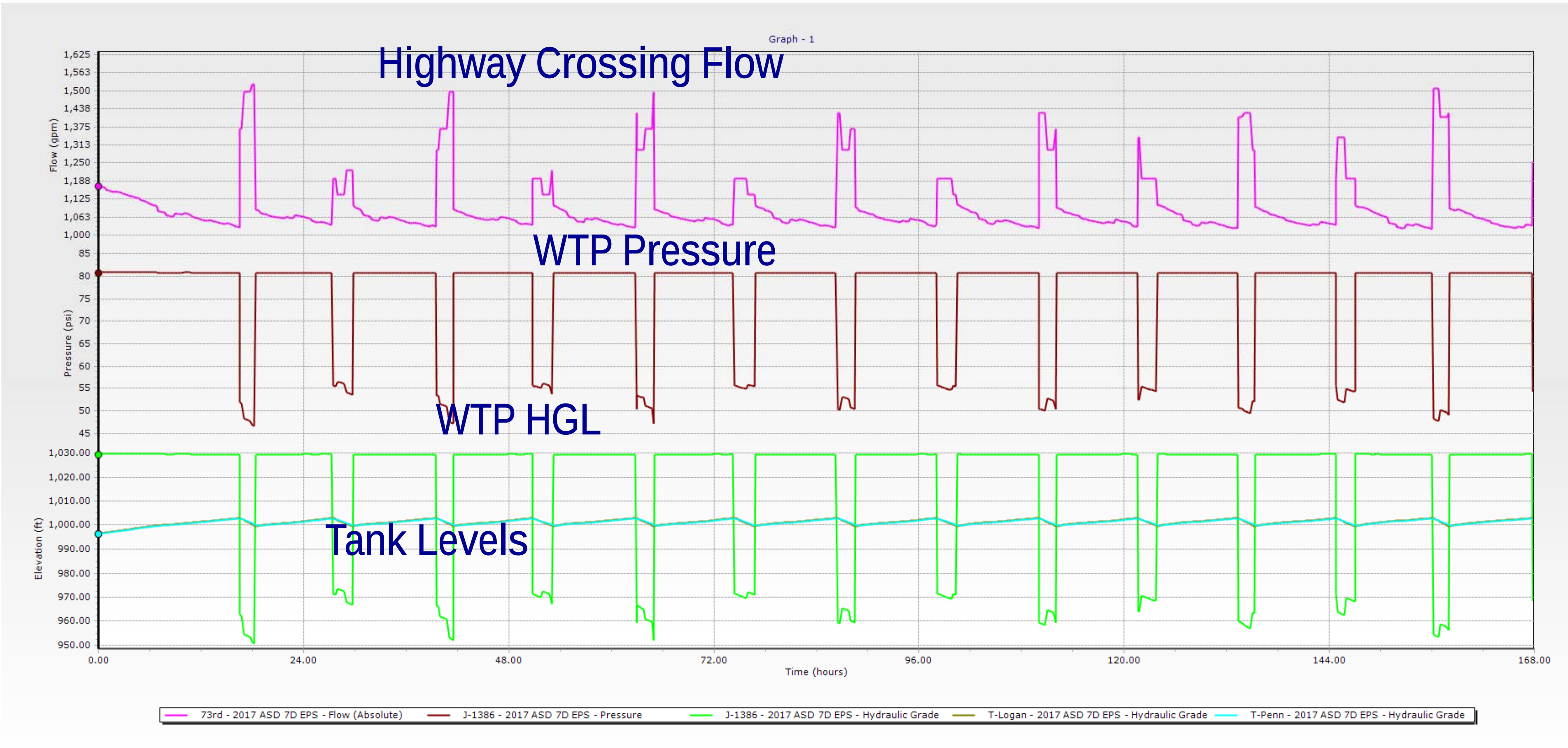
Results: Satisfactory operation: Tanks float together – major constrictions not present

Average Summer Day Operation – 66th Open (all others closed)



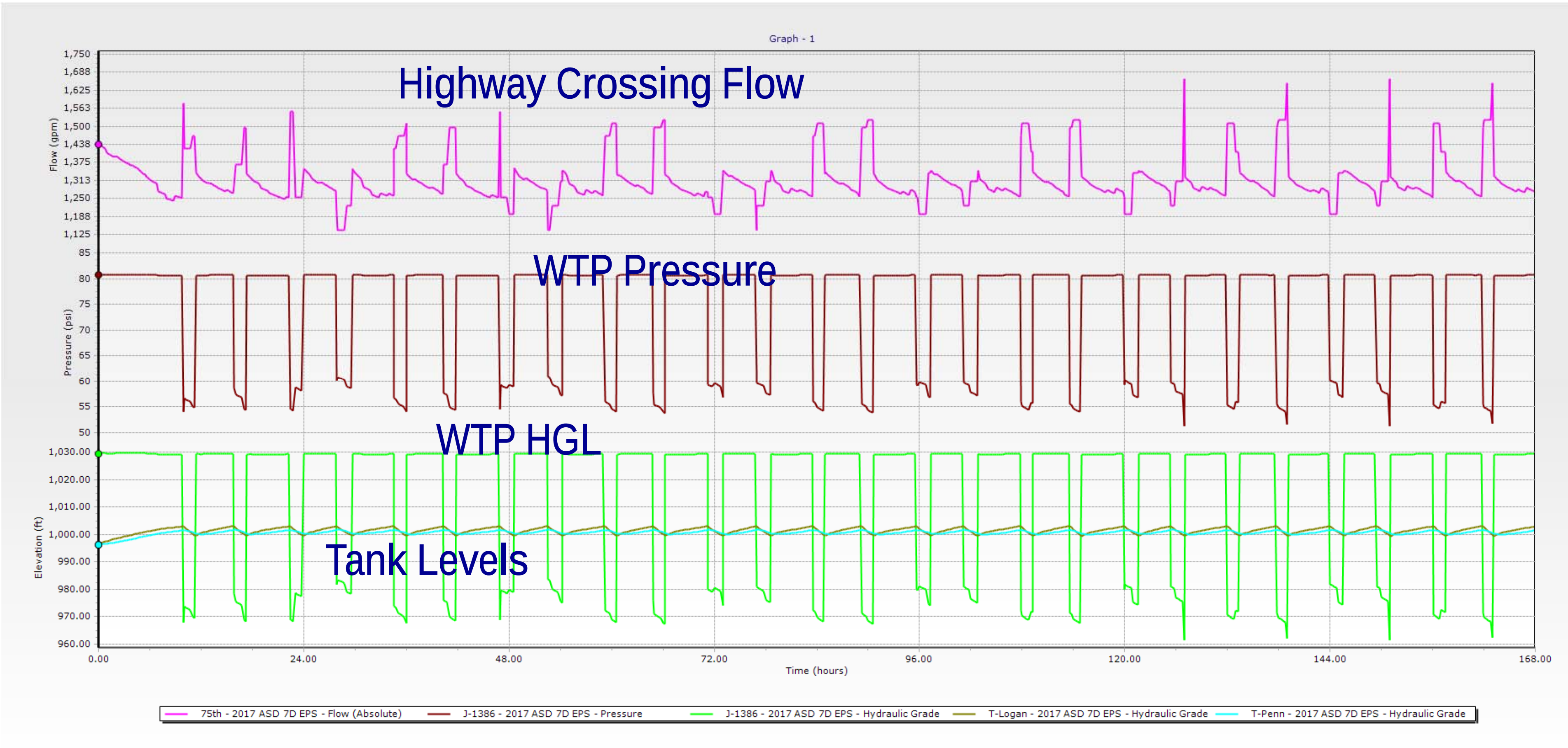
Results: Adequate operation with VFDs on at WTP to sustain pressure: Crossing is limited to 1,000 gpm flow on filling cycle, 1,500 gpm on tank draining cycle. If WTP high service pumps are off, water system, west of 35W have subpar pressure

Average Summer Day Operation – 73rd Open (all others closed)



Results: Adequate operation with VFDs on at WTP to sustain pressure: Crossing is limited to 1,000 gpm flow on filling cycle, 1,500 gpm on tank draining cycle. If WTP high service pumps are off, water system, west of 35W have subpar pressure

Average Summer Day Operation – 75th Open (all others closed)



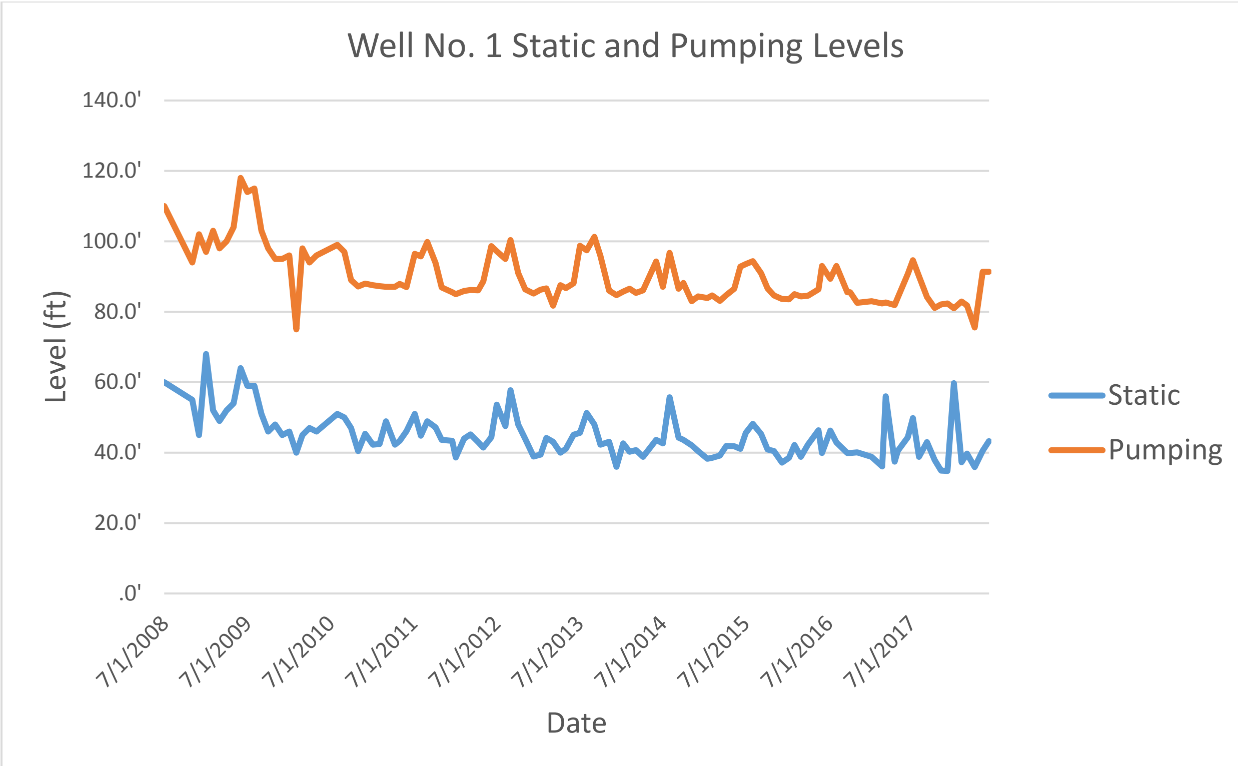
Results: Adequate operation with VFDs on at WTP to sustain pressure: Crossing is limited to 1,200 gpm flow on filling cycle, 1,500 gpm on tank draining cycle. If WTP high service pumps are off, water system, west of 35W have subpar pressure.

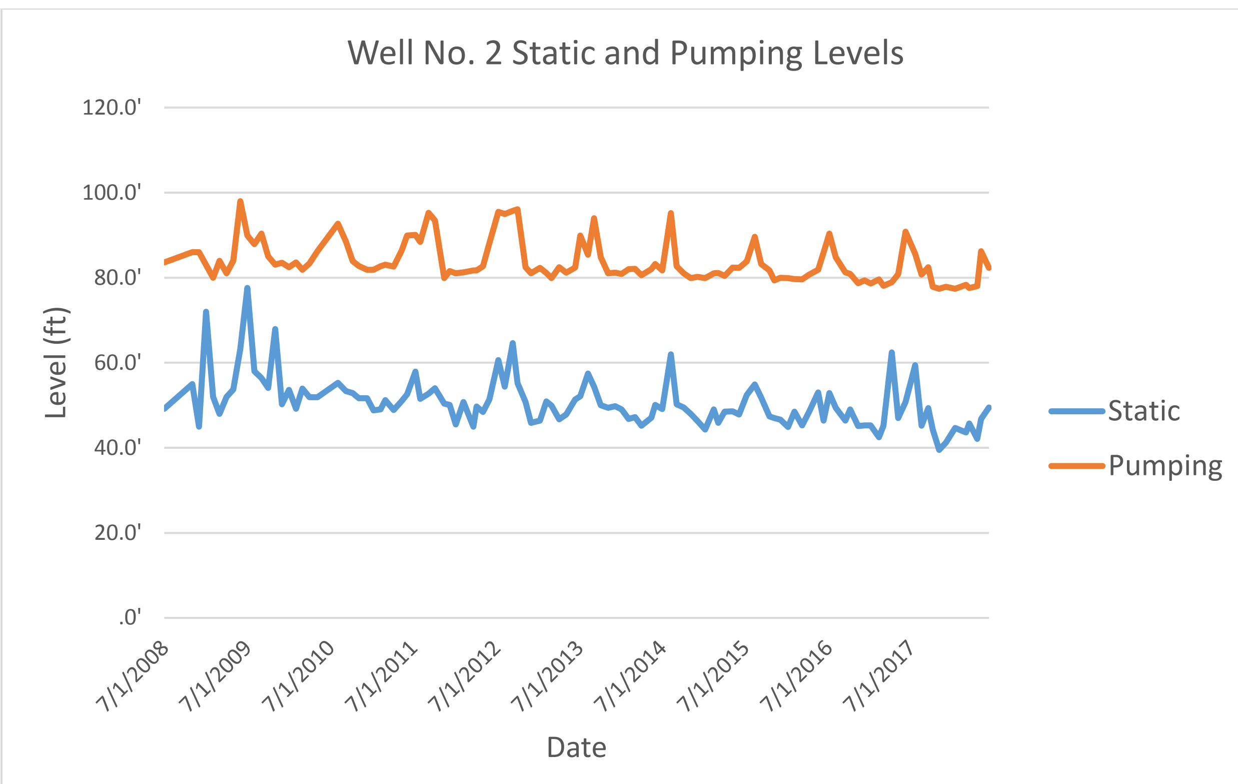
Appendix E

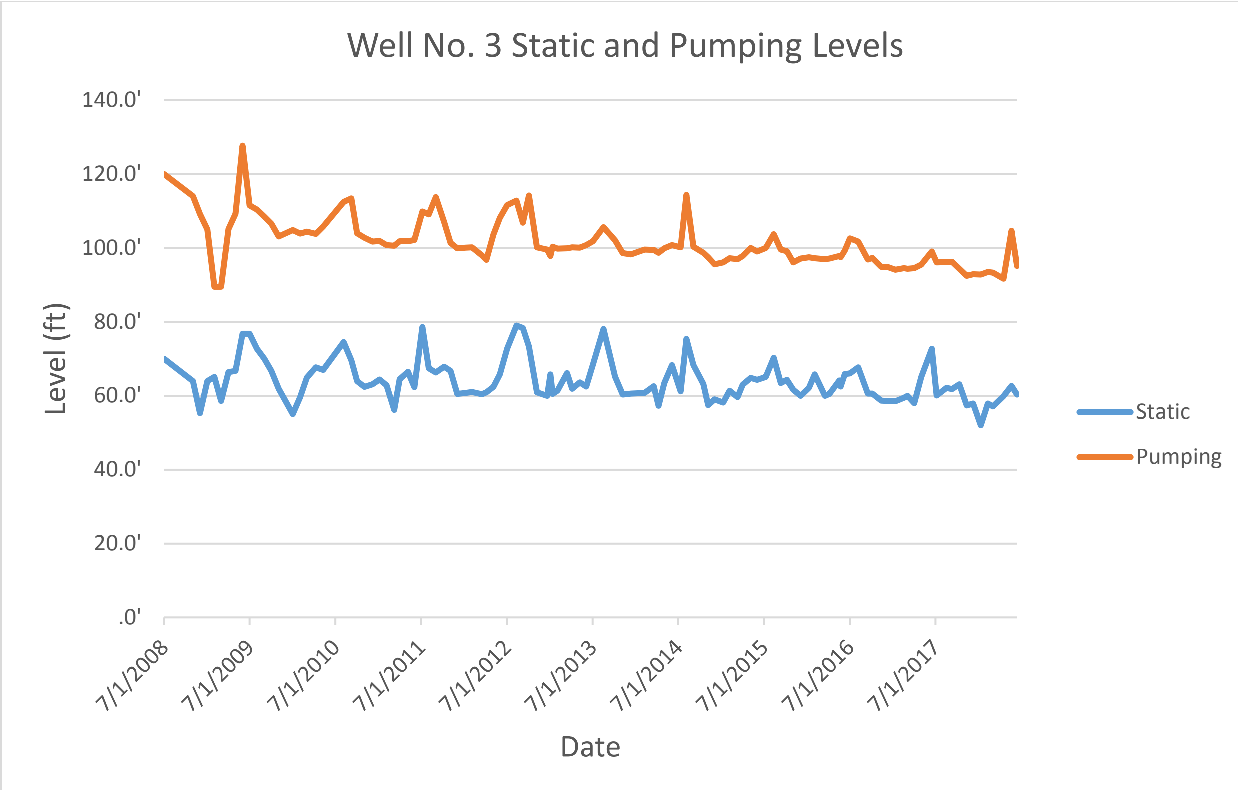
Water Model Data

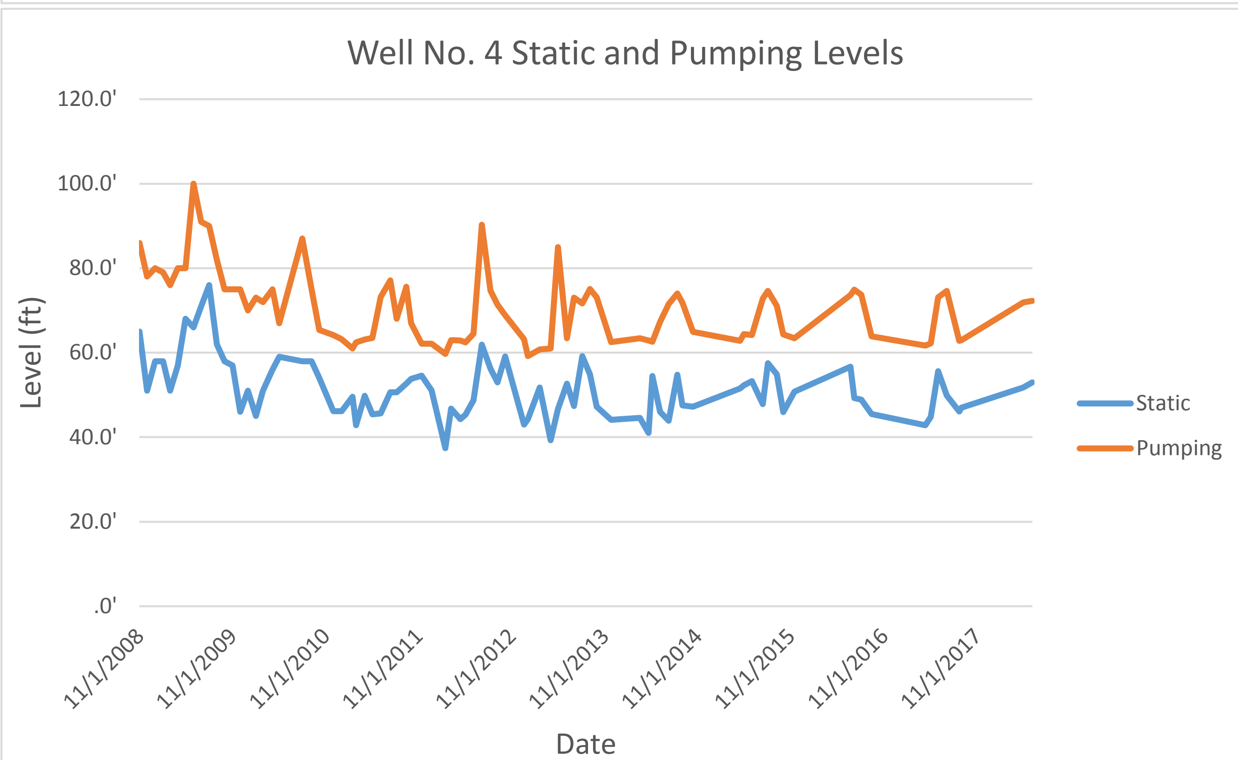
Appendix F

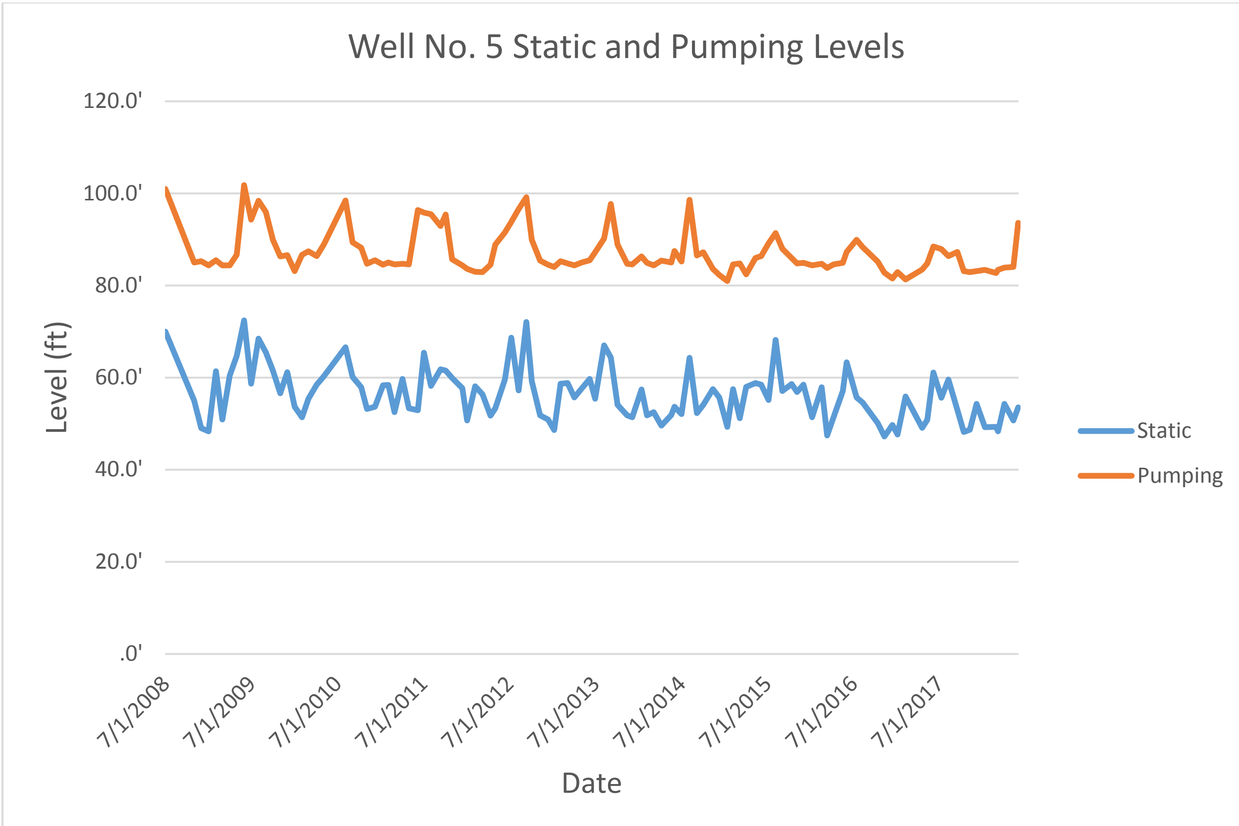
Well Drawdown Records

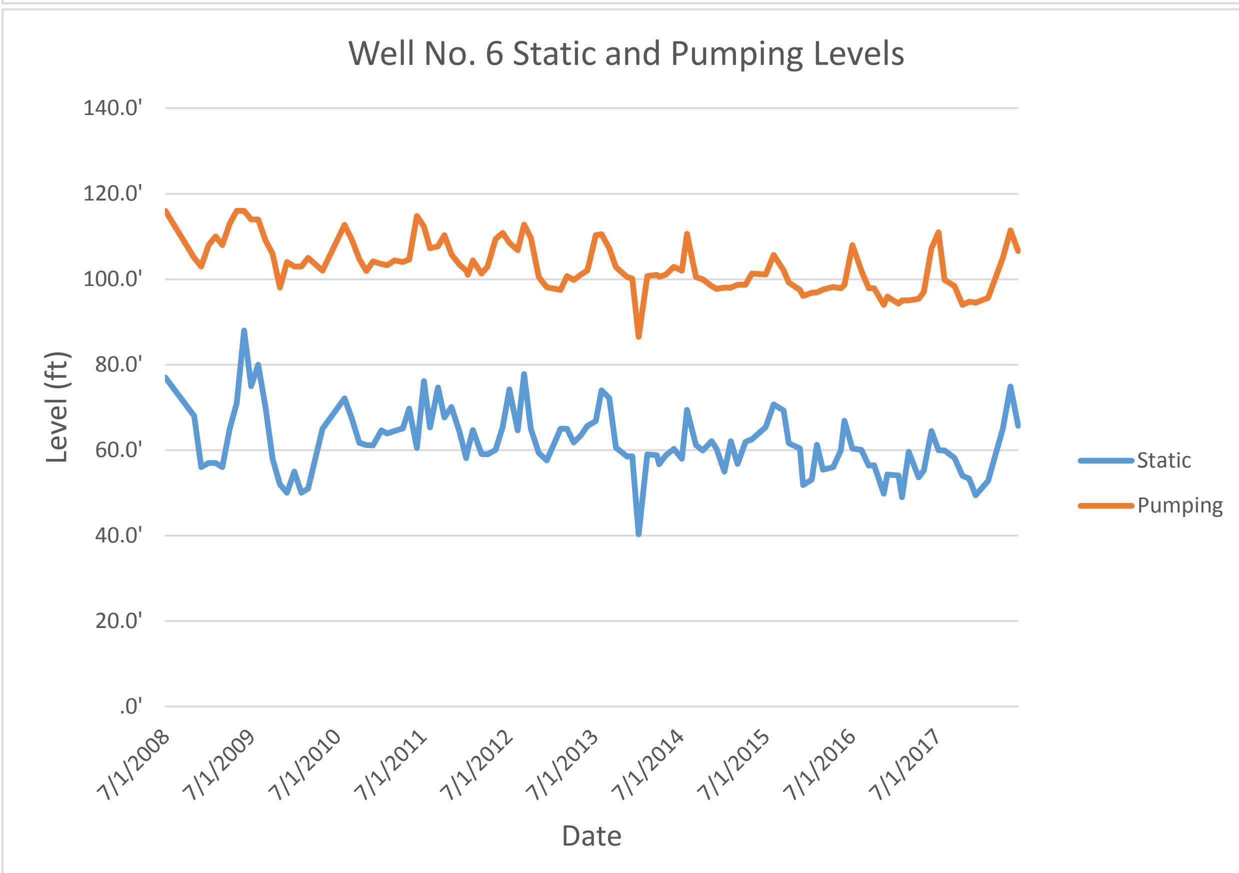

Well No. 1 Static and Pumping Levels
140.0'
120.0'
100.0'
80.0'
60.0'
40.0'
20.0'
.0'
Level (ft)
7/1/2008
7/1/2009
7/1/2010
7/1/2011
7/1/2012
7/1/2013
7/1/2014
7/1/2015
7/1/2016
7/1/2017
Date
Static
Pumping

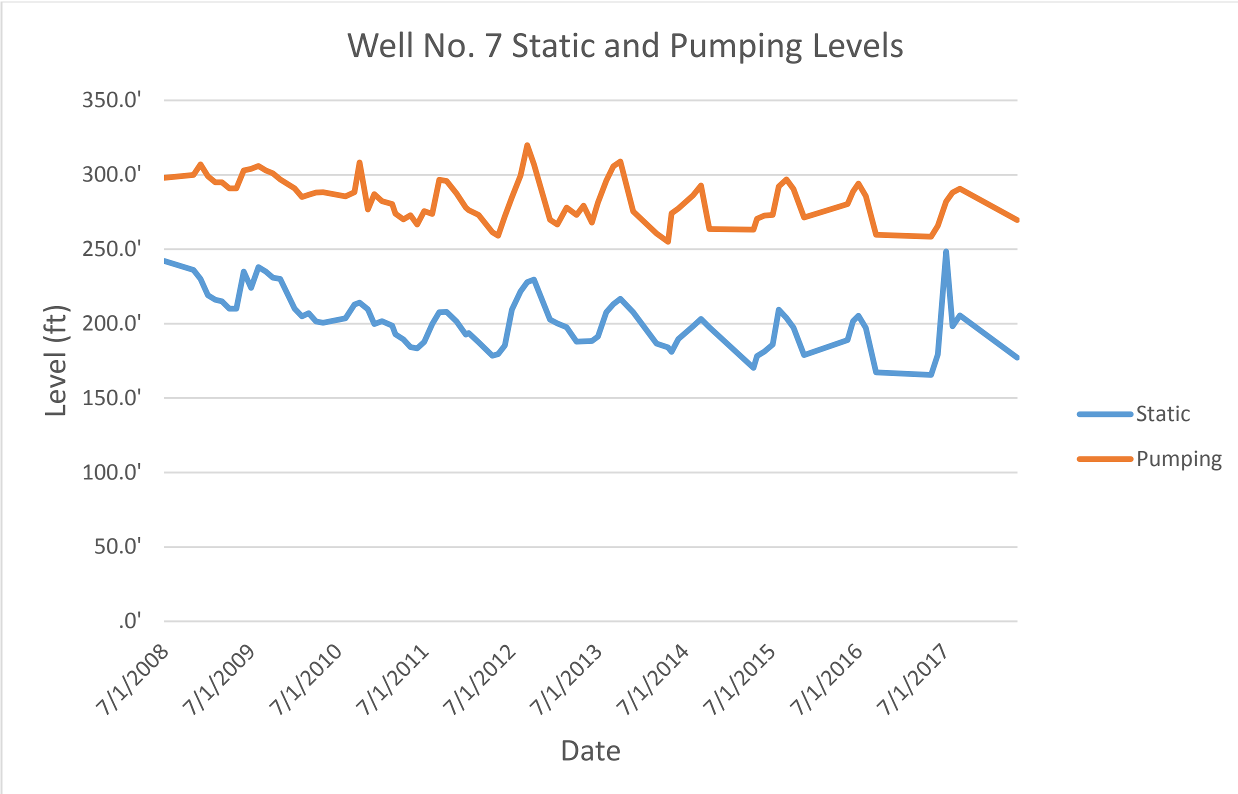

Well No. 2 Static and Pumping Levels
120.0'
100.0'
80.0'
60.0'
40.0'
20.0'
.0'
Level (ft)
7/1/2008
7/1/2009
7/1/2010
7/1/2011
7/1/2012
7/1/2013
7/1/2014
7/1/2015
7/1/2016
7/1/2017
Date
Static
Pumping


Well No. 3 Static and Pumping Levels
140.0'
120.0'
100.0'
80.0'
60.0'
40.0'
20.0'
.0'
Level (ft)
7/1/2008
7/1/2009
7/1/2010
7/1/2011
7/1/2012
7/1/2013
7/1/2014
7/1/2015
7/1/2016
7/1/2017
Date
Static
Pumping


Well No. 4 Static and Pumping Levels
120.0'
100.0'
80.0'
60.0'
40.0'
20.0'
.0'
Level (ft)
11/1/2008
11/1/2009
11/1/2010
11/1/2011
11/1/2012
11/1/2013
11/1/2014
11/1/2015
11/1/2016
11/1/2017
Date
Static
Pumping


Well No. 5 Static and Pumping Levels
120.0'
100.0'
80.0'
60.0'
40.0'
20.0'
.0'
Level (ft)
7/1/2008
7/1/2009
7/1/2010
7/1/2011
7/1/2012
7/1/2013
7/1/2014
7/1/2015
7/1/2016
7/1/2017
Date
Static
Pumping


Well No. 6 Static and Pumping Levels
140.0'
120.0'
100.0'
80.0'
60.0'
40.0'
20.0'
.0'
Level (ft)
7/1/2008
7/1/2009
7/1/2010
7/1/2011
7/1/2012
7/1/2013
7/1/2014
7/1/2015
7/1/2016
7/1/2017
Date
Static
Pumping



Well No. 7 Static and Pumping Levels
350.0'
300.0'
250.0'
200.0'
150.0'
100.0'
50.0'
.0'
Level (ft)
7/1/2008
7/1/2009
7/1/2010
7/1/2011
7/1/2012
7/1/2013
7/1/2014
7/1/2015
7/1/2016
7/1/2017
Date
Static
Pumping

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