Table 5-1 – Existing Water Production Wells

Well Name	Pressure Zone	Unique Well Number	Normal Operational Capacity (gpm)	Allowed Pumping Time per Day (Hours)	Daily Capacity (MGD)
Well No.2	Normal	206803	300	24	0.4
Well No.3	Normal	205978	Emergency		
Well No.4	Normal	206854	716	24	1.0
Well No.5	Normal	206855	850	24	1.2
Well No.6	Normal	180922	1,175	24	1.7
Well No.7	Normal	415975	1,100	24	1.6
Well No.8	Normal	500657	1,100	24	1.6
Well No.9	1st High	554214	1,050	24	1.5
Well No.10	Normal	578948	1,125	24	1.6
Well No.11	1st High	611084	1,000	24	1.4
Well No.12	1st High	626775	810	24	1.2
Well No.13	1st High	674456	1,036	24	1.5
Well No.14	1st High	694904	380	24	0.5
Well No.15	Normal	694921	1,150	24	1.7
Well No.16	Normal	731139	1,450	24	2.1
Well No.17	Normal	731140	1,400	24	2.0
Well No.20	1st High	722624	1,142	24	1.6
Well No.21	1st High	722625	1,175	24	1.7
Total			**16,960**	--	**24.4**
Two Highest Yielding Wells (Well No. 16 & 17)					**4.1**
Firm Capacity (Minus Two Wells)					**20.3**
Shakopee does not have any water treatment					

Source: City Records

5.4 Reliable Pumping Capacity & Storage

Now that the reliable supply capacity for the whole system was established, the system can be further broken down to assess the ability of each pressure zone to deliver adequate water service to the customers within each zone. This analysis will also help to determine the most optimal locations for future supply wells in relation to pressure zone layout.

While the entire system was evaluated for reliable supply capacity, with two wells out of service, each service zone can be evaluated as follows:

- Reliable pumping capacity (Wells and booster stations) of each pressure zone should be equal to or greater than the zone's maximum day pumpage requirements.
- Sufficient water storage capacity should exist in each pressure zone to meet peak hour and other short-term demands.

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.

5.4.1 Water Storage Needs

The purpose of a water distribution system is to deliver water in adequate quantity and at acceptable pressure from the source of supply to the customers. A water system should be capable of meeting all demands during the period of maximum use without reducing pressure below an acceptable limit. This can be achieved though the combination of supply and storage facilities working together to sustain system demands.

In general, elevated water storage tanks serve water systems in multiple ways. The primary purpose is to provide stored water to supply water to the system in the event of a supply shortage. Supply facilities (such as wells and booster stations) work to fill the water storage tanks and pump directly to satisfy customer water demands. In the event of a well or supply facility failure due to power outage etc. the storage facility holds water in reserve to feed customers with water despite a loss of power.

Furthermore, system storage is used as a "cushion" to equalize fluctuations in customer demands, establish and maintain water system pressures, provide operational flexibility for water supply facilities, and improve water supply reliability. As customer demands exceed supply capacities during peak hour conditions, these excess demands must be met by depleting available storage. The amount of storage depleted is referred to as equalizing storage for peak hour requirements.

Of equal importance is a water storage tanks ability to support water flows for fire protection. A water storage facility does this in two different functions. First, the storage facility holds water in reserve to supply high levels of flows that exceed the capacity of the water supply wells. Additionally, the placement of a storage facility within the water system supports nearby pressure and flows increasing the available flows to the nearby distribution system.

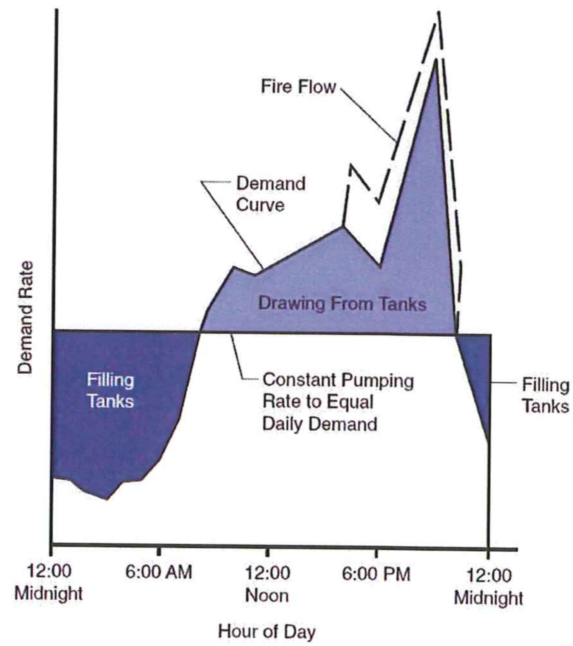
In Summary, the functions of water distribution storage include:

- Equalizing storage (sometimes termed operational storage).
- Fire storage.
- Emergency storage.

Each of these storage components are further defined below:

Equalizing storage

Equalizing storage works to allow the supply & treatment pumping systems to be sized and operate to produce at the rate of average demand over the course of a day. For example, during peak hours of water use, when customers are using large amounts of water, system demand may exceed the production rate of the water supply/treatment. It is during this time when water storage facilities will drain to satisfy the increased system demand. This concept is further illustrated in the figure below.



Fire Storage

Fire storage includes water held in the tank in the case of an emergency. To assure a reliable supply for fire protection, this reserve storage should not be utilized to meet peak hour requirements and should be available when needed. 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. Since this memo intends to size water storage for a part of the water system that is primarily residential in nature, a common high end goal for residential fire flow is to provide a flow rate of 1,500 gpm for 2 hours. This figure will be used as a basis for estimating the amount of water to be held in the proposed storage tank for fire protection.

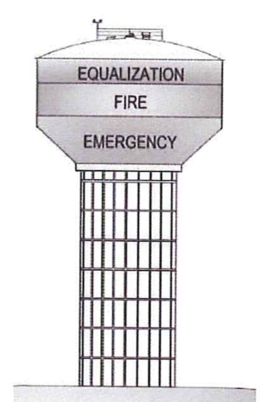
Emergency Storage

Emergency storage is required to meet system water demands during an emergency event that limits or disrupts supply. Some examples of emergency events include water main breaks, equipment failure, and power failure or source contamination.

Water Storage Sizing Criteria

As new users are continually added to the Shakopee water system, water usage will continue to increase. As noted earlier, there is a strong relationship between water storage needs, system supply and system water demands. One of the important functions that an elevated water storage tank provides is delivery of water to feed system demands that exceed the supply capacity. This function helps to sustain consistent system pressures in the water system during periods of high demand. In a similar fashion, the tank will fill when supply flow rates exceed the demand rate during periods of low demands (in the middle of the night for example). For purposes of this analysis two separate sizing criteria were utilized in order to establish when the additional of additional storage to the South water system will be required.

WATER STORAGE ALLOCATION



The sizing criteria are as follows:

1. ***Requirement 1*** - *Average daily consumption should not exceed the available storage.* This sizing metric is commonly used by the Minnesota Department of Natural Resources (DNR) when determining if additional water storage is warranted.
2. ***Requirement 2*** - *Available storage should be large enough to provide equalization storage (15% of MD) plus (+) Fire storage (+) 1/2 Average Day Demand for reserve storage. (Fire storage based on largest land use fire flow requirement in the zone being analyzed)*

This sizing practice is a commonly used industry requirement for storage that also accounts for hourly system operation in order to satisfy peak water demands.

5.4.2 Water Supply and Storage Needs Analysis

To determine the water supply and storage needs of a community, average daily demands, peak demands, and emergency needs must be considered. In the sections below, calculations are used to determine future water supply and storage volume requirements for the SPUC water system. Water storage facilities should be capable of supplying the desired rate of fire flow for the required length of time during peak demands when the water system is already impacted by other uses and with the largest supply pump out of service.

The calculations below assume that maximum day demands are occurring on the system, storage volume is reduced by peak demands greater than firm supply pumping rate (i.e. equalization storage is expended). For purposes of this analysis, it is assumed that the "firm capacity" of the water supply wells and booster pumps (largest pump out of service) is capable of supplying maximum day demands.

Because there are multiple pressure zones in the SPUC water system, served by elevated storage, it is important to evaluate the needs of each zone separately. In the case of

5.4.2.1 Total System Storage

To determine the water storage needs of a community, average daily demands, peak demands, and emergency needs must be considered. The storage tanks of the water system are listed in Table 5-2. The volumes in Table 5-2 are compared to the projected storage needs in Table 5-3. The analysis below indicates that system as a whole has a surplus of storage throughout the planning period.

Table 5-2 – Existing Water Storage Facilities

Facility Name	Capacity (gal)	Useable Volume (gal)	Overflow Elev.	Headrange (ft)	Construction Style
Main Zone					
Tank 1	2,000,000	2,000,000	933.0	43.0	Stand Pipe
Tank 2	250,000	250,000	933.0	24.0	Pedestal Sphere
Tank 3	1,500,000	1,500,000	933.0	35.0	Hydropillar
Tank 5	2,500,000	2,000,000	933.0	35.0	Ground
Tank 6	2,500,000	2,000,000	933.0	35.0	Ground
High Zone 1					
Tank 4	500,000	500,000	1015.0	28.0	Pedestal Spheroid
Tank 7	2,500,000	2,000,000	1015.0	34.5	Ground
Total	**11,750,000**	**10,250,000**			

Table 5-3 – Pumping Capacity & Storage Analysis for Entire System

	Design Demand Year		
	2020	2030	2040
Pumping Capacity Analysis			
Maximum Day Demand (mgd)[1]	17.9	21.0	24.0
Average Day Demand	6.5	7.6	8.7
Existing Firm Supply Capacity (mgd)[2]	20.3	20.3	20.3
Recommended Storage Volume			
Maximum Day Equalization Volume (gallons)[4]	2,680,000	3,140,000	3,610,000
Fire Protection Volume (gallons)[5]	630,000	630,000	630,000
Reserve Volume (gallons; 15% of Total)[6]	3,226,000	3,785,000	4,345,000
Recommended Total Volume (gallons)	*6,536,000*	*7,555,000*	*8,585,000*
Existing Storage & Pumping Volume			
Surplus Firm Pump Volume (gallons)[7]	310,000	(80,000)	(470,000)
Tank 1	2,000,000	2,000,000	2,000,000
Tank 2	250,000	250,000	250,000
Tank 3	1,500,000	1,500,000	1,500,000
Tank 4	500,000	500,000	500,000
Tank 5	2,000,000	2,000,000	2,000,000
Tank 6	2,000,000	2,000,000	2,000,000
Tank 7	2,000,000	2,000,000	2,000,000
Total Existing Volume Available (gallons)	*10,250,000*	*10,250,000*	*10,250,000*
Water Storage Mass Balance	3,714,000	2,695,000	1,665,000
Additional Storage Recommended (gallons)	**None**	**None**	**None**

1 See Table 4-7.

2 See Table 5-1.

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.

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 Firm Pump Volume is the difference between maximum day demand and Firm Pumping Capacity which is available to supplement fire protection for 3 hours.

5.4.2.2 Normal Zone

Projections of water needs in the Normal Zone is shown in Table A-1 of Appendix A. Total supply capacity of the Normal Zone is shown in Table 5-4. The total capacity of the Normal Zone is 14.3 mgd, assuming all wells can operate 24 hours per day. With the largest well in the zone out of service, the reliable supply capacity of the Normal Zone is 12.8 mgd.

Table 5-4 – Supply Capacity into Normal Zone

Well Name	Pressure Zone	Unique Well Number	Normal Operational Capacity (gpm)	Allowed Pumping Time per Day (Hours)	Daily Capacity (MGD)
Well No.2	Normal	206803	300	24	0.43
Well No.3	Normal	205978	Emergency Well		
Well No.4	Normal	206854	716	24	1.03
Well No.5	Normal	206855	850	24	1.22
Well No.6	Normal	180922	1,175	24	1.69
Well No.7	Normal	415975	1,100	24	1.58
Well No.8	Normal	500657	1,100	24	1.58
Well No.10	Normal	578948	1,125	24	1.62
Well No.15	Normal	694921	1,150	24	1.66
Well No.16	Normal	731139	1,450	24	2.09
Well No.17	Normal	731140	1,400	24	2.02
		Total	**10,366**	**--**	**14.93**
Highest Yielding Well (Well No. 16)					**2.09**
Firm Capacity (Minus Well No. 16)					**12.84**

With the projections from Table A-1 discussed in Section 4 previously, the Normal Zone may be analyzed for potential supply and storage needs. Table 5-5 analyzes the pumping and storage capacity of the Normal Zone. According to the demand projections in Table A-1 and the analysis in Table 5-5, the **Normal Zone** may be in need of additional supply and/or interzone transfer capacity of **2.6 MGD (1,800 gpm)** over the next 20 years. No additional storage, however, is anticipated to be required over the same planning period.

Table 5-5 – Supply & Storage Analysis for Normal Zone Dependencies

	Design Demand Year		
	2020	2030	2040
Pumping Capacity Analysis			
Maximum Day Demand (mgd)[1]	12.87	14.14	15.42
Average Day Demand (mgd)	4.56	4.99	5.42
Existing Firm Supply Capacity (mgd)[2]	12.84	12.84	12.84
Firm Supply and/or Interzone Transfer Capacity Mass Balance (mgd)[3]	**-0.03**	**-1.30**	**-2.58**
Recommended Storage Volume			
Maximum Day Equalization Volume (gallons)[4]	1,930,000	2,120,000	2,310,000
Reserve Storage (1/2 AD)	2,279,000	2,494,000	2,710,000
Fire Protection Volume (gallons)[5]	630,000	630,000	630,000
Preliminary Recommended Total Volume (gallons)	*4,839,000*	*5,244,000*	*5,650,000*
Existing Storage & Pumping Volume			
Surplus Firm Pump Volume (gallons)[7]	0	(160,000)	(320,000)
Tank 1	2,000,000	2,000,000	2,000,000
Tank 2	250,000	250,000	250,000
Tank 3	1,500,000	1,500,000	1,500,000
Tank 4	2,000,000	2,000,000	2,000,000
Tank 5	2,000,000	2,000,000	2,000,000
Tank 6	7,750,000	7,590,000	7,430,000
Total Existing Volume Available (gallons)	*0*	*(160,000)*	*(320,000)*
Water Storage Mass Balance	2,911,000	2,346,000	1,780,000
Additional Storage Recommended (gallons)	**None**	**None**	**None**

1 Includes Normal Zone and East Zone See Table A-1 and A-5.

2 See Table 5-4.

3 A positive value represents a surplus. A negative valve represents a deficiency.

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.

5 Fire Protection storage was calculated based on one fire of 3,500 gpm for 3 hours.

6 Surplus Firm Pump Volume is the difference between maximum day demand and Firm Pumping Capacity which is available to supplement fire protection for 3 hours.

5.4.2.3 First High Zone

Projections of water needs in the First High Zone were shown in Table A-2 of Appendix A. Total supply and pumping capacity of the First High Zone is shown in Table 5-6. The supply capacity of the First High Zone is assumed to be provided by the wells within the zone plus the Well 9 booster station. The total well supply capacity of the First High Zone is 9.5 mgd, assuming all wells can operate 24 hours per day. With the largest well in the zone out of service, the reliable pumping capacity of the First High Zone is 7.8 mgd. For purposes of this zone analysis, it is assumed that supply from the first high zone must also support and supply the second high zones (Central and West). With this assumption in mind, table 5-7 lists maximum daily demands that include the previously mentioned zones.

Table 5-6 – Supply Capacity into First High Zone

Well Name	Unique Well Number	Normal Operational Capacity (gpm)	Allowed Pumping Time per Day (Hours)	Daily Capacity (MGD)
Well No.9	554214	1,050	24	1.51
Well No.11	611084	1,000	24	1.44
Well No.12	626775	810	24	1.17
Well No.13	674456	1,036	24	1.49
Well No.14	694904	381	24	0.55
Well No.20	722624	1,142	24	1.64
Well No.21	722625	1,175	24	1.69
Booster 9 Pump 1	N/A	1,000	Surplus Supply from Normal Zone not available, See Table 5-5	
Booster 9 Pump 2	N/A	1,000		
	Total	**8,594**	**--**	**9.50**
			Highest Yielding Well (Well No. 21)	**1.69**
			Firm Capacity (Minus Well No. 21)	**7.80**

Table 5-7 analyzes the pumping and storage capacity of the First High Zone, including the 2nd high zones which are dependent on supply from the 1st High pressure zone. According to the demand projections in Table A-2 and the analysis in Table 5-7, the **1st High Zone** may be in need of additional supply and/or interzone transfer capacity of **.80 MGD (580 gpm)** over the next 20 years to serve zone specific needs. In Addition, the 2040 planning period indicates a storage deficit of about 500,000 gallons. This deficit is driven by demands in the second high zones. In the future, it is anticipated that additional supply will be added to the system which will decrease the storage needs. Furthermore, storage going to likely be added in the Second high zone which will effectively be available to benefit the analysis documented in table 5-7.

Table 5-7 – Supply & Storage Analysis for 1st High Zone Dependencies

	Design Demand Year		
	2020	2030	2040
Pumping Capacity Analysis			
Maximum Day Demand (mgd)[1]	4.99	6.81	8.64
Average Day Demand (mgd)	1.54	1.77	2.01
Existing Firm Supply Capacity (mgd)[2]	7.80	7.80	7.80
Firm Supply and/or Interzone Transfer Capacity Mass Balance (mgd)[3]	**2.81**	**0.99**	**-0.83**
Recommended Storage Volume			
Maximum Day Equalization Volume (gallons)[4]	750,000	1,020,000	1,300,000
Reserve Storage (1/2 AD)	768,000	886,000	1,005,000
Fire Protection Volume (gallons)[5]	630,000	630,000	630,000
Recommended Total Volume (gallons)	2,148,000	2,536,000	2,935,000
Existing Storage & Pumping Volume			
Surplus Firm Pump Volume (gallons)[6]	350,000	120,000	(100,000)
Tank 4	500,000	500,000	500,000
Tank 7	2,000,000	2,000,000	2,000,000
Total Existing Volume Available (gallons)	2,850,000	2,620,000	2,400,000
Storage or Pumping Volume Mass Balance (gallons)[3]	**702,000**	**84,000**	**-535,000**

[1] Includes First High and both Second High Zones. See Table A-2, A-3 and A-4.

[2] See Table 5-6.

[3] A positive value represents a surplus. A negative valve represents a deficiency.

[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.

[5] Fire Protection storage was calculated based on one fire of 3,500 gpm for 3 hours.

[6] Surplus Firm Pump Volume is the difference between maximum day demand and Firm Pumping Capacity which is available to supplement fire protection for 3 hours.

5.4.2.4 Second High Central Zone

Projections of water needs in the Second High Central Zone were shown in Table A-3 of Appendix A. Total supply and pumping capacity of the Second High Central Zone is shown in Table 5-8. The supply capacity of the Second High Central Zone is assumed to be provided only by the booster pumps within the zone and will be called the pumping capacity. The total capacity of the Second High Central Zone is 2.88 mgd, assuming all pumps can operate 24 hours per day. With the largest single booster pump in the zone out of service, the reliable pumping capacity of the Second High Central Zone is1.44 mgd.

Table 5-8 – Pumping Capacity in 2nd High Central Zone

Pump Name	Normal Operational Capacity (gpm)	Daily Capacity (MGD)
Valley Creek 1	1,000	1.44
Valley Creek 2	1,000	1.44
Total	**2,000**	**2.88**
	Largest Pump	**1.44**
	Firm Capacity (Largest Pump)	**1.44**

With the projections from Table A-3 discussed in Section 4 previously, the Second High Central Zone may be analyzed for potential supply and storage needs. Table 5-9 analyzes the pumping and storage capacity of the Second High Central Zone. According to the demand projections in Table A-3 and the analysis in Table 5-9, over the next 20 year planning period the Second High Central Zone can be served by the existing booster station facility. As the system grows, it will be beneficial from an operational perspective to add storage to the zone, by the need for the additional storage may not present itself in the current planning period. It is anticipated that eventually the Central and West 2nd high pressure zones will grow together, forming one large zone. When this occurs, the zones will be able to benefit from shared water storage facilities. It is anticipated that the West 2nd high zone will require storage before the Central 2nd high zone. Water storage addition options for these pressures zones is further examined later in this report.

Table 5-9 – Supply & Storage Analysis for 2nd High Central Zone

	Design Demand Year		
	2020	2030	2040
Pumping Capacity Analysis			
Maximum Day Demand (mgd)[1]	0.06	0.19	0.32
Average Day Demand (mgd)	0.02	0.07	0.12
Existing Firm Supply Capacity (mgd)[2]	1.44	1.44	1.44
Firm Supply and/or Interzone Transfer Capacity Mass Balance (mgd)[3]	**1.38**	**1.25**	**1.12**
Recommended Storage Volume			
Maximum Day Equalization Volume (gallons)[4]	10,000	30,000	50,000
Reserve Storage (1/2 AD)	12,000	35,000	58,000
Fire Protection Volume (gallons)[5]	300,000	300,000	300,000
Recommended Total Volume (gallons)	*322,000*	*365,000*	*408,000*
Existing Storage & Pumping Volume			
Surplus Firm Pump Volume (gallons)[6]	170,000	160,000	140,000
No Storage			
Total Existing Volume Available (gallons)	*170,000*	*160,000*	*140,000*
Storage or Pumping Volume Mass Balance (gallons)[3]	**-152,000**	**-205,000**	**-268,000**

1 See Table A-3.
2 See Table 5-8.
3 A positive value represents a surplus. A negative valve represents a deficiency.
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.
5 Fire Protection storage was calculated based on one fire of 2,500 gpm for 2 hours.
6 Surplus Firm Pump Volume is the difference between maximum day demand and Firm Pumping Capacity which is available to supplement fire protection for 3 hours.

5.4.2.5 Second High West Zone

Projections of water needs in the Second High West Zone were shown in Table A-4 of Appendix A. Total supply and pumping capacity of the Second High West Zone is shown in Table 5-10. In the short term, the supply capacity of the Second High West Zone is assumed to be provided only by the booster pumps within the zone and will be called the pumping capacity. The total capacity of the Second High West Zone is 2.88 mgd, assuming all pumps can operate 24 hours per day. With the largest single booster pump in the zone out of service, the reliable pumping capacity of the Second High West Zone is 1.44 mgd.

Table 5-10 – Pumping Capacity into 2nd High West Zone

Pump Name	Normal Operational Capacity (gpm)	Daily Capacity (MGD)
Windermere 1	1,000	1.44
Windermere 2	1,000	1.44
Total	**2,000**	**2.88**
	Largest Pump	**1.44**
	Firm Capacity (Largest Pump)	**1.44**

With the projections from Table A-4 discussed in Section 4 previously, the Second High West Zone may be analyzed for potential supply and storage needs. Table 5-11 indicates that the Second High West Zone is anticipated to need additional supply and/or interzone transfer **capacity of 1.4 MGD (1,000 gpm)** equivalent to one new well over the next 20 years. Additionally, as this pressure zone grows, it will be beneficial to add water storage to this zone. Keeping in mind that this zone will eventually grow, expand and connect to the Central 2nd high zone. Therefore the water storage needs of the combines zones should be examined so that the water storage need commonalities can be considered when sizing future storage facilities. To put it simply, the total water storage needs of the combined zones (considered a single zone) will bill less than if the zones were left isolated from each other.

Table 5-11 – Supply & Storage Analysis for 2nd High West Zone

	Design Demand Year		
	2020	2030	2040
Pumping Capacity Analysis			
Maximum Day Demand (mgd)[1]	0.68	1.72	2.76
Average Day Demand (mgd)	0.24	0.62	1.00
Existing Firm Supply Capacity (mgd)[2]	1.44	1.44	1.44
Firm Supply and/or Interzone Transfer Capacity Mass Balance (mgd)[3]	**0.76**	**-0.28**	**-1.32**
Recommended Storage Volume			
Maximum Day Equalization Volume (gallons)[4]	100,000	260,000	410,000
Reserve Storage (1/2 AD)	122,000	310,000	498,000
Fire Protection Volume (gallons)[5]	300,000	300,000	300,000
Recommended Total Volume (gallons)	522,000	870,000	1,208,000
Existing Storage & Pumping Volume			
Surplus Firm Pump Volume (gallons)[6]	100,000	510,000	560,000
No Storage			
Total Existing Volume Available (gallons)	*100,000*	*510,000*	*560,000*
Storage or Pumping Volume Mass Balance (gallons)[3]	**-422,000**	**-360,000**	**-648,000**

1 See Table A-4.

2 See Table 5-10.

3 A positive value represents a surplus. A negative valve represents a deficiency.

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.

5 Fire Protection storage was calculated based on one fire of 2,500 gpm for 2 hours.

6 Surplus Firm Pump Volume is the difference between maximum day demand and Firm Pumping Capacity which is available to supplement fire protection for 3 hours. Assume the addition of two 1,000 gpm pumping units by 2040.

5.4.2.6 Combined 2nd High West & Central Storage

At a given point in the future, the 2nd High West and Central zones will inevitably grow together to form the 2nd High Zone. While the precise date for when this might occur is unknown, the combined water storage requirements for this zone can be calculated for the year 2040. The water storage requirements for this zone are calculated below. This will help later in the report to determine water storage construction phasing for both pressure zones as they will eventually be combined. The analysis below assumes the connection of the two zones into a single large zone. With this in mind, the two sections of pressure zone can share water reserved for fire protection, which reduces the storage volume compared to the independent analysis. Additional, two booster stations would be available to supply water to the pressure zone, providing an increase in firm capacity. These considerations lead to a recommended combined storage capacity of 1.0 MG for the future 2nd high zone. Options for providing this storage are discussed later in this report.

Table 5-12 – Supply & Storage Analysis for 2nd High Zone - Combined Central & West

	Design Demand Year		
	2020	2030	2040
Pumping Capacity Analysis			
Maximum Day Demand (mgd)[1]	0.74	1.91	3.07
Average Day Demand (mgd)	0.27	0.69	1.11
Existing Firm Supply Capacity (mgd)[2]	4.32	4.32	4.32
Firm Supply and/or Interzone Transfer Capacity Mass Balance (mgd)[3]	3.58	2.41	1.25
Recommended Storage Volume			
Maximum Day Equalization Volume (gallons)[4]	110,000	290,000	460,000
Reserve Storage (1/2 AD)	134,000	345,000	556,000
Fire Protection Volume (gallons)[5]	300,000	300,000	300,000
Recommended Total Volume (gallons)	*544,000*	*935,000*	*1,316,000*
Existing Storage & Pumping Volume			
Surplus Firm Pump Volume (gallons)[6]	450,000	480,000	340,000
No Storage			
Total Existing Volume Available (gallons)	*450,000*	*480,000*	*340,000*
Storage or Pumping Volume Mass Balance (gallons)[3]	**-94,000**	**-455,000**	**-976,000**

1 See Table A-4.

2 See Table 5-10, assumes addition of booster stations and supply wells.

3 A positive value represents a surplus. A negative valve represents a deficiency.

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.

5 Fire Protection storage was calculated based on one fire of 2,500 gpm for 2 hours.

6 Surplus Firm Pump Volume is the difference between maximum day demand and Firm Pumping Capacity which is available to supplement fire protection for 3 hours. Assume the addition of two 1,000 gpm pumping units by 2040.

5.4.2.7 East Zone

Projections of water needs in the East Zone were shown in Table A-5 of Appendix A. Total supply and pumping capacity of the East Zone is shown in Table 5-12. The supply capacity of the East Zone is assumed to be provided only by the booster pumps within the zone and will be called the pumping capacity. The total capacity of the East Zone is 2.88 mgd, assuming all pumps can operate 24 hours per day. With the largest single booster pump in the zone out of service, the reliable pumping capacity of the East Zone is 1.44 mgd.

Table 5-13 – Pumping Capacity into East Zone

Pump Name	Normal Operational Capacity (gpm)	Daily Capacity (MGD)
River View 1	1,000	1.44
River View 2	1,000	1.44
Total	**2,000**	**2.88**
	Largest Pump	**1.44**
	Firm Capacity (Largest Pump)	**1.44**

With the projections from Table A-5 discussed in Section 4 previously, the East Zone may be analyzed for potential supply and storage needs.. According to the demand projections in Table A-53, the East Zone is not anticipated to need additional supply and/or interzone transfer capacity over the next 20 years, however redundant supply may be needed. From a water storage perspective, the reduced development potential indicates that this pressure zone can continue to be served by a booster station rather than through the construction of an elevated storage tank. If the Utility did choose to construct an elevated tank, it is estimate that a 125,000 gallon thank would be sufficient to serve the ultimate pressure zone.

Table 5-14 – Supply & Storage Analysis for East Zone

	Design Demand Year		
	2020	2030	2040
Pumping Capacity Analysis			
Maximum Day Demand (mgd)[1]	0.26	0.34	0.42
Existing Firm Supply Capacity (mgd)[2]	1.44	1.44	1.44
Firm Supply and/or Interzone Transfer Capacity Mass Balance (mgd)[3]	**1.18**	**1.10**	**1.02**
Recommended Storage Volume			
Maximum Day Equalization Volume (gallons)[4]	40,000	50,000	60,000
Fire Protection Volume (gallons)[5]	180,000	180,000	180,000
Recommended Total Volume (gallons)	*220,000*	*230,000*	*240,000*
Existing Storage & Pumping Volume			
Surplus Firm Pump Volume (gallons)[6]	150,000	140,000	130,000
No Storage			
Total Existing Volume Available (gallons)	*150,000*	*140,000*	*130,000*
Storage or Pumping Volume Mass Balance (gallons)[3]	**-70,000**	**-90,000**	**-110,000**

1 See Table A-5.

2 See Table 5-12.

3 A positive value represents a surplus. A negative valve represents a deficiency.

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.

5 Fire Protection storage was calculated based on one fire of 2,500 gpm for 2 hours.

6 Surplus Firm Pump Volume is the difference between maximum day demand and Firm Pumping Capacity which is available to supplement fire protection for 3 hours.

5.5 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.

5.5.1 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. The Shakopee 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 Shakopee 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 C-1 in Appendix C and the test locations are shown in Figure C-1.

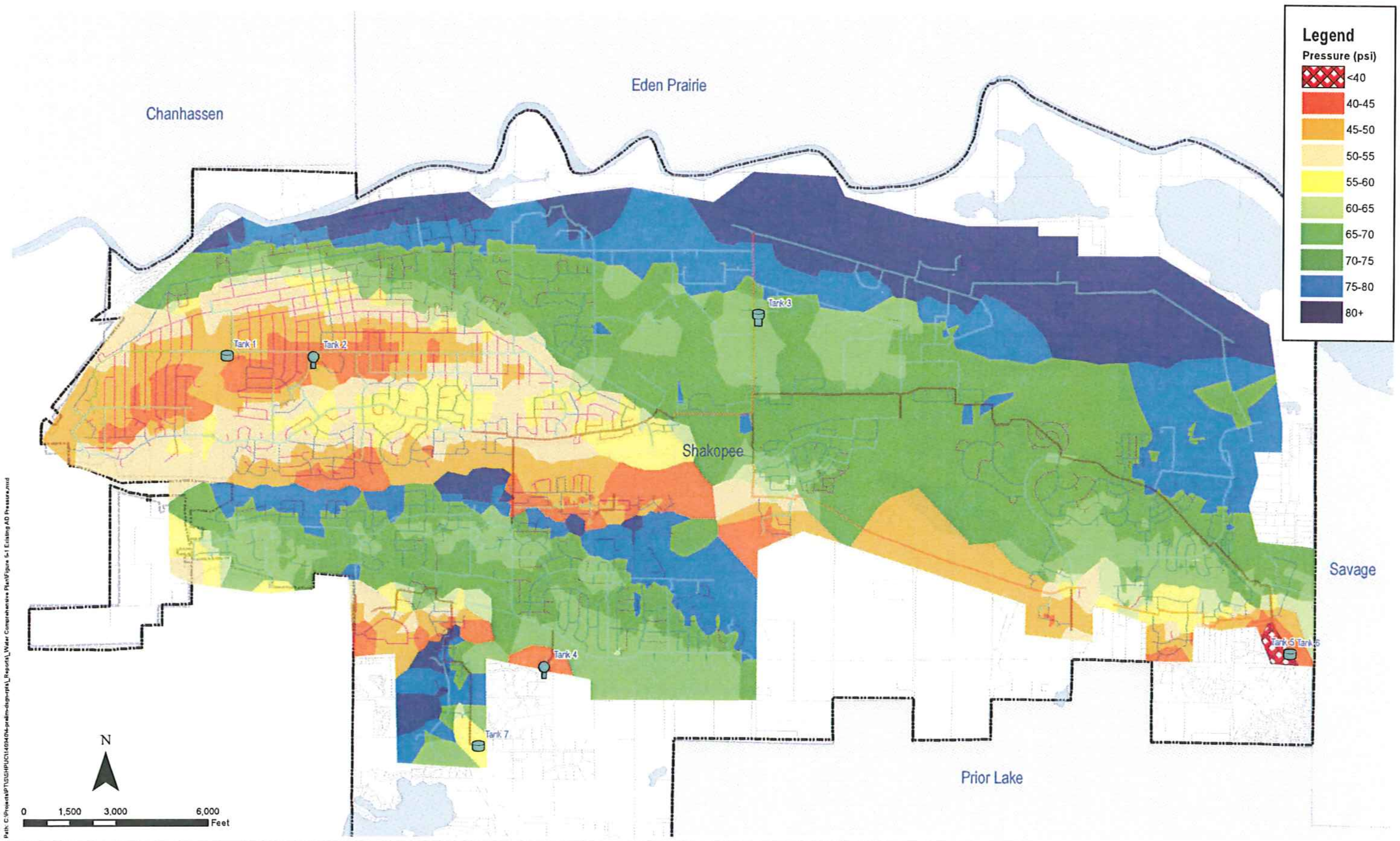
During the calibration process of the Shakopee water system hydraulic model, pumping rates, customer demands, and tower water levels were set to the conditions recorded during the field testing. Individual pipe roughness coefficients (C-factors) were adjusted until the calibrated system model closely simulated field test data as indicated in Table C-1

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.

5.5.2 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 Figure 5-1 for average day demand, Figure 5-2 for maximum day demand, and Figure 5-3 for 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 pressure zone.

Peak hour pipe velocities are shown in Figure 5-4. Only a small number of bottleneck water mains were found in Figure 5-4, indicated in red and orange. It may be recommended to upsize these high velocity mains or add additional loops.

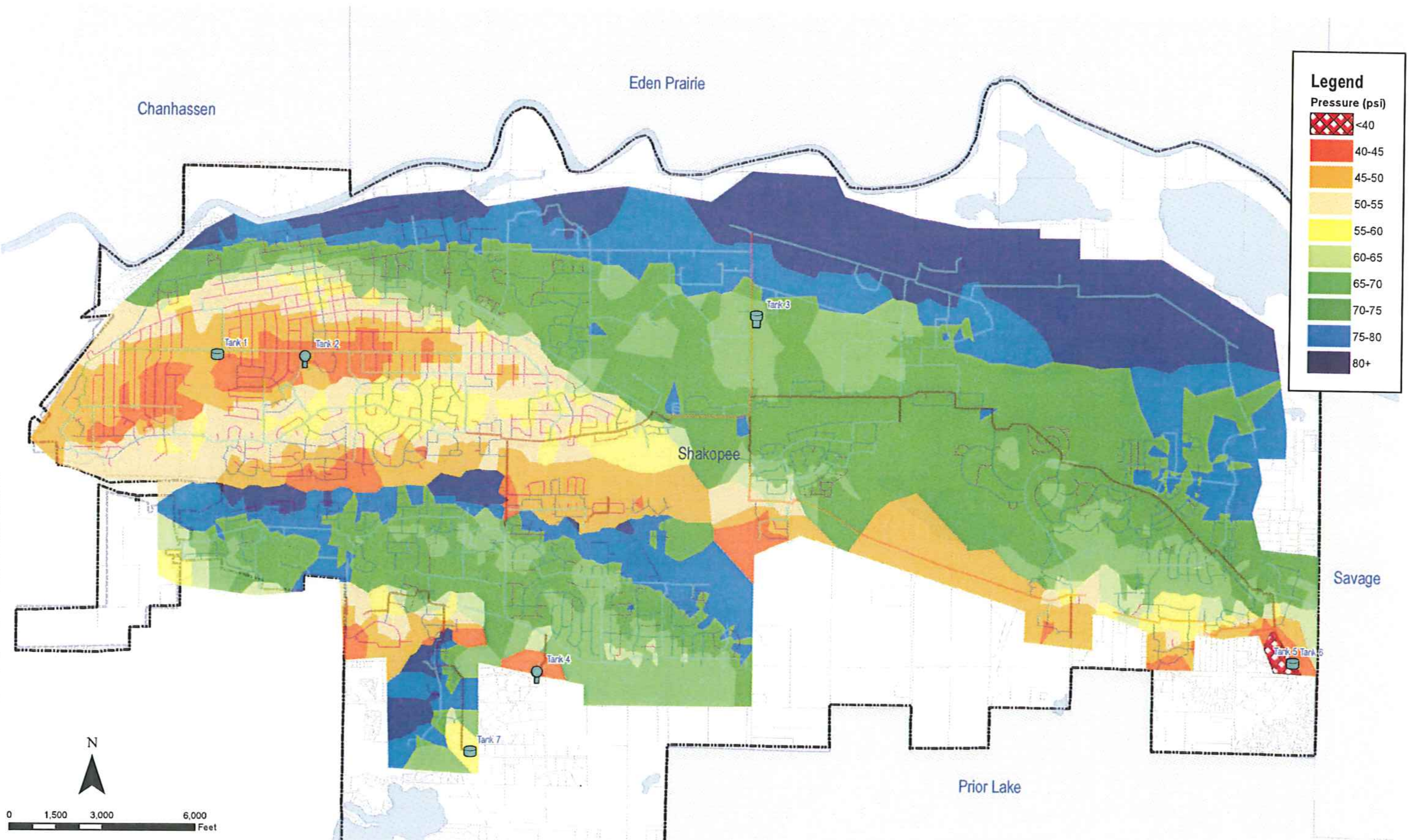


Project Number: SHPUC 140940
Print Date: Print Date: 8/28/2018
Map by:
Projection:
Source:

Model Notes:
-Water Towers at 10' Below Overflow
-Wells 7,8,9 & 21 ON
-Average Day Demand (5.0 MGD)

2018 Comprehensive Water Plan
Shakopee, Minnesota

FIGURE 5-1
Existing Water System Model
Average Day Demand Pressure



Project Number: SHPUC 140940
Print Date: Print Date: 8/28/2018

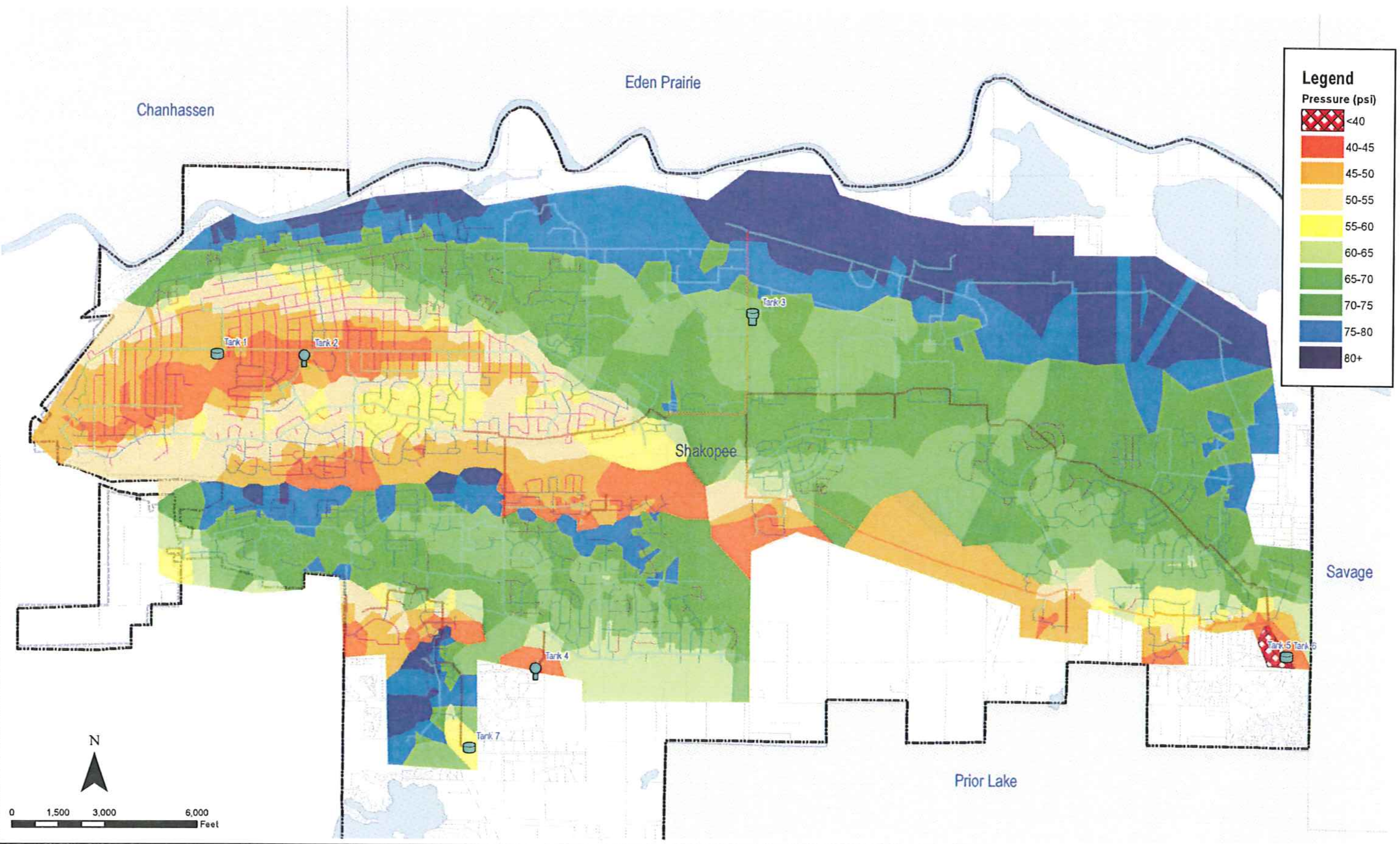
Map by:
Projection:
Source:

SEH

Model Notes:
-Water Towers at 10' Below Overflow
-Wells 7,8,9,11,12,13,17,20,21 ON
-Max Day Demand (12.5 MGD)

2018 Comprehensive Water Plan
Shakopee, Minnesota

FIGURE 5-2
Existing Water System Model
Max Day Demand Pressure



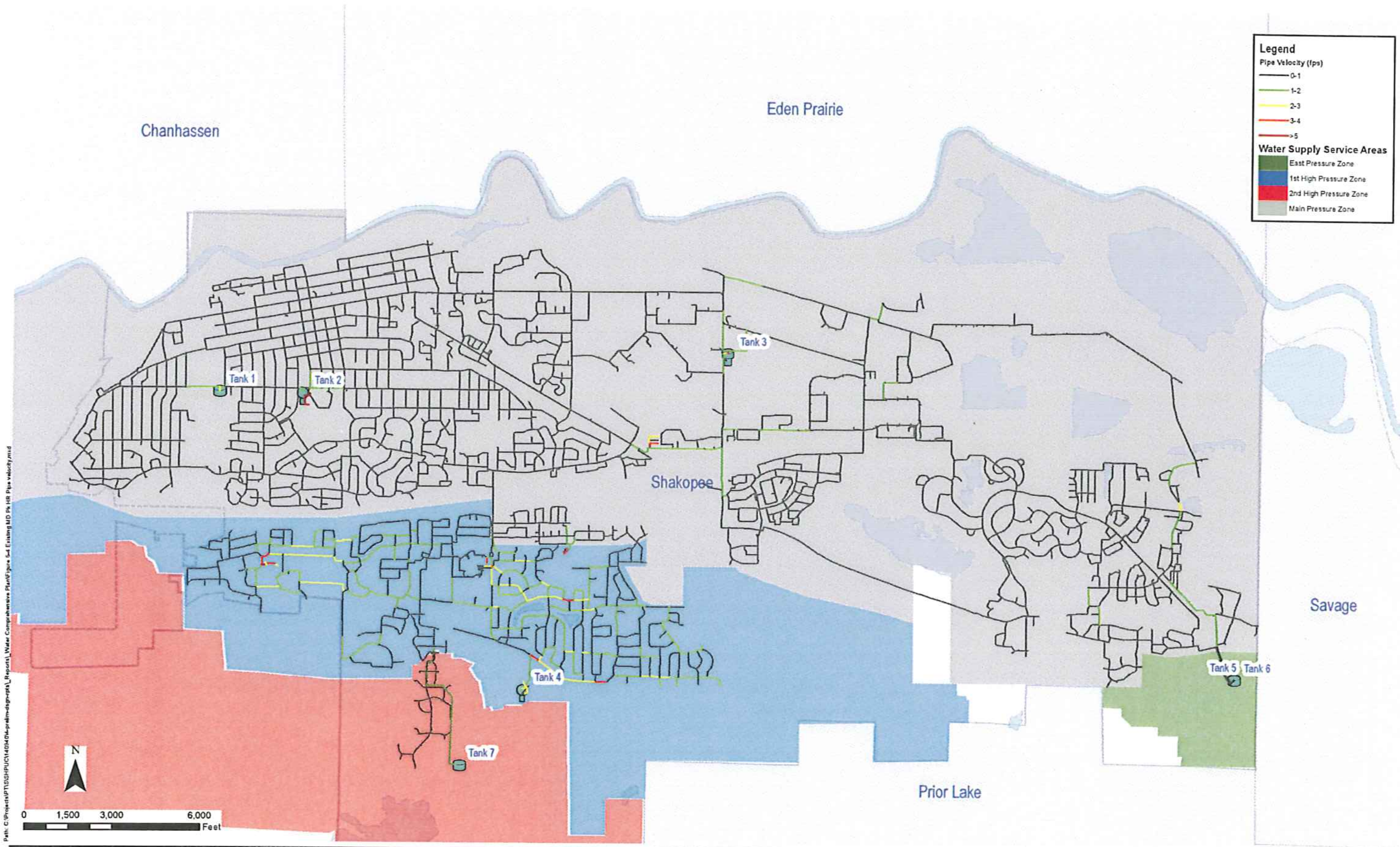
Project Number: SHPUC 140940
Print Date: Print Date: 9/6/2018

Map by:
Projection:
Source:

Model Notes:
-Water Towers at 10' Below Overflow
-Wells 7,8,9,11,12,13,17,20,21 ON
-Peak Hour Demand (14,800 gpm)

2018 Comprehensive Water Plan
Shakopee, Minnesota

FIGURE 5-3
Existing Water System Model
MD Peak Hour Demand Pressure



Project Number: SHPUC 140940
Print Date: Print Date: 7/2/2018

Map by:
Projection:
Source:

Model Notes:
-Water Towers at 10' Below Overflow
-Wells 7,8,9,11,12,13,17,20,21 ON
-Peak Hour Demand (14,800 gpm)

2018 Comprehensive Water Plan
Shakopee, Minnesota

FIGURE 4-8
Existing Water System Model
MD Peak Hour Pipe Velocity

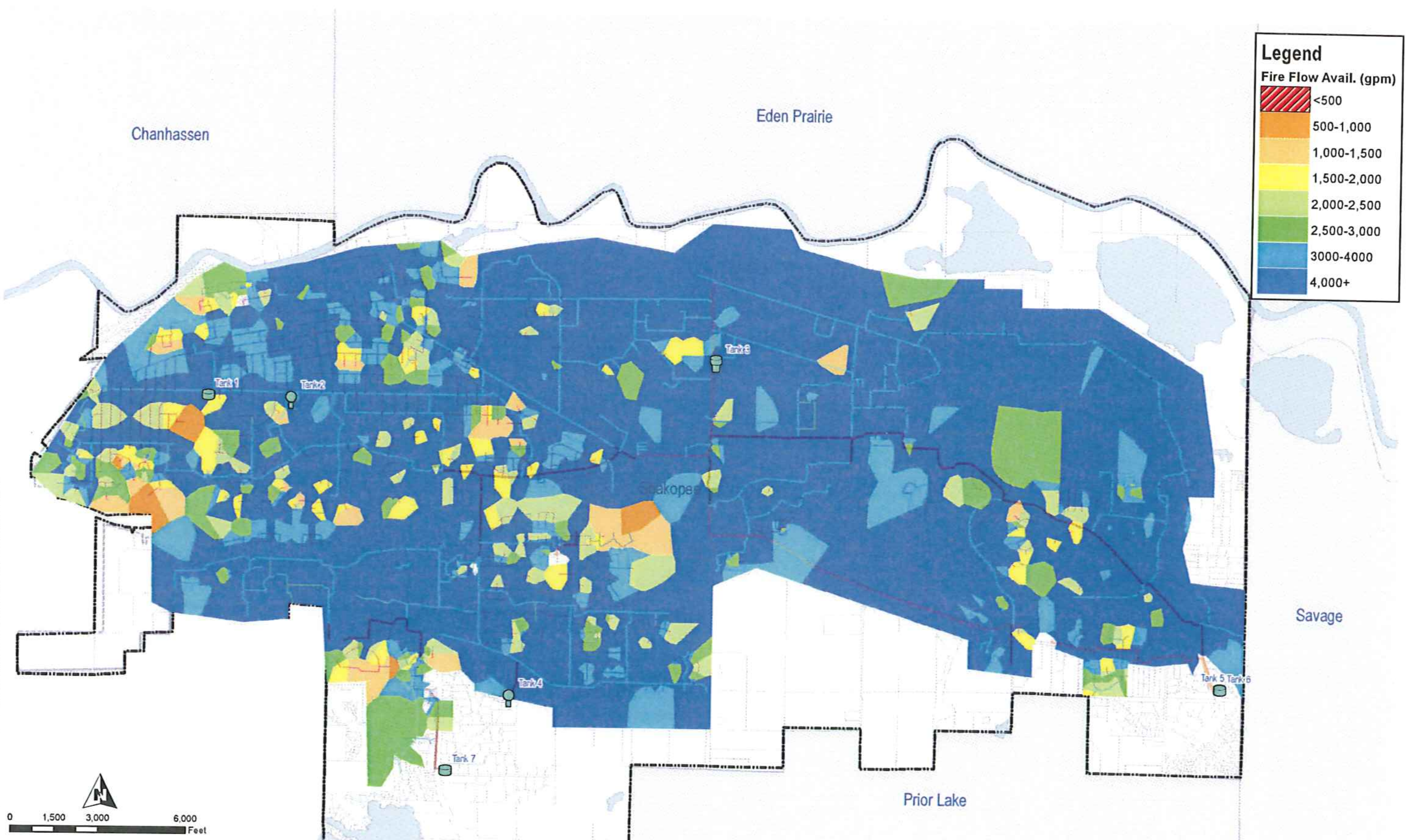
5.5.3 Available Flow for Fire Protection

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 5-5. 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.

The available flow across the Shakopee water system is generally 4,000 gpm + at 20 psi or greater. No nodes in the water model were found to have an available flow less than 500 gpm at 20 psi. Figure 5-6 shows the potential deficiencies for available flow in the system, based on land use. According to Figure 5-6, a handful of minor to moderate deficiencies may exist in the water system based on GIS land use. It is recommended that the City review these potential deficiencies case by case with the local landowners and their fire protection needs. Table 5-14 shows the basis for determining deficiencies, and 3,500 gpm is the maximum assumed needed available flow.

Table 5-15 – Needed Fire Flow Assumptions

Land Use	Needed Fire Flow (gpm)
Open Space	0
Roads	500
Parks	500
Mixed Use	1,500
Single Family	1,500
Medium Density Residential	2,000
Commercial	2,500
Entertainment	2,500
High Density Residential	2,500
Institutional	2,500
Business Park	3,500
Industrial	3,500



Project Number: SHPUC 140940
Print Date: Print Date: 8/28/2018

Map by:
Projection:
Source:

Model Notes:
-Water Towers at 10' Below Overflow
-Wells 7,8,9,11,12,13,17,20,21 ON
-Max Day Demand (12.5 MGD)
-Fire Flow Avail @ 20 psi Residual

2018 Comprehensive Water Plan
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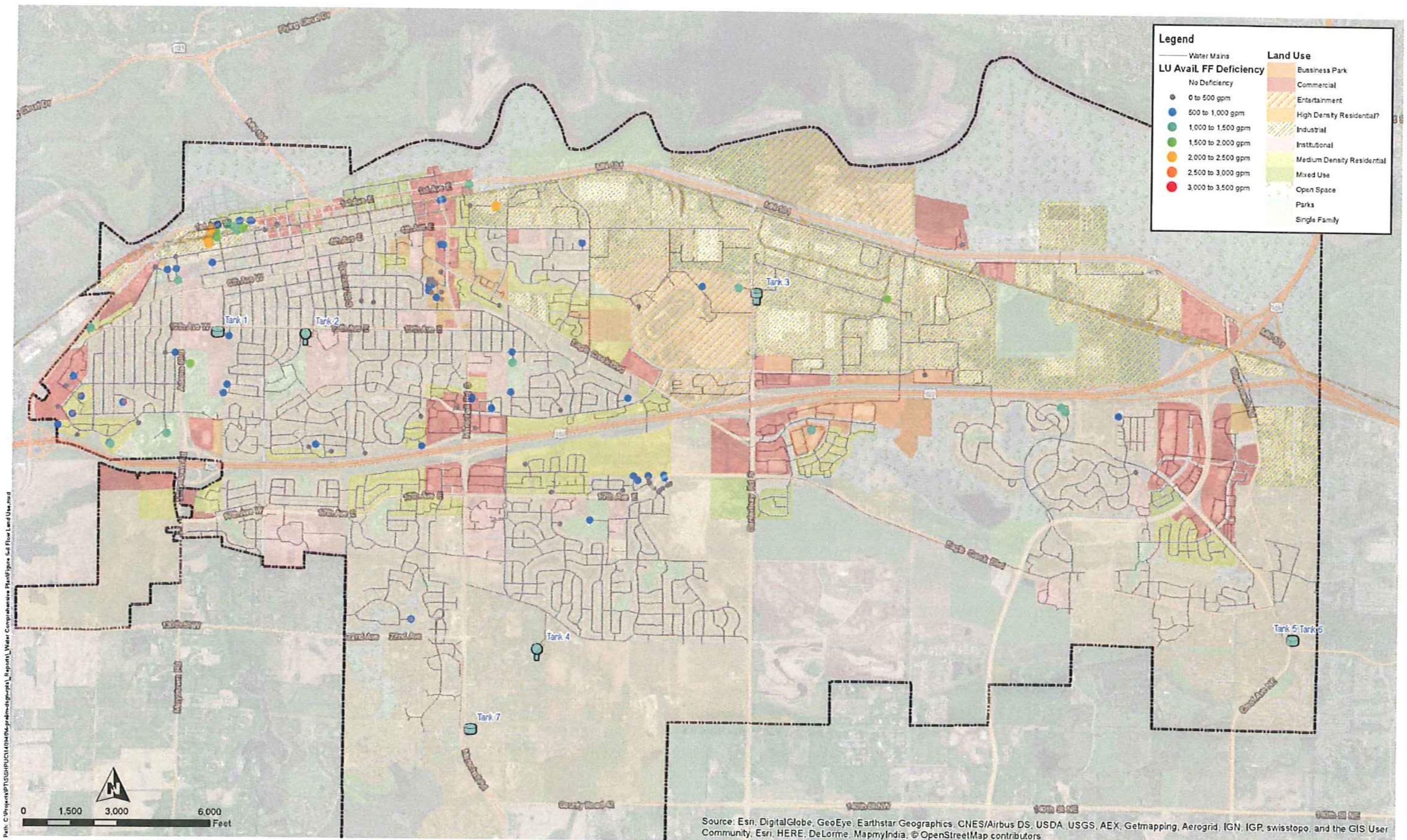
FIGURE 5-6
Existing Water System Model
Maximum Day Calc. Avail Fire Flow



SEH

Project Number: SHPUC 140940
Print Date: Print Date: 8/28/2018
Map by:
Projection:
Source:

Model Notes:
-Water Towers at 10' Below Overflow
-Wells 7,8,9,11,12,13,17,20,21 ON
-Max Day Demand (12.5 MGD)

2018 Comprehensive Water Plan
Shakopee, Minnesota

FIGURE 5-7
Existing Water System Model
Available Flow Deficiencies

5.6 Potential Service to Louisville Township

As part of the overall comprehensive plan effort, a preliminary high level estimate of additional water needs fir the Louisville Township was completed. Though this area is not included in the near term plan, it is important to understand the implications of demand if this area was to develop. This sections will provide a brief analysis of Louisville Township ultimate demand potential.

Figure 3-2 previously outlined the area of interest for the Louisville Township. The potential area comprises 9,300 acres. The following assumptions will be used for this analysis:

1. Development Assumed: Single family residential with ½ acre lots (Low Density Residential).
2. 80 percent of future area will be developed as single family residential. 20 percent will be roads or undevelopable from Table 4-9.
3. 490 gpd/acre from Table 4-9.
4. MD:AD ratio of 2.77 from Table 4-7.

With the above assumptions, the potential service area in the Louisville Township could add an additional average day demand of 3.6 mgd with a maximum day demand of 10 mgd at full buildout. These volumes are not included in any other analysis in this water comprehensive plan up to this point, nor are included in any other analysis or recommendation in this report.

5.7 Project specific water system analysis

As part of a comprehensive water system planning effort, SPUC initiated the analysis of some specific project areas as they relate to near term water system component sizing. With the newly calibrated hydraulic model, specific water system questions can be addressed with a high level of confidence. Some of the items analyzed include the incremental increase of fire flow availability experienced in the north western part of the downtown water system. Previous water system studies indicated that this section of the water system was lacking in fire flow capacity. The water model was utilized to demonstrate the incremental increase in fire flow experienced over the past 20 years as specific water mains were added, or replaced with larger sized Mains. The results of this analysis are included in Appendix E