FINAL

DISTRIBUTION SYSTEM WATER QUALITY STUDY

B&V PROJECT NO. 197824

PREPARED FOR

City of Dayton, MN

16 JULY 2018

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Executive Summary

The City of Dayton provides drinking water to its citizens using four different sources, depending on the location. One of these sources, Well #2 in the Northeast corner of the City, is currently experiencing water quality issues. The purpose of this study is to determine the possible causes of the water quality issues and to provide short and long-term recommendations for improving the water quality. Data was collected and analyzed over a two and half month period starting in February and ending in May 2018.

In general, it was determined that the water pumped from Well #2 has high levels of ammonia, sulfide, iron, and manganese. The City meets all the primary (health related) drinking water standards set forth by the Safe Drinking Water Act, but does exceed the secondary (aesthetic related) standards for iron and manganese which can cause the discolored water experienced by some residents near the water tower. The presence of sulfide explains the odor experienced by some residents as well. Based on the data analysis, the following short and long-term solutions can improve the water quality.

SHORT-TERM	LONG-TERM
1. Improve the phosphate feed system including dosage measurements, mixing, and chemical selection.	1. Determine the source of ammonia impacting Well #2
2. Optimize chlorine and phosphate dosages.	2. Investigate drilling a new well with improved water quality.
3. Investigate the possible benefits of adding chemicals, additional mixing at the water tower, and/or operational changes.	3. Build a treatment plant that can remove iron, manganese, ammonia, and sulfide.
4. Continue the monitoring program initiated by this study.	

Over the last decade of pumping, the testing noted that the the raw water quality from Well #2 has worsened, and this trend is expected to continue. With the existing Well #2 water quality and treatment infrastructure, water quality issues can be lessened, but cannot likely be completely eradicated. The short-term recommendations and even the first two long-term recommendations will only buy the City time until a water treatment plant is designed and constructed.

Introduction/Background

The City of Dayton has received complaints of drinking water odors and discoloration from residents. Complaints have been concentrated in one newer development of the City in the area served by Well #2. The scope of this study is to determine the possible causes of the water quality issues and to provide short and long-term recommendations for improving the water quality.

Dayton currently has a population of roughly 5,000 residents which obtain their drinking water from a variety of sources. Figure 1 shows a map of the City and the water distribution piping networks.

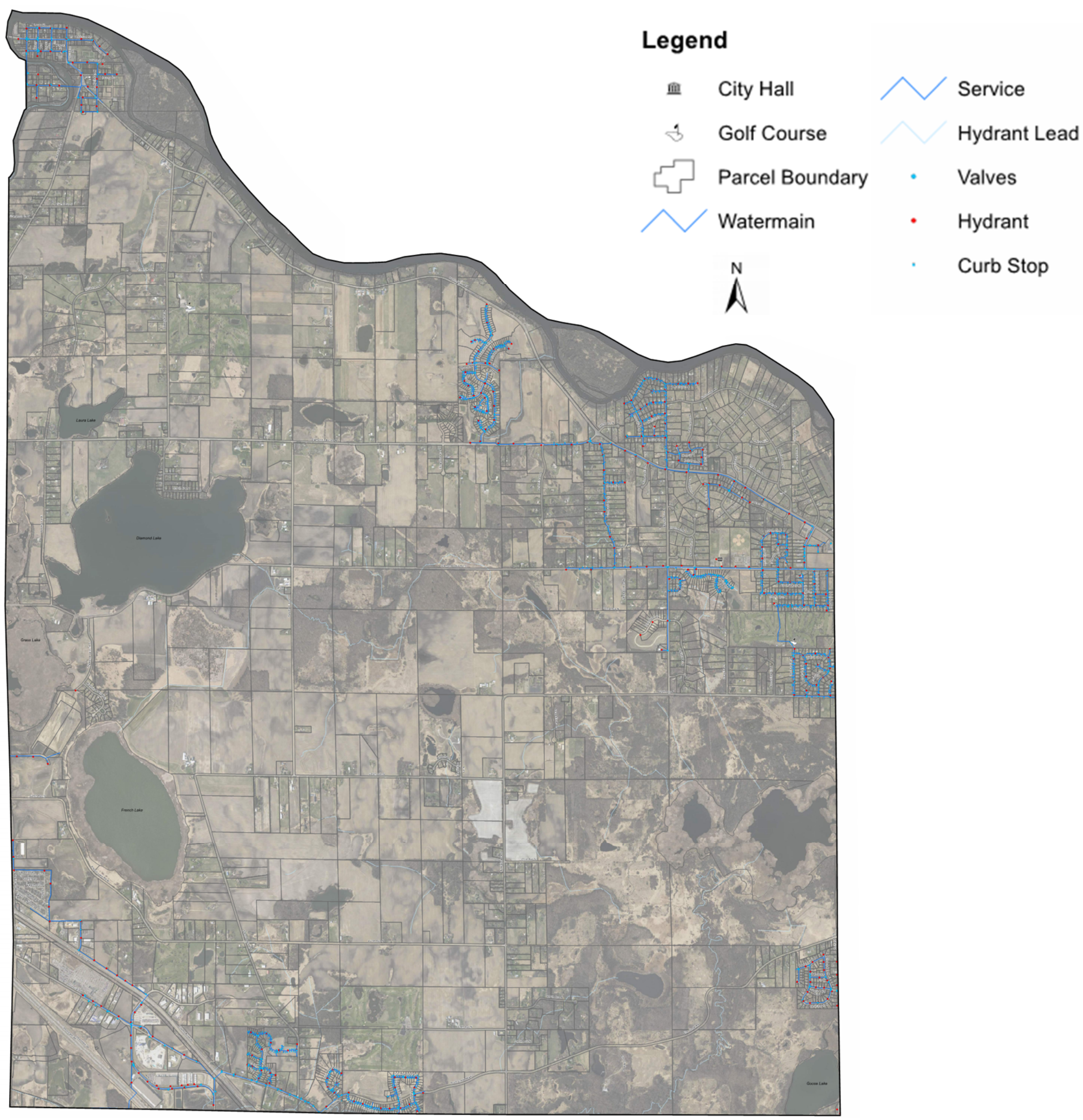

Figure 1: Dayton Water Distribution Map

The northwest part of the City is known as the Old Village and is served by the City of Dayton via Well #1. The southwest and southeast portions of the City are fed by the neighboring cities of Maple Grove and Champlin Park, respectively. The City of Dayton provides water for the northeast portion of the city via Well #2 which is the area that the City has received complaints for.

The well for System #2 was drilled in December of 2007 and associated treatment and storage were constructed in 2008. The most affected neighborhood consists of homes constructed within the past two years near the Water Tower for Well System #2. The City pumps and feeds chlorine at approximately 2 mg/L, Hawkins LPC-5 polyphosphate from 1 to 2 mg/L, and fluorine at 1 mg/L.

Data Collection

At the start of the study, minimal data was available for review so a program of point of entry and distribution system testing was initiated in February 2018. Table 1 shows the sampling recommended by Black & Veatch and implemented into the City's testing protocols.

Table 1: Dayton Water Quality Sampling Plan

SAMPLE PLAN	WELL #1	WELL #2	WATER TOWER
One Time Sampling			
General Chemistry Test	■	■	
Regulated Inorganic Chemicals	■	■	
EPA Volatile Organics	■	■	
Regulated Pesticides	■	■	
Total Coliform Rule	■	■	
Twice Per Week			
Free and Total Chlorine, Total Phosphate	■	■	■
Iron, Manganese, Ammonia, pH, Sulfate	■	■	■
Heterotrophic Plate Count			■

All water samples were collected by the City of Dayton over a 2.5-month period starting in February and ending in May 2018. City Staff as adopted this testing regime for future testing but results presented here coincide with the dates noted above. The City analyzed the constituents listed below (along with the Hach method used):

- Total/Dissolved Iron (2105769)
- Manganese (2651700)
- Ammonia as N (2668000)
- Sulfate (2106769)

- Orthophosphate (2106069)
- Total and Free Chlorine (2105625, 2105545)

All other samples were sent to Water Laboratories, Inc., in Elk River, MN.

Results & Discussion

WELL #1 SYSTEM

Table 2 shows the data collected for the Well #1 System.

Table 2: Well #1 System Water Quality Data

DATE	PH	TOTAL CL_2, MG/L	FREE CL_2, MG/L	NH_4-N, MG/L	SO_4, MG/L	FE, MG/L	MN, MG/L	TP, MG/L AS P
2/21/18		1.54	0.84			3.16		
2/26/18	7.52	0.09	0.06	<0.01	6	0.11	<0.01	
3/1/18	7.33	0.09	0.02	0.01	1	<0.01	0.01	
3/8/18	7.62	0.07	0.02	<0.01	<1	<0.01	0.03	
3/12/18	7.31	0.14	0.05	0.02	2	<0.01	0.01	
3/13/18								0.69
3/14/18								1.09
3/15/18	7.55	0.12	0.04	0.01	2	<0.01	0.03	
3/20/18	7.54	0.47	0.33	<0.01	<1	0.04	0.01	0.61
3/22/18	7.53	0.89	0.68	<0.01	2	0.03	0.01	0.61
3/26/18								0.61
3/27/18	7.46	0.58	0.36	<0.01	1	<0.01	<0.01	1.07
3/27/18	7.48	0.56	0.38	<0.01	1	0.01	0.01	0.61
4/2/18	7.63	0.39	0.25	<0.01	1	0.07	<0.01	
4/5/18	7.83	0.32	0.20	0.02	1	0.03	0.03	0.62
4/9/18	7.69	0.32	0.22	0.17	1	0.01	<0.01	0.61
4/11/18								0.62
4/19/18	7.36	0.27	0.11	<0.01	11	<0.01	<0.01	
4/25/18			0.05					
Average	**7.53**	**0.42**	**0.25**	**0.02**	**2.4**	**0.25**	**0.01**	**0.71**
Minimum	**7.31**	**0.07**	**0.02**	**<0.01**	**<1**	**<0.01**	**<0.01**	**0.61**
Maximum	**7.83**	**1.54**	**0.84**	**0.17**	**11**	**3.16**	**0.03**	**1.09**

The majority of the samples were obtained at the Senior Center kitchen, the distribution sample site for the Well #1 system. In Well System #1 the loss of chlorine residual from the storage to the distribution system was apparent. There was neither free chlorine nor total chlorine residual in the samples prior to March 20, indicating significant chlorine demand in the water.

Except for the initial hydrant sample, the iron levels are below the secondary standard as are the manganese levels. Levels of sulfate are both low and relatively consistent. The total phosphate levels, from the applied polyphosphate sequestrant are consistent.

On March 20, the chlorine dose in the Well 1 system was increased such that a chlorine residual became detectable at the sampling location. The increased chlorine dosage has been sufficient to permit consistent chlorine residuals at the sampling location since the March 20 sampling event.

WELL #2 SYSTEM

The Well #2 system consists of a pump station that withdraws water from the Tunnel City-Wonewoc aquifer, treats it through the addition of polyphosphate sequestrant (Hawkins LPC-5) and sodium hypochlorite for disinfection as well as fluoride to prevent tooth decay. The water is pumped to the distribution system that includes an elevated storage tank to provide consistent pressure in the system as well as capacity for fire suppression.

The system is an important source for the future growth of Dayton as it changes from a rural, agricultural community to a suburban residential community. The well water, like many ground and surface waters in central and southern Minnesota, is vulnerable to excess nitrogen (ammonia and nitrate) primarily from agriculture (Minnesota Pollution Control Agency, 2013). The presence of ammonia is now documented at Well #2 of the Dayton water supply.

The presence of hydrogen sulfide has also been documented in the Dayton system, directly through the foul odor complaints of customers in the neighborhoods around the Water Tower and indirectly through the changing concentrations of sulfate as the hydrogen sulfide is oxidized on the way to and within the Water Tower (which will be discussed in further detail below). There are also issues of iron and manganese in the raw water. These compounds have not always been successfully sequestered as demonstrated by discolored water and rusty water complaints.

Two sample sites were utilized in the Well #2 System. Table 3 shows data collected at the hydrant adjacent to the Well #2 System Well House.

Table 3: Well #2 Water Quality Data

DATE	PH	TOTAL CL_2, MG/L	FREE CL_2, MG/L	NH_4-N, MG/L	SO_4, MG/L	FE, MG/L	MN, MG/L	TP, MG/L AS P	OPO_4, MG/L AS P
2/21/18		1.69	0.01	0.23	2	0.6			
2/26/18	7.56	1.57	0.05	0.22	0	0.24	0.08		
3/1/18	7.27	1.59	0.18	0.26	0	0.16	0.08		
3/8/18	7.22	0.37	0.31	0.21	0	0.22	0.09		
3/12/18	7.55	1.62	0.12	0.20	0	0.16	0.08		

DATE	PH	TOTAL CL_2, MG/L	FREE CL_2, MG/L	NH_4-N, MG/L	SO_4, MG/L	FE, MG/L	MN, MG/L	TP, MG/L AS P	OPO_4, MG/L AS P
3/13/18								1.1	
3/14/18								3.95	
3/15/18	7.60	1.56	0.04	0.20	1	0.19	0.09		
3/19/18								1.03	
3/20/18	7.45	1.58	0.04	0.22	0	0.31	0.09		
3/21/18								1.05	
3/22/18	7.29	1.62	0.3	0.17	0	0.3	0.09		
3/26/18								1.08	
3/27/18	7.50	1.56	0.07	0.24	0	0.34	0.09	1.08	
3/28/18								1.1	
3/29/18	6.67	1.61	0.08	0.23	0	0.30	0.10		
4/2/18	7.51	1.52	0.04	0.21	0	0.31	0.08	1.1	
4/5/18	7.51	1.57	0.09	0.22	0	0.31	0.08	1.05	
4/9/18	7.19	1.69	0.05	0.23	0	0.36	0.08	1.18	
4/11/18	7.33	1.59	0.03	0.21	0	ND*	0.08	3.48	
4/17/18	7.48	1.60	0.05	0.22	0	ND*	0.08	1.4	
4/19/18	7.13	1.74	0.04	0.20	0	ND*	0.09	1.4	
4/24/18	7.33	0.1	0.01	0.25	0	0.42	0.09		0.41
4/26/18	7.20	0.78	<0.01	0.27	0	0.75	0.09		0.17
5/1/18	7.08	0.08	<0.01	0.26	0	ND*	0.09		0.40
5/3/18	7.25	0.15	0.02	0.26	0	ND*	0.10		
5/8/18	7.33	0.11	<0.01	0.24	0	ND*	0.09	1.33	
Average	7.32	1.22	0.07	0.23	<0.1	0.29	0.09	1.55	0.27
Minimum	6.67	0.08	0.01	0.17	0	0.16	0.08	1.03	0.16
Maximum	7.60	1.74	0.31	0.27	2	0.6	0.10	3.95	0.41

While there are good total chlorine residuals leaving the Well Station, it is all combined chlorine – there is little to no free chlorine. There is also the presence of ammonia detected at the well which exerts considerable chlorine demand as shown by the reaction below.

The reaction of ammonia with hypochlorite is:

$$NH_3 + 3HOCl \rightarrow NCl_3 + 3H_2O \qquad \text{Eq. 1}$$

Intentional chloramination to oxidize all of the ammonia requires 3 to 5 mg/L chlorine for every mg/L of ammonia. However, at greater than 8 mg/L chlorine to 1 mg/L of ammonia breakpoint is achieved, the point at which it can be assured that there is no free ammonia. Thus, for the levels of ammonia detected at Well #2, a dosing of 1.9 to 2.9 mg/l of chlorine would be required to oxidize the 0.17 to 0.26 mg/l of ammonia found at the well.

In addition, iron (Fe) was detected at levels near the secondary standard of 0.3 mg/l and manganese is detected at levels above the secondary standard of 0.05 mg/l. The oxidation of both of these metals can exert chlorine demand, though the oxidation of manganese is a slow process. A further discussion of the iron and manganese is continued in the section presenting the water tower data.

The total phosphate and orthophosphate data appear to be consistent with few exceptions. However, the LPC-5 which is a hexametaphosphate, should not have appreciable amounts of orthophosphate(OPO_4). Orthophosphate is a hydrolysis product of total phosphate that does not possess sequestering ability. Iron and manganese can oxidize to rusty looking water if the polyphosphate sequestering is compromised. A discussion was held with Hawkins (chemical supplier) on May 18, 2018. Concerns about the reversion of the polyphosphate product (Hawkins LPC-5) and detectable levels of orthophosphate were raised. Hawkins indicated that there are steps that can be taken to optimize the dosing of the current product.

Table 4 presents data collected at the Water Tower served by Well #2. The Water Tower is the major storage for the Well #2 system and is located adjacent to the neighborhood where the complaints of offensive odor and discolored water have been reported.

Table 4: Water Tower Water Quality Data

DATE	PH	TOTAL CL_2, MG/L	FREE CL_2, MG/L	NH_4-N, MG/L	SO_4, MG/L	FE, MG/L	DISSOLVED FE, MG/L	MN, MG/L	TP, MG/L AS P	OPO_4, MG/L AS P	HPC, MPN/100 ML	TANK LEVEL, FT	TANK STATUS
2/21/18		0.29	0.03	0.08	19	0.65						26.2	drawing
2/26/18	8.2	0.27	0.01	0.07	10	2.41		0.29				25.9	filling
3/1/18	8.05	0.34	0.02	0.06	10	1.52		0.22				25.9	drawing
3/5/18	8.15	0.22	0.02	0.09	19	0.56		0.16				26.7	drawing
3/8/18	8.15	0.30	0.03	0.12	1	0.71		0.13				26.1	filling
3/12/18	8.13	0.30	0.03	0.06	13	1.1		0.18				26.7	drawing
3/13/18									1.06		100		
3/14/18									0.69		1		
3/15/18	8.09	0.30	0.01	0.07	17	1.3		0.17				25.8	drawing
3/19/18									6.45		<1		
3/20/18	7.98	0.31	<0.01	0.08	5	0.96		0.19				26.6	drawing
3/21/18									4.13		3.1		
3/22/18	8.05	0.31	<0.01	0.08	<1	2.04		0.16				26.6	drawing
3/26/18									4.18		3.1		
3/27/18	7.99	0.34	0.01	0.08	9	1.15		0.19				27	filled
3/28/18									1.9				
3/29/18	7.99	0.33	0.03	0.09	13	1.1		0.17				26.7	drawing
4/2/18	7.99	0.32	0.03	0.1	8	1.35		0.21	4.45		13.5		
4/5/18	8	0.32	0.06	0.11	3	0.33		0.22	4.6				
4/9/18	7.97	0.31	0.01	0.09	10	2.33		0.21	5.05			27	drawing

DATE	PH	TOTAL CL_2, MG/L	FREE CL_2, MG/L	NH_4-N, MG/L	SO_4, MG/L	FE, MG/L	DISSOLVED FE, MG/L	MN, MG/L	TP, MG/L AS P	OPO_4, MG/L AS P	HPC, MPN/100 ML	TANK LEVEL, FT	TANK STATUS
4/11/18	7.44	0.78	0.02	0.13	1	0.43		0.07	2.0		140.5		
4/17/18	7.87	0.32	0.01	0.11	4	2.71	0.02	0.25	5.2	2.75	111	26.3	drawing
4/19/18	7.88	0.29	<0.01	0.11	11	3.3	0.01	0.43	5.25	0.9	90.6	25.5	filling
4/24/18	7.45	0.52	<0.01	0.11	<1	0.42	0.02	0.10		2.75	57.3		filling
4/26/18	7.43	0.33	<0.01	0.14	<1	0.75	0.03	0.11		3.04			filling
5/1/18	7.51	0.34	0	0.15	0	2.88	<0.01	0.23					
5/3/18	7.42	0.34	0.1	0.14	0	2.06	0.03	0.22					
5/7/18									2.55	1.66	56.5		
5/9/18											66.3		
Average	7.86	0.34	0.02	0.09	7	1.48	0.02	0.20	3.72	2.22	57.5	26.3	
Min	7.34	0.22	<0.01	<0.01	<1	0.33	0.01	0.07	0.69	0.9	1	25.5	
Max	8.20	0.78	0.06	0.17	19	3.3	0.03	0.43	6.45	3.04	140	27	

Sulfate concentration changes from 0 mg/L at the well to a maximum of 19 mg/L at the water tower. Sulfate is being created, most likely from oxidation of hydrogen sulfide and sulfide ions (HS^-) in the raw water. Since hydrogen sulfide gas is volatile, it is hard to analyze in the laboratory. Field analysis or odor testing at the sample site collection point is the best way to determine the presence of hydrogen sulfide. Aqueous hydrogen sulfide is a very noticeable odorous gas (rotten egg odor) that readily dissipates when water containing it is agitated or exposed to the atmosphere. Hydrogen sulfide is easily detected in the air at concentrations as low as 0.5 parts per billion (ppb). This concentration would generally equate to a hydrogen sulfide concentration near 0.5 mg/l in the water. Sulfides at this level will have a musty odor. Sulfides that exceed 1 mg/l in the water will generate the very noticeable and objectionable rotten egg odor.

The reactions of hydrogen sulfide with hypochlorite are:

$$H_2S + 2HOCl \rightarrow S^0 + 2Cl^- + 2H_2O \qquad \text{Eq. 2}$$

$$H_2S + 4HOCl \rightarrow H_2SO_4 + 4H^+ + 4Cl^- \qquad \text{Eq. 3}$$

In the first reaction, elemental sulfur, a small particulate, is produced and can be removed by filtration. In the second reaction, soluble sulfate ion is produced. It takes two to four molecules of hypochlorite to oxidize one molecule of hydrogen sulfide and the result is one molecule of sulfur or sulfate. To oxidize hydrogen sulfide completely to the sulfate form, 8.32 mg/l of chlorine are needed for each mg/l of hydrogen sulfide oxidized. The reaction is not a rapid one – approximately 20 minutes are required for completion. As the levels of sulfate at the Tower average 9 mg/l with a peak at 19 mg/l, equation 3 was used to determine what the raw water hydrogen sulfide must be, assuming that most of the sulfide reacts to sulfate.

Dissolved Fe is iron that remains in solution after a sample is passed through a 0.45 micron filter before analysis. The filter removes particulate iron. The majority of iron at the Water Tower site is particulate iron, indicating that the sequestrant is not functioning as it should to complex the iron before it can oxidize. Iron measurements at the Water Tower average 1.48 mg/l while the dissolved iron averages 0.02 mg/l. Assuming an average daily flow of 135,000 gallons per day and that most of the iron that enters the Water Tower settles there, then the Water Tower gains 1.7 pounds of iron each day. While this may not seem like much, consider that the secondary limit for iron is 0.3 mg/l, so the accumulating iron, when released during periods of high demand, can cause widespread rusty or discolored water throughout the system.

The measured iron and manganese levels at the Water Tower are much higher than at the well. As sulfide interferes with the iron analysis giving improper results, the higher iron results are another indicator that there is hydrogen sulfide at the Well and that it is oxidizing on the way to the Water Tower. Iron and manganese also exert chlorine demand, particularly if they are not completely sequestered prior to the addition of the hypochlorite. The reactions of hypochlorite with iron and manganese are presented below. The manganese oxidation is very slow.

$$2Fe^{2+} + H^{+} + HOCl \rightarrow 2Fe^{3+} + Cl^{-} + H_2O \qquad \text{Eq. 4}$$

$$2Mn^{2+} + H^{+} + HOCl \rightarrow 2Mn^{3+} + Cl^{-} + H^{2}O \qquad \text{Eq. 5}$$

It is also notable that the chlorine residuals are lost and the iron and manganese are oxidized by the time that the water travels from the well house to the water tank as shown by the tank fill statistics in Table 5 as compared to the overall tank water quality statistics.

Table 5: Water Tower Water Quality While Filling

DATE	PH	TOTAL CL_2, MG/L	FREE CL_2, MG/L	NH_4-N, MG/L	SO_4, MG/L	FE, MG/L	MN, MG/L
Average	8.05	0.30	0.01	0.095	7.8	1.89	0.26
Minimum	7.88	0.27	<0.01	0.07	1	0.71	0.13
Maximum	8.20	0.34	0.03	0.12	11	3.3	0.43

Based on the data collected at the water tank, an estimate of the chlorine demand of the Well #2 water was determined using sodium hypochlorite to oxidize all the reduced elements and compounds in the raw water. These calculations are presented in Table 6. A free chlorine residual of at least 0.5 mg/l is desirable after all of the raw water demand is satisfied so that there always a chlorine residual in the system in the event of a cross connection or pressure transient.

Table 6: Well #2 System Chlorine Demand

PARAMETER	MOL. WT., MG	CONC., MG/L	EQUIVALENT, MM/L	CL_2 EQUIVALENT, MM/L	CL_2 DOSE, MG/L	
NH_3-N	14	0.22	0.016	0.048	3.36	Eq. 1
H_2S	34	3.1	0.091	0.36	25	Eq. 3
Fe^{2+}	55.8	1.4	0.025	0.0125	0.88	Eq. 4
Mn^{2+}	55	0.21	0.004	0.002	0.14	Eq. 5
Cl_2	70					
Sum of demand dosing for chlorine					29.4	
Plus dose for residual					0.5	
Total required chlorine dose					29.9	

It is likely that some of the hydrogen sulfide dissipates in the Water Tower before the chlorine can oxidize it so that the calculation of chlorine demand is very conservative. Nevertheless, chlorine demand is much higher than the applied dose of chlorine resulting in a lack of residual at the Water Tower. The sulfide and metal oxidation reactions are reversible if the oxidant is consumed and conditions revert to an anoxic state. This can happen at the bottom of storage tanks if a layer of iron/manganese particulates build up and oxygen and chlorine are gone from the lowest parts of the tank.

Recommendations

WELL #1 SYSTEM

As discussed, the water quality at Well #1 is relatively stable and manageable. The recommendations for the Well #1 system are as follows:

1. Maintain chlorine dosing so that a chlorine residual of 0.40 to 0.60 mg/l total chlorine is detected at the Senior Center kitchen.
2. Maintain polyphosphate dosing so that a concentration of 0.50 to 0.70 mg/l as total phosphate is detected at the Senior Center kitchen.
3. Continue to monitor at a frequency of once a week.

WELL #2 SYSTEM

Given the water quality challenges present at Well #2, both short term mitigations as well as longer term permanent solutions will be required as Dayton seeks to expand the use of this well to serve new customers. Over the short term, some changes to operational best practices can be instituted to verify optimal sequestering of the iron and manganese and control of the hydrogen sulfide and ammonia in the raw water. These short-term steps are outlined below.

1. Obtain a scale for the polyphosphate feed, measure weight change, and determine dosing daily based on flow. Determine dosing for the chlorine gas feed also and record flow and dose information as well as free and total chlorine residual at the well house every day.

2. Optimize the phosphate feed

    a. Mix the polyphosphate into the water as completely as possible before the chlorine is added. That permits the polyphosphate to react with the iron and manganese before the chlorine can compete.

    b. Add the chlorine as far downstream of the polyphosphate feed as possible.

    c. Determine if there is a more appropriate phosphate product that can be used instead of the Hawkins LPC-5. Determine correct dose to optimally sequester iron and manganese.

3. Increase the chlorine dose no more than 10% and monitor chlorine residuals (free and total) as well as ammonia at the Well house and at the Water Tower. If there is still measurable ammonia at the Water Tower a week after the chlorine increase, increase the dose by 10% again and continue to monitor. The goal is no measurable ammonia at the Water Tower.

4. Add a chlorine feed system to the Water Tower site. Consideration should be given to adding chlorine as water flows out of the tank (during tank draw) so that water that flows to residents has a chlorine residual. Both flow direction and chlorine residual should be monitored. Combined with increased chlorine dosages at the well house, the goal is more consistent chlorine residuals within the distribution system.

5. Determine if the water tower could benefit from level operational changes, increased mixing, or inlet/outlet configuration changes.

6. Continue the current monitoring program though the frequency can drop to once a week once the chlorine dose is such that there is no measurable ammonia at the Water Tower.

However, with the current water quality, no amount of treatment with the existing facilities and recommended short term solutions will completely eliminate the present water quality issues. The short-term steps will only buy time until the longer-term solutions can be implemented which include:

1. Determining how ammonia is infiltrating the Well #2 aquifer. The major sources are anthropogenic, typically from agricultural fertilizers or local leachfields too close to the well. If Dayton intends to withdraw more water from the aquifer as the served population increases, the residence time of the water in the aquifer will decrease and pollutant levels may rise as soil microbes have less time to convert the ammonia to nitrite, nitrate, and finally nitrogen gas. If any monitoring wells remain from the Well #2 exploration activities, chemical monitoring of nitrogen species, iron, manganese, and sulfur species should be conducted.

2. Investigating if a new well with improved water quality can be installed. A new well has the additional benefit of providing a source for more water as Dayton grows. It could also serve as a backup to the existing Well #2 which currently has no redundancy.

3. Planning for treatment of the Well #2 water to remove hydrogen sulfide, ammonia, iron, and manganese prior to disinfection and distribution of the water to the service area. This is the ultimate solution to ensure consistent, high quality water for the City. The treatment capacity would need to be designed not only to treat the water quality that currently exists but to anticipate that water quality may deteriorate as more water is withdrawn from the aquifer.