CHAPTER 6

WATER SYSTEM EVALUATION

An important component of this study was the evaluation of the existing water system and performing a deficiency analysis. This chapter summarizes the findings from this evaluation.

6.1 EXISTING SYSTEM DEFICIENCY ANALYSIS

Water systems are analyzed, planned, and designed primarily through the application of basic hydraulic principles. Some important factors that must be considered when performing this analysis include:

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

For this study, an evaluation of the Sister Bay 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:

1. Pressure
2. Flow Capacity
3. Reliability
4. Supply
5. Storage

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

6.2 WATER SYSTEM COMPUTER MODEL

A computer model was developed of the Village's water distribution system. The Sister Bay system was modeled using *H_2OMap*, a pipe network program developed by MWH Soft. Individual system water pipe roughness coefficients were estimated based on the diameter and types of pipe materials, and approximate age of each section of water main using roughness aging curves developed from field testing of the Sister Bay system.

The Sister Bay water system model was calibrated using results of flow testing performed for this study in Fall 2005. Table 6-1 summarizes flow testing results. During the model calibration process, pumping rates, customer demands, and tower water levels were set to the field conditions, and pipe roughness coefficients were adjusted until the calibrated system model adequately simulated field test data.

TABLE 6-1

SYSTEM FLOW TEST RESULTS

SISTER BAY WATER UTILITY

VILLAGE OF SISTER BAY, WISCONSIN

Date of Testing: September 26 & 27, 2005

Test No.	Hyd. No.	Flowing Hydrant Street	Flowing Hydrant Street	Flow (gpm)	Hyd. No.	Residual Hydrant Street	Residual Hydrant Street	Static (psi)	Residual (psi)
F-1	254	North end of Hillcrest Drive Cul-de-sac		420	316	First Hydrant south of flowing		55	41
F-2	314	North end of Beach Road		508	34	Beach Road	Bayview Road	84	62
F-3	18	Bay Shore Drive - 3rd Hydrant south of Waters End Road		750	16	Bay Shore Drive - 4th Hydrant south of Waters End Road		59	38
F-4	96	Trillium Lane east of Birchwood Dr.		780	62	Birchwood Drive west of Trillium Ln.		83	59
F-5	157	North end of West Little Sister Road		828	155	1st Hydrant south of flowing		87	57
F-6	101	Bay Shore Drive west of Forest Lane		1,108	97	Bay Shore Drive	Meadow Lane	67	51
F-7	329	West end of Sunnyside Road		922	317	Sunnyside Road	Sunnyside Ct.	45	40
F-8	223	Cherrywood Lane	Koessl Lane	1,632	125	2nd Hydrant north of flowing		45	34
F-9	318	Last Hydrant east of WWTP		922	186	1st Hydrant west of flowing		82	52
F-10	245	East of Smith Drive		953	241	2nd Hydrant west of flowing		60	51
F-11	13	Mill Road	South Spring Dr.	998	37	Mill Road	Park Lane	48	38

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6.3 WATER SYSTEM PRESSURES

The Sister Bay water system model was used to evaluate existing water distribution system characteristics and identify deficiencies with respect to pressures and flow capacities. Water system pressure will vary around the service area based on differences in topographic elevations, as well as supply rates and customer demands. In general, as customer demands increase, pressures will decrease. Areas higher in topographic elevation will also tend to exhibit lower water system pressures.

A water distribution system must be designed to provide pressures within a range of minimum and maximum allowable conditions. When system pressure is too low, customers may complain of inadequate water supply, customer meters may tend to record inaccurately, and fire protection will be limited. Pressures that are too high can cause problems with system operation and maintenance, and will tend to cause higher consumption rates by customers. High water system pressures can also increase the amount of water loss, as leakage rates will increase with increases in system pressure.

The Wisconsin Administrative Code requires that municipal water systems be designed with a minimum pressure of 35 psi and a maximum pressure of 100 psi at all locations in the service area under normal operating conditions. Furthermore, water systems are required to be operated so that under fire flow conditions, the residual pressure in the system will not fall below 20 psi at any location.

Highest system pressures, between 80 and 90 psi, typically occur in low topographic elevation areas of the HLPZ in the far western portions of the Village along the Green Bay shoreline, and in areas along Woodcrest Road and Scandia Road. The lowest system pressures (30 to 40 psi) can occur in the Main Pressure Zone along the pressure zone boundary near the Highway 42 and 57 intersection. Pressures in the LGSD No. 1 can range between 40 and 80 psi. The lowest pressures in the District are typically in the far eastern and northeaster portion of the service area.

Figure 6-1 illustrates ranges of water system pressures throughout the Village for a current typical peak hour demand condition. As indicated in the figure, peak hour system pressures can vary between 30 and 90 psi.

6.4 FIRE FLOW CAPACITIES

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.

Fire protection needs vary with the physical characteristics of each building 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 Village'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.

Table 6-2 shows typical fire flow requirements for various land uses. 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. The minimum fire flow requirements used as a basis for evaluating the

TABLE 6-2

TYPICAL FIRE FLOW REQUIREMENTS

SISTER BAY WATER UTILITY
VILLAGE OF SISTER BAY, WISCONSIN

Land Use	**Range of Needed Fire Flows (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

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Sister Bay water system were 1,000 gpm in medium and low density residential areas, and 2,000 gpm in all high density residential and commercial development areas.

Figure 6-2 illustrates the estimated available fire flow throughout the Village for a typical maximum day water demand while maintaining a residual pressure of 20 psi throughout the system. In general, the majority of the Village is well protected with minimum fire flows of 2,000 gpm or higher in most high density residential and commercial areas. Areas with lower available flows are primarily located on the far northeastern extremity of the system in the HLPZ, where available fire flows are less than 1,000 gpm. There is a small isolated area in the northeast corner of the HLPZ (LGSD No. 1) where available fire flows are less that the code required minimum of 500 gpm at 20 psi. The hydraulic strength of the distribution system is limited in this area, resulting in limited available fire flows.

Figure 6-3 identifies areas where fire flow deficiencies currently exist. Deficiencies were identified where the basic Sister Bay/Liberty Grove Fire Department guidelines were not met for a particular land use as determined from the planning area land use map. The primary areas identified with fire flow deficiencies include the low flow areas in the LGSD and several locations in the HLPZ with high density residential development.

6.4.1 Pipe Velocities, Head Loss, and Flow Carrying Capacity

Pipe flow velocities within the distribution system are typically well below 1 foot per second (fps) under average demand conditions. Even during periods of higher demand, flow velocities typically do not exceed 5 fps anywhere in the system. Water main pipe segments that have high flow velocities or head losses have limited flow or transmission capacity caused by the limited number and/or sizes of water mains.

6.5 SUPPLY RELIABILITY

For any water utility to serve its customers and protect the public welfare, water system facilities, equipment, and distribution systems must be reliable under all operating conditions. Reliability of utility service comprises a large part of the Water Utility's investment in plant and equipment.

Wisconsin Administrative Code requires all pumping stations to be served by a power supply from at least two independent electrical substations, or from a standby, auxiliary power source dedicated to water supply use. As a general rule, the Utility should be able to reliably supply average day customer demands and maintain adequate fire protection using auxiliary power sources.

From a review of the alternative power and supply sources available, the system can supply approximately 2.1 mgd using standby power sources in the event of an emergency or other power interruption. Therefore, the system has sufficient auxiliary power to meet current needs and projected year 2025 average day pumpage requirements. It will be important for the Utility to continue to maintain a water supply capacity provided with auxiliary sources of power to meet a minimum of an average day water demand throughout the planning period.

6.6 WATER SUPPLY AND STORAGE

A critical step in long-range planning for the Sister Bay water system was identifying the future needs of the service area coupled with an assessment of water supply and storage requirements. Water supply and storage needs are closely related. The primary criteria used in determining required supply rates and

storage volumes include maximum and peak demands, operational characteristics, and fire protection needs.

6.6.1 Reliable Supply Capacity

It is frequently necessary to take a well pump out of service for periods of several days to several weeks for maintenance. Therefore, the reliable supply capacity of a water system is the total available delivery rate with the largest pumping unit out of service. For example, under present operating conditions, the existing wells have a combined total capacity of approximately 1,440 gpm as shown in Table 6-3. However, the reliable capacity of the supply wells is approximately 950 gpm with the largest unit (Well 1) out of service.

For evaluating a municipal water system, reliable supply capacity should at least equal maximum day pumpage requirements, assuming adequate storage is available. If this criterion is 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, Table 6-4 summarizes minimum future supply needs.

The water utility currently has adequate supply capacity, as the existing reliable capacity (1.37 mgd) is larger than the current design maximum day pumpage of 0.77 mgd. Figure 6-4 compares historical water supply capacities with historical maximum day pumpage requirements. As illustrated in the figure, the utility should have adequate reliable supply capacity to meet current maximum day demands in the system.

Figure 6-5 compares Sister Bay water supply capacities with historical and projected maximum day pumpage requirements. As illustrated in Figure 6-5, the Utility has sufficient reliable supply capacity to meet current and future water needs throughout the planning period.

6.6.2 Water Storage Needs

In addition to providing water for fire protection, 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. The primary criteria used in this study for evaluating storage volume needs includes average and peak demands, water supply capacities, and fire protection needs.

In general, storage facilities should be adequately sized to provide sufficient quantities of water for fire protection on days of maximum customer demands. Although storage requirements for fire protection are not anticipated to change over the planning period of this study, peak hour demands and reliable supply capacities will change as the Village grows and improvements are implemented.

Figure 6-6 illustrates general categories of system storage. 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. Storage should also be available for fire protection purposes. To assure a reliable supply for fire protection, this reserve storage should not be utilized to meet peak hour requirements.

In some instances, it may be desirable to provide additional reserve storage for other purposes. Reserve storage may be needed as a safety factor in emergencies or where customer demands are unpredictable

TABLE 6-3

RELIABLE SUPPLY CAPACITY

SISTER BAY WATER UTILITY
VILLAGE OF SISTER BAY, WISCONSIN

Supply Source	*Current Minimum Operating Capacities*	
Well Pumps:	**(gpm)**	**(MGD)**
Well 1	490	0.71
Well 2	480	0.69
Well 3	470	0.68
Total Supply Capacity	1,440	2.07
Less: Largest Supply Unit	490	0.71
RELIABLE SUPPLY CAPACITY	**950**	**1.37**

Notes

1. Approximate minimum operating capacities of well pumps based on current available operating data.

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TABLE 6-4

RECOMMENDED SUPPLY CAPACITY

SISTER BAY WATER UTILITY
VILLAGE OF SISTER BAY, WISCONSIN

	Actual 2005	Projected 2015	Projected 2025
Total Annual Pumpage (MGY)	89	100	122
Average Day Pumpage (MGD)	0.24	0.27	0.33
Design Maximum Day Pumpage (MGD)	0.77	0.86	1.05
Existing Reliable Supply Capacity (MGD)	1.37	1.37	1.37
ADDITIONAL CAPACITY REQUIRED (MGD)	**None**	**None**	**None**
ADDITIONAL CAPACITY REQUIRED (gpm)	***0***	***0***	***0***

Note

Design maximum day pumpage requirements were estimated based on 315% of average day pumpage.

* The above figures are based on the pumps running 24 hours per day.

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and fluctuate widely. Additional storage may also be desired where a Utility wishes to take advantage of off peak electrical rates for pumping. Additional reserve storage of approximately 10 to 15 percent is usually provided to allow an operating range for well and booster pump operation.

Three primary criteria were used to develop a relationship between supply capacities and optimum storage volumes for the Village of Sister Bay:

1. Reliable supply capacity should at least equal projected maximum day pumpage requirements.

2. Total available storage should be capable of meeting fire protection needs, assuming reliable supply capacity is just adequate to meet maximum day requirements. A base fire flow of 2,000 gpm for three hours was used.

3. Reliable supply capacity, plus available storage volume, should equal or exceed fire flow requirements plus maximum day requirements.

6.6.3 Available Storage Capacity

Total available system storage was calculated based on the effective storage volume available from the elevated tank and standpipe. The effective storage volume of the elevated storage tanks is the volume in storage above the lowest water level that could by maintained and provides minimum required pressures in the system. Under normal conditions, system pressures are required to be maintained above 35 psi. Under emergency conditions, pressures may be reduced to 20 psi.

Figure 6-7 illustrates this relationship between standpipe storage volume and required minimum water levels needed for establishing system pressures. Effective peak hour operating storage and emergency storage volumes for the Sister Bay system have been determined based on minimum required system pressures in the distribution system.

The effective storage volume from the standpipe is summarized in Table 6-5. Under normal operating conditions, the standpipe water level can drop approximately 4 feet below the overflow level before system pressures can fall below the required minimum 35 psi at the highest ground elevations served by the Main Pressure Zone. Therefore, the maximum effective peak hour storage volume of the standpipe is approximately 9,000 gallons. During fire flow or emergency situations, the standpipe water level can drop an additional 35 feet, resulting in an additional 73,000 gallons of water available. Therefore, the maximum total effective storage volume of the 0.1 MG standpipe is approximately 0.082 MG.

6.6.4 Supply and Storage Requirements

The amount of water storage required is related to available supply capacity. As supply capacity is increased, the amount of storage required decreases. This relationship is illustrated in Figure 6-8, which is a plot of supply and optimum storage requirements for the Sister Bay water system in the years 2005 and 2025. Optimum storage requirements were estimated assuming future supply capacities would just equal maximum day demands.

A point is plotted on the graph in Figure 6-8 that represents existing conditions where Sister Bay supply facilities have a reliable capacity of 950 gpm, and the total storage available is 0.232 MG. To comply with the design criteria specified earlier, the point that corresponds to actual reliable supply and storage capacities should fall on or above the supply-storage curves indicated in this figure. As illustrated in the

TABLE 6-5

EFFECTIVE STANDPIPE VOLUME

SISTER BAY WATER UTILITY

VILLAGE OF SISTER BAY, WISCONSIN

Design Volume (gallons)	100,000
Diameter (feet)	19
Head Range (feet)	48
Storage volume per foot (gallons)	2,100
Overflow elevation (feet USGS)	730
Highest elevation served in Main Zone (feet USGS)	645
Hydraulic Grade Elevation needed to provide minimum 35 psi to all areas	726
Maximum Effective Peak Hour Storage Volume (gallons)	9,000
Hydraulic Grade Elevation needed to provide minimum 20 psi to all Main Zone areas	691
Additional Effective Fire Protection and Emergency Storage Volume (gallons)	73,000
Total Effective Storage Volume (gallons)	**82,000**

Notes

1. Effective peak hour storage is considered the volume available which will continue to maintain pressures in the distribution system at a minimum of 35 psi.
2. Effective fire protection and emergency storage is considered the volume available which will continue to maintain pressures in the distribution system of a minimum of 20 psi.

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figure, while the Utility currently has adequate reliable supply capacity, there is inadequate water storage volume available to meet present and future system needs. Current and projected Sister Bay supply and storage needs are summarized in Table 6-6.

6.7 SUMMARY

This chapter summarized the findings from evaluation of the Sister Bay water system. Major findings from this evaluation include the following:

1. Under all normal operation conditions, the system provides pressures between 30 and 90 psi. There is only a very small isolated area where distribution system pressures can fall below the minimum required 35 psi. There are no locations in the existing water service area where pressures can exceed the maximum 100 psi.

2. There are several large areas within the HLPZ where available fire flows are below recommended minimum flows.

3. The system can adequately supply water to meet average day customer demands in using standby power generating equipment throughout the planning period.

4. The Utility has adequate reliable water supply capacity to meet current and projected future supply needs throughout the planning period.

5. The Utility has inadequate water storage volumes available to meet current and projected future storage needs.

TABLE 6-6

SUPPLY AND STORAGE NEEDS

SISTER BAY WATER UTILITY

VILLAGE OF SISTER BAY, WISCONSIN

SUPPLY REQUIREMENTS	**Actual 2005**	**Projected 2015**	**Projected 2025**
Recommended Reliable Supply Capacity (gpm)	530	600	730
Present Maximum Day Reliable Supply Capacity (gpm)	950	950	950
Additional Capacity Required (gpm)	**None**	**None**	**None**

STORAGE REQUIREMENTS	**Actual 2005**	**Projected 2015**	**Projected 2025**
Peak Hour Equalizing Requirements (gallons)	97,000	109,000	133,000
Optimum Fire Protection Needs (gallons)	360,000	360,000	360,000
Reserve Storage (gallons; 10% of Total)	50,000	52,000	54,000
Total Optimum Storage Requirements (gallons)	**507,000**	**521,000**	**547,000**
Total Storage Capacity (gallons):			
Jungwirth Tower	150,000	150,000	150,000
Hwy 57 Standpipe	82,000	82,000	82,000
Total	**232,000**	**232,000**	**232,000**
Additional Capacity Required (gallons)	***275,000***	***289,000***	***315,000***

Notes

1. Peak hour storage is storage required to meet demands which exceed the reliable supply capacity. Future peak hour equalizing storage requirements were calculated assuming the available supply is equal to the maximum day demand rate.
2. Reserve storage is storage required to provide a start/stop range for well pump operation and an emergency reserve storage supply.

C:\Documents and Settings\pplanton\My Documents\Projects\Sister Bay copy\Report\Chapter 6\[table6_x.xls]TABLE 6-6