CHAPTER 3

WATER SYSTEM ANALYSIS

TABLE OF CONTENTS

CHAPTER 3, WATER SYSTEM ANALYSIS

TABLES

FIGURES

Figure No Description On or Follows Page

CHAPTER 3

WATER SYSTEM ANALYSIS

OBJECTIVE

The objective of this chapter is to determine if system improvements are necessary to meet water quality standards and to meet projected demands. This chapter addresses the following elements:

- System design standards
- Water quality analysis
- System description and analysis
- Water rights analysis
- Summary of system deficiencies
- Selection and justification of proposed improvements

WATER SYSTEM STANDARDS

This section outlines the various standards that the North Beach Water District (NBWD) is required to, or has chosen to comply with. Standards include Water Quality Standards, and Planning Standards and Design Standards, as outlined in the following sections.

WATER QUALITY STANDARDS

NBWD is a public water supply system regulated by the Washington State Department of Health (DOH) Drinking Water Regulations, WAC--246-290, the latest edition of which is dated March 30, 2012, as well as sections of Code of Federal Regulations (CFR) Title 40, Parts 141 and 143, adopted by reference in WAC 246-290. NBWD has a ground water supply, so only ground water supply regulations apply.

PLANNING AND DESIGN STANDARDS

The Standards for planning and design for NBWD are based on commonly accepted standards including the following:

WAC 246-290, Group A Public Water Systems, Washington State Board of Health (July 2004)
This is the primary drinking water regulation used by DOH. It sets basic standards to assess capacity, water quality, and system reliability.

Water Use Efficiency Rule, Washington State Board of Health (January 2007)
The Water Use Efficiency (WUE) Rule is a collection of revisions to WAC 246-290, which have been incorporated into WAC 246-290. The WUE Rule revisions have added to and amended certain definitions, added WUE requirements to water system planning requirements and small water system management plans, added a new section requiring

installation of water service meters, and added new sections on Water Use Efficiency Planning, including Purpose and Applicability, Water Use Efficiency Program, Distribution System Leakage Standard, Water Use Efficiency Goal Setting, and Water Use Efficiency Performance Reports.

Water System Design Manual, Washington State Department of Health (December 2009)
These standards serve as guidance for the preparation of plans and specifications for Group A public water systems in compliance with WAC 246-290.

Recommended Standards for Water Works, A Committee Report of the Great Lakes - Upper Mississippi River Board of State Public Health and Environmental Manager (2012)
Commonly known as the Ten States Standards, this document formalizes the design standards recommended by a water supply committee representing ten Midwestern and upper Great Lake States and the Province of Ontario. The report of the Water Supply Committee was first published in 1953, and subsequently revised and published in 1962, 1968, 1976, 1982, 1992, 1997 and 2003. The report presents recommendations for both design and construction standards; however, the construction standards are somewhat general in nature with minor emphasis on materials specifications. Since surface water treatment is quite common in the Midwest and Upper Great Lakes, the Committee report tends to concentrate on water treatment plant design and operation.

Standard Specifications for Road, Bridge and Municipal Construction, Washington State Department of Transportation, American Public Works Association (2014)
These standards include detailed specifications for materials and workmanship of a wide variety of public works projects, including installation of public water supply facilities.

North Beach Water District Standard Specifications for Water Main Construction
These standards include detailed specifications for materials and workmanship for installation of water main extensions, including piping installation details, thrust blocking, in-line valves, fire hydrants, air release valves, service connections of various types, sample stations, blow offs, and pavement restoration applicable to developer extensions. A copy of these standards is contained in Appendix E.

SYSTEM CAPACITY STANDARDS

NBWD uses the DOH Water System Design Manual as a guide for establishing water system capacity standards. Table 3-1 lists the recommended standards from the DOH Manual and the NBWD policies with regards to each standard for general facility design.

TABLE 3-1

General Facilities Requirements

Standard	DOH Water System Design Manual	NBWD Standard
Average Day and Maximum Day Demand	Average day demand should be determined from previous metered water production and consumption data.	Average day consumption per ERU is **114 gpd.** The maximum day to average day factor is 2.44, and the maximum day consumption per ERU is **278 gpd**, as developed in Chapter 2 of this Plan.
Peak Hour Demand	Peak hour demand is determined using the following equation: PHD = (MDD/1440)((C)(N) + F) + 18 Where: MDD = Maximum Day Demand in gallons per day per ERU C = Coefficient from DOH Water System Design Manual Table 5-1 N = Number of connections, ERUs F = Factor from DOH Water System Design Manual Table 5-1	Peak hour demand is determined by applying the DOH Water System Design Manual Formula where MDD = 278 gpd per ERU, C=1.6 and F = 225, which simplifies to the equation: **PHD = 0.309 x N + 61**
Minimum System Pressure	The system should be designed to maintain a minimum of 30 psi in the distribution system under peak hour demand and 20 psi under fire flow conditions during MDD.	NBWD will meet or exceed the DOH required minimums.
Maximum System Pressure	Regulations do not address maximum system pressure. The Water System Design Manual, Chapter 8, part 8.1.7, recommends that pressures should not exceed 100 psi.	NBWD does not provide pressure in excess of 100 psi.
Minimum Pipe Sizes	The diameter of a transmission line shall be determined by hydraulic analysis. The minimum size distribution system line shall not be less than 6-inches in diameter, except for dead end lines not providing fire flow and only as justified by a hydraulic analysis.	Same as DOH Water System Design Manual

Standard	DOH Water System Design Manual	NBWD Standard
Valve Spacing	Sufficient valving should be placed to keep a minimum number of customers out of service when water is turned off for maintenance or repair.	Valves every 1,000 feet, three gate valves at every tee and four at every cross unless otherwise directed by the System Manager. Valves on each end of an easement or at each end of a water main in an easement.
Source Reliability	18 hours of source pumping to meet maximum day demand. Source capacity to replenish fire storage capacity within 72 hours while meeting maximum day demand. Redundancy in all critical pumping systems. Backup power supply for all critical pumping systems.	Same as DOH Standard.
Fire Standards	WAC 246-293-640 sets minimum fire flow standards for water systems with 1,000 or more service connections or located in a critical water supply service area. Pacific County has not set any more stringent standards applicable to the North Beach area, and has not disallowed nesting of standby and fire storage. Applicable state standards apply.	State minimum standards apply as follows: Land Use – Flow Capacity – Duration Residential – 500 gpm – 30 Minutes Commercial and Multi-Family – 750 gpm – 60 Minutes Hydrant Spacing: Minimum every 900 feet

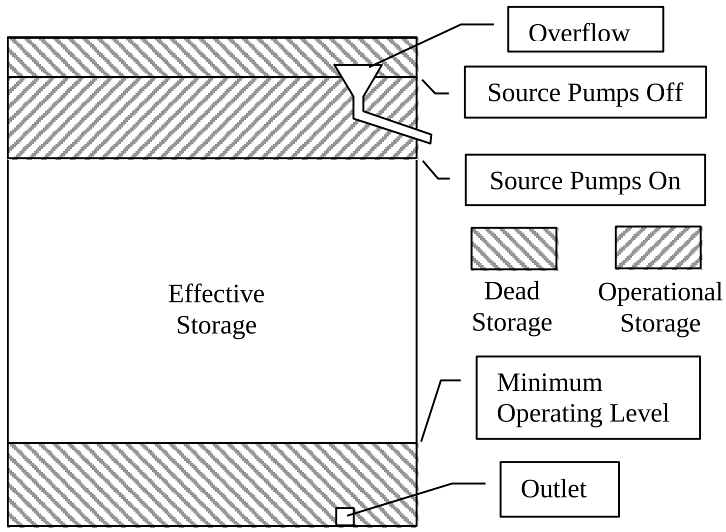
Storage Standards

Effective Storage

The nominal volume of a water reservoir is generally taken as the amount of water the reservoir could hold if filled all the way to the top of the reservoir wall. However, practically speaking, a reservoir cannot be filled to the top of the wall and a reservoir also cannot, under normal operational conditions, be drained completely. Therefore, there is a need to determine how much of a reservoir volume is *effective* storage, and how much effective storage a water system needs. Figure 3-1 is a conceptual diagram of a typical reservoir, showing effective, operational and dead storage volumes.

FIGURE 3-1

Typical Reservoir Effective, Operational and Dead Storage Volumes



The DOH Water System Design Manual identifies the following components of reservoir storage volume:

- Operational Storage
- Equalizing Storage
- Standby Storage
- Fire Suppression Storage
- Dead Storage

A reservoir's effective storage volume is the nominal volume less operational storage and dead storage. This volume must be large enough to accommodate the requirements for equalizing storage, standby storage and fire suppression storage.

Operational Storage

Operational storage is the amount of water that flows in and out of a reservoir during normal system control cycling. Reservoirs typically operate with a maximum water level at which all source pumps are turned off, and a minimum level at which all source pumps are turned on. The amount of water between these two levels depends upon the operational control levels and the dimensions of the system's reservoirs. The operational storage volume must be great enough to prevent excessive cycling of source pumps, and it must also be great enough so that the level controls can clearly differentiate between source pump on and off levels.

Equalizing Storage

Equalizing storage is the amount of water needed to meet peak system demand for a period of time when the system demand exceeds the system source capacity. The DOH Water System Design Manual recommends that this volume be estimated as PHD minus source capacity for 150 minutes, but not less than zero.

Standby Storage

Standby Storage is water held in reserve for emergency situations, such as temporary loss of a water source. The DOH Water System Design Manual recommends that this volume be estimated as 2 days of average day demand for the water system, less the amount of water that can be produced by the water system in one day with the largest source of supply out of service, but not less than 200 gallons per ERU.

Fire Suppression Storage

Fire Suppression Storage is the maximum fire flow rate standard times the maximum fire flow duration standard for the water system. The Uniform Fire Code sets minimum building standards based on fire flows available, but does not specifically set fire flow standards for water systems. Pacific County's building and fire code ordinances do not adopt a minimum fire flow standard to be applied to water utilities. WAC 246-293-601, et seq., sets state minimum fire flow standards for water systems with 1,000 or more service connections, or located within a critical water supply service area. NBWD currently has more than 1,000 service connections, so this regulation, at a minimum, applies. Fire flow standards are shown in Table 3-1. The maximum applicable standard for NBWD is 750 gpm for 60 minutes, which is 45,000 gallons of fire suppression storage.

Dead Storage

Dead storage is the volume of the reservoir that either cannot be utilized for storage because it is above the maximum operational water level of the reservoir, or cannot be withdrawn from the reservoir at the required rates while maintaining the minimum required system pressure or other required operating parameter. The amount of dead storage existing in a system depends on storage system dimensions, elevations, pumping systems, outlet design, and possibly other requirements such as disinfectant contact time.

Effective Storage Requirement

The amount of effective storage a water system needs will be referred to as the Effective Storage Requirement. The Effective Storage Requirement is based on equalizing, standby, and fire suppression storage, and will depend on whether or not "Nested Storage" is allowed. "Nested Storage," pursuant to WAC 246-290-010, means one component of storage is contained within the component of another. WAC 246-290-235 states, "Standby and fire suppression storage volumes may be nested with the larger of the two volumes being the minimum available, provided the local fire protection authority does not require them to be additive." Therefore, the Effective Storage Requirement will be either the sum of equalizing, standby and fire suppression, if "nesting" of standby and fire suppression storage is *not* allowed, or it will be the sum of equalizing storage plus the greater of standby or fire suppression storage if nesting of standby and fire storage *is* allowed. **For the NBWD, no local ordinance or authority has required fire storage to be additive, so nesting of standby and fire storage is allowed.** Table 3-2 summarizes the total effective storage requirements as they apply to the NBWD.

TABLE 3-2

Effective Storage Requirement

If Nesting Is Not Allowed by Local Fire Authority	If Nesting Is Allowed by Local Fire Authority	Standard Applicable to NBWD
The sum of: Equalizing Storage, plus Standby Storage, plus Fire Suppression Storage	The sum of: Equalizing Storage, plus The Greater of Standby Storage, or Fire Suppression Storage	The NBWD standard is based on nesting of standby and fire suppression storage.

WATER QUALITY ANALYSIS

The following sections evaluate the record of water quality for NBWD. Water quality analysis is divided into the categories of Source Water Quality, Delivered Water Quality, Water Quality Reporting, and Water Quality Complaints. Water quality standards that apply to the water distribution system, including coliform, lead and copper, disinfectant byproducts, and asbestos are discussed under the heading of Delivered Water Quality. A review of water quality monitoring requirements relative to water quality monitoring completed is included under the heading Water Quality Reporting, and a review of water quality problems and complaints is included under the heading Water Quality Complaints.

SOURCE WATER QUALITY

As described in Chapter 1, NBWD has eleven wells. The treatment processes provided for NBWD wells are filtration for removal of iron and manganese, and disinfection (chlorination) at all wells.

Inorganic Chemical and Physical Water Quality

<u>General IOC Tests</u>

NBWD's most recent inorganic chemical and physical (IOC) water quality monitoring results are summarized in Table 3-3. The Maximum Contaminant Level (MCL) for all inorganic chemical and physical water quality parameters for which there are MCLs are listed in the right hand column. All analyses indicating values at or above the MCL are indicated in bold. The only MCL exceedances indicated are arsenic, iron, manganese and color for the Source 12 taken on April 19, 2010. This sample was taken prior to the treatment system. The treatment system removes iron, manganese and arsenic, and iron and manganese were most likely the cause for the color. All samples taken after treatment meet all IOC standards.

TABLE 3-3

Source Inorganic Chemical Sampling Results

Location	**Source 6** (1)	**Source 11** (1)	**Source 12** (2)	**Source 10** (1)	**Source 6** (1)	**MCL** (3)
Sample Date	**3/27/2008**	**4/19/2010**	**4/19/2010**	**7/21/2010**	**4/18/2012**	
Primary Contaminants - All results milligrams per liter (mg/L) unless otherwise noted						
Antimony	NA (4)	<0.006	<0.006	<0.006	<0.006	0.006
Arsenic	0.008	0.001	**0.02**	0.008	0.009	0.01
Barium	NA (4)	<0.4	<0.4	<0.4	<0.4	2
Beryllium	NA (4)	<0.0008	<0.0008	<0.0008	<0.0008	0.004
Cadmium	NA (4)	<0.002	<0.002	<0.002	<0.002	0.005
Chromium	NA (4)	<0.02	<0.02	<0.02	0.001	0.1
Copper	NA (4)	<0.02	<0.02	<0.02	<0.02	1.3(5)
Cyanide	NA (4)	<0.01	<0.01	<0.01	<0.01	0.2
Fluoride	NA (4)	<0.5	<0.5	<0.5	<0.5	4(6)
Lead	NA (4)	<0.001	<0.001	<0.001	<0.001	0.015(5)
Mercury	NA (4)	<0.0004	<0.0004	<0.0004	<0.0004	0.002
Nickel	NA (4)	<0.1	<0.1	<0.1	<0.1	0.1
Nitrate-N	<0.2	0.22	<0.2	<0.2	<0.2	10
Nitrite-N	NA (4)	<0.2	<0.2	<0.2	<0.2	1
Total Nitrite/ Nitrate	NA (4)	0.22	<0.5	<0.5	<0.5	10
Selenium	NA (4)	<0.01	<0.01	<0.01	<0.01	0.05
Thallium	NA (4)	<0.002	<0.002	<0.002	<0.002	0.002
Secondary Contaminants - All results milligrams per liter (mg/L) unless otherwise noted						
Chloride	NA (4)	15	17	12	29	250
Fluoride	NA (4)	<0.5	<0.5	<0.5	<0.5	2(6)
Iron	0.062	<0.1	**3.67**	<0.1	0.05	0.3
Manganese	0.02	0.018	**0.86**	0.03	0.017	0.05
Silver	NA (4)	<0.1	<0.1	<0.1	<0.1	0.1
Sulfate	NA (4)	**2.7**	0.8	2	5.1	250
Zinc	NA (4)	<0.2	0.077	<0.2	<0.2	5

Location	**Source 6** (1)	**Source 11** (1)	**Source 12** (2)	**Source 10** (1)	**Source 6** (1)	**MCL** (3)
Sample Date	**3/27/2008**	**4/19/2010**	**4/19/2010**	**7/21/2010**	**4/18/2012**	
Unregulated Chemicals - All results milligrams per liter (mg/L) unless otherwise noted						
Color (color units)	NA (4)	<15	**80**	10	<15	15
Conductivity (μmho/cm) (7)	NA (4)	144	287	140	281	700
Hardness (as $CaCO_3$)	0.062	38.8	95.5	26.5	84.2	None
Sodium	NA (4)	11.6	19.3	9.17	13.8	20(8)
Total Dissolved Solids	NA (4)	NA (4)	NA (4)	NA (4)	174	500
Turbidity (NTU)	NA (4)	<0.1	0.6	0.21	0.29	1(9)

(1) Samples from Source 6 on 3/27/2008, from Source 11 on 4/19/2010, from Source 10 on 7/21/2010 and from Source 6 on 4/18/2012 were taken at a point after the filter system. Note, Source 6 is the North Well Field including North Wells 1-8. Source 10 is South Well 1, Source 11 is South Well 2, and Source 12 is South Well 4.
(2) Sample from Source 12 on 4/19/2010 was taken prior to treatment.
(3) MCL exceedances are shown in **bold**.
(4) NA signifies that the parameter was not analyzed or not reported in the lab report.
(5) The standards for Lead and Copper are distribution system action levels based on 90th percentile distribution sample values.
(6) Fluoride has both a primary and a secondary MCL. Concentrations above the secondary MCL cause aesthetic problems, while concentrations above the primary MCL are a public health concern.
(7) A μmho is a micro-mho, or one millionth of a mho (pronounced "mō"). A mho is a unit of electrical conductance, the inverse of an ohm, a unit of electrical resistance. (Note: mho is ohm spelled backward.) One mho of electrical conductance is capable of transmitting one amp of electrical current across a potential of one volt. One μmho of conductance will transmit one millionth of an amp (one micro-amp) at one volt, or one amp at one million volts (one megavolt).
(8) Sodium does not actually have an MCL, but EPA has established a level of 20 mg/L as a level of concern for individuals on low sodium diet.
(9) The turbidity MCL applies only to unfiltered surface water sources.

<u>Annual Nitrate Tests</u>

Additional IOC samples include annual nitrate samples. These samples are required in years when complete inorganic chemical samples are not required. No nitrates were detected in most of the samples. One sample from Source 6 in 2011 and three samples from Source 10 in 2006, 2009 and 2011 had detectable nitrate. All nitrate test results are well below the MCL of 10 mg/L. The highest level detected in any sample was 1.29 mg/L in a source 10 sample in 2011.

Radionuclides

Radionuclide test reports are summarized in Table3-4. MCLs are shown on the bottom line of the table. All radionuclide sample results are well below their respective MCL values.

TABLE 3-4

Source Radionuclide Sampling Results

Source	Date	Radium 228, pCi/L	Gross Alpha, pCi/L	Gross Beta, pCi/L
6	12/26/2007	<1		
	5/17/2010	<1	<3	<4
10	6/15/2009	<1	4.5	5.5
	10/26/2009	<1		
11	4/20/2009	1.2	<3	4.6
	8/31/2009	0.856		
	6/26/2012	<1		
	12/17/2012	<1		
12	6/15/2009	<1	3.1	5.9
	9/15/2009	<1		
MCLs		**5**	**15**	**50**

Volatile Organic Chemicals

Since the beginning of 2008 NBWD has taken six source Volatile Organic Chemical (VOC) samples. Table 3-5 summarizes the test results for those samples. The only VOCs detected in any sample were trihalomethanes (THMs), including bromodichloromethane ($BrCl_2CH$), dibromochloromethane (Br_2ClCH), and bromoform (Br_3CH). THMs are typically formed by the chlorination of water supplies containing organic matter. Four of the samples are labeled as treated water and two are labeled as untreated water. No VOCs, including THMs, were found in either untreated water sample, indicating that the THMs are not coming from the source water, but rather are being formed in the treatment process. The MCL for THMs is no more than an annual average of 80 µg/L total trihalomethanes (TTHMs) at any distribution system monitoring site. Source TTHMs are well below that standard. Distribution system TTHMs are discussed further under the subject of delivered water quality.

TABLE 3-5

Source VOC Sampling Results

Source	Date	Treated	$BrCl_2CH$, µg/L	Br_2ClCH, µg/L	Br_3CH, µg/L	TTHM, µg/L
S11	3/27/2008	Y	0.4	2.2	4.3	6.9
S01	3/27/2008	Y		1	1.6	2.6
S12	6/30/2008	Y	0.8	1.4	1.5	3.7
S10	6/15/2009	N	0	0	0	0
S11	6/15/2009	N	0	0	0	0
S06	10/5/2010	Y	0	0	0	0

Synthetic Organic Chemicals

Since 2002, only two samples have been taken by NBWD for synthetic organic chemicals (SOCs). These two samples were both taken from Source 6, the North Well Field, on June 15, 2009. One test was for general pesticides and one was for chlorophenoxy herbicides. No SOC chemicals were detected in either sample.

DELIVERED WATER QUALITY

Delivered water quality applies to a number of water quality monitoring requirements of the water distribution system. Monitoring of delivered water quality is necessary because some water quality parameters have been demonstrated to change in the distribution system, or even in the plumbing of buildings. The following sections summarize delivered water quality monitoring by NBWD.

Coliform Bacteria Monitoring

WAC 246-290-300(3) sets distribution system coliform monitoring requirements, and WAC 246-290-310(2) sets coliform bacteria maximum contaminant levels. The number of routine coliform samples required per monitoring period is based on the population served during the monitoring period as reported on the system's WFI form. Each monitoring period is a calendar month. The number of coliform samples required for NBWD per monitoring period varies by month due to seasonal variations in reported population served. Required sampling is as follows:

- January through March: 6 samples per month
- November and December: 7 samples per month
- April, May and October: 8 samples per month
- June through September: 9 samples per month

As the population changes, the monitoring requirements also change. Monitoring requirements in past years may have been different from these, as monitoring in future years may also change due to shifting spatial and temporal population distribution.

In general, a coliform MCL violation occurs when two or more coliform samples in one sampling period, or greater than five percent of all samples, have detectable coliform bacteria. An Acute MCL occurs if there is an MCL violation and any of the coliform positive samples are positive for Fecal Coliform or E. Coli. A Non-Acute MCL occurs if there is an MCL violation and none of the coliform positive samples are positive for Fecal Coliform or E. Coli.

The coliform monitoring record since 1999 was reviewed for this report. No samples were positive for fecal coliform or E. Coli, but there have been samples positive for total coliform. Dates of total coliform detections and number of positive samples are as follows:

- December 16, 2003 1 positive
- April 25, 2007 2 positive
- August 27, 2007 1 positive
- May 17, 2011 1 positive
- November 27, 2012 2 positive
- December 3, 2012 1 positive

Since two or more positive samples are required for a coliform MCL violation, the above positive samples only include two coliform MCL violations: April 2007 and November 2012. All of the positive coliform samples, except the December 3, 2012 sample, were routine samples, and the associated repeat samples were negative. The December 3, 2012 sample was one of six repeat samples and two source samples taken as follow-up for the two positive samples from November 27, 2012. There were also six additional investigative samples taken on December 10, 2012 that were all negative for total coliform.

Since January 2003 there have been 612 coliform samples reported to DOH for water system ID No. 63000C (currently North Beach Water District, formerly North Beach PDA and Ocean Park Water Company) and 100 coliform samples reported to DOH for water system ID No. 20051V (Pacific Water Company, now part of NBWD), a total of 712 samples for what is now NBWD. Out of these 712 samples there have been a total of six samples positive for total coliform and none positive for fecal coliform or E. Coli. These positive coliform samples account for only two non-acute coliform MCL violations. Positive coliform test results may occur due to several possible causes, including sampling error, contaminated sample bottles, lab error, and system contamination. The positive samples discussed above may represent occasional system contamination events or may represent some other occasional issues.

Disinfectant Byproduct Monitoring

Disinfectant Byproduct (DBP) monitoring is applicable to all water systems that provide water treated with chemical disinfectants. While NBWD does not treat water for the purpose of disinfection, NBWD does use ozone to oxidize iron, manganese and arsenic in the source water so that they can be filtered out in the system filters, and ozone is classified as a chemical disinfectant. Systems that treat water with ozone are required to monitor their distribution system for bromate. WAC 246-290-300 (6) (b) (iii) directs that water system using ozone for disinfection or oxidation must monitor for bromate in accordance with 40 CFR 141.132 (b) (3) (ii) (B). 40 CFR 141.132 (b) (3) (i) states that water system using ozone must take one sample per month for each treatment plant at the entrance to the distribution system. 40 CFR 141.132 (b) (3) (ii) (B) states that the sampling frequency may be reduced to quarterly if the system's running annual average bromate concentration is less than or equal to 0.0025 mg/L, but must return to monthly sampling any time the running annual average exceeds 0.0025 mg/L.

WAC 246-290-310 (4) (b) lists the MCL for bromate as 0.010 mg/L. 40 CFR 141.133 (b) (2) states that compliance with the bromate DBP standard shall be based on a running arithmetic average, computed quarterly, of all monthly samples, except that if more than one sample is taken in any given month the average of samples for that month shall be used as the value for that month.

<u>Bromate Monitoring Results</u>

Since January 2005, 164 bromate samples were taken from the entry points to the water system at the south wellfield and the north wellfield. Quarterly annual running averages of average monthly sample results are summarized in Table 3-6. Annual average bromate has never exceeded the MCL of 0.01 mg/L. The highest annual average was for the year ending June 30, 2011 at 0.0075 mg/L. The lowest annual average is for the year ending December 31, 2013 at 0.0007 mg/L. Since the year ending December 31, 2012, the quarterly calculated annual running averages for bromate have remained below 0.0025, so the NBWD appears to qualify for a reduction to quarterly monitoring.

TABLE 3-6

Disinfectant Byproduct Monitoring Results

Year Ending	Running Annual Average, mg/L	Year Ending	Running Annual Average, mg/L	Year Ending	Running Annual Average, mg/L
12/31/2008	0.0056	9/30/2010	0.0059	6/30/2012	0.0039
3/31/2009	0.0036	12/31/2010	0.0046	9/30/2012	0.0028
6/30/2009	0.0030	3/31/2011	0.0047	12/31/2012	0.0022
9/30/2009	0.0036	6/30/2011	0.0075	3/31/2013	0.0009
12/31/2009	0.0045	9/30/2011	0.0070	6/30/2013	0.0010
3/31/2010	0.0056	12/31/2011	0.0071	9/30/2013	0.0010
6/30/2010	0.0048	3/31/2012	0.0070	12/31/2013	0.0007

Asbestos

Asbestos fibers are measured as million fibers per liter greater than 10 micrometers in length (MFL>10 µm). The MCL is 7 MFL>10 µm. Two water samples are on record for asbestos. The first asbestos sample was taken on September 16, 1999, at Weller and SR 103. The lab report for the first sample indicates less than 0.098 MFL>10 µm. The second asbestos sample was taken on September 15, 2010 from the corner of 180th and Pacific Highway. The lab report for the second sample indicated 1.4 MFL>10 µm. Based on this sampling record, NBWD is in compliance with the standard for asbestos in the distribution system.

Lead and Copper Monitoring

Lead and copper monitoring is to determine if lead or copper are leaching out of customer service lines at a rate that produces concentrations that are a health concern. The rule requires that 90 percent of the representative samples do not exceed the action levels for lead or copper. If more than the allowable number of samples exceed the action level for either lead or copper, then the water system owner must take action to reduce the corrosivity of the water, or take other actions such as water service line replacement, to reduce the level of lead and copper at the tap. The action level for lead is 0.015 mg/L and the action level for copper is 1.3 mg/L.

Two rounds of lead and copper samples were collected in 2008, one round of sixteen samples in June and July, plus one round of eleven samples in September and October, and one round of twenty samples was taken in July through September of 2011. Previous samples were also taken earlier and reported in the previous water system plan. The highest level of lead was 0.006 mg/L in September 2008, which was also the highest 90th percentile level. The highest level of copper was 0.573 mg/L in September 2011, and the highest 90th percentile for copper was 0.361 mg/L in August 2011. Table 3-7 summarizes NBWD's lead and copper monitoring results. The data shows that NBWD is in compliance with the lead and copper standards.

TABLE 3-7

Lead and Copper Monitoring Results, 2008 - 2011

Percentile Rank	June – July 2008		Sept. – Oct. 2008		July – Sept. 2011	
	Lead, mg/L	Copper, mg/L	Lead, mg/L	Copper, mg/L	Lead, mg/L	Copper, mg/L
Highest Level	0.005	0.300	0.006	0.287	0.003	0.573
90th Percentile	0.005	0.300	0.006	0.287	0.003	0.361
Action Level	0.015	1.300	0.015	1.300	0.015	1.300

WATER QUALITY MONITORING AND REPORTING

General water quality monitoring requirements are summarized in WAC 246-290-300. NBWD has obtained several water quality monitoring waivers, which affect the monitoring requirements. Table 3-8 summarizes NBWD's monitoring requirements as shown on the Water Quality Monitoring Report for the Year 2014.

TABLE 3-8

Source Monitoring Requirements and Waivers for 2014

Monitoring Parameter	Sampling Requirement	Sampling Location
Coliform	6 per month Jan – Mar 7 per month Nov – Dec 8 per month Apr, May, Oct 9 per month June – Sept	Distribution System per Coliform Monitoring Plan
Asbestos	1 per 9 years	Distribution System
Lead and Copper	1 round per 3 years	Distribution System
Nitrate	1 per year per source	S-06, S-10, S-11
IOC	1 per 3 years	S-10
	1 per 9 years	S-06, S-11
VOC	1 per 6 years	S-06, S-10, S-11
Herbicides, SOC 515.2	1 per 3 years	S-10, S-11
	1 per 9 years	S-06
General Pesticides, SOC 525.2	Waiver 3 years	S-06, S-10, S-11
EDB and fumigants, SOC 504	Waiver 3 years	S-06, S-10, S-11
Insecticides, SOC 531.1	Blanket State Waiver	All Sources
Dioxin, SOC 1613	Blanket State Waiver	All Sources
Endothall, SOC 548.1	Blanket State Waiver	All Sources
Glyphosphate, SOC 547.1	Blanket State Waiver	All Sources
Diquat, SOC 549.1	Blanket State Waiver	All Sources

WATER QUALITY COMPLAINTS

NBWD handles water quality complaints pursuant to their policy for dealing with complaints as described in Chapter 1. In response to dirty water complaints, a water operator will generally check out the validity of the complaint by an on-site investigation and flush water mains if appropriate.

SYSTEM DESCRIPTION AND ANALYSIS

The following sections evaluate the existing water system facilities in terms of their capacities, physical conditions, and performance capabilities. Facilities are evaluated relative to existing and projected requirements based on growth and demand projections from Chapter 2.

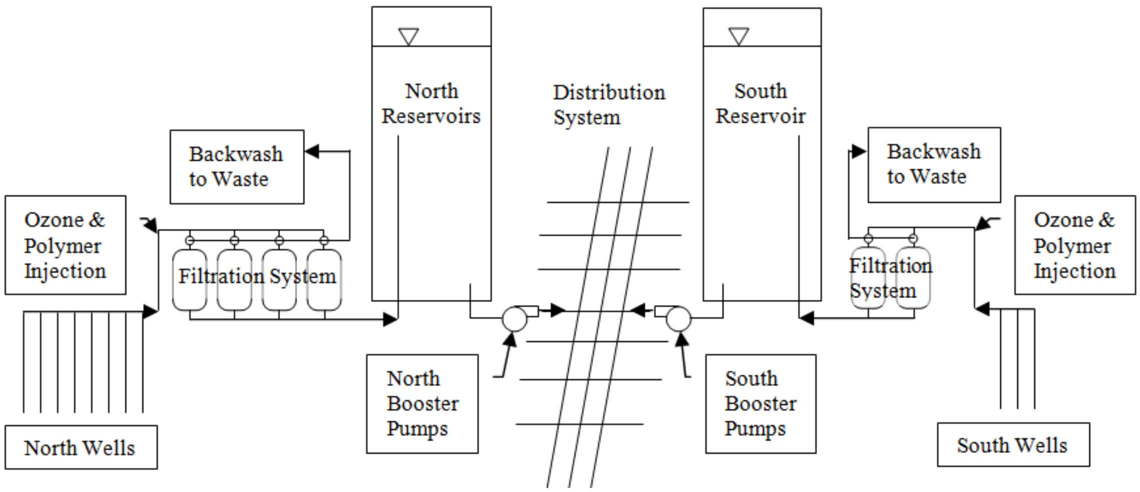
SOURCES

The NBWD wells are described in Chapter 1. Figure 3-2 is a conceptual schematic diagram of how the two well fields, storage tanks and booster pump stations operate.

The north well field and south well field both have filtration systems for iron and manganese, using ozone as an oxidant and polymer as a flocculant and filter aid. Both facilities have chlorine injection using sodium hypochlorite following filtration. Both systems discharge into reservoirs, and both have booster pump stations that pump out of the reservoirs and into the distribution system.

FIGURE 3-2

Schematic Diagram of Water System



Water Rights

Current and Historic Withdrawals

The NBWD water rights are summarized in Table 1-2. NBWD has a total water right capacity of 1,100 gpm and 696 ac-ft/yr. Installed source capacities of all wells are summarized in Table 1-3. NBWD has a combined installed pump capacity of 915 gpm. Therefore, NBWD's installed pumping capacity is well within NBWD's instantaneous water rights limits.

From Table 2-1 it can be seen that NBWD's maximum annual usage since 2008 has been 139.55 MG, which is 428.27 ac-ft/yr. Therefore, NBWD's annual usage is also well within NBWD's annual water rights limits.

Projected Withdrawals

Projected withdrawal rate requirements are compared to current water rights in Table 3-9. Average day demand and maximum day demand projections come from Table 2-11. Recommended Source Capacity is the capacity required to meet Maximum Day Demand in 18 hours per day of production. Projected annual water demand is average day demand, plus 3.1 percent for filter backwash, times 365 days per year and divided by 325,851 gallons per acre-foot. Table 3-9 shows that NBWD has adequate water rights to meet projected demands for the 20-year planning horizon. If growth and water usage develop as predicted, NBWD will have 439 gpm and 357 ac-ft/yr of surplus water right available by the year 2035.

TABLE 3-9

Projected Water Rights Status

Year	Recommended Source Capacity, gpm (1)	Instantaneous Water Rights Surplus/(Deficit), gpm (2)	Projected Annual Water Demand, ac-ft/yr (3)	Annual Water Rights Surplus/(Deficit), ac-ft/yr (4)
2015	701	399	358	338
2016	694	406	356	340
2017	688	412	353	343
2018	682	418	349	347
2019	676	424	346	350
2020	670	430	343	353
2021	666	434	341	355
2022	659	441	338	358
2023	655	445	335	361
2024	649	451	332	364
2025	644	456	329	367
2026	646	454	331	365
2027	647	453	332	364
2028	649	451	333	363
2029	651	449	333	363
2030	652	448	334	362
2031	654	446	335	361
2032	656	444	335	361
2033	657	443	336	360
2034	659	441	338	358
2035	661	439	339	357

(1) Recommended source capacity is the minimum source capacity necessary to meet projected Maximum Day Demand, from Table 2-11, in 18 hours of pumping.
(2) Instantaneous Water Rights Surplus is the total available instantaneous water rights of 1,100 gpm from Table 1-2, less the Recommended Source Capacity.
(3) Projected Annual Water Demand is annual production required to meet Average Day Demand from Table 2-11 plus 3.1 percent for filter backwash, times 365 days per year and divided by 325,851 gallons per acre-foot.
(4) Annual Water Rights Surplus is the total available annual water rights of 696 ac-ft/yr from Table 1-2, less the Projected Annual Water Demand.

Source Capacity Analysis

Table 1-3 shows that the existing wells have a combined installed withdrawal capacity of 915 gpm. As shown in Table 3-9 above, the 20-year projected source capacity recommendation is 661 gpm. Therefore, the NBWD water system has 254 gpm of excess source capacity over the 20-year demand projection. Table 1-3 also shows that NBWD has 780 gpm of source capacity with the largest source out of service. Therefore, NBWD has 117 gpm of excess source capacity with the largest source out of service.

Backup Power Supply

Each well site has two backup generators. The north well field has two 150 KW diesel generators with automatic transfer switches, which, combined, are capable of powering all facilities at the north well field. Each of these generators has a 220-gallon fuel tank capable running the generator for 18 hours at full load. The south well field has one 150 KW diesel generator and one 30 KW diesel generator. Both of these generators are also on automatic transfer switches and fuel tanks capable or running for extended periods. These two generators combined are capable of operating all equipment at the south well field with the exception of Well S-2. Well S-2 is located remote from the remainder of the SWF facilities and has a separate electrical service, so cannot be powered from the main SWF site. The generators are in good condition and exercised regularly so that they are ready to operate when needed.

WATER TREATMENT

North Beach Water District has water treatment facilities at both well fields. Both treatment systems are for the purpose of removing iron, manganese and arsenic from the source water, and use similar treatment schemes. Both treatment systems utilize ozone to oxidize the iron, manganese and arsenic to low solubility oxidation states, detention time to allow for the formation of particles that can be filtered from the water, and catalytic granular media pressure filters to remove the iron, manganese and arsenic. The filter systems are in good working order and have been effective in removing the target contaminants, as attested to by the inorganic chemical sampling results showing no exceedances for iron, manganese or arsenic in the treated water since the filters have been in operation. NBWD is currently experimenting with the treatment system to determine if they can attain an adequate level of treatment using just air or oxygen, without having to use ozone. Preliminary results of this study are promising, but final results are not yet available.

STORAGE

The existing system has four cast-in-place concrete reservoirs, as described in Chapter 1. Three reservoirs are located at the NWF facility and one is located at the SWF facility. All the three reservoirs at the NWF facility are 26 feet in diameter and 45 feet tall. The SWF reservoir is 30 feet in diameter by 40 feet tall.

General Condition

The tanks were last inspected and cleaned over six years ago. The reservoir and the vents and hatches were found to be in good condition. There are no noticeable leaks or problems with the reservoirs. NBWD plans to have the reservoirs cleaned and inspected in 2015.

Storage Capacity Analysis

Existing Effective Storage

As described earlier in this chapter, the effective storage capacity is that capacity of the reservoir that is reliably available in the reservoir and capable of being withdrawn from the reservoir at the rates and pressures required for the water use purposes. The three North Well Field Reservoirs are essentially identical 26-foot diameter by 45-foot tall, cast-in-place concrete reservoirs. The South Well Field reservoir is 30 feet in diameter and 40 feet tall. Details regarding dimensions and capacities of the four reservoirs are presented in Table 3-10. The telemetry control system for the well pumps is currently nonfunctional. Wells are turned on and off manually. There is a pending project for NBWD to upgrade their telemetry control system. Based on the physical dimensions and preliminary water levels control settings shown in in Table 3-10 it is estimated that the effective storage capacity of each of the three NWF reservoir is 153,722 gallons, and the effective capacity of the SWF reservoir is 178,221 gallons, for a total estimated effective storage capacity of 639,386 gallons.

TABLE 3-10

Reservoir Dimension and Capacity Details

Parameter	NWF Reservoirs, Each	NWF Reservoirs, Total	SWF Reservoir	Total, All Reservoirs
Diameter, feet	26		30	
Gallons per Foot	3,972	11,915	5,288	17,203
Height to Top of Wall, feet	45		40	
Gross Volume, gal	178,723	536,169	211,507	747,676
Height to Overflow, feet	44		39	
Source Pumps Off Level, feet	43.5		38.5	
Source Pumps On Level, feet	40		35	
Pump Cycle Volume, gal	13,901	41,702	18,507	60,209
Reservoir Outlet Height, feet	1		1	
Outlet Pipe Diameter, in	8		8	
Minimum Operating Level, feet	1.30		1.30	
Effective Storage Volume, gal	153,722	461,165	178,221	**639,386**

Effective Storage Standards

Storage standards for North Beach WD are based on recommendations of the Department of Health Water System Design Manual. The Design Manual recommends an effective storage standard, where nesting is allowed, based on the sum of the following:

- Equalizing Storage, plus the greater of:
    - Standby Storage, or
    - Fire Suppression Storage

Equalizing Storage

Equalizing storage is used to meet peak hour demands that exceed the installed system source capacity. The volume of equalizing storage recommended depends on peak hour system demands, the length of time the peak hour demands persist, the source production rate, and the mode of system operation. Sufficient equalizing storage must be provided in combination with available water sources and pumping facilities such that peak system demands can be satisfied.

The Water System Design Manual recommends that equalizing storage be calculated using the following equation, but in no case should it be less than zero:

$$V_{ES} = (Q_{PH} - Q_S) \times 150 \text{ minutes}$$

Where

V_{ES} = Equalizing storage component, gallons
Q_{PH} = Peak hourly demand, gpm
Q_S = Total source of supply capacity, excluding emergency sources, gpm

Q_{PH} is the Peak Hour Demand from Table 2-11. Q_S is the system source capacity of 915 gpm as shown in Table 1-3. The installed source capacity is greater than the highest peak hour demand as shown in Table 2-11. Therefore the equalizing storage requirement is zero, as shown in Table 3-11.

Standby Storage

Standby storage is provided in order to meet demands in the event of a system failure such as a power outage, an interruption of supply, or break in a major transmission line. The amount of emergency storage should be based on the reliability of supply and pumping equipment, standby power sources, and the anticipated length of time the system could be out of service.

The Water System Design Manual recommends that standby storage be calculated using the larger of the following two equations:

$$V_{SB} = 2(ADD)*(N)-T_m*(Q_S-Q_L)$$

Or

V_{SB} = 200 gallons x N

Whichever is greater, where

V_{SB} = Total standby storage component, gallons
ADD = Average daily demand per ERU, gpd per ERU
N = Number of ERUs for the design year
Q_S = Total source of supply capacity, excluding emergency sources, gpm
Q_L = Capacity of the largest single source serving the system, gpm
T_m = Maximum time remaining sources will be allowed to pump per day, minutes.

The recommended standby storage capacity for NBWD, according to the above formulas, is summarized in Table 3-16. Average Day Demand and number of ERUs are from Table 2-11. Q_S minus Q_L is 780 gpm. T_m is assumed to be 18 hours per day of source pumping. Recommended standby storage capacities for years 2015 through 2035, based on the DOH Water System Design Manual, are shown in Table 3-11. Note that the standby storage requirement is always 200 gallons per ERU. This is because 18 hours of pumping at 780 gpm produces 842,400 gallons, while two days of the highest ADD shown in Table 2-11 is just 620,000 gallons. With an ADD of 114 gallons per ERU, 200 gallons per ERU can support average system demand for 1.75 days.

Fire Suppression Storage

Fire suppression storage is provided to ensure that water for fighting fires is available when necessary. Fire suppression storage also reduces the impact of fire fighting on distribution system water pressure. The amount of water required for firefighting purposes is specified in terms of rate of flow in gallons per minute (gpm) and an associated duration. Fire flows must be provided at a residual water system pressure of at least 20 pounds per square inch (psi) at all water service connections.

Fire suppression storage is calculated using the following equation:

$$V_{FSS} = FF*T_m$$

Where

V_{FSS} = Volume of fire suppression storage component, gallons
FF = Fire flow rate, gpm
T_m = fire flow duration, minutes

NBWD's maximum fire flow standard is 750 gpm for 60 minutes. The associated fire suppression storage for this fire flow standard is 45,000 gallons. The fire suppression storage volume of 45,000 gallons is shown in Table 3-11. Because nesting of fire and standby storage is allowed, the total storage requirement is equalizing storage plus standby or fire suppression storage, whichever is greater.

Total Recommended Effective Storage

The total recommended effective storage capacities are summarized in Table 3-11 together with Existing Effective Storage as calculated in Table 3-10, and the projected storage surplus or deficit. Table 3-11 shows that NBWD has adequate storage to meet the recommendations of the DOH Water System Design Manual, as interpreted above, throughout the 20-year planning horizon, with a minimum surplus of 94,986 gallons.

TABLE 3-11

Projected Effective Storage Capacity Recommendations

Year	Recommended Effective Storage, gallons				Existing Effective Storage, gallons (4)	Storage Surplus/ (Deficit), gallons
	Equalizing (1)	Standby (2)	Fire Suppression	Total (3)		
2015	0	544,400	45,000	544,400	639,386	94,986
2016	0	539,800	45,000	539,800	639,386	99,586
2017	0	534,800	45,000	534,800	639,386	104,586
2018	0	530,200	45,000	530,200	639,386	109,186
2019	0	525,400	45,000	525,400	639,386	113,986
2020	0	521,200	45,000	521,200	639,386	118,186
2021	0	517,200	45,000	517,200	639,386	122,186
2022	0	512,400	45,000	512,400	639,386	126,986
2023	0	508,600	45,000	508,600	639,386	130,786
2024	0	504,200	45,000	504,200	639,386	135,186
2025	0	500,400	45,000	500,400	639,386	138,986
2026	0	501,800	45,000	501,800	639,386	137,586
2027	0	503,200	45,000	503,200	639,386	136,186
2028	0	504,400	45,000	504,400	639,386	134,986
2029	0	505,600	45,000	505,600	639,386	133,786
2030	0	506,800	45,000	506,800	639,386	132,586
2031	0	508,200	45,000	508,200	639,386	131,186
2032	0	509,600	45,000	509,600	639,386	129,786

Year	Recommended Effective Storage, gallons				Existing Effective Storage, gallons (4)	Storage Surplus/ (Deficit), gallons
	Equalizing (1)	Standby (2)	Fire Suppression	Total (3)		
2033	0	510,800	45,000	510,800	639,386	128,586
2034	0	512,200	45,000	512,200	639,386	127,186
2035	0	513,600	45,000	513,600	639,386	125,786

(1) Equalizing Storage is peak hour demand from Table 2-11, minus the existing source capacity of 915 gpm, times 150 minutes. Equalizing Storage is always zero, because source capacity of 915 gpm always exceeds peak hour demand.

(2) Standby Storage is two days of average day demand from Table 2-11, minus 18 hours of pumping at the existing source capacity of 780 gpm, or it 200 gallons per ERU, whichever is greater In this case, 200 gallons per ERU is always greater.

(3) Total Recommended Storage is the sum of equalizing, plus the greater of standby or fire suppression storage. In this case, equalizing storage is always zero and standby storage is always greater than fire suppression storage, so Total Recommended Storage is Standby Storage.

(4) Existing Effective Storage Capacity is from Table 3-10.

BOOSTER PUMP SYSTEM

Booster Pump System Capacity

As shown in Table 1-4, the two booster pump systems are capable of up to ~~3,169~~ 2,969 gpm with one of the large pumps out of service, and up to 3,719 gpm with all pumps operational~~, not counting the gasoline powered pump~~. The booster pump system must be capable of meeting average flow on a maximum day demand plus fire flow, or capable of meeting peak hour demand, whichever is greater, with one pump out of service. The highest peak hour demand shown in Table 2-11 is 891 gpm. The highest maximum day demand is 759,000 gpd, which is an average flow of 527 gpm. With a fire flow standard of 750 gpm, the maximum capacity the pumping system must meet is 1,277 gpm, so the existing booster pump system capacity is adequate to meet projected demands.

Booster Pump System Reliability

The fact that there are two separate booster pump systems that feed the system from two different locations adds a degree of reliability to the system. If for any reason one pump system becomes inoperable, the other pump system can keep water in the distribution system. As shown in Table 1-4, the NWF booster pump system is capable 1,869 gpm ~~without the gasoline pump and 2,069 gpm with the gasoline pump~~. The SWF booster pump system is capable of 1,850 gpm. So with either booster pump system completely out of service, the pumping system is still capable of meeting maximum system demand

DISTRIBUTION SYSTEM

The water distribution system includes all the piping distributing water from the source and storage facilities to the water customers. The following sections evaluate the general condition and the hydraulic capacity of the water distribution system.

General Description and Condition

The NBWD water distribution system is described in general terms in Chapter 1 under the heading "Transmission and Distribution System." The water distribution system has water mains of various ages, materials and sizes. Total length of water mains by water main diameter is shown in Table 1-5. The material of the mains is a combination of AC and PVC primarily. The older 4-inch and larger PVC is primarily SDR 26, rated for 160 psi. The AC pipe is mostly class 150. The older 3" and smaller PVC is class 200 or Schedule 40. Water mains installed since 2007 are all C900 PVC. Water main breaks have not been a significant issue for NBWD.

From Table 1-5, over fifty percent of the water distribution system is 2-inch water main. Based on mapping available, there are currently no fire hydrants located on any water main less than 6 inches in diameter. However, there are significant areas with no fire hydrants at all. WAC 246-293-650 (2) says that for all water systems with 1,000 or more service connections "fire hydrants shall be located at roadway intersections wherever possible and the distance between them shall be no further than 900 feet." To comply with this regulation NBWD will need to install a significant number of new fire hydrants, which will also require replacement of a significant amount of smaller water main with new 6-inch or larger water mains

Water Distribution System Looping

The water system is generally well looped with a minimal number of system dead-ends, or areas served by just one water main, particularly in the main part of the community or Ocean Park. However, the system does have certain dead-end areas. All services on and off from Sandridge Road north of 272nd Place are on one long dead-end line. North Addition, north of 272nd Place, has a single loop fed by a single line. J Lane north of 268th Place is a long dead end line. The Ridgewood development consists of a number of short cul-de-sacs off Birch Place, all of which are dead end lines. Ocean Meadows Unit One is served by one dead-end line. Several lanes extending west from SR 103 south of 237th Place are served by dead-end lines, and all services on and off from SR 103 south of 227th Street is one long dead-end line. The presence of North-South oriented lakes, marshes and ridges makes tying in the system between SR 103 and Sand Ridge Road difficult. However, there may be opportunities as the system continues to develop to tie in some of the long dead-end lines to create large loops.

Interties

NBWD currently has no interties with other utilities. The only utility nearby that would have the capacity to provide assistance to NBWD in the event of a system emergency is Surfside HOA. However, Surfside HOA is not currently interested in creating an intertie with NBWD. As NBWD continues to expand to the south, an intertie with the City of Long Beach may eventually be feasible.

Water Main Replacement Program

Life expectancy of distribution mains can vary significantly depending on the water main materials used, local soil conditions, and the construction practices used during water main installation. For planning purposes, it is estimated that the average life expectancy of the NBWD water mains is approximately 50 to ~~100~~ 75 years. Water mains are generally the most expensive part of a water system. Water main replacement costs in 2014 dollars can be expected to range from approximately $0.5 to $1.0 million per mile of water main. Factors that influence the cost of water main installation include size of the water main, the soil characteristics where the water main is to be installed, groundwater conditions at the water main installation location, number of services, hydrants and other appurtenances to be installed with the water main, existing utilities in the vicinity of the water main construction, and surface restoration requirements in the water main construction area.

Table 1-5 indicates that the system has approximately 56.14 miles of water main. At $0.5 to $1.0 million per mile for water main replacement, replacement of the entire distribution system could be expected to cost between $28 and $56 million. Since most of the NBWD water mains were installed over a time span of several years, the mains can also be expected to require replacement over a similar time span. Water facilities replacement cycles can lead to a financial "echo effect," in which replacement costs come back on the water system in waves as the various system components reach the end of their useful life. It is therefore wise to schedule replacement of facilities over an extended period to avoid having a wave of water facilities replacements hit the system at once.

It is recommended that NBWD institute a progressive facilities replacement program. In a progressive distribution main replacement program, NBWD would replace the water system's mains on a continuing basis, such that the mains will be replaced on a time schedule that matches their life expectancy and actual conditions. NBWD needs to give serious consideration to a progressive water distribution main replacement program to avoid having to do extensive water main replacement over a relatively short time period.

To replace the entire distribution system over a 50-year time period, an average of 1/50th of the system would be replaced annually. This would represent approximately 1.12 mile of water main replacement per year at an average estimated annual cost of approximately $560,000 to $1,120,000 per year in 2014 dollars. Water main replacement would be prioritized based on experience regarding the areas of the system that have the most problems with existing water mains, both in terms of water main failures and in terms of water main capacity.

Water Service Metering

The NBWD water system is fully metered. However, as discussed in Chapter 2, many of the meters, both service meters and source meters, are old and in need of replacement. The life expectancy of most water service meters is generally thought to be ten to twenty years. Based on the current 2,686 water service connections, to replace all water meters on a ten year cycle would require replacing an average of 269 meters per year, or five to six new water meters per week. A twenty-year meter replacement cycle would require replacing an average of 134 meters per year, or two to three meters per week. Note that in Chapter 2 under the heading Distribution System Leakage, it is stated that NBWD is currently replacing approximately 350 water service meters per year, intends to have all water meters replaced by 2017, and plans to initiate a ten-year replacement cycle after that.

Long-Term Fire Flow Capacity Goal

As stated in Table 3-1, WAC 246-293-640 requires water systems with 1,000 or more water service connections to provide fire flow capacity of 500 gpm sustainable for 30 minutes in residential areas and 750 gpm sustainable for 60 minutes in commercial and multi-family areas, and to have a maximum fire hydrant spacing of one every 900 feet. NBWD has the storage and pumping capacity to meet this standard, but the existing distribution system will need significant improvements to support fire hydrants every 900 feet.

Hydraulic Capacity Analysis – Modeling

The development of a computer hydraulic model, which can accurately and realistically simulate the performance of a water system in response to a variety of conditions and scenarios, has become an increasingly important element in the planning, design, and analysis of municipal water systems. The Washington State Department of Health's WAC 246-290 requires hydraulic modeling as a component of water system plans.

<u>Hydraulic Modeling Software</u>

The NBWD water system has been analyzed using MWHSoft's H2ONet hydraulic modeling software, which operates in an AutoCAD computer-aided design and drafting environment. The H2ONet model was created from the NBWD water system base map.

The H2ONet model is configured with a graphical user interface. All water system elements, including pipes, control valves, pumps, and reservoirs were assigned a unique graphical representation within the model. Each element was assigned a number of attributes specific to its function in the actual water system. Typical element attributes include spatial coordinates, elevation, water demand, pipe lengths and diameters, pipe friction coefficients and critical water levels for reservoirs. With attributes of each system element as the model input, the H2ONet software produces the model output in the form of flows and pressures throughout the simulated water system.

<u>Model Assumptions</u>

Prior to the calibration of the hydraulic model, the basic layout of the water system was recreated within the model. The lengths, diameters, and connection points of system piping are assigned using an updated base map of the water system. The locations of the wells and reservoirs were found on water system base maps, while the critical elevations of the reservoirs and the booster pump station were taken from previous reports, as-built information, and satellite imagery. A map of the water system model including node identifications is included in Appendix J. Results of hydraulic modeling are included in Appendix J. The assumptions regarding the modeling of all sources of supply and system demands are included in the following sections.

Booster Pumps

The booster pumps were manually controlled on/off to meet the modeled system demands. Actual pump curves were used to simulate realistic outputs based on downstream pressures. The pressure sustaining/reducing valve was modeled as just a pressure reducing valve with the downstream pressure set at 55 psi.

System Demands

A key element in the hydraulic modeling process is the distribution of demands throughout the water system. Total demand on the system is based on the projected demands from Table 2-11, Projected Water System Demands. Existing and future demands were distributed based on the location of existing water service connections and likely locations of future development. Nine demand sets were used in the hydraulic analysis.

2015 Average Daily Demands: These demands were used while calibrating the model.

2015 Maximum Day Demands: These demands were used to evaluate the existing system's ability to provide fire flow during the 2015 maximum day demand at the DOH requirement of 20 psi.

2015 Peak Hour Demands: These demands were used to verify the system is able to meet the DOH standards to supply domestic water at a minimum system wide pressure of 30 psi.

2021 Maximum Day Demands: These demands were used to evaluate the system's ability to provide fire flow during the projected 2021 maximum day demand at the DOH requirement of 20 psi with the 6-year Capital Improvement Plan implemented.

2021 Peak Hour Demands: These demands were used to verify the system is able to meet the DOH standards to supply domestic water at a minimum system wide pressure of 30 psi with the 6-year Capital Improvement Plan implemented.

2035 Maximum Day Demands: These demands were used to evaluate the system's ability to provide fire flow during the projected 2035 maximum day demand at the DOH requirement of 20 psi with the 20-year Capital Improvement Plan implemented.

2035 Peak Hour Demands: These demands were used to verify the system is able to meet the DOH standards to supply domestic water at a minimum system wide pressure of 30 psi with the 20-year Capital Improvement Plan implemented.

Model Calibration

The calibration of a hydraulic model provides a measure of assurance that the model is an accurate and realistic representation of the actual system. The hydraulic model of the NBWD water system was calibrated using data obtained from fire hydrant tests at various locations throughout the water system. Fire hydrant tests were conducted and recorded throughout the system by NBWD personnel during their 2007 flushing program. During these tests, static and residual pressures were recorded as staff opened hydrants and recorded the flow rate. Field results were used to calibrate the hydraulic model through verification and adjustment of pipe type, sizes, roughness coefficients, and elevations.

Seven locations throughout the distribution system were chosen to perform hydrant testing. The locations were chosen to provide flow and pressure data at the extremities of the distribution system. A description of each testing location is presented in Table 3-12.

TABLE 3-12

Hydrant Testing Locations

Test Number	Hydrant Number and Location	Pressure Reading Location
1		
2		
3		
4		
5		
6		
7		

Reservoir water levels and booster pump operating status was recorded during testing. A summary of the recorded reservoir levels and hydrant flow rates is presented in Table 3-13. The system conditions at the time of testing were replicated in the hydraulic model during the calibration process.

TABLE 3-13

System Conditions During Hydrant Tests

Test No.	Pumps Running	Reservoir Level, feet	Static Pressure, psi	Flow Pressure, psi	Pitot Pressure, psi	Flow, gpm

Using the system conditions for each hydrant test, the hydraulic model was used to generate static pressure and residual pressure at the measured hydrant flow rate. The total system demand at the time of the hydrant tests was based on production data from the booster pump station during the time of the tests. Model output was generated at points in the model equivalent to the locations of the hydrant tests.

Model output for static pressure was generated by running the model with demands based on the booster pump station output during the tests. Model output for residual pressure was generated at each hydrant test location by placing an added demand equal to the measured hydrant flow rate and recording the resulting pressure.

The system pressures and pipe flow rates determined in the hydraulic analysis are highly dependent on the friction loss characteristics established for each pipe. The friction losses occurring in lengths of pipe and various valves are accounted for in the hydraulic model. The friction factors for the pipes in the modeled system are adjusted throughout the calibration process until the model output best approximates the measured values. Hazen-Williams C-factors between 130 and 140 were used throughout the system. The friction factors for the pipes also compensate for system pressure losses through valves and pipe fittings.

The model output was produced for two data comparisons, static pressure and hydrant flow residual pressure. The values measured in the hydrant flow tests are compared to the model output values in Table 3-14.

TABLE 3-14

Calibration Results

Test No.	Flow (gpm)	Static Pressure (psi)			Residual Pressure (psi)		
		Field	Model	Difference	Field	Model	Difference

Hydraulic models are required to be within 5 psi of measured pressure readings for long-range planning, according to the DOH Water System Design Manual, Table 8-1. Calibration of the hydraulic model produced results that are within the 1 psi of actual field test data for static pressure and within 5 psi of field test data for residual pressure. No calibration results were outside the 5-psi guidelines from the Water System Design Manual.

Model Input

Model input assumptions have significant impacts on peak hour and fire flow results. Table 3-15 provides the booster pump status modeled for each scenario.

During peak hour scenarios, booster pumps identified in Table 3-15 are assumed to be operating. During fire flow scenarios, the booster pumps are operated as shown in Table 3-15.

During peak hour scenarios, operational and equalizing storage is removed from all reservoirs. During fire flow scenarios, operational, equalizing, and fire suppression storage is removed from all reservoirs.

TABLE 3-15

Booster Pump Status During Model Scenarios

Pump	Capacity	2015		2021		2035	
		PHD	Fire Flow	PHD	Fire Flow	PHD	Fire Flow
N-1	109						
N-2	120						
N-3	280						
N-4	500						
N-5	500						
N-6	120						
N-7	120						
N-8	120						
S-1	175						
S-2	175						
S-3	750						
S-4	750						

Peak Hour Demand Modeling Results

Pursuant to WAC 246-290-230 (5), a water system must maintain a minimum pressure of 30 psi in the distribution system under peak hour demand conditions. The existing distribution system has been modeled under 2015, 2021 and 2035 peak hour demand conditions and the minimum pressures are provided in Table 3-16. Results for all model nodes are included in Appendix J.

TABLE 3-16

Lowest System Pressures During Peak Hour Demand Conditions (1)

Scenario	Pressure and Location
2015 Peak Hour Demand	
2021Peak Hour Demand	
2035 Peak Hour Demand	

(1) The system was modeled with operating and equalizing storage removed from the reservoirs and pumps operating according to Table 3-15.

As shown in Table 3-16, pressures in the distribution system are predicted by the model to be at or above the minimum 30-psi requirement under peak hour demand.

Fire Flow Modeling Results

Pursuant to WAC 246-290-230 (6) a water system must be designed to provide adequate fire flow under maximum day demand conditions, while maintaining a minimum system pressure of 20 psi. While these conditions can be met throughout most of the system, the model predicts that certain locations are not able meet this fire flow standard. **Table 3-24 provides a list of fire flow deficiencies in the system.** The "Projects" column refers to projects discussed below to improve fire flows.

TABLE 3-17

Fire Flow Deficiencies During 2014 Maximum Day Demand Conditions

Hydrant	Location	Elevation (ft)	Required Fire Flow (gpm)	Available Fire Flow (gpm)	Project	Available Fire Flow after Project (gpm)

Distribution Improvements

Various water system improvements were modeled to determine the optimal improvements to alleviate the identified fire flow deficiencies. The following water system improvements were determined to be the most effective options to meet the fire flow requirements. The number in the Project column in Table 3-24 corresponds to the projects listed below. The projects are listed in priority order, with project number 1 the highest priority, because it addresses substantial fire flow deficiencies to four different hydrants, project number two the second highest priority because it addresses the greatest single hydrant fire flow deficiency, and so on, which addresses the lowest fire flow deficiency to a single hydrant. These projects are discussed in further detail in Chapter 8, Capital Improvement Plan.

Upgrade approximately 350 lineal feet of 6-inch water main to 8-inch water main on Stackpole Lane from 300th Place to X Place.
Upgrade approximately 1,000 feet of 4-inch water main to 6-inch water main on X Place.

A full fire flow node report is available in Appendix J.

WATER SYSTEM CAPACITY LIMITS

There are several factors that could limit water system capacity, including source capacity, storage capacity, booster pump capacity, annual water rights and instantaneous water rights capacity.

SOURCE CAPACITY LIMIT

As a planning goal, source capacity should be capable of meeting maximum day demand in 18 hours per day of pumping. From Table 1-4, total installed source capacity is 915 gpm. The installed source capacity limit can be calculated as follows:

$$\text{Source Capacity Connections Limit} = \frac{915 \text{ gpm x } 1{,}080 \text{ min/day}}{278 \text{ gpd per ERU}} = 3{,}554 \text{ ERUs}$$

Existing source capacity is adequate for up to 3,554 ERUs.

INSTANTANEOUS WATER RIGHT CAPACITY LIMIT

From Table 1-2, NBWD has 1,100 gpm of instantaneous water rights. Assuming that use of these rights would also be limited to 18 hours per day, the instantaneous water rights limit can be calculated as follows:

$$\text{Instantaneous Water Rights Connections Limit} = \frac{1{,}100 \text{ gpm x } 1{,}080 \text{ min/day}}{278 \text{ gpd per ERU}} = 4{,}273 \text{ ERUs}$$

Existing instantaneous water rights are adequate for up to 4,273 ERUs.

ANNUAL WATER RIGHT CAPACITY LIMIT

The annual water rights limit from Table 1-2 is 696 ac-ft/yr and the Average Day Demand per ERU from Table 3-1 is 114 gpd. The limit on ERUs due to the annual water right limit can be calculated as follows:

$$\text{Annual Water Rights Connections Limit} = \frac{696 \text{ ac-ft/yr x } 325{,}851 \text{ gal/ac-ft}}{365 \text{ days/year x } 114 \text{ gpd/per ERU}} = 5{,}450 \text{ ERUs}$$

Existing annual water rights are adequate for up to ERUs.

BOOSTER PUMP SYSTEM CAPACITY LIMIT

As discussed above, under the heading *Booster Pump System*, the installed booster pump capacity will meet projected peak hour demands and maximum day demand plus fire flow throughout the 20-year planning horizon, as well as projected buildout demands, with any one pump out of service. The system capacity limit based on installed booster pump capacity and PHD can be estimated by solving the PHD equation for the number of ERUs and setting PHD equal to the installed pumping capacity. The formula for PHD from Table 3-1 is as follows:

$$PHD = 0.309*N+61$$

Solving for the number of ERUs, N, yields the following:

$$N= \frac{PHD - 61}{0.309}$$

Inserting the installed pump capacity of 3,169 gpm with one pump out of service, from Table 1-4, for PHD yields the following:

$$N = \frac{3{,}169 - 61}{0.309} = 10{,}058 \text{ ERUs}$$

Existing booster pump capacity is adequate for up to 10,058 ERUs based on meeting PHD.

The system capacity limit based on the booster pump system meeting maximum day demand plus fire flow also needs to be evaluated. The Maximum Day Demand plus fire flow is expressed as follows:

$$Q = \frac{\text{MDD} * \text{N}}{1{,}440 \text{ minutes per day}} + \text{FF}$$

Solving this for N yields the following:

$$N = \frac{\text{Q -FF}}{\text{MDD}} * 1{,}440 \text{ Minutes per Day}$$

Inserting the installed pump capacity of 3,169 gpm with one pump out of service, from Table 1-4, fire flow of 750 gpm and MDD of 278 gpd per ERU yields the following:

$$N = \frac{3{,}169 - 750}{278} *1440 = 12{,}530 \text{ ERUs}$$

Since the limit on existing booster pump capacity based on meeting PHD is more restrictive than the limit based on meeting MDD plus fire flow, the ERU limit based on booster pump capacity is 10,058 ERUs.

STORAGE CAPACITY LIMIT

Table 3-11 projects that installed storage capacity will not become a limiting factor through the twenty-year planning horizon. To find the number of ERUs supportable by existing storage it is necessary to calculate storage requirements for various numbers of ERUs until the required storage exceeds the existing effective storage. Table 3-18 shows storage requirements for 3,115 ERUs and for 3,116 ERUs. The existing effective storage capacity is adequate for 3,115 ERUs, but it is 141 gallons deficient for 3,116 ERUs. Therefore, the existing storage capacity is adequate for up to 3,115 ERUs.

TABLE 3-18

Storage Requirement Limit

ERUs	Required Effective Storage, gallons				Existing Effective Storage, gallons (4)	Storage Surplus/ (Deficit), gallons
	Equalizing (1)	Standby (2)	Fire Suppression	Total (3)		
3,115	16,280	623,000	45,000	639,280	639,386	106
3,116	16,327	623,200	45,000	639,527	639,386	(141)

(1) Equalizing storage is peak hour demand based on the PHD formula developed in Chapter 2 and shown in Table 3-1, minus the existing source capacity of 915 gpm, times 150 minutes.
(2) Standby storage is two days of average day demand from Table 2-9, minus 18 hours of pumping at the existing source capacity of 780 gpm with the largest source out of service, or it is 200 gallons times the projected number of ERUs, whichever is greater.
(3) Total recommended storage is the sum of equalizing, plus the greater of either standby or fire suppression storage.
(4) Effective storage capacity is from Table 3-15.

The water system capacity limits derived above are summarized in Table 3-19. The most limiting factor is storage capacity, based on DOH Design Manual criteria, and limits the system to 3,115 ERUs. This is an additional 409 ERUs above the 2,706 ERUs represented by 2013 water use data, as shown in Table 2-8. With additional storage capacity, the system could expand to the source capacity limit of 3,554 ERUs, or an additional 848 ERUs. With additional source capacity, the system could expand to the instantaneous water right capacity of 4,273 ERUs, or an additional 1,567 ERUs. With additional instantaneous water rights, the system could expand to the annual water rights capacity limit of 5,450 ERUs, or an additional 2,744 ERUs. With additional annual water rights, the system could expand to the Booster Pump Capacity limit of 10,058 ERUs based on meeting peak hour demand, or an additional 7,352 ERUs. With additional booster pump capacity the system could expand beyond 10,058 ERUs.

TABLE 3-19

Water System Capacity Limits

Limiting Factor	System Capacity, ERUs	Existing Demand, ERUs	Available ERUs
Storage Capacity	3,115	2,706	409
Source Capacity	3,554	2,706	848
Instantaneous Water Right Limit	4,273	2,706	1,567
Annual Water Right Limit	5,450	2,706	2,744
Booster Pump Capacity, PHD	10,058	2,706	7,352

SUMMARY OF SYSTEM NEEDS AND CONCERNS

From the foregoing discussions, the following are the identified water system deficiencies. No attempt is made here to prioritize the deficiencies. Improvements to correct identified system deficiencies will be prioritized in Chapter 8, Capital Improvements.

SOURCE

The system currently has adequate source capacity to meet projected system demand. However, as discussed in Chapter 1, Wells N-1 and N-2 lack adequate sanitary control area, and Well N-3 is difficult to treat due to an elevated level of manganese. These wells are also the systems' oldest wells and are nearing the end of their useful life. Well N-7 is experiencing significant reduction in yield. N-7 well report shows the well is a 6-inch casing with a screened interval about ten feet higher that the rest of the wells in the North Wellfield. Its date of construction is not indicated on the well report. ~~Also~~ ~~w~~Wells S-1, S-2 and S-4 have lost capacity and have manganese levels making treatment difficult.

NBWD is in the process of developing new wells near the South Well Field. Three wells have been drilled and tested. The wells each produce in the neighborhood of 150 gpm, and do not have excessive iron or manganese. Preliminary tests indicate that treatment may be required for removal of arsenic and hydrogen sulfide. It is anticipated that design for these wells will be completed in 2014 and the wells will be put into service in 2015. Once these wells are in service NBWD anticipates removing Wells N-1, N-2 and N-3. The District plans on replacing N-7 in 2016.

WATER TREATMENT

The current water treatment system is effectively removing iron, manganese and arsenic to below regulatory levels. However, NBWD is ~~attempting~~ desires to reduce the operations cost of water treatment and simplify the treatment plant operation by using ambient air ~~or perhaps oxygen for oxidizing the water rather than~~as an oxidant instead of ozone.~~, since~~ Ozone production ~~of ozone required~~ requires a significant amount of electrical energy and ~~. Production of ozone~~ also contributes to corrosion of equipment in the water treatment building. The District commissioned Gray and Osborne, Inc. to conduct a pilot test described in chapter 1 (page 1-12). As a result of the conclusions of the pilot test the District has discontinued using ozone as an oxidant in favor of ambient air.~~If the pilot testing data indicates that this strategy is effective NBWD may modify their treatment system to eliminate the use of ozone.~~

WATER STORAGE

Existing water reservoirs are in good condition, and storage capacity is adequate for the 20-year planning horizon. However, the telemetry system associated with the reservoirs and wells needs improvement so that reservoir water levels can turn wells on and off, and so that water levels can be monitored from a central location.

CONTROL SYSTEM

The wells are currently operated manually because the control system to turn the wells on and off based on reservoir water level is not functioning. NBWD plans to replace the telemetry and control system in ~~2015~~2016.

WATER DISTRIBUTION SYSTEM

Based on a lack of water main breakage problems, the water distribution system is in generally acceptable condition. However, over half of the system is 2-inch water main and 65 percent is less than 6-inch water main. There are no fire hydrants on water main less than 6-inches in diameter, however, fire hydrant distribution within the service area does not meet the minimum standard of 900-foot spacing called for in WAC 246-293-640. To meet the 900-foot spacing standard would require upgrading many water mains to 6-inch or larger.

There is also a significant amount of the water system that is not looped. Tying some of the dead-end lines together would improve system hydraulics and water circulation.

The system is fully metered, but many of the meters are old and may not be providing accurate data. NBWD is currently replacing approximately 350 water service meters per year, and anticipates having all water meters replaced by 2017. After that NBWD intends to replace water meters on a ten-year replacement cycle.

BOOSTER PUMP SYSTEM

The booster pump system is generally adequate to serve the projected 20-year peak hour and maximum day plus fire flow water system demands with one pump out of service. Also, since the system has two separate booster pump systems at two different locations, there is redundancy in the booster pumping system that improves system reliability. However, there are some problems with coordination between the two booster pump systems. A central control system could help to better coordinate operations of the two booster pump systems.

BACKUP POWER SUPPLY

The existing backup power supplies for both Well Fields are adequate to power all facilities at the well field sites. However, if additional, higher capacity wells are to be developed for the South Well Field, additional backup power supply may also be needed at the South Well Field.