Sitka's Blue Lake Water Source

City and Borough of Sitka
Municipal Water System Master Plan

May, 2009

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CITY AND BOROUGH OF SITKA

WATER MASTER PLAN

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List of Abbreviations

ADEC	Alaska Department of Environmental Conservation
CBS	City and Borough of Sitka
CT	concentration × time
CPES	CH2M HILL Parametric Cost Estimating System
DBP	disinfection byproduct
D/DBPRs	Disinfectants/Disinfection By-Products Rules
EPA	Environmental Protection Agency
ESWTRs	Enhanced Surface Water Treatment Rules
FTE	Full time equivalent
gpm	gallons per minute
GWUDI	groundwater under direct influence (of surface water)
HAAs	haloacetic acids
HAA5	five haloacetic acids
IESWTR	Interim Enhanced Surface Water Treatment Rule
kWh	kilowatt-hour
LCR	Lead and Copper Rule
LPHO	low-pressure high-output
LRAAs	locational running annual averages
LT1ESWTR	Long Term 1 Enhanced Surface Water Treatment Rule
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	maximum contaminant level
mgd	million gallons per day
MP	medium-pressure
mJ/cm^2	milliJoules per square centimeter
nm	nano-meter
NTU	nephelometric turbidity units
O&M	operations and maintenance
OCC	off-line chemical cleaning
OMC	on-line mechanical cleaning
OMCC	on-line mechanical-chemical cleaning
psi	pounds per square inch
SDWA	Safe Drinking Water Act
1 D/DBPR	Stage 1 Disinfectants/Disinfection By-Products Rule
Stage 2 D/DBPR	Stage 2 Disinfectants/Disinfection By-Products Rule

List of Abbreviations

(continued)

SWTR	Surface Water Treatment Rule
THMs	trihalomethanes
TTHMs	total thihalomethanes
UPS	uninterruptable power supply
UV	ultraviolet
UVT	ultraviolet transmittance
UVDGM	Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule
VF	validation factor

EXECUTIVE SUMMARY
SITKA WATER MASTER PLAN

Purpose of Plan

The City and Borough of Sitka water system has been supplying water to residents of Sitka from the Blue Lake water source for over 32 years and some sections of the distribution system piping have been in service for over 50 years. It is important to periodically review the condition and performance of a water system to ensure its equipment and processes are still satisfactorily meeting the changing demands of a community and complying with State and federal regulations that ensure safe drinking water is being supplied.

In that regard the study:

- Prepared an inventory of water treatment facilities, water storage reservoirs, transmission lines, distribution lines and pump stations based on available as-built drawings and project records. The inventory was used to update the CBS water system computer model and to evaluate the ability of water storage reservoirs and pipes to meet domestic and fire flow water demands;

- Reviewed current and pending State and Federal regulations that impact the water system, particularly the US Environmental Protection Agency Surface Water Treatment Rule;

- Reviewed the condition of the water system and made recommendations for capital improvements to upgrade the system as needed to ensure water service can be reliable provided and to comply with water treatment regulatory requirements. Planning level cost estimates were developed for these capital improvement projects;

- Conducted a review of the water system financial status and provided financial recommendations that will allow CBS to maintain the financial heath and stability of the water utility while undertaking necessary capital improvements.

Recommendations and Conclusions

Area Wide Water System Demand

Area wide water system demand has remained relatively constant over the last 5 years and is anticipated to remain stable for the foreseeable future. This means, barring any significant new demands beyond those that already exist, an increase in water production capacity is not required. The following table is a summary of the average day area wide water system demand for the last five years and illustrates the water demand that has been occurring.

AREA WIDE WATER DEMAND

2004 AVG DAY = 3.437 MGD
2005 AVG DAY – 3.492 MGD
2006 AVG DAY = 3.298 MGD
2007 AVG DAY = 3.370 MGD
2008 AVG DAY = 3.306 MGD

Additional Water Storage Recommended

Current and planned water storage for the CBS water system includes a total of 2.95 million gallons in the following three water storage reservoirs.

- Harbor Mountain Tank = 0.75 MG (million gallons)
- 1.2 MG Tank = 1.2 MG
- Future Whitcomb Heights Tank = 1.0 MG

The recommended water storage for municipalities is typically one day of average water consumption (approximately 3.5 MG for Sitka) plus the maximum fire flow demand, which for Sitka is 3,500 gpm for 3 hours (0.63 MG). On that basis the system should have about 4.1 million gallons of water storage available for emergencies. The current water system storage capacity (including the new Whitcomb Heights Tank) is about 1.15 million gallons less than the recommended volume (i.e. less than one day emergency storage plus fire flow). Consequently an additional water storage reservoir is recommended with a capacity of at least 1.15 million gallons.

Minimum Water System Pressures

The minimum water system pressure allowed by State regulation is 20 psi under peak flow conditions. Water system model results indicate that most of the distribution system can maintain water system pressures in excess of 20 psi even under peak flow conditions. However, low water system pressures (less than 20 psi) can occur at the higher elevations in the Jarvis Street and Lance Drive areas and at high points of Sawmill Creek Road under peak flow conditions. Constructing a water storage reservoir in association with the existing Hillside Pump Station would address low water pressure issues in the higher elevations of the Lance Drive area as well as provide needed emergency water storage to improve water system pressures during peak demands in the Sawmill Creek Road area.

Water Treatment Regulatory Requirements

Probably the most significant impact for Sitka's water system in terms of required capital construction and increased operating costs, will be complying with regulations adopted by the U.S. Environmental Protection Agency that govern unfiltered surface water sources. All unfiltered surface water sources like Sitka's will need to provide additional treatment by October 1, 2014.

In 1989 the US Environmental Protection Agency adopted the Surface Water Treatment Rule (SWTR) to protect the public from waterborne diseases. The SWTR established standards for the removal or inactivation of *Giardia*, *Cryptosporidium* and viruses.

For CBS's unfiltered Blue Lake water source, inactivation of *Giardia* and viruses is currently being accomplished in accordance with the SWTR. This is done by keeping the disinfectant residual (chlorine) and contact times at concentrations and durations that are specified in the regulation. The contact times are met as water transits in the water transmission main from Sawmill Cove to Sitka. Water flow rates in the transmission main are carefully controlled to ensure sufficient contact time is achieved prior to the water reaching the distribution system and the first customer.

In 2006 the US Environmental Protection Agency adopted the Long Term 2 Enhanced Surface Water Treatment Rule, which specifically addresses inactivation of *Cryptosporidium*. *Cryptosporidium* is a parasitic protozoan that forms a protective cyst which makes it resistant to chlorine levels normally found in public water systems. *Cryptosporidium* and the disease it causes, *cryptosporidiosis*, was brought to the public's attention by an outbreak in 1993 in Milwaukee, Wisconsin. Up to 300,000 residents became ill during the outbreak and as many as 60 died. Several lawsuits were filed against the City of Milwaukee as a result of the outbreak.

The Long Term 2 Enhanced Surface Water Treatment Rule requires that Sitka and other unfiltered surface water systems (i.e. Juneau, Ketchikan, Unalaska and Kodiak) comply with the treatment requirements for *Cryptosporidium* by October, 2014.

Three treatment processes have been found to be effective at inactivating Cryptosporidium, 1) UV Disinfection, 2) Ozone Disinfection, and 3) Chlorine Dioxide Disinfection. Each of these treatment processes were evaluated for Sitka along with two filtration options. The capital cost for each option and the annual operation, maintenance and labor were compared. The following table is a summary of this comparison:

Treatment Alternative	Capital Cost	Annual O&M and Labor Costs	25 Yr Life Cycle Cost
UV Disinfection	$6,450,000	$180,000	$9,100,000
Ozone Disinfection	$27,300,000	$1,270,000	$39,800,000
Chlorine Dioxide Disinfection	$34,900,000	$1,420,000	$48,900,000
High-Rate Granular Filtration	$24,100,000	$1,090,000	$34,700,000
Membrane Filtration	$46,600,000	$2,220,000	$68,300,000

The recommended alternative for complying with the US Environmental Protection Agency's Long Term 2 Enhanced Surface Water Treatment Rule is UV Disinfection. The total estimated project costs to construct a UV Disinfection system for the Blue Lake water source including design, inspection, administration and contingencies is $6,450,000. The State has historically been participating in these projects by providing construction grants of up to 70% of the project cost. Contacts made with the Alaska Department of Environmental Conservation's Construction Grant Program indicate that it is very likely such a grant would be available for Sitka.

Capital Improvement Projects

Despite extensive expansion of the water system, there is continuing demand for water service in new areas such as the Whitcomb Heights area. There is also need for improvement, repair and replacement of aging existing water infrastructure to keep existing facilities functioning and to ensure the system can safely and reliably provide water to existing customers.

To accommodate demands for water service and to upgrade existing facilities it is essential Sitka develop a logical and feasible plan for addressing water system needs. In conjunction with CBS staff the water system was evaluated to consider the physical condition of existing facilities, the capacity of the system to meet water system demands and the need for flexibility to isolate areas of the water system for repairs. There are also portions of the existing system that need to be replaced or improved due to use of old outdated piping and/or isolated locations of newer pipe that are failing due to exterior corrosion. An example is the cast iron piping in older parts of town in which line breaks are becoming more common.

In developing the list of capital improvement projects for Sitka, the Alaska Department of Environmental Conservation was contacted to determine the likelihood of receiving grants and loans for water system improvements from the State. While there is no guarantee as to the level at which the water system grant and loan program will be funded from year to year, estimates of the potential for receiving grants and loans based on historic funding levels were made when developing the capital improvement plan.

The most significant capital improvement project in the near future is construction of the UV disinfection system for the Blue Lake water source. The project has been highlighted in the table below to indicate the time frame in which funding for the project needs to be available.

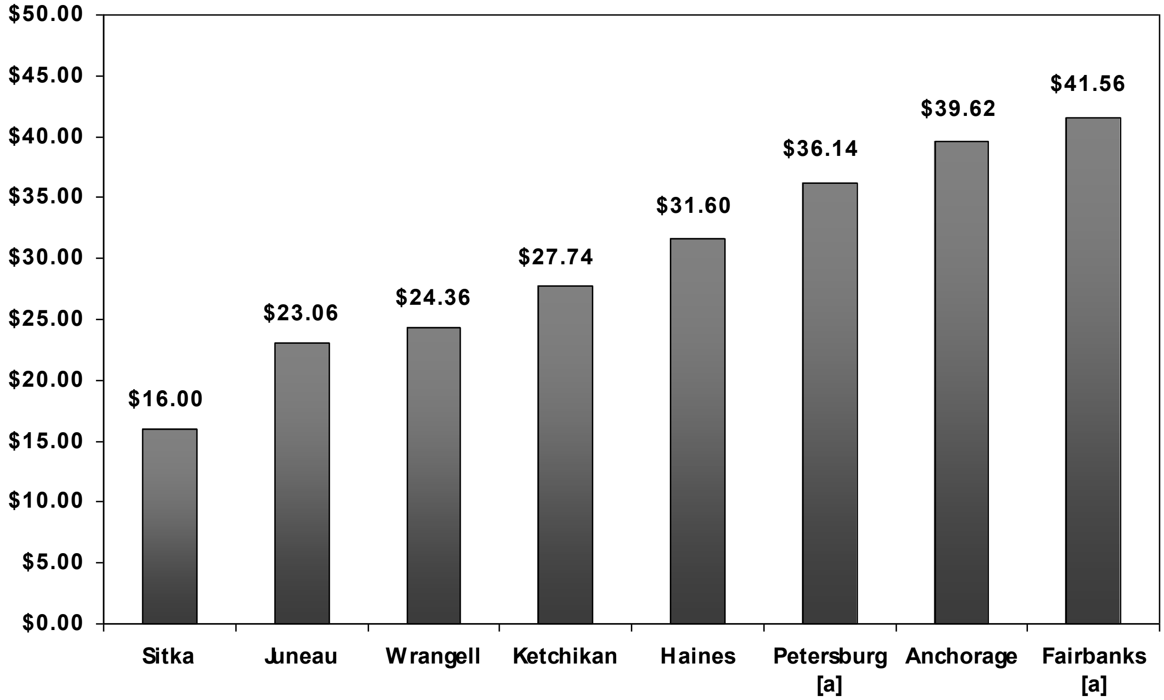
Sitka Water System
Capital Improvement Projects

Project	Total Estimated Project Cost	State Grant	State Loan	Sitka Water Fund	Projected Project Period
Abandon old HPR Main Connect Services to 16"	$307,500			FUNDED	-
Mills Street Water	$214,050			$214,050	2009
Areawide Water Meters (Four)	$360,000			$360,000	2009/2016
Misc. Water Imprvements for SMCR Paving Phase III	$150,000			$150,000	2010
Misc. Water Improvements for HPR Paving	$300,000			$300,000	2012
Replace Old Hydrants (est. 200 @ 9/yr.)	$1,500,000			$1,500,000	continuous
Blue Lake WTP UV Disinfection	$6,450,000	$4,515,000	$1,935,000		2012 - 2014
Eagle Way Water	$274,500	$274,500			2012
Blue Lake WTP Sawmill Cr Intake	$705,000	$282,000	$282,000	$141,000	2012
Repaint 1.2 MG Tank	$524,700		$524,700		2015
SMC Road Water Replacement	$849,330		$849,330		2016
Jeff Davis Street Water Upgrade	$877,200		$877,200		2017
Japonski Island Water Loop	$715,200	$572,160		$143,040	2017
Lincoln Street Water Upgrade	$1,032,450		$1,032,450		2018
Erler Street Water Upgrade	$398,250			$398,250	2018
Granite Cr Road Water	$165,000			$165,000	2018
Japonski Bridge Water Upgrade	$2,850,000	$2,280,000		$570,000	2019
Connect Hillside PS to Lance Dr and Haley Ave Tank	$1,207,500	$845,250	$362,250		2019
Haley Ave 2.0 MG Tank	$5,182,500	$3,627,750	$1,554,750		2020
Lake Street Water Upgrade	$443,820		$443,820		2020
Wortman Loop PS Improvements	$322,500		$322,500		2020
Connect Benchlands Upper Zone to Wortman Loop	$799,500		$799,500		2020
Connect Indian River Rd to Jarvis St.	$843,900		$843,900		2022
Harris Is. Water Replacement	$148,875	$74,438		$74,438	2024
Replace Air Vac Valves (est. 12)	$180,000			$180,000	2025
Relocate Airport Road Water	$1,456,800		$1,456,800		2025
Kashevaroff Street Water	$243,900			$243,900	2027
Connect Benchlands to Harbor Mt. Tank	$2,404,500		$2,404,500		2029
Lake Street to Pherson St and Verstovia Ave. Water	$1,168,500		$1,168,500		2029
Stargavin Water	$970,950	$873,855		$97,095	2030
Connect Granite Cr Rd to Harbor Mt. Rd	$867,000		$867,000		2030
Blue Lake WTP New Supply Line	$3,450,000	$2,415,000	$1,035,000		-
Benchlands Kramer Ave. Water Trunk	$3,499,500	$3,499,500			-
TOTAL	$40,862,925	$19,259,453	$16,759,200	$4,536,773	

Water System Financial Program

The water system financial program developed for this study is based on the understanding that the water utility operates as a self-supporting enterprise fund and, as such, receives revenue for payment of services on a user fee basis as opposed to property taxes or other non-utility revenue sources. For this study, utility rates are established to recover the full cost of the local share of capital expenditures, operating & maintenance expenses, debt service and related coverage requirements, and provide for an adequate level of reserves.

Particular attention was paid to generating the financial resources needed to construct and operate the new treatment facilities required to comply with the current Federal regulations concerning inactivation of *Cryptosporidium*. User fees have not increased since July, 2002 and currently are significantly lower than other communities in Alaska. The following chart shows Sitka's water utility rates compared to other Alaska communities.



[a] assumes average use of 90 gallons per day

The following table presents the proposed rate forecast through 2015. This rate strategy was designed to smooth in the necessary rate increases over time, while integrating best management practices, funding the capital program, and meeting the annual operational needs of the water utility. This financial management plan puts the utility in the position to qualify for state grants and low interest loans for funding major project which helps spread the financial burden over time and allows the utility to keep adequate cash in investments earning higher rates of return that the loan interest rate (currently at about 1.5%).

Rate Forecast	2009	2010	2011	2012	2013	2014	2015
Monthly Base Rate per Unit [1]	$16.00	$18.24	$20.79	$23.70	$27.02	$30.81	$35.12
Monthly Dollar Impact	$0.00	$2.24	$2.55	$2.91	$3.32	$3.78	$4.31

[1] Based rate applies per dwelling unit for residenital; varies for commercial customers based on unit equivalents

Following implementation of the proposed rate strategy for the study period, CBS staff expects future year rate increases to correspond with annual inflationary levels. It is recommended that CBS regularly review all underlying assumptions and update the rate analysis as necessary to meet financial obligations of the water utility.

Chapter 1
Water System Inventory

The purpose of this chapter is to briefly identify and characterize the main features of the Sitka Water System. This information will be used to make recommendations for improvements to the existing facilities and to make recommendations for additional improvements that may be necessary for the system to adequately serve its consumers. There are five major components to the Sitka water system as follows:

- Blue Lake Water Source and Treatment Plant (located at Sawmill Cove, adds chlorine for disinfection and fluoride to prevent tooth decay, controls rate of flow into the water system from Blue lake)

- Water Transmission and Distribution System Piping (transports water to town and distributes it to consumers)

- Corrosion Control Facility (located at Jarvis Street, adds soda ash to the water to change the pH which controls lead and copper concentrations in the water system)

- Water Storage Tanks (located at Harbor Mountain Road and at Charteris Street, used to meet peak water demands such as would occur during a fire)

- Water booster pumps serve the higher elevations of the Wortman Loop Area and the Hillside area (Eliason Loop)

Blue Lake Water Source

The primary source of water for Sitka is Blue Lake which is located above Sawmill Cove at an elevation of approximately 310' (Latitude 57.053N Longitude 135.330W). The lake is fed by glacier, snowmelt and rain precipitation and generally has very high quality water. Water Quality is monitored daily for turbidity, pH, and temperature.

The water is transported from Blue Lake to the Blue Lake Water Control Building in an 84" diameter penstock whose main purpose is to provide water to the Blue Lake Hydroelectric facility. A 20" diameter tap and shutoff valve was attached to the penstock to allow the City to withdraw water from the penstock for use in its potable water system. The 20" piping leads into the Blue Lake Water Control Building where chlorine is added to the water for disinfection and fluoride is added to the water to prevent tooth decay. Inside the Blue Lake Control Building the 20" piping splits into two parallel 12" lines. Each of these lines has a pressure reducing/flow control valve that controls the rate of flow into Sitka's water system. The flow is controlled automatically through a feedback signal from flow meters on each of the lines. The flow rates are manually selected by Sitka's water system operators and are set to keep the two water tanks in town full.

The water pressure from the penstock into the Blue Lake Water Control Building is about 106 psi and the pressure out of the pressure reducing/flow control valves is about 76 psi. The floor of the Blue Lake Water Control Building is at elevation 63.8'. Hence the hydraulic grade line of the water as it leaves the Blue Lake Water Control Building is at about 240' (63.8' + 2.31ft/psi x 76psi = 240').

The following pictures show Blue Lake and the transmission penstock:

Figure 1
Blue Lake Water Source

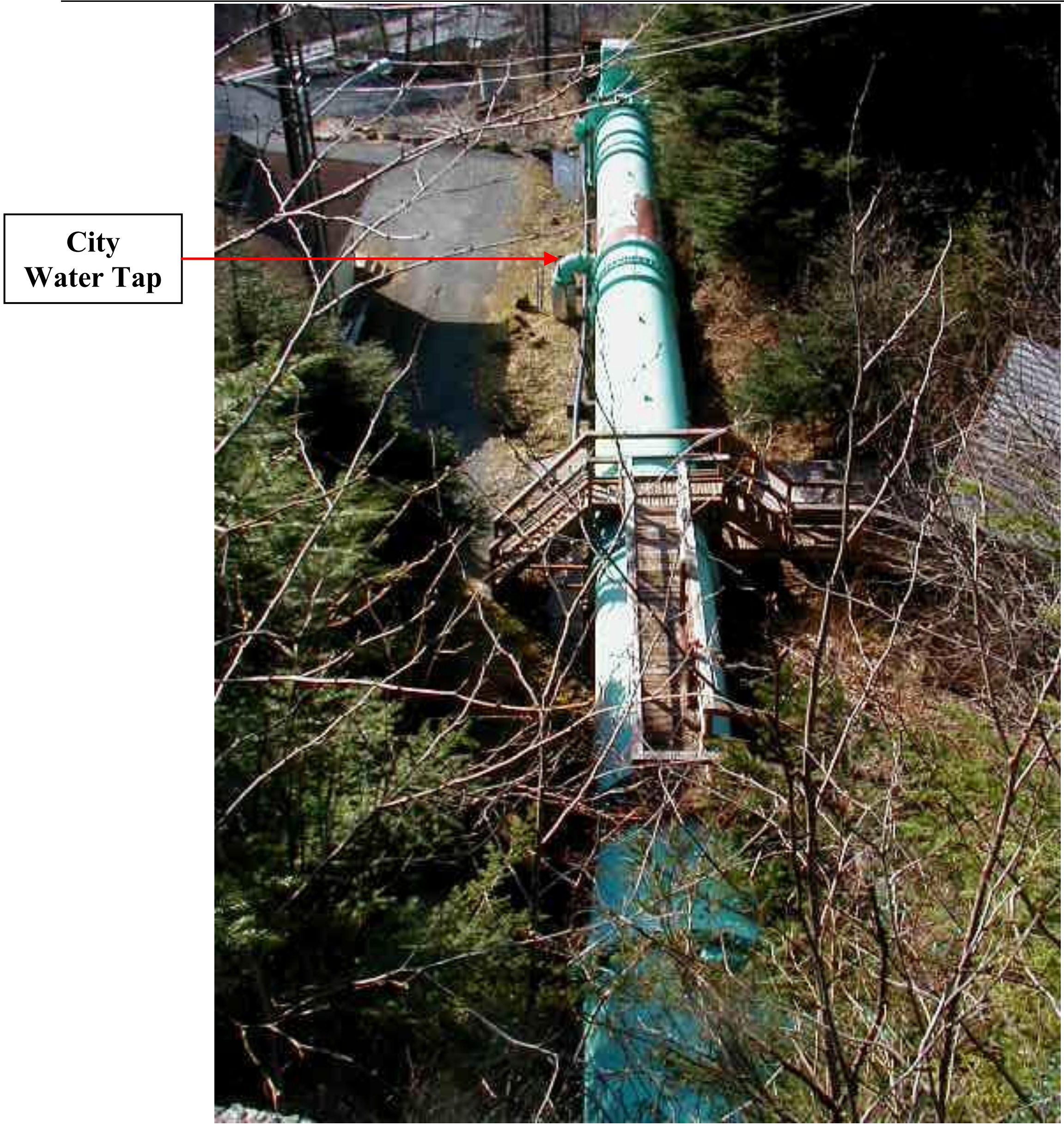


Figure 2
Blue Lake Penstock and City Water Tap

The City's water supply is an unfiltered surface water source and consequently must meet the State and Federal monitoring requirements for systems that do not provide filtration. These requirements are detailed in 40 CFR 141.74 (b). The City must monitor for fecal or total coliform bacteria at least 3 times per week, and whenever the turbidity of the source water exceeds 1 NTU.

In addition the City must determine the inactivation ratio for the protozoan giardia lamblia cysts. Exposure to giardia can cause symptoms similar to the flu. Severe diarrhea, vomiting, abdominal pain, and/or fever often accompany the disease. Though the majority of people recover from the disease within a week, individuals with low or developing immune systems (AIDS patients, children and the elderly) can die from the effects of exposure to this protozoan.

The Federal government has determined chlorine concentrations and contact times that are effective against giardia. The CT values (chlorine concentration x time) vary with water temperatures and pH value. The CT values necessary to inactivate giardia are listed in the tables contained in 40 CFR 141.74 (b).

Generally it is desirable to maintain chlorine concentrations in public water systems below 1.0 mg/l in order to control complaints about "chlorine" taste or smell in the water. Sitka seeks to maintain its chlorine concentration below 1.0 mg/l.

Sitka uses the volume in the water transmission line between the chlorination facilities and the first water consumers beyond Jarvis Street to achieve its contact time for the Blue Lake water source. The water transmission line from the Blue Lake Water Control Building to Jarvis Street consists of about 11,190' of 30" pipe and 14,145' of 24" pipe. The total volume of water in these pipes is about 806,910 gallons. So contact time is determined by dividing the set point flow rate at the Blue Lake Water Control Building in gallons per minute into the total volume in the transmission piping. For instance the contact time for a set point flow rate of 2,600 gpm is about 310 minutes (806,910 gallons/2,600gpm = 310 minutes).

Figure 3 Flow Control Valves at Blue Lake Water Treatment Plant

In addition to the transmission line from Blue Lake to Jarvis Street, there is an additional 2,345' of 24" water pipe between Jarvis Street and Jeff Davis Street. The total volume of water in this section of line is 59,980 gallons. This section of line provides some additional contact time but the pH of the water has been increased by the addition of soda ash to control lead and copper at the Corrosion Control Facility and consequently the CT requirements are different for the different pH. So generally this section of line is not used to determine compliance with the required CT values.

The pH of the water from Blue Lake is usually about 7.0. The required CT time for water with pH 7.0, a chlorine concentration of 1.0 mg/l and a water temperature of 0.5 °C according to 40 CFR 141.74 (b) Table 1.1 is 210. So with 806,910 gallons of storage in the water lines between the Blue Lake Water Control Building and Jarvis Street, the flow rate that achieves a CT of 210 is 3,840 gpm (806,910 gallons/CT of 210 = 3,840 gpm). This flow rate is the effective maximum flow rate from Blue Lake unless additional contact volume is provided for the water. A flow rate of 3,840 gpm is equivalent to about 5.530 million gallons per day.

Water Transmission and Distribution System Piping

The City and Borough of Sitka has about 250,560' (47.5 miles) of water transmission and distribution system piping. Over 3,240' of the pipe is asbestos cement pipe that is known to be brittle and susceptible to leaks. About 10,500' of the pipe has been in use for over 40 years; over 79,000' of pipe has been in use between 30 and 40 years.

Figure 4 New High Density Polyethylene Piping on Indian River Bridge

Sitka purchased water distribution modeling software called WaterCad for Windows that has an AutoCad interface that allows the user to create and model the water distribution system network directly within the drafting environment. This gives access to the drafting and presentation tools of AutoCad while still allowing water modeling tasks like editing, hydraulic calculations, and data management.

The Sitka water system can be modeled through WaterCad in the stand-alone mode or in the AutoCad mode. In the stand-alone mode the modeling interaction is more streamlined by virtue of the fact that the editing environment is a dedicated water network editor. In the stand-alone mode, less system resources and memory are required.

The City's "RoughPipes.dwg" water network files were provided by the City to prepare the inventory of water pipes and to update the water model. The blueprints and drawings of the Sitka water system in the City's record files were reviewed and information such as the year installed, pipe material, blueprint location, pipe diameter, and length of pipe were checked against the data files in the RoughPipes network. In addition the AutoCad version of RoughPipes was updated by moving water lines and junctions to line up with easements and right-of-ways; some lines that had been drawn as many short segments were joined into single pipes, street names were added to the AutoCad version of the water network display. Additionally street names were added to the network piping data tables so that the pipes could be identified by the street in which they are found.

The updated water system network has been renamed SitkaPipeInventory and has been furnished to Sitka on a CD.

There are four tables included at the end of this chapter that sort the pipe inventory data according to Street Name (Table 1), Date of Pipe (Table 2), Pipe Materials (Table 3) and Pipe Label (Table 4). These tables were exported from WaterCad as tab delimited files to Microsoft Excel and reproduced for this report.

Corrosion Control Facility

The City of Sitka conducted an initial round of monitoring for lead and copper in 1997 and the samples indicated that the action levels for both lead and copper were exceeded requiring a corrosion control study. The Blue Lake water supply is considered corrosive due to its low pH and low alkalinity. The addition of chlorine and fluoride further depresses the pH and increases the corrosiveness of the water

In 1998, Sitka began construction of a corrosion control facility. The intent of this facility is to feed soda ash into the water system to increase the pH to a target level of 8.0. At this pH level leaching of lead and copper is significantly reduced.

The system was designed for a range of flows, soda ash dosages, and target pH. The peak flow was assumed to be 5.0 million gallons per day, maximum soda ash dose was assumed to be 16 mg/l, and the high target value for pH was assumed to be 9.0. Under these peak conditions the facility would be using about 670 lbs of soda ash/day.

Under average design conditions of a 3.5 million gallon per day flow, soda ash dosage of 8 mg/l, and a target pH of 8.0 the facility would be using about 230 lbs/day of soda ash.

Figure 5 Corrosion Control Facility on Jarvis Street

Water Storage Tanks

The Sitka water system has two existing water storage tanks. One tank is located at the top of Harbor Mountain Road and the other is located at the top of Charteris Street.

The Harbor Mountain tank is located out Halibut Point Road and provides water for peak demands in that area. The base of the tank is at elevation 192' and the top water surface in the tank is at elevation 211'. The tank is about 20' tall and 85' in diameter. It has a nominal capacity of 750,000 gallons.

Figure 6 Harbor Mountain Water Tank (0.75 MG)

The tank on Charteris Street is known as the 1.2 million gallon tank and it provides for peak flows in the downtown area and the beginning of Halibut Point Road. The base of the tank is at elevation 178’ and the top water surface in the tank is at elevation 220’ (approximately 9’ higher than the Harbor Mountain tank). The tank is about 42’ tall and 70’ in diameter.

Figure 7 1.2 MG Tank on Charteris Street

Both tanks are fed from the Blue Lake water source and are in the same service zone. Consequently in order to fill the 1.2 MG tank, the Harbor Mountain tank must be full since it is at a lower elevation. It is reported that each tank has an altitude control valve that is supposed to close when the tank is full, but they are not currently in use. Water level in the tanks is controlled by regulating the flow control valves at the Blue Lake Water Control Building. If the tank levels are low the flow from Blue Lake is increased. If the tanks are full, the flow from Blue Lake is decreased. Since the altitude control valves are not in use, the Harbor Mountain tank frequently overflows while the 1.2 million gallon tank is being filled.

Water Booster Pump Stations

Water booster pump stations are frequently used to supply water to areas that are too high to be served by water tanks. For instance with a water surface elevation of about 211' at the harbor Mountain Tank, the water system pressure at elevation 165' is about 20 psi. Any development about that elevation will have water system pressures less than 20 psi.

Sitka currently has two water booster pump stations, one serving the Wortman Loop area and the other serving the Hillside area (Eliason Loop).

The Wortman Loop water booster pump station does not have any standby power generation capability and consequently cannot provide water during power outages whereas the Hillside water booster pump station has an emergency generator to ensure residents of the area receive water during power outages.

Figure 8 Wortman Loop Water Booster Pump Station

Figure 9 Hillside Water Booster Pump Station

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-95	A Street	6	124.9	372	Ductile Iron	SJ-79	SJ-73	1979	S-130
JP-20	Airport Rd.	16	124.9	252	Ductile Iron	JJ-22	JJ-20	1992	Hanging File Pg 33
JP-206	Airport Rd.	8	124.9	403	Cast iron	JJ-138	JJ-205	1967	M-52
JP-207	Airport Rd.	8	124.9	223	Cast iron	JJ-205	JJ-206	1967	M-52
JP-208	Airport Rd.	8	124.9	132	Cast iron	JJ-206	JJ-203	1984	M-52
JP-209	Airport Rd.	6	124.9	242	Cast iron	JJ-206	JJ-207	1967	M-52
P-338	Airport Rd.	16	124.9	769	Ductile Iron	JJ-30	JJ-203	1992	Hanging File Pg 32
P-339	Airport Rd.	16	124.9	1,410	Ductile Iron	JJ-203	JJ-22	1992	Hanging File Pg 33
P-351	Airport Rd.	8	124.9	800	Cast iron	JJ-144	JJ-141	1967	M-52
P-352	Airport Rd.	8	124.9	432	Cast iron	JJ-141	JJ-138	1967	M-52
P-335	Airport Road	16	124.9	1,474	Ductile Iron	JJ-20	JJ-10	1992	Hanging File Pg 32
JP-139	Alice loop	12	124.9	123	Ductile Iron	JJ-130	JJ-135	1985	W-124
JP-219	Alice loop	8	124.9	283	Ductile Iron	JJ-214	JJ-125	2002	
P-366	Alice loop	8	124.9	508	Cast iron	JJ-208	JJ-214	2002	
P-367	Alice loop	8	124.9	676	Ductile Iron	JJ-125	JJ-130		
P-368	Alice loop	8	124.9	564	Ductile Iron	JJ-130	JJ-127	1985	W-124
P-369	Alice loop	8	124.9	699	Ductile Iron	JJ-127	JJ-125	1985	W-124
SP-197	American St.	6	124.9	140	Ductile Iron	SJ-132	SJ-134		
SP167	American St.	6	124.9	170	Ductile Iron	SJ-122	SJ-134		S-149
P-306	Andrew Hope St.	8	124.9	626	Ductile Iron	J-207	J-210	1994	Flat File Pg 37
P-307	Andrew Hope St.	8	124.9	442	Ductile Iron	J-210	J-211	1994	Flat File Pg 37
SP-141	Andrews St.	6	124.9	534	Cast iron	SJ-110	J-247		W-86
SP-237	Anna Dr.	8	124.9	175	Ductile Iron	SJ-180	SJ-181	1985	S-151
SP-238	Anna Dr.	8	124.9	362	Ductile Iron	SJ-181	SJ-182	1985	S-151
SP-239	Anna Dr.	6	124.9	394	Ductile Iron	SJ-181	SJ-185	1985	S-151
P-387	Bahovec Ct.	8	130.0	475	Ductile Iron	J-164	J-165	1989	Flat File Pg 25
SP-112	Baranof St.	6	124.9	207	Cast iron	SJ-90	SJ-91	1971	W-11
SP-114	Baranof St.	6	124.9	401	Cast iron	SJ-90	SJ-139	1970	W-132
SP-175	Baranof St.	6	124.9	179	Cast iron	SJ-141	SJ-140	1975	W-106
SP-176	Baranof St.	6	130.0	231	Ductile Iron	SJ-140	SJ-139	1975	W-106
SP-184	Baranof St.	6	124.9	189	Ductile Iron	SJ-142	SJ-141	1975	W-106
SP-187	Baranof St.	6	124.9	318	Ductile Iron	SJ-142	SJ-143	1975	W-106
P-384	Barker St.	6	130.0	330	Ductile Iron	J-162	J-163	1986	S-150
P-400	Barracks St.	6	130.0	186	Ductile Iron	SJ-121	J-178		
P-441	Beardslee Way	8	150.0	398	HDPE	SJ-158	J-258	2005	
P-442	Beardslee Way	8	150.0	503	HDPE	J-258	J-261	2005	
P-298	Biorka St.	8	124.9	631	Cast iron	SJ-147	J-271	1967	W-88
SP-177	Biorka St.	6	124.9	676	Ductile Iron	SJ-140	SJ-147		
P-426	Blueberry lane	4	130.0	552	Ductile Iron	J-226	J-227		
SP-75	Brady St.	8	124.9	316	Ductile Iron	SJ-63	SJ-64	1975	W-109
P-398	Buhrt Cir.	6	130.0	277	Ductile Iron	SJ-76	J-176	1989	S-163
P-439	Burkhart St.	8	130.0	381	Ductile Iron	SJ-168	J-234	1995	Flat File Pg 41
SP-217	Burkhart St.	6	124.9	660	Ductile Iron	SJ-166	SJ-168	1986	S-164
P-344	Cascade Cr. Drive	12	130.0	162	Cast iron	SJ-36	SJ-37		W-63, W-104

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-48	Cascade Cr. Drive	8	124.9	642	Ductile Iron	SJ-36	J-196	1989	S-158
SP-286	Cascade Cr. Drive	12	130.0	284	Cast iron	SJ-37	SJ-38		W-63, W-104
P-267	Cascade Cr. Road	8	124.9	10	Ductile Iron	J-220	J-221	1992	W-138
P-268	Cascade Cr. Road	8	124.9	54	Ductile Iron	J-221	SJ-40	1989	S-158
P-269	Cascade Cr. Road	8	124.9	276	Ductile Iron	J-196	J-221	1989	S-158
SP-81	Cascade St.	8	124.9	1,008	Ductile Iron	SJ-65	SJ-68	1975	W-109
P-422	Cedar Beach Rd.	8	150.0	1,145	HDPE	J-194	J-201	2001	
JP-210	Charcoal Dr.	8	130.0	245	Ductile Iron	JJ-120	JJ-208	2002	
P-364	Charcoal Dr.	8	130.0	265	Ductile Iron	JJ-22	JJ-120		Flat File Pg 25
P-300	Charles St.	6	124.9	400	Ductile Iron	SJ-75	SJ-62	1979	S-130
SP-88	Charles St.	8	124.9	581	Ductile Iron	SJ-75	SJ-76	1989	S-163
SP-89	Charles St.	10	124.9	165	Ductile Iron	SJ-75	SJ-77	1979	S-130
P-277	Charteris St.	14	124.9	342	Cast iron	SJ-47	J-243	1968	W-46, W-47
P-278	Charteris St.	8	124.9	976	Ductile Iron	J-242	J-200	1996	
P-343	Charteris St.	6	124.9	68	Ductile Iron	J-270	SJ-47	1968	W-47
SP-54	Charteris St.	14	124.9	437	Cast iron	J-243	SJ-48	1968	W-46
SP-56	Charteris St.	14	124.9	390	Cast iron	SJ-48	J-224	1968	W-46
P-419	Chirikov Dr.	10	130.0	501	Ductile Iron	J-192	J-193		
P-375	Circle E.	8	130.0	437	Ductile Iron	SJ-17	J-157	1999	
SP-126	Crabapple Dr.	6	124.9	450	Ductile Iron	SJ-95	SJ-96	1980	W-117
P-301	Crescent Dr.	8	124.9	313	Ductile Iron	J-250	J-206		
SP-18	Darrin Dr.	6	130.0	882	Cast iron	SJ-18	SJ-19		
P-429	Davidoff st.	16	124.9	249	Ductile Iron	J-229	J-224	1992	W-138
SP-61	Davidoff St.	8	130.0	545	Ductile Iron	J-224	SJ-51	2005	Flat File Pg 28
P-294	DeArmond St.	6	124.9	175	Cast iron	J-247	SJ-115		
SP-142	DeArmond St.	6	130.0	406	Cast iron	J-247	SJ-111		W-86
SP-106	DeGroff St.	10	124.9	391	Cast iron	SJ-89	SJ-88	1968	W-34
SP-111	DeGroff St.	6	124.9	345	Cast iron	SJ-89	SJ-90	1970	W-10
SP-113	DeGroff St.	6	124.9	897	Cast iron	SJ-90	SJ-148	1970	W-9
SP-47	Dodge Cir.	12	124.9	738	Cast iron	SJ-35	SJ-36	1972	W-64, W-104
P-270	Donna Dr.	6	124.9	260	Ductile Iron	J-196	J-241	1997	Flat File Pg 27
P-336	Edgecumbe Dr.	12	130.0	147	Cast iron	J-272	SJ-45	1972	W-62, W-109
P-346	Edgecumbe Dr.	12	130.0	49	Cast iron	PMP-1	J-272	1972	W-62, W-109
P-430	Edgecumbe Dr.	12	124.9	227	Cast iron	SJ-48	J-230	1972	W-62, W-104
P-431	Edgecumbe Dr.	12	124.9	126	Cast iron	J-230	PMP-1	1972	W-62, W-109
SP-50	Edgecumbe Dr.	12	124.9	1,047	Cast iron	SJ-38	SJ-44	1972	W-104, W-64
SP-51	Edgecumbe Dr.	12	124.9	419	Cast iron	SJ-45	SJ-44	1972	W-62, W-109
SP-63	Edgecumbe Dr.	12	124.9	1,077	Cast iron	SJ-48	SJ-56	1968	W-45
SP-64	Edgecumbe Dr.	12	124.9	1,082	Cast iron	SJ-56	SJ-57	1968	W-43
SP-65	Edgecumbe Dr.	12	124.9	784	Cast iron	SJ-57	SJ-58	1968	W-43
SP-73	Edgecumbe Dr.	12	124.9	469	Cast iron	SJ-58	SJ-61	1968	W-43
SP-281	Edgecumbe Dr.	12	124.9	2,037	Cast iron	SJ-38	SJ-39	1972	W-65, W-63, W-104
SP-143	Erler St.	10	124.9	220	Ductile Iron	SJ-115	SJ-116	1987	S-157
SP-146	Erler St.	10	124.9	271	Ductile Iron	SJ-116	SJ-117	1987	S-157

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-150	Erler St.	10	124.9	256	Ductile Iron	SJ-118	SJ-117	1987	S-157
SP-151	Erler St.	10	124.9	416	Ductile Iron	SJ-118	SJ-119	1987	S-157
P-405	Etolin St.	8	124.9	321	Ductile Iron	SJ-145	J-183	1980	W-116
P-406	Etolin St.	6	124.9	473	Ductile Iron	J-183	SJ-142	1980	W-116
SP-181	Etolin St.	8	130.0	410	Ductile Iron	SJ-150	SJ-145	1980	W-116
SP-172	Etolin Way	4	124.9	359	Ductile Iron	SJ-127	SJ-136		
SP-182	Finn Alley	8	124.9	573	Cast iron	SJ-145	SJ-144	1968	W-20
SP-67	Furuhelm St.	8	124.9	620	Ductile Iron	SJ-59	SJ-60	1983	S-136
SP-76	Gavin St.	8	124.9	202	Ductile Iron	SJ-64	SJ-65	1975	W-109
SP-77	Gavin St.	6	124.9	439	Ductile Iron	SJ-65	SJ-66	1979	W-110
P-332	Georgeson loop	14	130.0	781	Cast iron	J-263	J-270	1968	W-47
P-280	Georgson loop	8	124.9	780	Ductile Iron	J-199	J-200	1996	
P-281	Georgson loop	8	124.9	772	Ductile Iron	J-199	J-198	1996	
P-282	Georgson loop	8	124.9	638	Ductile Iron	J-198	J-270	1996	Flat File Pg 28
P-432	Gibson Pl	4	130.0	567	Ductile Iron	J-229	J-230		
P-333	Granite Cr. Road	8	150.0	1,556	HDPE	J-264	SJ-12	2002	
SP-49	H.P.R at Cascade Ave.	8	124.9	33	Cast iron	J-267	SJ-40	1963	W-96
SP-43	Halibut Pt Road	12	124.9	325	Cast iron	SJ-30	SJ-32	1977	W-60
SP-83	Halibut Pt. Rd.	14	124.9	667	Cast iron	SJ-63	SJ-92	1968	W-40
P-265	Halibut Pt. Road	16	130.0	1,092	Ductile Iron	SJ-34	J-220	1992	W-138
P-266	Halibut Pt. Road	16	130.0	902	Ductile Iron	J-220	J-222	1992	W-138
P-290	Halibut Pt. Road	8	124.9	547	Ductile Iron	SJ-54	J-245	1975	W-109
P-334	Halibut Pt. Road	6	130.0	637	Cast iron	SJ-7	J-265	1977	W-92
P-341	Halibut Pt. Road	6	124.9	666	Cast iron	SJ-33	J-268	1963	W-95
P-342	Halibut Pt. Road	6	124.9	26	Ductile Iron	SJ-33	SJ-34	1977	W-61
P-371	Halibut Pt. Road	10	130.0	67	Ductile Iron	SJ-2	J-153	1989	Flat files
P-372	Halibut Pt. Road	6	130.0	238	Ductile Iron	J-153	J-154	1989	Flat files
P-376	Halibut Pt. Road	12	124.9	294	Cast iron	SJ-17	J-158	1977	W-54
P-377	Halibut Pt. Road	12	124.9	432	Cast iron	J-158	SJ-18	1977	W-54
P-379	Halibut Pt. Road	12	124.9	155	Cast iron	SJ-18	J-160	1977	W-54
P-380	Halibut Pt. Road	12	124.9	455	Cast iron	J-160	SJ-20	1977	W-54
P-381	Halibut Pt. Road	4	130.0	90	Ductile Iron	J-160	J-161		
P-382	Halibut Pt. Road	6	124.9	209	Ductile Iron	SJ-24	J-162	1986	S-150
P-385	Halibut Pt. Road	12	124.9	797	Cast iron	SJ-24	J-164	1977	W-56
P-386	Halibut Pt. Road	12	124.9	607	Cast iron	J-164	SJ-26	1977	W-56
P-388	Halibut Pt. Road	12	124.9	1,066	Cast iron	SJ-29	J-166	1977	W-59
P-389	Halibut Pt. Road	12	124.9	610	Cast iron	J-166	SJ-30	1977	W-60
P-428	Halibut Pt. Road	16	124.9	615	Ductile Iron	J-222	J-229	1992	W-138
SP-1	Halibut Pt. Road	12	124.9	418	Ductile Iron	SJ-1	SJ-2	1989	Flat files
SP-2	Halibut Pt. Road	12	124.9	683	Ductile Iron	SJ-2	SJ-3	1989	Flat files
SP-3	Halibut Pt. Road	12	124.9	4,413	Ductile Iron	SJ-3	SJ-4	1989	Flat files
SP-4	Halibut Pt. Road	12	124.9	519	Ductile Iron	SJ-4	SJ-5	1987	S-159
SP-5	Halibut Pt. Road	12	124.9	972	Cast iron	SJ-5	SJ-6	1977	W-92
SP-6	Halibut Pt. Road	10	124.9	225	Ductile Iron	SJ-6	J-265		W-192

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-7	Halibut Pt. Road	12	124.9	1,727	Cast iron	SJ-6	SJ-8	1977	W-92
SP-9	Halibut Pt. Road	12	124.9	1,551	Cast iron	SJ-8	SJ-10	1977	W-93
SP-10	Halibut Pt. Road	12	124.9	688	Cast iron	SJ-10	SJ-11	1977	W-50
SP-11	Halibut Pt. Road	12	124.9	1,396	Cast iron	SJ-11	SJ-13	1977	W-51
SP-12	Halibut Pt. Road	12	124.9	394	Cast iron	SJ-12	SJ-13	1977	W-52
SP-13	Halibut Pt. Road	12	124.9	1,334	Cast iron	SJ-14	SJ-12	1977	W-52
SP-16	Halibut Pt. Road	12	124.9	546	Cast iron	SJ-14	SJ-17	1977	W-53
SP-20	Halibut Pt. Road	12	124.9	1,165	Cast iron	SJ-20	SJ-21	1977	W-55
SP-35	Halibut Pt. Road	12	124.9	461	Cast iron	SJ-21	SJ-24	1977	W-55
SP-38	Halibut Pt. Road	12	124.9	1,433	Cast iron	SJ-26	SJ-27	1977	W-57
SP-39	Halibut Pt. Road	12	124.9	872	Cast iron	SJ-27	SJ-28	1977	W-58
SP-40	Halibut Pt. Road	12	124.9	790	Cast iron	SJ-28	SJ-29	1977	W-58
SP-44	Halibut Pt. Road	6	124.9	1,241	Cast iron	SJ-32	SJ-33	1963	W-95
SP-45	Halibut Pt. Road	12	124.9	1,232	Cast iron	SJ-32	SJ-34	1977	W-60, W-61
SP-57	Halibut Pt. Road	8	124.9	949	Cast iron	SJ-40	SJ-41	1963	W-96
SP-59	Halibut Pt. Road	8	124.9	363	Ductile Iron	SJ-41	SJ-43	1975	W-109
SP-68	Halibut Pt. Road	8	124.9	1,518	Ductile Iron	SJ-43	SJ-52	1975	W-109
SP-69	Halibut Pt. Road	8	124.9	672	Ductile Iron	SJ-52	SJ-53	1975	W-109
SP-70	Halibut Pt. Road	8	124.9	426	Ductile Iron	SJ-53	J-245	1975	W-109
SP-71	Halibut Pt. Road	8	124.9	406	Ductile Iron	SJ-54	SJ-55	1975	W-109
SP-74	Halibut Pt. Road	14	124.9	367	Cast iron	SJ-55	SJ-63	1968	W-40
SP-120	Halibut Pt. Road	16	124.9	159	Cast iron	SJ-125	SJ-119	1966	S-177
SP-121	Halibut Pt. Road	8	124.9	1,116	Ductile Iron	SJ-119	SJ-113	1975	W-109
SP-122	Halibut Pt. Road	8	124.9	388	Ductile Iron	SJ-113	SJ-98	1975	W-109
SP-123	Halibut Pt. Road	8	124.9	98	Ductile Iron	SJ-98	SJ-97	1975	W-109
SP-125	Halibut Pt. Road	8	124.9	230	Ductile Iron	SJ-97	SJ-95	1975	W-109
SP-127	Halibut Pt. Road	8	124.9	431	Ductile Iron	SJ-95	SJ-93	1975	W-109
SP-129	Halibut Pt. Road	8	130.0	622	Cast iron	SJ-93	SJ-92		
JP-9	Harbor Dr.	12	124.9	145	Ductile Iron	JJ-9	JJ-10		
JP-77	Harbor Dr.	10	124.9	202	Ductile Iron	JJ-76	JJ-77		
JP-78	Harbor Dr.	10	124.9	149	Cast iron	JJ-77	JJ-10		
P-348	Harbor Dr.	12	124.9	1,008	Ductile Iron	JJ-1	JJ-9		
SP-193	Harbor Dr.	12	124.9	738	Ductile Iron	SJ-128	SJ-129	1968	W-24
SP-200	Harbor Dr.	12	124.9	567	Cast iron	SJ-130	SJ-129	1968	W-24
SP-290	Harbor Mtn. Rd.	18	124.9	10	Ductile Iron	ST-1	SJ-15	1983	W-121
SP-14	Harbor Mtn. Road	18	124.9	2,366	Ductile Iron	SJ-14	SJ-15	1983	W-121
P-410	Harvest Way	6	130.0	295	Ductile Iron	SJ-167	J-186		
P-317	Heab Didrickson St.	8	124.9	648	Ductile Iron	J-255	J-257	2005	
SP-149	Hemlock St.	6	124.9	755	Ductile Iron	SJ-114	SJ-118	1988	W-130
P-402	Hirst St.	6	130.0	99	Cast iron	SJ-86	J-180		
SP-103	Hirst St.	6	124.9	335	Cast iron	SJ-87	SJ-86		
P-312	Indain River Road	18	124.9	1,374	Cast iron	J-208	SJ-155	1971	Flat File Pg 37
P-313	Indain River Road	8	124.9	350	Ductile Iron	J-208	J-253	2000	Flat File Pg 37
P-314	Indain River Road	8	124.9	850	Ductile Iron	J-253	J-254	2000	Flat File Pg 37

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-308	Indian River Road	18	124.9	452	Cast iron	J-207	J-208	1971	Flat File Pg 37
P-407	Indian River Road	18	124.9	840	Cast iron	SJ-154	J-184	1971	Flat File Pg 37
P-408	Indian River Road	18	124.9	875	Cast iron	J-184	J-207	1971	Flat File Pg 37
SP-245	Islander Dr.	6	124.9	1,084	Ductile Iron	SJ-188	SJ-189	1979	W-111, 112, 113
P-325	Jamestown Dr.	8	124.9	470	Ductile Iron	SJ-178	J-214	1977	S-124, S-125
P-326	Jamestown Dr.	8	124.9	569	Ductile Iron	J-214	J-215	1977	
P-438	Jarvis St	8	124.9	449	Ductile Iron	J-233	SJ-157	1987	S-155
P-437	Jarvis St.	8	124.9	251	Ductile Iron	SJ-156	J-233		
SP-211	Jarvis St.	8	124.9	641	Ductile Iron	SJ-157	SJ-158	1987	S-155
SP-288	Jarvis St.	8	124.9	593	Ductile Iron	SJ-158	SJ-159	1987	S-155
P-299	Jeff Davis St.	8	124.9	80	Cast iron	J-250	SJ-150	1968	W-22
P-305	Jeff Davis St.	8	124.9	472	Ductile Iron	J-251	SJ-151	1968	W-22
SP-180	Jeff Davis St.	8	130.0	375	Cast iron	SJ-149	J-250	1968	W-22
SP-202	Jeff Davis St.	8	124.9	305	Cast iron	J-251	SJ-150	1968	W-22
P-304	John Brady Dr.	12	130.0	772	Ductile Iron	J-204	J-251	2004	Flat File Pg 37
P-284	Johnston St.	8	124.9	866	Ductile Iron	J-197	J-243	1996	Flat File Pg 28
P-311	Joseph St.	6	124.9	303	Ductile Iron	J-209	J-210	1994	Flat File Pg 37
P-316	Joseph St.	6	124.9	241	Ductile Iron	J-256	J-209	1994	Flat File Pg 37
SP-154	Kaagwaantaan St.	8	124.9	1,413	Ductile Iron	SJ-104	SJ-109	1982	S-135
P-409	Kaasda Heen Cir.	6	130.0	277	Ductile Iron	J-184	J-185	1998	
P-287	Kashevaroff St.	8	124.9	328	Ductile Iron	SJ-59	J-203	1987	Flat File Pg 29
P-288	Kashevaroff St.	6	124.9	240	Ductile Iron	SJ-59	J-244	1987	
P-289	Kashevaroff St.	6	124.9	165	Ductile Iron	J-244	J-202	1987	Flat File Pg 29
P-291	Kashevaroff St.	8	124.9	419	Ductile Iron	SJ-57	J-245		
SP-157	Katlian Ave	12	124.9	267	Cast iron	SJ-105	SJ-106	1968	W-25
SP-158	Katlian Ave	12	124.9	443	Cast iron	SJ-106	SJ-107	1968	W-25
SP-159	Katlian Ave	12	124.9	362	Cast iron	SJ-107	SJ-108	1968	W-26
SP-161	Katlian Ave	12	124.9	389	Cast iron	SJ-108	SJ-131	1968	W-25
SP-130	Katlian Ave.	12	124.9	655	Cast iron	SJ-92	SJ-100	1968	W-32
SP-131	Katlian Ave.	12	124.9	224	Cast iron	SJ-100	SJ-101	1968	W-32
SP-132	Katlian Ave.	12	124.9	1,021	Cast iron	SJ-101	SJ-102	1968	W-31, W-32
SP-153	Katlian Ave.	12	124.9	511	Cast iron	SJ-102	SJ-104	1968	W-31
SP-155	Katlian Ave.	12	124.9	243	Cast iron	SJ-104	SJ-105	1968	W-31
P-404	Kelly St.	6	130.0	237	Ductile Iron	SJ-152	J-182	1985	S-146, SH 9
P-416	Kiksadi Ct.	6	130.0	319	Ductile Iron	J-189	J-191	1995	
P-292	Kimsham st.	2	147.0	522	Copper	SJ-58	J-246	1980	W-115
SP-66	Kimsham St.	8	124.9	406	Ductile Iron	SJ-58	SJ-60	1983	S-136
SP-99	Kincaid St.	6	124.9	257	Cast iron	SJ-85	SJ-84		Flat File Pg 36
P-327	Knutson Dr.	8	124.9	252	Ductile Iron	SJ-180	J-217	1993	M-244
P-328	Knutson Dr.	6	124.9	692	Ductile Iron	J-217	J-218	1993	M-244
P-329	Knutson Dr.	6	124.9	355	Ductile Iron	J-218	J-219	1993	M-244
P-330	Knutson Dr.	6	124.9	340	Ductile Iron	J-219	J-217	1993	M-244
P-347	Kramer Ave.	12	130.0	1,000	Ductile Iron	SJ-31	Theoretical Hydrant at 150' in Benchlands Subdivision		
SP-42	Kramer Ave.	8	124.9	589	Ductile Iron	SJ-30	SJ-31	1985	M-177

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-82	Lake St.	10	124.9	296	Cast iron	SJ-70	SJ-71	1968	W-37
SP-100	Lake St.	10	124.9	979	Cast iron	SJ-82	SJ-83	1968	W-36, W-35
SP-101	Lake St.	10	124.9	708	Cast iron	SJ-83	SJ-71	1968	W-37, W-36
SP-102	Lake St.	10	124.9	404	Cast iron	SJ-84	SJ-87	1968	W-34
SP-107	Lake St.	10	124.9	173	Cast iron	SJ-88	SJ-87	1968	W-34
SP-108	Lake St.	6	124.9	731	Cast iron	SJ-88	SJ-125	1966	W-87
SP-119	Lake St.	12	124.9	312	Cast iron	SJ-126	SJ-125	1965	S-53
SP-171	Lake St.	12	124.9	334	Cast iron	SJ-127	SJ-126	1965	S-53
SP-192	Lake St.	12	124.9	268	Cast iron	SJ-128	SJ-127	1965	S-53
SP-285	Lake St.	10	124.9	433	Cast iron	SJ-82	SJ-84	1968	W-35
SP-124	Lakeview Dr.	6	124.9	657	Ductile Iron	SJ-97	SJ-94	1988	W-127
SP-128	Lakeview Dr.	6	124.9	1,327	Ductile Iron	SJ-93	SJ-94	1988	W-127
P-324	Lance Dr.	6	124.9	630	Ductile Iron	SJ-169	J-213	1992	W-134
P-433	Lance Dr.	6	124.9	291	Ductile Iron	SJ-168	J-231	1979	S-129
P-434	Lance Dr.	6	124.9	523	Ductile Iron	J-231	SJ-170	1979	S-129
P-435	Lance Dr.	6	124.9	323	Ductile Iron	SJ-168	J-232	1978	S-128
P-436	Lance Dr.	6	124.9	588	Ductile Iron	J-232	SJ-169	1981	S-133
JP-100	Lifesaver Dr.	10	113.0	88	Asbestos Cement	JJ-30	JJ-97	1992	Hanging File
JP-142	Lifesaver Dr.	8	124.9	53	Cast iron	JJ-30	JJ-138	1992	Hanging File
P-340	Lifesaver Dr.	10	113.0	672	Asbestos Cement	JJ-118	JJ-98		
P-349	Lifesaver Dr.	10	113.0	911	Asbestos Cement	JJ-98	JJ-109		
P-413	Lilian Dr.	6	130.0	1,161	Ductile Iron	J-260	J-259	2001	W-136
P-403	Lincoln St.	6	130.0	106	Ductile Iron	SJ-144	J-181	1985	S-147, SH 53
SP-188	Lincoln St.	8	124.9	651	Ductile Iron	SJ-143	SJ-144	1985	S-147, SH 52
SP-189	Lincoln St.	8	124.9	284	Ductile Iron	SJ-143	SJ-135	1985	S-147, SH 52
SP-191	Lincoln St.	8	124.9	293	Ductile Iron	SJ-135	SJ-128	1985	S-147, SH 51
SP-194	Lincoln St.	10	124.9	623	Ductile Iron	SJ-128	SJ-133	1985	S-147
SP-196	Lincoln St.	10	124.9	204	Ductile Iron	SJ-133	SJ-132	1985	S-147
SP-198	Lincoln St.	10	124.9	515	Ductile Iron	SJ-132	SJ-131	1985	S-147
SP-201	Lincoln St.	8	124.9	364	Ductile Iron	SJ-144	SJ-151	1985	S-147, SH 53
SP-203	Lincoln St.	6	124.9	1,104	Ductile Iron	SJ-151	SJ-152	1985	S-146, SH 9
JP-101	Livesaver Dr.	10	113.0	86	Asbestos Cement	JJ-97	JJ-98		
SP-195	Maksostoff St.	8	150.0	154	HDPE	SJ-133	SJ-129	2002	Flat File Pg 35
SP-136	Marine St.	10	124.9	270	Cast iron	SJ-98	SJ-112	1968	W-28
SP-144	Marine St.	10	124.9	628	Cast iron	SJ-116	SJ-112	1968	W-28
SP-145	Marine St.	10	124.9	380	Cast iron	SJ-116	SJ-120	1968	W-27
SP-163	Marine St.	10	124.9	699	Cast iron	SJ-121	SJ-120	1968	W-26
P-411	Marys Court	6	130.0	449	Ductile Iron	J-262	J-187	2002	
P-296	Merrill Street	6	124.9	868	Cast iron	SJ-91	J-249	1967, 1975	W-94, S-93
SP-204	Metlakatla St.	6	124.9	650	Ductile Iron	SJ-152	SJ-153	1985	S-146, SH 9
P-279	Mills St.	8	124.9	477	Ductile Iron	J-198	J-200	1996	
P-283	Mills St.	8	124.9	350	Ductile Iron	J-198	J-197	1996	
P-285	Mills St.	6	124.9	354	Cast iron	J-197	SJ-56		
SP-78	Moller Ave.	6	124.9	422	Ductile Iron	SJ-66	SJ-67	1979	W-110

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-93	Monastery st.	8	124.9	254	Ductile Iron	SJ-74	SJ-79	1979	S-130
SP-94	Monastery St.	8	124.9	343	Ductile Iron	SJ-79	SJ-80	1979	S-130
SP-96	Monastery St.	8	124.9	190	Ductile Iron	SJ-80	SJ-81		
SP-98	Monastery St.	6	124.9	794	Cast iron	SJ-81	SJ-85		
SP-104	Monastery St.	6	124.9	390	Cast iron	SJ-86	SJ-85		
SP-105	Monastery St.	2	150.0	209	HDPE	J-269	SJ-89	1996	W-137
SP-110	Monastery St.	10	124.9	555	Cast iron	J-248	SJ-89	1968	W-33
SP-117	Monastery St.	6	124.9	363	Ductile Iron	J-248	SJ-137	1969	W-107
SP-173	Monastery St.	6	124.9	240	Ductile Iron	SJ-136	SJ-137	1969	W-107
SP-190	Monastery st.	6	124.9	290	Ductile Iron	SJ-135	SJ-136	1969	W-107
P-318	Naomi Kanosh lane	8	124.9	550	Ductile Iron	J-254	J-257	2002	W-135
SP-62	NE of Fergisun loop	12	130.0	429	Ductile Iron	J-263	ST-2	1998	
SP-133	New Archangel St.	8	130.0	234	Ductile Iron	SJ-102	SJ-103	1968	W-30
SP-137	New Archangel St.	8	124.9	258	Cast iron	SJ-112	SJ-113	1968	W-30
SP-138	New Archangel St.	8	124.9	228	Cast iron	SJ-112	SJ-111	1968	W-30
SP-139	New Archangel St.	8	124.9	237	Cast iron	SJ-111	SJ-110	1968	W-30
SP-140	New Archangel St.	8	124.9	262	Cast iron	SJ-110	SJ-103	1968	W-30
SP-22	Nicole Dr.	10	124.9	182	Ductile Iron	SJ-221	SJ-22	1981	W-122
SP-31	Nicole Dr.	10	124.9	273	Ductile Iron	SJ-21	SJ-221	1981	W-122
SP-169	Observatory St.	8	124.9	459	Cast iron	SJ-123	SJ-124	1968	W-23
SP-134	O'Cain St.	6	124.9	222	Cast iron	SJ-103	SJ-99	1968	W-29
P-262	O'Connell Bridge	12	100.0	1,360	Steel	SJ-130	JJ-1	1980	Flat File Pg 35
JP-212	Off Alice loop	8	124.9	216	Ductile Iron	JJ-208	JJ-209		
JP-213	Off Alice loop	8	124.9	104	Ductile Iron	JJ-209	JJ-210	1967	
JP-216	Off Alice Loop	8	124.9	534	Ductile Iron	JJ-210	JJ-212		Flat File Pg 39
P-370	Off Alice loop	8	124.9	690	Ductile Iron	JJ-214	JJ-210	2002	
P-378	Off Circle E	6	130.0	329	Ductile Iron	J-158	J-159		
P-302	Off Crescent Dr.	8	124.9	634	Ductile Iron	J-206	J-205		
SP-160	Off Katlian Ave	10	124.9	115	Cast iron	SJ-108	SJ-109		
P-264	Off Kinkroft Way	6	124.9	447	Ductile Iron	J-195	SJ-223	1993	
P-396	Off Lake St.	8	150.0	661	HDPE	SJ-70	J-174	2006	
P-401	Off Lincoln St.	4	130.0	164	Ductile Iron	SJ-134	J-179	1989	S-129
SP-199	Off lincoln St.	12	124.9	503	Cast iron	SJ-131	SJ-130	1968	W-24
P-303	Off Metlakatla	12	130.0	802	Ductile Iron	J-252	J-204	2004	
SP-156	off of Erler St.	12	124.9	402	Cast iron	SJ-105	SJ-115	1968	W-27
P-297	Off Park St.	4	124.9	300	Ductile Iron	J-249	SJ-148		
P-412	Off Price St.	6	150.0	269	HDPE	J-261	J-188	2002	
JP-34	Off Seward Ave.	8	113.0	320	Asbestos Cement	JJ-33	JJ-34		
JP-57	Off Seward Ave.	10	124.9	156	Ductile Iron	JJ-56	JJ-57	1984	S-154
JP-58	Off Seward Ave.	10	124.9	90	Ductile Iron	JJ-57	JJ-58	1984	S-154
JP-59	Off Seward Ave.	8	124.9	157	Ductile Iron	JJ-58	JJ-59	1984	S-154
JP-60	Off Seward Ave.	10	124.9	222	Ductile Iron	JJ-58	JJ-60	1984	S-154
JP-61	Off Seward Ave.	6	124.9	132	Ductile Iron	JJ-60	JJ-61	1984	S-154
JP-62	Off Seward Ave.	6	124.9	92	Ductile Iron	JJ-61	JJ-62	1984	S-154

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
JP-152	Off Seward Ave.	8	124.9	274	Ductile Iron	JJ-33	JJ-147		
JP-153	Off Seward Ave.	8	124.9	59	Ductile Iron	JJ-147	JJ-148		
JP-154	Off Seward Ave.	8	113.0	339	Asbestos Cement	JJ-148	JJ-149		
JP-155	Off Seward Ave.	8	113.0	275	Asbestos Cement	JJ-149	JJ-150		
JP-156	Off Seward Ave.	8	150.0	216	HDPE	JJ-150	JJ-151		
P-350	Off Seward Ave.	8	130.0	351	Cast iron	JJ-147	JJ-144	1967	M-52
P-353	Off Seward Ave.	8	124.9	689	Ductile Iron	JJ-159	JJ-34		
P-354	Off Seward Ave.	8	113.0	548	Asbestos Cement	JJ-34	JJ-151		
P-397	Off Verstovia St.	6	130.0	299	Ductile Iron	SJ-72	J-175		
P-309	Off Yaw Dr.	12	124.9	481	Ductile Iron	J-208	J-256	1994	Flat File Pg 37
SP-185	Oja St.	6	124.9	552	Ductile Iron	SJ-141	SJ-146	1980	W-116
SP-118	Oja Way	6	130.0	499	Ductile Iron	SJ-137	SJ-126	1969	W-131
SP-135	Osprey St.	6	124.9	729	Cast iron	SJ-99	SJ-98	1968	W-29
SP-178	Park St.	4	124.9	235	Cast iron	SJ-147	SJ-148		
SP-186	Park St.	6	124.9	242	Ductile Iron	SJ-146	SJ-147	1980	W-116
SP-24	Patterson Way	6	124.9	364	Ductile Iron	SJ-22	SJ-23	1981	W-122
P-293	Peterson St.	10	124.9	192	Cast iron	J-246	SJ-55	1968	W-41
SP-72	Peterson St.	10	124.9	505	Cast iron	J-246	SJ-61	1968	W-41
SP-79	Peterson St.	10	124.9	722	Cast iron	SJ-61	SJ-68	1968	W-41
SP-80	Peterson St.	10	124.9	150	Cast iron	SJ-70	SJ-68	1968	W-37
SP-90	Pherson St.	8	124.9	801	Ductile Iron	SJ-77	SJ-78	1989	S-163
SP-91	Pherson St.	8	124.9	373	Ductile Iron	SJ-62	SJ-77	1979	S-130
SP-92	Pherson St.	8	124.9	348	Ductile Iron	SJ-62	SJ-80	1979	S-130
P-320	Price St.	12	124.9	114	Ductile Iron	J-260	J-259	1986	S-164
P-321	Price St.	12	124.9	135	Ductile Iron	J-259	SJ-165	1986	S-164
P-322	Price St.	8	150.0	706	HDPE	SJ-167	J-261	2002	
P-323	Price St.	8	150.0	375	HDPE	J-261	J-262	2002	
SP-215	Price St.	12	124.9	362	Ductile Iron	J-260	SJ-166	1986	S-164
SP-216	Price St.	12	124.9	344	Ductile Iron	SJ-166	SJ-167	1988	
P-423	Rands Dr.	6	130.0	429	Ductile Iron	SJ-187	J-225	1985	S-145
P-383	Ross St.	6	124.9	376	Ductile Iron	J-162	SJ-25	1986	S-150
P-310	Rudolph Walton Cir	6	124.9	320	Ductile Iron	J-209	J-212	1994	Flat File Pg 37
P-390	Sand dollar Dr.	6	130.0	789	Ductile Iron	J-166	J-167	1987	Flat File Pg 26
P-295	Sawmill Cr. Road	6	124.9	10	Ductile Iron	SJ-138	J-248	1969	W-107
P-331	Sawmill Cr. Road	8	124.9	775	Ductile Iron	SJ-194	J-216	1980	W-118
P-417	Sawmill Cr. Road	14	124.9	213	Cast iron	SJ-173	J-192	1972	W-68
P-418	Sawmill Cr. Road	14	124.9	1,417	Cast iron	J-192	SJ-177	1972	W-68, W-67
P-420	Sawmill Cr. Road	14	130.0	78	Ductile Iron	SJ-180	J-194	1980	W-118
P-421	Sawmill Cr. Road	14	130.0	101	Ductile Iron	J-194	SJ-183	1980	W-118
P-424	Sawmill Cr. Road	12	124.9	1,842	Ductile Iron	SJ-190	J-226	1980	W-118
P-425	Sawmill Cr. Road	12	124.9	625	Ductile Iron	J-226	SJ-191	1980	W-118
P-427	Sawmill Cr. Road	12	130.0	1,034	Ductile Iron	J-216	J-228	1992	W-133
SP-109	Sawmill Cr. Road	16	124.9	513	Cast iron	SJ-125	SJ-138	1966	S-177
SP-115	Sawmill Cr. Road	16	124.9	768	Cast iron	SJ-139	SJ-148	1966	S-177

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-116	Sawmill Cr. Road	16	124.9	285	Cast iron	SJ-139	SJ-138	1966	S-177
SP-179	Sawmill Cr. Road	16	124.9	675	Cast iron	SJ-148	SJ-149	1966	S-177
SP-206	Sawmill Cr. Road	18	124.9	237	Cast iron	SJ-149	SJ-?	1966	S-177
SP-207	Sawmill Cr. Road	18	124.9	176	Cast iron	SJ-?	SJ-154	1966	S177
SP-209	Sawmill Cr. Road	14	124.9	2,406	Cast iron	SJ-154	SJ-156	1972	W-72
SP-214	Sawmill Cr. Road	14	124.9	900	Cast iron	SJ-162	SJ-165	1972	W-70
SP-220	Sawmill Cr. Road	14	124.9	628	Ductile Iron	SJ-170	SJ-165	1972	W-69
SP-221	Sawmill Cr. Road	14	124.9	511	Cast iron	SJ-170	SJ-172	1972	W-68
SP-222	Sawmill Cr. Road	12	124.9	24	Ductile Iron	SJ-172	SJ-171		
SP-223	Sawmill Cr. Road	14	124.9	550	Cast iron	SJ-172	SJ-173	1972	W-68
SP-229	Sawmill Cr. Road	14	124.9	683	Cast iron	SJ-177	SJ-178	1972	W-67
SP-230	Sawmill Cr. Road	24	124.9	2,710	Ductile Iron	SJ-?	SJ-160	1987	W-125, SH 1
SP-231	Sawmill Cr. Road	24	124.9	542	Ductile Iron	SJ-160	SJ-161	1987	W-125, SH 2
SP-232	Sawmill Cr. Road	24	124.9	1,312	Ductile Iron	SJ-161	SJ-164	1987	W-125, SH 2
SP-233	Sawmill Cr. Road	24	124.9	1,103	Ductile Iron	SJ-164	SJ-171	1987	W-125, SH 2
SP-234	Sawmill Cr. Road	24	124.9	4,473	Ductile Iron	SJ-171	SJ-184	1987	W125, SH 3 & 4
SP-235	Sawmill Cr. Road	14	124.9	512	Cast iron	SJ-178	SJ-179	1972	W-66
SP-236	Sawmill Cr. Road	14	124.9	939	Cast iron	SJ-179	SJ-180	1972	W-66
SP-241	Sawmill Cr. Road	12	124.9	15	Ductile Iron	SJ-183	SJ-184	1987	W-125
SP-242	Sawmill Cr. Road	14	130.0	1,245	Ductile Iron	SJ-183	SJ-186	1980	W-118
SP-246	Sawmill Cr. Road	12	124.9	1,354	Ductile Iron	SJ-186	SJ-190	1980	W-118
SP-248	Sawmill Cr. Road	12	124.9	1,427	Ductile Iron	SJ-191	SJ-192	1980	W-118
SP-249	Sawmill Cr. Road	12	124.9	4	Ductile Iron	SJ-192	SJ-194	1980	W-118
SP-250	Sawmill Cr. Road	24	124.9	6,227	Ductile Iron	SJ-184	SJ-193	1987	W-125, SH 4, 5, 6, 7
SP-251	Sawmill Cr. Road	30	124.9	2,091	Ductile Iron	SJ-193	SJ-195	1987	W-125, SH 6, 7
SP-280	Sawmill Cr. Road	12	124.9	30	Ductile Iron	SJ-192	SJ-193	1987	W-125
SP-212	Sawmill Cr. Road	14	124.9	1,044	Cast iron	SJ-156	SJ-162	1972	W-70
SP-289	Sawmill Cr. Road	30	124.9	15,000	Ductile Iron	SR-1	SJ-195	1987	W-125
JP-66	Seward Ave.	6	124.9	50	Ductile Iron	JJ-65	JJ-66	1984	S-154
JP-67	Seward Ave.	6	124.9	72	Ductile Iron	JJ-66	JJ-67		S-154
JP-222	Seward Ave.	12	124.9	31	Ductile Iron	JJ-215	JJ-73	1984	S-154
P-337	Seward Ave.	12	124.9	2,004	Ductile Iron	JJ-53	JJ-37	2004	
P-357	Seward Ave.	10	124.9	301	Ductile Iron	JJ-215	JJ-70	1984	S-154
P-358	Seward Ave.	12	124.9	590	Ductile Iron	JJ-70	JJ-65	1984	S-154
P-359	Seward Ave.	12	124.9	165	Ductile Iron	JJ-65	JJ-56	1984	S-154
P-360	Seward Ave.	12	124.9	454	Ductile Iron	JJ-56	JJ-53	1984	S-154
P-362	Seward Ave.	6	124.9	129	Ductile Iron	JJ-227	JJ-215	1984	S-154
P-363	Seward Ave.	10	124.9	603	Cast iron	JJ-76	JJ-73		
SP-162	Seward St.	10	124.9	220	Cast iron	SJ-109	SJ-121		S-149
SP-165	Seward St.	10	124.9	190	Ductile Iron	SJ-121	SJ-122	1986	
SP-168	Seward St.	10	124.9	140	Ductile Iron	SJ-122	SJ-123	1986	S-149
SP-170	Seward St.	12	124.9	680	Ductile Iron	SJ-123	SJ-127	1992	S-180
P-271	Shelikof Way	6	124.9	10	Ductile Iron	J-222	J-223	1978	S-123
P-272	Shelikof Way	6	124.9	54	Ductile Iron	J-223	SJ-41	1978	S-123

TABLE 1
SITKA WATER SYSTEM PIPE INVENTORY
BY
STREET NAME

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-58	Shelikof Way	6	124.9	559	Ductile Iron	J-223	SJ-42	1978	S-123
SP-243	Shotgun Alley	8	124.9	797	Ductile Iron	SJ-186	SJ-187	1980	W-118
SP-244	Shotgun Alley	8	124.9	1,049	Ductile Iron	SJ-187	SJ-188	1980	W-118
SP-15	Shuler Dr.	6	124.9	455	Ductile Iron	SJ-14	SJ-16	1975	W-105
P-394	Sigtnaka Way	6	130.0	260	Cast iron	SJ-100	J-172		
P-395	Sigtnaka Way	4	130.0	626	Ductile Iron	J-172	J-173		
SP-97	Sirstad St.	8	124.9	1,242	Ductile Iron	SJ-81	SJ-72	1975	W-103
P-319	Smith St.	8	150.0	1,044	HDPE	J-258	SJ-163	1998	Flat File Pg 39
SP-213	Smith St.	8	130.0	447	Ductile Iron	SJ-162	SJ-163	1983	Flat File Pg 39
SP-23	Somer Dr.	6	124.9	257	Ductile Iron	SJ-221	SJ-223	1981	W-122
SP-147	Spruce St.	6	124.9	571	Ductile Iron	SJ-117	SJ-114	1989	W-129
SP-148	Spruce St.	6	124.9	136	Ductile Iron	SJ-114	SJ-113	1989	W-129
P-392	Tilson St.	6	130.0	465	Ductile Iron	SJ-60	J-170	1983	S-136
P-399	Tlingit Way	2	150.0	400	HDPE	SJ-120	J-177	1996	W-137
JP-84	Tongass Dr.	12	124.9	1,167	Ductile Iron	JJ-92	JJ-20	2004	
P-355	Tongass Dr.	12	124.9	671	Ductile Iron	JJ-53	JJ-92	1984	S-154
P-373	Valhalla Dr.	6	130.0	229	Ductile Iron	J-155	SJ-9	1978	W-108
P-374	Valhalla Dr.	6	130.0	141	Ductile Iron	SJ-9	J-156	1978	W-108
SP-84	Verstovia Ave.	8	124.9	304	Ductile Iron	SJ-71	SJ-72	1975	W-103
SP-85	Verstovia Ave.	10	124.9	545	Ductile Iron	SJ-72	SJ-73	1979	S-130
SP-86	Verstovia Ave.	10	124.9	214	Ductile Iron	SJ-73	SJ-74	1979	S-130
SP-87	Verstovia Ave.	10	124.9	277	Ductile Iron	SJ-74	SJ-75	1979	S-130
SP-8	Viking Way	6	124.9	287	Ductile Iron	SJ-8	SJ-9	1978	W-108
P-415	Vitskari St.	8	130.0	54	Ductile Iron	J-189	J-190	1995	Flat File Pg 41
P-440	Vitskari St.	8	130.0	140	Ductile Iron	J-234	J-189	1995	Flat File Pg 41
P-393	Wachusetts Wt.	6	130.0	826	Ductile Iron	SJ-58	J-171	1974	W-128
SP-46	West of Dodge Cir.	12	124.9	582	Cast iron	SJ-34	SJ-35	1977	W-61, W-104
SP-224	Wolff Dr.	6	124.9	309	Ductile Iron	SJ-173	SJ-174		W-98
SP-225	Wolff Dr.	6	124.9	589	Ductile Iron	SJ-174	SJ-175		
SP-226	Wolff Dr.	6	124.9	410	Ductile Iron	SJ-175	SJ-176		W-98
SP-227	Wolff Dr.	6	124.9	310	Ductile Iron	SJ-176	SJ-174		W-98
P-276	Wortman loop	6	124.9	10	Ductile Iron	SJ-47	J-242	1996	
SP-52	Wortman loop	6	124.9	934	Ductile Iron	SJ-44	SJ-46	1979	S-114
SP-53	Wortman Loop	6	124.9	707	Ductile Iron	J-242	SJ-46	1979	S-115
P-315	Yaw Drove	12	124.9	667	Ductile Iron	J-253	J-255	2005	

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-341	Halibut Pt. Road	6	124.9	666	Cast iron	SJ-33	J-268	1963	W-95
SP-44	Halibut Pt. Road	6	124.9	1,241	Cast iron	SJ-32	SJ-33	1963	W-95
SP-49	H.P.R at Cascade Ave.	8	124.9	33	Cast iron	J-267	SJ-40	1963	W-96
SP-57	Halibut Pt. Road	8	124.9	949	Cast iron	SJ-40	SJ-41	1963	W-96
SP-119	Lake St.	12	124.9	312	Cast iron	SJ-126	SJ-125	1965	S-53
SP-171	Lake St.	12	124.9	334	Cast iron	SJ-127	SJ-126	1965	S-53
SP-192	Lake St.	12	124.9	268	Cast iron	SJ-128	SJ-127	1965	S-53
SP-108	Lake St.	6	124.9	731	Cast iron	SJ-88	SJ-125	1966	W-87
SP-109	Sawmill Cr. Road	16	124.9	513	Cast iron	SJ-125	SJ-138	1966	S-177
SP-115	Sawmill Cr. Road	16	124.9	768	Cast iron	SJ-139	SJ-148	1966	S-177
SP-116	Sawmill Cr. Road	16	124.9	285	Cast iron	SJ-139	SJ-138	1966	S-177
SP-120	Halibut Pt. Road	16	124.9	159	Cast iron	SJ-125	SJ-119	1966	S-177
SP-179	Sawmill Cr. Road	16	124.9	675	Cast iron	SJ-148	SJ-149	1966	S-177
SP-206	Sawmill Cr. Road	18	124.9	237	Cast iron	SJ-149	SJ-?	1966	S-177
SP-207	Sawmill Cr. Road	18	124.9	176	Cast iron	SJ-?	SJ-154	1966	S177
JP-206	Airport Rd.	8	124.9	403	Cast iron	JJ-138	JJ-205	1967	M-52
JP-207	Airport Rd.	8	124.9	223	Cast iron	JJ-205	JJ-206	1967	M-52
JP-209	Airport Rd.	6	124.9	242	Cast iron	JJ-206	JJ-207	1967	M-52
JP-213	Off Alice loop	8	124.9	104	Ductile Iron	JJ-209	JJ-210	1967	
P-298	Biorka St.	8	124.9	631	Cast iron	SJ-147	J-271	1967	W-88
P-350	Off Seward Ave.	8	130.0	351	Cast iron	JJ-147	JJ-144	1967	M-52
P-351	Airport Rd.	8	124.9	800	Cast iron	JJ-144	JJ-141	1967	M-52
P-352	Airport Rd.	8	124.9	432	Cast iron	JJ-141	JJ-138	1967	M-52
P-277	Charteris St.	14	124.9	342	Cast iron	SJ-47	J-243	1968	W-46, W-47
P-293	Peterson St.	10	124.9	192	Cast iron	J-246	SJ-55	1968	W-41
P-299	Jeff Davis St.	8	124.9	80	Cast iron	J-250	SJ-150	1968	W-22
P-305	Jeff Davis St.	8	124.9	472	Ductile Iron	J-251	SJ-151	1968	W-22
P-332	Georgeson loop	14	130.0	781	Cast iron	J-263	J-270	1968	W-47
P-343	Charteris St.	6	124.9	68	Ductile Iron	J-270	SJ-47	1968	W-47
SP-54	Charteris St.	14	124.9	437	Cast iron	J-243	SJ-48	1968	W-46
SP-56	Charteris St.	14	124.9	390	Cast iron	SJ-48	J-224	1968	W-46
SP-63	Edgecumbe Dr.	12	124.9	1,077	Cast iron	SJ-48	SJ-56	1968	W-45
SP-64	Edgecumbe Dr.	12	124.9	1,082	Cast iron	SJ-56	SJ-57	1968	W-43
SP-65	Edgecumbe Dr.	12	124.9	784	Cast iron	SJ-57	SJ-58	1968	W-43
SP-72	Peterson St.	10	124.9	505	Cast iron	J-246	SJ-61	1968	W-41
SP-73	Edgecumbe Dr.	12	124.9	469	Cast iron	SJ-58	SJ-61	1968	W-43
SP-74	Halibut Pt. Road	14	124.9	367	Cast iron	SJ-55	SJ-63	1968	W-40
SP-79	Peterson St.	10	124.9	722	Cast iron	SJ-61	SJ-68	1968	W-41
SP-80	Peterson St.	10	124.9	150	Cast iron	SJ-70	SJ-68	1968	W-37
SP-82	Lake St.	10	124.9	296	Cast iron	SJ-70	SJ-71	1968	W-37
SP-83	Halibut Pt. Rd.	14	124.9	667	Cast iron	SJ-63	SJ-92	1968	W-40
SP-100	Lake St.	10	124.9	979	Cast iron	SJ-82	SJ-83	1968	W-36, W-35
SP-101	Lake St.	10	124.9	708	Cast iron	SJ-83	SJ-71	1968	W-37, W-36
SP-102	Lake St.	10	124.9	404	Cast iron	SJ-84	SJ-87	1968	W-34

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-106	DeGroff St.	10	124.9	391	Cast iron	SJ-89	SJ-88	1968	W-34
SP-107	Lake St.	10	124.9	173	Cast iron	SJ-88	SJ-87	1968	W-34
SP-110	Monastery St.	10	124.9	555	Cast iron	J-248	SJ-89	1968	W-33
SP-130	Katlian Ave.	12	124.9	655	Cast iron	SJ-92	SJ-100	1968	W-32
SP-131	Katlian Ave.	12	124.9	224	Cast iron	SJ-100	SJ-101	1968	W-32
SP-132	Katlian Ave.	12	124.9	1,021	Cast iron	SJ-101	SJ-102	1968	W-31, W-32
SP-133	New Archangel St.	8	130.0	234	Ductile Iron	SJ-102	SJ-103	1968	W-30
SP-134	O'Cain St.	6	124.9	222	Cast iron	SJ-103	SJ-99	1968	W-29
SP-135	Osprey St.	6	124.9	729	Cast iron	SJ-99	SJ-98	1968	W-29
SP-136	Marine St.	10	124.9	270	Cast iron	SJ-98	SJ-112	1968	W-28
SP-137	New Archangel St.	8	124.9	258	Cast iron	SJ-112	SJ-113	1968	W-30
SP-138	New Archangel St.	8	124.9	228	Cast iron	SJ-112	SJ-111	1968	W-30
SP-139	New Archangel St.	8	124.9	237	Cast iron	SJ-111	SJ-110	1968	W-30
SP-140	New Archangel St.	8	124.9	262	Cast iron	SJ-110	SJ-103	1968	W-30
SP-144	Marine St.	10	124.9	628	Cast iron	SJ-116	SJ-112	1968	W-28
SP-145	Marine St.	10	124.9	380	Cast iron	SJ-116	SJ-120	1968	W-27
SP-153	Katlian Ave.	12	124.9	511	Cast iron	SJ-102	SJ-104	1968	W-31
SP-155	Katlian Ave.	12	124.9	243	Cast iron	SJ-104	SJ-105	1968	W-31
SP-156	off of Erler St.	12	124.9	402	Cast iron	SJ-105	SJ-115	1968	W-27
SP-157	Katlian Ave	12	124.9	267	Cast iron	SJ-105	SJ-106	1968	W-25
SP-158	Katlian Ave	12	124.9	443	Cast iron	SJ-106	SJ-107	1968	W-25
SP-159	Katlian Ave	12	124.9	362	Cast iron	SJ-107	SJ-108	1968	W-26
SP-161	Katlian Ave	12	124.9	389	Cast iron	SJ-108	SJ-131	1968	W-25
SP-163	Marine St.	10	124.9	699	Cast iron	SJ-121	SJ-120	1968	W-26
SP-169	Observatory St.	8	124.9	459	Cast iron	SJ-123	SJ-124	1968	W-23
SP-180	Jeff Davis St.	8	130.0	375	Cast iron	SJ-149	J-250	1968	W-22
SP-182	Finn Alley	8	124.9	573	Cast iron	SJ-145	SJ-144	1968	W-20
SP-193	Harbor Dr.	12	124.9	738	Ductile Iron	SJ-128	SJ-129	1968	W-24
SP-199	Off lincoln St.	12	124.9	503	Cast iron	SJ-131	SJ-130	1968	W-24
SP-200	Harbor Dr.	12	124.9	567	Cast iron	SJ-130	SJ-129	1968	W-24
SP-202	Jeff Davis St.	8	124.9	305	Cast iron	J-251	SJ-150	1968	W-22
SP-285	Lake St.	10	124.9	433	Cast iron	SJ-82	SJ-84	1968	W-35
P-295	Sawmill Cr. Road	6	124.9	10	Ductile Iron	SJ-138	J-248	1969	W-107
SP-117	Monastery St.	6	124.9	363	Ductile Iron	J-248	SJ-137	1969	W-107
SP-118	Oja Way	6	130.0	499	Ductile Iron	SJ-137	SJ-126	1969	W-131
SP-173	Monastery St.	6	124.9	240	Ductile Iron	SJ-136	SJ-137	1969	W-107
SP-190	Monastery st.	6	124.9	290	Ductile Iron	SJ-135	SJ-136	1969	W-107
SP-111	DeGroff St.	6	124.9	345	Cast iron	SJ-89	SJ-90	1970	W-10
SP-113	DeGroff St.	6	124.9	897	Cast iron	SJ-90	SJ-148	1970	W-9
SP-114	Baranof St.	6	124.9	401	Cast iron	SJ-90	SJ-139	1970	W-132
P-308	Indian River Road	18	124.9	452	Cast iron	J-207	J-208	1971	Flat File Pg 37
P-312	Indain River Road	18	124.9	1,374	Cast iron	J-208	SJ-155	1971	Flat File Pg 37
P-407	Indian River Road	18	124.9	840	Cast iron	SJ-154	J-184	1971	Flat File Pg 37
P-408	Indian River Road	18	124.9	875	Cast iron	J-184	J-207	1971	Flat File Pg 37

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-112	Baranof St.	6	124.9	207	Cast iron	SJ-90	SJ-91	1971	W-11
P-336	Edgecumbe Dr.	12	130.0	147	Cast iron	J-272	SJ-45	1972	W-62, W-109
P-346	Edgecumbe Dr.	12	130.0	49	Cast iron	PMP-1	J-272	1972	W-62, W-109
P-417	Sawmill Cr. Road	14	124.9	213	Cast iron	SJ-173	J-192	1972	W-68
P-418	Sawmill Cr. Road	14	124.9	1,417	Cast iron	J-192	SJ-177	1972	W-68, W-67
P-430	Edgecumbe Dr.	12	124.9	227	Cast iron	SJ-48	J-230	1972	W-62, W-104
P-431	Edgecumbe Dr.	12	124.9	126	Cast iron	J-230	PMP-1	1972	W-62, W-109
SP-47	Dodge Cir.	12	124.9	738	Cast iron	SJ-35	SJ-36	1972	W-64, W-104
SP-50	Edgecumbe Dr.	12	124.9	1,047	Cast iron	SJ-38	SJ-44	1972	W-104, W-64
SP-51	Edgecumbe Dr.	12	124.9	419	Cast iron	SJ-45	SJ-44	1972	W-62, W-109
SP-209	Sawmill Cr. Road	14	124.9	2,406	Cast iron	SJ-154	SJ-156	1972	W-72
SP-212	Sawmill Cr. Road	14	124.9	1,044	Cast iron	SJ-156	SJ-162	1972	W-70
SP-214	Sawmill Cr. Road	14	124.9	900	Cast iron	SJ-162	SJ-165	1972	W-70
SP-220	Sawmill Cr. Road	14	124.9	628	Ductile Iron	SJ-170	SJ-165	1972	W-69
SP-221	Sawmill Cr. Road	14	124.9	511	Cast iron	SJ-170	SJ-172	1972	W-68
SP-223	Sawmill Cr. Road	14	124.9	550	Cast iron	SJ-172	SJ-173	1972	W-68
SP-229	Sawmill Cr. Road	14	124.9	683	Cast iron	SJ-177	SJ-178	1972	W-67
SP-235	Sawmill Cr. Road	14	124.9	512	Cast iron	SJ-178	SJ-179	1972	W-66
SP-236	Sawmill Cr. Road	14	124.9	939	Cast iron	SJ-179	SJ-180	1972	W-66
SP-281	Edgecumbe Dr.	12	124.9	2,037	Cast iron	SJ-38	SJ-39	1972	W-65, W-63, W-104
P-393	Wachusetts Wt.	6	130.0	826	Ductile Iron	SJ-58	J-171	1974	W-128
P-290	Halibut Pt. Road	8	124.9	547	Ductile Iron	SJ-54	J-245	1975	W-109
SP-15	Shuler Dr.	6	124.9	455	Ductile Iron	SJ-14	SJ-16	1975	W-105
SP-59	Halibut Pt. Road	8	124.9	363	Ductile Iron	SJ-41	SJ-43	1975	W-109
SP-68	Halibut Pt. Road	8	124.9	1,518	Ductile Iron	SJ-43	SJ-52	1975	W-109
SP-69	Halibut Pt. Road	8	124.9	672	Ductile Iron	SJ-52	SJ-53	1975	W-109
SP-70	Halibut Pt. Road	8	124.9	426	Ductile Iron	SJ-53	J-245	1975	W-109
SP-71	Halibut Pt. Road	8	124.9	406	Ductile Iron	SJ-54	SJ-55	1975	W-109
SP-75	Brady St.	8	124.9	316	Ductile Iron	SJ-63	SJ-64	1975	W-109
SP-76	Gavin St.	8	124.9	202	Ductile Iron	SJ-64	SJ-65	1975	W-109
SP-81	Cascade St.	8	124.9	1,008	Ductile Iron	SJ-65	SJ-68	1975	W-109
SP-84	Verstovia Ave.	8	124.9	304	Ductile Iron	SJ-71	SJ-72	1975	W-103
SP-97	Sirstad St.	8	124.9	1,242	Ductile Iron	SJ-81	SJ-72	1975	W-103
SP-121	Halibut Pt. Road	8	124.9	1,116	Ductile Iron	SJ-119	SJ-113	1975	W-109
SP-122	Halibut Pt. Road	8	124.9	388	Ductile Iron	SJ-113	SJ-98	1975	W-109
SP-123	Halibut Pt. Road	8	124.9	98	Ductile Iron	SJ-98	SJ-97	1975	W-109
SP-125	Halibut Pt. Road	8	124.9	230	Ductile Iron	SJ-97	SJ-95	1975	W-109
SP-127	Halibut Pt. Road	8	124.9	431	Ductile Iron	SJ-95	SJ-93	1975	W-109
SP-175	Baranof St.	6	124.9	179	Cast iron	SJ-141	SJ-140	1975	W-106
SP-176	Baranof St.	6	130.0	231	Ductile Iron	SJ-140	SJ-139	1975	W-106
SP-184	Baranof St.	6	124.9	189	Ductile Iron	SJ-142	SJ-141	1975	W-106
SP-187	Baranof St.	6	124.9	318	Ductile Iron	SJ-142	SJ-143	1975	W-106
P-325	Jamestown Dr.	8	124.9	470	Ductile Iron	SJ-178	J-214	1977	S-124, S-125
P-326	Jamestown Dr.	8	124.9	569	Ductile Iron	J-214	J-215	1977	

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-334	Halibut Pt. Road	6	130.0	637	Cast iron	SJ-7	J-265	1977	W-92
P-342	Halibut Pt. Road	6	124.9	26	Ductile Iron	SJ-33	SJ-34	1977	W-61
P-376	Halibut Pt. Road	12	124.9	294	Cast iron	SJ-17	J-158	1977	W-54
P-377	Halibut Pt. Road	12	124.9	432	Cast iron	J-158	SJ-18	1977	W-54
P-379	Halibut Pt. Road	12	124.9	155	Cast iron	SJ-18	J-160	1977	W-54
P-380	Halibut Pt. Road	12	124.9	455	Cast iron	J-160	SJ-20	1977	W-54
P-385	Halibut Pt. Road	12	124.9	797	Cast iron	SJ-24	J-164	1977	W-56
P-386	Halibut Pt. Road	12	124.9	607	Cast iron	J-164	SJ-26	1977	W-56
P-388	Halibut Pt. Road	12	124.9	1,066	Cast iron	SJ-29	J-166	1977	W-59
P-389	Halibut Pt. Road	12	124.9	610	Cast iron	J-166	SJ-30	1977	W-60
SP-5	Halibut Pt. Road	12	124.9	972	Cast iron	SJ-5	SJ-6	1977	W-92
SP-7	Halibut Pt. Road	12	124.9	1,727	Cast iron	SJ-6	SJ-8	1977	W-92
SP-9	Halibut Pt. Road	12	124.9	1,551	Cast iron	SJ-8	SJ-10	1977	W-93
SP-10	Halibut Pt. Road	12	124.9	688	Cast iron	SJ-10	SJ-11	1977	W-50
SP-11	Halibut Pt. Road	12	124.9	1,396	Cast iron	SJ-11	SJ-13	1977	W-51
SP-12	Halibut Pt. Road	12	124.9	394	Cast iron	SJ-12	SJ-13	1977	W-52
SP-13	Halibut Pt. Road	12	124.9	1,334	Cast iron	SJ-14	SJ-12	1977	W-52
SP-16	Halibut Pt. Road	12	124.9	546	Cast iron	SJ-14	SJ-17	1977	W-53
SP-20	Halibut Pt. Road	12	124.9	1,165	Cast iron	SJ-20	SJ-21	1977	W-55
SP-35	Halibut Pt. Road	12	124.9	461	Cast iron	SJ-21	SJ-24	1977	W-55
SP-38	Halibut Pt. Road	12	124.9	1,433	Cast iron	SJ-26	SJ-27	1977	W-57
SP-39	Halibut Pt. Road	12	124.9	872	Cast iron	SJ-27	SJ-28	1977	W-58
SP-40	Halibut Pt. Road	12	124.9	790	Cast iron	SJ-28	SJ-29	1977	W-58
SP-43	Halibut Pt Road	12	124.9	325	Cast iron	SJ-30	SJ-32	1977	W-60
SP-45	Halibut Pt. Road	12	124.9	1,232	Cast iron	SJ-32	SJ-34	1977	W-60, W-61
SP-46	West of Dodge Cir.	12	124.9	582	Cast iron	SJ-34	SJ-35	1977	W-61, W-104
P-271	Shelikof Way	6	124.9	10	Ductile Iron	J-222	J-223	1978	S-123
P-272	Shelikof Way	6	124.9	54	Ductile Iron	J-223	SJ-41	1978	S-123
P-373	Valhalla Dr.	6	130.0	229	Ductile Iron	J-155	SJ-9	1978	W-108
P-374	Valhalla Dr.	6	130.0	141	Ductile Iron	SJ-9	J-156	1978	W-108
P-435	Lance Dr.	6	124.9	323	Ductile Iron	SJ-168	J-232	1978	S-128
SP-8	Viking Way	6	124.9	287	Ductile Iron	SJ-8	SJ-9	1978	W-108
SP-58	Shelikof Way	6	124.9	559	Ductile Iron	J-223	SJ-42	1978	S-123
P-300	Charles St.	6	124.9	400	Ductile Iron	SJ-75	SJ-62	1979	S-130
P-433	Lance Dr.	6	124.9	291	Ductile Iron	SJ-168	J-231	1979	S-129
P-434	Lance Dr.	6	124.9	523	Ductile Iron	J-231	SJ-170	1979	S-129
SP-52	Wortman loop	6	124.9	934	Ductile Iron	SJ-44	SJ-46	1979	S-114
SP-53	Wortman Loop	6	124.9	707	Ductile Iron	J-242	SJ-46	1979	S-115
SP-77	Gavin St.	6	124.9	439	Ductile Iron	SJ-65	SJ-66	1979	W-110
SP-78	Moller Ave.	6	124.9	422	Ductile Iron	SJ-66	SJ-67	1979	W-110
SP-85	Verstovia Ave.	10	124.9	545	Ductile Iron	SJ-72	SJ-73	1979	S-130
SP-86	Verstovia Ave.	10	124.9	214	Ductile Iron	SJ-73	SJ-74	1979	S-130
SP-87	Verstovia Ave.	10	124.9	277	Ductile Iron	SJ-74	SJ-75	1979	S-130
SP-89	Charles St.	10	124.9	165	Ductile Iron	SJ-75	SJ-77	1979	S-130

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-91	Pherson St.	8	124.9	373	Ductile Iron	SJ-62	SJ-77	1979	S-130
SP-92	Pherson St.	8	124.9	348	Ductile Iron	SJ-62	SJ-80	1979	S-130
SP-93	Monastery st.	8	124.9	254	Ductile Iron	SJ-74	SJ-79	1979	S-130
SP-94	Monastery St.	8	124.9	343	Ductile Iron	SJ-79	SJ-80	1979	S-130
SP-95	A Street	6	124.9	372	Ductile Iron	SJ-79	SJ-73	1979	S-130
SP-245	Islander Dr.	6	124.9	1,084	Ductile Iron	SJ-188	SJ-189	1979	W-111, 112, 113
P-262	O'Connell Bridge	12	100.0	1,360	Steel	SJ-130	JJ-1	1980	Flat File Pg 35
P-292	Kimsham st.	2	147.0	522	Copper	SJ-58	J-246	1980	W-115
P-331	Sawmill Cr. Road	8	124.9	775	Ductile Iron	SJ-194	J-216	1980	W-118
P-405	Etolin St.	8	124.9	321	Ductile Iron	SJ-145	J-183	1980	W-116
P-406	Etolin St.	6	124.9	473	Ductile Iron	J-183	SJ-142	1980	W-116
P-420	Sawmill Cr. Road	14	130.0	78	Ductile Iron	SJ-180	J-194	1980	W-118
P-421	Sawmill Cr. Road	14	130.0	101	Ductile Iron	J-194	SJ-183	1980	W-118
P-424	Sawmill Cr. Road	12	124.9	1,842	Ductile Iron	SJ-190	J-226	1980	W-118
P-425	Sawmill Cr. Road	12	124.9	625	Ductile Iron	J-226	SJ-191	1980	W-118
SP-126	Crabapple Dr.	6	124.9	450	Ductile Iron	SJ-95	SJ-96	1980	W-117
SP-181	Etolin St.	8	130.0	410	Ductile Iron	SJ-150	SJ-145	1980	W-116
SP-185	Oja St.	6	124.9	552	Ductile Iron	SJ-141	SJ-146	1980	W-116
SP-186	Park St.	6	124.9	242	Ductile Iron	SJ-146	SJ-147	1980	W-116
SP-242	Sawmill Cr. Road	14	130.0	1,245	Ductile Iron	SJ-183	SJ-186	1980	W-118
SP-243	Shotgun Alley	8	124.9	797	Ductile Iron	SJ-186	SJ-187	1980	W-118
SP-244	Shotgun Alley	8	124.9	1,049	Ductile Iron	SJ-187	SJ-188	1980	W-118
SP-246	Sawmill Cr. Road	12	124.9	1,354	Ductile Iron	SJ-186	SJ-190	1980	W-118
SP-248	Sawmill Cr. Road	12	124.9	1,427	Ductile Iron	SJ-191	SJ-192	1980	W-118
SP-249	Sawmill Cr. Road	12	124.9	4	Ductile Iron	SJ-192	SJ-194	1980	W-118
P-436	Lance Dr.	6	124.9	588	Ductile Iron	J-232	SJ-169	1981	S-133
SP-22	Nicole Dr.	10	124.9	182	Ductile Iron	SJ-221	SJ-22	1981	W-122
SP-23	Somer Dr.	6	124.9	257	Ductile Iron	SJ-221	SJ-223	1981	W-122
SP-24	Patterson Way	6	124.9	364	Ductile Iron	SJ-22	SJ-23	1981	W-122
SP-31	Nicole Dr.	10	124.9	273	Ductile Iron	SJ-21	SJ-221	1981	W-122
SP-154	Kaagwaantaan St.	8	124.9	1,413	Ductile Iron	SJ-104	SJ-109	1982	S-135
P-392	Tilson St.	6	130.0	465	Ductile Iron	SJ-60	J-170	1983	S-136
SP-14	Harbor Mtn. Road	18	124.9	2,366	Ductile Iron	SJ-14	SJ-15	1983	W-121
SP-66	Kimsham St.	8	124.9	406	Ductile Iron	SJ-58	SJ-60	1983	S-136
SP-67	Furuhelm St.	8	124.9	620	Ductile Iron	SJ-59	SJ-60	1983	S-136
SP-213	Smith St.	8	130.0	447	Ductile Iron	SJ-162	SJ-163	1983	Flat File Pg 39
SP-290	Harbor Mtn. Rd.	18	124.9	10	Ductile Iron	ST-1	SJ-15	1983	W-121
JP-57	Off Seward Ave.	10	124.9	156	Ductile Iron	JJ-56	JJ-57	1984	S-154
JP-58	Off Seward Ave.	10	124.9	90	Ductile Iron	JJ-57	JJ-58	1984	S-154
JP-59	Off Seward Ave.	8	124.9	157	Ductile Iron	JJ-58	JJ-59	1984	S-154
JP-60	Off Seward Ave.	10	124.9	222	Ductile Iron	JJ-58	JJ-60	1984	S-154
JP-61	Off Seward Ave.	6	124.9	132	Ductile Iron	JJ-60	JJ-61	1984	S-154
JP-62	Off Seward Ave.	6	124.9	92	Ductile Iron	JJ-61	JJ-62	1984	S-154
JP-66	Seward Ave.	6	124.9	50	Ductile Iron	JJ-65	JJ-66	1984	S-154

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
JP-208	Airport Rd.	8	124.9	132	Cast iron	JJ-206	JJ-203	1984	M-52
JP-222	Seward Ave.	12	124.9	31	Ductile Iron	JJ-215	JJ-73	1984	S-154
P-355	Tongass Dr.	12	124.9	671	Ductile Iron	JJ-53	JJ-92	1984	S-154
P-357	Seward Ave.	10	124.9	301	Ductile Iron	JJ-215	JJ-70	1984	S-154
P-358	Seward Ave.	12	124.9	590	Ductile Iron	JJ-70	JJ-65	1984	S-154
P-359	Seward Ave.	12	124.9	165	Ductile Iron	JJ-65	JJ-56	1984	S-154
P-360	Seward Ave.	12	124.9	454	Ductile Iron	JJ-56	JJ-53	1984	S-154
P-362	Seward Ave.	6	124.9	129	Ductile Iron	JJ-227	JJ-215	1984	S-154
JP-139	Alice loop	12	124.9	123	Ductile Iron	JJ-130	JJ-135	1985	W-124
P-368	Alice loop	8	124.9	564	Ductile Iron	JJ-130	JJ-127	1985	W-124
P-369	Alice loop	8	124.9	699	Ductile Iron	JJ-127	JJ-125	1985	W-124
P-403	Lincoln St.	6	130.0	106	Ductile Iron	SJ-144	J-181	1985	S-147, SH 53
P-404	Kelly St.	6	130.0	237	Ductile Iron	SJ-152	J-182	1985	S-146, SH 9
P-423	Rands Dr.	6	130.0	429	Ductile Iron	SJ-187	J-225	1985	S-145
SP-42	Kramer Ave.	8	124.9	589	Ductile Iron	SJ-30	SJ-31	1985	M-177
SP-188	Lincoln St.	8	124.9	651	Ductile Iron	SJ-143	SJ-144	1985	S-147, SH 52
SP-189	Lincoln St.	8	124.9	284	Ductile Iron	SJ-143	SJ-135	1985	S-147, SH 52
SP-191	Lincoln St.	8	124.9	293	Ductile Iron	SJ-135	SJ-128	1985	S-147, SH 51
SP-194	Lincoln St.	10	124.9	623	Ductile Iron	SJ-128	SJ-133	1985	S-147
SP-196	Lincoln St.	10	124.9	204	Ductile Iron	SJ-133	SJ-132	1985	S-147
SP-198	Lincoln St.	10	124.9	515	Ductile Iron	SJ-132	SJ-131	1985	S-147
SP-201	Lincoln St.	8	124.9	364	Ductile Iron	SJ-144	SJ-151	1985	S-147, SH 53
SP-203	Lincoln St.	6	124.9	1,104	Ductile Iron	SJ-151	SJ-152	1985	S-146, SH 9
SP-204	Metlakatla St.	6	124.9	650	Ductile Iron	SJ-152	SJ-153	1985	S-146, SH 9
SP-237	Anna Dr.	8	124.9	175	Ductile Iron	SJ-180	SJ-181	1985	S-151
SP-238	Anna Dr.	8	124.9	362	Ductile Iron	SJ-181	SJ-182	1985	S-151
SP-239	Anna Dr.	6	124.9	394	Ductile Iron	SJ-181	SJ-185	1985	S-151
P-320	Price St.	12	124.9	114	Ductile Iron	J-260	J-259	1986	S-164
P-321	Price St.	12	124.9	135	Ductile Iron	J-259	SJ-165	1986	S-164
P-382	Halibut Pt. Road	6	124.9	209	Ductile Iron	SJ-24	J-162	1986	S-150
P-383	Ross St.	6	124.9	376	Ductile Iron	J-162	SJ-25	1986	S-150
P-384	Barker St.	6	130.0	330	Ductile Iron	J-162	J-163	1986	S-150
SP-165	Seward St.	10	124.9	190	Ductile Iron	SJ-121	SJ-122	1986	
SP-168	Seward St.	10	124.9	140	Ductile Iron	SJ-122	SJ-123	1986	S-149
SP-215	Price St.	12	124.9	362	Ductile Iron	J-260	SJ-166	1986	S-164
SP-217	Burkhart St.	6	124.9	660	Ductile Iron	SJ-166	SJ-168	1986	S-164
P-287	Kashevaroff St.	8	124.9	328	Ductile Iron	SJ-59	J-203	1987	Flat File Pg 29
P-288	Kashevaroff St.	6	124.9	240	Ductile Iron	SJ-59	J-244	1987	
P-289	Kashevaroff St.	6	124.9	165	Ductile Iron	J-244	J-202	1987	Flat File Pg 29
P-390	Sand dollar Dr.	6	130.0	789	Ductile Iron	J-166	J-167	1987	Flat File Pg 26
P-438	Jarvis St	8	124.9	449	Ductile Iron	J-233	SJ-157	1987	S-155
SP-4	Halibut Pt. Road	12	124.9	519	Ductile Iron	SJ-4	SJ-5	1987	S-159
SP-143	Erler St.	10	124.9	220	Ductile Iron	SJ-115	SJ-116	1987	S-157
SP-146	Erler St.	10	124.9	271	Ductile Iron	SJ-116	SJ-117	1987	S-157

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-150	Erler St.	10	124.9	256	Ductile Iron	SJ-118	SJ-117	1987	S-157
SP-151	Erler St.	10	124.9	416	Ductile Iron	SJ-118	SJ-119	1987	S-157
SP-211	Jarvis St.	8	124.9	641	Ductile Iron	SJ-157	SJ-158	1987	S-155
SP-230	Sawmill Cr. Road	24	124.9	2,710	Ductile Iron	SJ-?	SJ-160	1987	W-125, SH 1
SP-231	Sawmill Cr. Road	24	124.9	542	Ductile Iron	SJ-160	SJ-161	1987	W-125, SH 2
SP-232	Sawmill Cr. Road	24	124.9	1,312	Ductile Iron	SJ-161	SJ-164	1987	W-125, SH 2
SP-233	Sawmill Cr. Road	24	124.9	1,103	Ductile Iron	SJ-164	SJ-171	1987	W-125, SH 2
SP-234	Sawmill Cr. Road	24	124.9	4,473	Ductile Iron	SJ-171	SJ-184	1987	W125, SH 3 & 4
SP-241	Sawmill Cr. Road	12	124.9	15	Ductile Iron	SJ-183	SJ-184	1987	W-125
SP-250	Sawmill Cr. Road	24	124.9	6,227	Ductile Iron	SJ-184	SJ-193	1987	W-125, SH 4, 5, 6, 7
SP-251	Sawmill Cr. Road	30	124.9	2,091	Ductile Iron	SJ-193	SJ-195	1987	W-125, SH 6, 7
SP-280	Sawmill Cr. Road	12	124.9	30	Ductile Iron	SJ-192	SJ-193	1987	W-125
SP-288	Jarvis St.	8	124.9	593	Ductile Iron	SJ-158	SJ-159	1987	S-155
SP-289	Sawmill Cr. Road	30	124.9	15,000	Ductile Iron	SR-1	SJ-195	1987	W-125
SP-124	Lakeview Dr.	6	124.9	657	Ductile Iron	SJ-97	SJ-94	1988	W-127
SP-128	Lakeview Dr.	6	124.9	1,327	Ductile Iron	SJ-93	SJ-94	1988	W-127
SP-149	Hemlock St.	6	124.9	755	Ductile Iron	SJ-114	SJ-118	1988	W-130
SP-216	Price St.	12	124.9	344	Ductile Iron	SJ-166	SJ-167	1988	
P-268	Cascade Cr. Road	8	124.9	54	Ductile Iron	J-221	SJ-40	1989	S-158
P-269	Cascade Cr. Road	8	124.9	276	Ductile Iron	J-196	J-221	1989	S-158
P-371	Halibut Pt. Road	10	130.0	67	Ductile Iron	SJ-2	J-153	1989	Flat files
P-372	Halibut Pt. Road	6	130.0	238	Ductile Iron	J-153	J-154	1989	Flat files
P-387	Bahovec Ct.	8	130.0	475	Ductile Iron	J-164	J-165	1989	Flat File Pg 25
P-398	Buhrt Cir.	6	130.0	277	Ductile Iron	SJ-76	J-176	1989	S-163
P-401	Off Lincoln St.	4	130.0	164	Ductile Iron	SJ-134	J-179	1989	S-129
SP-1	Halibut Pt. Road	12	124.9	418	Ductile Iron	SJ-1	SJ-2	1989	Flat files
SP-2	Halibut Pt. Road	12	124.9	683	Ductile Iron	SJ-2	SJ-3	1989	Flat files
SP-3	Halibut Pt. Road	12	124.9	4,413	Ductile Iron	SJ-3	SJ-4	1989	Flat files
SP-48	Cascade Cr. Drive	8	124.9	642	Ductile Iron	SJ-36	J-196	1989	S-158
SP-88	Charles St.	8	124.9	581	Ductile Iron	SJ-75	SJ-76	1989	S-163
SP-90	Pherson St.	8	124.9	801	Ductile Iron	SJ-77	SJ-78	1989	S-163
SP-147	Spruce St.	6	124.9	571	Ductile Iron	SJ-117	SJ-114	1989	W-129
SP-148	Spruce St.	6	124.9	136	Ductile Iron	SJ-114	SJ-113	1989	W-129
JP-20	Airport Rd.	16	124.9	252	Ductile Iron	JJ-22	JJ-20	1992	Hanging File Pg 33
JP-100	Lifesaver Dr.	10	113.0	88	Asbestos Cement	JJ-30	JJ-97	1992	Hanging File
JP-142	Lifesaver Dr.	8	124.9	53	Cast iron	JJ-30	JJ-138	1992	Hanging File
P-265	Halibut Pt. Road	16	130.0	1,092	Ductile Iron	SJ-34	J-220	1992	W-138
P-266	Halibut Pt. Road	16	130.0	902	Ductile Iron	J-220	J-222	1992	W-138
P-267	Cascade Cr. Road	8	124.9	10	Ductile Iron	J-220	J-221	1992	W-138
P-324	Lance Dr.	6	124.9	630	Ductile Iron	SJ-169	J-213	1992	W-134
P-335	Airport Road	16	124.9	1,474	Ductile Iron	JJ-20	JJ-10	1992	Hanging File Pg 32
P-338	Airport Rd.	16	124.9	769	Ductile Iron	JJ-30	JJ-203	1992	Hanging File Pg 32
P-339	Airport Rd.	16	124.9	1,410	Ductile Iron	JJ-203	JJ-22	1992	Hanging File Pg 33
P-427	Sawmill Cr. Road	12	130.0	1,034	Ductile Iron	J-216	J-228	1992	W-133

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-428	Halibut Pt. Road	16	124.9	615	Ductile Iron	J-222	J-229	1992	W-138
P-429	Davidoff st.	16	124.9	249	Ductile Iron	J-229	J-224	1992	W-138
SP-170	Seward St.	12	124.9	680	Ductile Iron	SJ-123	SJ-127	1992	S-180
P-264	Off Kinkroft Way	6	124.9	447	Ductile Iron	J-195	SJ-223	1993	
P-327	Knutson Dr.	8	124.9	252	Ductile Iron	SJ-180	J-217	1993	M-244
P-328	Knutson Dr.	6	124.9	692	Ductile Iron	J-217	J-218	1993	M-244
P-329	Knutson Dr.	6	124.9	355	Ductile Iron	J-218	J-219	1993	M-244
P-330	Knutson Dr.	6	124.9	340	Ductile Iron	J-219	J-217	1993	M-244
P-306	Andrew Hope St.	8	124.9	626	Ductile Iron	J-207	J-210	1994	Flat File Pg 37
P-307	Andrew Hope St.	8	124.9	442	Ductile Iron	J-210	J-211	1994	Flat File Pg 37
P-309	Off Yaw Dr.	12	124.9	481	Ductile Iron	J-208	J-256	1994	Flat File Pg 37
P-310	Rudolph Walton Cir	6	124.9	320	Ductile Iron	J-209	J-212	1994	Flat File Pg 37
P-311	Joseph St.	6	124.9	303	Ductile Iron	J-209	J-210	1994	Flat File Pg 37
P-316	Joseph St.	6	124.9	241	Ductile Iron	J-256	J-209	1994	Flat File Pg 37
P-415	Vitskari St.	8	130.0	54	Ductile Iron	J-189	J-190	1995	Flat File Pg 41
P-416	Kiksadi Ct.	6	130.0	319	Ductile Iron	J-189	J-191	1995	
P-439	Burkhart St.	8	130.0	381	Ductile Iron	SJ-168	J-234	1995	Flat File Pg 41
P-440	Vitskari St.	8	130.0	140	Ductile Iron	J-234	J-189	1995	Flat File Pg 41
P-276	Wortman loop	6	124.9	10	Ductile Iron	SJ-47	J-242	1996	
P-278	Charteris St.	8	124.9	976	Ductile Iron	J-242	J-200	1996	
P-279	Mills St.	8	124.9	477	Ductile Iron	J-198	J-200	1996	
P-280	Georgson loop	8	124.9	780	Ductile Iron	J-199	J-200	1996	
P-281	Georgson loop	8	124.9	772	Ductile Iron	J-199	J-198	1996	
P-282	Georgson loop	8	124.9	638	Ductile Iron	J-198	J-270	1996	Flat File Pg 28
P-283	Mills St.	8	124.9	350	Ductile Iron	J-198	J-197	1996	
P-284	Johnston St.	8	124.9	866	Ductile Iron	J-197	J-243	1996	Flat File Pg 28
P-399	Tlingit Way	2	150.0	400	HDPE	SJ-120	J-177	1996	W-137
SP-105	Monastery St.	2	150.0	209	HDPE	J-269	SJ-89	1996	W-137
P-270	Donna Dr.	6	124.9	260	Ductile Iron	J-196	J-241	1997	Flat File Pg 27
P-319	Smith St.	8	150.0	1,044	HDPE	J-258	SJ-163	1998	Flat File Pg 39
P-409	Kaasda Heen Cir.	6	130.0	277	Ductile Iron	J-184	J-185	1998	
SP-62	NE of Fergisun loop	12	130.0	429	Ductile Iron	J-263	ST-2	1998	
P-375	Circle E.	8	130.0	437	Ductile Iron	SJ-17	J-157	1999	
P-313	Indain River Road	8	124.9	350	Ductile Iron	J-208	J-253	2000	Flat File Pg 37
P-314	Indain River Road	8	124.9	850	Ductile Iron	J-253	J-254	2000	Flat File Pg 37
P-413	Lilian Dr.	6	130.0	1,161	Ductile Iron	J-260	J-259	2001	W-136
P-422	Cedar Beach Rd.	8	150.0	1,145	HDPE	J-194	J-201	2001	
JP-210	Charcoal Dr.	8	130.0	245	Ductile Iron	JJ-120	JJ-208	2002	
JP-219	Alice loop	8	124.9	283	Ductile Iron	JJ-214	JJ-125	2002	
P-318	Naomi Kanosh lane	8	124.9	550	Ductile Iron	J-254	J-257	2002	W-135
P-322	Price St.	8	150.0	706	HDPE	SJ-167	J-261	2002	
P-323	Price St.	8	150.0	375	HDPE	J-261	J-262	2002	
P-333	Granite Cr. Road	8	150.0	1,556	HDPE	J-264	SJ-12	2002	
P-366	Alice loop	8	124.9	508	Cast iron	JJ-208	JJ-214	2002	

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-370	Off Alice loop	8	124.9	690	Ductile Iron	JJ-214	JJ-210	2002	
P-411	Marys Court	6	130.0	449	Ductile Iron	J-262	J-187	2002	
P-412	Off Price St.	6	150.0	269	HDPE	J-261	J-188	2002	
SP-195	Maksostoff St.	8	150.0	154	HDPE	SJ-133	SJ-129	2002	Flat File Pg 35
JP-84	Tongass Dr.	12	124.9	1,167	Ductile Iron	JJ-92	JJ-20	2004	
P-303	Off Metlakatla	12	130.0	802	Ductile Iron	J-252	J-204	2004	
P-304	John Brady Dr.	12	130.0	772	Ductile Iron	J-204	J-251	2004	Flat File Pg 37
P-337	Seward Ave.	12	124.9	2,004	Ductile Iron	JJ-53	JJ-37	2004	
P-315	Yaw Drove	12	124.9	667	Ductile Iron	J-253	J-255	2005	
P-317	Heab Didrickson St.	8	124.9	648	Ductile Iron	J-255	J-257	2005	
P-441	Beardslee Way	8	150.0	398	HDPE	SJ-158	J-258	2005	
P-442	Beardslee Way	8	150.0	503	HDPE	J-258	J-261	2005	
SP-61	Davidoff St.	8	130.0	545	Ductile Iron	J-224	SJ-51	2005	Flat File Pg 28
P-396	Off Lake St.	8	150.0	661	HDPE	SJ-70	J-174	2006	
P-296	Merrill Street	6	124.9	868	Cast iron	SJ-91	J-249	1967 1975	W-94, S-93
JP-9	Harbor Dr.	12	124.9	145	Ductile Iron	JJ-9	JJ-10		
JP-34	Off Seward Ave.	8	113.0	320	Asbestos Cement	JJ-33	JJ-34		
JP-67	Seward Ave.	6	124.9	72	Ductile Iron	JJ-66	JJ-67		S-154
JP-77	Harbor Dr.	10	124.9	202	Ductile Iron	JJ-76	JJ-77		
JP-78	Harbor Dr.	10	124.9	149	Cast iron	JJ-77	JJ-10		
JP-101	Livesaver Dr.	10	113.0	86	Asbestos Cement	JJ-97	JJ-98		
JP-152	Off Seward Ave.	8	124.9	274	Ductile Iron	JJ-33	JJ-147		
JP-153	Off Seward Ave.	8	124.9	59	Ductile Iron	JJ-147	JJ-148		
JP-154	Off Seward Ave.	8	113.0	339	Asbestos Cement	JJ-148	JJ-149		
JP-155	Off Seward Ave.	8	113.0	275	Asbestos Cement	JJ-149	JJ-150		
JP-156	Off Seward Ave.	8	150.0	216	HDPE	JJ-150	JJ-151		
JP-212	Off Alice loop	8	124.9	216	Ductile Iron	JJ-208	JJ-209		
JP-216	Off Alice Loop	8	124.9	534	Ductile Iron	JJ-210	JJ-212		Flat File Pg 39
P-285	Mills St.	6	124.9	354	Cast iron	J-197	SJ-56		
P-291	Kashevaroff St.	8	124.9	419	Ductile Iron	SJ-57	J-245		
P-294	DeArmond St.	6	124.9	175	Cast iron	J-247	SJ-115		
P-297	Off Park St.	4	124.9	300	Ductile Iron	J-249	SJ-148		
P-301	Crescent Dr.	8	124.9	313	Ductile Iron	J-250	J-206		
P-302	Off Crescent Dr.	8	124.9	634	Ductile Iron	J-206	J-205		
P-340	Lifesaver Dr.	10	113.0	672	Asbestos Cement	JJ-118	JJ-98		
P-344	Cascade Cr. Drive	12	130.0	162	Cast iron	SJ-36	SJ-37		W-63, W-104
P-347	Kramer Ave.	12	130.0	1,000	Ductile Iron	SJ-31	Theoretical Hydrant at 150' in Benchlands Subdivision		
P-348	Harbor Dr.	12	124.9	1,008	Ductile Iron	JJ-1	JJ-9		
P-349	Lifesaver Dr.	10	113.0	911	Asbestos Cement	JJ-98	JJ-109		
P-353	Off Seward Ave.	8	124.9	689	Ductile Iron	JJ-159	JJ-34		
P-354	Off Seward Ave.	8	113.0	548	Asbestos Cement	JJ-34	JJ-151		
P-363	Seward Ave.	10	124.9	603	Cast iron	JJ-76	JJ-73		
P-364	Charcoal Dr.	8	130.0	265	Ductile Iron	JJ-22	JJ-120		Flat File Pg 25
P-367	Alice loop	8	124.9	676	Ductile Iron	JJ-125	JJ-130		

TABLE 2
SITKA WATER SYSTEM PIPE INVENTORY
BY
DATE OF PIPE

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-378	Off Circle E	6	130.0	329	Ductile Iron	J-158	J-159		
P-381	Halibut Pt. Road	4	130.0	90	Ductile Iron	J-160	J-161		
P-394	Sigtnaka Way	6	130.0	260	Cast iron	SJ-100	J-172		
P-395	Sigtnaka Way	4	130.0	626	Ductile Iron	J-172	J-173		
P-397	Off Verstovia St.	6	130.0	299	Ductile Iron	SJ-72	J-175		
P-400	Barracks St.	6	130.0	186	Ductile Iron	SJ-121	J-178		
P-402	Hirst St.	6	130.0	99	Cast iron	SJ-86	J-180		
P-410	Harvest Way	6	130.0	295	Ductile Iron	SJ-167	J-186		
P-419	Chirikov Dr.	10	130.0	501	Ductile Iron	J-192	J-193		
P-426	Blueberry lane	4	130.0	552	Ductile Iron	J-226	J-227		
P-432	Gibson Pl	4	130.0	567	Ductile Iron	J-229	J-230		
P-437	Jarvis St.	8	124.9	251	Ductile Iron	SJ-156	J-233		
SP-6	Halibut Pt. Road	10	124.9	225	Ductile Iron	SJ-6	J-265		W-192
SP-18	Darrin Dr.	6	130.0	882	Cast iron	SJ-18	SJ-19		
SP-96	Monastery St.	8	124.9	190	Ductile Iron	SJ-80	SJ-81		
SP-98	Monastery St.	6	124.9	794	Cast iron	SJ-81	SJ-85		
SP-99	Kincaid St.	6	124.9	257	Cast iron	SJ-85	SJ-84		Flat File Pg 36
SP-103	Hirst St.	6	124.9	335	Cast iron	SJ-87	SJ-86		
SP-104	Monastery St.	6	124.9	390	Cast iron	SJ-86	SJ-85		
SP-129	Halibut Pt. Road	8	130.0	622	Cast iron	SJ-93	SJ-92		
SP-141	Andrews St.	6	124.9	534	Cast iron	SJ-110	J-247		W-86
SP-142	DeArmond St.	6	130.0	406	Cast iron	J-247	SJ-111		W-86
SP-160	Off Katlian Ave	10	124.9	115	Cast iron	SJ-108	SJ-109		
SP-162	Seward St.	10	124.9	220	Cast iron	SJ-109	SJ-121		S-149
SP-172	Etolin Way	4	124.9	359	Ductile Iron	SJ-127	SJ-136		
SP-177	Biorka St.	6	124.9	676	Ductile Iron	SJ-140	SJ-147		
SP-178	Park St.	4	124.9	235	Cast iron	SJ-147	SJ-148		
SP-197	American St.	6	124.9	140	Ductile Iron	SJ-132	SJ-134		
SP-222	Sawmill Cr. Road	12	124.9	24	Ductile Iron	SJ-172	SJ-171		
SP-224	Wolff Dr.	6	124.9	309	Ductile Iron	SJ-173	SJ-174		W-98
SP-225	Wolff Dr.	6	124.9	589	Ductile Iron	SJ-174	SJ-175		
SP-226	Wolff Dr.	6	124.9	410	Ductile Iron	SJ-175	SJ-176		W-98
SP-227	Wolff Dr.	6	124.9	310	Ductile Iron	SJ-176	SJ-174		W-98
SP-286	Cascade Cr. Drive	12	130.0	284	Cast iron	SJ-37	SJ-38		W-63, W-104
SP167	American St.	6	124.9	170	Ductile Iron	SJ-122	SJ-134		S-149

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
JP-34	Off Seward Ave.	8	113.0	320	Asbestos Cement	JJ-33	JJ-34		
JP-100	Lifesaver Dr.	10	113.0	88	Asbestos Cement	JJ-30	JJ-97	1992	Hanging File
JP-101	Livesaver Dr.	10	113.0	86	Asbestos Cement	JJ-97	JJ-98		
JP-154	Off Seward Ave.	8	113.0	339	Asbestos Cement	JJ-148	JJ-149		
JP-155	Off Seward Ave.	8	113.0	275	Asbestos Cement	JJ-149	JJ-150		
P-340	Lifesaver Dr.	10	113.0	672	Asbestos Cement	JJ-118	JJ-98		
P-349	Lifesaver Dr.	10	113.0	911	Asbestos Cement	JJ-98	JJ-109		
P-354	Off Seward Ave.	8	113.0	548	Asbestos Cement	JJ-34	JJ-151		
JP-78	Harbor Dr.	10	124.9	149	Cast iron	JJ-77	JJ-10		
JP-142	Lifesaver Dr.	8	124.9	53	Cast iron	JJ-30	JJ-138	1992	Hanging File
JP-206	Airport Rd.	8	124.9	403	Cast iron	JJ-138	JJ-205	1967	M-52
JP-207	Airport Rd.	8	124.9	223	Cast iron	JJ-205	JJ-206	1967	M-52
JP-208	Airport Rd.	8	124.9	132	Cast iron	JJ-206	JJ-203	1984	M-52
JP-209	Airport Rd.	6	124.9	242	Cast iron	JJ-206	JJ-207	1967	M-52
P-277	Charteris St.	14	124.9	342	Cast iron	SJ-47	J-243	1968	W-46, W-47
P-285	Mills St.	6	124.9	354	Cast iron	J-197	SJ-56		
P-293	Peterson St.	10	124.9	192	Cast iron	J-246	SJ-55	1968	W-41
P-294	DeArmond St.	6	124.9	175	Cast iron	J-247	SJ-115		
P-296	Merrill Street	6	124.9	868	Cast iron	SJ-91	J-249	1967, 1975	W-94, S-93
P-298	Biorka St.	8	124.9	631	Cast iron	SJ-147	J-271	1967	W-88
P-299	Jeff Davis St.	8	124.9	80	Cast iron	J-250	SJ-150	1968	W-22
P-308	Indian River Road	18	124.9	452	Cast iron	J-207	J-208	1971	Flat File Pg 37
P-312	Indain River Road	18	124.9	1,374	Cast iron	J-208	SJ-155	1971	Flat File Pg 37
P-332	Georgeson loop	14	130.0	781	Cast iron	J-263	J-270	1968	W-47
P-334	Halibut Pt. Road	6	130.0	637	Cast iron	SJ-7	J-265	1977	W-92
P-336	Edgecumbe Dr.	12	130.0	147	Cast iron	J-272	SJ-45	1972	W-62, W-109
P-341	Halibut Pt. Road	6	124.9	666	Cast iron	SJ-33	J-268	1963	W-95
P-344	Cascade Cr. Drive	12	130.0	162	Cast iron	SJ-36	SJ-37		W-63, W-104
P-346	Edgecumbe Dr.	12	130.0	49	Cast iron	PMP-1	J-272	1972	W-62, W-109
P-350	Off Seward Ave.	8	130.0	351	Cast iron	JJ-147	JJ-144	1967	M-52
P-351	Airport Rd.	8	124.9	800	Cast iron	JJ-144	JJ-141	1967	M-52
P-352	Airport Rd.	8	124.9	432	Cast iron	JJ-141	JJ-138	1967	M-52
P-363	Seward Ave.	10	124.9	603	Cast iron	JJ-76	JJ-73		
P-366	Alice loop	8	124.9	508	Cast iron	JJ-208	JJ-214	2002	
P-376	Halibut Pt. Road	12	124.9	294	Cast iron	SJ-17	J-158	1977	W-54
P-377	Halibut Pt. Road	12	124.9	432	Cast iron	J-158	SJ-18	1977	W-54
P-379	Halibut Pt. Road	12	124.9	155	Cast iron	SJ-18	J-160	1977	W-54
P-380	Halibut Pt. Road	12	124.9	455	Cast iron	J-160	SJ-20	1977	W-54
P-385	Halibut Pt. Road	12	124.9	797	Cast iron	SJ-24	J-164	1977	W-56
P-386	Halibut Pt. Road	12	124.9	607	Cast iron	J-164	SJ-26	1977	W-56
P-388	Halibut Pt. Road	12	124.9	1,066	Cast iron	SJ-29	J-166	1977	W-59
P-389	Halibut Pt. Road	12	124.9	610	Cast iron	J-166	SJ-30	1977	W-60
P-394	Sigtnaka Way	6	130.0	260	Cast iron	SJ-100	J-172		
P-402	Hirst St.	6	130.0	99	Cast iron	SJ-86	J-180		

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-407	Indian River Road	18	124.9	840	Cast iron	SJ-154	J-184	1971	Flat File Pg 37
P-408	Indian River Road	18	124.9	875	Cast iron	J-184	J-207	1971	Flat File Pg 37
P-417	Sawmill Cr. Road	14	124.9	213	Cast iron	SJ-173	J-192	1972	W-68
P-418	Sawmill Cr. Road	14	124.9	1,417	Cast iron	J-192	SJ-177	1972	W-68, W-67
P-430	Edgecumbe Dr.	12	124.9	227	Cast iron	SJ-48	J-230	1972	W-62, W-104
P-431	Edgecumbe Dr.	12	124.9	126	Cast iron	J-230	PMP-1	1972	W-62, W-109
SP-5	Halibut Pt. Road	12	124.9	972	Cast iron	SJ-5	SJ-6	1977	W-92
SP-7	Halibut Pt. Road	12	124.9	1,727	Cast iron	SJ-6	SJ-8	1977	W-92
SP-9	Halibut Pt. Road	12	124.9	1,551	Cast iron	SJ-8	SJ-10	1977	W-93
SP-10	Halibut Pt. Road	12	124.9	688	Cast iron	SJ-10	SJ-11	1977	W-50
SP-11	Halibut Pt. Road	12	124.9	1,396	Cast iron	SJ-11	SJ-13	1977	W-51
SP-12	Halibut Pt. Road	12	124.9	394	Cast iron	SJ-12	SJ-13	1977	W-52
SP-13	Halibut Pt. Road	12	124.9	1,334	Cast iron	SJ-14	SJ-12	1977	W-52
SP-16	Halibut Pt. Road	12	124.9	546	Cast iron	SJ-14	SJ-17	1977	W-53
SP-18	Darrin Dr.	6	130.0	882	Cast iron	SJ-18	SJ-19		
SP-20	Halibut Pt. Road	12	124.9	1,165	Cast iron	SJ-20	SJ-21	1977	W-55
SP-35	Halibut Pt. Road	12	124.9	461	Cast iron	SJ-21	SJ-24	1977	W-55
SP-38	Halibut Pt. Road	12	124.9	1,433	Cast iron	SJ-26	SJ-27	1977	W-57
SP-39	Halibut Pt. Road	12	124.9	872	Cast iron	SJ-27	SJ-28	1977	W-58
SP-40	Halibut Pt. Road	12	124.9	790	Cast iron	SJ-28	SJ-29	1977	W-58
SP-43	Halibut Pt Road	12	124.9	325	Cast iron	SJ-30	SJ-32	1977	W-60
SP-44	Halibut Pt. Road	6	124.9	1,241	Cast iron	SJ-32	SJ-33	1963	W-95
SP-45	Halibut Pt. Road	12	124.9	1,232	Cast iron	SJ-32	SJ-34	1977	W-60, W-61
SP-46	West of Dodge Cir.	12	124.9	582	Cast iron	SJ-34	SJ-35	1977	W-61, W-104
SP-47	Dodge Cir.	12	124.9	738	Cast iron	SJ-35	SJ-36	1972	W-64, W-104
SP-49	H.P.R at Cascade Ave.	8	124.9	33	Cast iron	J-267	SJ-40	1963	W-96
SP-50	Edgecumbe Dr.	12	124.9	1,047	Cast iron	SJ-38	SJ-44	1972	W-104, W-64
SP-51	Edgecumbe Dr.	12	124.9	419	Cast iron	SJ-45	SJ-44	1972	W-62, W-109
SP-54	Charteris St.	14	124.9	437	Cast iron	J-243	SJ-48	1968	W-46
SP-56	Charteris St.	14	124.9	390	Cast iron	SJ-48	J-224	1968	W-46
SP-57	Halibut Pt. Road	8	124.9	949	Cast iron	SJ-40	SJ-41	1963	W-96
SP-63	Edgecumbe Dr.	12	124.9	1,077	Cast iron	SJ-48	SJ-56	1968	W-45
SP-64	Edgecumbe Dr.	12	124.9	1,082	Cast iron	SJ-56	SJ-57	1968	W-43
SP-65	Edgecumbe Dr.	12	124.9	784	Cast iron	SJ-57	SJ-58	1968	W-43
SP-72	Peterson St.	10	124.9	505	Cast iron	J-246	SJ-61	1968	W-41
SP-73	Edgecumbe Dr.	12	124.9	469	Cast iron	SJ-58	SJ-61	1968	W-43
SP-74	Halibut Pt. Road	14	124.9	367	Cast iron	SJ-55	SJ-63	1968	W-40
SP-79	Peterson St.	10	124.9	722	Cast iron	SJ-61	SJ-68	1968	W-41
SP-80	Peterson St.	10	124.9	150	Cast iron	SJ-70	SJ-68	1968	W-37
SP-82	Lake St.	10	124.9	296	Cast iron	SJ-70	SJ-71	1968	W-37
SP-83	Halibut Pt. Rd.	14	124.9	667	Cast iron	SJ-63	SJ-92	1968	W-40
SP-98	Monastery St.	6	124.9	794	Cast iron	SJ-81	SJ-85		
SP-99	Kincaid St.	6	124.9	257	Cast iron	SJ-85	SJ-84		Flat File Pg 36

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-100	Lake St.	10	124.9	979	Cast iron	SJ-82	SJ-83	1968	W-36, W-35
SP-101	Lake St.	10	124.9	708	Cast iron	SJ-83	SJ-71	1968	W-37, W-36
SP-102	Lake St.	10	124.9	404	Cast iron	SJ-84	SJ-87	1968	W-34
SP-103	Hirst St.	6	124.9	335	Cast iron	SJ-87	SJ-86		
SP-104	Monastery St.	6	124.9	390	Cast iron	SJ-86	SJ-85		
SP-106	DeGroff St.	10	124.9	391	Cast iron	SJ-89	SJ-88	1968	W-34
SP-107	Lake St.	10	124.9	173	Cast iron	SJ-88	SJ-87	1968	W-34
SP-108	Lake St.	6	124.9	731	Cast iron	SJ-88	SJ-125	1966	W-87
SP-109	Sawmill Cr. Road	16	124.9	513	Cast iron	SJ-125	SJ-138	1966	S-177
SP-110	Monastery St.	10	124.9	555	Cast iron	J-248	SJ-89	1968	W-33
SP-111	DeGroff St.	6	124.9	345	Cast iron	SJ-89	SJ-90	1970	W-10
SP-112	Baranof St.	6	124.9	207	Cast iron	SJ-90	SJ-91	1971	W-11
SP-113	DeGroff St.	6	124.9	897	Cast iron	SJ-90	SJ-148	1970	W-9
SP-114	Baranof St.	6	124.9	401	Cast iron	SJ-90	SJ-139	1970	W-132
SP-115	Sawmill Cr. Road	16	124.9	768	Cast iron	SJ-139	SJ-148	1966	S-177
SP-116	Sawmill Cr. Road	16	124.9	285	Cast iron	SJ-139	SJ-138	1966	S-177
SP-119	Lake St.	12	124.9	312	Cast iron	SJ-126	SJ-125	1965	S-53
SP-120	Halibut Pt. Road	16	124.9	159	Cast iron	SJ-125	SJ-119	1966	S-177
SP-129	Halibut Pt. Road	8	130.0	622	Cast iron	SJ-93	SJ-92		
SP-130	Katlian Ave.	12	124.9	655	Cast iron	SJ-92	SJ-100	1968	W-32
SP-131	Katlian Ave.	12	124.9	224	Cast iron	SJ-100	SJ-101	1968	W-32
SP-132	Katlian Ave.	12	124.9	1,021	Cast iron	SJ-101	SJ-102	1968	W-31, W-32
SP-134	O'Cain St.	6	124.9	222	Cast iron	SJ-103	SJ-99	1968	W-29
SP-135	Osprey St.	6	124.9	729	Cast iron	SJ-99	SJ-98	1968	W-29
SP-136	Marine St.	10	124.9	270	Cast iron	SJ-98	SJ-112	1968	W-28
SP-137	New Archangel St.	8	124.9	258	Cast iron	SJ-112	SJ-113	1968	W-30
SP-138	New Archangel St.	8	124.9	228	Cast iron	SJ-112	SJ-111	1968	W-30
SP-139	New Archangel St.	8	124.9	237	Cast iron	SJ-111	SJ-110	1968	W-30
SP-140	New Archangel St.	8	124.9	262	Cast iron	SJ-110	SJ-103	1968	W-30
SP-141	Andrews St.	6	124.9	534	Cast iron	SJ-110	J-247		W-86
SP-142	DeArmond St.	6	130.0	406	Cast iron	J-247	SJ-111		W-86
SP-144	Marine St.	10	124.9	628	Cast iron	SJ-116	SJ-112	1968	W-28
SP-145	Marine St.	10	124.9	380	Cast iron	SJ-116	SJ-120	1968	W-27
SP-153	Katlian Ave.	12	124.9	511	Cast iron	SJ-102	SJ-104	1968	W-31
SP-155	Katlian Ave.	12	124.9	243	Cast iron	SJ-104	SJ-105	1968	W-31
SP-156	off of Erler St.	12	124.9	402	Cast iron	SJ-105	SJ-115	1968	W-27
SP-157	Katlian Ave	12	124.9	267	Cast iron	SJ-105	SJ-106	1968	W-25
SP-158	Katlian Ave	12	124.9	443	Cast iron	SJ-106	SJ-107	1968	W-25
SP-159	Katlian Ave	12	124.9	362	Cast iron	SJ-107	SJ-108	1968	W-26
SP-160	Off Katlian Ave	10	124.9	115	Cast iron	SJ-108	SJ-109		
SP-161	Katlian Ave	12	124.9	389	Cast iron	SJ-108	SJ-131	1968	W-25
SP-162	Seward St.	10	124.9	220	Cast iron	SJ-109	SJ-121		S-149
SP-163	Marine St.	10	124.9	699	Cast iron	SJ-121	SJ-120	1968	W-26

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-169	Observatory St.	8	124.9	459	Cast iron	SJ-123	SJ-124	1968	W-23
SP-171	Lake St.	12	124.9	334	Cast iron	SJ-127	SJ-126	1965	S-53
SP-175	Baranof St.	6	124.9	179	Cast iron	SJ-141	SJ-140	1975	W-106
SP-178	Park St.	4	124.9	235	Cast iron	SJ-147	SJ-148		
SP-179	Sawmill Cr. Road	16	124.9	675	Cast iron	SJ-148	SJ-149	1966	S-177
SP-180	Jeff Davis St.	8	130.0	375	Cast iron	SJ-149	J-250	1968	W-22
SP-182	Finn Alley	8	124.9	573	Cast iron	SJ-145	SJ-144	1968	W-20
SP-192	Lake St.	12	124.9	268	Cast iron	SJ-128	SJ-127	1965	S-53
SP-199	Off lincoln St.	12	124.9	503	Cast iron	SJ-131	SJ-130	1968	W-24
SP-200	Harbor Dr.	12	124.9	567	Cast iron	SJ-130	SJ-129	1968	W-24
SP-202	Jeff Davis St.	8	124.9	305	Cast iron	J-251	SJ-150	1968	W-22
SP-206	Sawmill Cr. Road	18	124.9	237	Cast iron	SJ-149	SJ-?	1966	S-177
SP-207	Sawmill Cr. Road	18	124.9	176	Cast iron	SJ-?	SJ-154	1966	S177
SP-209	Sawmill Cr. Road	14	124.9	2,406	Cast iron	SJ-154	SJ-156	1972	W-72
SP-212	Sawmill Cr. Road	14	124.9	1,044	Cast iron	SJ-156	SJ-162	1972	W-70
SP-214	Sawmill Cr. Road	14	124.9	900	Cast iron	SJ-162	SJ-165	1972	W-70
SP-221	Sawmill Cr. Road	14	124.9	511	Cast iron	SJ-170	SJ-172	1972	W-68
SP-223	Sawmill Cr. Road	14	124.9	550	Cast iron	SJ-172	SJ-173	1972	W-68
SP-229	Sawmill Cr. Road	14	124.9	683	Cast iron	SJ-177	SJ-178	1972	W-67
SP-235	Sawmill Cr. Road	14	124.9	512	Cast iron	SJ-178	SJ-179	1972	W-66
SP-236	Sawmill Cr. Road	14	124.9	939	Cast iron	SJ-179	SJ-180	1972	W-66
SP-281	Edgecumbe Dr.	12	124.9	2,037	Cast iron	SJ-38	SJ-39	1972	W-65, W-63, W-104
SP-285	Lake St.	10	124.9	433	Cast iron	SJ-82	SJ-84	1968	W-35
SP-286	Cascade Cr. Drive	12	130.0	284	Cast iron	SJ-37	SJ-38		W-63, W-104
P-292	Kimsham st.	2	147.0	522	Copper	SJ-58	J-246	1980	W-115
JP-9	Harbor Dr.	12	124.9	145	Ductile Iron	JJ-9	JJ-10		
JP-20	Airport Rd.	16	124.9	252	Ductile Iron	JJ-22	JJ-20	1992	Hanging File Pg 33
JP-57	Off Seward Ave.	10	124.9	156	Ductile Iron	JJ-56	JJ-57	1984	S-154
JP-58	Off Seward Ave.	10	124.9	90	Ductile Iron	JJ-57	JJ-58	1984	S-154
JP-59	Off Seward Ave.	8	124.9	157	Ductile Iron	JJ-58	JJ-59	1984	S-154
JP-60	Off Seward Ave.	10	124.9	222	Ductile Iron	JJ-58	JJ-60	1984	S-154
JP-61	Off Seward Ave.	6	124.9	132	Ductile Iron	JJ-60	JJ-61	1984	S-154
JP-62	Off Seward Ave.	6	124.9	92	Ductile Iron	JJ-61	JJ-62	1984	S-154
JP-66	Seward Ave.	6	124.9	50	Ductile Iron	JJ-65	JJ-66	1984	S-154
JP-67	Seward Ave.	6	124.9	72	Ductile Iron	JJ-66	JJ-67		S-154
JP-77	Harbor Dr.	10	124.9	202	Ductile Iron	JJ-76	JJ-77		
JP-84	Tongass Dr.	12	124.9	1,167	Ductile Iron	JJ-92	JJ-20	2004	
JP-139	Alice loop	12	124.9	123	Ductile Iron	JJ-130	JJ-135	1985	W-124
JP-152	Off Seward Ave.	8	124.9	274	Ductile Iron	JJ-33	JJ-147		
JP-153	Off Seward Ave.	8	124.9	59	Ductile Iron	JJ-147	JJ-148		
JP-210	Charcoal Dr.	8	130.0	245	Ductile Iron	JJ-120	JJ-208	2002	
JP-212	Off Alice loop	8	124.9	216	Ductile Iron	JJ-208	JJ-209		
JP-213	Off Alice loop	8	124.9	104	Ductile Iron	JJ-209	JJ-210	1967	

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
JP-216	Off Alice Loop	8	124.9	534	Ductile Iron	JJ-210	JJ-212		Flat File Pg 39
JP-219	Alice loop	8	124.9	283	Ductile Iron	JJ-214	JJ-125	2002	
JP-222	Seward Ave.	12	124.9	31	Ductile Iron	JJ-215	JJ-73	1984	S-154
P-264	Off Kinkroft Way	6	124.9	447	Ductile Iron	J-195	SJ-223	1993	
P-265	Halibut Pt. Road	16	130.0	1,092	Ductile Iron	SJ-34	J-220	1992	W-138
P-266	Halibut Pt. Road	16	130.0	902	Ductile Iron	J-220	J-222	1992	W-138
P-267	Cascade Cr. Road	8	124.9	10	Ductile Iron	J-220	J-221	1992	W-138
P-268	Cascade Cr. Road	8	124.9	54	Ductile Iron	J-221	SJ-40	1989	S-158
P-269	Cascade Cr. Road	8	124.9	276	Ductile Iron	J-196	J-221	1989	S-158
P-270	Donna Dr.	6	124.9	260	Ductile Iron	J-196	J-241	1997	Flat File Pg 27
P-271	Shelikof Way	6	124.9	10	Ductile Iron	J-222	J-223	1978	S-123
P-272	Shelikof Way	6	124.9	54	Ductile Iron	J-223	SJ-41	1978	S-123
P-276	Wortman loop	6	124.9	10	Ductile Iron	SJ-47	J-242	1996	
P-278	Charteris St.	8	124.9	976	Ductile Iron	J-242	J-200	1996	
P-279	Mills St.	8	124.9	477	Ductile Iron	J-198	J-200	1996	
P-280	Georgson loop	8	124.9	780	Ductile Iron	J-199	J-200	1996	
P-281	Georgson loop	8	124.9	772	Ductile Iron	J-199	J-198	1996	
P-282	Georgson loop	8	124.9	638	Ductile Iron	J-198	J-270	1996	Flat File Pg 28
P-283	Mills St.	8	124.9	350	Ductile Iron	J-198	J-197	1996	
P-284	Johnston St.	8	124.9	866	Ductile Iron	J-197	J-243	1996	Flat File Pg 28
P-287	Kashevaroff St.	8	124.9	328	Ductile Iron	SJ-59	J-203	1987	Flat File Pg 29
P-288	Kashevaroff St.	6	124.9	240	Ductile Iron	SJ-59	J-244	1987	
P-289	Kashevaroff St.	6	124.9	165	Ductile Iron	J-244	J-202	1987	Flat File Pg 29
P-290	Halibut Pt. Road	8	124.9	547	Ductile Iron	SJ-54	J-245	1975	W-109
P-291	Kashevaroff St.	8	124.9	419	Ductile Iron	SJ-57	J-245		
P-295	Sawmill Cr. Road	6	124.9	10	Ductile Iron	SJ-138	J-248	1969	W-107
P-297	Off Park St.	4	124.9	300	Ductile Iron	J-249	SJ-148		
P-300	Charles St.	6	124.9	400	Ductile Iron	SJ-75	SJ-62	1979	S-130
P-301	Crescent Dr.	8	124.9	313	Ductile Iron	J-250	J-206		
P-302	Off Crescent Dr.	8	124.9	634	Ductile Iron	J-206	J-205		
P-303	Off Metlakatla	12	130.0	802	Ductile Iron	J-252	J-204	2004	
P-304	John Brady Dr.	12	130.0	772	Ductile Iron	J-204	J-251	2004	Flat File Pg 37
P-305	Jeff Davis St.	8	124.9	472	Ductile Iron	J-251	SJ-151	1968	W-22
P-306	Andrew Hope St.	8	124.9	626	Ductile Iron	J-207	J-210	1994	Flat File Pg 37
P-307	Andrew Hope St.	8	124.9	442	Ductile Iron	J-210	J-211	1994	Flat File Pg 37
P-309	Off Yaw Dr.	12	124.9	481	Ductile Iron	J-208	J-256	1994	Flat File Pg 37
P-310	Rudolph Walton Cir	6	124.9	320	Ductile Iron	J-209	J-212	1994	Flat File Pg 37
P-311	Joseph St.	6	124.9	303	Ductile Iron	J-209	J-210	1994	Flat File Pg 37
P-313	Indain River Road	8	124.9	350	Ductile Iron	J-208	J-253	2000	Flat File Pg 37
P-314	Indain River Road	8	124.9	850	Ductile Iron	J-253	J-254	2000	Flat File Pg 37
P-315	Yaw Drove	12	124.9	667	Ductile Iron	J-253	J-255	2005	
P-316	Joseph St.	6	124.9	241	Ductile Iron	J-256	J-209	1994	Flat File Pg 37
P-317	Heab Didrickson St.	8	124.9	648	Ductile Iron	J-255	J-257	2005	

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-318	Naomi Kanosh lane	8	124.9	550	Ductile Iron	J-254	J-257	2002	W-135
P-320	Price St.	12	124.9	114	Ductile Iron	J-260	J-259	1986	S-164
P-321	Price St.	12	124.9	135	Ductile Iron	J-259	SJ-165	1986	S-164
P-324	Lance Dr.	6	124.9	630	Ductile Iron	SJ-169	J-213	1992	W-134
P-325	Jamestown Dr.	8	124.9	470	Ductile Iron	SJ-178	J-214	1977	S-124, S-125
P-326	Jamestown Dr.	8	124.9	569	Ductile Iron	J-214	J-215	1977	
P-327	Knutson Dr.	8	124.9	252	Ductile Iron	SJ-180	J-217	1993	M-244
P-328	Knutson Dr.	6	124.9	692	Ductile Iron	J-217	J-218	1993	M-244
P-329	Knutson Dr.	6	124.9	355	Ductile Iron	J-218	J-219	1993	M-244
P-330	Knutson Dr.	6	124.9	340	Ductile Iron	J-219	J-217	1993	M-244
P-331	Sawmill Cr. Road	8	124.9	775	Ductile Iron	SJ-194	J-216	1980	W-118
P-335	Airport Road	16	124.9	1,474	Ductile Iron	JJ-20	JJ-10	1992	Hanging File Pg 32
P-337	Seward Ave.	12	124.9	2,004	Ductile Iron	JJ-53	JJ-37	2004	
P-338	Airport Rd.	16	124.9	769	Ductile Iron	JJ-30	JJ-203	1992	Hanging File Pg 32
P-339	Airport Rd.	16	124.9	1,410	Ductile Iron	JJ-203	JJ-22	1992	Hanging File Pg 33
P-342	Halibut Pt. Road	6	124.9	26	Ductile Iron	SJ-33	SJ-34	1977	W-61
P-343	Charteris St.	6	124.9	68	Ductile Iron	J-270	SJ-47	1968	W-47
P-347	Kramer Ave.	12	130.0	1,000	Ductile Iron	SJ-31	Theoretical Hydrant at 150' in Benchlands Subdivision		
P-348	Harbor Dr.	12	124.9	1,008	Ductile Iron	JJ-1	JJ-9		
P-353	Off Seward Ave.	8	124.9	689	Ductile Iron	JJ-159	JJ-34		
P-355	Tongass Dr.	12	124.9	671	Ductile Iron	JJ-53	JJ-92	1984	S-154
P-357	Seward Ave.	10	124.9	301	Ductile Iron	JJ-215	JJ-70	1984	S-154
P-358	Seward Ave.	12	124.9	590	Ductile Iron	JJ-70	JJ-65	1984	S-154
P-359	Seward Ave.	12	124.9	165	Ductile Iron	JJ-65	JJ-56	1984	S-154
P-360	Seward Ave.	12	124.9	454	Ductile Iron	JJ-56	JJ-53	1984	S-154
P-362	Seward Ave.	6	124.9	129	Ductile Iron	JJ-227	JJ-215	1984	S-154
P-364	Charcoal Dr.	8	130.0	265	Ductile Iron	JJ-22	JJ-120		Flat File Pg 25
P-367	Alice loop	8	124.9	676	Ductile Iron	JJ-125	JJ-130		
P-368	Alice loop	8	124.9	564	Ductile Iron	JJ-130	JJ-127	1985	W-124
P-369	Alice loop	8	124.9	699	Ductile Iron	JJ-127	JJ-125	1985	W-124
P-370	Off Alice loop	8	124.9	690	Ductile Iron	JJ-214	JJ-210	2002	
P-371	Halibut Pt. Road	10	130.0	67	Ductile Iron	SJ-2	J-153	1989	Flat files
P-372	Halibut Pt. Road	6	130.0	238	Ductile Iron	J-153	J-154	1989	Flat files
P-373	Valhalla Dr.	6	130.0	229	Ductile Iron	J-155	SJ-9	1978	W-108
P-374	Valhalla Dr.	6	130.0	141	Ductile Iron	SJ-9	J-156	1978	W-108
P-375	Circle E.	8	130.0	437	Ductile Iron	SJ-17	J-157	1999	
P-378	Off Circle E	6	130.0	329	Ductile Iron	J-158	J-159		
P-381	Halibut Pt. Road	4	130.0	90	Ductile Iron	J-160	J-161		
P-382	Halibut Pt. Road	6	124.9	209	Ductile Iron	SJ-24	J-162	1986	S-150
P-383	Ross St.	6	124.9	376	Ductile Iron	J-162	SJ-25	1986	S-150
P-384	Barker St.	6	130.0	330	Ductile Iron	J-162	J-163	1986	S-150
P-387	Bahovec Ct.	8	130.0	475	Ductile Iron	J-164	J-165	1989	Flat File Pg 25
P-390	Sand dollar Dr.	6	130.0	789	Ductile Iron	J-166	J-167	1987	Flat File Pg 26

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-392	Tilson St.	6	130.0	465	Ductile Iron	SJ-60	J-170	1983	S-136
P-393	Wachusetts Wt.	6	130.0	826	Ductile Iron	SJ-58	J-171	1974	W-128
P-395	Sigtnaka Way	4	130.0	626	Ductile Iron	J-172	J-173		
P-397	Off Verstovia St.	6	130.0	299	Ductile Iron	SJ-72	J-175		
P-398	Buhrt Cir.	6	130.0	277	Ductile Iron	SJ-76	J-176	1989	S-163
P-400	Barracks St.	6	130.0	186	Ductile Iron	SJ-121	J-178		
P-401	Off Lincoln St.	4	130.0	164	Ductile Iron	SJ-134	J-179	1989	S-129
P-403	Lincoln St.	6	130.0	106	Ductile Iron	SJ-144	J-181	1985	S-147, SH 53
P-404	Kelly St.	6	130.0	237	Ductile Iron	SJ-152	J-182	1985	S-146, SH 9
P-405	Etolin St.	8	124.9	321	Ductile Iron	SJ-145	J-183	1980	W-116
P-406	Etolin St.	6	124.9	473	Ductile Iron	J-183	SJ-142	1980	W-116
P-409	Kaasda Heen Cir.	6	130.0	277	Ductile Iron	J-184	J-185	1998	
P-410	Harvest Way	6	130.0	295	Ductile Iron	SJ-167	J-186		
P-411	Marys Court	6	130.0	449	Ductile Iron	J-262	J-187	2002	
P-413	Lilian Dr.	6	130.0	1,161	Ductile Iron	J-260	J-259	2001	W-136
P-415	Vitskari St.	8	130.0	54	Ductile Iron	J-189	J-190	1995	Flat File Pg 41
P-416	Kiksadi Ct.	6	130.0	319	Ductile Iron	J-189	J-191	1995	
P-419	Chirikov Dr.	10	130.0	501	Ductile Iron	J-192	J-193		
P-420	Sawmill Cr. Road	14	130.0	78	Ductile Iron	SJ-180	J-194	1980	W-118
P-421	Sawmill Cr. Road	14	130.0	101	Ductile Iron	J-194	SJ-183	1980	W-118
P-423	Rands Dr.	6	130.0	429	Ductile Iron	SJ-187	J-225	1985	S-145
P-424	Sawmill Cr. Road	12	124.9	1,842	Ductile Iron	SJ-190	J-226	1980	W-118
P-425	Sawmill Cr. Road	12	124.9	625	Ductile Iron	J-226	SJ-191	1980	W-118
P-426	Blueberry lane	4	130.0	552	Ductile Iron	J-226	J-227		
P-427	Sawmill Cr. Road	12	130.0	1,034	Ductile Iron	J-216	J-228	1992	W-133
P-428	Halibut Pt. Road	16	124.9	615	Ductile Iron	J-222	J-229	1992	W-138
P-429	Davidoff st.	16	124.9	249	Ductile Iron	J-229	J-224	1992	W-138
P-432	Gibson Pl	4	130.0	567	Ductile Iron	J-229	J-230		
P-433	Lance Dr.	6	124.9	291	Ductile Iron	SJ-168	J-231	1979	S-129
P-434	Lance Dr.	6	124.9	523	Ductile Iron	J-231	SJ-170	1979	S-129
P-435	Lance Dr.	6	124.9	323	Ductile Iron	SJ-168	J-232	1978	S-128
P-436	Lance Dr.	6	124.9	588	Ductile Iron	J-232	SJ-169	1981	S-133
P-437	Jarvis St.	8	124.9	251	Ductile Iron	SJ-156	J-233		
P-438	Jarvis St	8	124.9	449	Ductile Iron	J-233	SJ-157	1987	S-155
P-439	Burkhart St.	8	130.0	381	Ductile Iron	SJ-168	J-234	1995	Flat File Pg 41
P-440	Vitskari St.	8	130.0	140	Ductile Iron	J-234	J-189	1995	Flat File Pg 41
SP-1	Halibut Pt. Road	12	124.9	418	Ductile Iron	SJ-1	SJ-2	1989	Flat files
SP-2	Halibut Pt. Road	12	124.9	683	Ductile Iron	SJ-2	SJ-3	1989	Flat files
SP-3	Halibut Pt. Road	12	124.9	4,413	Ductile Iron	SJ-3	SJ-4	1989	Flat files
SP-4	Halibut Pt. Road	12	124.9	519	Ductile Iron	SJ-4	SJ-5	1987	S-159
SP-6	Halibut Pt. Road	10	124.9	225	Ductile Iron	SJ-6	J-265		W-192
SP-8	Viking Way	6	124.9	287	Ductile Iron	SJ-8	SJ-9	1978	W-108
SP-14	Harbor Mtn. Road	18	124.9	2,366	Ductile Iron	SJ-14	SJ-15	1983	W-121

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-15	Shuler Dr.	6	124.9	455	Ductile Iron	SJ-14	SJ-16	1975	W-105
SP-22	Nicole Dr.	10	124.9	182	Ductile Iron	SJ-221	SJ-22	1981	W-122
SP-23	Somer Dr.	6	124.9	257	Ductile Iron	SJ-221	SJ-223	1981	W-122
SP-24	Patterson Way	6	124.9	364	Ductile Iron	SJ-22	SJ-23	1981	W-122
SP-31	Nicole Dr.	10	124.9	273	Ductile Iron	SJ-21	SJ-221	1981	W-122
SP-42	Kramer Ave.	8	124.9	589	Ductile Iron	SJ-30	SJ-31	1985	M-177
SP-48	Cascade Cr. Drive	8	124.9	642	Ductile Iron	SJ-36	J-196	1989	S-158
SP-52	Wortman loop	6	124.9	934	Ductile Iron	SJ-44	SJ-46	1979	S-114
SP-53	Wortman Loop	6	124.9	707	Ductile Iron	J-242	SJ-46	1979	S-115
SP-58	Shelikof Way	6	124.9	559	Ductile Iron	J-223	SJ-42	1978	S-123
SP-59	Halibut Pt. Road	8	124.9	363	Ductile Iron	SJ-41	SJ-43	1975	W-109
SP-61	Davidoff St.	8	130.0	545	Ductile Iron	J-224	SJ-51	2005	Flat File Pg 28
SP-62	NE of Fergisun loop	12	130.0	429	Ductile Iron	J-263	ST-2	1998	
SP-66	Kimsham St.	8	124.9	406	Ductile Iron	SJ-58	SJ-60	1983	S-136
SP-67	Furuhelm St.	8	124.9	620	Ductile Iron	SJ-59	SJ-60	1983	S-136
SP-68	Halibut Pt. Road	8	124.9	1,518	Ductile Iron	SJ-43	SJ-52	1975	W-109
SP-69	Halibut Pt. Road	8	124.9	672	Ductile Iron	SJ-52	SJ-53	1975	W-109
SP-70	Halibut Pt. Road	8	124.9	426	Ductile Iron	SJ-53	J-245	1975	W-109
SP-71	Halibut Pt. Road	8	124.9	406	Ductile Iron	SJ-54	SJ-55	1975	W-109
SP-75	Brady St.	8	124.9	316	Ductile Iron	SJ-63	SJ-64	1975	W-109
SP-76	Gavin St.	8	124.9	202	Ductile Iron	SJ-64	SJ-65	1975	W-109
SP-77	Gavin St.	6	124.9	439	Ductile Iron	SJ-65	SJ-66	1979	W-110
SP-78	Moller Ave.	6	124.9	422	Ductile Iron	SJ-66	SJ-67	1979	W-110
SP-81	Cascade St.	8	124.9	1,008	Ductile Iron	SJ-65	SJ-68	1975	W-109
SP-84	Verstovia Ave.	8	124.9	304	Ductile Iron	SJ-71	SJ-72	1975	W-103
SP-85	Verstovia Ave.	10	124.9	545	Ductile Iron	SJ-72	SJ-73	1979	S-130
SP-86	Verstovia Ave.	10	124.9	214	Ductile Iron	SJ-73	SJ-74	1979	S-130
SP-87	Verstovia Ave.	10	124.9	277	Ductile Iron	SJ-74	SJ-75	1979	S-130
SP-88	Charles St.	8	124.9	581	Ductile Iron	SJ-75	SJ-76	1989	S-163
SP-89	Charles St.	10	124.9	165	Ductile Iron	SJ-75	SJ-77	1979	S-130
SP-90	Pherson St.	8	124.9	801	Ductile Iron	SJ-77	SJ-78	1989	S-163
SP-91	Pherson St.	8	124.9	373	Ductile Iron	SJ-62	SJ-77	1979	S-130
SP-92	Pherson St.	8	124.9	348	Ductile Iron	SJ-62	SJ-80	1979	S-130
SP-93	Monastery st.	8	124.9	254	Ductile Iron	SJ-74	SJ-79	1979	S-130
SP-94	Monastery St.	8	124.9	343	Ductile Iron	SJ-79	SJ-80	1979	S-130
SP-95	A Street	6	124.9	372	Ductile Iron	SJ-79	SJ-73	1979	S-130
SP-96	Monastery St.	8	124.9	190	Ductile Iron	SJ-80	SJ-81		
SP-97	Sirstad St.	8	124.9	1,242	Ductile Iron	SJ-81	SJ-72	1975	W-103
SP-117	Monastery St.	6	124.9	363	Ductile Iron	J-248	SJ-137	1969	W-107
SP-118	Oja Way	6	130.0	499	Ductile Iron	SJ-137	SJ-126	1969	W-131
SP-121	Halibut Pt. Road	8	124.9	1,116	Ductile Iron	SJ-119	SJ-113	1975	W-109
SP-122	Halibut Pt. Road	8	124.9	388	Ductile Iron	SJ-113	SJ-98	1975	W-109
SP-123	Halibut Pt. Road	8	124.9	98	Ductile Iron	SJ-98	SJ-97	1975	W-109

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-124	Lakeview Dr.	6	124.9	657	Ductile Iron	SJ-97	SJ-94	1988	W-127
SP-125	Halibut Pt. Road	8	124.9	230	Ductile Iron	SJ-97	SJ-95	1975	W-109
SP-126	Crabapple Dr.	6	124.9	450	Ductile Iron	SJ-95	SJ-96	1980	W-117
SP-127	Halibut Pt. Road	8	124.9	431	Ductile Iron	SJ-95	SJ-93	1975	W-109
SP-128	Lakeview Dr.	6	124.9	1,327	Ductile Iron	SJ-93	SJ-94	1988	W-127
SP-133	New Archangel St.	8	130.0	234	Ductile Iron	SJ-102	SJ-103	1968	W-30
SP-143	Erler St.	10	124.9	220	Ductile Iron	SJ-115	SJ-116	1987	S-157
SP-146	Erler St.	10	124.9	271	Ductile Iron	SJ-116	SJ-117	1987	S-157
SP-147	Spruce St.	6	124.9	571	Ductile Iron	SJ-117	SJ-114	1989	W-129
SP-148	Spruce St.	6	124.9	136	Ductile Iron	SJ-114	SJ-113	1989	W-129
SP-149	Hemlock St.	6	124.9	755	Ductile Iron	SJ-114	SJ-118	1988	W-130
SP-150	Erler St.	10	124.9	256	Ductile Iron	SJ-118	SJ-117	1987	S-157
SP-151	Erler St.	10	124.9	416	Ductile Iron	SJ-118	SJ-119	1987	S-157
SP-154	Kaagwaantaan St.	8	124.9	1,413	Ductile Iron	SJ-104	SJ-109	1982	S-135
SP-165	Seward St.	10	124.9	190	Ductile Iron	SJ-121	SJ-122	1986	
SP-168	Seward St.	10	124.9	140	Ductile Iron	SJ-122	SJ-123	1986	S-149
SP-170	Seward St.	12	124.9	680	Ductile Iron	SJ-123	SJ-127	1992	S-180
SP-172	Etolin Way	4	124.9	359	Ductile Iron	SJ-127	SJ-136		
SP-173	Monastery St.	6	124.9	240	Ductile Iron	SJ-136	SJ-137	1969	W-107
SP-176	Baranof St.	6	130.0	231	Ductile Iron	SJ-140	SJ-139	1975	W-106
SP-177	Biorka St.	6	124.9	676	Ductile Iron	SJ-140	SJ-147		
SP-181	Etolin St.	8	130.0	410	Ductile Iron	SJ-150	SJ-145	1980	W-116
SP-184	Baranof St.	6	124.9	189	Ductile Iron	SJ-142	SJ-141	1975	W-106
SP-185	Oja St.	6	124.9	552	Ductile Iron	SJ-141	SJ-146	1980	W-116
SP-186	Park St.	6	124.9	242	Ductile Iron	SJ-146	SJ-147	1980	W-116
SP-187	Baranof St.	6	124.9	318	Ductile Iron	SJ-142	SJ-143	1975	W-106
SP-188	Lincoln St.	8	124.9	651	Ductile Iron	SJ-143	SJ-144	1985	S-147, SH 52
SP-189	Lincoln St.	8	124.9	284	Ductile Iron	SJ-143	SJ-135	1985	S-147, SH 52
SP-190	Monastery st.	6	124.9	290	Ductile Iron	SJ-135	SJ-136	1969	W-107
SP-191	Lincoln St.	8	124.9	293	Ductile Iron	SJ-135	SJ-128	1985	S-147, SH 51
SP-193	Harbor Dr.	12	124.9	738	Ductile Iron	SJ-128	SJ-129	1968	W-24
SP-194	Lincoln St.	10	124.9	623	Ductile Iron	SJ-128	SJ-133	1985	S-147
SP-196	Lincoln St.	10	124.9	204	Ductile Iron	SJ-133	SJ-132	1985	S-147
SP-197	American St.	6	124.9	140	Ductile Iron	SJ-132	SJ-134		
SP-198	Lincoln St.	10	124.9	515	Ductile Iron	SJ-132	SJ-131	1985	S-147
SP-201	Lincoln St.	8	124.9	364	Ductile Iron	SJ-144	SJ-151	1985	S-147, SH 53
SP-203	Lincoln St.	6	124.9	1,104	Ductile Iron	SJ-151	SJ-152	1985	S-146, SH 9
SP-204	Metlakatla St.	6	124.9	650	Ductile Iron	SJ-152	SJ-153	1985	S-146, SH 9
SP-211	Jarvis St.	8	124.9	641	Ductile Iron	SJ-157	SJ-158	1987	S-155
SP-213	Smith St.	8	130.0	447	Ductile Iron	SJ-162	SJ-163	1983	Flat File Pg 39
SP-215	Price St.	12	124.9	362	Ductile Iron	J-260	SJ-166	1986	S-164
SP-216	Price St.	12	124.9	344	Ductile Iron	SJ-166	SJ-167	1988	
SP-217	Burkhart St.	6	124.9	660	Ductile Iron	SJ-166	SJ-168	1986	S-164

TABLE 3
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE MATERIALS

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-220	Sawmill Cr. Road	14	124.9	628	Ductile Iron	SJ-170	SJ-165	1972	W-69
SP-222	Sawmill Cr. Road	12	124.9	24	Ductile Iron	SJ-172	SJ-171		
SP-224	Wolff Dr.	6	124.9	309	Ductile Iron	SJ-173	SJ-174		W-98
SP-225	Wolff Dr.	6	124.9	589	Ductile Iron	SJ-174	SJ-175		
SP-226	Wolff Dr.	6	124.9	410	Ductile Iron	SJ-175	SJ-176		W-98
SP-227	Wolff Dr.	6	124.9	310	Ductile Iron	SJ-176	SJ-174		W-98
SP-230	Sawmill Cr. Road	24	124.9	2,710	Ductile Iron	SJ-?	SJ-160	1987	W-125, SH 1
SP-231	Sawmill Cr. Road	24	124.9	542	Ductile Iron	SJ-160	SJ-161	1987	W-125, SH 2
SP-232	Sawmill Cr. Road	24	124.9	1,312	Ductile Iron	SJ-161	SJ-164	1987	W-125, SH 2
SP-233	Sawmill Cr. Road	24	124.9	1,103	Ductile Iron	SJ-164	SJ-171	1987	W-125, SH 2
SP-234	Sawmill Cr. Road	24	124.9	4,473	Ductile Iron	SJ-171	SJ-184	1987	W125, SH 3 & 4
SP-237	Anna Dr.	8	124.9	175	Ductile Iron	SJ-180	SJ-181	1985	S-151
SP-238	Anna Dr.	8	124.9	362	Ductile Iron	SJ-181	SJ-182	1985	S-151
SP-239	Anna Dr.	6	124.9	394	Ductile Iron	SJ-181	SJ-185	1985	S-151
SP-241	Sawmill Cr. Road	12	124.9	15	Ductile Iron	SJ-183	SJ-184	1987	W-125
SP-242	Sawmill Cr. Road	14	130.0	1,245	Ductile Iron	SJ-183	SJ-186	1980	W-118
SP-243	Shotgun Alley	8	124.9	797	Ductile Iron	SJ-186	SJ-187	1980	W-118
SP-244	Shotgun Alley	8	124.9	1,049	Ductile Iron	SJ-187	SJ-188	1980	W-118
SP-245	Islander Dr.	6	124.9	1,084	Ductile Iron	SJ-188	SJ-189	1979	W-111, 112, 113
SP-246	Sawmill Cr. Road	12	124.9	1,354	Ductile Iron	SJ-186	SJ-190	1980	W-118
SP-248	Sawmill Cr. Road	12	124.9	1,427	Ductile Iron	SJ-191	SJ-192	1980	W-118
SP-249	Sawmill Cr. Road	12	124.9	4	Ductile Iron	SJ-192	SJ-194	1980	W-118
SP-250	Sawmill Cr. Road	24	124.9	6,227	Ductile Iron	SJ-184	SJ-193	1987	W-125, SH 4, 5, 6, 7
SP-251	Sawmill Cr. Road	30	124.9	2,091	Ductile Iron	SJ-193	SJ-195	1987	W-125, SH 6, 7
SP-280	Sawmill Cr. Road	12	124.9	30	Ductile Iron	SJ-192	SJ-193	1987	W-125
SP-288	Jarvis St.	8	124.9	593	Ductile Iron	SJ-158	SJ-159	1987	S-155
SP-289	Sawmill Cr. Road	30	124.9	15,000	Ductile Iron	SR-1	SJ-195	1987	W-125
SP-290	Harbor Mtn. Rd.	18	124.9	10	Ductile Iron	ST-1	SJ-15	1983	W-121
SP167	American St.	6	124.9	170	Ductile Iron	SJ-122	SJ-134		S-149
JP-156	Off Seward Ave.	8	150.0	216	HDPE	JJ-150	JJ-151		
P-319	Smith St.	8	150.0	1,044	HDPE	J-258	SJ-163	1998	Flat File Pg 39
P-322	Price St.	8	150.0	706	HDPE	SJ-167	J-261	2002	
P-323	Price St.	8	150.0	375	HDPE	J-261	J-262	2002	
P-333	Granite Cr. Road	8	150.0	1,556	HDPE	J-264	SJ-12	2002	
P-396	Off Lake St.	8	150.0	661	HDPE	SJ-70	J-174	2006	
P-399	Tlingit Way	2	150.0	400	HDPE	SJ-120	J-177	1996	W-137
P-412	Off Price St.	6	150.0	269	HDPE	J-261	J-188	2002	
P-422	Cedar Beach Rd.	8	150.0	1,145	HDPE	J-194	J-201	2001	
P-441	Beardslee Way	8	150.0	398	HDPE	SJ-158	J-258	2005	
P-442	Beardslee Way	8	150.0	503	HDPE	J-258	J-261	2005	
SP-105	Monastery St.	2	150.0	209	HDPE	J-269	SJ-89	1996	W-137
SP-195	Maksostoff St.	8	150.0	154	HDPE	SJ-133	SJ-129	2002	Flat File Pg 35
P-262	O'Connell Bridge	12	100.0	1,360	Steel	SJ-130	JJ-1	1980	Flat File Pg 35

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
JP-9	Harbor Dr.	12	124.9	145	Ductile Iron	JJ-9	JJ-10		
JP-20	Airport Rd.	16	124.9	252	Ductile Iron	JJ-22	JJ-20	1992	Hanging File Pg 33
JP-34	Off Seward Ave.	8	113.0	320	Asbestos Cement	JJ-33	JJ-34		
JP-57	Off Seward Ave.	10	124.9	156	Ductile Iron	JJ-56	JJ-57	1984	S-154
JP-58	Off Seward Ave.	10	124.9	90	Ductile Iron	JJ-57	JJ-58	1984	S-154
JP-59	Off Seward Ave.	8	124.9	157	Ductile Iron	JJ-58	JJ-59	1984	S-154
JP-60	Off Seward Ave.	10	124.9	222	Ductile Iron	JJ-58	JJ-60	1984	S-154
JP-61	Off Seward Ave.	6	124.9	132	Ductile Iron	JJ-60	JJ-61	1984	S-154
JP-62	Off Seward Ave.	6	124.9	92	Ductile Iron	JJ-61	JJ-62	1984	S-154
JP-66	Seward Ave.	6	124.9	50	Ductile Iron	JJ-65	JJ-66	1984	S-154
JP-67	Seward Ave.	6	124.9	72	Ductile Iron	JJ-66	JJ-67		S-154
JP-77	Harbor Dr.	10	124.9	202	Ductile Iron	JJ-76	JJ-77		
JP-78	Harbor Dr.	10	124.9	149	Cast iron	JJ-77	JJ-10		
JP-84	Tongass Dr.	12	124.9	1,167	Ductile Iron	JJ-92	JJ-20	2004	
JP-100	Lifesaver Dr.	10	113.0	88	Asbestos Cement	JJ-30	JJ-97	1992	Hanging File
JP-101	Livesaver Dr.	10	113.0	86	Asbestos Cement	JJ-97	JJ-98		
JP-139	Alice loop	12	124.9	123	Ductile Iron	JJ-130	JJ-135	1985	W-124
JP-142	Lifesaver Dr.	8	124.9	53	Cast iron	JJ-30	JJ-138	1992	Hanging File
JP-152	Off Seward Ave.	8	124.9	274	Ductile Iron	JJ-33	JJ-147		
JP-153	Off Seward Ave.	8	124.9	59	Ductile Iron	JJ-147	JJ-148		
JP-154	Off Seward Ave.	8	113.0	339	Asbestos Cement	JJ-148	JJ-149		
JP-155	Off Seward Ave.	8	113.0	275	Asbestos Cement	JJ-149	JJ-150		
JP-156	Off Seward Ave.	8	150.0	216	HDPE	JJ-150	JJ-151		
JP-206	Airport Rd.	8	124.9	403	Cast iron	JJ-138	JJ-205	1967	M-52
JP-207	Airport Rd.	8	124.9	223	Cast iron	JJ-205	JJ-206	1967	M-52
JP-208	Airport Rd.	8	124.9	132	Cast iron	JJ-206	JJ-203	1984	M-52
JP-209	Airport Rd.	6	124.9	242	Cast iron	JJ-206	JJ-207	1967	M-52
JP-210	Charcoal Dr.	8	130.0	245	Ductile Iron	JJ-120	JJ-208	2002	
JP-212	Off Alice loop	8	124.9	216	Ductile Iron	JJ-208	JJ-209		
JP-213	Off Alice loop	8	124.9	104	Ductile Iron	JJ-209	JJ-210	1967	
JP-216	Off Alice Loop	8	124.9	534	Ductile Iron	JJ-210	JJ-212		Flat File Pg 39
JP-219	Alice loop	8	124.9	283	Ductile Iron	JJ-214	JJ-125	2002	
JP-222	Seward Ave.	12	124.9	31	Ductile Iron	JJ-215	JJ-73	1984	S-154
P-262	O'Connell Bridge	12	100.0	1,360	Steel	SJ-130	JJ-1	1980	Flat File Pg 35
P-264	Off Kinkroft Way	6	124.9	447	Ductile Iron	J-195	SJ-223	1993	
P-265	Halibut Pt. Road	16	130.0	1,092	Ductile Iron	SJ-34	J-220	1992	W-138
P-266	Halibut Pt. Road	16	130.0	902	Ductile Iron	J-220	J-222	1992	W-138
P-267	Cascade Cr. Road	8	124.9	10	Ductile Iron	J-220	J-221	1992	W-138
P-268	Cascade Cr. Road	8	124.9	54	Ductile Iron	J-221	SJ-40	1989	S-158
P-269	Cascade Cr. Road	8	124.9	276	Ductile Iron	J-196	J-221	1989	S-158
P-270	Donna Dr.	6	124.9	260	Ductile Iron	J-196	J-241	1997	Flat File Pg 27
P-271	Shelikof Way	6	124.9	10	Ductile Iron	J-222	J-223	1978	S-123
P-272	Shelikof Way	6	124.9	54	Ductile Iron	J-223	SJ-41	1978	S-123
P-276	Wortman loop	6	124.9	10	Ductile Iron	SJ-47	J-242	1996	

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-277	Charteris St.	14	124.9	342	Cast iron	SJ-47	J-243	1968	W-46, W-47
P-278	Charteris St.	8	124.9	976	Ductile Iron	J-242	J-200	1996	
P-279	Mills St.	8	124.9	477	Ductile Iron	J-198	J-200	1996	
P-280	Georgson loop	8	124.9	780	Ductile Iron	J-199	J-200	1996	
P-281	Georgson loop	8	124.9	772	Ductile Iron	J-199	J-198	1996	
P-282	Georgson loop	8	124.9	638	Ductile Iron	J-198	J-270	1996	Flat File Pg 28
P-283	Mills St.	8	124.9	350	Ductile Iron	J-198	J-197	1996	
P-284	Johnston St.	8	124.9	866	Ductile Iron	J-197	J-243	1996	Flat File Pg 28
P-285	Mills St.	6	124.9	354	Cast iron	J-197	SJ-56		
P-287	Kashevaroff St.	8	124.9	328	Ductile Iron	SJ-59	J-203	1987	Flat File Pg 29
P-288	Kashevaroff St.	6	124.9	240	Ductile Iron	SJ-59	J-244	1987	
P-289	Kashevaroff St.	6	124.9	165	Ductile Iron	J-244	J-202	1987	Flat File Pg 29
P-290	Halibut Pt. Road	8	124.9	547	Ductile Iron	SJ-54	J-245	1975	W-109
P-291	Kashevaroff St.	8	124.9	419	Ductile Iron	SJ-57	J-245		
P-292	Kimsham st.	2	147.0	522	Copper	SJ-58	J-246	1980	W-115
P-293	Peterson St.	10	124.9	192	Cast iron	J-246	SJ-55	1968	W-41
P-294	DeArmond St.	6	124.9	175	Cast iron	J-247	SJ-115		
P-295	Sawmill Cr. Road	6	124.9	10	Ductile Iron	SJ-138	J-248	1969	W-107
P-296	Merrill Street	6	124.9	868	Cast iron	SJ-91	J-249	1967, 1975	W-94, S-93
P-297	Off Park St.	4	124.9	300	Ductile Iron	J-249	SJ-148		
P-298	Biorka St.	8	124.9	631	Cast iron	SJ-147	J-271	1967	W-88
P-299	Jeff Davis St.	8	124.9	80	Cast iron	J-250	SJ-150	1968	W-22
P-300	Charles St.	6	124.9	400	Ductile Iron	SJ-75	SJ-62	1979	S-130
P-301	Crescent Dr.	8	124.9	313	Ductile Iron	J-250	J-206		
P-302	Off Crescent Dr.	8	124.9	634	Ductile Iron	J-206	J-205		
P-303	Off Metlakatla	12	130.0	802	Ductile Iron	J-252	J-204	2004	
P-304	John Brady Dr.	12	130.0	772	Ductile Iron	J-204	J-251	2004	Flat File Pg 37
P-305	Jeff Davis St.	8	124.9	472	Ductile Iron	J-251	SJ-151	1968	W-22
P-306	Andrew Hope St.	8	124.9	626	Ductile Iron	J-207	J-210	1994	Flat File Pg 37
P-307	Andrew Hope St.	8	124.9	442	Ductile Iron	J-210	J-211	1994	Flat File Pg 37
P-308	Indian River Road	18	124.9	452	Cast iron	J-207	J-208	1971	Flat File Pg 37
P-309	Off Yaw Dr.	12	124.9	481	Ductile Iron	J-208	J-256	1994	Flat File Pg 37
P-310	Rudolph Walton Cir	6	124.9	320	Ductile Iron	J-209	J-212	1994	Flat File Pg 37
P-311	Joseph St.	6	124.9	303	Ductile Iron	J-209	J-210	1994	Flat File Pg 37
P-312	Indain River Road	18	124.9	1,374	Cast iron	J-208	SJ-155	1971	Flat File Pg 37
P-313	Indain River Road	8	124.9	350	Ductile Iron	J-208	J-253	2000	Flat File Pg 37
P-314	Indain River Road	8	124.9	850	Ductile Iron	J-253	J-254	2000	Flat File Pg 37
P-315	Yaw Drove	12	124.9	667	Ductile Iron	J-253	J-255	2005	
P-316	Joseph St.	6	124.9	241	Ductile Iron	J-256	J-209	1994	Flat File Pg 37
P-317	Heab Didrickson St.	8	124.9	648	Ductile Iron	J-255	J-257	2005	
P-318	Naomi Kanosh lane	8	124.9	550	Ductile Iron	J-254	J-257	2002	W-135
P-319	Smith St.	8	150.0	1,044	HDPE	J-258	SJ-163	1998	Flat File Pg 39
P-320	Price St.	12	124.9	114	Ductile Iron	J-260	J-259	1986	S-164
P-321	Price St.	12	124.9	135	Ductile Iron	J-259	SJ-165	1986	S-164

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-322	Price St.	8	150.0	706	HDPE	SJ-167	J-261	2002	
P-323	Price St.	8	150.0	375	HDPE	J-261	J-262	2002	
P-324	Lance Dr.	6	124.9	630	Ductile Iron	SJ-169	J-213	1992	W-134
P-325	Jamestown Dr.	8	124.9	470	Ductile Iron	SJ-178	J-214	1977	S-124, S-125
P-326	Jamestown Dr.	8	124.9	569	Ductile Iron	J-214	J-215	1977	
P-327	Knutson Dr.	8	124.9	252	Ductile Iron	SJ-180	J-217	1993	M-244
P-328	Knutson Dr.	6	124.9	692	Ductile Iron	J-217	J-218	1993	M-244
P-329	Knutson Dr.	6	124.9	355	Ductile Iron	J-218	J-219	1993	M-244
P-330	Knutson Dr.	6	124.9	340	Ductile Iron	J-219	J-217	1993	M-244
P-331	Sawmill Cr. Road	8	124.9	775	Ductile Iron	SJ-194	J-216	1980	W-118
P-332	Georgeson loop	14	130.0	781	Cast iron	J-263	J-270	1968	W-47
P-333	Granite Cr. Road	8	150.0	1,556	HDPE	J-264	SJ-12	2002	
P-334	Halibut Pt. Road	6	130.0	637	Cast iron	SJ-7	J-265	1977	W-92
P-335	Airport Road	16	124.9	1,474	Ductile Iron	JJ-20	JJ-10	1992	Hanging File Pg 32
P-336	Edgecumbe Dr.	12	130.0	147	Cast iron	J-272	SJ-45	1972	W-62, W-109
P-337	Seward Ave.	12	124.9	2,004	Ductile Iron	JJ-53	JJ-37	2004	
P-338	Airport Rd.	16	124.9	769	Ductile Iron	JJ-30	JJ-203	1992	Hanging File Pg 32
P-339	Airport Rd.	16	124.9	1,410	Ductile Iron	JJ-203	JJ-22	1992	Hanging File Pg 33
P-340	Lifesaver Dr.	10	113.0	672	Asbestos Cement	JJ-118	JJ-98		
P-341	Halibut Pt. Road	6	124.9	666	Cast iron	SJ-33	J-268	1963	W-95
P-342	Halibut Pt. Road	6	124.9	26	Ductile Iron	SJ-33	SJ-34	1977	W-61
P-343	Charteris St.	6	124.9	68	Ductile Iron	J-270	SJ-47	1968	W-47
P-344	Cascade Cr. Drive	12	130.0	162	Cast iron	SJ-36	SJ-37		W-63, W-104
P-346	Edgecumbe Dr.	12	130.0	49	Cast iron	PMP-1	J-272	1972	W-62, W-109
P-347	Kramer Ave.	12	130.0	1,000	Ductile Iron	SJ-31	Theoretical Hydrant at 150' in Benchlands Subdivision		
P-348	Harbor Dr.	12	124.9	1,008	Ductile Iron	JJ-1	JJ-9		
P-349	Lifesaver Dr.	10	113.0	911	Asbestos Cement	JJ-98	JJ-109		
P-350	Off Seward Ave.	8	130.0	351	Cast iron	JJ-147	JJ-144	1967	M-52
P-351	Airport Rd.	8	124.9	800	Cast iron	JJ-144	JJ-141	1967	M-52
P-352	Airport Rd.	8	124.9	432	Cast iron	JJ-141	JJ-138	1967	M-52
P-353	Off Seward Ave.	8	124.9	689	Ductile Iron	JJ-159	JJ-34		
P-354	Off Seward Ave.	8	113.0	548	Asbestos Cement	JJ-34	JJ-151		
P-355	Tongass Dr.	12	124.9	671	Ductile Iron	JJ-53	JJ-92	1984	S-154
P-357	Seward Ave.	10	124.9	301	Ductile Iron	JJ-215	JJ-70	1984	S-154
P-358	Seward Ave.	12	124.9	590	Ductile Iron	JJ-70	JJ-65	1984	S-154
P-359	Seward Ave.	12	124.9	165	Ductile Iron	JJ-65	JJ-56	1984	S-154
P-360	Seward Ave.	12	124.9	454	Ductile Iron	JJ-56	JJ-53	1984	S-154
P-362	Seward Ave.	6	124.9	129	Ductile Iron	JJ-227	JJ-215	1984	S-154
P-363	Seward Ave.	10	124.9	603	Cast iron	JJ-76	JJ-73		
P-364	Charcoal Dr.	8	130.0	265	Ductile Iron	JJ-22	JJ-120		Flat File Pg 25
P-366	Alice loop	8	124.9	508	Cast iron	JJ-208	JJ-214	2002	
P-367	Alice loop	8	124.9	676	Ductile Iron	JJ-125	JJ-130		
P-368	Alice loop	8	124.9	564	Ductile Iron	JJ-130	JJ-127	1985	W-124
P-369	Alice loop	8	124.9	699	Ductile Iron	JJ-127	JJ-125	1985	W-124

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-370	Off Alice loop	8	124.9	690	Ductile Iron	JJ-214	JJ-210	2002	
P-371	Halibut Pt. Road	10	130.0	67	Ductile Iron	SJ-2	J-153	1989	Flat files
P-372	Halibut Pt. Road	6	130.0	238	Ductile Iron	J-153	J-154	1989	Flat files
P-373	Valhalla Dr.	6	130.0	229	Ductile Iron	J-155	SJ-9	1978	W-108
P-374	Valhalla Dr.	6	130.0	141	Ductile Iron	SJ-9	J-156	1978	W-108
P-375	Circle E.	8	130.0	437	Ductile Iron	SJ-17	J-157	1999	
P-376	Halibut Pt. Road	12	124.9	294	Cast iron	SJ-17	J-158	1977	W-54
P-377	Halibut Pt. Road	12	124.9	432	Cast iron	J-158	SJ-18	1977	W-54
P-378	Off Circle E	6	130.0	329	Ductile Iron	J-158	J-159		
P-379	Halibut Pt. Road	12	124.9	155	Cast iron	SJ-18	J-160	1977	W-54
P-380	Halibut Pt. Road	12	124.9	455	Cast iron	J-160	SJ-20	1977	W-54
P-381	Halibut Pt. Road	4	130.0	90	Ductile Iron	J-160	J-161		
P-382	Halibut Pt. Road	6	124.9	209	Ductile Iron	SJ-24	J-162	1986	S-150
P-383	Ross St.	6	124.9	376	Ductile Iron	J-162	SJ-25	1986	S-150
P-384	Barker St.	6	130.0	330	Ductile Iron	J-162	J-163	1986	S-150
P-385	Halibut Pt. Road	12	124.9	797	Cast iron	SJ-24	J-164	1977	W-56
P-386	Halibut Pt. Road	12	124.9	607	Cast iron	J-164	SJ-26	1977	W-56
P-387	Bahovec Ct.	8	130.0	475	Ductile Iron	J-164	J-165	1989	Flat File Pg 25
P-388	Halibut Pt. Road	12	124.9	1,066	Cast iron	SJ-29	J-166	1977	W-59
P-389	Halibut Pt. Road	12	124.9	610	Cast iron	J-166	SJ-30	1977	W-60
P-390	Sand dollar Dr.	6	130.0	789	Ductile Iron	J-166	J-167	1987	Flat File Pg 26
P-392	Tilson St.	6	130.0	465	Ductile Iron	SJ-60	J-170	1983	S-136
P-393	Wachusetts Wt.	6	130.0	826	Ductile Iron	SJ-58	J-171	1974	W-128
P-394	Sigtnaka Way	6	130.0	260	Cast iron	SJ-100	J-172		
P-395	Sigtnaka Way	4	130.0	626	Ductile Iron	J-172	J-173		
P-396	Off Lake St.	8	150.0	661	HDPE	SJ-70	J-174	2006	
P-397	Off Verstovia St.	6	130.0	299	Ductile Iron	SJ-72	J-175		
P-398	Buhrt Cir.	6	130.0	277	Ductile Iron	SJ-76	J-176	1989	S-163
P-399	Tlingit Way	2	150.0	400	HDPE	SJ-120	J-177	1996	W-137
P-400	Barracks St.	6	130.0	186	Ductile Iron	SJ-121	J-178		
P-401	Off Lincoln St.	4	130.0	164	Ductile Iron	SJ-134	J-179	1989	S-129
P-402	Hirst St.	6	130.0	99	Cast iron	SJ-86	J-180		
P-403	Lincoln St.	6	130.0	106	Ductile Iron	SJ-144	J-181	1985	S-147, SH 53
P-404	Kelly St.	6	130.0	237	Ductile Iron	SJ-152	J-182	1985	S-146, SH 9
P-405	Etolin St.	8	124.9	321	Ductile Iron	SJ-145	J-183	1980	W-116
P-406	Etolin St.	6	124.9	473	Ductile Iron	J-183	SJ-142	1980	W-116
P-407	Indian River Road	18	124.9	840	Cast iron	SJ-154	J-184	1971	Flat File Pg 37
P-408	Indian River Road	18	124.9	875	Cast iron	J-184	J-207	1971	Flat File Pg 37
P-409	Kaasda Heen Cir.	6	130.0	277	Ductile Iron	J-184	J-185	1998	
P-410	Harvest Way	6	130.0	295	Ductile Iron	SJ-167	J-186		
P-411	Marys Court	6	130.0	449	Ductile Iron	J-262	J-187	2002	
P-412	Off Price St.	6	150.0	269	HDPE	J-261	J-188	2002	
P-413	Lilian Dr.	6	130.0	1,161	Ductile Iron	J-260	J-259	2001	W-136
P-415	Vitskari St.	8	130.0	54	Ductile Iron	J-189	J-190	1995	Flat File Pg 41

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
P-416	Kiksadi Ct.	6	130.0	319	Ductile Iron	J-189	J-191	1995	
P-417	Sawmill Cr. Road	14	124.9	213	Cast iron	SJ-173	J-192	1972	W-68
P-418	Sawmill Cr. Road	14	124.9	1,417	Cast iron	J-192	SJ-177	1972	W-68, W-67
P-419	Chirikov Dr.	10	130.0	501	Ductile Iron	J-192	J-193		
P-420	Sawmill Cr. Road	14	130.0	78	Ductile Iron	SJ-180	J-194	1980	W-118
P-421	Sawmill Cr. Road	14	130.0	101	Ductile Iron	J-194	SJ-183	1980	W-118
P-422	Cedar Beach Rd.	8	150.0	1,145	HDPE	J-194	J-201	2001	
P-423	Rands Dr.	6	130.0	429	Ductile Iron	SJ-187	J-225	1985	S-145
P-424	Sawmill Cr. Road	12	124.9	1,842	Ductile Iron	SJ-190	J-226	1980	W-118
P-425	Sawmill Cr. Road	12	124.9	625	Ductile Iron	J-226	SJ-191	1980	W-118
P-426	Blueberry lane	4	130.0	552	Ductile Iron	J-226	J-227		
P-427	Sawmill Cr. Road	12	130.0	1,034	Ductile Iron	J-216	J-228	1992	W-133
P-428	Halibut Pt. Road	16	124.9	615	Ductile Iron	J-222	J-229	1992	W-138
P-429	Davidoff st.	16	124.9	249	Ductile Iron	J-229	J-224	1992	W-138
P-430	Edgecumbe Dr.	12	124.9	227	Cast iron	SJ-48	J-230	1972	W-62, W-104
P-431	Edgecumbe Dr.	12	124.9	126	Cast iron	J-230	PMP-1	1972	W-62, W-109
P-432	Gibson Pl	4	130.0	567	Ductile Iron	J-229	J-230		
P-433	Lance Dr.	6	124.9	291	Ductile Iron	SJ-168	J-231	1979	S-129
P-434	Lance Dr.	6	124.9	523	Ductile Iron	J-231	SJ-170	1979	S-129
P-435	Lance Dr.	6	124.9	323	Ductile Iron	SJ-168	J-232	1978	S-128
P-436	Lance Dr.	6	124.9	588	Ductile Iron	J-232	SJ-169	1981	S-133
P-437	Jarvis St.	8	124.9	251	Ductile Iron	SJ-156	J-233		
P-438	Jarvis St	8	124.9	449	Ductile Iron	J-233	SJ-157	1987	S-155
P-439	Burkhart St.	8	130.0	381	Ductile Iron	SJ-168	J-234	1995	Flat File Pg 41
P-440	Vitskari St.	8	130.0	140	Ductile Iron	J-234	J-189	1995	Flat File Pg 41
P-441	Beardslee Way	8	150.0	398	HDPE	SJ-158	J-258	2005	
P-442	Beardslee Way	8	150.0	503	HDPE	J-258	J-261	2005	
SP-1	Halibut Pt. Road	12	124.9	418	Ductile Iron	SJ-1	SJ-2	1989	Flat files
SP-2	Halibut Pt. Road	12	124.9	683	Ductile Iron	SJ-2	SJ-3	1989	Flat files
SP-3	Halibut Pt. Road	12	124.9	4,413	Ductile Iron	SJ-3	SJ-4	1989	Flat files
SP-4	Halibut Pt. Road	12	124.9	519	Ductile Iron	SJ-4	SJ-5	1987	S-159
SP-5	Halibut Pt. Road	12	124.9	972	Cast iron	SJ-5	SJ-6	1977	W-92
SP-6	Halibut Pt. Road	10	124.9	225	Ductile Iron	SJ-6	J-265		W-192
SP-7	Halibut Pt. Road	12	124.9	1,727	Cast iron	SJ-6	SJ-8	1977	W-92
SP-8	Viking Way	6	124.9	287	Ductile Iron	SJ-8	SJ-9	1978	W-108
SP-9	Halibut Pt. Road	12	124.9	1,551	Cast iron	SJ-8	SJ-10	1977	W-93
SP-10	Halibut Pt. Road	12	124.9	688	Cast iron	SJ-10	SJ-11	1977	W-50
SP-11	Halibut Pt. Road	12	124.9	1,396	Cast iron	SJ-11	SJ-13	1977	W-51
SP-12	Halibut Pt. Road	12	124.9	394	Cast iron	SJ-12	SJ-13	1977	W-52
SP-13	Halibut Pt. Road	12	124.9	1,334	Cast iron	SJ-14	SJ-12	1977	W-52
SP-14	Harbor Mtn. Road	18	124.9	2,366	Ductile Iron	SJ-14	SJ-15	1983	W-121
SP-15	Shuler Dr.	6	124.9	455	Ductile Iron	SJ-14	SJ-16	1975	W-105
SP-16	Halibut Pt. Road	12	124.9	546	Cast iron	SJ-14	SJ-17	1977	W-53
SP-18	Darrin Dr.	6	130.0	882	Cast iron	SJ-18	SJ-19		

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-20	Halibut Pt. Road	12	124.9	1,165	Cast iron	SJ-20	SJ-21	1977	W-55
SP-22	Nicole Dr.	10	124.9	182	Ductile Iron	SJ-221	SJ-22	1981	W-122
SP-23	Somer Dr.	6	124.9	257	Ductile Iron	SJ-221	SJ-223	1981	W-122
SP-24	Patterson Way	6	124.9	364	Ductile Iron	SJ-22	SJ-23	1981	W-122
SP-31	Nicole Dr.	10	124.9	273	Ductile Iron	SJ-21	SJ-221	1981	W-122
SP-35	Halibut Pt. Road	12	124.9	461	Cast iron	SJ-21	SJ-24	1977	W-55
SP-38	Halibut Pt. Road	12	124.9	1,433	Cast iron	SJ-26	SJ-27	1977	W-57
SP-39	Halibut Pt. Road	12	124.9	872	Cast iron	SJ-27	SJ-28	1977	W-58
SP-40	Halibut Pt. Road	12	124.9	790	Cast iron	SJ-28	SJ-29	1977	W-58
SP-42	Kramer Ave.	8	124.9	589	Ductile Iron	SJ-30	SJ-31	1985	M-177
SP-43	Halibut Pt Road	12	124.9	325	Cast iron	SJ-30	SJ-32	1977	W-60
SP-44	Halibut Pt. Road	6	124.9	1,241	Cast iron	SJ-32	SJ-33	1963	W-95
SP-45	Halibut Pt. Road	12	124.9	1,232	Cast iron	SJ-32	SJ-34	1977	W-60, W-61
SP-46	West of Dodge Cir.	12	124.9	582	Cast iron	SJ-34	SJ-35	1977	W-61, W-104
SP-47	Dodge Cir.	12	124.9	738	Cast iron	SJ-35	SJ-36	1972	W-64, W-104
SP-48	Cascade Cr. Drive	8	124.9	642	Ductile Iron	SJ-36	J-196	1989	S-158
SP-49	H.P.R at Cascade Ave.	8	124.9	33	Cast iron	J-267	SJ-40	1963	W-96
SP-50	Edgecumbe Dr.	12	124.9	1,047	Cast iron	SJ-38	SJ-44	1972	W-104, W-64
SP-51	Edgecumbe Dr.	12	124.9	419	Cast iron	SJ-45	SJ-44	1972	W-62, W-109
SP-52	Wortman loop	6	124.9	934	Ductile Iron	SJ-44	SJ-46	1979	S-114
SP-53	Wortman Loop	6	124.9	707	Ductile Iron	J-242	SJ-46	1979	S-115
SP-54	Charteris St.	14	124.9	437	Cast iron	J-243	SJ-48	1968	W-46
SP-56	Charteris St.	14	124.9	390	Cast iron	SJ-48	J-224	1968	W-46
SP-57	Halibut Pt. Road	8	124.9	949	Cast iron	SJ-40	SJ-41	1963	W-96
SP-58	Shelikof Way	6	124.9	559	Ductile Iron	J-223	SJ-42	1978	S-123
SP-59	Halibut Pt. Road	8	124.9	363	Ductile Iron	SJ-41	SJ-43	1975	W-109
SP-61	Davidoff St.	8	130.0	545	Ductile Iron	J-224	SJ-51	2005	Flat File Pg 28
SP-62	NE of Fergisun loop	12	130.0	429	Ductile Iron	J-263	ST-2	1998	
SP-63	Edgecumbe Dr.	12	124.9	1,077	Cast iron	SJ-48	SJ-56	1968	W-45
SP-64	Edgecumbe Dr.	12	124.9	1,082	Cast iron	SJ-56	SJ-57	1968	W-43
SP-65	Edgecumbe Dr.	12	124.9	784	Cast iron	SJ-57	SJ-58	1968	W-43
SP-66	Kimsham St.	8	124.9	406	Ductile Iron	SJ-58	SJ-60	1983	S-136
SP-67	Furuhelm St.	8	124.9	620	Ductile Iron	SJ-59	SJ-60	1983	S-136
SP-68	Halibut Pt. Road	8	124.9	1,518	Ductile Iron	SJ-43	SJ-52	1975	W-109
SP-69	Halibut Pt. Road	8	124.9	672	Ductile Iron	SJ-52	SJ-53	1975	W-109
SP-70	Halibut Pt. Road	8	124.9	426	Ductile Iron	SJ-53	J-245	1975	W-109
SP-71	Halibut Pt. Road	8	124.9	406	Ductile Iron	SJ-54	SJ-55	1975	W-109
SP-72	Peterson St.	10	124.9	505	Cast iron	J-246	SJ-61	1968	W-41
SP-73	Edgecumbe Dr.	12	124.9	469	Cast iron	SJ-58	SJ-61	1968	W-43
SP-74	Halibut Pt. Road	14	124.9	367	Cast iron	SJ-55	SJ-63	1968	W-40
SP-75	Brady St.	8	124.9	316	Ductile Iron	SJ-63	SJ-64	1975	W-109
SP-76	Gavin St.	8	124.9	202	Ductile Iron	SJ-64	SJ-65	1975	W-109
SP-77	Gavin St.	6	124.9	439	Ductile Iron	SJ-65	SJ-66	1979	W-110
SP-78	Moller Ave.	6	124.9	422	Ductile Iron	SJ-66	SJ-67	1979	W-110

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-79	Peterson St.	10	124.9	722	Cast iron	SJ-61	SJ-68	1968	W-41
SP-80	Peterson St.	10	124.9	150	Cast iron	SJ-70	SJ-68	1968	W-37
SP-81	Cascade St.	8	124.9	1,008	Ductile Iron	SJ-65	SJ-68	1975	W-109
SP-82	Lake St.	10	124.9	296	Cast iron	SJ-70	SJ-71	1968	W-37
SP-83	Halibut Pt. Rd.	14	124.9	667	Cast iron	SJ-63	SJ-92	1968	W-40
SP-84	Verstovia Ave.	8	124.9	304	Ductile Iron	SJ-71	SJ-72	1975	W-103
SP-85	Verstovia Ave.	10	124.9	545	Ductile Iron	SJ-72	SJ-73	1979	S-130
SP-86	Verstovia Ave.	10	124.9	214	Ductile Iron	SJ-73	SJ-74	1979	S-130
SP-87	Verstovia Ave.	10	124.9	277	Ductile Iron	SJ-74	SJ-75	1979	S-130
SP-88	Charles St.	8	124.9	581	Ductile Iron	SJ-75	SJ-76	1989	S-163
SP-89	Charles St.	10	124.9	165	Ductile Iron	SJ-75	SJ-77	1979	S-130
SP-90	Pherson St.	8	124.9	801	Ductile Iron	SJ-77	SJ-78	1989	S-163
SP-91	Pherson St.	8	124.9	373	Ductile Iron	SJ-62	SJ-77	1979	S-130
SP-92	Pherson St.	8	124.9	348	Ductile Iron	SJ-62	SJ-80	1979	S-130
SP-93	Monastery st.	8	124.9	254	Ductile Iron	SJ-74	SJ-79	1979	S-130
SP-94	Monastery St.	8	124.9	343	Ductile Iron	SJ-79	SJ-80	1979	S-130
SP-95	A Street	6	124.9	372	Ductile Iron	SJ-79	SJ-73	1979	S-130
SP-96	Monastery St.	8	124.9	190	Ductile Iron	SJ-80	SJ-81		
SP-97	Sirstad St.	8	124.9	1,242	Ductile Iron	SJ-81	SJ-72	1975	W-103
SP-98	Monastery St.	6	124.9	794	Cast iron	SJ-81	SJ-85		
SP-99	Kincaid St.	6	124.9	257	Cast iron	SJ-85	SJ-84		Flat File Pg 36
SP-100	Lake St.	10	124.9	979	Cast iron	SJ-82	SJ-83	1968	W-36, W-35
SP-101	Lake St.	10	124.9	708	Cast iron	SJ-83	SJ-71	1968	W-37, W-36
SP-102	Lake St.	10	124.9	404	Cast iron	SJ-84	SJ-87	1968	W-34
SP-103	Hirst St.	6	124.9	335	Cast iron	SJ-87	SJ-86		
SP-104	Monastery St.	6	124.9	390	Cast iron	SJ-86	SJ-85		
SP-105	Monastery St.	2	150.0	209	HDPE	J-269	SJ-89	1996	W-137
SP-106	DeGroff St.	10	124.9	391	Cast iron	SJ-89	SJ-88	1968	W-34
SP-107	Lake St.	10	124.9	173	Cast iron	SJ-88	SJ-87	1968	W-34
SP-108	Lake St.	6	124.9	731	Cast iron	SJ-88	SJ-125	1966	W-87
SP-109	Sawmill Cr. Road	16	124.9	513	Cast iron	SJ-125	SJ-138	1966	S-177
SP-110	Monastery St.	10	124.9	555	Cast iron	J-248	SJ-89	1968	W-33
SP-111	DeGroff St.	6	124.9	345	Cast iron	SJ-89	SJ-90	1970	W-10
SP-112	Baranof St.	6	124.9	207	Cast iron	SJ-90	SJ-91	1971	W-11
SP-113	DeGroff St.	6	124.9	897	Cast iron	SJ-90	SJ-148	1970	W-9
SP-114	Baranof St.	6	124.9	401	Cast iron	SJ-90	SJ-139	1970	W-132
SP-115	Sawmill Cr. Road	16	124.9	768	Cast iron	SJ-139	SJ-148	1966	S-177
SP-116	Sawmill Cr. Road	16	124.9	285	Cast iron	SJ-139	SJ-138	1966	S-177
SP-117	Monastery St.	6	124.9	363	Ductile Iron	J-248	SJ-137	1969	W-107
SP-118	Oja Way	6	130.0	499	Ductile Iron	SJ-137	SJ-126	1969	W-131
SP-119	Lake St.	12	124.9	312	Cast iron	SJ-126	SJ-125	1965	S-53
SP-120	Halibut Pt. Road	16	124.9	159	Cast iron	SJ-125	SJ-119	1966	S-177
SP-121	Halibut Pt. Road	8	124.9	1,116	Ductile Iron	SJ-119	SJ-113	1975	W-109
SP-122	Halibut Pt. Road	8	124.9	388	Ductile Iron	SJ-113	SJ-98	1975	W-109

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-123	Halibut Pt. Road	8	124.9	98	Ductile Iron	SJ-98	SJ-97	1975	W-109
SP-124	Lakeview Dr.	6	124.9	657	Ductile Iron	SJ-97	SJ-94	1988	W-127
SP-125	Halibut Pt. Road	8	124.9	230	Ductile Iron	SJ-97	SJ-95	1975	W-109
SP-126	Crabapple Dr.	6	124.9	450	Ductile Iron	SJ-95	SJ-96	1980	W-117
SP-127	Halibut Pt. Road	8	124.9	431	Ductile Iron	SJ-95	SJ-93	1975	W-109
SP-128	Lakeview Dr.	6	124.9	1,327	Ductile Iron	SJ-93	SJ-94	1988	W-127
SP-129	Halibut Pt. Road	8	130.0	622	Cast iron	SJ-93	SJ-92		
SP-130	Katlian Ave.	12	124.9	655	Cast iron	SJ-92	SJ-100	1968	W-32
SP-131	Katlian Ave.	12	124.9	224	Cast iron	SJ-100	SJ-101	1968	W-32
SP-132	Katlian Ave.	12	124.9	1,021	Cast iron	SJ-101	SJ-102	1968	W-31, W-32
SP-133	New Archangel St.	8	130.0	234	Ductile Iron	SJ-102	SJ-103	1968	W-30
SP-134	O'Cain St.	6	124.9	222	Cast iron	SJ-103	SJ-99	1968	W-29
SP-135	Osprey St.	6	124.9	729	Cast iron	SJ-99	SJ-98	1968	W-29
SP-136	Marine St.	10	124.9	270	Cast iron	SJ-98	SJ-112	1968	W-28
SP-137	New Archangel St.	8	124.9	258	Cast iron	SJ-112	SJ-113	1968	W-30
SP-138	New Archangel St.	8	124.9	228	Cast iron	SJ-112	SJ-111	1968	W-30
SP-139	New Archangel St.	8	124.9	237	Cast iron	SJ-111	SJ-110	1968	W-30
SP-140	New Archangel St.	8	124.9	262	Cast iron	SJ-110	SJ-103	1968	W-30
SP-141	Andrews St.	6	124.9	534	Cast iron	SJ-110	J-247		W-86
SP-142	DeArmond St.	6	130.0	406	Cast iron	J-247	SJ-111		W-86
SP-143	Erler St.	10	124.9	220	Ductile Iron	SJ-115	SJ-116	1987	S-157
SP-144	Marine St.	10	124.9	628	Cast iron	SJ-116	SJ-112	1968	W-28
SP-145	Marine St.	10	124.9	380	Cast iron	SJ-116	SJ-120	1968	W-27
SP-146	Erler St.	10	124.9	271	Ductile Iron	SJ-116	SJ-117	1987	S-157
SP-147	Spruce St.	6	124.9	571	Ductile Iron	SJ-117	SJ-114	1989	W-129
SP-148	Spruce St.	6	124.9	136	Ductile Iron	SJ-114	SJ-113	1989	W-129
SP-149	Hemlock St.	6	124.9	755	Ductile Iron	SJ-114	SJ-118	1988	W-130
SP-150	Erler St.	10	124.9	256	Ductile Iron	SJ-118	SJ-117	1987	S-157
SP-151	Erler St.	10	124.9	416	Ductile Iron	SJ-118	SJ-119	1987	S-157
SP-153	Katlian Ave.	12	124.9	511	Cast iron	SJ-102	SJ-104	1968	W-31
SP-154	Kaagwaantaan St.	8	124.9	1,413	Ductile Iron	SJ-104	SJ-109	1982	S-135
SP-155	Katlian Ave.	12	124.9	243	Cast iron	SJ-104	SJ-105	1968	W-31
SP-156	off of Erler St.	12	124.9	402	Cast iron	SJ-105	SJ-115	1968	W-27
SP-157	Katlian Ave	12	124.9	267	Cast iron	SJ-105	SJ-106	1968	W-25
SP-158	Katlian Ave	12	124.9	443	Cast iron	SJ-106	SJ-107	1968	W-25
SP-159	Katlian Ave	12	124.9	362	Cast iron	SJ-107	SJ-108	1968	W-26
SP-160	Off Katlian Ave	10	124.9	115	Cast iron	SJ-108	SJ-109		
SP-161	Katlian Ave	12	124.9	389	Cast iron	SJ-108	SJ-131	1968	W-25
SP-162	Seward St.	10	124.9	220	Cast iron	SJ-109	SJ-121		S-149
SP-163	Marine St.	10	124.9	699	Cast iron	SJ-121	SJ-120	1968	W-26
SP-165	Seward St.	10	124.9	190	Ductile Iron	SJ-121	SJ-122	1986	
SP-168	Seward St.	10	124.9	140	Ductile Iron	SJ-122	SJ-123	1986	S-149
SP-169	Observatory St.	8	124.9	459	Cast iron	SJ-123	SJ-124	1968	W-23
SP-170	Seward St.	12	124.9	680	Ductile Iron	SJ-123	SJ-127	1992	S-180

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-171	Lake St.	12	124.9	334	Cast iron	SJ-127	SJ-126	1965	S-53
SP-172	Etolin Way	4	124.9	359	Ductile Iron	SJ-127	SJ-136		
SP-173	Monastery St.	6	124.9	240	Ductile Iron	SJ-136	SJ-137	1969	W-107
SP-175	Baranof St.	6	124.9	179	Cast iron	SJ-141	SJ-140	1975	W-106
SP-176	Baranof St.	6	130.0	231	Ductile Iron	SJ-140	SJ-139	1975	W-106
SP-177	Biorka St.	6	124.9	676	Ductile Iron	SJ-140	SJ-147		
SP-178	Park St.	4	124.9	235	Cast iron	SJ-147	SJ-148		
SP-179	Sawmill Cr. Road	16	124.9	675	Cast iron	SJ-148	SJ-149	1966	S-177
SP-180	Jeff Davis St.	8	130.0	375	Cast iron	SJ-149	J-250	1968	W-22
SP-181	Etolin St.	8	130.0	410	Ductile Iron	SJ-150	SJ-145	1980	W-116
SP-182	Finn Alley	8	124.9	573	Cast iron	SJ-145	SJ-144	1968	W-20
SP-184	Baranof St.	6	124.9	189	Ductile Iron	SJ-142	SJ-141	1975	W-106
SP-185	Oja St.	6	124.9	552	Ductile Iron	SJ-141	SJ-146	1980	W-116
SP-186	Park St.	6	124.9	242	Ductile Iron	SJ-146	SJ-147	1980	W-116
SP-187	Baranof St.	6	124.9	318	Ductile Iron	SJ-142	SJ-143	1975	W-106
SP-188	Lincoln St.	8	124.9	651	Ductile Iron	SJ-143	SJ-144	1985	S-147, SH 52
SP-189	Lincoln St.	8	124.9	284	Ductile Iron	SJ-143	SJ-135	1985	S-147, SH 52
SP-190	Monastery st.	6	124.9	290	Ductile Iron	SJ-135	SJ-136	1969	W-107
SP-191	Lincoln St.	8	124.9	293	Ductile Iron	SJ-135	SJ-128	1985	S-147, SH 51
SP-192	Lake St.	12	124.9	268	Cast iron	SJ-128	SJ-127	1965	S-53
SP-193	Harbor Dr.	12	124.9	738	Ductile Iron	SJ-128	SJ-129	1968	W-24
SP-194	Lincoln St.	10	124.9	623	Ductile Iron	SJ-128	SJ-133	1985	S-147
SP-195	Maksostoff St.	8	150.0	154	HDPE	SJ-133	SJ-129	2002	Flat File Pg 35
SP-196	Lincoln St.	10	124.9	204	Ductile Iron	SJ-133	SJ-132	1985	S-147
SP-197	American St.	6	124.9	140	Ductile Iron	SJ-132	SJ-134		
SP-198	Lincoln St.	10	124.9	515	Ductile Iron	SJ-132	SJ-131	1985	S-147
SP-199	Off lincoln St.	12	124.9	503	Cast iron	SJ-131	SJ-130	1968	W-24
SP-200	Harbor Dr.	12	124.9	567	Cast iron	SJ-130	SJ-129	1968	W-24
SP-201	Lincoln St.	8	124.9	364	Ductile Iron	SJ-144	SJ-151	1985	S-147, SH 53
SP-202	Jeff Davis St.	8	124.9	305	Cast iron	J-251	SJ-150	1968	W-22
SP-203	Lincoln St.	6	124.9	1,104	Ductile Iron	SJ-151	SJ-152	1985	S-146, SH 9
SP-204	Metlakatla St.	6	124.9	650	Ductile Iron	SJ-152	SJ-153	1985	S-146, SH 9
SP-206	Sawmill Cr. Road	18	124.9	237	Cast iron	SJ-149	SJ-?	1966	S-177
SP-207	Sawmill Cr. Road	18	124.9	176	Cast iron	SJ-?	SJ-154	1966	S177
SP-209	Sawmill Cr. Road	14	124.9	2,406	Cast iron	SJ-154	SJ-156	1972	W-72
SP-211	Jarvis St.	8	124.9	641	Ductile Iron	SJ-157	SJ-158	1987	S-155
SP-212	Sawmill Cr. Road	14	124.9	1,044	Cast iron	SJ-156	SJ-162	1972	W-70
SP-213	Smith St.	8	130.0	447	Ductile Iron	SJ-162	SJ-163	1983	Flat File Pg 39
SP-214	Sawmill Cr. Road	14	124.9	900	Cast iron	SJ-162	SJ-165	1972	W-70
SP-215	Price St.	12	124.9	362	Ductile Iron	J-260	SJ-166	1986	S-164
SP-216	Price St.	12	124.9	344	Ductile Iron	SJ-166	SJ-167	1988	
SP-217	Burkhart St.	6	124.9	660	Ductile Iron	SJ-166	SJ-168	1986	S-164
SP-220	Sawmill Cr. Road	14	124.9	628	Ductile Iron	SJ-170	SJ-165	1972	W-69
SP-221	Sawmill Cr. Road	14	124.9	511	Cast iron	SJ-170	SJ-172	1972	W-68

TABLE 4
SITKA WATER SYSTEM PIPE INVENTORY
BY
PIPE LABEL

Label	Street Name	Diameter (in)	Hazen- Williams "C"	Length (ft)	Material	Start Node	Stop Node	Date of Pipe	Drawing Location
SP-222	Sawmill Cr. Road	12	124.9	24	Ductile Iron	SJ-172	SJ-171		
SP-223	Sawmill Cr. Road	14	124.9	550	Cast iron	SJ-172	SJ-173	1972	W-68
SP-224	Wolff Dr.	6	124.9	309	Ductile Iron	SJ-173	SJ-174		W-98
SP-225	Wolff Dr.	6	124.9	589	Ductile Iron	SJ-174	SJ-175		
SP-226	Wolff Dr.	6	124.9	410	Ductile Iron	SJ-175	SJ-176		W-98
SP-227	Wolff Dr.	6	124.9	310	Ductile Iron	SJ-176	SJ-174		W-98
SP-229	Sawmill Cr. Road	14	124.9	683	Cast iron	SJ-177	SJ-178	1972	W-67
SP-230	Sawmill Cr. Road	24	124.9	2,710	Ductile Iron	SJ-?	SJ-160	1987	W-125, SH 1
SP-231	Sawmill Cr. Road	24	124.9	542	Ductile Iron	SJ-160	SJ-161	1987	W-125, SH 2
SP-232	Sawmill Cr. Road	24	124.9	1,312	Ductile Iron	SJ-161	SJ-164	1987	W-125, SH 2
SP-233	Sawmill Cr. Road	24	124.9	1,103	Ductile Iron	SJ-164	SJ-171	1987	W-125, SH 2
SP-234	Sawmill Cr. Road	24	124.9	4,473	Ductile Iron	SJ-171	SJ-184	1987	W125, SH 3 & 4
SP-235	Sawmill Cr. Road	14	124.9	512	Cast iron	SJ-178	SJ-179	1972	W-66
SP-236	Sawmill Cr. Road	14	124.9	939	Cast iron	SJ-179	SJ-180	1972	W-66
SP-237	Anna Dr.	8	124.9	175	Ductile Iron	SJ-180	SJ-181	1985	S-151
SP-238	Anna Dr.	8	124.9	362	Ductile Iron	SJ-181	SJ-182	1985	S-151
SP-239	Anna Dr.	6	124.9	394	Ductile Iron	SJ-181	SJ-185	1985	S-151
SP-241	Sawmill Cr. Road	12	124.9	15	Ductile Iron	SJ-183	SJ-184	1987	W-125
SP-242	Sawmill Cr. Road	14	130.0	1,245	Ductile Iron	SJ-183	SJ-186	1980	W-118
SP-243	Shotgun Alley	8	124.9	797	Ductile Iron	SJ-186	SJ-187	1980	W-118
SP-244	Shotgun Alley	8	124.9	1,049	Ductile Iron	SJ-187	SJ-188	1980	W-118
SP-245	Islander Dr.	6	124.9	1,084	Ductile Iron	SJ-188	SJ-189	1979	W-111, 112, 113
SP-246	Sawmill Cr. Road	12	124.9	1,354	Ductile Iron	SJ-186	SJ-190	1980	W-118
SP-248	Sawmill Cr. Road	12	124.9	1,427	Ductile Iron	SJ-191	SJ-192	1980	W-118
SP-249	Sawmill Cr. Road	12	124.9	4	Ductile Iron	SJ-192	SJ-194	1980	W-118
SP-250	Sawmill Cr. Road	24	124.9	6,227	Ductile Iron	SJ-184	SJ-193	1987	W-125, SH 4, 5, 6, 7
SP-251	Sawmill Cr. Road	30	124.9	2,091	Ductile Iron	SJ-193	SJ-195	1987	W-125, SH 6, 7
SP-280	Sawmill Cr. Road	12	124.9	30	Ductile Iron	SJ-192	SJ-193	1987	W-125
SP-281	Edgecumbe Dr.	12	124.9	2,037	Cast iron	SJ-38	SJ-39	1972	W-65, W-63, W-104
SP-285	Lake St.	10	124.9	433	Cast iron	SJ-82	SJ-84	1968	W-35
SP-286	Cascade Cr. Drive	12	130.0	284	Cast iron	SJ-37	SJ-38		W-63, W-104
SP-288	Jarvis St.	8	124.9	593	Ductile Iron	SJ-158	SJ-159	1987	S-155
SP-289	Sawmill Cr. Road	30	124.9	15,000	Ductile Iron	SR-1	SJ-195	1987	W-125
SP-290	Harbor Mtn. Rd.	18	124.9	10	Ductile Iron	ST-1	SJ-15	1983	W-121
SP167	American St.	6	124.9	170	Ductile Iron	SJ-122	SJ-134		S-149

Chapter 2
Transmission and Distribution System Piping Evaluation

Water system design criteria regarding system pressures and water storage requirements are generally based on standard sanitary engineering principles and practices. Many of these standard practices are included in guidance documents that are specifically referenced in the Alaska Drinking Water Regulations, 18 AAC 80, as promulgated by the Alaska Department of Environmental Conservation (ADEC). One such guidance standard included in State regulation and used by many states is the "Recommended Standards for Water Works, Great Lakes-Upper Mississippi River Board of State Sanitary Engineers". This guidance document is better known by its common name, the Ten State Standards.

The water pressure and storage criteria established in the 10 State Standards are:

- The minimum pressure anywhere in the distribution system under all conditions of flow (which includes fire flows) should be 20 psi;
- The pressure anywhere in the system should not be less than 35 psi during normal operation;
- The normal working pressure in the system should be approximately 60 to 80 psi (Note: CBS design direction allows for operation pressures between 40 and 90 psi to allow higher elevations to receive adequate water pressure);
- Reservoir storage volumes should have sufficient storage capacity to provide emergency reserve equal to one day of average water consumption, plus sufficient additional storage to meet fire flow demands.

Domestic Demand

The primary source of water for Sitka is Blue Lake which is located above Sawmill Cove at an elevation of approximately 342' (Latitude 57.053N Longitude 135.330W). The lake is fed by glacier, snowmelt and rain precipitation and generally has very high quality water. Water Quality is monitored daily for turbidity, pH, and temperature. The daily water demand for Sitka is recorded by the Public Works Department and has averaged about 3.5 million gallons per day for the three year period 2004 through 2006. The following table contains the flow records from the Blue Lake Water Treatment Plant (BLWTP) recorded by CBS.

<u>SITKA AREA WIDE WATER DEMAND</u>

2004 AVG DAY = 3.437 MGD
2005 AVG DAY – 3.492 MGD
2006 AVG DAY = 3.298 MGD
2007 AVG DAY = 3.370 MGD
2008 AVG DAY = 3.306 MGD

The water is transported from Blue Lake to the Blue Lake Water Control Building in a combination of an 84" diameter penstock and an unlined rock tunnel whose main purpose is to provide water to the Blue Lake Hydroelectric facility. A 20" diameter tap and shutoff valve was attached to the penstock to allow the City to withdraw water from the penstock for use in its potable water system. The 20" piping leads into the Blue Lake Water Control Building where chlorine is added to the water for disinfection and fluoride is added to the water to prevent tooth decay. Inside the Blue Lake Control Building the 20" piping splits into two parallel 12" lines. Each of these lines has a pressure reducing/flow control valve that controls the rate of flow into Sitka's water system. The flow is controlled automatically through a feedback signal from flow meters on each of the lines. The flow rates are manually selected by Sitka's water system operators and are set to keep the two water tanks in town full. Generally the setpoint flow of the flow control valves in the BLWTP is about 2,600 gpm. This is equal to about 3.74 MGD.

The water pressure from the penstock into the Blue Lake Water Control Building is about 106 psi and the pressure out of the pressure reducing/flow control valves is about 76 psi. The floor of the Blue Lake Water Control Building is at elevation 63.8'. Hence the hydraulic grade line of the water as it leaves the Blue Lake Water Control Building is at about 240' (63.8' + 2.31ft/psi x 76psi = 240').

In order to evaluate water storage based on demand some consideration must be given to the possibility of increased water demand in the future. Communities in Southeast are seeing small but steady increases in water demand as population increases, additional demand from seafood processing and increased water service to the cruise ship industry. Predicting the actual increase in water demand from these users is highly uncertain. For this reason we evaluated the capacity of the existing water transmission and distribution system for flow rates of 2,600 gpm (3.74 MGD) which is a typical setpoint setting for the flow control valves and a flow rate of 3,850 gpm (5.54 MGD). The flow rate of 3,850 gpm is effectively the maximum flow rate the Blue Lake source can provide while meeting the State chlorine contact requirements for treatment of giardia lamblia and is based on the transit time for water to flow from the Blue Lake Water treatment plant to the first user. The flow rate of 3,850 gpm also represents an increase of about 50% above current demand.

Fire Flow Requirements

Water system fire flow requirements are typically based on buildings and other facilities to be protected. There is a wide array of factors that are used to establish fire flows. These include criteria such as the size of the facilities being served; the fire resistance of the construction; separation distance from adjacent buildings; whether a facility has a sprinkler system or not; as well as many other criteria. Fire flows in water systems are evaluated by the Insurance Services Office (ISO) and are used, along with other factors, such as the training and capacity of the fire department, to determine fire insurance rates. Generally the ISO gives significant credit to any water system capable of providing fire flow in excess of 250 gpm and give progressively greater credit for systems capable of higher flows.

The State Fire Marshall's office and Sitka Building Office were contacted to discuss design criteria for fire flows in a water system. The 2003 International Fire Code contains the "Minimum Required Fire Flow and Flow Duration for Buildings" in Table B105.1. These minimum required flows range from a low of 1,500 gpm lasting for a 2 hour duration, up to a fire flow of 8,000 gpm lasting for a 4 hour duration. A typical fire flow for commercial and high density residential areas that has been used by other communities in Southeast is 3,500 gpm with a 3 hour duration. The State Fire Marshall and the Sitka Building Official office both felt this fire flow would be good for the type of commercial and high density residential development that might occur in Sitka.

Additionally, the CBS City Engineer, Dan Jones discussed fire flow requirements with the insurance services office and they also confirmed the needed fire flow that the ISO grades a community on is 3,500 gpm.

For lower density commercial development and residential development the fire flow requirements are usually assumed to be about 1,500 gpm.

Areawide Water Storage Requirements

As previously discussed, water storage requirements should be sufficient for one day of average water demand plus fire flow. If it is assumed average water demand for Sitka is currently about 3.5 MGD and that fire demand is 630,000 gallons (3,500 gpm x 3hr fire duration x 60 minutes = 630,000 gallons), then total water storage for Sitka should be on the order of 4.1 million gallons at today's flows. If the water demand increases to 5.5 MGD, then the water storage in Sitka should be increased to about 6.1 million gallons.

Currently Sitka is served by two water tanks, the 1.2 Million Gallon Reservoir on Charteris Street and the Harbor Mountain Reservoir (0.75 million gallons). There is also a 1.0 MG water storage tank under construction to serve the Whitcomb Heights area.

The combined total storage capacity for these tanks is 2.95 million gallons. This is nearly 1.15 million gallons less than is desirable for Sitka at today's demand and 3.2 million gallons less than should be provided for future water demand. Consequently Sitka should have at least an additional 1.15 million gallons of water storage, in addition to the 2.95 million gallons currently available, to provide a reserve capable of providing one day of water demand.

Water storage tanks are generally distributed throughout a water system to better provide fire flows at the point of need. Since the two existing tanks are located north of town and there is none located south of town, a water tank should be provided out Sawmill Creek Road to support development that occurs in that area and to provide fire flows in that area. Additional water tanks or water booster pump stations are also required to serve elevations that are higher than can be served by the Sitka water system, such as Whitcomb Heights Subdivision. The highest lots in the proposed subdivision are at about elevation 350' which is significantly higher than the Sitka water system can serve without booster pumps. The combined capacity of future tanks should be about 4.1 million gallons.

Water Transmission and Distribution System Piping

The City and Borough of Sitka has about 250,560' (47.5 miles) of water transmission and distribution system piping. Over 3,240' of the pipe is asbestos cement pipe that is known to be brittle and susceptible to leaks. About 10,500' of the pipe has been in use for over 40 years; over 79,000' of pipe has been in use between 30 and 40 years.

Sitka purchased water system modeling software called WaterCad for Windows that has an AutoCad interface that allows the user to create and model the water system network directly within the drafting environment. This gives access to the drafting and presentation tools of AutoCad while still allowing water modeling tasks like editing, hydraulic calculations, and data management.

The Sitka water system can be modeled through WaterCad in the stand-alone mode or in the AutoCad mode. In the stand-alone mode the modeling interaction is more streamlined by virtue of the fact that the editing environment is a dedicated water network editor. In the stand-alone mode, less system resources and memory are required.

The City's "RoughPipes.dwg" water network files were provided by the City to prepare the inventory of water pipes and to update the water model. The blueprints and drawings of the Sitka water system in the City's record files were reviewed and information such as the year installed, pipe material, blueprint location, pipe diameter, and length of pipe were checked against the data files in the RoughPipes network. In addition the AutoCad version of RoughPipes was updated by moving water lines and junctions to line up with easements and right-of-ways; some lines that had been drawn as many short segments were joined into single pipes, street names were added to the AutoCad version of the water network display. Additionally street names were added to the network piping data tables so that the pipes could be identified by the street in which they are found.

The updated water system network has been renamed SitkaPipeInventory and has been furnished to Sitka on a CD.

Three new versions of the Sitka Water Model were prepared to allow for modeling different demand and flow scenarios. These versions took the existing Sitka Water Model and made global water demand adjustments so that the areawide demand for water was:

3.74 MGD (2,600 gpm) representing an average day water demand

5.54 MGD (3,850 gpm) representing a peak day demand

7.37 MGD (5,120 gpm) representing a peak hourly water demand

Tables 1, 2, 3, and 4 contain the results of the water modeling. The following information is contained in the tables:

- The setpoint flow for the flow control valves at the BLWTP
- The areawide water demand used for the model runs
- The locations selected for reporting, These locations include:
    - the End of Halibut Point Road (HPR),
    - the end of the water system on Japonski Island,
    - the end of the water system at the Sawmill Cove Industrial Park,
    - the intersection of Kramer Ave. and HPR,
    - a location at about elev. 150' along Kramer Ave.,
    - the intersection of Lake Street and Lincoln Street.
    - the intersection of Jarvis Street and Sawmill Creek Road (SMCR)
    - the upper end of Jarvis Street
    - the upper end of Lance Drive
    - the intersection of Shotgun Alley and SMCR
- the resulting water pressures at each location under the assumed water demand and the setpoint for the flow control valves
- the flow rate that would occur with a 20 psi residual pressure at the end of HPR, the end of Japonski Is. and the end of SMCR
- system pressures under conditions of a 3,500 gpm fire at the intersection of Lake St. and Lincoln St.
- system pressures under conditions of a 1,500 gpm fire at the intersection of Shotgun Alley and SMCR
- system pressures under conditions of a 1,500 gpm fire at the intersection of Kramer Ave and HPR
- the impact tanks at Whitcomb Heights (Benchlands) and at the upper end of Lance Drive would have on system pressures

Additionally, the model shows that water system expansion into areas such as Granite Creek, Indian River, Benchlands, and beyond Sawmill Cove Industrial Park are feasible provided system elevations do not exceed about 150'. Any water system development above this elevation will require pumps.

Water System Model Findings

1) Under average day demand the water system appears to provide adequate pressures and flows to most areas. As development occurs at higher elevations (above about 150') pressures will be less than 30 psi. This is true of the upper elevations in the Lance Drive area where low water pressures occur even under conditions of normal water demand.

2) During large fire demands of 3,500 gpm, some areas of the water system currently have negative or very low water pressures. These area include Upper Lance Drive and the high point on Sawmill Creek Road at the Shotgun Alley intersection.

3) The water system can provide flows in excess of 1,500 gpm to the extreme ends of the water system but again it will result in some areas will having negative pressure

4) Most of the pressure problems are between Indian River and Sawmill Cove especially at the upper elevations in the Lance Drive area and at the high point on Sawmill Creek Road at the Shotgun Alley intersection.

5) Water pressures in the water system are improved by locating new water tanks at Kramer Ave. and in the vicinity of Lance Drive.

6) There are elevations in the vicinity of Lance Drive that are above 150' that will continue to have low pressure issues even with the addition of a water storage tank in that area unless a separate pressure zone is created for serving the higher elevations of the Lance Drive area.

7) In order to receive the full benefit of water tanks, including stored water volume and operating pressures, the tanks need to be kept full.

Recommendations

1) Modify the Blue Lake Water Treatment Plant so that the flow control valves can adjust to changing water demand automatically. Flow will still need to be limited for inactivation of giardia, but under peak demand periods (such as during a fire) the flow control valves need to allow the maximum flow rate from Blue Lake in order to meet the water demand.

2) Provide altitude control valves for all water tanks. This will allow the tanks to be kept full without overflowing. Keeping the tanks full will ensure water storage is kept at its maximum and will ensure maximum operating pressures throughout the water system.

3) Construct at least one 1.15 million gallon tank to meet water system needs in the event of an interruption in water supply. The tank should be located south of town to meet peak water demands in that area. The tank located south of town could be incorporated into a high elevation system serving the upper elevations of Lance Drive and other future development along Haley Ave. A connection to the low elevation system via a pressure reducing valve should also be provided so that flow from the tank can be used to meet peak water system demands in the low elevation water zone.

4) Limit water system expansion to elevations less than 150’ unless there are plans to provide water booster pumps and upper pressure zones to serve the areas.

TABLE 1 PRESSURES AND FLOWS
BLWTP FLOW CONTROL VALVE SETPOINT 2,600 GPM
AND AVERAGE DAILY DEMAND OF 2,600 GPM

FCV Setpoint Flow At Blue Lake 2,600 gpm

Areawide Water Demand 2,600 gpm Average Daily Demand (3.74 MGD)

Location and Resulting Pressure	Node Number	Node Elevation	Average Day Demand of 2,600 gpm	Avg. Day Plus Flow w/ 20psi at end of HPR	Avg. Day Plus Flow w/ 20psi at end of Japonski Is.	Avg. Day Plus Flow w/ 20psi at Sawmill Cove	Avg Day Plus 3,500 gpm demand at Lake St. and Lincoln St.	Avg. Day Plus 1,500 gpm demand at Shotgun Alley and SMCR	Avg Day Plus 1,500 gpm demand at Kramer Ave. and HPR
End of Halibut Point Road (HPR)	SJ-1	25'	82	2010 gpm	80	80	80	80	80
End of Japonski Island	JJ-150	25'	88	88	1740 gpm	79	53	81	86
End of Sawmill Creek Road (SMCR)	J-228	25'	87	87	78	1730 gpm	55	62	86
Kramer Ave. and HPR	SJ-30	25'	84	83	80	80	74	81	79
Kramer Ave. at elev. 150'		150'	30	29	26.3	26.3	20	26.6	24.9
Lake St. and Lincoln St.	SJ-128	21'	89	89	79	80	54	81	87
Jarvis St. and SMCR	SJ-156	24'	88	88	79	72	56	75	87
Upper Jarvis St.	SJ-159	75'	66	66	57	49	33	52	65
Upper Lance Drive	SJ-213	182'	19.5	19.5	10.6	-0.3	-13.2	3.2	18
Shotgun Alley and SMCR	SJ-186	142'	36.7	36.6	27.8	5.4	4	11.4	35.2
Water Tanks and Reservoir Flows (gpm)									
1.2 MG Tank (Charteris St.)		220'	0	190 gpm	1380 gpm	1380 gpm	2460 gpm	1290 gpm	850 gpm
Harbor Mtn. Tank		211'	0	1820 gpm	360 gpm	350 gpm	1040 gpm	210 gpm	650 gpm
Blue Lake Water Source		240' [1.]	2600 gpm	2600 gpm	2600 gpm	2600gpm	2600 gpm	2600 gpm	2600 gpm

1. At 240' exit pressure from BLWTP is 76psi

TABLE 2 PRESSURES AND FLOWS
BLWTP FLOW CONTROL VALVE SETPOINT 3,850 GPM
AND AVERAGE DAILY DEMAND OF 2,600 GPM

FCV Setpoint Flow At Blue Lake 3,850 gpm
Areawide Water Demand 2,600 gpm Average Daily Demand (3.74 MGD)

Location and Resulting Pressure	Node Number	Node Elevation	Average Day Demand of 2,600 gpm	Avg. Day Plus Flow w/ 20psi at end of HPR	Avg. Day Plus Flow w/ 20psi at end of Japonski Is.	Avg. Day Plus Flow w/ 20psi at Sawmill Cove	Avg Day Plus 3,500 gpm demand at Lake St. and Lincoln St.	Avg. Day Plus 1,500 gpm demand at Shotgun Alley and SMCR	Avg Day Plus 1,500 gpm demand at Shotgun Alley and SMCR w/ Lance Rd Tank at Elev 230'
End of Halibut Point Road (HPR)	SJ-1	25'	82	2010 gpm	80	81	80	81	82
End of Japonski Island	JJ-150	25'	88	88	1810 gpm	84	72	85	86
End of Sawmill Creek Road (SMCR)	J-228	25'	87	87	84	1830 gpm	76	67	70
Kramer Ave. and HPR	SJ-30	25'	84	83	82	82	79	83	83
Kramer Ave. at elev. 150'		150'	30	29	28	28	25	29	29
Lake St. and Lincoln St.	SJ-128	21'	87	88	84	85	73	86	86
Jarvis St. and SMCR	SJ-156	24'	88	88	85	78	77	80	82
Upper Jarvis St.	SJ-159	75'	66	66	63	54	55	57	59
Upper Lance Drive	J-213	182'	19.5	19.5	16.3	4.6	8	8.2	21
Shotgun Alley and SMCR	SJ-186	142'	36.7	36.6	34	9.2	25	16.3	19.8
Water Tanks and Reservoir Flows (gpm)									
1.2 MG Tank (Charteris St.)		220'	0	190 gpm	980 gpm	750 gpm	1630 gpm	600 gpm	440 gpm
Harbor Mtn. Tank		211'	0	1820 gpm	30 gpm	0	620 gpm	0	0
Blue Lake Water Source		240' [1.]	2600 gpm	2600 gpm	3400 gpm	3680gpm	3850 gpm	3500 gpm	3290 gpm
Proposed Benchlands Tank		230'	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Proposed Lance Rd Tank		230'	N/A	N/A	N/A	N/A	N/A	N/A	370 gpm

1. At 240' exit pressure from BLWTP is 76psi

TABLE 3 PRESSURES AND FLOWS
BLWTP FLOW CONTROL VALVE SETPOINT 3,850 GPM
AND PEAK DAILY DEMAND OF 3,850 GPM

FCV Setpoint Flow At Blue Lake 3,850 gpm
Areawide Water Demand 3,850 gpm Peak Daily Demand (5.54 MGD)

Location and Resulting Pressure	Node Number	Node Elevation	Peak Day Demand of 3,850 gpm	Pk. Day Plus Flow w/ 20psi at end of HPR	Pk. Day Plus Flow w/ 20psi at end of Japonski Is.	Pk. Day Plus Flow w/ 20psi at Sawmill Cove	Pk. Day Plus 3,500 gpm demand at Lake St. and Lincoln St.	Pk. Day Plus 1,500 gpm demand at Shotgun Alley and SMCR	Pk. Day Plus 3500 gpm at Lake St. and Lincoln St. w/ Lance Rd Tank	Pk. Day Plus 3500 gpm at Lake St. and Lincoln St. w/ Benchlands Tank
End of Halibut Point Road (HPR)	SJ-1	25'	80	1970 gpm	80	80	80	80	80	80
End of Japonski Island	JJ-150	25'	85	85	1750 gpm	81	59	82	66	63
End of Sawmill Creek Road (SMCR)	J-228	25'	85	84	81	1720 gpm	61	61	70	65
Kramer Ave. and HPR	SJ-30	25'	83	82	80	81	75	81	77	80
Kramer Ave. at elev. 150'		150'	28.4	28.1	26.5	26.5	20.6	26.7	22.8	25.8
Lake St. and Lincoln St.	SJ-128	21'	86	86	81	82	59	83	67	63
Jarvis St. and SMCR	SJ-156	24'	86	86	82	74	62	76	71.4	66
Upper Jarvis St.	SJ-159	75'	63	63	60	49	40	52	49	44
Upper Lance Drive	J-213	182'	17.1	17.1	13.3	-0.01	-6.6	3.2	16.5	-2.9
Shotgun Alley and SMCR	SJ-186	142'	34.1	34	30.4	4.9	10.5	10.5	19.9	14.2
Water Tanks and Reservoir Flows (gpm)										
1.2 MG Tank (Charteris St.)		220'	630 gpm	2000 gpm	1310 gpm	1300 gpm	2350 gpm	1180 gpm	2030 gpm	1830 gpm
Harbor Mtn. Tank		211'	100 gpm	680 gpm	440 gpm	420 gpm	1150 gpm	320 gpm	1000 gpm	650 gpm
Blue Lake Water Source		240' [1.]	3120 gpm	3140 gpm	3850 gpm	3850 gpm	3850 gpm	3850 gpm	3850 gpm	3850 gpm
Proposed Benchlands Tank		230'	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1020 gpm
Proposed Lance Rd Tank		230'	N/A	N/A	N/A	N/A	N/A	N/A	470 gpm	N/A

1. At 240' exit pressure from BLWTP is 76psi

TABLE 4 PRESSURES AND FLOWS
BLWTP FLOW CONTROL VALVE SETPOINT 3,850 GPM
AND PEAK HOURLY DEMAND OF 5,120 GPM

FCV Setpoint Flow At Blue Lake 3,850 gpm
Areawide Water Demand 5,120 gpm Peak Hourly Demand (7.37 MGD)

Location and Resulting Pressure	Node Number	Node Elevation	Peak Hourly Demand of 5,120 gpm	Pk. Day Plus Flow w/ 20psi at end of HPR	Pk. Day Plus Flow w/ 20psi at end of Japonski Is.	Pk. Day Plus Flow w/ 20psi at Sawmill Cove	Pk. Day Plus 3,500 gpm demand at Lake St. and Lincoln St.	Pk. Day Plus 1,500 gpm demand at Shotgun Alley and SMCR	Pk. Day Plus 3500 gpm at Lake St. and Lincoln St. w/ Benchlands Tank	Pk. Day Plus 3500 gpm at Lake St. and Lincoln St. w/ Lance Rd. Tank	Pk. Day Plus 3500 gpm at Lake St. and Lincoln St. w/ Lance Rd. and Benchland Tanks
End of Halibut Point Road (HPR)	SJ-1	25'	80	1920 gpm	79	79	79	79	82	79	82
End of Japonski Island	JJ-150	25'	83	82	1600 gpm	74	40	75	52	54	62
End of Sawmill Creek Road (SMCR)	J-228	25'	81	81	72	1550 gpm	41	51	52	58	66
Kramer Ave. and HPR	SJ-30	25'	81	81	78	78	68	78	88	73	88
Kramer Ave. at elev. 150'		150'	27.1	26.6	23.9	24.1	14.2	24	34	18	34
Lake St. and Lincoln St.	SJ-128	21'	84	84	75	76	41	76	53	55	63
Jarvis St. and SMCR	SJ-156	24'	83	83	74	67	43	67	54	60	67
Upper Jarvis St.	SJ-159	75'	61	60	52	43	20	43	31.9	38	45
Upper Lance Drive	J-213	182'	13.6	13.4	4.9	-7.1	-27.1	-6.2	-15.1	20.6	20.7
Shotgun Alley and SMCR	SJ-186	142'	30.5	30.4	21.8	-1.3	-10.1	0.2	1.8	7.9	15.3
Water Tanks and Reservoir Flows (gpm)											
1.2 MG Tank (Charteris St.)		220'	1070 gpm	1140 gpm	1820 gpm	1790 gpm	3120 gpm	1760 gpm	1650 gpm	2620 gpm	1290 gpm
Harbor Mtn. Tank		211'	440 gpm	2250 gpm	1050 gpm	1030 gpm	1650 gpm	1010 gpm	0	1440 gpm	0
Blue Lake Water Source		240' [1.]	3610 gpm	3650 gpm	3850 gpm	3850 gpm	3850 gpm	3850 gpm	3850 gpm	3850 gpm	3850 gpm
Proposed Benchlands Tank		230'	N/A	N/A	N/A	N/A	N/A	N/A	3120 gpm	N/A	2870 gpm
Proposed Lance Rd Tank		230'	N/A	N/A	N/A	N/A	N/A	N/A	N/A	710 gpm	610 gpm

1. At 240' exit pressure from BLWTP is 76psi

Chapter 3

Summary of Current and Pending Federal Regulations that Impact Sitka's Water Treatment Facilities

Overview

This chapter contains a summary of Federal regulations that are likely to affect CBS's water system during the coming years. The summary is based on regulatory information provided by the U.S. Environmental Protection Agency (EPA).

The Federal regulations that are summarized in this document include the following current and pending rules:

- ***Surface Water Treatment Rule*** (SWTR, published June 29, 1989)
- ***Enhanced Surface Water Treatment Rules*** (ESWTRs)
  - ***Interim Enhanced Surface Water Treatment Rule*** (IESWTR, promulgated December 16, 1998; final revisions published January 16, 2001)
  - ***Long Term 1 Enhanced Surface Water Treatment Rule*** (LT1ESWTR, promulgated January 14, 2002)
  - ***Long Term 2 Enhanced Surface Water Treatment Rule*** (LT2ESWTR, promulgated January 6, 2006)
- ***Disinfectants/Disinfection By-Products Rules*** (D/DBPRs)
  - ***Stage 1 Disinfectants/Disinfection By-Products Rule*** (Stage 1 D/DBPR, promulgated December 16, 1998; final revisions published January 16, 2001)
  - ***Stage 2 Disinfectants/Disinfection By-Products Rule*** (Stage 2 D/DBPR, promulgated January 4, 2006)
- ***Lead and Copper Rule*** (LCR, promulgated June 7, 1991; minor revisions published January 12, 2000)

Summary of Regulatory Impacts to City and Borough of Sitka

The City and Borough of Sitka (CBS) is currently serving a community of less than 10,000 people with an unfiltered surface water. CBS's water system meets all current regulations, with treatment operations being driven primarily by the Surface Water Treatment Rule, and some additional treatment added to meet the Lead and Copper Rule.

The Long Term 2 Enhanced Surface Water Treatment Rule requires inactivation of *Cryptosporidium*. Additional control of disinfection by-products is also required through the Stage 2 Disinfectants/Disinfection By-Products Rule. Therefore, any treatment modifications incorporated to address microbial inactivation must also consider the impacts to disinfection by-products.

Surface Water Treatment Rule (SWTR)

The SWTR establishes treatment and monitoring requirements for all public water systems that use surface water. The SWTR requires that all surface water sources be treated to achieve a minimum 3-log removal of *Giardia* and 4-log removal of enteric viruses.

CBS currently operates its treatment facilities under the category of filtration avoidance. Because filtration is not provided, CBS currently achieves all microbial inactivation required for SWTR compliance using chlorine disinfectant along with residence time in a clearwell.

Filtration Avoidance

The SWTR requires filtration of all surface water supplies unless stringent source water quality, disinfection criteria, and site specific conditions are met. The following requirements pertain to public water systems operating under filtration avoidance (such as CBS):

Source Water Quality Criteria

The source water prior to disinfection must have:

- Fecal coliforms ≤ 20/100 mL, or;
- Total coliforms ≤ 100/100 mL in at least 90 percent of the samples taken for the previous six months.

Furthermore, the turbidity level of the source water prior to disinfection must not exceed 5 NTU unless:

- The State determines that the event was caused by unusual or unpredictable circumstances, and;
- There have not been more than two events in the past twelve months or more than five events in the past 120 months, where an event is a series of consecutive days in which at least one turbidity measurement each day exceeds 5 NTU.

Disinfection Criteria

For filtration avoidance, CBS's disinfection facilities must meet the following criteria:

- The calculated CT must meet or exceed the CT value stated in the SWTR.
- CBS must have redundant disinfection components including an auxiliary power supply with automatic startup and alarm; or if approved by the State, automatic shutoff of the water supply when the residual drops below 0.2 mg/L for more than four hours.

- The chlorine disinfection concentration entering the distribution system must not be less than 0.2 mg/L for more than four hours.
- CBS must maintain detectable disinfectant residual in the distribution system or show that the heterotrophic plate count is not higher than 500/mL.
- Turbidity samples are to be taken at least once every 4 hours. If turbidity exceeds 1 NTU, one raw water sample must be collected for fecal or total coliform analysis.

Site-Specific Criteria

For filtration avoidance, site-specific criteria include:

- Maintenance of a watershed control program
- Subjection to an annual onsite inspection
- No history of waterborne disease outbreaks
- Compliance with the monthly MCL for total coliforms
- Compliance with disinfection by-product regulations

Watershed Protection

The SWTR also establishes watershed protection requirements for filtered and unfiltered systems. Source water protection is considered as the first barrier in a holistic approach toward reducing contaminant levels in drinking water. Because information on the inactivation of *Cryptosporidium* is still somewhat limited, watershed protection in unfiltered systems is a particularly important barrier for protection against this microbial pathogen.

Under the provisions of the SWTR, public water systems must maintain a watershed control program that minimizes the potential for source water contamination by viruses and *Giardia* cysts. The SWTR provisions state that a watershed control program must satisfy the following objectives:

- Characterize watershed ownership and hydrology;
- Identify characteristics of the watershed and activities within the watershed that might have an adverse effect on water quality, and;
- Minimize the potential for source water contamination by *Giardia lamblia* and viruses.

The public water system must demonstrate through ownership and/or written agreements with landowners within the watershed that it can control all human activities which may have an adverse impact on the microbiological quality of the source water. Both natural and human-caused sources of watershed contamination to be controlled are listed in the EPA Guidance Manual. These sources include wild animal populations, wastewater treatment plants, grazing animals, feedlots, and recreational activities.

The public water system must also undergo an annual on-site inspection to assess the watershed control program and disinfection process. A report of the on-site inspection summarizing all findings must be prepared on an annual basis.

Filtration

If CBS is unable to maintain its filtration avoidance status as defined by the above-mentioned criteria, it will be required to install filtration facilities. Filtration technology alternatives that are currently available to CBS include conventional granular media filters, pressure filters, and membrane filtration technology. Filtration will be considered as one of the alternatives in a companion technical memorandum titled, "*Comparison of Treatment Alternatives for Compliance with the Long Term 2 ESWTR*." The Long Term 2 regulation is discussed in more detail below.

Enhanced Surface Water Treatment Rules (ESWTRs)

The ESWTRs were issued as a supplement to the SWTR in order to provide additional microbial and disinfection controls for surface water systems. The ESWTRs were implemented in separate stages as the Interim Enhanced Surface Water Treatment Rule (IESWTR), and Stage 1 and Stage 2 Long-term Enhanced Surface Water Treatment Rules (LT1ESWTR and LT2EWSTR). These rules build upon the provisions set forth in the SWTR by providing improved public health protection against *Cryptosporidium*, while addressing risk tradeoffs with disinfection by-products (DBPs).

The ESWTRs added *Cryptosporidium* monitoring and inactivation to the watershed control requirements for unfiltered surface water systems. Other specific provisions that have an impact on CBS include disinfection profiling and benchmarking provisions, and a requirement that unfiltered surface water systems conduct initial source water monitoring for *Cryptosporidium*.

Disinfection Profiling and Benchmarking

CBS was required to develop a disinfection profile of the water system's disinfection practices by determining *Giardia* and virus log inactivations computed over a 1-year period based on daily operational data. The benchmark was developed by calculating average log inactivation of all the days for each calendar month, and determining the calendar month with the lowest average log inactivation. The lowest average month becomes the critical period, or benchmark for that year.

Unfiltered Systems

The provisions for unfiltered systems in the LT2ESWTR are:

1) Continue to meet filtration avoidance criteria, and;
2) Provide 4-log virus inactivation, and;
3) Provide 3-log *Giardia lamblia* inactivation, and;
4) Provide 2 or 3-log *Cryptosporidium* inactivation depending on its presence in the source water. If the source water monitoring demonstrates a mean level of *Cryptosporidium* above 1 oocysts/100 liters, then the system must provide at least 3-log *Cryptosporidium* inactivation. and;
5) Meet overall inactivation requirements using a minimum of two disinfectants.

Ongoing monitoring and any eventual reassignment to the level of additional *Cryptosporidium* inactivation requirement will be consistent with requirements for other systems of comparable size, with the provision that unfiltered systems must demonstrate that their mean *Cryptosporidium* occurrence level continues to be less than or equal to 1 count in 100 liters (or equivalent, using advanced methods), or provide a minimum 3-log *Cryptosporidium* inactivation.

Initial Source Water Monitoring for Cryptosporidium

Unfiltered surface water systems that meet filtration avoidance criteria must conduct initial source water monitoring for *Cryptosporidium*. Systems must submit to the primacy agency the sampling schedule, location and source water monitoring description no later than January 1, 2010. Monitoring involves 24 consecutive months of monthly *Cryptosporidium* sampling or 12 months of sampling (twice per month), beginning no later than April 1, 2010.

The results of the source water monitoring will then be used to establish the following treatment requirements for unfiltered systems:

— At least 2-log (99 percent) *Cryptosporidium* removal/inactivation if *Cryptosporidium* level is less than or equal to 1 oocyst/100 L.

— At least 3-log (99.9 percent) *Cryptosporidium* removal/inactivation if *Cryptosporidium* level is above 1 oocyst/100 L, or if the unfiltered surface water system chooses not to monitor for *Cryptosporidium.*

Overall inactivation requirements for unfiltered systems must be met using a minimum of two disinfectants.

Filtered Systems

Although CBS does not currently filter, a summary of filtration requirements is provided below. Based on *Cryptosporidium* monitoring, each system will be classified in a bin as shown in Table 2, each of which is assigned an additional *Cryptosporidium* treatment that the system must provide beyond the 2-log reduction requirement. The additional treatment can be provided thorough several options which are presented in a toolbox format in the regulation.

TABLE 1
Results of Monitoring for Cryptosporidium

oocysts in Source Water (#/L)	Bin Classification	Additional Log Removal (Inactivation) (1) for Conventional Filtration Treatment, Diatomaceous Earth Filtration, or Slow Sand Filtration	Additional Log Removal (Inactivation) (1) For Direct Filtration
<0.075	1	No additional treatment	No additional treatment
>/=0.075 and <1.0	2	1[3]	1.5[3]
>/=1.0 and <3.0 (2)	3	2[4]	2.5[4]

TABLE 1
Results of Monitoring for Cryptosporidium

oocysts in Source Water (#/L)	Bin Classification	Additional Log Removal (Inactivation) (1) for Conventional Filtration Treatment, Diatomaceous Earth Filtration, or Slow Sand Filtration	Additional Log Removal (Inactivation) (1) For Direct Filtration
>/=3 (2)	4	2.5[4]	3[4]

1. Treatment in addition to filtration
2. At least 1-log is required by inactivation
3. PWSs may use any technology or combination of technologies from the microbial toolbox in section IV.D. in LT2ESWTR.
4. PWSs must achieve at least 1-log of the required treatment using ozone, chlorine dioxide, UV, membranes, bag filtration, cartridge filtration, or bank filtration.

The LT2ESWTR also includes a regular monitoring program of the source water for protozoans. The two key items in the LT2ESWTR are new *Cryptosporidium* inactivation requirements and a new set of standards on particle counting for filtration compliance to enhance or replace turbidity standards.

Installation of New Treatment Facilities

CBS is required to comply with these *Cryptosporidium* inactivation requirements no later than October 1, 2014 (or October 1, 2016 if an extension is granted for required capital improvements). Approved treatment techniques for compliance with the *Cryptosporidium* inactivation requirements include disinfectants such as ozone, chlorine dioxide, and ultraviolet (UV) light. Other approved methods include off-stream storage of raw water, lime softening, slow sand filtration, bank filtration, membrane filtration, bag filters, and cartridge filters.

Disinfectants/Disinfection By-Products Rules (D/DBPRs)

The D/DBPRs apply to all water systems that add a chemical disinfectant during any part of the treatment process. The rules are being implemented in two separate stages—Stage 1 and Stage 2. The D/DBPRs address levels of disinfection by-products that are allowed in finished water supplies. Historically, the DBPs that were regulated under the SWTR were the total trihalomethanes (TTHMs). The D/DBPRs expand the DBP regulations to include five haloacetic acids (HAA5s).

Stage 1 D/DBPR

The Stage 1 rule establishes MCLs of 80 μg/L for TTHMs and 60 μg/L for HAA5. As of January 1, 2004 CBS's water system, as one of small systems serving less than 10,000 people, was required by the Stage 1 D/DBPRs to collect DBP samples from the distribution system on a quarterly basis and to comply with the rule. Compliance is based on a running annual average (RAA) of all sampling sites.

The Stage 1 D/DBPR also contains maximum residual disinfectant levels (MRDLs) for chlorine. CBS is required to limit the chlorine residual of water entering the distribution system to less than 4 mg/L as Cl_2, based on a running annual average. Chlorine samples are required to be taken at the same points in the distribution system as samples currently taken for compliance with the Total Coliform Rule.

Stage 2 D/DBPR

The Stage 2 D/DBPR was promulgated simultaneously with the LT2ESWTR to address concerns about risk tradeoffs between pathogens and DBPs. The Stage 2 D/DBPR addresses reductions in DBP occurrence peaks in the distribution system based on changes to compliance monitoring provisions. Compliance monitoring will be preceded by an initial distribution system evaluation (IDSE) with the purpose of selecting site-specific optimal sampling points for capturing peaks of TTHMs and HAA5s. The monitoring frequencies and locations of IDSE depend on the system type and size.

Compliance with the maximum contaminant levels for two groups of disinfection byproducts (TTHMs and HAA5s) will be calculated for each monitoring location in the distribution system. This approach, referred to as the locational running annual average (LRAA), differs from running annual average (RAA) calculation defined in Stage 1 requirements. The LRAA avoids the high DBP occurrences at certain locations by ensuring every monitoring site is in compliance with the MCLs on an annual average. The DBP MCLs remain the same as Stage 1 MCLs - 80 μg/L for TTHMs and 60 μg/L for HAA5s.
Each system must determine if they have exceeded an operational evaluation level based on their compliance monitoring results. A system that exceeds an operational evaluation level is required to conduct an operational evaluation and submit a report to their state that identifies actions that may be taken to mitigate future high DBP levels, particularly those that may jeopardize their compliance with the DBP MCLs. The schedule of IDSE and monitoring compliance varies by water system size. CBS is required to submit IDSE monitoring plan by April 1, 2008, complete an IDSE by March 31, 2010, submit IDSE report by July 1, 2010 and begin Stage 2 compliance monitoring by October 1, 2013.

Lead and Copper Rule (LCR)

Published in 1991, the LCR established monitoring requirements for lead and copper, whereby CBS is required to monitor consumers' taps for lead and copper every six months. Water samples at the customers' tap must not exceed the following action levels:

— ***Lead:*** 0.015 mg/L detected at the 90^{th} percentile of all samples.

— ***Copper:*** 1.3 mg/L detected at the 90^{th} percentile of all samples.

If the action levels are exceeded for either lead or copper, CBS is required to collect source water samples and to submit the data with a treatment recommendation to the State. Additionally, if the lead action level is exceeded, CBS is required to present a public education program to its customers within 60 days of learning the results. The public education program must be continued as long as CBS water system exceeds the lead action levels. Sitka exceeded the action levels and the Corrosion Control Facility was constructed on Jarvis Street to address this issue.

Chapter 4
Water Sampling Protocol and Water Quality Evaluation

Objectives

The City and Borough of Sitka (CBS) wants to maintain "Filtration Avoidance" for its water supply. To comply with current and proposed Federal regulations under the Safe Drinking Water Act and Surface Water Treatment Rule for systems that are avoiding filtration, the CBS's water system is required to add a second disinfectant to meet the inactivation requirements for viruses, *Giardia*, and *Cryptosporidium* no later than October 1, 2014[1]. Ultraviolet (UV) light is the additional disinfectant that is preferred for systems like the CBS's that are currently using a chemical disinfectant such as chlorine. The purpose of this study is to evaluate the feasibility of implementing UV disinfection for the CBS's water supply as a secondary disinfectant to be used in conjunction with chlorine.

The purpose of this chapter is to outline the water sampling and testing protocols for the UV Feasibility Study to supplement data collected by CBS since 2005. The water quality information collected as part of this task and previous sampling will be used to develop design criteria for the UV system.

Sample Collection

Location: Samples will be collected at two locations:

(1) Raw water samples will be collected at the existing sample tap Blue Lake WTP upstream of any chemical addition. All samples collected on a given day should be collected at the same time.

(2) Chlorinated samples will be collected at a sample tap closest to the possible connection point for UV disinfection, likely immediately downstream of the chlorine injection point.

Samples will be collected by CBS staff and analyzed on site or sent to a certified laboratory as specified in Table 1 below.

Sample Parameters, Schedule, and Responsibility

Sampling Schedule

Water sampling will be conducted in a combination of daily, monthly, and quarterly samples as described in Table 1 below. A description of the purpose of sampling for each parameter is described below:

[1] Based on requirements of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2). Deadline may be extended to October 1, 2016 if capital improvements are required, as is the case with CBS.

- **UV 254 Absorbance** is the primary design criteria for sizing UV equipment.
- **Turbidity** will be collected to provide some correlation with historical data; however, turbidity is not a perfect indicator of UV 254.
- **Total organic carbon (TOC)** is an indicator of the presence of organics in the water that may contribute to the absorption of UV light, thus potentially increasing the required "dose".
- **Hardness** will be used to determine the potential for scaling from calcium and magnesium when water temperature or pH changes. The scale formed will interference with the light transmission through the quartz lamp sleeves.
- **Iron and manganese** will be used to determine the potential for scaling and interference with disinfection due to light absorption.
- **Nitrate** can be converted to nitrite through the UV process.

TABLE 1
Sampling Schedule

Sample Parameter	Blue Lake – Raw Water	Chlorinated Water	Analyzed By
UV 254 Absorbance	Daily or as available	Daily or as available	CBS
Turbidity	Daily or as available	Daily or as available	CBS
Total Organic Carbon (TOC)	Quarterly	none	Certified Lab
Total Hardness	Weekly	none	CBS or lab
Iron	Quarterly[1]	none	CBS or lab
Manganese	Quarterly[1]	none	CBS or lab
Nitrate	Quarterly	none	CBS or lab

Note 1: Iron and manganese should also be measured before, during and after any lake turnover events as this can be a time of unexpected, high iron and manganese levels. It is challenging to predict when lake turnover occurs, but it is typically in the spring and late summer periods and is typically accompanied with a sharp increase in raw water turbidity.

Data Reporting

It is recommended that the CBS start the weekly and quarterly water quality sampling based on this sampling protocol as soon as possible and continue for at least one year to quantify seasonal variations in water quality. Daily sampling for UV 254 and Turbidity should continue until a new facility is brought online.

The purpose of this is to evaluate the City and Borough of Sitka's (CBS's) water quality in regards to current and future water treatment regulations related for both microbial inactivation and disinfection by-product (DBP) formation. It is expected that CBS will be required to add a second disinfectant to meet the inactivation requirements for viruses, *Giardia*, and *Cryptosporidium* in order to maintain filtration avoidance status by October 1, 2014[2]. Ultraviolet (UV) light is the additional disinfectant that is most often used for unfiltered systems like CBS's that are currently using a chemical disinfectant such as chlorine. UV disinfection will be compared to other viable treatment methods currently available to the CBS.

The water sampling will also provides a summary of the water quality evaluation and the recommendations for implementation of disinfection alternatives to meet future drinking water regulations. In addition to microbial inactivation, CBS is required to be in compliance with regulated levels of disinfection by-products within the water distribution system.

Water quality data have been collected by CBS staff, including ultraviolet absorbance, turbidity and temperature. The intent of collecting this water quality data was to further evaluate UV feasibility for CBS's water system and begin design criteria development for these facilities.

Raw and Treated Water Quality

Data were collected on the temperature, turbidity, and UV absorbance for the raw water from Blue Lake in CBS's system. This information was collected to help correlate seasonal trends and water quality observed during this monitoring program with available historical data. Samples were collected at the sample sink in the Blue Lake WTP. The sample is collected from the transmission main just after it leaves the penstock. The sample is representative of the raw water entering the treatment plant.

The data presented in this section were collected simultaneously with the Ultraviolet transmittance (UVT) data discussed later in this memorandum. The range and averages of the parameters monitored are presented in Table 1. Temperature and turbidity results collected over the sampling period are typical values for CBS's source.

TABLE 2
Source Water Quality: Blue Lake

Parameter	Minimum	Maximum	Average	Number of Samples
Temperature (C) [1]	1.0	14.0	5.2	418
Turbidity (ntu) [1]	0.03	5.83	0.68	426
UV Absorbance (/cm) [1]	0.011	0.050	0.024	427
UVT (%)[1]	89.1	97.5	94.7	427

[2] Required under the proposed Long Term 2 Enhanced Surface Water Treatment Rule, this date may be extended to October 1, 2016 if capital improvements are required (as is the case with CBS)

TABLE 2
Source Water Quality: Blue Lake

Parameter	Minimum	Maximum	Average	Number of Samples
Hardness (mg/L as $CaCO_3$)	--	--	Very low[2]	Not measured routinely
Nitrate (mg/L as N)	Not detected	0.262	--	Not measured routinely
Iron (mg/)	--	--	Very low[2]	Not measured routinely
Manganese (mg/L)	--	--	Very low[2]	Not measured routinely

1. Data collected October 2005 to September 2007.
2. Based on CBS's recollection of past samples.

Other parameters, including nitrate, iron, manganese, and hardness have been measured historically but are not routinely measured. Hardness is often an indicator of potential fouling on UV lamp sleeves. Results indicate that the Blue Lake raw water source is a soft water that would likely not cause any significant fouling due to hardness. Iron and manganese can also cause fouling on UV sleeves. The Blue Lake supply has historically had very low levels of both iron and manganese.

Nitrate can lead to the formation of nitrite, which has adverse health impacts. However, nitrate levels are sufficiently below the maximum contaminant levels (MCLs) for the Blue Lake source water and will not affect the treatment for CBS's water system.

Ultraviolet Transmittance (UVT)

Water samples were collected for Ultraviolet (UV) analysis from the Blue Lake source as described previously. UV 254 absorbance samples were collected and analyzed on-site by CBS staff and results provided to CH2M HILL. The UV absorbance measurements were taken using HACH Method #10054 and Standard Methods # 5910 B, UV Absorption Monitoring for Organic Constituents, which includes a pre-treatment step of filtration through a paper filter; however, the filtration step was not used for these samples since they will not be filtered prior to UV treatment.

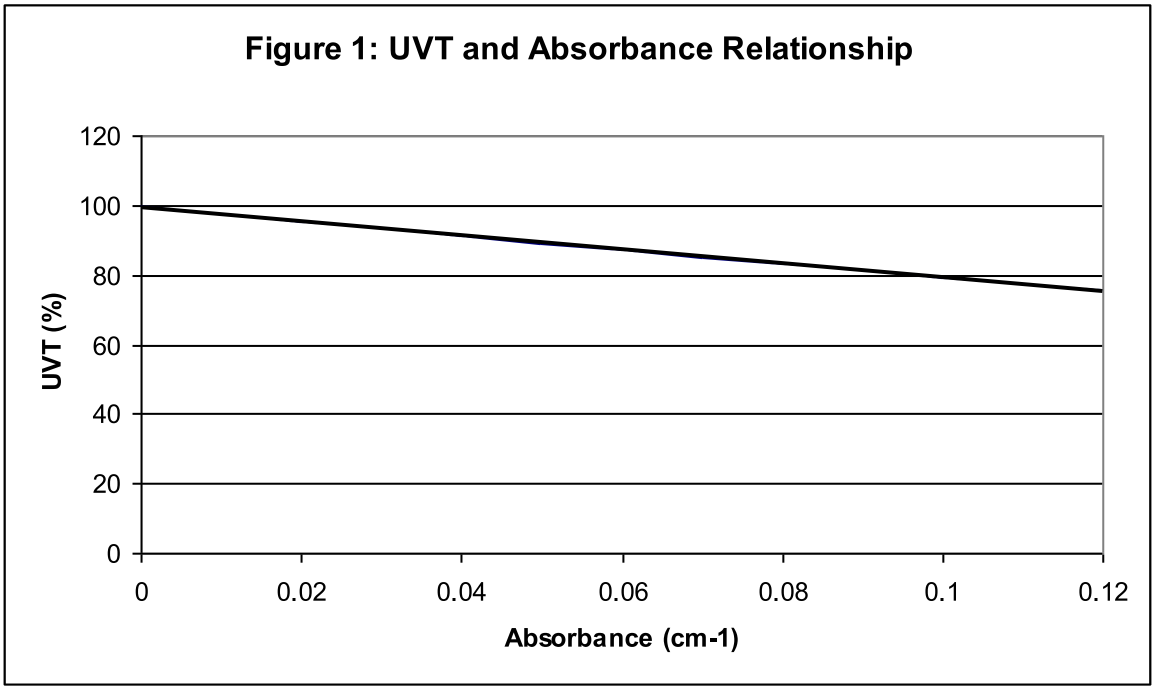
The absorbance was then converted to UV transmittance. UV absorbance can be converted to UV transmittance by the following equations:

$$A = \log\left(\frac{100}{\%T}\right) \quad \text{or} \quad T = 100 * 10^{-A}$$

where A = Absorbance (cm^{-1}) and

T = Transmittance (%)

The relationship between UVT and UV absorbance is also depicted in Figure 1.



On-Site UVT Analysis

UVT data was collected from Blue Lake as described above. The results of the on-site UVT analysis as well as turbidity data are depicted in Figure 2 and summarized previously in Table 1. UV absorbance for all on-site analysis was measured at a wavelength of 254 nm over 1 cm and converted to UV transmittance per centimeter.

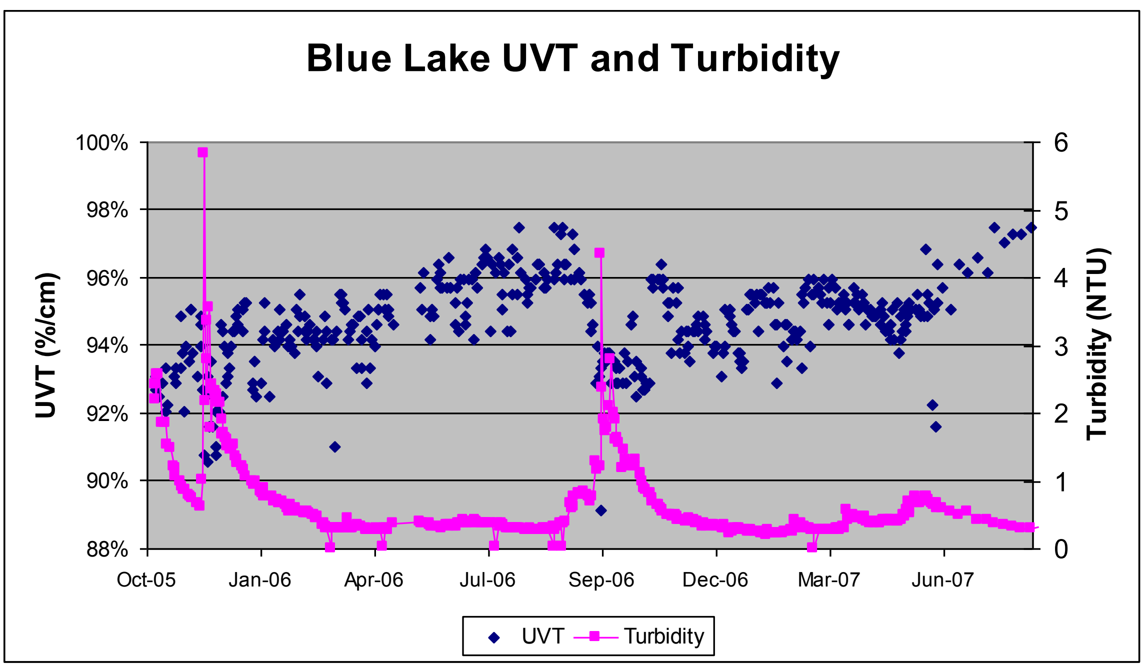


FIGURE 2
Blue Lake UVT (unfiltered) and Turbidity

The Blue Lake supply samples ranged from 89.1 to 97.5% in UVT. This range is appropriate for application of UV disinfection without filtration. The turbidity is lower than 5 NTU, which meets the Surface Water Treatment Rules requirement of "the turbidity level of the source water prior to disinfection must not exceed 5 NTU". While it is possible to experience times when UVT and Turbidity may fluctuate irrespective of the other, generally an increase in turbidity will correspond to a decrease in UVT as shown in Figure 2.

Comparison of the raw versus chlorinated (finished water) samples on similar sources has shown that chlorination will improve the UVT of the water. In all cases where samples were collected for raw and finished water on the same day, the UVT for the finished water sample was higher than the UVT for the raw water sample. The finished water samples resulted in UVTs with an average of 1.7% higher than the raw water samples. This indicates that less energy is required from the UV system to inactivate *Cryptosporidium* downstream of chlorination as compared to upstream of chlorination. This may impact the final siting of the facility. Additional water quality monitoring should be performed if UV disinfection of chlorinated water is to be considered.

Samples presented in this memorandum were collected over a two year period. There is no historical information regarding the UVT of CBS's water; therefore, there is no indication of whether these data are representative of long term trends or are atypical. This issue is important as UVT is the primary parameter for sizing a UV system and the more data that are available, the less conservative we can be in sizing for low UV transmittance. In addition, small changes in the UVT of 1 or 2 percent on a routine basis can impact the power requirements for the UV system depending on the range for selected equipment. Power and equipment consideration and sensitivity requirements should be considered during pre-design of UV facilities.

Based on the results presented in this memorandum, it is recommeded that UV facilities on the raw water be sized for a minimum UVT of 88.0%. This is based on a minimum measured UVT of 89.1% and a small amount of safety factor. The UV equipment, however, should be validated to operate to a minimum UVT of 80.0% at reduced flow rates. Using 80% UV transmittance as the minimum operating value takes into account that the data collected may be indicative of a typical year and lower UVTs would be experienced during a worst-case year. Further conservatism can be built in terms of redundant units and adequate power supply if desired. For optimal UV system sizing, seasonal demands should also be considered. A different UVT may be used with summer flows and winter flows. The combination requiring the most power or largest units would then determine the equipment selection.

Locating the UV facilities following chlorination and chlorine contact would increase the design UVT to roughly 89.5% as chlorine has been shown to increase the UVT of similar waters. This value allows for the same conservatism for the raw water UVT described above.

It is important to continue to collect UVT data for both raw and chlorinated water to assist in future UV facilities' design. The design UVT should be reevaluated prior to initiating UV facilities' final design based on additional water quality data collected over upcoming years.

A sampling plan will be developed as a separate document to guide the continued monitoring.

Disinfection By-products

CBS has collected samples from the distribution system to determine actual disinfection by-product levels as part of their compliance monitoring for the Stage 1 DBPR. The results of this testing are summarized below. Additional disinfection by-product formation potential tests can also be performed to determine the impact of potential treatment changes if needed in the future.

CBS has collected and analyzed samples for total trihalomethanes (TTHMs) and five haloacetic acids (HAA5) as part of the monitoring program required for compliance with the Stage 1 DBPR. Samples were collected by CBS staff and sent to a certified laboratory for analysis. Samples for Stage 1 compliance must be collected quarterly; however, CBS qualifies for reduced monitoring since the DBPs are very low. Monitoring is now performed annually. The sample location was selected to represent the location with the longest detention time in the distribution system. The results of the annual compliance testing are presented in Table 2.

TABLE 3
TTHM and HAA5 Distribution System Compliance Testing, Sitka, Alaska

Date Sampled	TTHM (mg/L)	HAA5 (mg/L)
September 2005	22.9	29.0
October 2006	22.9	28.5
October 2007	16.3	17.7

Compliance with the Stage 1 DBPR is based on a running annual average (RAA). The compliance levels established in the rule are 80 µg/L for TTHMs and 60 µg/L for HAA5s. CBS is well within compliance levels for both TTHMs and HAA5s for Stage 1 DBPR for the sampling based on the RAA. The Stage 2 DBPR will have little impact on CBS's results. The Stage 2 DBPR will ultimately require system to maintain the 80 µg/L and 60 µg/L compliance levels for TTHMs and HAA5s, respectively, based on a locational running annual average (LRAA). CBSs TTHMs and HAA5s are both very low and not a concern related to the selected treatment technique for compliance with the Long Term 2 requirements for Cryptosporidium inactivation.

Recommendations

1) CBS should continue to monitor on-site for UVT at raw and chlorinated sample locations. Continued monitoring can help to further refine the design criteria for the facilities. The additional data will also ensure that data presented herein is representative of CBS's water sources. If the data collected to date are not representative, the sizing of the facilities could be affected.

2) CBS should evaluate the possibility of locating the UV facilities following chlorination. Additional data should be collected to determine if chlorinated samples would positively affect the UVT of the raw water.

3) The UV facilities should be sized for a minimum UVT of 88.0% at the design flow rate based on data collected to date. Higher design values may be considered if the facilities are located following chlorination. The design values should be reevaluated once additional data is collected. Seasonal criteria may also be considered when the project enters design.

Chapter 5

Comparison of *Cryptosporidium* Treatment Alternatives

Summary

In this chapter, ultraviolet (UV) disinfection is compared to other viable treatment methods that are currently available to the City and Borough of Sitka (CBS) for complying with Federal regulations for treatment of *Cryptosporidium*. In addition to UV disinfection, the other treatment methods that are evaluated include ozonation, chlorine dioxide disinfection, membrane filtration, and granular media filtation.

UV disinfection, ozonation, and chlorine dioxide disinfection involve the incorporation of a second disinfectant to the CBS's existing treatment facilities for inactivation of *Cryptosporidium*. This additional disinfectant could be applied either prior to or after the existing chlorination facilities and would be used in conjunction with chlorine. Membrane filtration, and granular media filters involve the addition of filtration technology to the CBS's existing treatment facilities for removal of *Cryptosporidium*. The membrane filtration method could also be installed upstream of the existing chlorination facilities and the granular media filtration method could be installed up or downstream of the existing chlorination facilities, and both would be used in conjunction with chlorine.

For each treatment alternative examined in this technical memorandum, separate capital expenditure estimates are developed for a maximum treatment plant capacity of 6.0 mgd. The 6.0 mgd capacity represents the assumption made for this analysis of CBS's maximum peak hour demand from residential, commercial, and industrial customers. Further evaluation will be required in order to determine the actual design flow prior to the design of any future treatment alternative.

Table S1 contains a summary of the capital (including construction and non-construction costs) and life cycle costs for the various treatment options that were examined in this technical memorandum. Capital and life cycle costs are computed in 2008 dollars. These are order-of-magnitude estimates, accurate to within +50 percent to –30 percent.

TABLE S1
Summary Table of Capital and Life Cycle Costs for *Cryptosporidium* Treatment Alternatives
City and Borough of Sitka Water Treatment Plant

Treatment Alternative	Capital Cost	Annual O&M and Labor Costs	25 Yr Life Cycle Cost
UV Disinfection	$5,500,000	$360,000	$9,100,000
Ozone Disinfection	$27,300,000	$1,270,000	$39,800,000
Chlorine Dioxide Disinfection	$34,900,000	$1,420,000	$48,900,000
High-Rate Granular Filtration	$24,100,000	$1,090,000	$34,700,000
Membrane Filtration	$46,600,000	$2,220,000	$68,300,000

An examination of the various treatment options contained in Table S1 reveals that UV disinfection is the most cost effective and viable alternative available to CBS for treatment of *Cryptosporidium*. From a capital cost perspective, installation of UV facilities would require approximately $5.5 million of capital outlay depending on the level of treatment that is required for *Cryptosporidium*, whereas the remaining options require between $24.1 and $46.6 million of capital expenditures.

UV facilities (structures only) also require the least amount of land, at about 0.04 acres, whereas the remaining options (structures only) would require between 0.20 and 1.34 acres of land. Therefore, we recommend planning for UV disinfection facilities at the City and Borough of Sitka WTP in order to comply with the requirements for *Cryptosporidium* treatment.

Overview

In order to comply with federal regulations, the City and Borough of Sitka (CBS) will be required to install additional treatment for removal and/or inactivation of *Cryptosporidium*. The primary regulatory drivers for additional water treatment are contained in the Long Term 2 Enhanced Surface Water Treatment Rule (LT2).

This technical memorandum examines the viability and cost of five separate processes that are currently available to CBS for treatment of *Cryptosporidium*.

The treatment processes that are examined in this technical memorandum are:

1) Ultraviolet (UV) disinfection – To maintain filtration avoidance
2) Ozonation - To maintain filtration avoidance
3) Chlorine dioxide disinfection – To maintain filtration avoidance
4) Membrane filtration (MF) membrane treatment – To add a filtration process
5) High-rate granular media filtration – To add a filtration process

A brief summary of the Long Term Enhanced Surface Water Treatment Rules (LT1 and LT2) is also provided in this technical memorandum. For additional details on these and other regulatory requirements that relate to CBS's water treatment practices, the reader is referred to Chapter 3 – *Summary of Current and Pending Federal Regulations that Impact Sitka's Water Treatment Facilities*.

Regulatory Requirements

The Long Term Enhanced Surface Water Treatment Rules were implemented in two separate stages. The final Stage 1 rule (abbreviated LT1ESWTR, or LT1) was promulgated on January 14, 2002, and applies to all surface water systems serving less than 10,000 persons. The final LT2 was promulgated on January 6, 2006, and applies to all surface water systems, regardless of size.

CBS's water treatment plant is classified as an unfiltered surface water treatment facility which serves less than 10,000 persons. This section contains abbreviated summaries of the *Cryptosporidium* treatment requirements contained in the LT1 and LT2 rules that will have a direct impact on CBS's treatment plant operations and facilities.

The CBS is currently classified as a filtration avoidance water system. In order for the disinfection alternatives (UV Disinfection, Ozone, and Chlorine Dioxide) to be implemented for CBS, the system must maintain its filtration avoidance status. Any change in this status would require CBS to add a filtration process and comply with the regulations as a filtered water system.

LT1ESWTR Requirements

The main *Cryptosporidium* treatment requirements of the final LT1 rule that pertain to CBS's water treatment facilities are as follows:

- Maximum contaminant level goal (MCLG) of zero for *Cryptosporidium*.
- Inclusion of *Cryptosporidium* in the watershed control requirements for unfiltered surface water systems.

LT2ESWTR Requirements

The main *Cryptosporidium* treatment requirements of the LT2 rule that pertain to CBS's water treatment facilities are as follows:

- Small unfiltered surface water systems that meet filtration avoidance criteria must conduct initial source water monitoring for *Cryptosporidium*. Monitoring requirements involve at least 24 consecutive months of sampling if source water is sampled once per month or 12 consecutive months of sampling if samples are collected twice per month. The sampling schedule and location must be submitted by January 1, 2010 and the monitoring must start no later than April 1, 2010.
- Alternatively, unfiltered systems have the option to forgoe the monitoring requirements, and instead proceed with the design and construction of a facility that will provide 3-log

inactivation of *Cryptosporidium*. If they decide to take this approach, notification must be provided to this effect by January 1, 2010.

- The results of source water monitoring will be used to establish the following treatment requirements for unfiltered systems:
  - 2-log (99%) *Cryptosporidium* inactivation if *Cryptosporidium* levels are ≤ 1 cyst/100 L.
  - 3-log (99.9%) *Cryptosporidium* inactivation if *Cryptosporidium* levels are > 1 cyst/100 L.
  - Overall inactivation requirements for unfiltered systems, including 3-log *Giardia* inactivation and 4-log virus inactivation, must be met using a minimum of two disinfectants.
- Installation of a treatment technique for compliance with *Cryptosporidium* inactivation requirements must be completed no later than October 1, 2014 or October 1, 2016 if an extension is granted for required capital improvements.

The LT2 includes a "microbial toolbox" which contains a list of approved methods for treatment of surface water supplies for removal/inactivation of *Cryptosporidium*. Approved methods include disinfectants such as ozone, chlorine dioxide, and ultraviolet (UV) light. Other methods contained in the toolbox that can be used to treat for *Cryptosporidium* include off-stream storage of raw water, lime softening, slow sand filtration, bank filtration, membrane filtration, bag filters, and cartridge filters. For unfiltered systems that continue to meet the filtration avoidance criteria, it is necessary to select an "upper bin technology," such as UV, ozone, or chlorine dioxide, to meet the *Cryptosporidium* requirements.

When ozone or chlorine dioxide is used as the primary disinfectant, compliance is based on the well-established CT principle used for chemical disinfectants, where C is the residual concentration of chemical disinfectant and T is the contact time. When UV light is used as the primary disinfectant, compliance is based on the UV dose. The UV dose concept is fashioned after the CT concept, with the dose being the product of the intensity of UV light (measured in energy per unit area) and the UV exposure time.

The LT2 contains tables for *Cryptosporidium* inactivation using either ozone or chlorine dioxide as the chemical disinfectant. These tables contain the necessary CT values based on water temperature and log inactivation of *Cryptosporidium*. Similar tables for UV disinfection of *Cryptosporidium*, *Giardia*, and viruses that are based on UV dose are also included. It is important to note that the dose tables include the UV doses necessary for effective disinfection in the laboratory, and for full-scale UV application, it is necessary to increase the UV dose by a validation factor (VF). Typical VF values for unfiltered system disinfection targets are between 2 and 5, meaning that full-scale doses will need to be increased by that amount for full-scale application.

Evaluation and Comparison of Treatment Options

In this chapter, we evaluate five different alternatives as possible treatment methods that CBS may consider in order to comply with the LT2 requirements for *Cryptosporidium* removal. Three of the treatment alternatives involve the incorporation of a second disinfectant to the treatment facilities for inactivation of *Cryptosporidium*. This additional disinfectant could be applied either prior to or after the chlorine injection point, and would be used in conjunction with chlorine. Two of the treatment alternatives involve the addition of filtration technology to the treatment facilities for removal of *Cryptosporidium*. The filtration methods could also be installed up or downstream of the chlorine injection point, and would be used in conjunction with existing chlorination facilities.

The five treatment alternatives that are examined in this technical memorandum are (1) UV disinfection, (2) ozonation, (3) chlorine dioxide disinfection, (4) membrane filtration, and (5) high-rate granular media filtration. An estimate of total capital expenditures and life cycle costs is provided for each treatment alternative using the CH2M HILL Parametric Cost Estimating System (CPES) tool. Costs are indexed to 2008 dollars.

For each treatment alternative, estimates are developed for a plant capacity of 6.0 mgd. The 6.0 mgd capacity represents the assumption made for this analysis of CBS's maximum peak hour demand from residential, commercial, and industrial customers. The assumed peak hour demand is based on current consumption plus a factor of safety to ensure adequate treatment capacity. Part of the predesign for a new facility will include a more detailed look at CBS's water demand and required design capacity.

In order to maintain filtration avoidance status, CBS will either be required to provide 2-log or 3-log *Cryptosporidium* inactivation in order to maintain its filtration avoidance status. CBS has the option to monitor for Cryptosporidium in order to determine if 2-log treatment can be provided. Otherwise, CBS may install a system capable of 3-log inactivation of Cryptosporidium and forgo source water monitoring.

Discussions and cost estimates for each of the five treatment alternatives are presented in the following sections. These are order-of-magnitude estimates of capital costs for construction and engineering, based on 2008 dollars. According to the American Association of Cost Engineers, order-of-magnitude cost estimates are accurate within +50 percent to –30 percent. These are estimates for initial capital outlay, annual operating cost, and life cycle costs to be used for comparison of the various treatment alternatives.

Ultraviolet (UV) Disinfection

Disinfection of drinking water using ultraviolet (UV) light has been practiced extensively in Europe and is now common throughout the United States. UV light disinfects water by rendering pathogenic microorganisms incapable of reproducing. This is accomplished by disrupting the genetic material in cells. The genetic material, namely DNA, will absorb light in the ultraviolet range—primarily between 200 nm and 300 nm in wavelength. If the DNA absorbs too much UV light it will be damaged to the point that it is unable to replicate. It has been found that the energy required to damage DNA is much less than that required to actually destroy the organism. The effect is the same however, since a microorganism cannot infect if it is unable to reproduce.

Ultraviolet light has been found to be particularly effective at inactivating the protozoans *Cryptosporidium* and *Giardia* in drinking water. In comparison, strong oxidants such as free chlorine, ozone, and chlorine dioxide are much less effective since *Cryptosporidium* and *Giardia* form cysts which are highly resistant to these chemicals. This effectiveness does not apply to viral disinfection, where chemical oxidants have been found to be much more effective for inactivation of viruses than UV light.

Properties of UV Light

UV disinfection uses electromagnetic radiation in the form of ultraviolet light to inactivate microorganisms, which is different from the mechanism that oxidant-based disinfectants use. UV disinfection is a physical process that uses photochemical energy to prevent cellular proteins and nucleic acids (i.e., DNA and RNA) from further replication. The germicidal effect of UV light is accomplished through the dimerization of pyridimine nucleobases on the DNA molecules to distort the normal helical structure and prevent cell replication. A cell that cannot replicate cannot infect. The range of UV electromagnetic rays covers 40 to 400 nm in wavelength. The germicidal UV wavelengths range from 200 to 300 nm with the optimum germicidal effect occurring at 253.7 nm.

UV electromagnetic energy is typically generated by the flow of electrons from an electrical source through ionized mercury vapor in the lamp. Several manufacturers have developed systems to align UV lamps in vessels or channels to provide UV light in the germicidal range for inactivation of bacteria, viruses, and protozoans. UV disinfection utilizes either low pressure lamps that emit maximum energy output at a wavelength of 254 nm, medium pressure lamps that emit energy at wavelengths from 180 to 1370 nm, or lamps that emit at other wavelengths in a high intensity “pulsed” manner.

UV light quickly dissipates into water to be absorbed or reflected off material within the water. As a result, no residual disinfectant is produced by UV light. This process is attractive from a disinfection by-product (DBP) formation standpoint; however, a secondary chemical disinfectant is required to maintain a residual within the distribution system.

Disinfection with UV Light

The inactivation of microorganisms by UV light is directly related to UV dose, a concept similar to CT used for oxidant-based disinfectants such as chlorine and ozone. The average UV dose is calculated as the product of the light intensity, I (units of milliwatts per square centimeter, mW/cm^2) and the exposure time, T (seconds). The product IT is typically expressed in units of energy per area as millijoules per square centimeter (i.e., mJ/cm^2). UV intensity is a function of water UV transmittance and UV reactor geometry, as well as lamp age and fouling. Exposure time is estimated from the UV reactor specific hydraulic characteristics and flow patterns.

Since the UV dose is primarily based on the light intensity, water quality parameters that have the greatest effect on UV dose are turbidity and suspended solids, which have the ability to shield microorganisms from the UV light, and some organic and inorganic compounds that can absorb UV energy.

UV Disinfection Requirements for *Cryptosporidium* Inactivation

EPA published a table of required UV doses as part of the promulgated LT2ESWTR. The table specifies UV doses needed to achieve up to 4 log inactivation of *Giardia lamblia*, up to 4 log inactivation of *Cryptosporidium*, and up to 4 log inactivation of viruses.

The final LT2ESWTR provides dose requirements for inactivation of *Cryptosporidium*, *Giardia*, and viruses. The inactivation requirements contained in the dose table are as follows:

- *Cryptosporidium* inactivation: 2-log = 5.8 mJ/cm^2; 3-log = 12 mJ/cm^2
- *Giardia* inactivation: 3-log = 11 mJ/cm^2
- Virus inactivation: 4-log = 186 mJ/cm^2

Note that the dosages for virus inactivation are higher than original values listed in the Surface Water Treatment Rule because of resistance of certain viruses like Adenovirus to UV light. Although the current dose requirements for *Cryptosporidium* are less than originally anticipated (original doses in the 30 to 40 mJ/cm^2 range), the application of the Validation Factor (VF) for full-scale application means that, depending on the validation testing approach utilized for the selected equipment, the equipment size and power requirements for UV disinfection may be similar.

Disinfection By-products of UV Light

As a physical process, UV disinfection leaves no UV residual, and overdosing is not of environmental concern. Also, UV disinfection has a major advantage over chemical disinfectants in that it produces little or no disinfection by-products.

Studies have shown that there is no appreciable increase in trihalomethane (THM) or haloacetic acid (HAA) concentrations as a result of UV disinfection at doses that would be applicable in water treatment. However, low levels of formaldehydes and assimilable organic carbon may be produced in the finished water as a result of the UV treatment process at high UV doses.

UV Disinfection Process Variables

The UV process uses electromagnetic energy to inactivate microorganisms, and research indicates that typical water quality parameters such as pH, temperature, alkalinity, and total inorganic carbon do not appear to impact the overall effectiveness of UV disinfection. Hardness and iron and manganese concentrations affect the rate of lamp fouling, although automatic lamp cleaning systems incorporated in the current generation of UV equipment have minimized the impact of hardness on system design and operation.

The effectiveness of UV disinfection is mainly impacted by water quality parameters that prevent UV electromagnetic energy from reaching target microorganisms. Particles, turbidity, and suspended solids may shield microorganisms from UV light or scatter UV light to prevent it from reaching target microorganisms. Recent studies indicate that turbidity levels up to 5 NTU (as has been allowed for unfiltered systems) do not adversely impact the effectiveness of UV disinfection. Some organic compounds (e.g., phenols, humic/fulvic acids) and inorganics (e.g., iron, manganese, nitrate) absorb energy and reduce the UV transmittance of the water being treated. Thus, UV transmittance (UVT) is commonly used as process controls at UV facilities.

UVT of water is measured by a spectrophotometer set at a wavelength of 254 nm using a 1-cm thick layer of water. The resulting measurement represents the absorption of energy per unit depth, or absorbance. Early spectrophotometric analysis of CBS's raw water supply produced an average absorbance value of 0.025/cm, which is low. This corresponds to a transmittance of 94 percent per cm, which is very good.

Continuous-wave UV light at doses and wavelengths typically employed in drinking water applications does not significantly change the chemistry of water, nor does it significantly interact with any of the chemicals commonly found in water. Therefore, no natural physicochemical features of the water are changed, and no chemical agents are introduced into the water.

UV Disinfection System Design

The main components of a UV disinfection system are mercury arc lamps, a reactor, and ballasts. The source of UV light is either low-pressure or medium-pressure mercury arc lamps with low or high intensities. Producing UV light requires electricity to power UV lamps. Ballasts control the power to the UV lamps.

UV Lamps

The lamps that are typically used in UV disinfection consist of a quartz tube filled with an inert gas, such as argon, and small quantities of mercury. The optimum wavelength range to effectively inactivate microorganisms is 250 to 270 nm. The intensity of the light emitted by the lamp dissipates as the distance from the lamp increases.

Both low-pressure and medium-pressure lamps are available for disinfection applications. Low-pressure lamps emit their maximum energy output at a wavelength of 253.7 nm, while medium-pressure lamps emit energy with wavelengths ranging from 180 to 1370 nm. The intensity of medium-pressure lamps is much greater than low-pressure lamps. Thus, fewer medium-pressure lamps are required for an equivalent dosage. Medium pressure lamps have approximately 15 to 20 times the germicidal UV intensity of low-pressure lamps. The medium pressure lamp disinfects faster and has greater penetration capability because of its higher intensity. However, these lamps operate at higher temperatures with a higher energy consumption. The higher operating temperatures of medium pressure lamps compared to low pressure lamps results in a shorter lamp life.

Ballasts

Ballasts are transformers that control the power to the UV lamps. Ballasts must be kept in controlled environment in order to keep from overheating and prevent premature failure. Typically, the ballasts generate enough heat to require cooling fans or air conditioning.

Two types of transformers are commonly used with UV lamps; namely, electronic and electromagnetic. Electronic ballasts operate at a much higher frequency than electromagnetic ballasts, resulting in lower operating temperatures, less energy use, less heat production, and longer ballast life.

Reactors

Most conventional UV reactors are available in two types; namely, closed vessel and open channel. For drinking water applications, the closed vessel is generally the preferred UV reactor for the following reasons:

- smaller footprint
- no requirement for free water surface
- minimized pollution from airborne material
- minimal potential for personnel exposure to UV light
- modular design for installation simplicity

Instrumentation and Controls

Additional design features for conventional UV disinfection systems should include:

- UV intensity sensors to detect lamp output intensity
- UV transmittance sensor to monitor quality of raw water
- alarms and shut-down systems
- automatic or manual cleaning cycles.

Hydraulic Design Considerations

The major elements that should be considered in the hydraulic design of a UV closed vessel reactor are: dispersion, turbulence, effective volume, residence time distribution, and flow rate. These issues are addressed in the design of the reactor by the manufacturer. The upstream and downstream piping configuration is also important to minimize the impact of installation. Ideally, long straight lengths of pipe should be installed upstream and downstream of the reactors, on the order of as much as 10 pipe diameters upstream and 5 pipe diameters downstream. If a 90-degree bend was tested during validation upstream of the reactor, the UVDGM recommends adding 5 pipe diameters of straight pipe upstream of the UV reactor.

Operational Considerations

UV disinfection facilities should be designed to provide flexibility in handling varying flow rates. For lower flow rates, a single reactor vessel should be capable of handling the entire flow rate. A second reactor vessel with equal capacity of the first reactor should be provided for redundancy. For higher flow rates, multiple reactor vessels can be provided with lead/lag operation and flow split capability to balance run time for each reactor vessel, and to avoid hydraulic overloading. If the plant flows do not vary significantly, then one reactor with a redundant unit may be sufficient.

For the flow rates being considered for CBS, it appears that flows are low enough to use one online plus one redundant reactor to treat the entire range of system flow rates. For some manufacturers, two online plus one redundant may be required to meet the maximum design flow. The number and capacity of the reactors to be used is typically determined during the predesign phase.

The output of UV lamps diminishes with time. Two factors that affect their performance are: 1) solarization which is the effect UV light has on the UV lamp, causing it to become opaque, and 2) electrode failure which occurs when electrodes deteriorate progressively each time the UV lamp is cycled on and off. Frequent lamp cycling will lead to premature lamp aging. Guaranteed lamp life is determined by the manufacturer and varies for each system. Low-pressure lamps generally have a longer life than medium pressure, though specific vendor lamp life will vary.

Fouling of the quartz sleeve reduces the amount of UV light reaching the water. The quartz sleeve has a transmittance of over 90 percent when new and clean. Over time, the surface of the quartz sleeve that is in contact with the water starts collecting organic and inorganic debris (e.g., NOM, iron, manganese, calcium, silt), causing a reduction in transmissibility.

Quartz sleeve cleaning may be accomplished by physical or chemical means. Physical alternatives include automatic mechanical wipers, ultrasonic devices, high water pressure wash, and air scour. Chemical cleaning agents include citric, sulfuric, or hydrochloric acid. A UV reactor vessel may contain one or more physical cleaning systems along with provisions for an occasional chemical cleaning. In low-hardness, low-iron waters such as CBS's it is still recommended that automatic cleaning devices be installed even though fouling potential may be relatively low. Low pressure UV systems are also less prone to fouling and may not require automated cleaning.

Standby Power

Producing UV light requires electricity to power the electronic ballasts, which in turn power the UV lamps. Since disinfection is of utmost importance in producing potable water, the UV system should remain in service during periods of primary power failure. A dual power feed system or essential circuitry powered by a standby generator are typical ways to achieve the desired reliability.

Loss of power or significant temporary disruptions in the power supply will cause the UV reactors to shut down. These systems can take several minutes to re-start. Utilities have addressed the issue in two primary ways to prevent untreated water from going to the distribution system: (1) provide an uninterruptible power supply (UPS), or (2) shut down the flow of water to the UV system upon power failure.

In the Final UVDGM, applicable guidance pertains to the amount of "off-specification operation" that is allowable, but the primacy agency will ultimately establish requirements. At this point off-specification requirements have not been established for the state of Alaska. The decision whether or not to include the design of a UV facility should be made during the predesign phase. Most UV systems in the US do not use a UPS, as it is not required by the US EPA. However for systems on power grids with any frequent power fluccuation, a UPS may be necessary. Power quality observations will provide additional data to determine the best approach for CBS.

Advantages of UV Disinfection

The following advantages are realized when using UV light as a disinfectant for inactivation of *Cryptosporidium*:

- An effective disinfectant against both *Cryptosporidium* and *Giardia.*
- Little or no production of DBPs.
- Unlike chemical disinfectants, efficiency does not depend upon typical water quality parameters such as pH and temperature.
- UV disinfection is a physical process rather than a chemical oxidant; thus eliminating the need to generate, handle, transport, or store toxic/hazardous or corrosive chemicals.
- There is no residual effect that can be harmful to humans or aquatic life.
- UV systems are easy to operate.
- UV disinfection requires a shorter contact time when compared to other disinfectants.
- UV disinfection equipment requires less space than other methods.

Limitations of UV Disinfection

The following limitations must be considered when using UV light as a disinfectant for inactivation of *Cryptosporidium*:

- Does not produce a residual. Must be followed by a secondary disinfectant (i.e., chlorine) for maintaining a disinfectant residual in the distribution system.
- Limited effectiveness against viruses. Must be used together with another chemical disinfectant (i.e., chlorine) for achieving viral inactivation CT requirements.
- Effectiveness can be compromised as turbidity increases.
- A preventive maintenance program is necessary to control fouling of lamp sleeves.
- There is no measurable residual to indicate the efficacy of UV disinfection.
- Validation testing is required to demonstrate the effectiveness of specific UV equipment. Validation testing introduces a great deal of complication into the evaluation and approval of UV disinfection systems. However, validation testing also provides the means of ensuring that an operating UV disinfection system is meeting the established performance targets at the water treatment facility.

Cost Estimate for Installation of UV Disinfection Facilities at the City and Borough of Sitka WTP

Space requirements and cost estimates for the UV facility are based on CBS's available daily transmittance data and the Final LT2 Rule. The CPES, a cost estimating tool, was used to prepare order-of-magnitude cost estimates for installation of UV disinfection facilities at the CBS WTP. The estimate was generated based on the requirements for 3-log *Cryptosporidium* inactivation. This log inactivation level represents the extreme that CBS will be required to provide in order to comply with the regulations for unfiltered surface water systems. An assumed peak plant flow rate of 6.0 mgd was used to generate capital cost estimates. Further evaluation will be required in order to determine the actual design flow prior to the design of any future treatment alternative.

For CBS's water treatment plant, the UV disinfection facilities can be located within the process train either upstream or downstream of the existing chlorine feed system. The UV system would be used to provide primary disinfection, whereas chlorine would be used as a secondary disinfectant for providing distribution system residual. The chlorination facilities would also be used in conjunction with the existing pipeline to provide the necessary CT requirements for inactivation of viruses. The physical sequence of these two disinfectants in the process train will not affect their disinfection credit.

The following set of assumptions was used to arrive at cost estimates for UV disinfection facilities:

- Medium pressure lamps based on 3 (2 Online + 1 Redundant) Trojan Technologies UV SWIFT 4L12. This configuration has a 12-inch diameter flange connection and associated piping, and requires approximately 35 KW of electricity. Other manufacturers' systems have been found to be similar in cost and equipment size.
- UV system is located in a stand-alone building.
- Flow through UV reactors is by gravity – no pumping required. (Note pumping may be required based on final layout and vendor selection. A detailed design analysis is required.)
- Design UV absorbance of raw water supply = 0.045/cm (i.e., UVT = 90 percent) based on recent water quality monitoring.
- UV disinfection facilities includes UV reactors, lamps, ballasts, sleeves, uninterruptible power supply (UPS), facilities building, instrumentation and controls.
- UV light is used as the primary disinfectant, with the existing chlorination facilities used to provide a disinfectant residual in the distribution system and CT requirements for virus inactivation.
- Power Costs: $0.09/kwh
- Additional Labor: 1 Full Time Equivalent (more or less may be required based on operational strategy and current staff workload.
- Average Treatment Plant Flow: 4.0 mgd

Table 1 contains order-of-magnitude capital cost estimates for the installation of UV disinfection facilities at the City and Borough of Sitka WTP. The estimate is based on 3-log *Cryptosporidium* inactivation, and an assumed peak plant design capacity of 6.0 mgd. Annual operating costs include labor, chemicals, maintenance, replacement parts, electricity, and maintenance and are based on an annual average flow rate of 4.0 mgd.

The results of Table 1 indicate that the capital requirements for installation of UV disinfection facilities at the CBS WTP are approximately $5.5 million. The costs are provided in 2008 dollars. Currently, the construction market is experiencing significant fluccuation in material and labor costs which have resulted in unusual cost escalation. These are order-of-magnitude estimates for capital expenditures, accurate to within +50 percent to –30 percent.

TABLE 1
Estimated Capital and Annual Operating Costs for UV Disinfection Facilities
6.0-mgd Plant Capacity

Cost Category	Costs
Construction Costs[1]	$3,800,000
Non-Construction Costs[2]	$1,700,000
Total Capital Cost[3]	*$5,500,000*
Annual Operating Cost[3]	*$374,000*

1. Construction costs include UV facilities building, UV disinfection system, uninterruptible power supply (UPS), instrumentation and controls, demolition, sitework, yard electrical, yard piping, and contractor markups.
2. Non-construction costs include permitting (5%), engineering (15%), services during construction and commissioning/startup (15%), and legal/administrative fees (10%).
3. Order-of-magnitude cost estimate, in 2008 dollars.

Table 2, below contains the space requirements for the installation of UV disinfection facilities at the City and Borough of Sitka WTP. The entire UV system, including lamps, reactors, UPS, instrumentation and controls, would be housed in a single building.

TABLE 2
Space Requirements for UV Disinfection Facilities

Unit Process	Structure Space Requirement
UV Disinfection	1500 sf
Total Building Area	1500 sf (0.03 ac)
Approximate Structure Footprint	30' W x 50' L

The results of Table 2 indicate that a UV facility will require 1,510 square feet (0.03 acres) of land for buildings alone. This building size applies to a medium pressure system. Low pressure systems will require a slightly larger space. Note that this applies only to the building footprint, and does not include land requirements for roads, driveways, loading/unloading zones, parking, setbacks etc.

Preliminary observation suggests that the chlorination facility property has adequate space to contain the UV disinfection facility. The configuration could be arranged to use the UV system to disinfect either the raw water or the chlorinated water.

Ozonation

Ozone is one of the most powerful disinfectants available for use in water treatment, and has been used in Europe since the early 1900s. It has more recently found acceptance in the United States, with more than 250 plants currently using ozone. Most of these plants have a capacity of less than 1 mgd and use ozone as an oxidant for taste and odor control, as opposed to a disinfectant for regulatory compliance. Other types of disinfectants are usually used for *Cryptosporidium* and *Giardia* inactivatioin. This is primarily due to the high CT requirements for inactivation of *Cryptosporidium* and *Giardia* with ozone.

Properties of Ozone

Ozone is a tri-atomic form of oxygen (i.e., O_3). Ozone is a powerful oxidant, and is highly corrosive and toxic. The gaseous form is colorless with a pungent odor that is readily detectable at concentrations as low as 0.02 ppm.

Ozone gas is extremely unstable. Consequently, it must be manufactured onsite and used immediately. It has a very short half-life (less than 30 minutes) under normal conditions encountered in water treatment. The gas is manufactured by passing air or oxygen between two electrodes. A high potential (between 10,000 and 30,000 volts) is applied across the electrodes, which converts some of the oxygen to ozone.

Ozone is sparingly soluble in water. While ozone is more soluble than di-atomic oxygen (i.e., O_2), it is 12 times less soluble than chlorine. Consequently, typical concentrations of ozone residuals encountered during water treatment when the ozone generation system uses air as the source of oxygen range from less than 0.1 to 1 mg/L, although concentrations up to 4 mg/L are attainable when the ozone generation system uses liquid oxygen in place of air.

Ozone is used as a disinfectant because of its efficacy against bacteria, viruses, and protozoa at low doses. Ozone can be applied at various points in the treatment train, although it is usually applied early in the treatment process. Unlike chlorine, the disinfection effectiveness of ozone is not affected by pH.

Due to its short half-life, ozone decays quickly and does not maintain a residual for downstream processes. Therefore, ozonation can be used as a primary disinfectant but must be followed by a secondary disinfectant (i.e., chlorine) in order to establish a residual in the distribution system.

Ozone Disinfection

The calculation of CT for ozone is similar to other chemical disinfectants, with accurate determinations of residual concentration being a prerequisite for effective disinfection. Primary disinfection credit is achieved by the residual concentration and the effective contact time. Ample monitoring points should be included to allow close monitoring of residual concentrations. Ozone can only be used as a primary disinfectant because it cannot maintain a residual in the distribution system. Thus, ozone disinfection should be coupled with a secondary disinfectant, such as chlorine, for a complete disinfection system.

Ozone CT Requirements for *Cryptosporidium* Inactivation

The ozonation CT requirements for disinfection of *Cryptosporidium* are contained in the LT2ESWTR. The CT requirements are a function of water temperature (ranging from < 0.5 to 25 °C) and targeted level of *Cryptosporidium* inactivation (ranging from 0.5-log to 3-log inactivation).

For CBS's water treatment facilities, *Cryptosporidium* inactivation requirements will be determined by the outcome of source water monitoring that will likely be required for compliance with the LT2ESWTR. For unfiltered surface water systems the level of *Cryptosporidium* inactivation will either be 2-log or 3-log. Recent sampling indicates that the minimum temperature for CBS's raw water supply is 1 °C. According to the LT2, ozonation CT requirements for *Cryptosporidium* inactivation at 1 °C are 46 mg·min/L for 2-log inactivation and 69 mg·min/L for 3-log inactivation. These CT values are for systems that measure both the initial and the final ozone residual in each cell of the contact chamber and use the geometric mean of the two values for the residual ozone concentration, C.

Ozone Demands and Ozonation By-products

Since ozone is such a powerful oxidant, it has been found to have many other uses than just for disinfection, such as iron and manganese oxidation and reduction, taste and odor removal, removal of color, reduction of disinfection by-product (DBP) precursors, and increasing the biodegradable dissolved organic carbon (BDOC) in the water. These reactions with organic and inorganic compounds cause an ozone demand in the water treated, which must be satisfied during the ozonation process prior to developing any measurable ozone residual.

In water, ozone demands are exerted by the following reactions:

- Reactions with natural organic matter (NOM) contained in the raw water supply. The oxidation of NOM by ozone leads to the formation of various chemical by-products, including aldehydes, organic acids, and aldo- and ketoacids.
- Reactions with synthetic organic compounds (SOCs) present in the raw water supply. Some SOCs can be oxidized and mineralized under favorable conditions.
- Oxidation of bromide ion (Br^-). Oxidation of bromide leads to formation of hypobromous acid, hypobromite ion, bromate ion (a regulated DBP), brominated organics, and bromamines.
- Reactions with dissolved inorganics contained in the raw water supply. Inorganic reducing agents such as iron, manganese, and hydrogen sulfide will exert an ozone demand that must be satisfied before an ozone residual can be established in the ozonated water.
- Reactions with taste and odor compounds contained in the raw water supply. Taste and odor compounds, such as geosmin and methyl isoborneol (MIB) are oxidized by ozone.

As noted above, the ozonation process does form DBPs, most notably brominated species. If bromide is detected in the raw water, the potential for bromate formation should be measured. Bromates are regulated with an MCL of 10 μg/L. Although the formation of bromate can be mitigated with pH depression or pre-chloramination, at the high CT values required at CBS' cold water temperatures, bromate formation may be a potential fatal flaw for the use of ozone alone. Other DBPs that form during ozonation include aldehydes, ketones, and carboxylic acids.

Ozonation System Design

Ozone is expensive to install and dangerous to handle. Therefore, separate facilities are required for the production of ozone and also for storage of liquid oxygen (LOX) if used as the feed gas. The production and feed systems for ozone, as well as monitoring systems require extensive training in order for operators to effectively operate the system.

When designing an ozonation system as the primary means of *Cryptosporidium* inactivation, the following design criteria must be considered:

- ozone target dose
- ozone demand and residual decay rates
- CT requirements to meet the regulatory guidelines for inactivation of *Cryptosporidium*.

Ozonation System Components

Ozone water treatment systems have four basic components:

1) a gas feed system
2) an ozone generator
3) an ozone contactor
4) an off-gas destruction system.

The gas feed system provides a clean, dry source of oxygen to the generator. The ozone contactor transfers the ozone-rich gas into the water to be treated, and provides contact time for ozonation reactions to occur. The final process step, off-gas destruction, is required as ozone gas is toxic in the concentrations present in the off-gas. Some ozonation systems include an off-gas recycle system that returns the ozone-rich off-gas to the first contact chamber to reduce the ozone demand in the subsequent chambers. Some systems may also include an optional quench chamber to remove any ozone residual that remains in solution.

Gas Feed System

Gas feed systems used in the ozonation process are classified as using air, high purity oxygen, or a combination of the two. High purity oxygen can be purchased and stored as a liquid, or it can be generated on-site through either a cryogenic process, with vacuum swing adsorption, or with pressure swing adsorption. Cryogenic generation of oxygen is a complicated process that is only feasible for large water systems.

Liquid oxygen feed systems are relatively simple, consisting of a storage tank, evaporators to convert the liquid to a gas, filters to remove impurities, and pressure regulators to limit the gas pressure to the ozone generators.

Air feed systems for ozone generators are fairly complicated as the air needs to undergo proper conditioning to prevent damage to the generator. Air that is fed to the generator must be clean and dry, with a maximum dew point of –60 °C, and free of contaminants. Air preparation systems typically consist of air compressors, filters, dryers, and pressure regulators.

Particles and moisture cause arcing within the generator, which damages generator dielectrics. Particles greater than 1 μm and oil droplets greater than 0.05 μm should be removed by filtration. Moisture removal can be achieved by either compression or cooling, which lowers the moisture holding capacity of the air, and by dessicant drying, which strips moisture from the air. Dessicant dryers are required for all air preparation systems.

Ozone Generator

Two different geometric configurations for the electrodes are used in ozone generators: (1) concentric cylinders, and (2) parallel plates. The parallel plate configuration is commonly used in small generators, and can be air-cooled.

Most of the electrical energy input to an ozone generator (about 85 percent) is lost as heat. Because of the adverse impact of temperature on the production of ozone, adequate cooling should be provided to maintain generator efficiency. For the concentric cylinder configuration, excess heat is usually removed by water flowing around the electrodes. The cylindrical tubes are usually arranged in either a horizontal or vertical configuration in a stainless steel shell, with cooling water circulated through the shell.

Ozone generators are classified by the frequency of the power applied to the electrodes. Low frequency (50 to 60 Hz) and medium frequency (60 to 1,000 Hz) generators are the most common found in the water industry. Medium frequency generators are efficient and can produce ozone economically at high concentrations, but they generate more heat than low frequency generators and require more complicated power supply to step up the frequency supplied by the power utility.

Ozone Contactors

Once ozone gas is transferred into water, the dissolved ozone reacts with the organic and inorganic constituents, including any pathogens. Ozone not transferred into the process water during contacting is released from the contactor as off-gas. Transfer efficiencies of greater than 80 percent typically are required for efficient ozone disinfection.

Common ozone transfer mechanisms that are used in the water industry include: (1) bubble diffusers, (2) injectors, and (3) turbine mixers.

Bubble diffuser contactors use ceramic or stainless steel diffusers that are either rod-type or disc-type to generate fine gas bubbles. Contactor volume is determined in conjunction with the applied ozone dosage and residual concentration to satisfy the disinfection CT requirements. Bubble-diffuser contactors are typically constructed with 20-foot water depths to achieve 85 to 95 percent ozone transfer efficiency. Since all of the ozone is not transferred into the water, the contactor chambers are covered to contain the off-gas. Off-gas is routed to an ozone destruction unit, usually catalysts, thermal, or thermal/catalysis.

For the injector method, ozone is injected into the water stream under negative pressure. A venturi section is used to generate the negative pressure on the ozone gas, which pulls the ozone into the water stream. The gas-to-liquid ratio is a key parameter in the design of injector contacting systems. This ratio should be less than 0.067 cfm/gpm in order to optimize ozone transfer efficiency. Meeting this criterion typically requires relatively low ozone dosages and ozone gas concentrations greater than 6 percent. High concentration ozone gas can be generated using a medium-frequency generator and/or liquid oxygen as the feed gas. To meet the CT disinfection requirements, additional contact time is required after the injector, typically in a plug flow reactor. The additional contact volume is determined in conjunction with the applied ozone dosage and estimated residual ozone concentration to satisfy the disinfection CT requirement. Since all of the ozone is not transferred into the water, the contactor chamber is covered to contain the off-gas. Off-gas is then routed to an ozone destruction unit.

Off-gas Destruction System

The concentration of ozone in the off-gas from a contactor is usually well above the permissible discharge limit. Thus, off-gas that is collected from the ozone contactors must be treated for destruction of the remaining ozone prior to its release to the atmosphere. The off-gas ozone destruction system is designed to reduce the ozone concentration to less than 0.1 ppm, the current limit set by OSHA for worker exposure in an eight hour shift. This is accomplished by elevating the temperature of the off-gas to 100 °C in the presence of a catalyst. A blower is used on the discharge side of the destruct unit to pull the air from the contactor, placing the contactor under a slight vacuum to ensure that no ozone escapes.

Instrumentation

Ozone technology requires careful monitoring for ozone leaks which pose a health hazard. Instrumentation should be provided for ozone systems to protect both personnel and the equipment. Gas phase ozone detectors should be provided in spaces such as generator and destruct rooms where ozone gas may be and personnel are routinely present. An ozone detector is also needed on the outlet from the off-gas destruct unit to ensure that the unit is working properly. These units should be interlocked with the ozone generator controls to shut down the ozone generation system should excess ozone be detected. A dew point detector on the feed gas supply just upstream of the generator is required to protect the generator from moisture in the feed gas. Flow switches on the cooling water supply are needed to protect the generator from overheating and a pressure switch to prevent over-pressurization.

Other instrumentation can be used to monitor and control the ozone process, although manual control is adequate for small systems, but most small systems are designed to operate automatically, particularly in remote areas. Ozone monitors can be used in conjunction with process flow meters to match ozone dose to process demands and control ozone generation. Sophisticated control schemes can be implemented to minimize the cost of dosing with ozone and reduce operator attention requirements. Many systems include residual monitoring at various points in the contactor to maintain a desired ozone residual and prevent energy-wasting overdosing.

Operation and Maintenance of Ozonation System

Even though ozone systems are complex, using highly technical instruments, the process is highly automated and very reliable. The production and feed systems require extensive training for operators to effectively run the system. Maintenance on ozone generators requires skilled technicians. If trained maintenance staff are not available at the plant, the work can be done by the equipment manufacturer.

Ozone generators should be checked on a daily basis when in operation. After a shutdown, dry air or oxygen should be allowed to flow through the generator to ensure that any moisture has been purged prior to energizing the electrodes. At initial start up and after long down times, this process may take up to 12 hours and usually longer when air is the feed gas.

Filters and dessicant air preparation systems should be changed periodically, with the frequency depending on the quality of the inlet air and the number of hours in operation. Compressors require periodic service, depending on the type and operating time. Piping and contact chambers should be inspected periodically to check for leaks and corrosion.

Dielectric tubes require cleaning when the generator efficiency drops by 10 to 15 percent. Cleaning is usually required every 4 to 5 years. Cleaning the tubes is usually performed by the manufacturer since it is a delicate operation and the tubes are fragile and expensive. Adequate space should be provided for the cleaning operation and for storage of spare tubes.

Advantages of Ozonation

The following advantages are realized when using ozone to treat water for *Cryptosporidium* inactivation:

- Produces no taste or odors in finished water.
- Used to control taste and odor problems associated with raw water.
- Oxidation of iron, manganese, and color.
- May reduces levels of DBP precursors in raw water.
- Disinfection efficacy is not significantly affected by pH.
- Provides a barrier for removal of contaminants of potential concern (CPCs), including synthetic organic chemicals (SOCs).
- Ozonation systems are highly automated and easy to operate.
- Decays rapidly in water.

Limitations of Ozonation

The following limitations must be considered when using ozone to treat water for *Cryptosporidium* inactivation:

- Ozone is highly toxic.
- Expensive to generate, and must be produced on-site.
- Much less soluble in water than chlorine; thus, special mixing devices are necessary.
- Ozone destroying device is needed at the exhaust of the ozone reactor to prevent toxicity and fire hazards.
- May produce undesirable ozonation by-products such as aldehydes and ketones when reacting with NOM present in the raw water supply. Also produces bromate when raw water contains the bromide ion.
- Provides no residual, and therefore, must be used in conjunction with a secondary disinfectant.
- Increases assimilable organic carbon (AOC) and BDOC, so ozone is often coupled with biological filtration to ensure biological stability through the distribution system
- The ozonation process produces high dissolved oxygen levels in the finished water supply, thereby increasing the finished water corrosivity and potential for microbial regrowth in the distribution system.

Cost Estimate for Installation of Ozonation Facilities at the City and Borough of Sitka WTP

The CPES cost estimating tool was used to prepare order-of-magnitude cost estimates for installation of ozonation facilities at the CBS WTP. CT requirements for *Cryptosporidium* inactivation using ozone as the primary disinfectant were obtained from the final LT2ESWTR. The estimate was generated based on the requirements for 3-log *Cryptosporidium* inactivation. This log inactivation level represents extreme that CBS will be required to provide in order to comply with the regulations for unfiltered surface water systems. An assumed peak plant flow rate of 6.0 mgd was used to generate capital cost estimates. Further evaluation will be required in order to determine the actual design flow prior to the design of any future treatment alternative.

For CBS's water treatment plant, the most likely location of ozonation facilities in the process train is upstream of the existing chlorine feed system. The ozonation facilities would be used to provide primary disinfection, whereas chlorine would be used as a secondary disinfectant for providing distribution system residual.

The following set of assumptions was used to arrive at cost estimates for ozonation facilities:

- Type of feed gas: Liquid Oxygen (NOTE: If an adequate supply of Liquid Oxygen is not available in Sitka, this would be changed to air. This would result in a significant increase in operating costs.)
- Ozone transfer mechanism: Diffused bubble
- Minimum water temperature: 1 °C
- Immediate ozone demand: 0.4 mg/L based on studies conducted on similar water sources

- Applied ozone dose: 5.5-7.5 mg/L
- Ozone residual decay rate: 0.02/min based on studies conducted on similar water sources
- Ozone transfer efficiency: 95%
- Contactor basin side water depth: 20 ft
- CT requirements for 3-log *Cryptosporidium* inactivation: 69 mg·min/L
- Ozone system components: 2 over/under contactor basins, 2 ozone generators, diffusion system, instrumentation and valves, ozone destruct units, and cooling system.
- A finished water pump station is required to boost ozonated water into the distribution system.
- Ozone is used as the primary disinfectant, with the existing chlorination facilities used to establish a disinfectant residual in the distribution system.
- Power Costs: $0.09/kwh
- Additional Labor: 1 Full Time Equivalent (more or less may be required based on operational strategy and current staff workload.
- Average Treatment Plant Flow: 4.0 mgd

Table 3 contains order-of-magnitude capital cost estimates for the installation of ozonation facilities at the City and Borough of Sitka WTP. Two separate estimates are provided, based on 2-log and 3-log *Cryptosporidium* inactivation, and an assumed maximum plant capacity of 6.0 mgd. Annual operating costs include labor, chemicals, maintenance, replacement parts, electricity, and maintenance and are based on an annual average flow rate of 4.0 mgd.

TABLE 3
Estimated Capital and Annual Operating Costs for Ozonation Facilities
6.0-mgd Plant Capacity

Cost Category	Costs
Construction Costs[1]	$18,800,000
Non-Construction Costs[2]	$8,500,000
Total Capital Cost[3]	*$27,300,000*
Annual Operating Cost[3]	*$1,387,000*

1. Construction costs include buildings, ozonation facilities, post-ozonation pump station, demolition, sitework, yard electrical, yard piping, and contractor markups.
2. Non-construction costs include permitting (5%), engineering (15%), services during construction and commissioning/startup (15%), and legal/administrative fees (10%).
3. Order-of-magnitude cost estimate, in 2008 dollars.

The results of Table 3 indicate that the anticipated capital requirement for installation of ozonation facilities at the City and Borough of Sitka WTP is approximately $27.3 million.

The costs are provided in 2008 dollars. Currently, the construction market is experiencing significant fluccuation in material and labor costs which have resulted in unusual cost escalation. These are order-of-magnitude estimates for capital expenditures, accurate to within +50 percent to –30 percent.

In Table 4 below, the space requirements for the ozonation facilities are provided. The structures that are required for ozonation facilities include two contactor basins, one ozone generator building, one ozone destruct building, and one booster pump building.

TABLE 4
Space Requirements for Ozonation Facilities

Unit Process	Structure Space Requirement
Ozone Generation	2,660 sf
Ozone Destruct	720 sf
Ozone Contactor	2,210 sf
Liquid Oxygen Storage	1,700 sf
Ozone Quench	880 sf
Finished Water Pump Station	640 sf
Total Building Area	8,810 sf (0.20 ac)
Approximate Structure Footprint	88' W x 100' L

The results of Table 4 indicate that installation of ozonation facilities will require approximately 0.20 acres of land. The main point worth noting about the space requirements is the volume of the contactor basins, where the required volume is 150,000 gallons. This is a direct result of the relatively high CT requirements for *Cryptosporidium* removal when ozone is used as the disinfectant. Note that these figures only apply to the area required for structures, and do not include land requirements for roads, driveways, loading/unloading zones, parking, etc.

Based on a preliminary analysis of the existing chlorine facility site, ozone facilities could not be installed by CBS without relocating the existing chlorination facilities.

Chlorine Dioxide

Chlorine dioxide has uses both as an oxidant and a primary disinfectant in water treatment. Currently, there are over 500 public water systems world-wide that use chlorine dioxide to treat potable water. It is produced by the reaction of sodium chlorite with chlorine, and must be generated on-site at the treatment plant.

Properties of Chlorine Dioxide

Chlorine dioxide (ClO_2) is a powerful chemical oxidant. It is a relatively small, volatile, and highly energetic molecule that reacts strongly with reducing agents. Despite its volatility, chlorine dioxide does remain fairly stable in dilute solution in the absence of light.

One of the most important physical properties of chlorine dioxide is its high solubility in water. In contrast to the hydrolysis reactions of chlorine gas in water, chlorine dioxide does not hydrolyze when added to water; instead, it remains in solution as a dissolved gas. Chlorine dioxide is approximately 10 times more soluble in water than chlorine, even though its volatility allows for easy removal with a minimal amount of aeration. Unlike ozone, chlorine dioxide can be used for post-CT disinfectant credit to establish a disinfectant residual for the distribution system.

Chlorine dioxide cannot be compressed or stored commercially as a gas because it is explosive under pressure. Therefore, it is never shipped, and must be generated on-site. Most commercial generators use sodium chlorite ($NaClO_3$) as the common precursor feedstock chemical to generate chlorine dioxide for drinking water application. Conventional systems generate chlorine dioxide by reacting sodium chlorite with an acid and either chlorine (gaseous or aqueous), or hydrogen peroxide (otherwise known as purate).

Chlorine dioxide generation and addition to water produces by-products of chlorite and chlorate, both of which can be harmful to humans. The Stage 1 Disinfectants and Disinfection By-products Rule regulates both chlorine dioxide and chlorite levels in drinking water. The maximum residual disinfectant level (MRDL) for chlorine dioxide is 1.0 mg/L, and the maximum contaminant level (MCL) for chlorite is 0.8 mg/L. The formation of chlorite greatly limits the dose that can be applied to water. If the oxidant demand of the water to be treated with chlorine dioxide is greater than 1.4 mg/L, the formation of chlorite in the water may exceed the chlorite MCL. Chlorine dioxide can also produce distribution system related taste and odor at residual levels above 0.4 mg/L. Typical doses in water treatment vary between 0.07 and 2.0 mg/L.

As an oxidant, chlorine dioxide can be used to treat taste and odors in the raw water. Chlorine dioxide destroys phenolic compounds that cause taste and odors, as well as the compounds associated with decaying vegetation and algae. Chlorine dioxide can also be used to remove dissolved iron and manganese from water by reacting with the soluble ions to form insoluble precipitates.

Chlorine Dioxide Disinfection

The calculation of CT for chlorine dioxide is similar to other chemical disinfectants, with accurate determinations of residual concentration being a prerequisite for effective disinfection. Primary disinfection credit is achieved by the residual concentration and the effective contact time. It has been found in practice that because of the volatile nature of the gas, chlorine dioxide works extremely well in plug flow reactors such as pipelines. It can be easily removed from dilute aqueous solution by turbulent aeration in rapid mix tanks or purging in recarbonation basins. For post-CT disinfection credit, chlorine dioxide can be added before clearwells or transmission pipelines. Ample monitoring points should be included to allow close monitoring of residual concentrations.

Chlorine Dioxide CT Requirements for *Cryptosporidium* Inactivation

The chlorine dioxide CT requirements for disinfection of *Cryptosporidium* are contained in the LT2ESWTR. The CT requirements are a function of water temperature (ranging from <

0.5 to 25 °C) and targeted level of *Cryptosporidium* inactivation (ranging from 0.5-log to 3-log inactivation).

For CBS's water treatment facilities, *Cryptosporidium* inactivation requirements will be determined by the outcome of source water monitoring that is expected for compliance with the anticipated LT2ESWTR. For unfiltered surface water systems the level of *Cryptosporidium* inactivation will either be 2-log or 3-log. Recent sampling indicates that the minimum temperature for CBS's raw water supply is 1 °C. According to the Final LT2, chlorine dioxide CT requirements for *Cryptosporidium* inactivation at 1 °C are 1,220 mg·min/L for 2-log inactivation and 1,830 mg·min/L for 3-log inactivation. These CT values are for systems that measure both the initial and the final chlorine dioxide residual in the contact chamber and use the geometric mean of the two values for the residual concentration, C. These CT values, combined with the realistic limits on chlorine dioxide dose to remain in compliance with the chlorite MCL, mean that a contact basin with a contact time on the order of 1,800 minutes (30 hours) would be required.

Chlorine Dioxide Disinfection By-products and Oxidation Demands

Chlorine dioxide produces chlorite and chlorate as byproducts in water, both of which are regulated under the Stage 1 Disinfectants/Disinfection By-products Rule. Chlorine dioxide does not produce halogenated DBPs, and can be used as one mechanism for the reduction of DBP precursors (by oxidation of organic material) in water. However, the possibility does exist for the production of nonhalogenated DBPs that are not currently regulated, but may be regulated in the future.

Chlorite and chlorate are produced in varying ratios as endproducts during chlorine dioxide treatment and subsequent degradation. The primary factors affecting the concentrations of chlorine dioxide, chlorite, and chlorate in finished drinking water involve:

- dosage applied/oxygen demand ratio
- blending ratios of sodium chlorite and chlorine during the generation process
- exposure of water containing chlorine dioxide to sunlight
- reactions between chlorine and chlorite when free chlorine is used for distribution system residual maintenance
- levels of chlorate in sodium chlorite feedstock.

Numerous inorganic and biological materials found in raw water will react with chlorine dioxide. Chloride, chlorite, and chlorate ions are the dominant degradation species arising from these reactions. Chlorite is the primary product of chlorine dioxide reduction. Approximately 50 to 70 percent of the chlorine dioxide consumed by oxidation reactions is converted to chlorite under conditions typical in water treatment. The application of 2 mg/L chlorine dioxide produces between 1 and 1.4 mg/L of chlorite.

Chlorite is relatively stable in the presence of organic material but can be oxidized to chlorate by free chlorine if added as a secondary disinfectant. Chlorate is therefore produced through the reaction of residual chlorite and free chlorine during secondary disinfection.

EPA recommends that the total concentration of chlorine dioxide, chlorite, and chlorate be less than 1.0 mg/L as Cl_2. In addition, chlorine dioxide concentrations exceeding 0.4 to 0.5 mg/L may contribute to taste and odor problems in finished water. Due to these issues, the use of chlorine dioxide to provide a disinfectant residual is somewhat limited in moderate to high TOC water. In low oxidant-demand water, chlorine dioxide residuals may last several days.

Design of ClO_2 Disinfection System

Major equipment that is required for a chlorine dioxide disinfection system includes stock chemical storage and feed systems, chlorine dioxide generators, and feed piping and injection equipment. When designing a disinfection system that utilizes chlorine dioxide as the primary means of *Cryptosporidium* inactivation, the following design criteria must be considered:

- chlorine dioxide contact concentrations
- competing oxidation demands
- managing chlorine dioxide dose to maintain compliance with chlorite MCL
- CT level to meet the regulatory requirements for inactivation of *Cryptosporidium*.

System Components

Chlorine dioxide disinfection systems have two basic components:

1) chlorine dioxide generator
2) contactor basins.

Chlorine dioxide generators are relatively simple mixing chambers. The chambers are frequently filled with media (Teflon chips, ceramic or raschig rings) to generate hydraulic turbulence for mixing. The generators require careful monitoring of the chemical feed rates and mixture to ensure the most efficient production of chlorine dioxide. If not carefully monitored, chlorine dioxide generation can produce excess chlorine, as well as excessive concentrations of chlorites that cannot be easily removed from the process stream.

Contactor basins should be designed to optimize hydraulics and minimize short circuiting, with sufficient detention time to meet the CT requirements for *Cryptosporidium* removal.

Operational Considerations and Monitoring Requirements

Chlorine dioxide systems typically include the following operational considerations and monitoring requirements:

- Storage and feeding in a designated space.
- Storage in clean, closed, non-translucent containers. Exposure to sunlight, UV light, or excessive heat will reduce product strength.
- Avoid storage and handling of combustible or reactive materials, such as acids or organic materials, in the sodium chlorite area.

- Secondary containment for storage and handling areas to accommodate the worst case spill with sumps provided to facilitate recovery.
- A water supply near storage and handling areas for cleanup.
- Adequate ventilation and air monitoring.
- Flow monitoring on all chemical feed lines, dilution water lines, and chlorine dioxide solution lines.
- Air contact with chlorine dioxide solutions should be controlled to limit the potential for explosive concentrations building up within the generator. Chlorine dioxide concentrations greater than 10 percent should be avoided.
- The MRDL for chlorine dioxide is 0.8 mg/L and the MCL for chlorite is 1.0 mg/L. This means that if the oxidant demand is greater than about 1.4 mg/L, chlorine dioxide may not be used as a disinfectant because the chlorite/chlorate ion by-products might exceed the maximum allowable level.
- Daily monitoring for chlorite and chlorine dioxide is required at the entrance to the distribution system. For any daily sample that exceeds the chlorine dioxide MRDL of 0.8 mg/L or the chlorite MCL of 1.0 mg/L, the system must take additional samples in the distribution system the following day at the locations specified in the Disinfectants/Disinfection By-products Rule.

Advantages of Chlorine Dioxide Use

The following advantages may be realized when using chlorine dioxide as a disinfectant for *Cryptosporidium* inactivation:

- Taste and odors resulting from algae and decaying vegetation, as well as phenolic compounds, are controlled by chlorine dioxide.
- Chlorine dioxide is easy to generate.
- Oxidation of iron, manganese.
- Provides plant control over algae growth.
- Does not produce halogenated DBPs.

Limitations of Chlorine Dioxide Use

The following limitations must be considered when using chlorine dioxide as a disinfectant for *Cryptosporidium* inactivation:

- Requires an extremely long reaction time for inactivation of *Cryptosporidium.*
- The process forms chlorite and chlorate as by-products.
- Costs associated with training, sampling, and laboratory testing for chlorite and chlorate are high.

- The cost of sodium chlorite is high.
- The chlorine dioxide dose cannot exceed 1.4 mg/L in order to limit the total combined concentration of chlorine dioxide, chlorite, and chlorate to a maximum of 1.0 mg/L.
- Chlorine dioxide gas is explosive, so it must be generated on-site.
- Chlorine dioxide can produce noxious odors in some systems. Dialysis patients may be adversely affected by the presence of chlorine dioxide in water.
- The process of producing chlorine dioxide includes the storage and use of multiple hazardous chemicals

Cost Estimate for Installation of ClO_2 Disinfection Facilities at the City and Borough of Sitka WTP

The CPES cost estimating tool was used to prepare an order-of-magnitude cost estimate for installation of chlorine dioxide disinfection facilities at the CBS WTP. CT requirements for *Cryptosporidium* inactivation using chlorine dioxide as the primary disinfectant were obtained from the Final LT2ESWTR. The estimate was generated based on the requirements for 3-log *Cryptosporidium* inactivation. This log inactivation level represents extreme that CBS will be required to provide in order to comply with the regulations for unfiltered surface water systems. An assumed peak plant flow rate of 6.0 mgd was used to generate capital cost estimates. Further evaluation will be required in order to determine the actual design flow prior to the design of any future treatment alternative.

For the City and Borough of Sitka water treatment plant, the most likely location of chlorine dioxide injection in the process train is upstream of the existing chlorine feed system. The chlorine dioxide would be used to provide primary disinfection, whereas chlorine would be used as a secondary disinfectant for providing distribution system residual. The installation of chlorine dioxide would require a new clearwell downstream of the chlorine facility to provide the necessary chlorine contact time.

The following set of assumptions was used to arrive at cost estimates for chlorine dioxide facilities:

- Purate chlorine dioxide generation system using sodium chlorate, hydrogen peroxide, and sulfuric acid.
- Minimum water temperature: 1 °C.
- Chlorine dioxide first order decay constant: 0.00025/min*.

  * NOTE: 0.00025/min is an extremely low value for chlorine dioxide decay. Testing has **not** been conducted on the CBS water but it would likely show that the decay rate for chlorine dioxide would be higher. If a higher decay rate were found in CBS water, the cost of the chlorine dioxide alternative would increase significantly.

- Chlorine dioxide dose: 1.4 mg/L.
- 3,000 min (2.1 days) of chlorine dioxide contact time

- CT requirements for 3-log *Cryptosporidium* inactivation: 1,830 mg·min/L.
- CT Reservoirs: Two 6.25 million gallon, circular reinforced concrete, serpentine flow, w/ cover. The reservoirs are at atmospheric pressure.
- Chlorine dioxide system components: contactor basin, chlorine dioxide generator, purate tanks, sulfuric acid tanks, instrumentation and valves.
- Chlorine dioxide is used as the primary disinfectant, with the existing chlorination facilities used to provide a disinfectant residual in the distribution system.
- Booster pump station: 4 vertical turbine pumps to pump water into the distribution system.
- Power Costs: $0.09/kwh
- Additional Labor: 1 Full Time Equivalent (more or less may be required based on operational strategy and current staff workload.
- Average Treatment Plant Flow: 4.0 mgd

Table 5 contains order-of-magnitude capital cost estimates for the installation of chlorine dioxide disinfection facilities at the City and Borough of Sitka WTP. The estimate provided is based on 3-log *Cryptosporidium* inactivation, and an assumed maximum plant capacity of 6.0 mgd. Annual operating costs include labor, chemicals, maintenance, replacement parts, electricity, and maintenance and are based on an annual average flow rate of 4.0 mgd.

TABLE 5
Estimated Capital and Annual Operating Costs for Chlorine Dioxide Disinfection Facilities
6.0-mgd Plant Capacity

Cost Category	Costs
Construction Costs[1]	$24,100,000
Non-Construction Costs[2]	$10,800,000
Total Capital Cost[3]	*$34,900,000*
Annual Operating Cost[3]	*$1,500,000*

1. Construction costs include buildings, chlorine dioxide disinfection facilities, demolition, sitework, yard electrical, yard piping, and contractor markups.
2. Non-construction costs include permitting (5%), engineering (15%), services during construction and commissioning/startup (15%), and legal/administrative fees (10%).
3. Order-of-magnitude cost estimate, in 2008 dollars.

The results of Table 5 indicate that the capital requirements for installation of chlorine dioxide disinfection facilities at the CBS WTP is approximately $34.9 million, depending on the level of treatment that is required. The costs are provided in 2008 dollars. Currently, the construction market is experiencing significant fluccuation in material and labor costs which have resulted in unusual cost escalation. These are order-of-magnitude estimates for capital expenditures, accurate to within +50 percent to –30 percent.

The space requirements for the chlorine dioxide disinfection facilities are presented in Table 6. The structures that are required for chlorine dioxide disinfection facilities include the chlorine dioxide generator and CT reservoirs.

TABLE 6
Space Requirements for Chlorine Dioxide Disinfection Facilities

Unit Process	Stucture Space Requirement
Chlorine Dioxide Generation	2,090 sf
Clearwells, Each (2 Total)	27,760 sf
Finished Water Pump Station	660 sf
Total Building Area	58,270 sf (1.34 ac)
Approximate Structure Footprint	188' W x 400' L[1]

1. Approximate Facility Size based on space required for two 188’ diameter CT Reservoirs.

The results of Table 6 indicate that installation of chlorine dioxide treatment facilities will more than 1.34 acres of land. The main point worth noting about the space requirements is the considerable size of the CT reservoirs, where the required volume is 12.5 million gallons, depending on the level of treatment provided. This is a direct result of the extremely high CT requirements for *Cryptosporidium* inactivation when chlorine dioxide is used as the disinfectant. Note that these figures only apply to the area required for structures, and do not include land requirements for roads, driveways, loading/unloading zones, parking, etc.

Based on the size and cost of the chlorine dioxide system, it is clear that it is not practical to consider it further for use at the City and Borough of Sitka.

Membrane Filtration

A membrane, or more properly, a semipermeable membrane, is a thin layer of material capable of separating substances when a driving force is applied across the membrane surface. Membrane processes can be separated into four basic categories—reverse osmosis, nanofiltration, ultrafiltration, and microfiltration. Reverse osmosis (RO) and nanofiltration (NF) are used to remove dissolved inorganic compounds such as sodium, calcium, and magnesium ions, or dissolved organic compounds such as humic and fulvic acids that make up the primary source of DBP precursors. They operate at transmembrane pressures of about 80 to 1,200 psi. Ultrafiltration (UF) and microfiltration, on the other hand, cannot remove dissolved materials, and are limited to the removal of particulate material. UF membranes have a nominal pore size of between 0.003 and 0.03 μm, whereas MF membranes have a nominal pore size of between 0.05 and 0.5 μm. UF and microfiltration operate at transmembrane pressures of about 5 to 100 psi.

Microfiltration membranes, because of pore size, are generally limited to removal of bacteria and protozoans like *Giardia* and *Cryptosporidium*, while UF membranes have the added feature of removing not only protozoans and bacteria, but also viruses. Some microfiltration membranes are also credited with virus removal though.

Membrane processes have become more attractive for potable water treatment in recent years due to the increased stringency of drinking water regulations. In this document, we will focus on the microfiltration/ultrafiltration membrane process as it applies to *Cryptosporidium* removal.

Membrane Filtration (MF) Process

Membrane filtration (MF) is loosely defined as a membrane separation process using membranes with a 0.1-μm (or smaller) nominal pore size, and a relatively low feedwater operating pressure of 15-60 psi. Representative materials removed by MF include sand, silt, clays, *Giardia lamblia*, *Cryptosporidium*, cysts, algae, and most bacterial species. MF is not an absolute barrier to viruses in all cases; however, when used in combination with disinfection, it is an effective means of eliminating viruses.

The primary impetus for the more widespread use of MF has been the increasingly stringent requirements for removing particles and microorganisms from drinking water supplies. Additionally, there has been a growing emphasis on limiting concentrations and number of chemicals that are applied during water treatment. By physically removing pathogens, membrane filtration can significantly reduce chemical addition as compared to conventional filtration technology.

MF membranes provide absolute removal of particulate contaminants from a feed stream by separation based on retention of particulates on the membrane surface. In the simplest design, the MF process involves pumping of raw feed water under pressure onto a membrane. For municipal-scale drinking water applications, the commercially available membrane geometries that are the most commonly employed are spiral wound, tubular, and hollow capillary fiber. However, spiral-wound configurations are not normally employed for MF due to the flat-sheet nature of the membrane, which presents difficulties in keeping the membrane surface clean. Unlike spiral-wound membranes, hollow-fiber and tubular configurations allow the membrane to be backwashed, a process by which fouling due to particulate and organic materials is controlled.

The components of most commercially-available MF membrane plants include feed pumps, cleaning tanks, automatic backwash system, and membrane modules. Product water recovery (ratio of finished water flowrate to raw water flowrate) for MF technology ranges from 85 to 95 percent, and can be even higher in cases where the raw water has low levels of suspended solids.

Operational and Maintenance Considerations

In Membrane Filtration, there are two methods for maintaining or re-establishing permeate flux after membranes are fouled: (1) membrane backwashing, and (2) chemical cleaning.

Membrane Backwashing

In order to prevent the continuous accumulation of solids on the membrane surface, the membrane is periodically backwashed. Unlike backwashing for conventional media filtration, the backwashing cycle for MF takes only a few minutes. Both liquid and gas backwashing are employed with MF technology. For most systems, backwashing is fully automatic.

Chemical Cleaning

If backwashing is incapable of restoring the flux, then membranes are chemically cleaned. The variables that should be considered in cleaning MF membranes include frequency and duration of cleaning, chemicals and their concentrations, cleaning and rinse volumes, temperature of cleaning, recovery and reuse of cleaning chemicals, neutralization and disposal of cleaning chemicals.

Residuals Handling Facilities

Residuals handling facilities for treatment of waste streams are often a major component of the MF process. Waste streams that are generated as part of the MF process include high-turbidity water from routine backwash operations, and chemical solutions that are used to remove foulants from the membrane surfaces. Waste stream volumes generated during routine backwash operations can amount to between 5 and 15 percent of the total finished water production, depending on the raw water quality. For most applications, backwash water can be discharged to a sewer with no additional treatment. Spent chemical solutions may require neutralization before being discharged to a sewer. If there is no sewer connection available, the treatment plant will need to install residuals handling facilities. These facilities may include such devices as clarifiers, solids thickeners, neutralization tanks, and solids drying beds.

Advantages of Membrane Filtration

The following advantages are realized when using membrane filtration to treat water for removal of *Cryptosporidium*:

- Very effective for removal of protozoa and bacteria, with greater than 5-log (99.999%) removal.
- Reliability of consistent effluent quality.
- Automation provides ease of operation.

Limitations of Membrane Filtration

The following limitations must be considered when using membrane filtration to treat water for removal of *Cryptosporidium*:

- Does not provide residual disinfection. Must be followed by a secondary disinfectant (i.e., chlorine) for maintaining a disinfectant residual in the distribution system.
- Need to clean membranes using acids, oxidants, and caustic solutions.
- Produces a waste stream that will likely require treatment.
- Post-filter disinfection required for viral inactivation.

Cost Estimate for Installation of MF Treatment Facilities at the City and Borough of Sitka WTP

The CPES cost estimating tool was used to prepare an order-of-magnitude cost estimate for installation of membrane filtration facilities at the CBS WTP. A peak plant flow rate of 6.0 mgd was used to generate the capital cost estimate. Further evaluation will be required in order to determine the actual design flow prior to the design of any future treatment alternative. Because MF does not provide adequate virus inactivation or disinfectant residual, it is assumed that MF would be used in conjunction with the existing chlorination facilities at the treatment plant.

For CBS's water treatment plant, the proper location of MF treatment facilities in the process train is upstream of the existing chlorine feed system. The MF system would provide filtration of bacteria and protozoa, whereas chlorine would be used as a primary disinfectant for viral inactivation and for establishing a residual disinfectant concentration in the distribution system.

The following set of assumptions was used to arrive at cost estimates for membrane filtration facilities:

- Hollow fiber MF technology based on Pall Corp. If CBS were to ultimately select MF, additional vendor systems would be considered.
- MF system is located in a stand-alone building, along with supporting electrical facilities and chemical systems.
- Process waste is discharged to a backwash equalization and decant facility and then recycled upstream of the membrane filtration facility.
- Virus inactivation and distribution system residual disinfectant is provided by existing chlorination facilities.
- MF system provides greater than 5-log removal of *Cryptosporidium*.
- MF facilities include MF rack and modules, feed pumps, backwash pumps, air scour system, chemical tanks/pumps, membrane facilities building, instrumentation and controls.
- Flux Rate: 90 gallons/sf/day
- Chemical Cleaning Frequency: 100 days
- Number of Skids: 5 online + 1 redundant
- Power Costs: $0.09/kwh
- Additional Labor: 1 Full Time Equivalent (more or less may be required based on operational strategy and current staff workload.
- Average Treatment Plant Flow: 4.0 mgd

Table 7, below contains an order-of-magnitude capital cost estimate for the installation of membrane filtration facilities at the City and Borough of Sitka WTP. A single estimate is provided, based on 2008 dollars and an assumed maximum plant capacity of 6.0 mgd. Annual operating costs include labor, chemicals, maintenance, replacement parts, electricity, and maintenance and are based on an annual average flow rate of 4.0 mgd.

The results of Table 7 indicate that the installation of membrane filtration facilities at the CBS WTP will cost $46.5 million. The costs are provided in 2008 dollars. Currently, the construction market is experiencing significant fluccuation in material and labor costs which have resulted in unusual cost escalation. This is an order-of-magnitude estimate for capital expenditures, accurate to within +50 percent to –30 percent.

TABLE 7
Estimated Capital and Annual Operating Costs for Membrane Filtration Facilities
6.0-mgd Plant Capacity

Cost Category	Capital Costs
Construction Costs[1]	$32,100,000
Non-Construction Costs[2]	$14,400,000
Total Capital Cost[3]	*$46,500,000*
Annual Operating Cost[3]	*$2,370,000*

1. Construction costs include facilities building, membrane filtration rack and modules, feed pumps, backwash pumps, air scour system, chemical tanks/pumps, instrumentation/controls, demolition, sitework, yard electrical, yard piping, and contractor markups.
2. Non-construction costs include permitting (5%), engineering (15%), services during construction and commissioning/startup (15%), and legal/administrative fees (10%).
3. Order-of-magnitude cost estimate, in 2008 dollars.

Table 8 contains the space requirements for the membrane filtration facilities. All membrane filtration facilities would be contained in a single facilities building.

TABLE 8
Space Requirements for Membrane Filtration Facilities

Unit Process	Structure Space Requirement
Flocculation	1,070 sf
Membrane Filtration	9,600 sf
Polymer System	340 sf
Alum System	5,740 sf
Backwash Recycle Basin	1,610 sf
Finished Water Pump Station	640 sf
Total Building Area	19,000 sf (0.44 ac)
Approximate Structure Footprint	100' W x 190' L

The results of Table 8 indicate that the MF facilities building will require 0.44 acres of land. Note that this applies only to the building footprint, and does not include land requirements for roads, driveways, loading/unloading zones, parking, etc.

Based on the necessary size required for membrane filtration facilities for the City and Borough of Sitka, it does not appear to be possible to locate membrane filtration on the site of the existing chlorine facility and so in order to install membrane filtration, the existing chlorination facility would need to be relocated downstream of the membrane facility.

Granular Media Filtration

The final method to be considered in this technical memorandum for removal/inactivation of *Cryptosporidium* is high-rate gravity granular media filtration.

High-Rate Granular Filters

The CPES cost estimating tool was used to generate a cost estimate and space requirements for installation of high-rate gravity filters at the CBS WTP. The high-rate granular media filtration process contains the following basic elements:

1) Coagulant addition and mixing, with alum as the coagulant.
2) Gravity filtration through granular media filters.
3) Backwash waste facilities.

For CBS's water treatment plant, the likely location of conventional filtration facilities in the process train is upstream of the existing chlorine feed system. The conventional filtration system would be used to provide the necessary removal of suspended solids and microorganisms, whereas chlorine would be used as a primary disinfectant and for establishing a residual disinfectant concentration in the distribution system. Under this treatment scenario, a portion of the 4.4 million gallon clearwell capacity would become available as equalization storage to cover the peaking requirements of CBS's water customers.

The following assumptions were used to generate cost estimates:

- Alum and polymer used for coagulation of raw water.
- Rapid mix system consisting of an in-line static mixer.
- Flocculation with 15 minutes of retention time
- Dual media filters consisting of 60-inches of anthracite over 12-inches of sand.
- Filter backwash consisting of bed fluidization and air scour.
- A post-filtration pump station is required to pump filtered water into the distribution system.
- Process waste is discharged to a backwash equalization and decant facility and then recycled upstream of the filtration plant

- Filter loading rate of 10 gpm/sf
- Filter run time prior to backwashing of 12 hours, minimum
- Power Costs: $0.09/kwh
- Additional Labor: 1 Full Time Equivalent (more or less may be required based on operational strategy and current staff workload.
- Average Treatment Plant Flow: 4.0 mgd

Table 9 contains an order-of-magnitude capital cost estimate for the installation of high-rate granular filtration facilities at the City and Borough of Sitka WTP. A single capital cost estimate is provided, based on 2008 dollars and a maximum plant capacity of 6.0 mgd. Annual operating costs include labor, chemicals, maintenance, replacement parts, electricity, and maintenance and are based on an annual average flow rate of 4.0 mgd.

TABLE 9
Estimated Capital Costs for High-Rate Granular Filtration Facilities
6.0-mgd Plant Capacity

Cost Category	Price
Construction Costs[1]	$16,600,000
Non-Construction Costs[2]	$7,500,000
Total Capital Cost[3]	*$24,100,000*
Annual Operating Cost[3]	*$1,200,000*

1. Construction costs include control building, gravity filters, chemical pretreatment system, backwash pumps, chemical tanks/pumps, instrumentation/controls, post-filtration pump station, demolition, sitework, yard electrical, yard piping, and contractor markups.
2. Non-construction costs include permitting (5%), engineering (15%), services during construction and commissioning/startup (15%), and legal/administrative fees (10%).
3. Order-of-magnitude cost estimate, in 2008 dollars.

The results of Table 9 indicate that the capital requirements for installation of high-rate gravity filtration facilities at the City and Borough of Sitka WTP total $24.1 million.

Table 10 contains the space requirements for the gravity filters. The space estimate includes a chemical storage building, rapid mix facilities, blower building, filters, and post-filtration pump station.

TABLE 10
Space Requirements for Gravity Filters

Unit Process	Structure Space Requirement
Flocculation	1,070 sf
High-Rate Granular Filtration	5,530 sf
Polymer System	340 sf
Alum System	5,740 sf
Backwash Recycle Basin	1,430 sf

TABLE 10
Space Requirements for Gravity Filters

Unit Process	Structure Space Requirement
Flocculation	1,070 sf
High-Rate Granular Filtration	5,530 sf
Finished Water Pump Station	640 sf
Backwash Supply Pump Station	540 sf
Total Building Area	14,750 sf (0.34 ac)
Approximate Structure Footprint	100' W x 150' L

The results of Table 10 indicate that the gravity filters and pump station will require 0.34 acres of land. Note that this applies only to the building footprints, and does not include land requirements for roads, driveways, loading/unloading zones, parking, etc.

Due to site constraints at the existiong chlorination facility, it would likely not be possible to locate gravity filtration systems there. Another site would need to be determined for location of a gravity filtration system.

Summary of Capital Costs and Space Requirements for Treatment Alternatives

Table 11 contains a summary of the capital costs and space requirements for the various treatment options that were examined in this technical memorandum. Capital costs are order-of-magnitude estimates, computed in 2008 dollars. 25-yr life cycle costs are based on current capital costs and 5% inflation on the annual operating costs for each facility.

TABLE 11
Summary of Capital and Life Cycle Costs for *Cryptosporidium* Treatment Alternatives
City and Borough of Sitka Water Treatment Plant

Treatment Alternative	Capital Cost	Annual O&M and Labor Costs	25 Yr Life Cycle Cost	Approximate Structure Area
UV Disinfection	$5,500,000	$374,000	$9,200,000	1,500 sf (0.03 ac)
Ozone Disinfection	$27,300,000	$1,487,000	$40,900,000	8,810 sf (0.20 ac)
Chlorine Dioxide Disinfection	$34,900,000	$1,500,000	$49,600,000	58,270 sf (1.34 ac)
High-Rate Granular Filtration	$24,100,000	$1,170,000	$35,500,000	14,750 sf (0.34 ac)
Membrane Filtration	$46,600,000	$2,370,000	$69,800,000	19,000 sf (0.44 ac)

An examination of the five treatment options contained in Table 13 reveals that UV disinfection is the most cost effective alternative for treatment of *Cryptosporidium* from both a capital and life cycle cost perspective. From the capital cost perspective, installation of UV facilities would require approximately $5.5 million of capital outlay (2008 dollars), whereas the remaining options require between $24.1 and $46.6 million of capital cost. UV facility's structures also require the least amount of land, at about 0.03 acres, whereas the remaining options require between 0.20 and 1.34 acres of land. As a baseline requirement, each alternative will meet the treatment requirements of the LT2ESWTR. Therefore, we recommend planning for UV disinfection facilities at the City and Borough of Sitka WTP in order to comply with recently promulgated requirements for *Cryptosporidium* treatment.

Chapter 6
UV Disinfection System Evaluation and Conceptual Design

Introduction

Congress passed the Safe Drinking Water Act (SDWA) to improve public health. The SDWA 1966 amendments required the U. S. Environmental Protection Agency (EPA) to develop Drinking Water Rules to balance certain health risks. On January 5, 2006, EPA promulgated the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) to address health effects of the microbial pathogen *Cryptosporidium* and its resistance to traditional disinfection practices. Additionally, LT2ESWTR requires all filtration avoidance systems to add a second disinfectant.

The purpose of installing an Ultraviolet (UV) disinfection system at City and Borough of Sitka's (CBS) water treatment facilities is to provide the required second disinfectant. Between the two disinfectants, UV and chlorination disinfection, *Giardia*, *Cryptosporidium* and viruses are to be inactivated at or above the required inactivation amounts: 99.9 percent (3-log) for *Giardia* and *Cryptosporidium;* 99.99 percent (4-log) for viruses. By providing 3-log *Cryptosporidium* inactivation, CBS does not need to perform *Cryptosporidium* monitoring required by LT2ESWTR.

This technical memorandum provides a preliminary engineering analysis of the available UV disinfection system alternatives for CBS's water treatment facilities. A conceptual design was conducted to determine the feasibility of three potential UV equipment systems for CBS's water treatment facilities in terms of the building footprint, hydraulics, and piping configuration. Preliminary cost estimates are provided based on UV equipment vendors' quotes and the UV system conceptual design.

This technical memorandum contains sections on the following topics:

- UV process design parameters for CBS's water system
- Comparative evaluation of commercially available UV disinfection systems
- Conceptual design
- Planning level cost estimate. Life cycle costs compare three UV disinfection systems to assist CBS with budget estimate and financial planning.

UV Disinfection Process Design Parameters

The process design parameters used to size and select UV disinfection equipment for CBS's water system are: (1) design flow rates, (2) inactivation goals, (3) water quality of CBS's water supply, and (4) level of redundancy. These design parameters are quantified and discussed in the sections that follow.

Design Flow Rate

Design flow rate is one of the fundamental process design parameters that is used to size and select UV reactors. The peak hour design flow rate is typically used as part of the sizing and selection process for UV reactors, whereas the average design flow rate is used to provide cost estimates for operations and maintenance.

The current CBS water treatment facilities consist of a control building and the water distribution system. The control building is located by a penstock that draws the water from Blue Lake and sends it to a hydropower plant. Two flow control valves are located in the lower level of the control building. The chlorine and fluoride storage rooms are on the upper level of the building. Raw water enters the control building through a 20-inch diameter pipe diverted from the penstock and flows through the control valves, receives chlorine and fluoride addition before it enters the 30-inch diameter water transmission main. The disinfection CT credit by chlorine is currently achieved in approximately three miles of water transmission main before the first user. The flow output from the Blue Lake Water Treatment Plant control building is regulated by flow control valves based on the water demand in the distribution system and is typically adjusted once per day.

Figure 1 presents the daily flows recorded at the plant from January to November 2006. The greatest demand on the water plant occurred in March 2006, when the production was set from 3,400 gallon per minute (gpm) to a peak of 3,800 gpm over an 8 day period. Since the population in CBS is not expected to grow in the next ten to fifteen years, the City has identified a desired design peak flow rate of at least 4,167 gpm (6.0 mgd) with a fully redundant disinfection system.

Continually providing sufficient disinfection capacity to meet system demands is critical because UV disinfection systems do not receive any disinfection credit if the water exceeds the reactor's maximum validated capacity. The active UV reactor must be on at all times water flows through the system. UV disinfection does not provide a residual. Provision for future flow increase is recommended given the unknowns about future peak demands. Disinfection at future higher flow rates could be accomplished through installing reactors with higher capacity, or reserving building space for one or more future reactors. For CBS's case, having higher-capacity reactors appears to be cost effective based on the suggested system costs provided by UV manufacturers. The actual approach to accommodating future peak flow rates should be evaluated during the design phase.

Figure 1 also shows that during the 11-month period the flows ranged from 1,900 gpm (2.8 mgd) to 3,800 gpm (5.5 mgd), with an average of 2,500 gpm (3.6 mgd). Given that the December 2006 data was not available and the trend shows the flow rate would be higher than 2,500 gpm most of the time during that month, the annual average flow at UV facility is estimated at 4.0 mgd (2,780 gpm) with a safety factor taken into consideration.

In a summary, the suggested design flow rates for CBS's UV system are:

- Peak flow = 6.0 mgd
- Average flow = 4.0 mgd

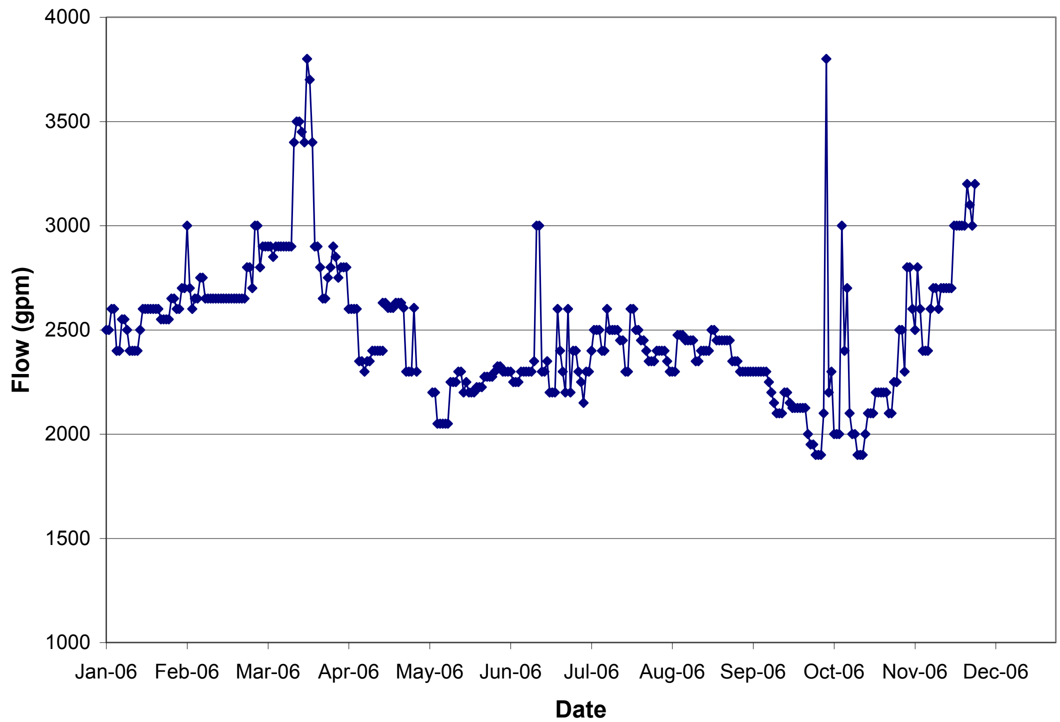


FIGURE 1
CBS BLUE LAKE WATER TREATMENT PLANT FLOW DATA (JANUARY TO NOVEMBER 2006)

Inactivation Goals

The primary purpose of installing a UV disinfection facility on CBS's water supply system is to meet the requirements of LT2ESWTR by providing a means for inactivation of *Cryptosporidium* and provide a second disinfectant. The inactivation requirement of Giardia and virus are currently met by chlorine and the 3-mile distribution pipeline. However, since the UV dose requirement for *Giardia* inactivation is lower than the UV dose requirement for *Cryptosporidium* inactivation, it is beneficial to take credit using UV for *Giardia* inactivation. This could simplify CT reporting and potentially reduce the chlorine dose and/or pipeline length required for virus inactivation. The following are the performance goals for the proposed UV disinfection facility:

- Provide 3-log *Cryptosporidium* inactivation
- Provide 3-log *Giardia* inactivation

Given that the UV dose requirements for 4-log virus inactivation are significantly higher than the UV dose requirements for the above inactivation goals, UV disinfection will not be used for virus inactivation. Virus inactivation has been and will continue to be accomplished by the existing chlorination system and CT provided in the three-mile water transmission main. With UV disinfection as the primary disinfectant, there is a potential benefit of reducing the chlorine dose or shortening the 30-inch pipeline contactor. The chlorine dose could be reduced based on maintaining chlorine residual in the distribution system. Alternatively if the chlorine residual is maintained at just 1 mg/L, only about 1,500 feet of the 30-inch pipeline contactor is required to provide CT for virus inactivation.

Water Quality

UV transmittance, particles and dissolved constituents that foul lamp sleeves and other wetted components are the most significant water quality parameters impacting UV disinfection effectiveness.

UV transmittance (UVT) is a major process design parameter affecting reactor performance. As UVT decreases, due to particles and dissolved compounds in the source water, the UV light intensity throughout the reactor decreases. This results in a UV dose reduction delivered to the target microorganisms. Therefore, water with low UVT requires larger UV systems with greater power requirements to achieve target organism inactivation compared to systems for waters with high UVT.

Particles can also impact UV disinfection performance. Particles may scatter light and reduce the UV intensity delivered to the microorganisms. Particles may also shield microorganisms from UV light, thereby reducing disinfection effectiveness.

Compounds dissolved in the water can cause UV reactor fouling on the external surfaces of the lamp sleeves and other wetted components, such as UV intensity sensor monitoring windows. Lamp sleeves fouling reduces UV light transmittance through the sleeve into the water, thereby reducing disinfection efficiency. Monitoring window fouling impacts UV intensity and dose monitoring. Hardness, alkalinity, temperature, iron and manganese concentration, and pH all influence the fouling rate and, subsequently, lamp sleeve cleaning frequency. To account for fouling, a lamp sleeve fouling factor is incorporated into system design.

Water quality data collected between October 2005 and September 2007 were analyzed and the design recommendations were discussed in Chapter 4 – *Water Sampling Protocol and Water Quality Evaluation*. In summary, the conclusions are:

- The preliminary test results indicate that CBS's raw water has very low levels of suspended solids, hardness, iron and manganese. These characteristics suggest that the Blue Lake water supply is compatible with UV disinfection with an automatic sleeve cleaning system. Excessive lamp sleeve fouling is not anticipated.
- Historical turbidity levels in the feed water to a future UV system have been around 0.6 NTU, with values always less than 5 NTU. This application meets the SWTR filtration avoidance criteria established by EPA and the Alaska Department of Environmental Conservation (ADEC). Consistent with the Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule (UVDGM), the impacts of particles on UV performance is anticipated to be minimal, and the UV dose requirements of the LT2ESTWTR are applicable.
- Water supply sample test data indicate the Blue Lake UV transmittance ranged from 89.1% to 97.5% during the two-year sampling. A conservative UVT value of 88% is recommended for preliminary UV equipment sizing and selection.

- Water quality data collected from two other Alaska filtration avoidance water systems indicate that chlorinated water normally has higher UVT than unchlorinated water. Therefore, adding UV disinfection after chlorination has the potential advantage of energy cost reduction. Raw water and chlorinated water UVT monitoring should be continued to provide more data to help refine important design parameters. UV disinfection typically reduces chlorine residual concentration, so additional chlorination may be required to maintain CBS's target chlorine residual in its water distribution system.
- Test data indicate that TTHMs and HAA5s throughout CBS's distribution system are lower than the compliance levels for DBPRs. With the Stage 2 Disinfectants/Disinfection By-Products Rule (Stage 2 D/DBPR Rule) and the shift to locational running annual averages (LRAAs), the CBS expects to continue to comply with DBP limits. Thus, the formation of disinfection byproducts was not considered related to the selected treatment technique for compliance with LT2ESWTR *Cryptosporidium* inactivation and second disinfection requirements.

Level of Redundancy

A UV system with the design criteria described above must be able to apply the appropriate UV dose under the worst-case simultaneous conditions which include:

- UV transmittance of 88 percent.
- Peak design flow rate of 6.0 mgd.
- Reduced end of lamp life UV output.
- Fouled lamp sleeves.

For systems like the CBS's that uses UV as the primary disinfectant, a minimum of two equally sized UV reactors must be provided in the UV disinfection process. This level of redundancy is necessary to ensure that the UV disinfection system can deliver the design dose at plant capacity while one UV reactor is out of service.

Standby power is recommended given that power outages are common in the area. An uninterruptable power supply (UPS) is also recommended. A UPS allows for standby generation to be brought on-line during a power outage without the UV system going out of service. Without the UPS the UV reactors immediately cease functioning during a power failure and typically take several minutes to come back into service as the UV reactors require cool down and warm up periods. As part of conceptual design, a UPS has been incorporated for the purpose of facility sizing and cost estimating. The necessity of a UPS will be evaluated during the final design. The evaluation shall consist of a power quality study, looking at the UV system isolation valve response time, UV reactor restart time and regulatory requirements for off-spec operation limits.

UV Disinfection Process Design Criteria Summary

Table 1 summarizes process design criteria used for CBS's UV design equipment preliminary sizing and selection.

TABLE 1
UV Disinfection System Design Criteria - City and Borough of Sitka

Component	Value
Design Basis	3-log *Cryptosporidium* Inactivation
UV Dose (at bench-scale from LT2ESWTR)*	12 mJ/cm^2
Lamp Type	Low-Pressure, High-Output or Medium Pressure
Reactors	
Type	Closed Vessel
Number, Service	Per UV supplier
Number, Standby	1
Design UV Transmittance	88 %
Flows	
Maximum – Peak Hour	6.0 mgd
Average	4.0 mgd
Standby Power	24 hour back-up
Uninterruptible Power Supply (UPS)	5 minutes

Note:
* UV dose for full-scale application will be increased from the LT2ESWTR by the UV reactor’s Validation Factor (VF).

UV Disinfection System Alternatives Description

Two typical types of UV reactors that are available for use in the CBS’s UV disinfection facility: Low-Pressure High-Output (LPHO) and Medium Pressure (MP).

The fundamental differences between LPHO and MP reactors include the lamp intensity output and energy efficiency (which influences the UV reactor configuration and size), lamp life and replacement, number of lamps, power use, power modulation capabilities, and sleeve cleaning.

UV Reactor Configuration and Size

Municipal water treatment UV reactors typically consist of closed-vessel pressurized reactors containing UV lamps, lamp sleeves, UV intensity sensors, lamp sleeve wipers (optional), and temperature sensors. UV lamps are housed within the lamp sleeves, which protect the lamps. Several UV reactor configurations are available. Reactors can be in-line (i.e., straight through flow), S-shaped, or U-shaped, depending on the UV manufacturer and specific installation site constraints.

Typically, LPHO reactors have a larger footprint than MP reactors because more UV lamps are needed to deliver the same required UV dose. MP reactor footprints will also vary, depending on lamp orientation (e.g., parallel versus perpendicular to flow).

Lamp Life and Replacement

UV lamps degrade as they age resulting in a reduction in UV output. Lamp degradation impacts dose delivery over time. Lamps are usually replaced when UV output falls to some percent of the original new-lamp intensity.

Lamp life varies between LPHO and MP reactors. Most manufacturers provide warranties of 8,000 – 12,000 hours for LPHO lamps and 4,000 – 8,000 hours for MP lamps. Although the lamp life for LPHO reactors is greater than that for MP reactors, more lamps are needed for an LPHO reactor. The actual number of lamps replaced during a given period, therefore, may be less for MP reactors since MP lamps last 50 – 100 percent longer than LPHO lamps.

For UV system design, a lamp aging and lamp sleeve fouling factor is applied to ensure that the UV reactors meet the design conditions at the end of lamp life, with fouled lamp sleeves.

As part of A UV equipment system pre-purchase or pre-selection solicitation process, a minimum lamp aging/fouling factor is recommended. The UV manufacturers can also be allowed to use more less conservative factors, provided their factors have been suitably proven (i.e. certified by an independent 3^{rd}-party).

Power Use

The UV light emitted by low-pressure lamps is essentially monochromatic at 253.7 nm and is near the microbial inactivation spectrum peak. MP lamps emit a much broader spectrum light, some of which is at 253.7 nm. Therefore LPHO UV systems are more efficient than the MP systems in converting electricity to germicidal light. This means that LPHO systems use less power. LPHO systems can be designed to modify UV light intensity from each lamp and power draw based on water quality to help optimize power use.

With MP lamp's broad spectral energy distribution, MP systems are much less efficient at converting energy to germicidal energy. This results in greater power use for the same amount of disinfection effectiveness compared to LPHO disinfection systems.

Power Modulation Capabilities - Ballasts

The ability of the UV equipment to adjust lamp power or number of UV lamps energized will affect the energy use. Unlike the other issues described, power modulation capabilities depend on UV equipment design and not lamp type.

UV disinfection systems rely on ballasts to supply the appropriate power to energize and operate the UV lamps. The common UV reactor ballasts are either electronic or electromagnetic ballasts. Compared to transformer-based magnetic ballasts, electronic ballasts provide almost continuous intensity adjustment. Electronic and electromagnetic ballasts each have specific advantages and disadvantages. Electromagnetic ballasts are more resistant to power surges and allow a greater separation distance between the UV reactor and control panel. However UV lamps powered by electromagnetic ballasts tend to have more lamp end-darkening and have shorter lives compared to lamps powered by electronic ballasts. Electronic ballasts are generally more power efficient, but they are more susceptible to power quality problems. Typically LPHO UV systems use electronic ballasts, while MP systems use either electronic or electromagnetic ballasts. As described later in this TM, the both MP systems considered for CBS use electromagnetic ballasts.

Sleeve Cleaning

UV lamps are housed within lamp sleeves to help keep the lamp at optimal operating temperature and to protect the lamp from breaking. Lamp sleeves are tubes of quartz (or vitreous silica). Both the internal and external surface of the sleeves could potentially foul. External surface fouling, which is far more common, is caused by the reaction of compounds in the water with the lamp sleeve's surface. External sleeve fouling must be removed by chemical or mechanical cleaning. UV reactor manufacturers have developed different lamp sleeve cleaning approaches. They include off-line chemical cleaning (OCC), on-line mechanical cleaning (OMC), and on-line mechanical-chemical cleaning (OMCC) methods. Internal sleeve fouling arises from the deposition of material from components within the lamp or sleeve due to temperature and exposure to UV light. The UV reactor manufacturers control internal lamp sleeve fouling through appropriate material selection.

During OCC, the reactor is shut down, drained, and flushed with a cleaning solution. Solutions used to clean lamp sleeves include citric acid, phosphoric acid, or a food-grade proprietary solution provided by the UV reactor manufacturer. The reactor is rinsed and returned to operation after sufficient time is allowed to dissolve the foulants. Taking a reactor off-line for cleaning typically results in higher maintenance costs for OCC systems compared to clean-in-place systems.

OMC and OMCC systems are built-in UV reactor components that consist of wipers that are driven by either screws attached to electric motors or pneumatic pistons. In OMC system, mechanical wipers may consist of stainless steel brush collars or Teflon rings that move along the lamp sleeve. In OMCC system, physical-chemical wipers have a collar filled with food-grade cleaning solution that moves along the lamp sleeve. The wiper physically removes fouling on the lamp sleeve surface while the cleaning solution within the collar dissolves fouling materials. The use of mechanical and physical-chemical wipers does not necessitate that the UV reactor be drained. Therefore, the reactor can remain on-line while the lamp sleeves are cleaned.

LPHO reactors typically have OCC systems, and MP reactors typically have OMC systems. Although OCC systems tend to be more labor intensive than OMC systems, OMC systems typically have more parts to replace. The extent of fouling will determine maintenance (labor and parts) requirements and costs.

Table 2 summarizes LPHO and MP lamp type operational advantages and disadvantages.

Table 2
Mercury Vapor Lamp Comparison

	LPHO	MP
Comparative Advantages	• Higher germicidal UV efficiency; nearly all output at 254 nm • Smaller power draw per lamp (less reduction in dose if lamp fails) • Longer lamp life	• Higher UV energy output/lamp • Fewer lamps for a given application—less lamps for landfill disposal • Smaller reactors
Comparative Disadvantages	• More lamps needed for a given application—more lamps for landfill disposal • Larger or more reactors	• Higher operating temperature can accelerate fouling • Shorter lamp life—more frequent lamp changes • Higher power draw per lamp • Lower electrical to germicidal UV conversion efficiency

System Hydraulics

Commercial water treatment UV disinfection systems have different inlet and outlet hydraulic conditions, depending on inlet and outlet location and orientation. The hydraulic conditions are an important aspect to consider when evaluating UV systems.

The LT2ESWTR requires the use of validated UV reactors to receive inactivation credit for *Cryptosporidium* and *Giardia*. A validated UV reactor has demonstrated it can provide the required level of inactivation for a given application for a range of operating conditions (*i.e.*, lamp power, UVT, and flowrate). Validation testing may be conducted either on-site or off-site. UV system selection, design and validation must take the inlet and outlet hydraulic conditions into consideration. The UV Disinfection Guidance Manual for the Final LT2ESWTR (November 2006) recommends three UV reactor inlet and outlet piping options to ensure the UV dose delivery is equal to or greater than the UV dose delivered when the reactor was validated off-site. The CBS facility will need to comply with one of these three options:

1. Minimum length of five straight pipe diameters upstream of UV reactor: The straight pipe length upstream of each UV reactor at the UV facility is the validation test straight pipe length plus a minimum of five (5) pipe diameters.
2. Identical inlet and outlet conditions: Validation Test Inlet and outlet conditions must match those used at the WTP for at least ten (10) pipe diameters upstream and five (5) pipe diameters downstream of the UV reactor.
3. Velocity profile measurement: Water velocity measured at evenly spaced points through a given cross-section of the flow upstream and downstream of the reactor is within 20 percent of the theoretical velocity with both the validation test stand and the

WTP installation. Theoretical velocity is defined as the flow rate divided by the cross-sectional area.

Option 1 is more applicable for validation and installation of UV reactors for CBS's UV facility. The new UV building would have some flexibility to match how the procured UV reactor was validated, with the five additional upstream pipe diameters of straight piping. UV manufacturers select different inlet and outlet piping conditions for their validation tests. These hydraulic configurations affect the overall piping length and building dimensions for the CBS installation.

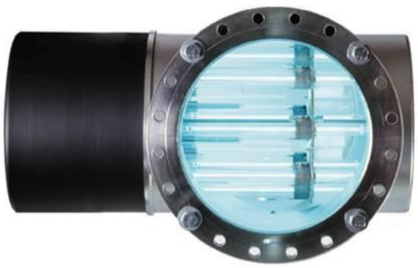
UV Equipment Comparative Evaluation

Using the process design parameters and equipment design criteria discussed in the previous sections, three potential UV equipment manufacturers were asked to provide technical information and preliminary estimates for capital, operational, and life-cycle costs. The equipment and vendors being evaluated in this exercise are:

- Calgon Sentinel® UV system – MP
- Trojan System UVSwift™ – MP
- Wedeco BX-Series™ UV system – LPHO

A Wedeco BX-Series™ UV reactor is shown in Figure 2. A Trojan MP reactor and Calgon MP reactor are shown in Figure 3. The vendors were allowed to select their specific reactor-type that was deemed most suitable for the CBS design criteria. For example, Trojan provided a cost quote based on the use of their SWIFT 4L12 reactor. Although a 4L24 reactor would allow a total of two reactors (rather than three 4L12 reactors), Trojan had the freedom to decide which reactor to propose based on their own internal economic evaluations.

FIGURE 2
Low Pressure High Output UV Reactor – Wedeco- BX-Series™



Trojan UV Swift™

Calgon Sentinel®

FIGURE 3
Medium Pressure UV Reactors

Table 3 contains UV manufacturers' equipment design components.

TABLE 3
Preliminary Design Components for UV Disinfection Equipment - City and Borough of Sitka

Description	Units	Calgon	Trojan	Wedeco
Model	-	Sentinel 6 x 4 kW	UVSwift 4L12	BX 1800
Type of lamp	-	MP	MP	LPHO
Maximum flow per reactor	mgd	8.0	3.8	5.6
No. of reactors req'd	no.	1 duty + 1 standby	2 duty + 1 standby	2 duty + 1 standby
Maximum flow capacity of proposed system	mgd	8.0	7.6	11.2
No. of lamps per reactor	no.	6	4	18
Total no. of lamps (duty and standby)	no.	12	12	54
Lamp arrangement	-	Perpendicular to flow	Perpendicular to flow	Parallel to flow
UV inlet & outlet condition based on validation hydraulic condition (option 1 in UVDGM)		3+5 pipe diameter upstream, 1 pipe diameter downstream	0+5 pipe diameter upstream, since 90-deg elbow directly at inlet of the reactor during validation	3+5 pipe diameter upstream, 2 pipe diameter downstream
Total no. of ballasts	no.	6	12	27
Total no. of sleeves	no.	12	12	54
Total no. of sensors	no.	12	12	3
Maximum peak flow headloss per reactor	in	11	5.7	11.5
Flange diameter	in	18	12	16
Reactor width	in	46	36-1/2	29
Reactor length	in	38-1/4	20-3/4	118-3/8

TABLE 3
Preliminary Design Components for UV Disinfection Equipment - City and Borough of Sitka

Description	Units	Calgon	Trojan	Wedeco
Reactor height	in	38-1/2	19	43-1/2
Maximum pressure	psi	150	150	150
Ballast type	-	Electromagnetic	Electromagnetic	Electronic
Max. Power consumption per Reactor	kW	27	27	9.4
Power consumption @ avg flow, and UVT of 88 percent	kW	15.2	16.1	5.5
Cleaning system (1)	-	OMC	OMCC	OCC
Lamp life expectancy	hr	5,000	5,000	12,000
# of Lamps Changed/ year	no.	10.5	14.0	26.3
Sleeve life expectancy	yr	5	10	20
Ballast life expectancy	yr	10	10	5
Sensor life expectancy	yr	5	10	10
Power Supply/Control Panel Dimensions	in	85H x 67W x 26D	48H x 36W x 18D	84H x 32W x 24D

(1) OMC - On-Line Mechanical Cleaning; OMCC - On-Line Mechanical-Chemical Cleaning; OCC – Off-Line Chemical Cleaning

Preliminary Construction Cost Estimates

Table 4 provides preliminary construction cost estimates for the three Table 3 UV disinfection systems. UV reactor equipment costs provided by the equipment manufacturers were based on the information communicated to the manufacturers and the resulting manufacturer cost quote/system layout. In each case, the manufacturer was told the disinfection target (i.e. 3-log crypto inactivation). The manufacturer was allowed to utilize their validation test factor to determine their proposed equipment. Total construction costs include preliminary estimates to design and construct a separate UV building to contain the UV disinfection system, along with an emergency power generator, UPS, piping, valves, and related appurtenances. It was assumed that the building would be a 2-story concrete masonry unit (CMU) building, with the UV room in the basement and the electrical room, mechanical room, office and laboratory space on the ground floor. The UV room floor plan was dimensioned with sufficient space to accommodate the duty UV reactors with one standby reactor to handle the determined peak flow.

The CPES, a cost estimating tool, was used to prepare cost estimates for the UV building. The cost estimates prepared for this report are in 2008 dollars, and are order-of-magnitude estimates, accurate to within plus 50 percent to minus 30 percent of the estimated cost.

The following markups were used to obtain the total construction cost:

- Contractor Overhead = 10%
- Contractor Profit = 5%

- Mob/Bonds/Insurance = 5%
- Contingency = 30%

TABLE 4
UV Disinfection Facility Preliminary Construction Cost Estimate - City and Borough of Sitka

	Calgon	Trojan	Wedeco
Model	Sentinel 6x4kW	UVSwift 4L12	BX 1800
No. of Reactors	2	3	3
Flange Dia. (in)	18	12	16
Equipment Quote	$ 214,000	$ 247,700	$ 296,000 [1]
Construction Cost [2]	$ 4,200,000	$ 4,300,000	$ 5,000,000

1. Cost includes equipment base cost and cost for optional automatic wiping system. Three-reactor system cost was estimated based on two-reactor system quote, assuming 35% cost increase.
2. Construction costs include UV facilities building, UV disinfection system, UPS, instrumentation and controls, demolition, sitework, yard electrical, yard piping, contractor markups and market adjustment.

The construction costs for the proposed UV facility for CBS are expected to range between 4.2 million (+50%, -30%) and 5.0 million (+50%, -30%) among the three systems. The major reason for the increased construction cost than what was presented in *TM3 – Comparison of Cryptosporidium Treatment Alternatives for the City and Borough of Sitka's Water Treatment Facilities* is the additional upper level building space was included in this estimate. The above-grade building space for supporting equipment, office and water testing area, etc. have been added to the conceptual design and cost estimate. The accommodation of the upper level space is described in more details in section "UV System Building Layout and Footprint" below.

One additional consideration that should be incorporated in the selection of the UV equipment system for the CBS project is the additional amount of flexibility that the validated conditions for each equipment offering provide. For example, a particulate system that was evaluated may be validated for a maximum flowrate of 7 mgd or a minimum UVT of 85 percent. This range of design conditions could provide additional flexibility for the CBS operation to minimize off-specification operation. A clear understanding of the full flexibility associated with each manufacturer is recommended as one consideration during equipment selection.

Preliminary Operational and Maintenance Cost Estimates

Preliminary operations and maintenance (O&M) cost for the three UV disinfection systems were estimated using CPES as well. Categories of O&M costs included in the evaluation are electrical power, O&M labor, replacement of lamps, ballasts, sleeves, and calibration and replacement of sensors.

The following assumptions were used to develop the O&M cost.

- Power unit cost: $0.09/kWh

- O&M labor for UV system: 1 full time equivalent (FTE) for any of three systems. A labor cost of $67,000 including salary and benefits is assumed for one FTE.
- Average flow rate: 4 mgd
- Building electrical requirements are 2 Watts/sf for heating and lighting.
- Design UVT: 88%
- Manufacturer's system-specific certified lamp aging/fouling factor
- Manufacturer's system-specific validation factors to meet 3-log Crypto inactivation requirement

Table 5 summarizes the annual O&M costs, including O&M cost associated with the UV building, O&M cost associated with the yard electrical, yard piping and etc., and labor cost.

TABLE 5
Summary of Annual O&M Costs for Evaluated UV System - City and Borough of Sitka

	Calgon	Trojan	Wedeco
UV Facility O&M Cost	**$60,500**	**$67,100**	**$64,800**
UV Equipment Elect. Power	$12,000	$12,600	$8,670
Building Elect. Power	$2,000	$1, 800	$2,000
Lamp Replacement	$5,330	$7,500	$7,400
Ballast Replacement	$620	$660	$1,500
Sleeve Replacement	$610	$170	$110
Sensor Replacement	$2,200	$1,250	$90
Sensor Recalibration	$840	$4,230	$2,800
Repair & Maintenance of UV Building	$26,800	$27,700	$31,500
Contingency (20%)	$10,100	$11,200	$10,800
Other Repair & Maintenance Cost associated with yard electrical, yard piping, etc.	**$36,000**	**$37,000**	**$37,000**
O&M Labor (1 FTE)	**$67,000**	**$67,000**	**$67,000**
TOTAL ANNUAL O&M COST	**$163,000**	**$171,000**	**$168,000**

Life Cycle Cost Estimates

Life cycle costs for the three systems were estimated based on the construction costs annual O&M costs developed above. The calculation was based on a 25-year life expectancy, a 4% annual interest rate. Table 6 summarizes the life cycle costs.

TABLE 6
Summary of Life Cycle Cost for Evaluated UV System - City and Borough of Sitka

	Calgon	Trojan	Wedeco
Construction Cost[1]	$ 4,200,000	$ 4,300,000	$ 5,000,000
Annual O&M Cost[2]	$ 256,000	$ 267,000	$ 271,000
25-yr Life Cycle Cost[2 3]	$ 6,300,000	$ 6,500,000	$ 7,100,000

1. Construction costs include UV facilities building, UV disinfection system, UPS, instrumentation and controls, demolition, sitework, yard electrical, yard piping, and contractor markups. No permitting, engineering, service during construction or legal/admin fees are included.
2. Annual O&M costs and life cycle costs were based on a 25-year life expectancy, a 4% annual interest rate.
3. Life cycle costs were calculated based on the construction cost and O&M cost. Non-construction cost was not included.

The cost differences among the three systems are not significant considering the accuracy range for this type of cost estimate. All systems appeared to be feasible for CBS's water treatment facilities in terms of required footprint, piping connection, O&M requirement, and power requirement, etc. All three systems merit more detailed analysis as the CBS moves forward with UV system design. Typically prior to design, an equipment pre-selection (or pre-purchase) process is completed since each UV system has its unique space and power requirements. The selection process may be based on cost alone or an evaluated set of criteria including the non-monetary consideration. For the CBS UV project, UV equipment system pre-selection or pre-purchase is recommended to streamline the design process.

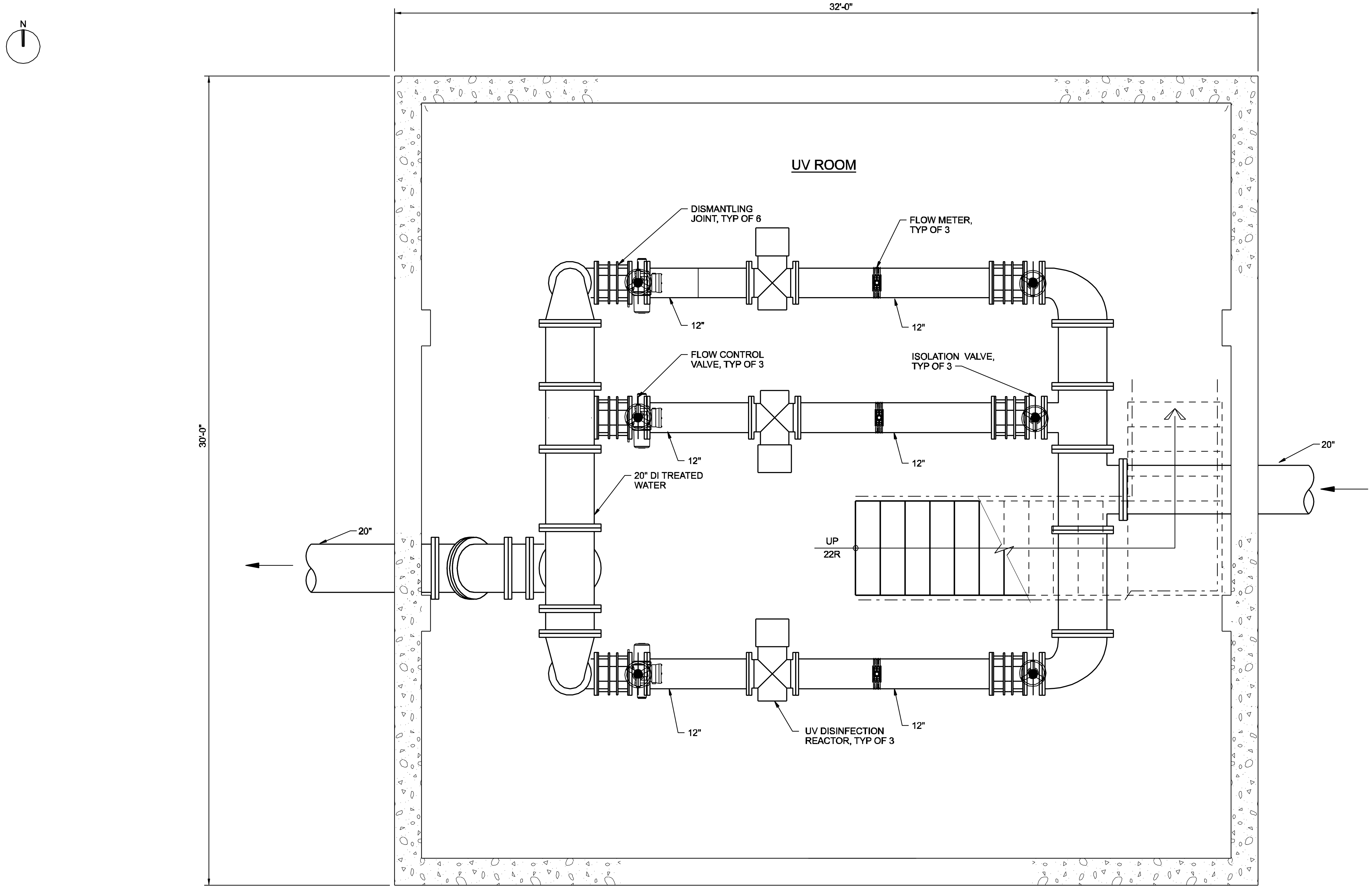
Conceptual UV Disinfection System Design

Because all three UV disinfection systems evaluated are feasible for CBS's water treatment facility, the conceptual design was conducted based on all three, with the intent to provide CBS with the maximum flexibility. The total capital costs were estimated to assist CBS with the budgetary and financial planning.

UV Disinfection System Building Layout and Footprint

This new UV facility will consist of a UV treatment system with all accessories located in a new 2-story building on the water treatment plant site, adjacent to the existing control building. The UV process room and all the supporting spaces will be provided on the upper floor. The UV reactors will be located in a basement so that piping can enter and leave the building below grade. The UV control panels will be located on the ground-level floor, in the UV process room. The building's ground-level floor will also house the electrical room, as well as some office and water test space. The electrical room will house the UPS.

The UV basement room preliminary layouts for the three UV manufacturers are presented in Figures 4 to 6. The room was sized to provide sufficient space for the duty and standby reactors to treat up to 5.6 mgd flow with one standby unit. Sufficient space was provided to allow the clearance around the reactor and between the pipe/reactor and wall. The inlet and outlet piping conditions recommended by each manufacturer were accommodated. Additional means of optimizing the equipment layout will be investigated during detailed



PLAN
1/4"=1'-0"

FIGURE 4

CITY AND BOROUGH OF SITKA

PRELIMINARY LAYOUT FOR
MEDIUM PRESSURE UV SYSTEM
BASED ON TROJAN SYSTEM

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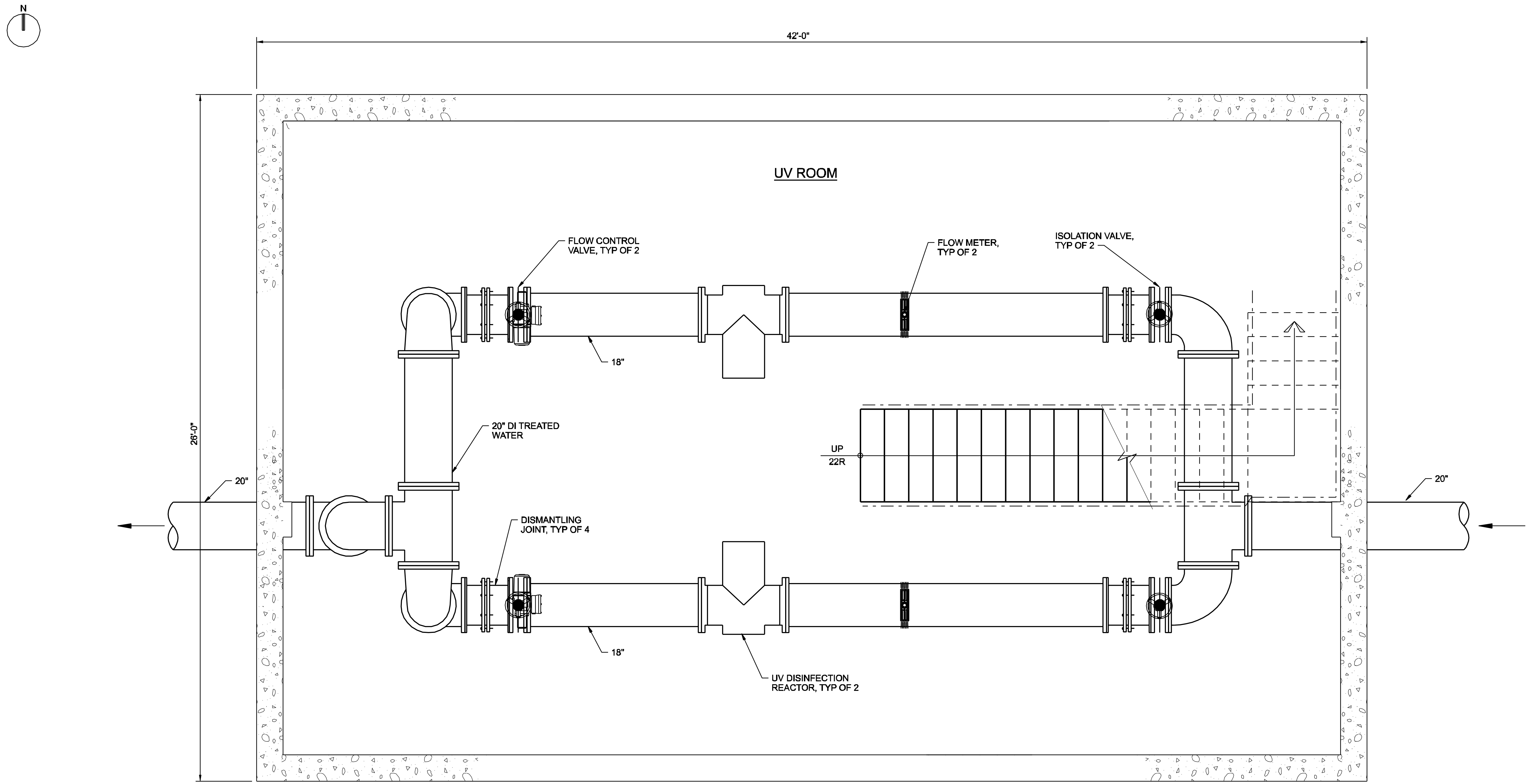

PLAN
1/4"=1-0"

FIGURE 5

CITY AND BOROUGH OF SITKA

PRELIMINARY LAYOUT FOR
MEDIUM PRESSURE UV SYSTEM
BASED ON CALGON SYSTEM

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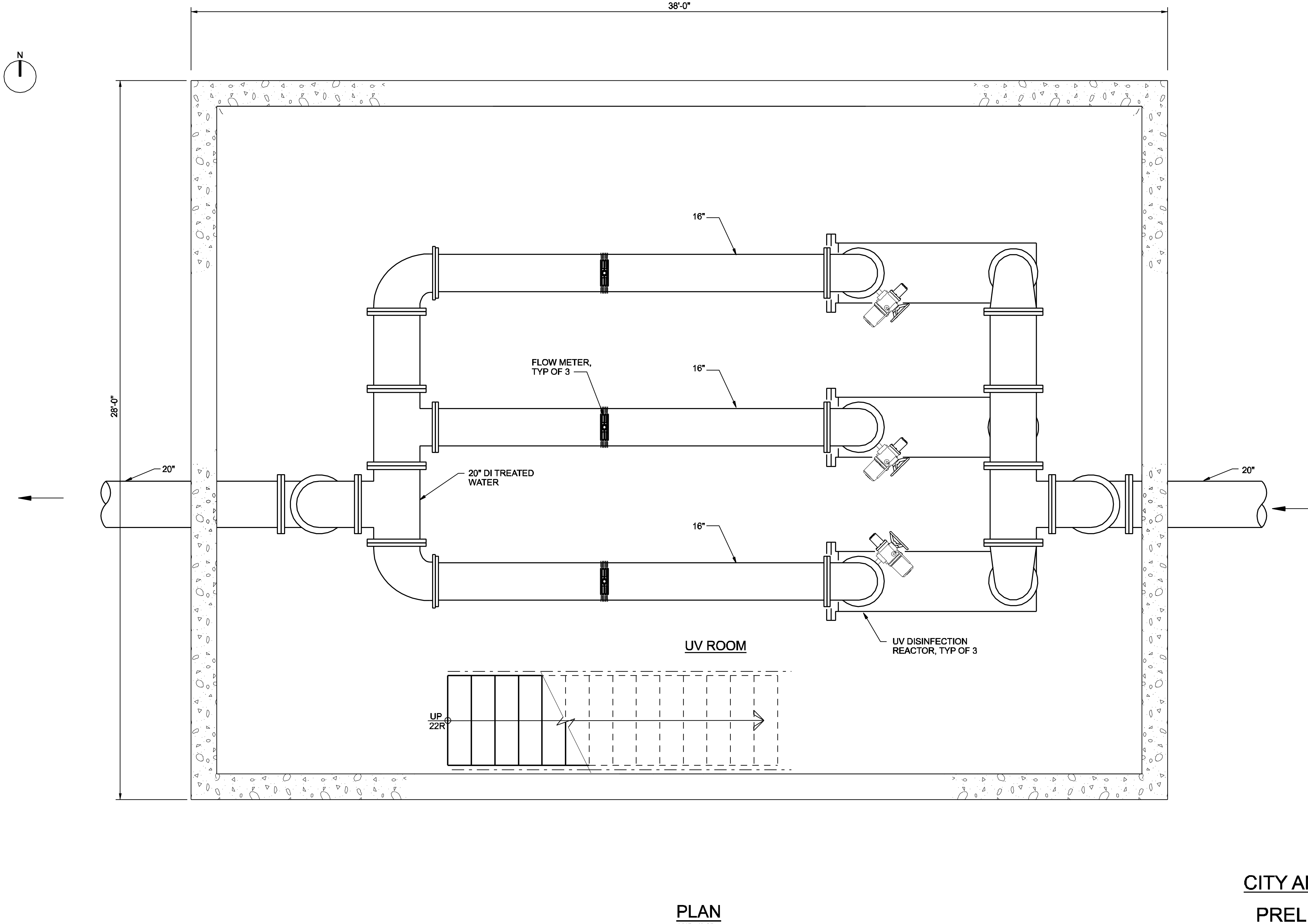

FIGURE 6

CITY AND BOROUGH OF SITKA

PRELIMINARY LAYOUT FOR LOW PRESSURE UV SYSTEM BASED ON WEDECO SYSTEM

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design. For example, for a system with 1 duty and 1 standby reactor, it may be desirable to install a single flowmeter, and a flow control valve may not be required.

The sizing requirements for the three systems are presented in Table 7. The space requirements provided in Table 7 apply to the building footprint and do not include land requirements for roads, driveways, loading and unloading zones, parking, etc.

TABLE 7
UV Disinfection Facility Space Requirements - City and Borough of Sitka

UV Facility	Calgon	Trojan	Wedeco
UV Room Dimensions (basement))	42’ x 26’	32’ x 30’	38’ x 28’
Total Building Area (basement and ground-level)	2,000 sf	1,920 sf	2,100 sf
Total Building Footprint	42’ x 26’ (0.023 ac)	32’ x 30’ (0.022 ac)	38’ x 28’ (0.024 ac)

The UV reactors will require an isolation valve upstream of each UV reactor followed by a flow meter. Immediately downstream of each UV reactor, a flow control valve (which also serves as an isolation valve for the UV reactor) will also be required. The footprint allows for enough straight run of piping to produce sufficiently accurate readings from the flow meters and uniform flow through the UV reactors.

The footprint assumes that the process flow piping, valving, and UV reactors are located in the basement. The ballasts would be located at the ground level, presuming the distance from the reactors meets the specific UV manufacturer criteria. The UPS would be located in a separate electrical room at the ground level. Stairways will provide for access to the UV reactors. This layout keeps the electrical equipment away from any potential high moisture areas.

UV Disinfection Facility Location

The UV Disinfection Facility building would be partially located in the gravel parking lot to the west of the existing control building and would sit on top of the existing 30-inch pipeline downstream of the control building. The edge of the UV building would be approximately 40 feet away from the existing penstock and 15 feet away from the control building. Part of the hill to the south would need to be excavated to allow space for UV Facility building. The assumption used in this conceptual design is UV disinfection of chlorinated water. The 20-inch pipe from the control building will go straight into the UV Facility building. A 20-inch UV outlet header will come out on the building’s west side and gets connected to the existing 30-inch water transmission pipe via a reducer. Figures 7 to 9 show the location of the new UV facility building and the possible piping connection.

Since this location is connected to the water distribution system and downstream of the flow control valves, the pressure in the UV inlet pipe is assumed to be less than 150 psi – the maximum operating pressure of either of these three equipment system options. Since the flow control valves could be adjusted to regulate the pressure upstream of the UV system,

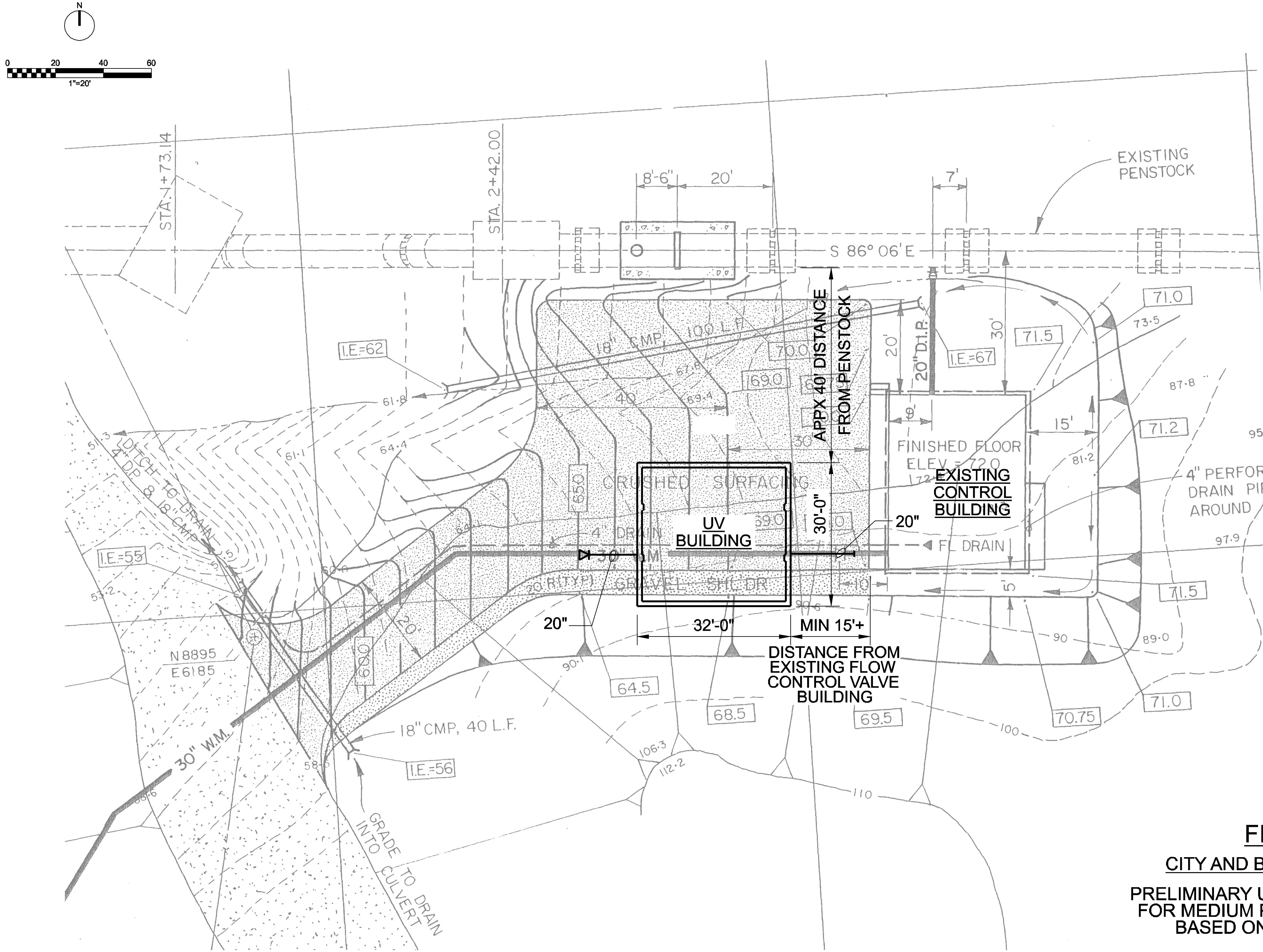

FIGURE 7

CITY AND BOROUGH OF SITKA

PRELIMINARY UV BUILDING SITE PLAN
FOR MEDIUM PRESSURE UV SYSTEM
BASED ON TROJAN SYSTEM

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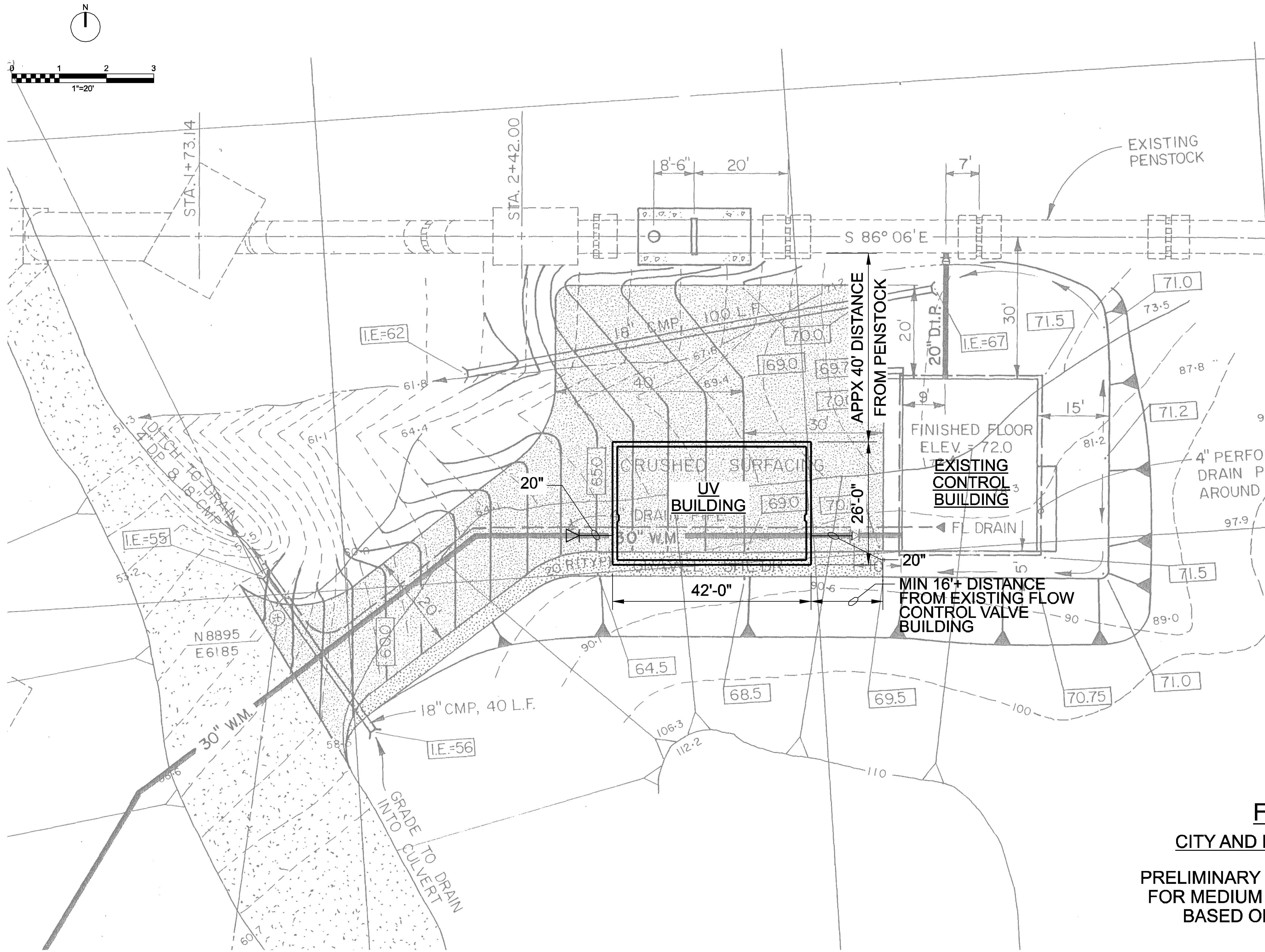

FIGURE 8

CITY AND BOROUGH OF SITKA

PRELIMINARY UV BUILDING SITE PLAN
FOR MEDIUM PRESSURE UV SYSTEM
BASED ON CALGON SYSTEM

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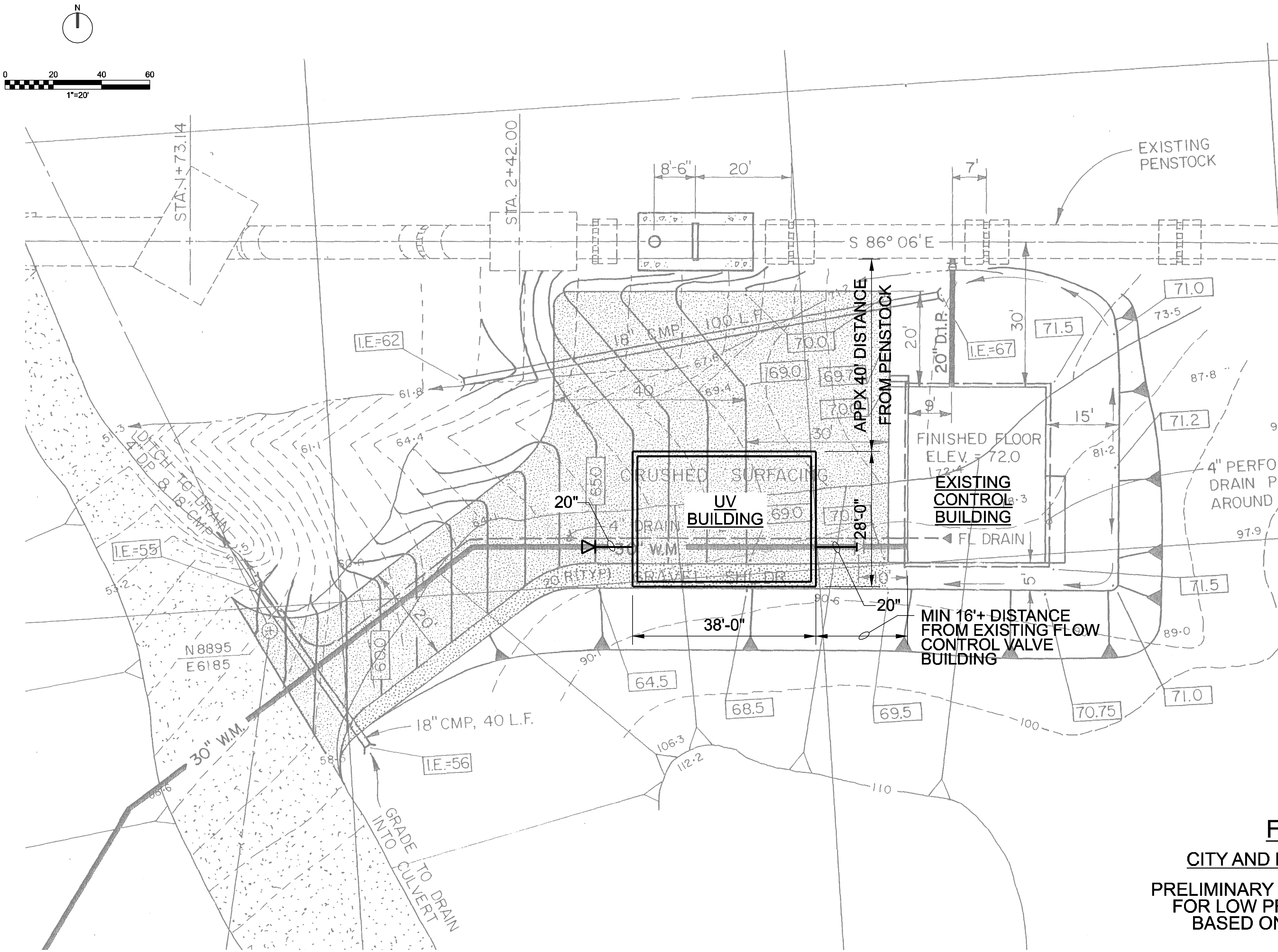

FIGURE 9

CITY AND BOROUGH OF SITKA

PRELIMINARY UV BUILDING SITE PLAN
FOR LOW PRESSURE UV SYSTEM
BASED ON WEDECO SYSTEM

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and the total headloss through the UV system will not be significant (less than 2 feet), sufficient head will be obtained at the UV outlet pipe to deliver the treated water to the end users without additional pumping. However the system hydraulics should be investigated in greater detail during the design process.

Preliminary Budget for the Project

Using CPES, a series of non-construction markups were added to the total construction cost and obtain the total capital costs (shown in Table 8).

The non-construction markups include:

- Permitting: 2%
- Engineering, surveying, geotechnical, and soils testing: 15%
- Services During Construction (SDC): 15%
- Owner Legal/Administrative: 10%
- Startup, programming, and operator training, warranty period services: 5%

TABLE 8
Capital Cost Estimate of UV Systems - City and Borough of Sitka

	Calgon	Trojan	Wedeco
Construction Cost	$ 4,200,000	$ 4,300,000	$ 5,000,000
Non-construction cost	$ 2,000,000	$ 2,000,000	$ 2,400,000
Total Capital Cost (1)	$ 6,200,000	$ 6,300,000	$ 7,400,000

(1) 2008 dollars, accuracy within +50% and -30%

All the construction, capital and O&M cost estimates provided above are budget estimates (Class 4 cost estimates as defined by the Association for the Advancement of Cost Engineers), made without detailed engineering data. It is normally expected that estimates of this type are accurate to within plus 50% to minus 30%. The cost estimates shown have been prepared for guidance in the project evaluation and implementation from the information available at the time of the estimate. The final costs of the project will depend on actual labor and materials costs, competitive market conditions, final project costs, implementation schedule and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

Alternative Location for CBS's UV Disinfection System

A preliminary study has been performed to evaluate the possibility of locating the UV system in the existing control building's basement. This evaluation shows that if the existing basement control valves and associated piping are removed, there may be enough space to put the proposed UV reactors and piping (by all three suppliers) into the existing building space and provide the required minimum equipment clearance. This conclusion is based on the following assumptions:

- The existing flow control valves and associated piping in the basement would be demolished, and a new flow control valve would be installed in a vault on the pipeline upstream or downstream of the control building.
- An above-grade, 20 ft x 20 ft electrical room would be built adjacent to the existing control building. But no extra space would be provided for lab, office, restroom, and storage etc, as compared to the proposed new UV Facility building.
- The space reserved for future pump installation in the control building basement would instead be used as the location for the UV power supply and control panels. Alternatively, the power supply and control panels could be put in the new electrical room, assuming the maximum wiring length requirements of the UV manufacturers are not exceeded.
- A bypass pipeline would be required during basement demolition and construction of the UV system. The chemical injection point would also need to be re-located, likely to an additional vault outside of the building.

The preliminary cost analysis shows that putting the UV reactors in the existing control building could potentially save up to 20 percent of construction cost, as compared to building a new UV Disinfection Facility building. That is, the construction cost would be approximately $3.5 million compared to $4.3 million, based on the use of Trojan equipment. The primary reduction in cost is due to the elimination of the new UV Disinfection Facility building, which eliminated a new lab, office, restroom, and storage areas. The cost estimate includes costs for a new vault and electrical room.

While this alternative appears feasible based on this preliminary assessment, there are several additional considerations that would need to be addressed early on. These considerations include the following:

- The control building basement is very limited in space. With UV reactors installed, it will be challenging to access the UV equipment for daily and weekly maintenance tasks.
- No new lifting device is incorporated in the existing basement. The portable hoist is required when the UV reactors need to be lifted.
- The only access from the upper level to the basement consists of a stairway and a 3’x3’ floor door. The 3’x3’ floor door is not large enough to get the UV Reactors into the basement, so a new hole would have to be cut and a larger floor door put in. This may or may not be feasible due to structural impacts on the slab. In addition, this will pose difficulty and add cost during the construction. If this alternative is selected for further evaluation, the structural evaluation will need to be conducted immediately as a “fatal flaw” analysis to determine the feasibility of this option.
- Installation of the UV system in the control building’s basement may require pipe penetrations and other types of building modifications, which may potentially cause compliance issues with the International Building Code.
- Mechanical and electrical code compliance required for any building modifications could significantly add costs.

If CBS is interested in further pursuing this alternative, a more detailed investigation of the existing control building needs to be performed as the first step during the predesign phase to verify its feasibility. This investigation should focus first on structural issues, and if the structural analysis indicates this option is feasible, and then also including system hydraulics, flow control and constructability concerns.

Chapter 7
Capital Improvement Projects

Despite extensive expansion of the water system, there is continuing demand for water service in new areas such as the Whitcomb Heights area. There is also need for improvement, repair and replacement of aging existing water facilities to keep existing facilities functioning and to ensure the system can safely and reliably provide water to existing customers.

To accommodate demands for water service and to upgrade existing facilities it is essential Sitka develop a logical and feasible plan for addressing water system needs. In conjunction with CBS staff the water system was evaluated to consider the physical condition of existing facilities, the capacity of the system to meet water system demands and the need for flexibility to isolate areas of the water system for repairs. There are also portions of the existing system that need to be replaced or improved due to use of old outdated piping. An example is the old asbestos cement piping on Japonski Island in which line breaks are becoming more common.

In developing the list of capital improvement projects for Sitka, the Alaska Department of Environmental Conservation was contacted to determine the likelihood of receiving grants and loans for water system improvements from the State. While there is no guarantee as to the level at which the water system grant and loan program will be funded from year to year, estimates of the potential for receiving grants and loans based on historic funding levels were made when developing the capital improvement plan.

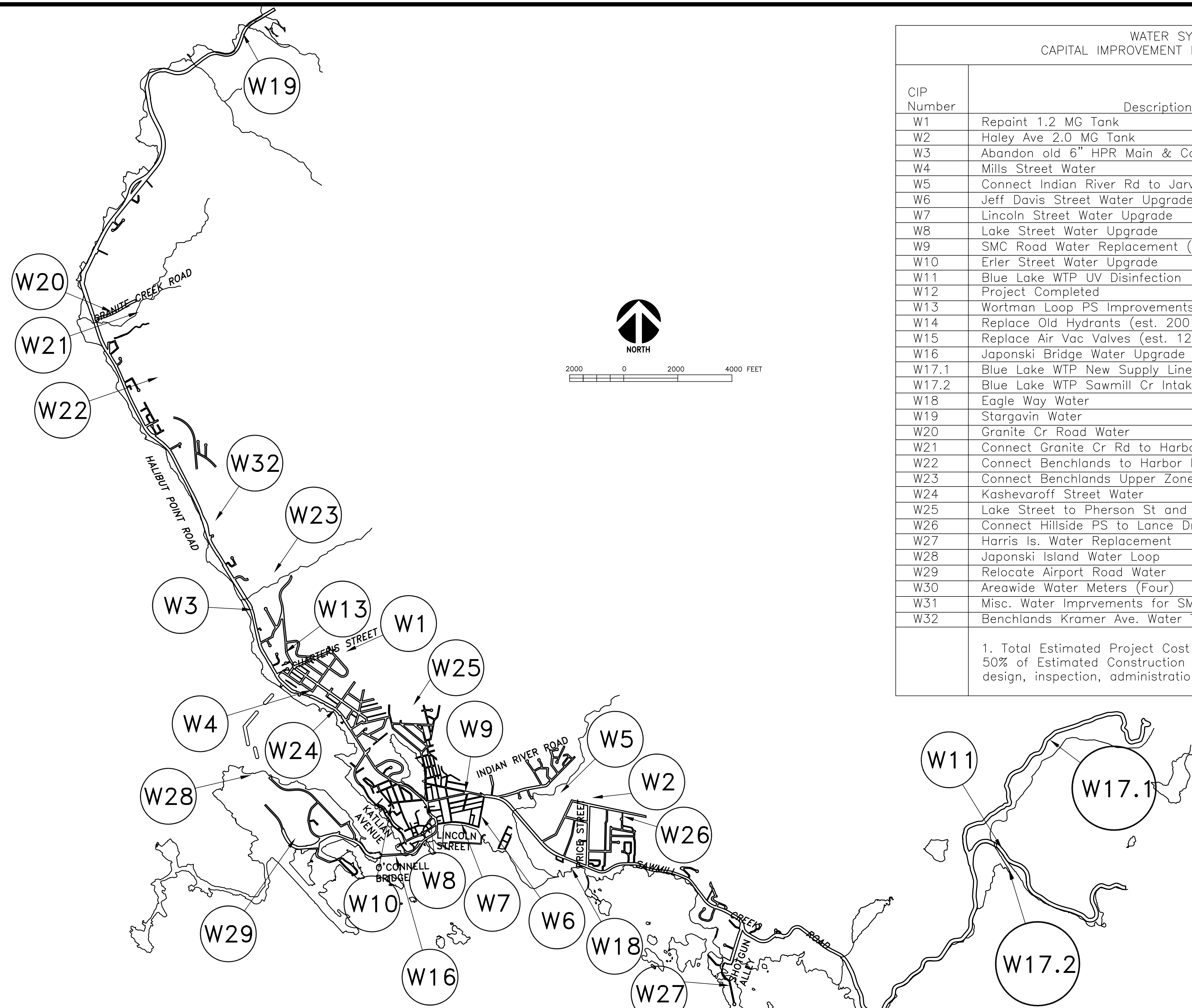
The most significant capital improvement project in the near future is construction of the UV disinfection system for the Blue Lake water source. The project has been highlighted in the table below to indicate the time frame in which funding for the project needs to be available.

Cost estimates for the proposed capital improvement projects were developed using unit bid prices for similar work elsewhere in Sitka. The projects and associated cost estimates are planning level estimates that will be refined during design as more accurate quantities are determined.

Following is a summary of the identified capital improvement projects sorted by the anticipated project period.

TABLE 1 - SITKA CAPITAL IMPROVEMENT PROJECTS

	Project	Total Estimated Project Cost	State Grant	State Loan	Sitka Water Fund	Projected Project Period
W3	Abandon old HPR Main Connect Services to 16"	$307,500			FUNDED	-
W4	Mills Street Water	$214,050			$214,050	2009
W30	Areawide Water Meters (Four)	$360,000			$360,000	2009/2016
W31	Misc. Water Imprvements for SMCR Paving Phase III	$150,000			$150,000	2010
W12	Project Completed					
W14	Replace Old Hydrants (est. 200 @ 9/yr.)	$1,500,000			$1,500,000	continuous
W11	Blue Lake WTP UV Disinfection	$6,450,000	$4,515,000	$1,935,000		2012 - 2014
W18	Eagle Way Water	$274,500	$274,500			2012
W17.2	Blue Lake WTP Sawmill Cr Intake	$705,000	$282,000	$282,000	$141,000	2012
W1	Repaint 1.2 MG Tank	$524,700		$524,700		2015
W9	SMC Road Water Replacement	$849,330		$849,330		2016
W6	Jeff Davis Street Water Upgrade	$877,200		$877,200		2017
W28	Japonski Island Water Loop	$715,200	$572,160		$143,040	2017
W7	Lincoln Street Water Upgrade	$1,032,450		$1,032,450		2018
W10	Erler Street Water Upgrade	$398,250			$398,250	2018
W20	Granite Cr Road Water	$165,000			$165,000	2018
W16	Japonski Bridge Water Upgrade	$2,850,000	$2,280,000		$570,000	2019
W26	Connect Hillside PS to Lance Dr and Haley Ave Tank	$1,207,500	$845,250	$362,250		2019
W2	Haley Ave 2.0 MG Tank	$5,182,500	$3,627,750	$1,554,750		2020
W8	Lake Street Water Upgrade	$443,820		$443,820		2020
W13	Wortman Loop PS Improvements	$322,500		$322,500		2020
W23	Connect Benchlands Upper Zone to Wortman Loop	$799,500		$799,500		2020
W5	Connect Indian River Rd to Jarvis St.	$843,900		$843,900		2022
W27	Harris Is. Water Replacement	$148,875	$74,438		$74,438	2024
W15	Replace Air Vac Valves (est. 12)	$180,000			$180,000	2025
W29	Relocate Airport Road Water	$1,456,800		$1,456,800		2025
W24	Kashevaroff Street Water	$243,900			$243,900	2027
W22	Connect Benchlands to Harbor Mt. Tank	$2,404,500		$2,404,500		2029
W25	Lake Street to Pherson St and Verstovia Ave. Water	$1,168,500		$1,168,500		2029
W19	Stargavin Water	$970,950	$873,855		$97,095	2030
W21	Connect Granite Cr Rd to Harbor Mt. Rd	$867,000		$867,000		2030
W17.1	Blue Lake WTP New Supply Line	$3,450,000	$2,415,000	$1,035,000		-
W32	Benchlands Kramer Ave. Water Trunk	$3,499,500	$3,499,500			-
	TOTAL	$40,562,925	$19,259,453	$16,759,200	$4,236,773	



WATER SYSTEM CAPITAL IMPROVEMENT PROJECT SUMMARY

CIP Number	Description	Total Estimated Project Cost[1]
W1	Repaint 1.2 MG Tank	$524,700
W2	Haley Ave 2.0 MG Tank	$5,182,500
W3	Abandon old 6" HPR Main & Conn. Services to 16"	$307,500
W4	Mills Street Water	$214,050
W5	Connect Indian River Rd to Jarvis St.	$843,900
W6	Jeff Davis Street Water Upgrade	$877,200
W7	Lincoln Street Water Upgrade	$1,032,450
W8	Lake Street Water Upgrade	$443,820
W9	SMC Road Water Replacement (part of ADOTPF Proj.)	$849,330
W10	Erler Street Water Upgrade	$398,250
W11	Blue Lake WTP UV Disinfection	$6,450,000
W12	Project Completed	–
W13	Wortman Loop PS Improvements	$322,500
W14	Replace Old Hydrants (est. 200 @ 9/yr.)	$1,500,000
W15	Replace Air Vac Valves (est. 12)	$180,000
W16	Japonski Bridge Water Upgrade	$2,850,000
W17.1	Blue Lake WTP New Supply Line	$3,450,000
W17.2	Blue Lake WTP Sawmill Cr Intake	$705,000
W18	Eagle Way Water	$274,500
W19	Stargavin Water	$970,950
W20	Granite Cr Road Water	$165,000
W21	Connect Granite Cr Rd to Harbor Mt. Rd	$867,000
W22	Connect Benchlands to Harbor Mt. Tank	$2,404,500
W23	Connect Benchlands Upper Zone to Wortman Loop (3)	$799,500
W24	Kashevaroff Street Water	$243,900
W25	Lake Street to Pherson St and Verstovia Ave. Water	$1,168,500
W26	Connect Hillside PS to Lance Dr and Haley Ave Tank	$1,207,500
W27	Harris Is. Water Replacement	$148,875
W28	Japonski Island Water Loop	$715,200
W29	Relocate Airport Road Water	$1,456,800
W30	Areawide Water Meters (Four)	$360,000
W31	Misc. Water Imprvements for SMCR Paving Phase III	$150,000
W32	Benchlands Kramer Ave. Water Trunk	$3,499,500

1. Total Estimated Project Cost includes an additional 50% of Estimated Construction Cost to account for design, inspection, administration and contingencies.

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REV	DATE	BY	DESCRIPTION

SCALE GRAPHIC
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DATE MAR 2009

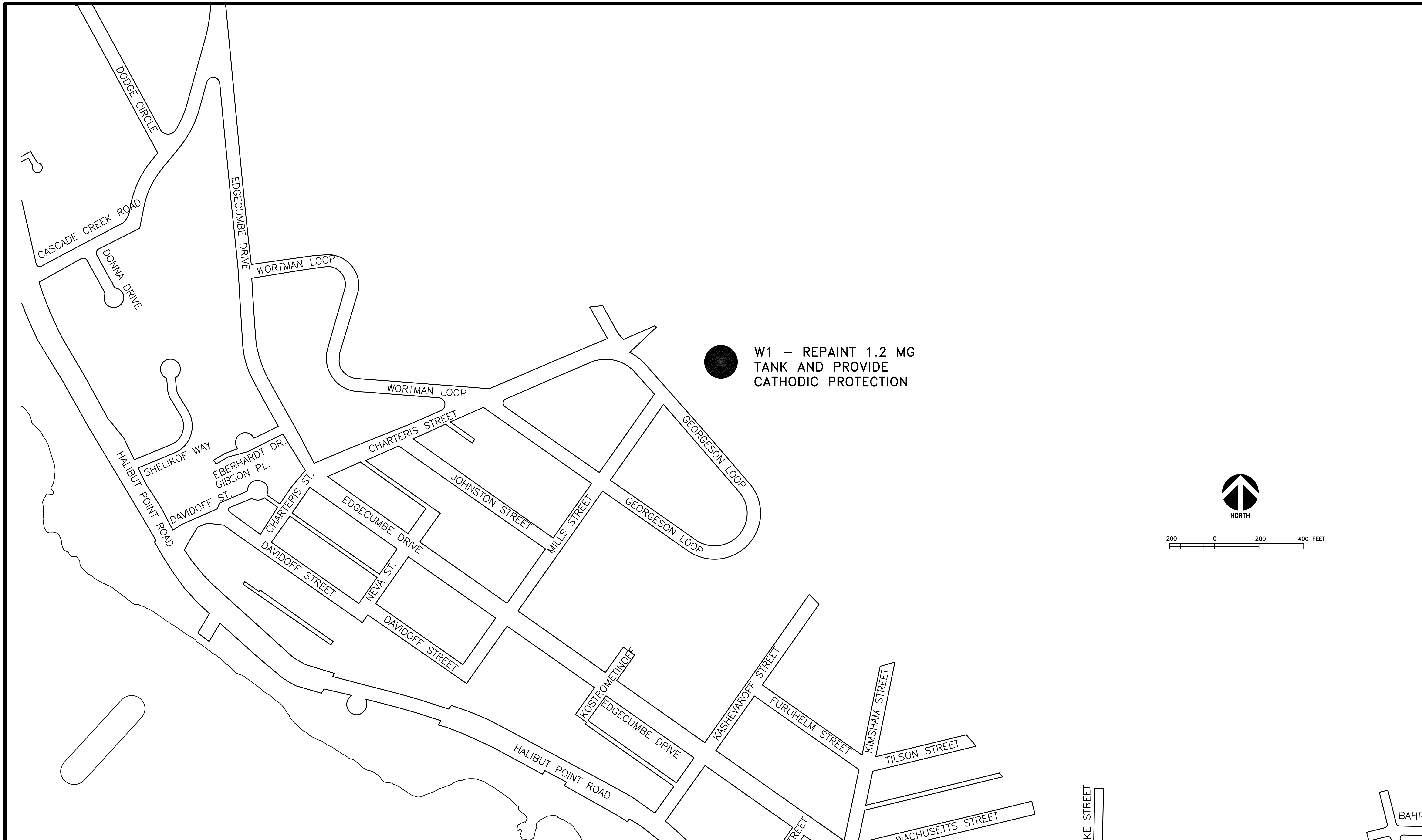
SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

WATER SYSTEM
CAPITAL IMPROVEMENTS

DRAWING W-0

SHEET No.



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W1 – REPAINT 1.2 MG
TANK AND PROVIDE
CATHODIC PROTECTION

DRAWING
W1
SHEET No.

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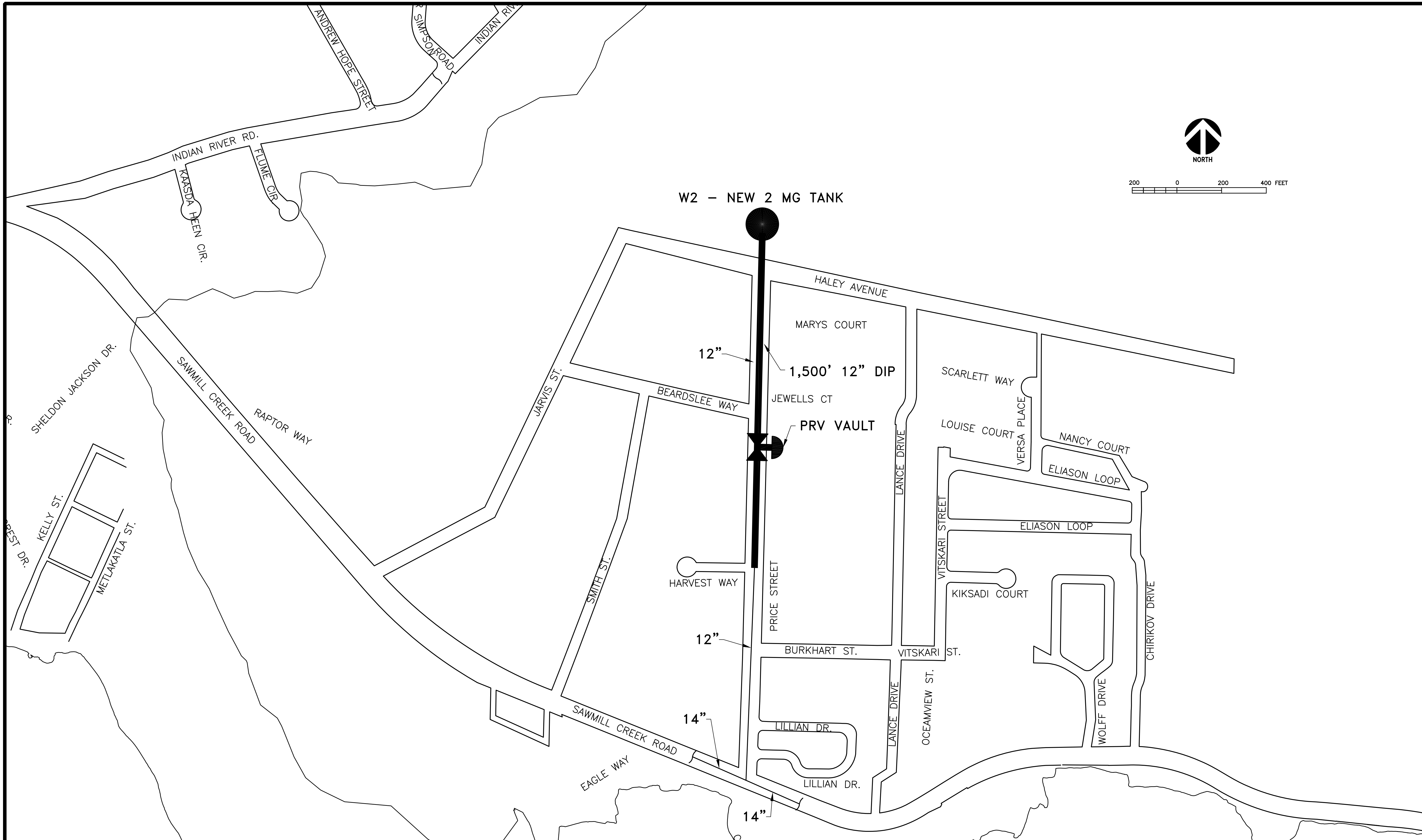

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SITKA WATER MASTER PLAN

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712 WEST 12TH STREET
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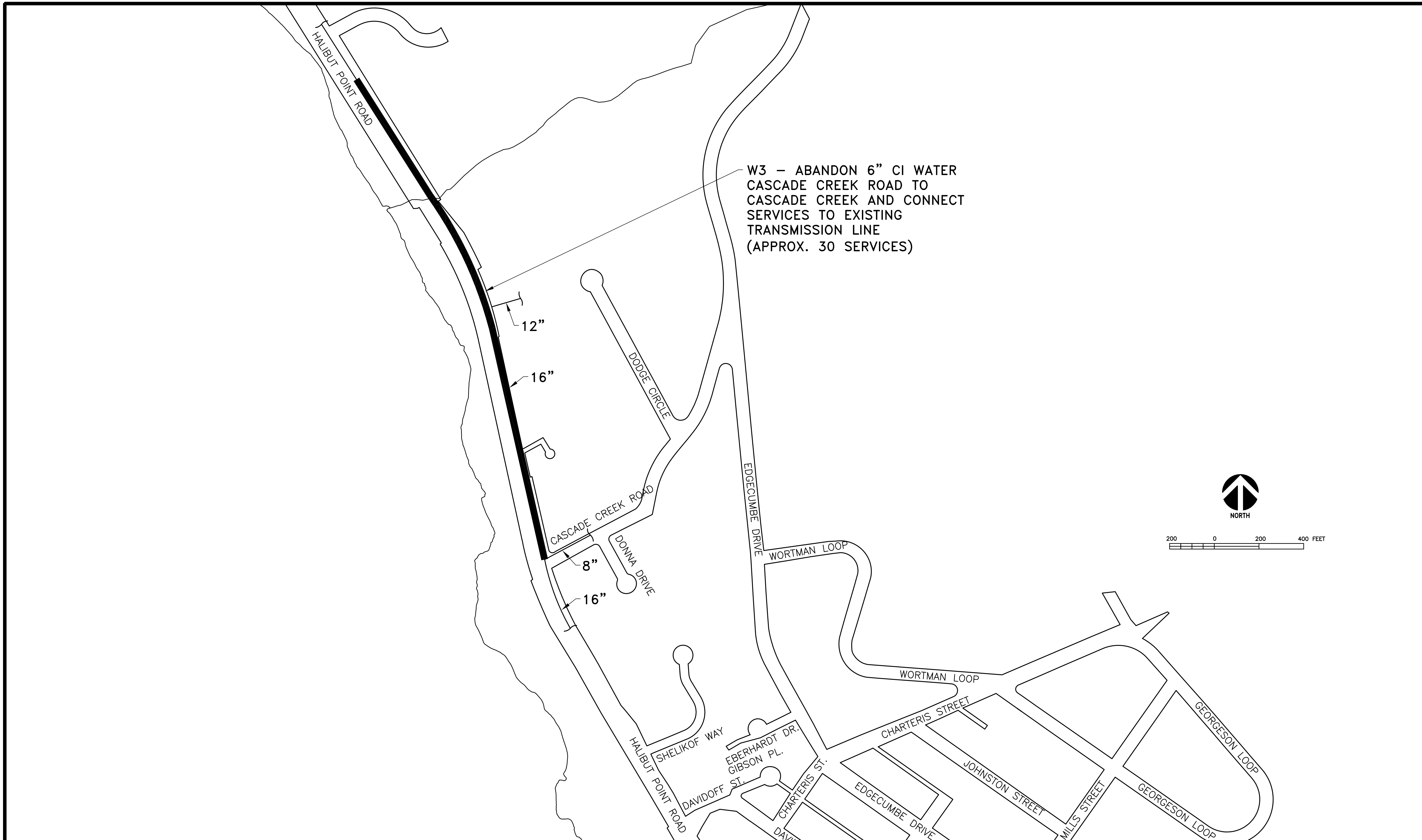
W2 - NEW 2 MG TANK AND 1,500' 12" DIP

DRAWING W2

SHEET No.



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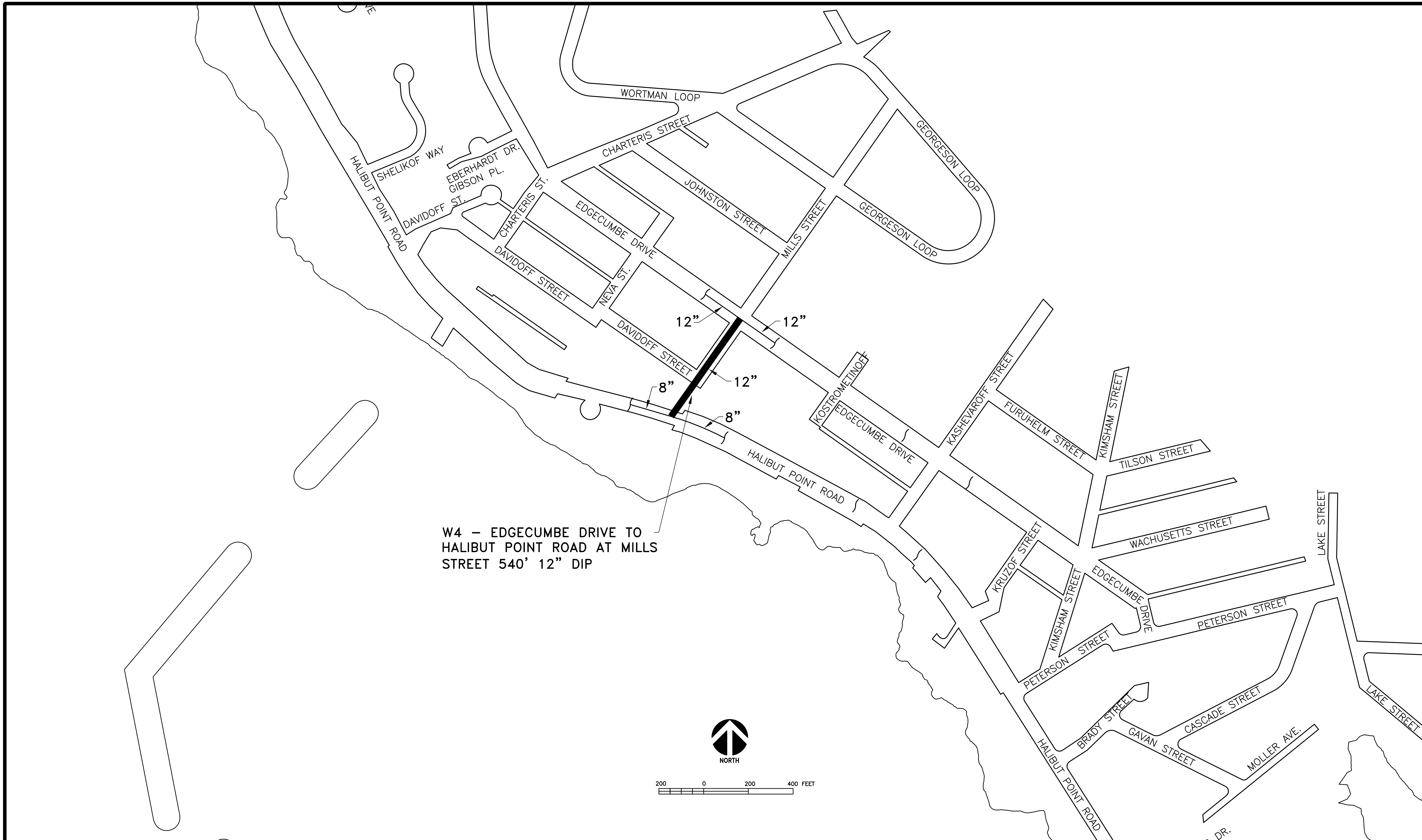
W3 – ABANDON 6" CI WATER
CASCADE CREEK ROAD TO
CASCADE CREEK AND CONNECT
SERVICES TO EXISTING
TRANSMISSION LINE

DRAWING
W3
SHEET No.



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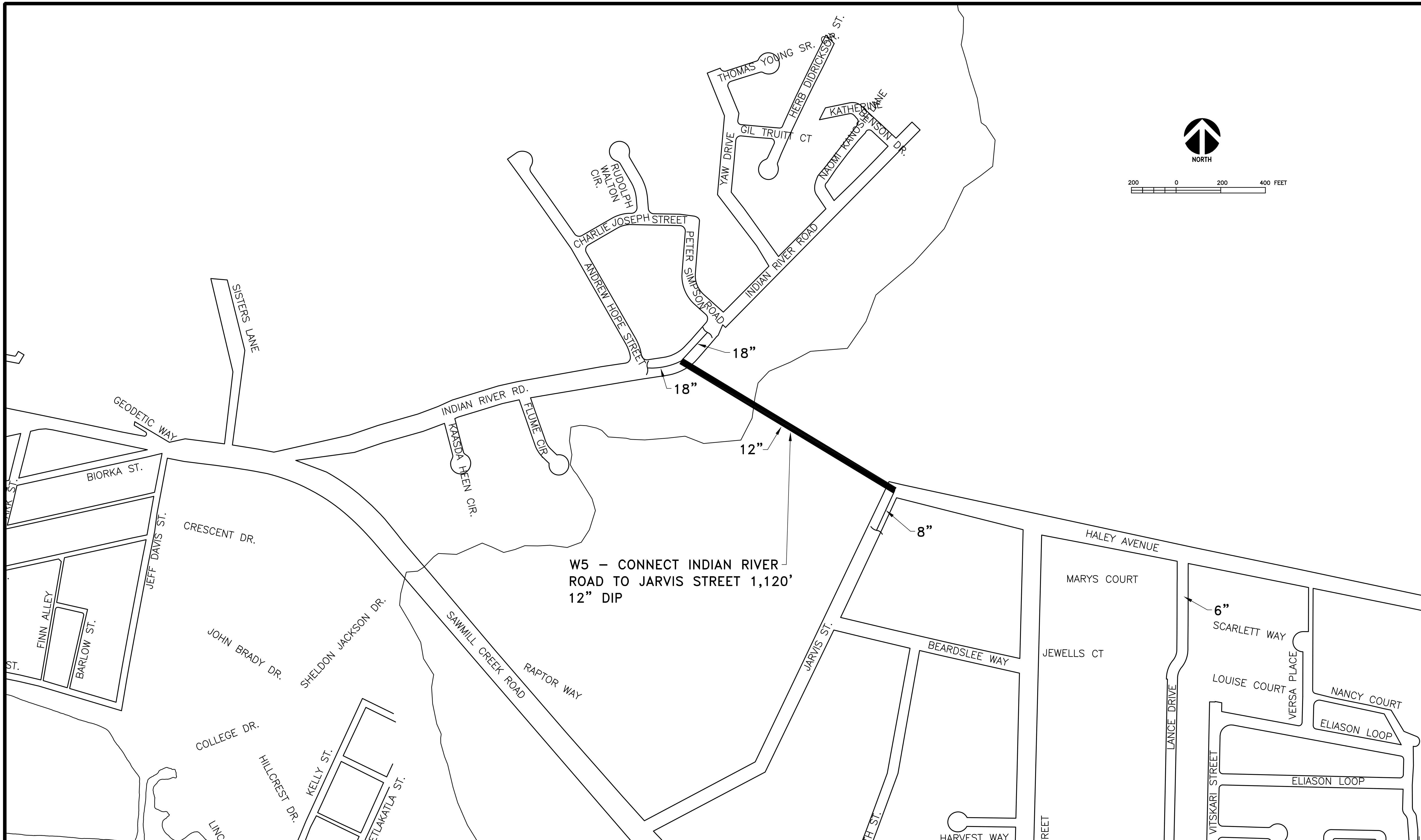
W4 – EDGECUMBE DRIVE TO HALIBUT POINT ROAD AT MILLS STREET 540' 12" DIP

DRAWING
W4
SHEET No.



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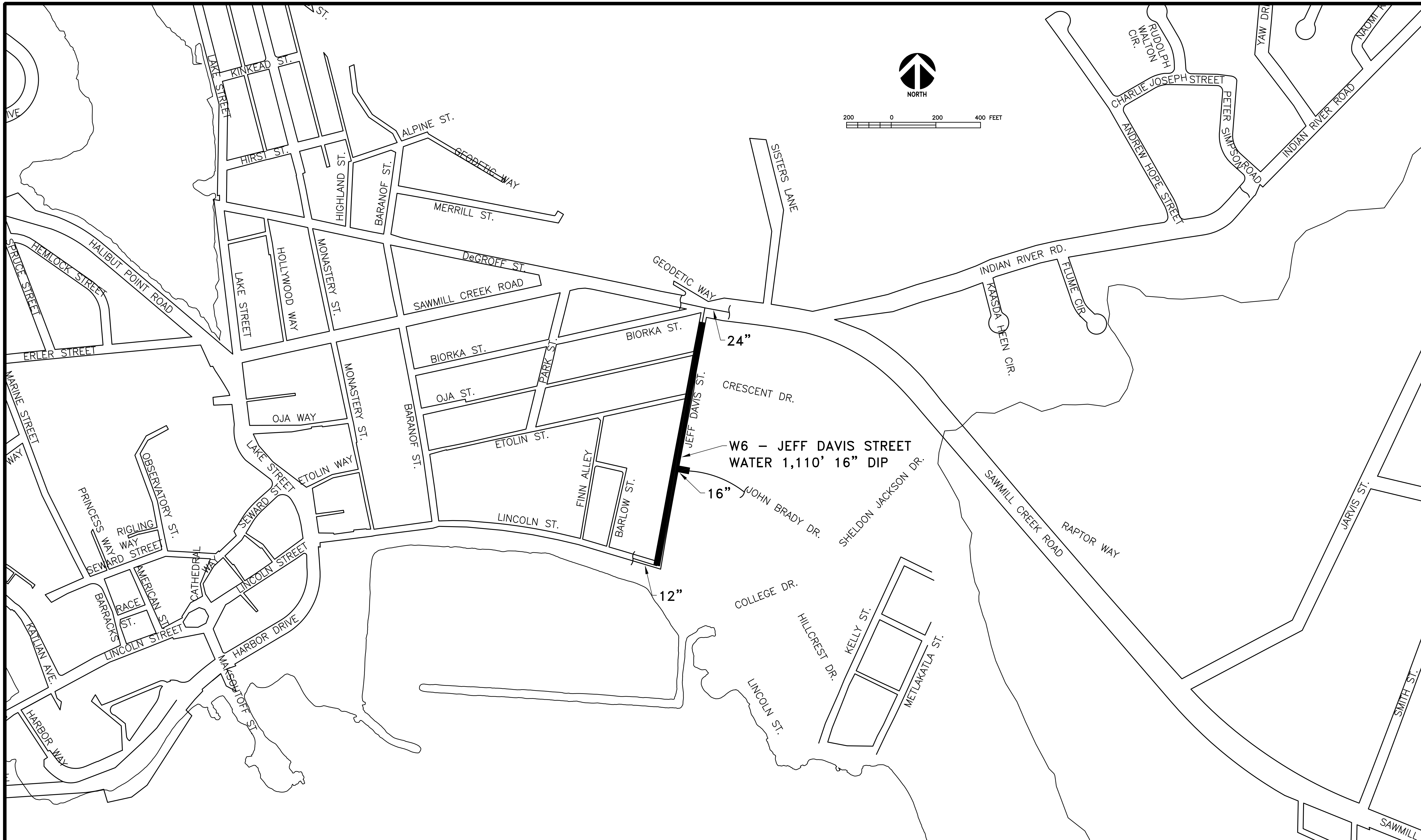
W5 – CONNECT INDIAN RIVER ROAD TO JARVIS STREET 1,120' 12" DIP

DRAWING W5

SHEET No.



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W6 – JEFF DAVIS STREET WATER
1,110' 16" DIP

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W6
SHEET No.

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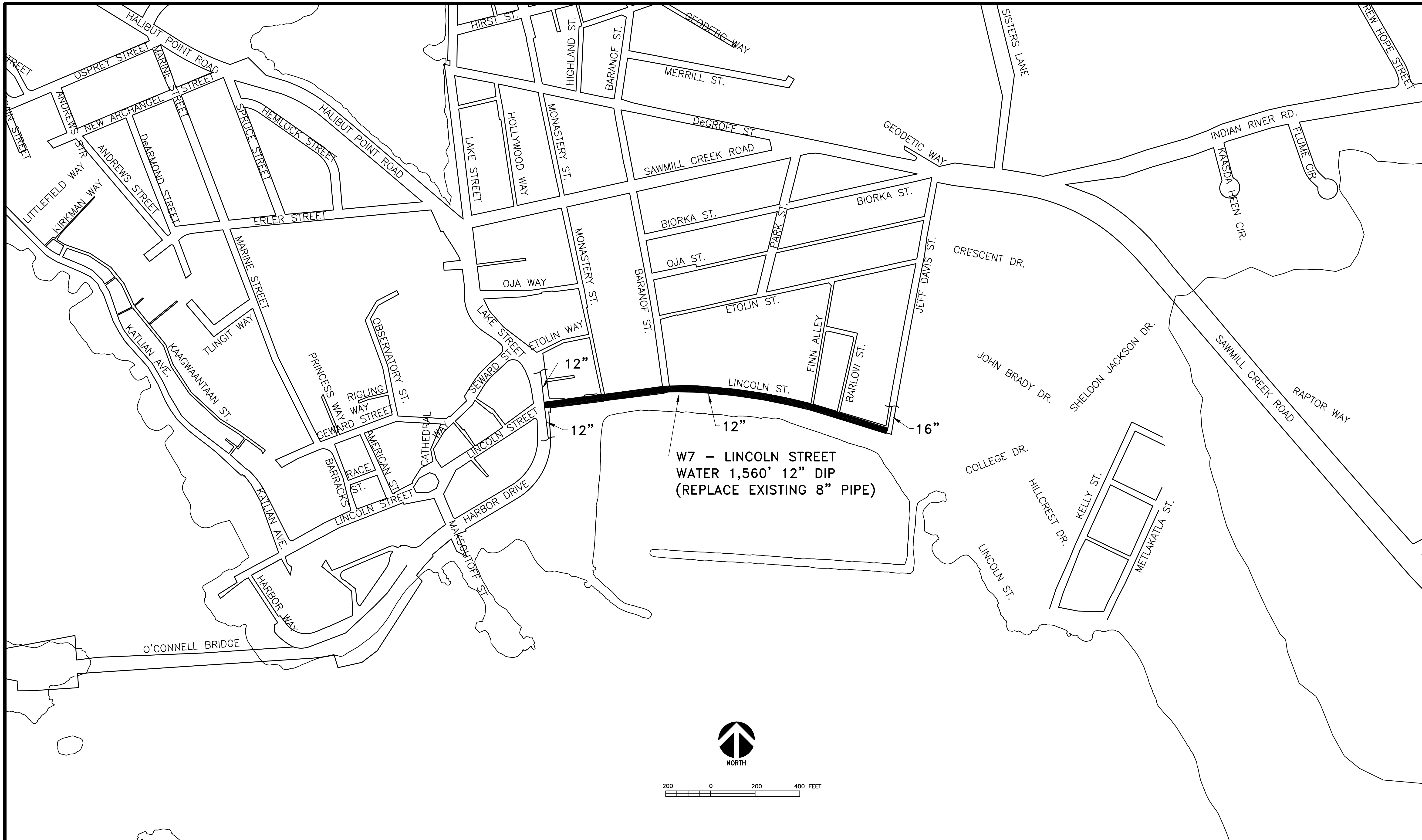

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W7 – LINCOLN STREET WATER
1,560’ 12” DIP

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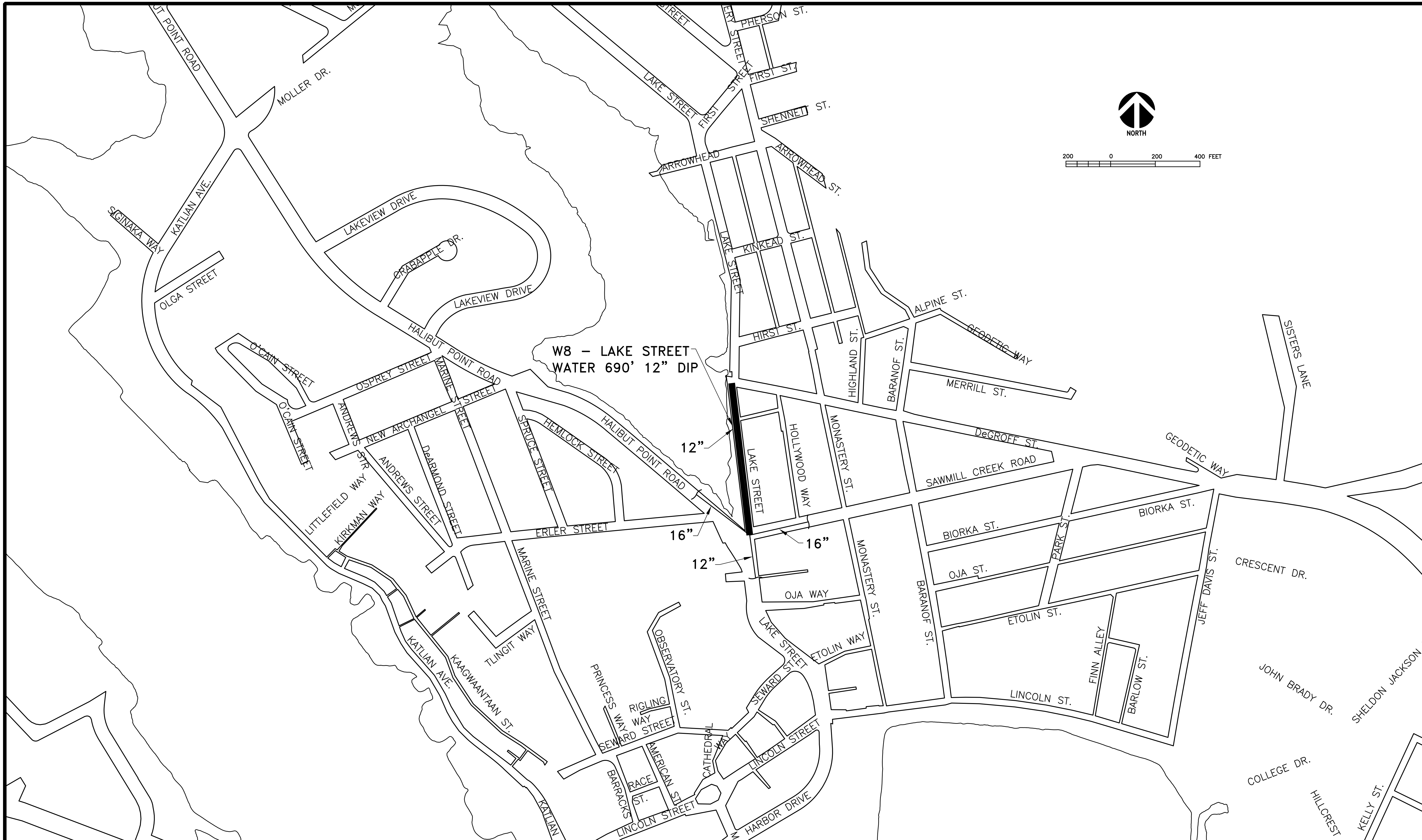

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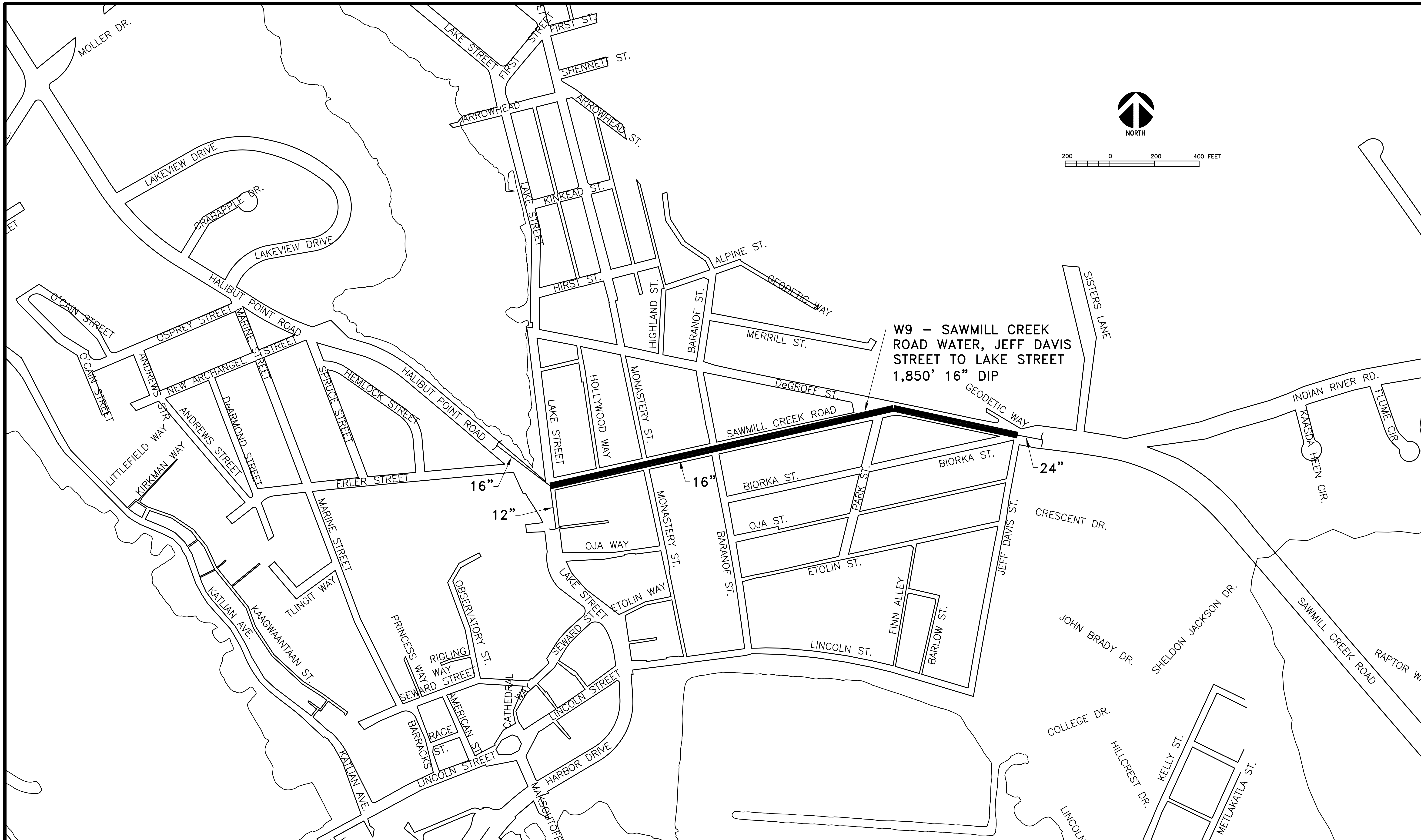
W8 – LAKE STREET WATER 690' 12" DIP

DRAWING W8

SHEET No.



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W9 – SAWMILL CREEK ROAD WATER, JEFF DAVIS STREET TO LAKE STREET 1,850' 16" DIP

DRAWING: W9

SHEET No.

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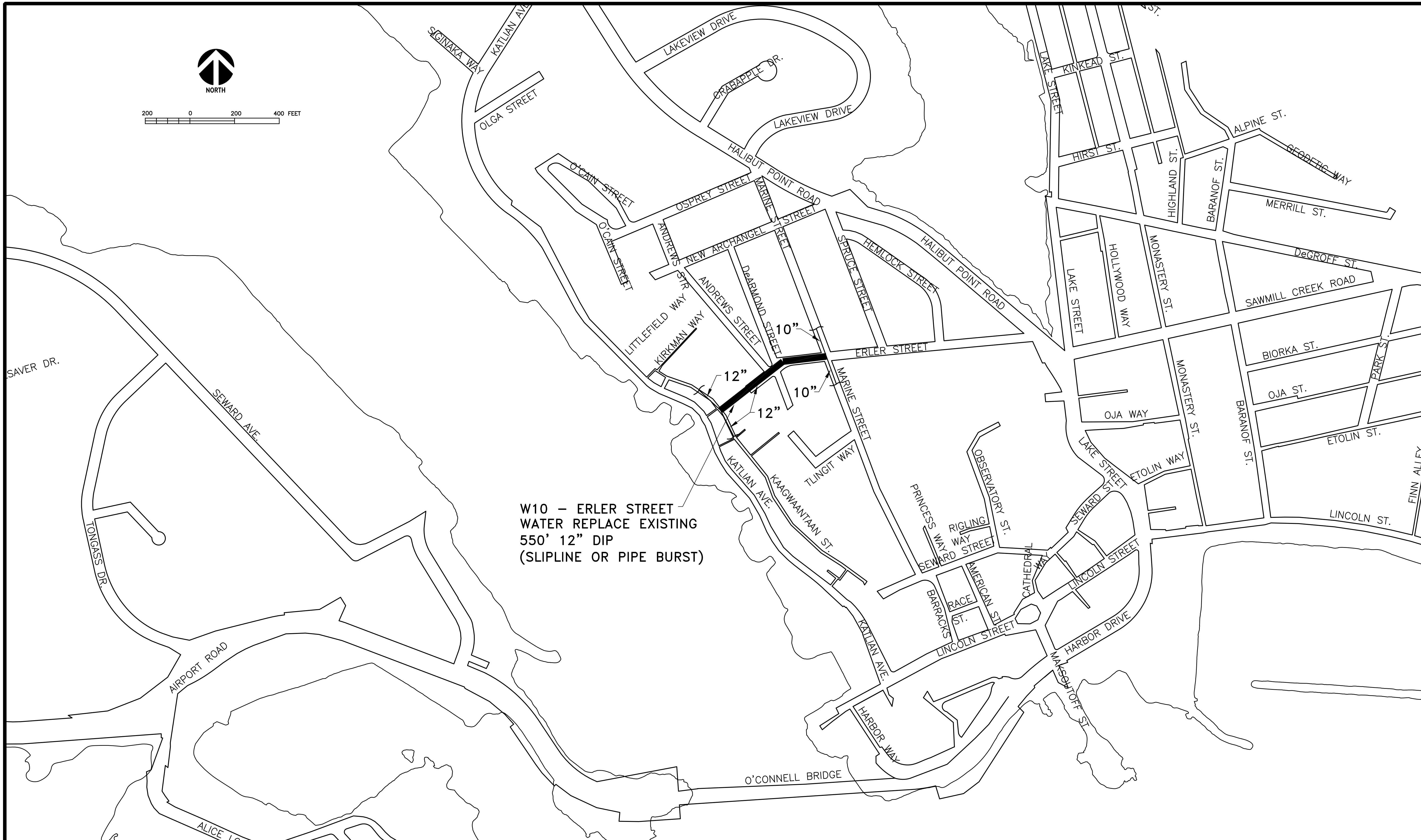

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DATE MAR 2009

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W10 – ERLER STREET WATER REPLACE EXISTING 550' 12" DIP

DRAWING W10
SHEET No.

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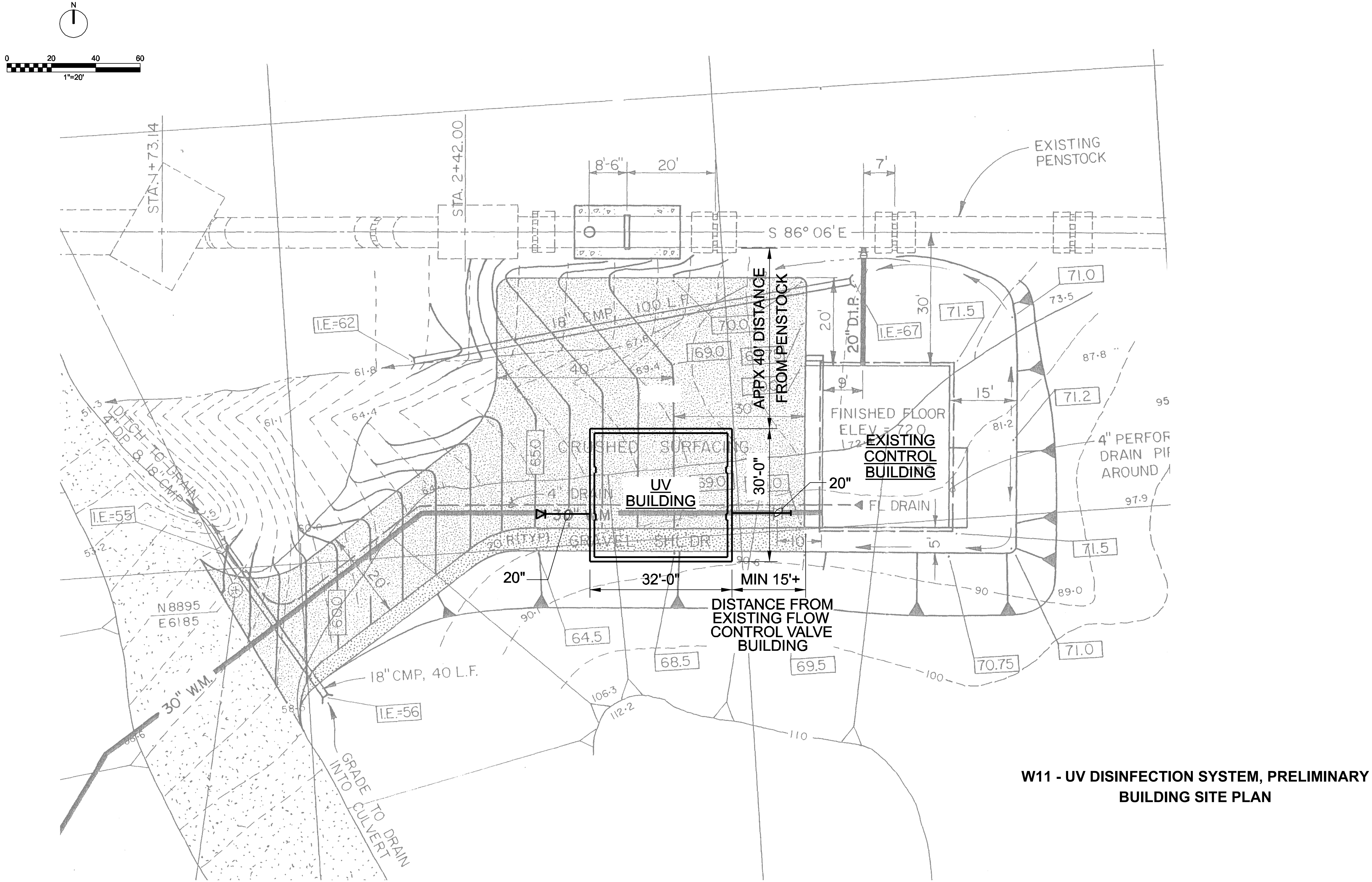
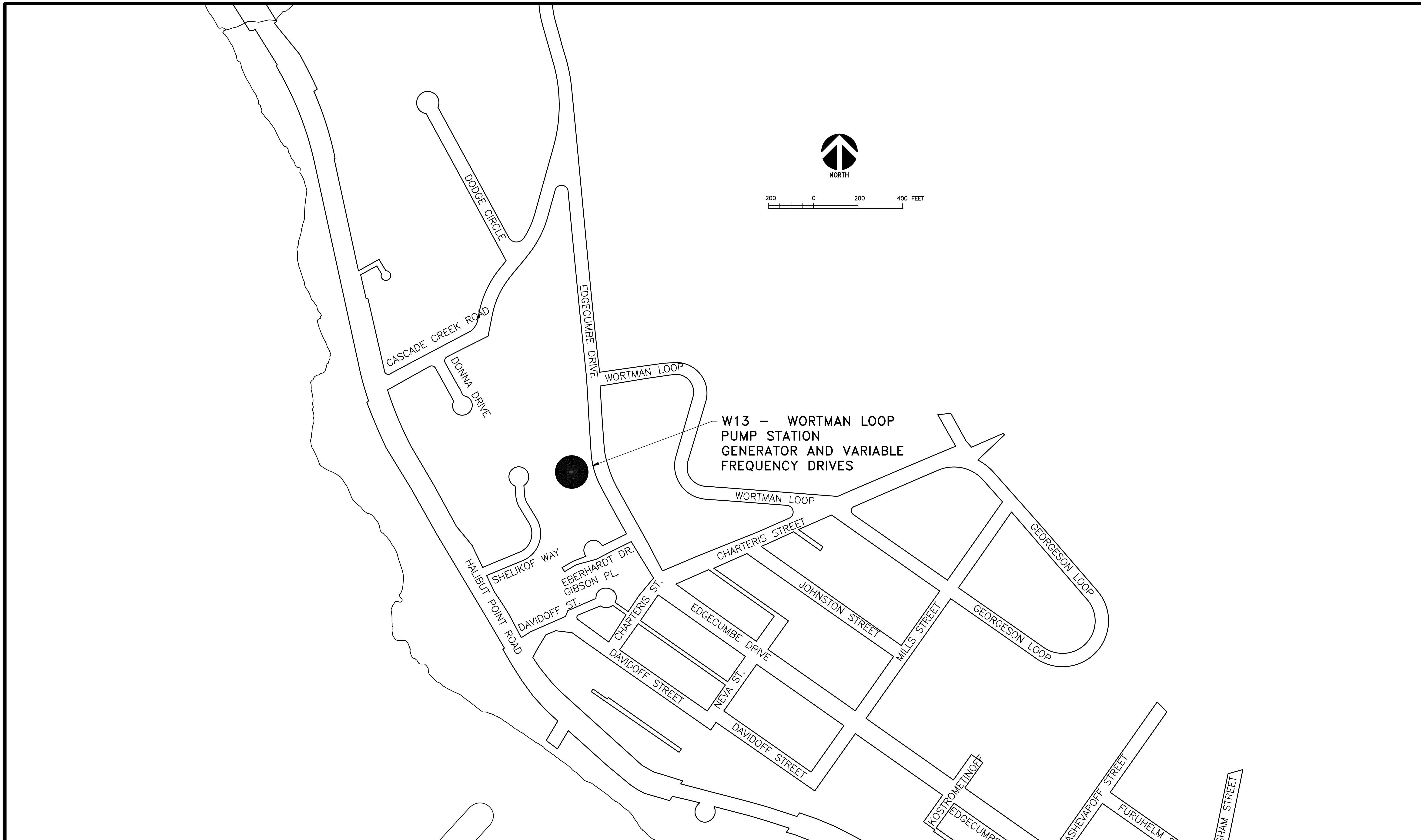


W11 - UV DISINFECTION SYSTEM, PRELIMINARY BUILDING SITE PLAN

FILENAME: FIG7-367387.dgn PLOT DATE: 5/27/2008 PLOT TIME: 12:01:25 PM



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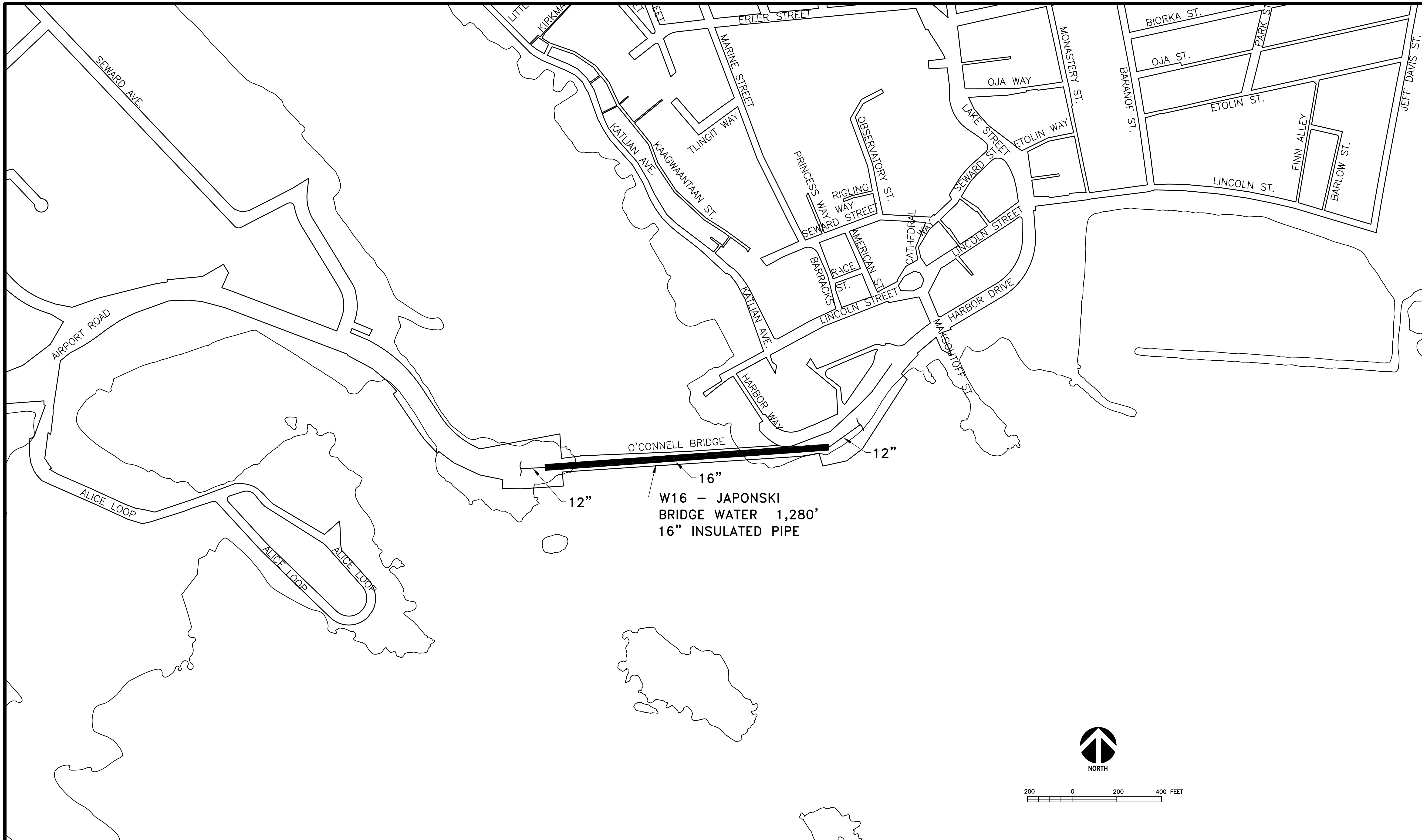
W13 – WORTMAN LOOP PUMP STATION GENERATOR, VFD'S & EXPANSION TANK

DRAWING W13
SHEET No.



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DATE MAR 2009

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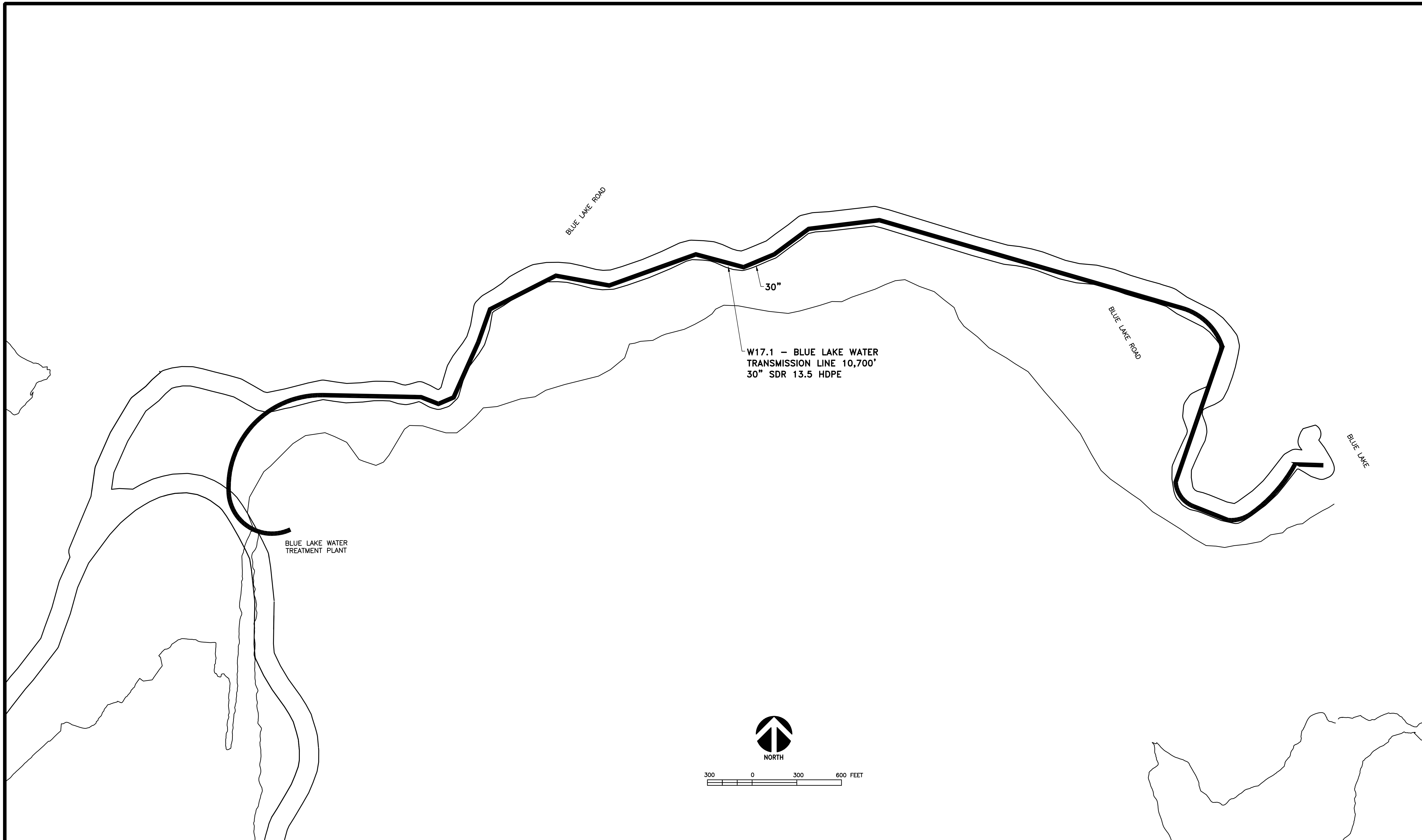
W16 – JAPONSKI BRIDGE WATER
1,280' 16" INSULATED PIPE

DRAWING
W16
SHEET No.



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SITKA WATER MASTER PLAN

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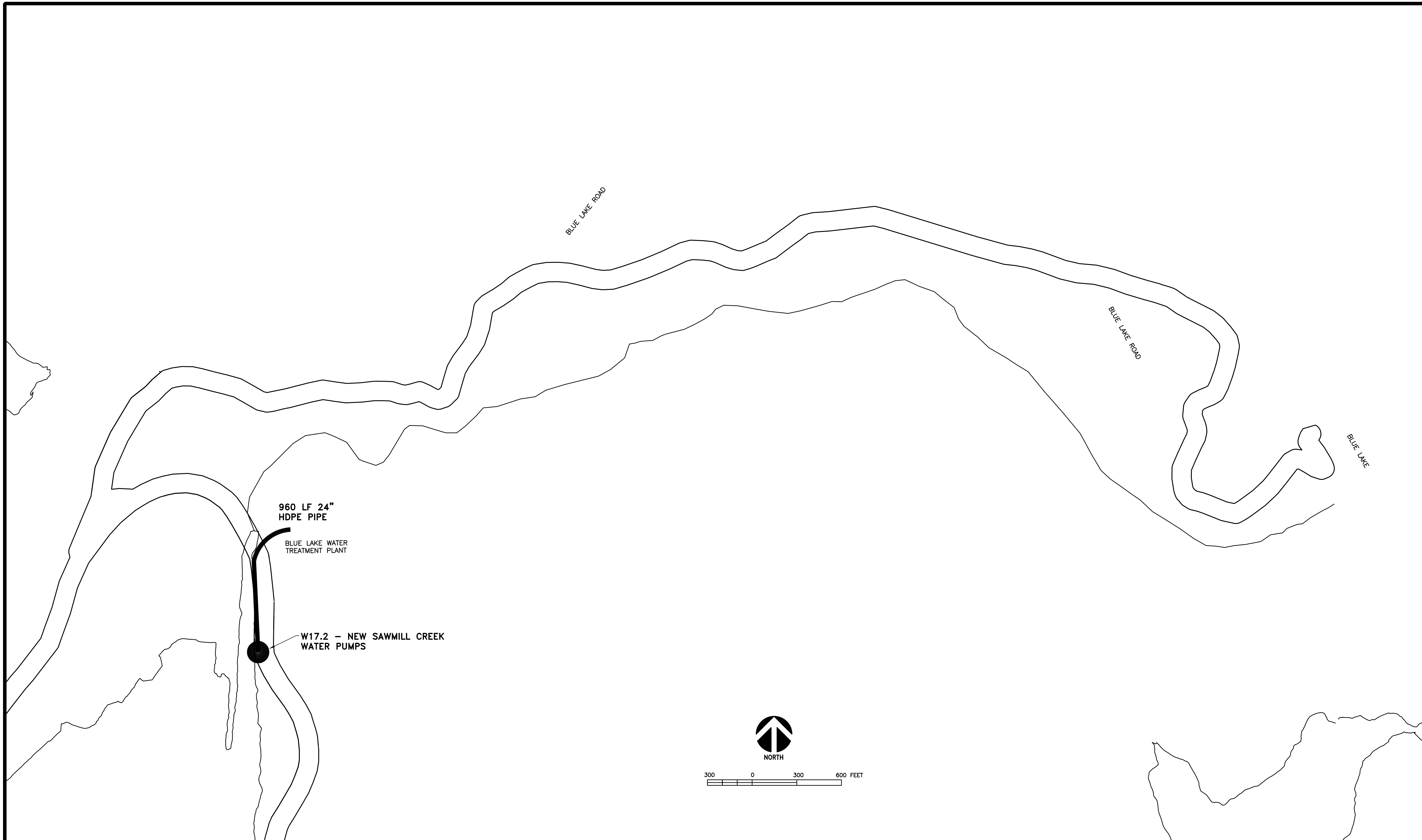
W17.1 – BLUE LAKE WATER TRANSMISSION LINE 10,700' 30" SDR 13.5 HDPE

DRAWING W17.1

SHEET No.



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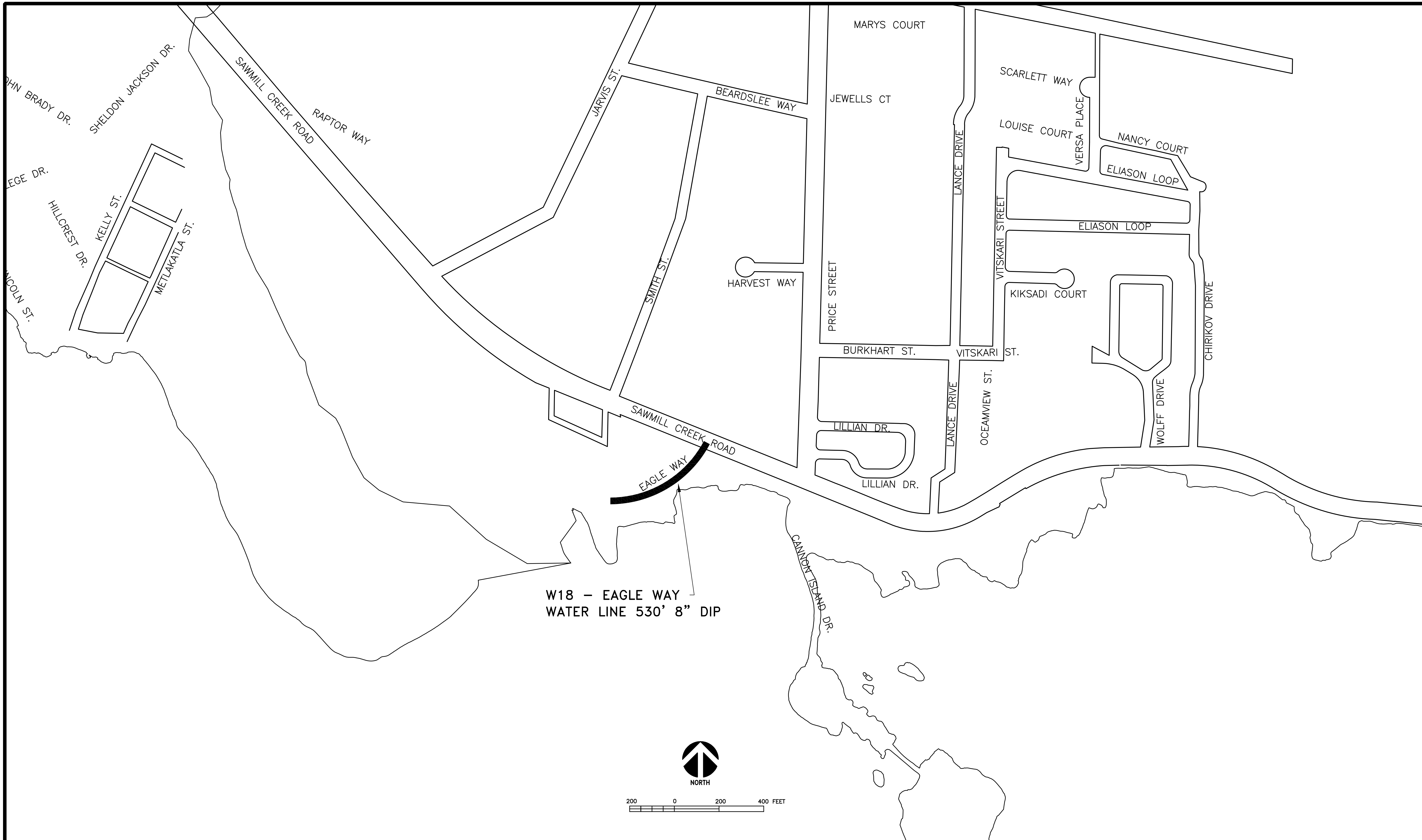
W17.2 – SAWMILL CREEK WATER IMPROVEMENTS

DRAWING W17.2

SHEET No.



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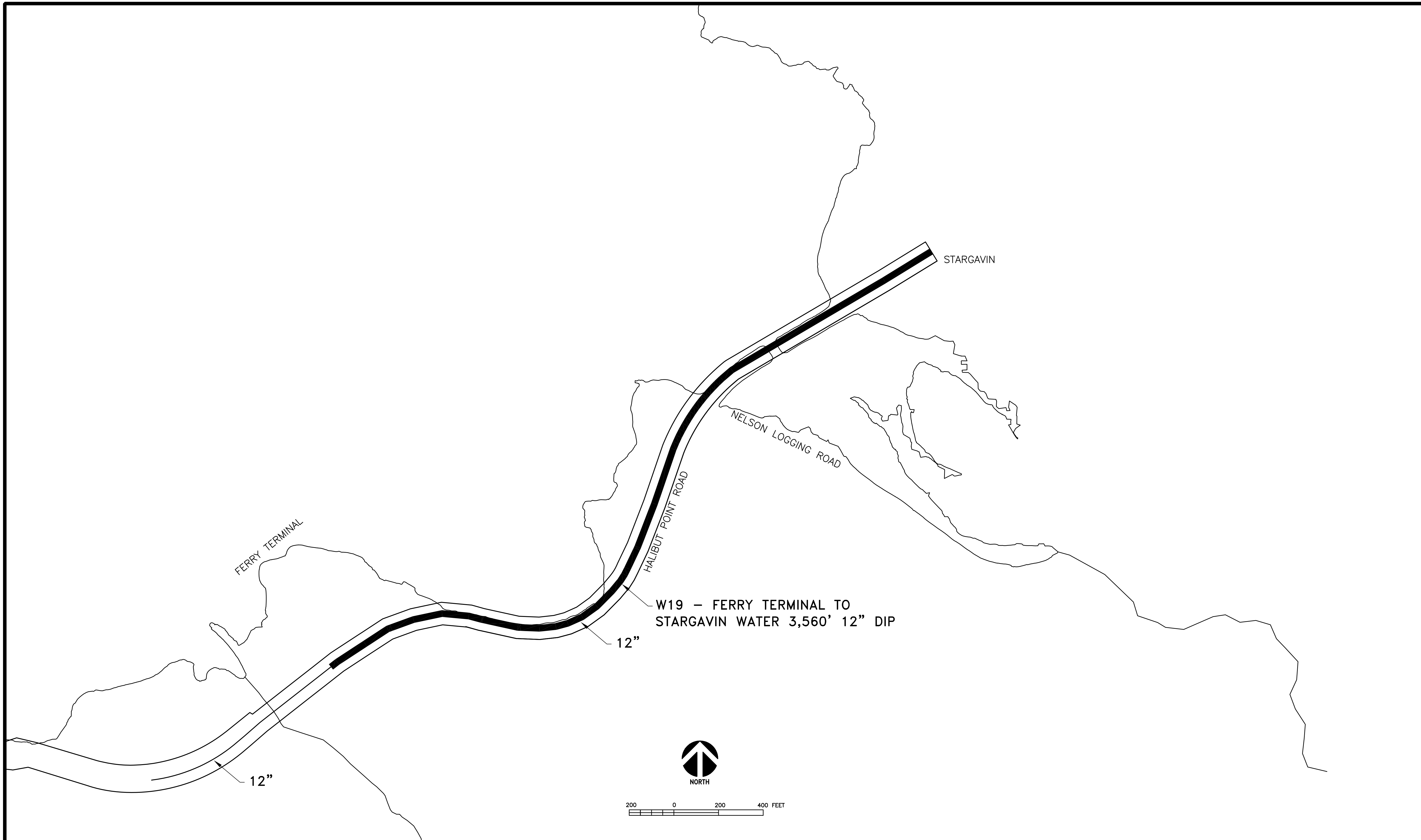
SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W18 – EAGLE WAY WATER LINE 530' 8" DIP

DRAWING W18

SHEET No.



REV	DATE	BY	DESCRIPTION

SCALE GRAPHIC
DESIGNED JLD
DRAWN GDM
CHECKED JLD
DATE MAR 2009

SITKA WATER MASTER PLAN

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W19 – FERRY TERMINAL
TO STARGAVIN WATER
3,560' 12" DIP

DRAWING W19
SHEET No.

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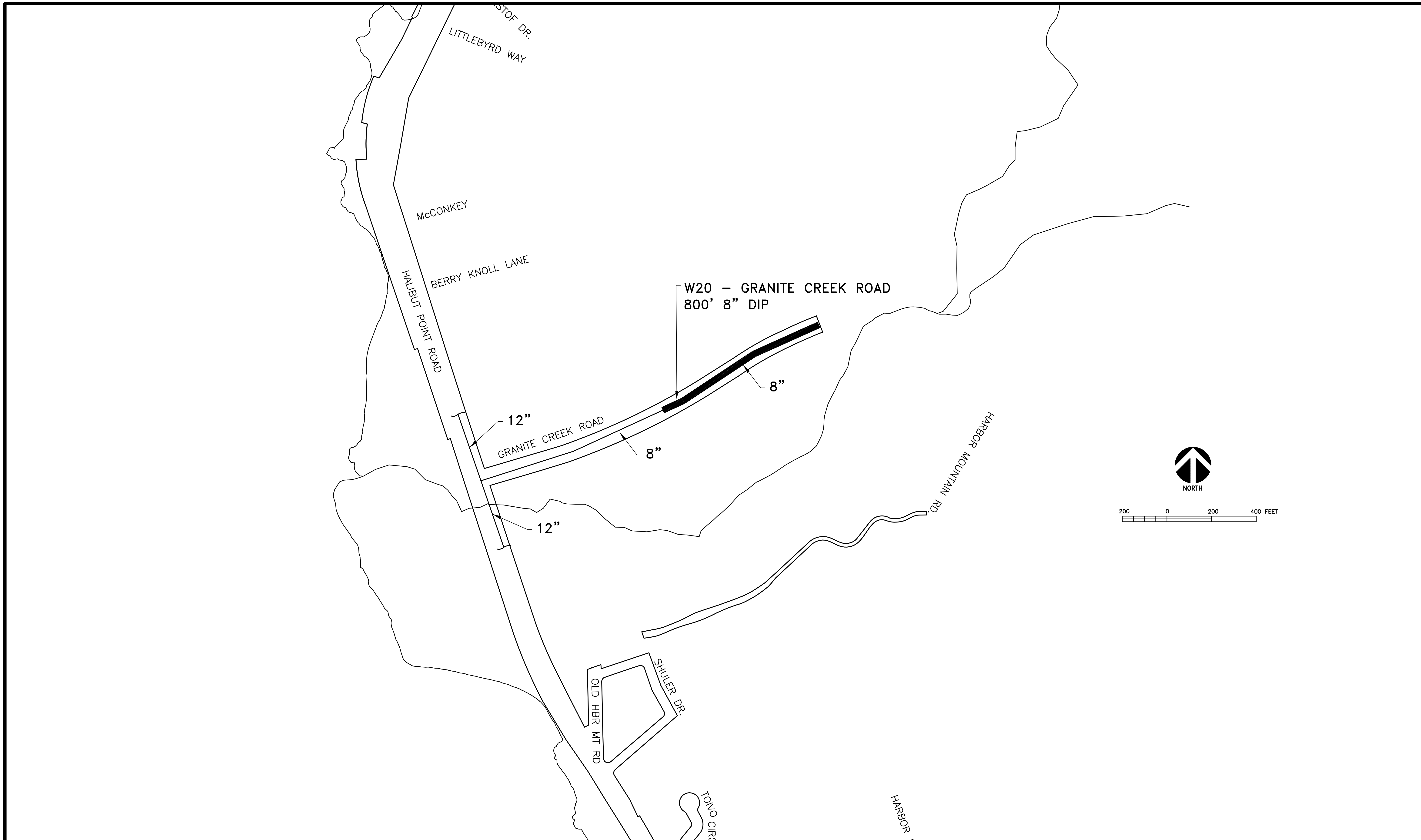

REV	DATE	BY	DESCRIPTION

SCALE GRAPHIC
DESIGNED JLD
DRAWN GDM
CHECKED JLD
DATE MAR 2009

SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W20 – GRANITE CREEK ROAD
800' 8" DIP

DRAWING W20

SHEET No.

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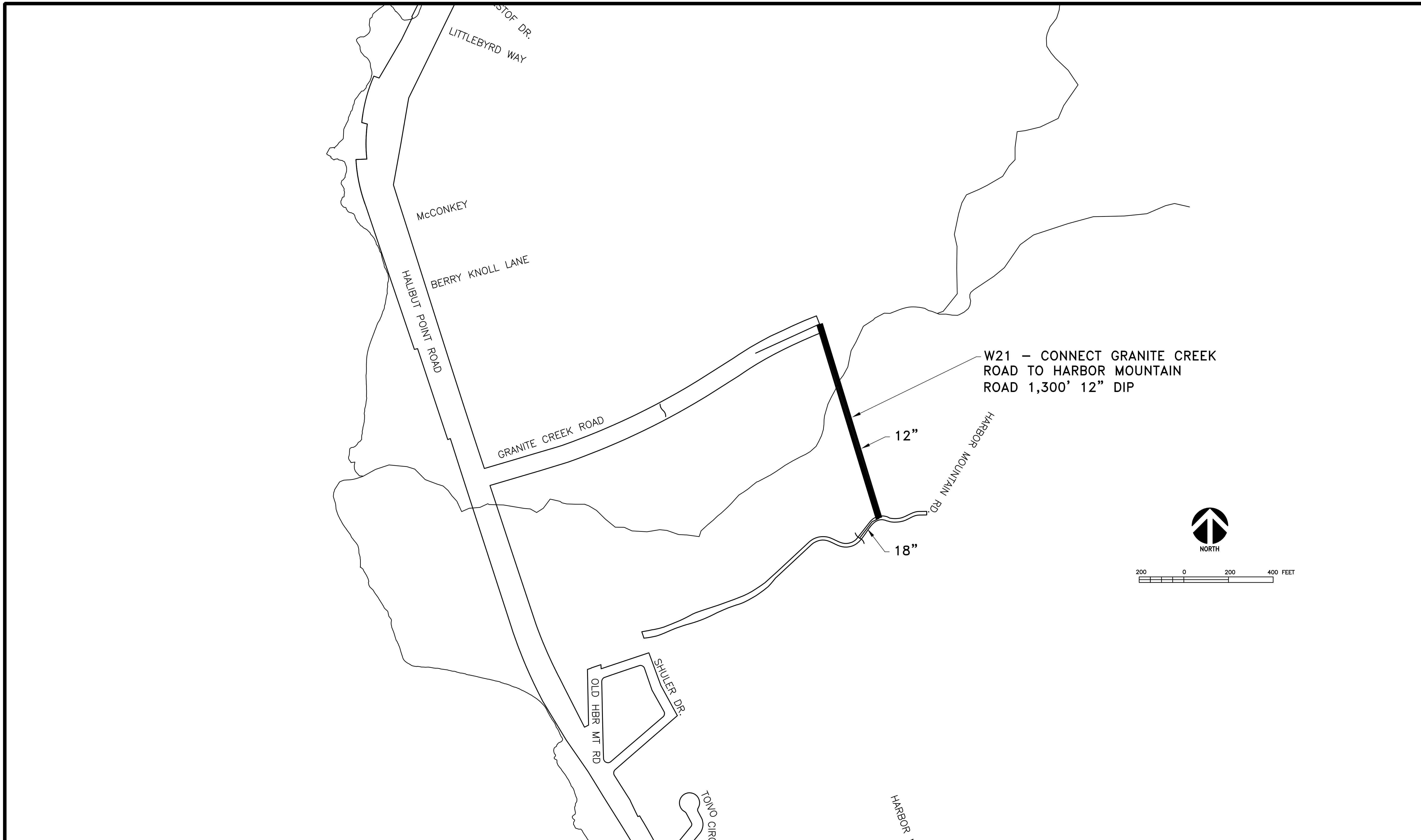

REV	DATE	BY	DESCRIPTION

SCALE GRAPHIC
DESIGNED JLD
DRAWN GDM
CHECKED JLD
DATE MAR 2009

SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W21 – CONNECT GRANITE CREEK
ROAD TO HARBOR MOUNTAIN
ROAD 1,300' 12" DIP

DRAWING
W21
SHEET No.

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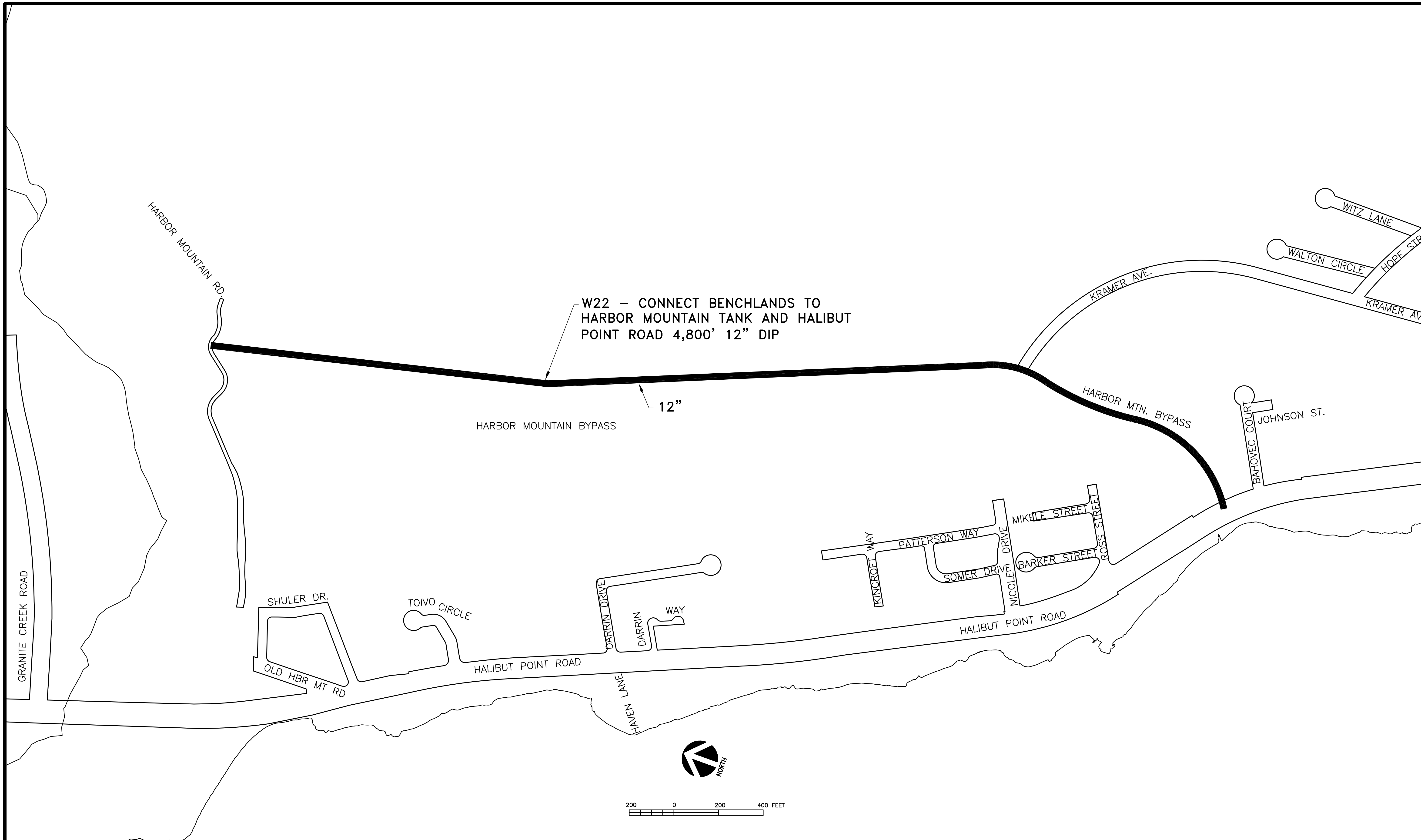

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CHECKED JLD
DATE MAR 2009

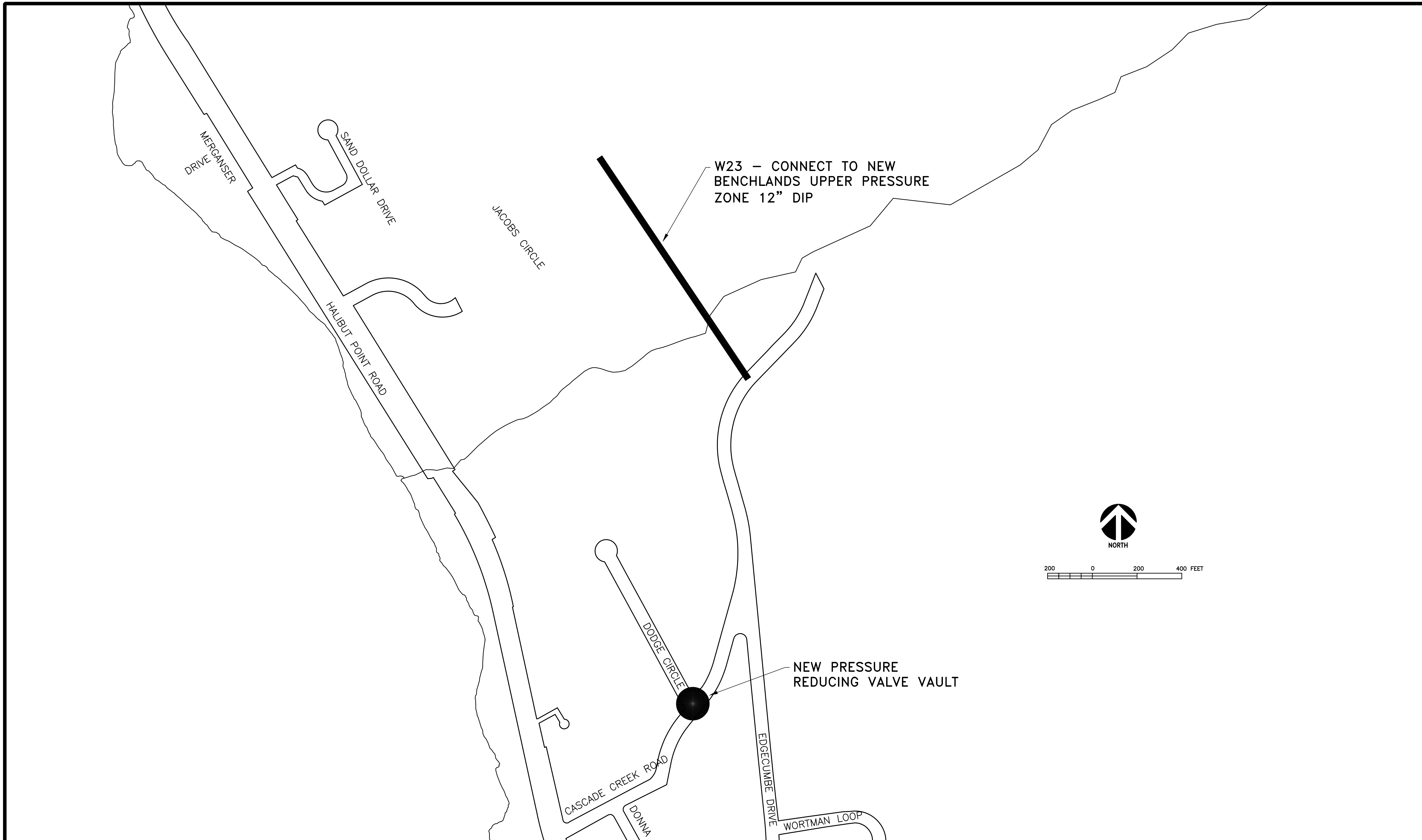
SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W22 – CONNECT BENCHLANDS TO HARBOR MOUNTAIN TANK AND HALIBUT POINT ROAD 4,800' 12" DIP

DRAWING W22

SHEET No.



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CHECKED JLD
DATE MAR 2009

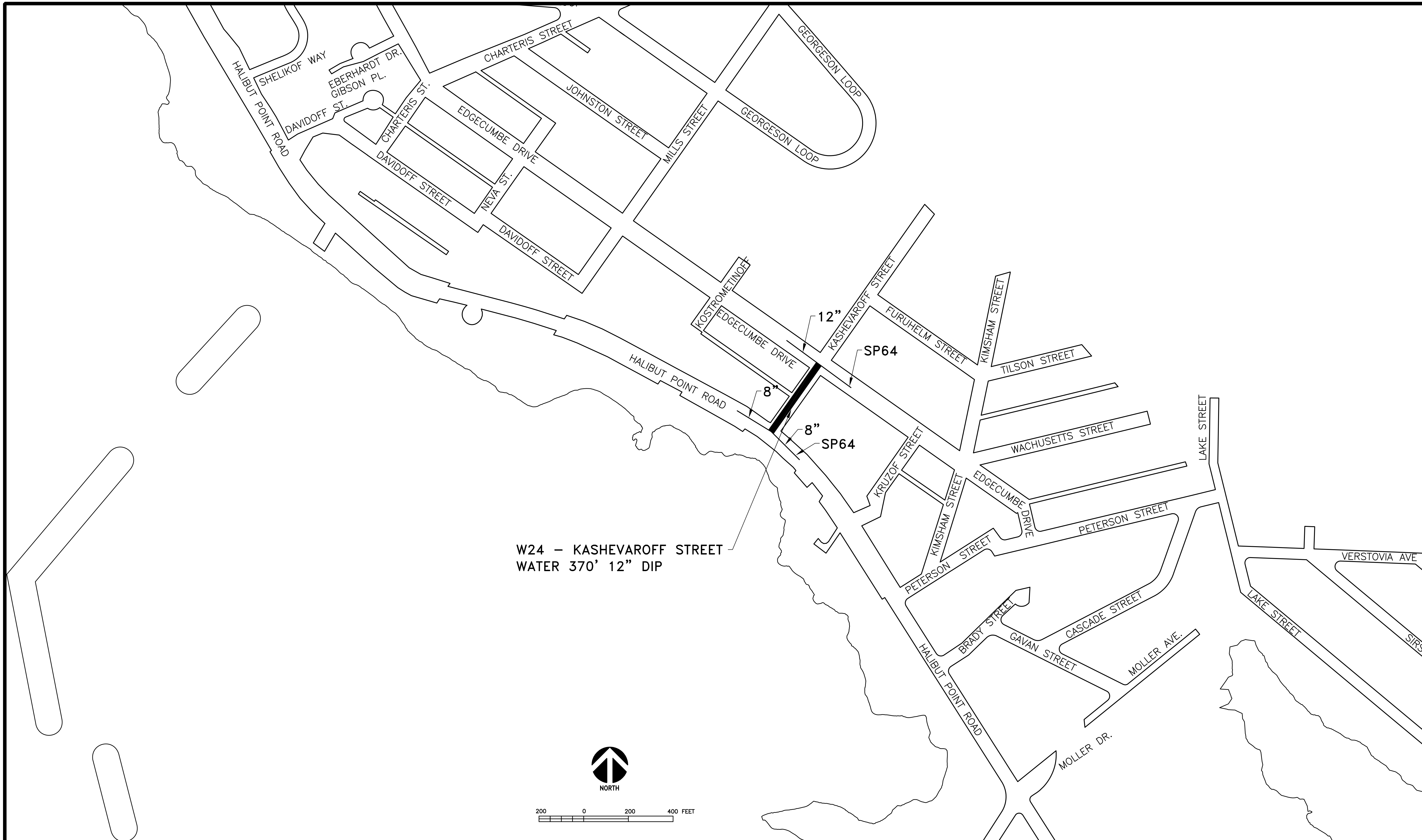
SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W23 – CONNECT TO NEW BENCHLANDS UPPER PRESSURE ZONE 12" DIP

DRAWING W23

SHEET No.



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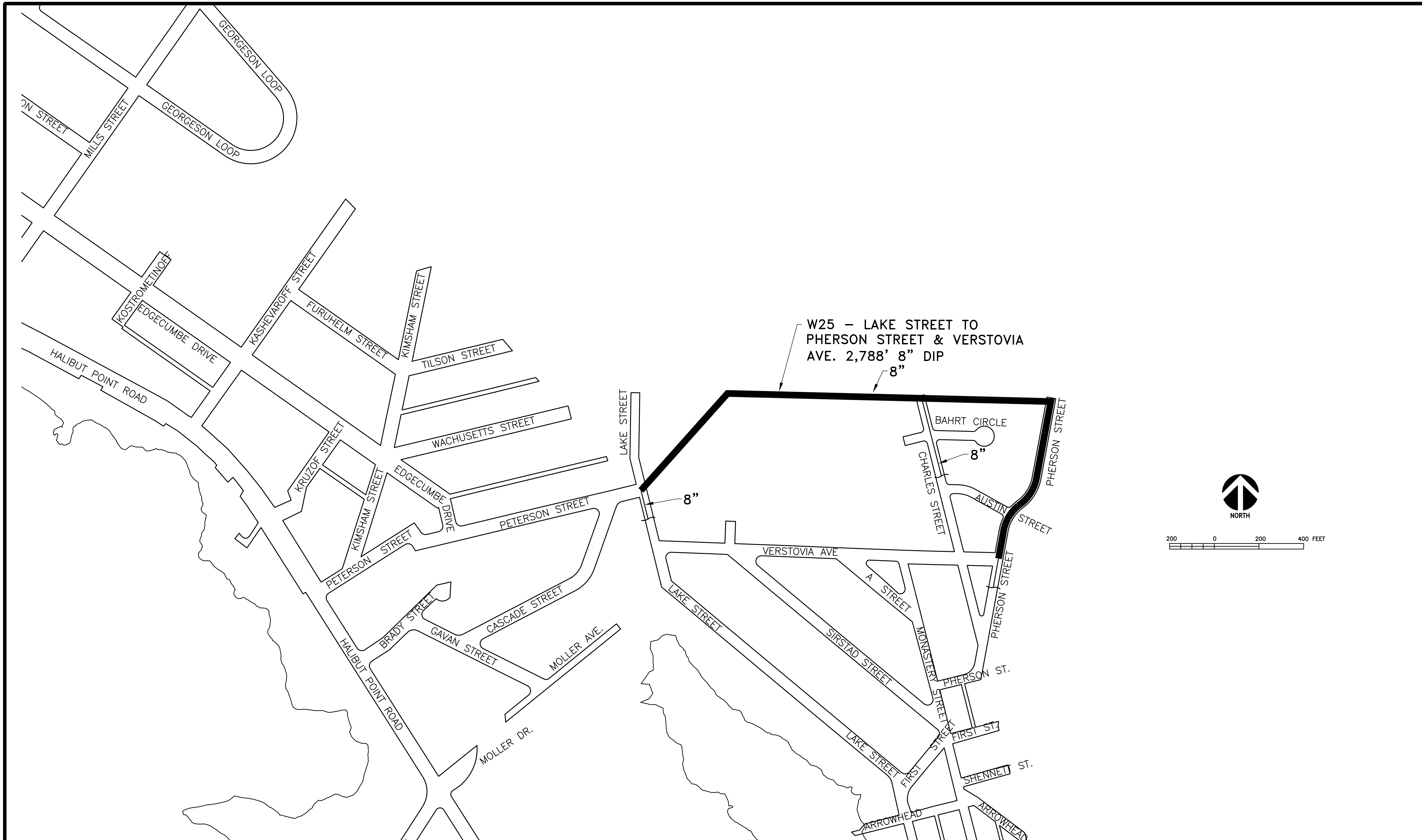
DATE MAR 2009

SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W24 – KASHEVAROFF STREET
WATER 370' 12" DIP

DRAWING
W24
SHEET No.



REV	DATE	BY	DESCRIPTION

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DRAWN GDM
CHECKED JLD
DATE MAR 2009

SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W25 – LAKE STREET TO
PHERSON STREET AND
VERSTOVIA AVE.
2,788' 8" DIP

DRAWING
W25
SHEET No.

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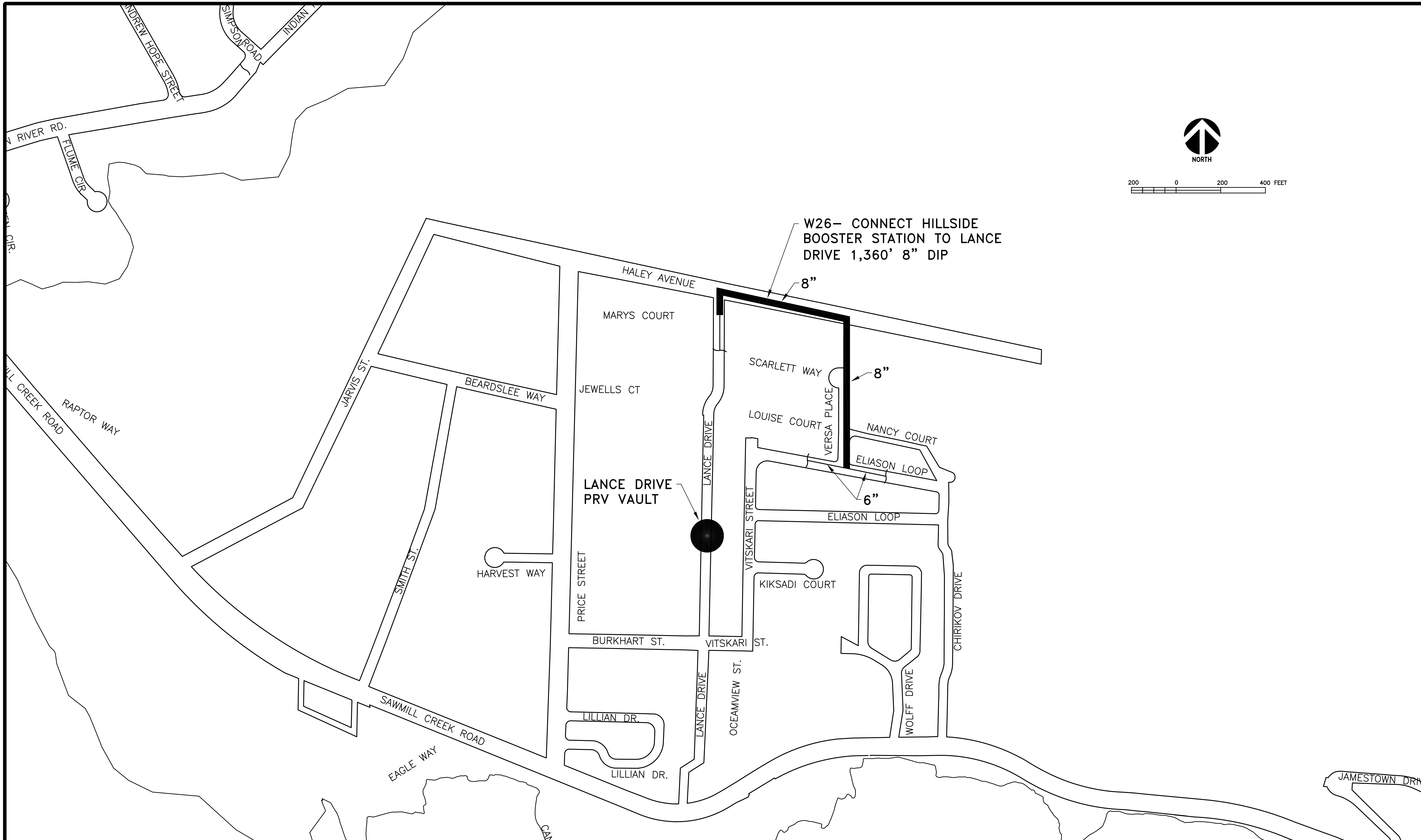

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REV	DATE	BY	DESCRIPTION

SCALE GRAPHIC
DESIGNED JLD
DRAWN GDM
CHECKED JLD
DATE MAR 2009

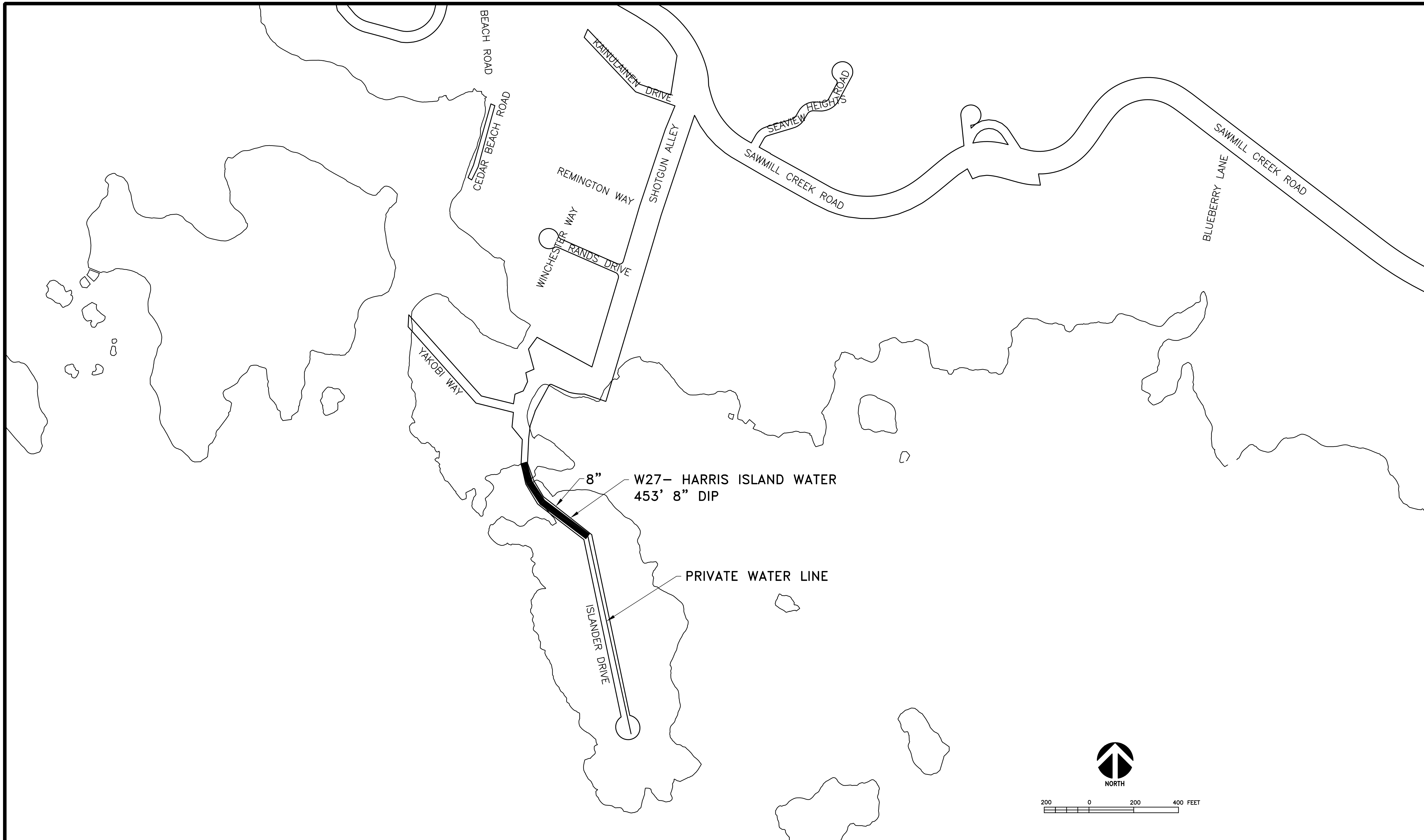
SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W26– CONNECT HILLSIDE BOOSTER STATION TO LANCE DRIVE 1,360' 8" DIP

DRAWING W26

SHEET No.



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DRAWN GDM
CHECKED JLD
DATE MAR 2009

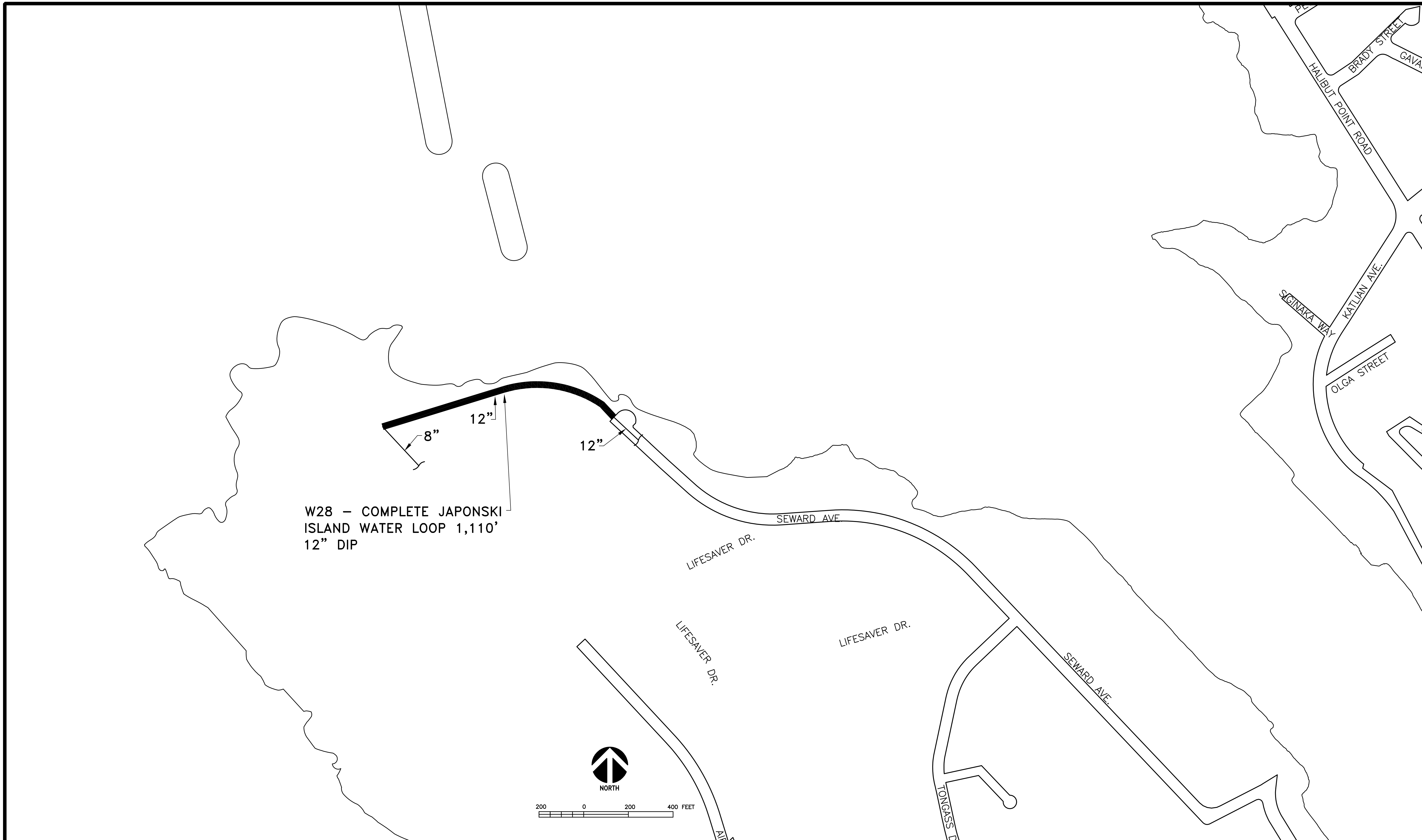
SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W27- HARRIS ISLAND WATER 453' 8" DIP

DRAWING W27

SHEET No.



REV	DATE	BY	DESCRIPTION

SCALE GRAPHIC
DESIGNED JLD
DRAWN GDM
CHECKED JLD
DATE MAR 2009

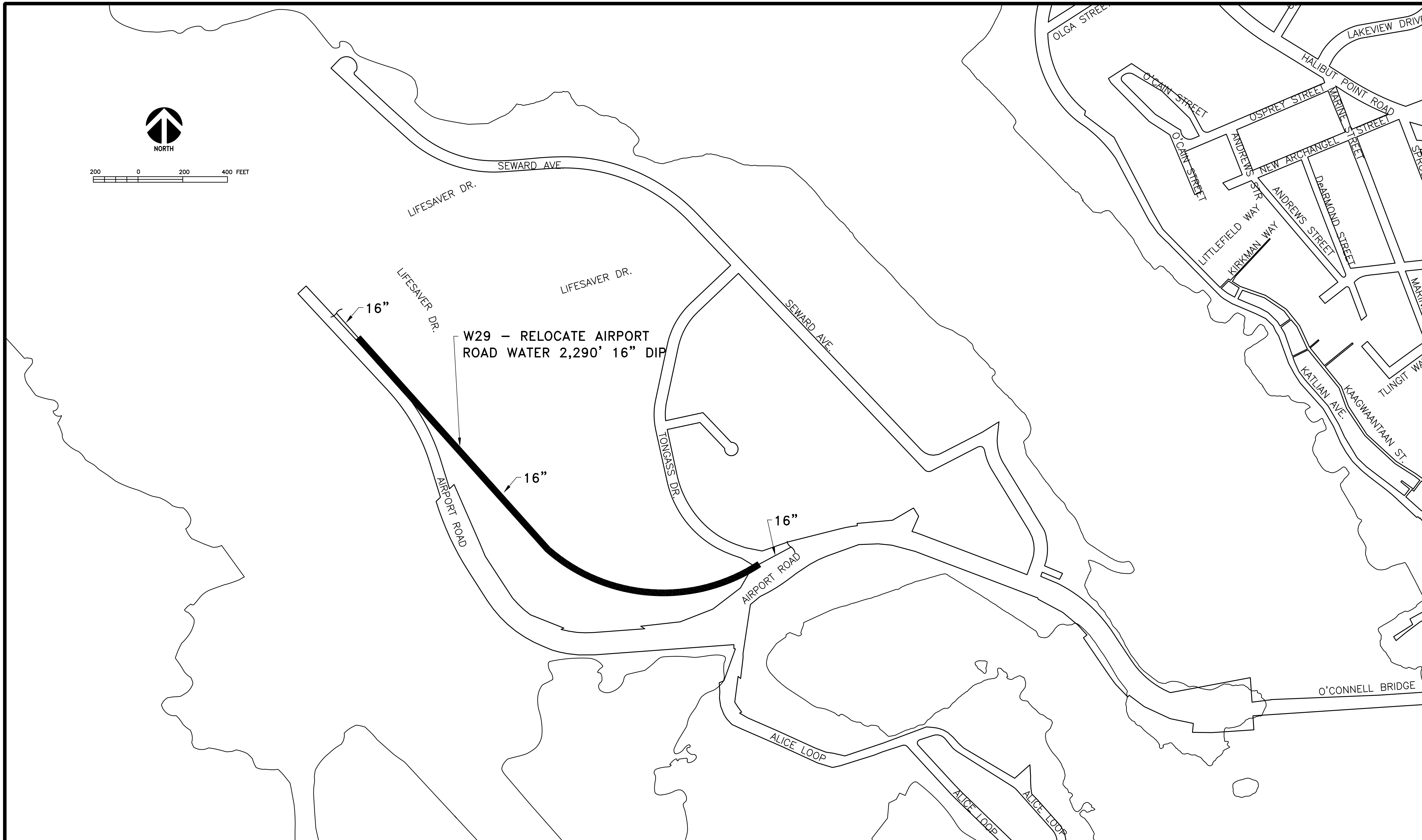
SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W28 – COMPLETE JAPONSKI ISLAND WATER LOOP 1,110' 12" DIP

DRAWING
W28
SHEET No.

G:\2cad\se_ak\Sitka\Sitka Water Plan\Sitka-Water-Plan.dwg PLOT: March 23, 2009 at: 10:26am Administrator



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REV	DATE	BY	DESCRIPTION

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DESIGNED JLD
DRAWN GDM
CHECKED JLD
DATE MAR 2009

SITKA WATER MASTER PLAN

Carson Dorn Inc.
712 WEST 12TH STREET
JUNEAU, ALASKA 99801
(907) 586-4447

W29 - RELOCATE AIRPORT ROAD WATER 2,290' 16" DIP

DRAWING
W29
SHEET No.

Chapter 8
Water System Financial Program

Working with Carson Dorn Engineers and CBS, FCS GROUP provided the Water System Financial Program in support of the City and Borough of Sitka's (CBS) Water System Master Plan. This memorandum documents the objectives, assumptions, findings, and recommendations for the Financial Program. The technical spreadsheet analysis is provided as an Appendix. Major elements of the analysis are listed below:

- Fiscal Policy Framework
- Capital Financing Strategy
- Revenue Needs Assessment (fiscal year 2009 – 2015)
- Rate Forecast (fiscal year 2009 – 2015)

Fiscal Policy Framework

Integration of fiscal policies into the financial planning process is considered a best management practice, necessary for maintaining the financial health and stability of the water utility. A brief summary of the key policies incorporated into the Financial Program is provided below:

Self Supporting Enterprise Fund

Rates were developed for this study based on the understanding that the water utility operates as a self-supporting enterprise fund and, as such, receive revenues for payment of services on a user fee basis as opposed to property taxes or other non-utility revenue sources. For this study, utility rates are established to recover the full cost of capital expenditures, operating & maintenance expenses, debt service and related coverage requirements, and provide for an adequate level of reserves.

The CBS maintains a single Water Fund in which operating and capital-related cash deposits and withdrawals are made. For purposes of this financial analysis, we have separated the Water Fund into an Operating Account and a Capital Account to identify appropriate sources and uses for each account.

Working Capital

The purpose of maintaining a working capital balance is to provide sufficient cash flow to meet daily operating expenses despite short-term variability in revenues, primarily caused by billing and expense payment cycles and seasonality in demand-based revenue streams. This study incorporates a minimum balance in the operating account equal to 30 to 45 days of annual operating & maintenance (O&M) expense sustained from rate revenue. This target level is consistent with industry practice for utilities with primarily flat rate systems since revenues are relatively stable year around. Metered rate structures warrant a higher target, typically ranging from 60 to 90 days of O&M.

The target balance should be evaluated as of June 30 of each fiscal year, with the balance expected to vary during the course of a year. In any year where the cash balance exceeds the target, we recommend transferring the excess to the capital account to help pay for capital projects.

The rate management strategy presented in this study demonstrates that this target is met in each year of the study period – averaging just over $100,000 per year.

Capital Contingency

A capital contingency is similar to a working capital balance, but is used for capital purposes. It provides a cash balance for funding emergency repairs (other than catastrophic events), unanticipated capital expenditures, and/or capital project cost overruns. This balance is established and maintained with interest earnings, system reinvestment funding from rates and excess working capital balances.

Consistent with industry practice, this study incorporates a target balance of 1% of water system fixed assets, ranging from about $100,000 to $270,000 a year.

System Reinvestment Funding

System reinvestment funding from rates provides for: (1) ongoing system integrity through reinvestment in the system – replacing physical assets with cash assets; (2) rate stability through regular accumulation of cash toward funding future replacement costs; and (3) charging customers commensurate with their consumption of system facilities.

Each year, water system assets lose value, and as they lose value they are moving toward eventual replacement. That accumulating loss in value and future liability is measured for financial purposes as annual depreciation expense, which is based on the original cost of the asset over its anticipated useful life. While this expense reflects the consumption of the existing asset at its original investment, the replacement of that asset will likely cost much more, factoring in inflation and construction conditions. Therefore, the added annual replacement liability is even greater than the recorded annual depreciation.

The City’s historical practice has been to fund capital needs through a combination of grants, loans, and “pay-as-you-go” funding from rates. While this approach meets annual capital funding needs, it would likely result in significant “spikes” in rates to fund inevitable peaks in infrastructure needs as water system assets age. This study introduces a system reinvestment funding policy to annually fund from rates an amount equal to annual depreciation expense. To mitigate near-term rate impacts, this policy was phased in over the study period. Current depreciation expense is $367,000. Applying the phase-in factor over the study period, funding will range from about $200,000 to just under $650,000 by the end of the study period. Funds will accumulate in years where system reinvestment funding deposits exceed capital replacement needs and will be drawn down as needed to minimize debt financing of replacement projects.

It is important to note that as state grant and low-cost loans are becoming more and more competitive, eligibility criterion are expanding to include review of best management practices such as system reinvestment funding policies.

Debt Management

Debt management policies are intended to: (1) provide an appropriate balance of debt and equity financing of capital needs; (2) maintain credit worthiness for future debt issuance; and (3) promote equity between existing and future ratepayers. As noted above, a combination of sources (grant, loan, and cash) has been used to fund capital. The priority of funding will of course continue to secure as much grant funding as possible, followed by the combination of low cost loans and cash financing. Standard loan/bond underwriter preference for municipalities is to maintain a debt-to-equity ratio of no greater than 50% debt / 50% equity (cash). To assist the CBS in maintaining this ratio, we recommend debt-financing no more than 75% of the capital program over a six-year rolling period.

Attainment of recommended debt management policies are discussed in more detail in the next section.

Capital Financing Strategy

The CBS has identified $40.9 million (current day dollars) in water capital improvement and replacement projects planned for construction 2009 through 2030. Incorporating assumed annual inflation of 6% per year, this equates to $80 million in total capital funding needs. Capital spending levels vary from year to year, with an average annual spending of roughly $3.6 million. The capital funding plan assumes a mix of funding from cash balances, annual system reinvestment funding from rates, and state grants and loans. State loans assume an interest rate of 1.5% and a 20-year repayment term.

Exhibit 1 summarizes the six-year capital financing plan (FY 2009-14).

Exhibit 1: Six-Year Capital Financing Plan

Capital Funding	2009	2010	2011	2012	2013	2014	2015
Total Capital Projects	**$ 589,732**	**$ 1,511,223**	**$ 4,008,647**	**$ 3,838,861**	**$ 3,146,953**	**$ 2,968,428**	**$ 841,014**
Grants	-	895,965	3,932,038	2,128,346	2,246,578	2,014,029	-
State Loan Proceeds	-	383,985	-	1,104,072	814,298	863,155	744,297
Direct Rate-Funding	-	-	-	60,223	-	-	
Use of Capital Fund Balance	589,732	231,273	76,609	546,220	86,078	91,243	96,717
Total Funding Sources	**$ 589,732**	**$ 1,511,223**	**$ 4,008,647**	**$ 3,838,861**	**$ 3,146,953**	**$ 2,968,428**	**$ 841,014**

Of the $80 million in planned capital costs, about $16.9 million, or 20%, is scheduled to occur during the study period. About $11.2 million (66%) is expected to be funded with grants, another $3.9 million (23%) funded from loans, with the remaining $1.8 (11%) funded from cash, primarily generated through system reinvestment funding. Based on this financing plan, the capital program will remain within the suggested debt management policy of funding no more than 75% of the program with debt.

Exhibit 2 summarizes the total capital financing plan (FY 2009-30).

Exhibit 2: Total Capital Financing Plan

Capital Funding		Total 2009 - 30
Total Capital Projects	**$**	**80,018,234**
Grants and Developer Donations		37,358,559
State Loan Proceeds		34,160,364
Rates / Cash Balance		8,499,312
Total Funding Sources	**$**	**80,018,234**

About $37.3 million (47%) is expected to be funded with grants, another $34.2 million (43%) funded from loans, with the remaining $8.5 million (11%) funded from cash. As reflected in the table, the percentage of funding from grants is expected to decrease over time. To minimize debt issuance, it will become more and more critical to fund system reinvestment through rates.

Revenue Needs Assessment

The revenue needs assessment determines the amount of annual revenue needed to be generated by user rates and forms the basis for a long-range financial plan and multi-year rate management strategy for the water utility. The analysis incorporates fiscal policies and forecasts of operating revenues and expenditures, debt service, and any other identified revenues or expenses related to utility operations to determine the sufficiency of the current level of rates. The following assumptions were used in this analysis:

- Revenue under existing rates is assumed to remain flat over the study period, currently at about $910,000; no growth in the customer base.
- The FY 2009 beginning cash balance of about $955,000 was provided by CBS staff and assigned to the operating account and capital account in accordance with fiscal policy recommendations. Interest earnings on available cash balances are assumed at 4% per year.
- Miscellaneous revenues and operating and maintenance (O&M) expenditures are based on the FY 2009 operating budget, escalated by 3.5% annual inflation. Miscellaneous revenues average about $60,000 a year. O&M expenses range from $769,000 to $1.1 million by the end of the study period.
- Debt service on existing state loans total just over $100,000 a year.
- Future years' debt service incorporates impacts of the proposed capital financing plan. State loans are assumed to fund capital needs in excess of grant and cash funding. Incremental debt service of about $25,000 begins in 2011 increasing to over $200,000 in new debt service by the end of the study period.
- System reinvestment funding is phased in over the study period beginning in 2010 at about $228,000, climbing to about $650,000 by the end of study period.

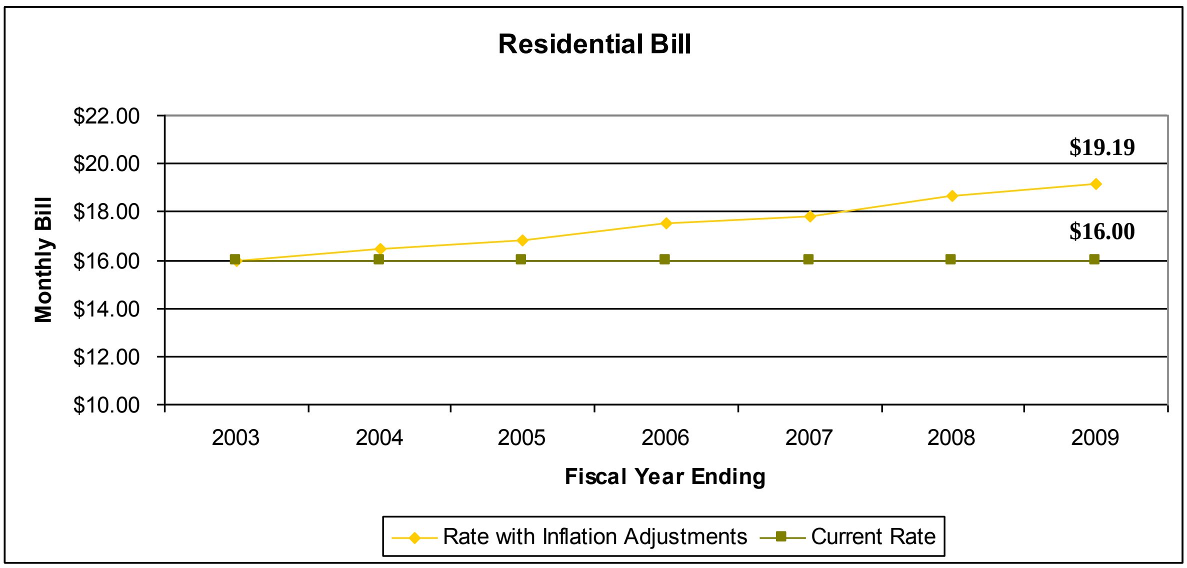
As shown in Exhibit 3, current revenues are insufficient to meet forecasted water utility financial obligations over the study period.

Exhibit 3: Revenue Needs Assessment

Revenue Requirements	2009	2010	2011	2012	2013	2014	2015
Revenues							
Rate Revenues Under Existing Rates	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619
Non-Rate Revenues	57,307	60,601	61,204	63,285	64,417	66,927	70,162
Total Revenues	**$ 967,926**	**$ 971,220**	**$ 971,823**	**$ 973,904**	**$ 975,036**	**$ 977,546**	**$ 980,781**
Expenses							
Annual Cash Expenditures	$ 768,810	$ 795,718	$ 823,568	$ 852,393	$ 882,227	$ 913,105	$ 1,115,064
Existing Debt Service	163,410	108,915	108,039	107,162	106,285	105,409	104,532
New Debt Service	-	-	24,671	24,671	95,320	147,350	201,692
Rate Funded System Reinvestment	-	227,277	286,313	391,354	509,372	628,908	640,000
Rate Funded CIP	-	-	-	60,223	-	-	-
Total Expenses	**$ 932,220**	**$ 1,131,910**	**$ 1,242,592**	**$ 1,435,803**	**$ 1,593,205**	**$ 1,794,772**	**$ 2,061,288**
Annual Surplus/(Deficiency)	**$ -**	**$ (160,690)**	**$ (270,769)**	**$ (461,900)**	**$ (618,168)**	**$ (817,227)**	**$ (1,080,507)**

It is important to note that CBS water rates have not kept pace with inflation, with the last increase implemented July 1, 2002. Exhibit 4 compares the monthly residential water bill under current rates ($16.00) versus where it should be ($19.19) just to account for annual inflation since the last increase[1].

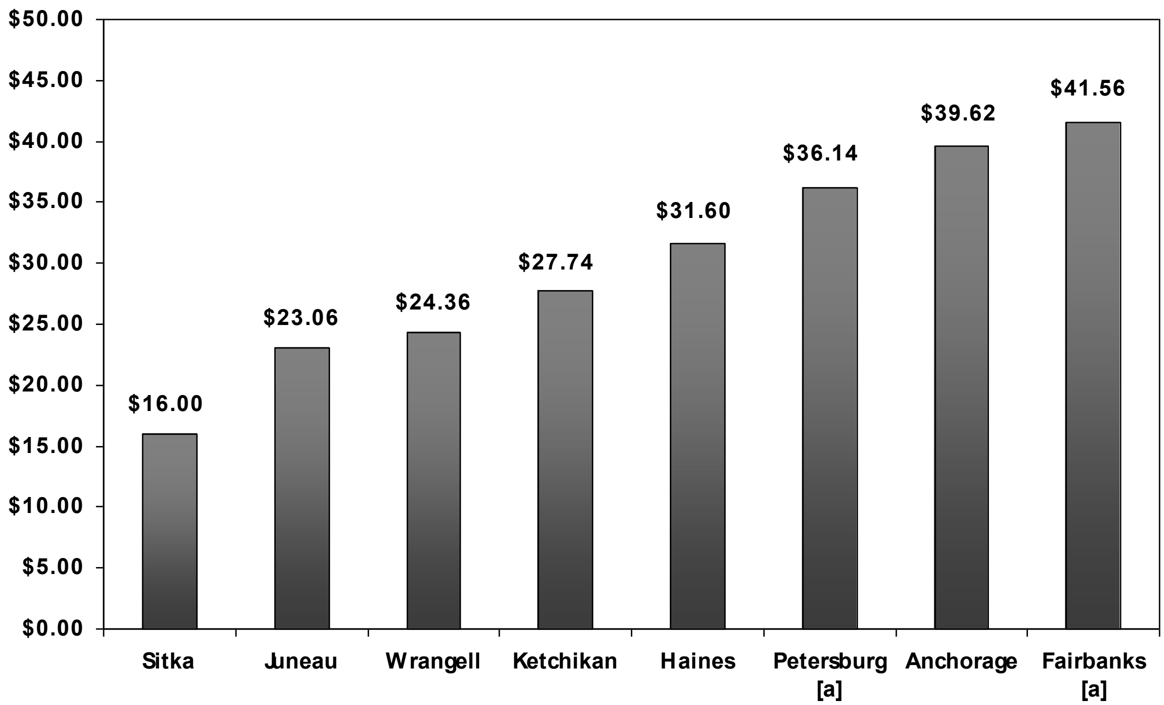
Exhibit 4: Typical Bill Inflation Comparison



For informational purposes only, Exhibit 5 presents a comparison of current water rates (as of January 2009) with a sampling of neighboring jurisdictions.

[1] Anchorage Consumer Price Index, FY 2002/03 – FY 2008/09; average inflation rate of 3% per year.

Exhibit 5: Comparison of Residential Water Bills



[a] assumes average use of 90 gallons per day

Rate Forecast

Exhibit 6 presents the proposed rate forecast for the study period. This rate strategy was designed to smooth in the necessary rate increases over time, while integrating best management practices, funding the capital program, and meeting the annual operational needs of the water utility.

Exhibit 6: Rate Forecast

Rate Forecast	2009	2010	2011	2012	2013	2014	2015
Monthly Base Rate per Unit [1]	$16.00	$18.24	$20.79	$23.70	$27.02	$30.81	$35.12
Monthly Dollar Impact	$0.00	$2.24	$2.55	$2.91	$3.32	$3.78	$4.31

[1] Based rate applies per dwelling unit for residenital; varies for commercial customers based on unit equivalents

Following implementation of the proposed rate strategy for the study period, staff expects future year rate increases to correspond with annual inflationary levels. FCS GROUP recommends regular review of all underlying assumptions and an update of the rate analysis as necessary to meet financial obligations of the water utility.

TECHNICAL APPENDIX

Financial Spreadsheet Model

The City and Borough of Sitka
Water Utility
Table 1 Summary

FY Ending

Capital Funding	2009	2010	2011	2012	2013	2014	2015
Total Capital Projects	**$ 589,732**	**$ 1,511,223**	**$ 4,008,647**	**$ 3,838,861**	**$ 3,146,953**	**$ 2,968,428**	**$ 841,014**
Grants	-	895,965	3,932,038	2,128,346	2,246,578	2,014,029	-
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Direct Rate-Funding	-	-	-	60,223	-	-	
Use of Capital Fund Balance	589,732	231,273	76,609	546,220	86,078	91,243	96,717
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Revenue Requirements	2009	2010	2011	2012	2013	2014	2015
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Rate Revenues Under Existing Rates	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619
Non-Rate Revenues	57,307	60,601	61,204	63,285	64,417	66,927	70,162
Total Revenues	**$ 967,926**	**$ 971,220**	**$ 971,823**	**$ 973,904**	**$ 975,036**	**$ 977,546**	**$ 980,781**
Expenses							
Annual Cash Expenditures	$ 768,810	$ 795,718	$ 823,568	$ 852,393	$ 882,227	$ 913,105	$ 1,115,064
Existing Debt Service	163,410	108,915	108,039	107,162	106,285	105,409	104,532
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Rate Funded System Reinvestment	-	227,277	286,313	391,354	509,372	628,908	640,000
Rate Funded CIP	-	-	-	60,223	-	-	-
Total Expenses	**$ 932,220**	**$ 1,131,910**	**$ 1,242,592**	**$ 1,435,803**	**$ 1,593,205**	**$ 1,794,772**	**$ 2,061,288**
Annual Surplus/(Deficiency)	**$ -**	**$ (160,690)**	**$ (270,769)**	**$ (461,900)**	**$ (618,168)**	**$ (817,227)**	**$ (1,080,507)**
Annual Rate Adjustment	**0.00%**	**14.00%**	**14.00%**	**14.00%**	**14.00%**	**14.00%**	**14.00%**
Cumulative Rate Increase	**0.00%**	**14.00%**	**29.96%**	**48.15%**	**68.90%**	**92.54%**	**119.50%**
Fixed Monthly Residential Rate	$16.00	$18.24	$20.79	$23.70	$27.02	$30.81	$35.12
		$2.24	$2.55	$2.91	$3.32	$3.78	$4.31
Rate Revenues After Rate Increase	$ 910,619	$ 1,038,106	$ 1,183,440	$ 1,349,122	$ 1,537,999	$ 1,753,319	$ 1,998,784
Net Cash Flow After Rate Increase	35,706	(33,204)	2,053	(23,397)	9,212	25,473	7,658
Coverage After Rate Increases	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Fund Balances - Projected Y-E	2009	2010	2011	2012	2013	2014	2015
Operating Reserves	$ 135,706	$ 102,502	$ 104,555	$ 81,159	$ 90,371	$ 115,844	$ 123,502
Capital Reserves	314,970	323,573	546,220	413,202	853,025	1,424,812	2,025,087
Debt Reserves	-	-	-	-	-	-	-
Total	**$ 450,677**	**$ 426,076**	**$ 650,776**	**$ 494,361**	**$ 943,396**	**$ 1,540,656**	**$ 2,148,589**
Combined Minimum Target Balance	*$ 168,691*	*$ 186,015*	*$ 228,391*	*$ 269,149*	*$ 303,070*	*$ 335,292*	*$ 360,302*

The City and Borough of Sitka
Water Utility
Table 2 Assumptions

	Economic & Financial Factors		FY (2008/) 2009	2010	2011	2012	2013	2014	2015
1	General Cost Inflation	based on Anchorage CPI 4 Year Average	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
2	Construction Cost Inflation	Per City/ JD	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%	6.00%
3	Labor Cost Inflation	Need City direction	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
4	Customer Growth	No Growth Projected by the City	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5	General Inflation plus Growth		3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
6	Benefits	Need City direction	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
7	Other Escalation		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8	No Escalation		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Fund Earnings	Based on Recent City Fund Earnings	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
	Southeast Alaska Population Projections - Sitka Borough			8,964					8,948

Accounting Assumptions		2009	2010	2011	2012	2013	2014	2015
FISCAL POLICY RESTRICTIONS								
Min. Op. Fund Balance Target (days of O&M expense)		30	30	30	30	30	30	30
Max. Op. Fund Balance (days of O&M expense)		45	45	45	45	45	45	45
Minimum Capital Fund Balance Target								
Select Minimum Capital Fund Balance Target	1	**Defined as % of Plant**						
1 - Defined as % of Plant								
Plant-in-Service in 2008	$ 9,960,417							
Minimum Capital Fund Balance - % of plant assets		1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%
2 - Amount at Right ==>		$ -	$ -	$ -	$ -	$ -	$ -	$ -

The City and Borough of Sitka
Water Utility
Table 2 Assumptions

RATE FUNDED SYSTEM REINVESTMENT

Select Reinvestment Funding Strategy	1	**Equal to Depreciation Expense**

Amount of Annual Cash Funding from Rates

1 - Equal to Annual Depreciation Expense

2 - Equal to Annual Depreciation Expense less Annual Debt Principal Payments

3 - Equal to Amount at Right ==>	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4 - Do Not Fund System Reinvestment	Phasing line	60%	70%	80%	90%	100%	100%

Capital Financing Assumptions

	2009	2010	2011	2012	2013	2014	2015
STATE LOAN							
Term (years)	20	20	20	20	20	20	20
Interest Cost	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%	1.50%

The City and Borough of Sitka
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Table 3 Existing Debt Input

Existing Debt Service - State Loans	2009	2010	2011	2012	2013	2014	2015
Corrosion Control Facility							
Annual Interest Payment	$ 6,282	$ 5,827	$ 5,360	$ 4,881	$ 4,391	$ 3,888	$ 3,373
Annual Principal Payment	18,215	18,670	19,137	19,616	20,106	20,609	21,124
Total Annual Payment	$ 24,497	$ 24,497	$ 24,497	$ 24,497	$ 24,497	$ 24,497	$ 24,497
State Loan - 783061							
Annual Interest Payment	$ 23,120	$ 7,504	$ 7,109	$ 6,714	$ 6,319	$ 5,924	$ 5,529
Annual Principal Payment	64,727	26,330	26,330	26,330	26,330	26,330	26,330
Total Annual Payment	$ 87,847	$ 33,834	$ 33,439	$ 33,044	$ 32,649	$ 32,254	$ 31,859
State Loan - 7831151							
Annual Interest Payment	$ 9,634	$ 9,152	$ 8,670	$ 8,189	$ 7,707	$ 7,225	$ 6,744
Annual Principal Payment	32,113	32,113	32,113	32,113	32,113	32,113	32,113
Total Annual Payment	$ 41,746	$ 41,265	$ 40,783	$ 40,301	$ 39,820	$ 39,338	$ 38,856
TOTAL STATE LOANS							
Annual Interest Payment	$ 39,036	$ 22,483	$ 21,140	$ 19,784	$ 18,417	$ 17,038	$ 15,646
Annual Principal Payment	115,055	77,113	77,580	78,059	78,549	79,052	79,567
Total Annual Payment	$ 154,090	$ 99,596	$ 98,719	$ 97,843	$ 96,966	$ 96,089	$ 95,213

The City and Borough of Sitka
Water Utility
Table 3 Existing Debt Input

Existing Debt Service - Other Loans	2009	2010	2011	2012	2013	2014	2015
Combined Water/Sewer Facility Loan							
Annual Interest Payment	$ 2,191	$ 2,084	$ 1,975	$ 1,865	$ 1,753	$ 1,640	$ 1,525
Annual Principal Payment	7,128	7,235	7,344	7,454	7,566	7,679	7,795
Total Annual Payment	$ 9,319	$ 9,319	$ 9,319	$ 9,319	$ 9,319	$ 9,319	$ 9,319
TOTAL OTHER LOANS							
Annual Interest Payment	$ 2,191	$ 2,084	$ 1,975	$ 1,865	$ 1,753	$ 1,640	$ 1,525
Annual Principal Payment	7,128	7,235	7,344	7,454	7,566	7,679	7,795
Total Annual Payment	$ 9,319	$ 9,319	$ 9,319	$ 9,319	$ 9,319	$ 9,319	$ 9,319

The City and Borough of Sitka
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Table 4 Operating Revenue and Expenditure Forecast

Revenues		FORECAST BASIS	Budget 2009	Projection 2010	Projection 2011	Projection 2012	Projection 2013	Projection 2014	Projection 2015
Rate revenues	4	Customer Growth	910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619
Jobbing - Labor	3	Labor Cost Inflation	42,671	44,164	45,710	47,310	48,966	50,680	52,454
Miscellaneous	1	General Cost Inflation	10,636	11,008	11,394	11,792	12,205	12,632	13,074
	1	General Cost Inflation	-	-	-	-	-	-	-
TOTAL REVENUES			**$ 963,926**	**$ 965,792**	**$ 967,723**	**$ 969,721**	**$ 971,790**	**$ 973,931**	**$ 976,147**

$ 60,642	Interest
758,440	State & Federal Revenue (grants)
15,600	connection fees
$ 834,681	
$ 1,798,607	Total Revenue with Adjustments
$ 1,798,607	Budget Revenue Total

Expenditures		FORECAST BASIS	2009	2010	2011	2012	2013	2014	2015
Operations									
Salaries	3	Labor Cost Inflation	$ 177,341	$ 183,548	$ 189,972	$ 196,621	$ 203,503	$ 210,625	$ 217,997
Benefits	6	Benefits	120,341	124,553	128,912	133,424	138,094	142,927	147,930
Non-personel operating expenses	1	General Cost Inflation	471,128	487,617	504,684	522,348	540,630	559,552	579,137
CIP Related Additional O&M	1	General Cost Inflation	-	-	-	-	-	-	170,000
Total Cash O&M Expenditures			**$ 768,810**	**$ 795,718**	**$ 823,568**	**$ 852,393**	**$ 882,227**	**$ 913,105**	**$ 1,115,064**

$ 36,555	Principal & Interest
$ 805,365	Total Expenditures with Adjustments
$ 805,365	Budget Expenditure Total

		2009	2010	2011	2012	2013	2014	2015
Depreciation Expense in 2008	$ 367,000							
Depreciation Expense	*Last year's plus annual additions from CIP*	$ 367,000	$ 378,795	$ 409,019	$ 489,192	$ 565,969	$ 628,908	$ 688,277
TOTAL EXPENSES		**$ 1,135,810**	**$ 1,174,513**	**$ 1,232,588**	**$ 1,341,585**	**$ 1,448,196**	**$ 1,542,013**	**$ 1,803,341**

The City and Borough of Sitka
Water Utility
Table 5 Capital Improvement Program

	FY 2008/	
Project Costs and O&M Impacts in Year:	2009	(Project costs are escalated using Construction Cost Inflation assumptions)

No	City and Burough of Sitka Capital Improvements Program	Current Cost	Year	Life in Years	Specific Funding Source 1-Enterprise Fund, 2-Grants & Developer Donations		TOTAL ESCALATED COSTS
	FY 2009 = 2008/09			50	1	Enterprise Fund	$ -
	2009 spending	589,732	2009	50	1	Enterprise Fund	589,732
	2010 spending	1,425,682	2010	50	1	Enterprise Fund	1,511,223
	2011 spending	3,567,682	2011	50	1	Enterprise Fund	4,008,647
	2012 spending	3,223,182	2012	50	1	Enterprise Fund	3,838,861
	2013 spending	2,492,682	2013	50	1	Enterprise Fund	3,146,953
	2014 spending	2,218,182	2014	50	1	Enterprise Fund	2,968,428
	2015 spending	592,882	2015	50	1	Enterprise Fund	841,014
	2016 spending	1,277,512	2016	50	1	Enterprise Fund	1,920,905
	2017 spending	1,660,582	2017	50	1	Enterprise Fund	2,646,715
	2018 spending	1,663,882	2018	50	1	Enterprise Fund	2,811,093
	2019 spending	2,918,182	2019	50	1	Enterprise Fund	5,226,019
	2020 spending	6,816,502	2020	50	1	Enterprise Fund	12,939,756
	2021 spending	68,182	2021	50	1	Enterprise Fund	137,195
	2022 spending	912,082	2022	50	1	Enterprise Fund	1,945,405
	2023 spending	68,182	2023	50	1	Enterprise Fund	154,153
	2024 spending	217,057	2024	50	1	Enterprise Fund	520,189
	2025 spending	1,704,982	2025	50	1	Enterprise Fund	4,331,253
	2026 spending	1,039,132	2026	50	1	Enterprise Fund	2,798,146
	2027 spending	312,082	2027	50	1	Enterprise Fund	890,787
	2028 spending	68,182	2028	50	1	Enterprise Fund	206,291
	2029 spending	3,641,182	2029	50	1	Enterprise Fund	11,677,763
	2030 spending	4,385,182	2030	50	1	Enterprise Fund	14,907,704
				50	1	Enterprise Fund	-
				50	1	Enterprise Fund	-
				50	1	Enterprise Fund	-
				50	1	Enterprise Fund	-
				50	1	Enterprise Fund	-
						Select Source	-
	Total Scheduled Capital Projects	**$ 40,862,925**					**$ 80,018,234**
	Total Source Document CIP	**40,862,925**					

The City and Borough of Sitka
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Table 6 Capital Funding Analysis

Summary of Expenditures	2009	2010	2011	2012	2013	2014	2015
TOTAL CAPITAL EXPENDITURES	**$ 589,732**	**$ 1,511,223**	**$ 4,008,647**	**$ 3,838,861**	**$ 3,146,953**	**$ 2,968,428**	**$ 841,014**

Capital Financing Plan	2009	2010	2011	2012	2013	2014	2015
Project Specific Grants / Developer Donations	$ -	$ 895,965	$ 3,932,038	$ 2,128,346	$ 2,246,578	$ 2,014,029	$ -
Project to be Funded	589,732	615,258	76,609	1,710,516	900,376	954,398	841,014
OTHER FUNDING SOURCES [NOTE A]							
State (ACWF/ADWF) Loan Proceeds	$ -	$ 383,985	$ -	$ 1,104,072	$ 814,298	$ 863,155	$ 744,297
Other Loan Proceeds	-	-	-	-	-	-	-
Capital Fund Balance	589,732	231,273	76,609	546,220	86,078	91,243	96,717
Rates	-	-	-	60,223	-	-	-
Total	$ 589,732	$ 615,258	$ 76,609	$ 1,710,516	$ 900,376	$ 954,398	$ 841,014
TOTAL CAPITAL RESOURCES	**$ 589,732**	**$ 1,511,223**	**$ 4,008,647**	**$ 3,838,861**	**$ 3,146,953**	**$ 2,968,428**	**$ 841,014**

New Debt Computations	2009	2010	2011	2012	2013	2014	2015
STATE LOAN							
Amount to Fund	$ -	$ 383,985	$ -	$ 1,104,072	$ 814,298	$ 863,155	$ 744,297

Debt Service Summary	2009	2010	2011	2012	2013	2014	2015
EXISTING DEBT SERVICE							
Annual Interest Payments	$ 41,227	$ 24,567	$ 23,115	$ 21,649	$ 20,171	$ 18,678	$ 17,171
Annual Principal Payments	122,183	84,348	84,924	85,513	86,115	86,731	87,361
Total Debt Service Payments	$ 163,410	$ 108,915	$ 108,039	$ 107,162	$ 106,285	$ 105,409	$ 104,532
NEW DEBT SERVICE							
Annual Interest Payments	$ -	$ -	$ 5,472	$ 5,472	$ 20,917	$ 32,233	$ 43,416
Annual Principal Payments	-	-	19,199	19,199	74,403	115,118	158,275
Total Debt Service Payments	$ -	$ -	$ 24,671	$ 24,671	$ 95,320	$ 147,350	$ 201,692
TOTAL DEBT SERVICE PAYMENTS	**$ 163,410**	**$ 108,915**	**$ 132,710**	**$ 131,833**	**$ 201,605**	**$ 252,759**	**$ 306,224**
Total Interest Payments	41,227	24,567	28,587	27,121	41,088	50,910	60,587
Total Principal Payments	122,183	84,348	104,123	104,712	160,518	201,849	245,637
Total Revenue Bond Payments Only	-	-	-	-	-	-	-

The City and Borough of Sitka
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Table 7 Revenue Requirements Analysis

Cash Flow Sufficiency Test	2009	2010	2011	2012	2013	2014	2015
EXPENSES							
Cash Operating Expenses	$ 768,810	$ 795,718	$ 823,568	$ 852,393	$ 882,227	$ 913,105	$ 1,115,064
Existing Debt Service	163,410	108,915	108,039	107,162	106,285	105,409	104,532
New Debt Service	-	-	24,671	24,671	95,320	147,350	201,692
Rate-Funded CIP	-	-	-	60,223	-	-	-
Rate Funded System Reinvestment	-	227,277	286,313	391,354	509,372	628,908	640,000
Additions Required to Meet Minimum Op. Fund Balance	-	-	-	-	-	-	-
Total Expenses	$ 932,220	$ 1,131,910	$ 1,242,592	$ 1,435,803	$ 1,593,205	$ 1,794,772	$ 2,061,288
REVENUES							
Rate Revenue	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619
Other Revenue	53,307	55,173	57,104	59,102	61,171	63,312	65,528
Operating Fund & Debt Reserve Fund Interest Earnings	4,000	5,428	4,100	4,182	3,246	3,615	4,634
Total Revenue	$ 967,926	$ 971,220	$ 971,823	$ 973,904	$ 975,036	$ 977,546	$ 980,781
NET CASH FLOW (DEFICIENCY) - Current Rate Levels	**$ 35,706**	**$ (160,690)**	**$ (270,769)**	**$ (461,900)**	**$ (618,168)**	**$ (817,227)**	**$ (1,080,507)**

Maximum Revenue Deficiency	2009	2010	2011	2012	2013	2014	2015
Maximum Deficiency From Tests	$ -	$ 160,690	$ 270,769	$ 461,900	$ 618,168	$ 817,227	$ 1,080,507
less: Net Revenue From Prior Rate Increases	-	-	(127,487)	(272,821)	(438,503)	(627,380)	(842,700)
Revenue Deficiency	$ -	$ 160,690	$ 143,282	$ 189,078	$ 179,665	$ 189,846	$ 237,807
Total Revenue Deficiency	**$ -**	**$ 160,690**	**$ 143,282**	**$ 189,078**	**$ 179,665**	**$ 189,846**	**$ 237,807**

The City and Borough of Sitka
Water Utility
Table 7 Revenue Requirements Analysis

Rate Increases	2009	2010	2011	2012	2013	2014	2015
Rate Revenue with no Increase	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619	$ 910,619
Revenues from Prior Rate Increases	-	-	127,487	272,821	438,503	627,380	842,700
Rate Revenue Before Rate Increase (Incl. previous increases)	910,619	910,619	1,038,106	1,183,440	1,349,122	1,537,999	1,753,319
Required Annual Rate Increase	0.00%	17.65%	13.80%	15.98%	13.32%	12.34%	13.56%
Number of Months New Rates Will Be In Effect	12	12	12	12	12	12	12
Info: Percentage Increase to Generate Required Revenue	*0.00%*	*17.65%*	*13.80%*	*15.98%*	*13.32%*	*12.34%*	*13.56%*
Policy Induced Rate Increases		14.00%	14.00%	14.00%	14.00%	14.00%	14.00%
ANNUAL RATE INCREASE	**0.00%**	**14.00%**	**14.00%**	**14.00%**	**14.00%**	**14.00%**	**14.00%**
CUMULATIVE RATE INCREASE	**0.00%**	**14.00%**	**29.96%**	**48.15%**	**68.90%**	**92.54%**	**119.50%**
Rate	$16.00	$18.24	$20.79	$23.70	$27.02	$30.81	$35.12
Funds above minimum	*72,516*	*37,101*	*36,865*	*11,099*	*17,859*	*40,795*	*31,853*

Impacts of Rate Increases	2009	2010	2011	2012	2013	2014	2015
Rate Revenues After Rate Increase	$ 910,619	$ 1,038,106	$ 1,183,440	$ 1,349,122	$ 1,537,999	$ 1,753,319	$ 1,998,784
Full Year Rate Revenues After Rate Increase	*910,619*	*1,038,106*	*1,183,440*	*1,349,122*	*1,537,999*	*1,753,319*	*1,998,784*
Net Cash Flow After Rate Increase	35,706	(33,204)	2,053	(23,397)	9,212	25,473	7,658

The City and Borough of Sitka
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Table 8 Fund Activity

WATER FUND	2009	2010	2011	2012	2013	2014	2015
OPERATING RESERVES							
Beginning Balance	$ 100,000	$ 135,706	$ 102,502	$ 104,555	$ 81,159	$ 90,371	$ 115,844
plus: Net Cash Flow after Rate Increase	35,706	(33,204)	2,053	(23,397)	9,212	25,473	7,658
less: Transfer of Surplus to Capital Fund	-	-	-	-	-	-	-
Ending Balance	$ 135,706	$ 102,502	$ 104,555	$ 81,159	$ 90,371	$ 115,844	$ 123,502
Minimum Target Balance	*63,190*	*65,402*	*67,691*	*70,060*	*72,512*	*75,050*	*91,649*
Maximum Funds to be Kept as Operating Reserves	*94,785*	*98,102*	*101,536*	*105,090*	*108,768*	*112,575*	*137,474*
Info: No of Days of Cash Operating Expenses	*64*	*47*	*46*	*35*	*37*	*46*	*40*
CAPITAL RESERVES							
Beginning Balance	$ 854,906	$ 314,970	$ 323,573	$ 546,220	$ 413,202	$ 853,025	$ 1,424,812
plus: Rate Funded System Reinvestment	-	227,277	286,313	391,354	509,372	628,908	640,000
plus: Connection Charges	15,600	-	-	-	-	-	-
plus: Grants / Developer Donations / Other Outside Sources	-	895,965	3,932,038	2,128,346	2,246,578	2,014,029	-
plus: Net Debt Proceeds Available for Projects	-	383,985	-	1,104,072	814,298	863,155	744,297
plus: Interest Earnings	34,196	12,599	12,943	21,849	16,528	34,121	56,992
plus: Transfer of Surplus from Operating Fund	-	-	-	-	-	-	-
plus: Direct Rate Funding	-	-	-	60,223	-	-	-
less: Capital Expenditures	(589,732)	(1,511,223)	(4,008,647)	(3,838,861)	(3,146,953)	(2,968,428)	(841,014)
Ending Balance	$ 314,970	$ 323,573	$ 546,220	$ 413,202	$ 853,025	$ 1,424,812	$ 2,025,087
Minimum Target Balance	$ 105,501	$ 120,614	$ 160,700	$ 199,089	$ 230,558	$ 260,243	$ 268,653
DEBT RESERVE							
Beginning Balance	$ -	$ -	$ -	$ -	$ -	$ -	$ -
plus: Reserve Funding from New Debt	-	-	-	-	-	-	-
Ending Balance	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Minimum Target Balance	-	-	-	-	-	-	-