UTILITY IMPROVEMENTS STUDY

CITY OF THORNE BAY

Thorne Bay, Alaska

July 2010

Prepared for:
City of Thorne Bay
and
ADEC Village Safe Water Program

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ACRONYMS AND ABBREVIATIONS

ADEC ....Alaska Department of Environmental Conservation
ADNR ....Alaska Department of Natural Resource
ANTHC.....................Alaska Native Tribal Health Consortium
AP&T ....Alaska Power and Telephone
ARRA ....American Recovery and Reinvestment Act
AWWA ....American Water Works Association
BOD.........................biological oxygen demand
CBJ ....City and Borough of Juneau
CBS..........................City and Borough of Sitka
CDBG.......................Community Development Block Grant
City..........................City of Thorne Bay
CT............................current transformer
DBP ....disinfection byproducts
DBPR ....Disinfectants and Disinfection Byproducts Rule
DCCED.....................Alaska Department of Commerce and Community Economic Development Department
DCRA.......................Alaska Division of Community and Regional Affairs
DO...........................dissolved oxygen
DOC.........................dissolved organic carbon
DOLWD ....Alaska Department of Labor and Workforce Development
EDA ....Economic Development Administration
EPA..........................US Environmental Protection Agency
ER............................Environmental Report
ft ....feet
GAAP.......................Generally Accepted Accounting Principles
GAC.........................granular activated carbon
GASB ....Government Accounting Standards Board
GLUMRB ....Great Lakes Upper Mississippi River Board
GPCPD.....................gallons per capita per day
gpd..........................gallons per day
gpm.........................gallons per minute
GUI..........................graphical user interface
HAAs ....haloacetic acids
I/O...........................input/output
I&I ....inflow and infiltration
KPC..........................Ketchikan Pulp Company
LF ....linear feet
LI ....Langlier Index
LTIESWTR................Long Term Interim Enhanced Surface Water Treatment Rule
MCL.........................maximum contaminant level
MGD........................million gallons per day
MMG.......................Municipal Matching Grant
NOVs.......................Notice of Violations
NPDES ....National Pollutant Discharge Elimination System
NRCS ....Natural Resources Conservation Service
O&M ....operations and maintenance
OSHA.......................Occupational Safety and Health Administration

PC .... personal computer
PER .... preliminary engineering report
PFD .... Permanent Fund Dividend
PILT .... payment in lieu of taxes
PLC .... programmable logic controller
POW .... Prince of Wales Island
POWCC .... Prince of Wales Chamber of Commerce
PRV .... pressure regulating valve
PVC .... polyvinyl chloride
RCA .... Regulatory Commission of Alaska
RMW .... remote maintenance worker
ROW .... right-of-way
RTU .... remote telemetry unit
RUBA .... Rural Utilities Business Advisor
SCADA .... supervisory control and data acquisition
SEASWA .... Southeast Alaska Solid Waste Authority
SGS .... SGS North America
SNC .... Significant Non-Complier
TBBDS .... Thorne Bay Business District Subdivision
TBD .... to be determined
THM .... trihalomethanes
TTHMs .... total trihalomethanes
TOC .... total organic carbon
TSS .... total suspended solids
USDA-RD .... US Department of Agriculture – Rural Development
USDA-RUS .... US Department of Agriculture – Rural Utility Service
USGS .... US Geological Survey
USFS .... US Forest Service
USKH .... USKH Inc.
UV .... ultraviolet
VFD .... variable frequency device
VSW .... ADEC Village Safe Water
WST .... water storage tank
WTP .... water treatment plant
WWTP .... wastewater treatment plant

1 INTRODUCTION

1.1 Project Overview

The City of Thorne Bay (City) provides water, sewer, and solid waste services to residents living in the north and east Thorne Bay areas; southside residents do not presently receive water or sewer services. The City has identified a number of goals for this project, including:

- Improving water treatment to maintain consistently high quality, pleasing drinking water to the community;
- Reducing inflow and infiltration (I&I) problems in the sewer collection system;
- Reducing maintenance issues in the City water and wastewater systems;
- Addressing planning, regulatory, and operational needs associated with the City's water, sewer, and solid waste utilities; and
- Developing plans for funding and constructing the recommended improvements.

1.1.1 Report Purpose

The purpose of this report is to provide a record of investigations and analysis conducted to develop utility improvement recommendations and plans. As part of this work the following activities have been conducted:

- Site visit and investigations by USKH Inc. (USKH) February 15-18, 2010, including hydrant flow testing and flocculent jar testing.
- Public meeting to present study plan to the community and Thorne Bay City Council (see Appendix A for documentation).

A 65 percent submittal of this report was made April 16, 2010, and a review conference followed on May 26th. Formal comments and responses from this draft report are provided in Appendix B.

1.2 City of Thorne Bay Overview - Project Planning Area

The City of Thorne Bay was incorporated in 1982 as a second class city in an unorganized borough. The City provides area residents with water, wastewater, and solid waste utilities, as well as emergency medical services (boat and ambulance), fire protection, and an emergency medevac helipad.

Pearl Nelson Community Park

Seaplanes are a common means of transport .

Thorne Bay Harbor provides over 100 slips to area vessels, with water and electric service at the slips, and restroom, showers, a fish cleaning station, boat launch, and other facilities in the harbor area.

1.2.1 Location

Located on the east coast of Prince of Wales Island (POW), the City of Thorne Bay is approximately 47 air miles from Ketchikan and is on the island road system 60 miles from Hollis and its ferry terminal, and 36 miles from Klawock and its airfield. It is also connected by road to Coffman Cove, Kasaan, Craig, Hydaburg, Naukati, and Whale Pass. Figure 1 shows the project location and vicinity.

The City was originally founded as a logging operation of Wes Davidson and was developed with long-term timber sales contracts between the US Forest Service (USFS) and Ketchikan Pulp Company (KPC). KPC operated a floating log camp in Thorne Bay starting in 1960, and by 1962 had moved its main operations to the community. During the 1960s, Thorne Bay was considered the largest logging camp in North America. Partly due to the land selection program provided with the Alaska Statehood Act, the City incorporated in 1982 and utilities previously owned or operated by KPC were transferred to the City. The City is within the Tongass National Forest, which is the largest unit in the national forest system at almost 17 million acres, including the majority of POW.

1.2.2 Environmental Resources

Climate

POW has a maritime climate, cool and moist, influenced by the Japanese current, which gives the island between 60 and 200 inches of precipitation per year. Average annual precipitation is 120 inches, including 40 inches of snow. Precipitation is discussed further in Section 5.

Mean temperatures range from around 35 degrees F in January to about 58 degrees F in July. Daylight on the longest day of the year is about 15½ hours with about 7 hours on the shortest day of the year.[1]

Topography

Most of the island is characterized by steep, forested mountains (2,000-3,000 feet high) carved by glacial ice that left deep U-shaped valleys with streams, lakes, saltwater straits, and bays. The forest is made up of Sitka spruce and western hemlock with some western red and yellow cedar, alder, and shore pine[1].

Wildlife

Sitka black tailed deer and black bear are the primary game animals, and the island supports several packs of wolves. Moose have been spotted on POW. While the streams and lakes contain a variety of trout, most people fish the salt water for the five species of salmon, or for halibut, red snapper, and other local species. Eagles are a common sight and a large number of waterfowl are present during the nesting season. Several migratory bird species spend the winter in the area including the trumpeter swan. The endangered short-tailed albatross and Eskimo curlew, a shorebird, may also frequent the area. Deer, salmon, halibut, shrimp, and crab are popular food sources.

Sitka deer can be seen along the roads.

[1] Based on information from Prince of Wales Chamber of Commerce (POWCC), http://www.princeofwalescoc.org/climate.html and Alaska Division of Community and Regional Affairs (DCRA), http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.cfm

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CITY of THORNE BAY
UTILITY IMPROVEMENTS STUDY

LOCATION & AREA MAP

July 2010

FIGURE
1

I:\1210000\DWGS\C\FIGURES\1210000_FIG1.DWG PLOTTED: Jul 16, 2010 – 2:30:48 PM (Glenn Sears)

1. WATER TREATMENT PLANT
2. WATER STORAGE TANK
3. BACKWASH PONDS
4. CITY MAINTENANCE SHOP
5. THORNE BAY SCHOOL
6. THORNE BAY BAPTIST CHURCH
7. STEVE METCALF FIELD
8. MARY LOU SWAIM MEMORIAL PARK AND FAIR GROUNDS
9. BAY CHALET COMMUNITY CENTER
10. USFS STORAGE LOT
11. USFS WAREHOUSE
12. USFS ADMISTRATION AND VISITOR CENTER
13. CITY RV PARK
14. USFS RESIDENTIAL COMPLEX
15. THE PORT CONVENIENCE STORE, FLOAT PLANE TERMINAL, AND U S POST OFFICE
16. FLOAT PLANE DOCK
17. NORTHLAND SERVICES
18. BARGE LANDING
19. OLD SOUTHEAST ISLAND SCHOOL DISTRICT FLOAT AND TEACHER RESIDENCE
20. TRACEY'S HEAVY EQUIPMENT REPAIR (FORMER KPC SHOP)
21. TIRE SHOP
22. ALASKA POWER & TELEPHONE (AP&T)
23. RV DUMP STATION
24. GAS STATION
25. THE PORTS TACKLE SHACK
26. POW GAS
27. WELCOME INN
28. BOAT LAUNCH RAMP
29. FIRE HALL
30. CITY HALL / CLINIC
31. VPSO / PW OFFICE
32. LIBRARY
33. PEARL NELSON COMMUNITY PARK
34. CHURCH OF THORNE BAY (SITE OF OLD WWTP)
35. ST. JOHNS CATHOLIC CHURCH
36. CITY SAND STORAGE (OLD VOLUNTEER FIRE BUILDING)
37. HARBOR MASTER OFFICE / PUBLIC RESTROOMS
38. BOAT HARBOR
39. RIPTIDE LIQUOR AND VIDEO
40. THORNE BAY MARKET
41. DEER CREEK BRIDGE (ONE LANE)
42. WASTEWATER TREATMENT PLANT
43. WASTEWATER CLARIFIER
44. RAW WATER INTAKE

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CITY of THORNE BAY
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CITY OF THORNE BAY
COMMUNITY MAP

July 2010

FIGURE 2

I:\1210000\DWGS\C\FIGURES\1210000_FIG2.DWG PLOTTED: Jul 16, 2010 - 2:30:53 PM (Glenn Sears)

Watershed

Deer Creek (Stream #102-70-1070) runs through the community and serves as a secondary water source. It also provides recreational opportunities and is a recognized anadromous fish stream for the presence of pink salmon. Deer Creek empties into Thorne Bay along the south side of the community core.

Thorne Bay (AK ID# 10103-602) is a Class 2 listed water body, specifically at the log storage area. Bark and wood debris are the previously impairing pollutant parameters[2]. The endangered humpback, bowhead, and finback whales, Steller sea lion, and leatherback sea turtle may occur in the waters of Thorne Bay.

The Thorne River (River #102-70-10580) enters into the head of the Thorne Bay and separates the main town from the residential area of South Thorne Bay Subdivision (see Figure 1). The river has populations of chum, coho, pink, and sockeye salmon; cutthroat trout; Dolly Varden; and steelhead trout.[3]

1.2.3 Growth Areas and Population Trends

Thorne Bay continues the tradition of the logging camp as most employment is related to small sawmills, USFS management of the Tongass National Forest, the Southeast Island School District, commercial fishing, tourism and lodging, and both local and state government services.

Population

Thorne Bay is located in the POW census area. Since the community was not established until after the 1960 census, the population record for the community is short, as shown in Table 1. The estimates provided in Table 1 are from the US Census (1970-2000) and the Alaska Department of Labor and Workforce Development (DOLWD, 2001-2008).

Table 1 - Population History

Source	Census Year	Population
US Census	1960	0
	1970	443
	1980	377
	1990	569
	2000	557
DOLWD	2001	521
	2002	501
	2003	481
	2004	499
	2005	486
	2006	481
	2007	465
	2008	439
	2009	424

2 Alaska Department of Environmental Conservation (ADEC), 2010. Alaska's 2010 Integrated Water Quality Monitoring and Assessment Report. Available at http://www.dec.state.ak.us/water/wqsar/pdfs/2010IntegratedReportPublicReviewDraft.pdf
3 Alaska Department of Fish and Game (ADF&G), 2010. Anadromous Fish Distribution. Available at http://gis.sf.adfg.state.ak.us/AWC_IMS/viewer.htm .

Between 2000 to 2008, the population of Thorne Bay has been generally declining at an annual average of 3.0 percent based on DOLWD projections, which are based on a standard methodology relying on administrative data: primarily Alaska Permanent Fund Dividend (PFD) data, vital statistics, and survey information.

Thorne Bay School Mural.

The 2008 State of Alaska Department of Commerce and Community Economic Development Department (DCCED) certified population is 440, indicating a 2.6 percent annual average population decline. DCCED population numbers are generally based on DOLWD estimates; however, an appeal process can be accessed by the communities to adjust numbers, which are the basis of Municipal revenue sharing.

In either case, it appears that the population of Thorne Bay is in decline with the general trend based on migration rather than birth/death rates. The DOLWD is predicting a decline in population for the POW-Outer Ketchikan census area as part of the Southeast Region of the state at between -1.01 and -1.86 percent for the period between 2006 and 2030 (DOLWD, 2007).

The 2000 census also shows that the population in Thorne Bay is relatively young with 28 percent below 18 years of age. Household sizes average 2.54 people, with 327 housing units. 43 of the housing units were categorized as vacant due to seasonal use and 219 were occupied for the census[4]. Note that the City has an average of 118 residential and 25 commercial water and sewer accounts, with a slight increase experienced in the summer with seasonal users and increased USFS staffing.

Thorne Bay consists of the City of Thorne Bay and the South Thorne Bay Subdivision, See Figure 1. There are approximately 122 housing units in the City of Thorne Bay and 134 housing units in the South Thorne Bay Subdivision and surrounding area. Water and wastewater services do not extend to those outside the City of Thorne Bay. Water and wastewater utility accounts in July 2010 numbered 122 residential and 28 commercial. 150 services and 210 residents will be considered for water and wastewater planning purposes. The remaining population is assumed to reside in the South Thorne Bay Subdivision and is not provided residential utility service.

Given that the community is subject to population swings based on employment availability and other factors it is reasonable for planning purposes to assume that the population is stagnant or increases at a modest rate. Using a 1.0 percent growth rate Thorne Bay will have a population of 550 in 2030, well below the design criteria initially established for the wastewater treatment plant (WWTP) (900 people) and the water treatment plant (WTP) (1,835 people). Where population estimates are required in this report this value will be used, although it is not anticipated that capacities would be reduced from existing levels.

[4] Alaska Department of Commerce, Community and Economic Development, Division of Community and Regional Affairs. 2010. Community Database Online – Thorne Bay. Available at http://www.commerce.state.ak.us/dca/commdb/CF_BLOCK.cfm.

Future Projects

The City developed a strategic economic development plan in 2008, published as *Moving Forward*[5], which identifies opportunities to increase the population and tax base, encourage and promote sustainable economic development projects, and continue upgrading its infrastructure. Three capital improvement projects have been constructed since *Moving Forward* was published; namely water treatment system upgrades; construction of Davidson Landing Harbor in South Thorne Bay; and South Thorne Bay Subdivision Roads Upgrades.

Future projects identified but not otherwise considered in this feasibility study include:

Unpaved Road at Thorne Bay School

Thorne Bay School Road Project

Problem: 600 feet of unpaved road accessing the Thorne Bay School. The unpaved portion has erosion issues and creates a maintenance problem on the busiest road in town.

Solution: Work with USFS-Thorne Bay Ranger District to pave.

Funding: $35,000 needed.
FY11 Legislative Appropriation of $150,000.

Schedule: Summer 2010.

Downtown Development Project

Problem: Services in Thorne Bay are scattered throughout the north side, while residential development is shifting to the south. Population is decreasing and small businesses are closing. The downtown area is severely underutilized.

Solution: Revitalize this section of town. Sell or use eight ocean-front lots and the former KPC building. Increase sales tax revenue, provide employment for residents, and offer an area for growth along Thorne Bay's waterfront. Businesses under consideration include container repair, a regional vocational education training facility, warehouse/storage units, restaurant, lodge, fish processing/cold storage, and/or an expanded commercial docking facility. The next phase of development involves road construction in the Thorne Bay Business District Subdivision (TBBDS).

Funding: $150,000 for TBBDS road construction with FY11 Legislative funding.

Schedule: Summer 2010.

[5] *Moving Forward*. 2008. City of Thorne Bay. https://www.thornebay-ak.gov/uploads/MOVING_FORWARD_2008.pdf

Oceanview Subdivision Project

Proposed Oceanview Subdivision

Problem: Limited residential property is available in Thorne Bay, particularly near the core on the north side.

Solution: Purchase 50+ acres of Alaska Department of Natural Resources (ADNR) land. Develop plan for roads and utilities. Sell 30 view and ocean front lots. Increase utility base, provide high value property for sale, and increase population.

Funding: $270,000 in City funding identified for land purchase; $250,000 needed for design and engineering.

Schedule: To be determined (TBD) as funding is identified.

Multi-Use Facility Project

Problem: Several aging facilities with numerous mechanical problems have separate operation, maintenance, and overhead costs. All facilities are in need of major repair or replacement.

City Hall

Solution: Construct a new multi-use facility to accommodate the functions of the existing City Hall, clinic, community building, and library. This will improve energy efficiency, decrease annual operations and maintenance (O&M), improve management, and provide a facility to meet the community needs.

Funding: $25,000 needed for conceptual design, $75,000 needed for design and engineering, TBD construction funding needed.

Schedule: TBD as funding is identified.

Comprehensive Land Management Plan

Problem: The City does not have a comprehensive land management plan to guide development.

Solution: Develop a plan that would include a water front master plan, comprehensive sanitation plan, and review of zoning regulation and City revenue policies.

Funding: No outside funding is being sought.

Schedule: The plan will be developed using existing City staff. A schedule is to be developed after priority projects are addressed.

Woody Biomass Industry Development Project

Problem: With the expiration of long-term timber contracts in 2001, the community has been left with a depressed economy, lack of family-wage jobs, and high unemployment.

Solution: Coordinate with local wood manufacturers and small sawmill owners to develop a wood products industry. As currently envisioned the industry would produce bricks and pellets for residential and commercial heating markets. This will allow Thorne Bay to capitalize on wood fiber (biomass) available within the Tongass National Forest.

Funding: Funding requirements are being developed.

Schedule: Ongoing. TBD as funding is identified.

Sortyard Development Project

Problem: City owns 8.64 acres of industrial waterfront property adjacent to the USFS barge landing and highway system that is not utilized. The area is partially filled tidelands that was originally conveyed by the State of Alaska and cannot be sold to private industry.

Solution: Provide lease or rental opportunities for industrial development to improve economic vitality and provide employment for Thorne Bay residents.

Funding: Funding requirements are being developed.

Schedule: Ongoing. TBD as funding is identified.

Vocational Education Development Project

Problem: POW has few vocational education training opportunities and a high school dropout rate that has been increasing.

Solution: Develop a vocational educational program in Thorne Bay. Initial program would focus on natural resource management and skills (e.g. welding) with immediate on-island employment availability (e.g. with mills, barge lines, USFS).

Funding: $2,000,000 facility construction and start-up costs, operational costs TBD

Schedule: Ongoing. TBD as funding is identified.

Tolstoi Deep Water Port and Regional Solid Waste Facility Project

Problem: The City is in the process of receiving approximately 6 acres of tidelands adjacent to Alaska Mental Health Trust and Tongass National Forest lands as a conveyance from the ADNR.

Solution: Complete survey for ADNR conveyance. Develop property to provide deep water port access for marine vessels (e.g. tourism, the Alaska Marine Highway System), mining and timber operations, and potentially a regional solid waste facility. The City has joined the Southeast Alaska Solid Waste Authority (SEASWA) along with the cities of Craig, Petersburg and Wrangell (as of April 2010) and is actively pursuing a regional disposal solution for Southeast Alaska communities.

Funding: $125,000 funding appropriated for FY11 by Legislature; $4000 to be expended for survey.

Schedule: Survey completed by Templin Survey, May 2010. Development of the site will be ongoing.

Central Watering Point Project

Problem: Approximately 25 percent of residents are not connected to the treated, piped drinking water system. Residential expansion currently occurring to the south of town will increase the number of residents relying on rain catchment, streams, or springs for a water supply. Use of untreated water puts these residents at increased risk for disease associated with insufficient sanitation.

Solution: Provide a central watering point on the piped community system where residents can access treated water supplies. Location has not yet been determined, allowing site selection to consider water distribution issues discussed in Section 4.

Funding: Funding requirements are being developed.

Schedule: Ongoing. TBD as funding is identified.

2 WATER TREATMENT IMPROVEMENTS

2.1 General

The City of Thorne Bay provides treated water for domestic consumption and fire protection. This is not always easy, as the raw water supply is derived from rainwater runoff impounded in a small lake (Water Lake).

Water Lake

Therefore, the water is very soft, has very low alkalinity, and has moderately high levels of dissolved organic carbon (DOC). Some of this carbon is removed in the existing treatment plant process, but a significant quantity remains. This DOC contributes to a number of water quality issues in the community:

- Decay of chlorine residual resulting when organic molecules (which are carbon-containing), and amines in the water react with chlorine. The reaction consumes chlorine and makes it hard for the City to maintain required residuals in portions of the distribution system. The low chlorine residual in the distribution system contributes to biofilm growths, but can also allow compounds called chloramines to form.
- Chloramines can form when decayed protein molecules, which are often present with organic carbon, react with chlorine, forming a nitrogen, hydrogen, and chlorine molecule. These can taste and smell much worse than the chlorine itself. Research indicates that the presence of chloramines may contribute to higher blood levels of lead where lead solder is present in older piping systems.
- Formation of disinfection byproducts (DBPs) resulting from the reaction of chlorine and carbon compounds. DBPs are carcinogenic chemicals including total trihalomethanes (TTHMs) and halocetic acids (HAAs). Thorne Bay consistently has TTHM and HAA levels exceeding the allowable maximum contaminant levels as established in the Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR). This is a regulatory issue and a potential health risk. Thorne Bay is presently on the Significant Non-Compliers List (SNC) for this reason.
- Growth of biofilms in the distribution system is created when bacteria living in the water consume the carbon and colonize the walls of the pipe, leading to considerable build-up of biological slime. This can create taste and odor problems in the water, and the films can harbor harmful pathogens. In Thorne Bay, taste and odor problems are not frequently reported, but the slime can slough off the pipe walls, and end up at the customer’s tap. The slime results in significant expenditures of staff time troubleshooting customer problems, and unclogging fouled pressure regulating valve (PRV) screens and other items. There are also unquantifiable impacts to the utility in terms of public relations and image.
- Soft water with low alkalinity can be aggressive water, attacking pipes, leading to leaks, and elevating lead and copper levels in the water supply.

Addressing these water quality concerns will provide better and safer water, and bring Thorne Bay into compliance with current water quality regulations.

2.2 Existing Water Treatment Facilities

Water Treatment Plant (WTP)

The City of Thorne Bay WTP was constructed in 1987 and uses direct filtration to treat surface water. This process is enhanced by the addition of a polymer based coagulant salt and a 2,500 gallon pressurized flocculation tank, which provides reaction time for flocculation and some degree of settling, before the process water is filtered through three 60-inch pressure filters.

Pressure Filters

The filtered water is dosed with liquid sodium hypochlorite, prior to being stored in a 286,000 gallon bolted steel tank. A sidestream circulates water out of, and back into the tank, allowing additional hypochlorite to be added as needed to maintain residual in the tank. The existing WTP process flow diagram is shown in Figure 3.

Water Lake, north of Thorne Bay, supplies raw water to the treatment process by means of a submersible pump in the lake and a 2,600-foot transmission pipe. A secondary source, Deer Creek, is available for backup operations if necessary, although it has not been used before and equipment to use this water is no longer available.

The pressurized flocculation tank provides approximately 60 to 70 minutes of reaction time at a typical WTP flow rate of 35 to 45 gpm. The coagulant dosage is regulated through use of a streaming current detector, NALCO 8105 is presently being used. This is a proprietary compound believed to consist of a blend of a polyamide with polyquarternary ammonium chloride, providing both coagulation and flocculation functions. The flocculation tank does effectively form and accumulate floc, which the operators drain every several days.

Flocculation Tank

The three existing water filters are loaded at a surface rate of less than 1 gpm/ft^2, resulting in very good filtration and relatively long filter runs, 48 hours or longer varying with seasonal raw water quality. Turbidity is monitored continuously on each individual filter in accordance with the Long Term Interim Enhanced Surface Water Treatment Rule (LTIESWTR). Turbidity is also monitored on the combined filter effluent prior to the storage tank.

Turbidity Meters

Chlorine is continuously dosed into the treated water (12 percent hypochlorite); the level of dosing appears to be manually monitored and adjusted. There is no on-line chlorine monitor or automatic adjustment. Soda ash (sodium carbonate) is also added for pH adjustment to control the corrosive nature of the water. This is also monitored and adjusted manually.

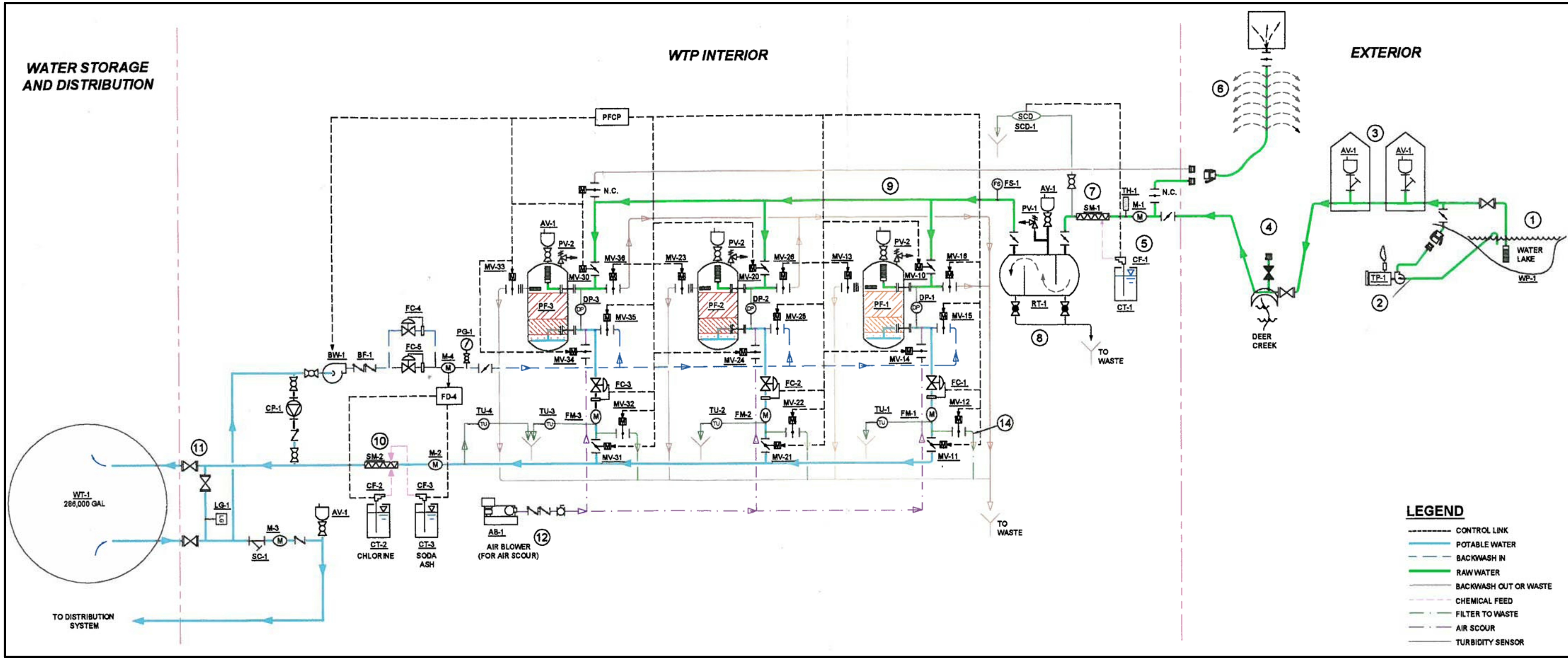
The WTP produces between 33,000 and 60,000 gallons of potable drinking water daily for the City. Table 2 summarizes data available for 2009 by month. The data as shown is water produced and sent to town and does not include backwash, overflows, or other demands at the WTP.

Table 2 - 2009 Water Production Summary

Month	Total Process Water to Town (gallons)	Average Daily Process Water to Town (gallons)	Maximum Daily Process Water to Town (gallons)	Minimum Daily Process Water to Town (gallons)
Jan-09	Not available	Not available	Not available	Not available
Feb-09	155,000	38,750	44,000	30,000
Mar-09	1,373,000	44,290	58,000	40,000
Apr-09	1,258,100	41,937	50,000	33,000
May-09	1,349,000	43,516	48,000	38,000
Jun-09	1,358,000	45,267	92,000	40,000
Jul-09	1,415,000	45,645	61,000	41,000
Aug-09	1,614,000	52,065	78,000	42,000
Sep-09	1,332,000	44,400	54,000	38,000
Oct-09	1,366,000	44,065	51,000	39,000
Nov-09	1,295,000	43,167	52,000	37,000
Dec-09	1,374,000	44,323	69,000	41,000
	January and February not included below. [1]			
TOTAL 2009	13,734,100	448,675	613,000	389,000
Maximum 2009	1,614,000	52,065	92,000	42,000
Minimum 2009	1,258,100	41,937	48,000	33,000
Note: February data is included in table as provided, but was incomplete and has not been incorporated into summary (e.g. total).				

In 2008 and 2009, the WTP underwent a series of improvements intended to rehabilitate treatment equipment, and to improve O&M. This included:

- Cleaning of the water intake piping and raw water transmission main, along with modifications of the raw water pumps, lowering them further into the lake resulting in a more uniform raw water quality throughout the year
- Improvements to plant piping, including upgrade of the filter control valves, and provision of piping and valves allowing for easy flushing of the WTP systems
- New filter media
- Cleaning of the water storage tank (WST)
- Installation of a backup generator



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UTILITY IMPROVEMENTS STUDY

WATER TREATMENT
PROCESS DIAGRAM

July 2010

FIGURE
3

2.2.1 Regulatory Status

Thorne Bay is a Class A community water system under ADEC regulations (18 AAC 80.1990), permitted as public water system AK2120216. In Alaska, water treatment systems are further classified according to a point rating system, with points assigned based on system components found in 18 AAC 74.120, which indicate system complexity. Thorne Bay's system has been classified as a Class 2 system based on the scoring shown in Table 3.

Table 3 - Thorne Bay Water Treatment Score

Score Category	Score
Size (Peak day design capacity, gallons per day) - 50,001 - 100,000	4
Water Supply Source - Surface water	6
Adjustment and Corrosion Control - pH adjustment	3
Coagulation - Primary coagulant	5
Mixing - In-line static mixers	1
Filtration - Granular media	8
Disinfection - Liquid and powdered hypochlorites	3
Sludge Treatment - Discharge to on-site pond, septic tank, or lagoon	2
Total	32

Should the Thorne Bay system complexity change, the system would be reclassified as indicated below:

- Class 1: Score 1 to 30
- Class 2: Score 31 to 55
- Class 3: Score 56 to 75
- Class 4: Score greater than 75

In order to construct, install, alter, renovate, operate, or improve a community water system, written approval from ADEC based on a plan review is required. The changes may result in modification of system class. The system class corresponds to the level or operator certification required and may therefore result in the need for additional operator training. Currently City staffing includes a Class 2 (primary Billy Jo Phillips) and a Class 1 operator (Jason Blair).

Thorne Bay is currently on the ADEC SNC List for violations of the Stage 1 Disinfectants and Disinfection Byproducts Rule (Stage 1 DBPR, 63 FR 69390 – 69476). Thorne Bay has HAAs and TTHM exceeding maximum contaminant levels (MCLs). There is also a history of violations for turbidity monitoring when the power has gone out, however, there are currently no open violations or concerns other than DBPs (Eric Burg, 7/2/10).

Stage 1 DBPR is a revision to LTIESWTR, the purpose of which is to improve public health protection by reducing exposure to DBPs. Some DBPs have been shown to cause cancer and reproductive effects in lab animals, and have suggested bladder cancer and reproductive effects in humans. The Stage 1 DBPR is the first stage in a set of rule changes to reduce the allowable levels of DBPs in drinking water. Stage 1 DBPR applies to all community and nontransient noncommunity water systems that use disinfectants. The rule establishes seven new standards and a treatment technique of enhanced coagulation or enhanced softening to reduce DBP exposure. The rule was designed to limit capital investments and avoid major shifts in disinfection technologies until additional information is available on the occurrence and health effects of DBPs[6]. MCLs related to the Stage 1 DBPR are shown in Table 4.

[6] US Environmental Protection Agency (EPA). Stage 1 Disinfectants and Disinfection Byproducts Rule (DBPR): A Quick Reference Guide. EPA 816-F-01-010. May 2001. Available at http://www.epa.gov/safewater/mdbp/qrg_st1.pdf.

Table 4- Stage 1 DBPR Regulated Contaminants/Disinfectants

Regulated Contaminant	MCL[1] (mg/L)	MCLG[1] (mg/L)	Regulated Disinfectants [2]	MRDL[2] (mg/L)	MRDLG[2] (mg/L)
Total Trihalomethanes (TTHM)	0.080		Chlorine	4.0 as CL_2	4
Chloroform		--			
Bromodichloromethane		Zero			
Dibromochloromethane		0.06			
Bromoform		Zero			
Five Haloacetic Acids (HAA5)	0.060		Chloramines	4.0 as CL_2	4
Monochloroacetic acid		--			
Dichloroacetic acid		Zero			
Trichloroacetic acid		0.3			
Bromoacetic acid		--			
Dibromoacetic acid		--	Chlorine dioxide	0.8	0.8
Bromate (WTPs that use ozone)	0.010	Zero			
Chlorite (WTPs that use chlorine dioxide)	1.0	0.8			

Notes:
1. MCLG means maximum contaminant level goal and is a target value but is not required by regulation at this time.
2. Stage 1 DBPR includes maximum residual disinfectant levels (MRDLs) and maximum residual disinfectant level goals (MRDLGs) which are similar to MCLs and MCLGs, but for disinfectants.

The Stage 1 DBPR further requires enhanced coagulation/enhanced softening to improve removal of DBP precursors for systems like Thorne Bay that use conventional filtration treatment. This portion of the rule sets total organic carbon (TOC) removal requirements based on source water TOC and alkalinity as shown in Table 5.

Table 5 - Required TOC Percent Removal

Source Water TOC (mg/L)	Source Water Alkalinity (mg/L as $CACO_3$)		
	0-60	>60-120	>120
>2.0 to 4.0	35.0%	25.0%	15.0%
>4.0 to 8.0	45.0%	35.0%	25.0%
>8.0	50.0%	40.0%	30.0%

With low alkalinity levels (13.8 mg/L during site visit) and TOC levels greater than 8 mg/L (12.8 mg/L during site visit) in its raw water, Thorne Bay has a minimum required removal of 50 percent. The WTP presently has better than 60 percent removal, but the remaining TOC is still resulting in elevated DBP levels. If DBP levels are not brought in line ADEC can assess penalties in accordance with 18 AAC 80.1220. The penalties would be at least $60 per day, and would most likely be more based on an ADEC calculation of the avoided cost of treatment and agency expenditures (e.g. time).

TOC varies seasonally, but only over a relatively limited range. Previously reported values[7] have ranged from about 9 to 13 mg/L. Lower levels of TOC are associated with reduction in the formation of DBPs. Also, as the carbon serves as a nutrient source for the growth of biomass, lower levels of TOC are also associated with a reduction in biogrowth in the distribution system. While there is no MCL for carbon, a target of less than 2 mg/L is suggested, and other water systems typically report little to no formation of DBPs or biofilm formation with treated water in proximity to this TOC limit. At Thorne Bay, the dissolved organic carbon (DOC) portion of TOC is the specific target for removal improvement. This is because the current program of coagulation and filtration is removing nearly all of the particulate TOC. Table 6 shows that the measured DOC accounted for all of the measured TOC during the testing conducted in February 2010.

Stage 2 DBPR continues the establishment of rules related to DBPs, requiring those systems using a primary or residual disinfectant other than ultraviolet (UV) light, to meet maximum contaminant levels as an average at each compliance monitoring location (instead of the system-wide average under Stage 1) for TTHMs and HAA5. The Stage 2 DBP rule also requires each system to determine if they have exceeded an operational evaluation level, which is identified using their compliance monitoring results. The operational evaluation level provides an early warning of possible future MCL violations, which allows the system to take proactive steps to remain in compliance. A system that exceeds an operational evaluation level is required to review their operational practices 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.[8]

2.3 Investigations and Findings

2.3.1 Water Treatment Plant (WTP)

Because the treated water produced and distributed in the City of Thorne Bay has very good aesthetics, with no apparent color, taste, or odor issues, the items of concern to this improvement study are not readily detectable by the consumer. Accordingly, water samples were collected from multiple locations within the treatment process, and submitted to SGS North America (SGS), for laboratory analysis. Complete test results as furnished by SGS are provided in Appendix C; specific parameters of immediate interest to the project are summarized here. Note that testing was performed at each significant active stage of the treatment process. This provides the raw water quality; the result of existing coagulation/flocculation/filtration; and the result of chlorine and soda ash addition with detention (reaction) time in the storage tank as shown in Table 6.

It is normal for addition of coagulants and other treatment chemicals to result in a small increase in total dissolved solids, which occurred as shown in Table 6 below.

Table 6 - Water Treatment Test Results

Parameter	Units	Raw Water	After Filters	Finished Water/Storage Tank	Maximum Contaminant Level	Recommended Goal
Sample IDs/Tags		300/400	200	100/500		
Hardness	mg/l	9.92	10.1	9.74		
Alkalinity	mg/l	13.9	13.4	32.4		
HCO3 Alkalinity	mg/l	13.9	13.4	32.4		
CO3 Alkalinity	mg/l	--	--	--		

[7] CE2 Engineers, Inc., in cooperation with ADEC Village Safe Water (VSW) Program. *Water Treatment System Study*. August 2002

[8] EPA. Stage 2 Disinfectants and Disinfection Byproduct Rule (Stage 2 DBP rule). June 2007. Available at http://www.epa.gov/safewater/disinfection/stage2/basicinformation.html#one.

Parameter	Units	Raw Water	After Filters	Finished Water/Storage Tank	Maximum Contaminant Level	Recommended Goal
OH Alkalinity	mg/l	--	--	--		
pH	pH	6.3	6.3	7.1	6.5-8.5	
Total Suspended Solids	mg/l	0.571	--	--		
Total Dissolved Solids	mg/l	46.3	38.8	56.3	500	
Langlier Index (LI) @ 40 degree F		-3.81	-3.81	-2.66	"non-corrosive"	-0.5 to +0.5
Turbidity	NTU	60	0.07-0.08	0.08	0.3	
Color	PCU	74	5	5	15	
Total Organic Carbon	mg/l	12.7	4.81	4.58		Less than 2
Total Organic Carbon, Dissolved	mg/l	12.8		4.52		Less than 2
Organic Carbon Removal	%			64%	50%	
Iron	mg/l	0.667	0.156		0.3	
Manganese	mg/l	0.018	0.013		0.05	
Total Trihalomethanes	ug/l			73.8	80	
Total Haloacetic Acids (HAA5)	ug/l			140	60	
Chlorine	Mg/l			0.4	4	0.2

2.3.2 Distribution System

In order to determine the quality of the water in the distribution system and to determine what effect, if any, the distribution system has on the quality of water, water samples were collected from three locations in the distribution system and distributed throughout the City in a manner intended to collect increasing water ages, beginning at the WTP and working away. The sample locations, and test results are summarized in Table 7, while the complete test report is provided in Appendix C. Figure 2 depicts the locations of the sampled buildings.

Table 7- Distribution System Test Results

Test	Units	Storage Tank	Bayview Chalet	City Hall	Grocery Store	Svend's Drive 4-Plex	Maximum Contaminant Level	Recommended Goal
Sample ID/Tag		100	1	2	3	4		
Hardness	mg/l	9.74	10	9.9	9.66			
Alkalinity	mg/l	32.4	33.4	32.9	33			
pH	pH	7.1	6.9	7	7		6.5-8.5	
Total Dissolved Solids	mg/l	56.3	42.5	38.8	50			
Langlier Index (LI) at 40 degree F		-2.66	-2.82	-2.73	-2.75		"non-corrosive"	-0.5 to +0.5
Total Organic Carbon	mg/l	4.58	4.59	4.57	4.53			less than 2
Total Organic Carbon, Dissolved	mg/l	4.52	5.56	5.15	4.65			less than 2
Dibromochloromethane	ug/l							60
Chloroform	ug/l	71.9	108	79.6	80.8			
Bromodichloromethane	ug/l	1.94	2.32	2.04	2.11			Zero
Bromoform	ug/l							Zero

Test	Units	Storage Tank	Bayview Chalet	City Hall	Grocery Store	Svend's Drive 4-Plex	Maximum Contaminant Level	Recommended Goal
Total Trihalomethanes	ug/l	73.8	110	81.6	82.9		80	
Monochloroacetic acid	ug/l	4.1		3.43	3.76			
Dichloroacetic acid	ug/l	53.6		45.8	43.6			Zero
Trichloroacetic acid	ug/l	82.4		89.1	85.8			300
Bromochloroacetic acid	ug/l							
Dibromoacetic acid	ug/l							
Total Haloacetic Acids (HAA5)	ug/l	140		138	133		60	
Copper	ug/l				76.3	121	1300	
Lead	ug/l				4.96	22.1	15	Zero
Free/Total Chlorine	Mg/l	0.4	ND	ND	ND	ND	4	0.2

The basic water quality parameters of hardness, alkalinity, pH, dissolved solids, and LI in the distribution system do not deviate significantly from those of the treated water produced by the WTP, suggesting the water is relatively stable as produced. Nor does the level of TOC and DOC vary significantly. USKH initially expected to see TOC and DOC quantities decrease, assuming that the biogrowths in the pipe were consuming the carbon, or for the value to go up, suggesting the pipes were shedding organisms into the water. Neither of these appears to be the case in general.

TTHMs and HAA5 were found at levels exceeding MCLs at all locations tested in the distribution system. TTHMs were slightly greater than the level at the WTP, resulting in the distribution system slightly exceeding the MCL of 80 mg/l for TTHMs. It is likely that a portion of the TTHMs of concern are produced in the distribution system, after the water leaves the tank. HAA5 levels also exceed the MCL, by a factor of about two times the limit. However, in this case, it appears that the bulk of this contaminant is created at the WTP itself, not in the distribution system.

The test results suggest, there is a significant increase in chloroform, bromodichloromethane, and TTHM between the WST and the Bayview Chalet. A repeat test is warranted to determine if this is a consistent results, or an indicator of biofilm in the system piping. The spike in chlorine-containing DBP compounds correspond to no free chlorine at the Bayview Chalet, a small rise in dissolved TOC, small rises in hardness and alkalinity, and a small drop in pH. All these factors together are consistent with chlorine oxidizing organic molecules – possible indication of biogrowth in the service pipe. This may or may not indicate biogrowth in the main itself, which has a relatively high average flow.

Additionally, each of the locations used in the hydrant flow testing program was checked for chlorine residual, while adjacent residences or commercial buildings were checked for the presence of copper in the water. See Section 4 for a summary of these flow locations. These field tests were done with free and total chlorine test strips (Hach AquaChek 5 in 1) and copper test strips (Hach Copper AquaChek). The chlorine test strips have a range of 0 to 10 mg/l for both free and total chlorine, with a detection limit somewhere between 0 and 0.5 mg/l (the lowest "reading" on the strip is 0.5 mg/l, lower levels give a partial reaction). This is not low enough for reliable determination of distribution system residuals, as minimum residual goal is only 0.2 mg/l. However, the test strips are very handy for quick checks during hydrant flow testing. In no case was chlorine residual detected during testing. This is not to say chlorine was not present; however, if there is a residual, it is well under 0.5 mg/l. The WTP dose of about 0.4 mg/l free chlorine would be sufficient to provide some reaction on these test strips; the fact that no apparent residual was detected suggests loss of residual due to chlorine demand in the distribution system, probably due to the DOC in the water and/or biofilm on the walls of the pipe.

The copper test strips have a detection limit of 0.2 mg/l. Copper was detected at low levels in two locations, as reported in the table. These locations were sampled for lead and copper, and analyzed by SGS, the results of which are shown in Table 7. The tested level of lead slightly exceeded the MCL for this contaminant at the Svend's Drive East 4-plex. The presence of lead and copper in the water is attributed to the aggressive, corrosive nature of the water, although only two locations with elevated levels were found, and only one of those has a possible exceedance. This may not be a significant issue, depending on what the City's regular compliance testing finds. It may warrant consideration of additional corrosion control on the treated water however (discussed in Section 2.4.2).

2.3.3 Coagulant Jar Testing

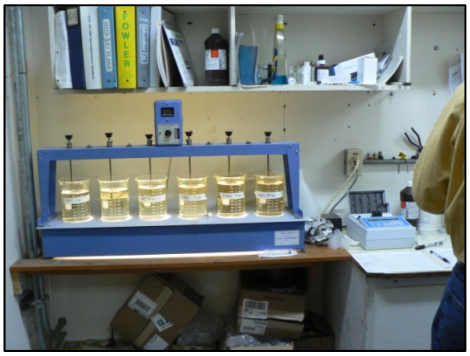
As part of the WTP investigation, a series of coagulant jar tests was performed to evaluate several different coagulant chemicals and dosages. This was done to examine the effectiveness of the existing coagulant system, and to determine if other coagulants, dosages, or practices would be beneficial to the water treatment process.

Jar testing was done on site using the WTP's six station gang tester. NALCO Inc provided a selection of polymer samples, which were diluted to a stock concentration of 10 mg/l using a laboratory balance and volumetric flask. This allowed for simple dosing of the 1 liter test jars using ordinary hypodermic syringes.

A total of six batteries of jar tests were run, six jars per battery, for a total of 36 jars. Five different coagulants were tested individually, and in combination, over a range of dosages. Jars were all dosed together, and rapid mixed at 280 rpm for 5 seconds, simulating the high shear mixer in use at the WTP. Jars were then continuously slow stirred for 30 minutes at 30 rpm. Onset of floc formation varied from 3 to 15 minutes depending on chemical and dosage, however all tests that formed floc had reacted by 15 minutes, and little to no change in tested turbidity was noted after 30 minutes. Note that the WTP's pressurized flocculation tank provides 70 to 90 minutes of detention.

Water Treatment Series

Chemical Stock Solution



Jar Testing

Floc Formation

Each jar with floc formation was filtered using a 60 ml syringe with 24 mm Whatman 934AH glass fiber filter in a syringe filter holder. The first 30 ml was wasted, and a sample cell filled with the remaining filtrate for both turbidity and color testing using the WTP's bench equipment. Wasting of the first part of the filtrate develops a filter cake on the glass fiber disk; this simulates both aging of the filter, but also improves solids removal as the accumulated filter cake provides physical filtration.

Jars that exhibited both low turbidity and low color, indicating good removal of both carbon and solids, were selected for laboratory testing. These jars were vacuum filtered through a 90 mm Whatman 934AH filter disk in a Buchner funnel for laboratory analysis by SGS. A total of five jar tests were analyzed for basic water quality parameters, but also specifically for removal of solids and organic carbon.

Test results are summarized in Table 8; this is a combination of both the bench testing in the WTP, and the SGS laboratory results. No jars were taken from the sixth battery.

Table 8 - Jar Testing Results

Test	Units	Source or Test Number						
		Raw Water	1	2	3	4	5	Finished Water
Sample ID/Tag			1	2	3	4		
Hardness	mg/l		10	9.9	9.66			
Alkalinity	mg/l		33.4	32.9	33			
pH	pH		6.9	7	7		6.5-8.5	
Total Dissolved Solids	mg/l		42.5	38.8	50			
Jar Test Battery #			1&2	1&2	3&4	5	5	
Sample ID/Tag from laboratory results		300/400	J#1	J#2	J#3	J#5	J#6	100/500
Coagulant			8185	8105	8186	8185/8105	8185/8105	8105
Dosage	mg/l		30	15	50	20/10	12/13	18+\-
NSF 61 Dose Limit	mg/l		40	20	66			
Rapid mix, 280 rpm	seconds		5	5	5	5	5	
Slow stir, 30 rpm	minutes		30	30	30	30	30	70+\-
Hardness	mg/l	9.92	10.3	10.4	10			9.74
Alkalinity	mg/l	13.9	13.5	14.7	13.6			32.4
pH	pH	6.3	6.4	6.4	6.4			7.1
Total Dissolved Solids	mg/l	46.3	41.3	38.8	30			56.3

Test	Units	Source or Test Number						
		Raw Water	1	2	3	4	5	Finished Water
Langlier Index (LI) @ 40 F		-3.81	-3.70	-3.65	-3.69			-2.66
Color - Field Test	PCU	105	0	6	0	2	0	5
Color - Lab Test	PCU	74	5	11	5			
TOC	mg/l	12.7	4.17	5.86	3.98	3.53	4.23	4.58
Percent Removal	%	0%	67%	54%	69%	72%	67%	64%
Turbidity	NTU	60	0.5-0.6	0.3-0.5	0.2	0.4	0.3	0.1

While the NALCO 8105 presently in use by the WTP achieves good removal of carbon (54 percent) and exceeds the 50 percent carbon removal requirement of the Stage 1 DBPR; several of the other coagulants tested did achieve better removal of carbon. The followings results were noted:

- The best removal of organic carbon with a single chemical was obtained with NALCO 8186, at 69 percent. This was very closely followed by NALCO 8185 at 67 percent.
- The combination of NALCO 8185 and 8105 used together achieved a very impressive 72 percent removal of the carbon.

It should be noted that the WTP itself, using NALCO 8105 and the three pressure filters, had a removal of 64 percent, somewhat more than the same chemical tested in the jar test. This is likely due to the variability of the jar test, but also due to the very low filter loadings used in the WTP. This suggests that the actual results of using NACLO 8185, 8186, or the 8185/8105 combination at the same filter loading rate might be slightly better than these initial jar tests show.

Extrapolating from the jar test results and the comparative improvement that may result from using the 8185/8105 combination with the WTP filter loading, the percent removal range for TOC would be between 72 and 82 percent. An exact determination would require pilot testing of the coagulant combination in the full scale plant.

For discussion purposes, a 75 percent TOC removal from raw water with a 12.7 mg/L concentration results in a TOC of 3.1 mg/L. This is quite good, and an improvement over the existing treatment, which presently results in a TOC of about 4.5 mg /L. The improved removal would result in a reduction in DBP formation; however, this value is still above the target of 2.0 mg/L associated with a low pipe biofilm formation potential

Based on dosing at optimum concentration from the jar tests, projected annual chemical costs using the tested polymers is shown in 0. These values assume using the same concentrations as the optimum jar test at the average daily flow production rate of 44,823 gallons per day (Table 2).

Table 9 - Projected Coagulant Use and Costs

Coagulant	Concentration [1] (mg/l)	Projected Daily Use [2] (gal.)	Cost/gal.	Annual Cost [3]
8105 [4] (current flocculent)	15	0.67	$58.21	$14,245.50
8185	30	1.34	$46.55	$22,784.18
8186	50	2.24	$48.76	$39,893.48
8105/8185	10/20	0.45/0.90	$58.21/$46.55	$24,870.68

Notes:

3. Concentrations are based optimum results from Table 8.
4. Projected use is based on production of 44,823 gallons per day and assumes application where mg/L is equivalent to ppm.
5. Annual costs are based on 365.25 days of use at the project rate and a quote provided by NALCO 07/01/10.
6. The City budgeted $6,500 for WTP chemicals in FY11 which includes NALCO 8105, chlorine, and soda ash. Based on projected costs differences, the City should anticipate additional chemical costs of approximately $11,000 for the optimum coagulant combination. This may be reduced slightly by offsets in chlorine use, which cannot currently be estimated.

It does appear that further experimentation with coagulants, perhaps in a full scale pilot, would be warranted for improved carbon removal with the current process equipment. While this does not appear to achieve the improvements necessary to address the DOC issues, this would reduce violations and improve water quality to some degree while the water treatment improvements are being designed and constructed.

2.4 Water Treatment Alternatives

The existing Thorne Bay WTP produces, in general, good water - free of taste, odor, and aesthetic problems - with some identified problems revolving around organic carbon, including formation of DBPs and biogrowth; and some degree of corrosivity. There are a number of viable alternatives to consider to address these items and to help the City achieve regulatory compliance. These include:

1. Optimization of Existing Coagulation and Flocculation Processes
2. Alkalinity/Corrosivity Adjustment
3. Alternative Disinfectant Systems
4. Membrane Filtration

A number of miscellaneous improvements or repairs that could be made to correct existing deficiencies have also been noted at the WTP and are discussed.

The goal in evaluating these alternatives is the removal of TOC for the associated reductions in biofilm growth, chlorine demand, and DBP formation. Generally TOC concentrations of less than 2.0 mg/L are accepted as required to prevent the growth of biofilms. It can also be expected that formation of DBP would be substantially reduced below MCLs, if the TOC was reduced to less than 2.0 mg/l, i.e.: less than half of that of the current treated water. Other goals include maintaining good taste and odor, minimizing corrosion potential, and minimizing chemical costs.

2.4.1 Optimization of Existing Coagulation and Filtration Process

Field evaluations and jar testing suggest that carbon removal can be improved with other coagulants. Based on the coagulants tested, the apparent optimum would be the addition of NALCO 8185 to the NALCO 8105 currently in use, at concentrations of 10 mg/L NALCO 8105 plus 20 mg/L NALCO 8185. This combination would either require pre-blending, or more efficiently, a second solution feed pump with the two feed stock streams combined in the existing static mixer at the coagulant injection point. This projected cost would be $6,000 as detailed in Appendix E. Note that this cost assumes that the project is done largely by the City and does not include the project markups that would be incurred with incorporation into a larger project. Annual coagulant costs of $25,000 would be expected, which is a significant increase over the current coagulant costs as noted in Table 9.

This results in only a minor increase in operational complexity and can be easily pilot tested and evaluated for effectiveness. To pilot test the new coagulant concentrations it is recommended that the WTP operator take the following steps:

- Repeat jar testing to insure repeatability.
- Obtain ADEC authorization to modify the system and approval of a pilot testing protocol.
- Purchase a supply of NALCO 8185 and a new solution feed/dosing pump.
- Dose the two coagulants into the treatment stream, beginning with the rates developed here. Monitor color and turbidity with existing WTP equipment.
- Adjust rates upwards and downwards in increments of 5 and 10 percent variation, and monitor apparent affect. Note that there will be a delay of at least 90 minutes before change is apparent due to retention time within the WTP.
- Water samples should be collected after filtration, for each trial, and analyzed for TOC
- Based upon color, turbidity, and TOC results, the optimum dosing rates may be determined, along with the degree of effectiveness.

Compared to pilot testing programs for other process changes, which may require on-site manufacturer's representatives, flow splitting, and extensive equipment purchases; the pilot testing of a polymer blend is relatively simple. Implementation effectiveness will be apparent in decreases in measured TOC values. Since this can be done in-house with City operators no costs other than purchase of the extra coagulant and TOC analysis have been associated with the pilot testing described above. It should be assumed however that the operator will need to allow several hours for extra monitoring and recording of result during the first month of operation, as well as a day or two of time for preparing a testing protocol and corresponding with ADEC prior to implementation. An allowance of $1,000 is included for extra analytical tests in the first month (see cost estimate, Appendix E).

While optimizing the existing coagulation and flocculation processes is recommended to achieve TOC removal to the extent practical with the current system, it is not expected to provide the 2 mg/L TOC targeted by the Stage 1 DBPR (discussed in Section 2.2.1), which is necessary for Thorne Bay to effectively address the biofilm growth and DBP issues in the system. As noted in the discussion of jar test results (Section 2.3.3), removal of between 72 and 82 percent of raw water TOC can be expected, which still results in finished water values of 2.3 to 3.6 mg/L. While this TOC reduction is definitely an improvement and would reduce DBPs (probably to less than MCLs), optimization alone cannot be expected to significantly reduce biofilm growth.

The addition of a secondary chemical does increase the system complexity and the system water treatment classification score as a “coagulant aid, flocculent, or filter aid” has a 3 point value in addition to the 5 points for the primary coagulant. The current score is 32 and the limit for a Class 2 is 55. This 3 point increase would not result in a reclassification of the system. Even with change in complexity the operational changes and costs would be negligible, resulting only from the need to maintain and stock a second chemical feed. System classification is explained in greater detail in Section 2.2.1.

Because of the very low projected cost and potential benefits, this alternative is recommended as part of a suite of "tool box" solutions to address the water quality produced by the Thorne Bay WTP.

2.4.2 Alkalinity/Corrosivity Adjustment

The existing finished water is moderately corrosive, as indicated by the LI of -2.66. Even with the soda ash used for pH adjustment, the water is still corrosive, and this accounts for the occasional high copper test result in the distribution system. It would also be corrosive to the water mains, except for the fact they are predominately polyvinyl chloride (PVC).

Alkalinity is the capacity of a water to neutralize acid, and thus the ability of the water to resist changes in pH. The most prevalent forms of alkalinity in water are combinations of carbonic acid (H_2CO_3), bicarbonate ion (HCO_3^-), and carbonate ion (CO_3^{-2}). The alkalinity, in combination with the calcium hardness, pH, temperature, and other ion parameters are used to calculate the LI of the water, which is an indicator of the aggression or corrosivity of the water to minerals and metals. A LI greater than zero is completely non-corrosive; but, in general, a value greater than -0.5 is considered acceptable in Alaska.

Some of the water treatment alternatives proposed here, including nanofiltration, will further remove dissolved solids from the water, reducing alkalinity and further increasing corrosivity (i.e., a more negative LI). Because of this, additional stabilization of the water and adjustment to one or more of the alkalinity and LI parameters is recommended. This may require increasing the dosage of soda ash presently being used, using another carbonate chemical, or adding an acid former such as carbon dioxide in combination with the carbonate to boost both alkalinity and carbonate without raising pH. Alternately, the corrosivity could be addressed by using a phosphate inhibitor chemical, without adjusting the water itself.

The Thorne Bay WTP currently uses soda ash (NA_2CO_3) for pH adjustment, a common practice in Alaska were small LI adjustments are needed. The finished water is adjusted to approximately 7.1 pH, resulting in a LI of -2.66 with current practices. The secondary MCL for pH is 8.5 maximum. Using the American Water Works Association (AWWA) LI calculator[9], it is estimated that raising the pH to 8.5 would result in a LI of about –0.94. It does not appear that soda ash alone will be able to achieve non-corrosive water, without resulting in excessively high pH.

It appears necessary to significantly increase alkalinity, or hardness, or both, to increase the LI (make it less negative) without exceeding pH limits. This is done using a combination of a carbonate chemical and carbonic acid, forming alkalinity in the water. Carbonate can be provided by soda ash or sodium bicarbonate; the carbonic acid is provided by carbon dioxide injection. Alternately, lime (hydrated calcium oxide, $CaOH_2$) can be used with the carbon dioxide, and this is very effective at adjusting the LI as it adds alkalinity and calcium hardness, and provides pH adjustment. Lime adds 1.35 mg/L of alkalinity per mg of lime. A dose of about 40 to 60 mg/L is roughly estimated to bring the LI to about -0.5. This requires about 500 pounds per month, to treat 1.5 million gallons per month.

[9] American Water Works Association (AWWA). Available at: http://www.awwa.org/Resources/RTWCorrosivityCalc.cfm?navItemNumber=1576&showLogin=N

Development of an effective corrosion control system for the Thorne Bay WTP, while very worthwhile, will require additional water quality testing and bench testing that is beyond the scope of this immediate study. However, for planning purposes, a hydrated lime system in combination with a carbon dioxide injection system is expected to be capable of raising the LI at the WTP to greater than -0.5, without excess pH. For Thorne Bay, a system would be expected to consist largely of a batching tank, with continuous mixer to maintain a dilute lime slurry in suspension, and a peristaltic meter pump for injection. Larger systems include dry lime handling equipment, but for Thorne Bay, batching from bagged lime should be sufficient. An unheated, roofed shelter would likely be required to protect a skid-mounted lime system and has been assumed as a 250-sf shelter for estimating purposes, although this could be combined with other WTP expansions as a heated space if desired. carbon dioxide injection is accomplished with a treatment side stream that dissolves the carbon dioxide into solution prior to injection.

The capital cost of an upgraded corrosion/alkalinity adjustment system is estimated at $567,700 including design and pilot testing, as detailed in Appendix E, and would be in addition to the costs for other alternatives that may require the adjustment system (e.g. nanofiltration). Additional operating time would be required, about an hour a day, for a total of about $8,000 per year at the $30.33 hourly rate. Chemical costs would be approximately $3,000 per year to purchase bagged lime and bottled carbon dioxide. Power cost will be incurred to run the lime conveyor and the mixing and injection system, using approximately 6 kW on a continuous basis, resulting in an additional power cost of $11,000 per year.

Changes to the alkalinity/corrosivity system will require ADEC approval and pilot testing similar to that for the coagulant optimization described in Section 2.4.1. It would be done in house and not require bids. Equipment rental is not likely available and the system will need to be designed, purchased, and installed and then pilot tested or adjusted to optimize results. An allowance of $1,000 is included for extra analytical tests in the first month of operations (see cost estimate, Appendix E).

The addition hydrated lime and carbon dioxide injection would change the scoring for Thorne Bay's water treatment process. Lime softening is worth 16 points and recarbonation is worth 8 points. This would increase the system score from 32 to 56. This increase would take the system just beyond the limits of a Class 2 system (55 points) and would result in a reclassification of the system to a Class 3 (56-75 points) with the associated need for operator certification upgrades. The cost for the initial training and upgrade of operator certifications has not been included in current cost estimates.

2.4.3 Alternative Disinfection Systems

UV Disinfection of Treated Water

Primary drivers in the production of DBPs are carbon in water, continual application of chlorine, and long residence time. To address the presence of chlorine, Thorne Bay could use an alternate disinfectant – UV light as the primary disinfectant. A small quantity of chlorine (approximately 0.3 mg/l) would still be required to provide system residuals and could be injected either in the WST or on the way to town. By using less chlorine, TTHMs, HAA5, and other disinfection byproducts are reduced.

There are several styles of UV systems on the market at this time including rectangular open channel, vertical pressure reactors, and horizontal pressure-tube reactors. The most efficient style of UV disinfection for small WTPs with low finished water turbidities is an array of horizontal pressure-tube reactors (e.g. Wallace & Tiernan Barrier A, see product data in Appendix D). For Thorne Bay, three 15 gpm reactors in parallel will provide sufficient disinfection at current production rates. Reactors would be linked to ballasts, controls, and the WTP power supply. Power consumption per reactor would be approximately 4 kW per year and provisions for backup power would be required. The existing backup generator would need to be evaluated against proposed equipment but is assumed sufficient at this time. The installation complexity would be somewhat dependant on the degree of control integration with the rest of the existing treatment facility. It will likely be necessary to expand the WTP floor area to accommodate the UV reactors, ballast, piping manifold, and controls. For estimating purposes, 250-sf of additional floor has been assumed.

UV disinfection would result in substantial reduction, if not elimination, of the immediate formation of DBPs in the WTP; however, the smaller dose of chlorine added to provide residual will likely form some DBPs in the distribution system. Even so, with a substantial reduction in chlorine use, the DBPs would be within the MCLs.

UV disinfection does not improve chlorine residual, as organic carbon in the distribution system will continue to decay the residual. There would be no reduction in biofilm growth either, as the UV disinfection will not affect organisms in the distribution system.

Pilot testing is not needed for UV as long as the US Environmental Protection Agency (EPA) design guidelines for energy density are met. UV is extremely effective on pathogens larger than viruses, as long as the water has low turbidity. An engineering report would be needed, making a recommendation on what system to design and specify for full scale construction and installation.

The addition of a UV disinfection system increases the complexity of the Thorne Bay water treatment system. UV disinfection is worth 3 points on the ADEC scale, in addition to the *"liquid and powered hypochlorites"* currently in use. This would increase the system score from 32 to 40, which is still within the limits of a Class 2 system (55 points) and would not result in a reclassification of the system. System classification is explained in greater detail in Section 2.2.1.

With the increase in complexity will come additional operator time to monitor and service equipment. There will be regular lamp and ballast replacement required. Assuming an additional 1-hour per week or 4 hours per month at the operator rate of $30.33 per hour[10], this is an additional annual operational expense of $1,500. Power for the UV system is expected to be the other increase in operational expenses. The current cost for power purchased from Alaska Power and Telephone (AP&T) is $0.21 per kWh[11], so the 12 kWs per year needed by the system will add an additional $22,090.32 per year. This is a total increase in operational costs of approximately $23,600 per year. This will be offset partially by an unspecified reduction in chlorine usage and time required to address customer complaints.

The overall system requirements as discussed here would include:

- Three, 15 gpm UV pressure-tube reactors with ballast, piping manifold, and controls.
- A 250-sf building expansion to accommodate new UV equipment.

Including design and contingencies the UV system is expected to cost approximate $431,400, as detailed in Appendix E.

[10] City staff costs are based on an operator labor rate provided by Justin Sornsin, May 25, 2010.
[11] Power costs provided by Alaska Power and Telephone (AP&T). July 2, 2010.

Chloramination of Treated Water

Another alternate disinfectant that may help address the issue of DBP formation in Thorne Bay is chloramines. Chloramines offer lower DBP formation potential than chlorine. Chloramines are actually a family of related inorganic oxidants, monochloramine, dichloramine, and trichloramine, which formed by adding ammonia in combination with chlorine. Organic chloramines will also be formed in waters with high TOC content (greater than 3.0 mg/l), such as those at Thorne Bay, when chlorinated. While all three forms will be present in some quantity, monochloromines are typically used in drinking water, while trichloromines are associated with swimming pools. Monochloromine generation is assured by the use of the correct equipment to add the ammonia to the chlorine at the point of injection.

Chloramines are more persistent than chlorine alone; that is, their reaction times are slower and therefore they have longer residual times in pipe networks. Conversely, chloramines can take longer to kill organisms and require a longer treatment time. For this reason chloramines would be used in Thorne Bay as a secondary disinfectant added as water enters the distribution system to establish a residual.

Research has shown that the half-life of inorganic chloramines can vary from one minute to 23 days, depending on the pH, alkalinity, temperature, and availability of carbon or other organic or inorganic molecules that are readily oxidized. In Thorne Bay, it is likely that the half-life would be on the order of hours. For chlorine in high TOC water, the half life is in the tens of minutes. Although this is a considerable improvement over the chlorine presently used, the chloramine half-life is not likely to be long enough to overcome the water ages found in the system, which exceed one week (see discussion on water age Section 4). Therefore, chloramination alone is not likely make a significant improvement to Thorne Bay's water. However, used in combination with more aggressive pipe flushing and/or water age management practices, as detailed in Section 4, chloramination would likely provide improvement on DBP formation and taste and odor. Chloramination is expected to also reduce biofilm growth; chloramines are more effective on films than free chlorine because of the longer residual times and slower kill, which seems to allow them to permeate through the biofilm colony, rather than just oxidizing the surface.

The equipment, installation, and operation of a chloramination system are relatively simple. An ammonia storage tank and injection feed pump/injector system would be added to the existing chlorination system and should not require a WTP expansion. A 55-gallon drum of 29 percent, 0.880 specific gravity aqueous ammonia is estimated to last approximately 3 years, resulting in a very low cost for the chemical ($1,800/year).

The new equipment should fit within the existing WTP and will cost approximately $11,400, as detailed in Appendix E. Note that this cost assumes that the project is done largely by the City and does not include the project markups that would be incurred with incorporation into a larger project. The new equipment would include conventional metering pump equipment similar to that on Thorne Bay's existing systems. The effect on DBP production will be relatively easy to pilot test and evaluate.

Chloramination pilot testing would be accomplished in the same manner as the coagulant optimization described in Section 2.4.1. It would be done in-house and would not require bids. Equipment rental is not likely available and the system will need to be designed, submitted to ADEC for plan review, purchased, and installed and then pilot tested or adjusted to optimize results. An allowance of $1,000 is included for extra analytical tests in the first month of operation (see cost estimate, Appendix E).

The addition of ammonia for chloramination using a liquid solution would change the scoring for Thorne Bay's water treatment process. Chloramination with liquid solution is worth 3 points in addition to the *"liquid and* *powered hypochlorites"* currently in use. This would increase the system score from 32 points to 35 points. This increase is within the limits of a Class 2 system (55 points) and would not result in a reclassification of the system.

The additional complexity results in increased operational costs associated with the maintenance and stocking of the new chemical feed. As mentioned above, there would be approximately $1,800 per year in new chemical costs. There will also be a small degree of maintenance and operational changes for the new equipment. Assuming an additional 3 hours per week or 12 hours per month at the operator rate of $30.33 per hour[12], this is an additional annual operational expense of $4,400, or a total increase in operational costs of approximately $6,200 per year. This will be offset partially by an unspecified reduction in chlorine usage and time required to address customer complaints.

The overall chloramination system as discussed here would include:

- A 50-gallon ammonia storage tank
- Injection feed pump
- Injection port

Including design and contingencies this system is expected to cost approximate $11,400, as detailed in Appendix E.

2.4.4 Upgraded Filtration (Nanofiltration) for Carbon Removal

Membrane filtration is the most direct approach to removing the carbon from the water, by simply filtering out carbon with a membrane sieve. This is a very effective process, capable of removing nearly all of the TOC, along with any other dissolved compounds in the water. Applicable processes are ultrafiltration, nanofiltration, and reverse osmosis, each using increasingly smaller membrane pores. Ultrafiltration membranes range from 0.005 to 0.1 microns; nanofiltration is a much smaller range, 0.001 to 0.005 microns. Determination of which process to use and an appropriate pore size requires a thorough analysis of the feed water and pilot testing is recommended for all systems. Pre-treatment will generally be required, as will chemical inhibitors and cleaning to prevent biogrowth on the membranes themselves.

For removal of dissolved carbon, the most common processes applicable to the Thorne Bay WTP would be ultrafiltration in place of the existing pressure filters, or nanofiltration after the existing pressure filters.

Ultrafiltration in Place of Existing Pressure Filters

The existing process in Thorne Bay involves dosing with the coagulant (discussed in Section 2.3.3) and filtering the water through multimedia granular pressure filters. These filters have a wide range of effective pore sizes, on the range of 1 to 100 microns, at least 10 times larger than an ultrafiltration membrane. To improve physical filtration of the flocculated water, the existing filters could be replaced with a tubular membrane system (e.g. GE Water Zeeweed or Z Box System, with hollow tubular membranes, see Appendix D for product data). The new treatment procedure would still include dosing with the coagulant, but would then directly filter water through the membrane. The physical process is similar to conventional pressure filters, but with a much smaller absolute pore size. The effectiveness of this process is typically from 50 to 90 percent removal for organic carbon. Thorne

[12] City staff costs are based on an operator labor rate provided by Justin Sornsin, May 25, 2010.

Bay would need at least 85 percent removal to obtain less than 2 mg/l, which is near the upper end of the performance scale.

It is likely that the ultrafiltration filters could be swapped into the same general location in the WTP as the existing granular filters. However, a pressure booster pump system would also be necessary, as ultrafiltration requires pressures somewhat above atmospheric pressure, and a higher pressure backwash would be needed. Rather than a new booster pump, the existing intake pump at Water Lake would likely be replaced. For estimating purposes it has been assumed that the new intake pump would be a 2-inch, 7.5 hp Grundfos capable of 50 gpm at 250 feet of head. Backwash water would likely require the addition of a scale reducer to remove the relatively low accumulation of calcium compound and associated organic material that will accumulate at the pores during filtration.

Using membrane ultrafiltration instead of granular media filtration will add to existing WTP O&M requirements although it will remain a one-step process. Anti-fouling chemicals costing approximately $4,000 per year will need to be added to the backwash supply, and backwash monitoring will require increased operator attention, at least initially, about 1 to 2 hours per week, up to 7 hours per month. At $30.33 per hour, this would be $2,600 per year in addition to existing labor costs. With the higher pressure needed to drive ultrafiltration will come increased power cost, estimated to be approximately $2,400 more per year, based on upsizing the existing pumps and running them about two-thirds of each day, on average.

Before an ultrafiltration system is installed to replace the existing filters it is important to pilot test the system to assure that TOC reduction objectives are met. Pilot testing would include a pilot design report, selection of alternative systems meeting the minimum requirement of the pilot design report, soliciting bids from the suppliers of those systems, engineering recommendation of the system to pilot, purchase or rental of the selected system, delivery and connection of the selected system, and at least a one-month pilot program, during which the pertinent parameters would be measured and compared with the side-by-side operation of the existing system. Once completed, an engineering report on the results of the pilot would be prepared, making a recommendation on what system to design and specify for full scale construction and installation. For estimating purposes the purchase of equipment not reusable at full scale and an allowance for laboratory sampling, as well as the test design and reporting, have been included as part of the project costs.

The change in filtration systems from granular media to membrane use would change the scoring for Thorne Bay's water treatment process. Granular media filtration is worth 8 points, all types of membrane filtration are 10. The change to membrane filtration would increase the system score from 32 points to 34 points, which is still within the limits of a Class 2 system (55 points) and would not result in a reclassification of the system. However with the requirement for alkalinity/corrosion adjustment as discussed in Section 2.4.2, there is an additional 24 points, which results in a score of 58 points, requiring classification as a Class 3 treatment system (56-75) with the associated need for operator certification upgrades. The cost for the initial training and upgrade of operator certifications has not been included in current cost estimates. System classification is explained in greater detail in Section 2.2.1.

The overall ultrafiltration system as discussed here would include:

- Demolition of existing pressure filters
- Replace intake pump at Water Lake with 2-inch, 7.5 hp Grundfos capable of 50 gpm at 250 feet of head
- Tubular membrane ultrafiltration system (e.g. GE Water Zeeweed or Z Box System, see product data in Appendix D)

- Add anti-fouling chemical and injection to backwash feed water
- Corrosion/alkalinity adjustment system as discussed in Section 2.4.2
- Month-long pilot testing program including equipment rental and associated reporting and design

Including design and contingencies an ultrafiltration system is expected to cost approximate $659,000, as detailed in Appendix E, not including corrosion/alkalinity adjustment.

Nanofiltration After Existing Pressure Filters

Another filtration alternative would be to add nanofiltration after the existing pressure filters. A spiral wound, pressurized membrane system similar to reverse osmosis but using an intermediate pore size membrane would be installed after the existing pressure filters (e.g.: GE Series E8, see product data in Appendix D). This would be a polishing process, and remove just about everything left in the water except for gases and salt-sized molecules. Thorne Bay should expect basically zero carbon after this process, but also very little if any alkalinity or hardness would be left resulting in aggressive, unstable water. Aggressive water is associated with corrosion of metal piping (main and services) and associate lead and copper issues. The water would need to be stabilized with a combination of carbon dioxide and lime as discussed in Section 2.4.2.

A GE Series E8-57K RO system fitted for nanofiltration would include eight 400-sf membranes in a 1-1-1 array. The system comes with a 15 hp pressurizing pump and integrated controls all mounted on a single skid about 13 feet long and 3.5 feet wide. A WTP addition of approximately 300-sf, would be required to house the additional equipment.

Membrane systems work well; it is likely that nanofiltration in combination with and downstream of the existing pressure filters will be very successful from both an effectiveness and cost standpoint, but must be implemented carefully. USKH has used membrane systems in the past with very good success to remove hardness and salts; carbon compounds, being a larger molecule should be relatively easy to remove with proper selection of membrane. This system would be expected to remove all or nearly all organic carbon, to well under 2 mg/l, resulting in elimination of nearly all DBP formation. Removal of the TOC would also reduce chlorine demand, while simultaneously improving system residuals, even in older water. The real question will be what may be necessary in the way of membrane maintenance (cleaning) to obtain good life. This is part of the reason the existing coagulation system should be optimized, as the better the water quality to the nanofiltration membrane, the easier it will be to run and maintain. Retaining the existing pressure filters means these are available for backup during maintenance or cleaning of membrane system.

Using membrane nanofiltration to supplement granular media filtration will add to existing O&M requirements. Anti-fouling chemicals costing approximately $4,000 per year will need to be added to the backwash supply, and backwash monitoring will require increased operator attention, at least initially; about 1 to 2 hours per week, up to 7 hours per month. At $30.33 per hour, this would be $2,600 per year in addition to existing labor costs. With the supplemental 15 hp pumps, nanofiltration will come with an increased power cost, estimated to be approximately $16,000 per year, based on operating the pump approximately 18 hours per day.

Before a nanofiltration system is installed it is important to pilot test the system to assure that TOC reduction objectives are met. Pilot testing would include a pilot design report, selection of alternative systems meeting the minimum requirement of the pilot design report, soliciting bids from the suppliers of those systems, engineering recommendation of the system to pilot, purchase or rental of the selected system, delivery and connection of the selected system, and at least a one-month pilot program, during which the pertinent parameters would be measured and compared with the side-by-side operation of the existing system. Once completed, an engineering report on the results of the pilot would make a recommendation on what system to design and specify for full scale construction and installation. Small systems (e.g. Homespring, see product data in Appendix D) may be available for use in pilot testing. Estimates in Appendix E also include allowances for laboratory sampling and testing, design, and reporting.

The addition of a membrane filtration process after the existing filters would change the scoring for Thorne Bay's water treatment process. All types of membrane filtration are worth 10 points and the addition of a corrosion inhibitor (pH adjustment is already included in the scoring) adds another 3 points. These additional points change the scoring from 32 points to 45 points, which is still within the limits of a Class 2 system (55 points). However with the requirement for alkalinity/corrosion adjustment as discussed in Section 2.4.2, adds an additional 24 points, which results in a total score of 69 points requiring classification as a Class 3 treatment system (56-75) with the associated need for operator certification upgrades. The cost for the initial training and upgrade of operator certifications has not been included in current cost estimates. System classification is explained in greater detail in Section 2.2.1.

The overall nanofiltration system as discussed here would include:

- Spiral wound, pressurized nanofiltration membrane system (e.g GE Series E8, see product data in Appendix D)
- An antifouling chemical injected into the backwash feed
- 300-sf WTP expansion for new filtration equipment
- Corrosion/alkalinity adjustment system as discussed in Section 2.4.2.
- Month-long pilot testing program including equipment rental and associated testing, reporting, and design

Including design and contingencies this system is expected to cost approximate $500,700 as detailed in Appendix E, not including corrosion/alkalinity adjustment.

2.4.5 Miscellaneous WTP Improvements

Chlorination Pump

The WTP has reported issues with their chlorination system, including short pump life and periodic loss of suction or pumping. Part of the issue here is the sizing of the pump; the existing Macroy D2-6 peristaltic pump is being run at full speed, maximum stoke, and is rated for 0.18 gph, which is just barely enough for the current dosing rates. The other part of the issue is likely the 12 percent hypochlorite solution used for chlorination. The higher strength solutions are usually associated with off-gassing, and solution decay. Off-gassing will break suction on the pump intake and vapor lock the pump diaphragm or check valves. Use of a 6 percent solution is recommended, pumped at a higher volume rate. To avoid pumping issues and use the lower solution strength, replacement of this pump with a diaphragm pump with a larger volume chamber will allow the pump to be run at a lower speed, leaving additional capacity and helping to avoid the current pump issues. Including design and contingencies this system is expected to cost approximate $1,800 as detailed in Appendix E. Note that this cost assumes that the project is by the City and does not include the project markups that would be incurred with incorporation into a larger project.

2.5 Water Treatment Recommendations

Regardless of the improvements that might be constructed at the WTP, Thorne Bay should consider the improvements associated with optimizing the existing coagulation/filtration process and alkalinity adjustment. While these fixes may not fully correct the existing issues with DBP and biofilm formation, they will result in some improvements.

Table 10 below summarizes some of the salient characteristics of the alternatives presented for comparison purposes.

Table 10 - Summary of Water Treatment Alternatives

Comparison Parameter	Optimizing Coagulation/ Filtration	Alkalinity/ Corrosivity Adjustment	UV Disinfection	Chloramination	Ultrafiltration Instead of Filters	Nanofiltration After Filters
New equipment costs [2]	$6,000	$567,700	$431,400	$11,400	$659,000	$500,700
Additional annual chemical costs [2]	$11,000	$3,000	$0	$1,800	$4,000	$4,000
Additional annual operational costs [2]	None	$19,000	$23,600	$4,400	$5,000	$18,600
Necessitates Corrosivity/Alkalinity Adjustment	No	Yes	No	No	Yes	Yes
ADEC Score [1]	35	56	40	35	58	69
Change in water treatment class	no	yes	no	no	yes	yes
Requires WTP Expansion [3]	No	250-sf shelter	250-sf	No	No	200-sf
TOC Removal	72 to 82%	No change	No change	No change	50-90%	Nearly 100%
Finished water TOC	2.3 to 3.6 mg/L	No	No	No	1.3 to 6.4 mg/L	<2 mg/L
Reduces DBP	Yes	No	Yes	Yes	Yes	Yes
Pilot Test Recommended	In-house	In-house	No	In-house	Yes	Yes
Addresses biofilm growth	Not significantly	No	Not expected	Yes	Yes	Nearly all
Chlorine use	Unchanged	No	Substantially reduced	Reduced	Reduced	Reduced

Notes:
1. The ADEC score is based on the system established by 18 AAC 74.120 (discussed in Section 2.2.1), and is a measure of system complexity. The range for Class 2 treatment system is 31 to 55. Scores includes alkalinity/corrosivity adjustment when required.
2. Not including costs associated with alkalinity/corrosivity adjustment when required.
3. Not including the shelter for alkalinity/corrosivity adjustment equipment when required.

To fully address the TOC in the finished water in Thorne Bay with its resultant DBP and biofilm formation it is clear that changes to the filtration system are required as no other alternative achieves the necessary results. To reliably produce water with less that 2 mg/L of TOC, the use of nanofiltration after the existing filters is recommended. The use of the nanofiltration alternative will also necessitate increases in the corrosion control and alkalinity adjustments made. The proposed water treatment improvements are:

- Optimization of existing coagulation/filtration process
- Alkalinity/corrosivity adjustment
- Nanofiltration after existing filters
- Chlorination pump replacement

As detailed in the cost estimate in Appendix E and summarized above the total project cost for the recommended alternative is $1.1 million including design, construction administration, and contingencies.

2.6 Water Treatment Implementation and Finance Plan

Funding of the recommended water treatment improvements will require a combination of local, state, and federal funding sources. There is not a single state or federal agency that will fund 100 percent of the project needs in Thorne Bay. Prior to seeking any outside funding, the City needs to ensure that local operations and matching funds are in good order. The City will also need to develop overall prioritization between the various utility and other community projects.

Section 8 discusses overall project prioritization and funding opportunities in greater detail and has identified the following opportunities as good or excellent matches for the water treatment improvements:

- Municipal Matching Grant (MMG) or ADEC Village Safe Water (VSW)
- US Department of Agriculture-Rural Utilities Service (USDA-RUS)
- Congressional Appropriation
- Denali Commission
- EPA
- Community Development Block Grant (CDBG)

Additional state and federal grant programs with a detailed outline and funding suitability matrix are provided in Section 8, along with a discussion of strategies related to funding.

3 WATER TREATMENT PLANT (WTP) AUTOMATION

3.1 Existing WTP Controls

The water from the source lake, Water Lake, is pumped up to the WTP, where a proprietary blend of an inorganic treatment chemical and a polymer (Nalco 8105) is injected at the static mixer. Meter (M-1) records the flow rate that is used to control the addition of coagulant through chemical feed pump (CF-1).

There is also a streaming current detector (SCD-1) that is monitored to adjust the coagulant feed rate based on multipliers the operator establishes manually. The water then passes through a reaction tank and is then fed through one of three pressure filters. A variable area flow meter (FM-1) monitors the rate of flow through Pressure Filter-1, and is intended to be monitored to adjust the flow control valve (FC-1). A turbidity meter (TU-1) monitors and records the turbidity of the filtered water from the Pressure Filter-1, and a differential pressure switch (DP-1) monitors the differential pressure across the filter media. The other two pressure filters operate in a similar manner, and have similar monitoring devices.

Another turbidity meter (TU-4) monitors the turbidity of the combined effluent. All four turbidity meters are connected to a personal computer (PC), which provides recording capability and charting.

The treated water then passes through a meter (M-2). Chlorine is then added to the filtered water for disinfection, and the water is measured for its pH. Soda ash is injected to adjust the pH of the water.

The treated water is then stored in the exterior water storage tank, which has a level gauge (LG-1) to indicate tank level. Compound meter (M-3) records the amount of water that flows out of the water tank to the water distribution main into town.

None of the valves have any motorized operator, and are all operated manually. During the course of the site visit, Billy Joe Phillips, Water/Wastewater Manager, and his team of operators mentioned they have had to come in at odd hours to start the filter cleaning process.

The WTP and the equipment inside it seemed to be in good condition. The electrical service appears to have been upgraded, but the meters and current transformer (CT) cabinets associated with the previous electrical service were abandoned in place. Disconnects and controllers for pumps were replaced and were also found abandoned in place.

Existing equipment includes:

- Streaming Current Detector: Milton Roy, Model SC5200
- Turbidity Meters: Hach 1720E Low Range
- Metering Pumps: Milton Roy Macroy-D Metering Pump
- Combinational Rate of Flow Controller and Solenoid Shut-off Valve: Cla-Val Model Nos. 43-01 and 643-01
- FlowMeter: SeaMetrics Model Nos. FT415 and FT420

3.2 Need for WTP Control Improvements

The operators of the WTP must currently be available at all times in case the pressure filters needed to be cleaned. It was expressed during the site visit that they had to come to the WTP at odd hours to clean the filters, and resume the normal operation of the WTP.

From the design drawings submitted to USKH, it appears that the initial plant design was intended to incorporate a sophisticated programmable logic controller (PLC) based WTP automation system, which was scaled down during the installation process. At the moment the WTP has a manual monitoring and control system, with some data logging capabilities as described above.

The flow meter monitoring flow of incoming raw water was not working properly during the site visit. This is a simple paddle type insertion meter, and subject to fouling. The WTP operators expressed a need to replace this faulty flow meter, ideally with a non-clogging magnetic flow meter.

Equipment that has been abandoned in place should be disconnected and removed properly– this would free up wall space for future control panels at the WTP and create a safer work environment. Power branch distribution circuits connected to abandoned equipment should be labeled as 'Spare' and can be reused to serve new equipment.

3.3 Alternative WTP Controls

3.3.1 Datalogging

Minimal Data Recording Using Existing Devices

The existing PC based data recording and trend display can be upgraded by adding additional input/output (I/O) circuitry to enable additional instrumentation devices in the future. Additional online instrumentation can include: pH, temperature, and residual chlorine.

The disadvantage is that the existing data monitoring system is inherently limited in capacity and capabilities. The system only monitors and provides no control features.

This solution would take advantage of an existing system and limit the costs of system installation to just the new monitors. The disadvantage of this system would be the lack of control and the limitations placed on the installation by the existing equipment. A cost of $27,300 is estimated as detailed in Appendix E, assuming the addition of 16 additional data values.

Minimal Data Recording using Programmable Logic Controller (PLC)

Alternatively, PLC could be provided to record the data monitored by the existing and future instrumentation. This microprocessor based device with modular I/O circuitry that monitors the status of field connected "sensor" inputs will be able to record the data for retrieval and display. This can be connected to a dumb terminal for display purposes, or a minimal configuration of a supervisory control and data acquisition (SCADA) package, only configured for monitoring.

Providing a barebones PLC system would enable upgrades the WTP at a future date, with the PLC, I/O, and installed instruments function being revised by programming tasks only. A SCADA headend software program such as IFIX or FactoryTalk would be used for viewing values, annunciation of alarms, and trending process values.

- Improved process control
- Reduction in overtime for staff
- Enhanced reporting and monitoring

A PLC system provides improved process control, while reducing staff effort (and associated overtime) and enhancing reporting and monitoring of the system. The system would also be able to add outputs to control actuators such as motor starters, solenoids, pilot lights/displays, speed drives, valves, etc., at a later point of time. The addition of new sensors and instruments is easily accomplished. The SCADA software (discussed in Section 3.3.2) would further allow the PLC system to provide advanced trending and alarm notification.

Disadvantages over other datalogging options include the higher cost for the PLC hardware over the cost of expanding the existing system.

A cost of $131,700 is estimated as detailed in Appendix E, assuming the addition of 16 additional data values.

Filter Sequencing Control with Dedicated Controller

Dedicated filter sequence controllers are commercially available, both with electronic controllers and older designs based on relays. These sequence controllers are designed to operate solenoid actuated valve operators based on elapsed time or differential pressure.

The advantage of these dedicated controllers is that they can be installed at low cost. They provide automatic operation of the filter backwash process.

The disadvantages of dedicated controllers are they are very limited in the operations they can perform, and it is not possible to configure them for special or custom applications. The dedicated controllers will not annunciate a remote alarm without the inclusion of other hardware and software. These controllers are customized in the field for a single application, and would have to be discarded if the WTP is upgraded in the near future.

A cost of $14,400 is estimated for the installation of a filter sequence controller with solenoid valve operators as detailed in Appendix E.

PLC System with Filter Sequencing

PLC systems, being modular, can be expanded in the future to provide filter backwash sequence control. The PLC, using real time measurements, would be capable of providing standard filter control sequences as well as custom configurations to fit the WTP applications. The filter sequence, being programmed, can readily be modified in the future.

If the City opted to install a PLC controller, the device would provide the data logging capability as well as providing filter control. The PLC can be used to control and monitor other processes, such as chlorination and other water additives and treatments. The PLC can monitor and annunciate alarms for unauthorized entry, freeze alarms, process alarms, and equipment failures.

The advantage of a PLC controller for filter sequencing is that it would provide custom configuration of the filter controls. The PLC can readily be expanded to integrate other equipment. A PLC configuration would eliminate dependency on a single source for filter controls.

The disadvantages are that PLC controllers are likely to be initially more expensive to install than dedicated controllers. Thorne Bay would also have to develop a relationship with a control system integrator to provide programming services.

A cost of $131,700 has been estimated for the PLC system with the addition of the filter sequencing as detailed in Appendix E.

3.3.2 SCADA

A SCADA system will usually have PLC units for local control in the WTP and other remote locations and then provide monitoring and control via a network connection from a central location. For Thorne Bay, the system would consist of a PLC system with I/O to monitor field inputs and sensors, coupled with SCADA software. The functionality of a PLC includes capabilities that include, water treatment process control, filter backwash sequence control, and monitoring of WTP instrumentation. The PLC would act as a remote telemetry unit (RTU), which provides intelligence in the field, and allows the central SCADA computer to communicate with field devices. The SCADA software provides a graphical user interface (GUI) for users to monitor and control water treatment and distribution, i.e.; to start a pump manually, you click an icon on the display with the mouse. The SCADA software provides trending capability, which graphs the data, to allow easy diagnosis of malfunctioning water system components as well as providing data for reporting. The SCADA system takes the advantages of individual PLC systems for pieces of equipment and allows control, monitoring, and reporting system-wide.

In the AUTO mode the filter backwashing of all filters will take place automatically. The water treatment process can be monitored by the PLC and the process controlled automatically. The backwash process can be initiated by pressure loss across the filter to minimize backwash waste.

A SCADA system would allow the system to be networked with other remote sites and plants – not just the WTP, but also WWTP as well. Such a system could also be used to monitor and control the lift stations in Thorne Bay. This would also provide historical reporting and trending observations for maintaining the process accurately, as well as to improve the efficiency of the overall treatment process. Reporting to regulatory agencies would be improved.

The advantages of a SCADA system are:

- Improved and centralized process control
- Reduction in overtime for staff
- Enhanced reporting and monitoring
- Reliable alarm annunciation

The disadvantages are the higher initial cost and the need for operator training on the new system.

USKH recommends the WTP be upgraded with a SCADA system with a PLC:

- VFD-controlled pumps
- Motorized valve operators
- 3-phase power monitoring
- Local power backup
- Ability to connect portable generator during sustained power outages
- Continuous in-flow and out-flow monitoring with new flow meters
- Automated insulation testing for lift station pump wirings
- Alarm notification – both local beacon and remote notification including phone dialer and e-mail.
- Approximately 100 tags, 25 analog and the remaining digital based on the following:

- 4 pressure
- 2 temperature
- 1 level
- 1 chlorine
- 1 pH
- 16 x 3 = 48 filters
- 4 meters
- 4 turbidity
- 6 chemicals
- 12 pumps
- 8 RO

A cost of $430,800 has been estimated for the SCADA system as detailed in Appendix E. It should be noted that VSW finds the use of SCADA warranted in cases where system adjustments are required and a PLC is needed (review comments, Appendix B, 5/19/10).

3.3.3 Instrumentation Improvements

In addition to consideration of overall control system improvements, additional upgrades to instrumentation have been identified, including:

- Replacement of existing raw water flow meter with a non-clogging magmeter. This would greatly improve accuracy and reliability of the raw water flow data.
- Addition of an online chlorine meter, sampling treated water flow to town. The WTP currently doses the storage tank continuously with chlorine to maintain residuals, but has to use manual testing to adjust the dose level. An online meter would automate this process, but also would provide alarms upon loss of residual.
- Addition of an analog pressure transducer to the treated water line, allowing the level of the water tank to be recorded by the data logging system.
- Replacement of the existing treated water meter with an electronic reporting meter, so that the treated water flow data could be recorded by the plant data logging system. At present, this is a manual meter and read once per day. By replacing the meter register with an electronic register, the flow data could be logged continuously. This would allow 1) determination of hourly demand peaks; and 2) notification of breaks, open hydrants, or other unexpected flows of concern.

A cost of $12,500 has been estimated for these improvements as detailed in Appendix E.

3.4 WTP Automation Implementation and Finance Plan

Funding of the recommended WTP automation will require a combination of local, state, and federal funding. Prior to seeking any outside funding, the City needs to ensure that local operations and matching funds are in good order. The City will also need to develop overall prioritization between the various utility and other community projects.

Section 8 discusses overall project prioritization and funding opportunities including providing details on state and federal grant programs and funding suitability matrix. Also discussed are funding strategies that would include combining WTP automation improvements with other upgrades, and/or funding the automation as an in-kind, local contribution to other projects.

4 WATER DISTRIBUTION IMPROVEMENTS

As discussed in Section 2, the City of Thorne Bay has an issue with carbon in its water, and associated with this, biofilm. Along with the biofilm, the utility has a large pipe inventory, low demands, and a number of deadends resulting in water quality issues associated with water age. Table 11 shows the water quality issues that the EPA associates with water age[13].

Table 11 - Water Quality Issues Associated with Water Age

Chemical Issues	Biological Issues	Physical Issues
*Disinfection By-product Formation	*Disinfection By-product Biodegradation	Temperature increases
Disinfectant Decay	*Nitrification	Sediment Deposition
*Corrosion Control Effectiveness	*Microbial regrowth/recovery/shielding	Color
Taste and Odor	Taste and Odor	
* Denoted water quality problems with direct potential public health impacts.		

Of the issues identified in Table 11, Thorne Bay experiences disinfection by-product formation, disinfectant decay, disinfection by-product biodegradation, and microbial issues, as discussed in Section 2. All of these issues are recognized as influencing public health and water quality. Improvements can be expected on these issues by removing biofilm growths and improving the water age in the system.

4.1 Existing Water Distribution Facilities

Water Lake, the local water source.

Raw water from Water Lake is collected at a floating intake structure with an 8-inch submersible pump and sent via an 8-inch aboveground insulated transmission line and two vacuum stations to the WTP (discussed in Section 2) and a single, 286,000-gallon bolted steel WST.

Water Storage Tank (WST)

The last interior inspection of the WST was conducted by an underwater diver in 2006. The City, with assistance from VSW remote maintenance workers (RMWs, Van Madding and Kyle Downing) then cleaned the tank in December 2008. During the cleaning, minor corrosion was noted and a quantity of accumulated biosolids, grit, rust, and other material was removed (8-10 inches[14]). The tank had no noted structural issues and was in good repair with the exception of an inoperable level sensor. The WST provides approximately 5.5 days of demand capacity based on maximum average daily demands (Table 2); or 5.0 maximum average days and 25 minutes of fire flow at 1,000 gpm.

[13] Table from *Effects of Water Age on Distribution System Water Quality*, EPA Office of Ground Water and Drinking Water, August 15, 2002, available at http://www.epa.gov/safewater/disinfection/tcr/pdfs/whitepaper_tcr_waterdistribution.pdf.

[14] Based on information provided during the May 26, 2010, review meeting on 2008 cleaning by Justin Sorsin.

The piped distribution system is supplied and pressurized by the WST. From the WST, a 12-inch PVC pipe feeds the community core. Approximately 75 percent of households are served by the City of Thorne Bay piped water system and are fully plumbed. The majority of the system was installed during the 1987-1988-1989 Water System Improvements project, which replaced an older steel distribution system in most areas, excluding the USFS facilities (built in 1982) and the trailer court systems in place at the time. Record drawings from the project indicate a pipe inventory of the approximate values in Table 12 and as shown in Figure 4. The pipes are plastic, C-900 Class 150 PVC.

Table 12- Water Distribution Pipe Inventory

Size	Approximate Length (Feet)
6-inch	3,450
8-inch	13,850
12-inch	1,880
TOTAL	19,180

Residents not connected, primarily on the south side of the community, use rain catchment, streams, or springs for a water supply. A central watering point is under consideration as discussed in Section 1.2.3.

With fewer than 500 service connections and a single pressure zone, Thorne Bay is a Class 1 water distribution system under ADEC regulations. This requires that the City maintain a Class 1 water distribution operator on staff. Currently City staffing includes two Class 1 operators: Billy Jo Phillips and Jason Blair.

4.2 Investigations and Findings

4.2.1 WaterCAD Model

The City of Thorne Bay performs system-wide flushing from hydrants approximately quarterly, or every 3 to 5 months depending on weather. Deadend lines (see Table 13) are flushed every 4 to 8 weeks to maintain water quality and chlorine residual. Flushing is done for between 5 and 15 minutes at each location until the chlorine residuals are elevated to indicate “new” water has reached the area. Operators test for chlorine and look for residuals consistent with water leaving the tank, with some modification at lower elevations to allow for the older water.

Table 13 - Water System Deadends

Location	Approximate Length (Feet)	Pipe Diameter (inches)	Pipe Storage (gallons)	Demand on Pipe (gallons/day)	Pipe Storage (days)
Charlie Brown Street	500	6	734	433	1.7
Scenic View Drive	650	6	955	852	1.1
Deer Creek Lane	267	6	392	293	1.3
Wolverine Court	195	6	286	575	0.5
Finney Drive	202	6	297	140	2.1
North Shore Line Drive (at Deer Creek bridge)	82	6	120	564	0.2
South Shore Line Drive (by Deer Creek)	280	8	731	88	8.3
Shore Line Drive to WWTP	1906	8	4977	2611	1.9
Shore Line Drive (by Port)	670	8	1749	137	12.8
USFS Drive	642	8	1676	205	8.2
Federal Way	1418	8	3703	2989	1.2
Spruce Lane (Trailer Park)	345	8	901	422	2.1

One of the issues to be addressed in this study is the establishment of a strategic system for flushing the water mains. A WaterCAD hydraulic network model was created for this purpose. The network schematic, as documented in Appendix G and shown in Figure 5, is based on record drawings and City input. Since all of the water customers are metered, the model incorporates actual 2009 annualized average meter data for water demand, and a theoretical diurnal curve.

The water model accuracy is limited by available data but is believed to provide a schematic representation of the system suitable for examining trends in the system, specifically water age. The model includes a schematic pipe network with elevations at junctions, pipe material type and size, and has the following known limitations:

- Elevation data was approximated from a US Geological Survey (USGS) map and may not represent actual ground elevations. This impacts system pressures.
- Demands were distributed from 2009 meter reading records and have been roughly placed by street. Demand distribution impacts system turnover and should be updated and adjusted to account for all water produced. At this time approximately 73 percent of water produced is accounted for in the billing records as shown in Table 14.
- A diurnal curve was approximated based on typical system curves and the City operator's belief that peak demands occurr between 7 and 9 AM and 3 and 7 PM (as reported by Justin Sornsin, verified via e-mail 5/25/10). No information on the magnitude of these peaks is available. This information is used to model the system in time.
- The network connectivity is based on available record drawings, although pipe lengths have been approximated from placement over a geo-referenced aerial photograph. Changes in pipe length impact system storage and hydraulic losses. The network has also undergone some simplification in that the nodes (and demands) are centralized at pipe intersections and approximate hydrant locations. Hydrants legs and services have not been included.
- Roughness coefficients (C values) used are based on published typical and have not been calibrated to account for the impacts expected based on the biofilm growth.
- The model has not been calibrated.

Table 14- 2009 Billed Usage versus Production

Month	Total Process Water to Town (gallons)	Billed Usage	Unbilled Usage	Percentage of Total Billed
Jan-09	Not available	628,000	-	-
Feb-09	155,000	1,068,000	(913,000)	689.0%
Mar-09	1,373,000	1,128,000	245,000	82.2%
Apr-09	1,258,100	710,000	548,100	56.4%
May-09	1,349,000	806,000	543,000	59.7%
Jun-09	1,358,000	1,082,000	-	-
Jul-09	1,415,000	1,033,000	382,000	73.0%
Aug-09	1,614,000	1,338,000	276,000	82.9%
Sep-09	1,332,000	1,238,000	94,000	92.9%
Oct-09	1,366,000	856,000	510,000	62.7%
Nov-09	1,295,000	871,000	424,000	67.3%
Dec-09	1,374,000	946,000	428,000	68.9%
	January and February not included below. [1]			
TOTAL	13,734,100	10,008,000	3,726,100	72.9%
Maximum	1,614,000	1,338,000	548,100	92.9%
Minimum	1,258,100	710,000	94,000	56.4%
Average	1,373,410	1,000,800	372,610	72.6%

Note:
1. February data is included in table as provided, but was incomplete and has not been incorporated into the summary (e.g. total).

Water age is directly related to quality, and the model allows users to examine which mains will benefit most by flushing. Despite the limitations discussed above, the network routing is believed to be representative and while the exact age may not be precise, the model can be used to show expected trends. The figures in Appendix F show daily results for water age in the system in a simulation that was run over a period of a week with the 2009 meter demand distribution as described in the model documentation (Appendix G). Not surprisingly, it shows that some of the deadends in town do not experience the demand necessary to bring in fresh water to the area. As these areas are not drawing "new" water from the tank, the ages match the length of the simulation. These areas are:

- Shore Line Drive (by the Port) and the Business District Loop
- USFS Drive
- South Shore Line Drive (by Deer Creek)

Examination of flushing from the ends of these lines (there is no hydrant at the end of South Shore Line Drive) found that the length of time needed for flushing varies. On USFS Drive where the demand is at a single building and water is drawn from the 12-inch main feeding town, almost directly from the tank (approximately 2,200 LF); flushing at about 1,000 gpm for just five minutes will replace all the water stored in the pipe and bring in water that is less than a day old. For Shore Line Drive and Business Loop Drive a full 0.5-hour (at 800 gpm) is needed just to bring in water that is less than a day old. At South Shore Line Drive an age of one day is reached in about 15 minutes at 1,000 gpm for this branch and the core within

The Port and Post Office

Rainy Lane. The exceptions are Finney Drive and Wolverine Court, although these nodes benefit from drawing the freshened water.

Of secondary concern are those deadends where the demands and location help with some turnover, but the water age is significantly higher than in the rest of the system, namely:

- Finney Drive
- Shore Line Drive to WWTP
- Federal Way
- North Shore Line Drive (at Deer Creek bridge)

Without flushing, water at Finney Drive stabilizes at between 75-80 hours; Shore Line Drive at WWTP at between 93-100 hours; North Shore Line Drive at 47-55 hours; and Federal Way at 124-133 hours. Surprisingly, Rainy Lane and Willow Drive (hydrant node J30, 74-80 hours) is also included in this group. Note that here, as in the remainder of this report, hours reported are based on the model and are meant to be representative of trends rather than actual times.

Other deadends, listed below, are near enough to the tank and experience the demand needed to keep the water from aging beyond about two days.

- Charlie Brown Street
- Scenic View Drive
- Deer Creek Lane
- Spruce Lane (trailer park)
- Wolverine Court

Water in these areas receives minimal benefit from flushing and should be dropped from deadend flushing in favor of flushing the other areas more frequently.

Unaccounted Water

As shown in Table 14, the WaterCAD model accounts for approximately 73 percent of water produced and sent to town. It follows that within town approximately 27 percent of the water distributed from the WTP is presently not accounted for. Of this quantity, an unknown portion is attributed to unmetered City accounts (e.g. Meter 3870454, CNTB Shop) and flows from hydrant flushing. Unaccounted for water would include system leaks and metering inaccuracies. In general, the City has not reported a known, ongoing issue with water system leaks. Isolated instances of service connection leaks have been reported, but are not believed to be widespread. Identifying leaks in the water distribution system is outside the scope of this report; however, it may be worthwhile for the City to refine the estimate of potential leaks by better tracking the unmetered and /or under reported water uses.

Note that the total process water actually treated in the WTP is greater than the volume of water that is distributed to town. This is because treated water used in the plant for backwash, filter rinsing, and other flushing purposes is not presently metered. It can be reasonably assumed that the difference in the WTP *"raw water"* meter readings, and the *"treated water"* meter readings at the WTP, is water diverted and used within the WTP itself. This does not factor into the distribution modeling, but is stated here to explain the considerable difference between raw water consumption and actual water distributed to town.

4.2.2 Hydrant Testing

Hydrant flushing by City Hall.

Standard fire hydrant flow tests are valuable for determining available fire flows, determining system pressures, and for model calibration. In a fire hydrant flow test, two hydrants are typically used. The upstream hydrant is the residual hydrant at which pressure will be measured before and during flow measurement at a second hydrant downstream (farther from source). Pressure prior to the test is referred to as the static pressure, and represents the normal operating pressure. The pressure during the flow test is the available residual pressure at that flow rate. The second hydrant is allowed to flow freely as an evaluation of available fire fighting water while the residual pressure is measured. The rate of flow is measured with a gauge, typically a pitot gauge that correlates the pressure of the water jet with the rate of flow.

Twenty-three (23) hydrant flow tests were conducted using 16 hydrant locations as shown on Figure 6. The field forms for these tests are provided in Appendix H. This information has been used to help estimate available flows (for flushing). This information may be useful in the future for model calibration and has at this point only been used for a “gut-check” level of review.

LEGEND:

WATER LINE
FIRE HYDRANT
(From Record Drawings)

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WATER SYSTEM
DISTRIBUTION SYSTEM

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FIGURE
4

I:\1210000\DWGS\C\FIGURES\1210000_FIG4.DWG PLOTTED: Jul 16, 2010 - 2:31:10 PM (Glenn Sears)

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WATER SYSTEM
WATER CAD MODEL

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FIGURE 5

I:\1210000\DWGS\C\FIGURES\1210000_FIG5.DWG PLOTTED: Jul 16, 2010 - 2:31:17 PM (Glenn Sears)

Valve #	Location
H1	Upper school
H2	Middle school
H3	Lower school
H4	Charlie Brown
H5	Scenic View Drive top
H6	Scenic View Drive middle
H7	Scenic View Drive & Freeman Drive
H8	1st down Sandy Beach Road, McGuires place
H9	Top of Federal Way, 75 feet off road
H10	1st down Federal Way
H11	2nd down Federal Way, at grass field
H12	3rd down Federal Way
H13	4th down Federal Way
H14	USFS Drive, Administration Office
H15	Sandy Beach Road Berkyville --- DO NOT FLUSH!!!
H16	Freeman Drive by Renos
H17	corner Svends Drive East & Freeman Drive
H18	Svends Drive East Four Plex
H19	Top Spruce Lane cul-de-sac
H20	Hemlock Loop
H21	Svends Drive South
H22	Svends Drive South & Shore Line Drive by church
H23	Creek Lane cul-de-sac
H24	Deer Street
H25	Deer Street & Freeman Drive
H26	Freeman Drive by City Hall
H27	Freeman Drive by Pearl Nelson Community Park
H28	Wolverine Court cul-de-sac
H29	Rainy Lane by Sawyer
H30	Rainy Lane & Willow Drive
H31	Rainy Lane by Seafords Lane
H32	Rainy Lane by church house
H33	Rainy Lane by liquor store
H34	Bay View Court
H35	Finney Drive
H36	Willow Drive & Finney Drive
H37	Shore Line Drive 1st by the Port
H38	Shore Line Drive 2nd from Promac Air
H39	Shore Line Drive 3rd by power house
H40	Shore Line Drive 4th by gas station
H41	Shore Line Drive 5th by RV dump
H42	Shore Line Drive 6th by City Dock
H43	Shore Line Drive 7th by TB Market
H44	Shore Line Drive 8th by bridge
H45	Shore Line Drive 9th by TB Boat Works
H46	Shore Line Drive 10th by City House
H47	Shore Line Drive 11th by Rochesters
H48	Shore Line Drive 12th by WWTP
H49	Business Loop Road & Shop Drive
H50	Business Loop Road
H51	End of USFS Drive

LEGEND:

W	WATER LINE
20	FIRE HYDRANT (TESTED FEB. 16 & 17, 2010)
19	FIRE HYDRANT (NOT TESTED)

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HYDRANT FLOW TEST LOCATIONS

July 2010

FIGURE 6

I:\1210000\DWGS\C\FIGURES\1210000_FIG6.DWG PLOTTED: Jul 16, 2010 – 2:31:58 PM (Glenn Sears)

4.3 Water Distribution Solution Alternatives

4.3.1 Traditional Flushing Program

For most distribution issues, flushing is the first choice for action – it is inexpensive, easily implemented, and requires no special equipment or training. It is however a short lived solution. Conventional flushing refers to the practice of opening one or more hydrants and letting the water run until sediment, biofilm, or low chlorine water is removed. As discussed above, the City currently has a flushing program where deadends are flushed every 4-8 weeks and the entire system is flushed quarterly. Once the system carbon and biofilm issues are addressed and an initial cleaning is done to remove accumulations, flushing will continue to be needed to address the age of water in deadends.

Standard methodologies call for replacing a minimum of three pipe volumes when flushing (see Table 15). The age of the water drawn into the pipe varies with location; so, 5 minutes at Federal Way draws in almost new water, while the same 5 minutes at Finney Drive will replace five pipe volumes but only replace it with older water. The model starts flushing at 105 hours into a weeklong (168-hour) simulation. Based on current modeling, water aged less than one day can be achieved in the lines with the flush times shown in Table 15. With the exception of the Shore Line Drive segment to the WWTP, all the times below are based on separate flushing schedules where flushing does not occur within the same day. Staggering of flushing events in this way will improve water quality throughout town by freshening the water more frequently, and will minimize tank drawdown and pressure impacts. For the WWTP line, times assume flushing by the bridge or on South Shore Line Drive prior to flushing at the WWTP.

Table 15 - Traditional Flushing Program

Flushing Location	Minimum Flushing Volume* (gallons)	Flushing Time to Day Old Water
Shore Line Drive (by the Port) and the Business District Loop (J37)	5,250	30 minutes
USFS Drive	5,000	5 minutes
South Shore Line Drive (by Deer Creek)	2,200	30 minutes
Finney Drive	900	10 minutes
Shore Line Drive to WWTP	15,000	30 minutes
Federal Way	11,100	5 minutes
North Shore Line Drive (at Deer Creek bridge)	400	15 minutes
TOTAL	39,850	

* Based on three times the pipe storage volume.
Flushing times are approximate. Actual times should consider achieved flows from the selected hydrant.

Costs associated with flushing are already incorporated in to the City budget and an estimate is provided in Table 16 for comparison purposes. Regardless of construction alternatives this program should be continued and the frequency increased, preferably to a monthly minimum at the indicated locations.

Table 16 - Traditional Flushing Program Cost

Description	Quantity	Units	Unit Cost	Subtotal
Water production [1]	39,850	gallons	$0.01	$400
City Staff Time [2]	5.5	hours	$30.33	$170
Total Monthly Cost				$570
Total Annual Cost				$6,840

1 Water production costs are operation costs and do not include depreciation of capital assets or repair and replacement costs. Unit cost is based on rate provided by Justin Sornsin, May 25, 2010.
2 City staff costs are based on an operator labor rate provided by Justin Sornsin, May 25, 2010.

Table 16 assumes a minimum of half an hour for each site flushed and that sites requiring more than 5 minutes of flushing will also require an additional half hour for driving, set up, and record keeping. Based on this a monthly traditional flushing program is a $6,840 annual expense.

4.3.2 Uni-Directional Flushing and Valves

A flushing program can do more than decrease the age or freshen the water in town. Ideally, flushing increases flow velocities to a level where the lines are cleaned and debris removed. Particularly in Thorne Bay with the current biofilm issue this should be a secondary goal. To accomplish this, velocities of 5 to 10 feet/second are desirable. At these velocities accumulated sediments, debris, and biofilm can be removed.

Although more time consuming and costly, the flushing program can be improved by developing it as a uni-directional program. The idea will be to start at the top of the system, so that clean pipes do not have debris or old water re-introduced, and to isolate lines so that water is drawn from a single direction to increase velocities; this is known as uni-directional flushing. Uni-directional flushing increases effectiveness by getting all the water in the network moving in the same direction. To accomplish this, the community needs to locate available isolation valves, determine their functionality, and develop a scheme to route water at increased velocities. No additional equipment is needed, although more than one person may be required to handle monitoring and equipment operation.

The first step to developing this program will be in locating, mapping, and determining the condition of existing valves. Paving work in the community resulted in mainline valves and manholes being paved over. The majority of manholes have been brought back to grade in recent years with the final ones scheduled to be raised in summer 2010. Only two water system valves however have been brought to grade. The effort to locate and raise valves needs to be expanded until all the valves are accessible. Based on record documents, the system is believed to have at least 47 valves, as shown in Figure 7. Completion of this task is estimated to cost $62,600 for 45 valves, as shown in Appendix E. The costs as estimated assume the use of cold patching; however, it would be preferable to schedule this with another road job when hot asphalt is available in Thorne Bay.

Once raised, the valves will need to be mapped. With the mapping, an asset assessment is needed to physically locate the valves and verify their operability. Ideally this will include exercising the valves and determining the number of turns required to close the valve, which is an indicator of line size that can assist in verifying the valve location where multiple pipes are present. Inoperable valves and their status (open or closed) should likewise be determined. This may be largely complete once all valves are brought to grade.

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WATER SYSTEM
VALVE LOCATIONS

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FIGURE
7

I:\1210000\DWGS\C\FIGURES\1210000_FIG7.DWG PLOTTED: Jul 16, 2010 - 2:32:02 PM (Glenn Sears)

While additional elevation information is needed to correctly calculate the velocities in the system, the WaterCAD model and system examination can be used to determine flow paths to create an initial uni-directional program. Water usage in this methodology can be reduced slightly over traditional flushing with a minimum of two pipe volumes recommended. The potential also exists that with the additional analysis and knowledge of service connection points, a means of rerouting the water (e.g. breaking loops) will be developed to increase flows and decrease water age in portions of town.

Costs associated with a uni-directional flushing program are difficult to evaluate without knowing the flushing scheme, with its associated valve use and flushing locations. For comparison purposes the estimate in Table 17, assumes that a traditional monthly flushing program is replaced with a uni-directional program. Twice the staff time has been assumed to account for the additional valve work and locations that may be involved. The water quantity is assumed to be 2/3 the traditional flushing volumes.

Table 17 - Uni-Directional Flushing Program Cost

Description	Quantity	Units	Unit Cost	Subtotal
One Time Costs				
Valve Assessment [1]	47	hours	$30.33	$1,430
Valve Recovery [2]	1	LS	$62,600	$62,600
Program Development [3]	40	hours	$30.33	$1,210
Total Cost				$65,240
Monthly Costs				
Water Production [4]	26,600	gallons	$0.01	$266
City Staff Time [5]	11	hours	$30.33	$340
Total Monthly Cost				$600
Total Annual Cost				$7,200

1. Assumes 1-hour per valve by City staff
2. Based on valve recovery as a single project, see discussion above. Costs associated are detailed in Appendix E.
3. Program development time will vary based upon complexity and staff experience. Time shown is for estimation purposes alone and assumes development of initial program documentation and model update and review.
4. Water production costs are operation costs and do not include depreciation of capital assets or repair and replacement costs. Unit cost is based on rate provided by Justin Sornsin, May 25, 2010.
5. City staff costs are based on an operator labor rate provided by Justin Sornsin, May 25, 2010.

Development of a program of this nature is recommended. Even with other system improvements that may reduce the need for flushing, improving flushing efficiency should be a goal. Development with existing staff resources has been assumed and additional costs have not been identified.

4.3.3 Flushing Hydrants

In addition to locating valves, the placement of hydrants should be considered for any flushing program. Thorne Bay is currently well covered with hydrants; however there are locations where the placement of a hydrant might be considered for flushing. The one location identified during this study is at the south end of Shore Line Drive near Deer Creek (J-123). Note that a hydrant in this location, or another means of flushing, has been assumed in the discussions above. The large storage capacity (over eight days) in the pipe means that even reducing the age of water at the beginning where the line feeds to the WWTP results in minimal improvements for this area because of the delayed impact. A hydrant at this location can be expected to cost $13,300, as shown in Appendix E if work is performed as a standalone project managed by the City and not subject to the markups of a larger project. The actual cost may be further reduced if the work is conducted as part of a larger project. Even if other actions are taken to address flows in this area (e.g. increases in demand, network modifications) a hydrant in this area will have uses for flushing and fire protection.

4.3.4 Continuous or Automated Flushing

With system deadends being a problem in terms of water quality, some utilities continuously run water from a blowoff to prevent stagnation and maintain disinfectant levels. In this scenario, velocities are low and not useful for cleaning, and costs are associated with the installation of a blowoff and the cost of water production. The technique can be “improved” with the installation of automated flushing devices that discharge water periodically with either programmable controls or activation by radio telemetry. Automation allows for higher velocities for shorter periods; reducing water consumption, providing some cleaning benefits, and allowing discharges to occur during low demand periods.

A major problem with designing continuous and automated flushing is addressing the discharge. Establishing suitability for placement was outside the scope of the current investigations. For blowoffs to be installed the wasted water has to be routed safely to avoid impacts to surrounding structures, erosion, or people and vehicles passing by. The sensitivity of the discharge point may also require neutralization of the chlorinated water. System design would need to address these issues and establish flushing quantities to meet identified goals for the location. O&M would include periodic system checks and operational consideration of the demand, particularly with automated events, in tank level management.

At this time the automated flushing option is not recommended in light of other alternatives available and the difficulties in establishing such as system. Installation of an automated blowoff system would require a blowoff, automated flushing control, connection to water and power systems, and valving to allow maintenance and installation. Assuming connection to a storm drain or other discharge point is available within 50 feet, a single blowoff is estimated at $27,400, as detailed in Appendix E.

4.3.5 Demand Placement or Creation

Like continuous or automatic flushing, the City might consider other means of increasing demands on deadends to prevent stagnation and improve disinfection levels. In Section 1.2.3, the City has identified a number of projects that will increase demands. Placement in areas where demand increases would be beneficial should be considered. Most noticeably, the deadend on Shore Line Drive (by the Port) could be addressed by developing the downtown area, placement of the central watering point, and/or extension to serve development of the Sort Yard. Development of these projects is outside of the scope of this project; however during the development of all future projects the City should require the impacts on the water system be specifically addressed. Thorne Bay Municipal Code (13.32.010) provides ,an application form for water service where this recommended requirement can be addressed.

4.3.6 Cleaning Program

The Thorne Bay water distribution system has not been cleaned since its installation. To remove accumulated biofilm growth and other materials in the system, whether on a periodic basis or to capitalize on WTP improvements to address the biofilm, the system should be cleaned. This is more extensive than flushing the mains, and can be done in a number of ways: mechanical scraping, pigging, air scour, or chemical treatments.

Mechanical Scraping and Jetting

For mechanical scraping, a series of holes are dug at intervals (~400 feet) and then rotating brushes are inserted and pushed through the pipelines to clean them. This is an expensive and disruptive process that has not been further considered for Thorne Bay, although it may be appropriate if conducted during a line repair or replacement project.

Hydroblasting, also known as jetting, uses a high pressure water spray to clean pipes, and has constraints similar to scraping. Additionally jetting can exceed the pressure limitations of PVC piping and result in system damage. For these reasons, jetting too has been rejected for further consideration.

Pigging (Swabbing)

Swabbing and pigging are the same technique using different tools, with swabs often treated as a type of pig. In swabbing, the cleaning tool is a simple polyurethane foam cylinder. Pigs are generally more sophisticated bullet-shaped devices with Velcro, carbide straps, plastic brushes, or wire brushes attached to improve cleaning. Pigging cleans the inside of pipes by the insertion of a pig, which is then pushed through the pipeline using hydraulic or pneumatic pressure while it cleans the pipe and removes debris. Selection of pigs and lengths for effective cleaning is important.

As pigs travel, they partially seal the pipe, pushing removed material in front. Some leakage past the pig is usually planned to provide lubrication and to help clean the pipe by providing a high velocity water stream at the pipe wall. Pigs therefore are only slightly smaller than the pipe being cleaned and increasingly larger pigs can be deployed with each pass as the line is cleaned. Pigging is most effective on large diameter pipe where access allows a series of progressively larger pigs to be deployed.

In order to pig a line, entry and exit points are needed and since this was not included in the system design, pigging will require creating access either by disassembling hydrants or by installing permanent launcher/receivers. Preferentially the access points will allow for introduction of pigs the size of the line to be cleaned. Although a foam pig can be launched on a 6-inch line to clean an 8- or 12-inch pipe, it will not clean as effectively, and pig options are limited. Prior to pigging, the location and types of valves and other restrictions must be determined. A pig cannot pass through a butterfly or 90-degree pivot valve and if caught in a system restriction will have to be removed by excavation.

Once a pigging program is developed it has the advantage of being repeatable, with the City purchasing or renting equipment for periodic cleanings. This may be required if issues associated with biofilm are not otherwise addressed.

Air Scour

Air scouring is a method to remove biofilms and sediment in water mains, which involves injecting filtered, compressed air into the mains, forcing a series of air slugs into the water flow in the main. *"The name is a misnomer because the air does no scouring – the water does – but the air causes the water to move at high velocity and great turbulence. The air lifts the sediments, breaks off soft scale deposits, and scours biofilm from the pipe"* (AWWA Research Foundation, 2003). The injection of air and purging can both occur using available hydrants.

Air scour has the advantage of using available infrastructure (hydrants) without excavation. Air scour can handle pipe lengths of up to 3,280 feet (1000m) at a time; although for Thorne Bay shorter lengths would be recommended to increase velocities and more effectively remove the bacteriological slimes. This is a fairly aggressive cleaning technique but generally the surge pressures created will not harm the pipe because the process is performed at below normal operating pressures, and the air cushions the water surge. Because it is more aggressive than typical flushing, this method can be expected to trigger more problems than flushing alone and should not be used on pipe believed to be in poor structural condition. However, pipe in poor structural condition should not be considered for cleaning in any event as it needs to be replaced.

The costs associated with air scour should be similar to flushing, with the additional cost of crew training and equipment: filtered air compressing equipment, air cooler, filters, hoses, hydrant tap, baffle box, and other supplies. Unfortunately the air scour process is patented in the United States and the patent holder no longer does this work, making the procedure unavailable.

Chemical Treatments

Chemical cleaning of pipes is also a possibility. Detergents, chloramines, and inhibited acids have all been used in this application. Prior to conducting a chemical cleaning program, the biofilm should be characterized so that the cleaning solution can be appropriately targeted. Once a solution is selected, discharge permits, if required should be sought.

To chemically clean pipes, a trailer-mounted pump is used to move the cleaning solution from a tank through a closed loop of piping and to a hydrant for discharge. The solution can be discharged back to the tank for reuse until such time as flow rates and pH level off indicating that no additional cleaning will be achieved with the solution. Service laterals should be closed and customers put on bypass during this process. Following cleaning, the pipe is disinfected using typical processes before being put back in service. The pipe storage capacity and tank size determine the length of pipe to be cleaned at a time. Solution types will determine the complexity of discharge and whether the neutralized water can be discharged locally (to ground) or to the sanitary sewer.

Of particular interest in chemical cleaning is the potential to combine this technique with other cleaning methods to remove biofilm growth. The type and strength of disinfectant residual is known to greatly influence the growth of biofilm, and chloramine is known to be more effective in combating bacterial growth than free chlorine (AWWA Research Foundation, 2003). Disinfecting the line with a strong chloramine solution following pipe cleaning, followed by purging, is recommended as added “insurance” for a biofilm growth removal program.

Cleaning Program Recommendation

It is recommended that at a minimum a full system cleaning be provided after WTP upgrades are online addressing TOC as a means of removing biofilm growth. Without biofilm removal, chlorine demand can be expected to remain high. To fully clean the pipes it is therefore assumed that a combination of chemical chloramine cleaning in conjunction with pigging will be required. Finding a contractor to do this work may be difficult as it is most often done by water systems. Many Alaskan contractors have experience with wastewater and process pipe cleaning, but not potable water systems. Work will include:

- Public notices and house by house notices (door hangers)
- Hydrant disassembly to allow access, points will need to be selected based on availability and valve placement, disassembly of 30 hydrants.

- Service bypass operations during cleaning (150 services used for estimating purposes).[15]
- Charging the line with cleaning solution of chloramines and/or other detergents.
- Pigging of lines to remove biofilm and other accumulations not otherwise removed by flushing
- System disinfection, pressure testing, hydrant reassembly, bypass removal, and service line flushing.

The cost for this work has been estimated at $1,065,000 as detailed in Appendix E and is assumed to require hiring of additional labor for a period of approximately 2 months.

Note that it is not recommended that the services themselves be cleaned with high strength chloramines, to avoid potential damage or leaching, particularly from copper services. Services should be flushed from interior tabs to provide some removal, and then be disinfected however. If interior taps are not to be run, services should be flushed thru disassembled meter pits before being returned to service.

4.3.7 Pipe Network Modifications

Another means of improving water quality in Thorne Bay is to reduce the system's reliance on flushing for water quality in the deadends, which can be done by completing loops. The extensions shown in Figure 5 were each considered as a means to create loops in the system. The extensions considered and their approximate lengths are summarized in Table 18. Costs for pipe construction are detailed in Appendix E. These extensions and their impacts on water age are discussed in the sections below.

Table 18 - Pipe Network Extensions

Extension	Approximate Length (LF)	Cost
Shore Line Drive to USFS Drive	750	$294,700
USFS Drive to Federal Way	360	$168,900
Greentree Federal Way Loop	3,500	$3,514,100
Charlie Brown Street to Scenic View Drive	210	$94,000
Scenic View Drive to Deer Creek Lane	300	$129,200
Shore Line Drive to Rainy Lane	120	$66,300
Note: Cost Estimate Details are Provided in Appendix E.		

Shore Line Drive to USFS Drive

The potential Shore Line Drive to USFS Drive pipe would be routed from the north end of Shore Line Drive (deadend near the Port, J37) north to the road connecting with Sandy Beach Road, to Sandy Beach and east up the hillside to the deadend on USFS Drive (J51). Connection in this manner involves approximately 750 feet of 8-inch piping, mostly in road ROWs. In the base model, the age of the two end nodes (J37 and J51) match the length of the simulation because of the low flow or lack of a demand. With the connection and no additional demands, water age at J37 fluctuates between 25.8 and 35 hours. For J51 the loop results in ages between 13.2 and 22.6 hours. These results are summarized in Table 19. Connection in this manner is expected to cost approximately $294,700, as detailed in Appendix E.

[15] The City maintains 209 water meters but there are approximately 40 that are unused (empty lots or houses, abandoned property, etc.) at any given time. Additionally some meters (e.g. USFS) may serve multiple residences. An average of 118 residential and 25 commercial services are in use. There is a slight increase reported with summer users and increases in USFS staffing – accounting for 122 residential and 28 commercial in July 2010.

Additional benefits with this loop might be achievable by changing other system routing, forcing water along the preferred routing. This has not been examined but would fall out of the analysis of a uni-directional flushing program. Development of this loop should also consider development projects that will influence demand and system extensions as discussed in Section 1.2.3.

USFS Drive to Federal Way

The potential USFS Drive to Federal Way pipe would remove the deadend on USFS Drive (J51) by connecting it to the pipe in Federal Way to the east (J-163). This routing would not impact the deadend on Federal Way (J9). This routing is short at approximately 360 feet of 8-inch pipe and would cut between the roads. Without the connection, modeling indicates water age on J51 as discussed above does not stabilize during the 168-hour scenario with the age matching scenario time; J-163 fluctuates between 33 and 41 hours; and J9 fluctuates between 124.2 and 133.2 hours.

With the connection, modeling indicates that water ages would fluctuate between 30.4 to 38.5 hours for J51; 20.6 to 24 hours for J-163; and 110.4 and 118 hours for J9. These results are summarized in Table 19 below. Connection in this manner is expected to cost approximately $168,900, as detailed in Appendix E.

Additional benefits with this loop might be achievable by changing other system routing, forcing water along preferred routing. This has not been examined but would fall out of the analysis of a uni-directional flushing program. This main extension is all on USFS land and they would be the primary beneficiary at the present time. Currently, the systems along Federal Way and USFS Drive are considered to be private and owned by the USFS. An investigation of the USFS utilities and their potential contribution to I&I is proposed (Section 5.8). Ownership issues and servicing of this line should be addressed before this loop is considered, particularly if the project is to be implemented by the City.

Shore Line Drive to Federal Way

Modeling indicates that combining the Shore Line Drive to USFS Drive and USFS Drive to Federal Way alternatives again changes the results with the junction ages dropping to 107 to 115.7 hours for J9; 31- to 39 hours for J37; 27-36.4 hours for J51; and 13.3 to 22.6 hours for J-163. These results are summarized in Table 19.

Table 19 - Scenario Ages including USFS Drive

Scenario Age (Hours)				
Junction	Base	Shore Line Drive to USFS Drive	USFS Drive to Federal Way	Shore Line Drive to Federal Way
J9	124.2-133.2	NA	110.4-118	107-115.7
J37	DS	25.8-35	NA	31-39
J51	DS	13.2-22.6	30.4-38.5	27-36.4
J-163	33-41	NA	20.6-24	13.3-22.6

1. DS means the junction age did not stabilize within the scenario period (168 hours) and the age matched the time step in all periods.
2. NA indicates the junction was not relevant to the scenario.

Note that in this scenario the water ages are all modeled to improve over the base, and improve over the USFS Drive to Federal Way scenario. Water age is best however for J37 and J51 with just the addition of a pipe from Shore Line Drive to USFS Drive, although this might be addressed by further routing changes as discussed above.

As noted for the USFS Drive to Federal Way segment, a project impacting USFS systems will require an increased knowledge of the existing system, agreements on ownership and maintenance, and should follow a determination of I&I issues from the system.

Greentree Federal Way Loop

While the previous scenarios are modeled to improve the conditions on Federal Way, they do not address the deadend on this largely residential street. To address the deadend and provide expanded service to the Greentree Heights Subdivision, a 12-inch loop was considered from the end of Federal Way across the undeveloped land (approximately 650 feet) to Bypass Road and then across to Sandy Beach Road south of the junction. This route is approximately 3,500 feet long and is expected to require the inclusion of a pump station and two PRV vaults to create a new high pressure zone. This scenario has the advantage of being configurable to provide improved pressures in the upper elevations of town (e.g. the school), where pressure complaints are common if water levels at the tank drop in excess of 3 feet.

Under this scenario the age at J9 was modeled to go from the 124.2 to 133.2 hour range reported in the base scenario to a range of 36.6 to 46.1 hours, a dramatic improvement over previous scenarios discussed. Connection in this manner is expected to cost approximately $3,514,100, as detailed in Appendix E. This system could be changed to a high pressure system served by a new tank (Section 4.3.8) although increased pumping capacity may still be required to fill the tank. Development of this alternative will need to address development plans and potential in the Greentree Heights Subdivision and should be developed in concert with that project.

Charlie Brown Street to Scenic View Drive and Deer Creek Lane

While Charlie Brown Street, Scenic View Drive, and Deer Creek Lane were found to have water ages of less than two days because of the demands attributed to them and their locations, these deadends can be largely removed by providing a 6-inch main (about 210 feet) from the end of Charlie Brown Drive (J-142) to the closest point on Scenic View Drive (J5), and then from the end of Scenic View Drive (J-146) to the nearest point (about 300 feet) on Deer Creek Lane (J24). This does not fully remove the deadend line on Deer Creek Lane, as a 150-foot segment will remain. Costs associated with these connections are estimated at $94,000 and $129,200 respectively for Charlie Brown Drive to Scenic View Drive and Scenic View Drive to Deer Creek Lane as detailed in Appendix E.

Table 20 - Scenario Ages including Scenic View Drive

Scenario Age (Hours)				
Junction	Base	Charlie Brown Street to Scenic View Drive	Scenic View Drive to Deer Creek Lane	Charlie Brown Street to Deer Creek Lane
J5	24.3 – 30.1	9.5 – 17.7	5.8 - 13.9	8.6 – 16.4
J24	25 – 33.7	NA (26.3-30.3)	10.6 – 19.2	11.4 - 20.3
J-142	49.6 - 58.7	7 - 15	NA	5.6 - 13.8
J-146	55 - 63.1	NA (44.6 - 48)	8.2 - 16.3	10.4 - 18.5

1. DS means the junction age did not stabilize within the scenario period (168 hours) and the age matched the time step in all periods.
2. NA indicates the junction was not involved in the scenario.

Additional benefits with this loop might be achievable by changing other system routing, forcing water along preferred routing. This has not been examined but would fall out of the analysis of a uni-directional flushing program and service connection locations relative to valves.

Shore Line Drive to Rainy Lane

The Shore Line Drive to Rainy Lane alternative would route a segment of 8-inch pipe approximately 120 feet long between the deadend on Shore Line Drive near Deer Creek (J-123) along the drive connecting to Rainy Lane (J-141). This is the location where flushing cannot currently occur as there is no hydrant available. Under this scenario the age at J-123 gives an unstabilized value that matches the scenario timestep to 47.7 to 55.1 hours. Likewise J-141 goes from 35.7 to 43.1 hours to 43.2 to 50.7 hours in this scenario, with the slight increase in the age reflecting a change in flow paths. Connection in this manner is expected to cost approximately $66,300, as detailed in Appendix E.

4.3.8 Pressure/Water Storage Improvements

At the upper elevations of Thorne Bay, particularly in the area of the school, there are concerns over low pressures. To avoid these concerns, the WST is operated within about 2 feet of capacity under normal conditions. During the site visit hydrant flow testing, static water pressure of 50 psi at the school and 41 psi at the end of Charlie Brown Street were measured before flushing. These dropped to 43 and 34 psi respectively as residuals during flushing.

To improve system pressure there are several options: creating a high pressure zone as discussed above and changing the elevation and therefore pressure provided by the WST. To change the pressure provided by the tank, alternatives include constructing a second or replacement tank at a higher elevation, replacing the existing tank with a taller tank at the current location, and extending the height of the existing WST.

The idea of adding a second WST appears to have merit in that it will provide additional storage capacity and, properly located, can provide for system extensions and increased pressures throughout town. Adding a second tank may cause operational issues – the WST must be managed to ensure tank turnover and this may require developing multiple pressure zones within the community, depending on the location of the new tank. This alternative cannot be fully considered without location alternatives being identified and researched. System expansion is not included in the present scope of work and two location alternatives have been discussed: Greentree Heights Subdivision and immediately above the existing tank.

Thorne Bay WST

Alternatively, the existing WST could be replaced at the present location with an increased height and/or storage capacity. This would avoid operational issues and can provide additional capacity if desired. Material and erection costs for a new WST are provided in Table 21. These costs do not include site development, site investigation, foundations, disinfection, and other costs, many of which are avoided by replacement on the current site. Each foot of increase in tank height corresponds to a pressure increase of 0.43 psi, so for the 32- and 40-foot height tanks shown in Table 21, the community would receive an additional 7 psi or 10 psi.

Rather than constructing a completely new WST, the existing tank could be expanded by adding a ring or two to the existing structure. These rings would be placed on the bottom to ensure that the load is properly supported, and prior to development of this option an interior inspection should be performed to confirm tank condition. This option would require rings and extension of appurtenances (e.g. ladder, overflow, level indicator, center poles), disassembly of existing tank, reassembly with additional capacity, and disinfection. The increase by 8- or 16 feet shown in Table 21 would provide 3.5 psi or 7 psi in additional pressure. Costs shown in Table 21 are based on an estimate provided by Columbia TecTank (see product data in Appendix D) and do not include site preparation or foundation construction, piping connection, tank unloading in Thorne Bay, or disinfection of the completed tank.

Table 21 - Tank Expansion Estimates – Tank Only

Nominal Descriptions	Materials	Labor	Freight	Total
New WST Construction:				
42’ diameter, 40' high (404,505-gallon)	$121,127	$86,255	$31,382	$268,764
55’ diameter, 32' high (563,318-gallon)	$161,559	$108,747	$73,090	$343,396
Expansion of Existing 55’ Diameter, 16’ High (286,000-gallon) WST to:				
24’ high (429,742-gallon)	42,038	151,876	27,122	$221,036
32’ high (572,229-gallon)	70,018	164,000	27,122	$261,140
1. See Appendix E for estimate information and assumptions.				

Attempting to expand the existing tank may not be feasible and will require some additional investigation before it can be reasonably attempted. Even with some additional investigation there will be the potential for failure and resulting loss of water storage in the community. Investigation costs can be expected to greatly reduce the $7,600 to $47,700 cost savings implied by expansion. Therefore, it is recommended that a new tank be constructed.

The new WST could be placed at the location of the existing tank; however the foundation will most likely have to be reconstructed and only basic site preparation costs would be avoided. To avoid the operational impacts associated with demolition of the existing tank and to provide additional storage, it is recommended instead that the new WST be located at a higher elevation to provide for greater pressure improvements than achievable on the current site. This will also allow for the use of the existing WST tank during construction, creation of new capacity, and potentially multiple pressure zones.

The new WST could be located in the Greentree Heights Subdivision or on the bluff overlooking the existing WTP, or in some other location. In order to provide a minimum system storage capacity of 7 days of supply and 90 minutes of fire flow at 1,500 gpm, a system capacity of approximately 500,000 gallons is desirable (using a maximum average day demand of 52,065 gallons, Table 2). This requires that the new tank provide at least 214,000 gallons. The 404,505-gallon tank quote has been used for estimating as this will exceed the minimum capacity, provide elevation/pressure improvements, and will almost meet desired capacities if the existing tank is removed from service.

As detailed in Appendix E, the new tank on a new site is estimated to cost $1,564,100. An allowance has been provided in the estimate for the necessary site investigations and design, which has been detailed to include sitework, foundation construction, and basic piping connections and controls. The site selected only becomes a cost issue for the transmission main and if land must be purchased. The costs for land purchase have not been included; only 100 LF of main are included in the current cost estimate. Note that the existing WST can either remain in service or be decommissioned. The issue of its future would be addressed in the design of the new tank.

4.4 Recommended Water Distribution Solution

Addressing the identified issues in the water distribution system will involve a variety of projects and operational changes as identified in this section. The following activities are recommended for implementation as discussed in the preceding sections and summarized here. All activities are needed and are presented here in a sequential more than prioritized order, with potential sequencing/prioritization indicated as appropriate.

- Flushing: Flushing is required as a routine maintenance, and until deadends are addressed, is a means of protecting public health by reducing water age. The existing flushing program should continue, with identified deadends being flushed monthly. The program should be conducted as a traditional flushing program until replaced by a uni-directional flushing program. Establishment of a uni-directional program will require recovery of main line valves and a commitment of staff time for program development.

- Demand Placement: In order to assess development project impacts on the water distribution system, both positive and negative, the City should take steps to require that the information be provided by developers. Modifications to the application for water service should be considered to address this.

- New Hydrant: To affectively address water age and maintain the system, all portions of the distribution network need to be flushed. One new hydrant is currently needed on the end of the Shore Line Drive at Deer Creek (J-123) to provide a means of flushing and improving water age on this deadend line. As a fire hydrant, the hydrant also increases fire protection measures available.

- Valve Recovery: Valves allow the proper maintenance and operation of a water distribution system, and in Thorne Bay the lack of accessible valves prevent the improvements available from uni-directional flushing and limits options in operation. Locating, mapping, bringing to grade, repaving, and initial exercising of approximately 45 valves, is necessary prior to the development of a uni-directional flushing or cleaning program.

- Cleaning Program: Biofilm growth in the distribution system is causing a number of regulatory and potential public health issues. To address the biofilm, a system wide cleaning should be conducted. This cannot be done until valves are recovered, and timing should consider water treatment upgrades for maximum effectiveness. Cleaning will include both pigging and chemical solutions with the use of chloramines recommended. Work will require a public notice campaign, and bypass of approximately 150 services during the cleaning activities.

- Pipe Network Modification: Six mainline extensions have been identified that will complete system loops, improving circulation and water age. Prioritization of these projects falls into two categories: those projects immediately addressable and those dependent on other developments. A suggested prioritization is proposed below.

    - Immediately Addressable – Highest Priority:

        - Shore Line Drive to Rainy Lane main extension: This project has the lowest cost and provides for the greatest age improvement in a line with low demand towards the end of the system.
        - Scenic View Drive to Deer Creek Lane main extension: This project can be combined with the project to extend to Charlie Brown Street but was given priority because of the water age improvements shown.

        - Charlie Brown Street to Scenic View Drive main extension: This project can be combined with the project to extend Deer Creek Lane.

    - Dependent – Secondary Priority:

        - Shore Line Drive to USFS Drive: This project is dependent on USFS approval for construction on their property and connection to their system. While it addresses issues with the City system at this end of Shore Line Drive, these issues may be more satisfactorily and easily addressed with the development of planned projects in the area and continuation of the existing flushing project.
        - Greentree Federal Way Loop main extension: This project is dependent on other development (Greentree Heights Subdivision) and involvement of the USFS. This project is best completed in conjunction with subdivision development and the construction of a new WST.
        - USFS Drive to Federal Way: This project would currently be the modification of a private system and will require the completion of an investigation of USFS utilities and addressing the related issues.

- New WST: Providing a new WST addresses pressure issues and provides storage capacity for fire flow and daily demands. The placement of the WST will require some study and consideration of other development projects under consideration.

4.4.1 Recommended Water Distribution Improvements Project Summary

Table 22 below summarizes the capital or one-time costs for the recommended projects. Ongoing maintenance activities, such as flushing, are generally not eligible for grant funding and have not been included; neither have estimated costs of City staff time for program development. Likewise projects outside the scope of this report are not included, such as those that might address low demands on deadends (demand placement of central watering point etc.).

Table 22- Water Distribution Improvements Project Summary

Project Name	Project Description	Primary Need for Project	Total Project Cost
New Flushing Hydrant	Provide one new hydrant for fire protection and use in flushing program	Public health, maintenance of water quality	$13,300
Valve Recovery	Locating, mapping, bringing to grade, repaving, and initial exercising of approximately 45 valves	System sustainability and operations	$62,600
System Cleaning	Provide full system cleaning to remove biofilms in water mains with a combination of chloramines and pigging	Public health, maintenance of water quality	$1,065,300
Shore Line Dr. to Rainy Lane Main Extension	Provide 120 LF of 8-inch PVC water main	Public health, maintenance of water quality	$66,300
Scenic View Dr. to Deer Creek Lane Main Extension	Provide 300 LF of 6-inch PVC water main	Public health, maintenance of water quality	$129,200
Charlie Brown St. to Scenic View Dr. Main Extension	Provide 210 LF of 6-inch PVC water main	Public health, maintenance of water quality	$94,000
Shore Line Dr. to USFS Dr. Main Extension	Provide 750 LF of 8-inch PVC water main	Public health, maintenance of water quality	$294,700

Project Name	Project Description	Primary Need for Project	Total Project Cost
Greentree Federal Way Loop	Provide 3500 LF of 12-inch PVC water main to serve new subdivision and improve system circulation including pump station and two PRV vaults to create a new high pressure zone	Public health, maintenance of water quality	$3,514,100
USFS Dr. to Federal Way Main Extension	Provide 360 LF of 8-inch PVC water main	Public health, maintenance of water quality	$168,900
New WST	Provide a new WST (404,505-gallon) on a new site including site selection, design, site preparation, and excluding transmission main beyond 100 LF and land purchase	Address pressure and storage needs	$1,564,100

State records[16] indicate that the Thorne Bay water distribution system is a Class 1 system with 203 service connections reported. None of the proposed changes will result in a change of system classification and associated operator certification requirements. To change the classification one level would require either an increase in service connections (over 500) or the addition of pressure zones (more than 4).

4.5 Water Distribution Implementation and Finance Plan

Funding of the recommended water distribution improvements will require a combination of local, state, and federal funding sources. There is not a single state or federal agency that will fund 100 percent of the project needs in Thorne Bay. Prior to seeking any outside funding, the City needs to ensure that local operations and matching funds are in good order. The City will also need to develop overall prioritization between the various utility and other community projects.

Section 8 discusses overall project prioritization and funding opportunities in greater detail and has identified the following opportunities as good or excellent matches for the water distribution improvements:

- VSW or MMG
- USDA-RUS
- Legislative and/or Congressional appropriations
- USFS
- Denali Commission
- EPA
- EDA
- CDBG

Additional state and federal grant programs with a detailed outline and funding suitability matrix are provided in Section 8, along with a discussion of strategies related to funding.

[16] ADEC, Alaska Certified Water/Wastewater Operator Database, https://myalaska.state.ak.us/dec/water/OpCert/Home.aspx?p=SystemSearchResults&search=Thorne+Bay, June 29, 2010.

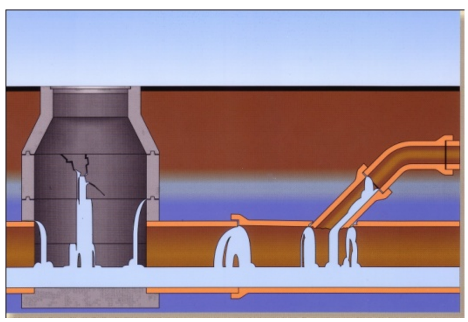
5 WASTEWATER INFILTRATION AND INFLOW

This portion of the City of Thorne Bay *Utility Improvements Study* was funded in part by a US Department of Agriculture, Rural Development (USDA-RD) grant and has been written to meet the requirements of a preliminary engineering report (PER) for wastewater facilities in accordance with USDA-RUS Bulletin 1780-3.

5.1 General

I&I is generated when storm water or groundwater enters a wastewater collection system. Storm water flowing directly into the wastewater collection system is typically considered as Inflow. Inflow can enter a wastewater collection system through manhole lids and direct connections of roof rain gutters and other stormdrain collection systems. Groundwater flowing into a wastewater collection system is typically considered Infiltration. Infiltration can enter a wastewater collection system through cracked pipes, leaky pipe joints, gaps in service connection joints, and through inappropriate connection of footing or ground drains.

Wastewater collection systems should be water tight, not letting storm water and groundwater in or wastewater out. Groundwater entering the collection system can erode fine grained soils supporting the pipe and the overlying road surface, overload the wastewater collection system backing up wastewater into homes or streets, and overload the WWTP causing inadequately treated wastewater to be discharged to the environment. Wastewater leaving the collection system can contaminate surface waters, groundwater, and aquifers used for drinking water.



Infiltration entering wastewater collection system

5.2 Project Planning Area

5.2.1 Location

Information on the location and area surrounding Thorne Bay is provided in Section 1.2.1.

5.2.2 Environmental Resources

A complete Environmental Report (ER) has been prepared for the proposed I&I projects and is provided in Appendix I. The ER was prepared as a companion to this portion of the City of Thorne Bay *Utility Improvement Study* in accordance with RUS Bulletin 1794A-602.

5.2.3 Growth Areas and Population Trends

Growth areas and population trends are discussed in Section 1.2.3.

5.3 Existing Facilities

The Thorne Bay wastewater system consists of approximately 15,000 LF of existing 6-inch main, 3,400 LF of forcemain, 110 manholes, and 5 lift stations. Wastewater is treated via bar screening and extended aeration at the WWTP prior to discharge to the bay. The discharge is at a deep water structure and is governed by a National Pollutant Discharge Elimination System (NPDES) permit (AKG517017). Figure 8 shows the overall wastewater collection area, including the forcemain to the WWTP south of town. Figure 9 is an enlargement of the wastewater collection system, without the force main to the WWTP

With fewer than 500 service connections and less than 15 lift stations, Thorne Bay is a Class 1 wastewater collection water system under ADEC regulations. Thorne Bay's WWTP has a system score of 29 making it a Class 1 WWTP. This requires that the City maintain a Class 1 operator for both wastewater collection and wastewater treatment. Currently, City staffing includes two Class 1 operators: Billy Jo Phillips and Jason Blair.

5.3.1 Location

The City of Thorne Bay wastewater collection system serves the downtown (core) area and consists of approximately 150 residential and commercial connections. The South Thorne Bay subdivisions, Goose Creek Industrial Area, and other outlying areas are not connected to the City's wastewater collection system. The system conveys the wastewater to the City's WWTP south of town.

5.3.2 History

In December 1988, VSW prepared a *Sewer System Engineering Study* at the request of the City of Thorne Bay. The City was being served by an antiquated, non-standard, poorly operating sewer system constructed during the early 1960s when Thorne Bay was a logging camp. The sewer collection system consisted of undersized collection mains, pipes installed below residential buildings, and had an insufficient number of manholes and cleanouts. The WWTP was undersized and did not meet federal or state secondary treatment standards, with an outfall directly into Thorne Bay's small boat harbor. The study recommended construction of a conventional gravity flow sewer system; several lift stations; a new WWTP; and a deep water ocean outfall. The design of the sewer collection system was accomplished by a VSW engineer; construction started in fall 1989 and was completed in spring 1990.

Since that time, the following wastewater projects have been completed.

- City staff completed construction of a new public restroom and shower facility at the municipal small boat harbor in 2008. An additional commercial lift station was installed to make a service connection point to the adjacent sewage force main.
- Initial improvements to the TBBDS were made, specifically installation of water and sewer mains to support proposed development.
- Manhole lids were raised to finish grade following 2002 road paving.

LEGEND:

S	SEWER LINE
FM	SEWER FORCE MAIN
•	SEWER MANHOLE
LS#1	SEWER LIFT STATION
	AREA WHERE FACILITIES DISCHARGE DIRECTLY TO THORNE BAY
S	SMOKE TESTED SEWER

USKH
SHARED VISION. UNIFIED APPROACH.

CITY of THORNE BAY
UTILITY IMPROVEMENTS STUDY
WASTEWATER COLLECTION SYSTEM

July 2010

FIGURE 8

I:\1210000\DWGS\C\FIGURES\1210000_FIG8.DWG PLOTTED: Jul 16, 2010 - 2:32:18 PM (Glenn Sears)

USKH
SHARED VISION. UNIFIED APPROACH.

CITY of THORNE BAY
UTILITY IMPROVEMENTS STUDY

WASTEWATER COLLECTION SYSTEM - ENLARGEMENT

July 2010

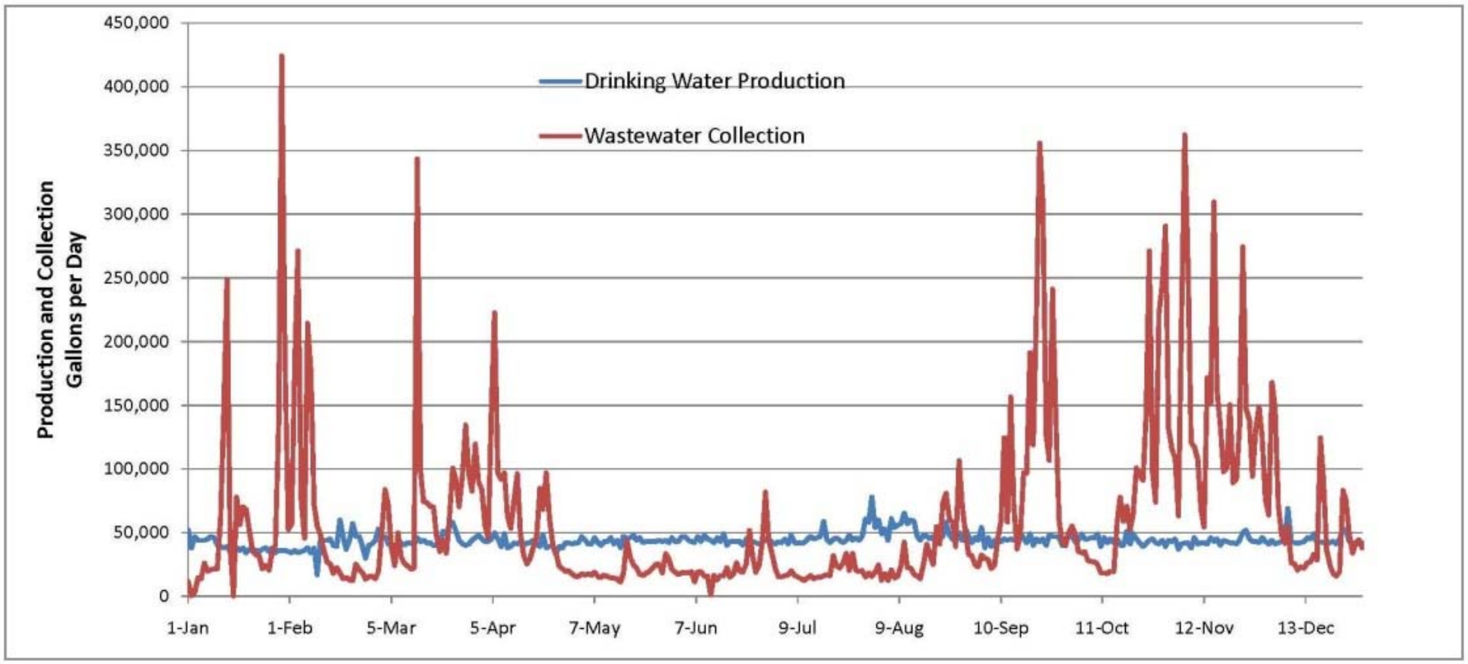
FIGURE 9

I:\1210000\DWGS\C\FIGURES\1210000_FIG9.DWG PLOTTED: Jul 16, 2010 - 2:32:22 PM (Glenn Sears)

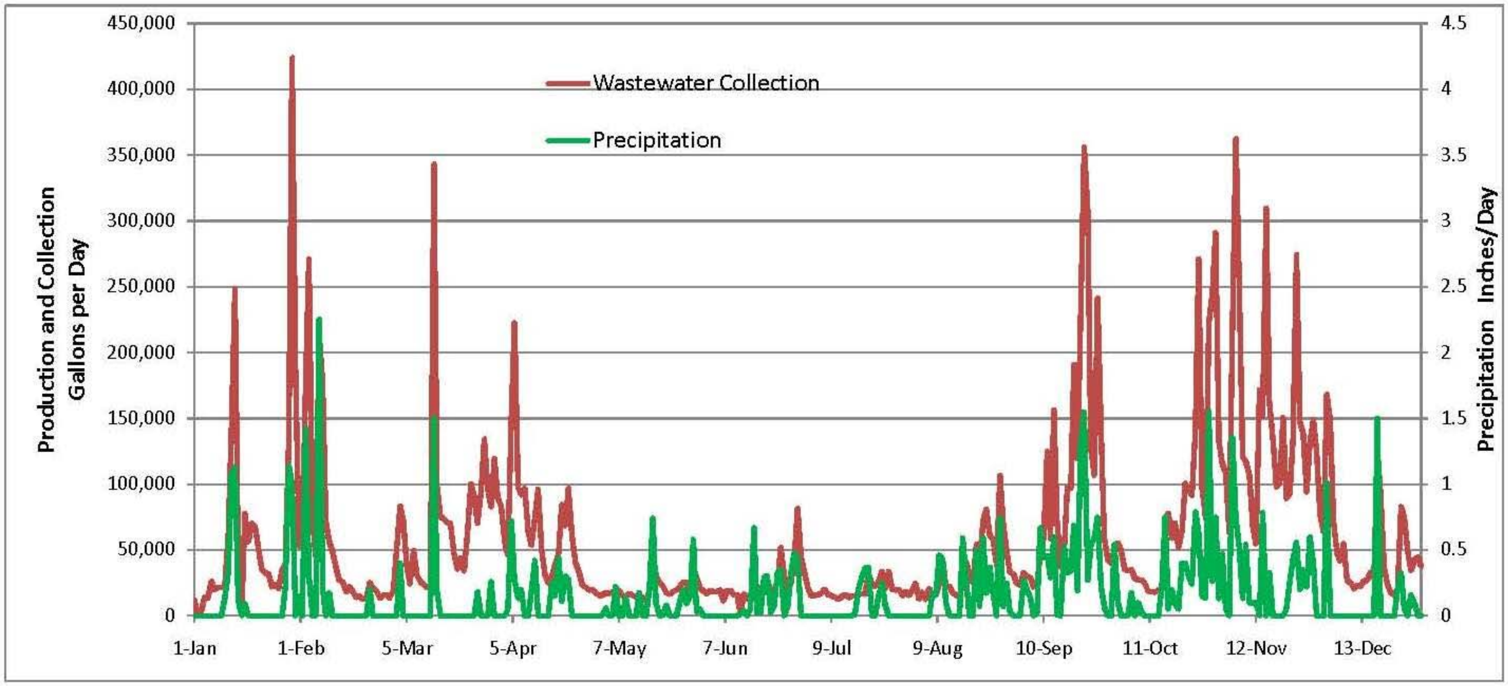
5.3.3 Inflow and Infiltration (I&I) Confirmation

Thorne Bay's potable water utility produces between 30,000 and 60,000 gallons of potable water daily. The City's residents use this water for drinking, bathing, and washing with a small amount of outdoor uses. With little industry in the area there are no known sources for major discrepancies between potable water use and water collected by the City's wastewater collection system. However, the wastewater utility receives much more water than the potable water utility produces. Graph 1 shows the daily potable drinking water produced by the City WTP. Overlaid on this graph is the daily wastewater received by the WWTP. This graph clearly shows that at certain times the WWTP is receiving more than ten times the amount of water than is being produced by the water system. This additional water is coming from I&I.

Graph 2 again, shows the daily wastewater received by the WWTP; however, this time the graph has been overlaid with the daily rainfall volumes. This graph shows a strong correlation between the daily rainfall and the wastewater received at the WWTP. Rain falling on the ground makes its way into the wastewater collection system through manhole lids, pipe connections, manholes joints, and poor manhole pipe penetration seals. Long-time City WWTP maintenance staff has observed a 4 to 6-hour time lag between storm events and the I&I surge reaching the WWTP. Field observations found no direct storm drain connections and few manhole lids in ditches or other storm water collection areas. Therefore, this short lag time is likely attributed to the rocky and free draining trench backfill materials used in Thorne Bay. It takes little time for storm water to runoff a road, along a ditch, and percolate through the rocky soils down to the wastewater pipe or manhole that often lie in a trench excavated in bedrock, and then find a hole to enter into the wastewater collection system.



Graph 1 - Drinking Water Production and Wastewater Collection



Graph 2 - Wastewater Collection and Rainfall

Graphs 1 and 2 indicate that 30 to 50 percent of the wastewater received at the WWTP is from I&I. Each year this results in approximately 6 to 10 million gallons of I&I water needlessly collected, pumped, and treated.

5.3.4 Facility Condition

A 2010 condition survey of the wastewater collection system found the basic infrastructure to generally be in fair condition with several specific areas needing repair or replacement. The following summary is based on a day long inspection of manholes in February 2010 by USKH, video inspection in March 2010 by the City, and City operator historical knowledge.

Manholes: Manhole barrel sections are concrete and structurally are in good condition. However, many of the joints between barrel sections are leaking, which is typically caused from joint gaskets slipping during construction. With the amount of joint leaking observed, it is very likely that no gaskets at all were installed when they were constructed. Pipes penetrate the manholes through a hole punched in the side of the manhole with the annular space between the pipe and manhole filled with a cement grout. This construction method has proven to be inadequate to accommodate the high groundwater table in several areas. The cement grout has cracked and/or pushed out allowing groundwater to flow into the manhole. The City has tried to repair these leaks several times using cement grout and a hydrophilic hand pack grout called Quad-Plug. Most of these repairs have also failed due to the high water pressure from the shallow groundwater.

Manhole Risers: Many of the manhole risers were raised following road paving in 2002. Early risers were constructed of bricks and concrete masonry units (CMU). These materials are not appropriate for this type of use, as they allow storm water to enter the manhole, and do not support heavy traffic loads.

Risers installed in the past several years have concrete grade rings. The grade rings are water tight when used with gaskets or wrapped in mastic. Several manholes have too many grade rings, exceeding Occupational Safety and Health Administration (OSHA) recommendations.

Example of early CMU riser

Example of concrete grade ring riser

Lift Stations: Thorne Bay has five lift stations, Lift Station No. 5 (LS#5) is less than 2-years-old, and the other four were constructed between 1989 and 1995 as part of the VSW Sewer System Improvements Project. These old lift stations have exceeded their design life. They frequently break down and repair parts are difficult to find. Thorne Bay has to spend an inordinate amount of time and money repairing, operating, and maintaining these lift stations. The high amounts of I&I place added wear tear on these lift stations compounding the maintenance problems. See Section 6 for a detailed discussion of lift stations.

Pipes: Wastewater collection system mainline pipes are predominantly constructed of cast iron with a couple of newer lines constructed of PVC. The pipes are in good condition. Pipes are buried fairly shallow, 4 to 6 feet deep. Blasting of bedrock was required in many places when constructing the wastewater pipes. The pipe bedding and trench backfill was done with a clean shot rock with a high water permeability. This has created a free path for groundwater to travel through the pipe bedding and trench backfill until it enters the wastewater collection system through holes in pipes or manholes.

WWTP: The Thorne Bay WWTP was built in 1994 and is designed to accommodate flows from a community of 900 with an average daily flow of 140,000 gallons (156 gallons per capita per day [GPCPD]) and a peak hourly flow of 420,000 gallons. The facility is permitted for a maximum daily flow of 400,000 gallons. The WWTP uses an extended aeration process and is classified by ADEC as a Class I facility. Wastewater is pumped via LS#1 to the WWTP at the south side of town where it is treated and discharged into Thorne Bay. Due to funding constraints, investigation of the WWTP was removed from the scope of this report.

Storm Drain: the City storm drain system consists of roadside ditches and cross culverts. This system requires frequent maintenance to remove debris and keep channels open, but is in good to fair condition.

5.3.5 Smoke Testing

In fall 2008, City utility staff and workers from the Alaska Rural Water Association, smoke-tested several areas suspected of having high I&I rates. Figure 8 identifies the areas tested. Because I&I flows were so high, City staff thought they would find roof drains and storm drains directly connected to the wastewater collection system. However, no direct connections were found. They did witness smoke coming up through the ground and around manholes, indicating that there were cracks, gaps, holes, or faulty joints where I&I could enter the system.

5.3.6 Video Inspections

In spring 2010, VSW loaned Thorne Bay a video camera and recorder to inspect the wastewater lines for I&I. City staff were able to inspect about 60 percent of the main lines before having to return the equipment. They inspected most of the lines in Rainy Lane, Svend's Drive, Freeman Drive, Spruce Lane, and Rainy Lane (see Appendix J for a complete listing of lines videoed). I&I in Thorne Bay's wastewater system is very sensitive to rainfall events. The weather during the inspection was dry, and as a result the crew did not observe very much infiltration and were unable to identify where the large volumes of I&I are entering the system.

Visual inspection of the manholes and the video inspections confirmed suspicions that a large portion of the I&I is coming from manholes - faulty pipe/manhole connections and cracks/breaks in between manhole rings and risers. A small amount of I&I is also coming from inadequate seals around manhole lids and manhole covers that are not water tight. Settlement bellies in pipe lines and leaky pipe connections were observed, but showed little I&I at the time of videoing.

A steady stream of clear water was observed coming from the USFS Admin site and also the USFS residential area. This was also witnessed during the site investigation in February 2010 by opening the manholes in Sandy Beach Road. The wastewater lines in USFS Drive and Federal Way were not videoed because the manholes have been covered over, limiting access.

It should be noted that because the video inspection could not be coordinated with a rain event, the full extent of I&I has not been determined, and additional leaks and issues are believed to exist that have not yet been identified. Information on the video inspection conducted by the City of Thorne Bay is provided in Appendix J.

5.3.7 Financial Status

The City typically subsidizes its wastewater utility between $55,000 and $77,000 per year from the general fund. The general fund includes receipts from Alaska state community revenue sharing, and federal subsidies such as Community Revenue Sharing and US Department of the Interior payments in lieu of taxes (PILT)[17]. See Table 23 for a summary of the operating expenses, collected fees, and subsidy for the last 4 years. During these years a senior citizen discount was offered at 50 percent of the utility fee. There have historically been 11 accounts (FY07 to FY10) qualifying for this rate reduction, or approximately 4 percent of the annual subsidy.

Table 23- Wastewater Subsidy Summary

Year	Income	Expenses	Subsidy
FY10	$62,960	$117,257	$54,297
FY09	$53,917	$112,828	$58,911
FY08	$51,302	$128,345	$77,043
FY07	$45,669	$106,675	$61,006

The City's FY11 budget (see Table 25) requires a subsidy of approximately $47,000. FY11 water and sewer rates are shown in Table 24 and include an increase of 20 percent, from $30 to $36 per month on a typical residential service. Additional charges have been considered, including a per gallon wastewater rate that would be tied directly to the potable water usage, which is currently metered. However, at this time these changes have not been implemented, and the City continues to operate with no debt or reserve accounts.

Table 24- FY11 Water and Sewer Rate Schedule

Classification	Description	Water	Sewer
Residential			
	Up to 3,000 gallons monthly	$36	$36
	Over 3,000 gallons	$12 per 1,000 gallons	
Commercial			
	Up to 5,000 gallons monthly	$60	$36
	Over 5,000 gallons	$12 per 1,000 gallons	
Note: Senior citizen discounts (50%) are available if funds are appropriated by the City Council.			

Of the total equipment maintenance and repair costs shown in Table 25, $10,400 was from the repair of the lift station pumps in FY10, and $12,000 has been projected for this in 2011. These costs do not include City staff labor and associated costs. Additional items covered by this line item include raising manholes to grade. The raising of manholes has cost an average of $1,200 each for the 47 raised since 2008. Raising the remaining 20 has been scheduled for FY11. This work is being done under a force account using Public Works labor and equipment. These items are included in the line items for materials, supplies, fuel, etc.

The wastewater system incurred $18,873 in electrical charges for FY10 and the City has budgeted $22,000 for electrical costs for FY11. These costs include electricity costs for the five lift stations, which over the past 3 years has averaged $3,500.

[17] "Payments in Lieu of Taxes" or PILT are Federal payments to local governments that help offset losses in property taxes due to nontaxable Federal lands within their boundaries.

Table 25 - FY10 and FY11 Approved Sewer Budgets

Description	FY10	FY11
Income		
Miscellaneous Income	$40.00	$40.00
Sales Tax	$2,420.00	$2,420.00
Sewer Fees	$60,500.00	$75,500.00
Total Income	$62,960.00	$77,96000
Expenses		
Building/Ground Maintenance and Repair	$ -	$500.00
Chemicals	$1,000.00	$500.00
Contract Labor[1]	$ -	$10,130.00
Dues, Subscriptions Licenses	$900.00	$1,100.00
Electricity	$19,000.00	$22,000.00
Equipment Maintenance and Repair	$3,000.00	$2,000.00
Equipment Purchase[2]	$15,000.00	$10,000.00
Health Insurance	$6,468.36	$7,115.22
Heating Fuel	$4,000.00	$5,500.00
Insurance (AMLJIA)	$803.00	$2,250.00
Internet Service Fees	$600.00	$600.00
Materials and Supplies	$2,000.00	$3,000.00
Payroll Expenses	$37,822.96	$38,729.60
Payroll Taxes	$983.39	$1,123.16
PERS	$8,301.26	$8,520.51
Postage & Freight	$1,500.00	$2,000.00
Telephone	$360.00	$360.00
Testing	$7,000.00	$7,000.00
Training	$50.00	$100.00
Vehicle Fuel	$1,500.00	$1,500.00
Vehicle Maintenance and Repair	$500.00	$500.00
Worker's Compensation	$6,468.36	$2,270.95
Total Expenses	$117,257.33	$126,799.44
Net Ordinary Income	($54,297.33)	($48,839.44)

Note:
1. Contract Labor includes $9,130 for required USDA Storm Water grant match.
2. Equipment purchase for FY11 includes a 3 Hp ($4,000) and 5 Hp ($5,000) pump for the lift stations.

5.4 Need for I&I Repair Project

Thorne Bay's wastewater collection system receives a large volume of I&I causing lift station pumps to wear out much faster, increasing annual electrical costs, and upsetting the biological balance at the WWTP, which results in improperly treated wastewater being discharged into Thorne Bay and discharge permit violations.

5.4.1 Health, Sanitation, Security

Public health and environmental health are compromised when untreated or undertreated wastewater is released into Thorne Bay where people recreate, travel, and harvest seafood. The high I&I flows overload the

WWTP reducing the level of treatment that occurs, and the inaccessibility of some of the manholes prevents rapid emergency repairs. The following sections outline the impacts of I&I flows on the wastewater system in Thorne Bay, explaining the impacts to the system security and viability.

Wastewater Treatment Balance

Wastewater treatment is a biological process where microbes are supplied with a nutrient source (wastewater); they consume the nutrients and leave clean/treated water. This process works best when there is a consistent nutrient source that supports a constant microbe population. Large changes in the concentrations of the nutrients disrupt the biological balance, alternately overfeeding and increasing the population and then starving the microbes, resulting in wastewater not being adequately treated before being discharged.

Regulatory Issues

The City's NPDES permit (AKG517017) allows the wastewater treatment system to discharge up to 400,000 gallons per day (0.4 million gallons per day - MGD). This permit requires the removal of 85 percent of the biological oxygen demand (BOD) and total suspended solids (TSS) with a maximum residual of 60 mg/l.

Over the past 5 years, Thorne Bay has exceeded the maximum discharge of 0.4 MGD nine times for at least one day during the monthly reporting period. Multiple exceedances in a month are reported as one violation. Table 26 lists other water quality parameters that the City monitors with the number of compliance issues recorded over the last 5 years.

Table 26- Test Results Not in Compliance (2005- 2010)

Monitoring Item	Requirement	# Times Not in Compliance
Total Flow	0.4 MGD	9
BOD – Maximum	L.T. 60 mg/l	0
BOD – 7-Day Average	L.T. 45 mg/l	0
BOD – 30-Day Average	L.T. 30 mg/l	0
TSS – Max	LT 60 mg/l	1
TSS- - 7-Day Average	L.T. 45 mg/l	0
TSS – 30-Day Average	L.T. 430 mg/l	0
Percent Removal BOD	85% min	2
Percent Removal TSS	85% min	11
Fecal Coliform 30-Day Average	100,000 max	11
Fecal Coliform	150,000 max	10
Dissolved Oxygen (DO)	2 mg/l	0
pH	6 min – 9 max	2
Residual Chlorine	L.T. 1 mg/l	0

Total flows, pH and chlorine residual are measured and recorded at least 5 days a week, while tests for BOD and TSS are performed twice a month and dissolved oxygen (DO) is tested once a week. Note that removal violations for TSS and BOD as well as the flow can be directly attributed to I&I, as the resulting dilution reduces treatment efficiencies. Because of testing frequency and reporting requirements it should be assumed that many exceedances are not recorded.

Utility Access

Thorne Bay paved its road system in 2002 without raising the manhole lids to the finished road grades. These system access points are critical to proper O&M of the utility systems. Thorne Bay residents are currently at risk of flooding, water outage, and property damage due to maintenance personnel not being able to quickly enter the manholes. City staff began raising manholes during fall 2008 and, to date, has brought 80 percent of these appurtenances to finished road grade with the remaining to be raised during spring/summer 2010.

5.4.2 System Operation and Maintenance (O&M)

Lift Station Pump Premature Failures

The pumps in Lift Station No. 2 (LS#2) have to be replaced about every two years, instead of a normal life of six years. Since the City began tracking revenues and expenditures through QuickBooks™ software in 2005, the City has spent over $60,500 replacing/rebuilding lift station pumps due to mechanical failure. Operators have attributed these frequent pump failures to the high volumes of I&I increasing the wear and tear on the lift stations. However, our controls engineer is not convinced that this is accurate for two reasons. First, large volumes of I&I will not make the pumps work any harder, only longer. If the pumps are sized correctly having the pumps run for twice as many hours will only have a minor effect on pump life expectancy. Second, LS#2 is reported to experience most of the problems. However, LS#1 receives more flow than LS#2, so it should have more problems if high I&I flows are the cause. But, LS#1 does not have the frequent pump replacements that LS#2 has. We think that a more likely explanation is that the pumps for LS#2 are not properly sized and/or the controls are not properly operating the pumps. One possibility is that the current control systems do not protect the pumps from operating conditions such as seal failure and over temperature conditions. These conditions are directly related to pump run times, and if not corrected, will lead to short pump life. Better control systems alert the operators to these conditions, allowing them to be corrected prior to pump failure. See Section 6 for further discussions on lift stations and recommendations for improvements.

Increased Electrical Costs

Electric costs to run the lift stations are much higher because of the need to pump all of the additional I&I volume. Annually, the City spends an average of $3,500 on electric costs for the lift stations. Much of this cost can be attributed to the high I&I.

Manholes

The City has spent a great deal of time and money in an effort to repair manholes that are leaking, constructed of blocks, or covered over with pavement. The actual costs are unknown because they are performed with City forces.

5.4.3 Growth

Growth in the planning area is expected to be limited and will not affect the capacity of the wastewater system. The WWTP was sized for a population of 900. As noted in Section 1.2.1, the 2008 DCCED certified population is 440 with continue population declines expected. Allowing for a modest growth of 1 percent, Thorne Bay is projected to have a population of 5,590 in 2030 with only half of those being connected to the wastewater system; thus, system demand is well below the design criteria initially established for the WWTP.

In general, the wastewater collection system pipe sizes are based on maintenance access and not wastewater capacities. Additional growth and expansion based on currently proposed projects such as the TBBDS, and the Greentree Heights and Oceanview subdivisions will help increase revenues while having a negligible impact on operational capacity of the wastewater collection system or the WWTP.

5.4.4 Conclusion

I&I into Thorne Bay's wastewater collection system needs to be reduced in order to reduce the O&M cost, and to protect the public and environment from inadequately treated wastewater being released into Thorne Bay. I&I into Thorne Bay's wastewater system totals more than one third of the total wastewater stream. The City has to divert limited funds from regular O&M to pay for the additional costs of collecting, pumping, and treating this additional I&I water. The community pays for these costs while receiving no benefit. The high I&I flows disrupt the natural biological balance at the City's WWTP, reducing the effectiveness of the treatment process, violating conditions of their wastewater discharge permit, and threatening public health.

I&I problem needs to be fixed to help protect Thorne Bay

5.5 I&I Mitigation Methods

Currently the method preferred by regulators and operators for handling I&I is to stop it from entering the wastewater collection system. Other methods include increasing the capacity of the wastewater system or diverting peak wastewater flows to storage until it can be sent back through the WWTP after the storm event has passed. Regulatory agencies generally prefer that I&I be stopped from entering the system. While capacity increases and peak attenuation may be considered for the WWTP as a means of addressing I&I, these methods involve analysis and modifications to the WWTP, which were excluded from the scope of this report. This report is concerned with the collection system as a means of addressing I&I. However, other alternatives that involve the WWTP will be briefly discussed.

5.5.1 WWTP Upgrades

Increased WWTP Capacity

Historically the preferred method for accommodating I&I has been to Increase the capacity of the wastewater collection system and WWTP to handle peak I&I flows. This method results in larger collection pipes, larger pumps, and an oversized WWTP that is not efficient in its use of electrical power; and a biological system that is being shocked by high flows, reducing the quality of treatment. Thorne Bay's current wastewater system can arguably be seen as an oversized system.

The benefit of an increased system capacity is that this solution is simple, is based on a system in use for years, and would have a reasonably well known maintenance costs. The drawbacks of an increased system capacity are the high initial capital costs, high operation costs for pumping and treating I&I, and the lower quality of effluent leaving the WWTP. Thorne Bay, like many cities, is seeing funding reductions for O&M. Therefore, reducing costs for pumping and treating I&I is a high priority.

Wastewater treatment regulations have become stricter over the years and this trend is expected to continue. In an effort to keep operators from diluting wastewater with large volumes of I&I, and not providing any real treatment of the wastewater, current regulations require the WWTP to remove 85 percent of TSS and BOD. WWTP's that have a large volume of I&I have a much more difficult time meeting this regulation.

EPA and ADEC consider infiltration to be excessive when it exceeds 120 GPCPD.[18] This is measured during dry weather and consists of domestic base flow plus infiltration. EPA and ADEC consider inflow to be excessive when it exceeds 275 GPCPD. This is measured during or after a storm event and consists of domestic base flow plus infiltration plus storm inflow. Approximately one half (210) of Thorne Bay's residents are connected to the wastewater collection system. Therefore, EPA and ADEC consider the I&I entering Thorne Bay's system to be excessive when it reaches 57,750 GPD. Thorne Bay exceeded this amount for 123 days in 2009, which is 50 percent of the days there was precipitation.

Communities that are still growing and adding new service areas with increased wastewater flows have additional problems with increasing capacity. The downstream networks are the first to be overloaded by peak flows. Replacing these downstream wastewater systems with larger pipes, pumps, and treatment plants is much more expensive due to the area being built up with new roads and buildings near the system. These communities often find that increasing capacity is not an economical option.

Increased capacity for Thorne bay would have to include modifications to the WWTP.

Diverting Peak Flows

A method tried by some cities to accommodate influent peaks is to divert the peak inflow into a storage tank where it can be sent through the WWTP at a later time. This provides a more uniform flow through the WWTP and prevents the WWTP from being overloaded with rapid changes in flow. This method is often used to flatten out the normal morning and evening wastewater peak flows. However, it is used less often to accommodate high I&I because of its significantly higher peaks and unpredictability.

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[18] 40 CFR 35.2005(b)(16), (28), (29)

The drawback of this method is that the volume of storage can be very large and it may have to be stored for several weeks during the rainy season when the inflow exceeds the WWTP operating capacity for a number of consecutive days. Based on 2009 data for Thorne Bay, storage capacity would need to be 2-4 million gallons. Diverting peak flows at the Thorne Bay WWTP could be accomplished through a diversion weir and gravity flow. However, the stored wastewater would have to be pumped back into the WWTP, increasing electrical, and O&M costs.

5.5.2 Stopping I&I

Stopping I&I from entering the wastewater collection system is preferred by owners and operators because it lowers the O&M costs and postpones the need to build larger collection and treatment facilities. Regulators prefer this method because, overall, it meets the intent of clean water regulations by providing treatment rather than dilution and minimizes the negative impact to the environment.

The drawback of trying to stop I&I is that there is not a fix-all method, repairs are often better suited for maintenance crews rather than construction contracts and success of an I&I project can vary significantly. Frequently when a repair is made to stop I&I at one location, the water will flow to another and enter the system, often referred to as *"chasing the leak"*. I&I projects typically experience a 30 percent to 50 percent reduction in I&I. Projects can be more successful in reducing I&I by pressure checking and repairing the entire system for leaks. One such I&I project in Cordova Alaska reported a 70 percent reduction in I&I. However, like the Cordova project which cost about $100 per linear foot, entire system repair requires a large amount of capital funding.[19]

Many wastewater system owners take a phased approach to stopping I&I. They start by fixing the large and easy to repair leaks, maximizing the gallons stopped per dollar spent. Then the move on to more difficult repairs as funding allows, until they reach an acceptable/manageable volume of I&I . There are several techniques to stop I&I from entering into a wastewater collection system, including:

- Open Trench Construction –repair by excavating and removing and replacing defective components.
- Slip Lining Existing Pipe– repair by sliding a new smaller pipe inside a larger existing pipe.
- Thermoformed Pipeliner – repair by sliding a folded pipeliner inside the existing pipe and inflating
- Cured-In-Place Pipe – repair by a flexible *"sock"* that is inflated and cured inside an existing pipe.
- Hydrophilic Grouting – repair by injection of hydrophilic grout into the soil outside the existing pipe.
- Pipe Bursting – repair by pulling a new pipe in place as the old pipe is broken by an expander.

Each of these techniques has its own strengths and weaknesses and is typically selected based on a project budget, location, accessibility, and characteristics of a specific project. Three techniques that are most applicable to the conditions in Thorne Bay are Open Trench Construction, Hydrophilic Grouting, and Thermoformed Pipelining. These techniques are explained in the following sections for consideration in developed alternatives.

Open Trench Construction

Open trench construction includes digging up the leaking pipe or manhole and repairing or replacing the defective components. After the underground work is completed, the excavation is backfilled and the road pavement or sidewalk replaced.

[19] Article by Colleen Mackne in the National Small Flows Clearing House (NSFC) news letter Spring 1999 Vol. 10, No.2

Manholes

Manholes are disassembled, removing the barrel sections and replacing the gaskets between the barrel sections. Manhole joints are coated with mastic and wrapped with a waterproof membrane. Many of the existing Thorne Bay manholes use cement bricks for grade rings. These would all be replaced with standard concrete grade rings and wrapped with waterproof mastic and membrane. Pipe penetrations into manholes would be reconstructed with a rubber boot to provide a seal in the annular space between the pipe and manhole. Manhole barrel sections that are damaged or have pipe penetrations that are chipped, cracked, or irregular and would not accommodate a rubber boot seal would be replaced.

Properly Waterproofed Manhole before Backfilling

Most of the existing manholes have a partial depth channel in the base. While crews are working on the manhole, these should be removed and replaced with a full depth channel. This will provide better support for grout around the pipe inlets and make for a cleaner manhole, keeping high flows off of the shelf.

Pipelines

Leaks in pipelines will typically occur at a lateral connection or a pipe joint. Open trench construction to fix leaky pipes could include a wrap around pipe repair clamp for isolated leaks that can be identified. However, in many cases removing and replacing the pipe turns out to be the most cost effective and dependable solution.

Installing a pipe bedding drain is applicable for some locations in Thorne Bay's system. Thorne Bay has shallow bedrock, so wastewater lines had to be blasted into the bedrock in many locations. Trenches were then backfilled with coarse shot rock making an easy path for groundwater to collect, like a French drain. Extending a drain pipe from the pipe bedding to a nearby ditch or storm drain would remove some of the ground water and keep it from entering the wastewater collection system. This technique will only work at specific locations with a nearby stormdrain system or steep grade where the water can be gravity drained from the bedding.

Hydrophilic Grouting

Hydrophilic grout is a prepolymer urethane resin that expands when it comes in contact with water, and then cures into a flexible gel. In its uncured form the grout is a viscous liquid that looks much like honey or medium-weight motor oil. Repairs to pipes and manholes are made by injecting the hydrophilic grout through the manhole or pipe and into the surrounding soil where the grout saturates the soils and gels into a waterproof mass that seals the leaks. Hydrophilic grout is a late comer in the chemical grout lineup. Chemical grouts have been used in stopping leaks in sewers for over 50 years and has proven to be a cost effective, long-term defense against infiltration of groundwater into structurally sound sewer systems. Early grouts were two parts, one a catalyst to activate and cure the grout. Many newer grout formulas (hydrophilic) use water as the catalyst. Several different chemical grouts, some hydrophilic, some two part, may be used on one project depending on the size of the leak, water pressure coming through the leak and soil composition around the pipe or manhole.

Hydrophilic grouting works on structurally sound pipes. Structural deficiencies in existing pipes or manholes will need to be addressed separately from grouting.

Most infiltration enters wastewater collection systems through joints, manholes, and service. Studies have shown that most infiltration into service lines occurs within a few feet of the main because of the shallower burial depths on services.

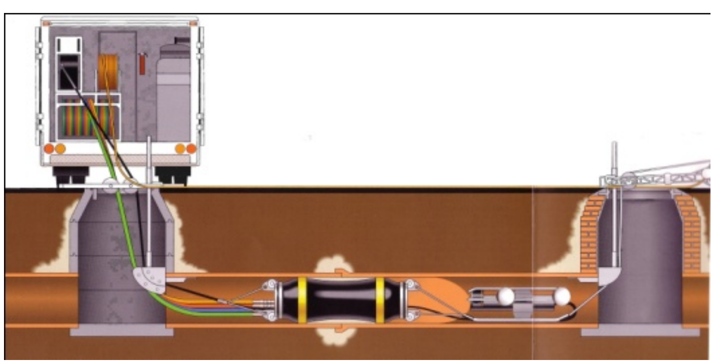
Manholes

Hydrophilic grouting of leaky manholes is performed by drilling holes through the wall of the manhole at several locations and then pumping grout through the manhole wall and into the surrounding soil. This process is repeated for the entire surface of the manhole to create a hydrophilic grout gel mass that completely encompasses the exterior of the manhole.

Piping

Hydrophilic and chemical grouting of a main line are typically performed by the following sequence:

- Clean and flush main line
- Insert an injection packer and camera. The injection packer is controlled remotely from a control truck through a cable pulley system extending between manholes.
- The packer is centered over a pipe joint and each end of the packer is inflated to form an airtight seal at each end, leaving an inner space in the middle of the packer and at the pipe joint.
- The inner space between the packer end seals is then pressurized with air to test if the joint leaks.
- If the joint leaks, hydrophilic grout is pumped into the packer inner space and forced out through the leaky pipe joint and into the surrounding soils.
- Packer and camera are advanced to the next joint.



Grouting Packer and Control Truck

The grout is given time to set and then the joint is re-pressurized to see if the leak has been fixed. If a the joint still leaks, the process is repeated until the joint can hold a positive pressure of about 1/2 psi for every foot of pipe burial depth.

Every step of the test and seal operation is recorded on videotape to provide a permanent record of the condition of the existing pipeline, initial air test results, the amount of grout injected, and the follow-up air pressure test.

Lateral services can be grouted in the same manner as the mainlines by using a different injection packer, which has a side probe that can extend from the mainline two to three feet to the first joint on the lateral and seal it off so that grout can be applied.

Thermoformed Pipelining

Thermoformed pipeliner pipe repair is performed by pulling a folded flexible pipeliner inside an existing pipe and then inflating the pipeliner with hot steam and curing it in place.

Thermoformed pipeliners are used in sanitary sewer, storm drain, and industrial pipe rehabilitation projects. They are shelf stable, inert, non-toxic, and some have NSF approval for use with potable water. Pipeliners are typically made from polyethylene or PVC

Pipeliners are available in sizes ranging from 3 inches to 30 inches. Thermoformed pipeliners have been installed on deteriorated pipes with burial depths greater than 50 feet and below groundwater depths of 20 feet. These factors that are well within the conditions found in Thorne Bay.

Construction access is needed at each end of the pipe; at one end a roll of pipeliner is fed into the pipe as it is being pulled through the pipe by a cable and winch at the other end of the pipe. After insertion, the pipeliner is heated and expanded with pressurized steam to stretch the liner tightly against the host pipe. The pipeliner is cooled with chilled air that is still under pressure to maintain the tight fit against the host pipe. A properly installed thermoformed pipeliner will have about a business card thickness annulus gap between the host pipe and the pipeliner.

The insertion, heating, and cooling of a thermoformed pipeliner can take 3 to 6 hours depending on pipeliner material and existing pipe conditions. Pipe lengths can be over 1,000 feet depending on pipe size and the condition of existing pipe.

Remote access equipment is then used to cut holes in the cured pipeliner for the existing lateral services. These services are easily identified by a pronounced dimple left in the cured pipeliner. Lateral services take 30 to 45 minutes each to restore. Effective technologies for proper end-sealing at the manholes and sealing at the lateral connections are routinely available.

Design properties, including the moduli, wall thickness, and material composition of thermoformed pipeliners are controlled in a centralized manufacturing facility, and are almost completely unaffected by field construction personnel. Thus, fewer design type problems are experienced in the field using this method.

Thermoformed Pipeliner

5.6 I&I Alternatives Considered

Six alternatives have been considered to stop I&I from entering the Thorne Bay wastewater collection system. These alternatives vary in how aggressive they are in eliminating I&I from a very aggressive replacement of the entire system in Alternative 1 to the No-Build option under Alternative 6. The alternatives developed are:

- Alternative 1 – System Wide Rebuild
- Alternative 2 – Manhole Repair
- Alternative 3 – System Wide Repair by Hydrophilic Grouting
- Alternative 4 – System Wide Repair by Thermoformed Pipelining
- Alternative 5 – Selective Repair and Investigation
- Alternative 6 – No-Build

5.6.1 Alternative 1 System Wide Rebuild

System Wide Rebuild: Description

The System Wide Rebuild alternative includes removal and replacement of the entire wastewater collection system. Often when repairing something old and worn out, the repairs happen in a piecemeal fashion and by the time everything is fixed the repairs end up costing more than replacing it with something new. Projects to stop I&I are no different. Stopping water from entering one leak in the system will often cause it to find its way down to the next leak in the system. Although the existing collection system is not veryold, this System Wide Rebuild Alternative provides a valuable comparison for the other less dramatic alternatives.

The System Wide Rebuild Alternative includes removal and replacement of most of the entire wastewater collection system using standard open trench construction method as discussed in Section 5.5.3. The work would include removal of two-thirds (10,000 LF) of the wastewater pipe, all (150) of service the connections, all (110) of the manholes, and the associated work to replace these items.

System Wide Rebuild: Construction Design Criteria

Design shall follow ADEC Wastewater Disposal regulations (18AAC 72.270).

The City of Thorne Bay has not adopted a standard for construction of utility systems. The standard construction specifications used by the City and Borough of Juneau (CBJ) and the City and Borough of Sitka (CBS) define design and construction practices that comply with ADEC regulations and have been found to meet the conditions in southeast Alaska similar to those in Thorne Bay.

System Wide Rebuild: Environmental Impacts

Open trench construction presents no unique environmental impacts from the other alternatives being considered. The new system will be a replacement of the existing and have impacts typical of construction and repair projects. In this case, they will be less than during the original construction as blasting will not be required. These impacts should not extend beyond the original disturbed areas. Detailed environmental impacts are included in the Environmental Report included in Appendix I.

System Wide Rebuild: Land Requirements

Thorne Bay's wastewater collection system is located within existing road ROWs and utility easements and will be replaced along the same alignment under this alternative. No additional ROW or easements will be required to complete this alternative.

System Wide Rebuild: Construction Problems

System Wide Rebuild alternative uses standard open trench construction methods and presents no construction problems that cannot be overcome with the appropriate design and effort. Some challenges with open trench construction to address include: working in wet rainy climate, high and rapidly flowing groundwater, disruption to traffic, and getting a suitable asphalt pavement patch when an asphalt plant is not on the island every construction season.

System Wide Rebuild: Cost Estimate

Costs for open trench construction range from $70 to $140 per linear foot of mainline pipe and $4,000 to $8,000 per manhole. Price varies depending on pipe size, number of lateral services, road surfacing, and project location.

Project costs include design, construction inspection, and administration. Estimated project cost for Thorne Bay's I&I remediation projects are as follows:

- Construction: $3,138,653
- Non-Construction: $1,026,814
- Annual O&M : $103,000

Project costs are based on material and labor for 2012 with all of the work being advertized and bid under one project. Planners and designers will need to make the appropriate price adjustments depending on proposed year of construction, portions of work completed by City crews, and specific project parameters. Project cost details are included in Appendix E.

System Wide Rebuild: Advantages/Disadvantages

Advantages

- Alternative would meet the project objectives of reducing I&I.

- Local contractors are experienced in these construction methods.
- City crews could perform much of the work.
- Finished product will have a longer expected life span.
- Frequently most cost effective option for small projects.
- Very reliable construction method for reducing I&I, with proper inspection.

Disadvantages

- Most expensive alternative.
- Would replace some pipes that have no problems.
- Roads get torn up and pavement patches reduce the life of the pavement.
- Construction interruptions to traffic and wastewater services will be greater than other options.
- Requires an asphalt pavement plant on the island, which does not happen consistently.
- Area of disturbed area expected to be 4 acres.

5.6.2 Alternative 2 – Manhole Repair

Manhole Repair: Description

A large portion of I&I entering the system is coming through the manholes. Several manholes including ones at Cedar Lane/Svend's Drive, Freeman Drive/Svend's Drive and Shore Line Drive/Business Loop have a constant *"garden hose"* stream of water entering the manhole. These types of leaks are obvious and should be first on the list of repairs. The Manhole Repair Alternative will address these obvious I&I leaks and structural deficiencies in manholes. Manholes that have structural deficiencies will be repaired by reconstruction. Structurally sound manholes will be repaired by grouting.

Manhole Reconstruction: Approximately 40 manholes have structural deficiencies, particularly those where the manhole lid is supported on cinder blocks. Conventional open trench construction is required to replace the blocks with concrete grade rings. Once excavated, it is more economical and reliable to completely reconstruct the manhole to stop the I&I. Manholes that have more than 18 inches of grade rings will also require reconstruction, which includes completely removing the manhole, including the first section of pipe entering the manhole. The manhole will then be reassembled using the old concrete barrel sections when they are structurally sound. All other materials will be new including, barrel gaskets, pipe penetration boots, grade rings, manhole lids, and geomembrane waterproof wrapping.

Manhole Grouting: Approximately 70 manholes are structurally sound and I&I can be eliminated in the manhole by grouting. Grouting of leaky manholes is performed by drilling holes through the wall of the manhole at several locations and then pumping grout through the manhole wall and into the surrounding soil. It is important to grout the entire manhole, otherwise the groundwater will just travel around the manhole and leak in the next available crack.

Manhole Repair: Design Criteria

Design shall follow ADEC Wastewater Disposal regulations (18 AAC 72), as well as the following ASTM standards for this method of construction:

- ASTM F2304-03 Standard Practice for Rehabilitation of Sewers Using Chemical Grouting

- ASTM F2414-04 Standard Practice for Sealing Sewer Manholes Using Chemical Grouting
- ASTM F2454-05 Standard Practice for Sealing Lateral Connections and Lines from the Mainline Sewer Systems by the Lateral Packer Method, Using Chemical Grouting

Use of standard construction practices specific to southeast Alaska is also recommended. These may include the standard construction specifications used by CBJ and/or CBS.

Manhole Repair: Environmental Impacts

Manhole repair presents no unique environmental impacts from the other alternatives being considered. This alternative provides repair of existing structures and has impacts typical of repair projects. These impacts should not extend beyond the original disturbed areas. Detailed environmental impacts are included in the Environmental Report included in Appendix I.

Manhole Repair: Land Requirements

Thorne Bay's wastewater collection system is located within existing road ROWs and utility easements. No additional ROW or easements will be required to complete this alternative which repairs existing structures.

Manhole Repair: Construction Problems

The Manhole Repair alternative uses both standard open trench construction and hydrophilic grouting methods. The standard construction components will require excavation and present no construction problems that cannot be overcome with the appropriate design and effort. Some challenges that the open trench construction option will need to address include, working in wet rainy climate, high and rapid flowing groundwater, disruption to traffic, and getting a suitable asphalt pavement patch when an asphalt plant is not on the island every construction season. Hydrophilic grouting is more of a specialty and the challenge will be getting a competent grouting contractor to come to a remote location for a relatively small amount of work, working with the construction difficulties noted above. Compounding these issues will be concerns about multiple mobilizations to address warranty work.

Manhole Repair: Cost Estimate

Costs for repairing a manhole will be $700 to $8,000 per manhole depending on whether the manhole just needs grouting or needs to be reconstructed.

Project costs include design, construction inspection, and administration. Estimated project cost for Thorne Bay's I&I remediation projects are as follows:

- Construction: $498,936
- Non-Construction: $163,228
- Annual O&M : $103,000

Project costs are based on material and labor for 2012 and all of the work being advertised and bid under one project. Planners and designers will need to make the appropriate price adjustments depending on proposed year of construction, portions of work completed by City crews, and specific project parameters. Project cost details are included in Appendix E.

Manhole Repair: Advantages/Disadvantages

Advantages

- Addresses the obvious I&I problems.
- City crews could perform some of the manhole reconstruction work.
- Manhole reconstruction is a reliable method for reducing I&I, with proper inspection.
- Manhole grouting would not tear up asphalt pavement.
- Construction impacts are localized at manholes
- The area of impact is not expected to exceed 150-sf per manhole reconstructed, or 0.15 acres.

Disadvantages

- Does not address I&I coming from sources other than manholes.
- May be difficult and expensive to get a grouting contractor to come to small Alaska community.
- Manhole reconstruction will require asphalt patching, which reduce the life of the pavement.

5.6.3 Alternative 3 – System Wide Repair - Hydrophilic Grouting

System Wide Repair - Hydrophilic Grouting: Description

The System Wide Repair using Hydrophilic Grouting will include a video inspection of the wastewater system, testing each of the joints and grouting leaking joints and grouting all of the manholes as discussed in Section 5.3.3. The work would grout two-thirds (10,000 LF) of the wastewater pipe, all (150) of the service connections, all (70) of the structurally sound manholes, rebuild 40 manholes with structural deficiencies, and the associated work to replace these items.

System Wide Repair - Hydrophilic Grouting: Design Criteria

Design of wastewater facilities shall comply with ADEC Wastewater Disposal regulations (18 AAC 72), as well as the following ASTM standards for this method of construction:

- ASTM F2304-03 Standard Practice for Rehabilitation of Sewers Using Chemical Grouting
- ASTM F2414-04 Standard Practice for Sealing Sewer Manholes Using Chemical Grouting
- ASTM F2454-05 Standard Practice for Sealing Lateral Connections and Lines from the Mainline Sewer Systems by the Lateral Packer Method, Using Chemical Grouting

System Wide Repair - Hydrophilic Grouting: Environmental Impacts

Hydrophilic grouting presents no unique environmental impacts from the other alternatives being considered. This alternative provides repair of existing structures and has impacts typical of repair projects. These impacts should not extend beyond the original disturbed areas. Detailed environmental impacts are included in the Environmental Report included in Appendix I.

System Wide Repair -Hydrophilic Grouting: Land Requirements

Thorne Bay's wastewater collection system is located within existing road ROWs and utility easements. No additional ROW or easements will be required to complete this alternative, which repairs existing structures.

System Wide Repair - Hydrophilic Grouting: Construction Problems

Hydrophilic grouting presents no construction problems that cannot be overcome with the appropriate design and effort. Some challenges that hydrophilic grouting need to address include: getting an competent grouting contractor to come to a remote location for a relatively small amount of work; working in a wet, rainy climate with high and rapidly flowing groundwater; and the difficulty of coming back to perform touch-up or warranty work.

System Wide Repair - Hydrophilic Grouting: Cost Estimate

Costs for hydrophilic grouting range from $30 to $60 per linear foot of mainline pipe and $700 to $2,000 per manhole. Price varies depending on pipe size, condition of existing pipe, number of lateral services, pipe accessibility, pipe length, and project location.

Project costs include design, construction, inspection, and administration. Estimated project costs for Thorne Bay's I&I remediation projects are as follows:

- Construction: $800,442
- Non-Construction: $261,866
- Annual O&M : $103,000

Project costs are based on material and labor for 2012 and all of the work being completed under one project. Planners and designers will need to make the appropriate price adjustments depending on proposed year of construction, portions of work completed by City crews, and specific project parameters. Project cost details are included in Appendix E.

System Wide Repair - Hydrophilic Grouting: Advantages/Disadvantages

Advantages

- Alternative would meet the project objectives of reducing I&I.
- Access is only needed at each end of the pipe and can be accomplished through existing manholes.
- Roads are not torn up, and asphalt pavement does not have to be replaced.
- Construction interruptions are short. Three to six hours for one pipe run.
- Grouting will fix leaks in both mainlines and manholes.
- Grouting of manholes can be performed by City crews with a moderate purchase of equipment, materials, and training.
- Construction impacts are localized at manholes.
- The area of impact is not expected to exceed 150-sf per manhole reconstructed, or 0.15 acres.
- Achieves all the advantages of manhole repair and extends to provide leak repair to piping without the extensive capital cost of full system replacement.

Disadvantages

- Equipment used to grout mainlines and laterals is large and needs good drivable access.
- Contractors experienced in mainline and lateral grouting will come from out of town: Seattle or Anchorage.
- Mobilization of a hydrophilic grouting contractor will be expensive.

- Structural deficiencies in existing pipe will need to be fixed by other methods.

5.6.4 Alternative 4 – System Wide Repair - Thermoformed Pipelining

System Wide Repair - Thermoformed Pipelining: Description

The System Wide Repair using Thermoformed Pipelining will include a video inspection of the wastewater system and lining most of the system with thermoformed pipelining as discussed in Section 5.3.5. Manholes will be repaired by grouting and rebuilding as discussed in section 5.5.5. The work would include lining two-thirds (10,000 LF) of the wastewater pipe, all (150) of the service connections, grouting all (70) of the structurally sound manholes, rebuilding 40 manholes with structural deficiencies, and the associated work to replace these items.

System Wide Repair - Thermoformed Pipelining: Design Criteria

Design of wastewater facilities shall comply with ADEC Wastewater Disposal regulations (18 AAC 72), as well as, the following ASTM standards for this method of construction:

- ASTM F1216. Thermoformed Pipeliner material choice, wall thickness and structural design.
- ASTM F1504, F1533 or F1871. Pipeliner materials

System Wide Repair - Thermoformed Pipelining: Environmental Impacts

Thermoformed pipelining presents no unique environmental impacts from the other alternatives being considered. This alternative provides repair of existing structures and has impacts typical of repair projects. These impacts should not extend beyond the original disturbed areas. Detailed environmental impacts are included in the Environmental Report included in Appendix I.

System Wide Repair - Thermoformed Pipelining: Land Requirements

Thorne Bay's wastewater collection system is located within existing road ROWs and utility easements. No additional ROW or easements will be required to complete this alternative, which repairs structures.

System Wide Repair - Thermoformed Pipelining: Construction Problems

Thermoformed pipelining presents no construction problems that cannot be overcome with the appropriate design and effort. Some challenges that the thermoformed pipe repair needs to address include: getting a competent contractor to come to a remote location for a relatively small amount of work, working in wet rainy climate with high and rapidly flowing groundwater, and that it is difficult to come back and perform touch-up or warranty work.

System Wide Repair - Thermoformed Pipelining: Cost Estimate

Costs for thermoformed pipelining range from $30 to $80. Price varies depending on pipe size, condition of existing pipe, number of lateral services, pipe accessibility, pipe length, and project location.

Project costs include design, construction inspection, and administration. Estimated project costs for Thorne Bay's I&I remediation projects are as follows:

- Construction: $1,403,445
- Non-Construction: $459,139
- Annual O&M : $103,000

Project costs are based on material and labor for 2012 and all of the work being completed under one project. Planners and designers will need to make the appropriate price adjustments depending on proposed year of construction, portions of work completed by City crews, and specific project parameters. Project cost details are included in Appendix E.

System Wide Repair - Thermoformed Pipelining: Advantages/Disadvantages

Advantages

- Alternative would meet the project objectives of reducing I&I.
- Access is only needed at each end of the pipe and can be accessed through existing manholes.
- Roads are not torn up, and asphalt pavement does not have to be replaced.
- Construction interruptions are short. Three to six hours for one pipe run.
- Pipeliner provides a fix to both a structural and leak problems in the existing pipe.
- Design properties, including the moduli, wall thickness, and material composition of thermoformed pipeliners are controlled in a centralized manufacturing facility, and are almost completely unaffected by field construction personnel.
- Variable site conditions have less of an influence upon design compliance and performance life predictability. Steep slopes, pipes with running groundwater, bends, off-sets, and diameter restrictions can be lined without detrimentally affecting pipe performance.

Disadvantages

- Equipment used to install and cure the pipeliner is large and needs good drivable access.
- Contractors experienced in thermoformed pipelining will come from out of town: Seattle or Anchorage.
- Mobilization of a thermoformed pipeliner contractor will be expensive.

5.6.5 Alternative 5 – Selective Repair and Investigation

Selective Repair and Investigation: Description

Alternative 5 – Selective Repair and Investigation uses a more progressive approach by addressing obvious and easily repaired items, further investigations, and selective repairs. This alternative consists of six parts that the City can use as a “tool box” to address I&I issues.

1. Investigate major I&I sources
2. Manhole reconstruction
3. Grouting equipment procurement
4. WWTP study
5. Manhole grouting
6. Selective mainline grouting.

Investigate Major I&I Sources:

The current video of the wastewater system did not identify the major sources of I&I. The Thorne Bay wastewater collection system was videoed in spring 2010. Precipitation during this time was little to none. The I&I increases rapidly and dramatically with the amount of precipitation as discussed in Section 5.4. Therefore, the video did not capture a high I&I event. Thorne Bay's system should be further investigated by surface observations and pipeline video during a rain event to identify sources of major I&I. Suspect areas can be pre-identified by visual inspection of manholes during or after a rain event. I&I flows after a rain event are up to 10 times the normal flows, so they should be easily identified visually and without the need for flow measuring devices.

A steady stream of clear water has been reported coming from the USFS Admin site and also the USFS residential area. The manholes in USFS drive and Federal Way have been covered over and are not readily accessible. Basic knowledge of the USFS utility system is unavailable and needs to be obtained and analyzed to determine if this is a source of significant I&I. The investigation should consist of smoke testing of the lines to identify any storm drain cross connections, locating and raising all the manhole lids, videoing the wastewater collection lines, mapping water and wastewater systems, and reviewing water meter readings. A method for stopping I&I can be selected, once the source is identified.

Manhole Reconstruction:

Approximately 40 manholes have structural deficiencies and need repair or replacement as discussed earlier. Leaks in the manholes will be eliminated when the manhole is reconstructed. A detailed description of this work is included with Alternative 2 in Section 5.6.2

Grouting Equipment Procurement:

Procuring grouting equipment and materials will allow the City to grout many of the manholes using their own staff and to perform spot repairs and regular I&I maintenance. Grouting equipment includes a portable grout pump capable of 3,000 psi pressure and 0.5 gpm flow rate, injection gun, hose, injection terminals, miscellaneous adaptors, and a 100- to 500-gallon base supply of grout.

WWTP Study:

As noted in Section 5.5.1, increasing the capacity of the wastewater system and diverting peak wastewater flows are two methods for dealing with I&I. Both of these methods would include making modifications to the WWTP. Although analysis of the WWTP was eliminated from the scope of this report, a study needs to be performed on the WWTP to determine what upgrades would be required to accommodate the I&I. The study should include verification of the sizes of tanks, pumps, weirs, piping, and adequacy of monitors, sensors and controls, and a review of plant operations. Construction and operations estimates for the WWTP upgrades would then be used to determine the extent of collection line repairs economically justifiable

Manhole Grouting:

Approximately 70 manholes are structurally sound, and I&I can be eliminated in the manhole by grouting. A detailed description of this work is included with Alternative 2 in Section 5.6.2

Selective Mainline Grouting:

Grouting of mainlines requires specialized equipment to run a packer through the wastewater line, pressure test each pipe joint, inject grout through leaky seals, and clean and retest the joint; all by remote access through existing manholes. This work would need to be performed by specialty contractors likely out of the Seattle area. Mobilizing and staging this contractor to Thorne Bay will be a large percentage of cost of grouting the mainlines, so the unit price for grouting will go down as the quantity of line goes up. Through the Investigate Major Sources of I&I phase of this alternative, the overall amount of mainline grouting can be reduced to selective sections, which are estimated at 3,000 feet, or 20 percent of the system.

Selective Repair and Investigation: Design Criteria

Design shall follow ADEC Wastewater Disposal regulations 18AAC 72, as well as the following ASTM standards for this method of construction.

- ASTM F2304-03 Standard Practice for Rehabilitation of Sewers Using Chemical Grouting
- ASTM F2414-04 Standard Practice for Sealing Sewer Manholes Using Chemical Grouting
- ASTM F2454-05 Standard Practice for Sealing Lateral Connections and Lines from the Mainline Sewer Systems by the Lateral Packer Method, Using Chemical Grouting

Use of standard construction practices specific to southeast Alaska is also recommended. These may include the standard construction specifications used by CBJ and CBS.

Selective Repair and Investigation: Environmental Impacts

The Selective Repair and Investigation Alternative presents no unique environmental impacts from the other alternatives being considered. This alternative provides repair of existing structures and has impacts typical of repair projects. These impacts should not extend beyond the original disturbed areas. Detailed environmental impacts are included in the Environmental Report included in Appendix I.

Selective Repair and Investigation: Land Requirements

Thorne Bay's wastewater collection system is located within existing road ROWs and utility easements. No additional ROW or easements will be required to complete this alternative which repairs existing structures.

Selective Repair and Investigation: Construction Problems

The Selective Repair and Investigation alternative uses both standard construction and hydrophilic grouting construction methods. The standard construction components will require excavation and present no construction problems that cannot be overcome with the appropriate design and effort. Some challenges that the open trench construction option will need to address include, working in wet rainy climate, high and rapid flowing groundwater, disruption to traffic, and getting a suitable asphalt pavement patch when an asphalt plant is not on the island every construction season. Hydrophilic grouting is more of a specialty and the challenge will be getting an competent grouting contractor to come to a remote location for a relatively small amount of work, working in wet rainy climate with high and rapid flowing groundwater; and that it is difficult to come back and perform touch-up or warranty work.

Selective Repair and Investigation: Cost Estimate

The Selective Repair and Investigation alternative is a combination of six "tool box" items that can be completed individually or as a combination of two or more separate items as funding becomes available. Project costs include design, construction inspection, and administration. Estimated project cost for Thorne Bay's I&I remediation projects are as follows:

Investigate Major I&I Sources

- Construction: $0
- Non-Construction: $50,000

Manhole Reconstruction

- Construction: $200,000
- Non-Construction: $100,000

Grouting Equipment Procurement

- Construction: $0
- Non-Construction: $17,000

WWTP Study

- Construction: $0
- Non-Construction: $200,000

Manhole Grouting

- Construction: $80,000
- Non-Construction: $30,000

Selective Mainline Grouting

- Construction: $300,000
- Non-Construction: $100,00

Project costs are based on material and labor for 2012 and all of the work being completed as a single, cohesive project. Planners and designers will need to make the appropriate price adjustments depending on proposed year of construction, portions of work completed by City crews, and specific project parameters. Project cost details are included in Appendix E.

Selective Repair and Investigation: Advantages/Disadvantages

Advantages

- Alternative would meet the project objectives of reducing I&I.
- Alternative can be phased to accommodate available funding and warrants for further I&I reductions.
- Funds can be spent first on high return I&I items.
- Local contractors experienced in much of the proposed work.
- City crews could perform some of the investigation and manhole reconstruction work.
- Access is only needed at each end of the pipe and can be obtained through existing manholes.
- Cutting and patching of asphalt paved roads are kept to a minimum.

- Grouting will fix leaks in both mainlines and manholes.
- Construction interruptions are short. Three to six hours for one pipe run.
- Traffic and wastewater services are not inconvenienced with construction interruptions.
- Construction impacts are localized at manholes
- The area of impact is not expected to exceed 150-sf per manhole reconstructed, or 0.15 acres.
- Achieves all the advantages of manhole repair and extends to provide leak repair to piping without the extensive capital cost of full system replacement.

Disadvantages

- May be difficult/expensive to get a grouting contractor to come to small Alaska community
- Manhole reconstruction will require asphalt patches, which reduce the life of the pavement.
- Contractors experienced in mainline and lateral grouting will come from out of town: Seattle or Anchorage.

5.6.6 Alternative 6 – No-Build

No-Build Alternative: Description

The no-build alternative includes constructing no improvements to the existing wastewater collection system and continuing to operate the system as-is. Leaks in pipes and manholes will increase over time if not fixed. I&I will increase over time which will increase the O&M of the wastewater system and increase the quantity and frequency of inadequately treated wastewater being discharged into Thorne Bay. In extreme cases water leaking into the wastewater system can erode the soils supporting, pipes, manholes and the overlying road causing sink holes in the road and or collapsing of the pipe. These failures will require emergency repairs to prevent injury to the public.

No-Build Alternative: Design Criteria

The wastewater collection system will continue to exist as it is and may not meet modern design criteria.

No-Build Alternative: Environmental Impacts

The no-build alternative will not address the current I&I problem, which causes discharge violations at the WWTP. While there will be no impacts related to construction (e.g. noise, sediment), the improvements realized from preventing untreated or undertreated wastewater releases, and reductions in O&M costs will not be achieved. Detailed environmental impacts are included in the Environmental Report included in Appendix I.

No-Build Alternative: Land Requirements

Thorne Bay's wastewater collection system is located within existing road ROWs and utility easements. No additional ROW or easements will be required as no system modifications will be made.

No-Build Alternative: Construction Problems

No construction is involved with the no-build alternative.

No-Build Alternative: Cost Estimate

The no-build alternative will not have any construction or non-construction costs. However, the annual O&M costs will be higher than the other alternatives.

Project costs include design, construction inspection, and administration. Estimated project cost for Thorne Bay's I&I No-Build Alternative are as follows:

- Construction: $0
- Non-Construction: $0
- Annual O&M: $117,000

Project cost details are included in Appendix E.

No-Build Alternative: Advantages/Disadvantages

Advantages

- No construction is required with its associated impacts to community traffic, roads, and services.

Disadvantages

- Alternative would not meet the project objectives of reducing I&I.
- O&M costs are high.
- City funding is diverted from other community needs to pay for high O&M costs.
- Discharge violations at the WWTP will continue.
- Public health is not protected.

5.7 Selection of I&I Repair Alternative

Selection of a recommended alternative is based on selecting items for their predictability for working in a small remote community, judicial use of public funds, and comparing of the alternatives with the purpose and need of the project. The following Alternative Rating Matrix summarizes many of the items considered in recommending an alternative.

Table 27 - I&I Repair Alternative Rating Matrix

	Alternative 1 - System-Wide Rebuild	Alternative 2 - Manhole Repair	Alternative 3 - System Wide Repair -Hydrophilic Grouting	Alternative 4 - System Wide Repair - Thermoformed Pipelining	Alternative 5 - Selective Repair & Investigation	Alternative 6 - No Build Alternative
Meets Project Objective	Yes	Yes	Yes	Yes	Yes	No
Prospect of Eliminating NOVs	Excellent	Good	Excellent	Excellent	Excellent	None
Local Contractors Can Construct	Yes	Part	No	No	Part	N/A
City Crews Can Do Some of the Work	Minor	Moderate	Limited	Minor	Part	N/A
Expected Life Span	40+	20+	20+	20+	20+	20
Reduced Road Surface Life	Yes	Part	Part	Part	Part	No
Construction Impacts	Moderate	Limited	Limited	Limited	Limited	None
Disturbed Area (Acres)	4.0	0.15	0.15	0.15	0.15	0
Addresses Manhole Defects	Yes	Yes	Yes	Yes	Yes	No
Environmental Impacts	Minor	Minor	Minor	Minor	Minor	Yes
Land Requirements	None	None	None	None	None	None
Construction Costs (Millions)	$ 4.1	$ 0.7	$ 1.0	$ 1.9	$ 0.6	$ 0.0
Potential Cost Reduction for Phasing	$ 0.0	$ 0.0	$ 0.0	$ 0.0	$ 0.2 - 0.5	$ 0.0
O&M Costs (Thousands)	$ 103	$ 103	$ 103	$ 103	$ 103	$ 117

5.8 Proposed I&I Repair Project (Recommended I&I Repair Alternative)

Thorne Bay presents some unique challenges to addressing the I&I problem due to minimal City funding, multiple external funding alternatives, few maintenance personnel, and remote location. Therefore, the recommended alternative is Alternative 5 – Selective Repair and Investigation. This alternative allows the City the greatest flexibility to address immediate needs with its own staff or local contractors, while planning for larger projects that will require mobilization by specialty contractors from the lower 48.

This recommended alternative will also allow the City to take a phased approach to stopping I&I. Specific projects can be tailored to the amount of available funding. Thorne Bay's wastewater collection system has several obvious and significant I&I leaks that can be fixed first, maximizing the gallons stopped per dollar spent. Then the larger and more complicated I&I projects can be pursued as needed to keep I&I under control and covered by funding.

The Recommended Alternative, Alternative 5, consists of six parts that the City can use as a *"tool box"* to operate and maintain their wastewater system. These six parts include; investigate major I&I sources, manhole reconstruction, grouting equipment procurement, WWTP study, manhole grouting, and selective mainline grouting. See Section 5.6.5 for a complete description of Alternative 5.

Total Project Cost Estimate

The recommended alternative, Alternative 5, is a combination of six "tool box" items that can be completed individually, or as a combination of two or more separate pieces as funding becomes available. Project costs include design, construction inspection, and administration. Estimated project cost for Thorne Bay's I&I remediation projects are as follows:

- Construction: $667,851
- Non-Construction: $468,488
- Annual O&M: $103,000

Detailed cost estimates are included in Appendix E.

Annual Operating Budget:

The Thorne Bay Sewer Enterprise fund collects fees for using the wastewater system. The number of users paying fees varies from month to month and year to year. Wastewater invoicing for June 2010 included the following number of accounts; 143 Residential, 14 Senior Residential, 30 Commercial, and 4 RV Dump Station users. Island Septic and Tyler Rental fees are collected on a pay-per-use basis. Wastewater fees are $30 per month for commercial and residential accounts, Senior Citizen accounts receive a 50 percent discount of $15 per month, and an RV dump station pays $5 per month. The City has approved a 20 percent rate increase to $36/month, which is expected to increase revenues by $15,000. This will reduce the amount of subsidy required from the City's general fund.

The recommended alternative will reduce the O&M costs for the lift stations and WWTP. The remaining items in the wastewater operating budget are fixed and will be little affected by the recommended alternative. The revisions to the annual operating budget for the wastewater system after completion of the recommended lift station repairs, which are detailed in Section 6, are shown in Table 28.

Table 28 - Estimated Operating Budget after Lift Station Repairs

Description	FY10	FY11	Proposed
Income			
Miscellaneous Income	$40.00	$40.00	$40.00
Sales Tax	$2,420.00	$2,420.00	$2,420.00
Sewer Fees	$60,500.00	$75,500.00	$75,500.00
Total Income	$62,960.00	$77,960.00	$77,960.00
Expenses			
Building/Ground Maintenance and Repair	$0.00	$500.00	$500.00
Chemicals	$1,000.00	$500.00	$500.00
Contract Labor	$0.00	$10,130.00	$0.00
Dues, Subscriptions Licenses	$900.00	$1,100.00	$1,100.00
Electricity	$19,000.00	$22,000.00	$18,000.00
Equipment Maintenance and Repair	$3,000.00	$2,000.00	$2,000.00
Equipment Purchase	$15,000.00	$10,000.00	$0.00
Health Insurance	$6,468.36	$7,115.22	$7,115.22
Heating Fuel	$4,000.00	$5,500.00	$5,500.00
Insurance (AMLJIA)	$803.00	$2,250.00	$2,250.00
Internet Service Fees	$600.00	$600.00	$600.00
Materials and Supplies	$2,000.00	$3,500.00	$3,500.00

Description	FY10	FY11	Proposed
Payroll Expenses	$37,822.96	$38,729.60	$38,729.60
Payroll Taxes	$983.39	$1,123.16	$1,123.16
PERS	$8,301.26	$8,520.51	$8,520.51
Postage and Freight	$1,500.00	$2,000.00	$2,000.00
Telephone	$360.00	$360.00	$360.00
Testing	$7,000.00	$7,000.00	$7,000.00
Training	$50.00	$100.00	$100.00
Vehicle Fuel	$1,500.00	$1,500.00	$1,500.00
Vehicle Maintenance and Repair	$500.00	$500.00	$500.00
Worker's Compensation	$6,468.36	$2,270.95	$2,270.95
Total Expense	$117,257.33	$126,799.44	$102,669.44
Net Ordinary Income	($54,297.33)	($48,839.44)	($24,709.44)

The Thorne Bay Sewer Enterprise fund does not have Debt Repayments, Debt Service Reserves, or Asset Reserves.

5.9 Conclusion and Recommendations

Excessive flows of I&I are entering Thorne Bay's wastewater collection system increasing O&M costs and threatening public health by discharging inadequately treated wastewater into Thorne Bay. The City should use the Preferred Alternative presented in Section 5.6.5 as their "tool box" to address I&I entering the wastewater collection system. The projects described in the preferred Alternative could be completed one at a time or if funding becomes available, as a couple of large projects.

One project phasing plan that is logical and would be a prudent use of public funds would include;

- Phase 1 - Investigate Major I&I sources, Grouting Equipment Procurement and half of the manhole reconstruction project. City Staff can perform all of Phase 1 work. Estimated total project cost of $311,118.
- Phase 2 - WWTP Study, performed by engineering consultant, and remaining manhole reconstruction project performed by a local contractor, estimated total project cost of $428,385.
- Phase 3 - Manhole Grouting and Mainline Grouting performed by specialty contractor. Estimated total project cost of $396,837.

State records indicate that the Thorne Bay wastewater collection and wastewater treatment systems are Class 1 systems. Improvements included in the Preferred Alternative will not result in a change of system classification and associated operator certification requirements. However, the WWTP is just two points away from being listed as a Class 2 system. Implementation of any changes recommended by the WWTP study is likely to bump it to a Class 2 system, which would require the City to upgrade their operators' certifications for the WWTP.

5.10 I&I Improvements, Implementation, and Finance Plan

Funding of the recommended wastewater collection improvements will require a combination of local, state, and federal funding sources. There is not a single state or federal agency that will fund 100 percent of the project needs in Thorne Bay. Prior to seeking any outside funding, the City needs to ensure that local operations and matching funds are in good order. The City will also need to develop overall prioritization between the various utility and other community projects.

There are numerous state and federal agencies that routinely fund waste water treatment projects in Alaska. Most outside funding agencies have strong public health components as their program focus. Wastewater improvement projects match these program focuses. Section 8 discusses overall project prioritization and funding opportunities in greater detail and has identified the following opportunities as good or excellent matches for the wastewater collection improvements:

- VSW or MMG
- USDA-RUS
- Legislative and/or Congressional appropriations
- USFS
- Denali Commission
- EPA

Additional state and federal grant programs with a detailed outline and funding suitability matrix are provided in Section 8, along with a discussion of strategies related to funding.

6 LIFT STATION IMPROVEMENTS

6.1 General

The City of Thorne Bay uses a number of sewage lift stations to pump collected wastewater from the community to the WWTP. The existing lift stations were constructed between 1988 and 1992. At the time they were generally adequate for the City's needs. However, at the present time the mechanical and electrical control systems have exceed their serviceable life. The City experiences regular component failure and it is difficult to service and operate the lift stations. Rehabilitation of the mechanical and electrical control systems is required at this time, along with a variety of other improvements appropriate to reduce operational costs.

6.2 Existing Lift Station Facilities

There are five lift stations in Thorne Bay. The following sections describe the facilities. It should be noted that there is little consistency between the facilities, which increases operational difficulty and is also likely to increase the cost of rehabilitation. Locations of the lift stations are show on Figures 7 and 8.

6.2.1 Lift Station No. 1 (LS#1) – Shore Line Drive

LS#1 is believed to have been originally constructed in 1988, but was replaced in 1992 with a larger system. This lift station takes flow from LS#2 and nearby Rainy Lane and pumps it directly to the WWTP. LS#1 is located towards the eastern limits of the City, on Shore Line Drive. It receives all wastewater flow from throughout Thorne Bay, and is a critical system. It includes the following:

- An 8-inch gravity sewer influent pipe, and a 6-inch sewer forcemain from LS#2
- A 6-inch sewer forcemain discharge to the WWTP.
- Overflow pipe with Tide-Flex valve to the mouth of Deer Creek. It is unclear (and unlikely) if this bypass straight to the ocean is permitted, even though it was original construction.
- A 6-foot inside diameter concrete wetwell, approximately 15 feet deep, flush with surrounding grade.
- Two 10hp, 480V 3 phase pumps. Specific pump flow is unknown, however the model of pump installed would be expected to produce approximately 400 gpm.
- Junction boxes for removal and replacement of pumps and controls are located inside the wet well, where they are difficult and unsafe to access. Consequently, rather than using proper splices inside the junction box, electric cords are cut and spliced outside the box where they are exposed to the humid environment.
- Control panel manufactured by Control Craft Industrial Panel Fabrications, Anchorage, Alaska, located inside a Hoffman NEMA 4X rated enclosure. The controls use a float system. The controls appeared to be in relatively good condition, compared to the other locations, probably because this panel has a heater. However, replacement parts for this panel are not readily available, and it is also likely the control panel is not compliant with current safety codes for wastewater pumping systems, as it did not appear to have intrinsically safe sensor circuits.
- Underground 3-phase, 480 V power service from a nearby power pole with a separate meter and 100 Amp, circuit breaker disconnect.
- There is no provision for an alarm system. The red beacon light on this panel was not an alarm light, but rather turned on to indicate a pump was running. This has been disabled because residents would regularly phone in this *"alarm."*
- A white indicator light intended to indicate actual alarm conditions has also been disconnected. This is an unusual alarm scheme, as typically a single red light is used to indicate an alarm (not a white light).

LS#1

Unusable Junction Boxes in Wet Well.

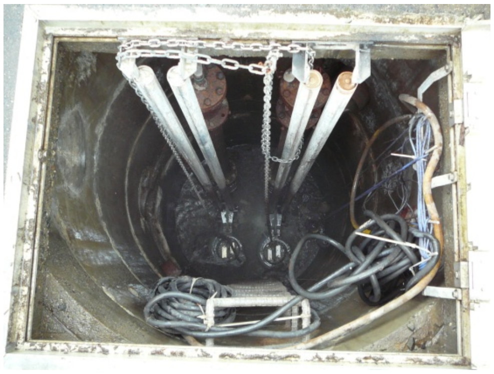
During the week of March 8, 2010, LS#1 experienced severe piping failures. The effluent discharge pipe from one of the pumps separated at an underground connection prior to the wye connection to the second pump. Further compounding the failure, an isolation valve on the sewer forcemain that would have allowed the second pump to remain in use was substantially rusted and inoperable. The failure resulted in discharge of raw wastewater to Thorne Bay. To address this issue and resulting discharge violation, City staff excavated to expose the area and repair the faulty connection. The piping failure is thought to be due to settlement of the lift station, and torque on the pipes that occurred last year when a pump impeller failed.

6.2.2 Lift Station No. 2 (LS#2) – Svend's Drive South and Shore Line Drive

LS#2 is believed to have been constructed in 1988 and takes flow from the majority of Thorne Bay, pumping it to LS#1. The lift station is located at Shore Line Drive and Svend's Drive South, and includes the following:

- Two 8-inch gravity sewer influent pipes, one of which receives flow from the 4-inch LS#4 sewer forcemain.
- A 6-inch sewer forcemain discharge to LS#1.
- Overflow pipe with Tide-Flex valve to Thorne Bay. It is unclear (and unlikely) if this bypass straight to the ocean is permitted, even though it was original construction.
- A 5-foot inside diameter concrete wetwell, approximately 14 feet deep, flush with surrounding grade.
- Underground 3-phase, 480 V power service from a nearby power pole with a separate meter and a 100-Amp, 3-pole circuit breaker disconnect. This service seems to have been an upgrade, and another meter possibly for a previous service connection has been abandoned in place on the control panel enclosure.
- Two 5 hp, 480 V 3 phase pumps. Specific pump flow is unknown, however the model of pump installed would be expected to produce approximately 300 gpm.
- Junction boxes for removal and replacement of pumps and controls are located inside the wet well, where they are difficult and unsafe to access. Consequently, rather than using proper splices inside the junction box, electric cords are cut and spliced outside the box, where they are exposed to the humid environment.

LS#2



Wet well with tangled, spliced cords due to lack of usable junction box.

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Control panel showing corrosion on exposed terminals, missing components, modifications.

- The control panel was manufactured by Flygt Corporation using a float system. The controls appeared to be in relatively poor condition, and there are signs of corrosion on the cabinet and control wiring. This panel has no heater to prevent condensation. There is considerable evidence this panel has been modified and repaired multiple times. There is unlabeled wiring and mismatched components, as well as non-functional or missing indicator lights. While this panel does have proper intrinsically safe control circuits, the hardware is definitely dated.
- LS#2 had two indicator lights installed on top of the lift-station enclosure. A red light was ON during the site-visit, and indicated that one of the pumps was operating. During the site visit it was determined that the control for the pump had some faulty float sensors that activated the pump even though there was not much flow through it. A white light is located next to the red light to indicate any alarm condition at the lift-station, however there is no provision for an alarm dialer or other remote alarm annunciator. This is an unusual alarm scheme, as typically a single red light is used to indicate an alarm (not a white light).

As discussed in Section 5, LS#2 receives a large quantity of I&I from the wastewater collection system upstream on Svend's Drive, Cedar Lane, Freeman Drive, Sandy Beach Road, and the USFS complex.

6.2.3 Lift Station No. 3 (LS#3) – Wolverine Court

LS#3 was constructed in 1992 to serve the residential area of Wolverine Court, reportedly using equipment salvaged from the original LS#1. This lift station is located at Wolverine Court and consists of the following:

- One 8-inch influent pipe from nearby Wolverine Court residences, one 8-inch influent pipe from the east section of Rainy Lane, and a 4-inch forcemain discharge to the gravity sewer to the west section of Rainy Lane.
- A 4.5-foot diameter concrete wetwell, about 11 feet deep, flush with ground.
- Two 3 hp, 480 V pumps. Specific pump flow is unknown, however the model of pump installed would be expected to produce approximately 150 gpm.
- Underground 3-phase, 480 V power service from a nearby power pole, with a separate meter and a 100-Amp, 3-pole circuit breaker disconnect.
- There is a Flygt Corporation manufactured F3000 type control panel for this lift station similar to that in use on LS#2. However, whereas the LS#2 panel appears to have been modified, LS#3 appears to be largely original equipment. There are signs of corrosion on the cabinet and control wiring. This panel has no heater to prevent condensation, and is lacking intrinsically safe control barriers required by current code. This panel would be hard to service, and because of its age, the reliability is suspect.
- LS#3 also had two indicator lights installed on top of the lift-station enclosure. A red light was ON during the site-visit, and indicated that one of the pumps in the lift-station was operating. A white light is located next to the red light to indicate any alarm condition at the lift-station. This is an unusual alarm scheme, as typically a single red light is used to indicate an alarm (not a white light). There are no provisions for an auto-dialer or other remote alarm.

LS#3

Control Panel with deteriorating components and wiring, corrosion on exposed terminals.

6.2.4 Lift Station No. 4 (LS#4) Business Loop Drive

LS#4 was constructed in or about 1991 to serve the businesses along Shore Line Drive and take flow from the uphill trailer court. The lift station is located on Shore Line Drive adjacent to Business Loop. Record documents for this location are sketchy, and largely state that LS#4 has pumps identical to LS#3. LS#4 appears to include:

- A single 8-inch influent pipe from nearby residences and a 4-inch forcemain discharge that flows to LS#2.
- Concrete wet well, unknown size or depth.
- Two 3hp, 480V pumps 3-phase pumps similar to LS#3.
- Underground 3-phase, 480 V power service from a nearby power pole with a separate meter and a 100-Amp, 3-pole circuit breaker disconnect.

- A control panel manufactured by Control Craft Industrial Panel Fabrications, Anchorage, Alaska, located inside a stainless steel Hoffman NEMA 4X rated enclosure. This cabinet has a heater to prevent condensation, and is probably in the best condition of LS#1 through LS#4. Even so, the wireway covers had been removed in the panel, suggesting recent need to troubleshoot and repair the panel. It appears that it has been necessary to replace the control floats at this location several times.
- This lift station also had two indicator lights installed on top of the lift station enclosure. A red colored light to indicate operation of the lift station, and an amber colored light to indicate any alarm condition at the lift station. This is an unusual alarm scheme, as typically a single red light is used to indicate an alarm (not an amber light).

LS#4

Control panel showing evidence of rewiring or troubleshooting.

Exposed splices in wet well due to lack of junction box.

6.2.5 Lift Station No. 5 (LS#5) Harbor

LS#5 is the newest lift station in town and was constructed in 2008 to serve the public restroom and shower facilities at the harbor. The lift station is located along Shore Line Drive, and is practically new. It includes the following:

- Single influent pipe from restroom facility
- Fiberglass wet well, relatively shallow, with an external fiberglass junction box
- Two 0.5 hp, pumps running on 3-phase power derived from a VFD controller, most likely at 230 V.
- Overhead 1-phase, 240 V power service from meter serving the restroom facilities with a 100-Amp, 2-pole circuit breaker disconnect.

- Control panel manufactured by Flygt Company located inside a Hoffman NEMA 4X rated enclosure, using the MultiTrode level sensor stick. While the level sensor is generally a 10-step device, in this control panel, the stick is hardwired for only three positions, and is not intended to be adjustable.
- There was one red light located on top of the control panel enclosure to indicate a possible alarm at the control panel, but no provisions for autodialer or other alarms.

LS#5 and control panel is well built and in good condition; it is not expected to require any major service or replacement.

LS#5 showing easy access junction box

Modern control panel with heater.

6.3 Investigation and Findings

The existing lift stations appear to be suitably sized for the City of Thorne Bay wastewater flows, and no problems were reported related to lift station capacity, or with the pumps themselves. However it is apparent that the control systems are rapidly reaching the end of their useful life, and continued reliability is a major concern. A number of items were also identified that make regular maintenance and operations generally difficult, impossible, or in some cases unsafe. The identified deficiencies include:

- Control panels have reached the end of their useful life, and are no longer maintainable.
- Each of the five lift stations in town has a different control panel configuration. LS#2 and LS#3 were originally of similar construction, but this is no longer true after various modifications and service efforts. The rest of the control panels are completely different. Not only does this make them difficult to service, it makes it difficult to train operators.
- The control panels in some cases have been modified during various attempts at maintenance, and this has likely voided the required UL listing on these panels. This may be a safety concern.
- Some of the control panels do not have intrinsically safe control circuits currently required in wastewater lift stations to reduce explosion hazards.
- Some of the control panels lack cabinet heaters, which prevent condensation and related internal moisture damage/corrosion of the controls.
- None of the lift stations has a transfer switch or other means of connecting a portable generator to power the lift station and prevent wastewater spills and discharge violations during extended power outages.
- While all of the lift stations appeared to have main disconnects, the style varied. Also, one or more of the locations had a very old style of fuse block disconnect; this style results in exposed terminals at high voltage levels when the fuse block is removed, whereas a modern “safety switch disconnect” is completely enclosed.

- Controls lack effective trouble alarms. Some of the locations had lights; however, the lights mean different things at each location and are non-standard. No location had a phone dialer or other remote alarm. No audio alarms were noted.
- Existing controls do not have run time meters, and there is no way to identify time in use, number of pumping cycles, or to estimate volumes pumped or efficiency.
- Electrical junction boxes in the lift stations are inaccessible, or otherwise too difficult to use. As a result, wiring splices have been made outside of the boxes, and simply taped over. This is unreliable and probably unsafe.
- Four of the five lift stations are using float switches for level control. Floats are acceptable and generally work, however they are subject to fouling. There are more reliable systems available for mainline lift stations.
- The piping in the lift stations is in uncertain condition, but it is known that the isolation valves are corroded and generally not functional; some piping and fittings have failed in recent months; and the check valves are either buried or not readily accessible for service and are likely failed at some locations. The lack of usable valves makes it very difficult to maintain pumping operations should one of the pumps fail and need to be replaced.
- Forcemains do not appear to have cleanouts or provisions for bypass pumping if the lift station was to fail.
- The wet wells do not appear to have vent pipes. The wastewater in a lift station may remain in the wet well for a period of hours, becoming septic. A vent is recommended to reduce the tendency for the associated gases to migrate into the rest of the distribution system.
- The lift stations lids are flush with grade. In some locations, this allows surface runoff to pool over the lids, contributing to inflow. At all locations this results in an open, unguarded fall hazard when the lid is open for maintenance; it is all too easy for the operator to accidently step into or slip around the open lid.

Replacement of the lift station controls and other overall lift station improvements are justified at this time. Alternatives for the rehabilitation are discussed in the following section.

6.4 Lift Station Alternatives

Complete replacement of the existing lift stations appears to be unnecessary, as the existing concrete wet wells are in good condition, did not appear to be obviously leaking or failing structurally, and appeared to have indefinite life remaining. This is good news, as the installation of a wet well structure, with associated excavation, dewatering, and site restoration can be upwards of $30-50,000. It should be possible to rehabilitate the existing lift stations, reusing the wet well. Alternatives for rehabilitation are developed in the following sections.

6.4.1 Replacement of Mechanical Systems

New lift station pumps, discharge bases, discharge piping, check valves, isolation valves, and replacement of the connection to the existing forcemain would substantially increase the reliability of the lift stations. It would also address the recent issue of buried pipe connections failing; the current generation of wastewater pumps is also more efficient than the outdated existing equipment. Equipment and parts inventories would also be standardized.

For purposes of durability, ductile iron piping with mortar lining and epoxy coated exterior is recommended. Ball style check valves should be provided within the wet well. New isolation valves should be provided, either in the wet well, or more preferably buried in valve boxes outside of the wet well. A cleanout should also be installed on the existing forcemain. This is useful for forcemain flushing, but also allows for very easy bypass pumping during construction, or for future lift station service.

The replacements listed here would provide a like-new mechanical system for approximately $75,000 per location. Plans should also include allowances for bypass pumping at approximately $60,000. The work is expensive because it requires work in confined spaces and excavation of existing piping; however, the result is a long term reduction in maintenance requirements, ease of operations, and electrical costs.

Note that the City's existing wastewater pumps are of various ages and conditions. While it would be best to provide a completely new mechanical installation, some of these pumps are still serviceable and could be considered for reuse (rather than replacement) on a case by case basis, equating to potential savings in the $5-$10,000 range per location. These parts could also be salvaged for use as spares.

6.4.2 Replacement of Control Systems

Replacement of the existing controls is essential to both the reliability of the lift stations, and to the ability to maintain and repair the controls. For reasons of compatibility, ease of maintenance, reduction in parts inventory, simplicity in operation, and overall cost reduction, standardization of controls is highly desirable.

Selection of a control system is not necessarily a straight forward proposition. A variety of controls are available, and most work well in their intended applications. Three general classes of controls are available for this project:

- **SCADA Based:** SCADA controls use a PLC at the lift station in conjunction with a communications network and headend computer to provide fully configurable digital and analog controls of any desired equipment. While the control panel uses standardized component modules, the design is purpose built to each customer's individual needs, and any variety of user interfaces can be provided; including GUIs, which are very popular, robust, and intuitive to use. SCADA hardware is usually easy to install and can be designed to control anything; the difficulty lies in developing and configuring the software systems. This usually requires a skilled, trained integrator. However, once it is programmed, the GUI interfaces are very easy to use. Note that one SCADA headend computer can generally be used for multiple functions, for example the water plant control and monitoring system and the lift station monitoring system can reside on one computer. For a smaller utility, this is a very cost effective configuration.

- **Dedicated Pump Controls:** A dedicated pump control is a PLC based control with a purpose made, pre-developed program written directly into the controller. The user can readily select from program options, but cannot modify the built in program. Thus, they are easy to set up and use, and usually do what they do well, but are unable do anything more. They provide many of the advantages of the full SCADA controls, including a good assortment of remote telemetry and SCADA control features without the need for programming or development. They do not offer the flexibility of a true PLC SCADA, but they also generally do not require computer experience to use. This type of system is among the most popular choices for municipal utility pump stations. A sample of three popular varieties of dedicated pump controllers in use throughout Alaska is included in Appendix D. The MultiSmart MTDPC controller is very sophisticated and provides enhanced pump protection and flow calculating, easy integration to alarm systems or SCADA, and can be used with both a pressure transducer and MultiTrode probe simultaneously for level control backup. The MTDPC is a basic controller used with a probe that is suitable for most lift stations, although the display and functions are not particularly easy to set up or alter. The Siemens LC 150 is extremely easy to use, with a pressure transducer, but offers little telemetry capability.

- **Analog Controls:** Analog controls typically use float switches and relays for direct on/off control of pumps. The City is familiar with these units, as this is the style of control currently used with floats on LS#1, LS#2, LS#3, and LS#4. The LS#5 controls are also analog; however, the floats have been replaced with the MultiTrode "Probe" sensor implemented in an analog manner (the Probe was originally intended for use with a PLC dedicated pump controller as described above). These panels are robust, but provide almost nothing in the way of user adjustment, and integration with SCADA and communications systems is difficult and limited. They can be used for municipal applications, but due to the lack of telemetry, most utilities are migrating away from this style of control.

It is recommended that all of the control systems be provided with some means of remote monitoring and alarm reporting. For SCADA systems, this is done with a phone or radio based telemetry network. This also works well for the dedicated controllers. Alarm reporting phone dialer hardware is also readily available and can be used for both the dedicated controllers and the analog controls. Hybrid systems using dedicated local controls, all reporting to a single SCADA headend computer, are very popular. This provides a dedicated standalone, local control, with the means to easily monitor the system from a single location. These systems also integrate easily with the Internet, allowing monitoring of systems from anywhere.

An additional consideration is the type of level sensor to be used in the wet well. There are several different devices in use; however, the following three are common in Alaska for mainline lift stations:

- **Floats:** Conventional tilting float switches are simple to use, and inexpensive. They are also prone to fouling in some locations, and cannot report actual depth of wet well.

- **Submersible Pressure Transducer:** This is a pressure sensor sitting on the bottom of the wet well, which is below the scum line, and thus is not subject to fouling. Pressure transducers have high resolution (better than 1-inch) and accuracy. They are used with more advanced control systems because they allow for accurate computation and tracking of both inflow into the lift station, and rate of pumping (in addition to basic on/ off control of the pumps). This is a very useful function, as it can provide volume data by lift station, allowing for various types of water and wastewater system flow analysis. Tracking the rate of pumping in this manner allows the "health" of the pumps to be monitored, as the rate of pumping will decline as the pump wears.

- **MultiTrode Probe (Probe):** This proprietary device detects electrical current flowing between metal plates on the probe and the water in the lift station. The Probe is very reliable, and not normally susceptible to fouling. The primary drawback to the probe is the lack of range and resolution. The Probes are generally limited to 10 steps, equally spaced over the length of the Probe shaft. For a deeper lift station, such as LS#2, a 10-foot long Probe would be required to cover the wet well from base to the height of the overflow pipe; this would place the sensing intervals 1-foot apart. This is often acceptable for basic on/off control, but limits accuracy if flow monitoring is being provided.

Regardless of the type of sensor selected, it is recommended that an alternate backup device be included for high level alarm, and for redundant on/off in the event the primary sensor fails. For floats, this is done with more floats. For a pressure transducer, this can be floats or a Probe; for the Probe, this can also be floats or a second Probe.

Control prices vary with sophistication and capabilities. As an example, installation of a MultiSmart based control system with a SCADA connection is expected to cost approximately $30,000 per location; including the control panel, installation and setup, control panel shelters and wet well sensors, whereas an analog control system similar to LS#5 with the recommended alarm dialer would likely be about half of that price.

Selection of a control system is a major consideration, as it sets the course for all future utility development in the City. After review of the control narratives and the product data provided, USKH can work with the City to select a system based upon the City's needs, desired operations and features, and future expectations.

6.4.3 Electrical Upgrades

Alternatives for lift station electrical upgrades include the following:

- **Replacement of Electric Switchgear:** This will include new fusible disconnect switches, a manual transfer switch, and a receptacle for a portable generator. This will improve the reliability of the power supply to the lift stations, enhance safety, and provide a means to power the lift station during service outages; thus avoiding unpermitted wastewater discharges.

- **Exterior Wet Well Junction Boxes:** Provide explosion proof junction boxes for pump power cords, and a weather tight (NEMA 4X) junction box for intrinsically safe control circuits. Junction boxes near the wet well are required for 1) installation of wiring, and 2) splicing of circuits during original or replacement installations. However, for ease of access, it is best if they are placed immediately outside of the wet well, where they can be safely and easily accessed. This encourages proper splicing practice inside the J box. For lift stations of this size the J boxes do not need to be large. A 6-inch diameter round box is sufficient on each of the two pumps, and an 8-inch by 12-inch box is sufficient for the controls.

- **Cable Plugs:** The removal and replacement of the pumps can be greatly eased, and the need for cutting or splicing of pump cables all but eliminated by providing explosion proof, interlocking cord plugs on the pump motor cables. Suitable waterproof, explosion proof cord plugs with UL approvals and the required number of pins have become available in recent years; one variety is the Russell Stoll series of plugs by Thomas Betts (see product data provided in Appendix D). This style of plug is recommended on all motor cables, as they allow the pump to be simply "unplugged" for removal, as if it was on an extension cord. Similar plugs are available for use with the control cables; however, control plugs with a sufficient number of pins are not currently UL approved. Therefore, for control cables, terminal strips are provide in the exterior junction boxes.

Estimated cost for the electrical improvements discussed here is approximately $40,000 per lift station location, including all underground and wet well wiring, and new switchgear, provided this work is combined with the control panel upgrades.

6.4.4 Structural Improvements

The existing concrete wet wells appear to be in good condition and do not require any major rehabilitation other than cleaning and patching of any surface defects or groundwater leaks that may be present (note these were obvious from the surface). However, two alternatives are worth considering:

- **Raising Lift Station Lids:** At present, the lids are flush with surrounding grade. This allows surface water to leak into the lid, presents a fall hazard when the lids are open, and also makes it possible for other debris such as stones or twigs on the ground surface to be easily kicked in. Raising the lid would be a relatively simple matter of adding a precast extension and pouring a new lid. A height of 18 to 30 inches above grade is enough to prevent water and soil from entering the wet well, and this increases worker safety. It also provides a knee height "work bench" for maintenance of the pumps and wet well equipment, and allows the junction boxes to be placed above ground, further improving access.

- **Replacement of Hatches:** Regardless of whether or not the lid is raised, the existing hatches should be replaced with a hatch that incorporates fall protection. One example is the Flygt Safe Hatch, which includes a safety grate, (see product data provided in Appendix D). In a typical configuration, the wet well is protected by a metal grate, allowing for inspection through the grate. When the grate is opened, the hole is covered on two or more sides by the open panels, forming guardrails. As an added benefit, pumps may be lifted clear of the wet well, and set on the grate panel and hosed down into the wet well.

The structural improvements discussed here are expected to cost approximately $30,000 per location including demolition of existing lids.

6.5 Recommended Lift Station Solution

It is recommended that the mechanical, control, electrical, and control improvements developed here be constructed for LS#1, LS#2, LS#3, and LS#4 in the relatively near future in address the identified deficiencies, to reduce operational and maintenance difficulty, and in order to prevent any additional releases of untreated wastewater to Thorne Bay. The projected project cost for these four sites is shown in the table below. The prices shown are estimates based upon bid prices received for a similar project in North Pole, Alaska in 2009. Those lift stations included VFDs in the control panels, which are not necessary here; and so the control panel prices have been reduced accordingly. These prices, by virtue of being construction bids, include overhead and profit. Force account construction would be less expensive; however, some of the work such as wiring and control integration would still need to be subcontracted to qualified trades.

Construction prices will be the best, and the results more uniform, if all four locations can be constructed as a single project. This is particularly true of the control improvements. However, if construction funding precludes this, LS#2 should be given priority, followed by LS#1, LS#3, and finally LS#4. Likewise, the SCADA monitoring system is optional, although of considerable benefit. If SCADA is desired, the headend equipment should be established in the very first project. It is substantially easier to add lift stations to an existing SCADA headend one at a time, than it is to try and construct a SCADA network to monitor existing controls after the fact.

LS#5 does not appear to require any rehabilitation at this time, and is not included in these costs. Integrating this lift station into a SCADA network would be a comparatively minor cost, if desired.

Table 29 - Lift Station Projected Costs

Item	# of Sites	Project Cost
Mechanical Systems	4	$ 302,559
Control Systems	4	$ 131,364
Electrical Upgrades	4	$ 164,246
Structural Improvements	4	$ 119,546
SCADA Headend, Field Telemetry	NA1	$ 120,000
Total Program Cost		$ 837,715
Cost estimate details are provided in Appendix E		

6.6 Lift Station Implementation and Finance Plan

Funding of the recommended lift station improvements will require a combination of local, state, and federal funding sources. There is not a single state or federal agency that will fund 100 percent of the project needs in Thorne Bay. Prior to seeking any outside funding, the City needs to ensure that local operations and matching funds are in good order. The City will also need to develop overall prioritization between the various utility and other community projects.

Section 8 discusses overall project prioritization and funding opportunities in greater detail and has identified the following opportunities as good or excellent matches for the lift station improvements:

- MMG
- Legislative and/or Congressional appropriations
- USFS

Additional state and federal grant programs with detailed outline and funding suitability matrix are provided in Section 8, along with a discussion of strategies related to funding.

7 LANDFILL PLANNING

7.1 Existing Solid Waste Facilities

The City provides refuse collection services, a regional baler, a recycling facility, and landfill, and participates in annual hazardous waste disposal events.

Thorne Bay Baler Facility

The existing, fenced cell was constructed with the baler facility in 1994. According to the permit renewal application submitted in January 2006, closure of the landfill was anticipated in 2024. At this time Cell 1 is still in operation and has some capacity after over 14 years of operation.

Waste is baled on site at a compaction of 2,500 pounds per square inch. The resulting bales are 68 inches by 29 inches by 45 inches and weigh an average of 2,170 pounds. The average weight is based on bale weights in February 2010 as shown in Table 30. Based on landfill records (summarized in Appendix K) the landfill had placed 4,911 bales from its opening through the end of 2009.

Table 30 - February 2010 Bale Weights

Bale Weight (pounds)
2,280
2,260
2,110
2,030
2,150
2,150
2,270
2,110

The Thorne Bay landfill solid waste permit (SWPOW001199320103MA) issued by ADEC expires October 30, 2010. The City currently intends to seek renewal of the permit.

7.1.1 Survey

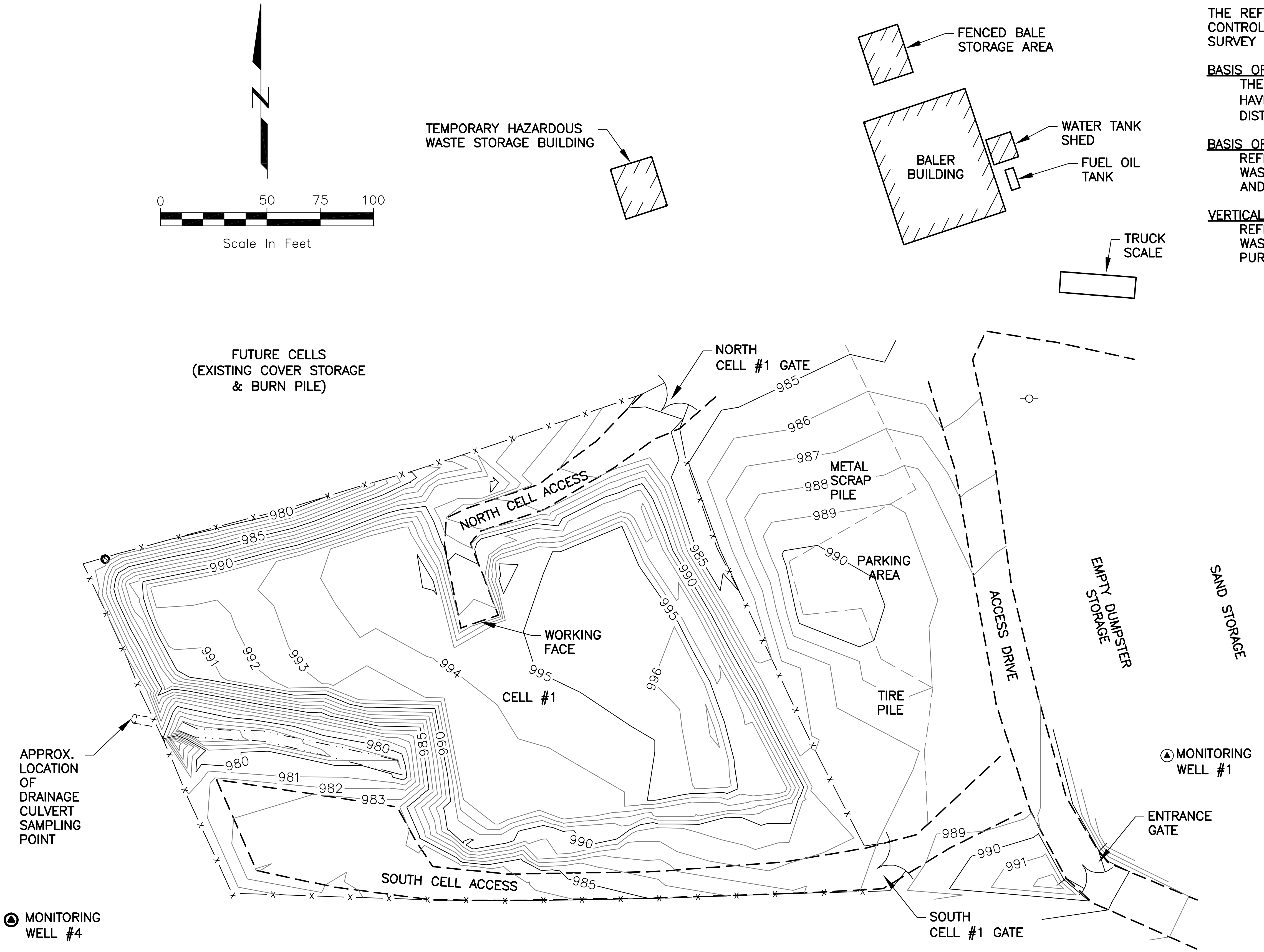
A topographic survey of the active landfill cell was performed in February 2010 by Templin Land Surveying. Information gathered was limited primarily to the elevations within the fence of the active cell. See Figure 10 for the current facility site plan.

THE REFERENCE MONUMENTS, LOCAL COORDINATES, AND VERTICAL CONTROL BELOW CORRESPOND TO THE ORIGINAL LANDFILL DESIGN SURVEY BY CRAIG TEMPLIN IN JAN. 1993.

BASIS OF BEARINGS:
THE REFERENCE MONUMENTS TO CORNER 1 OF ASLS NO. 92–158, HAVING A COMPUTED BEARING OF S 84°42'05" W AND A COMPUTED DISTANCE OF 163.00' WAS USED AS B.O.B. FOR THIS SURVEY.

BASIS OF COORDINATES:
REFERENCE MONUMENT 1 TO CORNER 1 OF ASLS NO. 92–158 WAS ASSIGNED A LOCAL COORDINATE OF: 5,000.00 FEET NORTH AND 5,000.00 FEET EAST.

VERTICAL CONTROL:
REFERENCE MONUMENT 1 TO CORNER 1 OF ASLS NO. 92–158 WAS ASSIGNED AN ASSUMED ELEVATION OF 1,000.00 FEET FOR PURPOSES OF THIS SURVEY.



MONUMENT #1

LEGEND

▲	MONITORING WELL
-○-	UTILITY POLE
o	4" PVC CASING
◆	SURVEY MONUMENT
——x——	FENCE
— — —	GRAVEL EDGE
— · · — · · —	GRADE BREAK
—992—	CONTOUR

USKH
SHARED VISION. UNIFIED APPROACH.

CITY of THORNE BAY
UTILITY IMPROVEMENTS STUDY

EXISTING LANDFILL SITE

July 2010

FIGURE 10

7.2 Need for Landfill Improvements

The City has been subsidizing solid waste operations for Thorne Bay residents, businesses, and surrounding communities since opening the processing facility in 1994. Between 1994 and 1999, the City contributed over $400,000 of general fund monies. Escalating expenses, aging infrastructure, and a stagnant customer base has resulted in escalation of the subsidy on an annual basis. Rates were adjusted and overhead and expenses reduced in December 2009 by reducing operational hours in an attempt to keep the subsidy to between $15,000 and $30,000 annually.

Table 31 - Landfill Operating Hours

Day	Schedule
Monday	Closed
Tuesday	In-town collection
Wednesday	Closed
Thursday	Public Hours 9 AM – 4 PM
Friday	Public Hours 9 AM – 4 PM
Alternating Saturday	Closed or Public Hours 9 AM – 4 PM
Sunday	Closed

Landfill space is always an issue. The City presently operates the only permitted landfill on POW, accepting waste from Thorne Bay and nearby communities (i.e.: Kasaan, Coffman Cove, Whale Pass, and Naukati).

With one active cell and room for two more, the remaining life at the landfill is a metric to be tracked carefully by the City. Determining the remaining capacity of the existing cell is the only task currently funded under the current project. This value will guide the ongoing development of plans for solid waste needs for both short- and long-term planning. The available space and corresponding time available before closure and when a new cell or solid waste alternative is required correspond with large expenses.

The survey as shown in Figure 10, indicates that the landfill has been developed with slopes of approaching 1:1 rather than the 2:1 shown on the record/design drawings (VSW, 1993) submitted with the permit application. These drawings likewise call for 6 inches of intermediate cover when bales are placed and a final cap of the following (top down):

- 2-4 feet of granular cover
- 1-foot of granular cover
- 60-mil impermeable membrane

According to Sandra Woods, ADEC Environmental Program Specialist (3/19/10, telephone conversation), the ADEC Solid Waste Program would like to see a maximum of 3:1 slopes and a final cover that is a total of 2 feet thick. The cover can include the 6 inches of interim cover being placed with the bales and should include at least 6 inches of topsoil and seed. The remaining material would preferably be clay or loam with a low permeability. A membrane is not required, although a reduced thickness might be approved if one is used.

The steep side slopes are a concern as they represent an ongoing maintenance issue – the City will be required to regrade the closed cell as it ages, materials settle, and the slopes slough. ADEC will not likely require changes to the slopes if it involves displacing waste as long as maintenance is conducted; however the slopes should be flattened to the extent possible.

7.2.1 Remaining Cell Capacity

Based on the contours shown in Figure 10, and an approximate finish grade elevation that assumes a minimum of 2 feet of cover is applied to the existing surface, and that a roughly rectangular top surface (215 feet by 130 feet) is created and sloped at 1-3 percent towards the west fence. A rough placement plan was created and from this it is estimated that 1,225 bales can still be placed in the existing cell.

Landfill records as summarized in Appendix K, indicate that between May 2004 and January 2010 the facility has averaged 28 bales a month. Without changes to this generation rate, the existing landfill cell can be expected to remain in service about 43 months or 3.5 years. With placement optimization, waste reduction programs, recycling, and other efforts this can likely be extended to at least 4 years; however during the final year, development of the new cell should be planned.

Bale Storage Area used for other storage.

Drainage trench in active cell

7.3 Landfill Alternatives

The City has reviewed a number of alternatives for addressing solid waste needs. While the development of these alternatives is outside the scope of this report, it is worth noting that the City has investigated, or is investigating the following alternatives:

- Extending the life of the existing cell or future facilities developed through the use of waste reduction, composting, and recycling programs; and alternative technologies such as waste-to-energy.
- Continued operation of the existing facility with the development of an additional cell.
- Developing a transfer facility in place of a solid waste disposal site and barging solid waste out of state (as is done in other POW island communities) or to a southeast regional landfill.
- Development of a regional landfill at the Tolstoi Port facility (discussed in Section 1.2.3). Initial site selection and investigation on a potential facility has been conducted and Thorne Bay has joined the SEASWA.

8 IMPLEMENTATION AND FINANCE PLAN

8.1 Indentified Projects and Priorities

Table 32 summarizes the recommendations provided in this report, not including those that are operational changes. These projects independently address the needs discussed in this report with the primary category addressed as indicated in the table. These are all high priority projects that can be conducted in any order with the following exceptions:

- System cleaning will require prior valve recovery and is most beneficial following the upgrade of the WTP.
- Pipe network modifications have been prioritized as discussed in Section 4.4. The three projects of highest priority are Shore Line Drive to Rainy Lane Main Extension; Scenic View Drive to Deer Creek Lane Main Extension; and Charlie Brown Street to Scenic View Drive Main Extension. The remaining water system extension projects are dependent on other developments as discussed.

Table 32 - Recommended Project Summary

Project Name	Project Description	Primary Need for Project	Total Project Cost
Water Treatment Plant (WTP) Improvements			
WTP Nanofiltration Upgrade	Installation of skid mounted nanofiltration membrane system with construction of 300-sf building expansion, including pilot testing and adding alkalinity and corrosion adjustment system	Public health, address NOVs	$1.1 million
WTP Automation	Provide SCADA system with PLC, alarm notification, VFD pumps, motorized valve operators, power monitoring and backup, flow metering, chlorine metering, and tank water level monitoring.	Sustainability and operations	$443,300
Water Distribution Improvements			
New Flushing Hydrant	Provide one new hydrant for fire protection and use in flushing program	Public health, maintenance of water quality	$13,300
Valve Recovery	Locating, mapping, bringing to grade, repaving, and initial exercising of approximately 45 valves	System sustainability and operations	$62,600
System Cleaning	Provide full system cleaning to remove biofilms in water mains with a combination of chloramines and pigging	Public health, maintenance of water quality	$1,065,300
Shore Line Dr. to Rainy Lane Main Extension	Provide 120 LF of 8-inch PVC water main	Public health, maintenance of water quality	$66,300
Scenic View Dr. to Deer Creek Lane Main Extension	Provide 300 LF of 6-inch PVC water main	Public health, maintenance of water quality	$129,200
Charlie Brown St. to Scenic View Dr. Main Extension	Provide 210 LF of 6-inch PVC water main	Public health, maintenance of water quality	$94,000
Shore Line Dr. to USFS Dr. Main Extension	Provide 750 LF of 8-inch PVC water main	Public health, maintenance of water quality	$294,700

Project Name	Project Description	Primary Need for Project	Total Project Cost
Greentree Federal Way Loop	Provide 3500 LF of 12-inch PVC water main to serve new subdivision and improve system circulation including pump station and two PRV vaults to create a new high pressure zone	Public health, maintenance of water quality	$3,514,100
USFS Dr. to Federal Way Main Extension	Provide 360 LF of 8-inch PVC water main	Public health, maintenance of water quality	$168,900
New Water Storage Tank (WST)	Provide a new WST (404,505-gallon) on a new site including site selection, design, site preparation, and excluding transmission main beyond 100 LF and land purchase	Address pressure and storage needs	$1,564,100
Lift Station Improvements			
Electrical Upgrades	Replace electrical switch gear, junction boxes, cables, and plugs on four existing lift stations	O&M	$220,000
Mechanical System Replacement	Replace pumps, valves, and piping on four existing lift stations	O&M	$400,000
Structural Improvements	Raise lids, install access hatches, and replace ladder rungs on four existing lift stations	Safety	$120,000
Control Systems Replacement	Replace controls, panels, and monitoring sensors on four existing lift stations	O&M	$200,000
SCADA Headend, Field Telemetry	SCADA system to monitor and operate equipment remotely.	O&M	$120,000
Wastewater Collection Improvements, I&I Repairs			
Investigate Major I&I Sources	Investigate I&I during wet weather to identify major sources of I&I and investigate USFS wastewater facilities	Address NOVs, O&M, energy reduction	$20,000
Manhole Reconstruction	Rebuild 40 manholes with structural deficiencies and repair leaks with gaskets and geomembrane wrap.	Safety, Public Health, O&M	$300,000
Grouting Equipment Procurement	Purchase grouting equipment for ongoing manhole maintenance program	O&M, address NOVs	$17,000
WWTP Study	Study WWTP for increased capacity or diverting peak wastewater flows.	Address NOVs	$200,000
Manhole Grouting	Grouting of 70 manholes	Address NOVs, O&M, energy reduction	$500,000
Selective Mainline Grouting	Grouting of 3,000 LF of mainline piping	Address NOVs, O&M, energy reduction	$500,000

8.2 Funding Sources

Any of the four potential project categories for the Thorne Bay Water Improvement Project will require a combination of local, state, and federal funding sources. There is not a single agency that can fund 100 percent of the project needs in the community. A tiered funding approach is critical.

State funds will require a local contribution and/or matching funds from the City. These local funds can be leveraged into state funding. The local and state funding can then be leveraged into additional federal funding. Prior to seeking any state and federal funding, the City needs to ensure the local operations and funding is in good order. State and federal funding agencies will scrutinize City operations prior to any capital funding.

A local funding match by state and federal agencies of between 10 and 40 percent of the total project cost could be required to fund the capital project. A common local contribution requirement is a 20 percent match of the project total. This 20 percent can often be a mix of funding and in-kind matching such as labor, equipment, and project management.

Before seeking external funding, the City needs to ensure that the rates are adequate for the operation of the utility. This does not necessarily mean that general fund subsidies are not included, but the utility rate model should include a capital accounts reserve fund. The state's Rural Utility Business Advisor (RUBA) program within the Division of Community and Regional Affairs (DCRA) is a good and free asset that can help with a review of the utility operations. The City has worked with RUBA in the past, and has accomplished many organizational and operational requirements for capital funding agencies. Prior to making capital applications, the City should contact RUBA to have an updated evaluation completed. An additional component to adequate and appropriate fiscal operations for the utility is a consistently high collection percentage for utility customer accounts. Thorne Bay currently has a utility collection rate greater than 95 percent (99 percent for FY09 reported by Dana Allison, 7/14/10).

State and federal agencies that fund water and sewer projects in rural Alaska have relatively focused areas that are eligible for funding. These focused areas typically involve correcting public health concerns. Projects that address and correct public health issues will be competitive in scoring for state and federal programs.

State and federal funding agencies do not typically fund projects that are considered ongoing O&M issues. O&M projects should be funded through local contributions and discretionary funding sources such as congressional and legislative appropriations. The program requirements for these funding sources are typically very broad.

8.2.1 Community Based Funding

Community Fundraising

Most state and federal funds require local contributions of either cost or in-kind support. These costs can range from 10 to 40 percent of the total project cost. The City may raise funds locally through numerous community based fundraising events. These activities can consist of local fundraisers (even bake sales). These activities are best run through non-profit or community interest groups from a funding community participation standpoint, as well as the ease of accounting.

- *Dates*: Ongoing
- *Critical Restrictions*: Funds must be accounted for through proper municipal accounting and Generally Accepted Accounting Principles (GAAP) and Government Accounting Standards Board (GASB).

City Reserve Accounts

An appropriate utility rate should include funding a contingency account that provides for unanticipated operational costs, as well as capital project matching. This fund needs to be compliant with the Regulatory Commission of Alaska (RCA) accounting and rate policies. RUBA is able to assist the City in determining and establishing the appropriate rate structure and accounting format.

- *Dates*: Ongoing
- *Critical Restrictions*: The accounting structure must be appropriate through RCA standards.

In-Kind

A critical component to any utility capital project will be in-kind contributions by the City. In-kind contributions may be contributed capital (cash), the use or purchase of project equipment, or City staff labor contributed to the project, or some combination of all three. The more in-kind contributions the City can provide the more competitive grant applications will be. The City should consider tracking capital improvements closely for possible use as in-kind contributions in the identified projects.

8.2.2 State Funding

State funding will be the source for the majority of funding for the water and sewer projects. There are several state grant programs that can be utilized.

Legislative

Legislative grants are direct funding appropriations from the Alaska legislature to communities. All phases of the Thorne Bay project could be included in a legislative grant.

- *Dates*: Discussion and application to Thorne Bay House Representative and Senator should be completed prior to session beginning in January.
- *Critical Restrictions:* Legislative grants are very flexible; however, the community needs to show the projects on the City's capital projects priorities list.
- *Source:* http://www.commerce.state.ak.us/dca/grt/grantsMenu.cfm

Village Safe Water (VSW)

VSW grants are the primary source of funding for small community water and sewer projects. This *Utility Improvements Study* is being funding in large part by the VSW, as were recent WTP upgrades. VSW utilizes a three year capital project priorities list. In addition to the three year list, VSW funds individual projects on a year-to-year basis using a competitive application process. Both the three year and year-to-year lists are amended each year to align the current program funding levels. Projects that are not in the three year priority list are eligible to compete for funding.

- *Dates*: Application dates vary each year. The VSW engineer assigned to Thorne Bay will be able to provide the application deadlines for each year.
- *Critical Restrictions*: VSW capital grants are focused heavily on community health indicators and projects that are providing water and sewer services to a community for the first time. For water systems the health indicators are measures indicating a human health risk, such as bacterial or chemical contaminants.
- *Source*: http://dec.alaska.gov/water/vsw/index.htm

Municipal Matching Grant (MMG)

The MMG is a grant program through the State Division of Water that provides partial funding to communities who are not eligible or applying for VSW funding.

- *Dates*: Applications are due at the end of February each year.
- *Critical restrictions*: There is a 15 percent community match for project funds. MMG and VSW funds cannot be combined.

- *Source*: http://dec.alaska.gov/water/MuniGrantsLoans/index.htm

Community Development Block Grant (CDBG)

The CDBG is a federal block grant that is provided to the state. The state then manages the distribution of funds to local communities for infrastructure development.

- *Dates*: Early December each year.
- *Critical Restrictions*: CDBG funds are competitive throughout the state. Projects should align with the CDBG mission to provide direct benefit to low and moderate income regions and provide for public health and safety. Thorne Bay currently qualifies as a low income region for CDBG.
- *Source:* http://www.commerce.state.ak.us/dca/grt/blockgrants.htm

8.2.3 Federal Programs

Congressional Appropriation

Congressional appropriations are often overlooked by small local governments in Alaska. This method is often used across the state for large projects; however, it is entirely appropriate to seek direct appropriations for small, critical components of a larger project.

- *Dates*: Ongoing.
- *Critical Restrictions*: Projects should be supported through various planning documents and capital project priorities list through the City.
- *Source*: http://murkowski.senate.gov/public/index.cfm?p=FederalGrants
- http://begich.senate.gov/public/index.cfm?p=FederalGrantFunding
- http://donyoung.house.gov/ConstituentServices/Grants.htm

American Reinvestment and Recovery Act (ARRA)

ARRA is federal legislation designed to promote employment through local funding of capital projects.

- *Dates*: Ongoing, funding currently through in 2011.
- *Critical Restrictions*: Projects must be construction ready and have permitting and environmental processes completed prior to ARRA funding applications.
- *Source*: http://omb.alaska.gov/10_omb/budget/IndexEconomicStimulus.htm

US Dept of Agriculture (USDA) Rural Development Service (RD)

The inflow and infiltration study portion of this *Utility Improvements Study* is being funding in large part by the USDA-RD, as is the associated Environmental Report (Appendix I). USDA-RD's program for utility projects is known as USDA-RUS. The majority of USDA-RD funds in Alaska are contracted directly from USDA to VSW and the Alaska Native Tribal Health Consortium (ANTHC). VSW and ANTHC then add state funds to the USDA funds and administer projects throughout the state. However, additional USDA-RD funds can be applied for directly from other national USDA-RD programs such as the community facility direct grants and rural community development initiative program.

- *Dates*: Ongoing

- *Critical Restrictions*: The national programs are primarily low interest long term loans. The interest rates may be as low as 1.75 percent and the loan term may be as long as 50 years. However, USDA-RD has made grant funds available to some communities as part of a grant/loan package.
- *Source:* http://www.rurdev.usda.gov/HCF_CF.html

USDA Natural Resource Conservation Service (NRCS)

NRCS focuses environmental issues and watershed programs. The watershed conservation program assists local communities in addressing issues of watershed conservation and enhancement.

- *Dates*: End of January each year
- *Critical restrictions*: Capital projects need to be tied with watershed issues such as inundation, pollution, impaired water bodies, or degradation of the watershed.
- *Source*: http://www.nrcs.usda.gov/

EPA Source Reduction Assistance

EPA awards grants supporting research, investigations, experiments, training, demonstrations, surveys, and studies. These awards are based on competitive applications.

- *Dates*: Varies depending on the EPA funding availability
- *Critical restrictions*: Capital projects need to be tied with watershed or source pollutant issues such as inundation, pollution, or impaired waterbodies.
- *Source:* http://www.epa.gov/p2/

US Forest Service

The USFS has limited grant funding programs for capital infrastructure projects of this nature; however, the USFS impact on the City infrastructure is substantial. The USFS ranger district has some discretionary funding mechanisms that can be budgeted within the USFS budget for small district specific projects. The USFS also has grant specific programs such as the Rural Community Assistance Program that address rural development on forestry dependent communities.

USFS District Specific Funding

- *Dates*: Ongoing. The City needs to engage the district ranger to discuss potential funding options
- *Critical Restrictions*: The USFS is subject to budget constraints.

USFS Rural Community Assistance Program

- *Dates*: Applications are due the first week of May.
- *Critical Restrictions*: The program is weighted heavy towards economic stimulus and projects that support or create jobs within the community.
- *Source*: http://www.fs.fed.us/r10/tongass/rca/index.shtml

Department of Commerce Economic Development Agency (EDA)

A little known federal agency for water and sewer projects, the EDA has a program for capital construction of public works projects that will lead to either employment or enhanced economic opportunity for the local community.

- *Date*: Ongoing
- *Critical Restrictions*: The region must be an EDA recognized economically distressed region (SE Alaska meets that criteria)
- *Source*: http://www.eda.gov/InvestmentsGrants/Investments.xml

8.3 Funding Matrix

The following matrix matches the funding sources outlined above with the recommended projects for the City. The grant programs are matched for alignment between the granting agency program requirements and the cost of the project. The rating system methodology is:

- Excellent: An excellent rating means the grant program is designed to fund the type of project being requested and the costs associated with the project are in line with grant funding availability.

- Good: A good rating means the project being requested is close to the overall goal of the grant program. There may be a few areas that are not in perfect alignment and may not score as high.

- Neutral: A neutral rating means the project is not outside of the scope of the grant; however, there may be areas within the project that do not fit the grant funding mission.

- Poor: A poor rating means there is a bad match between the mission of the grant requirements and the project being requested. Funding should not be actively sought for poor rated projects.

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Table 33 - Funding Suitability Matrix

Grant Program	MMG	VSW	Legis.	USDA-RUS	Congress	USDA-NRCS	Forest Service	Denali Comm.	EPA	EDA	CDBG
Water Treatment Plant (WTP) Improvements											
WTP Nanofiltration Upgrade	E	E	N	E	G	P	N	E	E	N	G
WTP Automation	G	N	G	N	G	P	P	N	N	G	G
Water Distribution Improvements											
New Flushing Hydrant	N	N	E	N	E	P	N	N	P	N	P
Valve Recovery	N	N	G	N	G	P	G	G	P	N	N
System Cleaning	N	N	E	N	E	P	E	P	G	G	P
Water Main Extensions	G	E	N	E	E	P	N	N	N	G	G
New Water Storage Tank (WST)	G	G	G	G	G	N	N	G	P	G	G
Lift Station Improvements											
Electrical	G	N	G	N	G	P	N	N	P	P	P
Structural and Mechanical	G	N	G	N	G	N	N	N	P	P	P
Control System Replacement	N	N	G	N	G	P	G	N	P	P	P
Waste Water Collection, I&I Repairs											
Investigate Major I&I Sources	N	N	P	N	E	P	E	P	P	P	P
Manhole Reconstruction	P	P	G	P	G	P	N	G	G	N	N
Procure Manhole Grouting Equipment	G	G	E	N	G	P	P	P	G	P	G
WWTP Study	G	E	E	E	E	N	N	G	G	P	P
Manhole Grouting	G	N	G	N	G	P	N	G	P	N	N
Selective Mainline Grouting	P	P	G	P	G	P	N	N	N	N	N
NOTES: E= excellent	G= Good N=Neutral		P=Poor								

8.4 Implementation Strategy

Given the extensive needs and the numerous utility projects, it will be important to prioritize and develop a funding sequence to fund the projects. Below is the recommended strategy and priority order the City can use to fund the utility projects. All of these items do not necessarily need to be completed sequentially; many of them may be performed concurrently.

1. Identify and implement any internal utility operations that can be improved such as utility rates, reserve account funding, and collection rates. Work with the RUBA program if needed.
2. Identify and utilize any specific community based funding sources, at a minimum this should establish base funds for matching.
3. Establish a capital project priorities list as required by the State Legislature.
4. Enter into discussions with the local USFS ranger district about system impacts and potential studies.
5. Open discussions with State House members, as well as Congressional and Senate representatives.

Based on the Funding Suitability Matrix (Table 32), the funding availability, and program alignment the top two or three funding sources for each project are listed in Table 33. Regardless of the project, community based in-kind funding will be a required component. In-kind funding is listed as a top funding source in those cases where the project is primarily O&M and may be difficult to fund under grant programs. Additional grouping strategies are discussed below.

Table 34 - Project Priority Funding Sources

Grant Program	Priority Funding Sources	Primary Need for Project
Water Treatment Plant (WTP) Improvements		
WTP Nanofiltration Upgrade	1. VSW 2. EPA 3. Denali Commission	Public health, address NOVs
WTP Automation	1. Legislature 2. Congress	System sustainability and operations
Water Distribution Improvements		
New Flushing Hydrant	1. Community in-kind 2. Legislature	Public health, maintenance of water quality
Valve Recovery	1. Community in-kind 2. Legislature	System sustainability and operations
System Cleaning	1. VSW 2. USFS 3. EPA	Public health, maintenance of water quality
Water Main Extensions	1. VSW 2. USDA 3. CDBG	Public health, maintenance of water quality
New Water Storage Tank (WST)	1. VSW 2. CDBG 3. Denali Commission	Address pressure and storage needs
Lift Station Improvements		
Electrical	1. Legislature 2. MMG 3. Congress	O&M

Grant Program	Priority Funding Sources	Primary Need for Project
Structural and Mechanical	1. Legislature 2. MMG 3. Congress	O&M and life-safety
Control System Replacement	1. Legislature 2. Congress 3. USFS	O&M
Waste Water Collection, I&I Repairs		
Investigate Major I&I Sources	1. USFS 2. Congress 2. USDA	Address NOVs, O&M, energy reduction
Manhole Reconstruction	1. Legislature 2. EPA 3. Denali Commission	Life-safety and health
Procure Manhole Grouting Equipment	1. Legislature 2. MMG 3. VSW	O&M, address NOVs
WWTP Study	1. VSW 2. USDA 3. Congress	Address NOVs and regulatory issues
Manhole Grouting	1. MMG 2. Legislature 3. Denali Commission	Address NOVs, O&M, energy reduction
Selective Mainline Grouting	1. Legislature 2. Congress	O&M

8.4.1 Project Grouping

Table 34 breaks down system wide improvements into individual projects. For the sake of grant applications and project funding; however grouping the individual projects into larger capital project applications is recommended as outlined below. This will require larger matching funds but allows multiple funding sources to be leveraged.

Water Treatment Plant (WTP) Improvements

Each project in this category should be treated as an individual project. The nanofiltration project is more suitable for capital funding than the WTP automation, thus the filtration project should be sought first. WTP automation can be difficult to fund because, while it improves process control and decreases operational costs it typically does not score as well for addressing direct health issues. Controls should be included in other projects and steps taken toward developing automation should be tracked as a possible in-kind contributions to the larger project. The caution here is that improvements made before full design of the nanofiltration system might ultimately become unnecessary and would also not count as an in-kind contribution.

Water Distribution Improvements

All of the mainline extension project should be grouped into two different project applications. The initial projects that should be grouped are the Shore Line Drive to Rainy Lane, Scenic View Drive to Deer Creek Lane, and Charlie Brown Street to Scenic View Drive. The remaining projects of Shore Line to USFS, Greentree Loop and USFS Drive to Federal Way should be grouped together as a secondary project once the priority extensions are funded and underway.

The new flushing hydrant, valve recovery, and system cleaning projects all have potential to be used as in-kind contributions to larger projects, or these projects could be grouped into a single project application. For example, system cleaning will be needed to address biofilm after the WTP upgrade is complete. Taken as a single project, City efforts on valve recovery and cleaning could then be used as in-kind to the WTP upgrades. Given the large labor cost associated with system cleaning, the cost of purchasing pigs and pumps for the cleaning may then be reasonable to include with the capital cost of the WTP upgrade.

The final project under water distribution improvements is the new WST. This project is large enough and independent enough that it should remain a separate project.

Lift Station Improvements

It will be more difficult to find funding for the lift station improvements than other projects, particularly if the lift stations are done as an independent project that can be considered an O&M issue. Funding opportunities and likelihood increase for the lift stations as part of an overall project addressing an identified health and environmental issue – I&I discharges in this case.

Wastewater Collection System and I&I Repairs

The WWTP Study and Investigating Major I&I Sources should be funded as independent projects and may be required prior to capital improvement applications to justify the improvements based on their cost effectiveness and environmental impacts.

City staff can perform much of the Investigating Major I&I Sources and Manhole Reconstruction projects. Combining these two projects will score better on funding applications than if they were applied for separately.

Manhole Grouting and Selective Mainline Grouting will require the services of a specialty contractor from the Lower 48 and should be combined to reduce the overall project costs. The Grouting Equipment Procurement project could be funded by the City and added to this combined project to satisfy requirements for matching funds