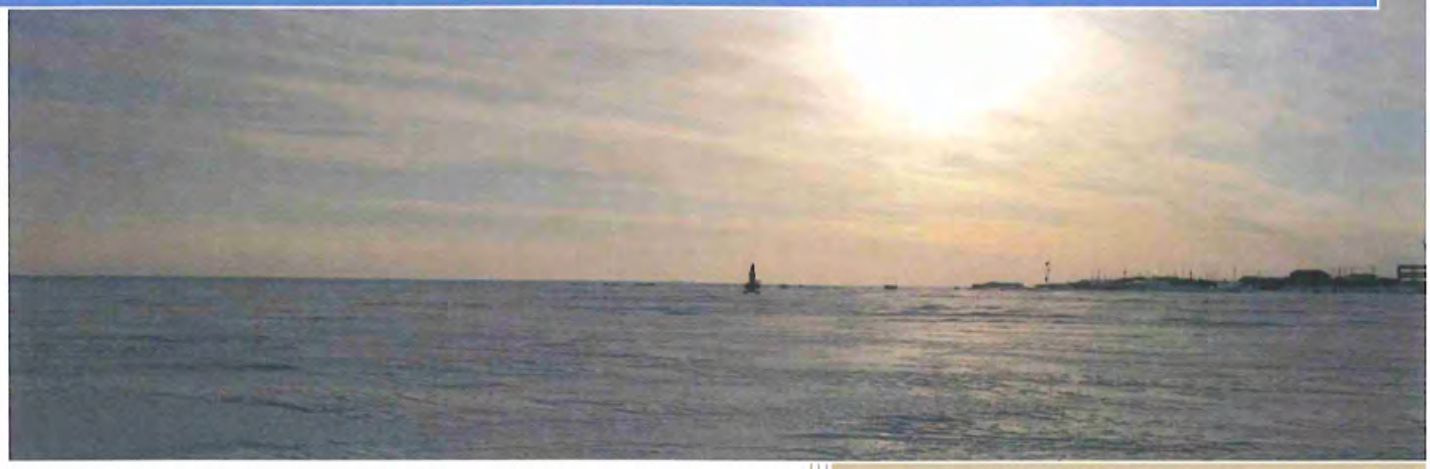
September 2011

Chefornak, Alaska Wastewater Lagoon & Force Main Design Analysis Report



Prepared for:
City of Chefornak
and
State of Alaska
Village Safe Water Program

Prepared by:
CE2 Engineers, Inc.

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I. Executive Summary

A new city wastewater lagoon and force main are to be constructed in Chefornak. Construction is scheduled to begin in the winter of 2011-2012. The wastewater lagoon will allow air, sunlight, and other natural processes to treat sewage.

This Design Analysis Report (DAR) provides detailed information on the elements required to design the Chefornak wastewater lagoon and force main extension. Design rationale, proposed configuration, permitting requirements, and preliminary project costs are included in this report. The proposed layout is shown on the next page in Figure 1.

Components of the proposed system include:

- Aboveground wastewater force main extension [2,052 linear feet (lf)] designed for sub-arctic conditions in rural Alaska. This is an extension to the new school force main.
- A three-cell, 4-acre wastewater lagoon that provides a pretreatment cell, a facultative primary treatment cell, and a polishing/storage cell. If current permitting standards [State of Alaska Department of Environmental Conservation (ADEC) Alaska Pollutant Discharge Elimination System (APDES)] are in effect at the time of construction completion, disinfection of the effluent to meet ADEC fecal coliform limits will be required.

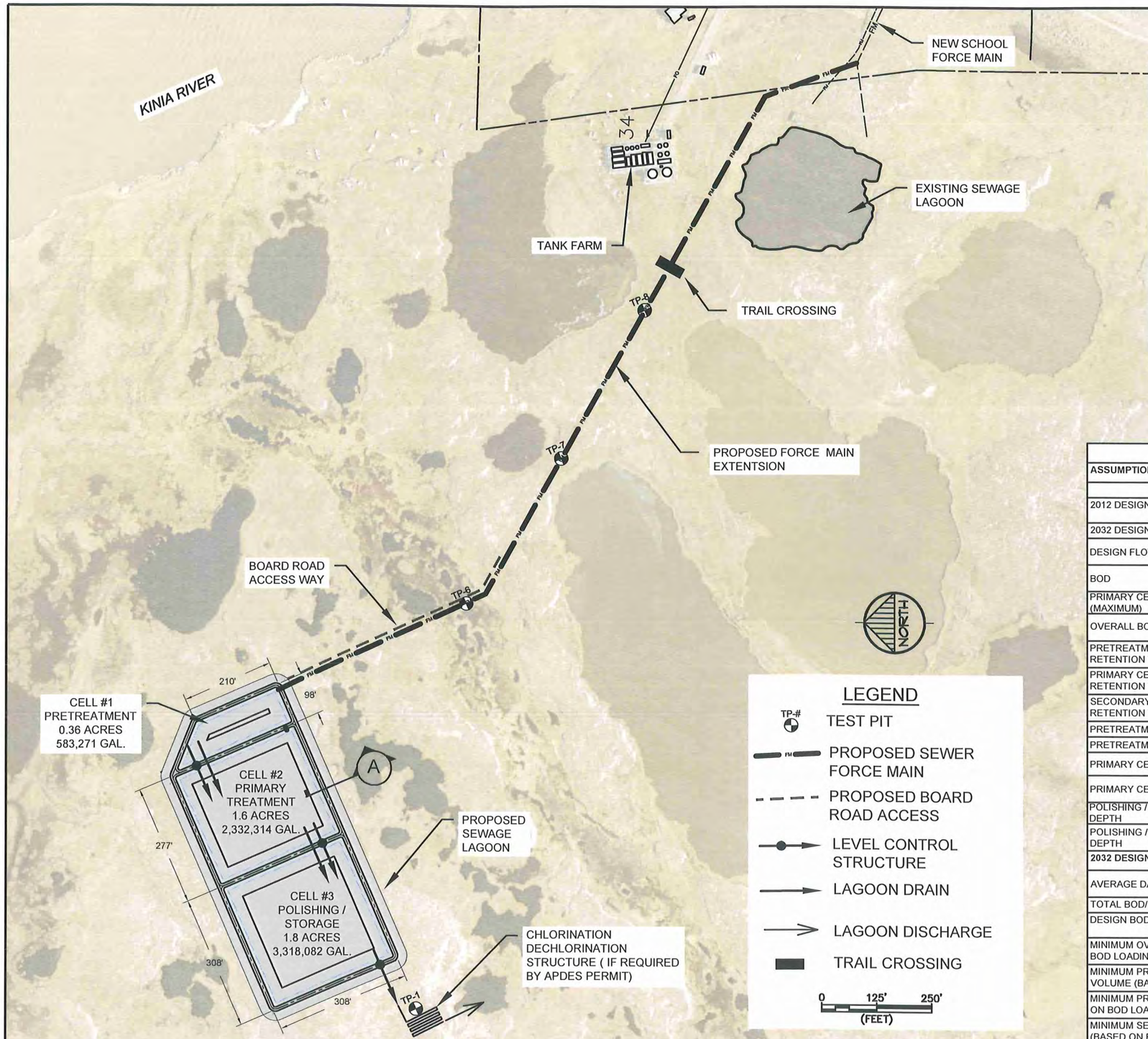
The majority of lagoon construction will occur in one winter season, weather permitting. Reshaping of the lagoon dikes after thawing and settlement will be accomplished in the following year.

The lift station (sewage pumping station) required to pump City wastewater to the new lagoon location will be designed and constructed as part of the honeybucket dump station. This lift station will also be utilized by the water treatment plant (WTP) and washeteria.

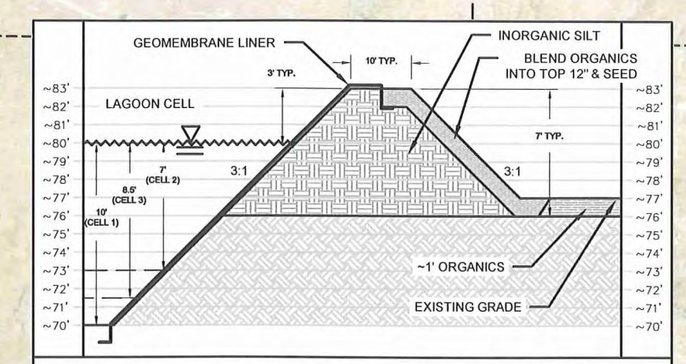
All major system components shall be sized to meet future demands and constructed with materials and methods for the expected 20-year design life. The 20-year design horizon will begin based on year 2012, and the end of the horizon will be year 2032.

The preliminary capital construction cost estimate for the wastewater lagoon and force main extension improvements is $1.74 million. An alternate option including a 6-foot-wide heavy-duty access boardwalk access co-located with the final 600 feet of force main extension is $2.04 million.

Site control for the lagoon and force main extension will be obtained from Chefarnrmute, Inc., the local village corporation.



NOTE: DIMENSIONS ARE TO CENTERLINE OF DIKE, AREAS ARE BASED ON WATER SURFACE AND VOLUMES EXCLUDE BOTTOM 2 FEET OF CELLS.



A TYPICAL DIKE CROSS-SECTION

3:1 VERTICAL SCALE

CHEFORNAK LAGOON DESIGN CRITERIA			
ASSUMPTIONS			
	QTY.	UNIT	NOTES
2012 DESIGN POPULATION	431	PEOPLE	2010 US CENSUS POPULATION (418) + 2 YEARS @ 1.5%
2032 DESIGN POPULATION	580	PEOPLE	ASSUMED GROWTH RATE OF 1.5% PER YEAR
DESIGN FLOW RATE	10	GAL/CAP-DAY	
BOD	0.17	LBS/CAP-DAY	2009 ADEC DRAFT LAGOON CONSTRUCTION GUIDELINES
PRIMARY CELL BOD LOADING (MAXIMUM)	30	LBS/ACRE	
OVERALL BOD LOADING (MAXIMUM)	20	LBS/ACRE	2009 ADEC DRAFT LAGOON CONSTRUCTION GUIDELINES
PRETREATMENT CELL MIN. HYDRAULIC RETENTION TIME (HRT)	5	DAYS	
PRIMARY CELL MIN. HYDRAULIC RETENTION TIME (HRT)	40	DAYS	2009 ADEC DRAFT LAGOON CONSTRUCTION GUIDELINES
SECONDARY CELL MIN. HYDRAULIC RETENTION TIME (HRT)	240	DAYS	2009 ADEC DRAFT LAGOON CONSTRUCTION GUIDELINES
PRETREATMENT CELL MAXIMUM DEPTH	10	FEET	
PRETREATMENT CELL DESIGN DEPTH	10	FEET	
PRIMARY CELL MAXIMUM DEPTH	10	FEET	2009 ADEC DRAFT LAGOON CONSTRUCTION GUIDELINES
PRIMARY CELL DESIGN DEPTH	5	FEET	ACTUAL DEPTH 7 FEET (BOTTOM 2 FEET EXCLUDED FROM VOLUME CALC)
POLISHING / STORAGE CELL MAXIMUM DEPTH	10	FEET	2009 ADEC DRAFT LAGOON CONSTRUCTION GUIDELINES
POLISHING / STORAGE CELL DESIGN DEPTH	6.5	FEET	ACTUAL DEPTH 8.5 FEET (BOTTOM 2 FEET EXCLUDED FROM VOLUME CALC)
2032 DESIGN CONDITIONS			
AVERAGE DAILY FLOW	13,800	GALLONS	DESIGN FLOW X DESIGN POP. + 8,000 GPD (WASHETERIA/SCHOOL)
TOTAL BOD/DAY PRODUCTION	98.6	LBS	
DESIGN BOD/DAY PRODUCTION	49.3	LBS	ASSUMING 50% BOD REDUCTION IN PRETREATMENT CELL
MINIMUM OVERALL SIZE (BASED ON BOD LOADING)	2.5	ACRES	
MINIMUM PRETREATMENT CELL VOLUME (BASED ON HRT)	69,000	GALLONS	
MINIMUM PRIMARY CELL SIZE (BASED ON BOD LOADING)	1.6	ACRES	
MINIMUM SECONDARY CELL SIZE (BASED ON BOD LOADING)	0.8	ACRES	
REQUIRED PRIMARY CELL VOLUME (BASED ON HRT)	552,001	GALLONS	
REQUIRED SECONDARY CELL VOLUME (BASED ON HRT)	3,312,004	GALLONS	
MINIMUM PRIMARY CELL SIZE	**1.6**	**ACRES**	BOD LOADING CONTROLS
MINIMUM SECONDARY CELL SIZE	**3,312,004**	**GALLONS**	HYDRAULIC RETENTION TIME CONTROLS

FIGURE 1

CHEFORNAK WASTEWATER LAGOON & FORCEMAIN DAR

PROPOSED (3 CELL) WASTEWATER LAGOON

CHEFORNAK, ALASKA

Scale: SEE GRAPHIC

Date: JUNE 2011

Drawn: CM

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G:\ACAD\CHEFORNAK\CYF1101 Sewage Lagoon\FIGURES\Fig 1 Lagoon Layout 3 Cell.dwg, 9/16/2011 1:09:13 PM, cmerz, LANIER MP C2050_LD520C PCL 6.pc3

II. Introduction

The Chefornak Wastewater Lagoon & Force Main Design Analysis Report (DAR) provides design rationale, design criteria, and design computations for design of the proposed wastewater lagoon and force main extension (see Figure 1) for the City of Chefornak. The DAR addresses applicable design elements such as wastewater volume calculations, thermodynamic calculations, hydraulic calculations, treatment design calculations, and capital and operating cost calculations. In addition, the DAR will document the required site control, construction, and operating permits. This DAR is the basis of the final project design.

Residents of the Kinia River community of Chefornak (2010 U.S. Census population 418) obtain water for in-home use and for all buildings except the school, washeteria and clinic by hauling buckets from the community watering points, collecting rainwater, or hauling water from natural water bodies in the local area. Human waste generated in homes and all buildings except the school, washeteria and clinic is collected in "honeybuckets" (five-gallon plastic pails lined with plastic bags). Laundry and showers are available at the community washeteria. Solid waste is hauled by residents to an open dump (Permitted Class III Landfill) at the edge of town.

The Chefornak City Council selected Choice B Core Sanitation Facilities by resolution on July 9, 2009. This document presents, in detail, the design criteria of the wastewater lagoon and sewer force main extension which was funded by Indian Health Service grant *AN10-NQ7 $1,681,729 - New Wastewater Lagoon and New Piping.* The major components of the proposed core sanitation facilities are:

- wastewater treatment lagoon
- sewer force main
- surface water intake
- raw water transmission piping
- water treatment plant and washeteria
- water storage tank
- rebuild the water distribution and watering points
- in town honeybucket dump site

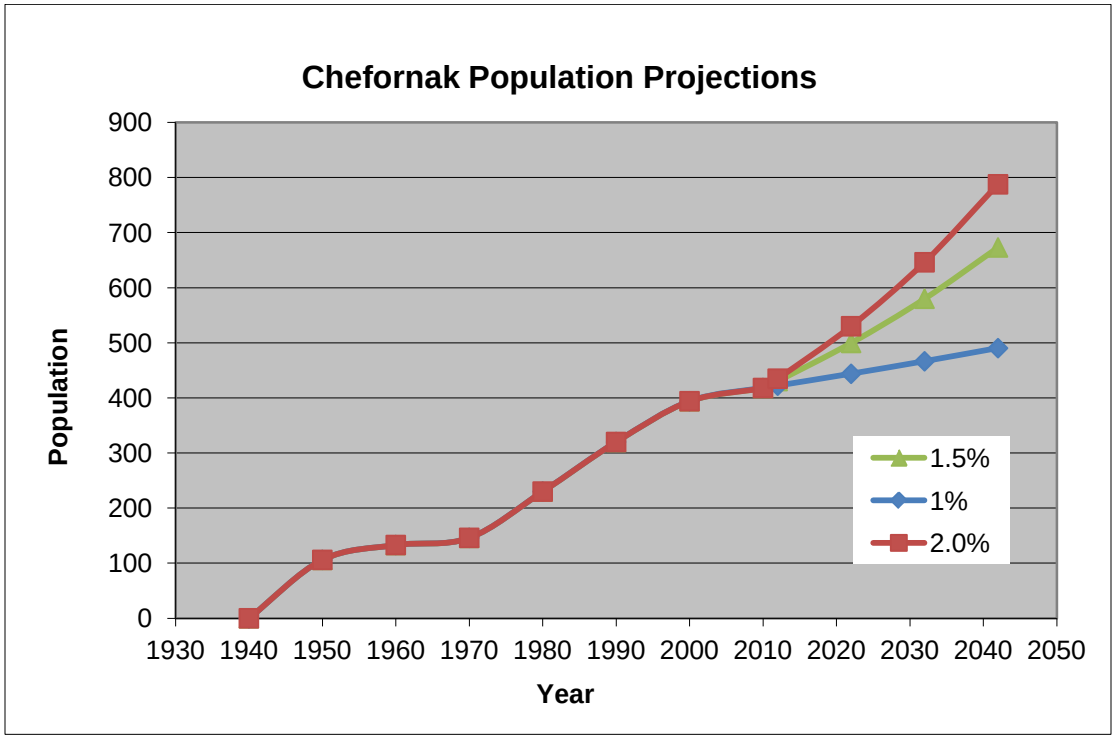
Construction of all components of Choice B will complete the funded capital infrastructure improvements.

III. Design Requirements and Considerations

A. Population

Accurately projecting population growth is difficult. A variety of factors affect population trends, most of which are volatile and subject to large swings in value. Economic conditions weigh heavily in these projections. Any increase in employment opportunities will have a positive impact on the population growth.

The 2010 US Census population count in Chefornak was 418 residents. The population growth rate for the community is estimated at 1.5% per year throughout the 20-year design life of the proposed sanitation improvements. Based on the above criteria, the population in 2032 is projected to be 580 persons.



For year 2032, the population calculation is:

$$P2032 = P2010 \times (1 + i)^n = 418 \times (1 + 0.015)^{22} = 580 \text{ persons.}$$

B. Flow Rates

Based upon water consumption data from other non-piped communities in western Alaska, and in consultation with plan review engineers at the Alaska Department of Environmental Conservation, a

design flow rate of 10 gallons per capita per day (gpcd) was selected as the design average residential daily water demand and wastewater flow.

We understand that for residents using honey buckets, actual water usage is typically much less (1 to 4 gallons per person per day). Using a higher design flow provides a factor of safety to ensure that the lagoon is designed to adequately treat the wastewater from the community.

Design flows used for component sizing in this DAR:

- Design Population—580 Persons (2032)
- Design Per Capita Residential Demand—10 gallons per capita day
- Design Daily Residential Demand—5,800 gallons per day
- Design Demand – Piped Water Facilities—8,000 gallons per day**
- Design Total Daily Water Demand—13,800 gallons per day

**Piped usage includes 5,000 gallons per day from the school for 365 days per year, and 3,000 gallons per day from the washeteria and City water treatment plant backwash (365 days per year).

C. Soil Conditions

The proposed wastewater lagoon and sewer force main extension will be located west of the City. Topography at the lagoon site is relatively flat with little to no vegetation, other than tundra. The ground surface consists of tundra surrounded by small lakes, ponds and small streams.

Soil conditions in eight test pits were logged by Golder Associates, Inc. in April 2011. Disturbed but representative soil samples were collected from the test pits as they were excavated. Excavation of the test pits was performed using a Hitachi EX 300 owned by the Chefornak Water & Sewer Project.

Test pit excavation, April 2011

In August 2011, CE2 Engineers inspected a hand dug test pit at the lagoon site, and inspected soils in the spoil piles from the April 2011 test pits. The purpose of this site investigation was to observe conditions

at the lagoon site in the summer, and to further evaluate the suitability of subsurface soils for construction of the lagoon berms.

The U.S. Geologic Survey (USGS) has mapped the soils in the area as undifferentiated surface deposits consisting of marine, river and deltaic sediments. Subsurface soil conditions were generally similar across the site, and are considered generally consistent with the USGS mapping. However, thermal states of the soils varied among test pits. The following soil conditions were observed:

- **Peat** (PT) – Surface soil consisting of frozen peat extended 1 to 2 feet below ground surface (bgs).
- **Organic Silt** (OL) – Organic silt was encountered below the peat in all test pits and extended up to 3 feet below ground surface in the lagoon area and up to 5 feet below ground surface along the force main alignment. The organic silt was usually frozen. However, a thawed 2 foot layer of organic silt was encountered below the mineral silt at a depth of 5 feet in TP-4.
- **Silt** (ML to MH) – Medium plastic to non-plastic mineral silt was encountered below the organic silt in all test pits, and extended to the depths excavated. In some areas, the silt contained trace organics and trace to some sand, with the sand content increasing with depth.
- **Groundwater** – Groundwater was encountered in two of the test pits at the time of excavation, TP-3 and TP-6. Test pit TP-6 was excavated in an inferred drainage channel that was surrounded by small ponds. The test pit became inundated with water after excavating approximately 3 feet below ground surface. A groundwater seep was encountered at approximately 10 feet below ground surface while excavating test pit TP-3.

If differing soil conditions are encountered during construction, further recommendations will be sought from a geotechnical engineer or engineering geologist. The complete soils report is attached as Appendix A.

D. Regulatory Requirements

According to current ADEC Lagoon Construction Guidelines (Feb 2009 Draft), a wastewater treatment and disposal lagoon system should meet the following key design requirements:

- Service life shall be a minimum of 20 years
- Maximum BOD_5 loading of 30 lbs/acre-day in the primary cell and 20 lbs/acre-day in the secondary cell. (North Dakota model)
- Total suspended solids (TSS) and BOD_5 removal of 85% or greater
- Minimum hydraulic retention time:
  - Primary Treatment Cell 40 days
  - Polishing/Storage Cell 240 days

- Erosion protection and revegetation is required on both the interior and exterior areas of the dike structure
- Lagoon shall be fenced to prevent unauthorized access.

E. Sewer Force Main Design Criteria

1. Extend Existing Force Main

The Lower Kuskokwim School District (LKSD) is currently constructing a major renovation/addition to the K-12 school. Part of that project is the construction of an advanced wastewater treatment plant and a new effluent force main (School Force Main) to the existing school lagoon (Old School Lagoon). That lagoon cannot be permitted under current wastewater discharge regulations. The City and LKSD have reached an agreement (attached as Appendix B) whereby the school will construct the force main to the existing lagoon with a pipe diameter that is capable of handling wastewater flow from the school as well as future flow from the city washeteria, water treatment plant backwash, and honeybucket dump station. The city will pay the extra cost of the larger diameter pipe. At such time as the city has constructed its wastewater pumping (lift) station, maintenance of the force main from the lift station to the new lagoon will become a city responsibility.

Old and new school force main locations

2. Capacity

The total design wastewater volume is 13,800 gallons per day. The average flow rate is approximately 10 gallons per minute (gpm). The peak wastewater inflow is calculated as:

$Q_{2032PK} = PF * Q_{2032Avg}$
Where:
Q_{2032PK} = Peak hourly flow rate at year 2032, gpm
PF = Peak hourly flow factor, 4
$Q_{2032\ Avg}$ = Average Wastewater Flow Rate

Q_{2032PK} = 4 * 10 gpm = 40 gpm

The minimum flow velocity shall be 3.5 feet per second. (2.5 – 3.25 is recommended in the Cold Regions Utility Monograph, Third Edition, pg. 9-21. However, per ADEC 3.5 feet per second has been found to re-suspend settled solids during intermittent pumping, as will occur in Chefornak.

A flow velocity of 3.5 feet per second will provide scour velocity in the force main. For a 4-inch nominal high-density polyethylene (HDPE) pipe, a minimum pumping rate of approximately 120 gallons per minute will provide a flow velocity of 3.5 feet per second. Given an average inflow of 10 gpm, a three-minute pumping cycle would occur approximately every 36 minutes. The head loss when pumping 120 gpm would be approximately 40 feet. Calculation spreadsheets are attached in Appendix C.

The dedicated school lift station will also pump into the common lagoon force main at approximately 72 gpm of secondary treated wastewater and reject water from their water treatment process. The flow from the school will produce approximately 3.5 feet per second scour velocity through several hundred feet of dedicated 3 inch force main connecting the LKSD facilities to the community system. While their wastewater flow and random cycling of the LKSD lift station will assist with freeze protection, scour velocities in the 4 inch lagoon force main will only be provided by the community lift station.

3. Pipe Specifications

Pipe sizing specifications are in accordance with American Society of Testing Materials (ASTM) standards which delineate quality and component material. The type, size, and standard dimension ratio (SDR), as delineated by the Plastics Pipe Institute (PPI) standards, are listed below.

1. **Carrier Pipe**: Force main shall be 4" HDPE, SDR 11, all HDPE piping shall be listed by the PPI with a designation of PE3408 and a cell classification of 345434C or better (as per ASTM D3350).
2. **Insulation**: Arctic pipe insulation shall be closed cell (ASTM D2341 cell classification 550674970034) urethane foam with a maximum K factor of 0.155 Btu-in/hr-sf-deg F. The

insulation core density shall be between 3.0 and 4.0 lbs/cubic feet; voids greater than 0.05 cubic inches beyond 24 inches of either end of the pipe section will be cause for rejection of the pipe.

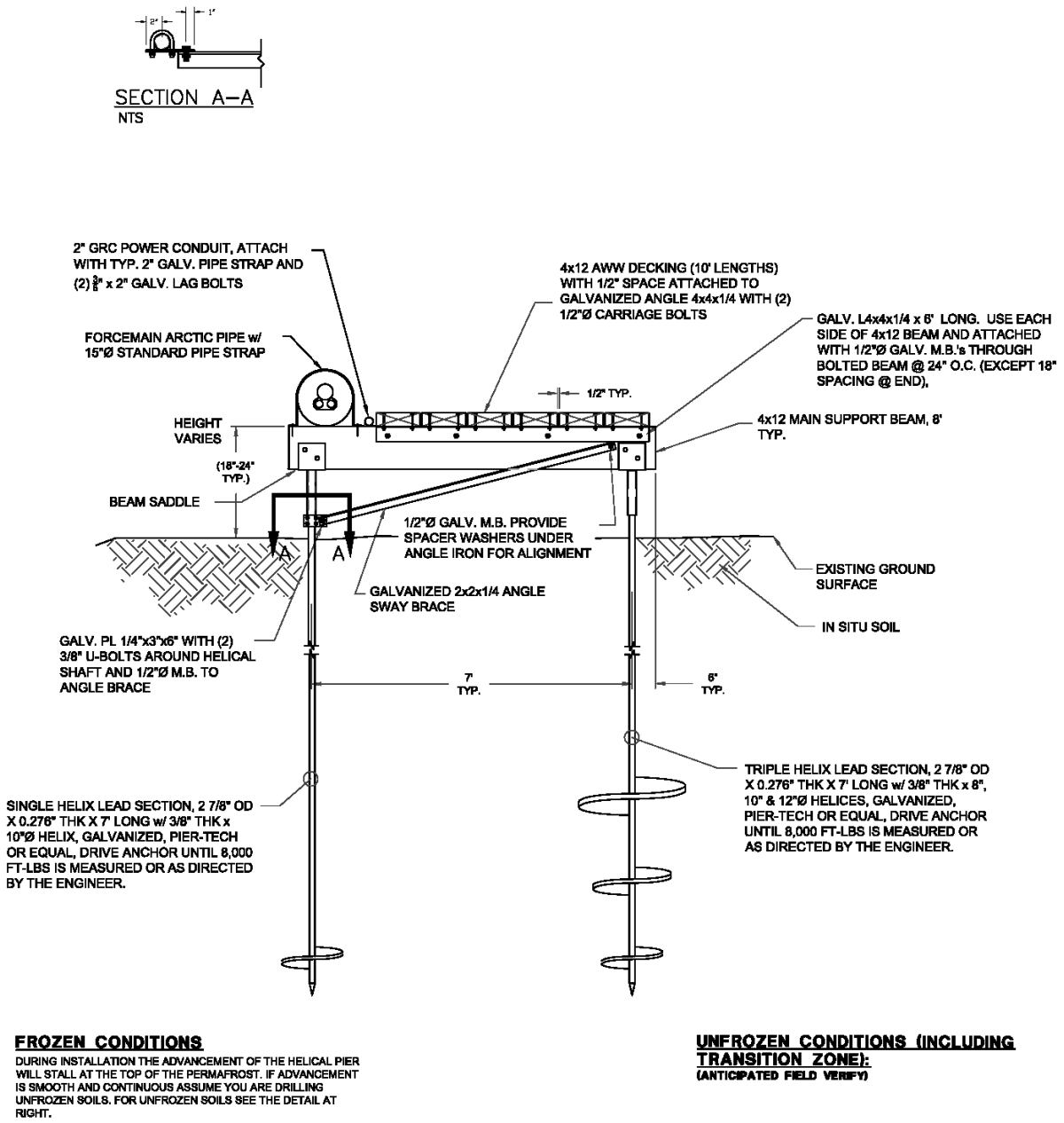
3. **Outer Jacket Material**: The outer jacket material for all arctic pipe and fittings shall be 16 gauge aluminum jacketed pipe with seams that will withstand a hydrostatic pressure of 5 feet of water with no leakage.
4. **Hydronic Heat Trace**: Hydronic heat trace shall be a minimum of 2" diameter HDPE, SDR 11 and listed by the PPI with a designation of PE340B and a cell classification of 345434C or better (as per ASTM D3350).
5. **Propylene Glycol:** Non-toxic food (industrial) grade glycol at 60% solution strength or -60°F freezing point. Corrosivity will be monitored at regular intervals and any required corrosion inhibitors will be added if required to maintain proper system operation.

4. Pipe Location, Cleanouts, and Structural Support

The 2,052 lineal feet of additional force main will be located across undisturbed tundra. The force main will be connected to the newly constructed school force main and extended to the proposed lagoon location.

The majority of the force main extension will be constructed by placing supports on helical piers installed to the appropriate depth. See Figure 2, on the next page, for details.

Figure 2—Helical pier-supported force main and access boardwalk option



Seven double-wye cleanouts will be uniformly spaced along the force main extension at approximately 300-foot intervals, to allow access to the force main in the event of plugging or freeze up.

5. Freeze Protection

When pumping at the scour velocity of 3.5 feet per second, the temperature drop in the 3,000 lf force main (school force main plus extension) at an ambient air temperature of -45°F is expected to be less

than 2°F. The normal entering temperature of the wastewater flow stream is estimated at 45°F. With ambient air at -45°F, the estimated heat loss from the force main is approximately 23,000 Btu/hour. Heat loss calculations are included in Appendix C.

Heat addition will be required to prevent freezing because of the variable wastewater flow. Potentially 12 to 15 hours of the no-flow condition could occur. A hydronic heat trace system composed of 2-inch HDPE piping (closed loop) enclosed in the insulated arctic pipe force main is proposed, operating with 50/50 propylene glycol and water. Glycol circulation rate will be designed to be less than 2.5 feet per second to minimize the energy used in pumping.

To maintain the wastewater temperature (ambient air -45°F) in the force main for 15 hours of no-flow would require 345,000 Btu of heat input. At 100,000 Btu output from an 80% efficiency boiler this will require about 3.5 gallons of fuel per day. System expansion tanks will be sized for operation from -45°F to 90°F.

For freeze protection and potential emergency thawing, it is common that the glycol heat trace be capable of delivering at least four times the required heat or 92,000 Btu/hour. The glycol heat trace system will be capable of protecting the sewer line from freezing during an indefinite no-flow period, if necessary.

This glycol will be circulated by pumps mounted in the new water treatment plant and partially heated by waste heat from the existing City power generation facility.

6. Access to Lagoon and Force Main Extension

Access to the lagoon is required for routine inspection, maintenance activities and twice yearly lagoon discharge. However, the need for access will be minimal during the first few years, until the lagoon fills and requires discharge. A minimal width boardwalk (six feet wide) adjacent to the final 600 feet of force main would provide summer four-wheeler access for personnel and equipment. See Figure 2 (page 10) depicting the proposed configuration.

7. Trail Crossings

The force main extension crosses a winter and summer trail. A “bridge” crossing over the pipeline is proposed at the trail crossing to facilitate trail usage. The location of the crossing was confirmed by the Chefornak City Council. A wide, well-marked crossing structure is needed, as this trail is used to haul boats (pulled by snow machines) to the coast in the spring for seal hunting.

F. Lagoon Design Criteria

1. Topographic Conditions

The proposed lagoon site is located west of the village, in an area of open tundra, surrounded by small lakes, ponds and streams. Based upon information provided by village elders, the area appears to be within the flood plain of the Kinia River. However, the specific lagoon location is on an area of slightly higher ground which has reportedly not flooded in recent memory.

2. Cell Configuration and Sizing

The selected design alternative is a 3-cell configuration, with a pre-treatment cell for solids removal and BOD reduction, followed by a primary treatment cell and a polishing/storage cell, sized in accordance with ADEC Lagoon Construction Guidelines.

- **Cell Depth**: ADEC guidelines allow for a maximum depth of 10 feet in the treatment cell and 5 feet in the polishing/storage cell, plus an additional 2 feet at the bottom which is not included in the volume calculations. The design utilizes a depth of 10 feet in the pre-treatment cell, an effective depth of 5 feet in the primary treatment cell and an effective depth of 6.5 feet in the polishing/storage cells. (Per ADEC guideline, effective depth = total depth minus 2 feet).
- **Pre-Treatment Cell**: Small pre-treatment cells, with a hydraulic retention time of 2 to 5 days, allow preliminary sedimentation of suspended solids, resulting in a reduction of BOD. The additional liquid depth (10 feet) in this cell will promote natural anaerobic treatment of the wastewater, although an aerobic zone is expected at the surface when the cell is ice-free. The pre-treatment cell for this design provides a much longer hydraulic retention time of approximately 55 days, and the treatment calculations assume a BOD removal of 50%.
- **Primary Treatment Cell**: ADEC design guidelines require a minimum hydraulic retention time of 40-60 days in the primary cell, and a maximum BOD loading of 30 lb/acre/day. In this case BOD loading is the controlling criteria, resulting in a minimum surface area of 1.6 acres. The resulting liquid volume provides a hydraulic retention of 169 days.
- **Polishing/Storage Cell**: ADEC design guidelines require a minimum of 240 days hydraulic retention time, resulting in a design cell size of approximately 3.4 million gallons and 2.3 acres.
- **Overall Sizing**: ADEC guidelines require a maximum overall loading of 20 lb/acre/day. The design provides 3.9 acres in the primary and secondary cells, with an overall BOD loading of 12.6 lb/acre/day.

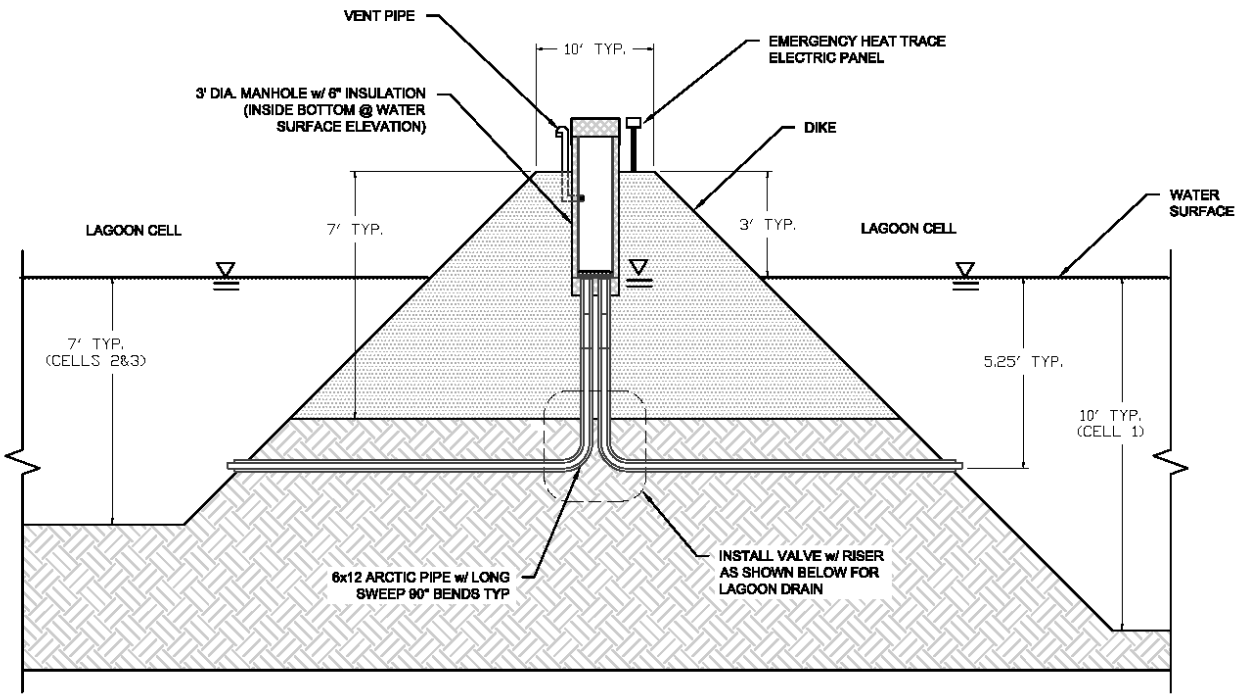
3. Hydraulic Retention Time

The overall volume of the lagoon, excluding the bottom two feet of liquid depth, is approximately 5.7 million gallons. The calculated hydraulic retention time in the polishing/storage cell is 240 days. (Hydraulic retention time is the length of time wastewater remains in the cell, from the time it enters until the time it is discharged or transferred.)

4. Level Control Structures

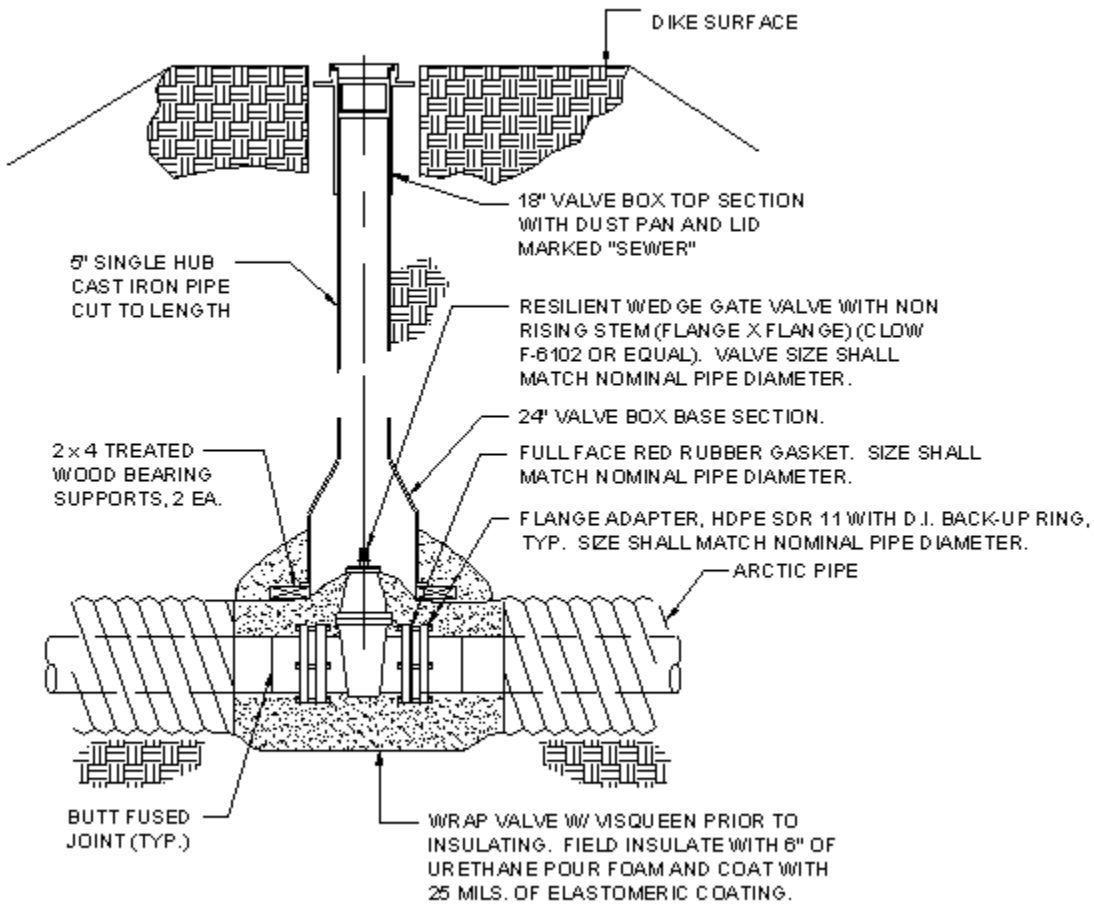
Overflow-type transfer structures between the cells will maintain the design liquid levels. An open flow channel will be formed across the manhole allowing for a minimum of 0.1 feet of drop. Separate, valved drain pipes are also planned, allowing cells to be drained as needed. Details are shown in Figures 3 and 4.

Figure 3—Lagoon level control structure



**Note that the flow is from right to left and the liquid level in the third cell will be varied.

Figure 4—Lagoon drain detail



5. Sludge Capacity

The pre-treatment cell depth of 10 feet and the primary cell depth of seven (7) feet will provide adequate sludge holding capacity for the 20-year design life of the lagoon. It is not expected that sludge will need to be pumped during the design life of the facility. Sludge volume calculations are included in Appendix D.

6. Storage Cell Drawdown

The polishing/storage cell will hold a minimum of 240 days of flow at the design year (13,800 gallons per day). At final (2032) design flow, the cell is proposed to be drawn down twice per year, in the spring after break-up, and in the fall to provide for 240 days of storage. At a discharge rate of 150 gallons per minute, the discharge periods in the spring and fall will be approximately 2 weeks long. During the early

years of operation, wastewater flows will be less than the design flow. If allowed by permit requirements, a single discharge period of approximately 2 weeks each year may be sufficient.

The discharge procedure will be to open a valve and discharge by gravity until the level of the cell is drawn down to the level of the surrounding tundra. To discharge the remaining liquid from the lagoon cell, a portable pump with a discharge hose will be placed in the outlet structure. A generator will power the discharge pump.

Prior to freeze-up each year, operators must inspect the lagoon to insure the liquid level in the storage cell is low enough to allow sufficient storage volume for the winter.

7. Discharge Limits

The lagoon will not discharge until 2013 or 2014 at the earliest. The lagoon is designed to treat the wastewater to the quality required for discharge to the surrounding tundra by current APDES standards, with the exception of the fecal coliform limits. The funding agency (VSW) expects this limit to be relaxed prior to the initial discharge. While a chlorination/dechlorination structure is shown on Figure 1, no design criteria are specified in this DAR, nor is the cost budgeted.

8. Winter Operation

Due to the heat from influent wastewater and insulation provided by snow cover, the maximum ice depth on the lagoon in winter is expected to be two feet or less. The lagoon will discharge twice yearly: in spring after breakup, and again in late summer to allow adequate hydraulic storage through the winter months.

Emergency electric heat trace is planned for the level control structures. In the event of a freeze-up of the transfer structure or the piping between lagoon cells, a generator could be used to energize the heat trace and thaw the structure. The generator and fuel could be stored at the lagoon in a connex, or could be hauled to the lagoon as needed. Other than this, no special winter operational procedures are anticipated during design flow conditions. If an extended period of low flow persists, the transfer structures become at risk of freezing.

IV. Land Status/Site Control

The proposed wastewater lagoon and force main are located on village corporation property. The village corporation is Chefarnrmute. The ANCSA 12(a) land entitlement to the village corporation from the federal government is 92,160 acres. The ANCSA 12(b) land has been reallocated to Chefarnrmute from the Regional Native Corporation. Under ANCSA 14(c)(3), village corporations must re-convey surface estates to the local city government to provide for community use and expansion. The local governing body is the City of Chefornak. The 14(c)(3) transfer has been completed; the plat was filed in October 2008. The BLM survey of the plat by Crazy Mountain, J.V. is scheduled to begin in mid-September 2011.

The subsurface estate for the wastewater lagoon will be obtained from Chefarnrmute after it trades surface lands with the federal government, represented by the U.S. Fish and Wildlife Service (FWS). This trade agreement has been drafted and is in process.

V. Environmental Determinations and Permits

The following permits, reviews, and concurrences must be acquired for this project, as noted:

- A Department of the Army (DOA) 404 wetlands permit for the placement of approximately 40,500 cubic yards of fill material into 4.0 acres was submitted on June 29, 2011.
- A Coastal Project Questionnaire will be prepared in conjunction with the DOA permit application, as required.
- The State Historic Preservation Office (SHPO) was requested in June 2011 to concur that the project will have no affect to historic properties in accordance with Section 106 of the National Historic Preservation Act.
- ADEC plan review and "Approval to Construct" are required for the wastewater force main piping and the lagoon prior to construction.
- An interim "Approval to Operate" for 90 days after completion will accompany the "Approval to Construct". Within 90 days after completion, record drawings and a signed "Certificate of Construction" must be submitted to ADEC to obtain final "Approval to Operate".
- The required Stormwater Pollution Prevention Plan (SWPPP) Notice of Intent (NOI) will be filed with the ADEC.
- An APDES permit is required for the lagoon treatment and disposal of wastewater. An NOI will be submitted to the ADEC Division of Water, Wastewater Discharge Authorization.
- A request for concurrence that the project will not adversely affect the endangered Spectacled Eider and/or critical habitat was submitted to the U.S. Fish & Wildlife Service (FWS) in June 2011.

VI. Preliminary Cost Estimates

A. Capital Cost Estimate

Table 1—Wastewater Lagoon & Force Main Extension

ITEM	DESCRIPTION	MATERIALS	BURDENED LABOR	EQUIPMENT	FREIGHT	TOTAL DIRECT COSTS	
1	General	$30,000	$48,400	$91,000	$33,690	$203,090	
2	Lagoon dikes	$140,850	$290,000	$200,500	$6,732	$638,082	
3	Force main	$144,510	$61,560	$25,500	$25,963	$257,533	
4	Boardwalk	$129,744	$99,000	$2,500	$45,771		$277,015
5	Pipe rack configuration	$2,500	$56,000	$1,200	$2,723	$62,423	
Total for Pipe Rack Option		**$317,860**	**$455,960**	**$318,200**	**$69,107**	**$1,161,127**	
Total for Boardwalk Access Option		**$445,104**	**$498,960**	**$319,500**	**$112,155**		**$1,375,720**

Design	**$162,558**	**$192,601**
CM Costs (12%)	**$139,335**	**$165,086**
VSW EMT (10%)	**$146,302**	**$173,341**
Honeybucket Dump Station	**$120,000**	**$120,000**
Payment to School for Force Main Upsizing	**$15,000**	**$15,000**
Total Project Cost for the Pipe Rack Configuration	**$1,744,000**	
Total Project Cost for the Boardwalk Option		**$2,042,000**

Assumptions for this preliminary capital cost estimate:

- 2011 dollars
- The majority of lagoon construction and force main/boardwalk foundation will occur during the winter (two seasons) with force main/boardwalk construction during the summer.
- Local on-site soils can be utilized for lagoon dike construction (assumes sufficient stability, compaction, and permeability)
- A dozer for tundra construction has been acquired and delivered to Chefornak. A local excavator is available.
- An adequate fuel supply is available, potentially through coordination with a simultaneous water treatment plant project
- Existing on-site materials and equipment including: 150 helical piers with extensions and beam saddles; treated lumber; and placement equipment will be available for use on this project
- Local operator(s) and laborers available
- No known environmental permitting limitations/constraints

B. Operating Cost Estimate

The lagoon and force main extension represents a portion of the total construction of "core" facilities; therefore a complete operating cost estimate is not presented. Two cost items directly related to the force main are the cost to maintain the in-transit wastewater temperature above freezing, and the electrical costs to circulate the glycol.

Yearly fuel oil usage is estimated at 450 gallons. At $7.80 per gallon the cost would be approximately $3,510. Yearly electrical usage for circulation is estimated at 2,400 kWh. At 66 cents/kWh (commercial rate) the cost would be approximately $1,600.

The annual operational cost for a monthly visual inspection of the lagoon is estimated to be $1,000 or less.

VII. Recommendations

Previous studies have concluded that the most cost-effective wastewater treatment in rural Alaska is a facultative lagoon. This DAR follows that conclusion; alternate advanced treatment technologies were reviewed previously but only the selected option, a facultative lagoon treatment, is presented in this DAR.

Based on the foregoing design data in this report, it is recommended that the school force main be extended to the proposed new lagoon location and a new three-cell facultative lagoon be constructed.

Appendices

Appendix A—Golder Associates Inc. Soils Report

September 23, 2011 113-95619

Mr. Mike Erdman, PE
CE2 Engineers, Inc.
8221 Dimond Hook Drive
Anchorage, AK 99507

RE: GEOTECHNICAL CONSIDERATIONS, REVISED WASTEWATER LAGOON BERM, CHEFORNAK, ALASKA

Dear Mike:

Golder Associates, Inc (Golder) has reviewed the revised civil engineering detail developed by CE2 Engineers (CE2) for the Chefornak Wastewater Lagoon. Based on our field findings and the quality of the mineral silt described by CE2 from our test pits after summer 2011 thaw, we consider the revised civil engineer detail suitable for the lagoon berm. This civil engineering detail is a revision from our original geotechnical recommendations for the lagoon berm. If the revised berm detail is adopted, several geotechnical conditions should be followed:

- The berm should be constructed as noted in the revised civil engineer's detail. Berm material should be constructed of drained, fully thawed mineral silt with an organic cap and vegetation as noted on the detail;
- The berm should be compacted with a tracked dozer or excavator to a uniform density. A dry density of approximately 85 to 90 percent of the material's maximum dry density as determined by ASTM D-1557 should be used. The mineral silt is moisture sensitive and the contractor may need to use specialized field methods to drain and maintain the soil moisture during compaction;
- The liner must not permit water infiltration into the underlying silt. The liner must be properly keyed along the bottom of the excavation and along the top of the berm;
- The civil engineer should verify the liner key along the top of the berm is adequate. If not, addition key methods such as embedded timber sills should be considered;
- Berm backslope vegetation should be designed, placed and germinated in one season to reduce erosion.

Differential settlement along the berm should be anticipated. The amount of settlement will depend on site preparation, mineral silt quality and moisture content, and compaction effort. We can provide guidelines for reasonably expected settlement as field construction is underway. Please contact us at 907-344-6001 if you have questions or comments.

Sincerely,

GOLDER ASSOCIATES INC.

Richard A. Mitchells, PE
Senior Geotechnical Engineer

Attachment, CE2 Revised Berm Detail, Chefornak Lagoon

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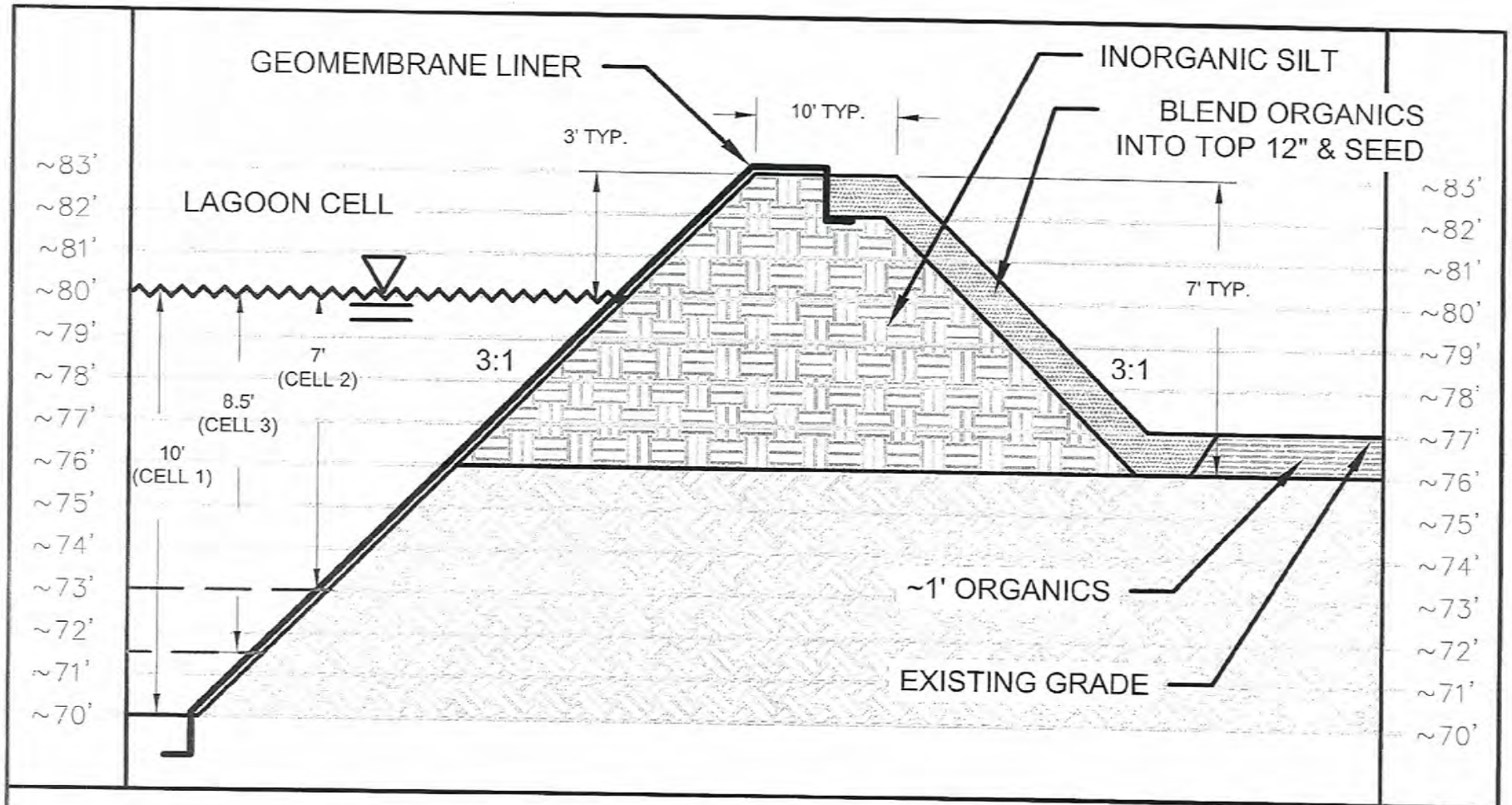

A

TYPICAL DIKE CROSS-SECTION

3:1 VERTICAL SCALE

G:\ACAD\CHEFORNAK\CYF1101 Sewage Lagoon\FIGURES\Fig 1 Lagoon Layout 3 Cell.dwg, 9/16/2011 1:03:28 PM, cmerz, HP LaserJet 5100 Series PCL6

July 20, 2011 113-95619

Mr. Mike Erdman, PE
CE2 Engineers, Inc.
8221 Dimond Hook Drive
Anchorage, AK 99507

RE: GEOTECHNICAL SERVICES FOR WASTEWATER LAGOON SITING, CHEFORNAK, ALASKA

1.0 INTRODUCTION

Golder Associates Inc. (Golder) is pleased to present this report to CE2 Engineers, Inc. (CE2) for the siting of a new wastewater lagoon and sewer force main in Chefornak, Alaska (Figure 1). We understand a new wastewater lagoon is approximately 2,000 feet westerly of the village and will be approximately four acres in size. A new above grade force main is also planned between the village and the lagoon with portions of the new force main roughly parallel to the existing bulk fuel facility.

A granular fill accessway does not exist beyond the existing bulk fuel facility or to the proposed lagoon site. We understand a granular fill accessway is not planned to the proposed lagoon site. Current civil engineering design includes a new six foot wide timber boardwalk between the village and the proposed lagoon for personnel and light equipment access. The boardwalk may be supported on All Weather Wood (AWW) sleepers, where feasible, or attached to smaller riser diameter helical anchors. Current engineering concepts include attaching the force main to the side of the boardwalk or the helical anchors.

We understand funding may not be available for concurrent construction of the lagoon, force main and the access boardwalk. Accordingly, a phased construction program may be implemented beginning with the lagoon and fed by a force main that is initially constructed using a wider spaced helical anchor system. Subsequent phases would include installation of additional helical anchors along the force main and the boardwalk.

Our services were performed in general accordance with our proposal to CE2 dated March 23, 2011. Our scope of work consisted of:

- advancing geotechnical test pits within the proposed lagoon footprint and along the proposed force main alignment
- visually logging each test pit as it was advanced for general subsurface conditions including soil classifications, thermal states, and groundwater levels
- collecting disturbed but representative soil samples from the test pits or excavator bucket
- installing PVC standpipes in select test pits for future ground temperature or groundwater level measurements, and
- conducting geotechnical laboratory testing on select soil samples to determine soil index properties including hydrometer analyses

Based on field and laboratory test findings, we have prepared this report summarizing our findings and conceptual-level geotechnical engineering recommendations for the lagoon area and force main pipeline foundations. Conceptual-level civil engineering plans for the proposed improvement and design grades and elevations were developed by CE2 for our review as part of this submittal. However, we understand

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the civil layout for the proposed improvements may depend on design flood elevation. CE2 is currently determining the appropriate elevation and refining the lagoon civil layout and geometry.

2.0 FIELD INVESTIGATION

The geotechnical exploration program consisted of advancing and sampling eight test pits (TP-1 through TP-8) at the approximate locations shown in Figure 1. The test pits were excavated between 5 and 18 feet below ground surface (bgs). Test Pits 1 through 5 were excavated within the proposed wastewater lagoon site. Test Pits 6 through 8 were excavated along the proposed sewer force main alignment. The test pit locations were determined by Mr. Mike Erdman, PE of CE2, who was also on-site during the subsurface exploration program. Excavation of the test pits was performed using a Hitachi EX 300 owned and operated by the city of Chefornak.

Soil conditions in the test pits were logged by Mr. Jacob Randazzo of Golder on April 3, 2011. Disturbed but representative soil samples were collected from the test pits or the excavator bucket. Soil samples were visually classified in the field according to the Unified Soil Classification System (USCS). Golder"s soil and ice classification systems are summarized in Figures 2 and 3, respectively. Test pit logs are presented in Figures 4 to 11.

Representative soil samples were retained in sealed polyethylene bags to preserve their natural moisture content. Retained soil samples were delivered to our Anchorage laboratory for additional soil classification and index property testing. Approximate test pit locations were recorded with a hand-held GPS instrument and used to plot the locations shown in Figure 1. Prior to backfilling the test pits, select test pits had sealed or slotted, one-inch, schedule-80 PVC installed for ground temperature or water level measurements. Test pits were backfilled with the excavated material using the excavator to match surrounding grade.

3.0 LABORATORY TESTING

Laboratory tests were performed in our Anchorage facility to determine index properties of the soil samples. Moisture content tests were performed on each sample and conducted in accordance with ASTM D 2216. Select samples were also tested for grain size distribution (ASTM C136), Atterberg Limits (ASTM D4318), and pore water salinity. Laboratory tests results are summarized in Table 1 and are also presented graphically on the borehole logs. Particle size distribution curves including hydrometer results are presented in Figure 13.

Three additional soil samples from the proposed lagoon area were submitted to DOWL HKM"s laboratory in Anchorage, Alaska for hydrometer analysis. The results from the tests are provided in Appendix A.

4.0 SUMMARY OF FINDINGS

4.1 General Setting

The proposed wastewater lagoon and sewer force main location is generally west of the village. Topography at the site is relatively flat with tundra vegetation. The ground surface consists of tundra surrounded by small lakes, ponds and small streams. At the time of our exploration, small boats used by village residents were present along the proposed force main line alignment, which was underwater.

4.2 Subsurface Conditions

The U.S. Geologic Survey (USGS) has mapped the soils in the area as undifferentiated surface deposits consisting of marine, river and deltaic sediments. Subsurface soil conditions were generally similar across the site and are considered generally consistent with the USGS mapping. However, soil thermal states varied among test pits. The following soil conditions were observed:

- Peat (Pt) – Surface soil consisting of frozen peat extended 1 to 2 feet below ground surface (bgs).

- Organic Silt (OL) – Organic silt was observed below the peat in all test pits and extended up to 3 feet bgs in the lagoon area and up to 5 feet bgs along the force main alignment. The organic silt was typically frozen. However, a thawed 2 foot thick layer of organic silt was observed below the mineral silt at a depth of 5 feet in Test Pit 4.
- Silt (ML to MH) – Medium plastic to non-plastic mineral silt was observed below the organic silt in all test pits and extended to the full depths excavated. In some areas, the silt contained trace amounts of organic material and trace to some sand, with the sand content increasing with depth, particularly in Test Pit 5.
- Groundwater – Groundwater was encountered in two of the test pits at the time of our fieldwork, Test Pit 3 and Test Pit 6. Test Pit 6 was excavated in an apparent drainage channel that was surrounded by small ponds. The test pit became inundated with shallow groundwater after excavating approximately 3 feet bgs. A groundwater seep was encountered at approximately 10 feet bgs while excavating Test Pit 3.

Test Pits 1 through 5, inclusive, were advanced within the proposed lagoon footprint. Based on subsurface conditions observed during the test pit explorations, the proposed lagoon site is considered to be an area of degrading permafrost. Small changes in surface conditions (e.g., snow drifts, disturbed tundra, etc.) can influence the thermal state of the underlying permafrost. We believe the active layer (expected depth of seasonal freeze/thaw) extends 3 to 4 feet below existing grade in the lagoon area. Permafrost was encountered below the active layer in most of the test pits excavated within the lagoon footprint. Based on discussions with CE2, we understand approximately 3 feet of icy inorganic silt may remain under the lagoon excavation footprint in some areas. This permafrost will thaw due to the planned site development. Based on thaw strain models developed for the Alyeska Pipeline project, we estimate strains on the order of 15 to 30 percent can be expected as the icy mineral silt thaws, depending on initial soil moisture content. Based on measured soil moisture contents in the frozen silt below the expected depth of excavation, thaw strains on the order of 6 to 8 inches should be expected.

A generalized geologic cross section of observed subsurface conditions at the lagoon site is presented in Figure 12. Summary particle size distribution data (dry weight basis percentages of gravel (G), sand (S), silt (M) and clay (C)) near the expected depth of lagoon excavation are also shown on this figure. For reference, particle size less than 0.002-mm was used to represent the clay fraction.

The extent of permafrost encountered varied among test pits. Well-bonded frozen soil was encountered below the inferred active layer to 9.5 feet below existing grade in Test Pit 2. All test pits within the lagoon footprint area encountered poorly bonded, marginally frozen soil extending 1 to 3.5 feet below the well-bonded soil and were underlain by thawed soil to the full excavation depths, except in Test Pit 1. From 12 to 15 feet below grade (depth of excavation) in Test Pit 1 a poorly bonded, marginally frozen soil was inferred from recovered soil samples.

Three test pits (TP-6 through 8, inclusive) were advanced along the proposed sewer force main alignment. Well-bonded permafrost was inferred below the active layer only in Test Pit 7 to approximately 8 feet below grade underlain by a nominal 2 foot thick poorly bonded, marginally frozen material. Test Pit 7 was terminated in the poorly bonded, marginally frozen soil. Test Pit 6 was excavated in a drainage swale and flowing water was encountered approximately 3 feet below grade at the time of the field work.

5.0 ENGINEERING DISCUSSION AND RECOMMENDATIONS

5.1 Wastewater Lagoon

Preliminary design grades and elevations for the proposed wastewater lagoon and force main alignment were based on the preliminary civil engineering design developed by CE2. We understand the wastewater lagoon will be excavated approximately 4 to 5 feet below existing grade, extending approximately 2 feet into mineral silt. Assuming the excavation concept will be adopted, the civil engineer is considering using the excavated material for the embankment berms. The majority of the excavated material will be organic and include 1 to 2 feet, possibly more, surface fibrous peat (tundra) with an

organic silt of varying thickness underlying surface peat. Organic material should not be used as embankment fill without significant treatment and stabilization.

The mineral silt may provide an improved core embankment material relative to the high organic content material. Mineral soil from the excavation may be used provided special construction techniques are used to stabilize the material as it thaws and drains. The resulting fill will be relatively low strength. The mineral silt will require special construction techniques such as the "burrito wrap" described below for use in embankments. It may be feasible to use the organic material for cap material over the embankment. We estimate approximately 2,500 feet of embankment will be required along the proposed lagoon perimeter. If the lagoon excavation material is not used for the embankment core nor does not provided sufficient volume, the perimeter embankment will most likely require fill from a local borrow site or imported from outside the village.

5.1.1 Embankment Options

Based on discussions with Mr. Erdman, several lagoon embankments options are under consideration during the conceptual design phase. Sheet piles installed around the lagoon perimeter were also discussed, but were not considered a viable option due to cost. If excavation within the lagoon footprint is conducted, embankment design using the excavated mineral silt material with an organic cap is expected. Due to the relatively poor embankment stability anticipated with the mineral silt, a geotextile encapsulated fill embankment („burrito wrap") should be considered. Alternatively, if excavation is not planned within the lagoon footprint, supersacks filled with local barrow material placed around the lagoon perimeter can be considered. Both embankment options have advantages and disadvantages.

Some general construction recommendations for geotextile wraps and the supersack concepts are summarized below.

- Geotextile Wrap
  - Excavate peat and organic silt to mineral soil within the lagoon embankment berm bearing footprint to limit differential movement and improve embankment stability.
  - Long-term consolidation of the mineral soil under the embankment should be expected as pore water dissipates. Determining the amount of primary and secondary consolidation is difficult without specialized geotechnical laboratory testing, which has not been performed. However, long term consolidation in the range of one to two feet is possible for unfrozen mineral soils from the Yukon-Kuskokwim if placed in embankments of similar geometry as expected at this site.
  - Organic material can be placed along the side slopes of the completed embankment to act as a buttress, which will improve the stability of the embankment. Side slopes on the order of 3 to 4H:1V (horizontal to vertical), or flatter, are recommended for the organic material cover, provided surface erosion protection is used. Vegetative cover should be established during the initial summer to reduce erosion and improve slope stability. If an organic cover is not placed over the geotextile wrap, the final grades will depend on the amount of thaw consolidation of the fill material, water produced during thaw, drainage through the geotextile, and strength of the geotextile, among other factors. Assuming a mineral silt with soil moisture contents in the range of 40 to 60 percent by dry weight are used for fill within the geotextile wrap, final side slopes on the order of 2 to 3H:1V, or flatter, should be expected.
  - If the embankment is constructed directly on the organic material, settlement and displacement of the organic material should be taken into consideration during embankment design. Settlements in the range of 50 percent, or more, of the pre-fill organic mat thickness should be expected.
  - Mineral silt should be used for fill. If the silt is placed frozen, up to approximately 50 percent thaw consolidation should be expected.

- Supersack
  - If granular soil can be obtained from the airstrip borrow source, supersacks may be backfilled and used as embankment berms.
  - Frozen fine grained soil should not be used as backfill for the supersacks.
  - Consideration should be given to the timing of construction and staging of material to limit the potential for frozen granular soils being placed in the supersacks.
  - Supersacks should be securely attached together to limit differential movement of the embankment.
  - A shallow three dimensional mat (plastic or wire) should be placed on the mineral silt prior to embankment construction to improve the supersack performance during settlement.
  - Supersacks may be stacked for increased height, but a double wide base course should be planned. A maximum of two vertical layers is advised. Stacked vertical sections will require additional engineering analysis.
  - The design of the embankment must consider the proximity of the excavation to the toe of the embankment as well as geometry of the embankment. If the embankment is placed too close to the excavation, undermining and slope stability may be a concern. We recommend the side slopes within the lagoon be established at 1H:1V or flatter and a minimum horizontal separation of ten feet used between the toe of the embankment and the crown of the estimated 3 to 4 foot deep lagoon excavation. The sideslope geometry within the lagoon should be expected to vary with time, ice loading, and water/wave action as the thawing slopes come to a stabilized angle of repose..

5.1.2 Seepage

The silt encountered near the proposed lagoon bottom generally contained less than 10 percent fine sand, approximately 75 to 85 percent silt and approximately 5 to 15 percent clay fraction. Based on particle size distribution and visual field classification, rough order of magnitude estimate of hydraulic conductivity was developed for conceptual design use. The in-place unfrozen mineral silt encountered 4 to 6 feet below the base of the proposed lagoon excavation depth (8 to 10 feet below existing grade) is expected to have hydraulic conductivities on the order of 10^{-4} to 10^{-6} centimeters per second (cm/sec). However, faster or slower hydraulic conductivities may occur depending on localized subsurface condition, soil thermal states, and site construction impacts. Based on the observed subsurface materials and laboratory test findings for mineral soils below the expected lagoon excavation depth, significant variation in hydraulic conductivities should be expected over relatively short vertical and horizontal distances. If hydraulic conductivity estimates of greater accuracy or a refined determination of hydraulic conductivity variation within the lagoon footprint is required, in-place testing and/or laboratory testing on undisturbed soil samples is advised.

5.2 Sewer Force Main and Boardwalk Access

We understand that helical anchors are being considered as vertical support members for the force main. AWW sleepers set at-grade may be used along portions of the boardwalk alignment. We understand the force main may be attached to the boardwalk rather than standalone helical anchors. If so, we recommend the boardwalk sleepers be secured with helical anchors to reduce the potential for buoyancy or unrestrained lateral movement in the event of high water or flooding. Helical anchors have been used with success in the Yukon-Kuskokwim area as vertical supports for above grade utility lines. Structural analysis for bending along the helical anchor riser is advised for lateral loads, particularly if eccentric loads are planned. Some considerations for helical pile vertical support members include:

- Frost forces acting along the helical anchor riser will most likely control the helix geometry and embedment design depth. Consideration should be given during the

design to ensure that sufficient uplift capacity is developed by the pile to resist seasonal frost.

- Installation in frozen ground and permafrost may require specialized installation methods and/or larger dimensioned riser shaft to permit greater installation torques.
- If soft or yielding materials, such as thawed zones, ice layers, or organic sections, are encountered at depth, deeper embedment or larger helical anchor geometry may be required to develop axial and lateral capacity.
- Lateral loading should be carefully considered, particularly if eccentric axial loads are planned.
- Helical anchors will most likely require multiple helices to develop adequate capacity and the uppermost helix must be embedded well below the expected depth of seasonal frost and at least 5 times the helix diameter into firm, non-yielding soil.
- We recommend that helical anchor risers be no less than 2-7/8 inch diameter. Depending on the loads and helix configuration, helices will likely be at least 12 inches in diameter. At least two helices are recommended, however additional engineering analysis is required to determine the helix and shaft geometry, embedment depths, and recommended installation and performance testing methods.
- Tangent points along the force main alignment may require multiple or larger dimensioned vertical risers sections to resist additional lateral loads that may be at these locations. We do not advise using guys to resist lateral loads without additional engineering analysis.

6.0 REVIEW AND FIELD QUALITY CONTROL

Our engineering recommendations provided with this submittal are considered conceptual-level and will require additional engineering analysis and assessment. Thus, the plans and specifications should be reviewed by us as the project design advances to verify they are in accordance with the intent of our conceptual-level recommendations. Also, upon completion of the project design, construction observation is recommended to permit verification of the construction methodology and soil conditions. Site observation during construction by a trained and experienced geotechnical engineer or engineering geologist will permit timely review and feedback to the design team specific to the geotechnical elements of this project.

7.0 USE OF REPORT

This report has been prepared for CE2 for use during the preliminary design of the proposed wastewater lagoon and sewer force main in Chefornak, Alaska. We have assumed the project engineering analysis and design will require refinement and revision during the design process we have assumed we will be provided an opportunity to review the engineering design as it progress prior to construction as well as to evaluate the need for additional investigation. If there are significant changes in the nature, design, or location of the facilities, we should be notified so that we may review our conclusions and recommendations and provide written modification or verification of the changes.

There are possible variations in subsurface conditions between the explorations conducted for this submittal and with time. Unanticipated soil conditions and thermal states may be encountered at this site that cannot be determined by a limited number of explorations or soil samples. Therefore, a contingency for unanticipated conditions should be included in the construction budget and schedule.

The work program followed the standard of care expected of professionals undertaking similar work in the State of Alaska under similar conditions. No warranty expressed or implied is made.

8.0 CLOSING

We appreciate the opportunity to provide work on this report. We are available to provide additional recommendations or comments once the design wastewater lagoon is further refined. Please contact us at 907-344-6001 if you have questions or comments.

Sincerely,

GOLDER ASSOCIATES INC.

Brenton B. Savikko, EIT
Staff Engineer

Richard A. Mitchells, PE
Senior Geotechnical Engineer

BBS/RAM/mlp

Attachments: Table 1 – Summary Laboratory Results
Figure 1 – Site Map
Figure 2 – Soil Classification/Legend
Figure 3 – Frozen Soil Classification/Legend
Figures 4 - 11 – Test Pit Logs
Figure 12 – Generalized Geologic Cross-Section
Figure 13 – Summary of Particle Size Distribution Results

Appendix A: DOWL/HKM Laboratory Results

TABLES

TABLE 1: SAMPLE SUMMARY

Client:	CE2	**Project No.:**	113-95619		
Project:	CE2 Chefornak Lagoon	**QA/QC By:**	J. Randazzo	**Date:**	5/1/2011
Location:	Chefornak, AK	**Reviewed By:**	S. Wilson	**Date:**	5/4/2011

SAMPLING DATA						CLASSIFICATION AND INDEX TEST RESULTS												
		DEPTH (ft)								GRADATION (%)								
SAMPLE LOCATION	SAMPLE NUMBER	TOP	BOTTOM	RECOVERY (%)	SAMPLE TYPE	NATURAL MOISTURE CONTENT (%)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	GRAVEL	SAND	FINES (SILT & CLAY)	SILT	CLAY	DESCRIPTION (USCS)	SALINITY (ppt)	TESTS / OTHER TESTS	
TP-1	1	1.0	1.5	100	GS	1491									PT			
TP-1	2	3.0	3.5	100	GS	243									ML	1.2		
TP-1	3	6.0	6.5	100	GS	36									ML			
TP-1	4	9.5	10.0	100	GS	57				0	4	96			ML			
TP-1	5	13.0	13.5	100	GS	45									ML			
TP-1	6	14.5	15.0	100	GS	40									ML	7.6		
TP-2	1	1.0	1.5	100	GS	1006									OL			
TP-2	2	3.0	3.5	100	GS	322									ML	1.0		
TP-2	3	10.0	10.5	100	GS	64									ML	7.3		
TP-3	1	1.0	1.5	100	GS	648									OL			
TP-3	2	3.5	4.0	100	GS	64									ML			
TP-3	3	6.0	6.5	100	GS	68	61	44	17						MH	4.3		
TP-3	4	10.0	10.5	100	GS	42				0	6	94			ML			
TP-3	5	15.0	15.5	100	GS	46									ML	7.8		
TP-4	1	1.5	2.0	100	GS	222									OL			
TP-4	2	2.5	3.0	100	GS	73									ML	6.5		
TP-4	3	5.0	5.5	100	GS	74									OL			
TP-4	4	9.0	9.5	100	GS	44				0	10	90	65.7	24.0	ML		MA	
TP-4	5	15.0	15.5	100	GS	43				0	33	67			ML	13.1		
TP-5	1	1.5	2.0	100	GS	114									OL	5.2		
TP-5	2	8.0	8.5	100	GS	71				0	10	90			ML	3.4		
TP-5	3	11.0	11.5	100	GS	49									ML			
TP-5	4	17.5	18.0	100	GS	42				0	33	67			ML			
TP-6	1	1.5	2.0	100	GS	1101									OL	2.0		
TP-6	2	3.0	3.5	100	GS	188									ML	5.3		
TP-7	1	1.0	1.5	100	GS	936									PT			
TP-7	2	2.0	2.5	100	GS	80									ML	2.9		
TP-7	3	8.0	8.5	100	GS	85									ML	2.8		
TP-8	1	1.0	1.5	100	GS	187									OL			
TP-8	2	2.0	2.5	100	GS	65									ML	4.1		
TP-8	3	5.0	5.5	100	GS	103									ML			
TP-8	4	7.0	7.5	100	GS	36				0	11	89	73.1	15.4	ML		MA	

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC_SAMPLE_SUMMARY] DFreese 7/19/11

Golder Associates Inc.
2121 Abbott Road, Suite 100, Anchorage, AK 99507
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TABLE 1: SAMPLE SUMMARY

Client:	CE2	**Project No.:**	113-95619		
Project:	CE2 Chefornak Lagoon	**QA/QC By:**	J. Randazzo	**Date:**	5/1/2011
Location:	Chefornak, AK	**Reviewed By:**	S. Wilson	**Date:**	5/4/2011

SAMPLING DATA						CLASSIFICATION AND INDEX TEST RESULTS												
SAMPLE LOCATION	SAMPLE NUMBER	DEPTH (ft)		RECOVERY (%)	SAMPLE TYPE	NATURAL MOISTURE CONTENT (%)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	GRADATION (%)					DESCRIPTION (USCS)	SALINITY (ppt)	TESTS / OTHER TESTS	
		TOP	BOTTOM							GRAVEL	SAND	FINES (SILT & CLAY)	SILT	CLAY				
TP-8	5	12.0	12.5	100	GS	45	34	30	4						ML	8.6		

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC_SAMPLE_SUMMARY] DFreese 7/19/11

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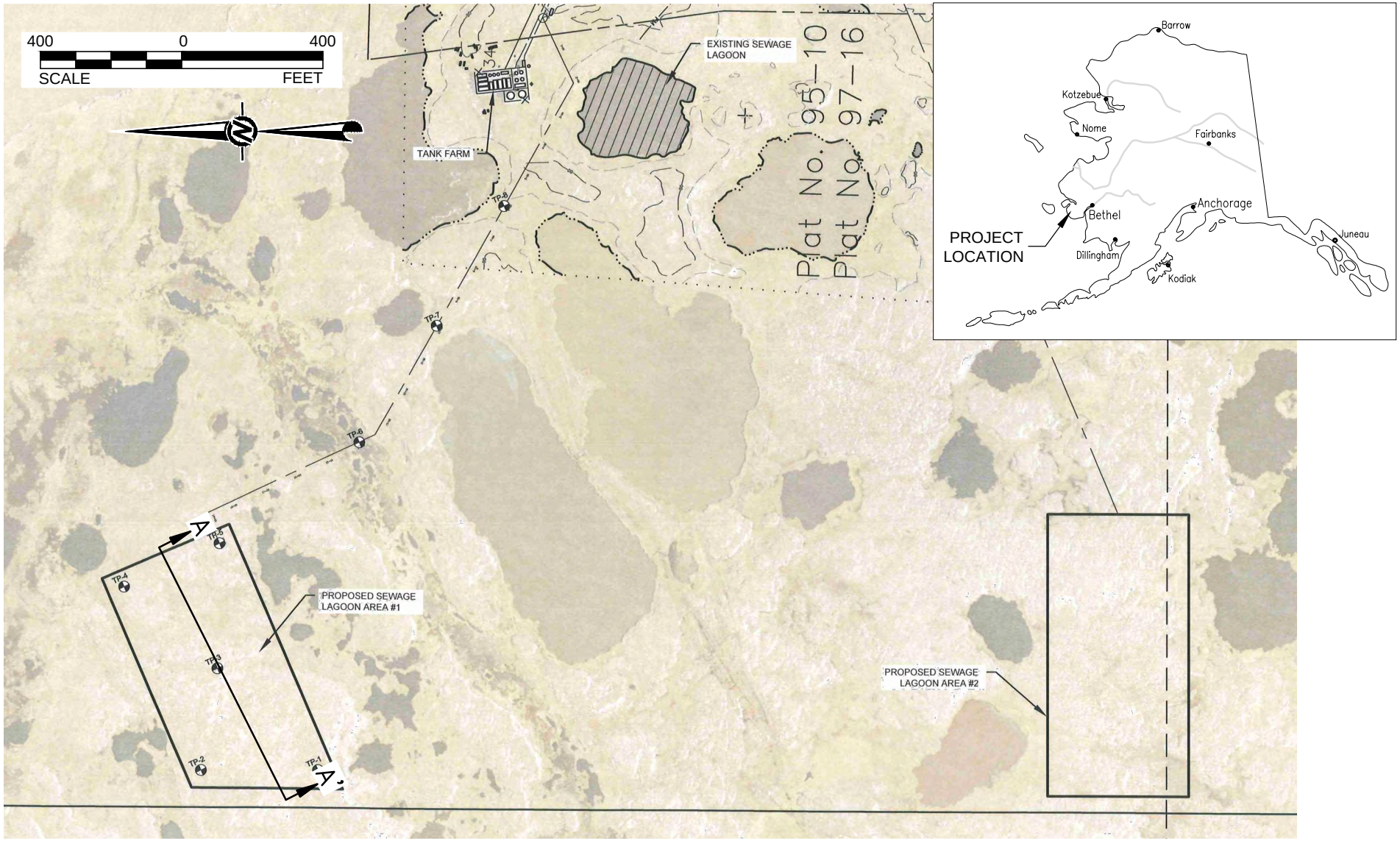
FIGURES



REFERENCE

1. ORIGINAL BASEMAP PREPARED BY CE2 ENGINEERS, INC. AND MODIFIED BY GOLDER ASSOCIATES.

Golder Associates

SCALE	AS SHOWN	
DESIGN	----	----
CADD	APG	7/19/11
CHECK	BBS	7/19/11
REVIEW	RAM	7/19/11
REV.	0	----

FILE No. VICINITY MAP.dwg

PROJECT No. 113-95619

TITLE

SITE MAP

CHEFORNAK LAGOON

CHEFORNAK, AK

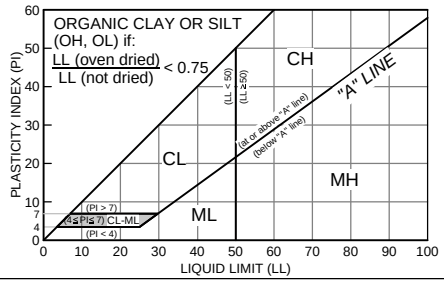
CE2 / CHEFORNAK / AK

FIG. **1**

J:\2011 jobs\113-95619 ce2 chefornak lagoon\CAD\VICINITY MAP.dwg | 7/19/2011 4:47 PM | AGarrigus | Anchorage, AK

UNIFIED SOIL CLASSIFICATION (ASTM D 2487-00)

MATERIAL TYPES	CRITERIA FOR ASSIGNING SOIL GROUP NAMES AND GROUP SYMBOLS USING LABORATORY TESTS			GROUP SYMBOL	SOIL GROUP NAMES & LEGEND	
COARSE-GRAINED SOILS >50% RETAINED ON NO. 200 SIEVE	GRAVELS >50% OF COARSE FRACTION RETAINED ON NO 4. SIEVE	CLEAN GRAVELS <5% FINES	$C_U \geq 4$ AND $1 \leq C_C \leq 3$	GW	WELL-GRADED GRAVEL	If soil contains ≥15% sand, add "with sand"
			$C_U < 4$ AND/OR $1 > C_C > 3$	GP	POORLY GRADED GRAVEL	
		GRAVELS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR CL	GM	SILTY GRAVEL	
			FINES CLASSIFY AS CL OR CH	GC	CLAYEY GRAVEL	
	SANDS ≥50% OF COARSE FRACTION PASSES ON NO 4. SIEVE	CLEAN SANDS <5% FINES	$C_U \geq 6$ AND $1 \leq C_C \leq 3$	SW	WELL-GRADED SAND	If soil contains ≥15% gravel, add "with gravel"
			$C_U < 6$ AND/OR $1 > C_C > 3$	SP	POORLY GRADED SAND	
		SANDS AND FINES >12% FINES	FINES CLASSIFY AS ML OR MH	SM	SILTY SAND	
			FINES CLASSIFY AS CL OR CH	SC	CLAYEY SAND	
FINE-GRAINED SOILS >50% PASSES NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT <50	PLASTICITY CHART		CL	LEAN CLAY	If soil contains coarse-grained soil from 15% to 29%, add "with sand" or "with gravel" for whichever type is prominent, or for ≥30%, add "sandy" or "gravelly"
				ML	SILT	
				OL	ORGANIC CLAY OR SILT	
	SILTS AND CLAYS LIQUID LIMIT ≥50			CH	FAT CLAY	
				MH	ELASTIC SILT	
				OH	ORGANIC CLAY OR SILT	
HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR		PT	PEAT	



Gravels or sands with 5% to 12% fines require dual symbols (GW-GM, GW-GC, GP-GM, GP-GC, SW-SM, SW-SC, SP-SM, SP-SC) and add "with clay" or "with silt" to group name. If fines classify as CL-ML for GM or SM, use dual symbol GC-GM or SC-SM.

Optional Abbeviations: Lower case "s" after USCS group symbol denotes either "sandy" or "with sand" and "g" denotes either "gravelly" or "with gravel"

$$C_U = \frac{D_{60}}{D_{10}} \qquad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

CRITERIA FOR DESCRIBING MOISTURE CONDITION (ASTM D 2488-00)

DRY	ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL IS BELOW WATER TABLE

COMPONENT DEFINITIONS BY GRADATION

COMPONENT	SIZE RANGE
BOULDERS	ABOVE 12 IN.
COBBLES	3 IN. TO 12 IN.
GRAVEL	3 IN. TO NO. 4 (4.76 mm)
COARSE GRAVEL	3 IN. TO 3/4 IN.
FINE GRAVEL	3/4 IN. TO NO. 4 (4.76 mm)
SAND	NO. 4 (4.76 mm) TO NO. 200 (0.074 mm)
COARSE SAND	NO. 4 (4.76 mm) TO NO. 10 (2.0 mm)
MEDIUM SAND	NO. 10 (2.0 mm) TO NO. 40 (0.42 mm)
FINE SAND	NO. 40 (0.42 mm) TO NO. 200 (0.074 mm)
SILT AND CLAY	SMALLER THAN NO. 200 (0.074 mm)
SILT	0.074 mm TO 0.005 mm
CLAY	LESS THAN 0.005 mm

DESCRIPTIVE TERMINOLOGY FOR PERCENTAGES (ASTM D 2488-00)

DESCRIPTIVE TERMS	RANGE OF PROPORTION
TRACE	0 - 5%
FEW	5 - 10%
LITTLE	10 - 25%
SOME	30 - 45%
MOSTLY	50 - 100%

RELATIVE DENSITY / CONSISTENCY ESTIMATE USING STANDARD PENETRATION TEST (SPT) VALUES

COHESIONLESS SOILS [a]		COHESIVE SOILS [b]		
RELATIVE DENSITY	N_1 (BLOWS/FOOT) [c]	CONSISTENCY	N_1 (BLOWS/FOOT) [c]	UNCONFINED COMPRESSIVE STRENGTH (TSF) [d]
VERY LOOSE	0 - 4	VERY SOFT	0 - 2	0 - 0.25
LOOSE	4 - 10	SOFT	2 - 4	0.25 - 0.50
COMPACT	10 - 30	FIRM	4 - 8	0.50 - 1.0
DENSE	30 - 50	STIFF	8 - 15	1.0 - 2.0
VERY DENSE	OVER 50	VERY STIFF	15 - 30	2.0 - 4.0
		HARD	OVER 30	OVER 4.0

(a) Soils consisting of gravel, sand, and silt, either separately or in combination possessing no characteristics of plasticity, and exhibiting drained behavior.

(b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.

(c) Refer to ASTM D 1586-99 for a definition of N. Values shown are based on N values corrected for overburden pressure (N_1). N values may be affected by a number of factors including material size, depth, drilling method, and borehole disturbance. N values are only an approximate guide for frozen soil or cohesive soil.

(d) Undrained shear strength, s_u= 1/2 unconfined compression strength, U_c. Note that Torvane measures s_u and Pocket Penetrometer measures U_c

SAMPLER ABBREVIATIONS

SS	SPT Sampler (2 in. OD, 140 lb hammer)	**C**	Core (Rock)
SSO	Oversize Split Spoon (2.5 in. OD, 140 lb typ.)	**TW**	Thin Wall (Shelby Tube)
HD	Heavy Duty Split Spoon (3 in. OD, 300/340 lb typ.)	**MS**	Modified Shelby
BD	Bulk Drive (4 in. OD, 300/340 lb hammer typ.)	**GP**	Geoprobe
CA	Continous Core (Soil in Hollow-Stem Auger)	**RC**	Air Rotary Cuttings
GS	Grab Sample from Surface / Testpit	**AG**	Auger Cuttings

LABORATORY TEST ABBREVIATIONS

Con	Consolidation	**P200**	Percent Fines (Silt & Clay)	**SpG**	Specific Gravity
Comp	Proctor Compaction (D698/D1557)	**pH**	Soil pH	**TC**	Thaw Consolidation/Strain
Dd	Dry Density	**PID**	Photoionization Detector	**TV**	Torvane
K	Thermal Conductivity	**PM**	Modified Proctor	**TX**	Unconfined Compression
MA	Sieve and Hydrometer Analysis	**PP**	Pocket Penetrometer	**W_C**	Liquid Limit (LL)
NP	Non-plastic	**PTLD**	Point Load	**W_P**	Plastic Limit (PL)
OLI	Organic Loss	**SA**	Sieve Analysis	**Ω**	Soil Resistivity

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SOIL CLASSIFICATION / LEGEND

Figure 2

FROZEN SOIL CLASSIFICATION (ASTM D 4083-89)

1. DESCRIBE SOIL INDEPENDENT OF FROZEN STATE	CLASSIFY SOIL BY THE UNIFIED SOIL CLASSIFICATION SYSTEM				
2. MODIFY SOIL DESCRIPTION BY DESCRIPTION OF FROZEN SOIL	MAJOR GROUP		SUBGROUP		
	DESCRIPTION	DESIGNATION	DESCRIPTION		DESIGNATION
	Segregated ice not visible by eye	N	Poorly bonded of friable		Nf
			Well bonded	No excess ice	Nbn
				Excess ice	Nbe
	Segregated ice visible by eye (ice less than 25 mm thick)	V	Individual ice crystals or inclusions		Vx
			Ice coatings on particles		Vc
			Random or irregularly oriented ice formations		Vr
			Stratified or distincltly oriented ice formations		Vs
			Uniformly distributed ice		Vu
3. MODIFY SOIL DESCRIPTION BY DESCRIPTION OF SUBSTANTIAL ICE STRATA	Ice greater than 25 mm thick	ICE	Ice with soil inclusions		ICE+soil type
			Ice without soil inclusions		ICE

FROST DESIGN SOIL CLASSIFICATION[1]

FROST GROUP[2]	GENERAL SOIL TYPE	% FINER THAN 0.02 mm BY WEIGHT	TYPICAL USCS SOIL CLASS
NFS[3] [MOA NFS]	(a) Gravels Crushed stone Crushed rock	0 to 1.5	GW, GP
	(b) Sands	0 to 3	SW, SP
PFS[4] [MOA NFS]	(a) Gravels Crushed stone Crushed rock	1.5 to 3	GW, GP
[MOA F2]	(b) Sands	3 to 10	SW, SP
S1 [MOA F1]	Gravelly soils	3 to 6	GW, GP GW-GM, GP-GM, GW-GC, GP-GC
S2 [MOA F2]	Sandy soils	3 to 6	SW, SP SW-SM, SP-SM, SW-SC, SP-SC
F1 [MOA F1]	Gravelly soils	6 to 10	GM, GC, GM-GC, GW-GM, GP-GM, GW-GC, GP-GC
F2 [MOA F2]	(a) Gravelly soils	10 to 20	GW, GP GW-GM, GP-GM, GW-GC, GP-GC
	(b) Sands	6 to 15	SM, SW-SM, SP-SM, SC, SW-SC, SP-SC, SM-SC
F3 [MOA F3]	(a) Gravelly soils	Over 20	GM, GC, GM-GC
	(b) Sands, except very fine silty sands	Over 15	SM, SC, SM-SC
	(c) Clays, PI>12	--	CL, CH
F4 [MOA F4]	(a) Silts	--	ML, MH, ML-CL
	(b) Very fine silty sands	Over 15	SM, SC, SM-SC
	(c) Clays, PI<12	--	CL, ML-CL
	(d) Varved clays or other fine-grained banded sediments	--	CL or CH layered with ML, MH, ML-CL, SM, SC, or SM-SC

(1) From U.S. Army Corps of Engineers (USACE), EM 1110-3-138, "Pavement Criteria for Seasonal Frost Conditions," April 1984
(2) USACE frost groups directly correspond to frost groups listed in Municipality of Anchorage (MOA) design criteria manual (DCM), 2007; except as noted.
(3) Non-frost susceptible
(4) Possibly frost susceptible, requires lab test for void ratio to determine frost design soil classification. Gravel with void ratio > 0.25 would be NFS; Gravel with void ratio < 0.25 would be S1; Sands with void ratio > 0.30 would be NFS; Sands with void ratio < 0.30 would be S2 or F2

ICE BONDING SYMBOLS

No ice-bonded soil observed

Poorly bonded or friable

Well bonded

DEFINITIONS

Candled Ice is ice which has rotted or otherwise formed into long columnar crystals, very loosely bonded together.

Clear Ice is transparent and contains only a moderate number of air bubbles.

Cloudy Ice is translucent, but essentially sound and non-pervious

Friable denotes a condition in which material is easily broken up under light to moderate pressure.

Granular Ice is composed of coarse, more or less equidimensional, ice crystals weakly bonded together.

Ice Coatings on particles are discernible layers of ice found on or below the larger soil particles in a frozen soil mass. They are sometimes associated with hoarfrost crystals, which have grown into voids produced by the freezing action.

Ice Crystal is a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in a combination with other ice formations.

Ice Lenses are lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss and commonly in repeated layers.

Ice Segregation is the growth of ice as distinct lenses, layers, veins and masses in soils, commonly but not always oriented normal to direction of heat loss.

Massive Ice is a large mass of ice, typically nearly pure and relatively homogeneous.

Poorly-bonded signifies that the soil particles are weakly held together by the ice and that the frozen soil consequently has poor resistance to chipping or breaking.

Porous Ice contains numerous voids, usually interconnected and usually resulting from melting at air bubbles or along crystal interfaces from presence of salt or other materials in the water, or from the freezing of saturated snow. Though porous, the mass retains its structural unity.

Thaw-Stable frozen soils do not, on thawing, show loss of strength below normal, long-time thawed values nor produce detrimental settlement.

Thaw-Unstable frozen soils show on thawing, significant loss of strength below normal, long-time thawed values and/or significant settlement, as a direct result of the melting of the excess ice in the soil.

Well-Bonded signifies that the soil particles are strongly held together by the ice and that the frozen soil possesses relatively high resistance to chipping or breaking.

Golder Associates

FROZEN SOIL CLASSIFICATION / LEGEND

Figure 3

RECORD OF BOREHOLE TP-1

PROJECT: CE2 Chefornak Lagoon
PROJECT NUMBER: 113-95619
LOCATION: Chefornak, AK

CLIENT: CE2
DRILLING DATE: 4/1/2011
EQUIPMENT: Excavator- Hitachi EX 300

DATUM: WGS 84
ELEVATION: n/a
COORDS: 60.16167° N 164.29778° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE – DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES – NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)	UNCORRECTED BLOWS / FT ■ (10 20 30 40); SALINITY (ppt) △; WATER CONTENT (PERCENT) W_P ⊢ W ⊣ W_L (10 20 30 40)	NOTES / TESTS / WATER LEVELS / GRAPHIC
0	Bucket	0.0 - 2.0 Frozen, light brown, fibrous PEAT, well bonded with approximately 40-50% visible ice by volume as individual ice crystals (PT, Vx)		PT			1	GS		6/6	1491 ○	
		2.0 - 3.0 Frozen, brown, ORGANIC SILT, well bonded with approximately 5-10% visible ice by volume as coatings on particles (OL, Vc)		OL		2.0						
		3.0 - 8.0 Frozen, gray, SILT, well bonded with approximately 5-10% visible ice by volume, grading to poorly bonded with no visible ice, trace organic material (ML, Vc to Nf)		ML		3.0	2	GS		6/6	△ 243 ○	
5							3	GS		6/6	○	Backfilled with excavated materials
		8.0 - 12.0 Dark gray to gray, SILT, low plasticity, trace organic material (ML)		ML		8.0	4	GS		6/6	57 ○	Gravel = 0%, Sand = 4%, P200 = 95.9%
10												
		12.0 - 15.0 Frozen, dark gray, SILT, poorly bonded friable (ML, Nf)		ML		12.0	5	GS		6/6	○	
							6	GS		6/6	△ ○	
15		Borehole completed at 15.0 ft.										
20												

Notes:

1) Test pit backfilled with excavated materials
2) No groundwater observed

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: CE2
DRILLER: Evan

LOGGED: J. Randazzo
CHECKED: D. Willman
CHECK DATE: 5/17/2011

Figure 4

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC BOREHOLE] DFreese 7/19/11

RECORD OF BOREHOLE TP-2

PROJECT: CE2 Chefornak Lagoon
PROJECT NUMBER: 113-95619
LOCATION: Chefornak, AK

CLIENT: CE2
DRILLING DATE: 4/1/2011
EQUIPMENT: Excavator- Hitachi EX 300

DATUM: WGS 84
ELEVATION: n/a
COORDS: 60.16253° N 164.29778° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE		BLOWS PER FT	REC / ATT (inch)	UNCORRECTED BLOWS / FT ■ (10 20 30 40) / SALINITY (ppt) △ / WATER CONTENT (PERCENT) W_P W W_L (10 20 30 40)	NOTES / TESTS / WATER LEVELS / GRAPHIC
0	Bucket	0.0 - 1.0 Frozen, light brown, fibrous PEAT, well bonded with approximately 40-50% visible ice by volume as individual ice crystals (PT, Vx)		PT									
		1.0 - 2.0 Frozen, brown, ORGANIC SILT, well bonded no excess ice (OL, Nbn)		OL		1.0	1	GS			6/6	1006	
		2.0 - 13.0 Frozen, gray, SILT, well bonded to 9.5 feet, approximately 10-15% visible ice by volume as coatings on particles, some organic material (ML, Vc to Nf)		ML		2.0	2	GS			6/6	△ 322	
5													1 inch PVC
		Poorly bonded at 9.5 feet											
10							3	GS			6/6	△ 64	
		Borehole completed at 13.0 ft.											
15		Notes: 1) Test pit backfilled with excavated materials 2) Closed-end 1 inch schedule 80 PVC installed to 13 feet, with 2 feet of stickup above grade 3) No groundwater observed											
20													

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: CE2
DRILLER: Evan

LOGGED: J. Randazzo
CHECKED: D. Willman
CHECK DATE: 5/17/2011

Figure 5

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC BOREHOLE] DFreese 7/19/11

RECORD OF BOREHOLE TP-3

PROJECT: CE2 Chefornak Lagoon
PROJECT NUMBER: 113-95619
LOCATION: Chefornak, AK

CLIENT: CE2
DRILLING DATE: 4/2/2011
EQUIPMENT: Excavator- Hitachi EX 300

DATUM: WGS 84
ELEVATION: n/a
COORDS: 60.16222° N 164.29689° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE – DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES – NUMBER	TYPE		BLOWS PER FT	REC / ATT (inch)	UNCORRECTED BLOWS / FT ■ (10 20 30 40) / SALINITY (ppt) △ / WATER CONTENT (PERCENT) W_P W W_L (10 20 30 40)	NOTES / TESTS / WATER LEVELS / GRAPHIC
0	Bucket	0.0 - 1.0 Frozen, light brown, fibrous PEAT, well bonded with approximately 40-50% visible ice by volume as individual ice crystals (PT, Vx)		PT									
		1.0 - 3.0 Frozen, brown, ORGANIC SILT, well bonded with approximately 5-10% visible ice by volume as coatings on particles (OL, Vc)		OL		1.0	1	GS			6/6	648	
		3.0 - 6.0 Dark gray, SILT, well bonded becoming friable below 5 feet, approximately 10% visible ice by volume (ML, Vc to Nbn)		ML		3.0	2	GS			6/6	64	
5		6.0 - 8.0 Moist, dark gray, elastic SILT, medium plasticity (MH)		MH		6.0	3	GS			6/6	△ ~~100~~	1 inch PVC
		8.0 - 16.0 Gray, SILT, trace sand layers observed below 15 feet (ML)		ML		8.0							
10							4	GS			6/6		Gravel = 0%, 10 ft Sand = 6%, WD P200 = 93.7%
15							5	GS			6/6	△	
		Borehole completed at 16.0 ft.											
20													

Notes:

1) Test pit backfilled with excavated materials
2) Groundwater seepage observed at 10 feet during excavation
3) Closed-end 1 inch schedule 80 PVC installed to 15 feet, with 5 feet of stick up above grade

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: CE2
DRILLER: Evan

LOGGED: J. Randazzo
CHECKED: D. Willman
CHECK DATE: 5/17/2011

Figure 6

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC BOREHOLE] DFreese 7/19/11

RECORD OF BOREHOLE TP-4

PROJECT: CE2 Chefornak Lagoon
PROJECT NUMBER: 113-95619
LOCATION: Chefornak, AK

CLIENT: CE2
DRILLING DATE: 4/2/2011
EQUIPMENT: Excavator- Hitachi EX 300

DATUM: WGS 84
ELEVATION: n/a
COORDS: 60.16314° N 164.29500° W

BORING METHOD: Bucket

DEPTH (ft)	SOIL PROFILE DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE		BLOWS PER FT	REC / ATT (inch)	UNCORRECTED BLOWS / FT ■ (10 20 30 40) / SALINITY (ppt) △ / WATER CONTENT (PERCENT) W_P W W_L (10 20 30 40)	NOTES TESTS WATER LEVELS GRAPHIC
0	0.0 - 1.0 Frozen, brown, fibrous PEAT, well bonded no excess ice (PT, Nbn)		PT									
	1.0 - 2.0 Frozen, brown, ORGANIC SILT, well bonded no excess ice (OL, Nbn)		OL		1.0	1	GS			6/6	222	
	2.0 - 5.0 Frozen, gray, SILT, well bonded to 4 feet, poorly bonded 4-5 feet, no visible ice, trace organic material (ML, Nbn)		ML		2.0	2	GS			6/6	△ 73	Backfilled with excavated materials
5	5.0 - 7.0 Moist, black, ORGANIC SILT, mixed with peat (OL)		OL		5.0	3	GS			6/6	74	
	7.0 - 9.0 Moist, gray, SILT (ML)		ML		7.0							
10	9.0 - 18.0 Gray, SILT, few fine sand grading to sandy SILT, sand is fine (ML)		ML		9.0	4	GS			6/6		Gravel = 0%, Sand = 10%, P200 = 89.7%, MA
15						5	GS			6/6	△	Gravel = 0%, Sand = 33%, P200 = 66.7%
	Borehole completed at 18.0 ft.											
20												

Notes:

1) Test pit backfilled with excavated materials
2) No groundwater observed

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: CE2
DRILLER: Evan

LOGGED: J. Randazzo
CHECKED: D. Willman
CHECK DATE: 5/17/2011

Figure 7

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC BOREHOLE] DFreese 7/19/11

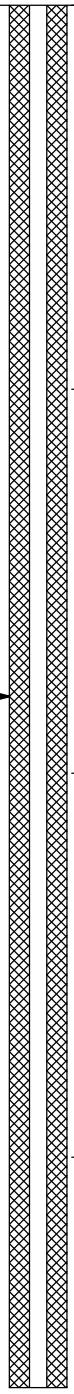
RECORD OF BOREHOLE TP-5

PROJECT: CE2 Chefornak Lagoon
PROJECT NUMBER: 113-95619
LOCATION: Chefornak, AK

CLIENT: CE2
DRILLING DATE: 4/2/2011
EQUIPMENT: Excavator- Hitachi EX 300

DATUM: WGS 84
ELEVATION: n/a
COORDS: 60.16231° N 164.29428° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE		BLOWS PER FT	REC / ATT (inch)	UNCORRECTED BLOWS / FT ■ (10 20 30 40); SALINITY (ppt) △; WATER CONTENT (PERCENT) W_P W W_L (10 20 30 40)	NOTES / TESTS / WATER LEVELS / GRAPHIC
0	Bucket	0.0 - 1.0 Frozen, brown, fibrous PEAT, well bonded no excess ice (PT, Nbn)		PT									
		1.0 - 2.0 Frozen, brown, ORGANIC SILT, well bonded no excess ice (OL, Nbn)		OL		1.0	1	GS			6/6	△ 114 ○	
		2.0 - 9.0 Frozen, gray to dark gray, SILT, well bonded, approximately 5-10% visible ice by volume, trace organic material (ML, Vc to Nf)		ML		2.0							
5		Poorly bonded at 7 feet					2	GS			6/6	△ 71 ○	Gravel = 0%, Sand = 10%, P200 = 90.0%
		9.0 - 18.0 Wet, gray to dark gray, sandy SILT, fine-grained sand, sand content increasing with depth (ML)		ML		9.0							1 inch PVC
10							3	GS			6/6	○	
15							4	GS			6/6	○	Gravel = 0%, Sand = 33%, P200 = 66.9%
		Borehole completed at 18.0 ft.											
20		Notes: 1) Test pit backfilled with excavated materials 2) Closed-end 1 inch schedule 80 PVC installed to 18 feet, with 2 feet of stickup above grade 3) No groundwater observed											



Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: CE2
DRILLER: Evan

LOGGED: J. Randazzo
CHECKED: D. Willman
CHECK DATE: 5/17/2011

Figure 8

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC BOREHOLE] DFreese 7/19/11

RECORD OF BOREHOLE TP-6

PROJECT: CE2 Chefornak Lagoon
PROJECT NUMBER: 113-95619
LOCATION: Chefornak, AK

CLIENT: CE2
DRILLING DATE: 4/2/2011
EQUIPMENT: Excavator- Hitachi EX 300

DATUM: WGS 84
ELEVATION: n/a
COORDS: 60.16136° N 164.29281° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE		BLOWS PER FT	REC / ATT (inch)	UNCORRECTED BLOWS / FT ■ (10 20 30 40); SALINITY (ppt) △; WATER CONTENT (PERCENT) W_P W W_L (10 20 30 40)	NOTES TESTS WATER LEVELS GRAPHIC
0	Bucket	0.0 - 0.5 Frozen, black, fibrous PEAT, well bonded no excess ice (PT, Nbn)		PT		0.5							
		0.5 - 1.5 Frozen, black, ORGANIC SILT, well bonded no excess ice (OL, Nbn)		OL		1.5	1	GS			6/6	△ 110 ○	Backfilled with excavated materials
		1.5 - 3.0 Wet, black, ORGANIC SILT (OL)		OL		3.0	2	GS			6/6	△ 188 ○	3 ft WD
		3.0 - 5.0 Wet, black, SILT, trace sand (ML)		ML									
5		Borehole completed at 5.0 ft.											
10													
15													
20													

Notes:

1) Test pit backfilled with excavated materials
2) Test pit excavated in potential drainage channel
3) Groundwater observed at 3 feet while excavating

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: CE2
DRILLER: Evan

LOGGED: J. Randazzo
CHECKED: D. Willman
CHECK DATE: 5/17/2011

Figure 9

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC BOREHOLE] DFreese 7/19/11

RECORD OF BOREHOLE TP-7

PROJECT: CE2 Chefornak Lagoon
PROJECT NUMBER: 113-95619
LOCATION: Chefornak, AK

CLIENT: CE2
DRILLING DATE: 4/2/2011
EQUIPMENT: Excavator- Hitachi EX 300

DATUM: WGS 84
ELEVATION: n/a
COORDS: 60.16069° N 164.29033° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE		BLOWS PER FT	REC / ATT (inch)	UNCORRECTED BLOWS / FT ■ (10 20 30 40); SALINITY (ppt) △; WATER CONTENT (PERCENT) W_P W W_L (10 20 30 40)	NOTES / TESTS / WATER LEVELS / GRAPHIC
0	Bucket	0.0 - 1.5 Frozen, brown, fibrous PEAT, well bonded no excess ice (PT, Nbn)		PT									
							1	GS			6/6	936	
		1.5 - 10.0 Frozen, gray, SILT, well bonded, no visible ice, trace fibrous organic material (ML, Nbn to Nf)				1.5							
							2	GS			6/6	△ 80	
5				ML									1 inch PVC
		Poorly bonded at 8 feet, trace sand					3	GS			6/6	△ 85	
10		Borehole completed at 10.0 ft.											
15													
20													

Notes:

1) Test pit backfilled with excavated materials
2) Closed-end 1 inch schedule 80 PVC installed to 10 feet, with 1.5 feet of stickup above grade
3) No groundwater observed

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: CE2
DRILLER: Evan

LOGGED: J. Randazzo
CHECKED: D. Willman
CHECK DATE: 5/17/2011

Figure 10

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC BOREHOLE] DFreese 7/19/11

RECORD OF BOREHOLE TP-8

PROJECT: CE2 Chefornak Lagoon
PROJECT NUMBER: 113-95619
LOCATION: Chefornak, AK

CLIENT: CE2
DRILLING DATE: 4/3/2011
EQUIPMENT: Excavator- Hitachi EX 300

DATUM: WGS 84
ELEVATION: n/a
COORDS: 60.16025° N 164.28892° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE		BLOWS PER FT	REC / ATT (inch)	UNCORRECTED BLOWS / FT ■ (10 20 30 40); SALINITY (ppt) △; WATER CONTENT (PERCENT) W_P W W_L (10 20 30 40)	NOTES TESTS WATER LEVELS GRAPHIC
0	Bucket	0.0 - 0.5 Frozen, brown, fibrous PEAT, well bonded no excess ice (PT, Nbn)		PT		0.5							
		0.5 - 1.5 Frozen, brown, ORGANIC SILT, well bonded with approximately 5% visible ice by volume as coatings on particles (OL, Vc)		OL		1.5	1	GS			6/6	187	
		1.5 - 3.5 Frozen, gray, SILT, trace sand, well bonded with approximately 5-10% visible ice by volume as coatings on particles (ML, Vc)		ML		3.5	2	GS			6/6	65	
		3.5 - 5.0 Frozen, dark gray, ORGANIC SILT to SILT with organics, interbedded fibrous peat, poorly bonded with no visible ice (OL to ML, Nf)		OL		5.0							
5		5.0 - 7.0 Moist, black, SILT, trace to few fine-grained sand, nonplastic (ML)		ML		7.0	3	GS			6/6	103	
		7.0 - 15.5 Moist, gray, SILT, low plasticity, trace sand (ML)		ML			4	GS			6/6		Gravel = 0%, Sand = 11%, P200 = 88.6%, MA 1 inch PVC
10							5	GS			6/6		
15		Borehole completed at 15.5 ft.											
20													

Notes:

1) Test pit backfilled with excavated materials
2) Closed-end 1 inch schedule 80 PVC installed to 15.5 feet, with 4.5 feet of stickup above grade
3) No groundwater observed

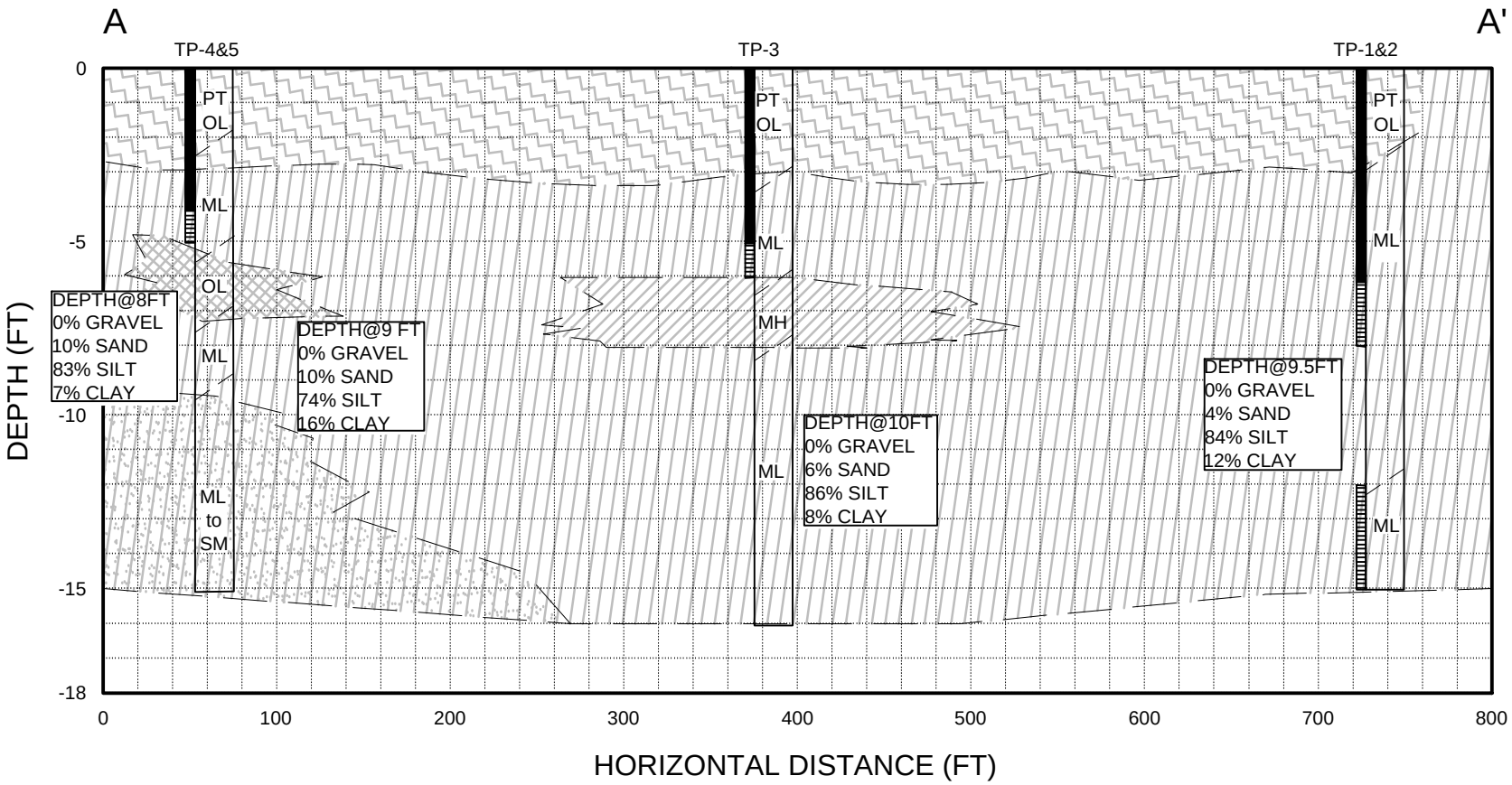
Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: CE2
DRILLER: Evan

LOGGED: J. Randazzo
CHECKED: D. Willman
CHECK DATE: 5/17/2011

Figure 11

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC BOREHOLE] DFreese 7/19/11



LEGEND

- PEAT AND ORGANIC SILT (OL to PT)
- SILT (ML)
- ELASTIC SILT (MH)
- ORGANIC SILT (OL)
- SAND TO SANDY SILT (SM to ML)
- FROZEN, WELL BONDED
- FROZEN, POORLY BONDED

DEPTH@9 FT 0% GRAVEL 4% SAND 84% SILT 12% CLAY	SAMPLE DEPTH HYDROMETER RESULTS BASED ON 0.002mm SIZE

Golder Associates

SCALE	AS SHOWN	
DESIGN	----	----
CADD	APG	6/30/11
CHECK	BBS	6/30/11
REVIEW	RAM	6/30/11
REV.	1	----

FILE No. VICINITY MAP.dwg

PROJECT No. 113-95619

TITLE

GENERALIZED GEOLOGIC CROSS-SECTION

CHEFORNAK LAGOON

CHEFORNAK , AK

CE2 / CHEFORNAK / AK

FIG. 12

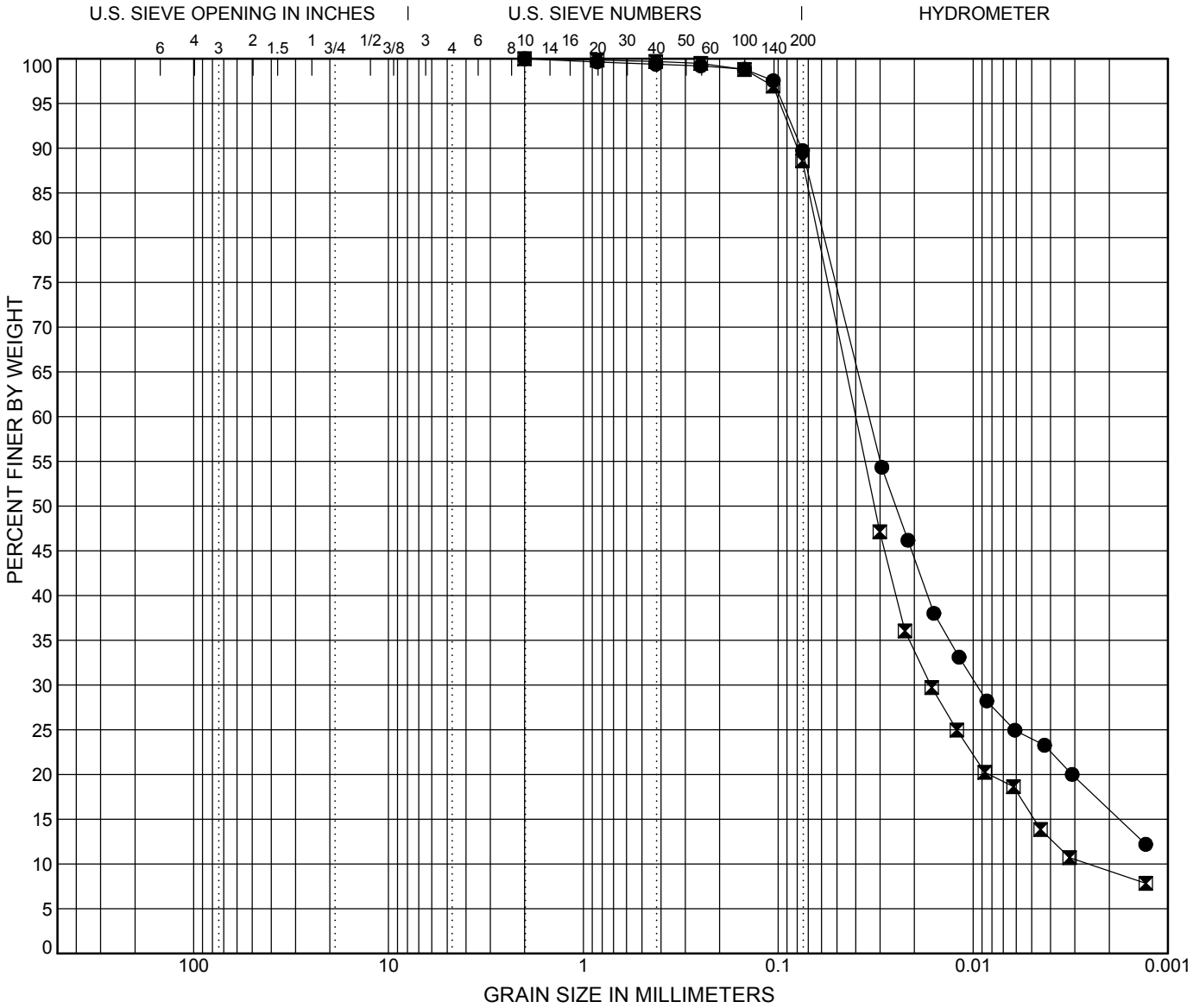
J:\2011 Jobs\113-95619 CE2 Chefornak Lagoon\CAD\VICINITY MAP.dwg | 7/19/2011 4:22 PM | AGarrigus | Anchorage, AK

Golder Associates

FIGURE 13: SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s)
ASTM D 422-63 (2007)

Client:	CE2	**Project No.:**	113-95619		
Project:	CE2 Chefornak Lagoon	**QA/QC By:**	J. Randazzo	**Date:**	5/1/2011
Location:	Chefornak, AK	**Reviewed By:**	S. Wilson	**Date:**	5/4/2011



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	%Fines %Silt	%Fines %Clay
●	TP-4	4	9.0	silt (ML)			0.0	10.3	65.7	24.0
⊠	TP-8	4	7.0	silt (ML)	2.7	15.5	0.0	11.4	73.1	15.4

CE2 CHEFORNAK LAGOON.GPJ LIBRARY-ANC(7-13-11).GLB [ANC LAB GRAIN SIZE] DFreese 7/19/11

Golder Associates Inc.
2121 Abbott Road, Suite 100, Anchorage, AK 99507
Tel: (907) 344-6001 Fax: (907) 344-6011 www.golder.com

Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

APPENDIX A

DOWL/HKM LABORATORY RESULTS

DOWL HKM

Client: Golder Associates Inc.
Project: CE2 Chefornak Lagoon
Work Order: A33155

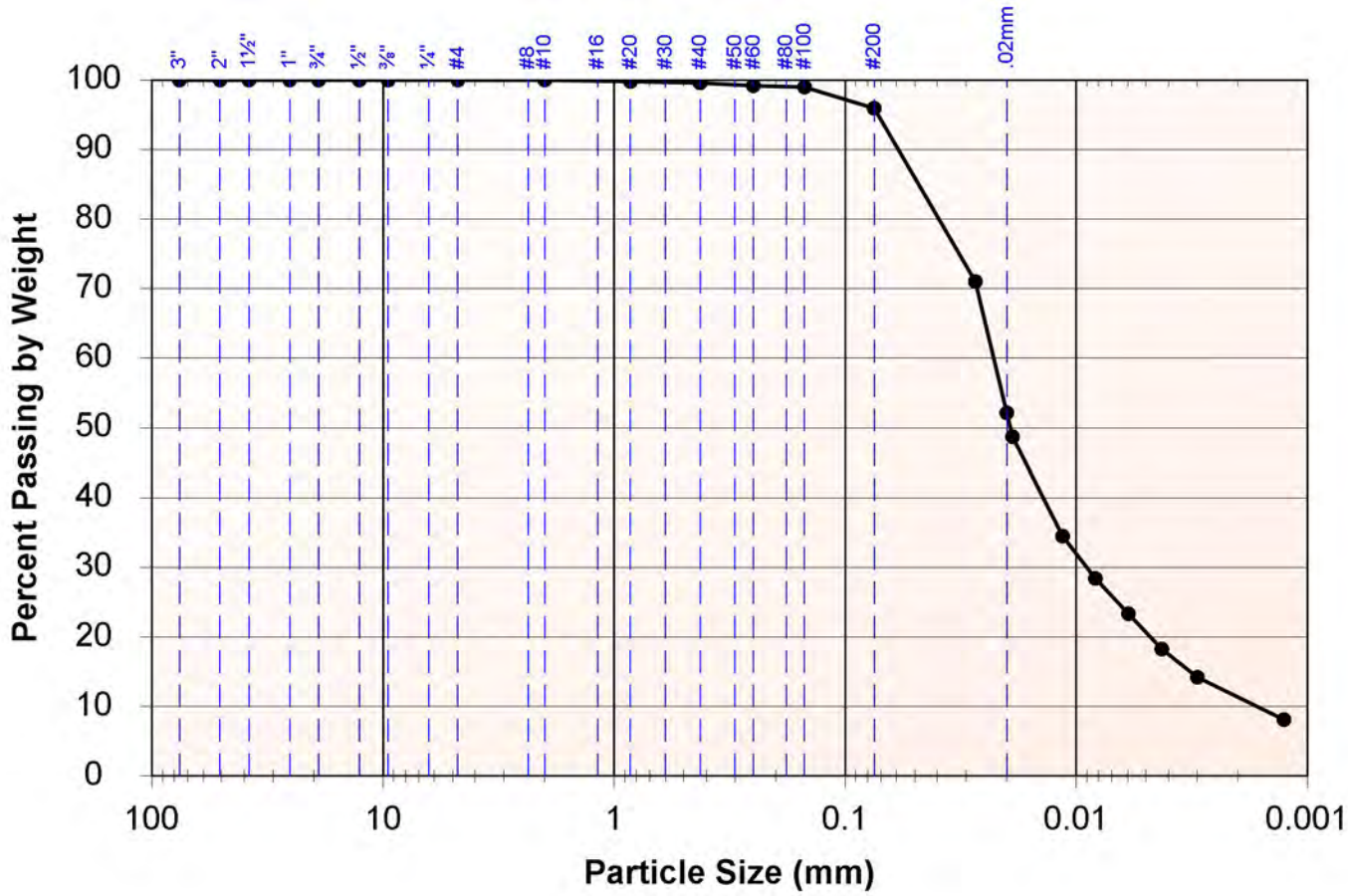
Particle Size Distribution

ASTM D422

Location: TP-1 #4

Lab Number	2011-727
Received	6/21/2011
Reported	6/24/2011

Engineering Classification: **Silt, ML**
Frost Classification: **F4**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	100%	
Total Weight of Coarse Fraction: 49.3g		
#10	100%	
#20	100%	
#40	100%	
#60	99%	
#100	99%	
#200	95.9%	
Total Weight of Fine Fraction: 49.3g		
0.02 mm	52%	

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DOWL HKM

Client: Golder Associates Inc.
Project: CE2 Chefornak Lagoon
Work Order: A33155

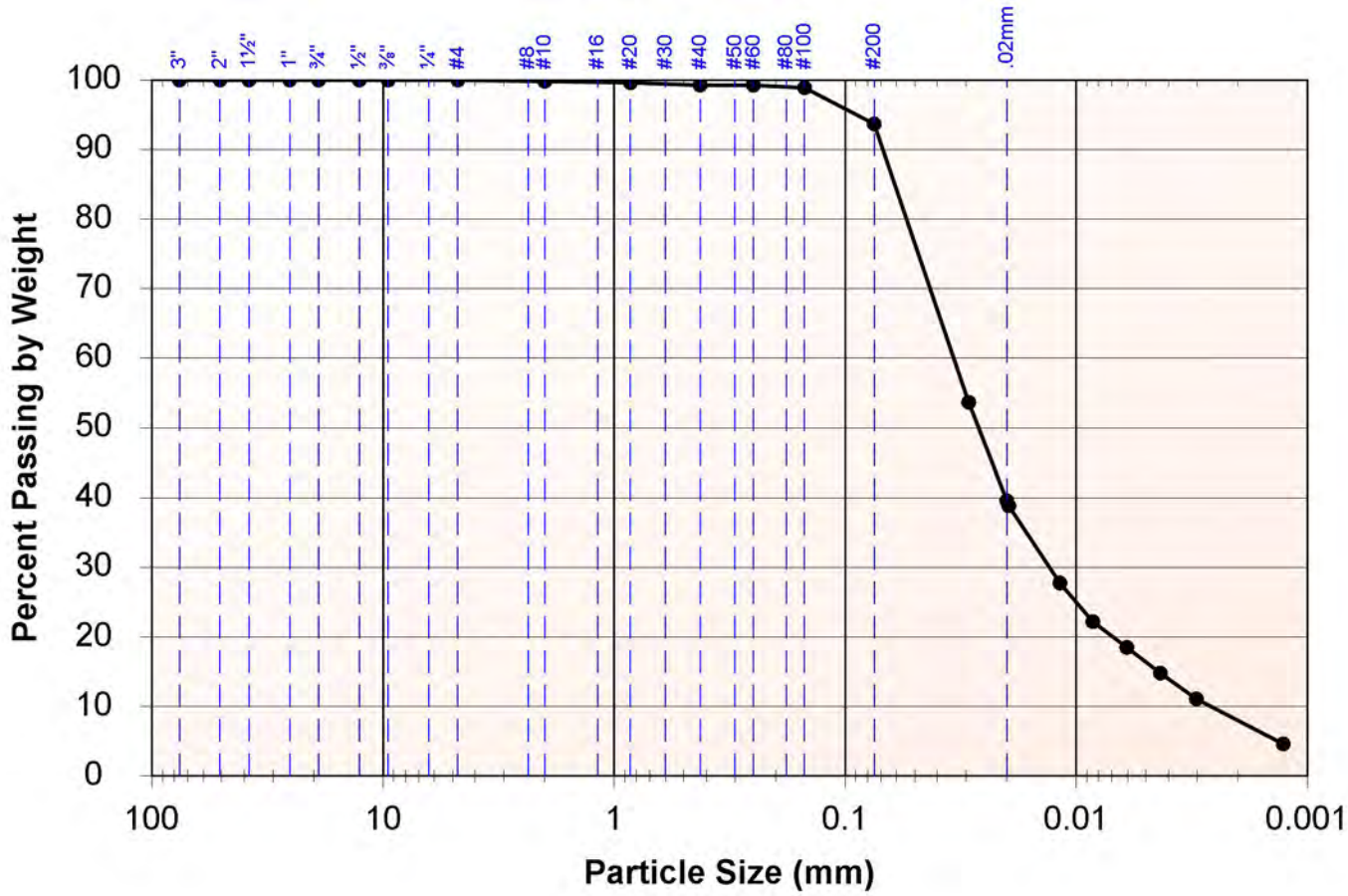
Particle Size Distribution

ASTM D422

Location: TP3 @ 10' #4

Lab Number	2011-728
Received	6/21/2011
Reported	6/24/2011

Engineering Classification: **Silt, ML**
Frost Classification: **F4**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	100%	
Total Weight of Coarse Fraction: 53.95g		
#10	100%	
#20	100%	
#40	99%	
#60	99%	
#100	99%	
#200	93.7%	
Total Weight of Fine Fraction: 53.95g		
0.02 mm	40%	

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DOWL HKM

Client: Golder Associates Inc.
Project: CE2 Chefornak Lagoon
Work Order: A33155

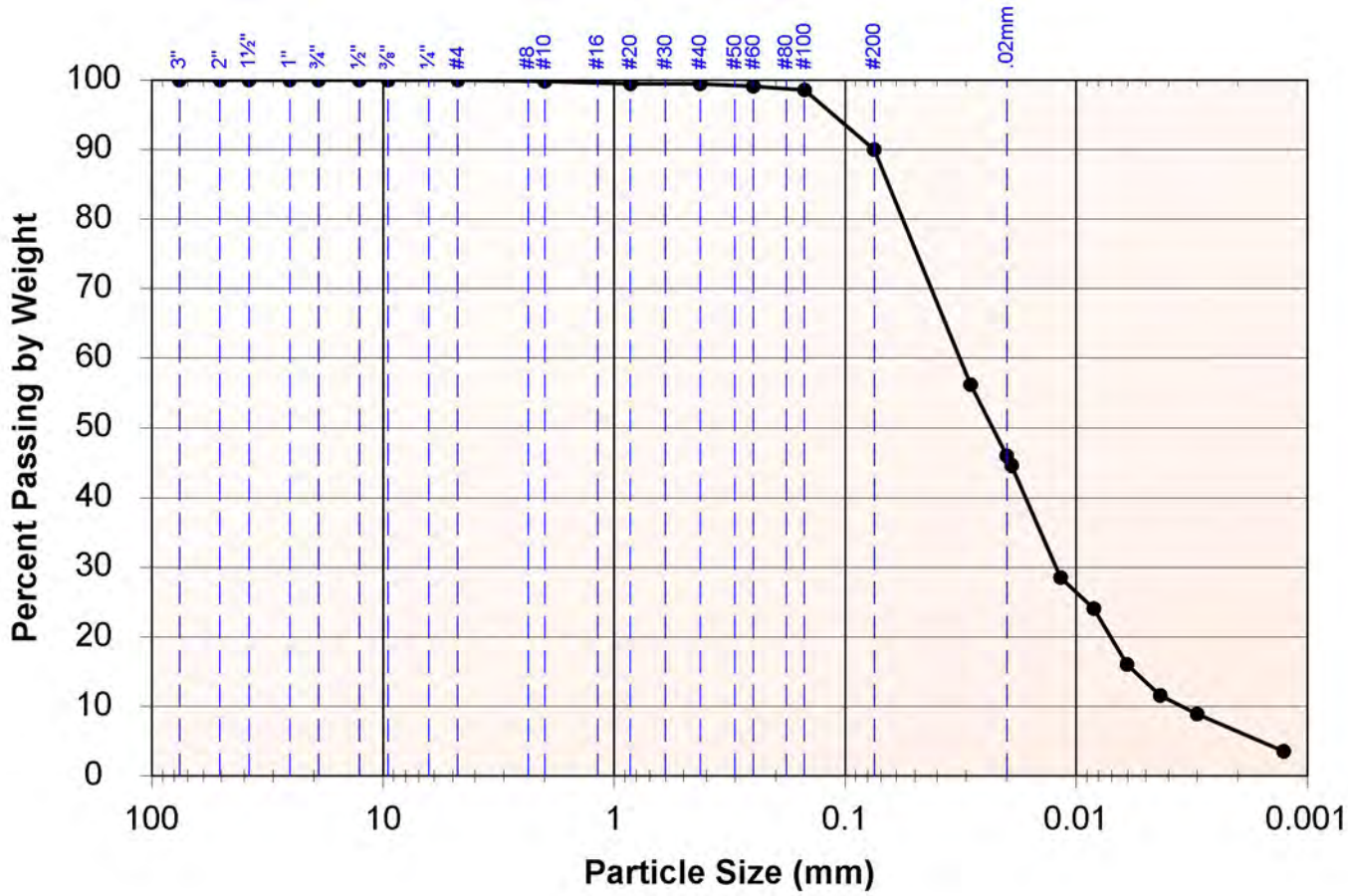
Particle Size Distribution

ASTM D422

Location: TP-5 @ 8 #2

Lab Number	2011-729
Received	6/24/2011
Reported	6/24/2011

Engineering Classification: **Silt, ML**
Frost Classification: **F4**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	100%	
Total Weight of Coarse Fraction: 55.96g		
#10	100%	
#20	99%	
#40	99%	
#60	99%	
#100	99%	
#200	90%	
Total Weight of Fine Fraction: 55.96g		
0.02 mm	46%	

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Appendix B—City/LKSD Wastewater Disposal Agreement

WASTEWATER DISPOSAL AGREEMENT

This Agreement is between the City of Chefornak (hereinafter called "City") and the Lower Kuskokwim School District (hereinafter called "LKSD") and is for the purpose of documenting the coordination of wastewater disposal systems pursuant to Alaska Administrative Code 18 AAC 72.205 (a) (5) and (10).

Background Information:

Chefarnrmute, Incorporated (hereinafter called "Corporation"), the Alaska Native Settlement Claims Act village corporation for Chefornak, is the current owner of the land on which the existing "School Tundra Pond" is situated. The Corporation has completed its 14(c)(3) process and has agreed to transfer the land on which the "School Tundra Pond" is located to the City of Chefornak as required. The authorized signature of a representative of the Corporation, below, indicates that the situation described above in this paragraph is true and that the Corporation authorizes the City to act on their behalf with regards to this property.

LKSD is constructing a Renovation/Addition project at the public school in Chefornak and desires to dispose of wastewater at the existing "School Tundra Pond."

In 1991, LSKD received a wastewater discharge permit from the Alaska Department of Environmental Conservation to dispose of 15,600 gpd of domestic sewage. The ownership of the land and the constructed outfall was not clarified at that time.

A 1991 LKSD lease with the Corporation showed that both parties understood that a sewage line and outfall would be constructed on the Corporation property.

LKSD's permit for wastewater discharge to the "School Tundra Pond" lapsed in 1996. Subsequently, the Corporation agreed, as noted above, to transfer property including the "School Tundra Pond" to the City.

The proposed modification of the LKSD wastewater system requires State approval. The City also desires that the LKSD dispose of wastewater at the City's future "Community Sewage Lagoon" to avoid locating two separate lagoons in the community.

The State of Alaska requires LKSD to obtain approval of the new school Plan for collection, treatment, and disposal of domestic wastewater. Upon approval of the Plan, the Alaska Department of Environmental Conservation (ADEC) will issue an "approval to construct" document to LKSD.

Agreement:

The City, Corporation, and LKSD agree with the following statements:

1. The Corporation owns the land on which the existing School Tundra Pond and the existing force main serving only the school are located and has agreed to transfer the property to the City via quitclaim deed as part of their 14(c)(3) process.

2. A state grant administered by LKSD, is providing a valuable community asset: a new force main from the new school to the School Tundra Pond.

3. LKSD will construct the new sewer force main as shown in the amended drawing attached as page 4 of this agreement.

4. The City will compensate the School project for the actual increase in material costs for the larger diameter force main. This cost is estimated by the City's engineer at $15,000

5. LKSD will comply with all applicable regulatory requirements that may affect construction and operation of the proposed wastewater collection and treatment systems.

6. The School Tundra Pond has no discharge permit, and the pond cannot receive a discharge permit from the ADEC.

7. LKSD agrees to construct a new 1,000.16 LF sewer force main as shown in the attached drawing (page 4,)and future site plan C3 2 n (page 6), and to maintain and operate the force main until the conclusion of the school renovation /addition construction project.

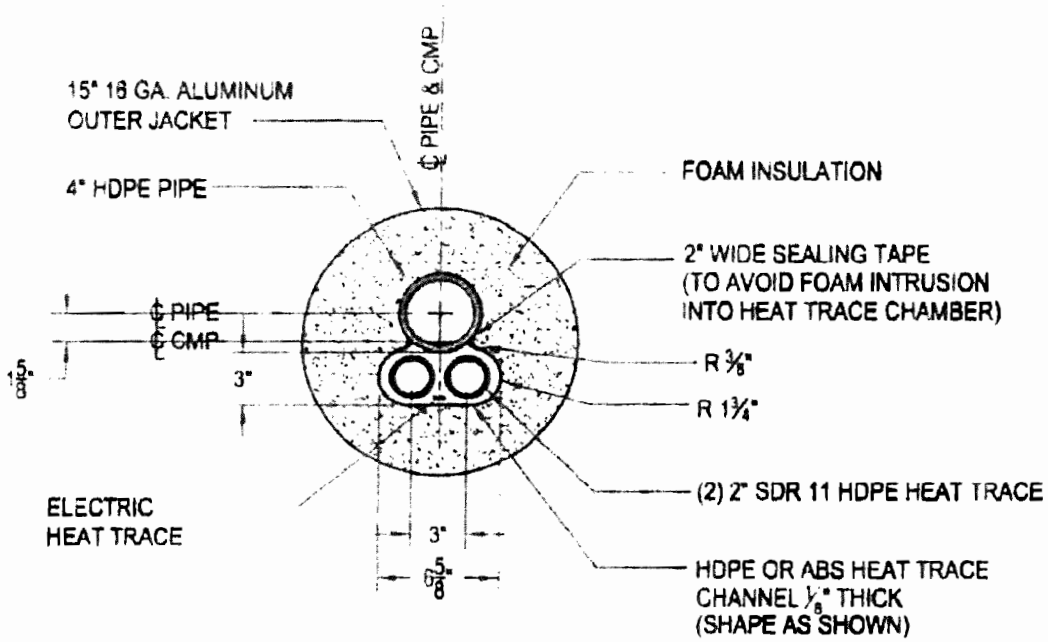
8. LKSD agrees that the City will discharge waste through the existing outfall as shown in the attached figure G2.3, dated 9/23/2009 (page 5), without resolving the issue of the ownership of the outfall. In 2010 and 2011, the City will only discharge waste from three washers, two showers and one toilet to the School Tundra Pond.

9. LKSD will transfer ownership of the sewer force main at the end of the warranty period and when the outfall is deemed structurally sound and operating as planned.

10 Upon assumption of ownership by the City, LKSD agrees to pay the City for the full operational and maintenance expense of providing wastewater service to the School proportional to the flow generated by the school. If costs are incurred by the City for operation of the force main before the City assumes ownership, these costs will be paid by LKSD. "Costs" would include lagoon testing, heat, and administrative costs.

11 As required by LKSD's approval to operate a water system, the City will supply Drinking Water to the new public School at a cost proportional to usage. LKSD

Sewer Force Main:



1
C3.2

4" X 15" HDPE ARCTIC PIPE CROSS SECTION - GLYCOL TRACED

N.T.S.

cannot dispose wastewater to the new wastewater force main from any source other than that of the City water supply.

12. Rates charged to LKSD for water and wastewater will reflect the actual cost of operating and maintaining the services provided to the School.

13. Liability for the waste generated will remain with the generator.

14. This Agreement will remain in effect until the City is able to provide a designed, constructed, and permitted lagoon for community-wide wastewater disposal on property for which the City is the recorded owner. The City currently has grant funding for this project. At that point, a new Wastewater Disposal Agreement will be executed.

Signed:

City of Chefornak

Signature

Robert Jimmy Mayor
Printed Name and Title

9/3/2010
Date

Lower Kuskokwim School District

Signature

Gary Baldwin, Superintendent

9/2/10
Date

Chefarnrmute, Incorporated

Signature

Robert Panrulk Pres/Gm
Printed Name and Title

9/9/10
Date

Appendix C—Heat Loss / Head Loss Calculations for Average Flow Velocity and Scour Velocity

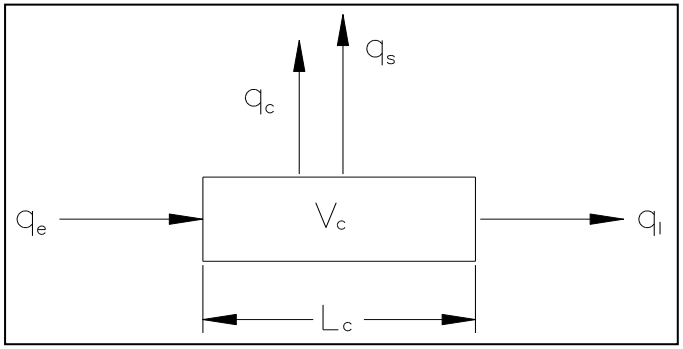
FORCEMAIN PIPING HEAT/HEAD LOSS CALCULATIONS
AVERAGE FLOW VELOCITY

INPUTS

PIPE O.D. (in)	4.5
PIPE I.D. (in)	3.68
INS. O.D. (in)	15
INS. I.D. (in)	4.5
Lc (ft)	50
KINS (BTU/hr*ft*F)	0.017
KHDPE (BTU/hr*ft*F)	0.225
Ti (F)	45
Ta (F)	-45
VELOCITY (ft/s)	0.38
C-FACTOR	140
Us (BTU/hr)	840

DERIVED QUANTITIES

Vc (CUFT)	3.69
Q (CUFT/S)	0.03
TIME (s)	131.6
Q *(GPM)*	*12.6*
	AVERAGE FLOW



$q_l = q_e - (q_s + q_c)$

STATION	ΔTEMP (F)	Te (F)	INCREMENTAL HEAT LOSS - qc (BTU)	POINT HEAT LOSS - qs (BTU)	No Service Connections	HEAT IN - qe (BTU)	HEAT LEAVING - ql (BTU)	TOTAL HEAT LOSS (BTU/HR)	TRANSIT TIME (MIN)	HEAD LOSS (FT)
0+00	0.0000	45.000	0.0000	0.0000		10375.3	0.0	0.0	0.00	0.00
0+50	0.0624	44.938	14.4030	0.0000		10375.3	10360.9	394.1	2.19	0.01
1+00	0.0624	44.875	14.3930	0.0000		10360.9	10346.5	787.9	4.39	0.02
1+50	0.0624	44.813	14.3830	0.0000		10346.5	10332.1	1181.4	6.58	0.03
2+00	0.0623	44.751	14.3731	0.0000		10332.1	10317.7	1574.6	8.77	0.04
2+50	0.0623	44.688	14.3631	0.0000		10317.7	10303.3	1967.6	10.96	0.05
3+00	0.0622	44.626	14.3531	0.0000		10303.3	10289.0	2360.3	13.16	0.06
3+50	0.0622	44.564	14.3432	0.0000		10289.0	10274.6	2752.7	15.35	0.08
4+00	0.0621	44.502	14.3332	0.0000		10274.6	10260.3	3144.9	17.54	0.09
4+50	0.0621	44.440	14.3233	0.0000		10260.3	10246.0	3536.8	19.74	0.10
5+00	0.0620	44.378	14.3133	0.0000		10246.0	10231.7	3928.4	21.93	0.11
5+50	0.0620	44.316	14.3034	0.0000		10231.7	10217.4	4319.7	24.12	0.12
6+00	0.0620	44.254	14.2935	0.0000		10217.4	10203.1	4710.8	26.32	0.13
6+50	0.0619	44.192	14.2836	0.0000		10203.1	10188.8	5101.6	28.51	0.14

FORCEMAIN PIPING HEAT/HEAD LOSS CALCULATIONS
AVERAGE FLOW VELOCITY

STATION	ΔTEMP (F)	Te (F)	INCREMENTAL HEAT LOSS - qc (BTU)	POINT HEAT LOSS - qs (BTU)	No Service Connections	HEAT IN - qe (BTU)	HEAT LEAVING - ql (BTU)	TOTAL HEAT LOSS (BTU/HR)	TRANSIT TIME (MIN)	HEAD LOSS (FT)
7+00	0.0619	44.130	14.2737	0.0000		10188.8	10174.5	5492.1	30.70	0.15
7+50	0.0618	44.068	14.2638	0.0000		10174.5	10160.3	5882.4	32.89	0.16
8+00	0.0618	44.006	14.2539	0.0000		10160.3	10146.0	6272.4	35.09	0.17
8+50	0.0617	43.944	14.2440	0.0000		10146.0	10131.8	6662.1	37.28	0.18
9+00	0.0617	43.883	14.2341	0.0000		10131.8	10117.5	7051.5	39.47	0.19
9+50	0.0617	43.821	14.2242	0.0000		10117.5	10103.3	7440.7	41.67	0.20
10+00	0.0616	43.759	14.2143	0.0000		10103.3	10089.1	7829.6	43.86	0.22
10+50	0.0616	43.698	14.2045	0.0000		10089.1	10074.9	8218.2	46.05	0.23
11+00	0.0615	43.636	14.1946	0.0000		10074.9	10060.7	8606.6	48.25	0.24
11+50	0.0615	43.575	14.1848	0.0000		10060.7	10046.5	8994.7	50.44	0.25
12+00	0.0614	43.513	14.1749	0.0000		10046.5	10032.3	9382.5	52.63	0.26
12+50	0.0614	43.452	14.1651	0.0000		10032.3	10018.2	9770.1	54.82	0.27
13+00	0.0614	43.391	14.1553	0.0000		10018.2	10004.0	10157.4	57.02	0.28
13+50	0.0613	43.329	14.1455	0.0000		10004.0	9989.9	10544.4	59.21	0.29
14+00	0.0613	43.268	14.1356	0.0000		9989.9	9975.7	10931.1	61.40	0.30
14+50	0.0612	43.207	14.1258	0.0000		9975.7	9961.6	11317.6	63.60	0.31
15+00	0.0612	43.146	14.1160	0.0000		9961.6	9947.5	11703.8	65.79	0.32
15+50	0.0612	43.084	14.1062	0.0000		9947.5	9933.4	12089.8	67.98	0.33
16+00	0.0611	43.023	14.0965	0.0000		9933.4	9919.3	12475.5	70.18	0.34
16+50	0.0611	42.962	14.0867	0.0000		9919.3	9905.2	12860.9	72.37	0.36
17+00	0.0610	42.901	14.0769	0.0000		9905.2	9891.1	13246.0	74.56	0.37
17+50	0.0610	42.840	14.0671	0.0000		9891.1	9877.1	13630.9	76.75	0.38
18+00	0.0609	42.779	14.0574	0.0000		9877.1	9863.0	14015.5	78.95	0.39
18+50	0.0609	42.718	14.0476	0.0000		9863.0	9848.9	14399.9	81.14	0.40
19+00	0.0609	42.658	14.0379	0.0000		9848.9	9834.9	14783.9	83.33	0.41
19+50	0.0608	42.597	14.0282	0.0000		9834.9	9820.9	15167.7	85.53	0.42
20+00	0.0608	42.536	14.0184	0.0000		9820.9	9806.9	15551.3	87.72	0.43
20+50	0.0607	42.475	14.0087	0.0000		9806.9	9792.9	15934.6	89.91	0.44
21+00	0.0607	42.415	13.9990	0.0000		9792.9	9778.9	16317.6	92.11	0.45
21+50	0.0606	42.354	13.9893	0.0000		9778.9	9764.9	16700.3	94.30	0.46
22+00	0.0606	42.293	13.9796	0.0000		9764.9	9750.9	17082.8	96.49	0.47

FORCEMAIN PIPING HEAT/HEAD LOSS CALCULATIONS
AVERAGE FLOW VELOCITY

STATION	ΔTEMP (F)	Te (F)	INCREMENTAL HEAT LOSS - qc (BTU)	POINT HEAT LOSS - qs (BTU)	No Service Connections	HEAT IN - qe (BTU)	HEAT LEAVING - ql (BTU)	TOTAL HEAT LOSS (BTU/HR)	TRANSIT TIME (MIN)	HEAD LOSS (FT)
22+50	0.0606	42.233	13.9699	0.0000		9750.9	9736.9	17465.0	98.68	0.48
23+00	0.0605	42.172	13.9602	0.0000		9736.9	9723.0	17847.0	100.88	0.50
23+50	0.0605	42.112	13.9505	0.0000		9723.0	9709.0	18228.6	103.07	0.51
24+00	0.0604	42.051	13.9408	0.0000		9709.0	9695.1	18610.1	105.26	0.52
24+50	0.0604	41.991	13.9311	0.0000		9695.1	9681.1	18991.2	107.46	0.53
25+00	0.0603	41.931	13.9215	0.0000		9681.1	9667.2	19372.1	109.65	0.54
25+50	0.0603	41.870	13.9118	0.0000		9667.2	9653.3	19752.7	111.84	0.55
26+00	0.0603	41.810	13.9022	0.0000		9653.3	9639.4	20133.1	114.04	0.56
26+50	0.0602	41.750	13.8925	0.0000		9639.4	9625.5	20513.2	116.23	0.57
27+00	0.0602	41.690	13.8829	0.0000		9625.5	9611.6	20893.0	118.42	0.58
27+50	0.0601	41.630	13.8732	0.0000		9611.6	9597.8	21272.6	120.61	0.59
28+00	0.0601	41.569	13.8636	0.0000		9597.8	9583.9	21651.9	122.81	0.60
28+50	0.0601	41.509	13.8540	0.0000		9583.9	9570.0	22031.0	125.00	0.61
29+00	0.0600	41.449	13.8444	0.0000		9570.0	9556.2	22409.8	127.19	0.62
29+50	0.0600	41.389	13.8348	0.0000		9556.2	9542.4	22788.3	129.39	0.64
30+00	0.0599	41.329	13.8252	0.0000		9542.4	9528.5	23166.5	131.58	0.65

3,000 Lineal Feet of Force Main

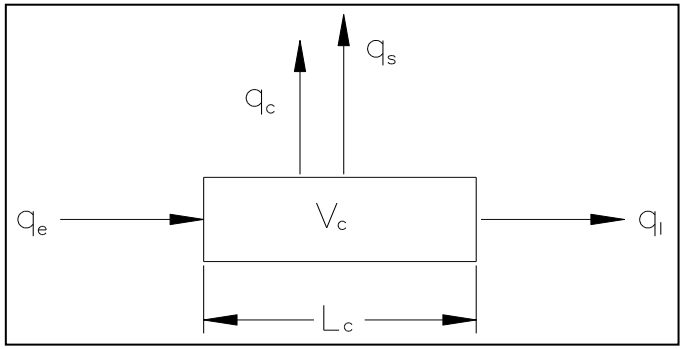
FORCEMAIN PIPING HEAT/HEAD LOSS CALCULATIONS
SCOUR VELOCITY

INPUTS

PIPE O.D. (in)	4.5
PIPE I.D. (in)	3.68
INS. O.D. (in)	15
INS. I.D. (in)	4.5
Lc (ft)	50
KINS (BTU/hr*ft*F)	0.017
KHDPE (BTU/hr*ft*F)	0.225
Ti (F)	45
Ta (F)	-45
VELOCITY (ft/s)	3.5
C-FACTOR	140
Us (BTU/hr)	840

DERIVED QUANTITIES

Vc (CUFT)	3.69
Q (CUFT/S)	0.26
TIME (s)	14.3
Q *(GPM)*	*116.1*
	SCOUR VELOCITY



$q_l = q_e - (q_s + q_c)$

STATION	ΔTEMP (F)	Te (F)	INCREMENTAL HEAT LOSS - qc (BTU)	POINT HEAT LOSS - qs (BTU)	No Service Connections	HEAT IN - qe (BTU)	HEAT LEAVING - ql (BTU)	TOTAL HEAT LOSS (BTU/HR)	TRANSIT TIME (MIN)	HEAD LOSS (FT)
0+00	0.0000	45.000	0.0000	0.0000		10375.3	0.0	0.0	0.00	0.00
0+50	0.0068	44.993	1.5638	0.0000		10375.3	10373.7	394.1	0.24	0.65
1+00	0.0068	44.986	1.5636	0.0000		10373.7	10372.1	788.1	0.48	1.31
1+50	0.0068	44.980	1.5635	0.0000		10372.1	10370.6	1182.1	0.71	1.96
2+00	0.0068	44.973	1.5634	0.0000		10370.6	10369.0	1576.1	0.95	2.62
2+50	0.0068	44.966	1.5633	0.0000		10369.0	10367.4	1970.0	1.19	3.27
3+00	0.0068	44.959	1.5632	0.0000		10367.4	10365.9	2364.0	1.43	3.93
3+50	0.0068	44.953	1.5630	0.0000		10365.9	10364.3	2757.8	1.67	4.58
4+00	0.0068	44.946	1.5629	0.0000		10364.3	10362.8	3151.7	1.90	5.24
4+50	0.0068	44.939	1.5628	0.0000		10362.8	10361.2	3545.5	2.14	5.89
5+00	0.0068	44.932	1.5627	0.0000		10361.2	10359.6	3939.3	2.38	6.55
5+50	0.0068	44.925	1.5626	0.0000		10359.6	10358.1	4333.1	2.62	7.20
6+00	0.0068	44.919	1.5625	0.0000		10358.1	10356.5	4726.8	2.86	7.86
6+50	0.0068	44.912	1.5623	0.0000		10356.5	10354.9	5120.5	3.10	8.51
7+00	0.0068	44.905	1.5622	0.0000		10354.9	10353.4	5514.2	3.33	9.17

FORCEMAIN PIPING HEAT/HEAD LOSS CALCULATIONS
SCOUR VELOCITY

STATION	ΔTEMP (F)	Te (F)	INCREMENTAL HEAT LOSS - qc (BTU)	POINT HEAT LOSS - qs (BTU)	No Service Connections	HEAT IN - qe (BTU)	HEAT LEAVING - ql (BTU)	TOTAL HEAT LOSS (BTU/HR)	TRANSIT TIME (MIN)	HEAD LOSS (FT)
7+50	0.0068	44.898	1.5621	0.0000		10353.4	10351.8	5907.9	3.57	9.82
8+00	0.0068	44.892	1.5620	0.0000		10351.8	10350.3	6301.5	3.81	10.48
8+50	0.0068	44.885	1.5619	0.0000		10350.3	10348.7	6695.1	4.05	11.13
9+00	0.0068	44.878	1.5618	0.0000		10348.7	10347.1	7088.7	4.29	11.79
9+50	0.0068	44.871	1.5616	0.0000		10347.1	10345.6	7482.2	4.52	12.44
10+00	0.0068	44.865	1.5615	0.0000		10345.6	10344.0	7875.7	4.76	13.10
10+50	0.0068	44.858	1.5614	0.0000		10344.0	10342.4	8269.2	5.00	13.75
11+00	0.0068	44.851	1.5613	0.0000		10342.4	10340.9	8662.6	5.24	14.41
11+50	0.0068	44.844	1.5612	0.0000		10340.9	10339.3	9056.0	5.48	15.06
12+00	0.0068	44.837	1.5610	0.0000		10339.3	10337.8	9449.4	5.71	15.72
12+50	0.0068	44.831	1.5609	0.0000		10337.8	10336.2	9842.8	5.95	16.37
13+00	0.0068	44.824	1.5608	0.0000		10336.2	10334.6	10236.1	6.19	17.02
13+50	0.0068	44.817	1.5607	0.0000		10334.6	10333.1	10629.4	6.43	17.68
14+00	0.0068	44.810	1.5606	0.0000		10333.1	10331.5	11022.6	6.67	18.33
14+50	0.0068	44.804	1.5605	0.0000		10331.5	10330.0	11415.9	6.90	18.99
15+00	0.0068	44.797	1.5603	0.0000		10330.0	10328.4	11809.1	7.14	19.64
15+50	0.0068	44.790	1.5602	0.0000		10328.4	10326.8	12202.3	7.38	20.30
16+00	0.0068	44.783	1.5601	0.0000		10326.8	10325.3	12595.4	7.62	20.95
16+50	0.0068	44.777	1.5600	0.0000		10325.3	10323.7	12988.5	7.86	21.61
17+00	0.0068	44.770	1.5599	0.0000		10323.7	10322.2	13381.6	8.10	22.26
17+50	0.0068	44.763	1.5598	0.0000		10322.2	10320.6	13774.7	8.33	22.92
18+00	0.0068	44.756	1.5596	0.0000		10320.6	10319.0	14167.7	8.57	23.57
18+50	0.0068	44.750	1.5595	0.0000		10319.0	10317.5	14560.7	8.81	24.23
19+00	0.0068	44.743	1.5594	0.0000		10317.5	10315.9	14953.7	9.05	24.88
19+50	0.0068	44.736	1.5593	0.0000		10315.9	10314.4	15346.6	9.29	25.54
20+00	0.0068	44.729	1.5592	0.0000		10314.4	10312.8	15739.5	9.52	26.19
20+50	0.0068	44.722	1.5591	0.0000		10312.8	10311.2	16132.4	9.76	26.85
21+00	0.0068	44.716	1.5589	0.0000		10311.2	10309.7	16525.3	10.00	27.50
21+50	0.0068	44.709	1.5588	0.0000		10309.7	10308.1	16918.1	10.24	28.16
22+00	0.0068	44.702	1.5587	0.0000		10308.1	10306.6	17310.9	10.48	28.81
22+50	0.0068	44.695	1.5586	0.0000		10306.6	10305.0	17703.6	10.71	29.47
23+00	0.0068	44.689	1.5585	0.0000		10305.0	10303.4	18096.4	10.95	30.12

FORCEMAIN PIPING HEAT/HEAD LOSS CALCULATIONS
SCOUR VELOCITY

STATION	ΔTEMP (F)	Te (F)	INCREMENTAL HEAT LOSS - qc (BTU)	POINT HEAT LOSS - qs (BTU)	No Service Connections	HEAT IN - qe (BTU)	HEAT LEAVING - ql (BTU)	TOTAL HEAT LOSS (BTU/HR)	TRANSIT TIME (MIN)	HEAD LOSS (FT)
23+50	0.0068	44.682	1.5583	0.0000		10303.4	10301.9	18489.1	11.19	30.78
24+00	0.0068	44.675	1.5582	0.0000		10301.9	10300.3	18881.7	11.43	31.43
24+50	0.0068	44.668	1.5581	0.0000		10300.3	10298.8	19274.4	11.67	32.09
25+00	0.0068	44.662	1.5580	0.0000		10298.8	10297.2	19667.0	11.90	32.74
25+50	0.0068	44.655	1.5579	0.0000		10297.2	10295.7	20059.6	12.14	33.40
26+00	0.0068	44.648	1.5578	0.0000		10295.7	10294.1	20452.1	12.38	34.05
26+50	0.0068	44.641	1.5576	0.0000		10294.1	10292.5	20844.7	12.62	34.70
27+00	0.0068	44.635	1.5575	0.0000		10292.5	10291.0	21237.2	12.86	35.36
27+50	0.0068	44.628	1.5574	0.0000		10291.0	10289.4	21629.6	13.10	36.01
28+00	0.0068	44.621	1.5573	0.0000		10289.4	10287.9	22022.1	13.33	36.67
28+50	0.0068	44.614	1.5572	0.0000		10287.9	10286.3	22414.5	13.57	37.32
29+00	0.0067	44.608	1.5571	0.0000		10286.3	10284.8	22806.9	13.81	37.98
29+50	0.0067	44.601	1.5569	0.0000		10284.8	10283.2	23199.2	14.05	38.63
30+00	0.0067	44.594	1.5568	0.0000		10283.2	10281.6	23591.5	14.29	39.29

3,000 Lineal Feet of Force Main

Appendix D—Sludge Volume Calculations

CHEFORNAK WASTEWATER LAGOON

SLUDGE VOLUME CALCULATIONS

Influent Suspended Solids (300 mg/l)	0.2	lb/cap/day
Total Retained Suspended Solids (150 mg/l)	0.1	lb/cap/day

Of the retained suspended solids, assume 75% is organic, which undergoes 50% digestion in the pre-treatment cell.

Digested Suspended Solids	0.0375	lb/cap/day
Remaining Suspended Solids	0.0625	lb/cap/day
2012 Design Population	431	
2012 Sludge Accumulation	9,832	lb sludge solids/yr
2032 Design Population	580	
2032 Sludge Accumulation	13,231	lb sludge solids/yr
Cumulative 20 Yr Sludge Solids Accumulation	240,599	lb

Assume consolidation of sludge, resulting in a wet solids content of 15% by weight.

8.34 lb/gal * 15% =	1.25	lb dry per gal of wet sludge
20 yr Wet Sludge Accumulation	192,325	gal
Assume 50% of sludge retained in pretreatment cell	96,163	gal
Minimum pre-treatment cell volume to insure <25% sludge accumulation.	384,650	gal
Design pre-treatment cell volume.	768,400	gal

Appendix E—Cost Estimate Detail

Chefornak 2011 Lagoon Force Main and Sewage Lagoon
Preliminary Cost Estimate
September 2011

DESCRIPTION	QUAN	UNITS	UNIT MAT'L COST	TOTAL MAT'L COST	LABOR HOURS	AVG LABOR RATE	TOTAL LABOR COST	UNIT EQUIP COST	TOTAL EQUIP COST	UNIT SUB COST	TOTAL SUB COST	UNIT FREIGHT COST	TOTAL FREIGHT COST	TOTAL COST
GENERAL														
SWPPP Materials	1	LS	$25,000	$25,000	312	$75	$23,400	$0		$0	$0	$0.55	$3,850	$52,250
Storage Connexes	2	EA	$2,500	$5,000	0	$0	$0	$0	$0	$0	$0	$0.55	$2,200	$7,200
Snow Machine w/ sled	1	EA		$0	0	$0	$0	$0	$11,000	$0	$0	$0.55	$440	$11,440
Equipment - D8 Dozer	1	EA							$50,000				$25,000	$75,000
Equipment - Light Plant	4	EA							$30,000			$0.55	$2,200	$32,200
Survey	1	LS								$25,000	$25,000			$25,000
				$30,000			**$23,400**		**$91,000**		**$25,000**		**$33,690**	**$203,090**
LAGOON BERMS														
Local Fill, Core	14259	CY	$0	$0	2880	$50	$144,000	$8	$108,000	$0	$0	$0.55	$0	$252,000
Local Fill, Face	16296	CY	$0	$0	1920	$50	$96,000	$6	$90,000			$0.55	$0	$186,000
Lagoon Interior Geomembrane Liner	13900	SY	$7.50	$104,250	480	$50	$24,000		$2,500					$130,750
Lagoon Exterior Slope Seeding	8400	SY	$1.50	$12,600	120	$50	$6,000	$0	$0	$0	$0	$0.55	$2,772	$21,372
Inlet/Outlet & Transfer Structures	4	EA	$6,000	$24,000	400	$50	$20,000	$0	$0	$0	$0	$0.55	$3,960	$47,960
				$140,850			**$290,000**		**$200,500**		**$0**		**$6,732**	**$638,082**
FORCE MAIN														
4" x 15" HDPE Arctic Pipe w/ 6" Heat Trace Channel	2052	LF	$36	$73,872	1231	$50	$61,560	$0	$6,000	$0	$0	$0.55	$16,929	$158,361
4" x 15" Long Sweep 90	1	EA	$1,200	$1,200	0	$0	$0	$0	$0	$0	$0	$0.55	$28	$1,228
4" x 15" 45 deg angle	5	EA	$1,000	$5,000	0	$0	$0	$0	$0	$0	$0	$0.55	$124	$5,124
2" HDPE Heat Trace	4200	LF	$2	$8,400	0	$0	$0	$0	$0	$0	$0	$0.55	$1,155	$9,555
15" Pipe Straps	200	EA	$15	$3,000	0	$0	$0	$0	$0	$0	$0	$0.55	$440	$3,440
1/2" x 4" Galv. Lag Bolts	400	EA	$0.51	$204	0	$0	$0	$0	$0	$0	$0	$0.55	$55	$259
3/8" x 2" Galv. Lag Bolts	400	EA	$0	$34	0	$0	$0	$0	$0	$0	$0	$0.55	$44	$78
Misc. HDPE Fittings	1	LS	$1,000	$1,000	0	$0	$0	$0	$0	$0	$0	$0.55	$138	$1,138
4" x 15" Force Main Double Wye Clean out	6	EA	$3,000	$18,000	0	$0	$0	$0	$0	$0	$0	$0.55	$660	$18,660
Clean out Top Assembly	12	EA	$650	$7,800	0	$0	$0	$0	$0	$0	$0	$0.55	$231	$8,031
Butt Fusion Machine	1	EA	$0	$0	0	$0	$0	$15,000	$15,000	$0	$0	$0.55	$165	$15,165
Generator	1	EA	$0	$0	0	$0	$0	$4,500	$4,500	$0	$0	$0.55	$220	$4,720
Half Shells	100	PR	$85	$8,500	0	$0	$0	$0	$0	$0	$0	$0.55	$275	$8,775
Pipe Coupling Bands	100	EA	$75	$7,500	0	$0	$0	$0	$0	$0	$0	$0.55	$825	$8,325
Glycol	1000	Gal	$10	$10,000	0	$0	$0	$0	$0	$0	$0	$0.55	$4,675	$14,675
				$144,510	**1231.20**		**$61,560**		**$25,500**		**$0**		**$25,963**	**$257,533**
BOARDWALK														
Triple Helix lead sections 5' long, 2-7/8" OD	60	EA	$146	$8,760	1980	$50	$99,000	$0	$2,500	$0	$0	$0.55	$2,574	$112,834
Helical extensions 5' long, 2-7/8" OD	60	EA	$175	$10,500	0	$0	$0	$0	$0	$0	$0	$0.55	$1,122	$11,622
Helical extensions 7' long, 2-7/8" OD	60	EA	$267	$16,020	0	$0	$0	$0	$0	$0	$0	$0.55	$1,419	$17,439
Beam seat bracket	70	EA	$33	$2,310	0	$0	$0	$0	$0	$0	$0	$0.55	$231	$2,541
5/8" X 6" HDG Through Bolts w/ washers and nuts	120	EA	$1	$70	0	$0	$0	$0	$0	$0	$0	$0.55	$66	$136
4" x 4" x 1/4" x 6' long angle (Galv)	140	EA	$200	$28,000	0	$0	$0	$0	$0	$0	$0	$0.55	$3,049	$31,049
2" x 2" x 1/4" 8' long angles	70	EA	$22	$1,540	0	$0	$0	$0	$0	$0	$0	$0.55	$983	$2,523
3/8" x 3" u-bolts w/ nuts & washers	140	EA	$3	$372	0	$0	$0	$0	$0	$0	$0	$0.55	$35	$407
4" x 12" x 8' long beam (treated)	70	EA	$44	$3,065	0	$0	$0	$0	$0	$0	$0	$0.55	$3,812	$6,876
4" x 12" x 20' long decking (treated)	200	EA	$109	$21,888	0	$0	$0	$0	$0	$0	$0	$0.55	$27,104	$48,992
1/2" x 5" HDG Through Bolt w/ nuts and washers	1600	EA	$1	$1,600	0	$0	$0	$0	$0	$0	$0	$0.55	$880	$2,480
Connector plates, 1/4" x 3" x 6" w/1/2" Ø MB	1	LS	$1,000	$1,000	0	$0	$0	$0	$0	$0	$0	$0.55	$141	$1,141
Single Helix lead sections 5' long 2-7/8 OD	60	EA	$135	$8,100	0	$115	$0	$0	$0	$0	$0	$0.55	$1,815	$9,915
Helical extensions 5' long, 2-7/8" OD	60	EA	$175	$10,500	0	$0	$0	$0	$0	$0	$0	$0.55	$1,122	$11,622
Helical extensions 7' long, 2-7/8" OD	60	EA	$267	$16,020	0	$0	$0	$0	$0	$0	$0	$0.55	$1,419	$17,439
				$129,744	**1980.00**		**$99,000**		**$2,500**		**$0**		**$45,771**	**$277,015**
PIPE RACK CONFIGURATION (Use helical piers that are currently on-site.)														
Triple Helix lead sections 5' long, 2-7/8" OD	60	EA	$0	$0	1120	$50	$56,000	$0	$1,200	$0	$0	$0.55	$0	$57,200
Helical extensions 5' long, 2-7/8" OD	60	EA	$0	$0	0	$0	$0	$0	$0	$0	$0	$0.55	$0	$0
Helical extensions 7' long, 2-7/8" OD	60	EA	$0	$0	0	$0	$0	$0	$0	$0	$0	$0.55	$0	$0
Beam seat bracket	200	EA	$0	$0	0	$0	$0	$0	$0	$0	$0	$0.55	$0	$0
5/8" X 6" HDG Through Bolts w/ washers and nuts	400	EA	$0	$0	0	$0	$0	$0	$0	$0	$0	$0.55	$0	$0
Single Helix lead sections 5' long 2-7/8 OD	70	EA	$0	$0	0	$0	$0	$0	$0	$0	$0	$0.55	$0	$0
Helical extensions 5' long, 2-7/8" OD	90	EA	$0	$0	0	$0	$0	$0	$0	$0	$0	$0.55	$0	$0
Helical extensions 7' long, 2-7/8" OD	90	EA	$0	$0	0	$0	$0	$0	$0	$0	$0	$0.55	$0	$0
4" x 12" x 8' long beam (treated)	50	EA	$50	$2,500	0	$0	$0	$0	$0	$0	$0	$0.55	$2,723	$5,223
				$2,500			**$56,000**		**$1,200**		**$0**		**$2,723**	**$62,423**
GRAND TOTAL				**$447,604**			**$529,960**		**$320,700**		**$25,000**		**$114,878**	**$1,438,142**