APPENDIX A

Geotechnical Report

December 31, 2019 19122864

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GEOTECHNICAL RECONNAISSANCE FINDINGS AND PRELIMINARY ENGINERING CONSIDERATIONS, WASTEWATER LAGOON SITES, DILLINGHAM, ALASKA

David:

This submittal summarizes our recent reconnaissance findings and preliminary geotechnical considerations for wastewater lagoon siting in Dillingham, Alaska. Our scope of services included reviewing historic geotechnical data near the proposed development sites, coordinating with you and CRW Engineering Group LLC (CRW) and advancing limited geotechnical explorations at a select location.

The approximate locations for the proposed wastewater lagoon sites and the geotechnical investigation conducted for this effort are summarized on the attached conceptual site plans developed by Bristol Engineering Services Company (BESC). All referenced locations are considered approximate.

1.0 PROJECT BACKGROUND SUMMARY

Dillingham relies on wastewater treatment lagoon and a buried outfall pipeline that extends to the adjacent bay. The existing wastewater treatment facility is along a shoreline that is experiencing continued erosion, posing a potential longer-term performance risk. The city has contracted with BESC to develop preliminary options and engineering/permitted feasibility assessments for either maintaining the existing wastewater lagoon facility or siting a new treatment facility in areas currently not subject to shoreline erosion risk.

BESC and CRW have identified two potential sites for a new wastewater treatment facility as well as options for in-place protection of the existing wastewater treatment facility. This purpose of the reconnaissance effort was for the engineering and permitting teams to visually assess each site in order to develop conceptual engineering and planning for the wastewater treatment system.

2.0 HISTORIC GEOTECHNICAL DATA

We relied on historic geotechnical data to support our reconnaissance observations. Most of the reviewed geotechnical data was located in the Dillingham central core district with some historic geotechnical information at the Kanakanak Hospital/communication tower area. Summary historic geotechnical data we reviewed included:

- City of Dillingham Public Works Test Pits, 1964. 7 shallow test pits were advanced 5 to10 feet below ground surface at the time of the field effort (bgs) at the former airstrip area to support public works projects. Beneath near surface fill and organics, stiff to hard clay was encountered northerly of the former airstrip with predominantly sandy soils southerly of the former airstrip.

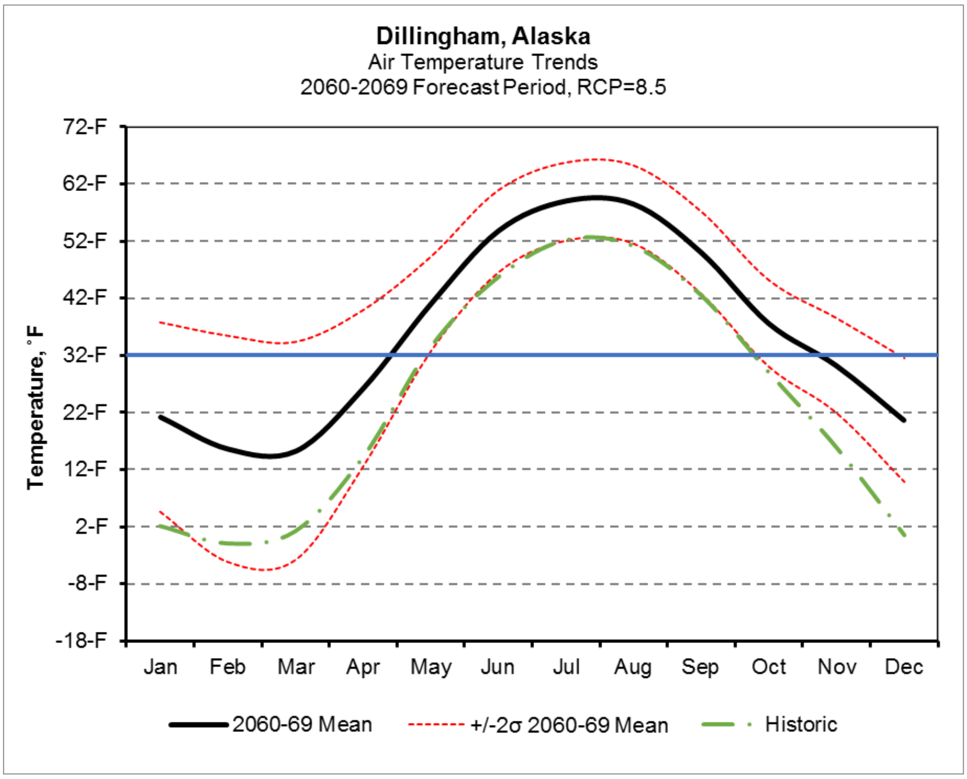
- ADOT/PF, 1969. ADOT/PF advanced numerous geotechnical test borings at the airport site to support site planning, development and engineering analysis. In general, subsurface conditions included surface organics to 4 feet becoming mineral silt to 13 to 15 feet.
- Harding Lawson Associates (HLA), 1974. HLA advanced four geotechnical borings along the access road from the radio tower to the subdivision to support buried utility siting and design. One test boring, TH-3, was located west of the roadway toward one of the proposed lagoon sites. Subsurface conditions at TH-3 included 2.5 feet of surface organics underlain by sandy clay to 16.5 feet, the boring termination depth
- US Public Health Service (USPHS), 1978. USPHS advanced 13 shallow test pits (8 in the subdivision/access roadway alignment, 5 around the former airstrip for a new water storage tank). All test pits encountered generally clayey soils with some silty sands encountered near the proposed new water storage tank area.
- DOWL Engineers (DOWL), 1980. DOWL advanced 11 test borings for the new elementary school project. The site was generally covered with a thin layer of silt and organic silt, underlain by silt and fine-grained sand with silt. A deposit of intermixed silt, sand and gravel underlies the fine-grained soils generally encountered at a depth of 7 to 10 feet and continued to the test boring termination depths of about 30 feet. The test borings encountered random zones of cobbles and potentially larger dimensioned material. The silty sand and gravel deposits were considered medium dense to dense and drilling refusal was observed in this material, primarily in zones with cobbles. The fine-grained deposits of silt and fine-grained sand were thickest in the boreholes drilled at lower elevations and on the sloping portions of the site. Groundwater was encountered near 30 feet bgs.
- JM Lambe, 1981. Lambe advanced 5 test borings at the current Bristol Inn and 4 test pits at the Senior Center site to support foundation design. At both sites, predominately sandy soils were encountered to 15 feet below grade becoming clayey materials beneath the sandy soils. The cohesive soils were considered stiff to hard.
- Duane Miller Associates (DMA), 1984/1985 DMA completed two subsurface investigations for an addition to the elementary school. Seven test borings were advanced near the existing school. In general, subsurface conditions below several feet of surface fill included silt and sandy silt to 5 and 6 feet underlain with silty sand to 12 and 14 feet that was underlain by sandy gravel with silt to borehole exploration depths of 15.5 feet.
- DMA, 1984. DMA advanced five test borings at the Senior Housing site near the Senior Center. Subsurface conditions were generally similar to those reported by Lambe at the Senior Center site; sandy soils to about 15 feet becoming stiff to hard clayey soil to 25 feet.
- DMA, 1986. DMA advanced eight test borings near the current Bristol Inn to support foundation design for office buildings. The test borings were advanced up to 38 feet deep. Subsurface conditions included sandy soils to about 15 feet becoming stiff to hard clay to about 25 to 36 feet. A sand and gravel deposit was encountered beneath the clay.
- DMA, 2000. DMA advanced 14 geotechnical test borings to support expansion and structures at the landfill site. In general, three in-place soil types were encountered in the area: organic bog soils (muskeg), wind deposited silt (loess), and sand and gravel fluvial and till deposits. Unclassified fill had been placed in the area near the existing landfill. The organic bog soils exist beneath the open areas and generally 6 feet in one boring. All of the borings encountered mineral silt beneath the organic soils. Sand and gravel was found beneath the silt in all of the borings. Other than seasonal frost at the top of the borings, no frozen ground was found in the borings.

- DMA, 2008. DMA advanced three geotechnical borings for a new chemical storage building at the Dillingham Airport. The subsurface conditions were sandy gravel fill 4.5 to 5-feet deep becoming mineral silt to 20 feet. At one location sand and gravel was encountered near 20 feet.
- DMA, 2010. DMA advanced five test boring at the Kanakanak Hospital site for a new water storage tank and water treatment discharge area. The in-place subsurface consisted of a thin surface layer of peat and organic silt underlain by an eolian silt deposit to 30 feet. At two locations, a thin organic silt and silty sand deposit was encountered starting at approximately 27 feet, near the base of the explorations. The eolian silt is a mineral soil and is considered non-plastic based on visual soil classification. At the proposed water treatment plant site, a 1.5 to 3 foot thick granular fill pad was encountered overlying the silt deposit. At the water storage tank site, a 2-foot thick layer of organic silt was observed below the silt layer at 26 and 27 feet deep. The organic silt observed at depth was underlain by silty sand to the depths explored, 30 feet deep at the water tank site.
- Golder, 2010. Golder advanced two test pits at the GCI TERRA Southwest Tower site. Subsurface conditions included a mineral silt with fine sand beneath a thin organic surface. The silt was moist, stiff to very stiff and was unfrozen to the depths explored, 17.5 feet.
- Golder, 2012. Golder advanced five test pits with a rubber tire backhoe in an area immediately west of the existing power plant for a planned step-up transformer. General subsurface conditions observed in the test pits included sand and gravel fill 1 to 5 feet thick. Beneath the fill, the in-place soils consisted of layers of silt and silty sand to the depth of the explorations, about 15 feet. The silt material observed at the site exhibited low to no plasticity with varying sand content.
- Golder, 2017. Golder advanced two shallow test pits at GCI's "C" Street facility in Dillingham to support the foundation rehabilitation of the tower. Both test pits were advanced along the northern portion of the lot along the edge of the existing granular fill section. The test pits encountered variable thickness surface organic to about two feet below grade with a distinct contact with a mineral silty sand to about 6 to 7 feet below grade.
- Golder, 2018. Golder advanced seven test pits to support site planning and foundation design for a new church along Main Street. Generally similar subsurface conditions were encountered beneath a variable thickness surface organic layer with a non-plastic silty fine sand to fine sandy silt encountered below the organic material. The mineral silts and fine sands had a noted increase in consistency/density with depth. The test pits were terminated 8 to 10 feet.

3.0 ENGINEERING CLIMATE INDICES

Dillingham is characterized by warm summers with relatively limited winter freezing periods. However, winter cold periods can occur with the potential for seasonal frost induced movements in unheated areas. Climate and associated key air temperature engineering parameters are modeled to reflect anticipated continued warming trends over the expected service life of the planned development.

To aid with our engineering analysis, we have summarized engineering climate indices for Dillingham modeled by the Scenarios Network for Alaska & Arctic Planning (SNAP) at the University of Alaska Fairbanks. The SNAP group uses five Intergovernmental Panel on Climate Change (IPCC) General Circulation Models (GCM) they consider most applicable for Alaska. SNAP includes several Representative Concentration Pathways (RCP) for their climate forecasts. For our analysis, an RCP of 8.5 (watts/m^2) was used. The model analysis results have variability. SNAP forecast data include the five GCM model average as well as the two standard deviation spread from the forecast mean air temperatures for the selected analysis period range.



For our engineering analysis, the key climate parameters derived from the SNAP data for Dillingham include Freezing Index (FI) and Thawing Index (TI), both as cumulate °F-days for each based on monthly average air temperature data. Summarized below are the SNAP derived approximate FI and TI data for the 1961-1990 historic and the 2060-2069 forecast period. As noted below, a general warming trend should be expected for the area over the project's anticipated service life.

Period		Average Air Temperature	Freeze Index	Thaw Index
1961-1990	Mean	23.9 F	4,890 F-days	2,000 F-days
2060-2069	5 Model Mean	35.8 F	1,890 F-days	3,310 F-days
2060-2069	Mean +2σ	46.8 F	10 F-days	5,430 F-days
2060-2069	Mean -2σ	24.7 F	4,600 F-days	2,020 F-days
ENGINEERING DESIGN INDICES			3,240 F-days	4,370 F-days

4.0 REGIONAL SETTING

Dillingham is located near the confluence of the Wood and Nushagak Rivers at the head of Bristol Bay. The regional terrain consists of irregularly shaped moraine knolls covered with spruce and birch forests separated by lower-lying wetlands and muskeg. Pleistocene glaciers extended throughout the area and deposited glacial outwash and till. As the glaciers retreated, wind-blown silt was deposited over the moraines and is mixed with volcanic deposits. Recently, organic soils have accumulated in the lower lying, wet areas. The central Dillingham townsite has been developed on a moraine knoll that is bordered by Bristol Bay to the south.

4.1 Inferred Site-specific Geologic Conditions

A visual reconnaissance was conducted at all three proposed sites. Primarily due to cultural impact permitting, site-specific geotechnical explorations were not advanced at any of the three proposed sites. However, one shallow test pit was advanced at the toe of the exiting fill pad at the City Shop. Summary geologic and inferred geotechnical conditions at each proposed site are summarized below.

4.1.1 Existing Lagoon Site (Site 1)

The existing lagoon site was developed by mass excavation of overlying materials to a suitable substrate. The treatment cells were excavated into the exposed bench. Based on a visual assessment, no significant slope instability issues were noted. The treatment cells are approximately 450 feet normal from the bay. The shoreline at the lagoons is unprotected and is experiencing shoreline erosion.

Coastal erosion mitigation measures include a sheet pile wall and armor rock installed along the shoreline within 700 to 800 feet (approximately) south of the lagoons. The zone with coastal protection measures appeared to reduce and possibly stabilize the progressive shoreline loss relative to unprotected areas northward along the shoreline.

Existing Lagoon Site, General Beachline Conditions and Locally Available Armor Rock, View NE

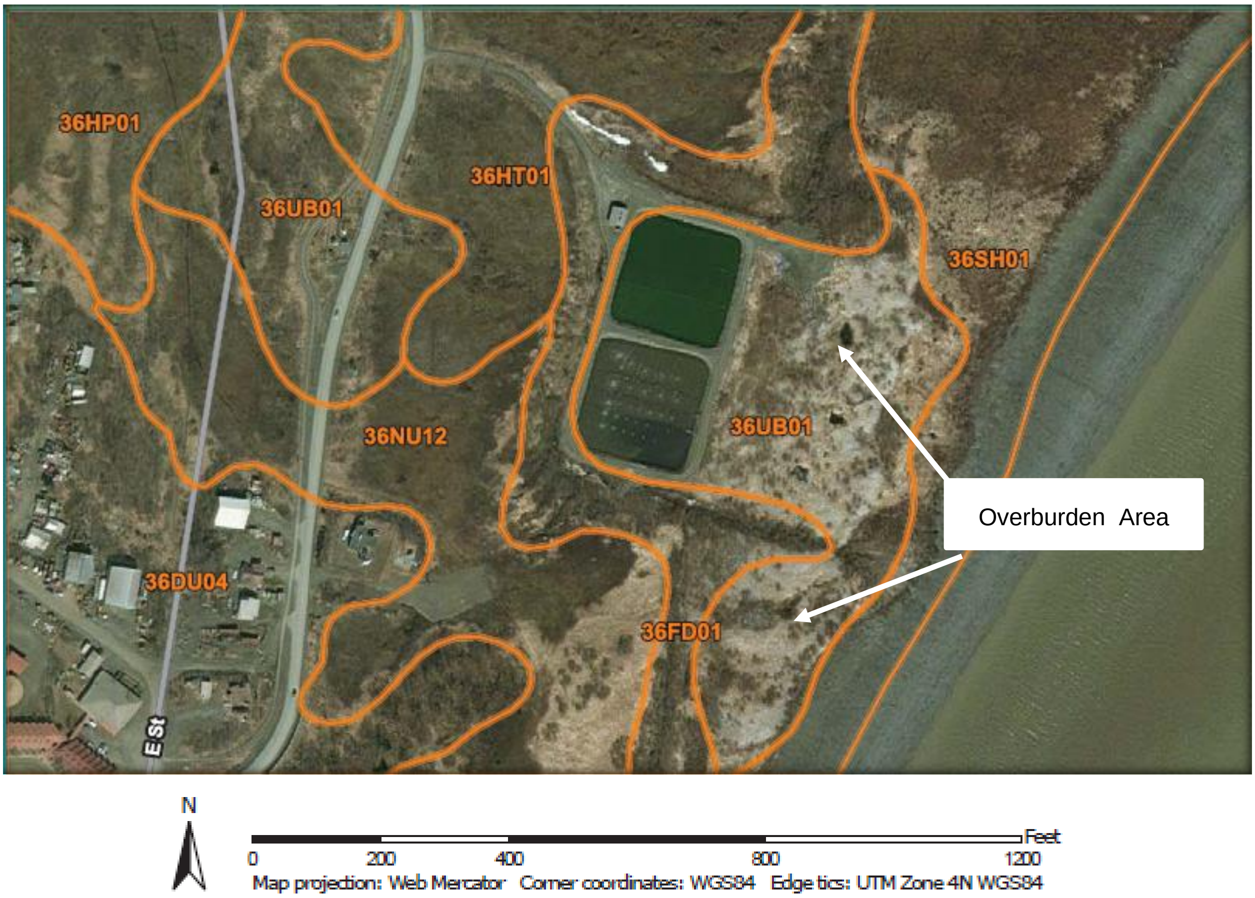
Bluff exposures along the unprotected shoreline roughly normal to the wastewater treatment cells indicated a several foot thick organic mat overlying silts with varying organic contents. Sloughing and slope instability along the unprotected area is prevalent.

Existing Lagoon Site, Beachline Conditions Showing Organic Mat Along Unarmoured Facing, View NE

The US Department of Agriculture, Natural Resources Conservation Service (NRCS) mapped the soils to approximately 6 feet below grade. The soils west of the existing lagoons are considered overburden from the lagoon development and should not be considered in-place materials. The nature and extent of the overburden deposits are undetermined but for geotechnical purposes should be considered unclassified fill with limited to no reliable placement quality control. As such, we do not consider the overburden fill material suitable for load bearing.

The exposed slope adjacent to the existing lagoons are classified by the NRCS as Flounder highly organic silt loam with increasing gravel content with depth (approximate 6 feet below undisturbed grade. It is reasonable to assume the existing lagoons were developed in the higher gravel content mineral soils. If so, these materials should be suitable for shallow foundation load bearing. The existing lagoons appear to be geotechnically stable with no visual indications of significant slope instability.

Near surface soils adjacent to the Founder loam have high organic content near surface peats becoming silt loams beneath the surface peaty layer, the Pellernarquq and Nushagak mucky peats.



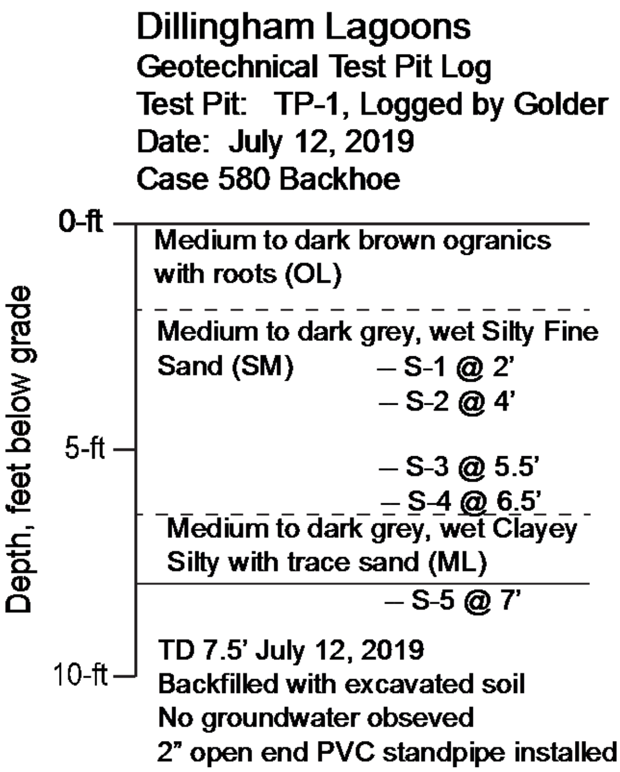
4.1.2 Site Near the City Shop (Site 2)

The site bounded by the city shop, radio tower/subdivision and residential development is a broad sloping grassland area with a drainage swale near the approximate middle of the observed area. Brush and shrub vegetation border the south and east margins of area. The city water and wastewater pipelines are buried along the margin of the brush and shrub zone roughly parallel to the road. Portions of the area were traversed by foot with noted shallow standing water present thorough the area. The area would not have supported tired or track mounted equipment without mats or other access improvements.

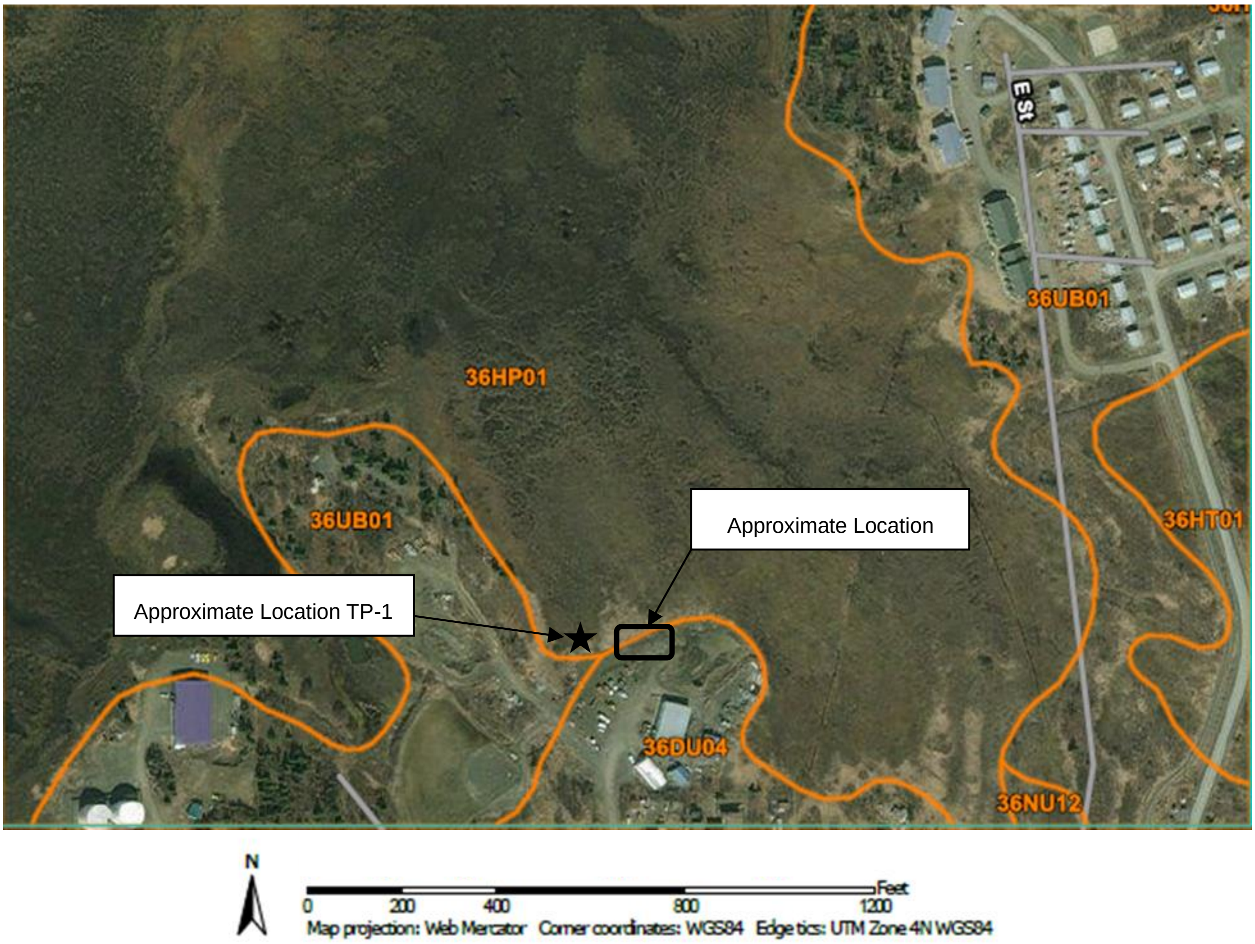
City personnel indicated the buried utility pipelines encountered hard clay, probably overconsolidated glacial deposits, along its alignment. This would coincide with the USPHS and HLA geotechnical finding summarized previously.

One shallow test pit was advanced by the city along the western margin of their fill pad. The test pit was advanced with a Case 580 rubber-tired backhoe. The general subsurface conditions encountered in this test pit are summarized below.

Site 2 Test Pit adjacent to City Shop fill pad



The US Department of Agriculture, Natural Resources Conservation Service (NRCS) mapped the soils to approximately 6 feet below grade. In the grassland area for this site, the NRCS soil classification was predominately the Wearyriver Peat, mostly organics over silty loam. This classification is in general accordance with the shallow test pit findings located at the edge of the City Shop fill pad.

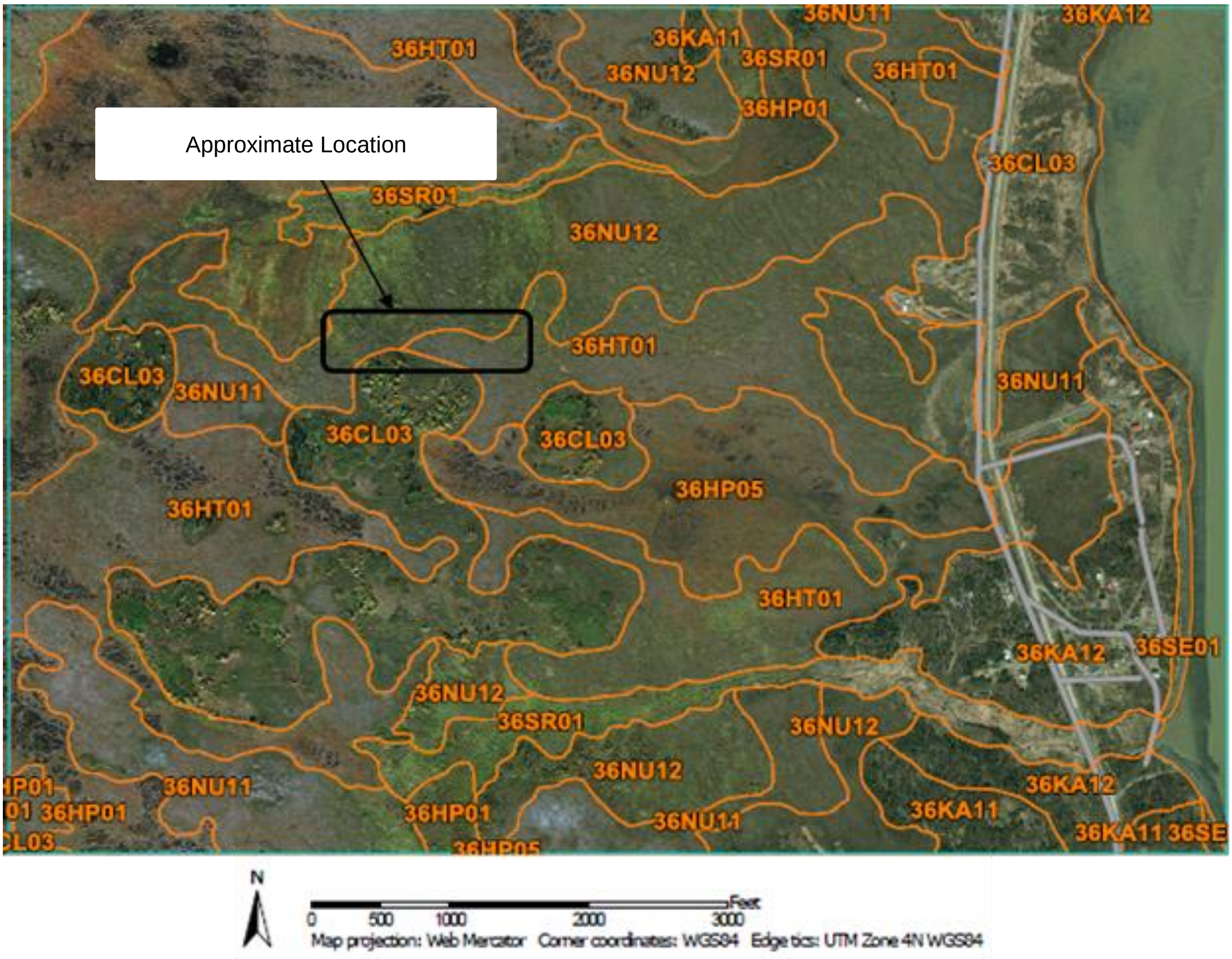


4.1.3 Himschoot/Yonashiro Site (Site 3)

Site 3 is a large tract that borders Kanakanak Road and extends westerly for approximately one mile. A series of topographic rises are present along the western margin of the tract. The majority of the area is mostly grass vegetation with defined surface drainages along the margins of the areas. Some standing water was present along Site 3 near the roadway with the majority of the site not accessed. A series of timber power poles borders the southern margin of the site. The power poles appeared to be direct site vertical with minimal leaning or other deflections.

Site 3 General View from Roadway, view west

The NRCS mapped the elevated areas as the Nushagak Clarkspoint Complex, a predominately well-drained silty loam with increasing sand content with depth (to about 6 feet). The lower lying, grassy areas were classified by the NRCS as the Pellernargug Wearyriver Complex and the Pellernargug Mucky Peat. Both classifications infer poorly drained, high organic content soils with some silty loam at depth in some areas. These soil classifications are expected to be in general accord with the glacial depositional environment in the area.



5.0 DISCUSSION

The existing wastewater treatment site appears to have adequate area for facility expansion using a similar mass excavation earthwork approach used for the current lagoons. However, shoreline protection is advised to control coastal erosion risks for extended use of this site. There are at least two rock quarries in the general area that may be able to produce riprap for shoreline armour material. Additional civil, geotechnical and coastal engineering analysis as well as permitting will be required to refine the appropriate armour system for this site. However, left unprotected, continued shoreline regression and erosion should be anticipated with the rate and geometry of additional shoreline loss requiring additional coastal process assessment and engineering evaluation.

The City Shop site may be a potential location for either a new lagoon or a new treatment plant. The lagoon option will need to address nearby existing and planned residential developments as well as current drainages within the grassland area. An embankment berm lagoon geometry can be considered but geotechnical risks including consolidation settlement of the underling cohesive soil from the embankment surcharge pressures will need to be evaluated. If a new treatment facility is being considered structure foundations will need to be determined. This will require additional site-specific geotechnical investigation and analysis. However, the mineral soils, both cohesive (plastic silt and clay) and non-cohesive (sand and gravel) are expected to provide suitable structure foundation support using driven closed end piles or larger dimensioned helical piles seated into an adequate bearing stratum. Conventional shallow foundations may be feasible for load bearing, settlement sensitive structures but additional evaluation to determine the consolidation settlement characteristics for the site soils will need to be determined. Building and embankment geotechnical design will require a more detailed site investigation at the desired structure footprints.

The Himschoot/Yonashiro Site may have similar development considerations as the City Shop site for a lagoon option. The better drained, upland areas within Site 3, if present, may provide better soil conditions for wastewater treatment cells but their distance from existing infrastructure will need to be addressed in the planning phase. As with Site 2, driven or helical piles and possibly conventional shallow foundations may be feasible foundation systems for settlement sensitive load bearing structures, such and treatment plants.

Our reconnaissance-level assessment indicated all three sites have potential for the proposed developments. However, additional geologic, civil, geotechnical and permitting efforts will be necessary to determine site-specific conditions as the project planning and design advances.

6.0 USE OF REPORT

This submittal is been prepared for use by BESC and their design team for planning and preliminary evaluation of wastewater treatment improvements in Dillingham. The summary findings provided with this submittal should not be used for engineering design without additional site-specific geotechnical data. As the project planning and preliminary designs advance, we should review submittal milestones to determine if they are in accordance with the intent of our preliminary findings and conclusions.

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. We appreciate the opportunity to provide work on this project. If you have comments or questions, please contact Richard Mitchells at 865-2537 at your convenience.

Golder Associates Inc.

Richard Mitchells, PE
Principal

Attachments: BESC developed Plans for Sites 1, 2 and 3
Test Pit TP-1 Geotechnical Laboratory Results

FIGURE 1
DILLINGHAM, ALASKA
WASTEWATER LAGOON RELOCATION STUDY
SITE 1 CONCEPTUAL LAYOUT

Bristol
ENGINEERING SERVICES COMPANY, LLC

DATUM:	DATE 8/1/2019	SHEET 1 of 3
PROJECTION:	DWN. DWB	
PROJECT No. 32200002	SCALE 1" = 250'	
	APPRVD. DWB	

Drawing: K:\JOBS\32200002 DLG LAGOONSTUDY\ACAD-DESIGN\01_CONCEPTUAL DESIGNS\32200002 DLG LAGOON STUDY_CONCEPTUAL LAYOUTS.DWG – Layout: SITE 1
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FIGURE 2
DILLINGHAM, ALASKA
WASTEWATER LAGOON RELOCATION STUDY
SITE 2 CONCEPTUAL LAYOUT

Bristol ENGINEERING SERVICES COMPANY, LLC	DATUM:	DATE 8/1/2019	SHEET
	PROJECTION:	DWN. DWB	**2**
		SCALE 1" = 150'	of
	PROJECT No. 32200002	APPRVD. DWB	3

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FIGURE 3
DILLINGHAM, ALASKA
WASTEWATER LAGOON RELOCATION STUDY
SITE 3 CONCEPTUAL LAYOUT

Bristol ENGINEERING SERVICES COMPANY, LLC	DATUM: PROJECTION: PROJECT No. 32200002	DATE 8/1/2019 DWN. DWB SCALE 1" = 500' APPRVD. DWB	SHEET 3 of 3

Drawing: K:\JOBS\32200002 DLG LAGOONSTUDY\ACAD-DESIGN\01_CONCEPTUAL DESIGNS\32200002 DLG LAGOON STUDY_CONCEPTUAL LAYOUTS.DWG – Layout: SITE 3
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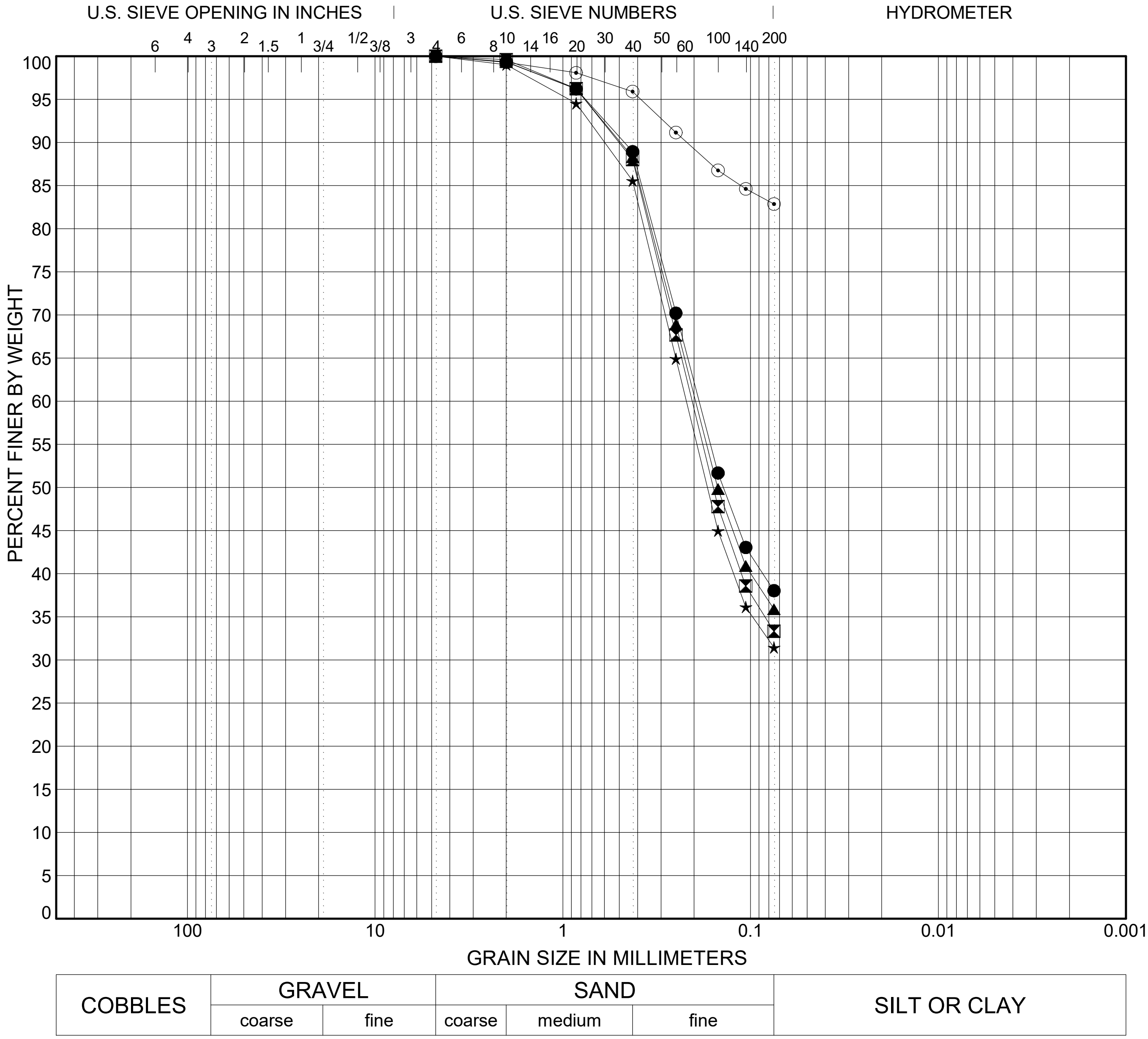
GOLDER

FIGURE 1: SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s)
ASTM C136, D422, and D6913

Client:	Bristol Engineering Services Company, LLC	**Project No.:**	19122864		
Project:	Dillingham Lagoon Study	**QA/QC By:**	J. Randazzo	**Date:**	7/30/2019
Location:	Dillingham, AK	**Reviewed By:**	T. Voeller	**Date:**	7/30/2019



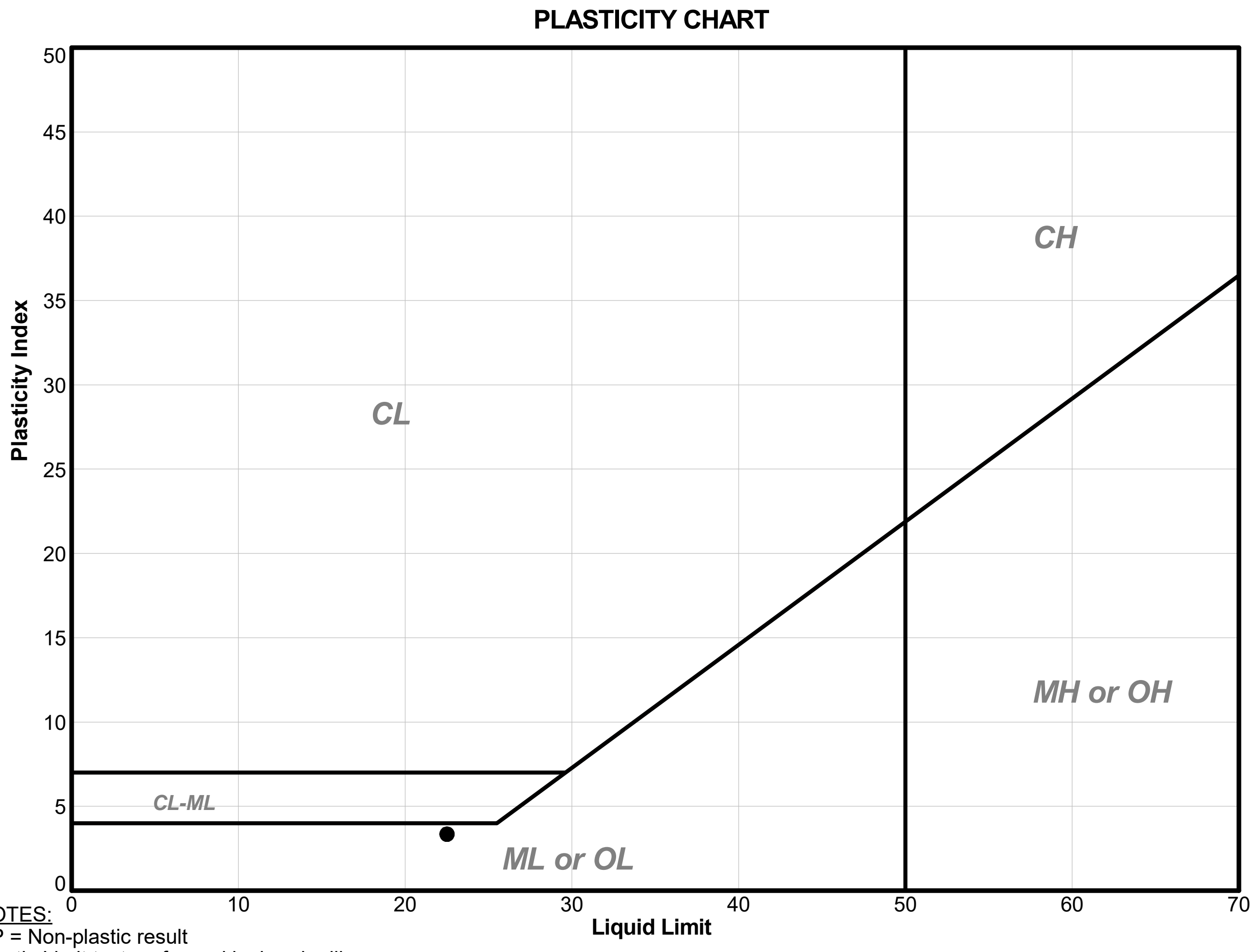
	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	% Fines	% < 0.02 mm
●	TH-1	1	2.0	silty sand (SM)	-	-	0	62	38.0	
⧗	TH-1	2	4.0	silty sand (SM)	-	-	0	67	33.3	
▲	TH-1	3	5.5	silty sand (SM)	-	-	0	64	35.9	
★	TH-1	4	6.5	silty sand (SM)	-	-	0	69	31.4	
⊙	TH-1	5	7.0	silty clay with sand (ML)	-	-	0	17	82.9	

19122864 BRISTOL DILLINGHAM LAGOON STUDY.GPJ LIBRARY-ANC(6-17-19).GLB [ANC LAB GRAIN SIZE] JKarp 9/20/19

FIGURE 2: LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX

Reference(s)
ASTM D4318

Client:	Bristol Engineering Services Company, LLC	**Project No.:**	19122864		
Project:	Dillingham Lagoon Study	**QA/QC By:**	J. Randazzo	**Date:**	7/30/2019
Location:	Dillingham, AK	**Reviewed By:**	T. Voeller	**Date:**	7/30/2019



NOTES:
NP = Non-plastic result
Plastic Limit test performed by hand rolling
Liquid Limit test performed using mechanical device

	Sample Location	Sample Number	Depth (ft)	Bottom (ft)	Passing #40 Sieve (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	USCS	Natural Moisture Content (%)
●	TH-1	5	7.0	7.5	96	23	19	4	ML	20

19122864 BRISTOL DILLINGHAM LAGOON STUDY.GPJ LIBRARY-ANC(6-17-19).GLB [ANC LAB ATTERBERG CASAGRANDE MULTI (10)] JKarp 9/20/19

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GOLDER

TABLE 1: SAMPLE SUMMARY

Client: Bristol Engineering Services Company, LLC		**Project No.:** 19122864	
Project: Dillingham Lagoon Study			
Location: Dillingham, AK		**Reviewed By:** T. Voeller	**Date:** 7/30/2019

SAMPLING DATA							CLASSIFICATION AND INDEX TEST RESULTS										
SAMPLE LOCATION	SAMPLE NUMBER	DEPTH (ft)		RECOVERY (%)	SAMPLE TYPE	BLOWS PER FOOT	NATURAL MOISTURE CONTENT (%)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	GRADATION (%)			ORGANIC CONTENT (%)	SALINITY (ppt) [(d) is directly meas.]	DESCRIPTION (USCS)	TESTS / OTHER TESTS
		TOP	BOTTOM								GRAVEL	SAND	FINES (SILT & CLAY)				
TH-1	1	2.0	3.0				24				0	62	38.0			SM	SA
TH-1	2	4.0	4.5				18				0	67	33.3			SM	SA
TH-1	3	5.5	6.0				21				0	64	35.9			SM	SA
TH-1	4	6.5	7.0				20				0	69	31.4			SM	SA
TH-1	5	7.0	7.5				20	23	19	4	0	17	82.9			ML	SA, PI

19122864 BRISTOL DILLINGHAM LAGOON STUDY.GPJ LIBRARY-ANC(6-17-19).GLB [ANC_SAMPLE_SUMMARY] JKarp 9/20/19

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