Pali Consulting

MEMORANDUM

January 28, 2019

Waterways Consulting, Inc.
1020 SW Taylor Street, Suite 380
Portland, Oregon 97205
Attention: Mr. Daniel Malmon

Limited Geotechnical Evaluation
North Bank Working Landscapes Project
Coos County, Oregon
Pali Consulting Project #014-18-001

1.0 INTRODUCTION

This memorandum provides Pali Consulting, Inc.'s (Pali Consulting's) limited geotechnical evaluation for the North Bank Working Landscapes Project (North Bank Project) in Coos County, Oregon. Waterways Consulting, Inc (Waterways) is designing the project for the Coos Soil and Water Conservation District (Coos SWCD) and requested that Pali Consulting provide limited geotechnical services for the project. Our work was completed in general accordance with our agreement with Waterways for the project dated November 4, 2018. The location of the site is shown on Figure 1.

The project is located at River Mile 7.5 of the Coquille River near Bandon, Coos County, Oregon. It includes restoration of approximately 43 acres of leveed agricultural land adjacent the river that was historically tidal marsh/wetland habitat. The work will include a new tide gate and culvert, approximately 3,000 feet of sinuous on-grade reconstructed tidal channel and repairs to an existing embankment. A site plan with the limits of the project area and significant site features is shown on Figure 2.

Due to available funding, Pali Consulting's work was limited for this project. Our scope of work included one day of field work using hand exploration and visual reconnaissance methods, an evaluation of geotechnical conditions of significance to the project, and this memorandum documenting our evaluation. This level of effort allowed evaluation of foundation conditions at the proposed tidegate and culvert location, assessment of on-site borrow material for reconstruction, and a qualitative assessment of significant geotechnical conditions that could affect the current levee and proposed reconstructed section. Our explorations did not allow for accurate estimates of settlement, seepage or stability of the levee, or accurate evaluation of conditions below the exploration depths. We understand that the Coos

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SWCD will rely on past performance of the existing levee to evaluate specific concerns related to these issues.

2.0 BACKGROUND INFORMATION

We reviewed geologic and soil mapping of the site, but our work did not include an evaluation of geologic hazards, such as earthquake shaking, and earthquake-induced liquefaction and tsunami inundation. These hazards may be significant at this site but were not within our scope of work to evaluate. A summary of our review follows.

2.1 GEOLOGY

The geology of the site is mapped in the Oregon Department of Geology and Mineral Industries (DOGAMI) Geologic Map of the Bandon & Part of Langlois Quadrangles, Oregon (Beaulieu, Baldwin 1973). The geologic mapping shows the site is mapped in Holocene aged Quaternary alluvium deposits. These deposits are described as unconsolidated sand, silt, clay and mud in the flood plains of major streams draining sandstone and siltstone terrain. It is also reported that these deposits can be associated with fresh water marsh and peat in places, and hazards include stream-bank erosion, ponding, high ground water, flooding, siltation, and compressible soils locally. These alluvial deposits are likely underlain by sedimentary rocks of the Roseburg Formation that are lower Eocene and older in age. The formation is further described as rhythmically bedded hard sandstone and siltstone with lesser amounts of conglomerate and shale that has low permeability and ground water potential. The formation is typically mantled by silt loam and loamy sand, and hazards include mass movement, erosion, and variable foundation conditions.

2.2 SOILS

Site soils within the area are mapped as Langlois silty clay loam, which is typically found on flat floodplains and has a parent material of mixed alluvium. The soil has a typical profile of silty clay loam from 0 to 10 inches, silty clay from 10 to 28 inches, and clay from 28 to 60 inches, with a depth to water table of 0 inches and a depth to restrictive features of more than 80 inches. It is described as very poorly drained with a hydrologic soil group classification of 'C/D'.

3.0 SITE CONDITIONS

We evaluated site conditions by conducting a geologic reconnaissance and completing hand subsurface explorations. Subsurface explorations and laboratory testing are described in Appendix A. Photographs from the site are included in Appendix B and noted in Table 1. The following sections describe our findings.

3.1 SURFACE CONDITIONS

The site is a rectangular parcel within the floodplain of the Coquille River. It is bounded on the west by an existing levee that parallels the river, on the east by North Bank Lane, and on the north and south by property lines. Alterations to the natural conditions at the site include the levee, shallow drainage ditches and the North Bank Lane road prism. Based on LiDAR of the site, elevations are between 5 and 7 feet within the broad floodplain which encompasses most of the project area. The ditches are 2 to 3 feet lower than the adjacent pastureland, with typical elevations of 3 to 4 feet. The top of the levee varies from about 8 to 10 feet in elevation. Along the east side of the site, the ground slopes up moderately to steeply a few feet to North Bank Lane which follows the toe of the adjacent hillside.

Vegetation is mostly pasture grasses with some spruce trees planted along the top of the levee and some native deciduous trees and shrubs along the river.

We completed a detailed reconnaissance and documented physical features along the levee. Specific locations where we collected information are noted on Figure 2. A summary of observations at these stations, along with laboratory test results and site photographs at representative locations are included in Table 1 below.

Table 1. Field Conditions

Station	Conditions/Notes	Soil Exposed / Laboratory Results	Face Height	Photo
T-1	North end of site.	No soil exposed.	0	B-1
T-2	Area of erosion/vertical face, trees above, rip rap in front.		2 – 3’	
T-3	Small piling in front of embankment; continues to east. Eroded behind piling.		3 - 4’	B-2
T-4	Severe erosion with increasing severity from T-2.		5’	
T-5	Undermined tree.	Fine sandy silt (ML), non-plastic.	5’	
T-6	Soil samples collected at 4’ and 1’ from top of levee.	Elastic silt (MH) over silt with fine sand (ML), low plasticity. Thin layer of gravel at base. Lab tests: 1’: #200 = 74%, LL = 53, PI = 22 (MH) 4’: #200 = 71%, LL = 42 PI = 14 (ML)	5’	B-3
T-7	Timber piles in front for erosion protection. Many insect holes along face. Height of face decreases to south through this section. Round and angular rip rap at waterline.	Fine sandy silt (ML), low plasticity.	3 - 5’	B-4
T-8	Trees absent; face of levee unvegetated. 4H:1V slope except 3H:1V eroded slope at high water line. N end of repaired area. Starts at	Fine sandy silt (ML), low plasticity.	0	B-5

Station	Conditions/Notes	Soil Exposed / Laboratory Results	Face Height	Photo
	end of piling and continues 100 to 200’ south.			
T-9	Rip rap on toe of levee at south end of repair. Face transitions to vertical, evidence of fallen “blocks” of soil.		5’	B-6
T-10	Borrow area for repair or low area landside of levee. Pile revetment along front of embankment here.	Clayey silt ~ 2’ below adjacent surface with extensive desiccation cracking. Lab Results: 2’: #200 = 85%, LL = 100 PI = 50 (MH)	NA	B-7
T-11	From T-10 to T-11 trees either toppled by erosion or cut off and undermined. Vertical face increases from north to south to 6’ high at T-11.		6’	
T-12		Silty fine sand (SM) to sandy silt (ML) in top 3’, grading to ML/MH at base.	3 - 5’	
T-13	Variable erosion and soils exposed are similar to others observed.		3 - 6’	B-8
T-14		3’ fill over 3’ native. Native is expansive based on desiccation cracks and field plasticity. Fill is silty fine sand with occasional boulders on surface and in outcrop.	6’	B-9
T-15	Similar erosion/configuration of lower bank on west side of river (see Photo A-12).	3’ sandy silt fill over 3’ silty clay. Less desiccation cracking. Interpret lower soil as native. Lab Results: 2’: #200 = 62%, LL = 32, PI = 5 (ML) 4’: #200 = 79%, LL = 42 PI = 35 (CL-ML)		B-10 B-11 (west shore)

Station	Conditions/Notes	Soil Exposed / Laboratory Results	Face Height	Photo
T-16	Erosion decreases.	Fine sandy silt fill over clayey silt. Interpret as fill over native soils.	3’	B-12
T-17	As T-15 but with higher bank		6 – 7’	B-13

As documented in Table 1, the levee exhibits significant distress along most of its length. The following specific conditions are noted:

- The waterside face of the levee is severely eroded along the majority of its length within the project area, creating a vertical face that ranges to as high as 5 or 6 feet and typically averages about 3 feet.
- Soils exposed in the levee appear to consist of fill overlying native alluvium. The fill is mostly fine sandy silt with low plasticity (ML). The native soil varies from silt (ML) to elastic silt (MH) and with some clay. The fill is likely from excavation within or near the project site, as the soils are similar to the native soils below the levee and encountered in our subsurface explorations. Subsurface explorations are described in the next section of this report.
- A number of timber revetments, rock rip rap toe protection and evidence of multiple grading and filling events are evident along the length of the levee, illustrating a long history of erosion, protection and repair and which continues to present.
- Timber piling and large woody brush/small trees along the base of the levee on the water side exhibited significant erosion behind them.

Landward of the levee, the site is a flat tidal marsh/field with some straight ditches constructed to drain the marsh/field and at least two low areas which are presumed to be low from past grading/borrow, including one noted as Station T-10 and Photo B-8. No prominent features are present which would suggest differences in subsurface conditions within the project area.

North Bank Lane comprises the east boundary of the project area. It is located at the toe of low hills along the east side of the site and is anticipated to be constructed on a cut and fill prism. The west side of the road prism slopes down steeply to the marsh/field and is presumed to be constructed of fill. Since no work is planned in this area as part of the project, this area was not further evaluated.

3.2 SUBSURFACE CONDITIONS

We completed two hand auger borings at the locations shown on Figure 2. Laboratory testing was conducted on representative samples collected from the borings. A description of our subsurface exploration program and laboratory testing, and logs of the borings are included in Appendix A. The soils we encountered are described in detail below.

Our hand augers encountered peat and organic soils at the surface from about 4 to 12 inches thick, underlain by silt and elastic silt to 6 feet deep in HA-1, located at a potential borrow location, and silt and clayey silt to 10.5 feet deep in HA-2, located at the proposed culvert and tide gate location. The silt transitioned to sand at 10.5 feet deep in HA-2, which continued to 11.5 feet deep, the maximum depth explored. HA-1 was terminated at 6 feet deep, so the presence and depth of sand was not confirmed at this location.

The silt varied from very soft to medium stiff within our borings. It was mottled near the surface, becoming grey with depth. The silt was mostly of low plasticity with one sample from HA-1 classifying as an elastic silt. The silt contained substantial fine sand. The laboratory sieve results measured between 58 and 83 percent passing the number 200 sieve, the division between fine-grained and coarse-grained soils. This means that the retained 17 to 42 percent of the samples are sand. Moisture contents in silts below the water table varied from 36 to 52 percent, while soils near the surface were measured as 15 percent in a silt sample in HA-2 and 77 percent from an organic soil near the surface in HA-1. Atterberg limits testing found plasticity indices of the soils to be moderate, between 15 and 22.

Sand was encountered in the bottom foot of HA-2. It classed as a silty sand due to 45 percent material passing the number 200 sieve; these soils probably transition without abrupt contacts between sands and silts. The sand had a moisture content of 36 percent based on one test.

Groundwater was encountered at depths of 3 feet in HA-1 and 9 feet in HA-2. HA-1 was left open for some time to stabilize, but HA-2 had to be backfilled before the groundwater level could stabilize. Groundwater will likely be higher than that observed in the explorations, particularly in HA-2, where soil coloring suggests static water is approximately 6 feet deep. Considering a surface elevation difference of two to three feet between the sites, the water level appears to be relatively level across the site and probably generally coincides with river level. Some lag likely occurs compared to tidal cycles and higher groundwater is also expected to be present intermittently or seasonally related to periods of heavy rain. Mottled soils suggest the seasonal groundwater table is likely near the surface during wet periods.

3.0 CONCLUSIONS

Based on our evaluation, the following are the primary geotechnical factors that will affect the project, (excluding seismic considerations).

- The existing levee is not constructed with soils that are typically suitable for such uses when not protected by erosion. The soils are fine-grained with significant sand and generally low plasticity. As such, they have low strength and are subject to erosion.
- Levee distress appears to be due to erosion of the sandy silt soils by the river. It does not appear due to a specific location relative to any geomorphic feature or due to substantial variations in composition or geometry of the levee. It appears to affect the levee through essentially its full length, but with variations in severity of erosion.
- Foundation soils are weak and prone to settlement. Significant changes to the existing levee that add weight, such as new alignments or adding fill to increase levee height or footprint, could result in embankment failure.
- On-site soils are not optimal for levee repair or construction. They are similar to those which the levee is currently constructed of, however. Most have low plasticity, but local areas may have elastic silts with high plasticity indices and these should be avoided for embankment borrow. Peat and organic soils, where present, should not be used in levee construction.

- The high water table will make borrow and earthworks construction difficult.

Our geotechnical recommendations are provided in the following sections.

4.0 RECOMMENDATIONS

Based on our evaluation, the following are the primary geotechnical factors that will affect the project, (excluding seismic factors).

4.1 Culvert and Tide Gate Support

We understand that a new culvert and tide gate system will be installed at the approximate location of HA-2. Based on our subsurface explorations and analyses, we recommend bearing pressures not exceed 1,500 pounds per square foot (psf) locally and 500 psf average across the structure footprint. The recommended allowable bearing pressure applies to the total of dead plus long-term live loads and may be increased by one-third for short-term loads.

We recommend a layer of rock be placed over the subgrade to limit disturbance prior to placing the culvert/tide gate structure on grade. If placed in the dry, the rock should consist of a 6-inch layer of pit or quarry run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in OSS 00330.14 – *Selected Granular Backfill* or OSS 00330.15 – *Selected Stone Backfill*. The imported granular material should also be angular, fairly well graded between coarse and fine material, have less than 5 percent by dry weight passing the U.S. Standard No. 200 Sieve, and have at least two mechanically fractured faces. If placed in the wet, a 12 to 18-inch thickness of imported granular material should be placed as a subgrade stabilization layer. The stabilization layer should meet the specifications of OSS 00330.14 Selected Granular Backfill, or OSS 0330.15 Selected Stone Backfill. Construction geosynthetic for soil stabilization (per Table 02320-4 of OSS 02320) may be used to prevent migration of fines into the void spaces of the coarser material. The rock should be compacted to a dense well-keyed condition with appropriate equipment, but not to cause damage or softening of the subgrade. Provided the structure is placed as recommended it should experience "static" settlement of less than 2 inches, with differential settlement of less than 1 inch over the culvert's span. Levee soils placed above the culvert/tide gate structure will cause additional settlement beyond those estimated above.

Lateral loads on footings can be resisted by friction on the bearing surface. Friction coefficients of 0.30 or 0.40 may be used for pre-cast concrete footings placed on native silt or a minimum 6-inch-thick layer of imported granular fill, respectively. Imported granular fill should meet the specifications provided in OSS 00330.14 – *Selected Granular Backfill* or OSS 00330.15 – *Selected Stone Backfill*. The imported granular material should also be angular, fairly well graded between coarse and fine material, have less than 5 percent by dry weight passing the U.S. Standard No. 200 Sieve, and have at least two mechanically fractured faces. It should be compacted to a well-keyed state as noted above.

Additional resistance to lateral loads can be achieved by passive earth pressures on the sides of embedded elements. However, passive resistance can only be relied upon 1 foot and greater below the ground surface, or the potential depth of scour or erosion, whichever is greater. Passive earth pressures can be calculated using an equivalent fluid weight of 290 pounds per cubic foot (pcf) for footings backfilled with compacted imported structural fill. The passive earth pressure and friction components may be combined, provided that the passive component does not exceed two-thirds of the total.

The above lateral resistance values do not include safety factors.

If any walls for the structure are restrained, they should be designed to resist at-rest earth pressures. We recommend the use of an at-rest earth pressure of 56 pcf acting as an equivalent fluid weight.

If the culvert/tidegate structure will be placed in an area of new levee construction, the settlement caused by the new levee fill could cause significant settlement of the culvert/tidegate. In this case, we would recommend constructing the levee first, monitoring settlement of the levee and installing the culvert/tidegate once survey has confirmed that settlement is acceptably complete.

4.2 Borrow Materials

We understand that borrow areas proposed at the site include the borrow area noted on Figure 2 and possibly soils from demolition of levee sections related to reconstruction.

HA-2 encountered about a foot of organic peat soil over silt and elastic silt. The peat soils are not suitable for levee construction and the silt and elastic silt soils are similar to those present in the existing levee. As noted in Section 3.0, the silt and elastic silt soils are not ideal for levee construction. However, if the performance of the current levee and regular repairs are acceptable or the levee face is protected as noted in Section 4.3, the soils can be used as borrow. If used as borrow, elastic silt (most readily identified by desiccation cracking when dry) should be avoided.

Groundwater was encountered at about 3 feet bgs in HA-2, so groundwater is expected to be present at similar depths in the borrow area and at similar elevation throughout the site. This will result in several geotechnical constraints on borrow operations, including:

- Caving of excavated slopes where they extend below the water table.
- Soils above optimum moisture content above the water table and saturated below. All soils will require drying before they can be compacted for levee fill and saturated soils will require a long drying period or larger laydown areas where they can be spread in thin lifts to dry.
- Dewatering can be considered to lower groundwater within the working borrow area but will be problematic. The fine-grained soils are often also dilatant. As such they will be difficult to dewater with well-points, but they will also be prone to raveling and collapse if a sump pump type system is used.
- The subgrade will be saturated, very soft and easily disturbed during most of the year.

Soils within the levee are expected to consist mostly of sandy silt with localized sand, organics, gravel, and elastic silt. If used as borrow, the sandy silt soils can be reused with the limitations noted earlier. However, the organics, gravel and elastic silt should be separated from the silt and not used for levee construction or any structural purposes.

Excavation, placement and compaction of the sandy silt soils should follow the recommendations as noted in Section 4.3 below.

4.3 Other Geotechnical Factors Affecting Levee Stability and Repair

As noted in Section 3.0, the deteriorated condition of the levee appears to be primarily due to the materials the levee is composed of. The soils are believed to be from on-site or nearby sources as testing and observations indicate the soils are similar to those encountered in our borings. Those soils consist of low to moderate plasticity silt with significant fine-sand. Such soils are subject to erosion as evidenced by the vertical faces along the majority of the levee and the multiple repairs that have been implemented over what appears to be several iterations. Reconstruction and repair of the levee using similar on-site soils will result in a levee of similar performance: continued erosion and repairs on a regular basis. Further, if storm frequency and magnitudes increase and sea levels rise as anticipated over the coming decades, the levee may perform to an even lesser level than it has historically.

With this understanding of future performance acceptable to the owner, repair or reconstruction of the levee should consider the following recommendations:

- Levee repairs should generally follow the existing levee footprint and geometry. Soils below the levee are weak and are prone to excessive settlement and failure if overloaded. Reconstruction within the previous footprint and geometry, should keep soil stresses within previous levels of loading, so not result in failure or excessive settlement.
- If a new levee section will be reconstructed outside the current levee footprint, we recommend the following:
  - The relocated levee should be constructed on the landward side of the existing levee and not closer to the water.
  - The existing section of levee to be replaced should be removed before the new section is constructed.
  - The new levee should be constructed per acceptable methods and guidelines such as the US Army Corps of Engineers Engineering Manual EM 1110-2-1913.
  - Levee construction should be staged and monitored closely to prevent subgrade failure. Our scope did not include explorations or analyses sufficient to provide specific guidelines for reconstruction related to subgrade failure, but similar projects we have designed have typically constructed such levees in lifts about 2 feet high each and with one or two weeks between construction of each lift to allow subgrade soils to drain and strengthen before the next lift is placed. This can be completed on a progressive basis, beginning at one end of the levee and working to the other, returning to the initial starting point after sufficient time has elapsed for construction of the next lift to begin.
- If continued erosion of the levee is not acceptable, then protection of the levee face will be required. This could be accomplished by armoring or possibly by a bioengineered facing. If the latter, vegetation should not include woody shrubs that could cause eddies and resulting erosion of the face, as noted behind piling and shrubs along the current levee face.

5.0 CONSTRUCTION MONITORING

Satisfactory earthwork and foundation performance depend to a large degree on quality of construction. Sufficient monitoring of the contractor’s activities is key to determining that the work is completed in accordance with our recommendations. Subsurface conditions observed during construction should be compared with those encountered during the subsurface exploration. Recognition of changed conditions often requires experience; therefore, Pali Consulting or their representative should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated.

We recommend that Pali Consulting be retained to monitor construction of geotechnical elements at the site to confirm that subsurface conditions are consistent with the site explorations and to confirm that the intent of the project plans and specifications relating to earthwork and culvert/tidegate installation are being met. In particular, we recommend that subgrade preparation and fill compaction for the culvert/tidegate be observed by Pali Consulting.

6.0 LIMITATIONS

This evaluation is based on a limited scope of work which was negotiated between Pali Consulting, Waterways and the Coos SWCD. The opinions and recommendations contained within this report are, therefore, based primarily upon surface observations supplemented with explorations of limited extent and depth. Our report should not be construed as a warranty or guarantee of site conditions or performance. Soil conditions can differ from those encountered during our field work, as well as during different seasons, from earth processes, from storms, or other factors that occur after our work has been completed.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with the standard of care in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

We appreciate the opportunity to provide this information for you. Please contact us if we can be of further assistance or if you have any questions.

7.0 REFERENCES

Oregon State Department of Transportation (ODOT) 2015. Oregon Standard Specifications for Construction (OSS).

United States Department of Agriculture (USDA) 2019, Natural Resources Conservation Service, "Web Soil Survey." https://websoilsurvey.nrcs.usda.gov.

US Army Corps of Engineers (USACE) 2000. Design and Construction of Levees, Engineering Manual EM 1110-2-1913.

Walker, G.W. and N.S. MacLeod 1991. Geologic map of Oregon: U.S. Geological Survey, scale 1:500,000.

Attachments:

Figures 1 and 2
Appendix A – Subsurface and Laboratory Testing
Appendix B – Site Photographs

Document ID: 014-18-001NorthBankGeotechnicalReport

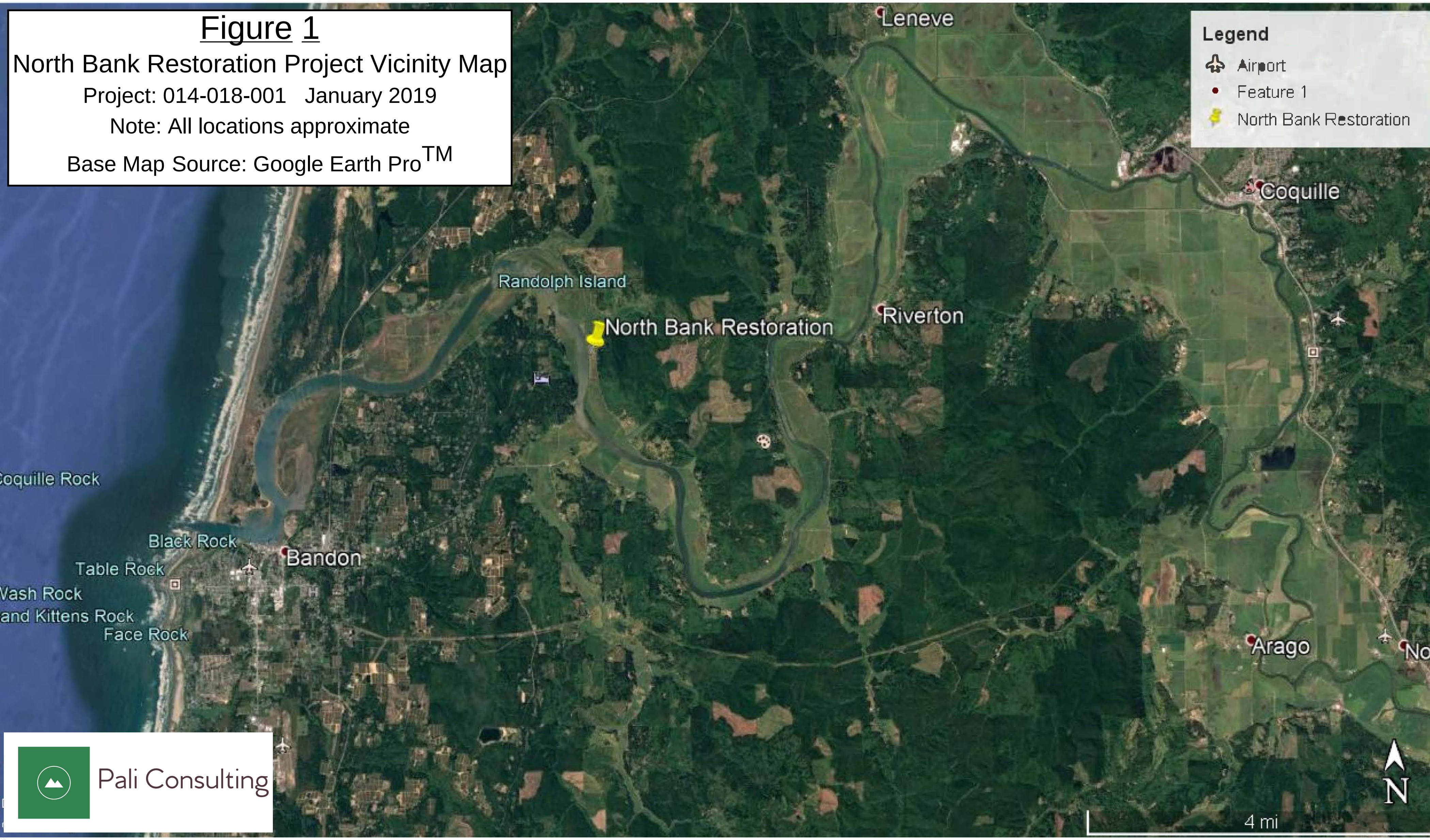
Figure 1

North Bank Restoration Project Vicinity Map

Project: 014-018-001   January 2019

Note: All locations approximate

Base Map Source: Google Earth Pro™



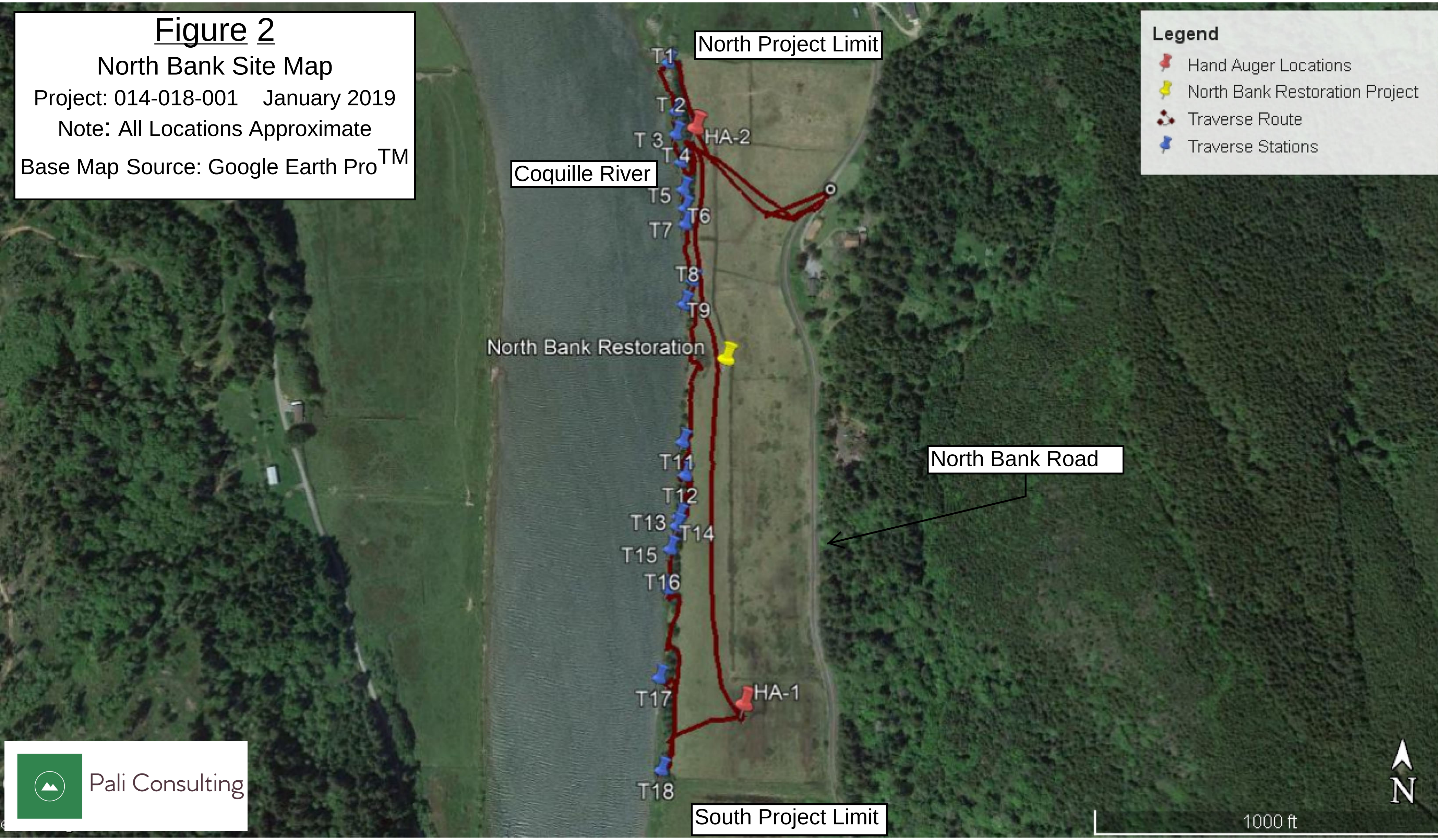


Figure 2
North Bank Site Map
Project: 014-018-001 January 2019
Note: All Locations Approximate
Base Map Source: Google Earth Pro™
Legend
Hand Auger Locations
North Bank Restoration Project
Traverse Route
Traverse Stations
North Project Limit
Coquille River
North Bank Restoration
North Bank Road
South Project Limit
HA-1
HA-2
T1
T 2
T 3
T 4
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1000 ft
Pali Consulting

ATTACHMENT A -
FIELD EXPLORATIONS AND LABORATORY TESTING

FIELD EXPLORATIONS

GENERAL

We evaluated subsurface soil and groundwater conditions at the site by completing two hand auger borings on November 15th, 2018. The hand auger borings were completed by an engineering geologist from Pali Consulting. The locations of the explorations are shown on Figure 2 of the report. The exploration locations were approximately located with a recreational grade GPS so should be considered accurate only to the degree implied by the locating methods used.

SAMPLING AND LOGGING

Soil samples were collected from the borings at the intervals noted on the exploration logs in this attachment. Sampling was completed by collecting "grab" samples for further evaluation. All disturbed samples obtained were sealed in watertight containers and transported to our laboratory for subsequent classification and testing. Soil sampling intervals are shown in the exploration logs in this attachment.

The field explorations were coordinated by an engineering geologist on our staff, who located the explorations, classified the various soil units encountered, obtained representative soil samples for geotechnical testing, observed and recorded groundwater conditions, and maintained a detailed log of each exploration. Exploration logs are included in this attachment.

LABORATORY TESTING

GENERAL

Soil samples obtained from the explorations were transported to our laboratory and evaluated to confirm or modify field classifications, as well as to evaluate engineering properties of the soils encountered. Representative samples were selected for laboratory testing. The tests were performed in general accordance with the test methods of the ASTM or other applicable procedures. Test results are indicated on the boring logs.

VISUAL CLASSIFICATIONS

Soil samples obtained from the explorations were visually classified in the field and in our geotechnical laboratory based on the USCS and ASTM classification methods. ASTM Test Method D2488 was used to classify soils using visual and manual methods. ASTM Test Method D2487 was used to classify soils based on laboratory test results.

Moisture Content

Moisture contents of samples were obtained in general accordance with ASTM Test Method D2216. The results of the moisture content tests completed on samples from the explorations are presented on the exploration logs, noted as “MC”, included in this Attachment.

Fines Content Analyses

Fines content analyses were performed to determine the percent of soils finer than the U.S. No. 200 Sieve, the boundary between sand size particles and silt size particles. The tests were performed in general accordance with ASTM Test Method D 1140. The test results are indicated on the exploration logs, noted as “P200”, included in this Attachment.

Atterberg Limits

Atterberg limits (liquid limit, plastic limit and plasticity index) of fine-grained soil samples were obtained in general accordance with ASTM Test Method D4318-02. The results of the Atterberg limits tests completed on samples from the explorations are presented on the exploration logs, noted as “ATT”, included in this Attachment.

KEY TO EXPLORATION LOGS

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SOIL CLASSIFICATION CHART

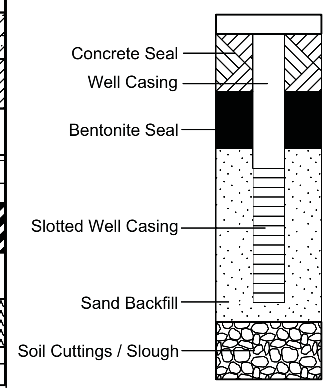
MATERIAL TYPES	MAJOR DIVISIONS		GROUP SYMBOL	SOIL GROUP NAMES & LEGEND
COARSE-GRAINED SOILS >50% RETAINED ON NO. 200 SIEVE	GRAVELS >50% OF COARSE FRACTION RETAINED ON NO 4. SIEVE	CLEAN GRAVELS <5% FINES	GW	WELL-GRADED GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVELS WITH FINES, >12% FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SANDS >50% OF COARSE FRACTION PASSES ON NO 4. SIEVE	CLEAN SANDS <5% FINES	SW	WELL-GRADED SAND
			SP	POORLY-GRADED SAND
		SANDS AND FINES >12% FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE-GRAINED SOILS >50% PASSES NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT<50	INORGANIC	CL	LEAN CLAY
			ML	SILT
		ORGANIC	OL	ORGANIC CLAY OR SILT
	SILTS AND CLAYS LIQUID LIMIT>50	INORGANIC	CH	FAT CLAY
			MH	ELASTIC SILT
		ORGANIC	OH	ORGANIC CLAY OR SILT
HIGHLY ORGANIC SOILS			PT	PEAT

Note: Multiple symbols are used to indicate borderline or dual classifications

OTHER MATERIAL SYMBOLS

- Concrete
- Asphalt
- Topsoil

WELL SYMBOLS



MOISTURE MODIFIERS

Dry	-	Absence of moisture, dusty, dry to the touch
Moist	-	Damp, but no visible water
Wet	-	Visible free water or saturated, usually soil is obtained from below the water table

SEEPAGE MODIFIERS

None	-	
Slow	-	< 1 gpm
Moderate	-	1-3 gpm
Heavy	-	> 3 gpm

CAVING MODIFIERS

None	-	
Minor	-	isolated
Moderate	-	frequent
Severe	-	general

MINOR CONSTITUENTS

Trace	-	< 5% (silt/clay)
Occasional	-	< 15% (sand/gravel)
With	-	5-15% (silt/clay) in sand or gravel 15-30% (sand/gravel) in silt or clay

SAMPLE TYPES

- Dames & Moore
- Standard Penetration Test (SPT)
- Shelby Tube
- Bulk or Grab
- Modified California Sampler

LABORATORY/ FIELD TESTS

ATT	-	Atterberg Limits
CP	-	Laboratory Compaction Test
CA	-	Chemical Analysis
CN	-	Consolidation
DD	-	Dry Density
DS	-	Direct Shear
HA	-	Hydrometer Analysis
OC	-	Organic Content
PP	-	Pocket Penetrometer (TSF)
P200	-	Percent Passing No. 200 Sieve
SA	-	Sieve Analysis
SW	-	Swell Test
TV	-	Torvane Shear
UC	-	Unconfined Compression

GROUNDWATER SYMBOLS

- Water Level (at time of drilling)
- Water Level (at end of drilling)
- Water Level (after drilling)

STRATIGRAPHIC CONTACT

- Distinct contact between soil strata or geologic units
- Gradual or approximate change between soil strata or geologic units

Notes:

Blowcount (N) is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted) per ASTM D-1586. See exploration log for hammer weight and drop.

N for oversize samplers is approximately correlated to equivalent SPT N by 50% reduction in N (Modified California and Dames & Moore samplers).

Refer to the report text and exploration logs for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the exploration locations at the time the explorations were made. The logs are not warranted to be representative of the subsurface conditoins at other locations or times.

HA-1

Project: North Bank Restoration | **Date: 11-15-18** | **Logged By: TWB**
Drill Rig: Hand Auger | **Hole Dia: 3 in** | **Sampler: Hand Auger**
Initial GW Depth: 3 ft | **Final GW: 3' bgs** | **Hole Elev: 6' MSL**

Description	**USCS Class**	**Graphic Log**	**Depth**	**Water**	**Sample**	**Penetration**	**Remarks and Lab Tests**
Brown, moist, very soft PEAT with SILT	PT		0				Thick roots/organics
Grey/brown/orange, moist to wet, soft SILT	ML		1		S-1		S-1 MC=77%
			2				Wet (saturated) and sticks to auger
Increasing plasticity and very soft							
			3	▼	S-2		S-2 MC=44% P200=66% ATT: LL=42, PI=15 Becomes saturated, dilatent Switched to solid auger to finish
Becomes grey, wet							
			4				
			5				
Grey, wet, very soft ELASTIC SILT	MH		6		S-3		S-3 MC=35% P200=58%
Boring completed at depth of 6.5 due to no sample retainage. Groundwater encountered at 3 feet.			7				

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Notes:

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HA-2

Project: North Bank Restoration | **Date: 11-15-18** | **Logged By: TWB**
Drill Rig: Hand Auger | **Hole Dia: 3 in** | **Sampler: Hand Auger**
Initial GW Depth: 9 ft | **Final GW: Not Determined** | **Hole Elev: 8' MSL**

Description	USCS Class	Graphic Log	Depth	Water	Sample	Penetration	Remarks and Lab Tests
Organic SILT/root mat	OH		0				
Light brown, dry, soft SILT	ML						S-1 MC=15%
Mottled brown/grey/orange, moist to dry, medium stiff SILT WITH CLAY	CL-ML		2				S-2
Becomes grey with orange and brown mottles, moist							S-3 MC=52%
			4				S-4 P200=83% ATT: LL=44, PI=17
Grey, wet, soft SILT	ML		6				S-5 MC=44%
Becomes very soft			8				S-6
				▼			
			10				S-7 MC=45%
							S-8 MC=40% P200=45%
Grey, wet, medium dense to dense fine SAND WITH SILT and shell fragments	SM						S-9 MC=36%
Boring completed at depth of 11.5. Groundwater encountered at 9 feet deep: not equilibrated.			12				
			14				

Notes:

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APPENDIX B –

FIELD PHOTOGRAPHS

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Photo B-1

Photo B-2

Photo B-3

Photo B-4

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Photo B-5

Photo B-6

Photo B-7

Photo B-8

Photo B-9

Photo B-10

Photo B-11

Photo B-12

Photo B-13