Report of Geotechnical Engineering Services
Proposed Boat Ramp
Black River
The Chehalis Reservation, Washington

Prepared for
HDJ Design Group and
The Confederated Tribes of the Chehalis Reservation

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15949-02

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CONTENTS

1.0 INTRODUCTION 1

2.0 PURPOSE, SCOPE, AND USE OF THIS REPORT 1

3.0 SITE AND PROJECT DESCRIPTION 2

4.0 SUBSURFACE CONDITIONS 3

4.1 Geologic and Soil Mapping 3

4.2 Soil Conditions 4

4.3 Groundwater Conditions 4

5.0 CONCLUSIONS AND RECOMMENDATIONS 5

5.1 General 5

5.2 Earthworks Recommendations 6

5.3 Boat Ramp Recommendations 11

5.4 Parking Lot and Drive Surfacing Recommendations 14

6.0 CONSTRUCTION OBSERVATIONS 14

7.0 REFERENCES 15

FIGURES

1 Vicinity Map
2 Site Plan

APPENDIX A
FIELD EXPLORATIONS

APPENDIX B
LABORATORY TESTING
1.0 INTRODUCTION

Hart Crowser, Inc. (Hart Crowser) is pleased to submit to HDJ Design Group (HDJ) and the Confederated Tribes of the Chehalis Reservation (Tribe) our report of geotechnical engineering services for the proposed boat ramp and associated parking lot located on the Black River to the west of Howanut Road on the Chehalis Reservation in Grays Harbor, Washington. Our work was completed in general accordance with our scope and fee estimate dated August 6, 2013. Following this introduction, the report is organized as follows:

- Purpose, Scope, and Use of This Report,
- Site and Project Description,
- Subsurface Conditions,
- Conclusions and Recommendations,
- Construction Observations, and
- References.

Appendices A and B present our field exploration logs and laboratory test results, respectively.

2.0 PURPOSE, SCOPE, AND USE OF THIS REPORT

The purpose of our work is to evaluate subsurface conditions for the proposed development and to provide geotechnical engineering services for design of specific project elements. For this study, we present our findings, conclusions, and recommendations for:

- Subsurface Conditions,
- Earthworks Recommendations,
- Boat Ramp Recommendations, and
- Parking Lot and Drive Surfacing Recommendations.
Our complete scope of work was described in our fee and scope dated August 6, 2013, and is summarized below:

- Review readily available geologic and soil maps that cover the site vicinity;
- Conduct a limited subsurface exploratory program consisting of hand augers and drive probes;
- Perform limited laboratory testing on selected soil samples;
- Complete geotechnical engineering analysis;
- Prepare a draft geotechnical engineering report (dated November 8, 2013) for the project team’s review; and
- Prepare this final geotechnical engineering report.

We completed this work in accordance with generally accepted geotechnical engineering practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. We make no other warranty, express or implied.

3.0 SITE AND PROJECT DESCRIPTION

The project site is located approximately one quarter mile west of Howanut Road (Figure 1). The proposed launch area is located within an undeveloped grass-covered pasture extending south of a meander bend in the Black River, a tributary stream of the Chehalis River. The site is located approximately 1,000 feet east of the Chehalis River, though is nearly 0.9 “river” miles from the junction of the Black River and the Chehalis River.

The ground surface at the site is generally level to slightly undulating. The south bank of the Black River is incised 2 to 3 feet into the edge of the adjacent pastureland. Based on topographic survey prepared by HDJ (see Figure 2), the pasture in the immediate vicinity of the proposed ramp and parking lot has elevations ranging from 84 to 87 feet. The river bank in the same area is approximately 10 to 12 feet high with average inclinations of 45 degrees (1 horizontal to 1 vertical [1H:1V]). Survey measurements indicate the average thalweg elevation is approximately 72 to 73 feet; however, there is a depression in the river where the bottom elevation is approximately 67 to 68 feet. On the date of the survey (October 22, 2013) the water level in the river at the proposed boat ramp was 77.2 feet.
The site has been used as an informal boat launch by tribal members and includes several dirt tracks and a low gap in the bank of the Black River at the proposed boat ramp site. The informal launch down the bank is steep, with gradients between approximately 22 and 35 degrees.

We understand the proposed project includes construction of a boat ramp, parking stalls, a driveway, and an access road. (The Tribe is designing the access road, which is not a part of our work.) The boat ramp will consist of concrete slabs installed at a 12- to 15-percent gradient. The parking lot and drive will have gravel surfacing.

Based on existing site grades, we anticipate that overall site grading will be relatively minor, with mass cuts and fills less than approximately 2 feet. However, ramp construction will require deeper cuts (on the order of 5 feet) into the river bank and 3 to 4 feet of fill at its toe.

According to preliminary information provided by other design team members, the following river elevations (NAVD88) are relevant to the project site:

- Ordinary High Water Level: 82 feet
- Operational High Water Level: 83 feet
- Operational Low Water Level: 75.3 feet
- 100-year Flood Level: 93 feet

If these elevations are incorrect or are updated based on final analysis, we should be contacted to review our findings and recommendations.

4.0 SUBSURFACE CONDITIONS

Our understanding of the subsurface conditions is based on information obtained from our soil exploration and laboratory testing program, as well as a review of geologic and soil maps.

4.1 Geologic and Soil Mapping

The geology of the site is mapped in the Washington Department of Geology and Earth Resources (DGER) Geologic Map of the Chehalis River Quadrangle, Washington (Logan 1987). As mapped by Logan (1987), the site is mantled by young alluvium of the Chehalis River. The shallow soils encountered during our investigation correspond with the published mapping.
The soils at the site are mapped by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), and associated data are available on their website (NRCS 2013). The NRCS maps the site as being blanketed by Chehalis silt loam. This soil is well drained, with moderate high to high permeability (0.6 to 2 inches/hour).

4.2 Soil Conditions

Our field exploration program consisted of five hand augered borings (HA/DP-1 through HA/DP-5) at the project site in October 2013. Drive probe tests were performed throughout the depth of the each hand augered boring. Each boring was advanced 4 to 6 feet below ground surface (bgs). The exploration locations are shown on Figure 2. Appendix A summarizes our exploration methods and presents our exploration logs. Laboratory test results are provided on the exploration logs and described and summarized in Appendix B.

Our borings and observations indicated the site is mantled by silty very fine Sand alluvium to at least 6 feet bgs, the maximum depth explored. In general the alluvial deposits had low plasticity, but in the river the deposits had moderate to high plasticity. The alluvium was typically very loose to loose, with drive probe blow counts typically ranging from 3 to 21 blows per 6 inches, averaging 9 to 10 blows per 6 inches.

We note that zones of soft/very loose, surficial muck are likely to be present within the river.

Explorations for this study reveal subsurface conditions at discrete locations across the project site; actual conditions in other areas could vary. The nature and extent of any such variations would not become evident until additional explorations are performed or during construction. If variations are observed, we may need to modify our conclusions and recommendations to reflect actual site conditions.

4.3 Groundwater Conditions

Groundwater was encountered at depths ranging from 2.5 to 3 feet bgs in HA/DP-2, HA/DP-3, and HA/DP-4. These water levels correspond to elevations of 83, 82.5, and 81.5 feet, dropping down towards the river, whose water surface elevation was approximately 77 feet in October 2013.
HA/DP-1, drilled at the far eastern end of the site, did not encounter groundwater during drilling. HA/DP-5 was drilled within the open waters of Black Creek. Given the flat nature of the site and its overall position on the Chehalis River floodplain, we anticipate that the seasonal high groundwater level may saturate the entire site soil between the ground surface and permanent groundwater table during the wet months of the year.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 General

This section of the report presents our geotechnical engineering conclusions and recommendations for the design and construction of the proposed improvements.

Based on our explorations, testing, and analyses, it is our opinion that the site is suitable for the proposed use, provided the recommendations in this report are included in design and construction. We have developed these recommendations based on the typical soil characteristics observed at the site and our understanding of the project. If the nature or location of the development is different than we have assumed, Hart Crowser should be notified so we can confirm or modify our recommendations.

Based on our investigation, we offer the following general summary of our conclusions:

- Due to the very loose to loose nature of the site soils, careful preparation of the boat ramp and parking lot subgrade will be required.

- Installation of the ramp will require “in water” cutting and filling for subgrade preparation. The use of a coffer dam or below water earthwork construction techniques may be employed, depending upon the contractor’s preference and permitting requirements. The different construction methodologies will require different subgrade preparation requirements, as discussed below.

- In the upland area, shallow groundwater can be expected at all times of the year. During the rainy season, it is likely that groundwater will be located at or near the ground surface. As a result of the shallow groundwater:
  
  - Permanent cuts into the river bank for the ramp should be laid back as flat as reasonable.
- Gravel-stabilized ditches/shoulders should be installed adjacent to the ramp to collect groundwater seepage and surface runoff.

- A layer of separation/drainage geotextile should be placed below the crushed rock subgrade materials.

  - The site soils are moisture sensitive and easily disturbed by construction activities when moist. The contractor should make efforts to reduce subgrade disturbance. This would include performing excavations using equipment that needs to work on top of the excavated subsurface, such as a long-reach tracked excavator.

### 5.2 Earthworks Recommendations

#### 5.2.1 General

Based on available information, we estimate mass grading for the site will include cuts and fills on the order of 2 feet deep/thick, though deeper excavations (on the order of 5 feet) and fills (on the order to 3 to 4 feet) will be required where the boat ramp cuts through the river bank and extends into the river.

All earthwork activities should be conducted in accordance with Washington State Department of Transportation’s (WSDOT) *Standard Specifications for Road, Bridge, and Municipal Construction* [WSS] (WSDOT 2012).

#### 5.2.2 Stripping

In upland areas, the existing surficial root zone should be stripped in all fill and pavement areas and for a 3-foot margin around such areas. We anticipate an average stripping depth of 4 to 6 inches. The actual stripping depth should be based on field observations at the time of construction.

In the river and on the river bank, existing vegetation and soft muck should be removed from the boat ramp alignment. We anticipate muck up to 12 inches may be present. Where work is completed in the dry (e.g., within a coffer dam), the actual depth of muck removal should be based on field observations at the time of construction.

Stripped material and muck should be transported off site for disposal or spread in an area designated by the Tribe.
5.2.3 Subgrade Preparation and Evaluation

Following stripping and prior to the placement of fills or improvements, the suitability of the subgrade should be evaluated by proofrolling with a fully loaded dump truck or similar heavy rubber-tired construction equipment to identify any remaining soft, loose, or unsuitable areas. Within coffer dams (if used) and in upland areas during wet weather, or when the exposed subgrade is wet or unsuitable for proofrolling, the prepared subgrade should be evaluated by observing excavation activity and probing with a steel foundation probe.

Where in water excavation work (e.g., no coffer dam) is completed and direct observation of the subgrade is not possible, the contractor shall use GPS-equipped excavation equipment, or similar methodologies to verify subgrade elevations.

A representative of Hart Crowser should evaluate the suitability of the subgrade via one of the above methods and identify areas indicative of soft or loose soil. If soft or loose zones are identified, these areas should be excavated to the extent indicated by Hart Crowser and replaced with structural fill.

We note that the near-surface upland site soils are moist, loose, silty, very fine sands that may be easily disturbed (e.g., pump and rut) by construction traffic. Therefore, the contractor shall assume that if not carefully executed, site preparation and excavation can create soft areas that are not suitable to support site improvements, and significant repair costs can result. Earthwork planning should include considerations for minimizing subgrade disturbance.

5.2.4 Excavation

Site soils generally consist of very loose to loose, silty, very fine sand within expected excavation depths. It is our opinion that conventional earthmoving equipment in proper working condition should be capable of making necessary excavations for the projects. The earthwork contractor should be responsible for providing equipment and following procedures, as needed, to excavate the site soils and to reduce subgrade disturbance during excavation.

Due to the presence of shallow groundwater and sandy soils, we anticipate that temporary vertical excavations will be subject to running and sloughing. Furthermore, excavations made underwater will not stand vertically. We anticipate that underwater excavation sidewalls will slough and run. Therefore, we recommend that both sides of underwater excavations be extended 2 feet or a distance equal to the excavation height, whichever is greater, beyond the desired excavation limits.
All above water excavations should be cut back or shored. Excavations should be made in accordance with applicable Occupational Safety and Health Administration (OSHA) and state regulations. Site soils are generally OSHA Type C.

5.2.5 Permanent Slopes

Permanent side-slope cuts into the river bank for the ramp should be laid back as flat as reasonable. We recommend maximum gradients of 25 percent (14 degrees) for non-stabilized slopes. If the slopes are covered with an 8- to 12-inch layer of stabilization rock (as specified below), they can have maximum gradients of 33 percent (18 degrees). If slopes are covered with a layer of scour protection rock (as specified below), then they can have a maximum gradient of 50 percent (26.6 degrees).

5.2.6 Dewatering

5.2.6.1 Upland Areas

At the time of our explorations, groundwater was approximately 2.5 to 3 feet below existing grades. We anticipate that groundwater may reach the ground surface during the winter and spring months. If upland excavations will extend below the groundwater table, the contractor should provide appropriate dewatering and stabilization measures, such as diversion ditches, sumps, stabilization rock, or similar measures.

Additionally, the contractor should be made responsible for temporary drainage of surface water to prevent standing water and/or erosion at the working surface.

5.2.6.2 In-Water Areas

The proposed grading for the boat ramp will require in-water excavation and filling work. A dewatered coffer dam may be used to perform ramp construction activities “in the dry,” or underwater earthwork methods may be used. If a coffer dam is installed, it may be constructed with sheet piles, sand bags, or other methods. Dewatering will likely require continual pumping with sump pumps to remove seepage water from the coffer dam. A wide variety of coffer dam and dewatering systems are available; consequently, we recommend that the contractor be responsible for selecting the appropriate system.
5.2.7 Structural Fills and Backfills

Fills should only be placed over a subgrade that has been prepared in conformance with the prior sections of this report. A variety of material may be used as structural fill at the site. However, all material used as structural fill should be free of organic matter or other unsuitable materials and should meet specifications provided in the WSS (WSDOT 2012). A brief characterization of some of the acceptable materials and our recommendations for their use as structural fill are provided below. For underwater fill placement stabilization, rock or scour protection rock (as characterized below) should be used.

Fills placed in upland areas and “in the dry” within a dewatered cofferdam should be placed at moisture contents within approximately 3 percent of optimum, as determined in accordance with ASTM International (ASTM) D 1557. The first 12 inches of soil fill and aggregate with less than 30 percent retained on the 3/4-inch sieve should be compacted to a firm and unyielding condition, and to a minimum of 90 percent of the fill’s maximum dry density (MDD), as determined by ASTM D 1557. After the lowest 12 inches, fills should be compacted to a minimum of 95 percent of the fill’s MDD, as determined by ASTM D 1557. During structural fill placement and compaction, a sufficient number of in-place density tests should be completed by Hart Crowser to verify that the specified degree of compaction is being achieved.

Aggregate materials with greater than 30 percent retained on the 3/4-inch sieve shall be compacted to a well-keyed and unyielding condition. Approval of the compactive effort should be based on observations of a proofroll or the contractor’s “means and methods” for compaction. Acceptable “means and methods” will generally involve the contractor matching appropriate lift thickness to the material and equipment being used for compaction.

5.2.7.1 On-Site Soils

On-site, near-surface soils that might be excavated and then used for on-site fill generally consist of moisture-sensitive silty very fine sand. This material may be used as structural fill if properly moisture conditioned; free of debris, organic materials, and particles over 6 inches in diameter; and meets the specifications provided in WSS 9-03.14(3) – Common Borrow. We note that the in situ moisture content of the on-site soil is higher than optimum, and will likely require mechanical aeration to dry it prior to use.
5.2.7.2 Imported Select Structural Fill

Imported granular material used as general structural fill should be pit or quarry run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in WSS 9-03.9(1) – Ballast, WSS 9-03.14(1) – Gravel Borrow, or WSS 9-03.14(2) – Select Borrow. 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.

5.2.7.3 Aggregate Base

Imported granular material used as aggregate base (base rock) for beneath the boat ramp and parking lot surfacing should be clean, crushed rock or crushed gravel and sand that is fairly well graded between coarse and fine. The base aggregate should meet the specifications provided in WSS 9-03.9 – Aggregates for Ballast and Crushed Surfacing, depending upon application, with the exception that the aggregate have less than 5 percent by dry weight passing a U.S. Standard No. 200 Sieve and have at least two mechanically fractured faces. The aggregate base should have a nominal particle size 1.5 inches. Alternatively, WSS 9-03.9(2) - Permeable Ballast may be used.

The aggregate base rock should be underlain by in a geotextile that meets the specifications provided in Table 3 of WSS 9-33.2 for soil separation or stabilization. The geotextile should be installed in conformance with the specifications provided in WSS 2 12 – Construction Geosynthetic.

5.2.7.4 Stabilization / Underwater Fill Material

Aggregate used for underwater fill placement or to stabilize subgrades, should consist of a clean, angular, crushed rock, such as ballast or quarry spalls. The material should have a maximum particle size of 4 inches, a nominal size between 2 and 4 inches, less than 5 percent by dry weight passing the U.S. Standard No. 4 Sieve, and at least two mechanically fractured faces. The material should be free of organic matter and other deleterious material. Material meeting the gradations of WSS 9-03.9(2) – Permeable Ballast, WSS 9-03.12(5) – Gravel Backfill for Drywells, or WSS 9-13.6 – Quarry Spalls is generally acceptable for use.

Where stabilization rock is installed above the water table, it should be underlain by a geotextile that meets the specifications provided in Table 3 of WSS 9-33.2 for soil stabilization. The geotextile should be installed in conformance with the specifications provided in WSS 2 12 – Construction Geosynthetic.
If the stabilization material will be placed below the water level, it should meet the specifications of WSS 9-13.6 – Quarry Spalls, WSS 9-03.9(2) – Permeable Ballast, or WSS 9-13.1(2) – Light Loose Riprap. If used, quarry spalls or riprap should be choked with material meeting the specifications of WSS 9-03.12(1) – Gravel Backfill for Foundations (Class A or B) or WSS 9-03.9(2) – Permeable Ballast to separate them from other aggregates which may be placed above the water level. Alternately, construction geosynthetic for soil stabilization (per Table 3 of WSS 9-33.2) may be used to prevent migration of the finer borrow into the voids spaces of the coarser underlying material.

5.2.7.5 Scour Protection Rock

Rock used for underwater slope or scour stabilization should consist of clean, angular, cobble- and boulder-sized rock meeting the specifications of WSS 9-03.4 – Rock for Erosion and Scour Protection. Class A or B rock may be used.

5.3 Boat Ramp Recommendations

5.3.1 General

In this section, we provide design recommendations and construction guidelines for the proposed boat ramp slab. If the boat ramp subgrade is prepared in the dry (e.g., upland areas or in-water areas with a dewatered coffer dam), then pre-cast or cast-in-place ramp panels may be used. However, if the ramp subgrade is prepared in the wet (e.g., below the water level), then pre-cast panels will be required and can be installed via “push slab” methodologies.

5.3.2 Subgrade

The boat ramp soil subgrade should be prepared in accordance with Section 5.2.3 - Subgrade Preparation and Evaluation. Subgrade preparation requirements vary for work completed in the dry (e.g., in a dewatered coffer dam, or above the water level) or below water level:

5.3.2.1 Upland / In the Dry Subgrades

Following subgrade preparation and evaluation, the subgrade shall be lined with a separation geotextile and then an 18-inch-thick layer of stabilization material should be installed. If desired, the upper 6 inches of this layer may consist of smaller aggregate base materials to allow for a more uniform surface onto which the slabs can be cast/placed. The stabilization material should be compacted to a firm and unyielding condition.

If soft or pumping conditions are noted at the soil subgrade elevation, then additional thicknesses of stabilization material may be required.
5.3.2.2 **Below Water Level Subgrades**

Due to the inability to directly observe the prepared subgrade below the water level and the difficulty with properly installing a separation geotextile, we recommend that the subgrade aggregate thickness be increased to 30 inches of stabilization material for below water subgrades. The first 12- to 18-inch lift of stabilization material should be placed in a top-down method; meaning that the installation shall start at the river bank water line and work out into the river. This will help to push muck and suspended sediment down away from the subgrade, and reduce pockets of trapped material. This first lift of stabilization material should be tamped with the excavator bucket to embed it into subgrade. The stabilization material should then be placed and tamped in 12-inch lifts to finished subgrade elevation.

The contractor should assume that stabilization material will be pushed into the underlying subgrade; therefore, greater volumes of material will likely be required than the 30-inch dimension would imply. In order to reduce this potential, the contractor may install a separation geotextile beneath the first lift of stabilization material.

We recommend that that vertical transition between the “below water” and “upland/in the dry” subgrade materials occur uniformly over a minimum 15-foot-long zone.

5.3.3 **Slab**

The concrete slab should have a minimum thickness of 6 inches. The concrete should meet the specifications provided in WSS 5 05 – Cement Concrete Pavement, and have a minimum compressive strength of 4,000 pounds per square inch (psi) with a nominal maximum aggregate size of 1.5 inches.

Typical boat ramp standards indicate that the slabs should be reinforced with #4 bars at 12 inches on center longitudinally, and 18 inches on center transversely. We recommend the reinforcing bars be epoxy coated to reduce corrosion potential.

If the slab is installed using push slab methodologies, we recommend the leading edge of the slab should have a slanted bottom (i.e., Jon-boat type bow) to reduce resistance during pushing.
5.3.4 **Shoulder Drains**

Due to the presence of shallow groundwater, which may result in seepage and erosion in cut slopes, we recommend that gravel drains be incorporated into the shoulders of the boat ramp. The drains should consist of minimum 2-foot wide ditches that extend at least 6 inches below the base of the “in the dry” gravel subgrade for the ramp. The ditches should be lined with a separation or drainage geotextile. The geotextile used for the slab subgrade can be extended across the ditch, or a separate geotextile may be used. The “ditches” can be filled with ballast to level with the shoulder elevation; effectively this creates a gravel-filled ditch that allows for collection and transport of groundwater seepage to the river, but reduces the potential for trailers getting stuck in an open ditch.

5.3.5 **Push Slab Considerations**

As noted previously, “push slab” construction methodology may be used to install the boat ramp slabs.

Push slabs should be formed and poured on dry land over a thin layer of sand or pea gravel. If the aggregate base for the upland portion of the slab is already in place, then a layer of visqueen should separate the sand and underlying aggregate base. The slope of the poured slab should be as close to the desired slope as possible. After the concrete has cured, the slab should be pushed into place with a bulldozer or excavator. A timber beam should be bolted in place to the pushing edge of the slab to protect the edge of the slab. The pushing shall be accomplished with the dozer/excavator blade square to the pushing edge with the blade edge centered on the timber. Timber shims shall be used to provide full bearing. When pushing commences, the blade hydraulics shall be in the “float” position to prevent accidental lifting/torqueing of the slab.

The upper 4 to 6 inches of aggregate base used to prepare the push slab subgrade may need to consist of smaller diameter clean crushed rock (e.g., AASHTO No. 57 rock) to facilitate sliding over the stabilization material.

5.3.6 **Scour**

Coast and Harbor Engineering is conducting the scour analysis for the project. The soils in the river bottom consist of silty fine sand are susceptible to scour and have a $D_{50}$ size of approximately 0.1 millimeters, which can be used in the scour analysis.
5.4 Parking Lot and Drive Surfacing Recommendations

We understand that a gravel surface is desired by the Tribe for the parking lot and drive aisle. The soil subgrade should be prepared in accordance with Section 5.2.3 - Subgrade Preparation and Evaluation. Following subgrade preparation and evaluation, the subgrade shall be lined with a separation geotextile.

The gravel surfacing should consist of 6 inches of aggregate base per Section 5.2.7.3 - Aggregate Base over 10 inches of select structural fill per Section 5.2.7.2 - Imported Select Structural Fill. Alternatively, 14 inches of aggregate base per Section 5.2.7.3 - Aggregate Base may be used.

6.0 CONSTRUCTION OBSERVATIONS

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

We recommend that Hart Crowser 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 project plans and specifications relating to earthwork and the ramp are being met. In particular, we recommend that site stripping, subgrade preparation, fill compaction, and cofferdam installation (if used) be observed by Hart Crowser. Compaction of all structural fill and aggregate should be tested to confirm that the specified compaction is met. Pavement subgrades should be observed and tested for compaction.
7.0 REFERENCES


Figure

Black River Boat Ramp
Chehalis Reservation, Washington

Vicinity Map

15949-02 11/13
HA/DP-1  Hand Auger/Drive Probe
Location and Number

HA/DP-2  (3')
HA/DP-3  (3')
HA/DP-4  (2.5')
HA/DP-5  (0')

HA/DP-1  (>4.5')

Hand Auger/Drive Probe Location and Number

(3') Depth to Groundwater

Source: Site survey by HDJ Design Group.

Black River Boat Ramp
Chehalis Reservation, Washington

Site Plan

Figure 2
APPENDIX A
FIELD EXPLORATIONS
APPENDIX A
FIELD EXPLORATIONS

General

We evaluated subsurface soil and groundwater conditions at the site by advancing five hand augered borings and drive-probe soundings in October 2013. The locations of the explorations are shown on Figure 2. The exploration locations were approximately located by comparison of locations with features on an aerial photograph and pacing from existing mapped features. Exploration locations should be considered accurate only to the degree implied by the methods used.

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 boring. The drive probe soundings were performed in general accordance with the methods described in Williamson (1994). Exploration logs are included in this appendix. Results of the laboratory testing are indicated on the exploration logs and are included in Appendix B.

Soil Sampling and Classification

Soil cuttings were sampled and classified in the field in general accordance with ASTM Standard Practice D 2488 “Standard Practice for the Classification of Soils (Visual-Manual Procedure).” Soil classifications and sampling intervals are shown in the exploration logs in this appendix.
### Soil Classification Chart

<table>
<thead>
<tr>
<th>Material Types</th>
<th>Major Divisions</th>
<th>Group Symbol</th>
<th>Soil Group Names &amp; Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Gravels</td>
<td>&gt;50% of coarse fraction retained on No. 4 sieve</td>
<td>GW</td>
<td>Well-graded Gravel</td>
</tr>
<tr>
<td>Clean Sands</td>
<td>&gt;50% of coarse fraction passes on No. 4 sieve</td>
<td>SW</td>
<td>Well-graded Sand</td>
</tr>
<tr>
<td>Inorganic Silts</td>
<td>Liquid limit ≤ 50</td>
<td>CL</td>
<td>Lean Clay</td>
</tr>
<tr>
<td>Inorganic Silts</td>
<td>Liquid limit &gt; 50</td>
<td>CH</td>
<td>Fat Clay</td>
</tr>
<tr>
<td>Organic Silts</td>
<td>Liquid limit ≤ 50</td>
<td>OL</td>
<td>Organic Clay or Silt</td>
</tr>
<tr>
<td>Organic Gravels</td>
<td>&gt;50% of coarse fraction retained on No. 200 sieve</td>
<td>GP</td>
<td>Poorly-graded Gravel</td>
</tr>
<tr>
<td>Organic Sands</td>
<td>&gt;50% of coarse fraction retained on No. 200 sieve</td>
<td>SP</td>
<td>Poorly-graded Sand</td>
</tr>
<tr>
<td>Organic Gravels</td>
<td>&gt;50% of coarse fraction retained on No. 200 sieve</td>
<td>GM</td>
<td>Clayey Gravel</td>
</tr>
<tr>
<td>Organic Gravels</td>
<td>&gt;50% of coarse fraction retained on No. 200 sieve</td>
<td>GC</td>
<td>Clayey Gravel</td>
</tr>
<tr>
<td>Organic Sands</td>
<td>&gt;50% of coarse fraction retained on No. 200 sieve</td>
<td>SM</td>
<td>Silty Sand</td>
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<tr>
<td>Organic Gravels</td>
<td>&gt;50% of coarse fraction retained on No. 200 sieve</td>
<td>SC</td>
<td>Clayey Sand</td>
</tr>
</tbody>
</table>

### Notes:
- Multiple symbols are used to indicate borderline or dual classifications.
- 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
  - 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

### Laboratory/Field Tests
- AT: Atterberg Limits
- CP: Laboratory Compaction Test
- CA: Chemical Analysis (Corrosivity)
- CN: Consolidation
- DD: Density
- DS: Direct Shear
- HA: Hydrometer Analysis
- OC: Organic Content
- PP: 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.
- When the Dames & Moore (D&M) sampler was driven with a 140-pound hammer (denoted on logs as D+M 140), the field blow counts (N-value) shown on the logs have been reduced by 50% to approximate SPT N-values.
- 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 conditions at other locations or times.
(SM) Loose, moist, brown SILTY very fine SAND, very low plasticity, trace fine sand, roots to 4" [Alluvium]

grades to very loose

grades to loose

Hand auger completed at 4' 6"
No groundwater encountered

Drive probe completed at 5'
(SM) Loose, moist to wet, brown SILTY very fine SAND, low plasticity, trace fine sand, roots to 4” [Alluvium]

grades to very loose, low plasticity to nonplastic

grades to wet, nonplastic

Hand auger completed at 4’ 6”
Groundwater at 3’ while drilling

Drive probe completed at 5’
**Client:** HDJ Design Group  
**Project Name:** Black River Boat Ramp  
**Project Number:** 15949-02  
**Project Location:** Howanut Road, Oakville, WA  
**Date Started:** 10/1/2013  
**Completed:** 10/1/2013  
**Ground Elevation:** 85.5 ft MSL  
**Hole Size:** 2.75"  

**Drilling Method:** Soil hand auger/drive probe  
**Logged By:** J. Lawes  
**Checked By:** D. Trisler  
**Drilling Contractor:** ---  
**Logging By:** ---  
**Drilling Method:** ---  

**Ground Water Levels:**  
- **AT TIME OF DRILLING:** 3.00 ft / Elev 82.50 ft  
- **AT END OF DRILLING:** ---  
- **AFTER DRILLING:** ---  

**Material Description:**  
- **SM** Loose, moist to wet, brown SILTY very fine SAND, low plasticity, roots to 4" [Alluvium]  
- Grades to very loose, wet, nonplastic  
- Grades to loose  
- Hand auger completed at 4' 6"  
  Groundwater at 3' while drilling

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Graphic Log</th>
<th>Material Description</th>
<th>Sample Type Number</th>
<th>Recovery %</th>
<th>Drive Probe Blowsig</th>
<th>Pocket Pen (in)</th>
<th>Dry Unit wt (pcf)</th>
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</thead>
<tbody>
<tr>
<td>0.0</td>
<td></td>
<td>(SM) Loose, moist to wet, brown SILTY very fine SAND, low plasticity, roots to 4&quot; [Alluvium]</td>
<td>GRAB 1</td>
<td>100</td>
<td>11</td>
<td>3</td>
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<tr>
<td>2.5</td>
<td></td>
<td>Grades to very loose, wet, nonplastic</td>
<td>GRAB 2</td>
<td>100</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
| 5.0       |             | Hand auger completed at 4' 6"  
Groundwater at 3' while drilling | | | | |

**Drive Probe Completed at 6'**
Hand auger and drive probe completed at 5’
Groundwater at 2’ 6”
River level - Black River

(SM) Loose, wet, mottled gray and red-brown SILTY to CLAYEY very fine SAND, low plasticity, grass and roots to 2" [Alluvium]

grades to very loose
Hand Auger completed at 6' (1' below mudline)

grades to loose

Drive probe completed at 9' (4' below mudline)
APPENDIX B
LABORATORY TESTING
APPENDIX B
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 International (ASTM) or other applicable procedures. A summary of the test results is included as Figure B-1.

Visual Classifications

Soil samples obtained from the explorations were visually classified in the field and in our geotechnical laboratory based on the Unified Soil Classification System (USCS) and ASTM classification methods. ASTM Test Method D 2488 was used to classify soils using visual and manual methods. ASTM Test Method D 2487 was used to classify soils based on laboratory test results.

Laboratory Test Results

Moisture Content

Moisture contents of samples were obtained in general accordance with ASTM Test Method D 2216. The results of the moisture content tests are presented on the boring logs in Appendix A and on Figure B-1 in this appendix.

Fines Determination

We determined the percentage of fines (material smaller than the No. 200 mesh sieve) on two samples. The tests were performed in general accordance with ASTM D 1140. The results are presented on the boring logs in Appendix A.

Atterberg Limits

Atterberg limits (liquid limit, plastic limit and plasticity index) of two fine-grained soil samples were obtained in general accordance with ASTM Test Method D 4318. The results of the Atterberg limits tests are presented on the exploration logs included in Appendix A and on Figure B-2 in this appendix.
<table>
<thead>
<tr>
<th>Borehole</th>
<th>Depth</th>
<th>Liquid Limit</th>
<th>Plastic Limit</th>
<th>Plasticity Index</th>
<th>Maximum Size (mm)</th>
<th>%&lt;#200 Sieve</th>
<th>Classification</th>
<th>Water Content (%)</th>
<th>Dry Density (pcf)</th>
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</thead>
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<tr>
<td>HA/DP-1</td>
<td>1.0</td>
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<td></td>
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<tr>
<td>HA/DP-1</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>HA/DP-1</td>
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<tr>
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<td>45</td>
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<td>13</td>
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<tr>
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<td>51.0</td>
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</table>
ATTERBERG LIMITS' RESULTS

CLIENT: HDJ Design Group
PROJECT NUMBER: 15949-02
PROJECT NAME: Black River Boat Ramp
PROJECT LOCATION: Howanut Road, Oakville, WA

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BOREHOLE DEPTH LL PL PI Fines Classification

- HA/DP-3 1.0 45 32 13 43 SILTY SAND(SM)
- HA/DP-5 5.0 75 36 39 24 SILTY SAND(SM)

FIGURE B-2