Oregon Manufacturing Innovation Center –
Research and Development
3701 Charles T. Parker Way
Scappoose, Oregon 97056

Prepared for

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PSI Project No. 07041279

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1 PROJECT INFORMATION

1.1 PROJECT AUTHORIZATION

This report presents the results of PSI's geotechnical investigation performed for the addition to the Oregon Manufacturing Innovation Center – Research and Development (OMIC R&D) in Scappoose, Oregon. The project is located southeast of the existing OMIC facility at 3701 Charles T. Parker Way in Scappoose. A Vicinity Map of the site location is presented on Figure 1. This investigation was performed for Mr. Craig Campbell in general accordance with PSI proposal number 0704-290441 and Oregon Institute of Technology Service Contract #727824.

1.2 PROJECT DESCRIPTION

Project information was provided by Mr. Craig Campbell and Leticia Hill of Oregon Institute and Technology. The provided information included:

- A request for quotation (RFQ), entitled "RFQ-#2019-45", and
- Exhibit A: Site Plan by Akaan Architecture and Design, LLC, dated August 1, 2019
- Attachments including a preliminary floor layout of the building created in Autocad, a spreadsheet with proposed equipment dimensions and loads, and drawings for a proposed internal 10 ton crane created by R&M Materials Handling,
- Structural drawings for the existing metal frame building owned by OMIC located Northwest of the proposed building created by Metallic Building Company, (date unavailable, does not include foundation drawings)
- Structural Design Calculations for the existing metal frame building performed by Metallic Building Company, (dated 2007)

Based on the provided information the proposed construction consists of a 35,000 square foot metal frame building at the Oregon Manufacturing Innovation Center Research and Development site. The building will consist of an 80 feet x 250 feet shop area on the east side of the building, and a 60 feet x 250 feet office area on the west side of the building. The site is approximately 9½ acres and the proposed building will be located in the southeast corner. Proposed parking spaces and drive lanes are located to the north and west of the proposed building. Secondary expansions will be located on the northeast and southwest corners of the site. Geotechnical investigations for these additional structures where beyond the scope of this report.

Based on the provided drawings of the existing metal frame building and email correspondence with Mr. Joshua Koch and Mr. Craig Campbell with OMIC on January 6, 2020, PSI understands that the shop area will be a clear span tapered column design(spanned 80 feet across the shop area), with longitudinal (N-S) columns spaced at approximately 20 feet. Based on the provided structural drawings for the existing building PSI anticipates that the metal frame will be supported by perimeter footings spaced at approximately 20 feet.

Based on the provided preliminary floor plan and proposed equipment loads and dimension PSI understands that various manufacturing equipment and machinery is being considered, including a floor mounted 400T Hydraulic Tryout Press, with a 10,000 psf to 15,000 psf floor slab load.

Additionally, a 10-Ton load capable indoor use gantry crane is proposed in the shop area. Based on the provided drawings, the crane hoist will be supported by a track spanning laterally across the 80 feet shop area, supported on beams longitudinally across the 250 feet shop area.

Based on the provided structural calculations for the existing, PSI anticipates maximum column loads on the order of 55 kips for the proposed structure. In addition, PSI anticipates transient loads on the order of 20 kips (maximum) from the gantry crane, based on the columns also supporting the gantry crane beams.

In addition to the Gantry Crane and Hydraulic Tryout Press mentioned above, PSI understands additional equipment is being considered. Where applicable, PSI has estimated the approximate floor slab loads for additional equipment based on the dimensions and anticipated loads provided in the provided spreadsheet:

Equipment	Area (ft^2)	Weight (lbs)	Anticipated Floor Stress (psf)
3DPM (Arc Welding Machine)	427	35273	83
Hybrid SLM or Laser Deposition Welding	287	28670	100
Fused Deposition Modeling (FDM)	50	6330	127
Binder Jetting, Single Pass Jetting (Printer)	8	214	27
Binder Jetting, Single Pass Jetting (Debinder)	8	330	41
Binder Jetting, Single Pass Jetting (Furnace)	24	1760	73
Metal FDM (Metal X)	3	160	53
Metal FDM (Sinter-2)	8	772	97
Metal FDM (Wash-2)	5	300	60
Selective Laser Melting (SLM)	156	6800	44
LENS Directed Energy Deposition (DED)	92	6600	72
Multi Jet Fusion printer	148	1653	11
Multi Jet Fusion processing unit	84	1786	21
DMLS	420	10218	24
DMP(SLM)	57	11000	193
Milling Machine (large)	137	6200	45
Milling Machine (small)	91	4500	49
Wire EDM	139	7700	55
Electrode EDM	66	11904	180
Injection Molding Machine	466	50000-100000	107 - 214
Blow Molding Machine	933	150000-200000	161 - 214
400T Hydraulic tryout Press (floor mtd)			10,000 - 15,000*
Vacuum forming machine	134	4000	30

*provided in spreadsheet, independently of area and weight

Should any of the above information or design basis made by PSI be inconsistent with the planned construction, it is requested that you contact us immediately to allow us to make any necessary modifications to this report. PSI will not be held responsible for changes to the project if not provided the opportunity to review the information and provide modifications to our recommendations.

1.3 PURPOSE AND SCOPE-OF-SERVICES

Based on correspondence with Mr. Craig Campbell and Leticia Hill, and PSI Proposal # 0704-290441, the purpose of this exploration was to evaluate and understand the subsurface geologic conditions at the site and to develop geotechnical foundation design criteria for support of the proposed building. The scope of the exploration included:

a) Reconnaissance of the project site;

b) Drill four borings to sixty or eighty feet deep or to ten (10) feet into native soil;

c) Maintain continuous logs of the explorations, collect samples at representative intervals, and observe groundwater conditions;

d) Perform laboratory testing,

e) Prepare a geotechnical engineering report that presents the following:

   a. Soil and groundwater conditions;

   b. Surcharge recommendations;

   c. Foundation recommendations for shallow spread footings, including allowable bearing capacity, lateral resistance parameters, and total and differential settlement;

   d. Deep foundation recommendations;

   e. Seismic design criteria, in accordance with the 2015 International Building Code including a seismic site class in accordance with ASCE 7-16, effective peak acceleration,

   f. Site preparations and grading recommendations, including over-excavation, general and temporary excavations, temporary and permanent slopes, fill placement and compaction criterial, suitability of on-site soil for fill, subgrade preparations for buildings and pavement, and wet weather earthwork procedures;

   g. Discuss groundwater conditions including recommendations for dewatering during construction and subsurface draining;

   h. Floor slab recommendations;

   i. Trench backfill recommendations;

   j. Pavement design recommendations

PSI did not provide services to investigate or detect the presence of moisture, mold or other biological contaminates in or around any structure, or any service that was designed or intended to prevent or lower the risk of the occurrence of the amplification of the same. The client acknowledges that mold is ubiquitous to the environment with mold amplification occurring when building materials are impacted by moisture. The client further acknowledges that site conditions are outside of PSI's control, and that mold amplification will likely occur, or continue to occur, in the presence of moisture. As such, PSI cannot and shall not be held responsible for the occurrence or recurrence of mold amplification.

1.4 FIELD EXPLORATION PROGRAM

PSI completed our field exploration of the project site on November 21 and 22, 2019. A site vicinity map is shown in Figure 1. The scope of the exploration included 4 hollow stem augers drilled to a depth of approximately 50 to 65 feet below the existing ground surface (bgs). The locations of the borings are shown in Figure 2, as coordinated with Mr. Campbell.

A representative from PSI's office observed the drilling and prepared borings logs of the conditions encountered. Individual logs of the borings are presented in Appendix A. It should be noted that the subsurface conditions presented on the boring logs are representative of the conditions at the specific locations drilled. Variations may occur and should be expected across the site. The soil morphology represents the approximate boundary between subsurface materials and the transitions may be gradual and indistinct. Water level information, if encountered, obtained during our field operations is also shown on the boring logs. Elevations referenced were obtained via Google Earth and should be considered approximations.

Sampling Procedures

Throughout the drilling operation, soil samples were obtained from the borings using a 2-inch outside-diameter Split Barrel Sampler in general conformance with the ASTM D1586 Test Methods. The samplers were driven into the soil 18 inches, or to refusal, with a 140-pound hammer free falling a distance of 30 inches. The blow counts required to drive the sampler in three consecutive 6-inch increments were recorded and are summarized on the boring logs contained in Appendix A, Boring Logs, General Notes, and Soil Classification Chart. The number of blows required to penetrate the last 12 inches is designated as the blow count, N.

Field Classification

Soil samples were initially classified visually in the field. Consistency, color, relative moisture, degree of plasticity, peculiar odors, and other distinguishing characteristics of the soil samples were noted. The terminology used in the soil classifications and other modifiers are depicted in the General Notes and Soil Classification Chart in Appendix A.

1.5 LABORATORY TESTING PROGRAM AND PROCEDURES

Soil samples obtained during the field explorations were examined in our laboratory. The physical characteristics of the samples were noted, and the field classifications were modified, where necessary. Representative samples were selected during the course of the examination for further testing. The laboratory test procedures are summarized below, and test data is provided on the boring logs in Appendix A and in the lab test data in Appendix B.

Moisture Content

Natural moisture content determinations were made on selected soil samples. The natural moisture content is defined as the ratio of the weight of water to the dry weight of soil, expressed as a percentage.

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Natural moisture content determinations were made on selected soil samples. The natural moisture content is defined as the ratio of the weight of water to the dry weight of soil, expressed as a percentage.

Visual-Manual Classification

The soil samples were classified in general accordance with guidelines presented in ASTM D2488. Certain terminology incorporating current local engineering practice, as provided in the Soil Classification Chart, included with, or in lieu of, ASTM terminology. The term which best described the major portion of the sample was used in determining the soil type (i.e., gravel, sand, silt or clay).

Sieve Analysis by Washing

The determination of the amount of material finer than the U.S. Standard No. 200 (75-µm) sieve was made on selected soil sample in general accordance with ASTM D1140. In general, the sample was dried in an oven and then washed with water over the No. 200 sieve. The mass retained on the No. 200 sieve was dried in an oven, and the dry weight recorded. Results from this test procedure assist in determining the fraction, by weight, of coarse-grained and fine-grained soils in the sample.

The determination of the gradation curve of the coarse-grained material was made on selected soil samples in general accordance with ASTM D422. In general, the oven dried mass retained on the No. 200 sieve is passed over progressively smaller sieve openings, by agitating the sieves by hand or by a mechanical apparatus. The mass retained on each sieve is recorded as a fraction of the total sample, including the percent passing the No. 200 sieve.

Atterberg Limits

The Atterberg Limits (ASTM D-4318) are defined by the liquid limit (LL) and plastic limit (PL) states of a given soil. These limits are used to determine the moisture content limits where the soil characteristics change from behaving more like a fluid on the liquid limit end to where the soil behaves more like individual soil particles on the plastic limit end. The plasticity index (PI) is the difference between the liquid limit and the plastic limit. The plasticity index is used in conjunction with the liquid limit to assess if the material will behave like a silt or clay.

2 SITE AND SUBSURFACE CONDITIONS

2.1 SITE DESCRIPTION

The proposed project site is located at 3701 Charles T. Parker Way in Scappoose, Oregon. The site currently contains an existing OMIC building in the western half of the lot. The site is bound by vacant fields and West Lane Road to the east. Ongoing quarry excavations and processing is located to the south and west, in addition to a prefabricated concrete pipe supplier to the west. Scappoose Creek is located approximately 150 feet north of the existing OMIC Facility. Limited parking areas are located surrounding the existing building.

Based on historical images in Google Earth, the location of the existing OMIC facility and proposed building was excavated as part of the quarry excavation, and contained standing water as recently as 2006. The site appears to be gradually infilled from approximately 1994 onward, and the existing OMIC facility and asphalt parking area was constructed sometime between 2006 and 2010. Grading and operations associated with the quarry appear to have occurred on the lot east to the OMIC facility as recently as 2016.

2.2 TOPOGRAPHY

Based on the available topographic information on Google Earth and observations during our site investigation, the current elevation of the project site is relatively flat in the area of proposed construction with elevations varying between approximately 34 to 36 feet, mean sea level (msl).

2.3 GEOLOGY

Based on a review of available geologic information published by the United States Geological Survey (USGS), the site is underlain by Quaternary aged Conglomerate (QTc), described as semi-consolidated pebbles and cobbles with minor lenses of basaltic and quartz sand. Locally, a gravel pit is identified by the geologic map, consistent with our site observations.

Based on a review of recently publicly available nearby well and geotechnical logs available in the Oregon Water Resources Department Well Log Database, locally, up to sixty feet of "Pit Fill" is identified, composed of silt, clay, sand, gravel and debris. Underlain by native clay, sand and gravel.

2.3.1 LOCAL FAULTING AND SEISMIC DESIGN PARAMETERS

PSI has reviewed the USGS Quaternary Fault and Fold Database of the United States. Table 1 summarizes distance and names of the closest mapped faults within about 25 miles of the project site.

Table 1 - Summary of Published, Nearby Faults

Fault Name	Approximate Distance (miles) and Direction from the Site
Portland Hills Fault	1.4, southwest
East Bank Fault	10.3, southeast
Oatfield Fault	10.6, south
Helvatia Fault	12.0, southwest
Lacamas Lake Fault	18.6, southeast
Gales Creek Fault Zone	19.4, southwest
Beaverton Fault Zone	20.3, south
Canby-Molalla Fault	23.6, south

As part of the procedure to evaluate seismic forces, the 2019 OSSC requires the evaluation of the Seismic Site Class, which categorizes the site based upon the characteristics of the subsurface profile within the upper 100 feet of the ground surface. As permitted in Table 20.3-1 of the 2016

American Society of Civil Engineers (ASCE) Minimum Design Loads and Associated Criteria for Buildings and other Structures, which is incorporated into the 2019 OSSC, PSI has assigned a seismic Site Class of "D" based on the anticipated undrained shear strength (S_u) of the lean clay fill material encountered in the test borings. Based on the results of our Atterberg Limits Testing program, the N-values recorded during SPT testing and correlations developed by Terzaghi and Peck (1967) and Sowers (1979), PSI has calculated an average S_u of of 1004 psf in B1; 1007 psf in B2; 1067 psf in B3, and 1423 in B4. Therefore, a designation of Site Class E is appropriate. The native clay, sand, and gravel soils observed underlaying the fill were observed to have N-values consistent with Site Class D.

Table 2 - Seismic Design Parameters – ASCE 7-16
(45.7677 °, -122.8726°) – SITE CLASS "D"

Period (seconds)	Mapped Spectral Acceleration Parameters (g)	Site Coefficients	Adjusted Spectral Acceleration Parameters (g)	Design Spectral Acceleration Parameters (g)	Period, T (sec)
0.0 (PGA)	PGA = 0.398	F_{PGA} = 1.202	PGA_M = 0.478	---	---
0.2 (S_s)	S_s = 0.864	F_a = 1.154	S_{ms} = 0.998	S_{Ds} = 0.665	T_0 = 0.157
1.0 (S_1)	S_1 = 0.415	F_v = 1.885	S_{m1} = 0.782	S_{D1} = 0.522	T_s = 0.785

Notes:
PGA_M = Maximum considered earthquake geometric mean peak ground acceleration adjusted for Site Class effects
FPGA = PGA site coefficient.
PGA_M = Maximum considered earthquake geometric mean peak ground acceleration adjusted for Site Class effects
S_S = Short period (0.2 second) Mapped Spectral Acceleration
S_1 = 1.0 second period Mapped Spectral Acceleration
S_{MS} = Spectral Response adjusted for site class effects for short period = $F_a \bullet S_S$
S_{M1} = Spectral Response adjusted for site class effects for 1-second period = $F_v \bullet S_1$
S_{DS} = Design Spectral Response Acceleration for short period = 2/3 • S_{MS}
S_{D1} = Design Spectral Response Acceleration for 1-second period =2/3 • S_{M1}
F_a = Short Period Site Coefficients
F_v = Long Period Site Coefficients
$T_0 = 0.2 \bullet S_{D1} / S_{Ds}$
$T_s = S_{D1} / S_{Ds}$

In accordance with ASCE 7-16, Chapter 11, for a Site Class D site with a S_1 >0.1, the F_V value is governed by Section 11.4.8. Section 11.4.8. requires a ground motion hazard analysis be performed for structures with seismic isolation elements or dampening systems on all sites with S_1 >0.6 or Site Class D with S_1 >0.2. Also, in section 11.4.8 is the exception that the ground motion hazard analysis "is not required for structures other than seismically isolated structures and structures with dampening systems where:" the seismic response coefficient of the structure (Chapter 12) meets specific requirements.

This report is based on no seismic isolation elements or dampening systems being installed. As such, the long period site coefficient, F_v values from Table 11.4-2 for the Code supplied S_1 values at this location are supplied in this report.

2.4 SUBSURFACE CONDITIONS

The subsurface profile described below is a generalized interpretation provided to highlight the major subsurface stratification features and material characteristics. The boring logs in Appendix A should be reviewed for more specific information. This record includes soil description, stratifications, penetration resistances, location of samples, and laboratory test data. The stratifications shown on the boring logs represent the conditions only at each of the exploration locations. The stratifications indicated on the boring logs represent the approximate boundary between subsurface materials. The actual transitions may be gradual. Subsurface soils and conditions may vary across relatively short distances at the site and may become apparent with additional explorations or excavation. If soil conditions are found to be different than those described herein, PSI should be allowed to reevaluate our recommendations, if necessary.

From the surface in the test borings, PSI generally observed approximately 38 to 43 feet of undocumented and uncontrolled fill in borings B1 through B4. PSI anticipates that the fill is composed of uncontrolled quarry tailings associated with the gravel pit as mentioned above. The fill generally consisted of a layer of poorly graded gravel with sand within the upper 1 to 2 feet. The gravel is underlain by poorly graded sandy lean clay with gravel and lean clay with sand and gravel. PSI anticipates that this fill is pit fill soils associated with the gravel pit infilling. Pit fill soils are generally a mix of unconsolidated gravel, sand, silt, and clay that is placed above native soils. Underlying the fill in borings B1 and B2 is lean clay with sand. In B3, the fill is underlain by sandy lean clay. In B4, the fill is underlain by poorly graded sandy gravel. In borings B1 and B3, the lean clay with sand and underlain by sandy lean clay with gravel. In B2, the lean clay with sand is underlain by poorly graded sand with clay.

2.5 GROUNDWATER

Groundwater was observed between 3 and 4 feet below grade in borings B1 and B2 and at 10 feet below grade in borings B3 and B4. Groundwater levels at this site are likely to vary as a result of the seasonal conditions and precipitation. Fluctuations in the groundwater level should be anticipated. It is recommended that the Contractor determine the groundwater levels at the time of the construction to evaluate groundwater impact on construction procedures. Groundwater or perched water may be approached in this area and the contractor should be prepared to handle such a condition.

2.6 HAZARD DISCUSSION

The following table presents a qualitative assessment of these issues considering the site class, the subsurface soil properties, the groundwater elevation, and probabilistic ground motions:

Table 3 – Qualitative Seismic Site Assessments

Liquefaction	Low	The area is mapped as being in a zone with a Low Liquification Hazard. PSI agrees with this assessment based on the discussion below.
Earthquake Shaking	Strong	The area is mapped as being in a zone of Strong Earthquake Shaking.
Slope Stability	Low to High	The site is relatively flat, however there are areas with moderate to high landsliding hazard mapped along the existing gravel pit, along the adjacent lot directly east of the site, and directly south of the proposed building.
Surface Rupture	Low	No known active faults underlie the site.
Flooding	High	Part of the south side of the site and existing adjacent gravel pit is located in a Special Flood Hazard Area as designated by Zone AE, based on available Flood Maps published by Federal Emergency Management Agency (FEMA) at the time of this report.

From the Oregon HazVu: Statewide Geohazards websites (https://gis.dogami.oregon.gov/hazvu/)

2.7 LIQUEFACTION POTENTIAL

In general, liquefaction is a condition where soils lose intergranular strength due to abrupt increases in pore water pressure. Pore water pressure increases typically occur during dynamic loading such as ground shaking during a seismic event. Liquefaction, should it occur on a site, can induce ground settlement and lateral spreading, which can result in damage to the structures. For liquefaction to occur, the following conditions must be present:

- The soil sediments must be in saturated or near-saturated conditions. At least 80-85 percent saturation is generally considered necessary for the liquefaction to occur.
- The soil must be predominately composed of non-plastic material such as sand or silt.
- The soil must generally have a plasticity Index (PI) of less than 7.
- The soil must be subjected to dynamic loading, such as an earthquake.

The site is mapped as having a low liquefaction potential based on the Oregon Geology and Mineral Industries (Oregon HazVu) hazard maps.

Based on discussions by Idriss and Boulanger, EERI, 2008, soils with a Plasticity Index of 7 or higher should exhibit “clay-like” behavior during dynamic loading, such as an earthquake. Based on the Atterberg test results, lean clay soil with PI greater than 7 was generally observed at saturated depths. Therefore, PSI agrees with the low liquefaction potential as mapped by DOAGMI. However, Idriss and Boulanger (2008) note that strain softening can occur in clay soils as a result of cyclic loading, which may result in settlement. Idriss and Boulanger (2008) do not provide a method for calculating settlement based on strain softening without specialized laboratory testing. For design purposes, PSI anticipates that a settlement of 1 to 2 inches maybe possible due to strain softening.

3 GEOTECHNICAL EVALUATION

The following geotechnical related recommendations have been developed on the basis of the subsurface conditions encountered and PSI's understanding of the proposed development. Should changes in the project criteria occur, a review must be made by PSI to determine if modifications to our recommendations will be required.

The primary concern at this site, which will affect the performance of the foundations for this structure, is the variable pit fill material that was observed in the test borings to depths ranging from 38 feet to 43 feet below the existing ground surface. Additional, concerns include the shear strength and compressibility of the lean clay fill, and relatively high groundwater table. These concerns are summarized below:

1. Existing undocumented fill materials of variable consistency were encountered within the building area to depths ranging from 38 feet to 43 feet.
2. The shear strength and compressibility of the upper fill soils will control the behavior of the proposed structure.
3. Relatively high water table may present construction difficulties for utilities and below grade excavations.

In addition to the geotechnical concerns identified above, PSI understands that a machine load of 10-15 ksf for the hydraulic press is anticipated, which will require special construction consideration.

3.1 EXISTING UNDOCUMENTED FILL

Based on PSI's soil borings, the site is underlain by up to 43 feet or greater of undocumented and uncontrolled fill. PSI anticipates that this fill is associated with recent gravel pit infill. The presence of the undocumented fill introduces a construction risk due to the potential for excessive and/or non-uniform settlement. The amount of risk is based on consistency of the fill and variations in the material property. For purposes of this report, PSI is providing the following definition of fill and the different classifications:

Fill – Man-placed soil is called "fill", and the process of placing it is termed "filling". One of the most common problems of earth construction is the wide variability of the source soil, termed "borrow". An essential part of the geotechnical engineering report is to provide guidance for the placement of fill from a borrow source in a manner that achieves the design parameters for the project being constructed. Fill is further classified by the placement process. The following lists various terms applied to fill placement practices:

a. **Uncontrolled Fill** - Fill material that consists of soil and/or non-soil materials that has been placed in a manner that does not produce consistent density, uniform moisture content at time of placement, and in general materials of durable physical characteristics is termed an uncontrolled fill.
b. **Undocumented Fill** - Fill material composed of soil that has **not** been observed by a geotechnical engineer or qualified technician under the direction of a geotechnical engineer during the actual fill placement process with physical measurements of lift thickness, dry density, moisture content at time of placement, location of tests and

fill soils placed, and the methodology of placement with types of placement equipment is termed undocumented fill.

c. **Structural Fill** - Fill material that is placed to have specific shear strength, permeability, consolidation, or other physical parameter(s) specific to the end use of the man placed soil material. Applications include, but are not limited to, retaining wall backfill, pond and landfill liners, embankments, dams, and bridge abutments.

The site is underlain by approximately 43-feet of undocumented and uncontrolled fill that is of variable consistency. The undocumented and uncontrolled fill consisted of very soft lean clay leans with pockets of dense gravel, organic material, and plastic debris. Based on standard penetration values and laboratory moisture contents, the fill appears to contain soft zones which can cause total and differential settlement between columns that may not be tolerated by the proposed structure. Due to the anticipated volume of fill, PSI anticipates that removal of the undocumented fill is not feasible on this site. Therefore, in order to accommodate limit differential settlement, (anticipated to be approximately 1 inch over 20 foot column spans for shallow footings without ground improvement) PSI recommends that the floor slab and columns be supported by deep ground improvement methods, drilled piers or driven or cast-in-place piles.

3.2 SHEAR STRENGTH AND COMPRESSIBILITY

The primary geotechnical property controlling the bearing capacity and compressibility of the soils bearing the applied loads is the shear strength of the soil. The applied foundation load on a shallow foundation up to 4 feet wide will be distributed through the 8 to 12 feet of soil generally beneath the footing. PSI believes the shear strength of some of the very soft lean clay in this zone may be as low as 975 psf. This shear strength is considered “undrained” or a “total stress” parameter and will be used in conjunction with other physical and geometric parameters to calculate an allowable bearing capacity. This corresponds to a bearing capacity of approximately 2,200 psf for a 4 feet wide footing at a depth of 1 foot.

Additionally, PSI anticipates that the compressibility of the soil within the fill is highly variable, as observed by inconsistent SPT N-values, therefore, unpredictable total and differential settlement across the span of the columns (i.e 80 feet in the shop area, and 20 feet along the perimeter and N-S internally) may be anticipated under foundation and floor slab loads.

3.3 GROUNDWATER

The relatively high water table may cause some construction difficulties in footing excavations and utility trenches below the water level. Depending on the depth of the excavations, some dewatering may be required. The soil will likely become softer as the excavation nears the water level. The softened soil may require some undercutting or soil improvements in the pavement and building areas.

4 CONCLUSIONS AND RECOMMENDATIONS

The following geotechnical recommendations have been developed based on the subsurface conditions encountered in the borings and PSI’s understanding of the proposed site additions. In PSI’s opinion, based on an evaluation of the data obtained from the soil borings, the proposed site is suitable for construction of the new additions, provided the geotechnical engineering recommendations in this report are followed.

4.1 SITE PREPARATION

To directly mitigate potentially large structural settlements, the highly loaded building areas should be supported on deep foundation system extending through the undocumented fill. This deep foundation system can consist of drilled piers, driven or cast-in-place piles, or soil modification to the subsurface with stone columns or rammed aggregate piers, and then place the foundation on shallow foundations. We recommend your structural engineer contract our engineers to discuss this site prior to providing further recommendations on foundation support. In addition to structure foundations, floor slabs should be supported on stone columns or rammed aggregate piers.

Other options to limit settlement of column footings and floor slab support includes surcharging the site with fill soils prior to construction as discussed below, which may mitigate total static settlement in lightly loaded building areas.

Pavement areas should be over excavated 3 feet and replaced with granular fill discussed herein (or build above current grades by 3 feet with granular fill).

4.2 SURCHARGE CONSIDERATIONS

Based on conversations with Mr. Campbell and Mr. William Doster with AKS Engineering, PSI understands that OMIC is considering surcharging the footprint of the proposed structure prior to construction. PSI understands that approximately 11,000 ft^3 of gravel fill is planned to be moved to the site from the adjacent property within the next three weeks, at the time of this report. Based on a unit weight of 125 pcf, PSI has calculated the following surcharge pressures with varying heights of fill and corresponding applied areas:

Height (ft)	Area (ft^2)	Surcharge (psf)
15	27 x 27	1,875
10	33 x 33	1,250
5	47 x47	625

Please note that significantly more material will be required to apply a meaningful surcharge to the proposed 140 ft x 250 ft footprint than the proposed 11,000 ft^3.

PSI has calculated the following settlements underneath the proposed building footprint based on our understanding of the project and the results of our laboratory testing program and data gathered during our geotechnical investigation:

Calculated Settlement			
Feature	Column Footing	Floor Slab	400T Hydraulic Press
Loading Criteria	55 kip structural load + 20 kip transient gantry crane load applied over 6 ft x 6 ft	214 psf applied over 140 ft x 250 ft	15,000 psf applied over 12 ft X 6 ft
Settlement (in)	**2.1**	**2.0**	**8.7**

PSI anticipates that appropriately applied and monitored surcharge may effectively mitigate settlement of column footings and the floor slab, which may limit the need for ground improvements or deep foundations in these areas. However, the 400T hydraulic press and other highly loaded building areas will require deep foundations or ground improvements regardless of surcharging as discussed below.

PSI has estimated preliminary settlement time and height of fill requirements to achieve the anticipated settlement of 2.1 inches, based on estimated C_v conditions from the results of our laboratory testing program and correlations provided by Holtz and Kovacs (1981).

Time to Achieve Settlement			
Based on a $C_v = 1 \times 10^{-3}$ cm^2/sec and a one-way drainage path of 5 feet			
Surcharge load	5 feet imported fill	10 feet imported fill	15 feet imported fill
Time (days)	43	11	5
Based on a C_v of 6×10^{-4} cm^2/sec and a one-way drainage path of 5 feet			
Surcharge load	5 feet imported fill	10 feet imported fill	15 feet imported fill
Time (days)	71	17	8

Please note that the coefficient of consolidation (C_v), used to estimate the time to achieve settlement, can vary widely and is difficult to predict without laboratory measurements. In order to more accurately assess the surcharge requirements, PSI recommends that additional undisturbed Shelby Tube Samples be recovered to a depth of approximately 50 feet, and time-consolidation testing be performed on at least two samples in accordance with ASTM D2435.

During placement, surcharge fills should be rolled over with heavy excavation equipment such as a roller, dozer or excavator, and should extend laterally a distance equal to the height of the pile outside of the building footprint Surcharge slopes should be limited to 1½H:1V for surcharges consisting of imported crushed aggregate.

The surcharge settlement should be monitored with settlement plates placed under the surcharge. PSI recommends a minimum of ten settlement plates be installed and surveyed to the nearest 0.01 foot immediately following the placement of the surcharge fill. Based on the results of the settlement monitoring, the surcharge can be removed when 90 percent of the primary consolidation is complete.

After the surcharge is complete, the surcharge fill can be placed as permanent structural fill for the project, as long as it meets the requirements in the project specifications.

PSI anticipates that secondary settlement may develop over the life of the structure, even with surcharging. Additionally, due to the variability in fill material encountered during our investigation, the structure should be designed to withstand acceptable differential settlement on the order of 1 inch across a 40 foot span, and some maintenance may be required for foundation elements and floor slabs.

4.3 EXCAVATION CONSIDERATIONS

Open excavations exceeding four feet are not anticipated; however, if they do occur, excavations should be performed in accordance with OSHA regulations as stated in 29 CFR Part 1926. The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor should evaluate the soil exposed in the excavations as part of the required safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified by local, state, and federal safety regulations. PSI is providing this information solely as a service to our client. PSI does not assume responsibility for construction site safety or the contractor's or other parties' compliance with local, state, and federal safety or other regulations.

During wet weather, earthen berms or other methods should be used to prevent runoff water from entering the excavations. The bottom of the excavations should be sloped to a collection point. Collected water within the foundation and utility trench excavations should be discharged to a suitable location outside the construction limits.

4.4 STRUCTURAL FILL MATERIALS

PSI should observe the subgrade prior to placing structural fill to document the subgrade condition and stability prior to placement of fill. We recommend a separator fabric be placed in the parking areas and floor slab areas prior to granular fill placement. This fabric may be an 8 ounce per square yard non-woven geotextile, such as Mirafi® 180N or equivalent, or a woven geotextile such as Mirafi® 500X or equivalent.

Proper control of placement and compaction of new fills should be observed by PSI. Structural fill should be placed in lifts not exceeding 8-inch loose lifts for large compaction equipment such as vibratory rollers or hoe-packs, but thinner lifts (4-inch loose lifts) may be necessary if small compaction equipment such as jumping jacks or plate compactors are to be used.

The fill placed shall be tested and documented by a geotechnical technician and directed by a geotechnical engineer to evaluate the placement of fill material. It should be noted that the geotechnical engineer of record can only certify the testing that is performed and the work observed and documented by that engineer or staff in direct reporting to that engineer. The following table summarizes the recommended compactive effort for various types of structural fill:

Material Tested	Proctor	Min % Dry Unit weight	Moisture Content Range	Frequency of Testing*
Structural Fill (Cohesive)	Modified	95%	-2 to +2%	1 per 1,000 cy of fill placed
Structural Fill (Granular)	Modified	95%	-2 to +2%	1 per 1,000 cy of fill placed
Random Fill (non-load bearing)	Modified	95%	-3 to +3%	1 per 3,000 cy of fill placed
Utility Trench Backfill/Wall Backfill	Modified	95%	-2 to +2%	1 per 200 linear feet/lift

*Minimum of 1 test per lift

The test frequency for the laboratory reference should be one laboratory Proctor test for every 10 field density tests for each material used on the site. If the borrow or source of fill material changes, a new reference moisture/density test should be performed.

Tested structural fill materials that do not achieve either the required dry density or moisture content range shall be recorded, the location noted, and reported to the Contractor and Owner. A re-test of the area should be performed after the Contractor performs remedial measures.

Imported Structural Fill

Imported structural fill should consist of pit-run or quarry-run rock, crushed rock, crushed gravel, or sand. The material should be well-graded between coarse and fine material, angular, have a plasticity index of 8 or less, and have less than 10 percent by weight passing the U.S. Standard No. 200 Sieve (75-µm).

Drain Rock

Drain rock, or "free-draining" material should have less than 2% passing the No. 200 sieve (washed analysis). Examples of materials that would satisfy this requirement include ¾-inch to ¼- inch or 1½-inch to ¾-inch crushed and washed rock.

4.5 FOUNDATIONS

PSI has calculated that a 6-foot wide spread footing supporting a column load of 75 kips (55 kip structural load and transient 20 kip gantry crane load) for a bearing capacity of roughly 2,100 psf, may settle as much as 2 inches in the lean clay pit fill. Furthermore, due to the variable soil conditions observed in the fill, and presence of organic material, differential settlement is difficult to predict, but may exceed our estimates where "soft pockets" occur.

Therefore, PSI recommends that the site be surcharged and monitored prior to construction, until primary settlement is achieve as described above, or ground improvement or deep foundations be used to support the structures proposed columns and floor slab. Ground improvement and deep foundations will be required for the 400T Hydraulic crane and other heavy loaded building areas, regardless of surcharging.

PSI recommends that the 400T Hydraulic tryout Press with anticipated stress of 10 ksf to 15 ksf be supported on its own foundation system independent of the floor slab. Based on the floor plan, and spreadsheet, PSI understands that the hydraulic press has dimensions of approximately 12 feet x 6 feet. (Note, the provided spreadsheet lists the area as 2 ft^2; PSI anticipates that this is a mistake and is basing our calculations on the provide length of 144 and 72. These dimensions are unitless, however, based on the floor plan, PSI anticipates that the dimension is inches. If our understanding of the Hydraulic press load and dimensions are incorrect PSI should be made aware to modify our calculations). For a 12 feet x 6 feet spread footing bearing at a depth of 1 foot, PSI has calculated an allowable bearing capacity of approximately 2,400 psf, which is an order of magnitude less than the anticipated stress of the hydraulic press. Additionally PSI, has estimated a total settlement of approximately 9 inches based on a 15 ksf stress acting on a 12 feet x 6 feet spread footing at a depth of 1 foot below grade. PSI recommends that the isolated footing be enlarged to distribute a maximum of 5,000 psf and be supported on ground improvement or deep foundations option are necessary to accommodate these loads.

Ground improvements, such as vibro stone columns (VSC) or rammed aggregate piers (RAP), may be used to limit anticipated settlement of the hydraulic press, and conventional spread footings and the floor slab. VSC/RAPs are essentially a column of stone that is tightly compacted, and the building foundation elements and the slab on grade and 8-inch granular mat can rest directly on top of the stone columns (see Section 4.5). At this site, PSI would estimate that a system of stone columns installed at a minimum area replacement ratio of 35% percent, extended to approximate depths of 50 feet below the proposed footing could be designed for a bearing capacity between 2,000 psf and 3,000 psf. The dimensions of the footing supporting the hydraulic press may need to increase to support the large anticipated stresses. These calculations are for estimation purposes only and should not be used as a stone column design. External footings should be installed at a minimum depth of 12 inches for frost protection in accordance with Columbia County specifications.

It is PSI's experience that these systems are typically designed by the specialty contractor based on their equipment and the sensitivity to the installation method. PSI can provide such contractor contacts, if necessary.

Driven or Augured in place piles can also be utilized in conjunction with a structural slab. If recommendations for such systems are needed, please have your structural engineer contact PSI.

4.6 FLOOR SLAB SUPPORT

Based on the provided spreadsheet, excluding the 400T Hydraulic Press, PSI has approximated equipment stresses of between 11 psf to 214 psf. PSI anticipates that these loads may be supported by the floor slab, provided the recommendations below are followed.

As mentioned previously, due to the presence of variable fill, PSI recommends that stone columns be used to support the slab on grade, a structural slab be used for floor slab support, or surcharge load be applied to limit total anticipated settlement. The slab-on-grade supported by ground improvements, should be underlain by at least 8 inches of clean (open-graded) granular material to provide uniform support and limit the risk of the capillary rise of moisture. Granular material, such as ¾-inch to ¼-inch crushed rock having less than 2 percent passing the U.S. Standard No.

200 sieve (75-µm) would be suitable for this purpose. The crushed rock should be compacted until it is "well-keyed". In addition, it will be appropriate to install a durable vapor-retarding membrane beneath the slab-on-grade to limit the risk of damp floors in areas that will have moisture-sensitive materials placed directly on the floor. The vapor-retarding membrane should be installed in accordance with the manufacturer's recommendations.

For subgrade prepared as recommended or properly compacted fill with 8 inches of capillary break material above, a modulus of subgrade reaction, k value, of 200 pounds per cubic inch (pci) may be used in the grade slab design based on values typically obtained from 1 foot by 1 foot plate load tests. However, depending on how the slab load is applied, the value will have to be geometrically modified. The value should be adjusted for larger areas using the following expression for cohesive and cohesionless soil:

Modulus of Subgrade Reaction, $k_s = \left(\frac{k}{B}\right)$ for cohesive soil, and $k_s = k\left(\frac{B+1}{2B}\right)^2$ for cohesionless soil.

where: k_s = coefficient of vertical subgrade reaction for loaded area;

k = coefficient of vertical subgrade reaction for 1x1 square foot area; and,

B = width of area loaded, in feet.

4.7 PAVEMENT

Prior to pavement construction, the pavement subgrade should be over-excavated to a depth of 3 feet and replaced with suitable granular structural fill. In lieu of extensive testing for determination of pavement subgrade support characteristics, PSI has provided the following estimated pavement subgrade parameters based on the laboratory analysis and experience in the general area of the project site with similar subgrade soils:

- Estimated Structural Fill Subgrade California Bearing Ratio (CBR) = 10 (based on 3 feet of structural fill)
- Estimated Structural Fill Subgrade Resilient Modulus (MR) = 9,388 psi
- Reliability = 95%
- Standard Deviation = 0.35 – Asphalt
- Standard Deviation = 0.45 – Concrete
- Pavement Design Life = 20 years
- Initial Serviceability Index = 4.2 – Asphalt
- Initial Serviceability Index = 4.5 – Concrete
- Terminal Serviceability Index = 2.0
- Estimated Traffic Volumes
    - Light-Duty – 30,000 ESALs (Construction and Service)
    - Heavy-Duty – 180,000 ESALs (Construction and Service)

Table 5: Recommended Pavement Section

	FLEXIBLE Light-Duty	FLEIXBLE Heavy-Duty	RIGID Heavy-Duty
Asphalt / Concrete Course	4 Inches Asphalt	4½ inches Asphalt	5 inches Concrete
Gravel Base Course	6 Inches	7 Inches	6 Inches

The recommended pavement sections in Table 3 are based on the AASHTO design methods for flexible and rigid pavement design, and a design life of 20 years. In addition, the ranges also represent typical light-duty and heavy-duty type pavement sections for use in preliminary design.

The "light duty" flexible pavement section is recommended for areas of passenger vehicle parking areas, and the "heavy duty" flexible pavement section is recommended for areas of drives and turning areas. In heavy truck lanes or turn areas or where refuse containers or other similar objects are to be placed on the pavement such that a considerable load is transferred from relatively small steel supports, it is recommended that rigid concrete pavement be provided. This will provide for the proper distribution of loads to the subgrade without causing deformation of the surface, especially during hot weather. It will also resist the wear resulting from dumpster pick-ups and vehicle traffic. Concrete design parameters include a 28-day mean modulus of rupture of 500 pounds per square inch (psi) and a 28-day mean modulus of elasticity of approximately 3,600,000 psi.

The concrete mix design should consist of a normal weight concrete with a minimum 28-day compressive strength of 4,000 psi when tested in accordance to ASTM C39. The concrete should contain an air entraining admixture to resist the effects of freezing and thawing. The design of joints, joint spacing, doweling and steel/wire mesh reinforcement was not included in PSI's Scope-of-Services, but should conform to the applicable local or ODOT requirements.

Periodic maintenance should be expected and performed on all pavements during the service life. The pavement materials and construction procedures should conform to Oregon Department of Transportation (ODOT), or appropriate local requirements. Pavements may be placed after the subgrade has been properly prepared as outlined in this report. The recommended pavement sections are based on the subgrade consisting of firm, undisturbed soil or structural fill, and that the pavement will be constructed during the dry summer months. Proof-rolling using a fully-loaded tandem-axle dump truck should be used to evaluate pavement subgrade. Soft areas disclosed by proof-rolling will likely require over-excavation and replacement with properly compacted structural fill. Some contingency should be provided by the Contractor for the repair of any soft areas.

Permanent, properly installed drainage is an essential aspect of pavement design and construction. All paved areas should have positive drainage to prevent ponding of surface water and saturation of the base course. This is particularly important in cut sections or at low points within the paved areas, such as around stormwater catch basins. Effective means to prevent saturation of the base course include installing weep holes in the sidewalls to catch basins. Allowances for proper drainage and proper selection of base materials are most important for the performance of pavements.

Vehicle traffic or the loading of partially constructed pavement sections will likely cause premature pavement failure. All vehicle traffic or pavement loading should be restricted until the pavement section has been completely constructed or the partial pavement section must be designed for this purpose, particularly if construction traffic will use the partial pavement.

5 GEOTECHNICAL RISK AND REPORT LIMITATIONS

The concept of risk is an important aspect of the geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools which geotechnical engineers use are generally empirical and must be used in conjunction with engineering judgment and experience. Therefore, the solutions and recommendations presented in the geotechnical evaluation should not be considered risk-free and, more importantly, are not a guarantee that the interaction between the soils and the proposed pavement section will perform as planned. The engineering recommendations presented in the preceding sections constitute PSI's professional estimate of those measures that are necessary for the proposed pavement section to perform according to the proposed design based on the information generated and referenced during this evaluation, and PSI's experience in working with these conditions.

The recommendations submitted are based on the available subsurface information obtained by PSI, and information provided by Mr. Craig Campbell. If there are any revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, PSI should be notified immediately to determine if changes in the recommendations are required. If PSI is not retained to perform these functions, PSI cannot be responsible for the impact of those conditions on the performance of the project.

The Geotechnical Engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. At that time, it may be necessary to submit supplementary recommendations. This report has been prepared for the exclusive use of Mr. Craig Campbell and his design consultants for the addition to the Oregon Manufacturing Innovation Center – Research and Development in Scappoose, Oregon.

FIGURES

Taken From Google Earth	intertek psi	OMIC R&D - Scappoose, OR	JOB NO.	7041279
		Site Vicinity Map	FIGURE NO.	1

Indicates Approximate location of Boring

Taken From Google Earth	intertek psi	OMIC R&D - Scappoose, OR	JOB NO.	7041279
		Boring Location Map	FIGURE NO.	2

APPENDIX A – SOIL INVESTIGATION LOGS, GENERAL NOTES, AND SOIL CLASSIFICATION CHART

GENERAL NOTES

SAMPLE IDENTIFICATION

The Unified Soil Classification System (USCS), AASHTO 1988 and ASTM designations D2487 and D-2488 are used to identify the encountered materials unless otherwise noted. Coarse-grained soils are defined as having more than 50% of their dry weight retained on a #200 sieve (0.075mm); they are described as: boulders, cobbles, gravel or sand. Fine-grained soils have less than 50% of their dry weight retained on a #200 sieve; they are defined as silts or clay depending on their Atterberg Limit attributes. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size.

DRILLING AND SAMPLING SYMBOLS

SFA: Solid Flight Auger - typically 4" diameter flights, except where noted.
HSA: Hollow Stem Auger - typically 3¼" or 4¼ I.D. openings, except where noted.
M.R.: Mud Rotary - Uses a rotary head with Bentonite or Polymer Slurry
R.C.: Diamond Bit Core Sampler
H.A.: Hand Auger
P.A.: Power Auger - Handheld motorized auger

SS: Split-Spoon - 1 3/8" I.D., 2" O.D., except where noted.
ST: Shelby Tube - 3" O.D., except where noted.
RC: Rock Core
TC: Texas Cone
BS: Bulk Sample
PM: Pressuremeter
CPT-U: Cone Penetrometer Testing with Pore-Pressure Readings

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. Split-Spoon.
N_{60}: A "N" penetration value corrected to an equivalent 60% hammer energy transfer efficiency (ETR)
Q_u: Unconfined compressive strength, TSF
Q_p: Pocket penetrometer value, unconfined compressive strength, TSF
w%: Moisture/water content, %
LL: Liquid Limit, %
PL: Plastic Limit, %
PI: Plasticity Index = (LL-PL),%
DD: Dry unit weight, pcf
▼,▽,▼: Apparent groundwater level at time noted

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Relative Density	N - Blows/foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	50 - 80
Extremely Dense	80+

ANGULARITY OF COARSE-GRAINED PARTICLES

Description	Criteria
Angular:	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular:	Particles are similar to angular description, but have rounded edges
Subrounded:	Particles have nearly plane sides, but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges

GRAIN-SIZE TERMINOLOGY

Component	Size Range
Boulders:	Over 300 mm (>12 in.)
Cobbles:	75 mm to 300 mm (3 in. to 12 in.)
Coarse-Grained Gravel:	19 mm to 75 mm (¾ in. to 3 in.)
Fine-Grained Gravel:	4.75 mm to 19 mm (No.4 to ¾ in.)
Coarse-Grained Sand:	2 mm to 4.75 mm (No.10 to No.4)
Medium-Grained Sand:	0.42 mm to 2 mm (No.40 to No.10)
Fine-Grained Sand:	0.075 mm to 0.42 mm (No. 200 to No.40)
Silt:	0.005 mm to 0.075 mm
Clay:	<0.005 mm

PARTICLE SHAPE

Description	Criteria
Flat:	Particles with width/thickness ratio > 3
Elongated:	Particles with length/width ratio > 3
Flat & Elongated:	Particles meet criteria for both flat and elongated

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% Dry Weight
Trace:	< 5%
With:	5% to 12%
Modifier:	>12%

GENERAL NOTES

(Continued)

CONSISTENCY OF FINE-GRAINED SOILS

Q_U - TSF	N - Blows/foot	Consistency
0 - 0.25	0 - 2	Very Soft
0.25 - 0.50	2 - 4	Soft
0.50 - 1.00	4 - 8	Firm (Medium Stiff)
1.00 - 2.00	8 - 15	Stiff
2.00 - 4.00	15 - 30	Very Stiff
4.00 - 8.00	30 - 50	Hard
8.00+	50+	Very Hard

MOISTURE CONDITION DESCRIPTION

Description	Criteria
Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term	% Dry Weight
Trace:	< 15%
With:	15% to 30%
Modifier:	>30%

STRUCTURE DESCRIPTION

Description	Criteria
Stratified:	Alternating layers of varying material or color with layers at least ¼-inch (6 mm) thick
Laminated:	Alternating layers of varying material or color with layers less than ¼-inch (6 mm) thick
Fissured:	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided:	Fracture planes appear polished or glossy, sometimes striated

Description	Criteria
Blocky:	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed:	Inclusion of small pockets of different soils
Layer:	Inclusion greater than 3 inches thick (75 mm)
Seam:	Inclusion 1/8-inch to 3 inches (3 to 75 mm) thick extending through the sample
Parting:	Inclusion less than 1/8-inch (3 mm) thick

SCALE OF RELATIVE ROCK HARDNESS

Q_U - TSF	Consistency
2.5 - 10	Extremely Soft
10 - 50	Very Soft
50 - 250	Soft
250 - 525	Medium Hard
525 - 1,050	Moderately Hard
1,050 - 2,600	Hard
>2,600	Very Hard

ROCK BEDDING THICKNESSES

Description	Criteria
Very Thick Bedded	Greater than 3-foot (>1.0 m)
Thick Bedded	1-foot to 3-foot (0.3 m to 1.0 m)
Medium Bedded	4-inch to 1-foot (0.1 m to 0.3 m)
Thin Bedded	1¼-inch to 4-inch (30 mm to 100 mm)
Very Thin Bedded	½-inch to 1¼-inch (10 mm to 30 mm)
Thickly Laminated	1/8-inch to ½-inch (3 mm to 10 mm)
Thinly Laminated	1/8-inch or less "paper thin" (<3 mm)

ROCK VOIDS

Voids	Void Diameter
Pit	<6 mm (<0.25 in)
Vug	6 mm to 50 mm (0.25 in to 2 in)
Cavity	50 mm to 600 mm (2 in to 24 in)
Cave	>600 mm (>24 in)

GRAIN-SIZED TERMINOLOGY

(Typically Sedimentary Rock)

Component	Size Range
Very Coarse Grained	>4.76 mm
Coarse Grained	2.0 mm - 4.76 mm
Medium Grained	0.42 mm - 2.0 mm
Fine Grained	0.075 mm - 0.42 mm
Very Fine Grained	<0.075 mm

ROCK QUALITY DESCRIPTION

Rock Mass Description	RQD Value
Excellent	90 -100
Good	75 - 90
Fair	50 - 75
Poor	25 -50
Very Poor	Less than 25

DEGREE OF WEATHERING

Slightly Weathered:	Rock generally fresh, joints stained and discoloration extends into rock up to 25 mm (1 in), open joints may contain clay, core rings under hammer impact.
Weathered:	Rock mass is decomposed 50% or less, significant portions of the rock show discoloration and weathering effects, cores cannot be broken by hand or scraped by knife.
Highly Weathered:	Rock mass is more than 50% decomposed, complete discoloration of rock fabric, core may be extremely broken and gives clunk sound when struck by hammer, may be shaved with a knife.

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

BORING B1

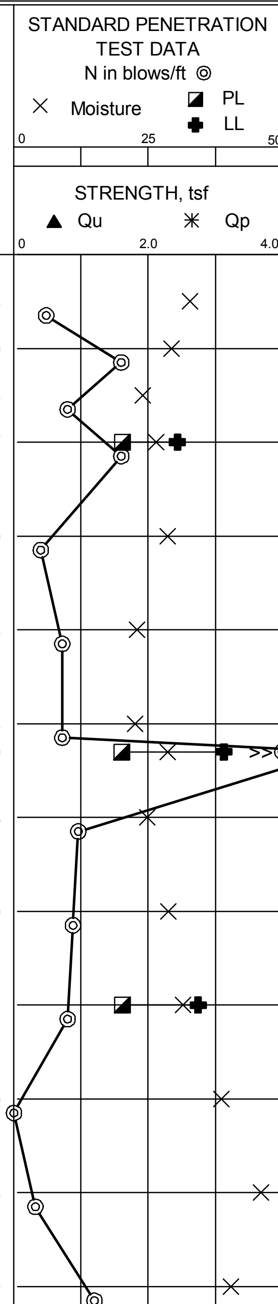
DATE STARTED:	11/21/19	DRILL COMPANY:	Steadfast Services, Inc
DATE COMPLETED:	11/21/19	DRILLER: Gunner	LOGGED BY: Staci Shub
COMPLETION DEPTH	56.5 ft	DRILL RIG:	Truck Mounted
BENCHMARK:	N/A	DRILLING METHOD:	Hollow Stem Auger
ELEVATION:	28 ft	SAMPLING METHOD:	ASTM D1586
LATITUDE:	45.7673°	HAMMER TYPE:	Automatic
LONGITUDE:	-122.8723°	EFFICIENCY	Unknown%
STATION: N/A	OFFSET: N/A	REVIEWED BY:	SB
REMARKS:			

Water

While Drilling	3	feet
Upon Completion	3	feet
Delay	N/A	

BORING LOCATION:

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT	Moisture, %	Additional Remarks
28	0			**POORLY GRADED GRAVEL with SAND FILL** Gray to dark gray, loose, moist, up to 4 inches	FILL			
		1	8	**SANDY LEAN CLAY with GRAVEL FILL** Brown, soft to stiff, moist to wet, subangular to subrounded gravel, trace plastic and wire debris	FILL	3-3-3 N=6	33	
		2	8			1-5-15 N=20	29	
		3	4			3-1-9 N=10	24	
		4	5			3-17-3 N=20	27	LL = 30 PL = 20
		5	2			2-2-3 N=5	29	
	20	6	2	**LEAN CLAY with SAND FILL** Brown, medium stiff to stiff, moist, organics throughout, trace sand, trace subangular to subrounded gravel up to 1/4 inch	FILL	3-4-5 N=9	23	
		7 / 8	1			3-4-5 N=9	23 / 29	LL = 39 PL = 20
		9	6			3-5-7 N=12	25	
		10	6			1-4-7 N=11	29	
	40	11	18	**LEAN CLAY with SAND** Brown, very soft to stiff, moist to wet, micaceous, black and gray mottling, trace subrounded gravel	CL-ML	0-4-6 N=10	31	LL = 34 PL = 20
		12	8			0-0-0 N=0	39	
	48	13	18	**SANDY LEAN CLAY with GRAVEL** Light brown to dark gray, very soft to stiff, moist to wet, micaceous	SP-SC	0-1-3 N=4	46	
		14	10			7-6-9 N=15	40	
	56.5			Boring Terminated at 56.5 feet bgs				



intertek psi
Professional Service Industries, Inc.
6032 N. Cutter Circle, Suite 480
Portland, OR 97219
Telephone: (503) 289-1778

PROJECT NO.:	07041279
PROJECT:	OMIC R&D
LOCATION:	33701 Charles T. Parker Way, Scappoose, Oregon

The stratification lines represent approximate boundaries. The transition may be gradual.

DATE STARTED: 11/21/19	**DRILL COMPANY:** Steadfast Services, Inc		
DATE COMPLETED: 11/21/19	**DRILLER:** Gunner	**LOGGED BY:** Staci Shub	
COMPLETION DEPTH 51.5 ft	**DRILL RIG:** Truck Mounted		
BENCHMARK: N/A	**DRILLING METHOD:** Hollow Stem Auger		
ELEVATION: 28 ft	**SAMPLING METHOD:** ASTM D1586		
LATITUDE: 45.7675°	**HAMMER TYPE:** Automatic		
LONGITUDE: -122.8726°	**EFFICIENCY** Unknown%		
STATION: N/A **OFFSET:** N/A	**REVIEWED BY:** SB		
REMARKS:			

BORING B2

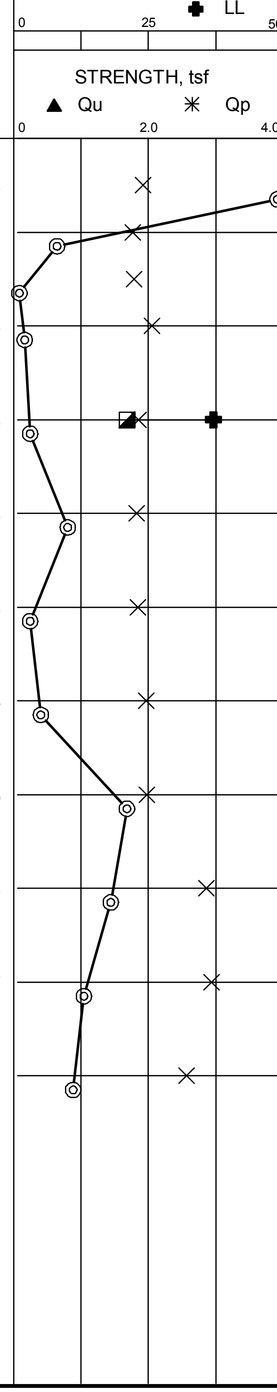
Water		
While Drilling	4	feet
Upon Completion	4	feet
Delay	N/A	

BORING LOCATION:

Depth, (feet)	MATERIAL DESCRIPTION	USCS Classification
0	**POORLY GRADED GRAVEL with SAND FILL** Gray to dark gray, loose, moist, up to 4 inches	FILL
	POORLY GRADED SAND with CLAY FILL Brown, very loose to to medim dense, moist to wet, heaving sand, trace plastic and wire debris	FILL
15	**LEAN CLAY with SAND FILL** Brown, soft to stiff, moist, heavy organics at 20 feet bgs, brick and plastic debris, trace sand, trace subangular to subrounded gravel up to 1/4 inch	FILL
38	**LEAN CLAY with SAND** Brown, very soft to stiff, moist to wet, black and gray mottling, trace subrounded gravel	CL-ML
48	**POORLY GRADED SAND with CLAY** Light brown to dark gray, very stiff, moist to wet, micaceous, trace subrounded gravel	SP-SC
51.5	Boring Terminated at 51.5 feet bgs	

Sample No.	Recovery (inches)	Blows / N	Moisture, %	Additional Remarks
1	8	21-28-21 N=49	24	
2	4	9-5-3 N=8	22	
3	2	1-0-1 N=1	22	
4	4	1-1-1 N=2	26	
5	8	1-1-2 N=3	23	LL = 37 PL = 21
6	8	6-5-5 N=10	23	
7	6	2-1-2 N=3	23	
8	10	1-2-3 N=5	25	
9	12	3-13-8 N=21	25	
10	8	3-9-9 N=18	36	
11	18	4-6-7 N=13	37	
12	16	2-4-7 N=11	32	

STANDARD PENETRATION TEST DATA
N in blows/ft
Moisture PL LL
STRENGTH, tsf
Qu Qp



Professional Service Industries, Inc.
6032 N. Cutter Circle, Suite 480
Portland, OR 97219
Telephone: (503) 289-1778

PROJECT NO.: 07041279
PROJECT: OMIC R&D
LOCATION: 33701 Charles T. Parker Way, Scappoose, Oregon

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B3

DATE STARTED:	11/22/19	**DRILL COMPANY:**	Steadfast Services, Inc
DATE COMPLETED:	11/22/19	**DRILLER:** Gunner	**LOGGED BY:** Staci Shub
COMPLETION DEPTH	61.5 ft	**DRILL RIG:**	Truck Mounted
BENCHMARK:	N/A	**DRILLING METHOD:**	Hollow Stem Auger
ELEVATION:	28 ft	**SAMPLING METHOD:**	ASTM D1586
LATITUDE:	45.7678°	**HAMMER TYPE:**	Automatic
LONGITUDE:	-122.8725°	**EFFICIENCY**	Unknown%
STATION: N/A	**OFFSET:** N/A	**REVIEWED BY:**	SB
REMARKS:			

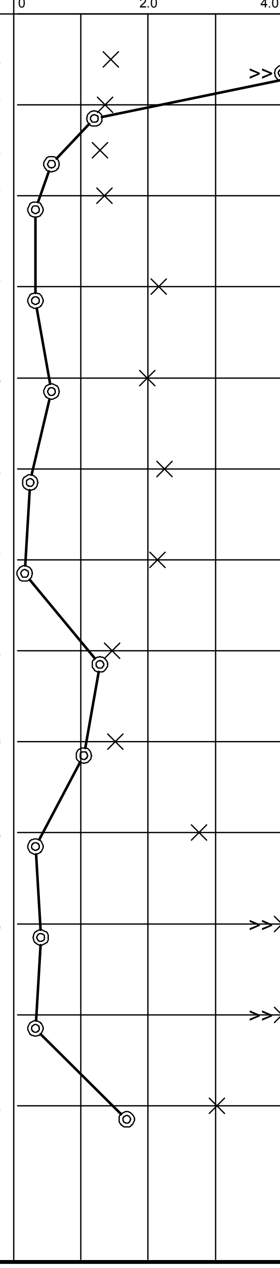
Water

While Drilling	10 feet
Upon Completion	10 feet
Delay	N/A

BORING LOCATION:

Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows	Moisture, %
0			**POORLY GRADED GRAVEL with SAND FILL** Gray to dark gray, loose, moist, up to 4 inches	FILL		
	1	8	**POORLY GRADED SAND with CLAY FILL** Brown, very loose to to medim dense, moist to wet, trace plastic and wire debris, trace gravel	FILL	5-10-43 N=56	18
5	2	8			10-9-6 N=15	17
	3	8			2-3-4 N=7	16
10	4	1			1-2-2 N=4	17
15	5	4	**LEAN CLAY with SAND and GRAVEL FILL** Brown, very soft to stiff, moist, cement and plastic debris, trace sand, subangular to subrounded gravel	FILL	1-3-1 N=4	27
20	6	8			2-2-5 N=7	25
25	7	6			0-1-2 N=3	28
30	8	10			0-0-2 N=2	27
35	9	1			20-7-9 N=16	18
40	10	1	**SAND LEAN CLAY** Light brown to dark gray, very stiff, moist to wet, micaceous, trace subrounded gravel	SP-SC	20-6-7 N=13	19
45	11	18			0-1-3 N=4	35
50	12	18			0-1-4 N=5	55
55	13	18			1-1-3 N=4	51
60	14	18	**SANDY LEAN CLAY with GRAVEL** Dark gray to brown, medium stiff to stiff, moist, micaceous, subrounded	GPS	6-12-9 N=21	38
			Boring Terminated at 61.5 feet bgs			

STANDARD PENETRATION TEST DATA N in blows/ft ◎ × Moisture PL LL 0 25 50 STRENGTH, tsf ▲ Qu ✳ Qp 0 2.0 4.0



Additional Remarks

Professional Service Industries, Inc.
6032 N. Cutter Circle, Suite 480
Portland, OR 97219
Telephone: (503) 289-1778

PROJECT NO.: 07041279
PROJECT: OMIC R&D
LOCATION: 33701 Charles T. Parker Way, Scappoose, Oregon

The stratification lines represent approximate boundaries. The transition may be gradual.

BORING B4

DATE STARTED:	11/22/19
DATE COMPLETED:	11/22/19
COMPLETION DEPTH	56.5 ft
BENCHMARK:	N/A
ELEVATION:	28 ft
LATITUDE:	45.7682°
LONGITUDE:	-122.8724°
STATION:	N/A
OFFSET:	N/A
REMARKS:	
DRILL COMPANY:	Steadfast Services, Inc
DRILLER:	Gunner
LOGGED BY:	Staci Shub
DRILL RIG:	Truck Mounted
DRILLING METHOD:	Hollow Stem Auger
SAMPLING METHOD:	ASTM D1586
HAMMER TYPE:	Automatic
EFFICIENCY	Unknown%
REVIEWED BY:	SB

Water		
∇	While Drilling	10 feet
▼	Upon Completion	10 feet
▼	Delay	N/A

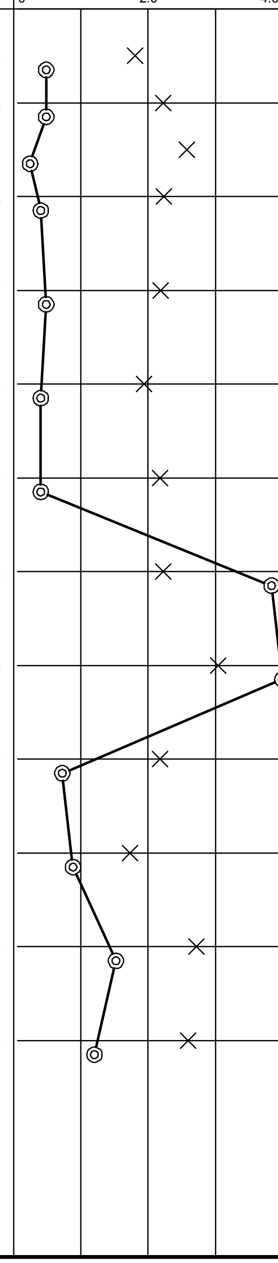
BORING LOCATION:

MATERIAL DESCRIPTION	USCS Classification
POORLY GRADED GRAVEL with SAND FILL Gray to dark gray, loose, moist, up to 4 inches	FILL
POORLY GRADED SAND with CLAY and GRAVEL FILL Brown, very loose to to medim dense, moist to wet, organics below 10 feet bgs including wood and timber debris, trace plastic debris, trace gravel	FILL
CLAY with SAND and GRAVEL FILL Brown to gray, very soft to stiff, moist, organic pockets, subangular to subrounded gravel	FILL
POORLY GRADED GRAVEL FILL Dark gray to brown, medium dense, moist, brick and plastic debris, subrounded to subangular	FILL
POORLY GRADED SANDY GRAVEL Dark gray to brown, medium dense, moist, micaceous, subrounded	GPS
Boring Terminated at 56.5 feet bgs	

Sample No.	Recovery (inches)	SPT (blows)	Moisture, %
1	8	4-2-4 N=6	23
2	6	2-3-3 N=6	28
3	10	2-1-2 N=3	32
4	10	1-2-3 N=5	28
5	6	3-3-3 N=6	27
6	8	3-2-3 N=5	24
7	6	1-3-2 N=5	27
8	12	1-14-34 N=48	28
9	16	36-40-10 N=50	38
10	18	3-4-5 N=9	27
11	18	6-4-7 N=11	22
12	18	1-18-9 N=19	34
13	18	2-6-9 N=15	33

STANDARD PENETRATION TEST DATA
N in blows/ft ◎
× Moisture ◪ PL ✚ LL
0 25 50
STRENGTH, tsf
▲ Qu ✳ Qp
0 2.0 4.0

Additional Remarks



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Professional Service Industries, Inc.
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Telephone: (503) 289-1778

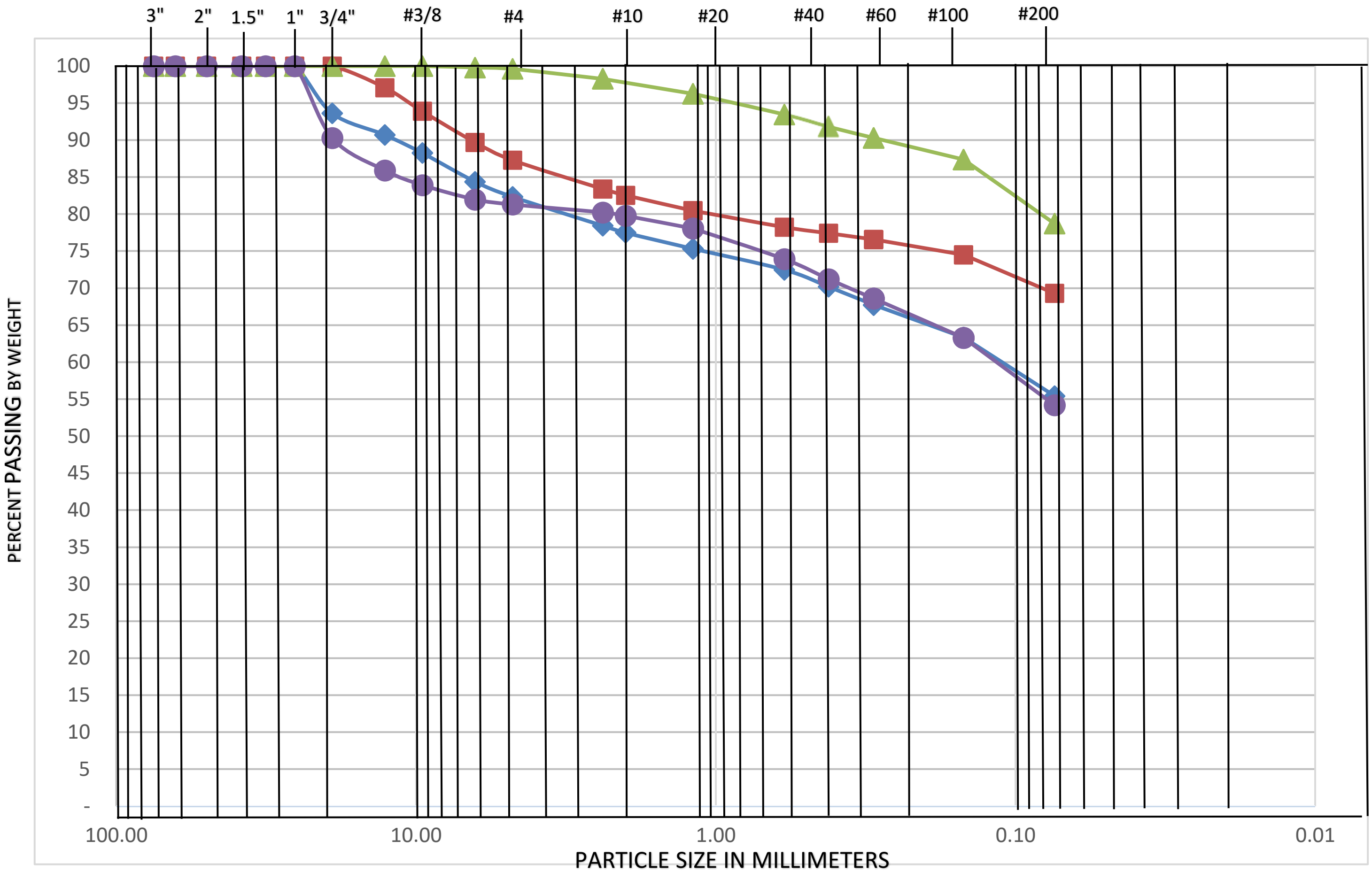
PROJECT NO.: 07041279
PROJECT: OMIC R&D
LOCATION: 33701 Charles T. Parker Way
Scappoose, Oregon

The stratification lines represent approximate boundaries. The transition may be gradual.

APPENDIX B – LABORATORY TEST RESULTS

PARTICLE SIZE ANALYSIS - ASTM (D-422)

Project Name	OMIC R&D	Project Location	Scappoose, OR
Project Number	7041279	Tested By	AD
Date of Sampling	11/22/2019	Date of Testing	12/4/2019
		Reviewed By	SB



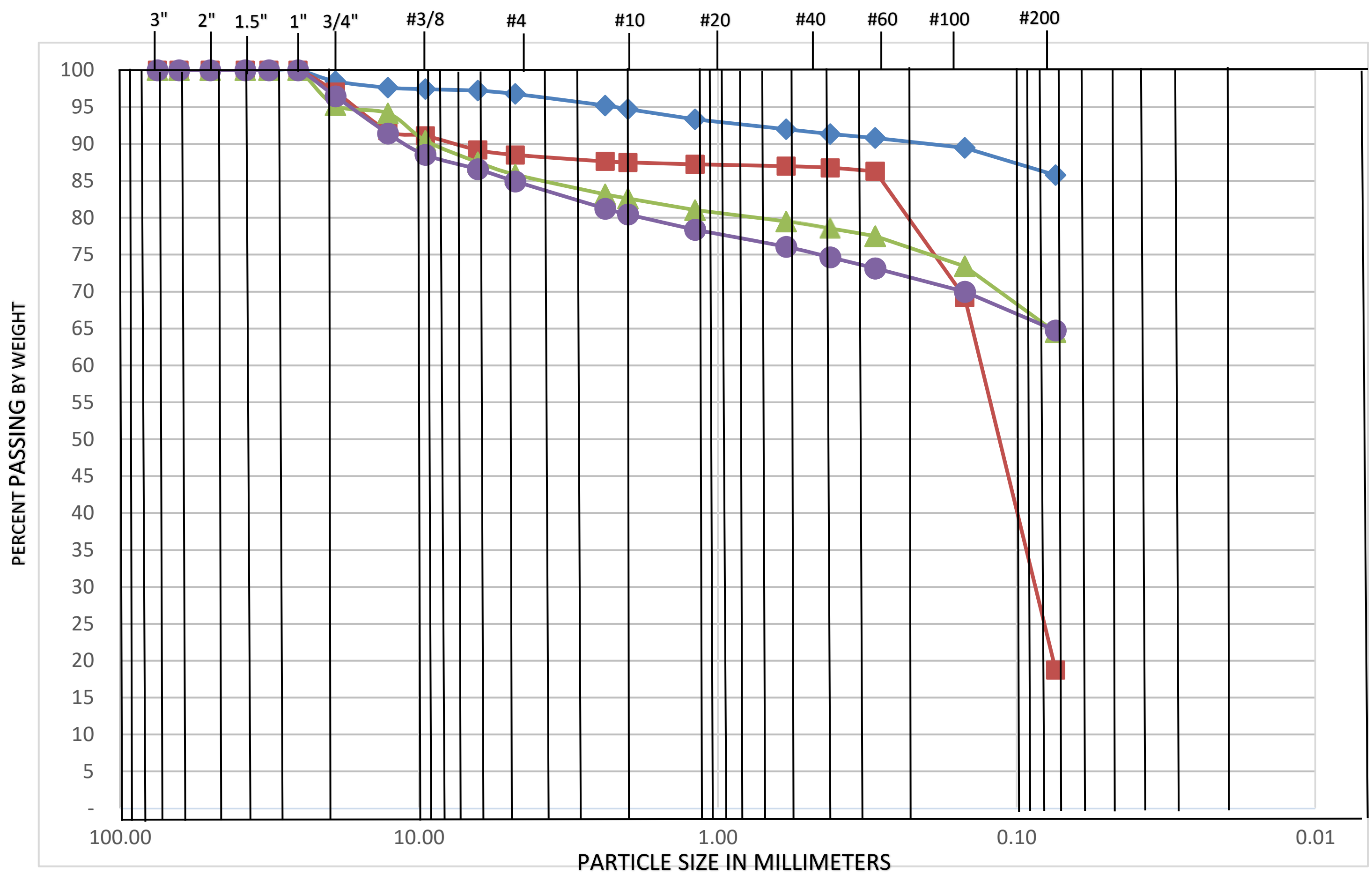
Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
Gravel		Sand			Fine Grained

Boring #	Depth	% Gravel	% Sand	% Fines	PL	LL	PI	Moisture (%)
B1	5	17.7%	26.9%	55.4%				29.3%
B1	26.0	0.0%	18.0%	69.3%				28.6%
B1	45	0.4%	20.9%	78.7%				38.6%
B1	55	18.7%	27.1%	54.2%				40.4%

Boring #	Depth	USCS Symbol	USCS Name	Plot Lines
B1	5	CL	Sandy Lean CLAY with Gravel	
B1	26.0	CL	Lean CLAY with Sand	
B1	45	CL	Lean CLAY with Sand	
B1	55	CL	Sandy Lean CLAY with Gravel	

PARTICLE SIZE ANALYSIS - ASTM (D-422)

Project Name	OMIC R&D	Project Location	Scappoose, OR
Project Number	7041279	Tested By	AD
Date of Sampling	11/22/2019	Date of Testing	12/4/2019
		Reviewed By	SB



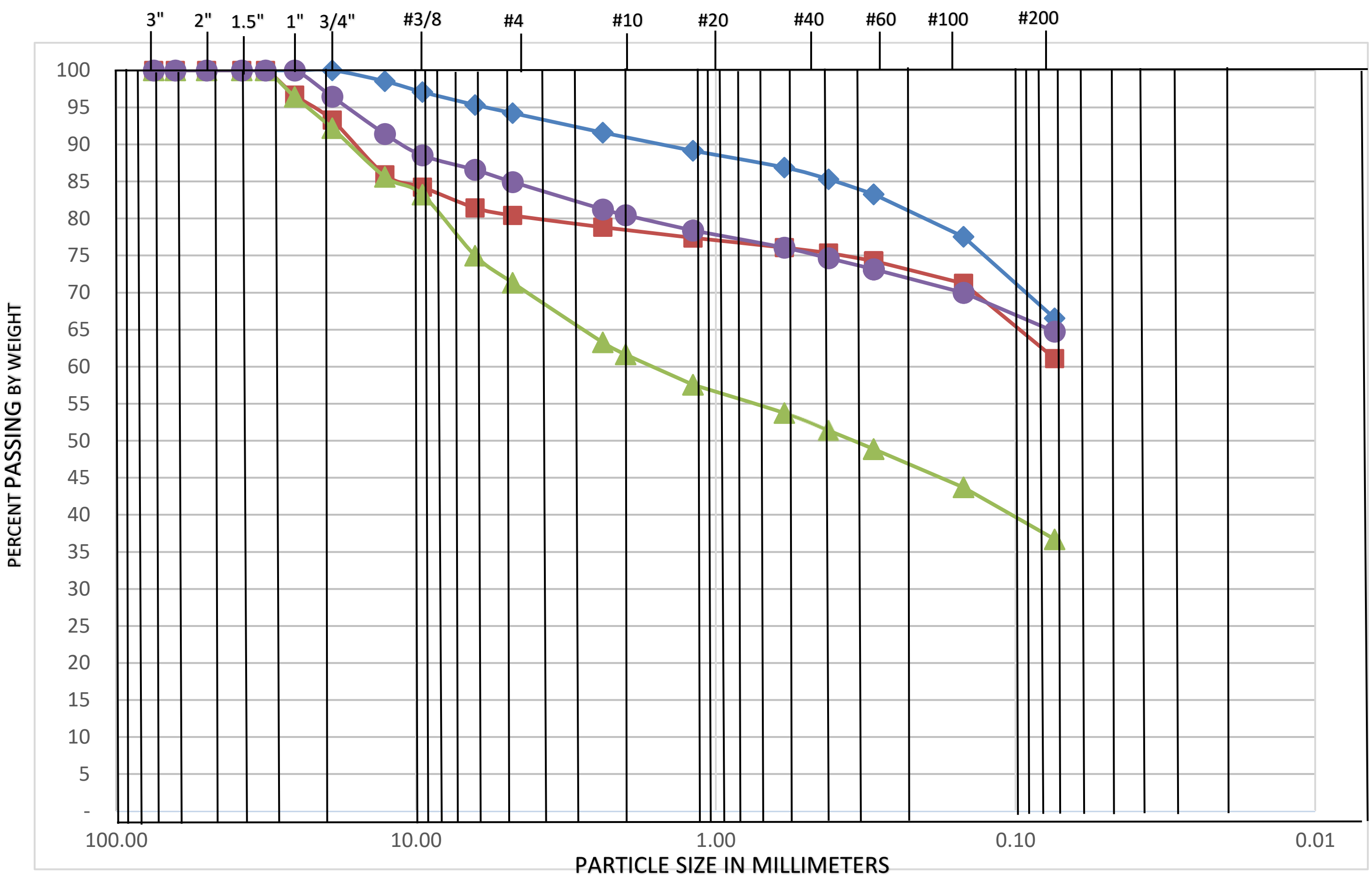
Gravel		Sand			Fine Grained
Coarse	Fine	Coarse	Medium	Fine	Silt/Clay

Boring #	Depth	% Gravel	% Sand	% Fines	PL	LL	PI	Moisture (%)
B2	45	3.2%	11.0%	85.8%				36.8%
B2	50	0.0%	69.8%	18.7%				32.1%
B3	20	14.2%	21.4%	64.5%				24.9%
B3	30	15.1%	20.2%	64.7%				26.7%

Boring #	Depth	USCS Symbol	USCS Name	Plot Lines
B2	45	CL	Lean CLAY with Sand	
B2	50	SP-SC	Poorly Graded SAND with Clay	
B3	20	CL	Lean CLAY with Sand	
B3	30	CL	Sandy Lean CLAY with Gravel	

PARTICLE SIZE ANALYSIS - ASTM (D-422)

Project Name	OMIC R&D		Project Location	Scappoose, OR	
Project Number	7041279		Tested By	AD	
Date of Sampling	11/22/2019	Date of Testing	12/4/2019	Reviewed By	SB



Coarse	Fine	Coarse	Medium	Fine	Silt/Clay
Gravel		Sand			Fine Grained

Boring #	Depth	% Gravel	% Sand	% Fines	PL	LL	PI	Moisture (%)
B3	45	5.8%	27.7%	66.5%				34.5%
B3	60	0.0%	19.3%	61.1%				37.8%
B4	20	28.7%	34.6%	36.7%				21.7%

Boring #	Depth	USCS Symbol	USCS Name	Plot Lines
B3	45	CL	Sandy Lean CLAY	
B3	60	CL	Sandy Lean CLAY	
B4	20	CL	Sandy Lean CLAY with Gravel	

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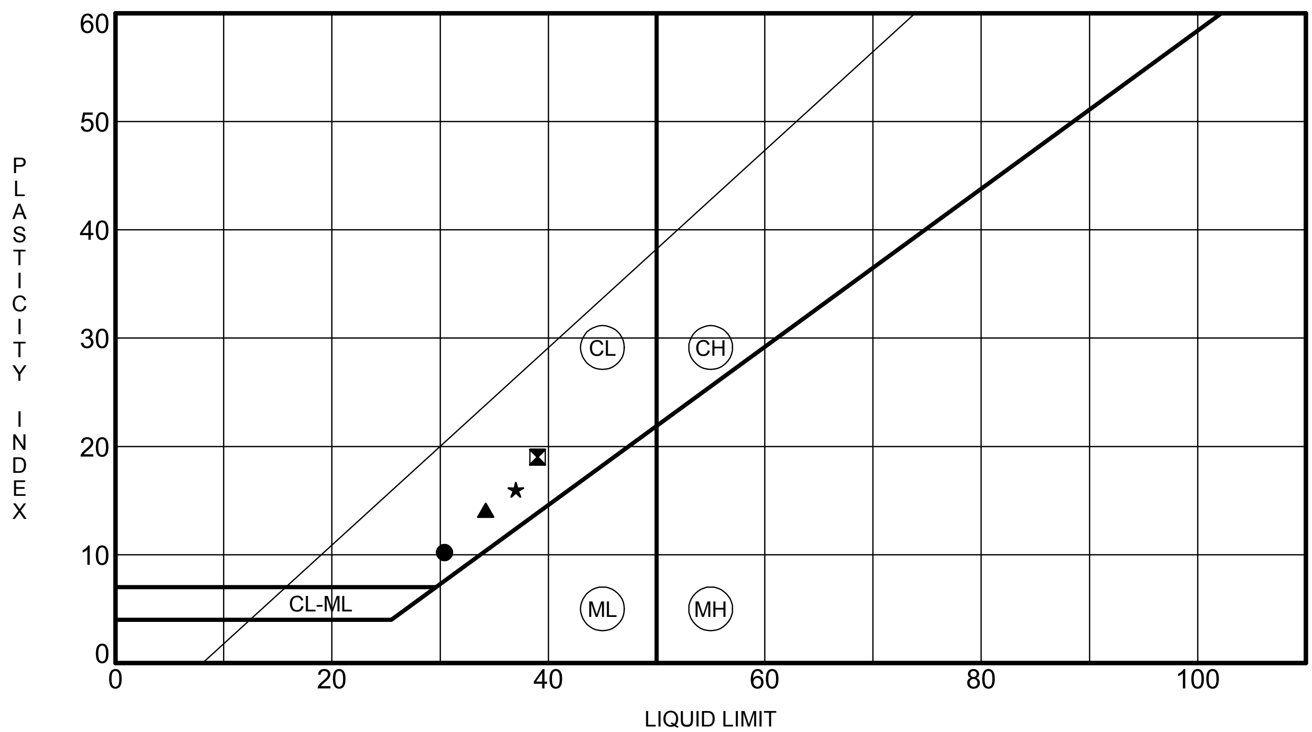

	Boring	Depth (ft)	LL	PL	PI	Fines	Classification (*Visual)
●	**B1**	**10.0**	**30**	**20**	**10**		
⧗	**B1**	**26.5**	**39**	**20**	**19**		
▲	**B1**	**40.0**	**34**	**20**	**14**		
★	**B2**	**15.0**	**37**	**21**	**16**		

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ATTERBERG LIMIT RESULTS

PSI Job No.: 07041279
Project: OMIC R&D
Location: 33701 Charles T. Parker Way
Scappoose, Oregon