

**Attachment H-1: Proposed Site Specific Geotechnical Work**

## PROPOSED SITE-SPECIFIC GEOTECHNICAL WORK

The following sections provide a generalized exploration program for the proposed alignments and describe proposed geotechnical exploration methods based on anticipated geologic conditions. The proposed schedule for site-specific geotechnical work, as required by OAR 345-021-0010(1)(h)(C), is provided in the main Exhibit H text, along with evidence of consultation with the DOGAMI regarding the appropriate site-specific geotechnical work, as required by OAR 345-021-0010(1)(h)(B).

### 3.0 Geotechnical Exploration Plan

Shannon & Wilson reviewed the proposed project alignments with respect to aerial photographs, topographic maps, existing geologic mapping, soils mapping, landslide mapping, and limited reconnaissance data (compiled by Shannon & Wilson and Shaw) to select preliminary proposed boring locations. Some proposed boring locations were adjusted slightly away from proposed tower locations based on known access or permitting considerations communicated to us by Tetra Tech, via HDR. Preliminary locations of the proposed borings are summarized in Table C1 in Appendix C. These locations are also shown on the Geologic Map sheets in Appendix A and the Landslide Inventory maps in Appendix E. In general, criteria for boring placement included borings at the following:

- A maximum spacing of approximately 1 mile along the alignments in areas anticipated to have variable ground conditions, and a maximum spacing of approximately 2 miles along the alignments in areas anticipated to have uniform ground conditions;
- Dead-end structures;
- Corners or significant changes in alignment heading (angle points);
- Crossings of highways, major roads, rivers, railroads, and utilities such as power transmission lines, natural gas pipelines, and canals;
- Locations necessary to verify anticipated lithologic changes and/or geologic hazards such as landslides, steep slopes, or soft soil areas;
- Locations of towers nearest to where Quaternary faults cross the alignment; and
- Locations for potential geo-seismic hazards such as liquefaction, lateral spreading, and seismic slope instability.

The desired boring locations were compared with areas that have already been surveyed for cultural, biological, or environmental sensitivity; and where the necessary right of entry permits

have already been granted by land owners. Where complete access clearance at a borehole location was not expected by the year 2019, the desired borehole location was removed from this preliminary exploration list.

The preliminary summary table provided in Appendix C presents 342 proposed boring locations, as well as information regarding the anticipated subsurface geology, anticipated drilling rig type, and justification for each boring. This information will need to be verified during a detailed field reconnaissance of the entire alignment, to be performed prior to drilling. The list of proposed borings currently includes 315 boreholes along the IPC Proposed Route; 3 boreholes for the West of Bombing Road Alternative 1; 2 boreholes for the West of Bombing Road Alternative 2; and 22 boreholes for the Morgan Lake Alternative.

The current list of proposed borings is preliminary and will change as the project progresses. Borings may be added, repositioned, or removed from the list based on future site reconnaissance, conditions encountered as the exploration program is performed, and site access constraints. Current borehole designations, based on the designation of the nearest tower, are also preliminary and subject to future revision. It should be expected that an initial phase of drilling will not have as many borings as currently shown in Table C1.

The depth of each boring will generally be no more than 50 feet below the designed finish grade of the transmission line centerline. Depths for drilling into hard soil or competent rock will vary depending on the information needed for design. Borings may be terminated at shallower depths if the blow counts (the number of blows required to advance a split-spoon sampler 12 inches) in soil materials exceed 50 blows per foot for a minimum of three consecutive samples taken at 5-foot intervals (a total depth interval of 15 feet). Borings may also be terminated at less than 50 feet when they have been advanced 10 feet into unweathered, competent rock, as determined by a field representative from examination of the recovered rock core.

### **3.1.1 Geotechnical Drilling Methods**

The purpose of the geotechnical drilling will be to evaluate the foundation conditions for the proposed transmission towers and substations. Geotechnical drilling will be accomplished using a variety of drilling methods, which will vary depending on the type of soil and rock expected within the anticipated completion depth of each boring. Some of the various methods anticipated to be implemented are discussed below.

### **3.1.1.1 Hollow Stem Auger Drilling**

Hollow Stem Auger (HSA) drilling consists of rotating and pushing a hollow drill stem with a continuous helical fin on the outside into the subsurface. The lead auger has a toothed bit at the bottom with a hole in the middle. During drilling, a center rod with a plug at the bottom is left inside the auger drill string to keep the center free of cuttings. The cuttings are brought to the surface on the outside of the augers by rotation of the helical fin. For sampling, the internal rod is withdrawn, and the plug is removed from the end of the rod and replaced with a soil sampler. The sampler is then inserted through the hollow auger stem and placed at the bottom of the borehole.

HSA drilling does not require water or drilling mud, making it ideal for work in remote areas where available water is scarce. It is also easier to determine the depth to groundwater, if it is encountered, as compared with other drilling methods. Another advantage is that the hole is essentially cased during drilling, so loose or caving materials do not inhibit drilling progress or sample quality. Augers can be used as casing in combination with mud rotary drilling or rock coring to temporarily support a borehole across loose materials. The principal disadvantage of HSA drilling is the potential for soil heave into the augers and/or unreliable blow counts when sampling in soft or loose soils below the water table. Under such conditions, mud rotary drilling is preferable. HSA generally cannot penetrate very dense gravels, large cobbles, or hard rock.

### **3.1.1.2 Mud Rotary Drilling**

Mud rotary borings are typically advanced using a smooth-walled hollow drill stem and a tri-cone bit, through which a fluid bentonite drilling mud is pumped. The drilling mud serves to cool the bit, keep the borehole open, and flush the cuttings to the surface. Returning drilling mud is typically passed through a screen and into a tub over the borehole. The screen collects the cuttings and the tub collects the mud for recirculation back into the hole. If a borehole cannot be kept open using mud alone, casing (such as a hollow stem auger) may be set to facilitate advancement of the hole. Mud rotary drilling requires a water source or a supply vehicle which may have difficulty accessing some boring locations. Also, due to the presence of drilling fluid, groundwater levels are often difficult to discern during drilling.

### **3.1.1.3 Rock Coring**

Rock core drilling is typically used to advance a borehole through rock and, at the same time, retrieve sample cores of the rock. This can be done using a conventional coring

system, where the core barrel with a diamond-impregnated bit is attached to a string of smaller diameter drilling rods. To retrieve the core sample, the entire string of drill rods must be pulled from the borehole. Today, wireline systems are more commonly used for rock coring. The wireline system also advances a core barrel behind a diamond-impregnated bit, but differs from the convention system in that the drill rods have a larger inside diameter and the core barrel contains an inner barrel. This inner barrel is inserted and retracted through the string of drill rods using a winch and a wireline system, while the rods and outer core barrel remain in the borehole. Clean water or water mixed with polymer is used to lubricate the casing, cool the bit, and flush fine cuttings from the hole.

### **3.1.2 Types of Drill Rigs**

The drilling techniques described above can be performed using rigs mounted on road-legal trucks, tracked vehicles, or mobile platforms. Truck-mounted drilling rigs will be used at all locations not inhibited by access restrictions. The other drilling rigs are proposed for areas where the truck-mounted drilling rigs cannot be used due to steep terrain and/or difficult access. Other vehicles and equipment may also be mobilized to each boring location and could include a water truck or support vehicle, an air compressor, the field representative's pickup truck or utility vehicle, and possibly another support pickup truck. In some areas, a dozer or grading equipment may be required to assist with access to boring locations.

#### **3.1.2.1 Truck-Mounted Drilling Rigs**

Truck-mounted drilling rigs are road-legal, heavy trucks that require access to be relatively flat (5 percent grade or less). They travel on existing roadways and two-track trails as close as possible to boring locations and then overland on firm ground. Truck rigs are typically 30 feet long, 8.5 feet wide, 12 feet high with mast down, and 25 to 35 feet high with the mast up. The gross vehicle weight of a truck rig is typically about 30,000 to 40,000 pounds.

#### **3.1.2.2 Track-Mounted Drilling Rigs**

Track-mounted drilling rigs are another alternative drill rig type for borings where there are softer ground conditions and/or up to 20 percent grade. These rigs are approximately 8,000 to 15,000 pounds with rubber tracks, resulting in approximately 10 psi ground pressure. This type of rig yields the lowest relative ground disturbance for mobile rigs on soft ground. Tracked rigs are typically 12 to 24 feet long, 6 to 8 feet wide, and 12 to 28 feet high with mast up. They are transported as close as possible to exploration sites on low-boy trailers, using existing roadways and two-track trails. From there, they track overland to boring locations.

While these rigs can traverse steeper terrain than truck rigs, most models still require a relatively flat area to set up for drilling. In some areas along the proposed alignment, this may require some minor grading and site preparation using an excavator or dozer. Some drilling contractors have track-mounted water haulers available, which facilitates mud rotary drilling and rock coring on track rigs in remote areas, away from water sources.

### **3.1.2.3 Platform Drilling Rigs**

Platform drilling rigs will be utilized to access areas that are too steep for the mobile drilling rigs (described above) to access. Platform rigs will generally be transported to the boring locations by helicopter, in 8 to 10 pieces, and assembled on site. Where tower sites are located high on steep slopes above existing roadways, platform drilling equipment can also be lifted into place using mobile cranes.

Platform rigs are approximately 6,000 to 7,000 pounds when assembled, and up to 32 feet high with the mast up. They generally have base dimensions on the order of 8 to 15 feet by 6 feet and have roughly 5-foot-long stabilizer legs that extend from all sides of the base to level the platform on slopes.

For helicopter transport, staging areas near existing roadways will be required to load the equipment to the helicopter.

For crane transport, staging areas will be required along roadways adjacent to the slopes where the rigs will be placed. Traffic control may be required if shoulder widths are insufficient.

### **3.1.3 Sampling Methods**

During drilling operations, samples will generally be taken at 2.5- to 5-foot depth intervals. Most soil sampling will be performed using split-spoon samplers. Thin-walled tubes may be used to sample fine-grained or cohesive soils. HQ or NQ core will generally be used to advance through and sample rock. These sampling methods are described further in the following subsections.

#### **3.1.3.1 Split-Spoon Sampling**

Disturbed samples in borings are typically collected using a standard 2-inch outside diameter (O.D.) split spoon sampler in conjunction with Standard Penetration Testing. In a Standard Penetration Test (SPT, ASTM D1586), the sampler is driven 18 inches into the soil using a 140-pound hammer dropped 30 inches. The number of blows required to drive the

sampler the last 12 inches is defined as the standard penetration resistance, or N-value. The SPT N-value provides a measure of in situ relative density of granular soils (silt, sand, and gravel), and the consistency of fine-grained, cohesive soils (silt and clay). All disturbed samples are visually identified and described in the field, sealed to retain moisture, and returned to the laboratory for additional examination and testing. In some cases, it may be necessary to use a larger sampler, such as a 3.25-inch O.D. Dames & Moore sampler, to collect a representative quantity of soil that contains coarse gravels.

### **3.1.3.2 Thin-Walled Tubes**

Relatively undisturbed samples of fine-grained and/or cohesive soils encountered in the borings may be obtained by pushing a 3-inch outside-diameter, thin-walled tube sampler (also known as Shelby tube sampler, ASTM D1587) a distance of approximately 2 feet into the bottom of the borehole using a hydraulic ram. After a thin-wall tube sample is recovered from the boring, it is sealed at both ends to prevent moisture loss and carefully transported back to the laboratory. Care is taken to keep the sample upright and to avoid dropping, jarring, or rough handling.

### **3.1.3.3 Coring**

HQ or NQ coring is typically used to advance through and sample rock. Core runs are typically 5 feet long. Core samples are photographed in a split tube immediately after extraction from the core barrel. The core is evaluated in the field to determine the percentage of the run recovered, as well as the Rock Quality Designation (RQD), defined as the sum of the length of core pieces 4 inches or more in length and divided by the total length of the drilled core run. The degree of weathering, soundness, joints and structural discontinuities, and other rock characteristics are documented on the boring logs. Rock core samples which are sensitive to moisture loss may be individually wrapped in the field with plastic wrap. All core is stored in waxed cardboard or plastic corrugated boxes which are labeled with the boring designation and depth intervals.

### **3.1.4 Boring Logs**

A field representative will be present during all drilling activities. The field representative will locate the boreholes, collect samples, and maintain logs of the materials encountered. The logs will include sample locations and types, sample descriptions, and notes regarding drilling methods, drill action, fluid loss, problems encountered during drilling, and the depth to groundwater (if observed). The boring logs will present a description of the soil and

rock materials encountered at each boring and the approximate depths at which material changes were observed. Soil samples will be described and identified visually, in general accordance with ASTM D2488, the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

### **3.1.5 Laboratory Testing**

Laboratory testing will be performed on soil and rock samples obtained from the borings to refine field descriptions and to provide index properties for use in engineering design. Laboratory tests for soils may include natural water content and density analyses, Atterberg Limits tests, particle-size analyses, and analytical testing for corrosivity potential. Testing on rock may include point load, unconfined compressive strength testing, and slake durability testing. All laboratory testing will be performed in accordance with applicable ASTM International (ASTM) or U.S. Army Corps of Engineers (USACE) standard test procedures.

### **3.1.6 Geophysical Surveys**

In addition to geotechnical drilling, non-invasive geophysical surveys may be conducted at substation expansion areas and remote areas that cannot be accessed by the previously described drilling equipment. Geophysical survey techniques may include electrical resistivity testing for grounding design or seismic refraction surveys, often used to profile depths to bedrock contacts.

## **3.2 Geotechnical Reporting**

Once the field explorations and laboratory testing are completed and engineering evaluation of the acquired data has been accomplished, a geotechnical report will be prepared in accordance with *Guidelines for Preparing Engineering Geologic Reports* (Oregon State Board of Geologist Examiners, 2014).

## **4.0 SEISMIC HAZARDS**

OAR 345-021-0010(1)(h)(E) states, “*An assessment of seismic hazards, in accordance with standard-of-practice methods and best practices, that addresses all issues relating to the consultation with the Oregon Department of Geology and Mineral Industries described in paragraph (B) of this subsection, and an explanation of how the applicant will design, engineer, construct, and operate the facility to avoid dangers to human safety and the environment from these seismic hazards. Furthermore, an explanation of how the applicant will design, engineer,*