Gorge 2nd Tunnel

# Appendix C: G2T Field Investigation Planning

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# PROJECT MEMORANDUM

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## 1 Introduction

This memorandum presents the field investigation program that is planned to obtain surface and subsurface geologic and geotechnical information for the design of the Gorge 2nd Tunnel (G2T). It includes the following:

- Planned field investigation, including the location and details of planned borings.
- Schedule and duration of field investigation activities.
- Method of drill site access and drilling equipment.
- Drilling activities, including borehole testing and imaging.
- Equipment layout and planned activities at each drilling site.
- Required drill site improvement to be performed by Seattle City Light (SCL)
- Potential impacts to drill sites during and after drilling.
- Details of site restoration, if needed.

## 2 Project Summary

The G2T project is located in the Ross Lake National Recreation Area in Washington's North Cascades, as shown in on the vicinity map (Figure 1). The approximately 11,000-foot long tunnel, which will parallel the existing power tunnel (G1T), will cross beneath a steep forested mountainside between the Gorge Powerhouse and the Gorge Dam (Figure 2). The eastern terminus of G2T will connect to G1T underground near the Gorge Dam intake. The G2T portal will be located at the western terminus of the new tunnel, directly north of the existing Gorge Powerhouse. The project owner is SCL, who is constructing the G2T to optimize power production at the Gorge Powerhouse. The Jacobs Associates (JA) team has been retained by SCL to carry out preliminary design

and geotechnical investigation for the new tunnel and the connections to the existing facilities.

## 3 Field Investigation Summary

The G2T field investigation is being conducted to obtain surface and subsurface geologic and geotechnical information for the design of the new tunnel. The G2T project field investigation consists of two phases:

- Geologic reconnaissance of the portal and tunnel alignment area, and
- Subsurface investigation comprising the drilling of six borings in the vicinity of the proposed G2T alignment.

The length and location of each boring has been selected to obtain critical information for tunnel design, including the following:

- Rock type, strength, weathering/alteration, permeability, and presence of deleterious accessory minerals (e.g. garnet and sulfides).
- Fracture (joint) spacing, orientation, aperture, and surface conditions (for block analysis).
- Characteristics of faults and major fractures that cross the G2T alignment (e.g. location, orientation, width, fracture spacing and aperture, weathering/alteration, permeability).
- Groundwater characteristics (e.g. groundwater level and permeability).

Project borings are located to obtain data from a variety of locations along the proposed G2T alignment that allow for drill rig and personnel access. Horizontal borings in a variety of orientations optimize rock mass data acquisition. The specific rational for each boring is discussed in Section 3.2 and summarized in Table 1.

### *3.1 Geologic Reconnaissance*

Geologic reconnaissance at the portal area was carried out on March10, 2009, and along accessible portions of the tunnel alignment and pertinent sections of the river bed channel on April 20 through April 24, 2009. During this reconnaissance work, the following tasks were performed:

- Slope conditions, including slope stability in the vicinity of the G2T portal location, were characterized.
- Bedrock properties in accessible outcrops, including lithology, hardness/strength, weathering, fracture orientation and spacing, and foliation (mineralogical

banding) in orthogneiss bedrock (layered metamorphic rock derived from igneous rock), were measured.

- The potential presence and nature of sheared fault zones that may cross the G2T alignment were evaluated. These features were initially identified on LIDAR imaging of the alignment area.
- Boring locations were selected and characterized.

### *3.2 Subsurface Investigation*

Six (6) borings are planned along the proposed G2T alignment to obtain subsurface information for tunnel design. Figure 2 shows plan and profile views of the boring locations, the location of the G2T and G1T alignments, and the location of the FERC right-of-way and Wilderness boundary envelopes.

All six borings will be drilled using either a track-mounted or helicopter-mobilized drill rig that will be delivered to the site on a lowboy trailer. Three (3) of the borings will be drilled horizontally into the mountainside near proposed tunnel elevation, two (2) of the borings will be drilled parallel to the G2T alignment from inside the Devil's Elbow Adit, and one (1) of the borings will be drilled at an angle into the mountainside uphill from the G2T portal location. Planning to date involves conducting all drilling operations during daylight hours.

Five of the borings (B-1, B-2, B-3, B-4, and B-6) will be drilled from within the FERC right-of-way. In order to avoid difficult hole-collaring and hole casing, it is recommended that Boring B-5 be drilled approximately 200 feet outside the FERC right-of-way, as discussed in Section 3.2.1.

Boring lengths range from 400 feet to 800 feet, with borehole diameters of approximately 6 inches or less. Table 1 summarizes the location, length, site access issues, and impacts of each of the borings. All six borings will be drilled using triple barrel wire-line coring techniques producing either H or N-sized (1.8 to 2.5 inch diameter) rock core. Rock core will be removed from the boring in 5-foot lengths, placed in a core box, and removed from the site for further analysis and testing.

During drilling (rock coring) operations, drilling water will be re-circulated so that the need for drilling water is significantly reduced. Since each boring will be cored from the surface, limited drill cuttings are expected. Once drilling has been completed, drilling water will be broadcast i.e. widely dispersed across the ground surface to prevent run-off into nearby streams or the Skagit River. Similarly, the minor amount of solid drill cuttings generated in each of the borings will be broadcast across the drill sites.

After each boring is drilled, down-hole imaging will be performed to measure fracture orientation. Bedrock permeability will be measured in the majority of the borings using

packer testing – this involves the testing of formation fracture permeability by measuring water flow while pumping into discrete intervals of the borehole.

Three of the borings (B-2, B-3, and B-5) will be installed with piezometers to measure groundwater levels, while the other three borings (B-1, B-4, and B-6) will be backfilled with cement grout. Each drilling site will be restored to pre-drilling conditions, except for tree removal and the presence of piezometer monuments at the three instrumented drill sites.

The following is a summary of drilling operations and site layout that is specific to each of the drill sites.

#### *3.2.1 Horizontal Borings (B-1, B-5, and B-6)*

A track-mounted drill rig will be used to drill three of the horizontal borings that are located within relatively easy access of a roadway. These borings include B-1, B-5, and B-6, as shown on Figure 2 and described in Table 1. Drill site equipment will consist of a track-mounted drill rig, one support truck, a water truck, a mobile restroom facility (e.g. port-a-potty), and a vehicle for the JA team geologist that is logging the boring. Each site will have a work crew that consists of a driller, two drilling helpers, and a JA team geologist. The drill site area dimensions will be approximately 30 feet by 40 feet, which will be modified to fit the available space without the removal of any standing trees. The boring locations for B-1, B-5, and B-6 are shown in Figure 3, 6, and 7, respectively.

Boring B-1, which will be drilled 400 feet parallel to the G2T alignment from the portal location, provides information on rock mass properties that will be encountered during the construction of the starter tunnel and the initiation of TBM drilling. Access to boring B-1, which will be located at the proposed G2T portal, will require SCL to temporarily remove a section of the chain link fence directly in front of the borehole location. Removing this section of fence will provide drill rig access from across the field on the north side of the Gorge Powerhouse upper parking lot.

Boring B-5, which will be drilled 750 feet toward the northeast into the mountainside northeast of the Devil's Elbow Adit, is located to obtain information to determine whether a fault underlies a linear valley directly east of the drill site. Boring B-5 is located approximately 200 feet outside the FERC right-of-way along the access road to the Devil's Elbow Adit. Locating the boring outside of the FERC boundary will the borehole to be collared directly into bedrock, which will reduce drilling delays associated with drilling into the boulder alluvial fan deposits located within the FERC boundary. Boring B-5 is located 90 feet south of the access road and can easily be reached by a track mounted drilling rig without removing any standing trees.

The 400-foot long boring B-6, which is located near the G2T upstream connection will provide information on the potential presence of a fault along the east side of a

prominent linear ridge that crosses the alignment in the vicinity of the access road bridge. Boring B-6 will be drilled horizontally into a bedrock outcrop along the south shoulder of the Devil's Elbow Adit access road. To improve site safety during drilling, several small boulders and a fallen tree will need to be removed, by SCL, from the slope 30 feet above the proposed drill site.

After drilling, testing, and imaging has been completed, a vibrating wire piezometer will be installed in boring B-5. The purpose of the piezometer is to measure groundwater pressures in the vicinity of the tunnel alignment. This instrument consists of a small pressure transducer that is positioned deep within the boring using a 1-inch PVC pipe (to verify placement). The transducer is connected to the surface via a wire cable. The piezometer apparatus is grouted into place using cement grout and a flush mount steel monument is installed at the surface to protect the transducer wire. Data loggers will be placed within each of the monuments to periodically record groundwater levels.

#### *3.2.2 Devil's Adit Horizontal Borings (B-3 and B-4)*

Horizontal borings B-3 and B-4 will be drilled 400 feet each into opposite sidewalls of the Devil's Elbow Adit approximately 1,000 feet into the adit. The purpose of these borings is to obtain information on rock mass properties within the mountainside along an 800-foot long interval adjacent the G2T alignment. A small track-mounted drill rig will be transported to the adit portal by helicopter and will then track into the adit to the borehole locations. Transporting the drill rig to the adit portal will require the removal of 6 to 8 alder trees, up to 12 inches in diameter, and construction of a temporary platform by SCL for landing the drill rig and drilling supplies. Figure 5 shows the location for this temporary access pad at the Devil's Elbow Adit portal.

A generator, ventilation system, and a light plant will be positioned at the adit drill site to remove exhaust fumes and illuminate drilling activities. The support truck, a and water truck, will be located in a staging area approximately 1,000 feet north of the adit portal near the western terminus of the gravel access road that parallels the southern shoreline of the Skagit River. A water line will connect the staging area with the drill site to provide water for drilling. The staging area is expected to be approximately 20 feet by 30 feet and be contained within the road surface near the western terminus of the access road. The drill site is expected to include approximately 30 feet of the 12 to 17 foot wide adit. A mobile restroom facility will either be positioned at the adit portal or at the staging area.

During the coring of the two borings, drilling water will be re-circulated through the drill system. After drilling and testing has been completed, the drilling water will be pumped out of the adit and broadcast across the ground surface.

A vibrating-wire pressure transducer will be installed in boring B-3. The transducer will be installed and completed in a manner similar to that described in section 3.2.1.

### *3.2.3 Inclined Boring (B-2)*

Boring B-2 will be located along the proposed G2T alignment corridor at approximately El. 1,200 feet on the mountainside above the existing surge tank (see Figures 2 and 4). The 800-foot long boring was located and oriented to intersect one of the major features crossing the G2T alignment: a lineament that most likely represents the Ladder Creek Fault that forms a depression above the borehole site. The boring, will also obtain inclined data on rock mass properties, including fracture orientations. A component drill rig and drilling equipment will be mobilized via helicopter to the drill site. Drill site dimensions are estimated to be approximately 20 by 30 feet. The four person work crew will access the site via foot. The location and orientation of this 800-foot long boring has been selected to intercept the Ladder Creek fault, to evaluate its properties where it crosses the proposed tunnel alignment. Once drilling, testing, and imaging has been completed, a 1.5-inch diameter standpipe piezometer (a small diameter well) will be installed to permit periodic monitoring of groundwater levels. The well will be completed with a locking monument cover that protects the well from tampering or accidental damage. The standpipe piezometer will also be equipped with a vibrating wire piezometer and a data logger for automated data collection.

## 4 Potential Short Term Impacts

Short term impacts associated with the drilling phase of the field investigation include the following:

- Drilling-related traffic and parked vehicles on access roadways.
- Limited ground disturbance associated with temporary drill staging areas adjacent to or at a distance from each of the drill sites.
- Noise associated with drilling and helicopter mobilization.
- Helicopter with drill equipment in air in the vicinity of the Devil's Elbow Adit and between the Gorge Powerhouse area and boring B-2 on the mountainside above the powerhouse.
- Construction of an approximately 20 foot by 20 foot temporary drop platform at the entrance to the Devil's Elbow Adit.
- Drilling water and limited cuttings broadcast across the drilling site to facilitate percolation and lessen impacts to vegetation.
- Use of an approximately 30 by 40 foot site near the Gorge Powerhouse to be used for a central drill staging area to stockpile supplies and drilling equipment. The site must be both truck and helicopter accessible.
- Removal of a small section of fencing to allow access to the B-1 boring location through the field on the north side of the Gorge Powerhouse upper parking lot.

- Use of a water source for drilling water. This source can either be located in Newhalem or closer to the drilling sites.
- The collar of boring B-6 is located within 200 feet (measured as approximately 150 feet) of the Skagit River shoreline. This is likely to result in the application for an in-water permit being required.

## 5 Potential Long Term Impacts

The long term impacts associated with the field investigation program will include the installation of three borehole monuments and limited tree removal required to access the drilling site for borings B-2, B-3 and B-4. Additionally, downed trees will need to be removed at boring B-2 and B-5 drill sites.

A steel monument that extends above the ground surface will be installed to protect the vibrating wire piezometer at boring B-2. This monument is expected to be approximately 10 inches across and less than 2 feet high. The steel monument on borings B-3 and B-5 is expected to be 10 inches in diameter and be flush with the ground surface or adit wall.

Six to eight small (<12 inch diameter) deciduous trees must be cleared to create space to construct a platform to permit drill access to the Devil's Elbow Adit. Site grading in front of the portal will also be required to create a sloping ramp for track-mounted drill access. The trees removed from the site can be used to construct the drill access platform, if needed. Three dead trees and two living small trees (<10 inches in diameter) will also need to be removed from the B-2 boring site.

It has been assumed that SCL will be responsible for carrying out this preparatory works for boring B-2 and the Devil's Elbow Adit holes.

Long term core storage will be required for rock core samples recovered during drilling. Approximately 90 core boxes with a diameter of 64 inches by 11.5 inches by 4 inches will be generated during drilling. These boxes should be stacked no higher than 6 boxes high (to allow for easy access) in a dry and secure core storage room or container. Core storage can either be located at the project site (preferable) or outside of the Newhalem area. Transportation of the core from the central drill staging area to an off-site storage area will be the responsibility of SCL.

## 6 Preliminary Schedule

The G2T subsurface investigation is planned to start in early July 2009 and is expected to be completed by the end of August. It is anticipated that up to three drilling rigs will be operating concurrently. Drilling operations will be performed on a 10 work shifts basis followed by four days off.

**Table 1. Field Investigation Boring Summary**

| Boring | Location[1] | Length (ft) | Purpose of Boring | Site Access | Required SCL Site Improvements | Site Impacts |
|---|---|---|---|---|---|---|
| B-1 | G2T Portal area directly north of the upper Powerhouse parking | 400 | B-1 investigates rock mass properties encountered during the construction of the starter tunnel and the initiation of TBM drilling. | Track-mounted drill rig access through field and open section of perimeter fence. | Temporary removal of a section of chain link fence to permit drill access | None |
| B-2 | Clearing on hillside above Surge Tank at approximately El. 1,200 feet | 800 | B-2 intersects the Ladder Creek Fault and provides inclined data on rock mass properties | Helicopter mobilization of component drill rig to drill site | Remove 3 dead and 2 living standing trees (<10 inch diameter), remove 4 small fallen trees for helicopter access | Tree removal and presence of above ground monument for standpipe piezometer |
| B-3 | Approximately 1,000 feet inside Devil's Elbow Adit | 400 | The purpose of these borings is to obtain information on rock mass properties within the mountainside along an 800-foot long interval adjacent the G2T alignment. | Helicopter mobilization of track-mounted drill rig to adit portal | Remove 6 to 8 small trees (<12 inch diameter), construct pad outside of adit portal to land drill rig | Tree removal and presence of flush-mounted piezometer monument on adit sidewall |
| B-4 | Approximately 1,000 feet inside Devil's Elbow Adit | 400 | | | | |
| B-5 | Into rock outcrop 90 feet south of the Devil's Elbow Adit access road | 750 | Data from B-5 will determine whether a fault underlies a linear valley directly east of the drill site. | Track-mounted drill rig access along existing road | Removal of 3 fallen trees (<10 inch diameter) | Presence of flush-mounted piezometer monument on rock outcrop |
| B-6 | Into a rock outcrop along the south shoulder of the access road (near bridge). | 400 | B-6 provides information on the potential presence of a fault along the east side of a prominent linear ridge in the vicinity of the access road bridge. | Track-mounted drill rig access along existing road | Removal of several small boulders and a fallen tree from slope 30 feet above drill site | Boring is located approximately 150 feet from the south edge of the river channel. |

[1] **Figure 2 shows a plan and profile view of the boring locations.**

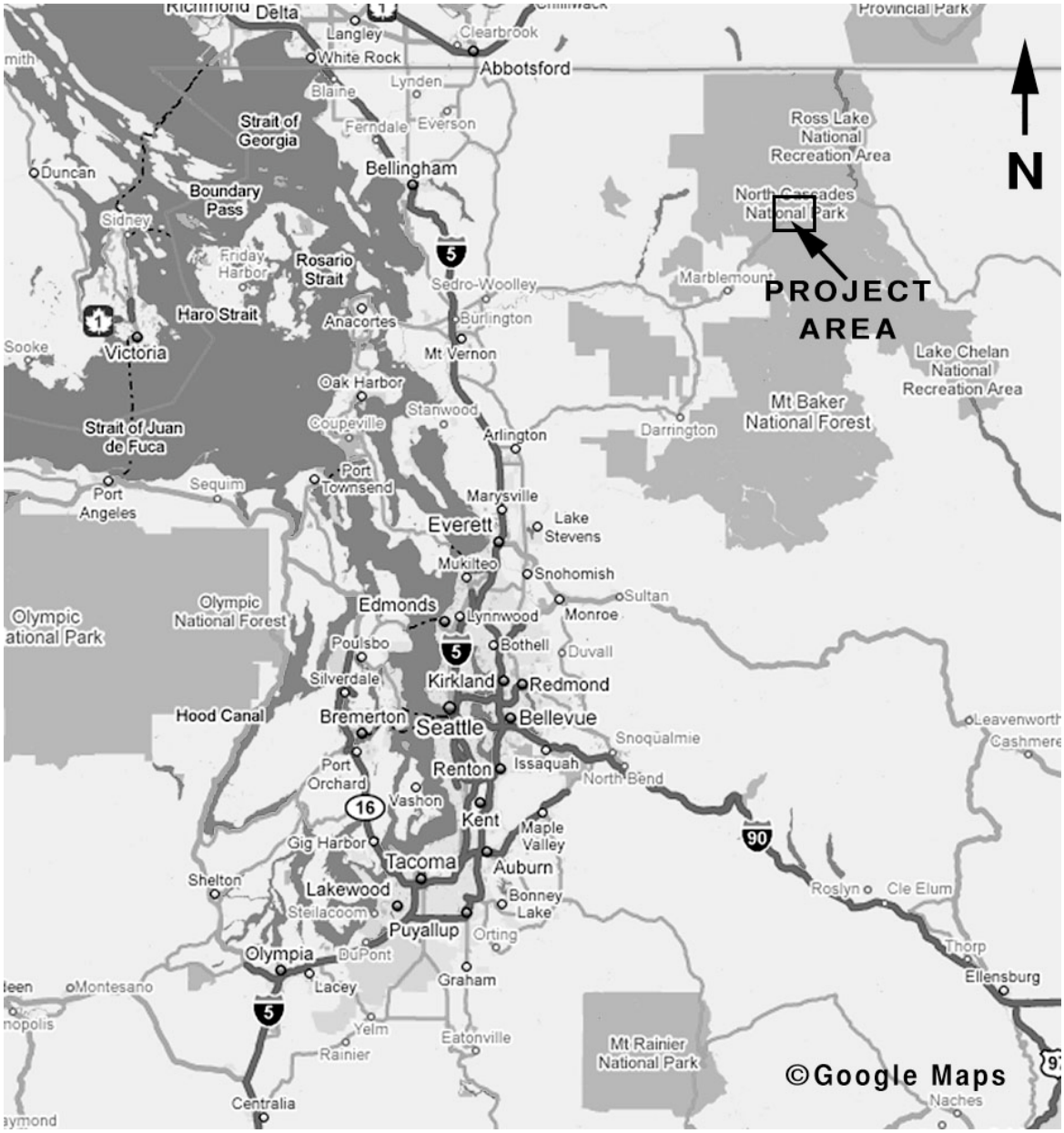


Figure 1. Vicinity map

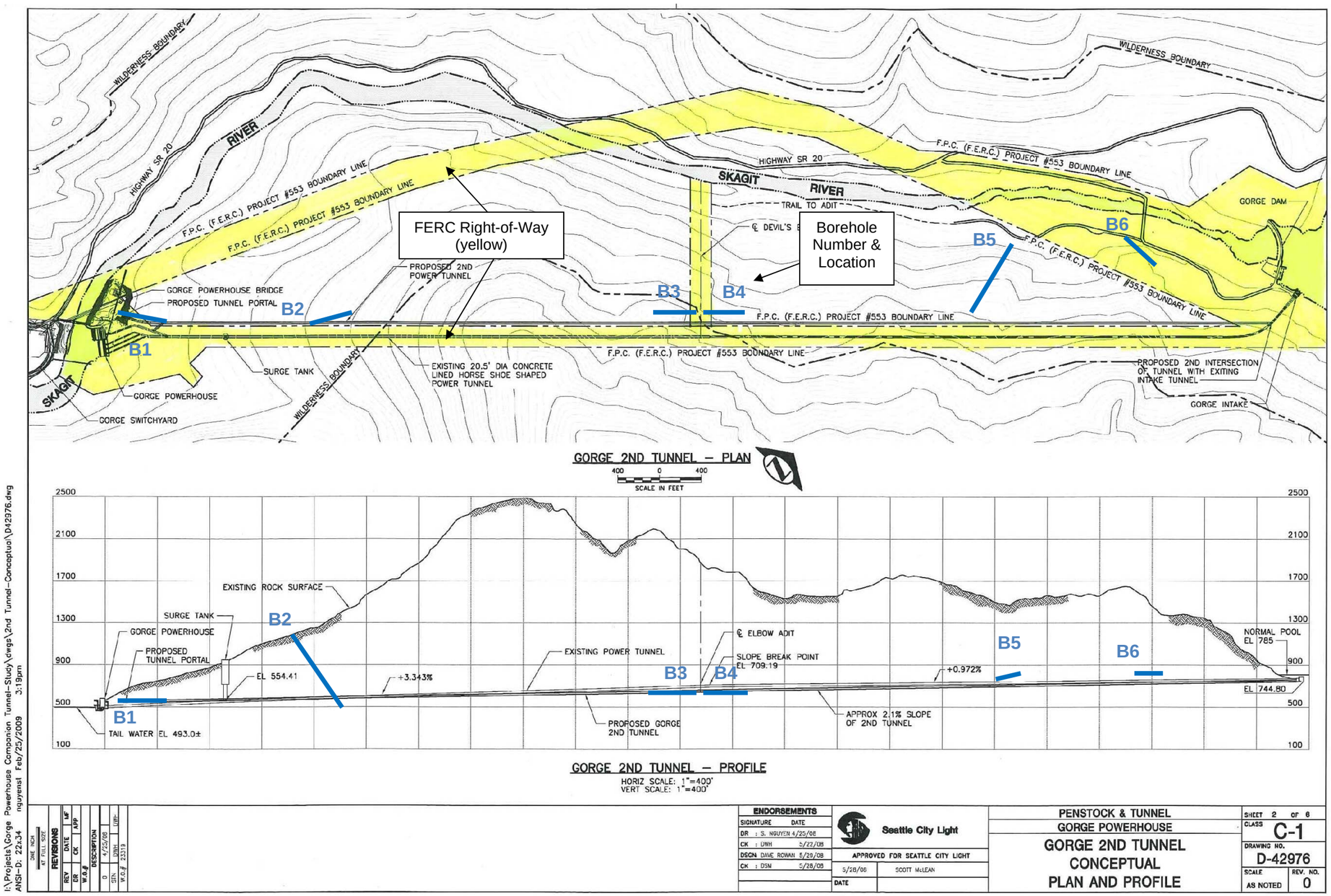


Figure 2. Site Plan with boring iocations

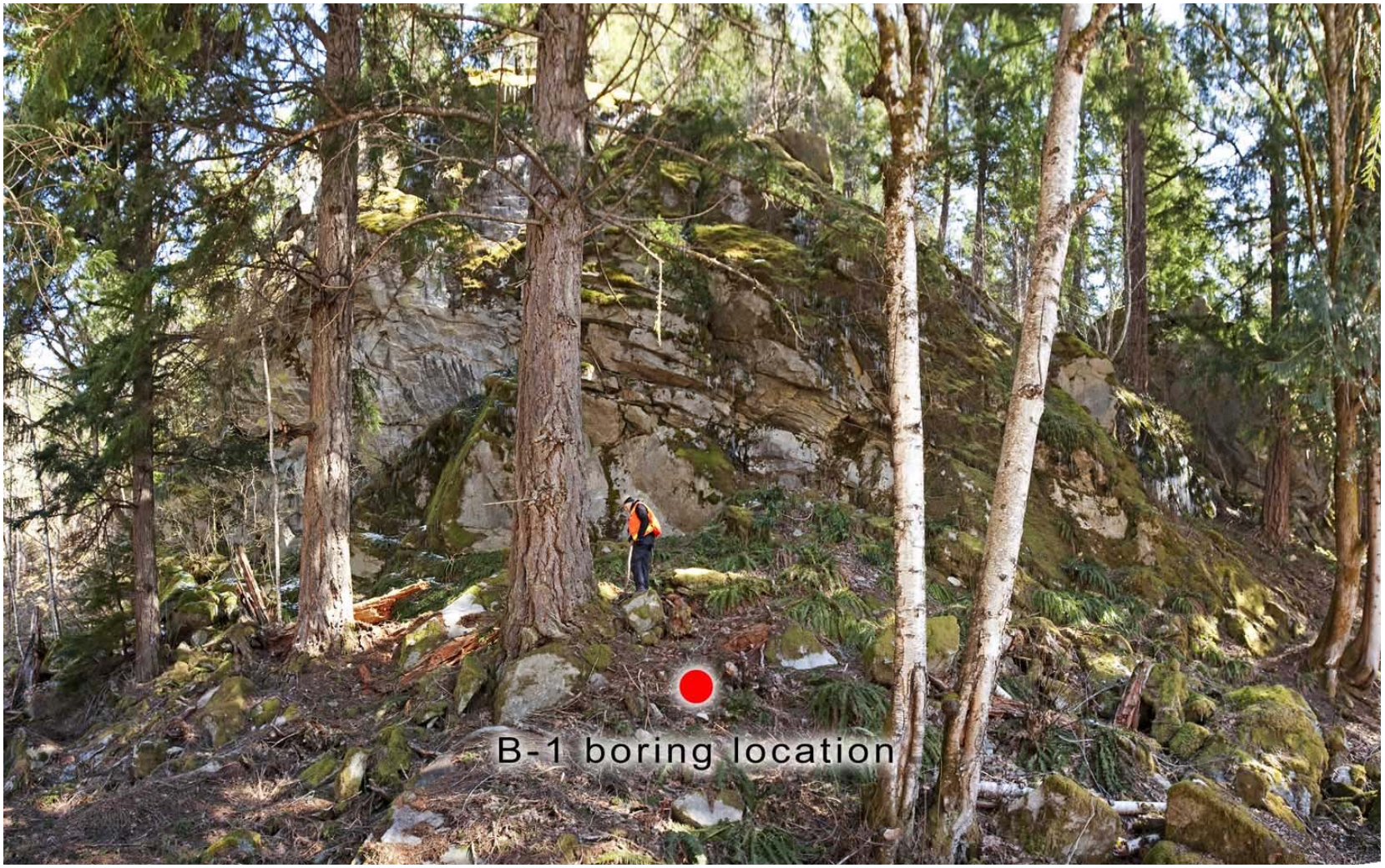


Figure 3. B-1 boring location

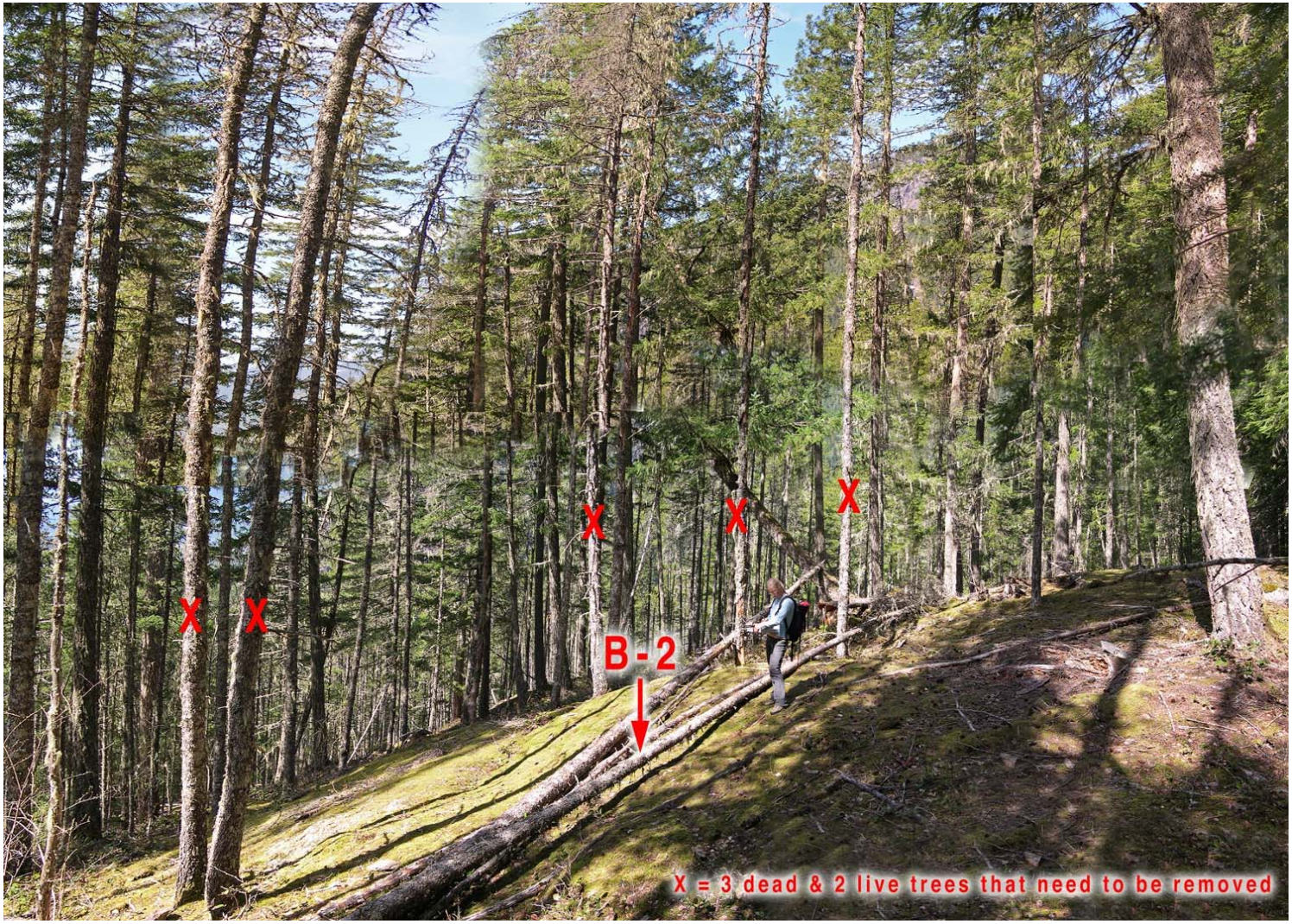


Figure 4. B-2 boring location

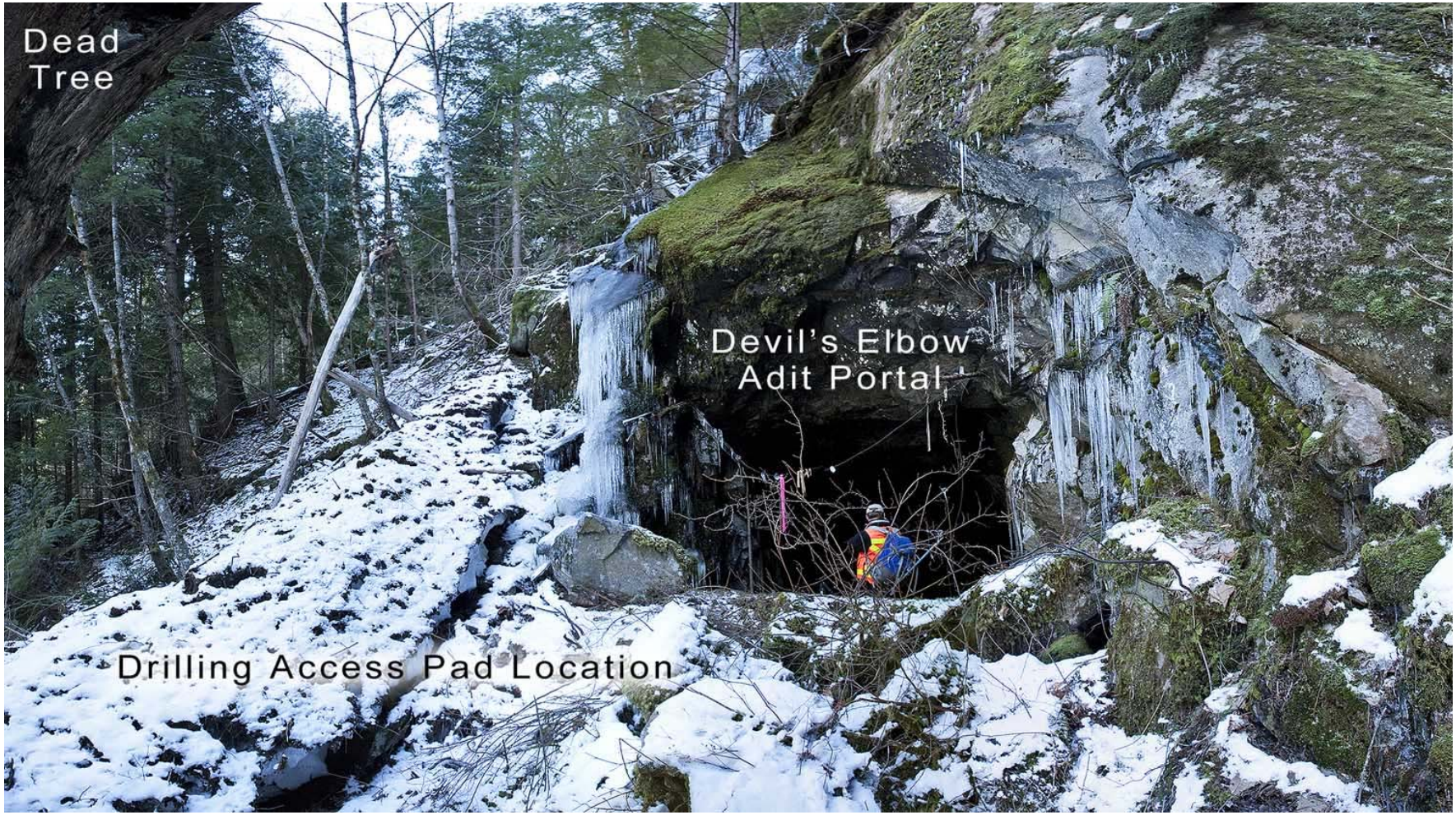


Figure 5. Access to B-3 and B-4 boring locations

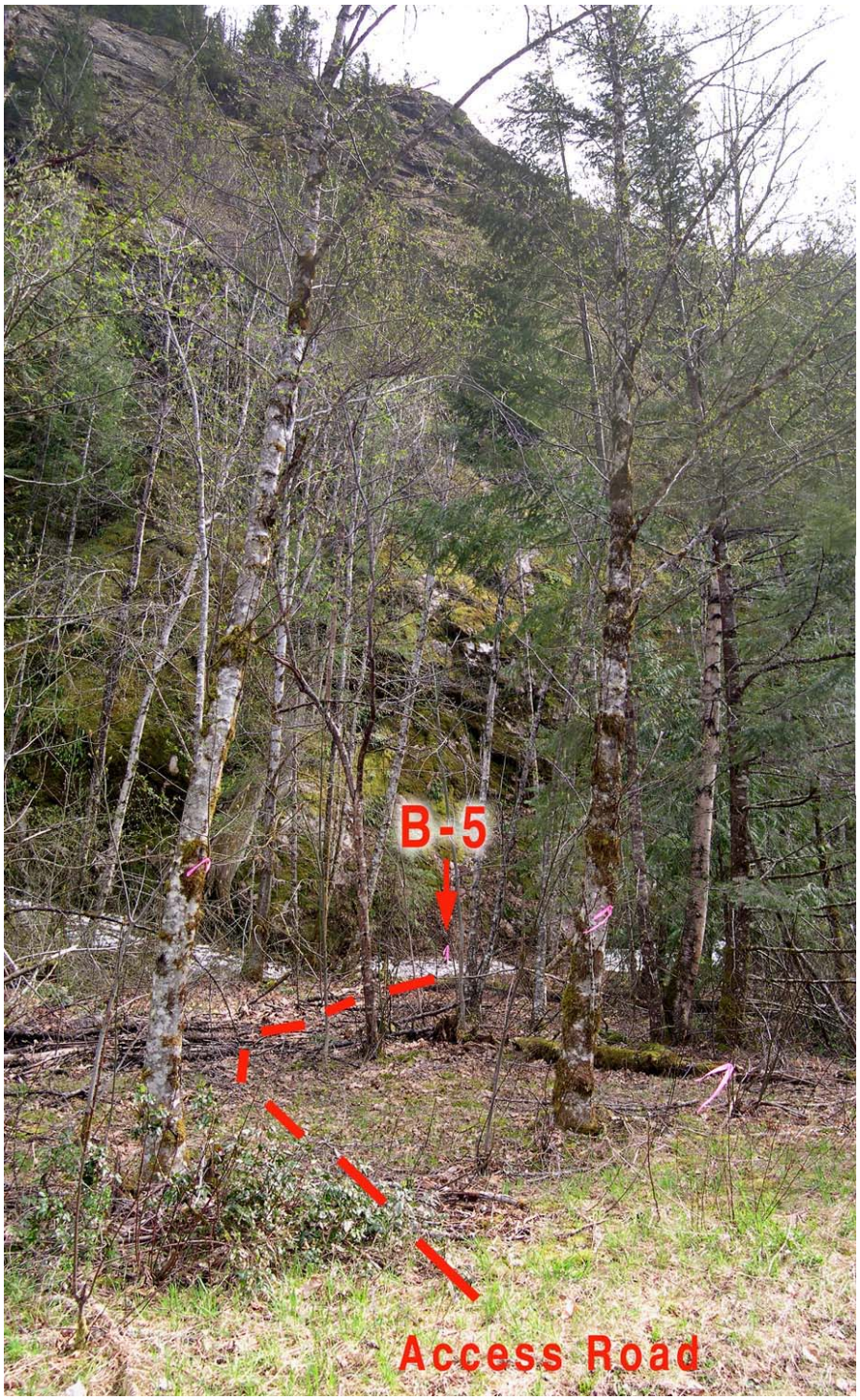


Figure 6. B-5 boring location

Figure 7. B-6 boring location