APPENDIX F5.2
COPCO NO. 1 ACCESS ROAD DESIGN

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1.0 SCOPE

The Copco No.1 Access Road Geotechnical Design Report Appendix contains an overview of the geotechnical design recommendations for temporary construction access roads for Copco dam removal as part of the Klamath River Renewal Project (KRRP).

This document is intended to provide a comprehensive overview of the geotechnical design development for the Copco No. 1 temporary construction access roads as part of the KRRP. The Project Drawings (100%

Design Drawing Package) and Appendix F1 of the 100% Design Report should be reviewed in conjunction with this document. The supporting figures and geotechnical data used for design are documented in the KRRP Geotechnical Data Report, Appendix I – Copco No. 1 Access Road Geotechnical Report.

2.0 METHODS

This investigation used the 100% Project Drawings and information obtained during the Site Investigation (SI) phase to develop geotechnical design parameters and help progress the KRRP transportation infrastructure design. This SI was completed to obtain information on the engineering properties of the rock, soil, groundwater, and to inform the designs and construction techniques for the proposed roads. The engineering properties of the project area rocks and soils were assessed using industry standard methods (e.g., CDC 2001, Williamson 1984, and BOR 2001). The rocks and soils were classified and assessed following the most recent ASTM methods.

The SI was completed in January 2021 (GSI 2021). The test pits, seismic refraction (SR), ground penetrating radar (GPR), and bedrock mapping sites were located along the proposed road alignment in safe accessible locations to characterize the spatial distribution of the terrane, rock, soil, and water conditions. This sampling scheme was intended to assess the spatial and temporal distribution of soil or rock near the ground surface. The SI comprised the following data collection:

- 12 test pits with logs and samples
- 2,940 ft of Seismic Refraction (SR) surveys over 11 transects
- 3,689 ft of Ground Penetrating Radar (GPR) surveys over 17 transects
- Bedrock outcrop surface maps and samples

Design criteria for the temporary construction access roads documented in KP Letter VA21-00436 "KRRP - Copco No. 1 And Copco No. 2 Temporary Construction Access Road – Design Criteria", (March 11, 2021), refer to Appendix F5.1 of this report.

- This phase of the analysis did not evaluate the permanent slope stability of the road prism rock and fill slopes.
- Static Factor of Safety (FOS) for temporary rock cut-slopes = 1.05.
- Seismic FOS for temporary rock cut-slopes = 1.0 (PGA = 0.036 - 100-year return interval).
- Static Factor of Safety (FOS) for temporary rock fill slopes = 1.5.
- Seismic FOS for temporary rock fill slopes = 1.1 (PGA = 0.036 - 100-year return interval).
- For rock cut and fill slopes, construction traffic line loads per VA21-00436.
- All temporary road prisms are on full bench rock cuts or rock fills founded on stable rock or rock rubble.
- New side cast spoils placed over existing loose fill, at least 2 feet above the 1% flood water surface level, and do not increase finished slope height or angle.

3.0 GEOLOGIC CONDITIONS

3.1 SURFACE AND SUBSURFACE CONDITIONS

The project area is underlain mainly by igneous rocks (Figure 1). The rock types include columnar basalt, blocky basalt, and cinder/pyroclastic flows that were erupted within the last 1 to 2 thousand years. The sequence of eruptions is a complex sequence of cinder cone eruptions interspersed with basalt eruptions. During this period of eruptions, the Klamath River was likely blocked by basalt flows, and available geologic data indicate that the river was dammed forming a lake 35 ft. higher than the present reservoir elevation (CDMG 1983). The modern outcrops express the sequence of eruptions where the base of the cinder cone to the north is covered by basalt that flowed from the south (Figure 2). Subsequently, the Klamath River incised through the basalt dam creating the present day river canyon. Diatomaceous earth deposits were used to understand the elevation and extent of the basalt dam (CDMG 1983). Though time, the river cut through the hard and soft rock forming the near vertical canyon walls and intermediate sloped benches formed by softer rock. The blocky and columnar basalt outcrops continuously shed columns of basalt forming colluvial slopes at the base of the outcrops. Occasionally, the rock slope faces topple in mass shedding large areas of loose rock into the river canyon.

The basalt and cinder outcrops were cut into to access the Copco No. 1 and No. 2 dam sites to include railroad and equipment access roads. The rock slopes were blasted and excavated to access the dam sites. Historical photographs show that there were intermittent large rock falls that blocked the rail and road access routes.

During construction, the spoils were side cast, and rail and road prisms are mainly composed of cut and fill. The side cast fill slopes are still present today and cover the lower half of the slopes within the project area (Figure 2). The existing road is supported by loose fill slopes on the outside edge of the road. The fill slopes tend to be composed of loose soil, rock, and metal and wood debris. The existing road traverse the fill slopes and there is active erosion and shallow failures, mainly along the outboard edge.

The SI results indicate that there are several existing road segments with loose uncompacted fill. SR and GPR data taken along and perpendicular to the roads match the direct observations made in the test pits and show that there are large wedges of loose fill along the outside edge of the road from east to west (Figure 2). The fill tends to be between 5 ft. and 20 ft. thick. The surveys detected large voids withing the road prisms especially at the lower end near Copco No. 1 dam.

The full bench rock cut road prisms tend to be stable less the frequent rock fall or topple from the cut-slope. The upper portion of the existing road tends to be in full bench or through cuts.

4.0 GEOLOGIC HAZARDS

4.1 ACTIVE FAULTS AND SEISMIC HAZARD ASSESSMENTS

Project construction and implementation would be subject to a low to moderate risk of damage from fault movement. Fault movement has the potential to affect the stability of the proposed structure(s). According to the CDC (2000), the closest known inactive fault is 16 miles east of the project area. Most of the faults east of the project area are considered active, and the most recent events were 4.3 and 4.4 magnitude earthquakes in 1974 and 2005, respectively. To initiate the dominant seismic hazards of the area, an earthquake would have a magnitude of 8.5 or greater (CDC, 1996).

Seismic movement from earthquakes has the potential to affect the stability of the proposed roads. According to the CDC (1997) and CDC (2006), the project area is not within a mapped Alquist-Priolo Earthquake Hazard Zone. It is unlikely that the proposed roads will be impacted by the effects of a large magnitude earthquake given that they are temporary. The proposed roads could be subjected to frequent smaller magnitude earthquakes. Small earthquakes may cause minor settling or shifting of unconsolidated sediments. Overall, there is a low risk of damaging earthquakes (Peterson 1996, Peterson 1999, and Toppozada, 2000).

4.2 LIQUEFACTION

Liquefaction typically occurs as a result of seismic events that cause the sudden loss of soil shear strength. The cyclic loading from an earthquake triggers liquefaction. The risk of liquefaction is based on the expected seismic event, soil properties, and groundwater depth. For liquefaction to occur the following must be present:

- Granular soils
- Low soil density
- High groundwater table

The project area rock or soils are granular in nature and lie atop dense volcanic rock. The risk of adverse impacts from liquefaction at the project area is low.

4.3 FLOODING HAZARD POTENTIAL

The flood hazard potential is addressed in Appendix F3 Hydrotechnical Design Report for Roads, Bridges, and Culverts.

4.4 DAM INUNDATION HAZARD POTENTIAL

The dam inundation hazard potential is addressed in Appendix F1 Roads, Bridges, and Culverts Design Details.

4.5 STREAM SCOUR

The stream scour hazard potential is addressed in Appendix F3 Hydrotechnical Design Report for Roads, Bridges, and Culverts.

4.6 EXPANSIVE SOILS

Potentially expansive clay soils were not encountered as part of the SI and the risk is low for the proposed road.

4.7 VOLCANIC HAZARDS

The project area is not within an area with recent volcanic activity, and the project area is in a zone that could be impacted by a volcanic eruption. Quantifying the volcanic risk to the project area is beyond the scope of this investigation. Overall, the risk of adverse impacts from volcanic activity at the project area is moderate to low.

4.8 SLOPE STABILITY

The project area is within a region with moderate to high landslide susceptibility. Based on the road locations, topography, and subsurface geology there is a high modern landslide risk. The loose fill slopes are prone to soil creep and shallow debris flows. The rock slopes are prone to rock topple. There are several existing rock slopes with active rock topple along the proposed road alignments. These sections of the roads have a high susceptibility to rock fall and large rock block topple failures.

4.9 TSUNAMIS AND SEICHE

Based on site location, elevation, and tsunami hazard mapping from the CGS website (http://maps.conservation.ca.gov/cgs/informationwarehouse/index.html?map=tsunami) the site is not in a tsunami inundation hazard zone. In addition, oscillatory waves (seiches) are considered unlikely due to the absence of large confined bodies of water in the site area.

4.10 EROSION AND SEDIMENTATION

There is a high erosion and sedimentation risk given that the proposed roads are adjacent to the Klamath River. Any construction related disturbance to the soils will increase the erosion risk, and temporary and permanent erosion control measures need to be implemented, per the Project Drawings and Technical Specifications, to keep storm water from discharging site soils and nutrients into the stream channels. Conceptual erosion and sediment control plans have been developed for each of the proposed road segments (see Project Drawings).

During construction, the contractor needs to implement the Temporary Erosion Control Plans as prescribed on the Project Drawings and California Construction General Permit Storm Water Pollution Prevention Plan (SWPPP) (Erosion and Sedimentation Control, Section 31 25 00) (California Water Board 2010a).

Post construction, the contractor needs to implement final erosion and sediment control measures that follow the Action Plan for the Klamath River Total Maximum Daily Loads (California Water Board 2010b). The final measures shall be implemented as shown on the Project Drawings and include embankment and disturbed area erosion control and controllable sediment discharge BMPs.

4.11 WILDLAND FIRE

The potential risk of wildfire depends on several factors, such as, abundance of flammable vegetation, high winds, topography, and seasonal weather. For the project area, there is a high threat of fire during the dry summer and fall periods due to chaparral and conifer vegetation and high winds. The project area has an extreme to elevated potential for wildfire hazard.

5.0 EARTHWORKS

5.1 SITE PREPARATION

Each project site should be stripped of vegetation and organic debris within the work limits. These materials should be stock piled and may be used as ground cover and revegetation efforts at the end of the project or disposed of offsite. Voids left from removal of debris should be replaced with native fill compacted to 90 percent relative compaction.

Project area stripping should include the demolition and removal of all existing structures including concrete foundations, metal debris, utility poles, underground utilities, concrete debris, vegetation, and other organic material in all the new road corridor and staging/spoils areas. Loose, weak, or otherwise unstable soil or rock in the road alignment corridor should be excavated and evaluated by KP for possible re-use as engineered fill. Utilities that extend into the construction area scheduled to be abandoned should be properly capped at the perimeter of the construction zone or moved as directed in the plans.

It is anticipated that large voids may be encountered during road construction, and voids large than 5 ft. across and 5 ft. deep should be reported to KP immediately and evaluated accordingly by the Project Engineer or designated representative. Based on the SI results, it is likely that abandon blasting adits, voids between large blocks of rock, and areas with decomposed organic matter (e.g., wood). The SI identified several locations with potential adits, and one adit that is known to exist near the north side of Copco No. 1 dam.

5.2 TRENCHES

Given the measured soil conditions, it is likely that the excavations can be sloped at 0.25H:1V with 4 ft. benches to 20 ft. bgs assuming that the Type A soil is homogeneous. At sites where the excavation is greater than 20 ft. deep, trench plates or other shoring methods will be needed due to depth of excavation. In addition, presence of saturated, medium dense, non-cohesive gravel excavations will need to be dewatered if water is present. Other shoring methods may be needed depending on the actual excavation depth and type of soil encountered during construction (OSHA 29 CFR 1926.650, 29 CFR 1926.651, and 29 CFR 1926.652). Shoring below 20 ft. bgs needs to be designed by a registered Professional Engineer. During construction, unusual changes in rock or soil strata should be evaluated by the Engineer or designated representative.

For temporary cut-slopes in soil or weathered rock, the slope angle should be no steeper than 1H:1V. For temporary cut-slopes in hard rock, the slope angle should be no steeper than 0.25H:1V. Final cut-slope angles may vary depending on the rock and soil conditions encountered. Variations in cut-slope angle can be field fit during construction as approved by the Engineer

5.3 CUT-SLOPES

This section provides rock slope recommendations for removal of bedrock in the back slope. Rock slope recommendations are provided for new construction access roads. The rock slope recommendations are based the following:

1. Rock type
2. Discontinuity (bedding, joints, fractures) orientation and frequency
3. Cut Height
4. Weathering
5. Presence of erodible material
6. Road orientation

An optimum rock slope design minimizes risk to the project and also minimizes the amount of excavation and stabilization required. Proper design includes selection of an optimum “safe” cut-slope angle together with an appropriate rock fall catchment area. The cut-slope is often referred to as a “cut-slope angle” vertical to horizontal (e.g., 1/4V:1H). The rock catchment area includes the flat ditch area plus the inslope that ends at the shoulder. The inslope normally varies between 1V:6H and 1V:4H.

Cut-slope angles were derived from an evaluation of rock mass characteristics, attained from a combination of measurement made of exposed bedrock faces. Additional factors considered for cut-slope selection include site conditions (groundwater, roadway orientation, and others) and professional judgement.

The rock slope design process was a trade off between stability and economics. Steep slopes and narrow ditches are usually less expensive to construct than the safer. Given that the geologic structure and type of rock vary considerably at each slope position within the project area, it is difficult to provide general guidelines for design recommendations that fit all circumstances. The following guidelines are created to fit typical conditions common to project area.

Soft rocks, which include principally cinder and pyroclastic rock, can be excavated without blasting. Hard basalt rock, will likely require blasting to excavate, include igneous, metamorphic rocks and carbonates. Tall rock cuts (10 ft to 30 ft in height) should closely follow the design criteria and Project Drawings. In the hard rock types, controlled blasting techniques may be required for final shaping of the cut face. Composite slopes, consisting of both soft and hard rock types (particularly with hard overlying soft) are susceptible to differential erosion and require careful consideration and field review by the Project Engineer or designated representative. Typically, the hard rock layer will be set back about 10 ft from the face of the underlying softer rock (e.g., cinder or loose rock rubble), with an impermeable bench constructed on top of the soft rock layer.

5.4 MATERIALS

Any construction Excavation and fill materials for the various components of the proposed road designs should follow the specifications listed in Table 5.1 according to the type and intended use. These material and placement and compaction, and testing specifications are based on the Copco Access Road design criteria.

Table 5.1 Excavation and Fill Material Types, Specifications and Testing for Copco Temporary Construction Access Roads

KP Material Type	Material Type	Material Specifications	Placement and Compaction Specifications	Compaction Test Type
Site Specific	Structural Sub-Grade	Firm and Unyielding Native Material free of debris, rocks > 4", and organics	Scarified subgrade to 8" depth, moisture conditioned to within 2% optimum moisture, and re-compacted to at least 95% relative compaction or until firm and unyielding under vibratory roller	ASTM D 698
Rock Fill	Rip-Rap	Crushed rock material generally 21” to 36” that consists of angular, durable rock and gravel, and <30% fines	Placed with heavy equipment, not dropped more than 2', compacted until firm and unyielding under mechanical movement of heavy equipment (worked in with appropriately sized excavator or bull dozer)	ASTM D 698

The proposed roads will be built using on-site material. Given that the majority of the roads will be full bench rock cut, there is limited need for material specifications.

For the rock fill along U-300, the material placed in temporary road embankments shall be hard, durable, angular, and shall have a fines content of less than 35% No.200 sieve.

Material shall be placed in maximum 1 ft. lifts and moisture conditioned to optimum levels, as approved by the Engineer during placement.

Backfill material for the temporary rock fill shall be as per the Project drawings in addition to meeting the following placement requirements.

Compaction to 90% relative density, to be achieved through the following observed method specification.

1. Minimum of 4 passes with a 20,000 lb vibratory roller, proof rolled (e.g., loaded 10 cubic yard minimum dump truck) to test for visible deflection, as measured every other lift.
2. For course granular fill (i.e., rock fill), material shall be compacted through track packing (18-ton minimum vehicle weight) as an alternative to vibratory rolling.

Material shall be placed in maximum 18 in. to 24 in. lifts and moisture conditioned to optimum levels, as approved by the Engineer during placement.

Material shall be free of organic debris and shall be moisture conditioned, as approved by the Engineer during placement.

5.5 TEMPORARY ROAD SEISMIC DESIGN

The seismic calculation tables are summarized in Table 5.2 and were developed using the recommended AASHTO seismic design parameters for temporary roads. The shallow subsurface material is classified using the site-specific soil and rock conditions. This classification is based on field observations and the measured engineering soil properties. For temporary structures, the seismic design criteria are based on a 100-year return period (this is equal to a 10% probability of exceedance in 10 years).

Table 5.2 Seismic Design Criteria

Site	Type	Site Class	Return Period (years)	PGA	S_1	S_s	S_{D1}	S_{DS}
Copco Construction Access Roads	Temporary	B	100	0.036	0.043	0.089	0.043	0.089

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