K3.15 GEOHAZARDS AND SEISMIC CONDITIONS

This appendix contains additional technical information on the following topics related to the affected environment for geohazards described in Section 3.15, Geohazards and Seismic Conditions:

- Liquefaction processes and depth
- Baseline geotechnical data coverage at the mine site

K3.15.1 Liquefaction

Liquefaction occurs when a saturated or partially saturated soil loses strength and stiffness in response to an applied stress, such as shaking from an earthquake. When soil is saturated by water, the water fills the gaps between the soil grains (i.e., pore spaces). In response to stress, this water increases in pressure and is forced to flow out of the soil toward zones of lower pressure, usually up to the ground surface. However, if the loading is rapidly applied and large enough, or is repeated many times (e.g., earthquake shaking), the water cannot flow out in time before the next cycle of load is applied and water pressure could build up and exceed the forces (contact stresses) between the grains of soil that keep them in contact with one another. These contacts between grains are the means by which weight from structures and overlying soil layers are transferred from the ground to deeper soil or rock. This loss of soil structure causes the soil to lose its strength, which triggers liquefaction where the soil behaves like a liquid.

The depth to which liquefaction can occur has implications for the behavior of saturated tailings in an earthquake (see Section 4.15, Geohazards and Seismic Conditions). Knowledge on the maximum depth of liquefaction has evolved in recent years because of large global earthquakes and resultant liquefaction (Bray 2013; Stewart and Knox 1995; Tchakalova 2018; WSDOT 2013). The Washington State Department of Transportation Geotechnical Design Manual M 46-03.09 limits the depth for considering liquefaction to 80 feet, but suggests that analyses be performed if loose materials are below 80 feet. Stewart and Knox (1995) conclude that it is possible for excessive porewater pressures to occur below 100 feet; these pressures are sufficient to overcome the stiffness created by overburden pressures and exceed the limit for liquefaction, and great earthquakes can generate stresses of sufficient intensity and duration to produce liquefaction conditions in unconsolidated sediments, even below 1,000 feet. Tchakalova (2018) adds that the maximum depth at which liquefaction can occur is probably the same as the maximum depth at which sands and silts can remain unconsolidated and maintain sufficient porosity and hydraulic conductivity, and that whatever those depths, earthquakes of M8.0 or greater can produce stresses in the hypocenter and epicenter zones sufficient to overcome overburden pressures below 1,000 feet.

K3.15.2 Baseline Geotechnical Data Coverage

Table K3.15-1 lists the approximate number of geotechnical drillholes, test pits, and seismic lines collected in and near the footprint of different facilities at the mine site. A summary of overburden deposits and bedrock encountered in each area is provided in Section 3.15, Geohazards and Seismic Conditions. Additional details regarding geotechnical conditions beneath the footprints of major embankments are provided in Appendix K4.15, Geohazards and Seismic Conditions.

Table K3.15-1: Baseline Geotechnical Data Coverage at Mine Site

Area	Facilities	Number of Drill Holes[1]	Number of Test Pits[1]	Number of Seismic Lines
NFK-West	Bulk TSF main embankment, impoundment, and quarries	39	37	9
NFK-East	Pyritic TSF and associated SCPs	14	38	9
NFK-North	Main WMP, bulk TSF main embankment SCP, emergency dump pond	29	13	0
Pit Area	Open pit and rim	31	30	6
Bulk TSF South	Bulk TSF South embankment, and associated SCP and sediment pond	11	10	2
South of Pit Area	Open pit WMP, pit overburden stockpile, and associated sediment ponds	7	20	3

Notes:

[1] Numbers are approximate as there may be overlap between adjacent areas.

NFK = North Fork Koktuli

SCP = seepage collection pond

TSF = tailings storage facility

WMP = water management pond

Source: Knight Piésold 2011c; PLP 2013a; PLP 2018-RFI 014; PLP 2019-RFI 014b