K3.15 GEOHAZARDS

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

- 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 substantially loses strength and stiffness in response to an applied stress, such as earthquake shaking, which causes it to behave like a liquid. When a soil is saturated by water, which often exists below the groundwater table, the water fills gaps between soil grains (i.e., pore spaces). In response to the soil compressing, this water increases in pressure and is forced to flow out of the soil to zones of low 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 the 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, and triggers liquefaction.

The depth to which liquefaction can occur has implications for the behavior of saturated tailings in an earthquake (see Section 4.15, Geohazards). 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 to determine liquefaction probability if loose materials are below 80 feet. Stewart and Knox (1995) conclude it is possible for excessive porewater pressures to exist considerably below 100 feet, that are sufficient to overcome the stiffness created by overburden pressures and exceed the thickness for liquefaction, and that great earthquakes can generate stresses of sufficient intensity and duration to produce liquefaction conditions in unconsolidated sediments 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 a 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.

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