4.2 Geologic Resources and Geotechnical Hazards

4.2.1 Effects Analysis Indicators and Methodology of Analysis

The analysis of effects to geologic resources and geotechnical hazards includes the following issues and indicators:

Issue: The minerals present at the site are economically valuable, and may contribute to the national goal of being economically independent in strategic metals, such as antimony.

***Indicators**:*

- Amount and value of ore extracted
- Depletion of mineral resources

Issue: Mining activities could change the existing topography and leave physical hazards if not properly designed and managed.

***Indicators**:*

- Alteration of natural topography
- Unstable slopes

Issue: Geological and geotechnical stability of the Stibnite Gold Project (SGP) facilities, including the tailings storage facility (TSF) and other mine components.

Indicators:

- Geological/Geotechnical suitability of the selected locations for the mining and facilities to be constructed.
- Long-term geologic/geotechnical stability of the proposed structures.

Geologic resources and geotechnical hazards were analyzed using data generated by Midas Gold Idaho, Inc. (Midas Gold) as part of the SGP development and other sources of information such as SRK Consulting (2012); STRATA, Inc. (STRATA) (2014a, 2016); Tierra Group 2018; M3 Engineering and Technology (2019); and Gillerman et al. 2019, as well as Geographic Information System spatial analyses, and review of additional scientific literature and applicable regulations.

4.2.2 Direct and Indirect Effects

The following analysis of effects associated with geologic resources and geotechnical hazards is considered within the overall context of the local and regional geology. Elements of this context include:

- A majority of the analysis area is on National Forest System lands within the Salmon River Mountains, a high-relief mountainous physiographic province of central Idaho with the presence of steep slopes that are subject to landslides and avalanches.
- The analysis area is comprised of relatively common types of rocks to the region (see Chapter 3.2) and common landforms (e.g., glacial and fluvial geomorphic features, asymmetric hillslopes).
- The area lacks protected or managed geologic resources, such as cave and karst formations, and contains rock units that generally preclude preservation of fossils.
- The analysis area is within the seismically active Centennial Tectonic Belt and it is anticipated to be subjected to earthquake ground shaking (URS Corporation 2013).
- The mine site includes disturbed areas as a result of previous mining activities, resulting in the presence of legacy mine features with associated slope stability and seismic stability considerations.
- The ore of interest (i.e., gold-, silver-, and antimony-bearing material) is economically valuable and/or of strategic importance.

4.2.2.1 Alternative 1

4.2.2.1.1 MINE SITE

Mining methods would include open pit mining and recovery and re-processing legacy tailings. In addition, the SGP includes limited underground exploration and sampling to be accessed via the Scout exploration decline (see Chapter 3.2, Affected Environment, and Chapter 2, Alternatives). The legacy tailings are in the Meadow Creek valley. Open pit mining methods would be implemented for three known mineral deposits: Yellow Pine, Hangar Flats, and West End. Reprocessing of the legacy tailings would be conducted early during SGP operations to mitigate discharge of legacy-tailings-derived sediment and heavy metal-containing leachates into Meadow Creek.

The legacy tailings, which were deposited in the Meadow Creek valley bottom without a liner system, are currently under the spent heap leach ore disposal area but within the planned footprint of the proposed Hangar Flats development rock storage facility (DRSF). The spent heap leach ore would be removed and reused for construction purposes as appropriate. The legacy tailings would then be removed and reprocessed.

Although there would be temporal overlap in the mine development and operations, the general sequence of mining would be the Yellow Pine deposit first, Hangar Flats deposit second, and the West End deposit third. This mining sequence is guided by the reclamation aspects of the SGP, which include backfilling the Yellow Pine pit with West End development rock to reclaim the approximate original gradient of the East Fork South Fork Salmon River (EFSFSR), to provide permanent fish passage, and facilitate aquatic habitat enhancement.

Mining of the three mineral deposits would be conducted using conventional open pit surface mining techniques with a series of benches from which development rock and ore would be extracted using standard mining equipment including blast-hole drills, shovels, loaders, and off-highway trucks.

4.2.2.1.1.1 Bedrock Geology and Mineral Resources

Approximately 168 million tons of ore and development rock would be mined from the Yellow Pine pit. Approximately 102 million tons of ore and development rock would be mined from the Hangar Flats pit. Approximately 166 million tons of ore and development rock would be mined from the West End pit.

Within the context of operations at mine pits, there would be direct impacts to bedrock during mining. The geologic resources impacted by the SGP mine pits would consist of relatively common types of rocks and the ore of interest. Depletion of the ore bodies would occur within the mine pits. Impacts to bedrock geology would be permanent from ground disturbances and reshaping of landforms by excavation and direct removal of materials.

4.2.2.1.1.2 Surficial Geology and Topography

Within the context of the mining area, there would be direct impacts to landforms, including hills, ridges, and valleys. Workings, tailings, and storage areas would be excavated and modified for reclamation, material re-use, or reprocessing. The effects would be localized and limited to discrete portions of the analysis area. After closure, the areas impacted by operations would be contoured and graded to blend into the surrounding landscape and the Yellow Pine pit would be backfilled. Some pit highwalls would remain post-closure.

4.2.2.1.1.3 Seismic Hazards

Seismic hazards, such as earthquakes, are a common geologic phenomenon in central Idaho and design and construction of dams, bridges, pipelines, within a mining area, is governed by regulation. In the event of a major earthquake near the mine site, impacts to mine site structures would range from low intensity, meaning no noticeable damage to structures, to moderate intensity, in which facility design is adequate to withstand earthquakes. Overall impacts resulting from earthquakes would be expected to cause minor to moderate damage, with a low probability of higher-intensity events that could cause greater damage. Impacts from earthquakes could be minimized with mitigative measures such as incorporation of existing geotechnical design standards and building code standards, as well as construction quality control, operations and maintenance, and surveillance.

Temporary effects from seismic hazards include minor damage that is easily reparable to permanent effects such as failure of a pit wall. Geographic extent of effects would be mostly localized, within the immediate vicinity of the various structure footprints. There would be a low probability of high-intensity effects at certain structures and SGP phases, such as pit walls in post-closure. These effects would be reduced to moderate severity through incorporation of standard geotechnical design criteria for pit walls, coffer dam, impoundment, slope, bench, and foundation design. Use of development rock to provide overlapping buttress support for the TSF would improve the geotechnical stability provided by the standard TSF embankments (see Geotechnical Stability Impacts, below, for more information).

4.2.2.1.1.4 Mass Wasting Hazards

Several landslides have been identified within the footprints of the proposed Hangar Flats and Yellow Pine pits, as shown on **Figure 3.2-5** (STRATA 2014a). The pits would be excavated as part of overall mining operations and hazards associated with these features within the footprint of the open pit would be removed.

Known landslides and rockfalls outside of the pits are not anticipated to cause adverse effects on mine operations (STRATA 2014a). The geographic extent of effects would be localized, within the immediate vicinity of these rockfall and landslide features. Effects would be temporary including minor damage that is easily reparable. It is possible that a rockfall or landslide could occur from a seismic event and cause greater effects on operations (URS Corporation 2013). Such high-intensity effects from mass wasting would be reduced to moderate-intensity effects through incorporation of existing geotechnical design standards and building code standards, as well as construction quality control, operations and maintenance, and surveillance.

Several areas of the mine site are within avalanche hazard zones described in 2019 by Midas Gold based on information from Midas Gold, Boise National Forest, and Payette National Forest (**Figure 3.2-5**) (Midas Gold 2019). Avalanche hazards are already present in the analysis area, and would not be substantially exacerbated by the SGP. Avalanche occurrence is largely a result of a combination of three factors: weather, snowpack, and terrain. The SGP would not substantially alter these factors. Blasting associated with mining operations could trigger avalanches; however, this would likely cause more frequent but less severe avalanches than would naturally occur without blasting. Presence of personnel at the mine site and increased value of facilities and structures as a result of Alternative 1 could increase the magnitude of impact through property damage and personal injury or loss of life from avalanches.

4.2.2.1.2 GEOTECHNICAL STABILITY OF PROPOSED MINE SITE STRUCTURES

4.2.2.1.2.1 TSF Dam and Hangar Flats DRSF

Excavation and processing of mineral resources proposed under Alternative 1 would produce fine-grained tailings with high water content to form a slurry. The tailings would be thickened, and process water recovered (tailings would be approximately 55 percent solids), neutralized, and pumped to the TSF (see Chapter 2, Alternatives, and Midas Gold 2016).

A slope stability analysis of the TSF dam design including the buttressing effect on the TSF dam by the Hangar Flats DRSF was performed by Tierra Group (2017). Slope stability analyses were performed for static or normal conditions and for a facility under earthquake event loading conditions, representing pseudo-static conditions. The TSF and Hangar Flats DRSF were analyzed to determine factors of safety[1] for two potential failure surfaces: 1) full height failure of the Hangar Flats DRSF; and 2) TSF dam failure resulting in loss of tailings containment.

Factors affecting slope stability include the height and the angle of the slope, soil properties, pore pressure within the slope, and external forces such as seismic ground acceleration. The term “factor of safety” is used to express how much stronger a feature is (e.g., tailings dam) to withstand the calculated load imposed on the structure. Factors of safety were calculated based on the currently proposed design of the Hangar Flats DRSF and the TSF dam (**Table 4.2-1**). At a factor of safety of 1.0 the two forces (design dam strength and load) are in balance – meaning the feature is not designed with any additional safety margin to withstand the intended load. The required regulatory ratio per Idaho Administrative Procedures Act (IDAPA) 37.03.05 for tailings dams under static (normal) conditions is 1.50 and under pseudo-static (earthquake) conditions is 1.0.

Table 4.2-1 Calculated Factors of Safety for Hangar Flats DRSF and TSF Dam

Case	Static Factor of Safety	Pseudo-Static (Operations) Factor of Safety	Pseudo-Static (Closure) Factor of Safety
Hangar Flats DRSF	2.58	2.20	1.46
TSF Dam	4.09	3.17	1.81

Table Source: Tierra Group 2017

Table Notes:

Minimum factor of safety for static load is 1.50; minimum factor of safety for earthquake load (pseudo-static) is 1.0 (IDAPA 37.03.05).

These static factor of safety levels for the Hangar Flats DRSF and the TSF would likely result in an annual probability of failure <10^{-7} or 1:10,000,000 in any individual year (Herza et al. 2018), assuming design, construction, maintenance, and oversite of the structure is performed at the highest levels of industry standard. Such a frequency of failure is considered to be extremely low.

Results of the Tierra Group (2017) study indicate the TSF dam and Hangar Flats DRSF would be stable under pseudo-static conditions. Pseudo-static conditions refer to additional load

[1] Factor of safety describes the safety margin and is calculated by the strength of the resisting forces divided by the strength of the stress imparted to the feature/structure (in this case, the TSF dam).

potential placed on the structure due to external forces, in this case an earthquake (Tierra Group 2017).

Earthquakes considered as part of the slope stability analysis by Tierra Group (2017) are:

- During operations with a 475-year return period[2] earthquake
- During post-closure with the maximum credible earthquake (MCE)[3].

The factor of safety of the design of the Hangar Flats DRSF and the TSF are within the levels required by regulation for maintaining geotechnical stability under normal, and earthquake conditions, provided they are designed, constructed and monitored in accordance with standard engineering practices.

4.2.2.1.2.2 Fiddle DRSF and West End DRSF

The Fiddle DRSF and West End DRSF would be constructed at a 2.5 (horizontal) to 1 (vertical) slope (2.5H:1V) (Midas Gold 2016) These two facilities would be regraded at closure to an overall slope of 3.5H:1V for the Fiddle DRSF and 3.2H:1V for the West End DRSF. In general, a 3:1 slope design is considered to be protective against a slope failure under most conditions. It is approximately the same as the slope of many of the surrounding natural areas, including the hillsides both north and south of Fiddle Creek.

As part of closure and final reclamation, the top of the Fiddle DRSF would be graded to promote positive drainage and prevent ponding of water on top of the development rock. The lower portion, or “toe,” of the DRSFs would be graded and seeded to promote facility stabilization and to mitigate sediment generation and migration. Fiddle Creek would be reestablished in a surface channel routed over the reclaimed Fiddle DRSF (see Chapter 2, Alternatives). Riparian plantings of grasses and shrubs, particularly willows, would provide cover to the reconstructed channel to provide riparian habitat, keep water shaded and cool, and stabilize the landform. The DRSF grading and contouring would produce a final topography that would conform to and blend with the surrounding landscape, as well as to produce a permanent and stable landform.

The waste rock would be extracted by the same means as ore rock via blasting and is anticipated to consist of angular-shaped and competent (i.e., strong and resistant to breaking, high compressive strength) granitic rocks (e.g., granodiorite), quartzite, and marble. Based on the size and type of the materials placed in the DRSFs, and the slope of the DRSF, the design would appear to be effective and would likely result in long term geotechnical stability of the features.

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[2] Return period (or recurrence interval) is the estimated average time between earthquake events.

[3] Maximum credible earthquake (MCE) is the largest earthquake that reasonably appears capable of occurring under the conditions of the presently known geological environment (IDAPA 36.03.06). The MCE represents the most severe ground shaking that could be expected at the site (return period from 2,500 years up to that of the MCE) for which structures must be designed to resist collapse and uncontrolled release.

4.2.2.1.2.3 Pit Slopes

A probabilistic geotechnical analysis was used to evaluate overall pit slope stability and compute Probability of Instability (POI) along specific cross-sectional transects within each of the pits (STRATA 2014b). The slope stability analyses rely on measured density and shear strength of the geologic units. POI was used to calculate appropriate bench widths. A bench is a ledge formed by excavating into the side of the pit, like a step, during mining. The slope stability information and POI is used to help determine the optimal bench width during mining – to be most efficient in rock extraction and yet maintain stability of the bench. Typically, in mining applications the acceptable POI value is in the range of 0.03 to 0.15, depending on potential impacts of slope movement. The higher the POI number, the less stable the bench or slope. Temporary slopes, such as the pit walls, often have recommended POI values near the upper end of this range, while long-term slopes have values near the lower end of the range. For a three-meter-wide bench, the POI for each pit area is as follows:

- Yellow Pine pit – POI 0.005 to 0.091
- West End pit – POI 0.001 to 0.007
- Hangar Flats pit – POI 0.001 to 0.012.

During the STRATA study (2014b) there was one area in the West End pit (on the north and west wall) with a computed POI for an assumed three-meter bench of 0.274 to 0.332 – higher than the acceptable POI range described above. Therefore, the bench width in this area would need to be designed wider than three meters.

The design of the pits includes the appropriate setback and benching in accordance with standard engineering principles and practices. Based on the design, and the strength of the underlying bedrock, failure of the pit walls during the scope of the SGP and beyond is considered to be unlikely.

4.2.2.1.3 GEOTECHNICAL SUITABILITY OF MINE STRUCTURE LOCATION

4.2.2.1.3.1 TSF Dam and Hangar Flats DRSF

Regarding geotechnical suitability of the proposed locations of the TSF and Hangar Flat DRSF, elements of design and construction that were used in screening alternative locations include requirement for site conditions that must be amenable for: meeting design criteria and considerations for tailing storage; a TSF with low-permeability liner; tailings dewatering methodology and construction of TSF underdrain system; containment capacity; avoidance of side-hill locations and steep topography; avoidance of excessive embankment (i.e., dam) heights; avoidance of areas that would preclude using placement of DRSF as buttress material; and downstream embankment construction (Midas Gold 2016, Appendix G). Midas Gold (2016) describes the evaluation of alternative sites for the TSF. The Meadow Creek valley site is surrounded by mountain topography that would be above the dam crest at peak processing. There are identified rockfalls above the Meadow Creek valley site (STRATA 2014a) that could impact the integrity of the liner during initial construction, but these risks can be mitigated with engineering controls (e.g., berms, rock nets, rock-fall berms).

The underlying materials and slope stability have been characterized by numerous investigations as described in Chapter 3.2, Affected Environment, and have been determined to be suitable for the proposed structures based on geotechnical investigations. The TSF and DRSF area include a discontinuous 5-foot thick layer of peat which would be removed along with topsoil and other potentially compressible/weak silt and clay soils encountered) during construction. The underlying bedrock is more than sufficiently competent to support the proposed structures because the rock types consist of quartz monzonite, diorite, granite and rhyolite (Tierra Group 2018). These engineering properties of these rock types includes high compressive strength (the resistance of a material to breaking under compression).

4.2.2.1.3.2 Fiddle DRSF and West End DRSF

The load imposed from waste rock placed in the Fiddle and West End DRSFs would be much less than the Hangar Flats DRSF and the TSF structures. The Fiddle and West End DRSF structures are large, but have a low slope, and would be placed on competent underlying bedrock with the soil removed. As such, based on currently available design and site information, both locations are suitable for the structures proposed with adherence to standard construction protocols for the placement and construction of this type of facility.

4.2.2.1.3.3 Pit Slope Design

The location of the pits is determined by the location of the ore rock to be extracted and cannot be altered or moved. The locations appear to be suitable for the proposed mining methods, with appropriate engineering setbacks and bench design.

4.2.2.1.4 POTENTIAL FAILURE SCENARIOS

4.2.2.1.4.1 TSF Dam and Hangar Flats DRSF

Based on the slope stability analysis of the proposed design of the TSF dam (Tierra Group 2017), failure of the TSF dam from a seismic event is considered to have extremely low probability. Therefore, analysis of failure-related effects is not included in this NEPA analysis. Design and construction of the TSF dam would be required to comply with regulations at IDAPA Section 37.03.05, Mine Tailings Impoundment Structure Rules. The pseudo-static (i.e., earthquake load) Factor of Safety for the TSF dam with the downstream design and buttressing from DRSF, has been calculated for the design earthquake events: once in 475-year event for operations phase; and the MCE event for post-closure phase. At TSF complete build-out, the operations-phase pseudo-static Factor of Safety would be 3.17, more than three times the minimum earthquake load Factor of Safety 1.00, per IDAPA Section 37.03.0. The post-closure phase Factor of Safety would be 1.81. The MCE event used for post-closure stability analysis is a much longer return period, meaning there is a lower probability of occurrence than the 475-year return period earthquake, but results in higher peak ground acceleration (see Section 3.2, Affected Environment, for information on peak ground acceleration). Additionally, at complete build-out of the TSF, the static load Factor of Safety would be 4.09, which is well above the minimum required static Factor of Safety of 1.50 per regulations at IDAPA Section 37.03.05.

Mears and Wilber Engineering (2013) evaluated the avalanche hazard around the TSF and the Hangar Flats DRSF. The assessment identified areas of high, moderate, and low risk of avalanche activity. The assessment indicates that both the TSF and Hangar Flats DRSF have a risk of being impacted by avalanches. Associated impacts from avalanches would be expected to be contained within the TSF or DRSF and are not expected to cause additional impacts.

4.2.2.1.4.2 Fiddle DRSF and West End DRSF

Based on the slope and design of the DRSFs and nature of the angular and competent rock placed in the DRSF, failure appears unlikely. Because of the attributes of the angular competent rock, a failure of these DRSF structures would result in only small slides at the toe of the DRSF. Impacts would be limited to the area immediately downgradient of the DRSF, and would consist of localized impacts to soil and vegetation. There would be no expected impacts to surface water bodies. See Chapter 2, Alternatives, for more description about routing of Fiddle and West End creeks around these DRSF facilities.

4.2.2.1.4.3 Pit Slope Design

Overall it is unlikely that failure of the pit slope, before or after mining, would result in significant environmental impacts to the SGP. This conclusion is based on the rock types (granite, marble, etc.), but also the edges and benches of the existing Yellow Pine, Midnight, and West End pits, which are still well defined since historic mining ceased. However, such a failure could result in socioeconomic impacts to the area, shutting down the mine for some period of time. A pit slope failure could impact health and safety of mine workers. Slumps or collapse post-mining into the resulting pit lakes at Hangar Flats and West End pits could result in water overtopping the rim of the pit lake, sending water downstream. West End pit water levels, water management, and water quality are described Section 4.9, Surface Water and Groundwater Quality.

4.2.2.1.5 MINE SITE SUPPORT FACILITIES AND INFRASTRUCTURE

Mine site support facilities and infrastructure that would potentially impact geology or be affected by geologic or geotechnical hazards include at the mine administration office, maintenance yards, haul roads, ore processing plant, Scout underground exploration portal and decline (located south of the planned ore processing plant (see Chapter 2, **Figure 2.3-2**), and storage facilities. New infrastructure would be located in areas that best facilitate operations without inhibiting access to mineral deposits or negatively impacting habitat. To the extent possible, new infrastructure would be placed within or near historically used areas.

Impacts would be minor provided mine support facilities and infrastructure would be designed in accordance with applicable building codes and in accordance with recommendations of site-specific geotechnical design reports.

4.2.2.1.5.1 Bedrock and Surficial Geology and Topography

Within the context of a legacy mining area, there would be direct impacts to bedrock during construction of new support facilities and infrastructure (e.g., ore processing facilities and new DRSFs and TSF). There also would be direct impacts to landforms including hills, ridges, and valleys. The effects would be localized, as they would be limited to discrete portions of the mine site in the immediate vicinity of proposed new facilities. The geologic resources impacted by construction of mine site support facilities under Alternative 1 would consist of relatively common types of rocks and the ore of interest.

4.2.2.1.5.2 Seismic Hazards

Earthquakes are a common geologic phenomenon in central Idaho and development of certain structures (e.g., dams, bridges, pipelines) is governed by regulation. In the event of an earthquake near the analysis area, effects to mine site support facilities and associated infrastructure are expected to range from low intensity effects (e.g., ground shaking) that may or may not be noticeable, to moderate intensity (e.g., design is adequate to withstand earthquakes), with a low probability of high-intensity effects at certain structures. Effects would range from temporary (e.g., minor damage that is easily reparable) to permanent (e.g., lateral displacement at fault crossings). The geographic extent of effects would be mostly localized, within the immediate vicinity of the various facility footprints. Impacts would be reduced to moderate intensity effects through incorporation of existing geotechnical design standards and building code standards, as well as construction quality control, operations and maintenance, and surveillance.

4.2.2.1.5.3 Mass Wasting Hazards

Although several mass wasting features have been identified in the vicinity of proposed mine support facilities and infrastructure (**Figure 3.2-5**), the proposed facilities' sites are not within the area to the south of the confluence of EFSFSR and Meadow Creek, which is reported to include soils conditions that are unsuitable as a foundation material (STRATA 2014a).

There is an ancient (glacial-age) landslide upslope of the proposed worker housing facility, about 1.3 miles upstream from the EFSFSR confluence with Meadow Creek (see Chapter 3.2, under "Southeast Area") (**Figure 3.2-5**). These glacial-age landslides are associated with groundwater seeps on steep slopes and may experience creep during wet periods (STRATA 2014a). Construction of the worker housing facility is not expected to exacerbate existing landslide hazards, provided the toe of the existing landslide is not disturbed during construction.

The geographic extent of effects would be mostly localized, within the immediate vicinity of the existing rockfall and landslide features. Effects would mostly be temporary (e.g., minor damage that is easily reparable), although there is a low probability of high-intensity effects from a major rockfall or landslide event, that would be reduced to moderate through incorporation of existing geotechnical design standards and recommendations of the geologic hazard assessment for additional geotechnical investigation at any proposed processing, crusher, or other infrastructure sites (STRATA 2014a).

Avalanche hazard areas also are present in proximity to the proposed mine support facilities and infrastructure (**Figure 3.2-5**). These existing avalanche hazards would not be exacerbated by the construction or operation of proposed facilities at the mine site, as such activities would not alter the three key factors of avalanche formation (weather, snowpack, and terrain). The increased number of personnel present at mine facilities, and increased value of facilities and structures at the mine as a result of Alternative 1 would increase the risk of damage, injury, and loss of life from the existing hazards.

4.2.2.1.6 Access Roads

Materials required for the proposed road upgrades/realignment would be obtained from local borrow sites that are being considered, as described above. In addition, spent heap leach ore from historical mining operations may be reused for road construction purposes.

Detailed geotechnical data has not been generated for the access roads. However, it is expected that geotechnical issues arising from these components would generally be minor compared to those described for the mine site and construction of access road would be required to follow standard engineering practices to address and prevent geotechnical failures.

4.2.2.1.6.1 Bedrock and Surficial Geology and Topography

Widening of access roads is anticipated during construction and would increase the size of existing cut-slopes, exposing bedrock upslope of road corridors. Exposed bedrock would become more susceptible to mechanical weathering such as ice heave and wedging, which could dislodge large blocks of bedrock into road corridors. Application of appropriate engineering design features would be incorporated into all road construction and foundation planning for the SGP, which could minimize the effects of frost heave and wedging. Although impacts to bedrock for the purposes of construction would be permanent and high in intensity, impacts would be much smaller in scale compared to other components of the SGP, such as mining operations. Impacts would be localized to areas where new and upgraded roads are needed.

Surficial geology and landforms would be directly impacted during construction activities, which would require construction and grading. Impacts would be localized to areas where new and upgraded roads are needed.

4.2.2.1.6.2 Seismic Hazards

Low to moderate intensity earthquakes are likely to occur during the SGP with a lower probability of a large event. Facilities would be designed to withstand moderate intensity seismic events. Therefore, impacts from seismic events are expected to be low. In the unlikely event that a large earthquake occurs in the vicinity of the Burntlog Route, moderate to high impacts should be anticipated. Effects would range from temporary (e.g., minor damage that is easily reparable) to permanent (e.g., lateral displacement of roads at a fault crossing and rockfall)

4.2.2.1.6.3 Mass Wasting Hazards

Slope stability effects would be low in intensity in low to moderate relief areas. The majority of the Burntlog Route alignment would not be impacted by significant mass wasting hazards; however, there is potential for slumping or rockfall in several sections which could impact road construction (STRATA 2016). **Figure 3.2-6** shows an overview of geohazards for the Burntlog and Yellow Pine Routes. Figures showing landslide hazards along the Burntlog Route are included as **Appendix E-1**. **Appendix E-2** is a desktop study of geohazards along both the Burntlog and Yellow Pine access routes. Application of appropriate siting, engineering design, construction, and maintenance protocols would be incorporated into all roads for the SGP, which could prevent or minimize potential for mass wasting thereby minimizing impacts.

A road segment in proximity to an avalanche runout zone and presence of workers or construction of facilities could increase the magnitude of impact from avalanche through damage to equipment, damage to structure, or personal injury or loss of life.

Existing avalanche hazards on the Yellow Pine Route would continue to exist and could impact travel during the construction period. Along the Burntlog Route, the potential impacts resulting from existing avalanche hazards would increase due to increased vehicular traffic during mine operations and reclamation/closure activities.

The Burntlog Route is generally viewed as having less susceptibility to avalanche hazards than the Yellow Pine Route (see Section 3.2, Affected Environment), as the proposed Burntlog Route generally runs higher up on the ridgelines; therefore, not crossing through potential avalanche paths (Midas Gold 2019).

4.2.2.1.7 UTILITIES

4.2.2.1.7.1 Bedrock and Surficial Geology and Topography

A new transmission line from the new Johnson Creek substation to the mine site, partially within a previously used transmission line right-of-way, would be constructed to supply electric service to the mine site. The right-of-way for the new transmission line would be approximately 100 feet wide. Upgrades to existing transmission lines also would be performed (within an expanded right-of-way (from 50 to 100 feet) as well as upgrades and new construction to electric infrastructure (e.g., substations, switching station, etc.). Additionally, there would be upgrades to existing communication towers as well as new communication sites. Impacts to bedrock for the purposes of utilities would be localized and permanent. Impacts would be limited to areas where new utility infrastructure, or upgrades to existing equipment is needed.

Surficial deposits would be affected in localized areas the expanded utility easements for pole replacement, trenching, or footings as needed. Surficial deposits would be affected in localized areas within these new communication sites.

Similarly, surficial geology and landforms would be directly impacted during utility upgrades. Impacts would be localized to areas where new utility infrastructure (or upgrades) is needed.

4.2.2.1.7.2 Seismic Hazards

As noted above, low to moderate intensity earthquakes are likely to occur during the SGP lifecycle with a lower probability of a larger event. Employment of current geotechnical and structural design standards during utility upgrades would allow facilities to withstand moderate intensity seismic events. Therefore, impacts from anticipated seismic events are expected to be low. However, in the unlikely event that a large earthquake occurs in the vicinity of the mine site, moderate to high impacts should be anticipated. Effects would range from temporary (e.g., minor damage that is easily reparable) to permanent (e.g., lateral displacement of utilities at a fault crossing).

4.2.2.1.7.3 Mass Wasting Hazards and Geotechnical Stability

Detailed geotechnical data or assessment of existing mass wasting hazards has not been generated for utility components. However, it is expected that geotechnical issues arising from these components would generally be minor compared to the mine site and their construction would follow standard engineering practices that address and prevent geotechnical failures.

Slope stability effects would mostly range from low in intensity (e.g., minor slumps or rockfall in low to moderate relief areas) to moderate intensity (e.g., design of tower adequate to meet static stability criteria).

4.2.2.1.8 OFF-SITE FACILITIES

Off-site facilities associated with Alternative 1 include the Stibnite Gold Logistics Facility on Warm Lake Road (County Road [CR] 10-579) and the Landmark Maintenance Facility near the intersection of Warm Lake Road and Johnson Creek Road (CR 10-413).

The Stibnite Gold Logistics Facility and Landmark Maintenance Facility would be sited in discrete, localized areas and, similar to the mine support facilities and infrastructure buildings, would incorporate existing geotechnical design standards.

4.2.2.1.8.1 Bedrock and Surficial Geology and Topography

Impacts to bedrock for the purposes of off-site facilities would be localized and permanent and would be limited to areas where facilities are needed.

Surficial geology and landforms would be directly impacted during facility construction. Impacts would be localized and long-term to permanent. The Stibnite Gold Logistics Facility has a post-mining land use designation of light industry, where it would remain un-reclaimed after mining operations and transferred to a third-party for light industrial uses, whereas the Landmark Maintenance Facility would be reclaimed as part of closure and reclamation.

4.2.2.1.8.2 Seismic Hazards

Low to moderate intensity earthquakes are likely to occur during the SGP lifecycle with a lower probability of a larger event. Facilities are anticipated to be designed to withstand moderate intensity seismic events. Therefore, impacts from anticipated seismic events are anticipated to be low. However, in the unlikely event that a large earthquake occurs in the vicinity of an off-site facility, moderate to high impacts should be anticipated. Effects would be temporary (e.g., minor to moderate damage that is easily reparable).

4.2.2.1.8.3 Mass Wasting Hazards and Geotechnical Stability

Detailed geotechnical data or assessment of existing mass wasting hazards has not been generated for off-site facility components of the SGP. However, it is expected that geotechnical issues arising from these components would generally be minor compared to the mine site and their construction would follow standard engineering practices that address and prevent geotechnical failures. Slope stability effects would mostly range from low in intensity (e.g., minor sloughing in low to moderate relief areas) to moderate intensity (e.g., design of buildings to meet static stability criteria).

4.2.2.2 Alternative 2

Impacts associated with geologic resources and geotechnical hazards under Alternative 2 would be the same as for Alternative 1, except as described below.

4.2.2.2.1 MINE SITE

Bedrock Geology and Amount of Ore Extracted – same as for Alternative 1.

Surficial Geology and Topography – same as for Alternative 1, except that the West End DRSF would not be developed; therefore, surficial geology in that area would not be impacted.

Seismic and Mass Wasting Hazards – same as for Alternative 1.

Geotechnical Stability – same as for Alternative 1, except that the West End development rock would be backfilled directly into the Midnight pit (within the West End pit) and partially backfilled the Hangar Flats pit. The backfilled development rock would not be compacted, except as it nears the final reclaimed surface of the backfilled area, although some compaction would naturally occur during placement, truck and dozer traffic over the top of the dumped rock, burial, and consolidation.

4.2.2.2.2 MINE SUPPORT FACILITIES AND INFRASTRUCTURE

Bedrock and Surficial Geology and Topography – same as for Alternative 1.

Seismic and Mass Wasting Hazards – same as for Alternative 1, except that the construction of additional facilities such as the limestone crushing plant and lime generation equipment in the ore processing plant area would further increase the risk of damage to such facility during avalanche or other mass wasting hazards.

Geotechnical Stability – same as for Alternative 1.

4.2.2.2.3 Access Roads

Bedrock and Surficial Geology and Topography – Same as for Alternative 1, except the Riordan Creek segment of the Burntlog Route would reduce disturbance and also would reduce the area of surficial geology disturbed by construction of such facilities.

Seismic and Mass Wasting Hazards and Geotechnical Stability – Same as for Alternative 1, except that:

- On-site lime generation would decrease haul truck trips and therefore decrease risks from existing avalanche or landslide hazards along the access roads. On the other hand, inclusion of a public access road through the mine site (Option 1 or Option 2) would increase vehicular traffic in the area and therefore subject additional drivers to avalanche risk within the mine site.

4.2.2.2.4 Utilities

Bedrock and Surficial Geology and Topography – The upgraded utility corridor would be realigned in two locations under Alternative 2 but overall the impacts would be the same as for Alternative 1.

Seismic and Mass Wasting Hazards and Geotechnical Stability – Same as for Alternative 1.

4.2.2.2.5 Off-Site Facilities

Bedrock and Surficial Geology and Topography – Same as for Alternative 1, except that impacts associated with the off-site maintenance facility would occur in a different location to Alternative 1.

Seismic and Mass Wasting Hazards and Geotechnical Stability – Same as for Alternative 1.

4.2.2.3 Alternative 3

4.2.2.3.1 Mine Site

Bedrock Geology and Amount of Ore Extracted – same as for Alternative 1, except there would be no reprocessing of legacy tailings in the Meadow Creek drainage.

Surficial Geology and Topography – same as for Alternative 1, except that impacts associated with the TSF would occur within the EFSFSR valley, rather than Meadow Creek. There is currently no specific geotechnical data available for the TSF under Alternative 3. This area is undisturbed by previous mining activities as compared to the TSF location for Alternative 1. The geologic hazards assessment identified landslide areas within and above the EFSFSR TSF location under Alternative 3 (STRATA 2014a, Detail D, feature LS-12). After closure, the area of the EFSFSR valley impacted by the TSF would be contoured and graded to blend into surrounding locations.

Seismic and Mass Wasting Hazards – same as for Alternative 1, except that the TSF and DSRF would overlap a large existing landslide on the south bank of the EFSFSR. As discussed below under geotechnical stability, detailed geotechnical analysis, including an assessment of the geotechnical suitability of the selected location to support the TSF and DSRF has not been undertaken.

Geotechnical Stability – same as for Alternative 1, except that TSF and DRSF would be in the EFSFSR valley rather than at Hangar Flats in Meadow Creek valley. Like Alternative 1, the DRSF would buttress the downstream slope of the TSF. The DRSF buttress for the TSF would be constructed in the same manner as described for Alternative 1 and would have constructed cut slopes of 2.5H:1V until regraded for reclamation.

Detailed geotechnical data, including Factors of Safety or assessment of the geotechnical suitability of the selected locations to support the EFSFSR TSF or DRSF, have not been generated. However, given that the design of the structures is proposed in a similar manner to Alternative 1, it is assumed that Factors of Safety also would be similar, and would therefore be more than adequate to maintain geotechnical stability under normal, and even earthquake, conditions, provided they are constructed to, and monitored, in accordance with standard engineering practices.

4.2.2.3.2 Mine Support Facilities and Infrastructure

Bedrock and Surficial Geology – same as for Alternative 1, except that areas of surficial geology disturbed from construction of the worker housing facility would be relocated to the Blowout Creek drainage.

Seismic and Mass Wasting Hazards – same as for Alternative 1, except that the worker housing facility would not be located adjacent to an existing landslide deposit.

Geotechnical Stability – same as for Alternative 1.

4.2.2.3.3 Access Roads

Bedrock and Surficial Geology – Similar to Alternative 1, except the Burntlog Route in the vicinity of the EFSFSR TSF would be rerouted further west, on a new road segment around the TSF, entering the mine site on a new road adjacent to Blowout Creek during operations.

Seismic and Mass Wasting Hazards and Geotechnical Stability – Same as for Alternative 1, except the rerouted segment of Burntlog Route closest to the mine site would avoid potential impacts related to a large landslide south of the EFSFSR and several smaller geohazard areas that occur along the Alternative 1 access road route.

4.2.2.3.4 Utilities

Bedrock and Surficial Geology – Same as for Alternative 1, except that approximately 2.5 miles of the new transmission line from the Johnson Creek substation to the mine site would be realigned.

Seismic and Mass Wasting Hazards and Geotechnical Stability – Same as for Alternative 1.

4.2.2.3.5 OFF-SITE FACILITIES

Bedrock and Surficial Geology – Same as for Alternative 1.

Seismic and Mass Wasting Hazards and Geotechnical Stability – Same as for Alternative 1.

4.2.2.4 Alternative 4

4.2.2.4.1 MINE SITE

Amount and Value of Ore Extracted – same as for Alternative 1.

Bedrock and Surficial Geology – same as for Alternative 1.

Seismic and Mass Wasting Hazards – same as for Alternative 1.

Geotechnical Stability – same as for Alternative 1.

4.2.2.4.2 MINE SUPPORT FACILITIES AND INFRASTRUCTURE

Bedrock and Surficial Geology – same as for Alternative 1.

Seismic and Mass Wasting Hazards – same as for Alternative 1.

Geotechnical Stability – same as for Alternative 1.

4.2.2.4.3 ACCESS ROADS

Bedrock and Surficial Geology – Impacts associated with construction of the Burntlog Route would not occur under Alternative 4; however, impacts from the proposed upgrade of the Yellow Pine Route (road widening and curve straightening along the Stibnite Road portion of McCall – Stibnite Road (CR 50-412) and construction of public access road through the mine site would require blasting, road cuts and retaining walls. Potential impacts along Stibnite Road (CR 50-412) and public access roads would be similar to those described for Alternative 1, in that newly exposed bedrock would become more susceptible to ice heave and wedging, which could dislodge large blocks of bedrock into road corridors. Application of appropriate engineering design features would be incorporated into all road construction and foundation planning for the SGP, which would minimize the effects of heave. Impacts associated with Stibnite Road upgrades would be permanent.

Seismic and Mass Wasting Hazards and Geotechnical Stability – Impacts associated with construction of the Burntlog Route would not occur under Alternative 4; however, the risk of damage, injury, or loss of life from mass wasting events along the Yellow Pine Route would be increased due to its location, particularly Stibnite Road (CR 50-412), because the route is within the runout zone for avalanches. Twelve avalanche paths were identified along Stibnite Road. Additionally, future avalanches along the Yellow Pine Route could result in road closures similar to those that occurred in March 2014 and April 2019. There are more areas of landslides and rockfalls along the Yellow Pine Route than there are along the Burntlog Route (45 landslide/ rockfall areas on Yellow Pine Route compared to 26 along Burntlog Route). See **Appendix E-2** for more information about geohazards along both the Burntlog and Yellow Pine routes. Construction of the road would require geotechnical design considerations related to widening of the existing road from the current width to up to 21 feet along with required rock blasting for bedrock cut slopes to achieve this width. It is noted that under Alternative 4, no secondary access for mine or public traffic would be provided.

4.2.2.4.4 UTILITIES

Bedrock and Surficial Geology – Same as for Alternative 1, except that the proposed helicopter access for construction and maintenance of very high frequency radio repeater and cell tower sites within inventoried roadless areas would reduce the area of surficial geology disturbed by construction of access to such facilities.

Seismic and Mass Wasting Hazards and Geotechnical Stability – Same as for Alternative 1.

4.2.2.4.5 OFF-SITE FACILITIES

Bedrock and Surficial Geology – Same as for Alternative 1, except that impacts associated with the Landmark Maintenance Facility would occur in a different location to Alternative 1.

Seismic and Mass Wasting Hazards and Geotechnical Stability – Same as for Alternative 1.

4.2.2.5 Alternative 5

Under Alternative 5, no action alternative would be approved and there would be no open-pit mining or ore processing at the mine site, or other supporting infrastructure corridors and facilities. Because there would be no new construction or new mining operations, Alternative 5 would not have any new direct or indirect effects on geology and geotechnical hazards.

Alternative 5 would not restore legacy mining impacts, such as the reclamation of physiography associated with underground mine workings, multiple open pits, development rock dumps, tailings deposits, heap leach pads, and spent heap leach ore piles in addition to legacy infrastructure.

Under Alternative 5, legacy geotechnical impacts would remain as they are today. These legacy conditions have been compounded by extensive forest fires over the past several decades, which have caused severe damage from soil erosion, landslides, and debris flows, and resultant sediment transport into local waterways.

Previous structures at the mine site were constructed with little, if any, geotechnical planning and oversight, and numerous failures already have occurred because of poor planning and design. For example, the erosion of the East Fork of Meadow Creek (Blowout Creek) is from the failure of a dam at that location. This has resulted in ongoing upstream erosion of the valley and deposition of the resulting sediments downstream. Previous pits (i.e., Yellow Pine pit, West End pit) were not necessarily designed to be stable during long- term exposure to the elements.

Various development rock piles and tailings piles are not necessarily properly graded or abandoned and may not be geotechnically stable; resulting in possible failure in the future. The design, construction, and reclamation of the subject waste rock dumps complied with federal and state standards at the time (1980s and 1990s) and these standards have not substantively changed since 1998. The waste rock piles were faced with coarse resistant rock and are not exhibiting signs of mass wasting.

4.2.3 Mitigation Measures

Mitigation measures required by the U.S. Forest Service (Forest Service) and measures committed to by Midas Gold as part of design features of the SGP are described in **Appendix D**, Mitigation Measures and Environmental Commitments; see **Table D-1**, Preliminary Mitigation Measures Required by the Forest Service, and **Table D-2**, Mitigation Measures Proposed by Midas Gold as SGP Design Features, respectively. The preceding impact analysis has taken these mitigation measures into consideration, as well as measures routinely required through federal, state, or local laws, regulations or permitting, such that the identified potential impacts of the SGP are those that remain after their consideration.

Mitigation measures may be added, revised, or refined based on public comment, agency comment, or continued discussions with Midas Gold and will be finalized in the Final EIS.

4.2.4 Cumulative Effects

The cumulative effects analysis area for geologic resources and geotechnical hazards that could be directly or indirectly affected by the SGP is the same as defined in Section 3.2 for the direct and indirect impact analysis, which is the entire footprint of disturbance of all SGP components.

Cumulative effects associated with the SGP consider the range of existing and foreseeable activities and their potential effects with respect to geologic resources and geotechnical hazards. Past and present actions that have, or are currently, affecting geologic resources and geotechnical hazards include mineral exploration and mining activities, infrastructure and road development and previous road construction or upgrades within the cumulative effects analysis area.

4.2.4.1 Common to All Action Alternatives

4.2.4.1.1 Depletion of Mineral Resources

Alternative 1 through Alternative 4 would have a permanent impact on ore reserves in the cumulative effects analysis area, which would combine with the impacts of past mining activities such as from Valley County Quarry Development, Fourth of July Mine, Camp Bird Mine, etc., that also have depleted ore reserves in this part of Idaho, as well as combine with any future mining operations in the region which would further deplete ore reserves. The contribution of the action alternatives to this cumulative impact would deplete an additional approximately 100 million tons of ore, the volume of ore proposed to be extracted under Alternatives 1 through 4.

4.2.4.1.2 SEISMIC AND MASS WASTING HAZARDS

Alternative 1 through Alternative 4 would increase risks from seismic and mass wasting hazards by introducing additional personnel and equipment into existing hazard areas. Geohazards and seismic conditions are site-specific, as individual project sites would be geologically removed from one another. A few of the reasonably foreseeable future actions (RFFAs) (e.g., mineral exploration and mining associated with Golden Hand No. 3, 4, and 8, Big Creek Fuels Reduction Project, Morgan Ridge Exploration Project, and Dewey Mine Sediment Stabilization Project) have the potential to add some additional traffic on Stibnite Road (CR 50-412) to access their respective project sites. Although Stibnite Road has an existing avalanche hazard (i.e., is located at the bottom of an avalanche runout zone) that could impact travel along the road, use of this road by the SGP and by RFFAs would not exacerbate the existing hazard, but it would add additional personnel on this road, which would increase the risk of damage, injury, or loss of life from the hazard.

4.2.4.1.3 GEOTECHNICAL HAZARDS

Some of the past mining activities at the mine site were conducted with little, if any, geotechnical planning and oversite. Various development rock piles and tailings piles may not be properly graded or abandoned and may not be geotechnically stable. Alternatives 1 through 4 would substantially reduce geotechnical risks associated with legacy mining operations through proposed reclamation activities. Comprehensive, designed and engineered solutions would be required to restore legacy mining features (Midas Gold 2016). New geotechnical risks would be associated with the proposed TSF and DRSF structures, but these risks would be prevented or minimized through incorporation of standard geotechnical design standards, as well as construction quality control, operations and maintenance, and surveillance.

Geohazards and seismic conditions are site-specific, as individual project sites would be geologically removed from one another. As such, the RFFAs would not increase risks associated with geotechnical hazards.

4.2.4.2 Alternative 5

Under Alternative 5, no action alternative would be approved and there would be no open-pit mining or ore processing at the mine site, or other supporting infrastructure corridors and facilities. The effects of past mining activities and their current geological/geotechnical conditions (e.g., alteration of topography/ridgelines, the presence of the Yellow Pine pit and current condition of the adjacent highwall slopes, reclaimed areas, etc.) would remain. Although none of the RFFAs identified in **Table 4.1-2** would physically overlap with action alternative disturbance footprints, forest management, motorized use of road systems, fire suppression, prescribed fire and wildfire, dispersed camping, fishing, and hunting activities would continue in the cumulative effects area and vicinity, which would be subject to existing geotechnical hazards, including seismic and mass wasting hazards. Under Alternative 5, Midas Gold would continue to comply with reclamation and monitoring commitments included in the applicable Golden Meadows Exploration Project Plan of Operations and Environmental Assessment (Forest Service 2015), which include reclamation of the drill pads and temporary roads by backfilling, re-contouring, and seeding using standard reclamation practices; however, as described in the Golden Meadows Environmental Assessment, the exploration and subsequent reclamation activities would have an insignificant direct effect to geology/soils and therefore an insignificant cumulative contribution.

4.2.5 Irreversible and Irretrievable Commitments of Public Resources

4.2.5.1 Common to All Action Alternatives

Implementation of Alternative 1 would result in the commitment of natural and man-made resources for new infrastructure, mine operations, remediation and habitat restoration, and post-mining reclamation. The predominant commitment of resources would be from the mining, which would deplete the valuable mineral assets in the targeted ore bodies. Gold, silver, and antimony are non-renewable resource that would be removed and then used, constituting an irreversible commitment.

Substantial labor and materials needs are anticipated throughout the life of the SGP. Utility upgrades and new infrastructure are required to facilitate mine operations and reclamation of historically damaged areas. Legacy mined waste rock would be incorporated into new construction to the extent feasible. Contaminated areas would be remediated during new construction as required.

Implementation of the SGP would remove the land from other uses while it is in operation, but the use would be converted back to habitat for native species and recreational uses through reclamation. The temporal loss of the land for some uses would be irretrievable. However, due to the current geotechnical condition of the land, some uses are not currently possible. Geotechnical stability would reclaim the possibility for some of these uses in the future.

From a geotechnical standpoint, SGP would add a small, incremental level of risk for long-term TSF, DRSF, or pit wall failure. Although this risk of failure likely would be very low, it would be unlikely to ever be eliminated completely.

4.2.6 Short-term Uses versus Long-term Productivity

4.2.6.1 Common to All Action Alternatives

Development of the SGP would result in short-term and long-term impacts to geology in the area. Surficial deposits and topography would undergo changes throughout the life cycle of the mine. Bedrock would primarily be impacted by depletion of the targeted ore bodies in the three pits. Short-term uses of the mineral resources would represent a beneficial use of these resources.

Consolidation and reprocessing of existing mined material at the mine site would result in improvements to geotechnical stability of site features. Post-mining reclamation is anticipated to provide an overall long-term geotechnical improvement at the mine site, facilitating the long-term productivity of the mine site.

4.2.7 Summary

Implementation of the SGP under all action alternatives would result in impacts to geologic resources. Under all action alternatives the same amount of minerals would be extracted, and these resources would be permanently depleted. Past-mining impacts have resulted in long-term impacts to the natural topography and the SGP activities could result in removal and/or stabilization of these past-mining impacts. Under all action alternatives the natural topography would be permanently altered through mining and placement of development rock and tailings. Highwalls would remain within all of the mine pits.

Past mining activities in the area were conducted with little, if any, geotechnical planning and oversite. Various development rock piles and tailings piles are not necessarily properly graded or abandoned and may not be geotechnically stable. Proposed features under all alternatives, including the TSF and DRSFs, would be designed for short- and long-term conditions under both static and earthquake conditions. Under Alternative 3 the area of the EFSFSR TSF and associated DRSF has not had detailed geotechnical analysis. The TSF location also would be placed in part on a large ancient landslide (STRATA 2014a, Detail D; see Chapter 3.2 for description of glacial-age landslides). Additional geotechnical studies would be needed to inform a TSF/DRSF design in this location.

Under all alternatives the Yellow Pine Route would be used for mine deliveries. Under Alternative 1, 2, and 3, the Yellow Pine Route would be used short-term for 1 to 2 years while the Burntlog Route is being constructed. Under Alternative 4, the Yellow Pine Route would be used from construction through operations and closure and the Burntlog Route would not be constructed. The Yellow Pine Route has more geotechnical hazards associated with landslides, and rockfalls (45 total) compared to the Burntlog Route (26 total) There are two avalanche paths mapped for the Burntlog Route versus 12 mapped avalanche paths for the Yellow Pine Route (**Appendix E-2**).

Table 4.2-2 provides a summary comparison of impacts associated with geologic resources and geotechnical hazards by issues and indicators for each alternative.

Table 4.2-2 Comparison of Geological Resources and Geotechnical Hazards Impacts by Alternative

Issue	Indicator	Baseline Conditions	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
The minerals present at the site are economically valuable, and they contribute to the national goal of being economically independent in strategic metals such as antimony.	Amount and value of ore extracted	Past mining projects are estimated to have extracted approximately 15 million tons of ore from the Hangar Flats, Yellow Pine, and West End areas	A total of 426 million tons of ore and development rock would be mined from the three open pits.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as baseline conditions.
	Depletion of mineral resources	Past mining projects have resulted in depletion of mineral resources.	Mineral resources would be permanently depleted within the pit areas.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as baseline conditions.
Mining of minerals present at the site could result in changes to the existing topography and the addition of physical hazards.	Alteration of natural topography	Past mining projects have resulted in long-term impacts to natural topography. Approximately 1,967 acres of existing disturbance lie within the SGP area.	A total of approximately 3,532 acres of land would be disturbed by proposed mining and related activities.	A total of approximately 3,423 acres of land would be disturbed by proposed mining and related activities. Same as Alternative 1.	A total of approximately 3,610, acres of land would be disturbed by proposed mining and related activities.	A total of approximately 3,218 acres of land would be disturbed by proposed mining and related activities.	Same as baseline conditions.
	Unreclaimed steep slopes	Past mining activities in the area were conducted with little, if any, reclamation. Various mine pit highwalls, development rock piles and tailings piles are not necessarily properly graded or abandoned and may over-steepened slopes.	Most SGP facilities would be reclaimed to blend with the surround topography. Some pit highwalls would remain in each of the mine pit areas.	Most SGP facilities would be reclaimed to blend with the surround topography. Some pit highwalls would remain in each of the mine pit areas.	Most SGP facilities would be reclaimed to blend with the surround topography. Some pit highwalls would remain in each of the mine pit areas.	Most SGP facilities would be reclaimed to blend with the surround topography. Some pit highwalls would remain in each of the mine pit areas.	No changes to existing conditions.
Geological and geotechnical stability of the SGP facilities, including the TSF and other mine components.	Geological/Geotechnical suitability of the selected locations for the structures to be constructed.	Past mining activities in the area were conducted with little, if any, geotechnical planning and oversite. Various development rock piles and tailings piles are not necessarily properly graded or abandoned and may not be geotechnically stable; resulting in risk of possible failure in the future.	Underlying materials have been tested and are suitable for proposed key facility locations.	Same as Alternative 1	Same as Alternative 1 for most facilities. The area of the EFSFSR TSF and associated DRSF has not had detailed geotechnical analysis. The TSF location also would be placed in part on a large existing landslide.	Same as Alternative 1	No changes to existing conditions.
	Long-term geologic/geotechnical stability of the proposed structures	Past mining activities in the area were conducted with little, if any, geotechnical planning and oversite. Various development rock piles and tailings piles are not necessarily properly graded or abandoned and may not be geotechnically stable; resulting in risk of possible failure in the future.	New structures have been designed with geotechnical stability for long-term stability.	Same as Alternative 1.	Same as Alternative 1 for most facilities. The area of the EFSFSR TSF and associated DRSF has not had detailed geotechnical analysis. The TSF location also would be placed in part on a large existing landslide.	Same as Alternative 1.	No changes to existing conditions.

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