4.1 Approach to Environmental Analysis

Chapter 4 describes the potential impacts on the environmental resources addressed in Chapter 3 that would occur under the Applicant's Proposed Project, the No Action Alternative, and the Modified Project Alternative. Section 4.1.1 explains the types of impacts that were evaluated, the terminology used to characterize potential impacts, and the time periods for impact assessment.

The site of the proposed Project and the nature of open-pit mining activity would lead to a complex interaction between groundwater, surface water, and a number of water-related resources. Section 4.1.2 provides an overview of the water-related resources and their interactions with groundwater. In this document, *water-related resources* include wetlands, streams, and other Waters of the U.S.; aquatic habitat and resources; groundwater and surface water quality and water supplies; floodplains; riparian communities; and terrestrial resources.

Groundwater and surface water modeling techniques were used to analyze impacts on groundwater and surface water resources. The modeling results were used to assess impacts on water related resources. Section 4.1.3 explains how the surface water-groundwater system generally would react to mining and groundwater lowering, and how these processes were simulated using models and additional analyses to describe potential direct and indirect impacts on water-related resources. A detailed description of the groundwater modeling is included in Appendix I.

This section also provides information on three other important topics related to the proposed Haile Gold Mine Project: financial assurances and bonding for reclamation and closure, analysis of potential facility failures, and background on the use and management of cyanide.

4.1.1 Characterization of Impacts

4.1.1.1 Types of Effects Considered

NEPA requires that three types of impacts[1] be evaluated: direct, indirect, and cumulative impacts, as described below:

- **Direct Effects –** Direct effects are caused by a proposed action and occur at the same time and place (40 CFR 1508.8). Examples of direct effects associated with the proposed Project include filling wetlands with overburden, excavating streams and wetlands for mine pits, lowering groundwater levels, disturbing cultural resources, removing vegetation, and disturbing wildlife.
- **Indirect Effects –** Indirect effects are caused by a proposed action but occur later in time or are farther removed in distance but still reasonably likely to occur. Indirect effects may include growth-inducing effects and other effects related to "induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems" (40 CFR 1508.8). Examples of indirect impacts associated with the proposed Project include increased traffic or congestion, long-term changes in wetlands and aquatic communities caused by changes in hydrologic regimes, and changes in the local or regional economy and employment.
- **Cumulative Effects –** Cumulative effects are additive or interactive effects that would result from the incremental impact of a proposed action when added to other past, present, and reasonably foreseeable future actions (RFFAs), regardless of what agency or person undertakes such other actions (40 CFR 1508.7). Examples of RFFAs that could interact with Project-related impacts to

[1] In this document, the terms *effects* and *impacts* are used interchangeably.

result in cumulative impacts are regional mining activities and urban and industrial development. Cumulative impacts are discussed in Chapter 5.

Adverse and beneficial effects of the Project were evaluated in four different dimensions. The potential direct and indirect impacts on each resource generally were considered in relation to the following:

- Magnitude (negligible, minor, moderate, or major);
- Duration (temporary, short-term, long-term, or permanent);
- Potential to occur (unlikely, possible, or probable); and
- Geographic extent (limited, local, regional)

In each of the resource impact subsections in this chapter, the methods used for analysis are described.

4.1.1.2 Time Periods for the Impact Assessment

Impacts on some resources may vary depending on the phase of the proposed Project. Accordingly, the impact assessment was divided into two time periods: active mining and post-mining. The active mining and post-mining periods and associated Project elements and activities are illustrated in Table 2-1. Although division of the analysis into these two time periods works well for most resource areas, it is less relevant for some resources, such as socioeconomics and recreation.

Active Mining Period

The active mining period includes Pre-Production, Year 0 (1 year of pre-mining activities such as construction of facilities and infrastructure[2]) through Mine Year 14 and includes construction of mine facilities, groundwater lowering, stream diversion, pit excavation, construction of all OSAs and PAG and tailings facilities, and all other Project activities through the end of active mining (Table 2-1). During the active mining period, the contact water treatment plant would be designed and constructed to treat contact water from the pit sumps and Johnny's PAG with discharge to Haile Gold Mine Creek, along with excess pit depressurization water. This period also includes ongoing reclamation for those phases of mining with SCDHEC-approved reclamation plans. Potential impacts differ considerably during the active mining period relative to the resource area being considered. For example, pit depressurization would be at its maximum in Mine Year 14, when groundwater levels would be drawn down the most. Consequently, Mine Year 14 may represent the period of greatest impact on groundwater and groundwater contributions to streamflow. For visual resources, however, some of the OSAs would have been reclaimed and revegetated by Mine Year 14, and the greatest impact on visual resources would be associated with a different year during the mining period.

Post-Mining Period

The post-mining period represents the period after active mining has ceased and final reclamation activities are being completed (re-grading, establishing vegetation, filling pit lakes, and monitoring reclamation activities). This includes Mine Year 15 through the currently projected end of the mine life. Note that in Mine Years 13–15 ore processing may continue even though mining (removal of ore from the pits) would cease. The post-mining period includes reclamation, closure, and the more extended monitoring period that would occur after closure.

[2] The socioeconomic analysis used a slightly different pre-production period; see Section 2.10.

The projected end of the mine life is an estimate, based on the estimated length of time for the pit lakes to fill, for the Duckwood TSF and Johnny's PAG facilities to drain down and be converted to passive treatment systems, and for other requirements that would be established by the SCDHEC for Haile to achieve closure of the mine. These estimated time periods are based on modeling and other analyses; state permitting actions and evaluations would be required as part of their completion. During the post-mining period, environmental conditions are expected to generally improve as a result of Haile's monitoring and management actions and from natural recovery processes.

4.1.2 Water-Related Resources

Among the many changes that may occur, one of the most important is that the proposed Project would substantially alter the surface water and groundwater systems in the Project area and vicinity. This would result in a range of potential impacts on water-related resources.

4.1.2.1 Identifying Water-Related Resources

Proposed mining activities would directly or indirectly alter surface water and groundwater processes. Potential effects on water and water-related resources primarily would result from:

- Disturbance of the land surface (e.g., construction, clearing, and vegetation removal);
- Lowering the groundwater level to allow pit excavation (groundwater lowering by pumping);
- Exposure of rock types with the potential to generate acid rock and acid mine drainage, leach heavy metals, and contribute other dissolved substances;
- Discharges of untreated groundwater (pit depressurization water) and treated water (from the contact water treatment plant and passive treatment systems);
- Collection, routing, detention, and discharge of stormwater (stormwater ponds);
- Eventual filling of the pit lakes, leading to groundwater coming into contact with backfilled overburden and pit highwalls with the potential for acid generation; and
- Groundwater flow from filled pit lakes toward lower Haile Gold Mine Creek and the Little Lynches River, and discharge of mine-affected groundwater into these streams.

The above listed activities may lead to changes in the surface water and groundwater systems, including:

- Changes in groundwater levels and flow paths;
- Changes in groundwater quality;
- Changes in the contribution of groundwater to streams and groundwater seepage areas;
- Changes in streamflow; and
- Changes in water quality in streams and wetlands.

These types of changes in the surface water and groundwater systems have the potential to affect the following water-related resources that rely to some extent for their viability or integrity on surface water or groundwater:

- Wetlands and riparian habitats;
- Streamflow and water quality;

- Aquatic resources;
- Groundwater levels and availability;
- Water supply (wells, springs, and ponds) and water quality; and
- Terrestrial vegetation and wildlife.

4.1.2.2 Mechanisms for Interaction Among Resources

Because the proposed mining has yet to occur, the analysis of potential impacts relied on a combination of field studies, modeling, and numerical analyses. The Applicant performed extensive surveys, testing, and engineering studies over a period of 3 years leading up to the application for a DA permit. Additional data were collaboratively collected by the USACE, the SCDHEC, and Haile during the NEPA process to supplement the data availability for groundwater modeling.

The following field studies were used to characterize the existing conditions of surface water and groundwater resources in the Project area:

- Studies of the underlying geology and hydrogeology;
- Laboratory studies of the acid-generating potential of the ore-bearing and host rocks;
- Long-term monitoring of the groundwater and surface water systems, including water levels and water quality;
- Tests of aquifer flow and characteristics and response to groundwater pumping;
- Inventory and characterization of water-related resources; and
- Compilation and analysis of literature and case studies from other gold mines (including two in South Carolina).

The results of these investigations were used to perform numerical modeling designed to simulate the operations of the mine and refilling of pits after the cessation of mining. The numerical modeling predicted changes to water levels and changes to water quality in both groundwater and surface water. These predicted changes to water levels and water quality were used to evaluate impacts on water-related resources.

The concepts that structured the water-related resource impact assessment are discussed below.

The Groundwater and Surface Water System Are Interconnected

Figure 4.1-1 illustrates the connectivity of groundwater and surface water. Rainfall and surface water infiltrate into the ground to recharge the shallow and deep groundwater aquifers. As shown in Figure 4.1-2, groundwater flows to the surface in other areas, contributing to streamflow and the hydrologic regime of wetland habitats. Groundwater generally flows from higher to lower elevations and contributes to streamflows. In the Project region, groundwater generally flows toward the east and becomes part of the flow in lower Haile Gold Mine Creek and the Little Lynches River (Figure 4.1-3).

The quality of the surface water and groundwater depends on rainfall, soils and mineral chemistry, activities on the land surface and underground, and the flow paths of the water through the ground. Owing to the specific characteristics of the Project region, the natural water quality tends to be slightly acidic.

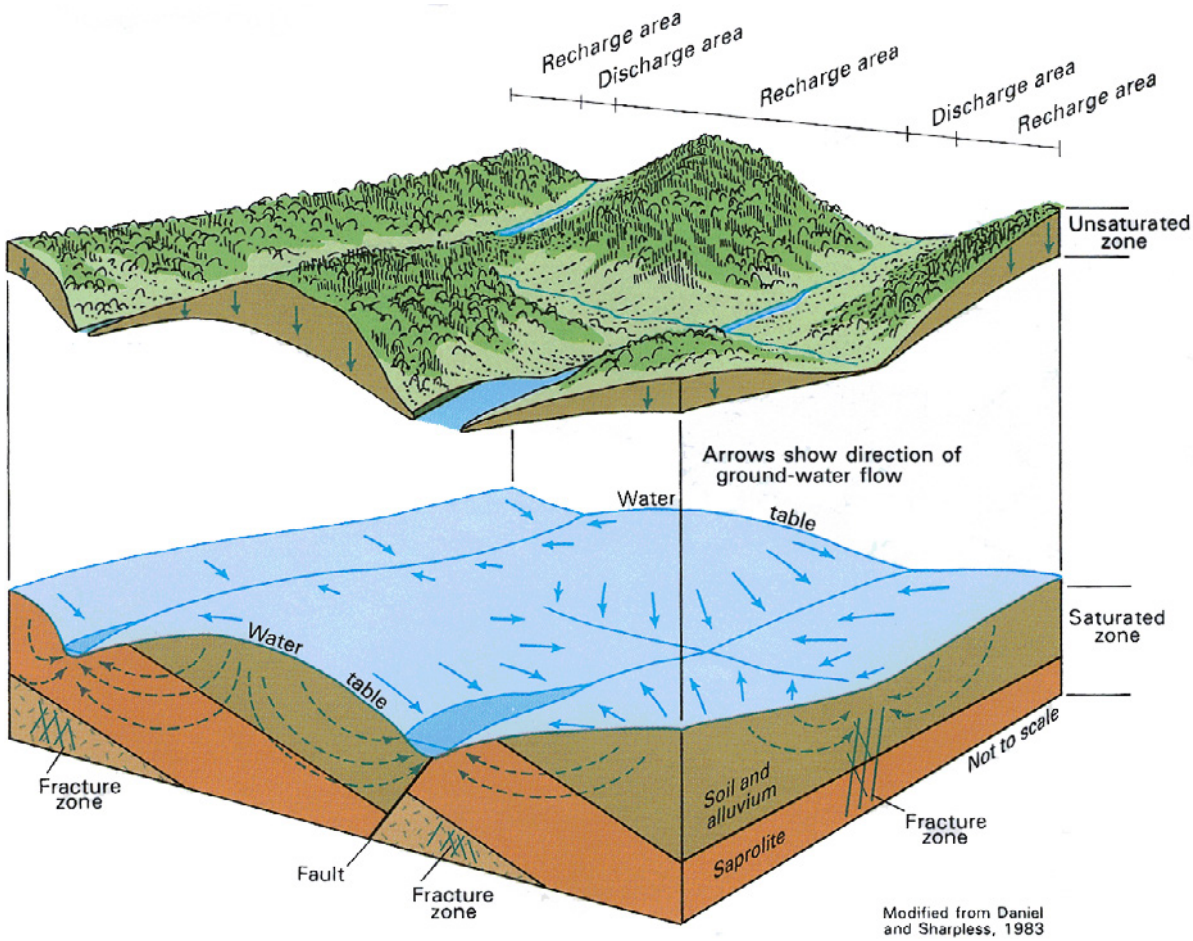

Figure 4.1-1 General Depiction of the Piedmont Groundwater System

Groundwater percolates downward through the unsaturated zone (shown lifted up) to the water table and then moves laterally to discharge points. The area of the Haile Gold Mine Project would be similar except that much of "soil and alluvium" layer above the saprolite consists largely of Coastal Plain Sands.

Source: from Miller (1990).

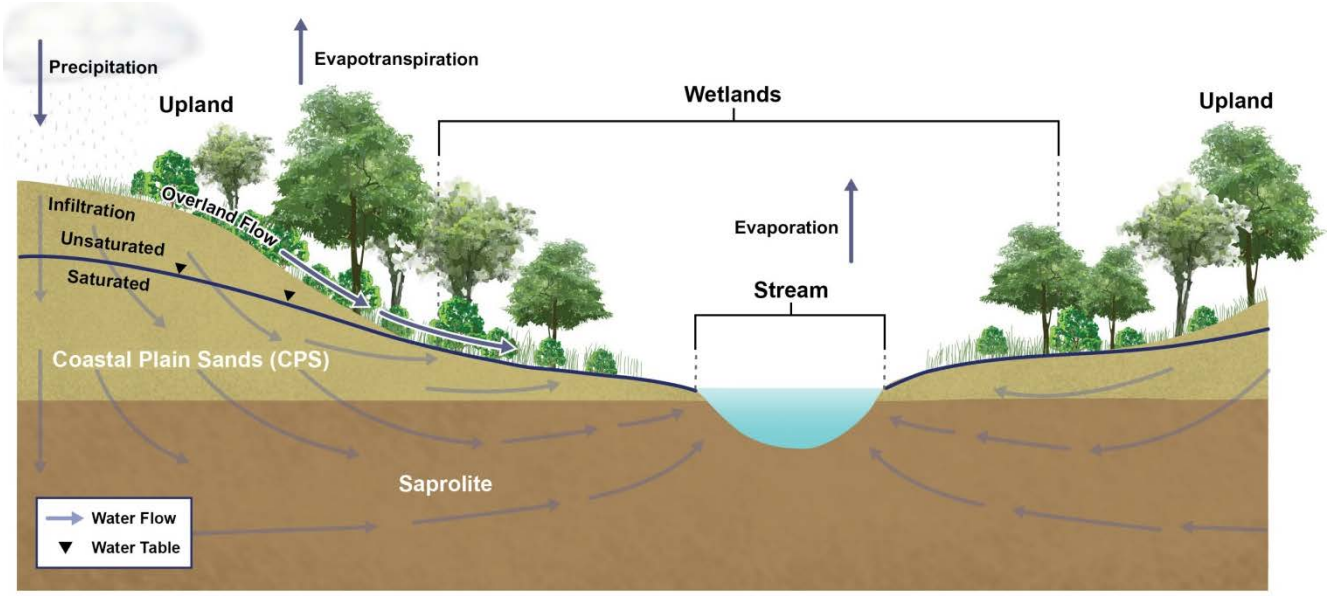

Figure 4.1-2 Conceptual Illustration of the Surface Water and Groundwater Hydrology in the Project Area

Surface water infiltrates to groundwater and groundwater flows contribute to streamflow and the hydrologic regime of wetland habitats in other areas.

Lowering the Groundwater for Mining Would Affect Groundwater and Surface Water

In open-pit mining, a dry pit is required to allow for blasting, excavation, and hauling overburden and ore. To maintain a dry pit, Haile would install a series of deep wells and then pump groundwater from these wells to lower the groundwater to below the pit bottom. This process of dewatering the pit is called *depressurization* or *dewatering* (refer to Appendix A for additional details). As the groundwater is pumped, groundwater levels decline, and groundwater flows toward the wells. The water pumped from the wells would be used for gold processing or would be discharged periodically into Haile Gold Mine Creek when there is excess water, particularly during average to wetter periods.

Lowering the groundwater through pumping creates a depression in the local groundwater aquifer. A "cone of depression" forms around each well and, as adjacent wells are pumped, the individual cones of depression join forming a localized "zone" of depression. Lowering groundwater levels around the mine also would reduce groundwater discharge to surface waterbodies such as streams and wetlands; and it could decrease water levels in nearby wells, springs, or ponds. After mining ceases, groundwater levels would be expected to recover (rise to their previous or near-previous levels) to various extents over years to decades. Groundwater levels would not recover fully in all areas.

The amount of water being pumped from the groundwater was simulated using a combination of a groundwater model, a water balance model, and supplemental spreadsheet analyses. All of the models used the field data and aquifer testing summarized earlier in this section. These are described more fully in Section 3.3, "Groundwater Hydrology and Water Quality."

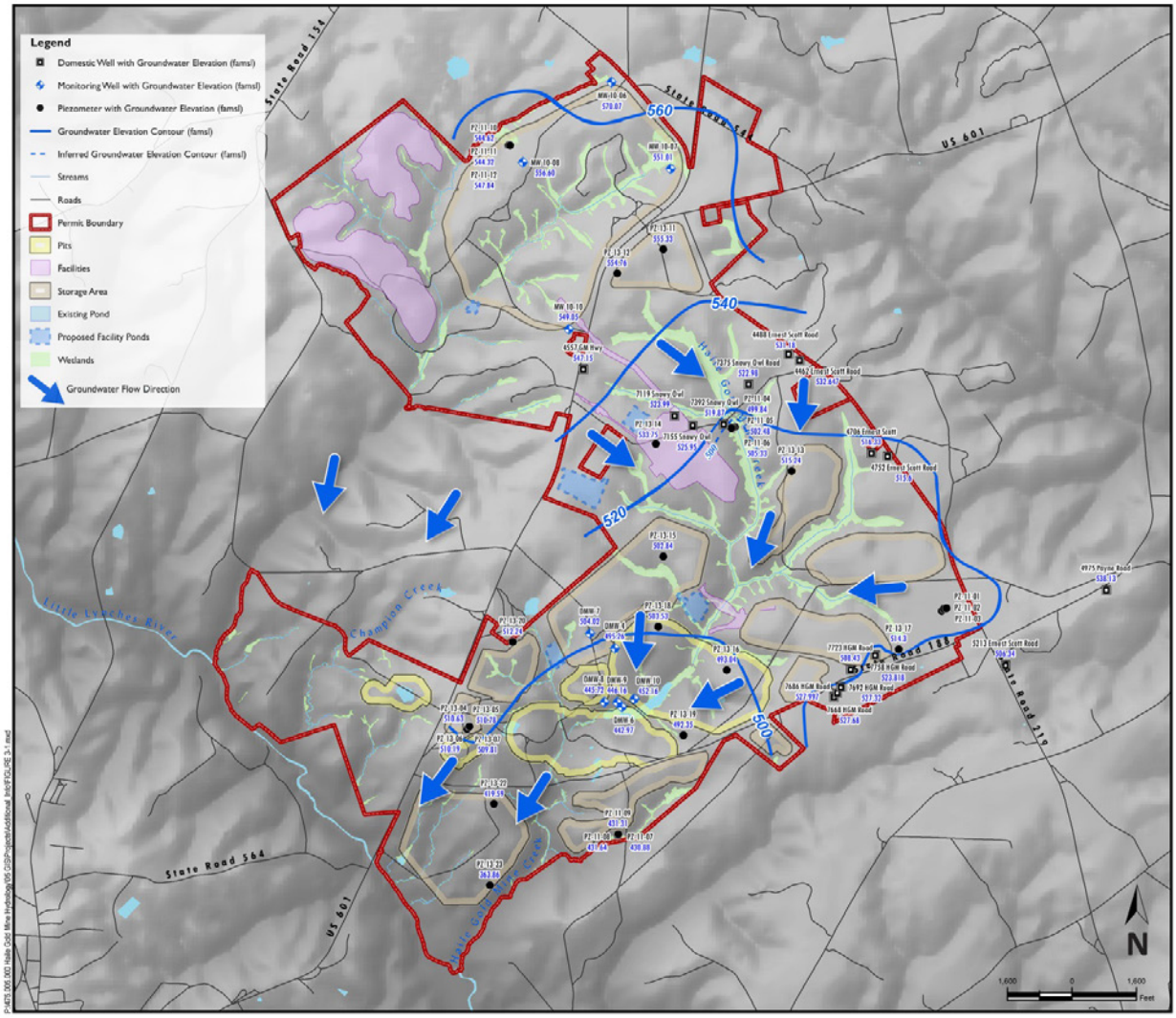

Figure 4.1-3 Groundwater Elevations and Generalized Direction of Groundwater Flow

Under existing conditions, groundwater flows toward the east and lower Haile Gold Mine Creek and the Little Lynches River.

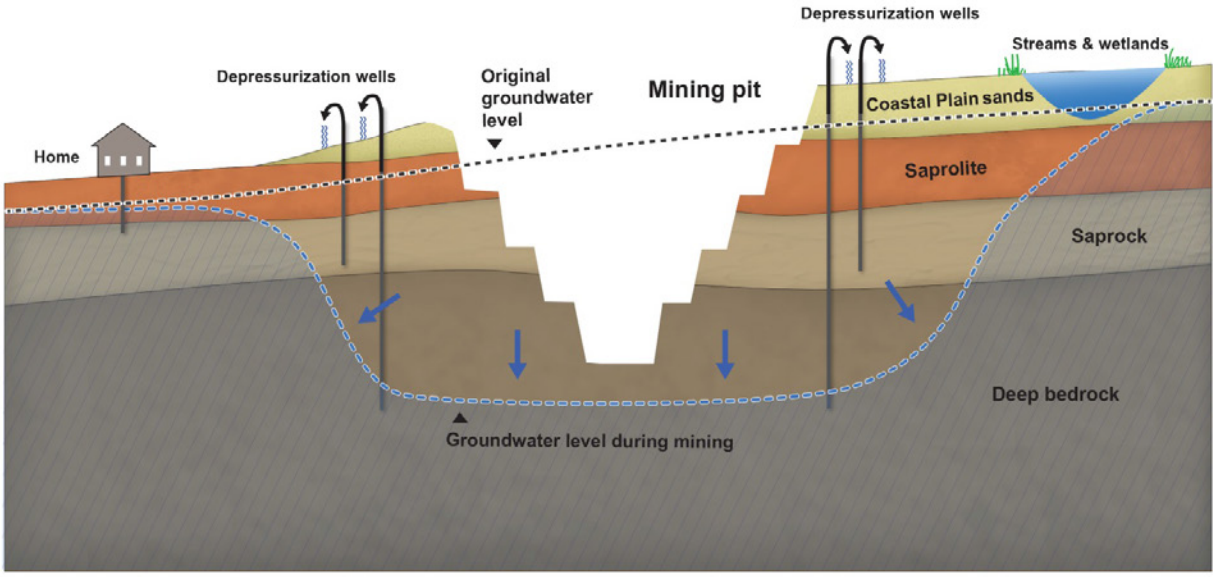

Figure 4.1-4 Conceptual Diagram Showing Groundwater Lowering

Pumping and lowering the groundwater (depressurization) to allow mining in the pit exposes the underlying rock to air and water and creates the potential for acid rock drainage.

Exposing Underlying Rock Would Create the Potential for Acid Rock Drainage

When exposed to air as a result of pit depressurization, the dewatered rocks oxidize (much like when metal rusts). When oxidized, pyrite (fool's gold) and other sulfide minerals that may be present generate acidic conditions (low pH) (referred to as *acid rock drainage*). When mining ceases and the pits are refilled, water again comes into contact with these minerals, which now have the potential to create acidic waters that can leach metals from the rocks. This would likely be the case at Haile Gold Mine, and studies by Haile have shown that some of the overburden rock and mineral ores have moderate to high potential for acid generation because of their sulfide minerals (iron-rich sulfide minerals) and pyrite content.

Acid generation occurs when the underlying rock is excavated, the minerals are exposed to air and water, and the minerals decompose (Figure 4.1-5). This process is accelerated by certain bacteria. The process can be rapid or slow, depending on the mineralogy of the rock. *Acid mine drainage* typically refers to the outflow of acidic water from (usually abandoned) metals mines or coal mines. Because of its low pH, many acid rock discharges also contain elevated levels of potentially toxic metals, especially nickel and copper, with lower trace levels of a range of other metals such as iron, manganese, and aluminum.

Acid Rock Drainage

Acid rock drainage is a natural oxidizing reaction that occurs when sulfide-bearing minerals are exposed to air and water, producing acidity and dissolving metals in water. Acidic drainage is found around the world, as a result of naturally occurring processes and as a result of activities associated with land disturbances (e.g., highway construction and mining) where acid-forming minerals are exposed at the surface of the earth.

Acid Mine Drainage

Acid mine drainage is the outflow of acid rock drainage from mines, underground workings, waste rock, and tailings after sulfide minerals have been exposed to air and water, oxidizing metal sulfides within the surrounding rock and overburden.

Figure 4.1-5 The Process of Acid Rock Drainage and Acid Mine Drainage

Consistent with industry practices, the Applicant conducted tests on numerous rock samples (cores) from various depths within the proposed mine area to determine the PAG content of the rock, its rate of development, and location. Tests that simulated the long-term weathering of rock types (*humidity cell tests*) at the Haile site also were conducted, with some tests lasting for more than 90 weeks. These tests quantified the amount of acid-generating potential in the rock at the Haile Gold Mine (Schafer 2010a, 2010b).

Haile identified three categories of PAG material in the underlying rock based on the results of this testing: Green Class (little PAG potential and not requiring special handling or limited uses), Yellow Class (low to moderate PAG potential and requiring special handling, storage, and long-term containment and closure), and Red Class (high potential for PAG material and requiring special handling, storage, and long-term containment and closure).

> ***Humidity Cell Tests***
>
> Humidity cell tests are designed to model the geological processes of rock weathering at the laboratory scale. The purpose of the test is to determine the rate of acid generation and variation over time in leachate water quality. The tests often are performed to confirm or reduce the uncertainty in the results of static prediction tests and to provide an assessment of acid rock drainage control options.

Haile proposes storing Green Class PAG overburden in aboveground OSAs. Green Class overburden storage is expected to cause minor impacts on future water quality. The Yellow Class PAG overburden would be treated with lime to neutralize the acid and then would be placed in completed pits. Red Class PAG overburden would be stored permanently in Johnny's PAG, a fully lined and covered facility that would be closed and monitored post-mining. After mining ceases and the pits are filled with water to form pit lakes, the pre-mining groundwater flow regime generally would be re-established toward lower Haile Gold Mine Creek and the Little Lynches River. As groundwater flows through the backfilled pits, water chemistry would be changed, and the affected groundwater ultimately would discharge into these streams. Drainage from Johnny's PAG would be treated at a water treatment plant permitted by the SCDHEC to meet state water quality standards before discharging into surface waters.

Land Disturbance Would Affect Streamflow and Water Quality

Land disturbance would result in alteration of runoff by changing the rate at which rainfall and surface water flow infiltrate into the ground, altering the watershed area that drains to some streams, and altering the percentage of rainfall that runs off. Actions such as land disturbance, creation of impervious and less pervious land surfaces, capture of rainfall in various mining facilities (e.g., Johnny's PAG, the Duckwood TSF, and the Mill), and managing stormwater runoff would alter infiltration into the groundwater. This would alter runoff volumes and directions in the Project area. Impacts on stream baseflow would largely result from groundwater lowering and a reduction in the contribution of groundwater to streams and wetlands in the Project vicinity.

In addition to affecting water quantity, land disturbance and mining would affect stream water quality. These changes could result from increased sedimentation, increases in dissolved and particulate constituents, and addition of nutrients (e.g., phosphorus and nitrogen) and pollutants.

Impacts Would Be Ongoing and Would Vary During and After Mining

As described in Section 2.2 and shown in Table 2-1, mine construction and operations would be continuous and changing over the active mining period, as would the impacts of mining on water resources and water-related resources. Areas disturbed by mining and mining-related activities would change throughout the life of the mine. Pits and OSAs would be opened sequentially, and would be closed and reclaimed as new areas are opened. Groundwater would be lowered for many years; groundwater levels would be lowest near the end of mining (in Mine Years 12 through 14). Haile Gold Mine Creek would be diverted to different areas within the area of pit-related activities several times over the active mining period (see Appendix A for additional details).

Reclamation would take place during (concurrent) and after mining, continuing the change in the landscape of the watershed and ongoing land disturbance. Stream channels would be re-established, and diversion of water from Haile Gold Mine Creek into Ledbetter Pit (to form Ledbetter Pit Lake) would continue for a number of years as the pit lake fills. Diversion of water to fill Ledbetter Pit Lake would considerably lower streamflows in Haile Gold Mine Creek for many years, depending on the diversion rate.

Following the completion of mining activities, groundwater lowering would cease, and groundwater levels would slowly return to near-original levels in many areas—although the groundwater in some areas would never attain the original elevation owing to mine-related changes such as backfill and lake formation. The recovery period for groundwater levels would vary considerably over the Project area, ranging from less than 5 years to more than 30 years after the cessation of mining. The flow regime in Haile Gold Mine Creek may be largely recovered by approximately Mine Year 30, but baseflows in some areas may never reach original flow rates due to permanently lowered groundwater contributions in the upper to middle part of the Haile Gold Mine Creek watershed. When mining was complete and the pits were refilled, modeling predicts that the direction and rate of groundwater flow toward lower Haile Gold Mine Creek and the Little Lynches River would be re-established, and that water quality would be affected until the incoming groundwater is able to buffer conditions in the backfilled pits.

4.1.3 Groundwater and Water Quality Models and Streamflow Analysis

The impact analysis for water-related resources relied on several interrelated analyses, including five separate modeling efforts further described under “Methods” in Sections 4.3, “Groundwater Hydrology and Water Quality” and 4.4, “Surface Water Hydrology and Water Quality.” These models, calibrated to site conditions, simulated the expected change in groundwater levels, groundwater contributions to streams (baseflow), and changes in surface water runoff—the three key inputs to the analysis of potential effects on water-related resources.

4.1.3.1 Groundwater Modeling

A site-specific groundwater model was developed based on the widely used MODFLOW software (Harbaugh 2005), which was calibrated and validated for the regional groundwater system in and around the Haile Gold Mine Project area. The model was created to characterize: (1) changes in groundwater levels and flow paths that would occur as a result of groundwater lowering; (2) how groundwater contributions to stream baseflow would change over the life of mining; and (3) how groundwater levels and flow paths would recover post-mining. The groundwater model also was used to simulate refilling of

Ledbetter Pit Lake and post-mining groundwater flow paths. Additional description and details of the groundwater modeling are provided in Section 4.3.

During pit dewatering, groundwater flow would be toward the dewatering wells around the pits (Figure 4.1-6). The groundwater pumped to the surface from the dewatering wells would be discharged directly to Haile Gold Mine Creek or would be used in gold processing at the Mill, in which case, it would become part of the closed-loop system of the Mill and the TSF. After mining is complete, groundwater quality would be affected by contact between groundwater and the highly mineralized rock within the pit and backfilled overburden. The resulting groundwater would move slowly over many years (approximately 50–70 years) toward lower Haile Gold Mine Creek and the Little Lynches River.

4.1.3.2 Groundwater Quality Modeling

Groundwater flowing through the backfilled pits would come into contact with pit highwalls and backfilled overburden with the potential for acid generation; this contact would be a potential source of chemical loads to groundwater. These chemical loadings and the resultant reactions were simulated with a geochemical model, PHREEQ (Parkhurst and Appelo 2013). Outputs from the geochemical modeling were input to the groundwater transport model to predict the direction and travel times for the groundwater to reach Haile Gold Mine Creek and the Little Lynches River, where the groundwater would discharge to these streams and mix with the surface waters.

4.1.3.3 Pit Lake Water Quality Impact Modeling

Pit lake water quality impacts were estimated using a combination of the MODFLOW Lake Package to simulate pit lake refilling, the PHREEC geochemistry model, mass balance spreadsheet analysis, and dilution (see Section 4.3 for descriptions of these models). The water quality of the pit lakes (Ledbetter, Small, and Champion) were simulated over time and in their proposed final reclaimed condition**.** This model also provided the basis for determining how much lime would be needed to maintain an appropriate pH level and other treatments that may be needed for overburden management in backfilled pits and the pit lakes.

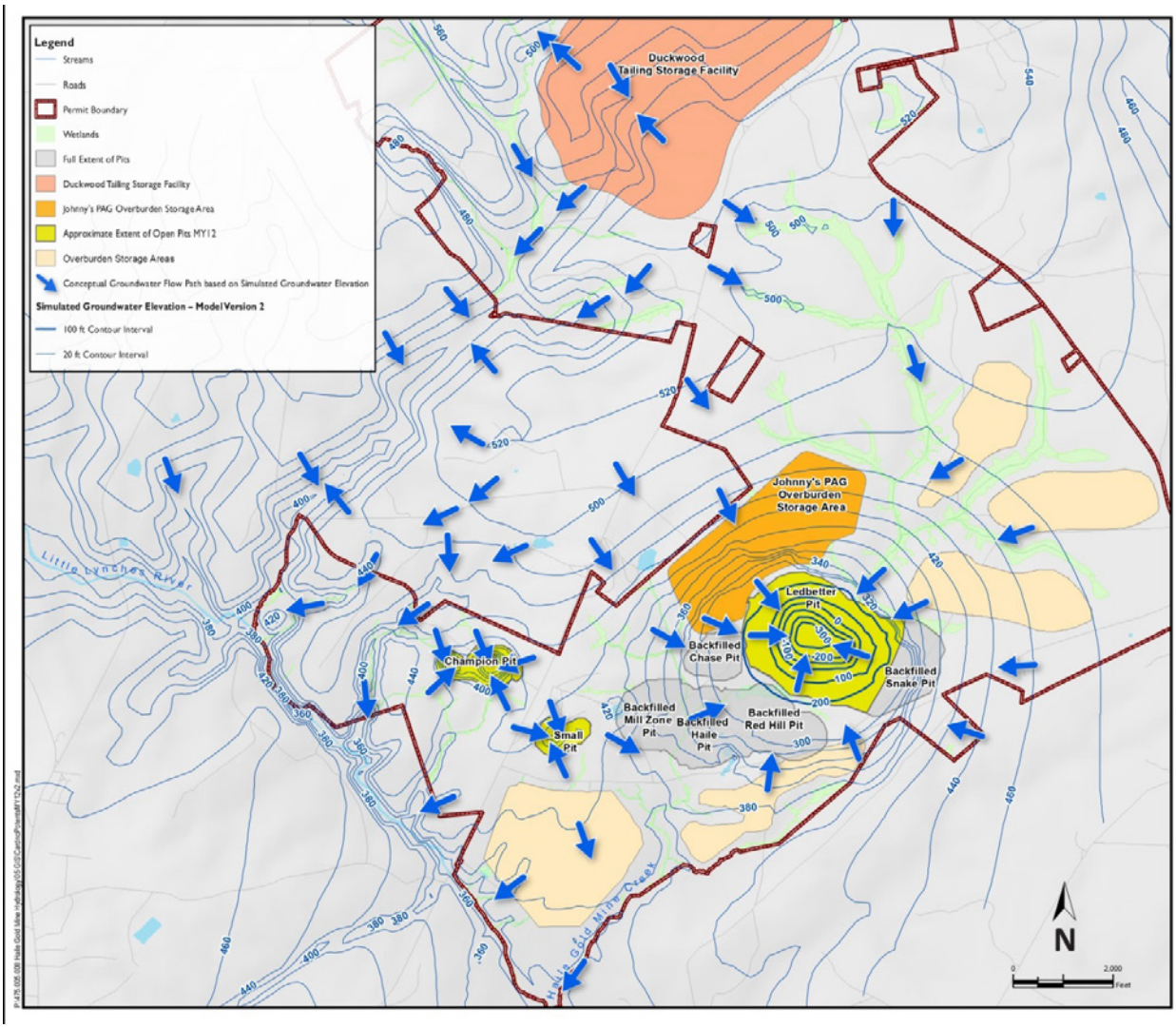

Figure 4.1-6 Illustration of the Direction of Groundwater Flow toward Ledbetter Pit during Mine Year 12

4.1.3.4 Streamflow Analysis

Streamflow consists of two main components: baseflow and runoff (Figure 4.1-7). *Baseflow* is the portion of streamflow that comes from deeper subsurface flow and delayed shallow groundwater flow contributions (Figure 4.1-2). *Runoff* is precipitation that is not absorbed by the soil and that "runs off" directly into streams. Runoff is periodic and is associated with precipitation events; during dry periods, runoff is often absent and streamflow is sustained by baseflow.

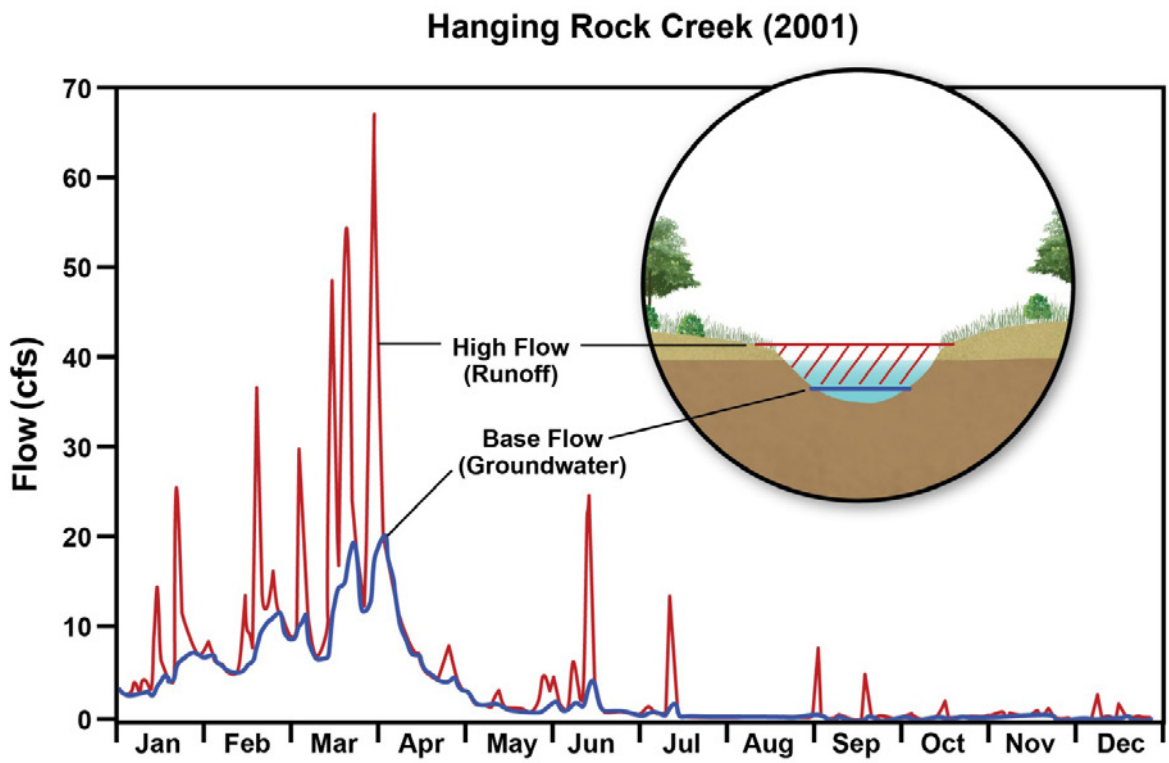

Figure 4.1-7 Illustration of the Two Components of Streamflow: Baseflow and Runoff

Streamflow data from the Project area and nearby USGS streamflow gages were used to characterize daily and monthly baseflow and runoff rates for streams in 16 subwatersheds (Figure 4.1-8) that formed the analysis units for streamflow impacts. The change in runoff due to watershed alteration (from a reduction in drainage area, stormwater management, and changes in runoff due to land disturbance) was based on spatial analysis and widely accepted hydrologic analysis methods that are discussed further in Sections 4.3 and 4.4. Changes in baseflows were simulated with the MODFLOW groundwater model.

4.1.3.5 Stream Water Quality Analysis

The characterization of potential changes in surface water quality included a combination of modeling and qualitative analysis**.** The groundwater quality impact model was used to predict long-term water quality contributions of groundwater to Haile Gold Mine Creek, Camp Branch Creek, and the Little Lynches River**.** Temperature modeling was used to determine the changes in the stream thermal regime due to land disturbance and clearing, streamflow reductions, piping of water, discharges of depressurization water, stormwater discharges, discharges from the water treatment plant, and—for the long-term—from the passive treatment systems that would be used to treat drainage from Johnny's PAG and the Duckwood TSF**.** The integration of these results and the ultimate assessment of impacts on stream water quality were based on the modeling results, best professional judgment, and literature on mining and watershed development impacts.

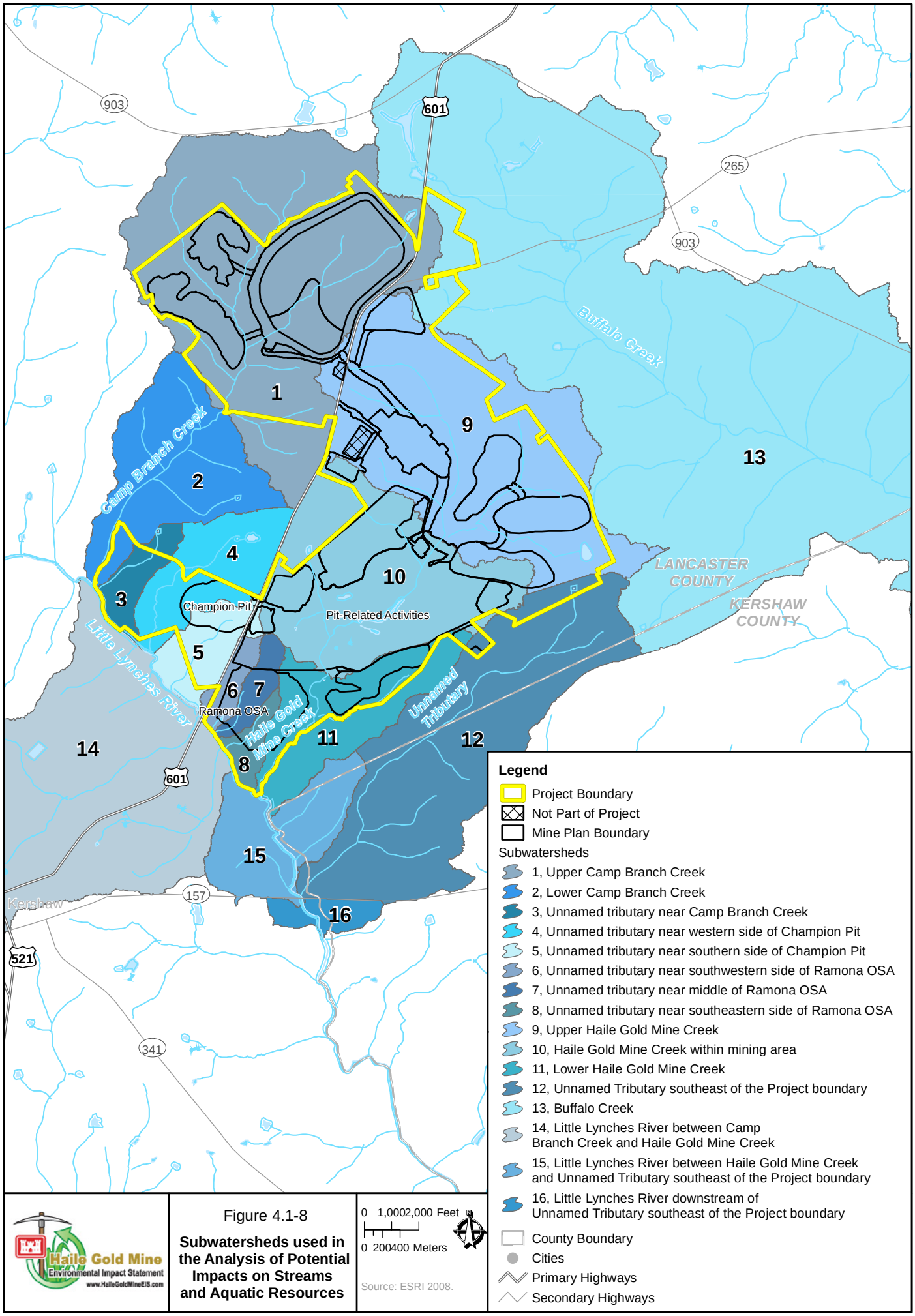

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Figure 4.1-8

Subwatersheds used in the Analysis of Potential Impacts on Streams and Aquatic Resources

4.1.4 Assessment of Impacts on Water-Related Resources

The impact analyses for water-related resources (wetlands, streams, and Waters of the U.S.; aquatic habitat and resources; groundwater and surface water quality and water supplies; floodplains; riparian communities; and terrestrial resources) relied on quantitative and qualitative assessments. The modeling described above provided most of the quantitative estimates for the impacts assessment, and additional quantitative modeling (e.g., stream temperature modeling) and qualitative evaluations were used to assess potential impacts.

Each resource-specific section that follows in this chapter describes the details of the environmental analysis (see discussions of "Methods" in each section). For stream and aquatic systems, and to some extent for wetlands, potential impacts generally were structured around factors known to be important to biological integrity (Karr et al. 1986). These include flow, watershed and habitat conditions, water quality, thermal regime (water temperature), and biological factors. Table 4.1-1 summarizes some of the elements important to the biological integrity of streams, aquatic resources, groundwater influences, and stream riparian areas and wetlands; and identifies some of the stressors that may occur as a result of the proposed Project.

Stressors

Stressors are natural environmental factors or factors resulting from human activity that affect or place constraints on the productivity of species, elicit biological or ecological responses, and affect the development of ecosystems. Stressors can be physical (temperature, rainfall, radiation), chemical (water quality, contaminants), and biological (alteration of habitat, competition, introduced species).

Table 4.1-1 Important Determinants of Biological Integrity and Potential Stressors for Water-Related Resources

Determinant of Biological Integrity	Potential Stressors
Flow regime	Stream diversion Groundwater lowering Baseflow reductions Runoff reductions Stormwater runoff
Watershed and habitat	Land use and land cover changes Habitat alteration due to flow changes Habitat fragmentation Sedimentation Stream channel alterations
Water quality	Water chemistry alteration (pH, total dissolved solids, suspended sediment, hardness) Contaminants Nutrient levels
Thermal regime	Stream temperature regime changes Maximum temperatures Water chemistry interactions
Biological factors	Food source alterations Species loss Invasive species

4.1.5 Use and Management of Cyanide

The use of cyanide at the Haile Gold Mine and its potential effects are addressed in various sections of this EIS. The Applicant's proposed use, recycling, and management of cyanide in the gold refining process and tailings storage and disposal are described in Appendix A. This section provides more information about cyanide, its chemical forms, how it would be used at Haile Gold Mine, and the protective measures in place to manage its use. This information is provided to support the analysis of the potential effects of cyanide use and potential mitigation measures in the resource-specific discussions. The potential impacts of cyanide use are discussed in Sections 4.4, "Surface Water Hydrology and Water Quality"; 4.8, "Terrestrial Resources"; 4.16, "Air Quality"; and 4.19, "Hazardous Materials and Waste."

4.1.5.1 What is cyanide?

Cyanide is a naturally occurring molecule of carbon and nitrogen. Low concentrations of cyanide are present in nature, for example in many insects and plants, including the pits and seeds of a wide range of vegetables, fruits, and nuts. The edible parts of these plants contain low levels of cyanide.

Cyanide and cyanide compounds are present in air, water, soil, and food from both natural and anthropogenic sources. We are exposed to cyanide in much of the everyday environment. For example, cyanide is present in road salt, cigarette smoke, and automobile exhaust; and it is used as a stabilizer in table salt.

Cyanide is widely used in commercial and industrial applications. In manufacturing, cyanide is used to make paper, textiles, and plastics; and it is present in the chemicals used to develop photographs. Cyanide is used in metallurgy for electroplating, metal cleaning, and removing gold from its ore. Cyanide gas is used to exterminate pests and vermin in ships and buildings.

Cyanide is highly reactive, occurs in many forms, and its chemistry is complex (CDC 2014). Forms of cyanide include free cyanide, which includes the cyanide anion itself (CN-) and hydrogen cyanide (HCN), either in a gaseous or aqueous state. Cyanide compounds may take many forms, including free cyanide, simple cyanides, complex cyanides (metallocyanides), and organic cyanides (nitriles). Free cyanide refers to the sum of molecular HCN and the cyanide anion, CN-. Free cyanide is the most toxic form of cyanide; it is bioavailable and toxic to organisms in aquatic environments. Cyanide can be lethal to humans and animals if absorbed, ingested, or inhaled in sufficient amounts.

Cyanide compounds are broadly classified into three categories; total cyanide, available or WAD cyanide, and free cyanide (Figure4.1-9)

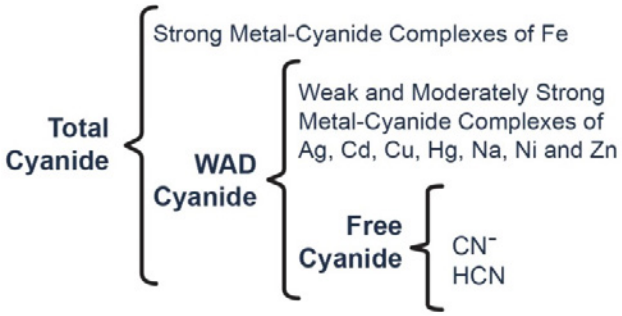

Figure 4.1-9 Broad Classification of the Categories of Cyanide Compounds

Source: O. I. Analytical n.d.

WAD cyanide is a commonly used measure of cyanide. WAD cyanide includes both free cyanide and WAD cyanide compounds, such as weak and moderately strong metal-cyanide complexes. The importance of these compounds is in relation to cyanide in the water environment. The amount of cyanide released from these compounds, and then becoming potentially toxic, depends on the acidity (pH) of the water in which cyanide is dissociated from its weakly bound metal complex. WAD cyanide is a more reliable measure for toxicity and is considered more biologically relevant than total cyanide because total cyanide includes stable compounds (e.g., ferrocyanide complexes) that do not contribute to toxicity (USEPA 1980; Eisler 1991).

4.1.5.2 How would cyanide be used at the Haile Gold Mine?

Cyanide would be used in process water at the Mill to extract gold from ore after crushing, grinding, and flotation. Cyanide would be delivered to the Mill as NaCN, a white crystalline powder constituting a weak metal-cyanide complex. It would be mixed with water to form a solution that then would be used to leach gold from ore using carbon-in-leach (CIL) tanks. In the CIL tanks, gold would be dissolved by cyanide and removed from solution by adsorbing to activated carbon. The pH in the CIL tanks would be maintained at greater than 10 to prevent cyanide from converting into HCN and volatilizing (turning into toxic gas).

After processing, the residual solution containing cyanide tailings would be treated. The cyanide tailings would be processed in a cyanide recovery thickener to solidify and recover a large percentage of the cyanide for recycling. If the remaining solution has a cyanide concentration of less than 50 mg/L WAD cyanide, it would be pumped through the tailings pipeline to the Duckwood TSF for storage. If the cyanide concentration exceeds this level, the solution would be directed to cyanide destruction tanks. The cyanide destruction tanks would treat cyanide using an SO_2/air process and then would direct the tailings to the TSF.

Within the TSF pond, the concentration of cyanide would be naturally reduced through precipitation and microbial degradation. The TSF pond would be constructed with both clay and HDPE liners, and would be built to withstand the peak flow from a 100-year 24-hour storm event, minimizing the possibility of overflow into the surrounding environment. The remaining cyanide solution in the TSF would be recycled and reused in the Mill to minimize the total amount of cyanide used and to reduce operational costs. Tailings stored in the TSF are expected to have residual cyanide concentrations throughout the ore processing phase of the Project.

4.1.5.3 What forms of cyanide would be present at the Haile Gold Mine?

Many of the forms of cyanide described above would be present at the Haile Gold Mine. Delivery of cyanide would generally be in the form of sodium cyanide. Once mixed with water to form a solution, it would be used in processing at the Mill, where many forms of weak and moderately strong metal-cyanide complexes (WAD cyanide) would be present. In the tailings slurry pipeline, cyanide would be present primarily as WAD cyanide, including some stable cyanide compounds. When tailings arrive at the TSF, cyanide and other chemicals would be present in the water. In the TSF, certain forms of cyanide would degrade further by direct exposure with sunlight and the atmosphere. One of the natural degradation processes for cyanide is its conversion from a liquid form into a gas, and thus some cyanide would be released to the atmosphere as HCN.

4.1.5.4 What protection measures would be in place?

The Applicant has proposed and committed to a number of measures to manage the associated risks and potential impacts of cyanide use. Haile has committed to managing cyanide use at the Haile Gold Mine in

compliance with the International Cyanide Management Code for the Manufacture, Transport, and Use of Cyanide in the Production of Gold (the Code) (International Cyanide Management Institute 2014). The Code commits signatories to procedures to manage the production, transport, storage, and use of cyanide; it requires compliance certification and third-party verification audits every 3 years. Haile is a signatory to the Code. With the first delivery of cyanide to Haile Gold Mine, the clock would start on the 3-year compliance audit.

Many of the measures to be implemented at Haile Gold Mine are driven by compliance with the Code, process requirements, and regulations. The following measures have been proposed and committed to by Haile.

- Transport handling and safety measures include:
  - Deliveries of sodium cyanide would be handled by standard operating protocols; deliveries would be made to containment areas with concrete pads and drain/collection systems.
  - Storage and use of chemicals/reagents in the process would occur within containment structures to protect against their release to the environment.
- At the Mill, redundant spill containment systems would be in place, including primary containment in vats, secondary containment by concrete containers, and the Process Event Pond would be designed to act as a failsafe to capture any spill that escaped the primary and secondary containment. The floor area and walls of the concrete containment areas are designed to capture 110 percent of the largest vessel (or container) in that process area plus stormwater (for the 100-year, 24-hour storm event) if the container is open to the sky. If a spill is greater than the facility's containment capacity, it would be captured and flow into the Process Event Pond and recycled into the Mill. The Process Event Pond is designed to capture quantities of spilled solution or slurry that may exceed the main process containment facilities, including tailings slurry pipeline contents, and reclaim water line contents (see Appendix A for details).
- Cyanide would be used only in the closed-loop process water used at the Mill. Under normal operating conditions, flow from the Mill would be pumped to the TSF. If the cyanide level is greater than or equal to 50 ppm WAD cyanide, the flow would be directed to the cyanide destruction tanks, where cyanide levels would be lowered to below 50 ppm (WAD) using a SO_2 and air process. Cyanide would be recycled to the extent practicable.
- The tailings slurry pipeline design includes spill containment measures; double-walled pipes with pressure sensors and lined trenches would direct any spill back to the Process Event Pond.
- The TSF, Process Event Pond, and other lined facilities would be fenced with an 8-foot chain link design to exclude wildlife.

4.1.6 Financial Assurances and Bonding

This section describes the concepts of financial assurances and bonding within the mining and metals industry, the requirements for bonding under the SCMA, and Haile's proposal for financial assurances and bonding.

4.1.6.1 What are financial assurances?

Mining companies have long been required to post security with governments to guarantee the performance of required activities for closure and reclamation at mine sites. State and federal regulatory agencies traditionally have required a form of financial assurances to ensure that reclamation performance standards are met in mining operations. In dealing with the legacy of abandoned mines, bankruptcies, and

mining company defaults, however, agencies sometimes lack sufficient funds to complete the necessary land reclamation, let alone to abate or provide long-term treatment of pollution discharges (Gorton 2013). The shortcomings of historical financial assurances have received considerable attention in recent years (USEPA 2009; ICMM 2005, 2006).

As outlined by the International Council on Mining and Metals (ICMM), mine closure and reclamation is an integral part of the modern mining life cycle, and an acceptable level of assurances that reclamation and closure will be fully funded by the mining company should be provided through the use of appropriate financial instruments (ICMM 2006). *Financial assurances* refers to the basic concept that a company or corporation affecting public lands or resources needs to provide the assurances that funds will be available during and after a project to complete the necessary activities to prevent or repair environmental damage. Also referred to broadly as "environmental financial assurances" (USEPA 2009; ICMM 2005), these are the financial arrangements made to guarantee the costs of reclaiming lands affected during mining in order to prevent or repair environmental damage at the end of a mine's life. Environmental financial assurances measures help to provide a guarantee to governments and communities that financial resources will be available for a range of circumstances (ICMM 2005).

Environmental financial assurances instruments include sureties (for example, fidelity bonds, surety bonds, performance bonds, and letters of credit). Sureties are guarantees issued by a bonding company, an insurance company, a bank, or another financial institution that agrees to hold itself liable for the acts or failures of a third party. The issuer of the surety also is referred to as the *surety*. Another form of financial assurance is a cash deposit with a responsible government agency. A new form, which has appeared in recent years, is an insurance policy, used in conjunction with other measures.

Preliminary closure and reclamation plans that are typically required as part of mine project feasibility studies should be updated as required, reflecting changes in environmental conditions and in mine operations. Similarly, arrangements for financial assurances should be designed to be revisited and revised during the life of the mine to reflect these changes. In all cases, detailed reclamation and closure plans, and adjustments to financial assurances, should be completed and approved before the outset of mining and should be revised as appropriate during the mine life. In addition to bonding, it is in the best interest of an active mining operation to develop and periodically review and update the closure plan and to modify its internal accrual process so that sufficient funds are available for reclamation and closure.

4.1.6.2 What are the requirements for financial assurances and bonding in the South Carolina Mining Act?

Under South Carolina mining regulations (Statutory Authority: 1976 Code, Section 48-20-110) the SCDHEC is responsible for administering the issuance of mining permits; reviewing and approving reclamation plans; collecting reclamation performance bonds; and inspecting all mining operations, and reclamation and other associated activities.

Before issuance of a permit, the SCMA requires that an applicant for a Mine Operating permit must file a bond with the SCDHEC, and upon approval of the application maintain the bond in force, as set forth in Section 48-20-110. The bond must be conditioned on the faithful performance of the requirements set forth in the SCMA and the regulations adopted pursuant to

Reclamation

Reclamation means the reasonable rehabilitation of the affected land for useful purposes and the protection of the natural resources of the surrounding area. Although both the need for and the practicability of reclamation control the type and degree of reclamation in a specific instance, the basic objective is to establish on a continuing basis the vegetative cover, soil stability, water conditions, and safety conditions appropriate to the area. Closure activities are a part of reclamation.

(SCMA Section 48-20-40)

it. The mine operator's liability under the bond must be maintained as long as reclamation is not completed in compliance with an SCDHEC-approved reclamation plan.

The general requirements for financial assurances for mines in South Carolina are set forth in Section 48-20-110 of the SCMA, as follows:

> *SECTION 48-20-110. Bonding or other security requirements. Each applicant for a certificate of exploration, and each applicant for an operating permit, shall file with the department, upon approval of the application, and maintain in force a bond in an amount set forth in this section. All bonds must be in favor of the State of South Carolina, executed by a surety approved by the Department of Insurance in the amount set forth in this section.*

Upon approval of the application, the SCDHEC will set the amount of the performance bond or other security required pursuant to the SCMA. No Mine Operating permit will be issued until the operator has deposited with the SCDHEC an acceptable performance bond or other security pursuant to Section 48-20-110. Termination of a Mine Operating permit does not relieve the operator of any obligations incurred under the approved reclamation plan or otherwise.

Pre-defined bond amounts are described in the SCMA for mining projects smaller than 25 acres. For mines larger than 25 acres, such as the proposed Haile Gold Mine, the SCDHEC has the authority to require a bond in an amount necessary to ensure proper reclamation. The SCMA regulation (R.61-89.200) requires the applicant to prepare a written estimate of the cost of reclamation activities. The cost estimate must reflect customary and prevailing rates for third-party completion of reclamation activities.

The SCMA requires that all bonds must be in favor of the State of South Carolina, executed by a surety approved by the Department of Insurance in the amount set forth in Section 48-20-110. The bond must be continuous in nature and must remain in force until canceled by the surety. Liability under the bond must be maintained as long as reclamation has not yet been completed in compliance with the approved reclamation plan unless released only upon written notification by the SCDHEC. In lieu of the surety bond required by the SCMA, the operator may file with the SCDHEC a cash deposit, registered securities acceptable to the SCDHEC, an assignment of a savings account in a South Carolina bank, or other securities acceptable to the SCDHEC.

Reclamation Plan

A *reclamation plan* is the operator's written proposal as required and approved by the SCDHEC for reclamation of the affected land, which includes but is not limited to:

- Proposed practices to protect adjacent surface resources;
- Specifications for surface gradient restoration, including sketches delineating slope angle, to a surface suitable for the proposed subsequent use of the land after reclamation is completed, and the proposed method of accomplishment;
- Manner and type of regevetation or other surface treatment of the affected areas;
- Method of prevention or elimination of conditions that are hazardous to animal or fish life in or adjacent to the area;
- Method of compliance with state air and water pollution laws;
- Proposed methods to limit significant adverse effects on adjacent surface water and groundwater resources;
- Proposed methods to limit significant adverse effects on significant cultural or historic sites;
- Method of rehabilitation of settling ponds;
- Method of control of contaminants and disposal of mining refuse;
- Method of restoration or establishment of stream channels and stream banks to a condition minimizing erosion, siltation, and other pollution;
- Maps and other supporting documents reasonably required by the department, and
- A time schedule, including the anticipated years for completion of reclamation by segments, that meets the requirements of Section 48-20-90.

(SCMA Section 48-20-40)

Upon completion of reclamation of an area of affected land, the operator contacts the SCDHEC, who will subsequently inspect the area. If the SCDHEC finds that reclamation has been properly completed, the operator will be notified in writing and released from further obligations regarding the affected land. At the same time, the SCDHEC will release the appropriate portion of a performance bond or other security posted under Section 48-20-110.

According to the SCMA and its regulations, an approved reclamation plan must be implemented during and following mining on a predetermined schedule. This involves developing and installing practices related to on-site water management, erosion and sediment control, overburden management, soil stability, visual screening, fugitive emissions, public safety, and establishment of vegetative cover. An annual reclamation report is required to be submitted to the SCDHEC each fiscal year. Other reports and monitoring may be required on a site-specific basis.

A number of other clauses in the SCMA address the requirements, amounts, conditions, and types of performance bonds or other security required; forfeiture; and revocation. Other specifics of the bonding and security requirements are presented in the SCMA,

4.1.6.3 What financial assurances and bonding are proposed for the Haile Gold Mine?

As part of the Applicant's Proposed Project, Haile prepared and submitted a proposed draft reclamation plan (AMEC 2013) (Appendix H), which is a revision to its originally submitted reclamation plan (Schlumberger Water Services 2010). Haile states that the Haile Gold Mine Reclamation Plan is primarily conceptual; it describes the general procedures and methods for achieving the final reclamation requirements and objectives. Haile's Reclamation Plan would be modified as necessary to meet the requirements of the SCMA and approved as appropriate by the SCDHEC. The Haile Gold Mine Reclamation Plan is designed to be refined over time as new information becomes available, and reclamation phases would be approved in advance by the SCDHEC as the detailed plans for phases of reclamation are submitted by Haile.

The Haile Gold Mine Reclamation Plan describes methods proposed to be used to reclaim land disturbed by mining, ore processing operations, and associated activities to a stabilized condition that will provide for the long- term protection of land and water resources, minimize the adverse impacts of mining, and support the intended post-mining land use.

The Applicant used the Haile Gold Mine Reclamation Plan as the basis for calculating estimated reclamation costs, identifying long-term post-reclamation monitoring and maintenance requirements, and determining the proposed amount of financial assurances. Haile's proposal for bonding outlines a number of important assumptions that describe the components of the mine closure and reclamation activities that would be covered by the bonds. The proposed approach is based on the total liability remaining at any point in the proposed Project operations.

Haile's revised cost estimate is generally based on 2013 costs obtained from current vendors, the Caterpillar Performance Handbook, 29th Edition (Caterpillar 1998); South Carolina Davis Bacon Labor Rate (U.S. Department of Labor 2013); RS Means Cost Data Online 2013 (RS Means 1023); and the Standardized Reclamation Cost Estimator (Nevada Division of Environmental Protection 2013) developed cooperatively by the U.S. Bureau of Land Management, the Nevada Division of Environmental Protection, and the mining industry. Haile has estimated the cost of closure and reclamation to be $34,764,979. At the time of publication of the Draft EIS, the State is reviewing this cost estimate.

The cost of closure and reclamation would vary during the life of the mine as operations progress. The highest amount of financial assurances in place would occur during Mine Year 8 (Table 2 in Appendix C

of the Haile Gold Mine Reclamation Plan). Haile recognizes in its reclamation plan that actual timing of the posting of financial assurances, as well as the portion of the financial assurances posted within particular time periods, is subject to regulation by and further discussions with the SCDHEC.

According to Haile, as mining activities progress, the Haile Gold Mine Reclamation Plan would be continuously refined and expanded, while adhering to the concepts outlined in the plan (AMEC 2013). Detailed reclamation Project information would be provided to the SCDHEC in advance of conducting the reclamation described in the Haile Gold Mine Reclamation Plan, in compliance with the SCMA, its regulations, and the Mine Operating permit conditions.

Financial assurances would be provided for proposed reclamation and closure activities to ensure that reclamation and closure would not become the financial responsibility of the State of South Carolina (Schafer and Schlumberger Water Services 2011). Currently, Haile's proposed Haile Gold Mine Reclamation Plan does not address contingencies for unplanned events or failures.

4.1.6.4 How and when would the SCDHEC decide on required financial assurances and bonding?

The SCDHEC is continuing review of Haile's application for a Mine Operating permit according to the SCMA and its regulations. The State is currently evaluating the financial assurances and bonding proposed by the Applicant. The State would set the amount of the required financial assurances and bonding if and when the application for a DA permit is approved.

4.1.7 Evaluation of Potential Facility Failures

According to Haile, the earth moving, industrial processing, and waste treatment and storage systems for the proposed Project have been designed to meet all applicable regulatory and engineering standards and codes. These standards are imposed on the Project through issuance of permits for construction and operations of the proposed Project required by a number of state and federal regulations and their implementing agencies. These standards address routine operations (e.g., water quality discharge standards through an NPDES permit) and low-probability, high-consequence events (e.g., seismic structural design standards address potential earthquakes).

The Draft EIS focuses primarily on construction and routine or expected operations of the proposed Project because these have the greatest duration and are likely to have the greatest cumulative consequence over the life of the Project. In some projects, however, environmental consequences may arise from events that are not normal or routine and are actually planned not to occur. Such events have a very low probability of occurrence. The typical causes of such low-probability events include extreme weather, seismic events, material failures, and human error. Analysis of a complex project as a series of interconnected systems to find those elements that could fail is called *failure mode analysis*.[3] Failure mode analysis is driven by identifying component failures that could shut down or have extreme consequences for the system and then attempting to quantify the consequences of the failure. The following sections describe (1) those elements of the proposed Haile Gold Mine whose failure could result in an important consequence to the environment; and (2) the means by which the potential for failure has been addressed in the Project facility design and plans for implementation of the Project.

[3] Rausand, Marvin and Arnljot Hoyland. 2003. System Reliability Theory: Models, Statistical Methods, and Applications. Second Edition. John Wiley & Sons, Inc. 664 pp.

4.1.7.1 Unintended Failures of Construction Activities

Project construction activities that could experience unintended failures with environmental consequences include releases from equipment fueling and maintenance activities, releases from hazardous materials storage, and failure of stormwater management and sedimentation protective systems. Other than accidents involving equipment or construction activities, weather events are the most likely source of events with unintended consequences. Normal construction planning includes consideration of adverse weather conditions based on local long-term weather data (see Section 4.18, "Health and Safety"). Construction BMPs, grading permits, and permits for stormwater management during construction take into account the likelihood and consequences of adverse weather conditions. The environmental analysis assumed that permits issued by the SCDHEC would adequately address the consequences of adverse weather during construction. The environmental analysis also assumes that (1) final construction plans reviewed by the SCDHEC will include BMPs for handling of fuel, lubricants, and other hazardous materials during construction; and (2) as part of its permits, the SCDHEC will require adequate stormwater management, sediment control, and SPCC plans.

4.1.7.2 Structural Failure of the TSF Embankment

Structural failure of the TSF embankment could occur from improper construction methods and materials or overtopping of the embankment and slope failure during an extreme weather event. Embankment failure would release tailings containing residual WAD cyanide to the environment. Depending on the location, volume, and timing of such a release, tailings material could reach surface waters, thus contributing contaminated sediments to streams and valleys, inundating lands, and covering terrestrial habitat. The SCDHEC has issued a dam construction permit and has verified the design and proposed construction methods to be used when constructing the embankment and filling the TSF during operations. The dam construction permit includes requirements for inspection of the construction operation. Design of the facility includes additional storage beyond the tailings volume to accept storm accumulations from the probable maximum precipitation event (48 inches of rainfall in 24 hours) while leaving an additional 4 feet of freeboard at the embankment (see Section A.5 in Appendix A).

4.1.7.3 Structural Failure of the TSF or Johnny's PAG Liner

The TSF and Johnny's PAG would be constructed with a liner to prevent leachate from the TSF or Johnny's PAG from reaching the groundwater. If a failure to the liner were to occur, leachate could enter the groundwater and potentially affect surface water where groundwater enters surface waters downgradient of the TSF or Johnny's PAG. A groundwater underdrain system would be installed beneath the liner that would be monitored to detect any contaminants that may enter the groundwater through a liner failure. Both facilities also would have drain systems installed over the liner to drain off any leachate at Johnny's PAG and to decant slurry water at the TSF. Finally, during site closure, Johnny's PAG would be capped with an impermeable HDPE geotextile to prevent infiltration of water from the cover material and providing an additional barrier to the formation of leachate (see Section A.5 in Appendix A). Final design, installation, and operation of these systems would be reviewed and permitted by the SCDHEC. The analysis in the Draft EIS assumes that the design, review, and approval of these facilities by the SCDHEC would consider potential but unlikely failures from extreme weather and seismic events.

4.1.7.4 Structural Failure of Mill Processing Equipment and Containment

The Mill would process ore in a series of sequential steps that include physical reduction and chemical slurry processing in large aboveground tanks. Failure of a tank or connecting piping could release the tank contents that could percolate through soils to the groundwater, enter surface waters, and affect terrestrial habitat. The tanks, piping, and other support equipment and hazardous materials receiving and storage

would be located within aboveground secondary containment systems. The design capacity of the containment would accommodate 110 percent of the maximum volume of the largest tank or storage facility within each secondary containment, allowing for a tank failure, tank piping failure, and drain down with additional containment capacity for a weather event or other system failure. Further, secondary storage at the Mill Site would drain to a 1.5-million-gallon Process Event Pond, providing further backup if the primary and secondary containments were to fail. The SCDHEC would review the adequacy of the Mill system final design and containment system as part of the Department's review of the application for a Mine Operating permit.

4.1.7.5 Structural Failure of the Tailings Slurry Pipeline or Reclaim Water Pipeline

If the slurry pipeline conveying tailings from the Mill to the TSF or the reclaim water pipeline recirculating slurry water to the Mill experienced a failure resulting in loss of pipeline integrity, slurry material containing degraded WAD cyanide could be released to the environment. Depending on its volume and velocity, the slurry material could flow to surface waters, affecting water quality and possibly flow. Some of the slurry liquid could percolate to groundwater and temporary effects on surface vegetation also could occur. To prevent these impacts, Haile has designed the slurry pipeline to be configured as a pipe within a pipe, forming a double-walled system. This configuration provides redundancy of confinement for the slurry. In addition, the slurry pipeline is to be installed in a trench that drains to the Process Event Pond, which could accommodate 110 percent of the pipeline capacity and precipitation from the 100-year, 24-hour rain event (see Section A.4 in Appendix A). Review of the adequacy of the tailings slurry pipeline and reclaim water pipeline final design and containment system would be undertaken by the SCDHEC as part of the Department's review of the application for a Mine Operating permit.

4.1.7.6 Slope Failure of an Overburden Storage Area

Overburden removed during mining and not re-used as pit backfill would be stacked and permanently stored in the OSAs. These earthen structures would be constructed with engineered slopes to prevent slope failure. The slopes also would include positive drainage for control of surface water runoff; they would be graded and vegetated concurrently as soon as feasible during active mining. Severe weather events and seismic shaking could cause slope failures. Any displaced Green and Yellow Class overburden material from a slope failure could enter surface waters, filling stream channels and causing changes in flow regime and potential increases in TSS concentrations. These changes could lead to effects on aquatic and riparian habitats. Design of the OSA slopes, monitoring requirements during construction, and ongoing monitoring during the post-mining reclamation and closure period would be reviewed and approved by the SCDHEC as part of the Department's review of the application for a Mine Operating permit.

Because such failures are not part of normal operations and are low-probability events, when, where, and to what extent failures may occur cannot be predicted. As discussed above, measures have been incorporated into the design of the Project to address the major failure modes identified.

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4.2 Geology and Soils

Activities that would directly affect the geology and soils in the Project area include changes to topography from removal, excavation, and relocation of overburden, and handling of soils, waste rock, and ore. Relocation and permanent storage of overburden in the OSAs and construction of the TSF could cause increased sedimentation. Potential indirect impacts include slope instability from seismic events and permanent, long-term changes in soil type from removal, relocation, and disturbance of soils and their associated mineral resources.

4.2.1 Methods

The amount of soil and rock material excavated and relocated in the Project area (in tons) was defined as the measure of direct impact. Indirect geological impacts were measured via available data from published literature, historical data, and available geotechnical studies. Mobilization of soil material as sediment by mining, reclamation, and closure activities also was considered as a direct impact of the Project. Direct impacts on soil were measured by the amount (in tons) and locations of soil that would be removed and affected by Project activities. Indirect impacts on soil were estimated through analysis of drainage and slope changes that would result from Project activities.

4.2.2 Impacts on Geology and Mineral Resources

The impacts of rock mining on the geology and waste rock and ore in the Project area are directly related to the actions completed during land clearing and the rock removal processes. The geology of the Project area and the identified mineralized zones dictate the locations and extent of proposed mining operations to recover gold from the open pits that would be constructed for the Project. Major direct impacts on the geological resources are probable and permanent, and include changes to the existing topography from the amount of rock and sediment removed from the Project area to develop the mine pits. Potential direct and indirect impacts related to seismicity also are addressed.

4.2.2.1 Modification of Geology and Soils

No Action Alternative

The No Action Alternative would result in no removal of soils, overburden rock, or mineral-bearing ore and would not create any new topographic features.

Applicant's Proposed Project

Moderate, permanent direct effects on the geology and soils in the Project area would be caused by removing surface soils and underlying rock from their existing natural setting and placing this material at other locations (the TSF and OSAs), creating eight open mine pits. The total planned footprint for excavating the eight pits is approximately 766 acres. Ultimately, mining would result in permanent extraction and temporary relocation of approximately 241 million tons of overburden and 34 million tons of ore. Mining operations are expected to remove all recoverable gold reserves proposed by Haile based on available technology and at current or reasonably foreseeable gold prices.

Open-pit mining would cause permanent modification of the existing topography (Section 4.14, "Visual Resources and Aesthetics" provides illustrations of these changes). Backfilling the open pits and using natural re-grade techniques during site reclamation would restore most of the mine pits to blend with the surrounding topography or, in some cases, create new topographic features such as the OSAs and the TSF. Approximately 67 million tons (28 percent) of the excavated overburden would be used during

mining to fully backfill four of the eight pits (Haile, Red Hill, Mill Zone, and Chase Pits) and partially refill one pit (Snake Pit).

Modified Project Alternative

The direct and indirect impacts on geological resources under the Modified Project Alternative would be similar to those described for the Applicant's Proposed Project. The differences would be the creation of a topographic feature at the site of the Holly and Hock TSF borrow areas from the permanent placement of overburden and a reduction in the amount of overburden stored at the Ramona OSA.

4.2.2.2 Impacts from Seismic Events

No Action Alternative

Under the No Action Alternative, the potential for direct impacts from naturally occurring seismic events would remain the same as the existing condition.

Applicant's Proposed Project

The potential for seismic events would remain the same regardless of the proposed Project or its alternatives. However, the presence of proposed Project facilities that could be affected by seismic events does increase the potential for indirect impacts such as slope and pit wall instability or induced failure of embankments. As noted in Section 3.2, no specific regulations based on historical seismic data govern the stability of proposed pits, pit slopes, TSF, OSAs, ore processing facilities, haul roads, or overpasses. As described below, proposed Project facilities have been designed by professional engineers to meet specific seismic standards. Further construction design of project facilities would continue to meet these standards.

Seismic hazards were evaluated to determine the potential threat posed by earthquakes related to proposed Project activities, specifically to construction of the TSF. AMEC Earth and Environmental, Inc. (AMEC) performed an updated site-specific seismic hazard assessment in December 2009 using EZ-Frisk, a commercially available software application for probabilistic seismic hazard ground motion prediction (AMEC 2010). The assessment evaluated earthquake potential based on location and magnitude, using regional historical data, as discussed below.

Based on data from the AMEC assessment, calculations, analysis, and review of other seismic reports, AMEC provided the Applicant with suggested guidelines and data for engineering and building designs for the TSF in the Project area (AMEC 2010). These design criteria were incorporated into the TSF design, as are outlined in the *Duckwood Tailings Storage Facility Detailed Design Report* completed by AMEC in 2012 (AMEC 2012). Stability during earthquake-induced ground motion was evaluated by SCDHEC pursuant to the International Commission of Large Dam (ICOLD) seismic design and performance standards (ICOLD 2014).

A detailed geotechnical and engineering analysis also was performed at the Haile Gold Mine site to determine the rock strength and quality classification for strata overlying the ore body (Golder Associates 2010). The configuration of the pits in the proposed Project was determined based on the location and configuration of the ore body, the characteristics of the rock, the hydrogeology of the groundwater system, and the economic and operational variables determined in the Feasibility Study.

The pit configuration determines the location and shape of the pits, along with the bench size within the pits, the access roads, pit wall slope angles, and the amount of material to be mined in each phase to

achieve a safe pit wall slope angle. Design factors must meet the current standard of care for safety, as defined by federal and state regulations (Golder Associates 2010). The recommended pit slopes were based on the available information from bore holes and represent a balance between maximum risk avoidance, such as requiring flatter slope angles and larger pits, and some risk of slope failure without jeopardizing the mine plan or worker safety. The pit engineering report indicates that steeper slope angles may be possible if actual conditions are found to be better than projected (Golder Associates 2010).

During a public meeting held in Atlanta, Georgia, on December 12, 2011, comments by the USEPA established the seismic safety factor for the Project site as 1.1 and the static loading safety factor for the Project site as 1.5.[1] These numbers are the recommended minimum slope stability safety factors for both seismic and static loading conditions (normal conditions), and are used as guidelines for engineering and construction of pertinent Project features. A numerically higher safety factor indicates the need for additional parameters to achieve the required slope stability for acceptable safe working conditions. A low safety factor indicates that the material on a site has more strength and can withstand greater measures, such as steeper slope angles or higher pit walls, before becoming unstable.

The SCDHEC certified the safety of the ring dike containing tailings and reviewed the stability of the TSF tailings impoundment with regard to earthquake and seismic risk, and issued Dams & Reservoirs Safety Permit 29-3337 on October 7, 2013.

Modified Project Alternative

The potential impacts associated with seismic events under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.2.3 Impacts on Soils

Mine activities that disturb the soils and remove vegetation can cause direct loss of the soil through excavation and erosion, as well as indirect impacts on the ability of the soil to sustain vegetation because of long-term changes in soil type and cover. The assessment of potential direct and indirect effects on soils considered the following:

- Loss of soils and surface material due to removal for excavation and facility construction;
- Erosion factors due to slope instability of constructed facilities;
- Erosion factors due to Project activities and associated changes to slopes and altered drainage patterns; and
- Long-term changes in soil type and cover resulting from both changes in the landscape and soil evolution over time caused by ongoing natural erosion.

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[1] The seismic safety factor and the static loading safety factor are calculated using two separate mathematical equations. Variables used for both safety factors include construction parameters, such as height and slope angles, and the physical properties of the soil and rock being used. In conjunction with these variables, the seismic safety factor incorporates additional historical earthquake data into the algorithm. The resulting values are the seismic and static loading safety factors (Nelson 2012; Shangyi and Yngren n.d.).

4.2.3.1 Loss of Soils and Surface Materials

No Action Alternative

Under the No Action Alternative, ongoing exploratory drilling to further define the extent of mineral reserves would cease. No further loss of soils and surface materials would occur from mining-related activities. Ongoing monitoring of the reclaimed sites would occur, with no loss of soils and surface materials.

Applicant's Proposed Project

The principal and major direct impact from implementation of the Applicant's Proposed Project would be removal and disturbance of soils and surface material for a 15-year period over approximately 57 percent (2,612 acres) of the 4,552 acres within the Project boundary. Approximately 1,338 acres of the 2,612 acres would be removed in preparation for pit excavation as part of the mining process and for facility and road construction. The remaining 1,274 acres of surface soils would be disturbed due to relocation of materials to four growth media storage areas, seven OSAs, and one TSF. Later, 67 million tons of overburden would be used as backfill for four pits and partial backfill for one pit.

The surface material, containing both growth media and topsoil, would be relocated to the four growth media storage areas (with a combined base footprint of 103 acres) for later use in reclamation and stabilizing storage sites (OSAs, Johnny's PAG, and the TSF). Approximately 162 million tons (67 percent) of the overburden material generated from digging the pits would be stored at the various OSAs. The overall footprint of the seven OSAs would be approximately 647 acres.

Approximately 67 million tons (28 percent) of the overburden would be backfilled in four of the eight pits (Haile, Red Hill, Mill Zone, and Chase Pits) and would be used to partially refill one pit (Snake Pit). Mining would cause permanent soil loss in three of the pits that would not be backfilled (Champion, Small, and Ledbetter Pits). Champion and Small Pits would be allowed to fill with water to form the Champion and Small Pit Lakes, while Ledbetter Pit would combine with Snake Pit to form the Ledbetter Pit Lake.

The remaining 12 million tons (5 percent) of overburden would be used to construct the 524-acre TSF. The TSF Stage I embankment would obtain approximately 1.5 million tons of overburden material from excavation of the tailings basin. Approximately 1 million tons of soil with low permeability and minor amounts of sand required for the composite liner and zoned embankment that are not available within the tailings basin would be augmented from the pre-production mining operations. The approximate 3.42 million tons of construction materials for Stage II and Stage III of the TSF would come from two borrow areas: Holly and Hock. The remaining 6.08 million tons required for Stage IV embankment would be obtained from the 601 OSA and the Ramona OSA.

Soil and surface materials would be reused for construction of mine facilities, backfill, and reclamation and stabilization of storage facilities; they will not be removed from the Project area. Therefore, the potential for net loss of these resources is negligible. However, as discussed in Section 4.2.3.3, the characteristics of the soil may be substantially modified.

Modified Project Alternative

Under this alternative, the amount of overburden that would be moved within the study area would be the same as for the Applicant's Proposed Project. The difference would be in the placement of overburden with more stored at the Holly and Hock TSF borrow areas and less at the Ramona OSA. All other direct

and indirect impacts on soils and surface materials would be the same as those described for the Applicant's Proposed Project.

4.2.3.2 Impacts from Erosion

No Action Alternative

Under the No Action Alternative, reclamation and closure would continue and no additional mining would take place. The areas within the project boundary previously affected by mining activities may experience a reduction in soil erosion as reclaimed areas continue to become more fully vegetated and stabilized.

Applicant's Proposed Project

Short-term erosion in the Project area from slope instability is probable and likely would result in moderate direct impacts. To avoid the potential for major erosion effects due to slope instability, the Applicant would construct the TSF and all OSAs in accordance with the Reclamation Plan approved by the SCDHEC, Division of Mining (Appendix H). The overall slope of the TSF would be 3:1 (horizontal: vertical), and all OSAs would contain alternating benches with an overall slope of 3:1. This design would provide surface water controls, limit erosion, and manage stormwater drainage while allowing for maximum storage and support. Other surface water controls would be constructed to limit erosion, such as a toe drain along the perimeter of the toe of the TSF footprint and channels to collect stormwater and sediment around the footprint of each OSA, as described in the Project Description (Chapter 2). As part of reclamation activities, all restored areas would be vegetated as specified in the Reclamation Plan (Appendix H). Maintenance of surface vegetation following reclamation would further control surface soil erosion.

Temporary erosion from changes in slope and altered drainage patterns is probable and likely would result in moderate direct impacts. Figure 3.2-3 illustrates the erosion K value of soils in the Project area, and Figure 3.2-4 shows the drainage classifications of soils in the Project area. As described in Section 3.2, the Upper Coastal Plain complex soils that are concentrated on the east side of the Project area have lower K values than the Piedmont soils, meaning that they are less susceptible to erosion by water.

Temporary erosion would occur in the Project area from mine activities causing ground disturbance, such as construction of overpasses, mine haul roads, and excavation of soils and rock materials. The Applicant would implement temporary erosion control measures to minimize erosion and soil loss associated with ground disturbances from mining activities. Increased erosion can generate from undisturbed areas and mine facilities.

Temporary and moderate soil erosion due to runoff from overpass construction is probable. The Applicant would be required to follow state and federal regulations to reduce erosion impacts associated with overpass construction. (See Section 3.2 for applicable regulations.) During construction, the Applicant would be responsible for ensuring that temporary and permanent sediment control basins and stormwater detention ponds were in place. The Applicant also would be responsible for ensuring that temporary erosion control measures were in place to prevent erosion and water pollution through the use of BMPs. Erosion control measures include the use of berms, silt basins, silt ditches, sediment dams, fiber roving, rolled erosion control products, silt fences, floating turbidity barriers, brush barriers, sediment tubes, inlet filters, bonded fiber matrix, flexible growth matrix, temporary flexible pipe slope drains, temporary seeding, and stabilized construction entrances in conformity with the Plans, the Specifications, SCDOT Standard Drawings, or as directed by the SCDOT Resident Construction Engineer (SCDOT 2007).

Temporary erosion also is likely to be caused by construction of mine hauls roads, resulting in moderate impacts. Drainage along constructed mine haul roads would be engineered with safety berms and drainage ditches to reduce erosion. To prevent runoff in undisturbed areas (referred to as *non-contact water*) coming into contact with mine facilities and operations, the Applicant would construct diversion facilities, such as diversion pipes and diversion channels. These facilities would route non-contact stormwater past active mining areas into natural drainage systems.

Runoff originating from mine facilities is probable and temporary, and has the potential to generate moderate erosion. To minimize erosion, the Applicant would stabilize disturbed areas by implementing surface roughening, seeding, mulching, and erosion control blankets. Concurrent reclamation practices would be implemented to minimize the duration of impacts and stabilize disturbed areas as quickly as possible. Runoff collection measures, such as construction of collection channels, sediment collection basins, and spillways, would be implemented to limit erosion and movement of soils that are not contained in place by the above measures. Water from the individual sediment ponds would be released into natural drainages and would not be used by the mine, allowing these surface flows to continue to their natural drainages, as outlined in the Applicant's Project Description (Appendix A).

Methods of managing sediment and erosion control during construction would follow guidelines presented in the *South Carolina DHEC Stormwater Management BMP Handbook* (SCDHEC 2005) and would comply with the conditions in Haile's Industrial General Permit. For the Mill area, an NPDES General Permit for Stormwater Discharges from Construction Activities would be required by the SCDHEC, Bureau of Water, Stormwater Permitting Section. Based on compliance with regulatory guidelines, the long-term impact of increased erosion is considered minor.

Modified Project Alternative

The height of the Holly and Hock TSF borrow areas would be increased under this alternative, which would change runoff amounts and patterns and could result in a slight increase in soil erosion in this area. The decreased height of the Ramona OSA may experience a slight decrease in soil erosion from that of the Applicant's Proposed Project. All other direct and indirect impacts on soils and surface materials would be the same as those described for the Applicant's Proposed Project.

4.2.3.3 Changes in Soil Type and Cover

No Action Alternative

Under the No Action Alternative, ongoing exploratory drilling to further define the extent of mineral reserves would cease. No further impacts related to changes in soil type or cover would occur. Ongoing monitoring of the reclaimed sites would continue.

Applicant's Proposed Project

Long-term, indirect impacts from changes in soil type and cover across the Project area are probable; these would result from changes in the landscape and from soil evolution over time. Soils are nonrenewable resources. Mining and extraction of mineral resources would result in extensive soil modification, removal of vegetation that could cause erosion, loss of the ability of soil to sustain vegetation, and movement of sediment into surface waters. Modification of the soil resource may result in an irretrievable loss of soil productivity, physical structure, and ecological function across the proposed mine site and across down-gradient lands if the mining area acts as a barrier to sourcing and supporting natural downslope transportation of geological material, water, and nutrients. Reclamation efforts potentially would restore the ecological integrity of these disturbed mine land areas through management

of physical, chemical, and biological disturbances of soils such as soil pH, fertility, microbial community, and various soil nutrient cycles that make the degraded land soil productive. However, reclamation efforts on the TSF and OSAs may not result in a fully stable, revegetated landscape due to unstable conditions over time or the inability of the geochemical composition to support native vegetation (Sheoran et al. 2010).

The South Carolina Mining Regulations require a minimum of 75 percent vegetative groundcover with no substantial bare spots (Haile 2012). See Section 4.8 for additional discussion of Project-related impacts on vegetation.

Modified Project Alternative

The impacts of changes in soil type and cover under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.2.4 Impact Summary

Table 4.2-1 presents a summary of impacts under each alternative for the key issues related to geology and soils.

4.2.5 Mitigation for Impacts on Geology and Soils

4.2.5.1 Applicant's Proposed Avoidance and Minimization Measures

The Project would cause permanent direct and indirect impacts on geological resources and soils. Activities that would directly affect the geology in the Project area include excavation, relocation, and disturbance of rock, soils, and waste rock and ore. The impacts of rock mining on the site geology and waste rock and ore are directly related to the actions completed during land clearing and the rock removal processes. Major direct impacts on the geological resources are unavoidable, and include excavation and removal of approximately 241 million tons of overburden and 34 million tons of ore rock from the geologic source in the Project area; disturbance of soils and surface material over an approximate area of 2,612 acres; and removal of vegetation and mining of mineral sources found within the associated soils. Once these impacts have occurred, no feasible means of restoring the original geologic structure are available.

The Applicant has incorporated Project design features and an MMP (Appendix G) and Mitigation Plan (Appendix B) to be approved by the SCDHEC to minimize and reduce other impacts related to seismicity, erosion, and loss of soil cover. The design features include slope and height criteria, surface water runoff management systems, and seismic design criteria. These features have been considered in the preceding analysis. The complete list of Applicant-proposed avoidance and minimization measures for geology and soils is provided in Chapter 6.

4.2.5.2 Additional Potential Mitigation Measures

Based on the Applicant's proposed design features, no additional measures are recommended; however, no mitigation is available to further reduce or avoid impacts on geology and soils.

Table 4.2-1 Summary of Impacts on Geology and Soils

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Modification of geology and soils	No removal of soils, overburden rock, or mineral-bearing ore and no new topographic features.	Permanent extraction and temporary relocation of approximately 241 million tons of overburden and 34 million tons of ore rock; permanent modification of the existing topography.	Similar to the Applicant's Proposed Project except for a reduction in the amount of overburden stored at the Ramona OSA and an increase in the amount of overburden stored at the Holly and Hock TSF borrow areas.
Impacts from seismic events	Potential for direct impacts from naturally occurring seismic events would remain the same as existing conditions.	Same potential for direct impacts from naturally occurring seismic events as the No Action Alternative; increased potential for seismic impacts on infrastructure.	Same as the Applicant's Proposed Project
Loss of soils and surface materials	No change in the current status of geologic and soils resources.	Loss of soils and surface material from removal, relocation, and disturbance of soils and surface material over approximately 2,612 acres.	The amount of overburden that would be moved within the study area would be the same as the Applicant's Proposed Project. The difference would be the placement of overburden; more would be stored at the Holly and Hock TSF borrow areas and less at the Ramona OSA.
Impacts from erosion	Areas previously affected by mining activities would experience a reduction in soil erosion as a result of improved vegetative stabilization.	Temporary soil erosion due to loss of vegetation and creation of the Duckwood TSF and seven OSAs.	Potential slight increase in erosion at the Holly and Hock TSF borrow areas from a greater height. Potential for slight decrease in soil erosion at the Ramona OSA from a reduced height.
Changes in soil type and cover	No change in the current status of soil type and cover.	Permanent alteration of soil type and cover, as well as loss of mineral resources found in the soils in the Project area.	Same as the Applicant's Proposed Project

OSA = overburden storage area

TSF = tailings storage facility

4.2.6 Literature Cited

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4.3 Groundwater Resources

This section describes the potential impacts of the proposed Haile Gold Mine on groundwater resources within and adjacent to the Project area. Impacts to groundwater in turn may affect resources that are linked to groundwater, including surface waters, wetlands, water quality, water supplies, and aquatic habitat.

As described in Section 4.1, "Approach to Environmental Analysis," operation of an open-pit mine requires that the mine pit be dry to allow for safe and efficient working conditions. Haile would lower the groundwater elevations for mining operations by installing a series of deep dewatering wells surrounding the pits, and then pump groundwater from these wells to lower the groundwater to below the pit bottom. This process is referred to as depressurization. Three primary impacts to groundwater resources are expected to occur as a result of the pit dewatering:

- Lowering of groundwater levels;
- Changes in water quality due to pit refilling and groundwater movement out of the backfilled pits after is has been in contact with PAG materials; and
- Changes in groundwater quality resulting from potential leaching from Johnny's PAG and the TSF.

Changes in groundwater levels may also affect groundwater quality within the aquifer beneath the Project area. Exposure of rock material that may contain sulfides and other PAG materials during excavation of overburden and ore has the potential to affect groundwater water quality. The mine operations plan is designed to minimize these impacts because excavated material with the potential to generate acid and leach metals would be characterized and stored appropriately (e.g., Red Class PAG overburden would be stored in Johnny's PAG), and precipitation on pit highwalls would be collected in a sump system at the bottom of the pits. This water would become part of the contact water system and treated at the water treatment plant.

Once active mining has ceased, most pits would be backfilled, and three pits would be refilled with water to create permanent pit lakes. Constituents leaching from the pit lakes and backfilled pits have the potential to adversely affect groundwater quality.

4.3.1 Methods

To determine the impacts on groundwater levels and groundwater quality, a model was developed to predict changes to groundwater that would result from the mine dewatering program. The predictions considered lowering and recovery of groundwater levels spatially (within and adjacent to the Project area) and over time (pre-mining, active mining, and post-mining). The model entailed a series of four linked computer models that used available well data in the Project area and pumping tests of certain wells to measure the rate of drawdown over predetermined pumping rates. Modeled results were compared to available data to assess the reasonableness of the model predictions. As previously noted, the modeling results also were used to predict impacts on water-related resources, including surface water hydrology, surface water quality, water supply, wetlands, and aquatic resources.

The following four linked models included:

- **Groundwater Model –** For the dewatering phase of pit mining operation the Cardno ENTRIX groundwater model (Cardno ENTRIX 2013) (Appendix I) describes changes to groundwater levels and flow directions, and predicts the maximum drawdown level during pit dewatering. The mine

operation plan and the mine dewatering profiles (AMEC 2012) were used as inputs to the model. The results of the Groundwater Model were also used to predict changes in stream baseflows.

- **Pit Refilling Model –** For refilling of the pits, the groundwater model summarized in Newfields and Schafer (2013) considers pit refilling by rainfall, streamflow, and groundwater inflow from mining backfill, pit lakes, and flow through Red, Yellow, and Green Class PAG material. The model also presents the final contours of the groundwater surface after pit refilling.
- **Particle Tracking Model –** The area potentially impacted by groundwater flowing through mined and backfilled pits was predicted using a particle tracking model. Particle tracking was done to predict long-term contaminant flow direction in groundwater, and travel time of the contaminants through the groundwater system after pit lake filling is complete. The results of the particle tracking model provide a depiction of the groundwater area that may be subject to groundwater quality impairment from mined areas. It is therefore very useful in predicting impacts, and in determining the optimum location of groundwater monitoring wells that would detect potential mine-related exceedences of groundwater quality (Newfields and Schafer 2013).
- **Post Closure Water Quality Model –** For groundwater quality, the mass load model described in Newfields and Schafer (2013) was the primary predictive tool employed. The model predicts groundwater quality effects during the post-mining period which includes filling of the pit lakes.

Each of these four models is described in greater detail in the following subsections. It must be understood that all numerical models are approximations that represent a series of compromises between computer-based calculations and field observations. Models almost never have as many field observations as would be desired in order to calibrate and validate them, and there are always margins of error in field observations that cannot be fully quantified. For this reason, sensitivity analysis was conducted for each of the models to assess the degree to which uncertainty in specific parameters or groups of parameters affect model results.

The groundwater quality model provides estimates of the quality of groundwater transporting metals and other chemical constituents from the PAG material through groundwater to surface waters. As such, these intermediate estimates of groundwater quality can be used to assess whether there is a reasonable potential that drinking water standards or background levels in groundwater may be exceeded after mining ceases. Specifically, conservative assumptions of the mass balance model include the following:

- All chemical loads from each source reach the confluence of Haile Gold Mine Creek and the Little Lynches River without reduction in concentration as a result of groundwater transport.
- Chemical loads are not diluted with unaffected groundwater.
- Chemical loads are not dispersed horizontally or vertically.
- Chemical loads are not transformed by precipitation or chemical speciation.
- Chemicals have zero travel time.

Based on the above assumptions, the groundwater quality model assumed that the highest metals concentration in groundwater that may be in contact with the formerly mined areas would be transported to area streams without any reduction in concentration. In actuality, the groundwater that contains dissolved metals from the formerly mined areas would travel through soil strata and mix with unaffected groundwater, thereby reducing the metals concentration. It may take up to years for this groundwater to flow to surface streams. Rather than model this reduction in concentration, the approach in this section was to use the groundwater modeling components of the Post-Closure Water Quality Report (Newfields and Schafer 2013) to assess which chemicals must be part of a groundwater monitoring and management

plan. The objectives of the groundwater monitoring program would be to detect any actual exceedances of groundwater quality criteria and to provide contingency measures in the event that monitoring reveals adverse effects to groundwater.

4.3.1.1 Groundwater Model

The groundwater model (Cardno ENTRIX 2013) predicted changes to groundwater levels and groundwater contributions to streamflow as a result of groundwater pumping to dewater the mine pits. The development and implementation of this model are summarized in the following subsections. A detailed description of this model can be found in Appendix I.

Field Basis for the Model and Model Evolution

Three successive groundwater flow models were developed in an effort to predict the extent of potential impacts on the natural hydrologic systems from the pumping of groundwater. The Schlumberger Water Services (SWS) model was developed in 2011, the AMEC model was developed in 2012, and the Cardno ENTRIX model was developed in 2013. This description relies primarily on the Cardno ENTRIX model, the results of which are used for impact assessment in this EIS. The initial models were modified considerably as a result of additional field data collection during 2013.

During the early stages of EIS development, extensive interagency discussions took place regarding the groundwater models. These discussions examined the available underlying data, their adequacy, their use in predicting groundwater changes, and their subsequent use in determining impacts on water-related resources for the impact analysis in the EIS. Ultimately, it was decided that additional data collection and model development would be needed to further develop an appropriately calibrated groundwater model.

Additional field investigations conducted in 2013 indicated that subsurface hydraulic conditions differed from the previous site conceptual model (SCM) used in the development of the earlier models, and that the SCM should be revised. The field investigation included installation of wells and piezometers, re-evaluation of geological data related to fracture density and orientation, and installation of a new groundwater pumping well. It also included a 7-day bedrock aquifer test conducted in March 2013 to determine the hydraulic coefficients of the bedrock and to assess the vertical flow and hydraulic connection between the shallow aquifers (CPS and saprolite) and deeper bedrock aquifer.

Based on the additional data, a number of revisions were made to the SCM. The saprolitic layers and the upper bedrock were found to have more groundwater flow than previously assumed in the SWS and AMEC models, and the lower bedrock (lower than approximately 400 feet below ground surface [bgs]) had lower groundwater flow than previously assumed. Notable findings included:

- The saprolite and sap-rock are not effective confining units to groundwater flow.
- Vertical flow through the saprolite, sap-rock, and upper bedrock is much faster than assumed in the SWS and AMEC models.
- Because the saprolite and sap-rock are poor confining units, vertical hydraulic gradients on the site are much smaller than previously believed.
- The sap-rock layer and upper bedrock layers have substantial horizontal fractures.
- The lower bedrock is generally dense and tight, with occasional horizontal fractures.
- The sap-rock layer is a major flow zone and is responsible for most production in wells.

- The hydraulic conductivity of the bedrock is higher at depths shallower than approximately 400 feet bls. At greater depths, the hydraulic conductivity is much lower. Significant horizontal variation in hydraulic conductivity of the bedrock is not apparent above or below approximately 400 feet bls.

Based on the revised SCM, Cardno ENTRIX developed a third model to better reflect the actual site conditions, as expressed in the new SCM of the aquifer system. The previous model was revised as follows:

- Calibration points were revised to eliminate data from faulty vibrating wire piezometers (VWPs) and to include new, more accurate piezometers and monitoring wells.
- The southern half of the modeled area was eliminated. This area was down-gradient of the Project area where no aquifer data or calibration points were available. This modification did not affect the findings of the model nor the model's ability to predict environmental consequences from proposed mine dewatering.
- A specified flow boundary was added along the new southern boundary of the model to preserve regional groundwater flow.
- The number of model layers was reduced from 13 to 7 layers. This reduction better reflects the open communication between the shallow (less than 400 feet bls) groundwater zones.
- Vertical transmissivity values for the CPS, saprolite, sap-rock, and upper bedrock were increased to reflect field data that indicated greater flow across these units.
- The horizontal transmissivity values of the sap-rock and upper bedrock were increased.
- The dikes were removed as hydraulic features in the model.
- The recharge to the model was increased.

Groundwater Terms

Transmissivity. A measure of how much water can be transmitted horizontally or vertically.

Dike. A vertical or near-vertical mass of igneous rock that has forced its way upward through overlying materials.

Saprolite. Soft, thoroughly decomposed rock rich in clay.

Saprock. The zone of rock below the lower saprolite where weathering is restricted to failure systems within the fresh rock mass.

Upper bedrock. The upper layer of consolidated rock underlying the surface.

Model Description

The Cardno ENTRIX model, a three-dimensional numerical groundwater flow model, simulates potential impacts on the site-wide hydrogeologic system from dewatering the mine pits. The model used the MODFLOW software (Harbaugh 2005).

Approach

Model grid dimensions, boundary conditions, and aquifer parameters were structurally modified to match the SCM. The modified steady-state model was then calibrated to average heads (levels) observed in 76 wells and baseflow estimated in 16 stream reaches. The calibration parameters included hydraulic conductivities (horizontal and vertical) of all model layers and groundwater recharge. The calibrated steady-state model was then used to develop two transient models. One transient model was developed to validate the 40-day aquifer performance test (APT) conducted by SWS in 2010 (after excluding water level elevation data from VWPs). The second transient model was developed to validate the 7-day

bedrock aquifer test in 2013. The validation process involved adjusting the storage coefficients of the model layers until the model satisfactorily simulated the APT. The final step involved using the calibrated and validated model to simulate potential impacts caused by pit dewatering at the site for a 14-year period.

Steady-State Model

The previous AMEC model, which consisted of 13 layers and spatially covered approximately 432 square miles, was modified by reducing the number of layers to seven and the modeled area (study area) to approximately 310 square miles. Approximately 122 square miles of the southern portion of the modeled area did not affect the model results.

The primary hydrogeologic units represented by the base model included the CPS (Layers 1 and 2), saprolite (Layers 3 and 4), sap-rock (Layers 5 and 6), and bedrock (Layers 7 through 13). The previous models were designed to reproduce apparently high vertical gradients in the aquifer system; these were based on head data from the VWPs that proved to be unreliable. After establishing that the actual gradients were much smaller, the number of vertical layers needed to reproduce the vertical flow in the system was reduced to seven. Layer 1 represented the CPS, Layer 2 represented the saprolite, Layer 3 represented the sap-rock, and Layers 4 through 7 represented the bedrock. The overall thickness of the primary hydrogeologic units used in the model was not modified.

Boundary Conditions

For the AMEC model, the external boundaries at the eastern, western, and northern sides of the model were simulated using “no-flow” cells. The external boundary at the southern side was represented by “constant head” cells, which simulated flow leaving the modeled area to the regional aquifers. For this study, the eastern, western, and northern boundary conditions were retained from the AMEC model. However, the southern boundary cells were simulated as a “specified flow” boundary. The simulated groundwater heads in the base model were analyzed and the flow values assigned based on the gradient across the selected southern model boundary cells. The location of the southern boundary cells was determined by trial-and-error runs of the base model. This process effectively truncated the model at approximately 5 miles south of the Project boundary by deactivating cells further south. It was noted that the hydrologic features simulated south of the revised southern boundary had minimal effects on model results within the study area. The internal boundary conditions of the earlier models were revised using MODFLOW River, Stream, and Drain Packages to represent rivers, streams, and drains, respectively. The same packages were used in the Cardno ENTRIX model; however, the river and stream cells were modified so that the stage elevations specified in each of these cells were set equal to their respective bottom elevation values. This step was necessary to prevent the river and stream cells from acting as infinite water “sources” that fed the aquifer for the mine dewatering simulations.

Calibration

Model calibration is the process of adjusting model parameters to produce simulated heads and flows that match field-measured values within a pre-established acceptable range of error. In this study, the steady-state model was calibrated to average water levels observed in 76 wells and estimated baseflow rates in 16 reaches within the model area.

The model was calibrated using PEST, a state-of-the-art automated parameter estimation software developed by Watermark Numerical Computing (2002). Numerous PEST simulations were carried out with different ranges of model parameters. The PEST runs produced acceptable calibration statistics.

Validation with Pump Test Data

The calibrated steady-state model was validated to drawdown data collected during two APTs conducted onsite. The first APT was the 40-day test conducted by SWS in August 2010, in the well identified as PW-09-01. The second APT was the 7-day bedrock aquifer test conducted in March 2013.

The steady-state models were validated by simulating the decline in groundwater heads observed during the 40-day APT when well PW-09-01 was pumped at a rate of 195 gpm. The validation process involved adjusting the storage coefficients of the seven model layers until the simulated decline in heads due to groundwater withdrawals reasonably matched the change in heads observed during the test. The pumping well PW-09-01 was simulated using the MODFLOW Well Package. Well cells were placed in Layer 3 (sap-rock) and Layer 4 (bedrock). Seventy percent of the pumpage was simulated from Layer 3, and 30 percent of the pumpage was simulated from Layer 4. This split in pumpage rate was considered reasonable because previous well testing data indicated that the production capacity of wells that are open to both the sap-rock and bedrock were between approximately three and four times higher than the production capacity of wells that were open only to the bedrock.

The shape and magnitude of the simulated hydrograph match reasonably well with the shape and magnitude of the observed water level decline during the 40-day APT. The calibration hydrograph suggests that the observed head gradually declined from 470 to 385 feet above msl, while the simulated head gradually declined from 470 to 412 feet above msl. This provides assurance that the model can be used as a predictive tool, capable of simulating the magnitude and rate of expansion of the cone of depression caused by dewatering within the aquifers of interest.

The steady-state model was validated a second time by simulating the 7-day 2013 bedrock aquifer test. Seven observation wells were used for this APT: two wells each completed in the CPS and saprolite units, and three wells completed in the bedrock. The pumping well PW-13-01 was simulated to withdraw 50 gpm from the bedrock (Layer 4).

The adequacy of transient calibration was evaluated by comparing the shape and magnitude of simulated and observed drawdown in the observation wells. In general, the shape of the modeled hydrograph response curves matched the observed shape of drawdown curves in the monitoring wells. Overall, the model was able to adequately simulate the water level responses observed in the field during the 7-day 2013 bedrock aquifer test, providing additional confidence in using the model as a predictive tool to simulate potential impacts from mine dewatering.

Sensitivity Analysis

The purpose of the sensitivity analysis was to quantify the uncertainty in the model caused by uncertainty in estimates of calibrated aquifer parameters. The sensitivity of selected model parameters was analyzed, including horizontal and vertical hydraulic transmissivity and groundwater recharge to model output.

The most sensitive model parameters are horizontal transmissivities in Layers 4 and 5 (which represent the upper bedrock) and vertical hydraulic transmissivities in Layers 2 and 3 (which represent saprolite and sap-rock, respectively). Changes to these parameters within the range of observed variability influence the simulated head values at target locations, simulated stream flows, and the general groundwater flow within the modeled area. Groundwater recharge into the CPS unit also was noted to be sensitive. The model output was relatively less sensitive to the remaining parameters analyzed.

Predictive Model Runs

The calibrated and validated Cardno ENTRIX model was used to run predictive simulations of mine pit dewatering during mining operations in order to evaluate potential changes in groundwater heads and flows. The objectives of the simulations were to evaluate (1) groundwater withdrawal rates required to dewater themine pits; (2) the extent and magnitude of resulting groundwater drawdowns; and (3) the subsequent effects on near-surface groundwater regimes[1] and stream baseflow in selected stream reaches.

The calibrated model developed for the dewatering study was divided into 23 stress periods to simulate the proposed mine plan during mining. Stress periods 1 through 12 simulated Mine Years 0 through 2 with 90-day time periods; stress periods 13 through 22 simulated Mine Years 3 through 12; and stress period 23 simulated a 2-year period after the active mining period, when dewatering is proposed to meet water supply demands at the site.

The MODFLOW Drain Package was used to simulate proposed dewatering at the site. The desired groundwater levels in the open pits during dewatering were specified in the Drain Package, and the package calculated the quantity of water that needed to be removed from the drain cells to achieve the desired groundwater levels. The Drain Package was imported into the calibrated model.

The water balance summary generated by the model was reviewed after each stress period to determine the groundwater withdrawal (pumping) rates required to suppress groundwater levels to depths specified in the mine plan. Results indicated that the cumulative initial rates during the Pre-Production year (Mine Year 0[2]) ranged from approximately 0.75 to 1.75 mgd, with an average of approximately 1.0 mgd. The cumulative pumping rate gradually increased from approximately 1.2 to 3.4 mgd from Mine Years 2 to 4. The average simulated pumping rate from Mine Years 5 through 12 ranged from approximately 2.5 mgd (Mine Year 6) to 3.5 mgd (Mine Year 8), with an average of 3.0 mgd.

The simulated areal extent of the overall zone of depression that results from all wells was reviewed for each mine year. For the purpose of this study, the outer boundary of the overall zone of depression was set to be the simulated 1-foot drawdown contour, which is the approximate detection limit of the model.

To assess potential impacts on the groundwater contribution to streams (the baseflow), the simulated baseflow during Mine Years 0 through 14 was compared to the pre-mining baseflow simulated by the calibrated steady-state model. The 16 stream reaches used in the baseflow calibration process of the steady-state model were selected for the baseflow analysis.

Groundwater models such as MODFLOW-SURFACT (the code used for model simulations) have limitations in simulating flow through the unsaturated zone, including meteorological parameters such as air temperature, humidity, solar radiation, and vegetation types. These limits are common to many groundwater modeling exercises and, if recognized and considered, do not unduly hamper their value.

4.3.1.2 Pit Refilling Model

After mining ceases, groundwater would likely flow towards the open pits until they are refilled. Newfields (2013) used the groundwater withdrawal model (Cardno ENTRIX 2013) as a starting point for the pit refilling model Groundwater inflows to open pits were simulated using the MODFLOW LAK3 package (Merrit and Konikow 2000). The LAK3 package uses model cells to represent a volume of space

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1 The *groundwater regime* refers to the conceptual hydrologic system used in estimating groundwater flow.

2 Mine Year 0 is the equivalent to Year Pre-Production in the mining schedule.

within the groundwater flow model grid. Variations in lake stages through the simulation are also influenced by an independent water budget that accounts for inflows from direct precipitation on the lake surface, surface runoff to the lake from the adjacent watershed, and any direct flows to the lake, and outflows from evaporation from the lake surface. This model is described in detail in Newfields and Schafer (2013). Although the pit refilling model is primarily used by the post-closure water quality impact analysis, it is also used by all of the water-related resource categories.

Cells within the modeled area of the groundwater withdrawal model were modified to represent the open volume within the Ledbetter, Champion, and Small pit lakes. In order to make the bottom of the Ledbetter pit consistent with the model layer structure, the existing model layer 10 was split into two model layers with the same physical properties but with the intervening model layer elevation consistent with the elevation of the bottom of the Ledbetter pit. The model simulated stage-volume relationship for the pit lakes was compared to actual stage-volume estimates, and minor modifications were made to the open pits (e.g., adding or deleting LAK3 cells at the pit margins) to achieve a general match between the simulated and actual stage-volume curves.

Areas that were assumed to be mined out and then backfilled were also added to the model. Backfilled areas were estimated and added to the model as zones of higher permeability.

Simulation of groundwater inflow to the open pits was performed for each model as follows:

- Model simulated groundwater elevations representing the end of the dewatering (Mine Year 12) were used as initial head conditions for the open pit simulations
- The LAK3 package requires input of pit lake water balance flow rates over time.

Because the rates of precipitation, runoff, and evaporation change as the lake fills, the appropriate rates must be updated based on preliminary simulations of groundwater inflows to the pit lake. A preliminary estimate of the pit lake water balance components was made using a spreadsheet model. The preliminary water balance estimates were then used to generate a preliminary simulation of pit filling. The water balance spreadsheet was then updated with simulated groundwater inflows, and a revised set of precipitation, runoff, and evaporation flows were then simulated with the model. Pit lake filling rates were iteratively simulated until a final simulation was achieved. Additional inflows to the Ledbetter Pit were added to represent the routing of some of Haile Gold Mine Creek flows into the lake during pit filling.

A sensitivity analysis was conducted using a series of nine model simulations of Ledbetter Pit Lake to evaluate the effects of input variations on selected predicted results. The model results were found to be most sensitive to the groundwater regime used (Figure 4.3-1).

4.3.1.3 Particle-Tracking Model

The particle-tracking model provides a prediction of the area of groundwater that may be affected by flow from pit lakes, backfilled pits, and OSAs after mining ceases and the dewatering pumps are turned off. During this period, the pits refill as modeled in the Pit Refilling Model. The particle-tracking model depicts how contaminants flow from mining-affected areas through the groundwater system to finally discharge at surface waters. The particle-tracking model is described in detail in Newfields and Schafer (2013). The particle-tracking model is primarily used in the analysis of groundwater described in this section and water supply as described in Section 4.5, “Water Supply and Floodplains.”

The particle tracking model approach simulates long-term groundwater flow direction and travel time after pit-lake filling is completed and illustrates groundwater interactions with local surface water (e.g.,

the nature and extent of potential groundwater discharge). The particle tracking results are also useful to guide the development of a monitoring network in terms of well locations and completion depths.

Particle tracking was performed using the USGS code MODPATH, which is designed for use with MODFLOW-based codes such as MODFLOW-SURFACT (the model used for the groundwater withdrawal model and the pit refilling model). The method tracks the flow of a "particle" of groundwater through a simulated flow system based on the magnitude and direction of the simulated hydraulic gradient, the hydraulic transmissivity of the material, and effective porosity. The hydraulic transmissivity of the aquifer was developed during model calibration and is discussed in detail in AMEC (2012).

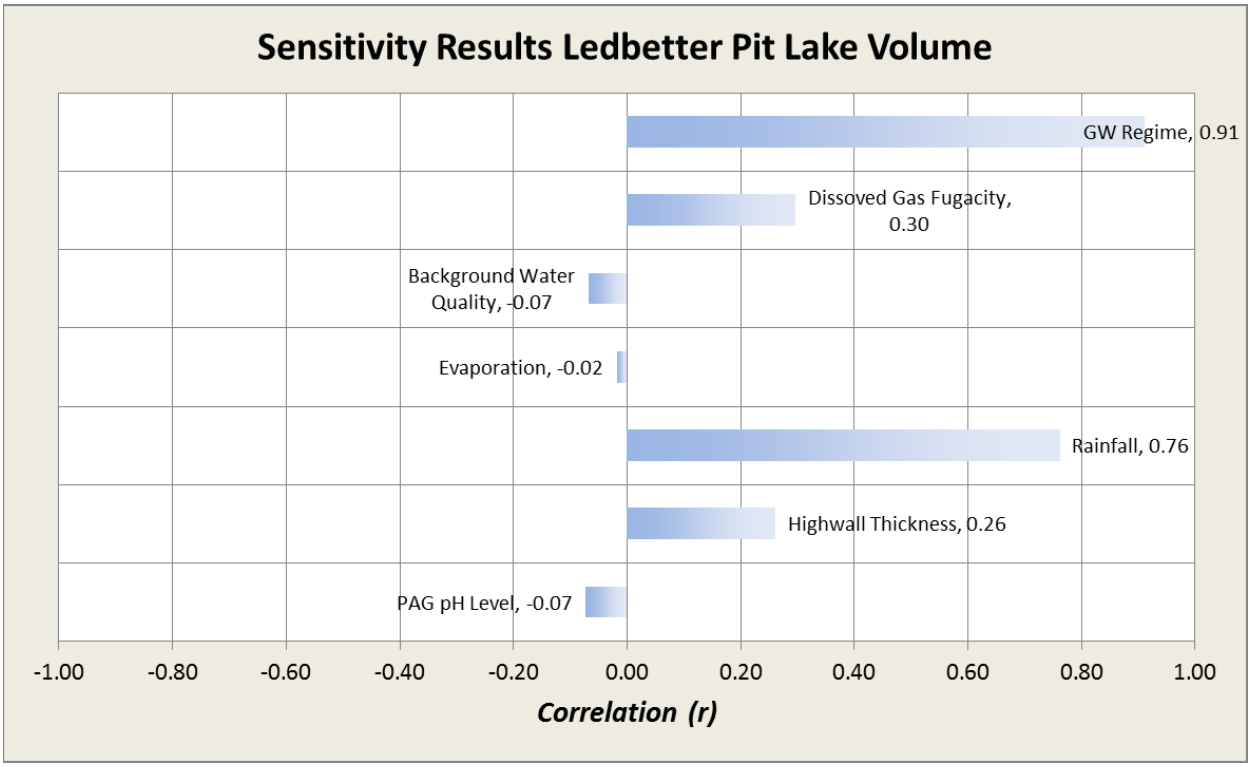


Figure 4.3-1 Correlation of Water Level in Mine Year 12 with Model Inputs

Effective porosity is defined as that portion of the total volume of interconnected pore space (the open space between grains of soil or rock) that contributes to groundwater flow (Domenico and Schwartz 1990), and is used in the calculation of groundwater travel time. Values of specific yield (e.g., drainable porosity) developed during model calibration (AMEC 2012) were used as effective porosity.

Particle tracks represent long-term groundwater flow conditions after the pit lakes have recovered to a "flow through" condition, where groundwater both flows into and out of the pit lakes. During the pit lake filling period, groundwater flow is toward the pit lakes. The particle tracking simulations focused on the period after the pit lakes were full, or approximately 18 to 30 years after pumping has ceased. This period represents a generally steady-state groundwater flow system through the lakes. The particles were tracked forward in time until they were removed from the modeled area through groundwater discharge to a model boundary such as surface water.

4.3.1.4 Post-Closure Water Quality Model

A mass load model was developed to evaluate the potential effects of the reclaimed Haile Gold Mine on surface water quality downstream of the facilities as it would be affected by groundwater inflow. The model is fully described in Newfields and Schafer (2013). The model consists of two components: prediction of pit lake and other mine facilities groundwater quality; and the mass load model, which numerically combines this groundwater contribution of mine-affected water to area surface waters. Together, this constitutes the post-closure water quality model. The results of the model are used by all of the water-related resource sections.

The location selected for analysis was the first point where all chemical loads from the mine converged, namely the confluence of Haile Gold Mine Creek and the Little Lynches River. The groundwater quality component of the model provides estimates of the quality of groundwater transporting metals and other chemical constituents from the source rocks through groundwater to surface waters. As such, these intermediate estimates of groundwater quality can be used to assess whether there is a reasonable potential that drinking water standards or background levels in groundwater may be exceeded after mining ceases. The model assumes that all chemical loads from each source reach the confluence of Haile Gold Mine Creek and the Little Lynches River without a reduction in concentration as a result of groundwater transport. The model over-predicted concentrations of chemicals in groundwater because of the following modeling assumptions:

- No dilution with unaffected groundwater occurs.
- No dispersion of chemicals horizontally or vertically.
- No chemical transformation by precipitation or chemical speciation occurs.
- There is zero travel time for groundwater between mined areas and receiving streams (the Little Lynches River and Haile Gold Mine Creek).

The results of the mass load model provided a determination of which chemicals must be part of a groundwater monitoring program to detect actual exceedances of groundwater quality criteria and to provide for contingency measures in the event that modeling reveals adverse effects.

Field Basis for the Model

The field basis for the post-closure water quality model is an extensive series of chemical tests of mined material to form acidic conditions that would lead to leaching of metals and other compounds, which would then affect groundwater, surface water, and water-related resources. Some tests were also run for a sufficient time to assess the potential for alkaline leaching conditions. The goal of the geochemical characterization program was to identify, manage, and mitigate geochemical risks at Haile Gold Mine. The baseline geochemical testing is provided in three reports available on the HaileGoldMineEIS.com website. The first testing included 0a2a336 static tests and 9 kinetic tests to assess acid generation potential. The second testing included additional static and kinetic tests as well as 10bhumidity cell tests up through week 84 (more than a year and a half) of testing (Schafer 2012b). The third testing included continuing results from the nine ongoing humidity cell tests on overburden samples and a tailings sample Class (Schafer 2010a, 2010b, 2012a, 2012b, 2013).

Model Description

Overall Approach

The objective of the mass load model is to identify likely post-mining effects on water quality from the Haile Gold Mine. Potential chemical releases from different facilities may travel by varied pathways, but based on particle tracking results, any chemical loads that originate from the mine and migrate in groundwater would reach the surface water system at the confluence of Haile Gold Mine Creek and the Little Lynches River. The model approach is to use two components to predict water quality in area streams after the cessation of mining. The first component is to calculate pit lake water quality and water quality from other mining-affected areas, using the constraints of the pit refilling model and the field geochemical data (Schafer 2010a). This first component predicts the concentrations of metals and other compounds at the mining source areas.

The model assumes that this mine-affected water (the concentrations predicted at the mining source areas) travels through groundwater without change and then discharges via groundwater baseflow into the area streams. The concentration in the stream is modeled as the combination of the mine-affected groundwater, added to the surface water flowing in area streams with no dilution.

The results of the mass load model over-predict the mining-related impacts to groundwater and surface water. In actuality, the concentrations at the source would dissipate as the groundwater flows to surface water. In addition, travel times for the mine-affected water to reach surface streams are expected to be longer than the model assumption of zero travel time. The model was not developed to predict water quality proximal to each individual mine facility but rather to assess overall potential mine impacts.

In the following, each component of the model (pit lake water quality and mass load model) is described separately, including the model set up, calibration, validation, sensitivity analysis, and predictive model runs.

Model Component One: Pit Lake Water Quality

The pit lake water quality component consists of a series of linked models that begins with simulated recovery of groundwater as described in the pit refilling model. The resultant water balance is expressed as a series of water quantities for different water sources in annual time steps in a spreadsheet model. The quantity of groundwater inflow through the weathered highwall of each open pit is then used to calculate time-dependent chemistry for the Red, Yellow and Green Class bedrock zones. The time-dependent chemistry, described below, simulates gradual rinsing of acidic weathering products from the oxidized highwall. The final step in the sequence of linked models was to execute a series of PHREEQC model simulations corresponding to each set of annual water balance inputs.

The mineral phases assumed to be present in the model are consistent with site observations and other pit lake models (Eary 1999; Castendyk and Eary 2009). The levels of carbon dioxide and oxygen modeled in the pit lake are consistent with a lake with low nutrient inputs and annual turnover (the process whereby the density stratification in a lake is lost due to seasonal change). The inflow of surface water makes the Ledbetter Pit Lake more prone to turnover than the Ridgeway Mine (nearby to Haile) pit lake, which has limited turnover (Flite 2006). During winter, surface water is expected to have much lower temperature (~38 F) and, despite a lower salinity. would have similar to higher density, especially in later stages of the model.

The pit lake water quality model uses distinct water quality signatures for each different source of surface water, groundwater, highwall runoff, or rainfall. Pit wall runoff from Red, Yellow, and Green Class

overburden areas were predicted to have uniform water quality (at pH 2.0, 3.0 and 6.0 respectively) throughout the 75-year model simulation period. It is likely that runoff from acidic portions of the highwall would become more dilute as weathering progresses; therefore, the current pit lake predictions are conservative.

Reported flows from numerical groundwater flow model simulations were aggregated into annual time steps for the purpose of predicting annual changes in water quality. Examples of a water balance for Run 14 (base case groundwater conditions) are shown in Figure 4.3-2 for inflow to Ledbetter Pit Lake. Initially, the primary input to Ledbetter Pit Lake would be groundwater, but by approximately Mine Year 10, the constant inflow of 450 gpm from upper Haile Gold Mine Creek would become dominant. As the lake surface area increases, direct rainfall contributions also increase. When the pit is filled, diversion of the water in Haile Gold Mine Creek would be suspended, causing a sharply increased inflow. At equilibrium, reached in Mine Year 18, input of water would equal losses. Evaporation would be approximately 284 gpm at equilibrium, but the majority of pit lake outflow would be surface flow into Haile Gold Mine Creek, which averages 1,185 gpm. Overall, Haile Gold Mine Creek is estimated to gain 345 gpm in Ledbetter Pit Lake due to groundwater contributions.

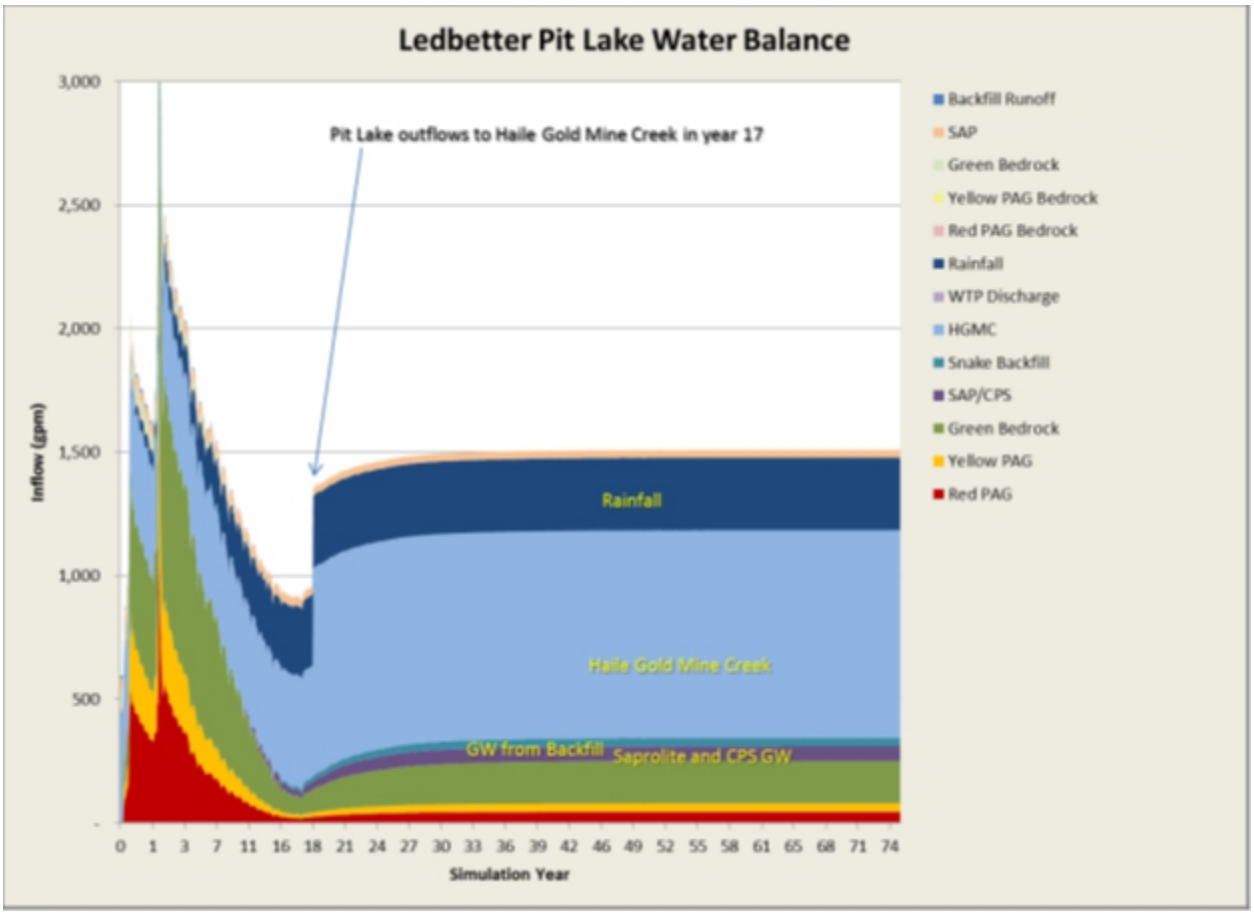


Figure 4.3-2 Inflow of Water to Ledbetter Pit Lake by Mine Year for Run 14

Champion and Small Pit Lakes are fed only by groundwater and rainfall. No water is diverted from Haile Gold Mine Creek or its tributaries into these pits. As Champion and Small Pit Lakes approach their equilibrium level, evaporation plus outflow from the pit lake into groundwater equals inflow from groundwater and rainfall.

Pit Lake Model Calibration

Background water quality is an important component of water quality prediction, both because it represents a mass load input to the model and because it provides a baseline comparison for model calibration. Baseline data from both surface water and groundwater were summarized to derive median, 25th, and 75th quartile percentages of dissolved ions. Data collected in 2010 and later were generally used to provide the most accurate analysis. Data from 2008 and 2009 also were used for shallow groundwater wells to increase sample numbers for calibration. The median values for background surface water and groundwater were used to develop a composite representation of water quality for each source. Bedrock groundwater flowing into the pits was an average of shallow and deep bedrock contributions, because groundwater flowing into the pits would be derived from both shallow and deep systems. Additionally, a composite average chemistry was computed for CPS and saprolite units based on the calibration.

Pit Lake Sensitivity Analysis

Predicted pH, metals, and other modeled compounds exhibited small variations between model runs. The sensitivity analysis for pH is representative, as described in this section (Figure 4.3-3). Newfields and Schafer (2013) provides sensitivity analysis for all compounds modeled.

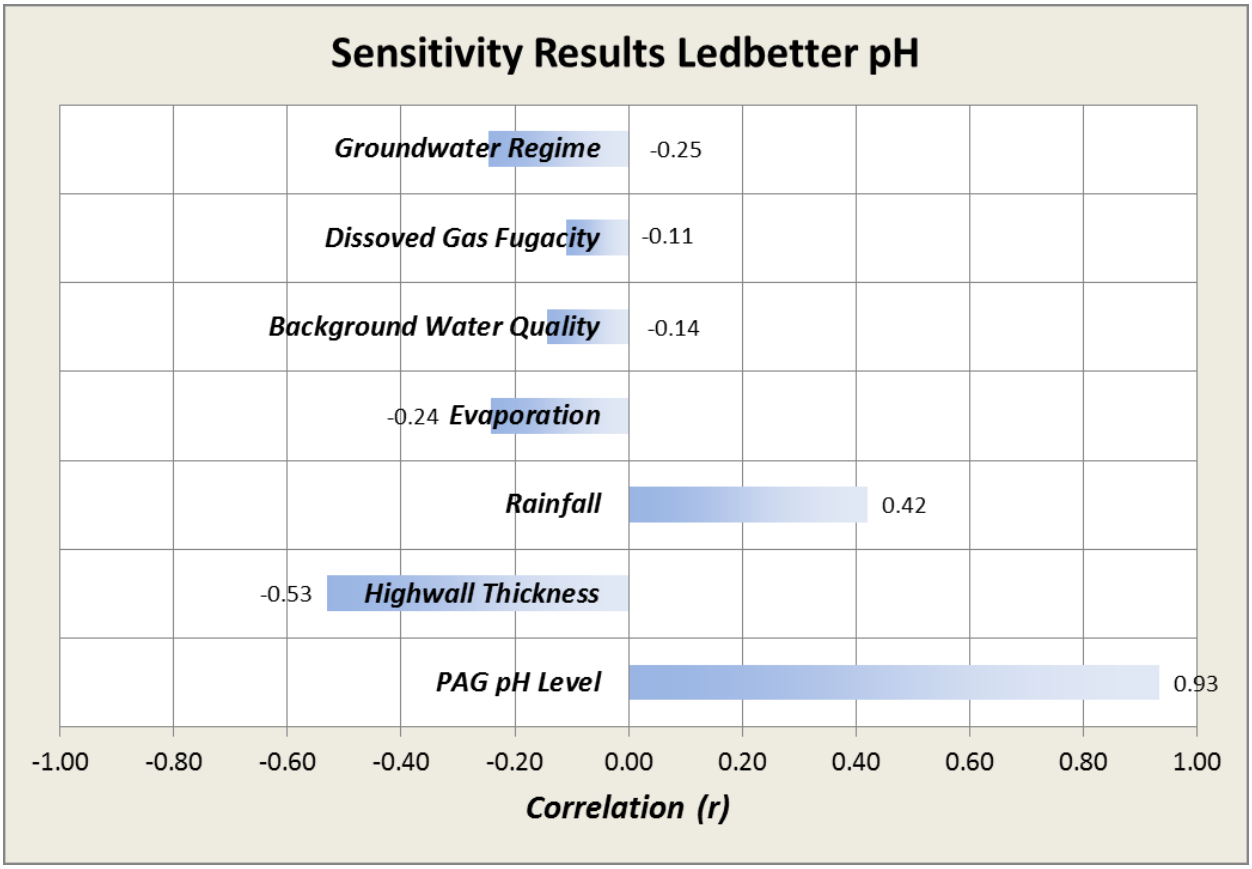


Figure 4.3-3 Correlation of pH in the Year When Outflow Begins with Stochastic Model Inputs

Predicted pH in each case tended to increase by approximately 0.3 unit across the simulations. The increasing trend likely results from the gradual reduction in water salinity through time. The input-output

correlation (Figure 4.3-3 shows that the model is most sensitive to the pH level assigned to Red and Yellow Class PAG rock in the highwall.

Pit Lake Predictive Model Runs

Seven different model runs were used to evaluate different possible combinations of groundwater hydrology, inflow from Haile Gold Mine Creek, location of the water treatment plant outfall, and use of added lime for pH control. The estimated inflow from upper Haile Gold Mine Creek was adjusted in different model runs to account for the range of expected availability of surface water diversions. The minimum available flow modeled is 69 gpm (0.15 cfs) because this is the maximum average annual amount that can be diverted without a South Carolina surface water withdrawal permit (3 million gallons per month). For purposes of this model, the safe yield of surface water withdrawal allowable under a South Carolina surface water withdrawal permit was estimated to range from 388 to 474 gpm (ERC 2013).

Most model runs assumed that lime would be added to the pit lake to maintain a near neutral pH and that the outfall for the water treatment plant would be moved upstream of Ledbetter Pit Lake after the end of active mining.

In order to conduct a probabilistic analysis of pit lake water quality, several key variables that were thought to contribute most to overall chemical loads were varied across a reasonable range of values. Nine simulations were run, each with randomly selected values for each selected parameter and each parameter being independent. This is known as a “stochastic” analysis. The primary intent of this analysis was to identify the relative sensitivity of model results to variability in input parameters.

The model values that were varied in the stochastic analysis included pH assigned to bedrock units in the weathered highwall, the thickness of the weathered bedrock zone, annual rainfall, annual evaporation, background water quality, and the dissolved gas concentration.

Model Component 2: Mass Load Model

The mass load model is based on the principal of conservation of mass for simulating the site water balance and chemical loads (Figure 4.3-4). In general, the contaminant loads predicted by the pit lake water quality model were added to natural flows in the local streams. The mass load model is structured so that water quality can be predicted across a range of flow conditions. The critical flow conditions included in the model were median flow (50 percent on the flow frequency curve), annual low flow (approximately 5 percent on the flow frequency curve), and 7Q10 low flow (the 7-day average flow that occurs less than once in 10 years, approximately 1 percent on the flow frequency curve).

The model consists of loads from seven different sources on Haile Gold Mine Creek; a pit lake that feeds directly into the Little Lynches River (Champion Pit Lake); and three sources that may affect Camp Branch Creek. Natural loads from unmined portions of each watershed also are included in the mass load model. Flows from the unmined portions of Camp Branch Creek and Haile Gold Mine Creek were estimated in proportion to the unit flow from the upper Little Lynches River. Groundwater flow from mine facilities was predicted using a two-step process. First, groundwater flows were determined for average conditions using ZoneBudget within MODFLOW. Next, the groundwater flow was scaled to flow duration using the proportional groundwater flows derived from the baseflow separation at Hanging Rock Creek (ERC 2012).

To assess potential impacts, water quality (e.g., constituent concentrations) was determined for background conditions and for post-mining conditions. The model calculates concentrations at the mouth

of Camp Branch Creek, the mouth of Haile Gold Mine Creek, and in the Little Lynches River below Haile Gold Mine Creek. Constituents include pH, TDS, calcium, magnesium, sodium, potassium, alkalinity (as bicarbonate), sulfate, chloride, boron, fluoride, nitrate (as N), orthophosphate, silica, aluminum, antimony, arsenic, barium, cadmium, copper, iron, lead, manganese, mercury, nickel, selenium, thallium, and zinc.

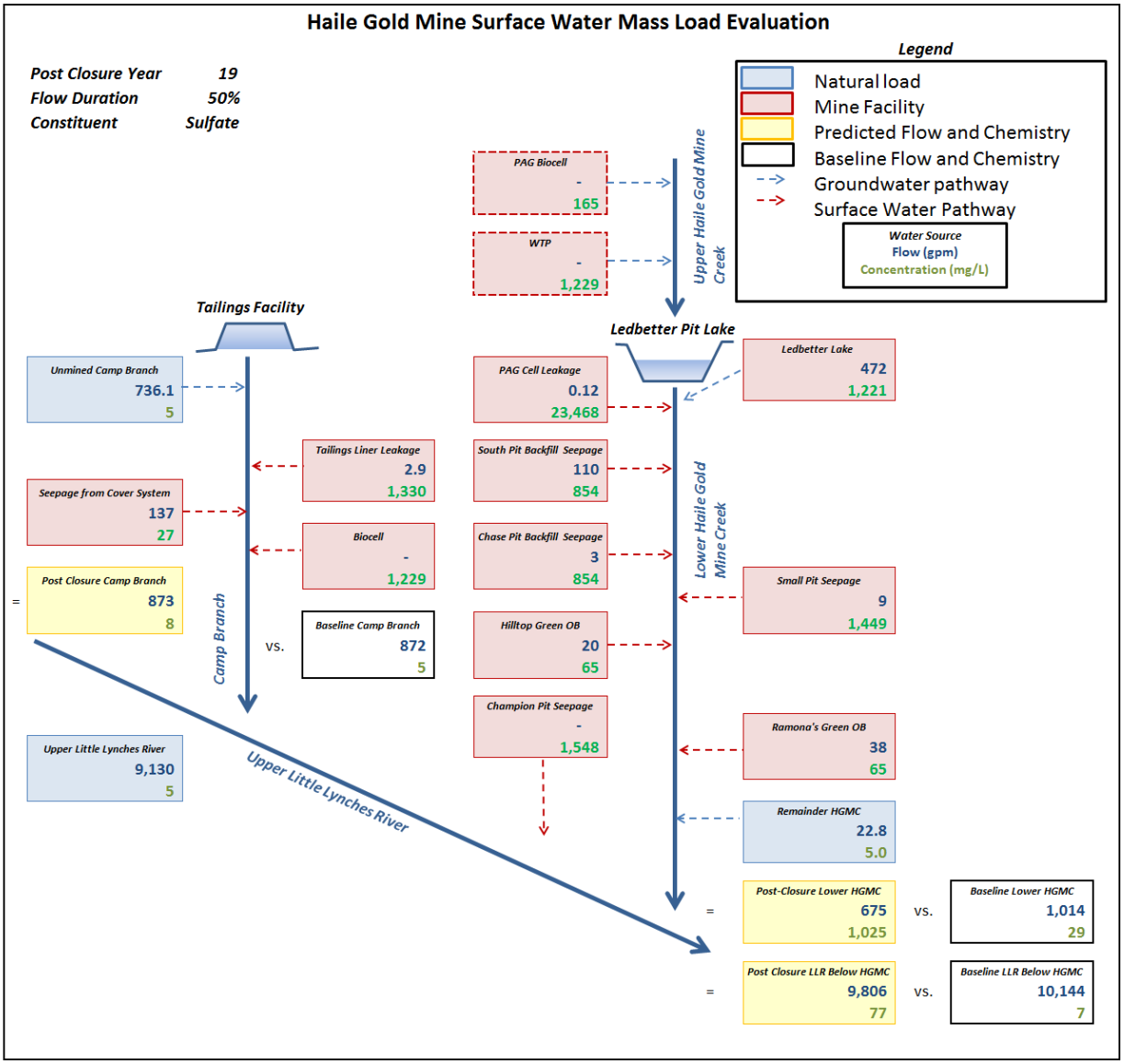


Figure 4.3-4 Mass Load Model Framework

Note: "South Pit" includes Mill Zone, Haile, and Red Hill Pits.

Mass Load Model Validation

To ensure that the model was correctly calculating loads and accurately reflected the observed variations in surface water quality, a validation run was developed. All mine inputs were set to zero flow and load for the validation. Model outcomes were compared to the distribution of measured water quality from 2009 to 2012. The median and range of water quality constituents for major ions measured at SW-13 (the Little Lynches River below Haile Gold Mine Creek) was similar to modeled results. Modeled ranges of metal ions also were similar to actual. The mass load model was able to correctly simulate natural variations in background water quality for the No Action alternative (Run 0).

Mass Load Model Limitations

Simulated concentrations should be interpreted as dissolved concentrations rather than total concentrations (*total concentration* is the dissolved concentration plus any suspended solids). Dissolved concentrations were used in the mass load model for a variety of reasons. The principal reason is that geochemical models used to simulate pit water quality and water within backfilled zones simulate only the dissolved fraction. The remaining portion of the total ion balance consists of precipitates, sediment, or organic matter associations, which cannot be easily simulated.

The mass load model does not account for chemical transformations that are likely to occur during transport. Ignoring these effects tends to cause the mass load model to over-estimate concentrations for those ions that may undergo transformations. Oxidation of subsurface waters that enter stream channels would tend to reduce iron and manganese concentrations. Nitrate is likely to undergo biological transformations that limit its transport in surface water. Highly acidic water would undergo neutralization reactions that remove most of its dissolved chemical mass. Consequently, nitrate and metal ion concentrations are most likely to be over-estimated in the mass load model.

Mass Load Model Sensitivity Analysis

Another objective of the mass load model was to identify the variables that had the most effect on model outcome and to estimate the variability of model results. The effect of varying input assumptions had a strong effect on predicted sulfate levels, with approximately a two-fold range in predicted sulfate from the 5th to 95th percentile results.

Model sensitivity was evaluated by correlating ranges of input values to ranges of outputs. For illustration purposes, sulfate in the Little Lynches River was correlated to input variables for Run 14 (Initial Outflow, with Low Flow Structure, Median Flow Regime). Pit lake water quality had the strongest correlation with sulfate in the Little Lynches River (Figure 4.3-5), followed by groundwater regime. The pit lake parameter determines the sulfate concentration of the pit lake source term, while the groundwater regime variable determines the pit lake outflow rate. Both of these variables affect sulfate loading from the pit lake, which is the primary source of both water and sulfate in Haile Gold Mine Creek (Figure 4.3-6). By year 75 post-closure, the pit lake was no longer the largest sulfate source (Figure 4.3-7). South Pit seepage accounted for approximately 75 percent of sulfate load in the Little Lynches River at year 75 post-closure. By year 75, sulfate from South Pit is expected to be much less than the value used in the model (854 mg/L) due to removal of the original sulfate load.

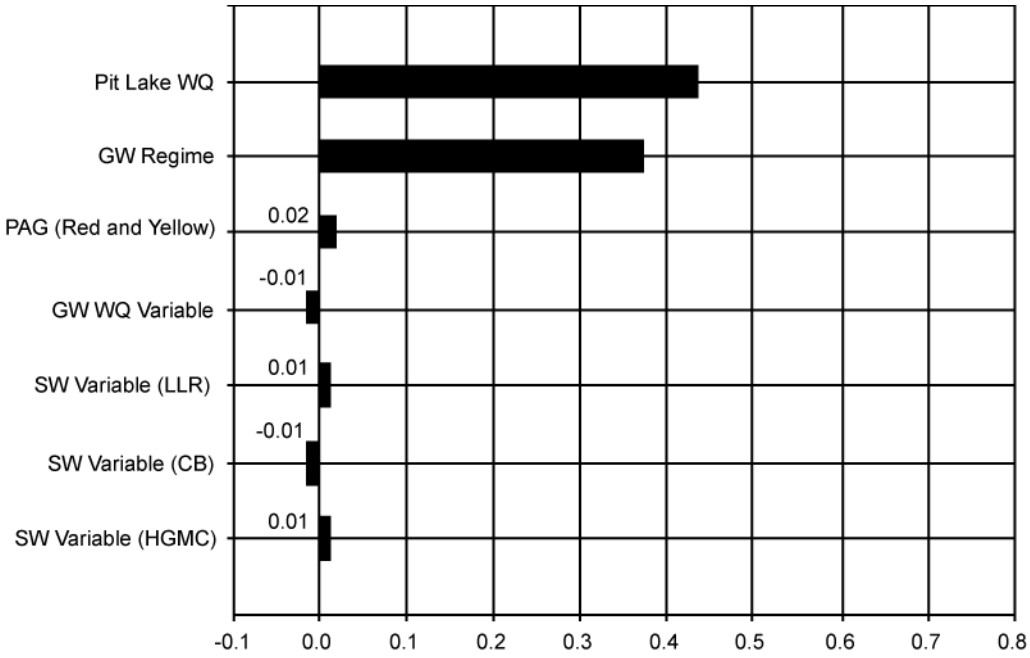


Figure 4.3-5 Spearman Rank Correlation for Sulfate in the Little Lynches River for Run 4

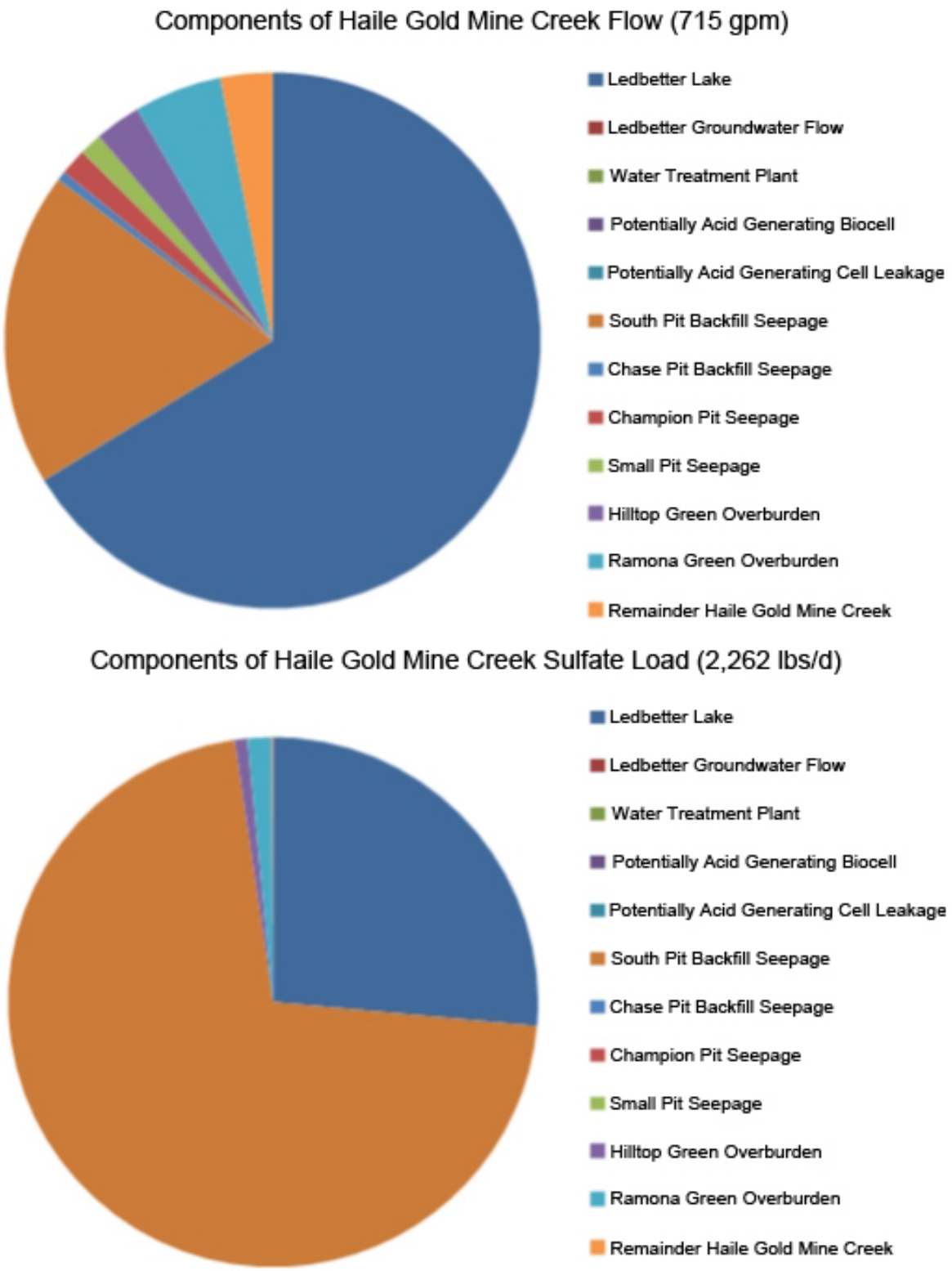


Figure 4.3-6 Components of Total Flow (above) and Load (below) for Sulfate in Haile Gold Mine Creek for Run 4

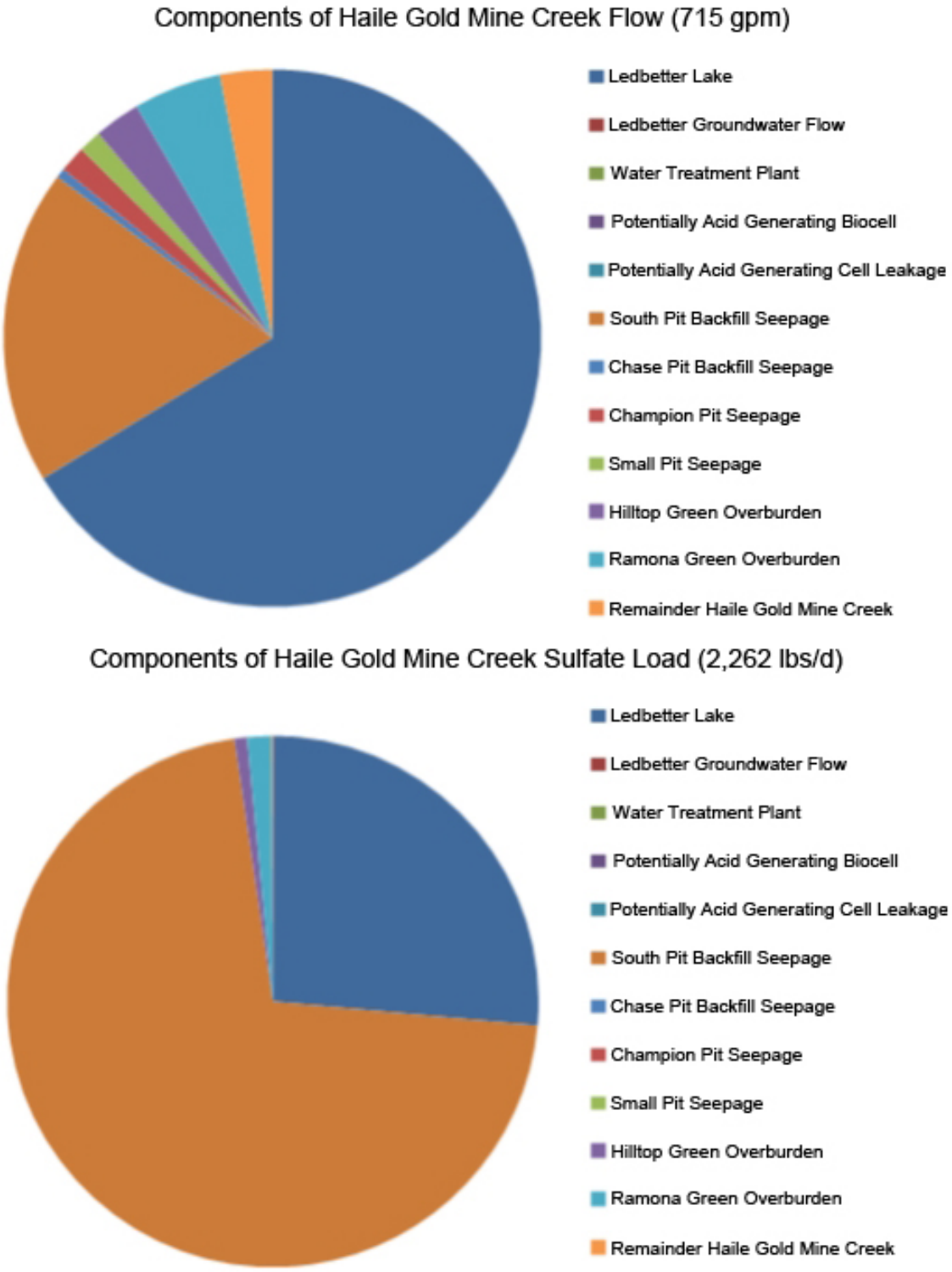


Figure 4.3-7 Components of Total Flow (above) and Load (below) for Sulfate in Haile Gold Mine Creek for Run 10

At low flows, the contribution of sulfate from Ledbetter Pit Lake was reduced (for annual low-flow cases) or eliminated (for 7Q10 flows). The resultant sensitivity analysis for Run 6 (Initial Outflow, with Low Flow Structure, 7Q10 Flow Regime) shows that the pit lake water quality term no longer has a significant effect on predicted sulfate in the Little Lynches River. Instead, the groundwater regime was positively correlated with sulfate while the PAG pH term was inversely correlated with sulfate. Most sulfate mass for this case was derived from South Pit or from leakage out of the passive treatment cell. Groundwater regime influences the calculated seepage rate out of South Pit. As the passive treatment cell pH declines, sulfate in Johnny's PAG seepage increases.

Mass Load Model Runs

The objective of the mass load model is to assess potential impacts on water quality at the confluence of Haile Gold Mine Creek and the Little Lynches River. The highest chemical loading was expected to occur when the pit lake initially discharges, which would occur 18 to 30 years after mining, depending on groundwater regime and other elements of the hydrologic water balance. Several model simulations focused on this critical time period. Presence or absence of a low-flow outlet was simulated at median, low, and 7Q10 flow regimes. Years 19, 30, and 75 post-closure also were simulated for median, low, and 7Q10 flow regimes.

The mass load model from the DA permit application was modified to be a probabilistic model. Several model inputs were selected for use as probabilistic variables. These included background water quality in Camp Branch Creek, Haile Gold Mine Creek, and the Little Lynches River, and shallow groundwater. For each of these variables, each chemical constituent was varied from the 25th to the 75th percentile of background concentrations. The median of each distribution was used as the central tendency for the modeled background water quality so that cases were weighted around the median.

The *groundwater regime* refers to the conceptual hydrologic system used in estimating groundwater flow. Other variables within the mass load model had intrinsic variability that was based on the groundwater regime, the time period modeled, or the surface water flow frequency. The surface water flow out of Ledbetter Pit and groundwater flows (e.g., seepage out of Champion and Small Pit Lakes and out of South Pit and Chase Pit backfill) each varied by groundwater regime and flow frequency. Flows derived from unmined portions of the watershed also varied according to the selected flow frequency.

Calculation of Dilution in Predicting Groundwater Quality

The focus of the post-closure water quality model (Newfields and Schafer 2013) is prediction of water quality in the Little Lynches River and Haile Gold Mine Creek. To conduct the analysis, the model predicts groundwater quality that flows to and discharges in the surface waterbodies. As described in this section, there was no quantification of any of the factors that are known to reduce concentrations of chemical constituents as the groundwater flows from the source in the contact zones with PAG material and highwalls to the surface waters. Newfields and Schafer (2013) prepared a memorandum that, in part, quantified one of these factors known to reduce chemical concentrations: dilution. In considering the relative contribution of the different mined areas that contribute elevated levels of metals and other constituents to the entire area affected by mining, they calculated a dilution factor of 13.1. Acknowledging that this is a likely upper bound to the amount of dilution that could occur, the memorandum uses best professional judgment to specify a lower bound of dilution as 5:1. The USEPA established national soil screening levels that calculated the amount of dilution that could occur between source areas of groundwater in contact with contaminated material, and the groundwater volume that would receive the contaminated material (USEPA 2002). Based on that guidance, a lower bound of dilution is more likely to be 3:1.

4.3.2 Impacts

In using the post-closure water quality model to predict impacts on groundwater, the model results were used first for comparison to relevant and enforceable water quality standards. For those constituents that may exceed these standards based on the contact water concentration, the range of dilution factors (from 3 to 13.1) also was considered as an additional applicable factor that would affect the impact analysis.

The proposed Project has the potential to reduce groundwater levels and alter groundwater flow directions adjacent to the mine pits during mine operations and reclamation, and to change groundwater quality during reclamation because of potential leaching from Johnny's PAG and the TSF. These three impacts are addressed in this section. Impacts on surface water and water-related resources are discussed in the sections specific to those resources.

4.3.2.1 Potential Impacts on Groundwater Levels

The proposed Project would require dewatering of mine pits during mine operations and would place large low-permeability mounds of overburden over permeable soils. The dewatering operations would cause drawdown in groundwater levels in the aquifers within and adjacent to the mine pits during mine operations. The drawdown would persist for some period during mine closure and post-reclamation as the lowered groundwater levels in the aquifers and the mine pits refill from regional groundwater flow and direct precipitation.

No Action Alternative

Under the No Action Alternative, it was assumed that the Project area would continue to be managed in a manner similar to existing conditions. The groundwater levels would remain in their current state.

Applicant's Proposed Project

Active Mining Period

Groundwater Withdrawal Rates

The groundwater mass balance summary generated by the model was reviewed after each of the 23 modeled time periods to determine the groundwater withdrawal (pumping) rates required to suppress groundwater levels to depths specified in the mine plan. The pumping rates were calculated as the average volume of water exiting through the drain cells per day. Figure 4.3-8 shows the simulated cumulative groundwater withdrawal rates during Mine Years 0 through 14.

Results indicated that the cumulative initial rates during the Pre-Production year (Mine Year 0) ranged from approximately 0.75 to 1.75 million gallons per day (mgd), with an average of approximately 1.0 mgd. The cumulative pumping rates gradually increased from approximately 1.2 to 3.4 mgd from Mine Years 2 to 4. The average simulated pumping rates from Mine Years 5 through 12 ranged from approximately 2.5 mgd (Mine Year 6) to 3.5 mgd (Mine Year 8), with an average of 3.0 mgd.

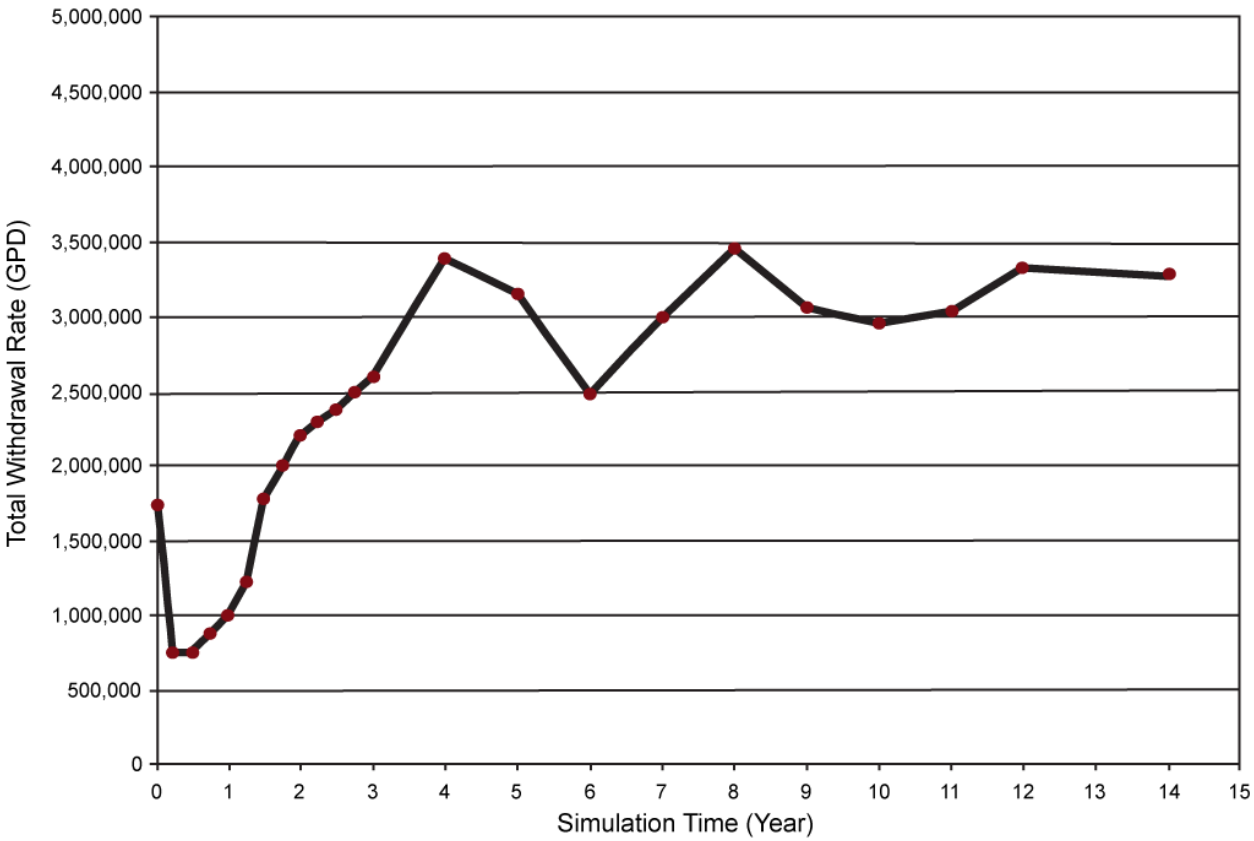


Figure 4.3-8 Simulated Cumulative Groundwater Withdrawal Rates from Mine Pits (Mine Years 0 through 14)

Simulated Drawdown of Groundwater Levels

Groundwater drawdowns resulting from dewatering were calculated by comparing the simulated water table elevation during mining to the average pre-mining water table elevation. Based on model results, the maximum simulated drawdown is listed in Table 4.3-1.

Table 4.3-1 Maximum Predicted Drawdown Locations

Mine Years	Location of Maximum Drawdown	Maximum Drawdown (feet)
0–2	Mill Zone Pit	144 (Mine Year 0) to 410 (Mine Year 2)
3–6	Snake Pit	373 feet (Mine Year 3) to 553 feet (Mine Year 4)
7–12	Ledbetter Pit	506 feet (Mine Year 7) to 842 feet (Mine Year 12)

The simulated areal extent of reduced groundwater levels was reviewed for each mine year. For the purpose of this study, the outer boundary of the zone of reduced groundwater levels was set to be the

simulated 1-foot drawdown contour, which is the detection limit of the model. The maximum simulated areal extent of the reduced groundwater levels occurred in Mine Year 12; simulated drawdowns are shown in Figure 4.3-9. The 1-foot drawdown contour extends outside the Project boundary to a maximum distance of approximately 2 miles beyond the southern and eastern edges of the mine pits, approximately 1.5 miles beyond the western edges of the pits, and approximately 3 miles beyond the northern edges of the pits. In some areas immediately adjacent to the Project area, groundwater levels were reduced from 25 to 50 feet in Mine Year 14, the year of the maximum reduction in groundwater levels.

Post-Mining Period

The recovery of water levels in the aquifer and mine pits was simulated by NewFields using the Cardno ENTRIX groundwater withdrawal model as the starting condition (NewFields and Schafer 2013). The results show that water levels begin to recover in the aquifers and pits as soon as mine dewatering ceases. Water levels would substantially recover in approximately 30 years. After groundwater levels have stabilized, they would likely remain below pre-mining water levels. The water levels would be lower by approximately 4 feet at Champion Pit, 6 feet at Small Pit, and 8.5 feet at Ledbetter Pit. Predicted groundwater contours at 75 years post-closure are shown in Figure 4.3-9 (Schafer 2013).

Modified Project Alternative

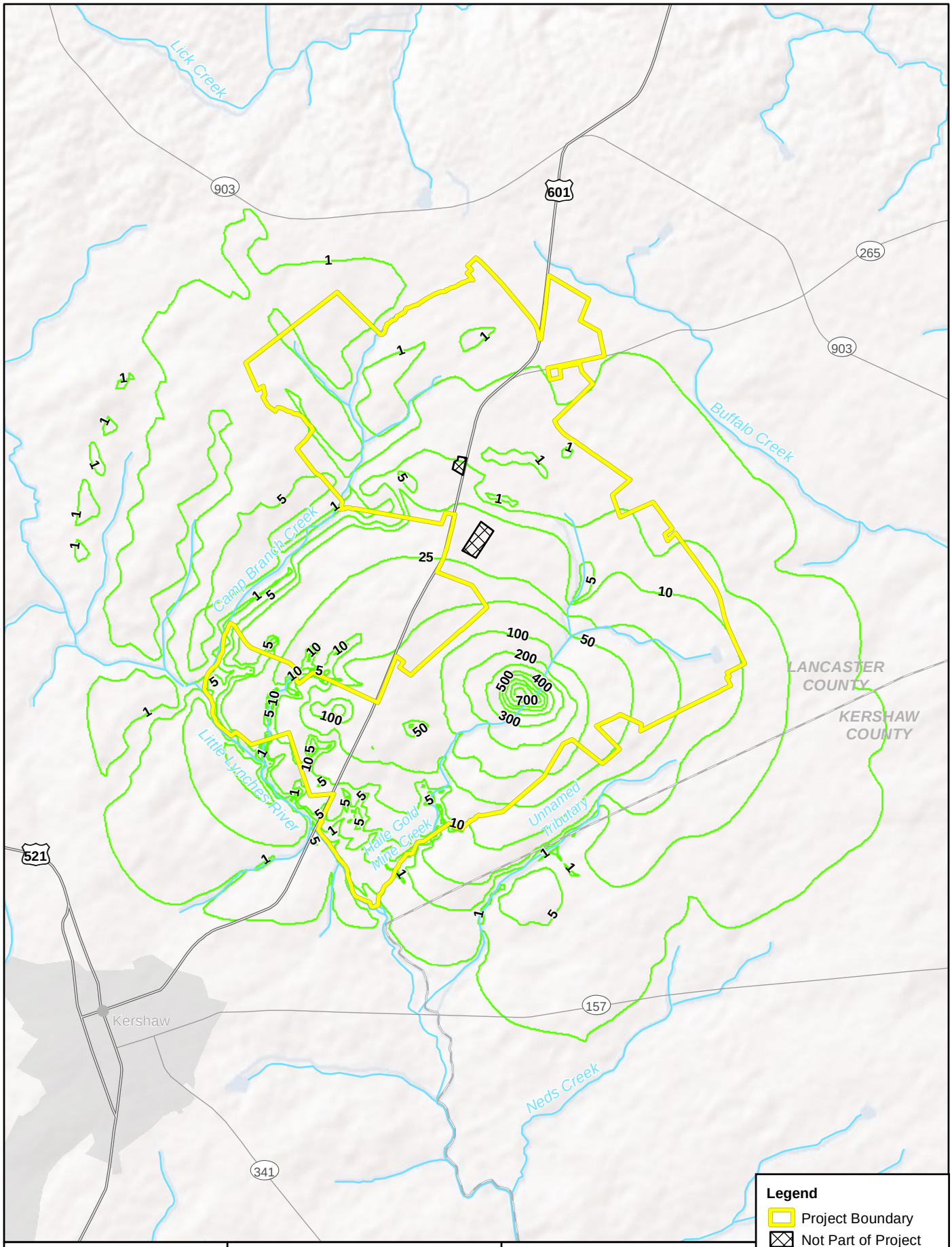
Under the Modified Project Alternative, impacts on groundwater levels would be the same as described for the Applicant's Proposed Project.

4.3.2.2 Potential Impacts on Groundwater Quality

Project impacts on groundwater quality would occur after the cessation of mining, when groundwater comes in contact with rocks, including sulfide minerals that have been oxidized and have acid-generating potential. The baseline geochemistry laboratory testing that was done using site-specific materials also assessed conditions under more neutral or slightly alkaline conditions. The results of this work and their use in conducting this impact analysis are summarized in Newfields and Schafer (2013).

Area of Groundwater Quality Impact

The results of the particle tracking model were used to depict the area of groundwater that may be adversely affected by mining operations. The particle tracking approach simulates groundwater flow direction and travel time as the pit lakes fill. The modeled particle tracks begin when the dewatering pumps are turned off and run for a sufficient duration to depict flow during refilling; in some cases, the model duration is 100 years. Early in the pit lake recovery period, groundwater flow is toward the pit lakes.



Haile Gold Mine Environmental Impact Statement
www.HaileGoldMineEIS.com

Figure 4.3-9

Simulated Drawdown Contours in Layer 2 Model Version 2 Mine Year 14

0 0.5 1 Miles
0 0.5 1 Kilometers

Source: ESRI 2008.

Legend

- Project Boundary
- Not Part of Project
- Contours (feet)
- County Boundary
- Cities
- Primary Highways
- Secondary Highways

Figures 4.3-10 and 4.3-11 depict the particle tracks for groundwater seepage from different mine-related infrastructure. The areas within the depicted particle tracks represent the groundwater areas that may be affected by mine-derived groundwater contamination. The pit lakes (Ledbetter, Small, Champion) fill in part with groundwater that has flowed through the oxidized highwalls from mining, and the groundwater impact of seepage from these lakes was assumed to affect the area depicted in Figures 4.3-10 and 4.3-11. The backfilled pits (primarily South and Chase) contain PAG material that would affect groundwater quality after the cessation of mining, as depicted in Figures 4.3-12 and 4.3-13.

The particle tracking analysis showed that groundwater flows in the vicinity of each of the pit lakes is predicted to be as follows:

- Champion Pit Lake
  - For the first few years of recovery, particles move toward Champion Pit Lake, and then flow predominantly toward the Little Lynches River.
  - Forty years after mining, particles spread wider because there is no initial flow toward the pit lake. The stabilized groundwater flow paths initiating from Champion Pit Lake flow toward Ledbetter Pit Lake, Haile Gold Mine Creek, and the Little Lynches River.
  - Travel times from Champion Pit to surface waters are simulated to be greater than 60 years.
- Small Pit Lake
  - The zone of depression around Small Pit is minor and only a slight flow toward Small Pit Lake would occur after the first several years. Generally groundwater would flow from the Small Pit area through the backfilled Mill Zone, Haile, and Red Hill Pits into Ledbetter Pit Lake, or toward Haile Gold Mine Creek. Groundwater flow paths from the western edge of Small Pit would flow toward the Little Lynches River.
  - Travel times from Small Pit to surface waters are simulated to be greater than 40 years.
- Ledbetter Pit Lake
  - As Ledbetter Pit Lake fills, groundwater would flow toward the pit from all directions until filling is complete.
  - After filling, groundwater would continue to flow toward Ledbetter Pit Lake after stable conditions are reached (around recovery year 40).
  - Flow toward Ledbetter Pit Lake would be discharged as surface water into Haile Gold Mine Creek downgradient of the pit lake.

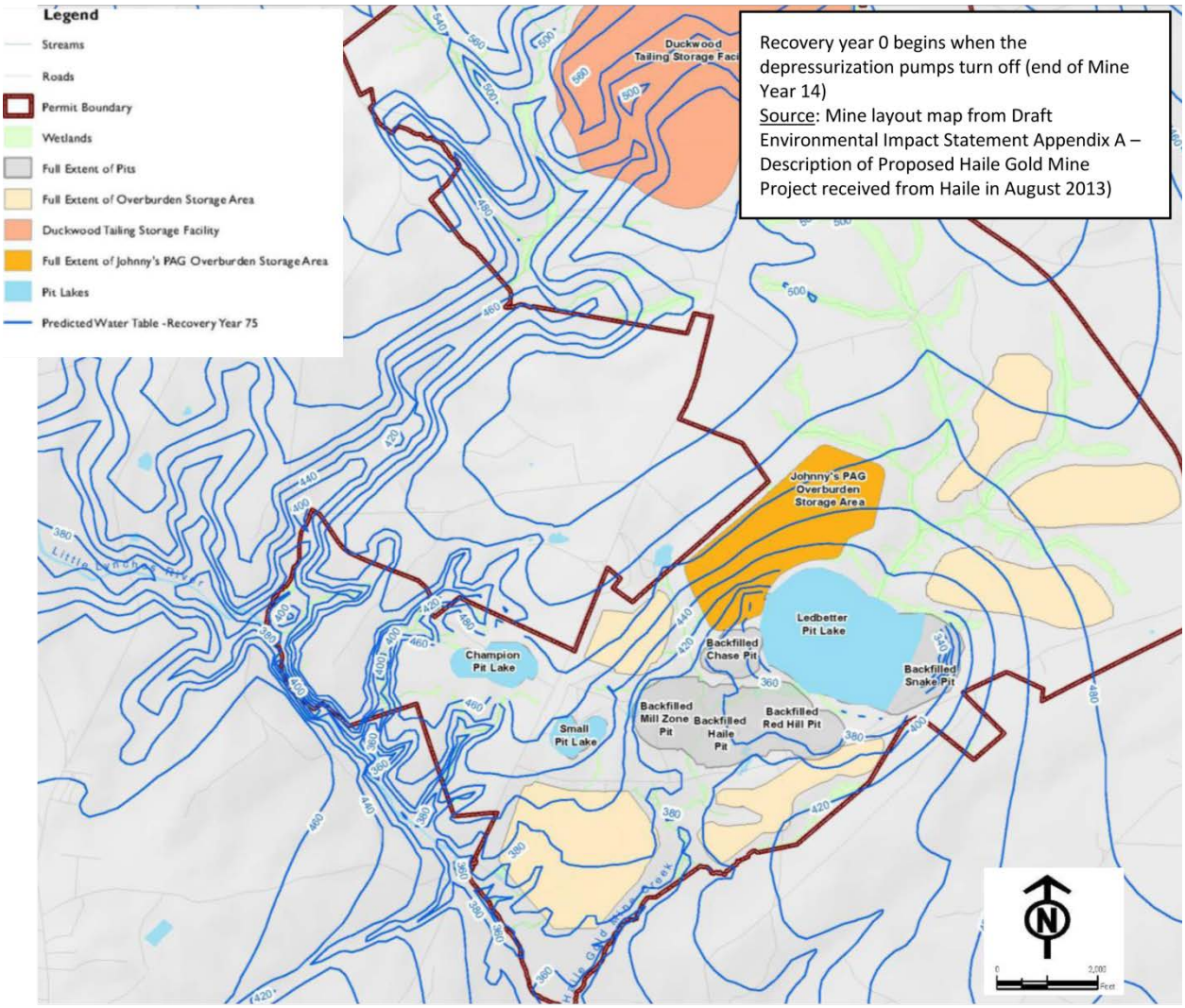


Figure 4.3-10 Simulated Groundwater Contours – 75 Years Post-Closure

Source: Schafer 2013.

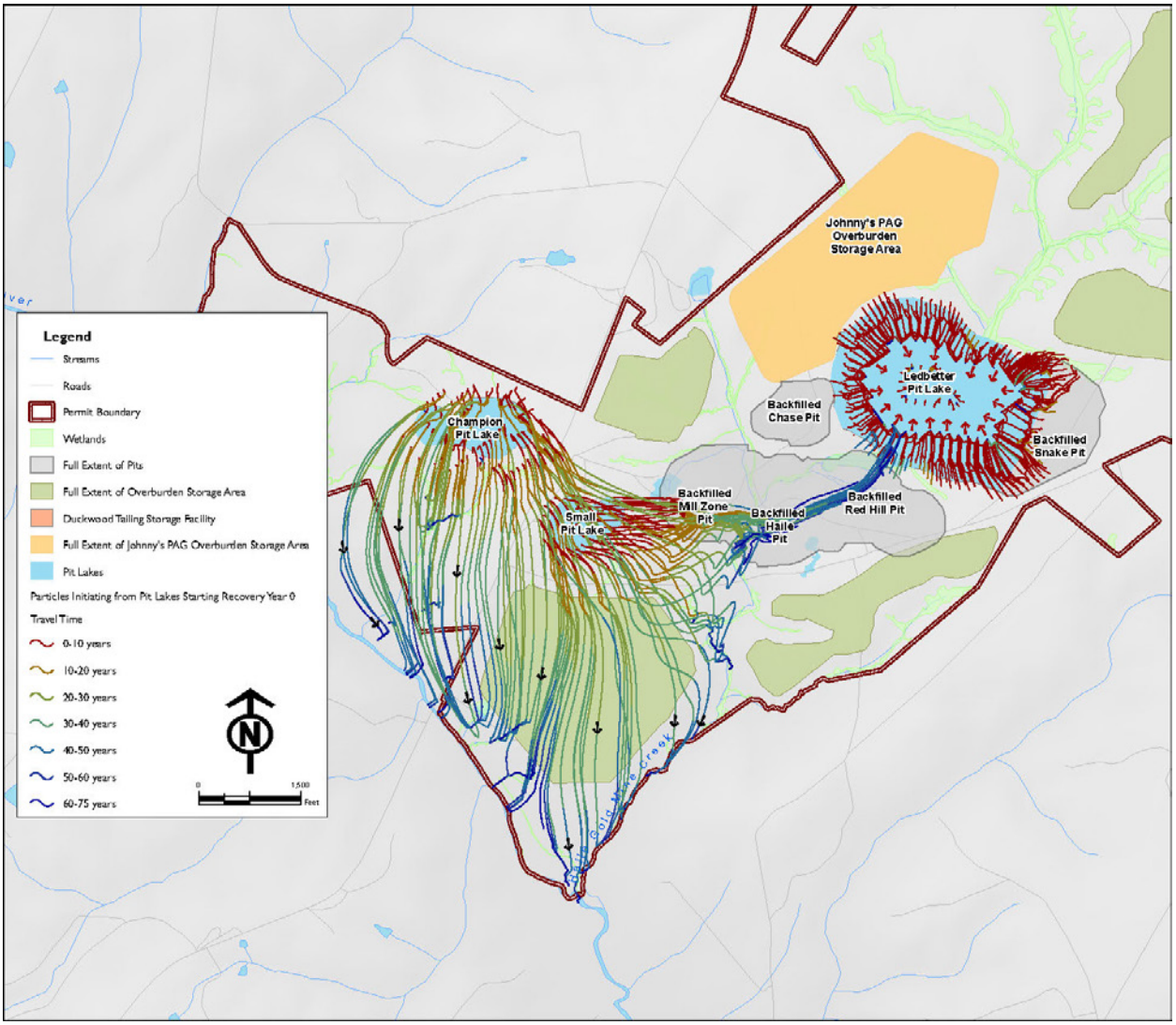


Figure 4.3-11 Simulated Groundwater Flow Paths from Ledbetter, Champion, and Small Pit Lakes Recovery – Mine Year 0

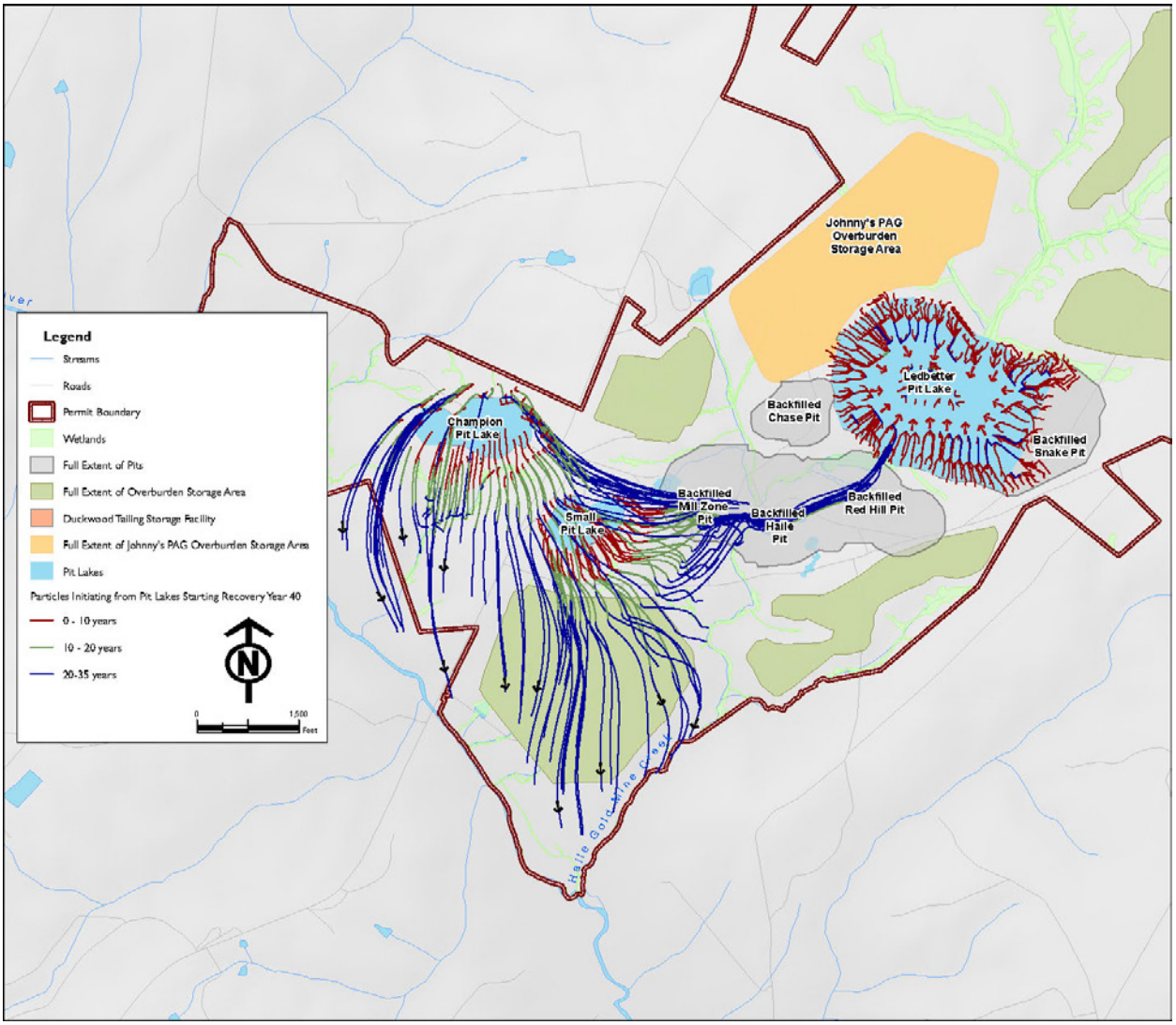


Figure 4.3-12 Simulated Groundwater Flow Paths from Ledbetter, Champion, and Small Pit Lakes Recovery – Mine Year 40

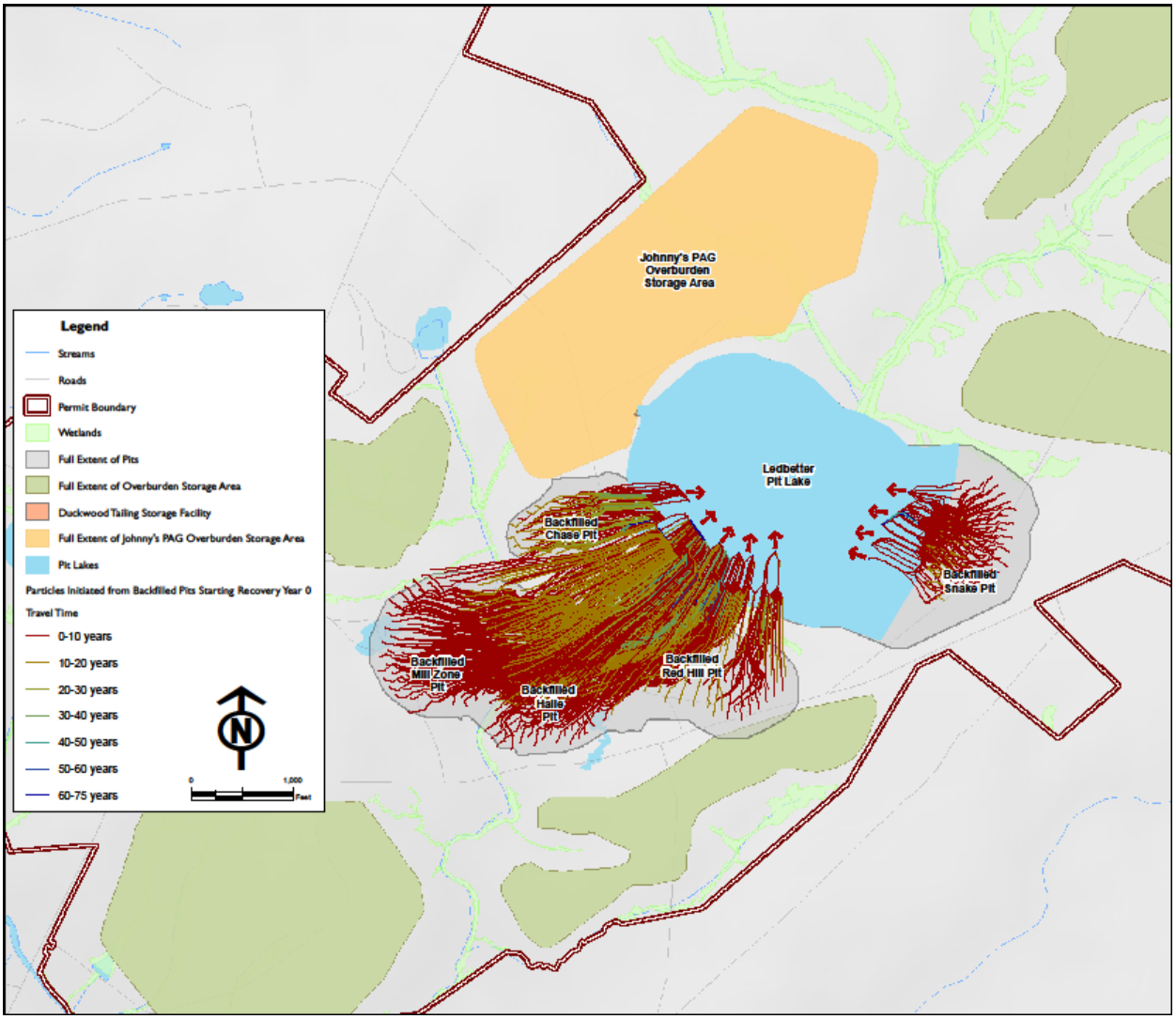


Figure 4.3-13 Simulated Groundwater Flow Paths from Backfilled Pits Beginning Recovery – Mine Year 0

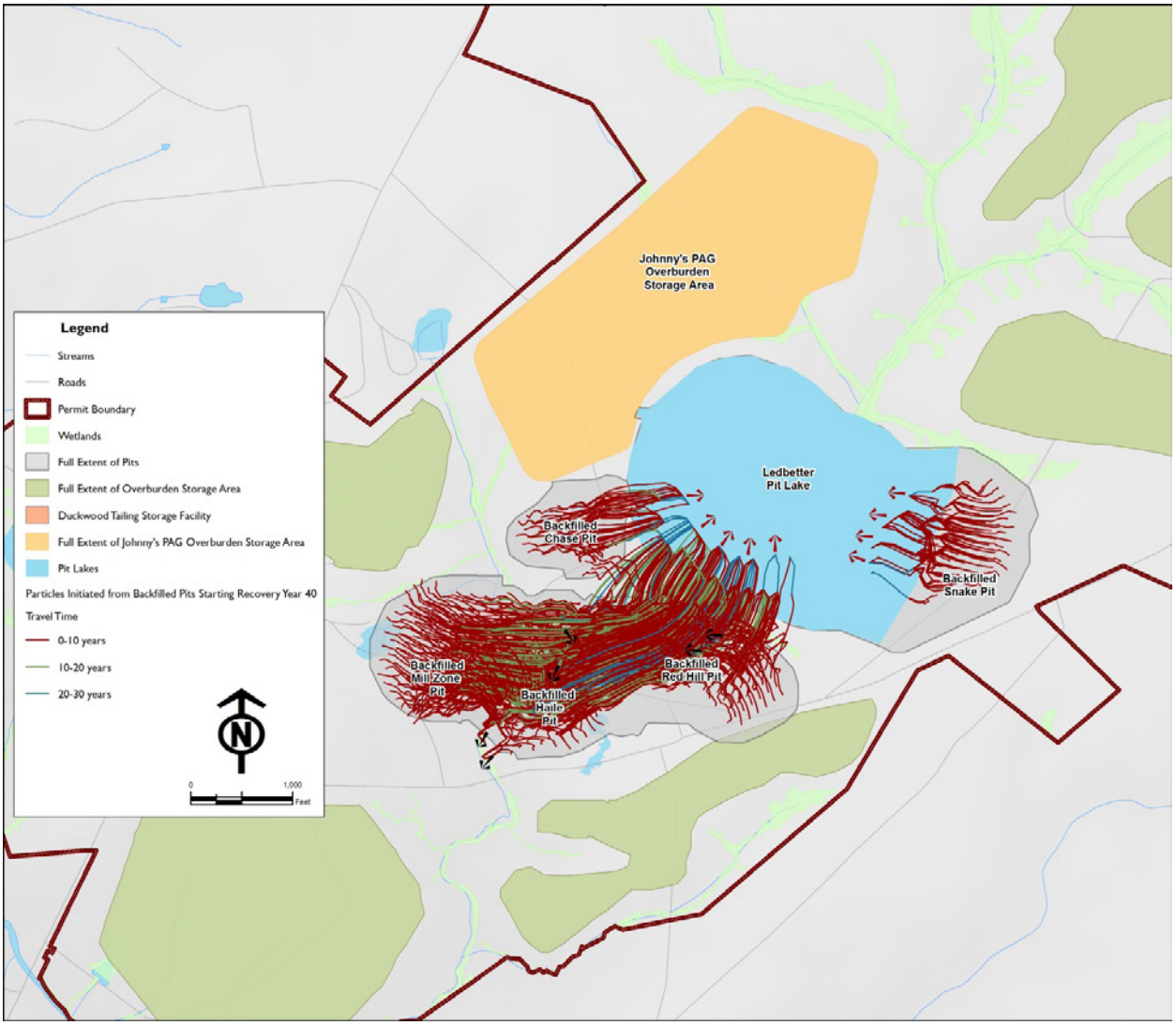


Figure 4.3-14 Simulated Groundwater Flow Paths from Backfilled Pits Beginning Recovery – Mine Year 40

Groundwater flow originating from areas that would be backfilled with mine material also was simulated using particle tracking. Results from the backfill simulation are shown in Figures 4.3-6 and 4.3-7, for particles initiated at time zero and initiated at 40 years, respectively. All groundwater flowing through backfilled pits both early and late in recovery was simulated as flowing into Ledbetter Pit Lake. Generally, travel times would be less than 30 years, with most less than 10 years, depending on the starting location and local hydraulic gradient of the particles.

No Action Alternative

Under the No Action Alternative, groundwater quality would follow the same trends as currently existing in the study area. The CPS and saprolite aquifers would continue to show some acid mine drainage impacts, with depressed pH and elevated dissolved solids and iron in several areas. The bedrock aquifer

would continue to maintain groundwater quality that is similar to native conditions for the aquifer. The impacts of groundwater discharge to the surface water system would be similar to current conditions.

Applicant's Proposed Project

Active Mining Period

During mine operations, groundwater would be drawn toward the mine dewatering system. Therefore, there would be no direct effect to groundwater quality during this phase.

Post-Mining Period

After mine dewatering pumping has ceased, the dewatered portion of the bedrock would fill with groundwater; metals, sulfate, and low pH waters would flow into the groundwater system. This mine-affected groundwater would flow from the pit lakes through the groundwater system and would discharge at Haile Gold Mine Creek and the Little Lynches River. The potential for mine operations to affect groundwater and surface water quality is greatest during mine closure and reclamation.

Numerical modeling was conducted to predict pit lake water quality and backfilled pit water quality after the cessation of mining. In this impact assessment, pit lakes (Ledbetter, Champion, Small) are addressed first, followed by backfilled pits (South and Chase).

The pit lake water quality modeling used distinct water quality characteristics for different sources of incoming water: precipitation, surface water, groundwater, and highwall runoff. It also used distinct chemical characteristics to represent where Yellow and Green Class material was used for pit backfill. The final sources of water considered in the pit lake modeling were bedrock groundwater that contacted the weathered highwall prior to reaching the pit lake. As groundwater flows through weathered highwall, secondary minerals that have accumulated from weathering of sulfide minerals would be removed, or "rinsed", by groundwater from the rock, increasing the concentration of some constituents, especially sulfate salts and certain metals.

Ledbetter Pit Lake

Ledbetter Pit Lake would be the largest permanent pit lake in the Project area post closure. Seepage would occur from Ledbetter Pit Lake to groundwater, which then would flow into the backfilled South Pit. Ledbetter Pit Lake would collect water from groundwater, precipitation, runoff from highwalls, and surface water from Haile Gold Mine Creek (AMEC 2013). Newfields and Schafer (2013) estimated that completely filling Ledbetter Pit Lake would take from 18 to 30 years after dewatering pumping ceases. Initially, the primary source of refilling would be groundwater, but by year 10 post-closure, the constant inflow (approximately 450 gpm) from upper Haile Gold Mine Creek would become dominant. Once Ledbetter Pit Lake is filled, Haile Gold Mine Creek would be directed through the lake and would discharge to lower Haile Gold Mine Creek below the lake. Once mining ceases, Ledbetter Pit would extend to an elevation of 340 feet below sea level, with surrounding highwalls approximately 540 feet above sea level. The pit lake would be fed by Haile Gold Mine Creek in the southwest corner, which would increase the rate of water recovery. The geologic compositions of the existing material within the pit, both submerged and exposed, is an important factor in determining the chemistry of groundwater flowing through it. Figure 4.3-15 depicts the area of exposed rock type in Ledbetter Pit. The highly pyritic material is located near the bottom. This area would be covered by backfill and situated below the final water level to decrease oxidation of sulfate and metals.

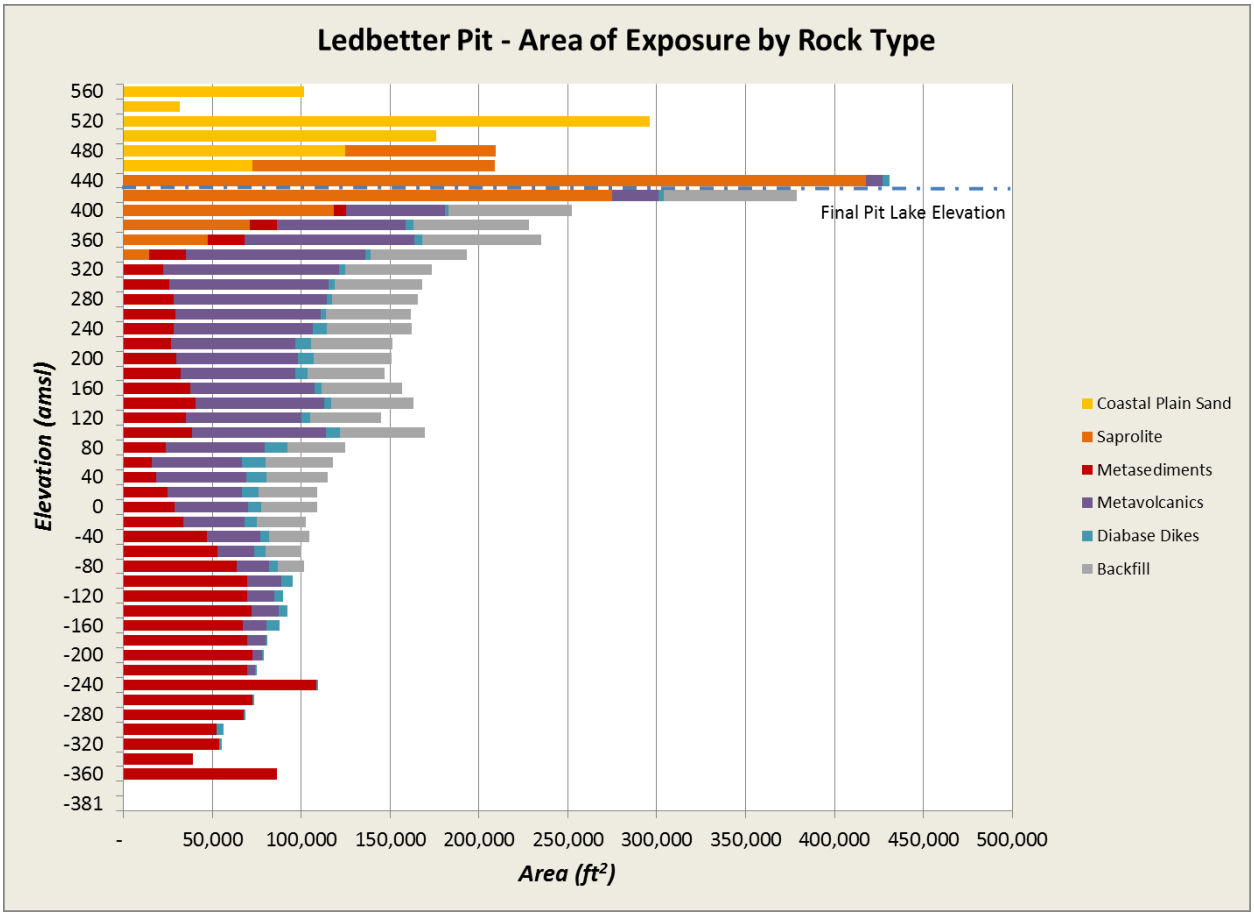


Figure 4.3-15 Ledbetter Pit Area of Exposure to Rock Type

When lime is added for pH control, the water is predicted to have a neutral pH and initially higher levels of sulfate, calcium, and TDS of approximately 2,200 mg/L (Schafer 2013). Calcium and sulfate ions would make up nearly 90 percent of the dissolved solids, while the metal levels are predicted to be low to non-detect due to the neutral pH. As Ledbetter Pit Lake fills, the TDS concentration is expected to decrease to approximately 1,000 to 1,700 mg/L at the point of outflow (the confluence of Haile Gold Mine and the Little Lynches River). Concentrations of TDS are expected to decrease slowly, until they reach a steady state (150 to 350 mg/L) at approximately year 75 post-closure. The predicted TDS concentrations initially would exceed secondary drinking standards, which are aesthetic (colored water).

With the addition of lime, pH is predicted to be from approximately 7.3 to 7.5 standard units. Without the introduction of lime, the pit lake is predicted to be acidic and to take approximately 60 years to stabilize. Ledbetter Pit Lake is estimated to need the addition of lime through year 13 (post-closure).

Metals concentrations were predicted to be low in Ledbetter Pit Lake. Figures 4.3-16 through 4.3-19 show the predicted concentrations of various constituents in Ledbetter Pit Lake. The red line in the figures represents predicted concentrations without the addition of lime. The blue line in the figures represents predicted concentrations after the addition of lime. The figures show that arsenic, cadmium, chloride, iron, and zinc would be below the drinking water standards with the addition of lime. It should be noted that antimony is predicted to exceed drinking primary drinking water standards, and sulfate, TDS and manganese are` predicted to exceed drinking secondary drinking water standards until approximately 40 to 50 years post-closure.

Although some constituents are modeled to have the potential to exceed drinking water standards, two other factors must be considered. First, considering the effects of dilution, the predicted concentrations would decrease by more than a factor of three. The modeled concentrations would then meet or slightly exceed drinking water standards. The predicted levels of constituents would fall below the drinking water standards at approximately 40 to 50 years post-closure. Second, the groundwater beneath the affected area is not currently used for human consumption and would not be available for potable water use in the future. Therefore, long-term impacts on groundwater quality due to the influence of Ledbetter Pit Lake are considered to be minor.

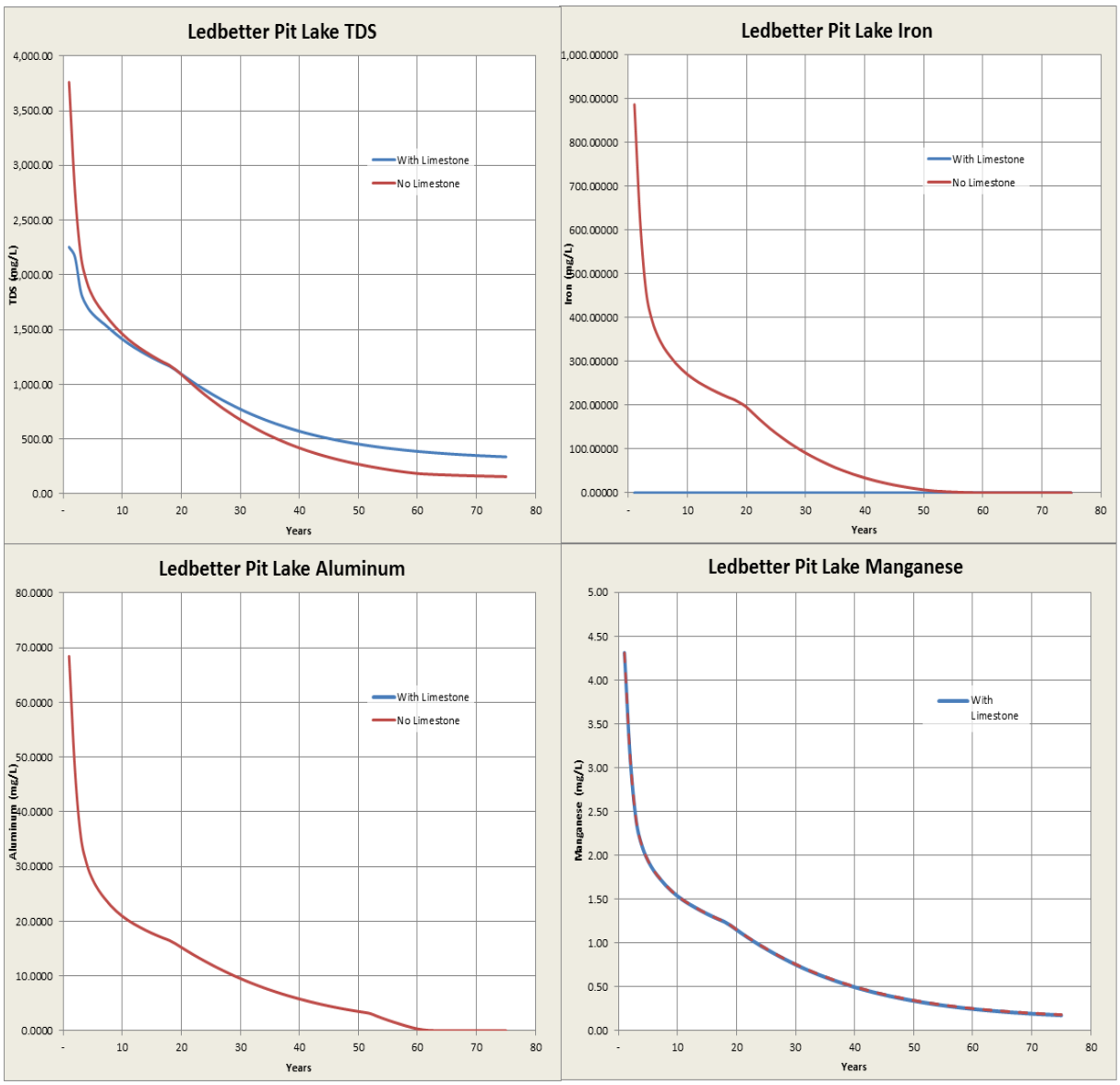


Figure 4.3-16 Potential Concentrations of TDS, Iron, Aluminum, and Manganese in Ledbetter Pit Lake

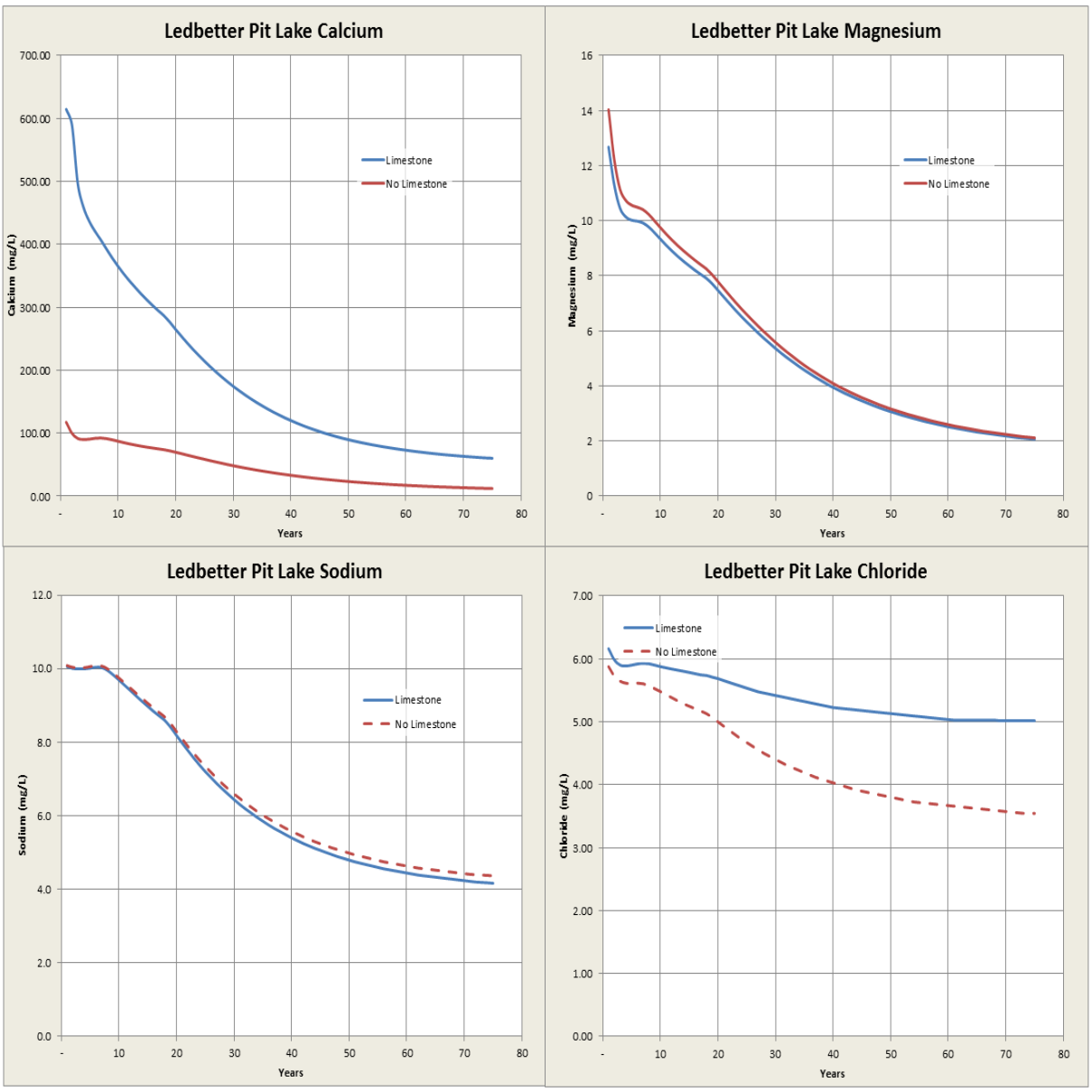


Figure 4.3-17 Potential Concentrations of Calcium, Magnesium, Sodium, and Chrloride in Ledbetter Pit Lake

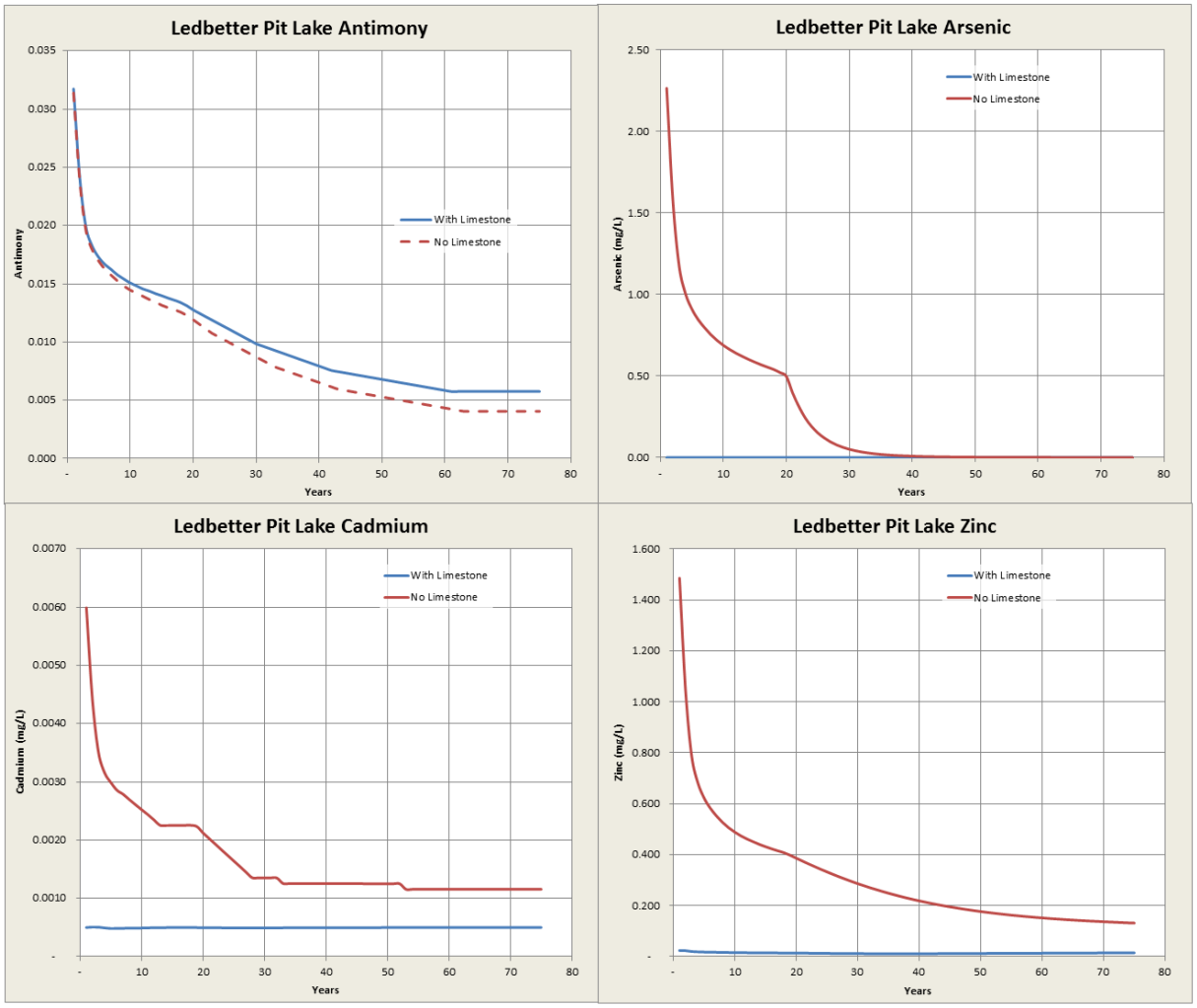


Figure 4.3-18 Potential Concentrations of Antimony, Arsenic, Cadmium, and Zinc in Ledbetter Pit Lake

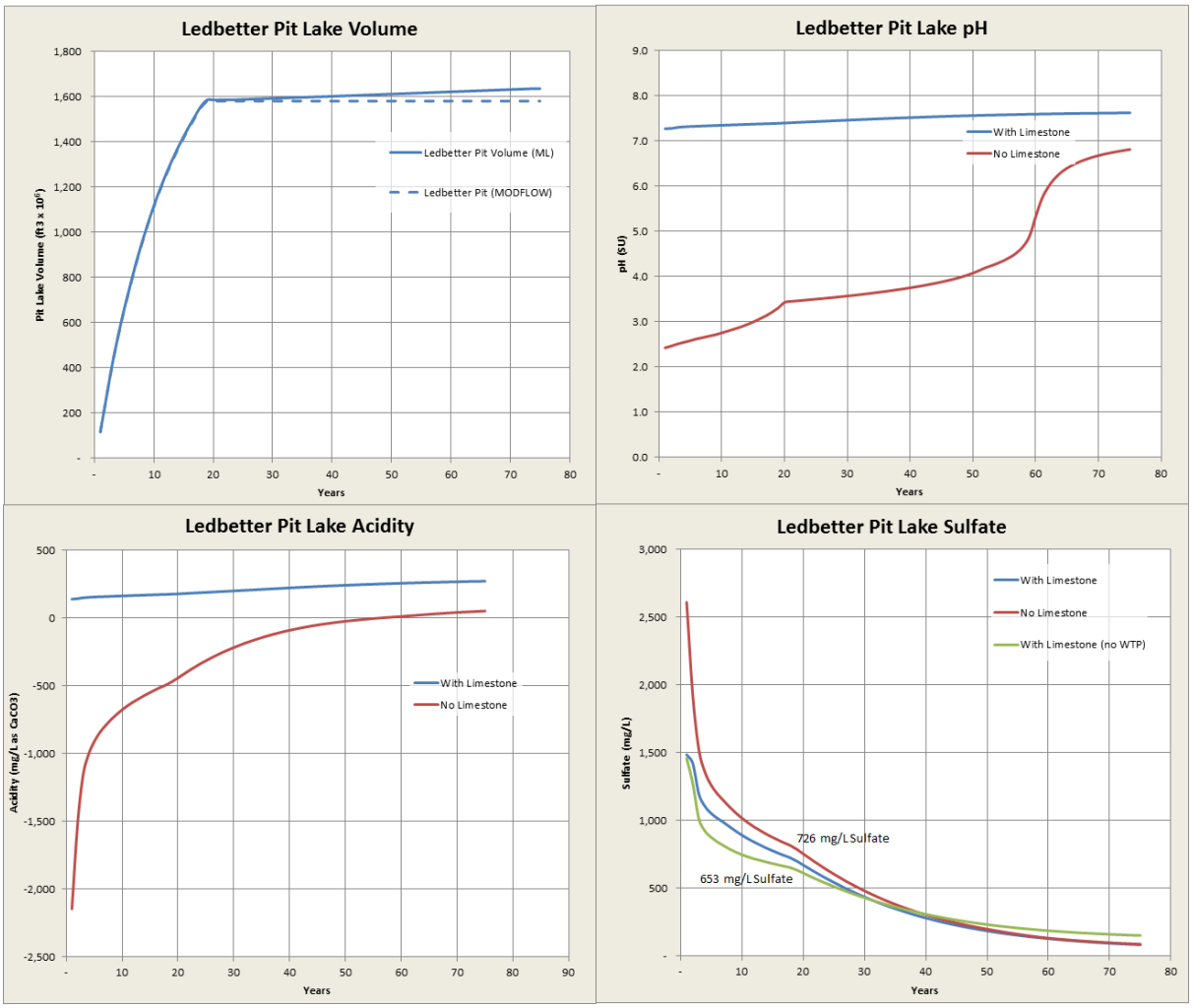


Figure 4.3-19 Potential Volume, pH, Acidity, and Concentrations of Sulfate in Ledbetter Pit Lake

Champion and Small Pit Lakes

Champion Pit Lake and Small Pit Lake also would collect water from groundwater, precipitation, and runoff from highwalls. Neither Champion nor Small Pit Lake would collect surface water, as no creek within the Project area would discharge to either waterbody. It is estimated that Champion and Small Pit Lakes would take approximately 10 to 50 years to fill, with a more gradual long-term recovery than Ledbetter Pit Lake. Champion Pit Lake is unusual in that it is recharged almost 50 percent by groundwater, compared to primarily precipitation and streamflow as recharge for the other pit lakes.

Groundwater would seep from these pit lakes, flowing in the direction of the Little Lynches River. Outflow from Champion and Small Pit Lakes occurs only as groundwater seepage and evaporation (AMEC 2013).

It is estimated that it would take approximately 20 years for these pits to reach equilibrium from inflow of groundwater, precipitation, and runoff**.** The TDS concentrations in Champion and Small Pit Lakes are

predicted to start at levels similar to Ledbetter Pit Lake (2,200 mg/L) and to decrease more slowly than Ledbetter Pit Lake. Based on historical data, the pit lake models may over-predict TDS concentrations. For example, historical data indicates that Champion Pit Lake had low pH levels without the addition of lime and that TDS concentrations ranged from 500 to 750 mg/L. After the addition of lime, TDS concentrations ranged from 400 to 600 mg/L. Without the addition of lime, Champion and Small Pit Lakes are predicted to remain acidic because of little to no dilution provided by surface water interaction.

Modeling of both pit lakes predicted low metal concentrations. The only metals predicted to have detectable concentrations were barium, manganese, nickel, and zinc. Considering the effects of dilution, the predicted groundwater concentrations would be more than three times lower than the model results.

The secondary drinking water standard for TDS is 500 mg/L, and the model results are greater than the standard. Although the effects of dilution would reduce the concentration by more than three times, there would still be an exceedance. Presently, groundwater is not used for supply within the zone affected by groundwater seepage from the pit lakes after filling. Therefore, long-term impacts to groundwater from the predicted increase in TDS concentrations are considered minor.

Backfilled Pits: South Pit and Chase Pit

As groundwater levels around disturbed areas recover, some groundwater flow would occur through backfilled pits, especially Mill Zone, Haile, and Red Hill (collectively known as South Pit). Changes to water chemistry would result from movement through the backfilled pits. This effect was modeled based on the composition of the backfilled rock, length of time the rock was exposed to oxidization, and groundwater fluctuations. The primary chemical process affecting groundwater chemistry through the backfilled pits would be oxidation of Yellow Class PAG material that would be used and neutralization of acidity through reaction with lime. Weathering and oxidation of Yellow Class PAG overburden that is expected to occur during mining was simulated by modeling background bedrock groundwater.

The system was simulated using oxygen and carbon dioxide levels that reflect subsurface conditions. The result of these reactions is an increase in calcium and sulfate ion concentrations in the groundwater. Sulfate and TDS were strongly correlated with oxidation rates; the greater the oxidation rate, the greater the predicted sulfate and TDS concentrations. Most metals showed little variability in the modeling.

The Chase Pit would be backfilled with Green Class overburden, saprolite, or Yellow Class overburden. If Yellow Class overburden is used as backfill, it would be treated with lime to decrease the acidification potential.

South Pit would be partially backfilled with low-sulfide rock (Green Class overburden) and Yellow Class overburden. Groundwater flowing through the pit would come in contact with the backfill zone.

Pit backfill would be placed under the final water table that would develop in the pits. Placing Yellow Class overburden beneath the water table would decrease oxidation affects and decrease the potential for acidic conditions to develop. All Yellow Class overburden would be treated with lime and covered with a minimum of 5 feet of saprolite material to decrease oxidation. During reclamation activities, the backfilled pits would be graded in a manner to minimize stormwater collection and decrease infiltration**.**

Table 4.3-2 shows the results for the modeled backfill water quality in South Pit. Because Chase Pit showed similar predicted water quality as South Pit, the water quality for South Pit was used to assess the effects on groundwater from Chase Pit. Results of the predicted water quality were compared to primary and secondary drinking water standards. Those standards that were exceeded are highlighted in red in Table 4.3-2.

The results in Table 4.3-2 show that pH, TDS, sulfate, manganese, iron, and antimony have the potential to exceed drinking water standards. Consideration of dilution, which would decrease these modeled concentrations by more than a factor of three, indicates that no primary drinking water standards are predicted to be exceeded by seepage from the backfilled pits.

Table 4.3-2 Results of Modeled Backfill Water Quality for South Pit Compared to Primary and Secondary Drinking Water Standards

Parameter	10%	90%	Median	SCDHEC Primary Drinking Water Standard	SCDHEC Secondary Drinking Water Standard
pH	6.29	7.26	7.06	**6.5–8.5**	-
TDS	800	2588	1367	-	**500**
Calcium	208	507	373	-	-
Magnesium	2.5	5.6	4.7	-	-
sodium	3.8	9.5	8.6	-	-
Potassium	1	1.2	1	-	-
Bicarbon	100	359	176	-	-
sulfate	398	1448	854	-	**250**
Chloride	5	5	5	-	-
Nitrate- N	0.89	0.89	0.89	10	-
Phosphorus	0.16	0.26	0.19	-	-
Boron	0.1	0.1	0.1	-	-
Fluoride	1	1	1	4	2
Aluminum	0.05	0.05	0.05	-	0.05–0.2
Arsenic	0.003	0.003	0.003	0.01	-
Barium	0.005	0.009	0.008	2	-
Cadmium	0.001	0.001	0.001	0.005	-
Copper	0.005	0.005	0.005	-	1
Iron	0	268.67	0.35	-	**0.3**
Mercury	0.0002	0.0002	0.0002	0.002	-

Table 4.3-2 Results of Modeled Backfill Water Quality for South Pit Compared to Primary and Secondary Drinking Water Standards (Continued)

Parameter	10%	90%	Median	SCDHEC Primary Drinking Water Standard	SCDHEC Secondary Drinking Water Standard
Manganese	0.11	0.43	0.38	-	**0.05**
Nickel	0.001	0.007	0.005	-	-
Lead	0.002	0.002	0.002	-	0.015
Antimony	0.003	0.005	0.005	**0.006**	-
Selenium	0.003	0.003	0.003	0.05	-
Thallium	0.001	0.001	0.001	0.002	-
Zinc	0.02	0.044	0.02	-	5

Notes:

- = no standard

SCDHEC = South Carolina Department of Health and Environmental Control

Standards that were exceeded are highlighted in red.

The groundwater flowing through backfilled pits is not currently used for human consumption and would not be available for human consumption in the future. Therefore, long-term impacts on groundwater quality from the backfilled pits are considered minor.

Modified Project Alternative

Under the Modified Project Alternative, impacts on groundwater quality would be the same as for the proposed Project.

4.3.2.3 Leaching Potential from the TSF and Johnny's PAG

No Action Alternative

Under the No Action Alternative, the TSF and Johnny's PAG would not be constructed; therefore, no impacts on groundwater would be caused by these facilities.

Applicant's Proposed Project

Precipitation falling on disturbed and exposed Red Class overburden material may have the potential to leach metals. If uncontrolled, the leachate could reach groundwater and adversely affect groundwater quality. PAG overburden would be stored in Johnny's PAG. This facility would be lined with an 80-mil geomembrane composite liner over a compacted soil liner. A drainage system beneath the geomembrane liner would prevent upwelling of groundwater from entering the Red Class PAG material. During active mining, contact water or seepage would be collected in a seepage collection system and be transferred to the Mill or water treatment system. Contact water would be treated to meet NPDES standards and discharged in accordance with Haile's NPDES permit. After active mining, the unit would be graded, stabilized, and capped with a 5-foot layer of saprolite overlain by a 60-mil geomembrane geotextile. An

additional layer of growth media would be installed over the geomembrane geotextile and vegetated. Additional measures to decrease oxidation of Red Class PAG overburden include installation of a 20-foot-high berm of saprolite around the perimeter and compaction of overburden placed within each bench. No geomembrane is completely impermeable, and the geomembrane may pass small volumes of leachate. However, the design of Johnny's PAG would both decrease the potential for infiltration of water into the cell and minimize the potential for migration of leachate out of the cell. Therefore, long-term impacts on groundwater quality from leaching of Johnny's PAG are considered minor.

Similar to Johnny's PAG, the TSF would be a closed cell and would be unlikely to lead to adverse impacts on groundwater. Therefore, potential long-term impacts on groundwater associated with leaching of PAG material are considered minor.

Modified Project Alternative

Relocation of overburden to reduce impacts on surface waters would not affect the leaching potential from Johnny's PAG or the TSF. Under the Modified Project Alternative, impacts on groundwater associated with potential leaching would be the same as described for the Applicant's Proposed Project.

4.3.3 Impact Summary

Table 4.3-3 presents a summary of impacts under each alternative for the three key issues related to groundwater resources.

4.3.4 Mitigation for Impacts on Groundwater

4.3.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included a number of avoidance and minimization measures in the design and plans for operating and managing the proposed Haile Gold Mine and has committed to implementing many of these measures as a part of the proposed MMP (Haile 2013) (Appendix G). These measures could become conditions of federal and state permits and certifications.

Applicant-proposed avoidance and minimization measures regarding groundwater are summarized below:

- Add lime amendment to Yellow Class PAG overburden used as pit backfill to minimize acid rock drainage during operations.
- Use a composite liner system (low-permeability soil liner and HDPE liner) at the TSF and Johnny's PAG to isolate any potential release of leachates from both units to the environment.
- Route groundwater from under Johnny's PAG and the TSF, and sample water quality.
- Install an HDPE cover on the TSF and Johnny's PAG during closure to prevent infiltration and formation of acid mine drainage.
- Install a double HDPE liner at the TSF Underdrain Collection Pond, 465 Collection Pond, 469 Collection Pond, and 19 Pond and install a single HDPE liner at the Process Event Pond.
- Implement a leak collection and recovery system (LCRS) at all double-HDPE-lined ponds.
- Measures for surface water may avoid or minimize impacts on groundwater hydrology and quality due to the interconnectedness of the surface and groundwater systems.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of avoidance and minimization measures proposed by the Applicant is provided in Chapter 6.

Table 4.3-3 Summary of Impacts on Groundwater

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Groundwater elevations	No change in the current groundwater elevations.	During active mining, groundwater elevations would be reduced within and adjacent to the Project area. The maximum extent of reduced groundwater levels would extend 3 miles to the north, 2 miles to the south and east, and 1.5 miles to the west of the mine pits. Groundwater levels could be reduced as much as 25–50 feet in areas immediately adjacent to the Project boundary. During the post-mining period, groundwater levels are expected to recover to near pre-mining elevations.	Same as the Applicant's Proposed Project.
Water quality in pit lakes and backfilled pits	Groundwater quality would follow the same trends as currently existing in the study area. The CPS and saprolite aquifers would continue to show some acid mine drainage impacts, with depressed pH and elevated dissolved solids and iron in several areas. The bedrock aquifer would continue to maintain groundwater quality that is similar to native conditions for the aquifer.	Some constituents could exceed primary and secondary drinking water standards but, considering dilution effects, are likely to meet standards in most cases. Groundwater in the Project area is not used for human consumption. Impacts are considered minor.	Same as the Applicant's Proposed Project.
Leaching potential from the TSF and Johnny's PAG	The TSF and Johnny's PAG would not be constructed; therefore, no impacts on groundwater would be caused by these facilities.	Liners and engineering isolation systems would minimize the potential for infiltration of leachates to groundwater. Potential impacts are minor.	Same as the Applicant's Proposed Project.

4.3.4.2 Additional Potential Mitigation Measures

In addition to the measures proposed by the Applicant, the USACE would consider other potential mitigation measures to reduce remaining impacts on groundwater from the proposed Project. Impacts on groundwater quality have been assessed using a model that does not have the capability of predicting reduction in the concentration of metals and other compounds from the source area. Accordingly, the impact analysis has identified compounds for which the drinking water standards may be exceeded. Consideration of dilution as one of the processes that would reduce the concentrations of metals and other

constituents indicate that the impacts are likely to be minor. However, to account for uncertainty in using the model results to accurately predict future concentrations of chemical constituents in groundwater, the following mitigation measure is suggested:

- Issue a moratorium on potable well installation within the zone of potential groundwater impact (as depicted by the particle tracking results). No new potable supply well may be installed within this area, unless the mine operator can demonstrate that water quality criteria are being and would continue to be met.

Groundwater in the potentially affected area is not currently used for human consumption. This suggested mitigation measure would ensure that this condition continues until such time that the mine operator can demonstrate that groundwater meets either the drinking water standard or the background conditions. The effect is considered minor. Because of the overall uncertainty regarding this important issue, it is prudent to require this measure to accompany implementation of the Groundwater Monitoring Plan.

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4.4 Surface Water Hydrology and Water Quality

Project-related direct and indirect impacts on surface water hydrology and water quality could occur during the entire life cycle of the mining process, including the post-closure phase. Four principal impacts were evaluated, including:

- Alteration to the watershed
- Changes to streamflow regime
- Changes to water temperature
- Changes to water quality

These impacts could occur as a result of land disturbance activities, pumping groundwater to dewater the mine pits, stream channel modifications and diversions, effluent discharge from the mine's contact water treatment plant, management of overburden and tailings materials, and changes in water chemistry from filling the pit lakes during the post-mining period. Section 4.3, "Groundwater Hydrology and Water Quality" describes the changes to the groundwater system as a result of mining and during the pit lake filling period. The changes to groundwater flow and groundwater quality would affect surface water flows and surface water quality.

4.4.1 Methods

Impacts on surface water hydrology and surface water quality were evaluated by focusing on the time period of maximum groundwater pumping for dewatering the mine pits (Mine Year 14). During this time, the change in groundwater and surface water hydrology would be the greatest. In addition to watershed alterations and hydrologic regime, effects on surface waters would be greatest in this year.

Two models, previously described in Section 4.3, "Groundwater Hydrology and Water Quality" also were used in the surface water analysis. The groundwater withdrawal model (Cardno ENTRIX 2013) was used to predict changes to baseflows in surface waters. Impacts on water quality during the post-mining period were evaluated based on the pit refilling model (Schafer, AMEC, and ERC 2013). During the post-mining period, surface water hydrology would return to near pre-Project conditions, but changes to surface water quality would be the greatest. More detailed descriptions of these assessments are provided in Appendix J.

The thermal model described in Section 4.1, "Approach to Environmental Analysis" was used to predict changes in surface water temperatures.

Impacts on surface waters and water quality were summarized by drainage basin for each relevant waterbody. Impacts on drainage basins, referred to as *subwatersheds*, were determined by overlaying the mine plan provided by Haile with the watershed boundaries for each stream in the study area (Figure 4.4-1).

4.4.1.1 Watershed Alteration

To quantify the potential watershed alterations from the proposed Project, GIS spatial analyses were performed using data provided by Haile. The year of the greatest extent of groundwater drawdown from mine-related pumping (Mine Year 14) was used to quantify impacts during active mining, rather than presenting the data for each mine year. In this way, the magnitude of Project impacts is bounded by those analyzed for the year of greatest disturbance.

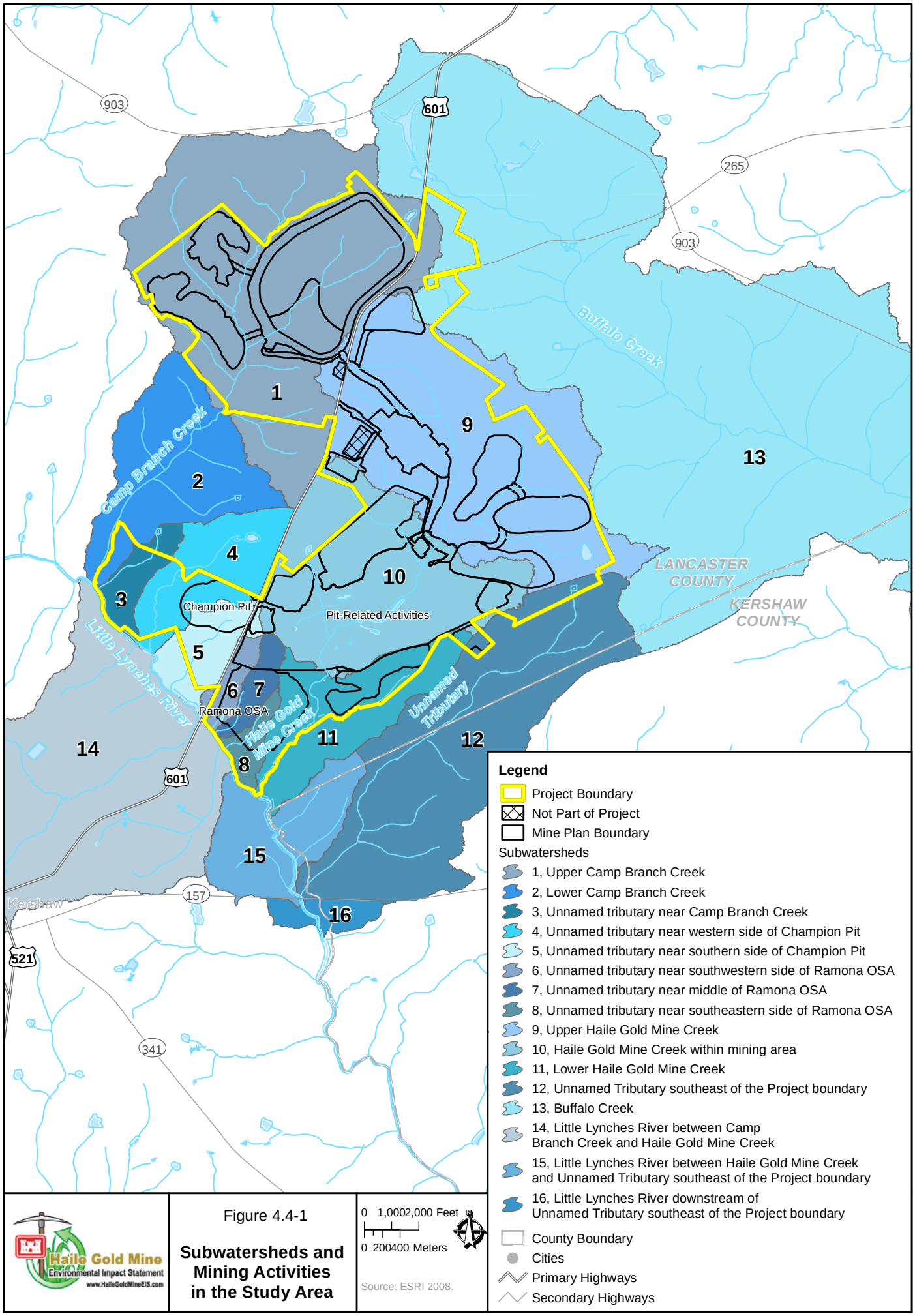

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Figure 4.4-1

Subwatersheds and Mining Activities in the Study Area

4.4.1.2 Changes to Streamflow Regime

Changes in streamflows during the active mining period were assessed for the baseflow and runoff flow regimes. Baseflow, also called *low flow* or *sustained flow*, is the portion of streamflow that comes from deeper subsurface flow and delayed shallow groundwater flow contributions. Runoff is precipitation that is not absorbed by the soil and that "runs off" directly into streams. Runoff is periodic and associated with precipitation events; during dry periods, runoff is often absent and streamflow is sustained by baseflow (see Section 4.1, "Approach to Environmental Analysis"). The groundwater model (Cardno ENTRIX 2013) was used to simulate the changes in baseflows resulting from groundwater pumping to support mining. Changes in watershed area or runoff coefficients were used to assess changes in runoff due to altered drainage area or land cover, topography, and permeability. Changes in runoff were based on proportional drainage areas (for lined areas that are effectively "removed" from the drainage area) and alteration of runoff coefficients for disturbed areas. Stream diversions and direct discharges were accounted for as point source discharges to lower Haile Gold Mine Creek.

4.4.1.3 Changes to Stream Temperature

A site-specific thermal model, using the software QUAL2K, was developed to estimate changes in stream temperature from proposed Project features and activities, as described in Section 4.1. Multiple thermal modeling scenarios were developed with various assumptions for baseflow contribution, water treatment plant discharge, and pit depressurization discharge. Three seasonal conditions were modeled. Each stream segment had different responses to the mining activity. Therefore, rather than pick a particular time to assess thermal impacts, the time that produced the greatest temperature change in any given stream segment was used to characterize the impact. In this way, the analysis bounds the magnitude of the impact for each stream segment.

Impacts were characterized in one of four categories based on the results of the thermal modeling:

- Model predicted not more than a 1 °F increase or decrease in stream temperature
- Model predicted between a 1 and 5 °F increase or decrease in stream temperature
- Model predicted between a 5 and 10 °F increase or decrease in stream temperature
- Model predicted a greater than 10 °F increase or decrease in stream temperature

For those streams that were not simulated using the QUAL2K thermal model because of their size or location outside of the extent of groundwater drawdown, likely thermal impacts were extrapolated using the relative change in baseflows (see Table 4.4-4 below). Baseflows for each stream segment during the various stages of mine life were provided by ERC (2013b). The relative percent changes among the tributaries were used to extrapolate the results of the thermal model to those streams that were not directly modeled by QUAL2K.

The SCDHEC standard for temperature in streams specifies no more than a 5 °F increase in temperature from discharge of a heated effluent (SCDHEC 2009, 2012). This standard is applicable where heated discharges occur, which is not the case for the proposed Project. However, the 5 °F temperature increment is a useful criterion for assessing impacts of temperature changes.

4.4.1.4 Changes in Water Quality

Existing reports, draft and final permits, water quality databases, and groundwater quality modeling were used to assess impacts on stream water quality. These data and numerical models included:

- Operational permits issued by the USACE and the SCDHEC;
- Haile Gold Mine, Inc. 2012a. Water Data Access Database.
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- Schafer. 2013b. Preliminary Little Lynches River Water Quality Results.
- Schafer. 2013c. Preliminary Water Quality Result Tables
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4.4.2 Impacts

To initiate the impact analysis, Project features and activities that would cause direct and indirect impacts within each subwatershed were identified (Table 4.4-1). The complete description of the proposed Project (Appendix A) provides greater detail regarding the nature and location of these facilities and activities.

4.4.2.1 Watershed Alteration

No Action Alternative

Under the No Action Alternative, reclamation and closure would continue and no additional mining would take place. The subwatersheds within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation. This would occur as a result of

improved vegetative stabilization, reduced erosion and sedimentation, and development of riparian and streamside cover and trees. Particularly in the previously mined areas of Haile Gold Mine Creek, these changes would eventually result in the development of natural land cover, forested stream buffers, less erosion and sedimentation, improved stream substrates, and generally improved stream conditions that would be typical of forested headwater streams of the Piedmont and Sandhills ecoregions.

Other subwatersheds in the study area, such as Camp Branch Creek, Buffalo Creek, and the unnamed tributaries draining to the Little Lynches River, would remain largely unchanged under the No Action Alternative, subject to any future watershed development that may occur.

Applicant's Proposed Project

Active Mining Period

Watershed disturbances involve changes in topography, soil permeability, vegetative cover, and routing and storage of water in the Project area. Some streams would be filled and covered by mining features (Table 4.4-2). Watershed disturbances could affect streamflows by altering the amount of runoff that reaches streams and the amount of water that percolates to the groundwater. Changes in land cover could cause increased sediment loads and sediment-associated pollutants in the basin directly affected and downstream. Johnny's PAG and the TSF would have HDPE liners and would be capped when mining is completed to prevent seepage through waste material into the groundwater system or nearby streams.

Table 4.4-2 shows the number of streams and land area that would be affected in the Project area under the Applicant's Proposed Project during active mining and post-mining. "Acres disturbed" indicates land cover and topographic changes. "Acres intercepted" indicates areas that effectively would be removed from the drainage area due to pit development or encapsulated features such as the TSF and Johnny's PAG. Table 4.4-3 presents the cumulative percent disturbance for each subwatershed.

During the active mining period, a total of 1,584 acres would be disturbed, and 927 acres would be intercepted and isolated from the stream system. A total of 31,258 feet of streams would be lost or diverted, and there would be two points of stream discharge (Ledbetter Pit Lake and the contact water treatment plant). Percent disturbance for the cumulative subwatersheds in the study area ranges from 0 to 93 percent.

Post-Mining Period

Except for some of the roads that are needed for post-mining activities or land uses, all of the disturbed areas in the watershed would be closed, graded, and stabilized with vegetation during the reclamation period. Pit lakes would occupy 182 acres, and 14,837 feet of stream would be covered by overburden storage facilities. Topographically, pits would be backfilled or would become pit lakes, but OSAs would remain altered. Following reclamation, there would be no further watershed alterations because Project facilities would be stabilized.

The impacts are considered major for Camp Branch Creek, Haile Gold Mine Creek, the unnamed tributary near the southern side of Champion Pit, and the three unnamed tributaries directly affected by Ramona OSA. The impacts are moderate for the unnamed tributary near the western side of Champion Pit, and low for the other subwatersheds in the study area. These changes would be temporary, and most of the impacts due to watershed disturbance would not occur once the areas are reclaimed. Impacts on other water-related resources such as wetlands or aquatic habitat are addressed in the respective sections of the EIS.

Table 4.4-1 Activities That Would Cause Direct and Indirect Impacts on Surface Waters in the Study Area

Subwatershed	Proposed Roads	Runoff Diversion Facilities	Sedimentation Ponds	Pit Development	Channel Modifications or Diversion	OSAs	Growth Media Storage Areas	Johnny's PAG	Duckwood TSF	Holly and Hock TSF Borrow Areas	Groundwater Discharge	On-site Water Treatment Plant Discharge	Mill and Process Ponds
1. Upper Camp Branch Creek	D	D	D	I	D				D	D			
2. Lower Camp Branch Creek	I	I	I	I	I				I	I			
3. Unnamed tributary near Camp Branch Creek				I									
4. Unnamed tributary near western side of Champion Pit	D			D									
5. Unnamed tributary near southern side of Champion Pit	D			D									
6. Unnamed tributary near southwestern side of Ramona OSA	D	D	D	I		D							
7. Unnamed tributary near middle of Ramona OSA	D	D	D	I		D							
8. Unnamed tributary near southeastern side of Ramona OSA	D	D	D	I		D							
9. Upper Haile Gold Mine Creek	D	D	D	I		D	D	D					D
10. Haile Gold Mine Creek within mining area	D	D	D	D	D	D	D	D					D
11. Lower Haile Gold Mine Creek	D	D	D	I		D					D	D	
12. Unnamed Tributary southeast of the Project boundary	D			I			D						
13. Buffalo Creek				I									
14. Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	I	I	I	I	I	I			I	I			
15. Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary	I	I	I	I	I	I	I	I	I	I	I	I	I
16. Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary	I	I	I	I	I	I	I	I	I	I	I	I	I

D = direct impact; I = indirect impact; OSA = overburden storage area

Table 4.4-2 Watershed Alteration under the Applicant's Proposed Project

Project Activity/Feature	Active-Mining Impacts	Post-Mining/Reclamation Impacts
Proposed haul and service roads	8 stream crossings 193 acres disturbed	2 stream crossings 185 acres reclaimed 8 acres disturbed for access road to major facilities
Runoff diversion facilities	~23 miles of diversion	~23 miles of diversion reclaimed
Sedimentation ponds	~27 acres of sedimentation pond	~27 acres reclaimed
Pit development /depressurization	362 acres intercepted 7,920 feet of stream lost 1 stream discharge	182 acres backfilled 180 acres as open pits • 115 acres as flow-through pit lake • 22 acres as full containment pit lakes • 56 acres remaining as exposed pit wall No stream discharge
Channel modifications and diversions	8,131 feet of stream diverted 13-acre detention structure	7,656 feet of stream reclaimed 475 feet of stream lost (subsumed by Ledbetter Pit Lake) 13 acres reclaimed
Overburden storage areas (OSAs)	488 acres disturbed 7,973 feet of stream lost	488 acres reclaimed 7,128 feet of stream lost
Growth media storage areas	103 acres disturbed	103 acres reclaimed
Johnny's PAG	159 acres intercepted 13 acres of collection ponds (465 & 469) 1,003 feet of stream lost	159 acres reclaimed 13 acres of passive treatment cells 1,003 feet of stream lost
Tailings storage facility (TSF)	93 acres disturbed 406 acres intercepted 2.3 acres of underdrain collection pond 6,230 feet of stream lost	499 acres reclaimed 2.3 acres of passive treatment cells 6,230 feet of stream lost
Holly and Hock TSF borrow areas	172 acres disturbed	172 acres reclaimed
Mill Site and Utility Pond	118 acres disturbed area	118 acres reclaimed
Contact water treatment plant	1 stream discharge	1 or 2 stream discharges, depending on make-up of draindown

Table 4.4-3 Cumulative Percent Watershed Disturbance under the Applicant's Proposed Project

Subwatershed	Cumulative Percent Disturbance from Mining Activities
1. Upper Camp Branch Creek	34.4
2. Lower Camp Branch Creek	26.1
3. Unnamed tributary near Camp Branch Creek	0.0
4. Unnamed tributary near western side of Champion Pit	12.8
5. Unnamed tributary near southern side of Champion Pit	26.0
6. Unnamed tributary near southwestern side of Ramona OSA	54.6
7. Unnamed tributary near middle of Ramona OSA	93.2
8. Unnamed tributary near southeastern side of Ramona OSA	42.7
9. Upper Haile Gold Mine Creek	28.5
10. Haile Gold Mine Creek within mining area	48.8
11. Lower Haile Gold Mine Creek	45.7
12. Unnamed Tributary southeast of the Project boundary	0.6
13. Buffalo Creek	0.1
14. Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	3.6
15. Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary	7.8
16. Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary	7.5

OSA = overburden storage area

Modified Project Alternative

Impacts on the watershed during the active mining period under the Modified Project Alternative would be similar to those described for the Applicant's Proposed Project, except for impacts related to the Ramona OSA and the Holly and Hock TSF borrow areas. Under the Modified Project Alternative, the Ramona OSA would be designed to avoid the unnamed tributaries in that area, and these streams would remain as features in the landscape.

Table 4.4-4 summarizes the impacts associated with the Modified Project Alternative. Nineteen more acres of land would be disturbed and 7,128 fewer feet of stream would be affected during the active mining period under the Modified Project Alternative compared to the Applicant's Proposed Project. Overall, slightly less stream length would be directly affected by watershed changes under the Modified Project Alternative than under the Applicant's Proposed Project. Acreages in Table 4.4-4 were estimated in mapview using GIS. Any discrepancies between these numbers and those listed in the Reclamation Plan are due to consideration of three-dimensional surface areas, such as those in OSAs.

Table 4.4-4 Watershed Alteration under the Modified Project Alternative

Project Activity/Feature	Active-Mining Impacts	Post-Mining/Reclamation Impacts
Overburden storage areas	679 acres disturbed 898 feet of stream lost	679 acres reclaimed 898 feet of stream lost

4.4.2.2 Changes to Streamflow

No Action Alternative

Under the No Action Alternative, reclamation and closure would continue and no additional mining would take place. The streamflows within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation. This would occur as land cover and vegetation revert back to a more natural condition. As a result, hydrologic cycle in the subwatersheds would more closely mimic that of an undisturbed watershed with less surface runoff and more infiltration and evapotranspiration.

Other subwatersheds in the study area, such as Camp Branch Creek, Buffalo Creek, and the unnamed tributaries draining to the Little Lynches River, would remain largely unchanged under the No Action Alternative, subject to any future watershed development that may occur.

Applicant's Proposed Project

Active Mining Period

Changes to the streamflow regime within and outside of the Project area would be caused by watershed changes, water storage in pit lakes, channel diversion and rerouting, groundwater pumping to dewater the mining pits, discharge of pit depressurization water, and effluent discharge from the water treatment plant. Depending on the stream segment, water flows would increase or decrease based on the net effects of these flow regime changes. These impacts would become more substantial as mining progresses (e.g., as pits become deeper and OSAs become larger). Impacts associated with pit lakes would be long term because these features would be permanent changes to the landscape.

Tables 4.4-5 through 4.4-8 show the relative and percent change in average annual baseflows, runoff flows, mine releases, and total flows. These changes assume that 69 gpm[1] (0.15 cubic feet per second [cfs]) would be diverted to fill Ledbetter Pit Lake during reclamation. To illustrate the duration and magnitude of impacts on streamflows, results are presented during active mining, 15 years after mining is completed (Mine Year 29), and 75 years after mining (Mine Year 89). Impacts are shown as the change in flow rate (cfs) and percent change relative to the No Action Alternative. Negative values indicate a reduction in flow relative to the No Action Alternative; positive values indicate an increase in flow. These tables present relative changes at an annual scale. Impacts could be greater in shorter time periods and could be disproportionately greater during low-flow periods. SCDHEC has indicated that actual diversions could range from 0 gpm to 80 percent of the average annual flow rate for the stream segment (SCDHEC 2013). Mean annual flow upstream of Ledbetter Pit Lake is approximately 2.5 cfs (Section 3.4); therefore, 80 percent of the average annual flow would be approximately 2 cfs).

[1] Based on the safe yield analysis for Haile Gold Mine (ERC 2013a).

An assumed diversion of 69 gpm (0.15 cfs) was used to derive the changes in flow presented in Tables 4.4-5 through 4.4-8. If post-mining diversion to fill Ledbetter Pit Lake exceeds this amount (that is, up to 2 cfs), the impact predicted for streamflows shown in the tables would be different.

The No Action Alternative represents flows without the proposed Project; the derivation of these flows is summarized in Appendix J. The percent change is not shown for mine releases because there are no substantial mine releases under the No Action Alternative from which to measure change. The discharges from current mine releases are very low flows from the passive treatment cells of typically less than 0.02 cfs (see Section 3.3).

Baseflow reductions of up to 77 percent would occur during mining. At the Little Lynches River, downstream of the mined area, the changes in baseflow would decrease by approximately 12 percent. Average annual runoff flows, which are less affected by groundwater withdrawals during mining, would range from decreases of 19 percent to increases of 12 percent. Changes to the Little Lynches River downstream of the mined area would be less than 1.6 percent. Changes to total annual flows would range from decreases of 45 percent to increases of 63 percent. Changes to the total annual flow in Little Lynches River downstream of the mined area would be up to 3.3 percent higher than the No Action Alternative.

Post-Mining Period

After mining, baseflows eventually would return to near natural conditions once groundwater pumping to dewater the mine pits ceases and groundwater elevations approach pre-mining levels. All areas except the pit lakes would again contribute runoff after disturbed areas have been reclaimed. Flows from the contact water treatment plant would decline during the post-mining period, as seepage from Johnny's PAG and the TSF declined to the point that these flows would be treated passively and discharged. Long-term, minor changes in streamflow may occur due to evaporation from open water surfaces and loss of flow storage capacity due to sedimentation in the pit lake. However, these impacts would likely be relatively small and are below the resolution of the models to accurately quantify.

Changes to streamflow are considered major for Haile Gold Mine Creek and all of the unnamed tributaries draining to the Little Lynches River. These impacts are moderate for Camp Branch Creek and the Little Lynches River downstream of Haile Gold Mine Creek. Impacts are low for Buffalo Creek and the Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek. Most of these impacts would be temporary, but pit lakes would cause permanent changes to streamflow in Haile Gold Mine Creek and the unnamed tributaries near Champion and Small Pit Lakes. Impacts on other water-related resources such as wetlands and aquatic habitat are addressed in those sections of the EIS.

Modified Project Alternative

Impacts on streamflows in most of the study area during active mining and post-mining under the Modified Project Alternative would be similar to those described for the Applicant's Proposed Project. It is estimated that flows in most stream segments would change by no more than 0.03 cfs under the Modified Project Alternative (ERC 2013b), which is a negligible change. The three unnamed tributaries in the vicinity of the Ramona OSA that would not be filled would continue to convey runoff and baseflows when groundwater levels were sufficiently high. Slightly less changes in streamflow, therefore, would occur under the Modified Project Alternative than described for the Applicant's Proposed Project.

Table 4.4-5 Relative Change and Percent Change in Average Annual Baseflows under the Applicant's Proposed Project

Subwatershed	Active Mining Period (Mine Year 14)	Post-Mining Period	
		Mine Year 29	Mine Year 89
1. Upper Camp Branch Creek	-0.14 cfs, -7.1%	-0.08 cfs, -3.9%	-0.03 cfs, -1.6%
2. Lower Camp Branch Creek	-0.22 cfs, -8%	-0.1 cfs, -3.7%	-0.04 cfs, -1.6%
3. Unnamed tributary near Camp Branch Creek	-0.02 cfs, -20.5%	-0.004 cfs, -4.1%	-0.002 cfs, -1.7%
4. Unnamed tributary near western side of Champion Pit	-0.1 cfs, -54.4%	-0.03 cfs, -16.1%	-0.02 cfs, -8.5%
5. Unnamed tributary near southern side of Champion Pit	-0.07 cfs, -49.1%	-0.01 cfs, -9.4%	-0.01 cfs, -4.5%
6. Unnamed tributary near southwestern side of Ramona OSA	-0.04 cfs, -32.1%	-0.01 cfs, -7.5%	-0.01 cfs, -4.5%
7. Unnamed tributary near middle of Ramona OSA	-0.06 cfs, -61.1%	-0.02 cfs, -22%	-0.01 cfs, -15.1%
8. Unnamed tributary near southeastern side of Ramona OSA	-0.02 cfs, -42.2%	-0.01 cfs, -23.3%	-0.01 cfs, -20.4%
9. Upper Haile Gold Mine Creek	-0.98 cfs, -61.4%	-0.44 cfs, -27.5%	-0.26 cfs, -16.3%
10. Haile Gold Mine Creek within mining area	-2.11 cfs, -77.3%	-0.14 cfs, -5.2%	0.23 cfs, 8.6%
11. Lower Haile Gold Mine Creek	-2.54 cfs, -73.6%	-0.36 cfs, -10.4%	0.04 cfs, 1.1%
12. Unnamed Tributary southeast of the Project boundary	-0.87 cfs, -55%	-0.43 cfs, -27.3%	-0.29 cfs, -18.6%
13. Buffalo Creek	-0.19 cfs, -2.4%	-0.17 cfs, -2.1%	-0.08 cfs, -0.9%
14. Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	-0.62 cfs, -2.3%	-0.36 cfs, -1.3%	-0.25 cfs, -0.9%
15. Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary	-3.16 cfs, -10.5%	-0.72 cfs, -2.4%	-0.22 cfs, -0.7%
16. Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary	-4.06 cfs, -12.4%	-1.11 cfs, -3.4%	-0.47 cfs, -1.4%

cfs = cubic feet per second; OSA = overburden storage area

Table 4.4-6 Relative Change and Percent Change in Annual Average Runoff Flows under the Applicant's Proposed Project

Subwatershed	During Active Mining	Post-Mining Period (Mine Year 29)	Post-Mining Period (Mine Year 89)
1. Upper Camp Branch Creek	-0.18 cfs, -15.2%	0.08 cfs, 6.8%	0.08 cfs, 6.8%
2. Lower Camp Branch Creek	-0.18 cfs, -11.5%	0.08 cfs, 5.2%	0.08 cfs, 5.2%
3. Unnamed tributary near Camp Branch Creek	No change in runoff	No change in runoff	No change in runoff
4. Unnamed tributary near western side of Champion Pit	-0.01 cfs, -2.8%	-0.01 cfs, -3.1%	-0.01 cfs, -3.1%
5. Unnamed tributary near southern side of Champion Pit	0.01 cfs, 10.9%	-0.01 cfs, -6.5%	-0.01 cfs, -6.5%
6. Unnamed tributary near southwestern side of Ramona OSA	-0.01 cfs, -13.4%	0 cfs, 9.8%	0 cfs, 9.8%
7. Unnamed tributary near middle of Ramona OSA	-0.01 cfs, -19.3%	0.02 cfs, 34.7%	0.02 cfs, 34.7%
8. Unnamed tributary near southeastern side of Ramona OSA	-0.01 cfs, -11.2%	0.02 cfs, 33.7%	0.02 cfs, 33.7%
9. Upper Haile Gold Mine Creek	0.11 cfs, 11.7%	0.08 cfs, 8.3%	0.08 cfs, 8.3%
10. Haile Gold Mine Creek within mining area	-0.09 cfs, -6.2%	0 cfs, 0.1%	0.05 cfs, 3.1%
11. Lower Haile Gold Mine Creek	-0.11 cfs, -5.8%	0.05 cfs, 2.6%	0.09 cfs, 5.2%
12. Unnamed Tributary southeast of the Project boundary	Runoff flows similar to pre-mining	Runoff flows similar to pre-mining	Runoff flows similar to pre-mining
13. Buffalo Creek	No change in runoff	No change in runoff	No change in runoff
14. Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	-0.2 cfs, -1.3%	0.1 cfs, 0.7%	0.1 cfs, 0.7%
15. Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary	-0.28 cfs, -1.6%	0.15 cfs, 0.9%	0.2 cfs, 1.1%
16. Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary	-0.27 cfs, -1.5%	0.15 cfs, 0.8%	0.2 cfs, 1.1%

cfs = cubic feet per second; OSA = overburden storage area

Table 4.4-7 Relative Change and Percent Change in Annual Average Mine Releases under the Applicant's Proposed Project

Subwatershed	Active Mining Period	Post Mining Period
1. Upper Camp Branch Creek	No mine releases	No mine releases
2. Lower Camp Branch Creek	No mine releases	No mine releases
3. Unnamed tributary near Camp Branch Creek	No mine releases	No mine releases
4. Unnamed tributary near western side of Champion Pit	No mine releases	No mine releases
5. Unnamed tributary near southern side of Champion Pit	No mine releases	No mine releases
6. Unnamed tributary near southwestern side of Ramona OSA	No mine releases	No mine releases
7. Unnamed tributary near middle of Ramona OSA	No mine releases	No mine releases
8. Unnamed tributary near southeastern side of Ramona OSA	No mine releases	No mine releases
9. Upper Haile Gold Mine Creek	No mine releases	No mine releases
10. Haile Gold Mine Creek within mining area	4.73 cfs	No mine releases
11. Lower Haile Gold Mine Creek	4.73 cfs[a]	No mine releases
12. Unnamed Tributary southeast of the Project boundary	No mine releases	No mine releases
13. Buffalo Creek	No mine releases	No mine releases
14. Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	No mine releases	No mine releases
15. Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary	4.73 cfs[a]	No mine releases
16. Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary	4.73 cfs[a]	No mine releases

Notes:

cfs = cubic feet per second; OSA = overburden storage area

The percent change is not shown for mine releases because there are currently no discharges from the mine other than flows from the passive treatment cells, which are typically less than 0.02 cfs (see Section 3.3, "Groundwater Hydrology and Water Quality").

[a] Flow change due to discharge in Haile Gold Mine Creek within the mining area.

Table 4.4-8 Relative Change and Percent Change in Annual Average Total Flows under the Applicant's Proposed Project

Subwatershed	Active Mining Period	Post-Mining Period (Mine Year 29)	Post-Mining Period (Mine Year 89)
1. Upper Camp Branch Creek	-0.33 cfs, -10.2%	0.004 cfs, 0.1%	0.05 cfs, 1.6%
2. Lower Camp Branch Creek	-0.41 cfs, -9.3%	-0.02 cfs, -0.5%	0.04 cfs, 0.9%
3. Unnamed tributary near Camp Branch Creek	-0.02 cfs, -12.3%	-0.004 cfs, -2.5%	-0.002 cfs, -1%
4. Unnamed tributary near western side of Champion Pit	-0.11 cfs, -26.5%	-0.04 cfs, -9.1%	-0.02 cfs, -5.6%
5. Unnamed tributary near southern side of Champion Pit	-0.06 cfs, -22.2%	-0.02 cfs, -8.1%	-0.01 cfs, -5.4%
6. Unnamed tributary near southwestern side of Ramona OSA	-0.04 cfs, -26.7%	-0.004 cfs, -2.5%	-0.001 cfs, -0.4%
7. Unnamed tributary near middle of Ramona OSA	-0.07 cfs, -45%	-0.005 cfs, -3.4%	0.002 cfs, 1.3%
8. Unnamed tributary near southeastern side of Ramona OSA	-0.02 cfs, -26.2%	0.005 cfs, 5.5%	0.006 cfs, 7%
9. Upper Haile Gold Mine Creek	-0.89 cfs, -35%	-0.36 cfs, -14.3%	-0.18 cfs, -7.3%
10. Haile Gold Mine Creek within mining area	2.71 cfs, 63.4%	-0.14 cfs, -3.3%	0.282 cfs, 6.6%
11. Lower Haile Gold Mine Creek	2.21 cfs, 41.8%	-0.31 cfs, -5.9%	0.132 cfs, 2.5%
12. Unnamed Tributary southeast of the Project boundary	-0.87 cfs, -36.3%	-0.43 cfs, -18.1%	-0.29 cfs, -12.3%
13. Buffalo Creek	-0.19 cfs, -1.7%	-0.17 cfs, -1.5%	-0.08 cfs, -0.7%
14. Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	-0.82 cfs, -1.9%	-0.25 cfs, -0.6%	-0.15 cfs, -0.3%
15. Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary	1.58 cfs, 3.3%	-0.56 cfs, -1.2%	-0.02 cfs, 0%
16. Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary	0.78 cfs, 1.5%	-0.96 cfs, -1.9%	-0.27 cfs, -0.5%

cfs = cubic feet per second; OSA = overburden storage area

4.4.2.3 Changes to Stream Temperature

No Action Alternative

Under the No Action Alternative, reclamation and closure would continue and no additional mining would take place. The water temperatures within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation. As streamflows and riparian canopy approach a more undisturbed condition, stream temperatures would be cooler, particularly in the warm summer months.

Other subwatersheds in the study area, such as Camp Branch Creek, Buffalo Creek, and the unnamed tributaries draining to the Little Lynches River, would remain largely unchanged under the No Action Alternative, subject to any future watershed development that may occur.

Applicant's Proposed Project

Active Mining Period

Changes in stream water temperatures from mining activities could result from any change to flow or water source. These changes can be caused by discharges from the water treatment plant, groundwater pumping to dewater the mine pits, the passive water treatment cells, stream diversions, discharges from sedimentation ponds, runoff from Project features, physical changes to streams, and the creation of pit lakes.

Discharges from the water treatment plant and the pit depressurization process would likely raise stream temperatures in receiving waters because this water would travel through aboveground pipes and would be heated by the sun prior to being released. Tables 4.4-9 through 4.4-11 show potential impacts on summer average water temperatures, summer low-flow water temperatures, and winter average water temperatures, respectively.

The analysis indicates that stream temperatures during low-flow conditions would be most sensitive to discharges from the water treatment plant and discharge of depressurization water. During active mining, the average stream temperatures typically would change by less than 5 °F relative to the No Action Alternative. In Haile Gold Mine Creek, however, stream temperatures could increase by 5 to 10 °F during summer average and winter average conditions, and by more than 10 °F during summer low-flow conditions. Discharges from passive treatment cells would not affect water temperatures to a high degree because the flow rates from these systems are low relative to streamflows (see Section 3.4).

Changes in streamflow would affect the residence time in the streams, which could lead to increased or decreased temperatures. Sedimentation ponds are open to the sun with potentially little shading; consequently, the water discharged from these ponds could be warmer than the stream water that is shaded by canopy in many places and generally well mixed relative to the ponds.

Runoff from land surfaces could increase water temperature. Water temperatures would be affected by exposure to solar inputs, sediment temperatures, ambient air temperatures, contributions from baseflows (that tend to have a more constant water temperature), and the diurnal and seasonal variability that otherwise would occur in the natural system.

Table 4.4-9 Potential Impacts on Summer Average Water Temperatures under the Applicant's Proposed Project

Subwatershed	Potential Active-Mining Impacts	Potential Post-Mining/ Reclamation Impacts
▪ Upper Camp Branch Creek ▪ Lower Camp Branch Creek ▪ Unnamed tributary near Camp Branch Creek ▪ Unnamed tributary near southern side of Champion Pit ▪ Unnamed tributary near southwestern side of Ramona OSA ▪ Unnamed tributary near southeastern side of Ramona OSA ▪ Buffalo Creek ▪ Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek ▪ Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary ▪ Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary	Likely not more than a 1 °F change in stream temperature	
▪ Unnamed tributary near western side of Champion Pit ▪ Unnamed tributary near middle of Ramona OSA ▪ Upper Haile Gold Mine Creek ▪ Unnamed Tributary southeast of the Project boundary	1 to 5 °F decrease in stream temperature	Likely not more than a 1 °F change in stream temperature
▪ Haile Gold Mine Creek within mining area ▪ Lower Haile Gold Mine Creek	5 to 10 °F increase in stream temperature or a 1 to 5 °F decrease in stream temperature	Likely not more than a 1 °F change in stream temperature

Table 4.4-10 Potential Impacts on Summer Low-Flow Water Temperatures under the Applicant's Proposed Project

Subwatershed	Potential Active-Mining Impacts	Potential Post-Mining/ Reclamation Impacts
▪ Upper Camp Branch Creek ▪ Lower Camp Branch Creek ▪ Unnamed tributary near Camp Branch Creek ▪ Unnamed tributary near western side of Champion Pit ▪ Unnamed tributary near southern side of Champion Pit ▪ Unnamed tributary near southwestern side of Ramona OSA ▪ Unnamed tributary near middle of Ramona OSA ▪ Unnamed tributary near southeastern side of Ramona OSA ▪ Unnamed Tributary southeast of the Project boundary ▪ Buffalo Creek ▪ Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek ▪ Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary ▪ Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary	Likely not more than a 1 °F change in stream temperature	
▪ Upper Haile Gold Mine Creek ▪ Lower Haile Gold Mine Creek	1 to 5 °F increase or decrease in stream temperature	Likely not more than a 1 °F change in stream temperature
▪ Haile Gold Mine Creek within mining area	Greater than 10 °F increase in stream temperature or a 1 to 5 °F decrease in stream temperature	Likely not more than a 1 °F change in stream temperature

Table 4.4-11 Potential Impacts on Winter Average Water Temperatures under the Applicant's Proposed Project

Subwatershed	Potential Active-Mining Impacts	Potential Post-Mining/ Reclamation Impacts
▪ Upper Camp Branch Creek ▪ Lower Camp Branch Creek ▪ Unnamed tributary near Camp Branch Creek ▪ Buffalo Creek ▪ Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	Likely not more than a 1 °F change in stream temperature	
▪ Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary ▪ Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary ▪ Unnamed tributary near western side of Champion Pit ▪ Unnamed tributary near southern side of Champion Pit ▪ Unnamed tributary near southwestern side of Ramona OSA ▪ Unnamed tributary near middle of Ramona OSA ▪ Unnamed tributary near southeastern side of Ramona OSA	1 to 5 °F decrease in stream temperature	Likely not more than a 1 °F change in stream temperature
▪ Unnamed Tributary southeast of the Project boundary ▪ Upper Haile Gold Mine Creek	1 to 5 °F decrease in stream temperature	
▪ Haile Gold Mine Creek within mining area ▪ Lower Haile Gold Mine Creek	5 to 10 °F increase or decrease in stream temperature	Likely not more than a 1 °F change in stream temperature

Post-Mining Period

Thermal alteration of the streams would decline after mining. Discharges of pit depressurization water would cease and water temperatures would eventually approach conditions similar to existing conditions. This would occur as groundwater levels rise and baseflows equilibrate to near pre-mining conditions and as riparian vegetation is re-established providing stream shading.

Pit lakes also would alter water temperatures by facilitating solar warming. Impacts due to pit lakes may be long term, as these features are permanent changes to the landscape.

Changes to temperature are considered major for Haile Gold Mine Creek within and downstream of the mining area because predicted changes could exceed the 5 °F comparison level. Changes are moderate (between 1 and 5 °F) for Upper Haile Gold Mine Creek, all but one unnamed tributary to the Little Lynches River, and the Little Lynches River downstream of both Haile Gold Mine Creek and the unnamed tributary southeast of the Project boundary. Impacts are low (less than 1 °F) in Buffalo Creek, Camp Branch Creek, the unnamed tributary near Camp Branch Creek, and the Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek. Changes to temperature would be temporary.

Modified Project Alternative

Impacts on surface water temperature in the study area during the active mining and post-mining periods under the Modified Project Alternative would be similar to those described for the Applicant's Proposed Project, except for impacts in the vicinity of the Ramona OSA. The three unnamed tributaries in this area would not be filled and these channels would convey flows during active mining. However, baseflows would likely be lower during mining relative to the No Action Alternative due to groundwater lowering. The water temperature of these streamflows likely would not change by more than 5 °F based on the predicted percent change in simulated baseflows.

4.4.2.4 Changes in Water Quality

No Action Alternative

Under the No Action Alternative, reclamation and closure would continue and no additional mining would take place. The water quality within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation, particularly as the current passive treatment systems, the seep at Haile Pit, and 188 Facility cease production of contact water (Haile 2012c).

Other subwatersheds in the study area, such as Camp Branch Creek, Buffalo Creek, and the unnamed tributaries draining to the Little Lynches River, would remain largely unchanged under the No Action Alternative, subject to any future watershed development that may occur.

Applicant's Proposed Project

Active Mining Period

Alteration of land topography, soil permeability, and vegetative cover would alter the amount of sediment and sediment-associated pollutants that runoff into streams. Changes to runoff amounts and patterns can cause erosion, or other water quality impairments. During the mining period, Haile would use a variety of measures to reduce potential water quality impacts. This section describes the potential impacts and summarizes the Applicant-proposed measures that address them.

Discharge from the water treatment plant would likely increase pH. Because the pre-mining pH condition is lower than State standards, the discharge could result in attainment of the standard. Concentrations of TSS, arsenic, cadmium, copper, lead, thallium, mercury, zinc, and selenium in receiving waters may increase as a result of contact water treatment plant discharge[2] (Appendix J). While this discharge would be subject to an NDPES discharge permit, which would include discharge limits that are set to maintain applicable State standards and protect the beneficial uses of the receiving water, impacts on water quality could still occur relative to the No Action Alternative. For example, the NPDES discharge permit does not contain numeric limits for sulfate concentration, and the SCDHEC's relevant secondary maximum contaminant limit is based on aesthetic concerns (e.g., taste, cloudiness). Many states are currently developing or implementing sulfate standards because sulfate has been shown to be toxic to aquatic organisms (Soucek and Kennedy 2005; Elphick et al. 2011), and its lethal effects tend to be mitigated to some degree by hardness in the water. For many of the streams in the study area, including lower Haile Gold Mine Creek, the water is relatively soft; and sulfate concentrations around 260 mg/L could cause

[2] Cyanide is included in the SCDHEC discharge permit No. SC0040479 for the contact water treatment plant, and discharge limits are provided in the permit; according to Haile, there is no source of cyanide to the contact water treatment plant. The contact water treatment plant treats only contact water, not process water from the Mill or the TSF; therefore, cyanide should not be present under normal operating conditions.

toxic effects. Because of the predominance of pyrite in the study area (Schafer 2013b), it is likely that sulfate concentrations in contact water and effluent from the water treatment plant could affect water quality. All contact water would be treated at the contact water treatment plant prior to discharge.

Stream diversions are not likely to affect water quality because the water would primarily be routed from one location to another; however, high discharge velocities could cause scour of the stream channels in the receiving stream, leading to increased suspended material in receiving waters. Haile would use energy dissipation devices to mitigate the impacts associated with high discharge velocities (see Appendix A).

Streamflow and temperature changes would affect residence time and biological, chemical, and/or geochemical reactions in the streams. Decreased streamflows during dry, warm conditions could lower dissolved oxygen concentrations as water becomes warmer and more stagnant. Increased residence time and warmer stream temperatures could affect nutrient transformations and algal growth and decay, leading to eutrophication[3] and diurnal swings in dissolved oxygen and pH. Alteration in the pH regime resulting from flow alterations, direct discharges, and eutrophication could affect chemical equilibrium, toxicological effects, and the solubility of metals.

Runoff from OSAs and growth media storage areas would flow through sedimentation ponds and therefore are not likely to cause significant impacts on water quality. However, runoff from borrow areas could affect water quality, as runoff from these disturbed areas would not be treated in sedimentation ponds.

Stream water quality in the study area likely would be dominated by runoff water quality conditions because the baseflow contribution to streamflow would be proportionally less. Water quality in lower Haile Gold Mine Creek would be dominated by the water quality conditions of both the depressurized groundwater that is discharged directly to Lower Haile Gold Mine Creek and discharge from the contact water treatment plant. Diversions of streamflows are not likely to affect water quality, other than changes associated with slightly increased temperatures as described above.

Haile's proposed use of runoff diversions and sedimentation ponds would reduce water quality impacts. Applicant-proposed sediment and erosion control practices include runoff diversion facilities (e.g., earthen berms, dikes, and piped conveyances) that route water away from disturbed areas or PAG material. In some cases, the runoff diversion facilities would discharge into sedimentation ponds that would manage stormwater flows and sedimentation. Sediment and erosion control would be regulated under State permits. Runoff diversion facilities and sedimentation ponds would be designed according to specifications described in the *Storm Water Management BMP Handbook* (SCDHEC 2005). Surface water quality could be affected by sedimentation ponds during larger storm events when erosive forces would contribute sediment and associated pollutant loads in receiving streams. Accordingly, the mining-related impacts on surface water quality are considered moderate.

Air emissions from blasting would deposit particulates and air pollutants to the land and water surfaces that may be transported to surface waters in the Project area. Blasting agents used to free overburden and ore typically contain an ammonium nitrate-fuel oil mixture; Haile would use an emulsified blasting agent to reduce the amount of nitrate released into the environment.

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[3] *Eutrophication* refers to excessive nutrients in a waterbody, usually caused by runoff of nutrients from the land. Such input stimulates algal blooms and bacteria growth, which contribute to depletion of oxygen in the water and anoxic conditions, and eventually leads to fish kills.

Vehicles using proposed roads would release air pollutants into the environment, along with emissions from the Mill (see Section 4.16, "Air Quality" for a discussion of air quality impacts). These releases would be regulated by the Title V Operating permit, which would limit the amount of pollutants released to the atmosphere and therefore the amount that would be deposited on land or water surfaces. Air quality impacts would be reduced following reclamation, after many of the roads and the Mill have been decommissioned, and the land has been regraded and vegetated.

Chemical storage, transport, and use, and final disposal of chemicals for ore processing could affect surface water quality in the event of an accidental release. The materials would be stored and used within spill containment structures that would require breaching for them to reach surface waters. The impact on surface water quality would depend on the type and quantity of the release that enters the surface water system.

Seepage or releases from the TSF (closed-looped system) or Johnny's PAG could alter surface water quality. Although the TSF and Johnny's PAG (the facilities that store tailings and Red and Yellow Classes of overburden) are designed to be self-contained, engineering failures such as liner tears or punctures or pump malfunctions could result in impacts on water quality.

For a summary of impacts by stream segment during active mining, refer to Appendix J.

Post-Mining Period

Post-mining, disturbed areas would be reclaimed, and groundwater elevations would eventually rise to near pre-mining levels. Three pit lakes would remain after mining. Runoff from reclaimed areas with failing slopes or reduced vegetated cover could contribute sediment and pollutants that could affect water quality. Haile would inspect these areas and implement corrective measures to mitigate impacts if reclaimed areas become unstable.

Collection ponds at Johnny's PAG and the TSF underdrain collection system would continue to collect seepage water that would be treated at the contact water treatment plant until flows have decreased sufficiently to be treated passively in passive water treatment cells. These cells would continue to discharge small volumes of water to streams in the study area after mining. Any discharge from the proposed passive treatment cells would be regulated by the SCDHEC under an NPDES discharge permit or a land application permit, and limits would be set to protect the designated uses of the water. These discharge flows are expected to be small relative to streamflows.

During reclamation, concentrations of sulfide, iron, and dissolved solids would likely be elevated in backfilled pits, as described in Section 4.3, "Groundwater Hydrology and Water Quality." Pit lakes could have low pH (acidic conditions) and associated elevated concentrations of sulfate, iron, and aluminum, similar to the water quality of historic pit lakes. Haile would neutralize the pit lakes with lime addition to raise pH and limit the dissolution of metals. Given the soft nature of the water in most of the study area, sensitive species could be affected by sulfate concentrations projected in the Little Lynches River and lower Haile Gold Mine Creek for several years once Ledbetter Pit Lake begins to discharge to Haile Gold Mine Creek. Thirty years after closure, sulfate levels could still be elevated with potentially toxic effects (Soucek and Kennedy 2005; Elphick et al. 2011) in soft waters during low and very low flow conditions. The unnamed tributaries near Small and Champion Pit Lakes and small streams near backfilled pits also could be affected by elevated sulfate concentrations.

Following closure of the mine, surface water quality impacts could still occur from migration of groundwater through backfilled areas and from the base of pit lakes, surface discharges from Ledbetter Pit Lake, runoff from reclaimed areas with failing slopes or vegetated cover, and discharge from passive

treatment cells. Water that flows from pit lakes during the post-mining period could affect water quality in Haile Gold Mine Creek and the Little Lynches River because of changes in the quality of the contributing groundwater system (see Section 4.3 for a discussion of groundwater quality and the numerical modeling to address this effect).

For Ledbetter Pit Lake, water quality modeling was conducted to simulate impacts at the year of initial outflow (Mine Year 27) and 30 and 75 years after mining (Mine Years 44 and 89, respectively). Calculations were performed before and after accounting for equilibrium with the atmosphere and sorption to ferrihydrite, a common mineral phase in the area that exerts a control on stability of some minerals that affect water quality (Schafer 2014). This modeling indicates that concentrations of TDS in the outflow would likely be elevated during the reclamation period and would decline over the long term. The modeling also indicates that the proposed Project would cause elevated concentrations of calcium, sulfate, and TDS in the pit lakes during the post-mining period.

Interaction of groundwater with Champion and Small Pit Lakes could affect water quality in the groundwater that contributes flow to the unnamed tributaries near Champion Pit. These segments could have increased concentrations of barium, calcium, manganese, nickel, sulfate, and zinc.

After atmospheric equilibrium and ferrihydrite precipitation are accounted for, concentrations of antimony, manganese, sulfate, and thallium could increase in some downstream surface waters and exceed surface water standards after groundwater from the mining area reaches Haile Gold Mine Creek and the Little Lynches River. The duration of the impacts and the affected flow regimes vary by parameter. Additional detail regarding the duration of impacts and affected flow regimes is provided in Table 4.4-12 and in Appendix J.

Schafer, AMEC, and ERC (2013) and Schafer (2014) developed a mass load model to predict potential impacts of the proposed Project on water quality in Little Lynches River downstream of Haile Gold Mine Creek. It is assumed that similar impacts would occur in Lower Haile Gold Mine Creek. The mass load model is described in Section 4.3. Simulations were performed for the year of initial outflow (Mine Year 27) and years 30 and 75 after mining (Mine Years 44 and 89, respectively). Three flow regimes were assessed: median (50th-percentile flows), low (5th-percentile flows), and very low (1st-percentile flows). Table 4.4-12 lists the parameters that could exceed an applicable or relevant water quality standard (see Section 3.4) based on these simulations. The numeric standards and the predicted average annual concentrations are provided in parentheses in the table.

The model predicts that both sulfate and manganese could exceed the secondary drinking water standard. Secondary drinking water standards are set by the USEPA to protect the aesthetic uses of water (e.g., taste, odor, color), and these constituents are regulated in South Carolina and are typically incorporated into various State permits. They are enforced in that they are typically treated as “indicator parameters” and could trigger a more rigorous monitoring program. An elevated indicator parameter would not necessarily trigger remediation. The predicted exceedances indicate that monitoring for these parameters would be prudent.

Table 4.4-12 Constituents for Which Water Quality Standards Could Be Exceeded in the Little Lynches River Downstream of Haile Gold Mine Creek (Predicted Average Annual Concentrations after Equilibrium is Modeled)

Constituent	No Action Alternative attains the standard? (Predicted No Action Concentration)	Simulated increase relative to the No Action Alternative?	Mine Year When Standard is Exceeded	Flow Conditions When Standard is Exceeded (Predicted Concentration for the Proposed Project)	Standard Exceeded under Proposed Project (Numeric Standard)
Sulfate	Yes (5 mg/L)	Yes	Mine Year 27	Very low flow (277 mg/L)	Relevant secondary drinking water standard (250 mg/L)*
Antimony	Yes (5 µg/L)	Yes	Mine Year 27 Mine Year 44	Median (6 µg/L) Low (8 µg/L) Very low (9 µg/L) Low (6 µg/L) Very low (6 µg/L)	Applicable human consumption (5.6 µg/L) and primary drinking water standards (6 µg/L)
Cadmium	No (1 µg/L)	No	Mine Year 89	Median (1 µg/L) Low (1 µg/L) Very low (1 µg/L)	Hardness adjusted CMC (0.9 µg/L) and CCC (0.1 µg/L) for Year 75[a]
Manganese	No (97 µg/L)	Yes	Mine Year 27 Mine Year 44	Median (70 µg/L) Low (130 µg/L) Very low (140 µg/L) Low (140 µg/L) Very low (220 µg/L)	Relevant secondary drinking water standard (50 µg/L)[b]
Mercury	No (0.2 µg/L)	No	Mine Years 27, 44, and 89	Median, low, and very low (0.2 µg/L for all years and flow conditions)	Applicable human consumption criteria (0.05 µg/L and 0.051 µg/L)
Thallium	No (1 µg/L)	Yes	Mine Years 27, 44, and 89	Median, low, and very low (ranges from 1 to 2 µg/L)	Applicable human consumption criteria (0.24 µg/L to 0.47 µg/L)

µg/L = micrograms per liter; mg/L – milligrams per liter

[a] Calculated by Schafer (2013c); hardness adjusted standards for the No Action Alternative simulation are criterion maximum concentration (0.5 µg/L) and criterion continuous concentration (0.1 µg/L).

[b] U.S. Environmental Protection Agency secondary drinking water standard.

The model also predicts that some primary drinking water standards could be exceeded: cadmium standards (adjusted for the hardness of the water) could be exceeded during each simulated flow regime approximately 75 years after closure (Mine Year 89). Antimony could exceed the applicable human consumption and primary drinking water standards during all three simulated flow regimes, even 30 years after closure (Mine Year 44). Mercury and thallium could exceed applicable human consumption standards. Note that the existing water quality database indicates that samples of mercury and thallium were less than the minimum reporting limit (MRL), except for one mercury sample. However, the MRL for mercury (0.2 µg/L) is greater than the human consumption criteria (0.050 µg/L for the consumption of water and organisms and 0.051 µg/L for the consumption of organisms only), and the MRL for thallium (1.0 µg/L) is greater than the human consumption criteria (0.24 µg/L for the consumption of water and organisms and 0.47 µg/L for the consumption of organisms only). Because the detection limits for these two parameters are above the water quality standards, it is not possible to determine whether concentrations exceed the standards under the No Action Alternative.

For a summary of impacts by stream segment post-mining, refer to Appendix J.

Simulated excursions under the No Action Alternative and proposed mining scenarios may be due to conservative modeling assumptions used in the mass load model. For example, setting background water quality equal to the minimum detection limit for parameters where samples were reported as less than the detection limits in the water quality database for the study area (the minimum detection limit is less than the minimum reporting limit). Therefore, although the model predicts minor exceedances of water quality standards for some parameters, the over-estimation inherent in the model (Schafer 2014) makes it difficult to predict whether the standards would be met or exceeded in the future. However, the model results indicate that monitoring for these parameters should be conducted, with contingency measures in the event that the standards are violated.

Failure of the containment systems at the TSF and Johnny's PAG could affect water quality. The impact on surface water quality would depend on the quantity of material that enters the surface water system.

Changes to water quality are considered moderate for all of the streams in the study area except for Buffalo Creek, which would have negligible impacts to water quality. These changes could be long term or permanent impacts for some parameters. While impacts would be mitigated to some degree by permit limits and management practices implemented during and after mining, some impacts on water quality could occur in localized areas (e.g., downstream of the contact water treatment plant or Ledbetter Pit Lake). While most of the water quality impacts caused by watershed disturbance would cease post-mining, impacts due to passive treatment cells could still occur, and some water quality standards could be exceeded once the groundwater system reaches equilibrium.

Modified Project Alternative

Impacts on surface water in the study area during the active mining and post-mining periods under the Modified Project Alternative would be similar to those described for the Applicant's Proposed Project, except for impacts related to waterways in the vicinity of the Ramona OSA and the Holly and Hock TSF borrow areas. Under the Modified Project Alternative, the three unnamed tributaries in proximity to the proposed Ramona OSA would not be filled and instead would remain as features in the landscape. The modified Ramona OSA could add sediment and associated pollutants to these tributaries, particularly during large storm events that exceed the design capacity of the sedimentation ponds. The modified Holly and Hock TSF borrow areas could contribute additional sediment and associated pollutants to the streams in this area due to the presence of stored overburden material. However, runoff conveyances and sedimentation ponds would be used to mitigate these impacts.

4.4.3 Impact Summary

Table 4.4-13 presents a summary of impacts under each alternative for the key issues related to surface water hydrology and water quality.

4.4.4 Mitigation for Impacts on Surface Water Hydrology and Water Quality

4.4.4.1 Applicant's Avoidance and Mitigation Measures

The Applicant has included a number of avoidance and minimization measures in the design and plans for operating and managing the proposed Haile Gold Mine. Haile has committed to many of these measures as a part of the proposed MMP (Haile 2013) (Appendix G); these measures are summarized below:

- Conduct post-mining reclamation and closure monitoring to ensure continued compliance with permit requirements.
- Use water-resistant ammonium nitrate emulsion blasting agent to minimize impacts on nearby waterbodies and groundwater.
- Implement a surface water monitoring and reporting program during operations and post-mining.
- Implement 50-foot vegetative buffers around otherwise non-affected surface waters.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of avoidance and minimization measures for surface water hydrology proposed by the Applicant is provided in Chapter 6. With implementation of the measures listed above, many of the temporary and long-term impacts on flow, temperature, and water quality would be mitigated.

4.4.4.2 Additional Potential Mitigation Measures

In addition to the measures proposed by the Applicant, the USACE will consider a number of other potential mitigation measures to reduce remaining impacts on surface water hydrology from the proposed Project, as listed below:

- To ensure minimum flows in Haile Gold Mine Creek, Ledbetter Pit Lake could be designed with a permanent minimum release structure.
- To mitigate impacts of reduced baseflows on streamflows, water temperatures, and water quality, mine releases could be pumped and discharged to other streams in the study area.
- To mitigate impacts on stream temperatures, holding ponds or constructed wetlands could be used to store water after transport in aboveground pipes and before discharge to surface waters. Additional mitigation measures include shading, covering, or burying the diversion pipes that are currently proposed as aboveground pipes.
- To mitigate sediment and sediment-associated pollutant loading from the borrow areas and proposed roads, sedimentation ponds could be used to treat runoff prior to discharge to streams.
- To mitigate water quality impacts associated with the drawdown of Ledbetter Reservoir, monitoring of the water quality and sediment quality could be conducted prior to discharge in order to determine whether treatment is required prior to discharge. Haile and the SCDHEC would develop contingency measures to address adverse water quality detected during monitoring.

Table 4.4-13 Summary of Impacts on Surface Water Hydrology and Water Quality

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Watershed alteration	Subwatersheds within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation as a result of improved vegetative stabilization, reduced erosion and sedimentation, and development of riparian and streamside cover and trees. Other subwatersheds in the study area would remain largely unchanged subject to any future watershed development that may occur.	During the active mining period, a total of 1,584 acres would be disturbed, and 927 acres would be intercepted and isolated from the stream system. A total of 31,258 feet of streams would be lost or diverted. Percent disturbance for the cumulative subwatersheds in the study area ranges from 0 to 93 percent. During the post-mining period, impacts are considered major for Camp Branch Creek, Haile Gold Mine Creek, the unnamed tributary near the southern side of Champion Pit, and the three unnamed tributaries directly impacted by Ramona OSA. Impacts are moderate for the unnamed tributary near the western side of Champion Pit, and low for the other subwatersheds in the study area. These changes would be temporary and most of the impacts due to watershed disturbance would not occur once the areas are reclaimed.	Similar to the Applicant's Proposed Project except that the three unnamed tributaries under the proposed Ramona OSA would not be filled and would remain as streams.
Streamflow regime	Streamflows within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation as land cover and vegetation revert back to a more natural condition. Other subwatersheds in the study area would remain largely unchanged subject to any future watershed development that may occur.	Baseflow reductions of up to 77 percent would occur during mining. At the Little Lynches River, downstream of the mined area, the changes in baseflow would decrease by approximately 12 percent. Average annual runoff flows, which are less affected by groundwater withdrawals during mining, range from decreases of 19 percent to increases of 12 percent. Changes to the Little Lynches River downstream of the mined area are less than 1.6 percent. Changes to total annual flows range from decreases of 45 percent to increases of 63 percent. Changes to the total annual flow in Little Lynches River downstream of the mined area are up to 3.3 percent higher than the No Action Alternative. These impacts are considered major for Haile Gold Mine Creek and all of the unnamed tributaries draining to the Little Lynches River. These impacts are moderate for Camp Branch Creek and the Little Lynches River downstream of Haile Gold Mine Creek. Impacts are low for Buffalo Creek and the Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek. After mining, baseflows eventually would return to near natural conditions once groundwater pumping to dewater the mine pits ceases and groundwater elevations approach pre-mining levels.	Same as the Applicant's Proposed Project except that the three unnamed tributaries under the proposed Ramona OSA would remain as streams and would continue to convey flow. Baseflows in these three segments would be lower than under the No Action Alternative. Modification of the configuration of Ramona OSA could alter the quantity of runoff affecting these channels.

Table 4.4-13 Summary of Impacts on Surface Water Hydrology and Water Quality (Continued)

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Stream temperature	Water temperatures within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation. As streamflows and riparian canopy approach a more undisturbed condition, stream temperatures would be cooler, particularly in the warm summer months. Other subwatersheds in the study area would remain largely unchanged subject to any future watershed development that may occur.	Decreased baseflows would tend to decrease stream temperatures throughout the study area during mining. In Haile Gold Mine Creek, mine releases piped aboveground could increase water temperatures in Haile Gold Mine Creek by more than 5.0 °F. These impacts are considered major for Haile Gold Mine Creek within and downstream of the mining area. These impacts are considered major for Haile Gold Mine Creek within and downstream of the mining area. Changes are moderate for Upper Haile Gold Mine Creek, all but one unnamed tributary to the Little Lynches River, and the Little Lynches River downstream of both Haile Gold Mine Creek and the unnamed tributary southeast of the Project boundary. Impacts are low in Buffalo Creek, Camp Branch Creek, the unnamed tributary near Camp Branch Creek, and the Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek.	Same as the Applicant's Proposed Project except that the three unnamed tributaries under the proposed Ramona OSA would remain as streams. Reduced baseflows likely would cause reductions in water temperature relative to the No Action Alternative.
Water quality	Water quality within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation, particularly as the current passive treatment systems, the seep at Haile Pit, and 188 Facility cease production of contact water. Other subwatersheds in the study area would remain largely unchanged subject to any future watershed development that may occur.	Water quality in each stream in the study area would likely be affected indirectly due to reduced baseflows during mining; these impacts could continue post-mining until baseflows stabilized. Direct discharges in Haile Gold Mine Creek from the Water Treatment Plant would affect water quality in this reach and the Little Lynches River downstream during mining and during reclamation while the passive treatment cells continue to treat seepage. Interactions with backfilled pits and pit lakes also could affect water quality in these streams. Passive treatment at the TSF post-mining could affect water quality in Upper and Lower Camp Branch Creek and in all segments of the Little Lynches River downstream of Camp Branch Creek. The entire study area could be affected by failure of containment systems or improper materials handling, except for the unnamed tributaries that drain to the Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek, Buffalo Creek, and the Unnamed Tributary southeast of the Project boundary. These impacts are considered moderate for all of the streams in the study area except for Buffalo Creek which would have negligible impacts to water quality.	Same as the Applicant's Proposed Project except that the three unnamed tributaries under the proposed Ramona OSA would remain as streams. Reduced baseflows likely would cause indirect impacts on water quality in these segments. Modification of the configuration of Ramona OSA could alter the quality of runoff affecting the stream channels.

- To mitigate water quality impacts caused by discharge from the water treatment plant, effluent could be treated in a constructed wetland or other polishing feature prior to discharge in order to provide additional treatment.
- To mitigate water quality impacts caused by discharge of groundwater pumped to dewater the mine pits (depressurization water that is not contact water), monitoring of the water quality could be conducted prior to discharge in order to determine whether treatment is required prior to discharge.
- To mitigate water quality impacts caused by discharge from passive treatment cells or Ledbetter Pit Lake, effluent could be treated in a constructed wetland or other polishing feature prior to discharge.
- To mitigate water quality impacts caused by interaction of the pit lakes with the underlying groundwater system during reclamation (as the pit lakes are filling), the pit lake water could be pumped and treated until the initial flush of contaminants has passed.
- To mitigate the impacts caused by precipitation onto and runoff from pit walls, pit walls could be sloped back, amended with lime, and vegetated.
- To mitigate water quality impacts associated with the disposal of dredged material from sedimentation ponds, Haile could monitor the quality of this material to determine whether final disposal should occur in a lined facility (Johnny's PAG or the TSF) rather than an OSA. Alternatively, Haile could alter the proposed Project such that material dredged from sedimentation ponds is disposed of only in a lined facility.
- To mitigate water quality impacts associated with potential failure of the contact water ponds at Johnny's PAG (the 465 and 469 Collection Ponds), an emergency pumping system could be designed to pump excess water to the ponds located at the Mill.

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4.5 Water Supply and Floodplains

Development, operations, and closure of the proposed Haile Gold Mine would alter groundwater levels and streamflows in the Project area (see Sections 4.3, "Groundwater Hydrology and Water Quality" and 4.4, "Surface Water Hydrology and Water Quality"). These changes have the potential to affect water supplies and existing and future water uses, and may affect runoff that contributes to water levels in floodplains during periods of higher streamflow. This section describes the potential impacts on water supply resources and floodplain conditions.

The water supply portion of this section addresses water availability for permitted uses and for existing groundwater uses known to occur in the area potentially affected by the Project, including any known agricultural, domestic, industrial and commercial, and public water supply uses. The remainder of the section describes potential impacts of the Project on regulated floodplains. As described in Section 3.5, two study areas have been delineated for this resource area: a surface water supply and floodplain study area, and a groundwater supply study area. As noted in Section 4.3, groundwater lowering would progress over the 14 years of active mining, and groundwater levels would generally be lowest in Mine Year14. Consequently, Mine Year14 was used for the evaluation of impacts related to groundwater supply.

4.5.1 Methods

4.5.1.1 Groundwater and Surface Water Supplies and Uses

Potential impacts on groundwater and surface water uses were addressed by surveying existing wells, springs, and ponds within a 2-mile radius of the proposed Project pit boundaries, water uses downstream, and public water suppliers in the Little Lynches River basin. The groundwater and surface water model results presented in Sections 4.3, "Groundwater Hydrology and Water Quality" and 4.4, "Surface Water Hydrology and Water Quality," were used to estimate the degree to which streamflows and groundwater levels would be affected. Sources of data for the analysis included the *Water Resources Inventory – Wells, Springs, and Ponds* (Kennedy Consulting Services 2013), water withdrawal and well permits issued by the SCDNR and the SCDHEC, and former domestic supply wells now being used by Haile as monitoring wells.

During Project operations, the groundwater aquifers in the Project area and vicinity would be lowered, also affecting groundwater contributions to streamflows. A calibrated groundwater flow model was developed to quantify the potential drawdown impacts on local aquifers and surface waters (described in Section 4.3). Each of the hydrogeologic units identified in the Project area was represented in the model. Model simulations were run to represent the conditions during each of the 14 years during which mining would take place, and during the groundwater recovery (the return of groundwater levels to near-original levels) that would occur after mining operations are complete. The inventoried well locations, in conjunction with the Mine Year14 groundwater drawdown contours, were used to characterize the potential impacts of Project-related aquifer lower on groundwater users in the Mine Year14 cone of depression.

Potential impacts on surface water supplies were evaluated quantitatively for permitted uses and qualitatively for undocumented uses downstream of the Project, by estimating the change in streamflows that would occur downstream of the Project at the permitted water use locations. Potential impacts on groundwater wells, ponds, and springs were quantitatively and qualitatively estimated on the basis of simulated groundwater level drawdowns.

Although estimating impacts on groundwater users involves the use of a groundwater model and surveys, estimates ultimately are at least partially qualitative. This is because some uncertainty is associated with

the estimated groundwater drawdown at each location; and the information about many of the wells, springs, and ponds is limited[1] or could not be obtained. Although groundwater lowering has the potential to occur in the vicinity of certain wells, springs, or ponds, the actual response at the surface or at depth may be variable. In the case of wells, the impacts experienced at the well from groundwater lowering may not impair the function of the well. Impacts would depend on the degree of drawdown, depth of the well, depth at which the pump was set within the well, and other factors.

4.5.1.2 Floodplain Encroachment and Inundation

Two types of potential Project impacts on floodplains in the Project area were identified. The first was *floodplain alteration*, defined as direct physical changes to the floodplain that may affect its ability to pass flood flows. The second was defined as indirect impacts on floodplain water elevations during the 100-year recurrence flood. These indirect impacts would result from watershed alterations and modification of runoff rates and concentrations that would contribute to a rise in the water surface elevation in the floodplain for the 100-year recurrence flood, adversely affecting floodway function.

An analysis was conducted to determine how regulated floodplains and peak streamflows downstream of the Project would be affected by Project operations (ERC 2013). The analysis included a GIS-based floodplain evaluation and development of a HEC-RAS hydraulic model (a model that can simulate peak flows and water elevations in natural channels and floodplains) to determine the likely extent of 100-year floodplains downstream of the Project.

4.5.2 Impacts

4.5.2.1 Impacts on Surface Water Supplies and Uses

No Action Alternative

Under the No Action Alternative, there would be negligible changes in surface water supplies, and existing surface water uses would not be affected. Haile Gold Mine currently uses little water within the Project boundary, and completion of reclamation activities would not be expected to result in any further impact on surface water resources or their uses for water supply.

Applicant's Proposed Project

Figure 4.5-1 is a map of the three reaches of the Little Lynches River where impacts were assessed. The Project-related impacts of surface water uses and water discharges are summarized for Mine Year 14 in Table 4.5-1, representing impacts during the maximum effect of the mine on streamflow. Table 4.5-1 shows the potential changes in streamflow by year in the Little Lynches River at three locations adjacent to, or downstream of, the Project.

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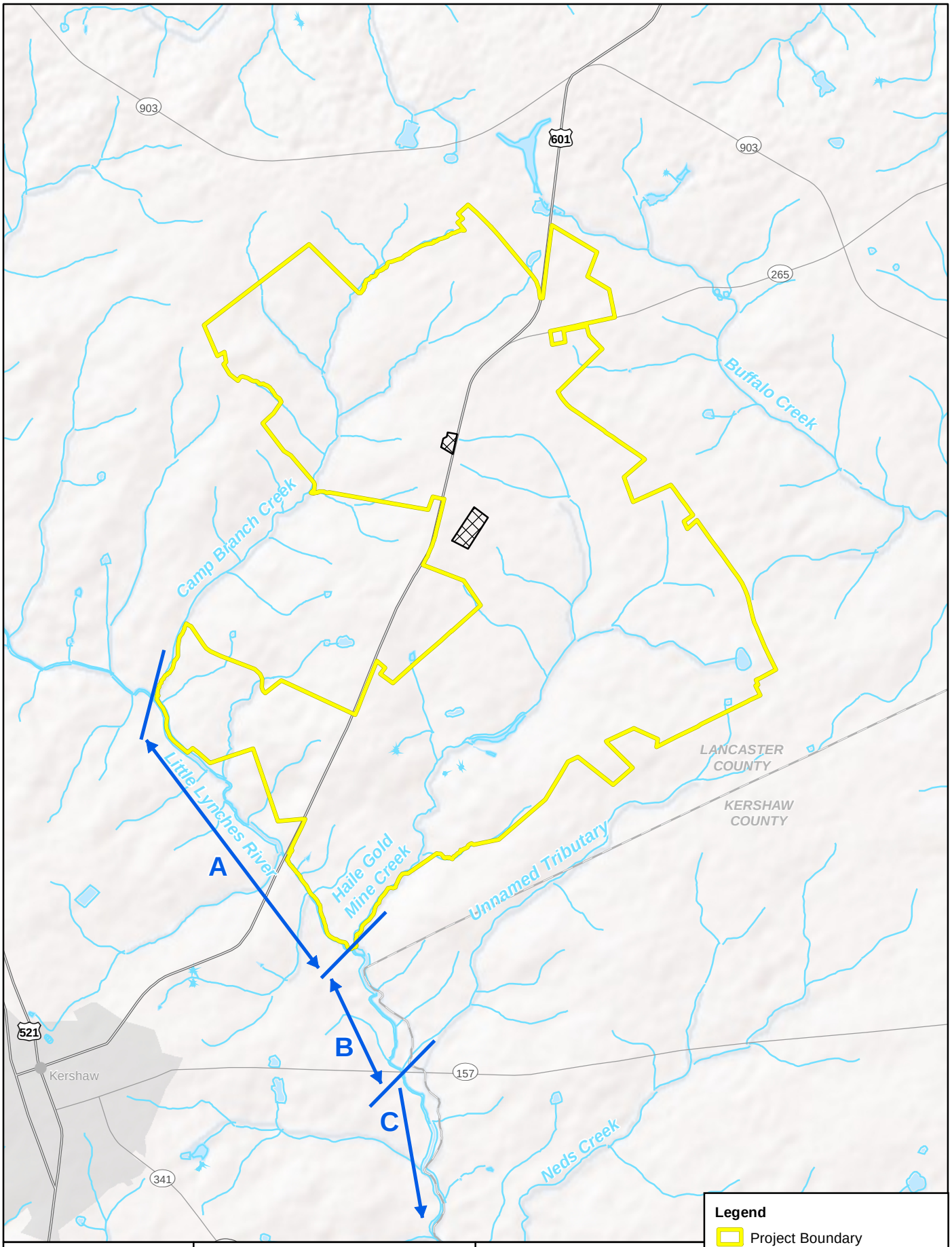
[1] The Kennedy Consulting Services, Inc. 2013 Water Resources Survey was based on mailed questionnaires, interviews, and examination of wells, when allowed. The survey was not designed to be exhaustive and depended greatly on the willingness of respondents to provide information.



Haile Gold Mine
Environmental Impact Statement
www.HaileGoldMineEIS.com

Figure 4.5-1

Locations of Estimated Changes in Streamflow in the Little Lynches River Downstream of the Proposed Haile Gold Mine

0 1,500 3,000 Feet
0 500 1,000 Meters

Sources: ESRI 2008, Haile 2013..

Legend

- Project Boundary
- Not Part of Project
- Little Lynches River Reaches
- Streams
- County Boundary
- Cities

Table 4.5-1 Changes to Average Annual Streamflow (cfs and percent of mean annual flow) in Three Reaches of the Little Lynches River during Project Operations (Mine Year 14)

Map Location (Map ID)	Waterbody and Drainage Area	Baseflow	Runoff	Mine Discharges	Total Flow
A	Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	-0.62 cfs (-2.3%)	-0.2 cfs (-1.3%)	0 cfs	-0.82 cfs (-1.9%)
B	Little Lynches River between Haile Gold Mine Creek and Unnamed Tributary southeast of the Project boundary	-3.16 cfs (-10.5%)	-0.28 cfs (-1.6%)	4.73 cfs	1.58 cfs, (+3.3%)
C	Little Lynches River downstream of Unnamed Tributary southeast of the Project boundary	-4.06 cfs (-12.4%)	-0.27 cfs (-1.5%)	4.73 cfs	0.78 cfs (+1.5%)

Notes:

cfs = cubic feet per second

Figure 4.5-1 shows the locations of the map IDs.

Total flow in the three affected reaches of the Little Lynches River generally would be affected by less than 3.3 percent on an average annual basis (Table 4.5-1). Impacts would range from slight streamflow reductions due to decreased surface water and groundwater contributions from the Haile Gold Mine Creek and Camp Branch Creek basins, to small streamflow increases in the two reaches downstream of Haile Gold Mine Creek.

The impacts on streamflow associated with the pit dewatering and watershed-altering activities of the mine operations generally would be a reduction in streamflow in the vicinity of the Project. The periodic discharge associated with mine pit dewatering would considerably increase streamflow in Haile Gold Mine Creek (Table 4.5-1). These discharges would not be continuous, however, and most likely would occur during periods of wet weather and higher streamflow, rather than under dry and drought conditions. These small potential changes in flow on an average annual basis may result in somewhat larger reductions in streamflow during dry and drought periods, because streamflow would be lower during such periods and the likelihood of excess pit dewatering discharges into Haile Gold Mine Creek would be lower.

Surface Water Users – Permitted Withdrawals (> 3 mgm)

The SCDHEC reports no permitted surface water withdrawals[2] within the Project area or within 50 miles downstream of the Project. The SCDHEC data indicate that no agricultural, domestic, industrial, commercial, or institutional surface water withdrawals are known to be located in the surface water study

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[2] A *surface water withdrawal* is defined as:

…A public water system withdrawing surface water in excess of three million gallons during any one month or any other person withdrawing surface water in excess of three million gallons during any one month from a single intake or multiple intakes under common ownership within a one-mile radius from any one existing or proposed intake. S.C. Code Ann. § 49-4-20(11) (Supp. 2002).

area (SCDHEC 2012a, 2012b). This includes potential withdrawals from streams within the Project boundary and the Little Lynches River immediately downstream of the Project boundary. Therefore, the Project would not cause impacts on existing permitted surface water withdrawals.

Although not within the surface water supply study area, three intakes were identified more than 100 miles downstream of the study area, within the greater Pee Dee River watershed on the Waccamaw River, Pee Dee River, and Black Creek. All of these intakes are downstream of, and fed by, the Lynches River (SCDHEC 2012a, 2012b). None of these permitted surface water withdrawals would be measurably affected. In addition to the permits being inactive, the effects of a less than 3.3-percent change in average streamflow in the Little Lynches River in the vicinity of the Project would not measurably affect river flow rates downstream, where watershed areas and flows are considerably greater and constitute less than 1 percent of the streamflow at the intakes.

Surface Water Users – Other Withdrawals (<3 mgm)

South Carolina's water withdrawal permitting program is recent (initiated in 2006), and information on the locations and rates of withdrawals for registered surface water users using less than 3 mgm is limited.[3] Data presented in the second South Carolina State Water Assessment (Wachob et al. 2009) indicate that reported surface water withdrawals from the Lynches River were limited in Kershaw and Lancaster Counties as of 2006. No data could be identified that documented specific users or use rates in this area. However, the streamflow impact analysis indicates that unidentified users withdrawing from the Little Lynches River immediately downstream of the Project could expect small changes in water available for withdrawal, ranging from a 1.9-percent decline to a 3.3-percent increase in available flow during Project operations. These changes would be reduced in a downstream direction, as flow increases within the Little Lynches River and into the Lynches River. These small potential changes in flow on an average annual basis may result in proportionately larger impacts on streamflow during dry and drought periods, because streamflow would be lower and the likelihood of excess pit depressurization water discharges into Haile Gold Mine Creek would be lower during drier periods. During the post-mining period, groundwater levels would slowly recover over many years, and total streamflow in the Little Lynches River would be expected to return to near pre-Project flows.

Water Suppliers

Several small utilities provide public water service to residents and businesses in the Project vicinity. Impacts on the operations of these utilities involving surface water uses would not occur, as each of these utilities withdraws their source water upstream of the Project area (Figure 3.5-4). It is important to note, however, that these utilities may play a role in mitigating the potential impacts associated with Project operations, should they occur. Haile's MMP (Appendix G) suggests that appropriate mitigation activities would take place if a well or withdrawal in the surface water study area is determined to have been adversely affected by Project operations (Haile 2013). For instance, mitigation for a dry or inoperable residential well might consist of Haile's arranging to connect the affected landowner to the nearest water system. Additional details on potential mitigation measures are provided in Section 4.5.4.

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[3] South Carolina has limited scientific information about the availability of its water supplies and future demands on those water supplies (SCHEC 2013).

Modified Project Alternative

The effects of the Modified Project Alternative on surface water supplies and uses would be the same as described for the Applicant's Proposed Project.

4.5.2.2 Impacts on Groundwater Supplies and Uses

No Action Alternative

Under the No Action Alternative, there would be negligible changes in groundwater levels and availability, and groundwater users would not be affected by the Project. Haile Gold Mine currently uses little or no groundwater within the Project boundary, and completion of reclamation activities would not result in further impacts on groundwater supplies or uses.

Applicant's Proposed Project

Ponds and Springs

The *Water Resources Inventory: Haile Gold Mine – Wells, Springs, and Ponds* (Kennedy Consulting Services 2013) identified 18 ponds and springs that are used for water supply or other beneficial uses within a 2-mile radius of the Project mine pit boundaries (Figure 4.5-2 and Table 4.5-2).[4]

Simulated groundwater drawdown contours for Mine Year14 are shown in Figure 4.5-2. These contours are representative of the groundwater lowering that would be experienced in wells, ponds, and springs in the groundwater supply study area.

It is important to note that, based on the simulated groundwater drawdowns, the wells, ponds, and springs in the groundwater supply study area would experience varying levels of impacts that could affect groundwater elevations and water availability differently at each water resource location. The actual impacts on self-supplied water users associated with Project operations would vary considerably due to localized differences in hydrogeologic conditions; the inherent uncertainty of the groundwater model; and differences in well, pond, and spring specifications (e.g., depth, flow rate, and pump configuration).

Table 4.5-2 provides an accounting of property owners with ponds or springs in the groundwater supply study area potentially affected by groundwater lowering associated with the Project. Table 4.5-3 characterizes the potential impacts on these ponds and springs.

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[4] The 2013 water resources inventory (Kennedy Consulting Services 2013) was based on mailed questionnaires, interviews, and examination of wells, when allowed. The survey was not designed to be exhaustive and depended greatly on the willingness of respondents to provide information.

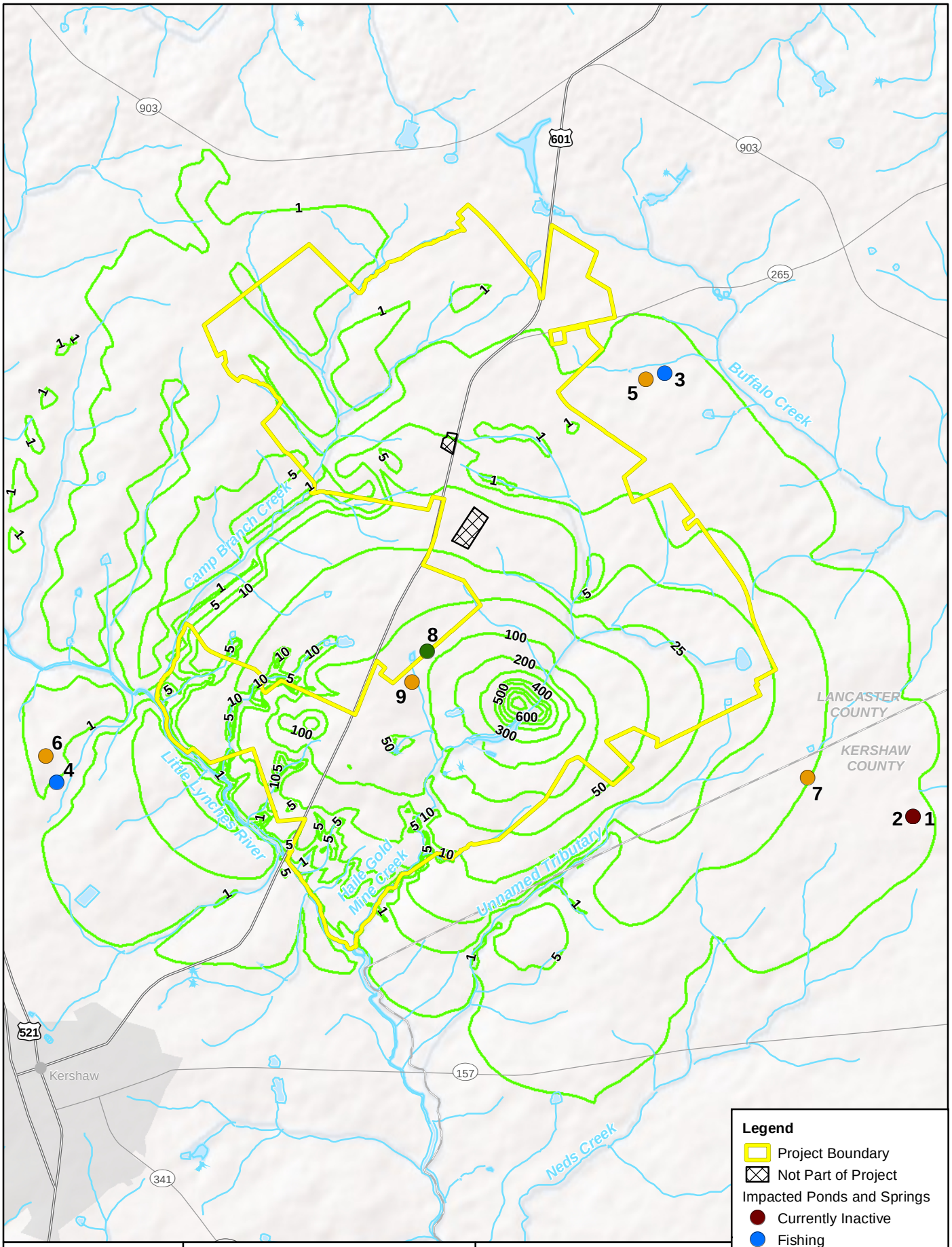

Figure 4.5-2

Simulated Groundwater Drawdown and the Location of Ponds and Springs Used for Water Supply or Other Beneficial Uses in the Groundwater Supply Study Area

0 1,500 3,000 Feet

0 500 1,000 Meters

Sources: ESRI 2008, Haile 2013.

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Table 4.5-2 Ponds and Springs Used for Water Supply and Other Beneficial Uses in the Groundwater Supply Study Area

Map ID[a]	County	Type	Status	Water Use	Pond Acreage	Pond Depth (feet)	Spring Flow (cfs)
1	Kershaw	Spring	Inactive	Unknown	N/A		Unknown
2							
3	Lancaster	Pond	Active	Fishing	0.3	10	N/A
4					0.5	10	
5				Irrigation	0.9	10	
6		Spring			N/A		0.5
7		Pond			1.1	5	N/A
8				Wildlife habitat	1.4	5	
9				Irrigation	3.0	20	

cfs = cubic feet per second

N/A = not available.

[a] Map ID numbers correspond with numbers in Figure 4.5-2.

Source: Summarized from Kennedy Consulting Services (2013).

Table 4.5-3 Potential Impact of Groundwater Drawdown on Ponds and Springs Used for Water Supply and Other Beneficial Uses in the Groundwater Supply Study Area

Map ID[a]	County	Status	Mine Year 14 Drawdown (ft)	Likelihood of Impacts
1	Kershaw	Inactive	Up to 5 ft	Unknown. Impacts are possible depending on the source of the spring (springs with a shallow source aquifer may be more vulnerable to Project drawdowns); assessment of the spring source would be needed.
2				
3	Lancaster	Active		Moderate to high (assuming that the pond is unlined). Impacts are partially dependent on pond depth. In a pond that is 10 feet deep in the center, groundwater lowering coupled with dry or drought conditions could lower or drain the pond.
4				
5				
6				Unknown. Impacts are possible depending on the source of the spring (springs with a shallow source aquifer may be more vulnerable to Project drawdowns); assessment of the spring source would be needed.
7			5 to 10 ft	High (assuming that the pond is unlined). Impacts are partially dependent on pond depth. In a pond that is 5 feet deep in the center; groundwater lowering coupled with dry or drought conditions could lower or drain the pond.
8			50 to100 ft	High (assuming that the pond is unlined). Impacts are partially dependent on pond depth. Groundwater lowering coupled with dry or drought conditions could lower or drain the pond.
9				

[a] Map ID numbers correspond with numbers in Figure 4.5-2.

Wells

A total of 39 private wells were identified within the 2-mile radius of the Project mine pit boundaries in the water resources inventory (Kennedy Consulting Services 2013) (Figure 4.5-3 and Table 4.5-4). Based on the simulated groundwater drawdowns, these wells would experience varying levels of lowered groundwater elevations at each location, potentially affecting well function and the future ability to supply water. The actual impacts on surrounding well users may vary considerably because of localized differences in hydrogeologic conditions not fully represented in the groundwater model, the inherent uncertainty of the groundwater model predictions, and differences in well construction specifications and depth across the groundwater supply study area. For example, 10 feet of predicted decline in groundwater levels in a 30-foot-deep well is more likely to impair well functionality than in a 250-foot deep well (because of a deeper pump depth and greater aquifer penetration, among other factors). Exact construction details, such as pump intake depths, are not available for each of the wells; however, the potential impacts are described in Table 4.5-5. Potential mitigation measures are discussed in Section 4.5.4.

Haile would monitor the impacts on water levels caused by groundwater lowering throughout the duration of the Project. Monitoring would include a series of groundwater monitoring wells within and outside the Project boundary. The wells would be monitored to determine how groundwater conditions are changing in response to Project operations, and to predict the potential effect of the changing conditions on surrounding water supplies (Haile 2013).

Anticipating the potential for these impacts to occur, Haile has committed to monitoring a group of strategically located wells to record changes in groundwater levels and changes in water quality. The SCDHEC Mine Operating permit will include conditions to ensure that water supply complaints are investigated by a third-party contractor and to require mitigation when it is substantiated that these effects are caused by the mine depressurization. Potential mitigation includes connecting affected users to an available potable water supply, re-working the well, or providing a new well.

As discussed in Section 3.5, groundwater well data and locations for wells in the groundwater supply study area were acquired from the SCDNR and the SCDHEC and from the water resources inventory for Haile Gold Mine (Kennedy Consulting Services 2013). The limitations associated with these data also are discussed in Section 3.5. The well locations, in conjunction with the Mine Year14 groundwater drawdown contours, were used to assess the likely impacts on groundwater users of aquifer lowering associated with the Project. Figure 4.5-3 is a map of the active and inactive private groundwater wells located outside the Project boundary that fall within the 1-foot drawdown contour associated with Mine Year 14 of Project operations. Table 4.5-4 lists the wells shown in Figure 4.5-3.

Modified Project Alternative

The effects of the Modified Project Alternative on groundwater supply and uses would be the same as those described for the Applicant’s Proposed Project.

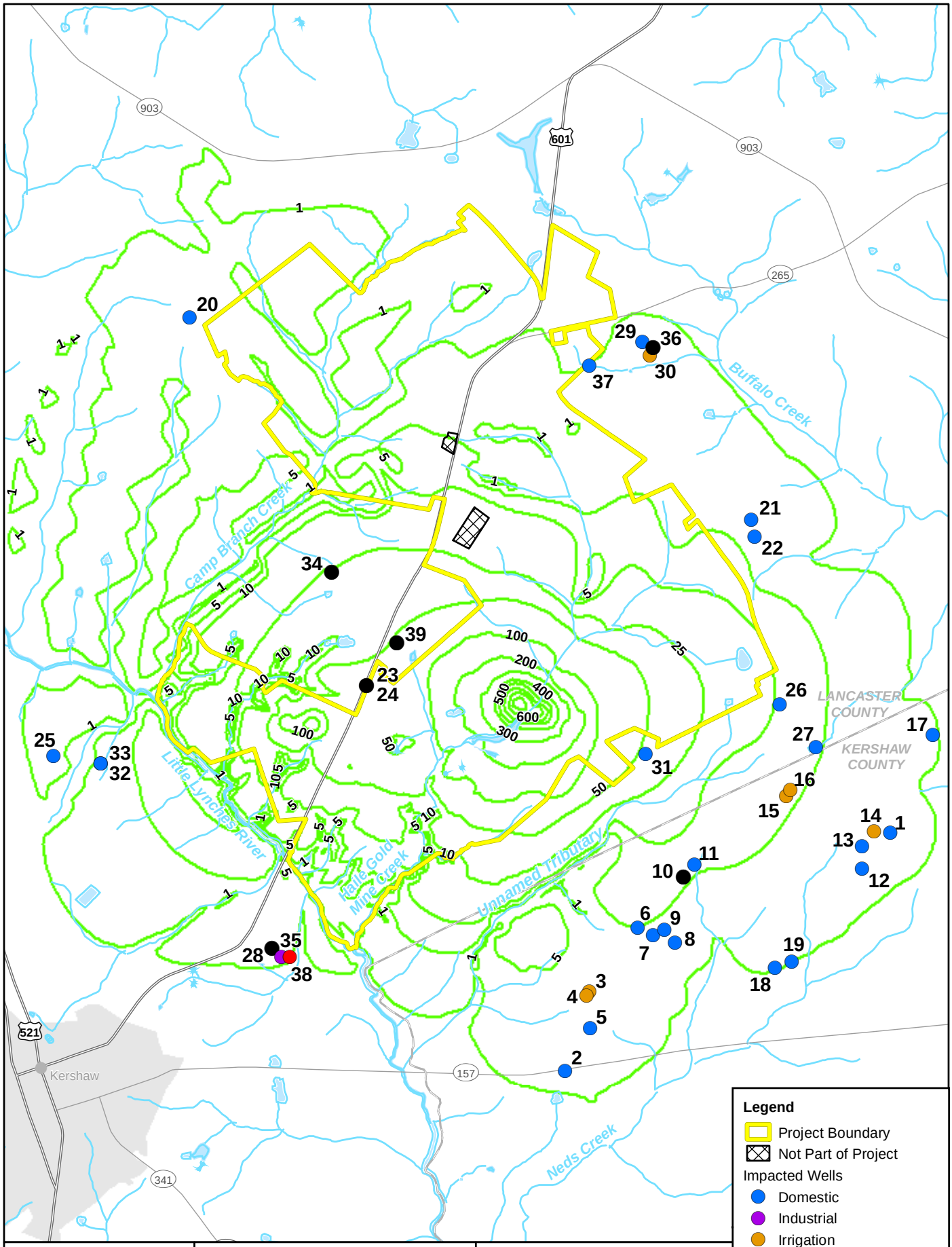

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Figure 4.5-3

Potential Impacts on Private Groundwater Supply Wells in the Groundwater Supply Study Area (Mine Year 14)

0 1,500 3,000 Feet
0 500 1,000 Meters

Sources: ESRI 2008, Haile 2013.

Table 4.5-4 Groundwater Wells in the Groundwater Supply Study Area Identified by the Water Resources Survey and SCDHEC and SCDNR Water Well Databases

Map ID	County	Well Status	Well Use	Diameter (in)	Cased Depth (ft)	Total Depth (ft)	Pump Depth (ft)
1	Kershaw	Active	Domestic	3	Unknown	65	Unknown
2		Active	Domestic	6	25	200	Unknown
3		Active	Irrigation	6	160	200	Unknown
4		Active	Irrigation	6	Unknown	205	Unknown
5		Active	Domestic	48	55	60	Unknown
6		Active	Domestic	2	22	30	Unknown
7		Active	Domestic	4	30	55	Unknown
8		Active	Domestic	6	32	145	Unknown
9		Active	Domestic	6	33	160	Unknown
10		Inactive	Inactive	2	Unknown	Unknown	Unknown
11		Inactive	Domestic	4	10–20	30–35	Unknown
12		Active	Domestic	6	29	205	Unknown
13		Active	Domestic	4	Unknown	250	Unknown
14		Active	Irrigation	6	27	500	Unknown
15		Active	Irrigation	6	19	325	Unknown
16		Active	Irrigation	6	17	285	Unknown
17		Active	Domestic	2	Unknown	30	Unknown
18		Active	Domestic	4	17	58	Unknown
19		Unknown	Domestic	4	Unknown	53	Unknown
20	Lancaster	Unknown	Domestic	6	Unknown	150	Unknown
21		Unknown	Domestic	6	Unknown	205	Unknown
22		Active	Domestic	6	Unknown	225	Unknown
23		Active	Irrigation	6	50	225	Unknown
24		Inactive	Inactive	36	27	60	Unknown
25		Active	Domestic	6	10	250	Unknown
26		Unknown	Domestic	6	Unknown	175	unknown
27		Active	Domestic	2	26	78	Unknown
28		Inactive	Inactive	Unknown	Unknown	Unknown	Unknown
29		Active	Domestic	6	Unknown	165	Unknown
30		Active	Irrigation	6	Unknown	185	Unknown
31		Active	Domestic	6	Unknown	205	Unknown
32		Unknown	Domestic	2	30	40	40
33		Unknown	Domestic	2	60	110	100
34		Inactive	Inactive	4	29	300	Unknown

Table 4.5-4 Groundwater Wells in the Groundwater Supply Study Area Identified by the Water Resources Survey and SCDHEC and SCDNR Water Well Databases

Map ID	County	Well Status	Well Use	Diameter (in)	Cased Depth (ft)	Total Depth (ft)	Pump Depth (ft)
35	Lancaster (Continued)	Unknown	Industrial	10	164	600	unknown
36		Inactive	Inactive	24	24	Unknown	Unknown
37		Unknown	Domestic	6	62	185	100
38		Unknown	Monitoring	Unknown	Unknown	196	Unknown
39		Inactive	Inactive	6	38	Unknown	Unknown

[a] Map ID numbers correspond with numbers in Figure 4.5-3.

Sources: Summarized from Kennedy Consulting Services (2013) and the South Carolina Department of Health and Environmental Control and South Carolina Department of Natural Resources well databases (SCDHEC 2012a, 2012b, 2012c; SCDNR 2012).

Table 4.5-5 Potential Impacts on Private Groundwater Wells in the Groundwater Supply Study Area

Map ID[a]	Water Service Available	Well Status	Mine Year 14 Drawdown	Likelihood of Impacts on Well Function
1	No	Active	Up to 5 feet	Low to moderate. Drawdown coupled with dry or drought conditions would be unlikely to impair this shallow well.
2				Low. These are deep wells with pumps that are likely set deep enough to avoid impacts.
3				
4				
5				Low to moderate. Drawdown coupled with dry or drought conditions has a small likelihood of impairing this shallow well.
6				
7				
8				Low. These are deep wells with pumps that are likely set deep enough to avoid impacts of up to 5 feet.
9				
10	Yes; BRWC	Inactive	5 to 10 feet	Likely low, but well specifications are not known.
11				Low to moderate. Drawdown coupled with dry or drought conditions has a small likelihood of impairing this shallow well.
12	No	Active	Up to 5 feet	Low. These are deep wells with pumps that are likely set deep enough to avoid impacts of up to 10 feet.
13	Yes; BRWC			
14				
15			5 to 10 feet	
16				

Table 4.5-5 Potential Impacts on Private Groundwater Wells in the Groundwater Supply Study Area (Continued)

Map ID[a]	Water Service Available	Well Status	Mine Year 14 Drawdown	Likelihood of Impacts on Well Function
17			Up to 5 feet	Low to moderate. Drawdown coupled with dry or drought conditions has a small likelihood of impairing this shallow well.
18	No	Active		
19	Yes; BRWC	Unknown		
20	Unknown	Unknown		Low. These are deep wells with pumps that are likely set deep enough to avoid impacts of up to 5 feet.
21				
22	No	Active		
23	Yes; Town of Kershaw	Active	50 to100 feet	High. Well could become inoperable or dry during mining.
24		Inactive		
25	Yes; BRWC	Active	Up to 5 feet	Low. These are deep wells with pumps that are likely set deep enough to avoid impacts of up to 10 feet.
26	Unknown	Unknown	5 to 10 feet	
27	Yes; LCW&SD	Active	5 to 10 feet	Moderate. Drawdown coupled with dry or drought conditions could impair production capacity of this shallow well.
28	Yes; Town of Kershaw	Inactive	Up to 5 feet	Likely low, but well specifications are not known.
29	Yes; LCW&SD	Active	Up to 5 feet	Low. These are deep wells with pumps that are likely set deep enough to avoid impacts of up to 5 feet.
30				
31	Yes; Unknown	Active	25 to 50 feet	Moderate to high. Pump could be inoperable or completely dry during mining, depending on pre-mining depth to water and pump depth.
32	Unknown	Unknown	Up to 5 feet	Low to moderate. Drawdown coupled with dry or drought conditions has a small likelihood of impairing this shallow well.
33	Unknown	Unknown	Up to 5 feet	Low. Pump is set at 100 feet deep.
34	Yes; Town of Kershaw	Inactive	25 to 50 feet	High. Well could become inoperable or dry during mining.
35	Unknown	Unknown	Up to 5 feet	Low. Based on construction specifications, this is a deep well with a pump depth of probably 100 feet or more.
36	Yes; LCW&SD	Inactive		Moderate. Drawdown coupled with dry or drought conditions could impair production capacity of this shallow well.
37	Unknown	Unknown		Low. These are deep wells with pumps that are likely set deep enough to avoid impacts of up to 5 feet.
38				Low. This is a deep monitoring well.

Table 4.5-5 Potential Impacts on Private Groundwater Wells in the Groundwater Supply Study Area (Continued)

Map ID[a]	Water Service Available	Well Status	Mine Year 14 Drawdown	Likelihood of Impacts on Well Function
39	Yes; Town of Kershaw	Inactive	50 to 100 feet	High. Well could become inoperable or dry during mining.

BRWC = Bethune Rural Water District

LCW&SD = Lancaster County Water and Sewer District

[a] Map ID numbers correspond with numbers in Figure 4.5-3.

4.5.2.3 Impacts on Surface Water and Groundwater Quality

The potential impacts of the Project on groundwater and surface water quality were evaluated on the basis of quantitative and qualitative assessments of changes in water quality described in Sections 4.3 and 4.4, respectively. This section assesses impacts on drinking water use from private wells and surface water sources by comparing changes in water quality to applicable South Carolina State Primary Drinking Water Regulation Standards (R.61-58) and relevant National Secondary Drinking Water Standards. These standards are listed in Section 3.4.

No Action Alternative

Under the No Action Alternative, monitoring of closure activities would continue, and no additional mining would take place. The groundwater and surface water quality in the Project area previously affected by mining activities would improve slowly over time following reclamation (see Sections 4.3 and 4.4). Other subwatersheds in the study area not affected by historical mining, such as Camp Branch Creek, Buffalo Creek, and the unnamed tributaries draining to the Little Lynches River, would remain largely unchanged under the No Action Alternative, subject to any future watershed development that may occur.

Applicant's Proposed Project

Active Mining Period

During active mining operations, changes to surface water quality are considered minor to moderate for all of the streams in the study area. Buffalo Creek would experience negligible impacts on surface water quality (Section 4.4). These changes could be long-term or permanent impacts for some parameters. Some impacts would be lessened by permit limits and management practices implemented during and after mining; other impacts on water quality could occur in localized areas (e.g., downstream of the contact water treatment plant or Ledbetter Pit Lake). Because there are no active, permitted surface water withdrawals on Haile Gold Mine Creek or for many miles downstream of the Project on the Little Lynches River, no impacts on downstream users are anticipated related to surface water quality. Changes in water quality could occur at unpermitted surface water withdrawal intakes downstream of the Project. Because the water quality during mining would be required to comply with State water quality standards, minor impacts would be expected for the water quality of surface water uses.

During mining, local groundwater levels would be lowered, and the direction of groundwater flow would be generally toward the pits (Section 4.3). Even though well water levels may be lowered by pit dewatering, water quality in the deep wells is not likely to be affected because the changes in groundwater levels are not expected to significantly influence the dissolution of minerals or the transport of additional

contaminants such as nutrients. Lowering of groundwater levels could cause a minor impact on water quality in the shallow wells in the CPS and shallow saprolite. The chemical composition of water in these wells is similar to rainfall, which is very soft (low hardness) with low mineral content. Water from wells in deeper rock typically has a higher mineral content than water from shallow wells. If lowering the groundwater alters the depth and the geologic source of the water, the water chemistry could change, possibly with noticeable impacts on appearance, taste, and odor.

Post-Mining Period

After mining operations are complete and the groundwater levels reach equilibrium, moderate impacts on surface water and groundwater quality could occur. These impacts would be experienced by groundwater between the mine pits and the Little Lynches River, and in lower Haile Gold Mine Creek and the Little Lynches River, where the groundwater would be discharged. For some water quality parameters, these impacts could be long term and persist for many years following mining (Sections 4.3 and 4.4). Most of the water quality impacts caused by watershed disturbance would cease post mining; however, impacts related to passive treatment cells could still occur, and some water quality standards could be exceeded once the groundwater system reaches equilibrium (Sections 4.3 and 4.4).

When mining is complete, groundwater levels would recover to near pre-Project levels, and regional groundwater flow would be slowly re-established. Groundwater flow would be toward lower Haile Gold Mine Creek and the Little Lynches River. Downgradient of the mine pits, groundwater quality would be affected by interactions with backfilled areas and the pit lakes. Even though the pH of the three pit lakes would be neutralized with lime amendments (Section 4.3), water quality simulations indicate that groundwater in the Project area would experience additional chemical loadings from contact with backfilled overburden and the pit lakes. As groundwater migrates from the backfilled pits and pit lakes toward the downgradient streams, some of the affected groundwater would contribute to streamflows (via baseflow) in lower Haile Gold Mine Creek and the Little Lynches River downstream of the Project.

Impacts associated with these changes in the water quality of lower Haile Gold Mine Creek and Little Lynches River would likely persist for a short distance, and would not affect any known permitted surface water withdrawals or groundwater wells. All existing private and public groundwater wells not owned by Haile are located upgradient of the backfilled pits and would not experience changes in water quality. While moderate changes to water quality could occur in the study area, these impacts would be confined to the vicinity of Project boundary and just downstream on the Little Lynches River. No impacts are expected on any permitted water withdrawals. In addition, the water quality model was developed with several conservative assumptions and likely over-predicts water quality impacts (Section 4.3). Therefore, changes to surface water supplies and groundwater wells likely would be minor.

Modified Project Alternative

The effects of the Modified Project Alternative on surface water and groundwater quality would be the same as described for the Applicant's Proposed Project.

4.5.2.4 Impacts on Regulated Floodplains

No Action Alternative

Under the No Action Alternative, there would be negligible changes in runoff and associated contributions of the Project area to streamflows. Therefore, the 100-year floodplain inundation level would not be affected, and no encroachment into regulated floodplains would occur. As Haile completes the reclamation activities for the former Haile Mine operations, revegetation and soil development would,

over many years, reduce runoff and reduce the effect of runoff from the Project area and its contribution to the 100-year floodplain inundation level.

Applicant's Proposed Project

All of the regulated FEMA Zone A floodplain areas are associated with the Little Lynches River and the downstream portions of certain tributaries along the southern boundary of the Project (Figure 3.5-4). The Project design includes no direct modification or encroachment that would alter the land use, topography, or vegetative cover of the regulated floodplains. The nearest planned earth-moving operations would occur at the Ramona OSA, which would be located more than 100 feet outside of the regulated floodplain.

The results of floodplain hydraulic modeling indicated that the 100-year floodwater elevation would be approximately 4 feet lower adjacent to the southern boundary of the Project near the Ramona OSA than at all nearby Project facilities. Therefore, no Project activities would affect or be affected by floodwater elevations during the 100-year flood (ERC 2013).

The indirect impact analysis focused on determining potential changes in flow downstream of the Project associated with land use alterations outside of regulated floodplains and with water releases and runoff from the proposed Project. Topographical and drainage alterations within the Project boundary, in the Haile Gold Mine Creek and Camp Branch Creek watersheds, would result in a reduction of the effective drainage area contributing to the Little Lynches River by 8 to 16 percent during Project operations. The effects of this reduction in contributing areas would be a small reduction in runoff from the proposed Project into the floodplain during flood conditions. It is important to note that the contribution of runoff from the Project boundary is approximately 0.12% of the 100-year flood volume in the Little Lynches River. Therefore, the potential change in runoff is minimal. During active mining, the effect of the Project is expected to be a small reduction in peak 100-year recurrence flows and floodwater elevations. No measurable impacts on downstream flood flows or impacts on floodplain function or classification are anticipated as a result of the Project (ERC 2013).

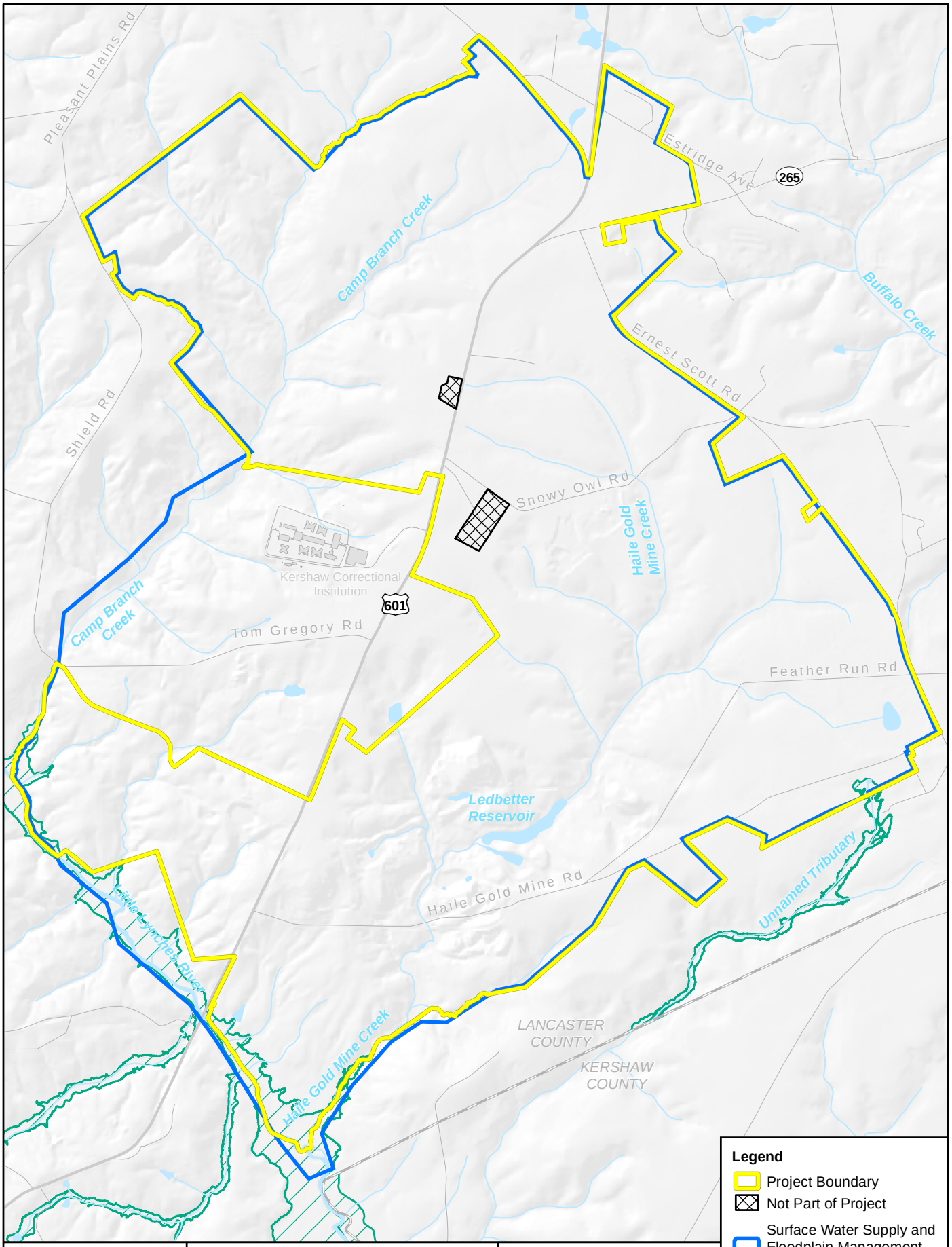
During the post-mining period, as the Project undergoes reclamation, the runoff from the Project site would be further reduced by increased vegetation, ground cover, and soil development, resulting in less contribution to the 100-year recurrence flows and elevations.

Modified Project Alternative

The effects of the Modified Project Alternative on regulated floodplains would be the same as described for the Applicant's Proposed Project.

4.5.3 Impact Summary

Table 4.5-6 contains a summary of impacts on water supply and floodplains under each alternative.



Legend

- Project Boundary
- Not Part of Project
- Surface Water Supply and Floodplain Management Study Area
- Regulated Floodplains FEMA Zone A
- Waterbodies
- County Boundary

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Figure 4.5-4

FEMA Zone A Floodplains in the Study Area

0 1,000 2,000 Feet
0 300 600 Meters

Sources: ESRI 2008, FEMA 2011, SCDNR 2012.

Table 4.5-6 Summary of Impacts on Water Supply and Floodplains

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Surface water supplies and uses	Negligible changes in surface water (stream) supplies; existing surface water uses would not be affected.	Small increases and reductions in streamflow, ranging from a 1.9-percent decline to a 3.3-percent increase in available flow, would minimally affect downstream permitted or registered water users under most conditions; could be exacerbated during drought periods. As a result of groundwater level lowering associated with the Project, impacts of varying degree may occur at privately owned ponds and springs that are used for water supply or other beneficial uses. Impacts may range from negligible to substantial, depending on the level of predicted drawdown and site-specific conditions. Mitigation measures may be needed to address potential impacts.	Same as the Applicant's Proposed Project.
Groundwater supplies and uses	Negligible changes in groundwater supplies; existing groundwater users would not be affected.	As a result of groundwater level lowering associated with the Project, impacts of varying degree may occur at privately owned wells that are used for water supply. Impacts likely would range from negligible to substantial, depending on the level of predicted drawdown and site-specific conditions. Mitigation measures would need to be instituted to address potential impacts.	Same as the Applicant's Proposed Project.
Surface water and groundwater quality for water supply	Negligible changes in groundwater and surface water supplies; existing groundwater and surface water users would not be affected.	As a result of changes in runoff, watershed alterations, pond development, and treatment plant discharges from the mine operations, changes in stream water quality in the vicinity of the Project are expected. Per permit conditions, the changes in surface water quality will maintain compliance with State water quality standards. The changes are not expected to result in impacts to surface water users in or downstream of the proposed Project. Additionally, changes in groundwater quality may occur due to groundwater drawdown and influences from the pits. The changes in groundwater resulting from the Project are not expected to impact groundwater users in the Project area.	Same as the Applicant's Proposed Project.
Floodplain encroachment and elevation of the 100-year flood	Negligible impacts on floodplains; floodplain designation and functionality would not be affected.	No potential impacts on floodplain integrity or 100-year flood elevations from Project operations.	Same as the Applicant's Proposed Project.

4.5.4 Mitigation for Impacts on Water Supply and Floodplains

4.5.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included a number of avoidance and minimization measures in the design and plans for operating and managing the proposed Haile Gold Mine. Some of the important measures for water supply include monitoring and addressing impacts on ponds, springs, and wells; conducting a survey and inventory of self-supplied water users in the Project area; and instituting a variety of engineering controls as part of the Project design to mitigate or minimize potential impacts. This section provides a brief overview of those measures.

Haile would monitor the impacts on groundwater levels and water quality associated with Project groundwater lowering throughout the life of the Project. Monitoring would consist of a series of groundwater monitoring wells within the Project boundary. The wells would be monitored to determine how groundwater conditions are changing in response to Project operations.

Anticipating the potential for groundwater impacts to occur, Haile has committed to monitoring a group of strategically located wells to record changes in groundwater levels and changes in water quality. The SCDHEC Mine Operating permit will include conditions to ensure that water supply complaints are investigated by a third-party contractor and, when substantiated that these effects are caused by the mine depressurization, mitigation will be required. Potential mitigation includes connecting affected users to an available potable water supply, re-working the well, or providing a new well.

Potential direct impacts on floodplains have been avoided in the Project design, and indirect Project impacts on 100-year flood elevations would be minimal. The Project design includes the following engineering controls that provide mitigation or avoidance of impacts on floodplains and surrounding water users:

- Construct mine facilities outside of the 100-year floodplain.
- Implement a program to provide a process for potentially affected users to address potential impacts on wells, ponds, and springs.
- Recycle/reuse process water to minimize water consumption.
- Manage water balance to minimize water consumption.
- Recycle/reuse contact water to minimize water consumption, within process constraints.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of Applicant-proposed avoidance and minimization measures related to water supply and floodplains is provided in Chapter 6.

4.5.4.2 Additional Potential Mitigation Measures

In addition to the Applicant-proposed measures described above specific measures for addressing impaired well function or production impacts on pond water levels and flows in springs could include the following:

- Deepen or replace shallow wells.
- Replace or modify well pumps.

- Replace wells, ponds, and springs used for water supplies with an alternative water supply that may include connections to a public water system, storage cisterns, or rooftop water collection/treatment systems.
- Install clay or synthetic liners in ponds.
- To mitigate potential impacts to water users, no water supply wells or surface water withdrawals should be permitted within the modeled zone of water quality impacts until monitoring indicates that all water quality standards are met.

With implementation of the measures listed above, impacts on groundwater and surface water users in the Project area could be alleviated or reduced. Additional proactive measures, prior to the start of the proposed mining operations, could be considered for wells, ponds, and springs with a high probability of impact from Project operations.

4.5.5 Literature Cited

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4.6 Wetlands and Other Waters of the United States

Activities that involve discharge of dredge and fill material into Waters of the U.S. are regulated by the USACE under Section 404 of the CWA. The proposed Project would result in direct and indirect impacts on Waters of the U.S. Construction of mine pits, OSAs, the TSF, the Mill, and haul roads would result in direct impacts and the permanent loss of wetlands and streams.

The proposed Project also could result in indirect impacts on Waters of the U.S. as a result of groundwater lowering that would alter wetland hydrology and change streamflows. Most wetlands in and surrounding the proposed Project are seepage wetlands associated with streams that are dependent on groundwater baseflows. Watershed alterations would contribute to indirect impacts on wetlands and streams from habitat fragmentation, changes in landscape topography, alterations in stream morphology, and changes in water quality and stream temperatures. The majority of these indirect impacts would result in temporal losses of wetland function or resources, and some losses could be permanent.

Hydrology is one of three factors, in addition to hydrophytic vegetation and hydric soils, that are used to define a wetland. Hydrology is ultimately what supports a wetland based on the USACE's definition.[1] Project-related activities that alter hydrology to the extent that wetlands are no longer inundated or saturated at a frequency or duration sufficient to support hydrophytic vegetation would result in a temporary, long-term, or permanent loss of some wetland resources. As described in Section 3.6, the wetlands in the Project area primarily consist of headwater systems that function as slope wetlands and discharge into headwater streams. Both of these systems are primarily groundwater driven. Pit dewatering activities would lower the groundwater table and reduce baseflows, resulting in adverse impacts on hydrology and the overall health of the wetland systems and any receiving waterbodies (streams). Likewise, because the streams are fed by surface runoff and groundwater baseflows (from riparian slope wetlands), streamflow alterations can be expected as a result of groundwater lowering and surface water alterations.

The extent of indirect impacts would depend on a number of variables, including baseline wetland conditions (e.g., hydrologic regimes, vegetative community, soils, surficial geology, and topography), the extent of groundwater drawdown in the area, and the duration of dewatering activities. Hydrologic alterations could result in a temporal or permanent loss of resources (and/or function). When groundwater lowering activities cease, the water table is expected to recover (partially or fully), in which case most wetland communities (or streams) are expected to return. However, even after groundwater levels recover, it could take years or decades for wetlands to re-establish. It could take several decades for the water table to recover (for further discussion of groundwater table recovery, see Section 4.3, "Groundwater Hydrology and Water Quality"), in which case most wetland communities would transition to upland habitats or transient communities vegetated with nuisance, exotic, and other opportunistic species. In addition, wetland and stream function may not return to the baseline condition but may return as a more degraded system or perhaps as an entirely different wetland habitat type.

In addition to hydrologic alterations, indirect wetland impacts could occur from watershed alterations. Direct impacts from the mine could cause habitat fragmentation between the upstream and downstream stream corridors. These watershed alterations could change stream morphology because of changes in streamflows and natural sedimentation patterns. The proposed Project also could result in water quality impacts and fluctuating stream temperatures, with the potential to cause indirect impacts on the receiving

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[1] *"Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions…"* 33 CFR 328.3[b]).

waterbodies (wetlands and streams) and the aquatic resources using those habitats. These indirect impacts may not necessarily result in permanent loss of resources but may result in functional losses or change in habitat types.

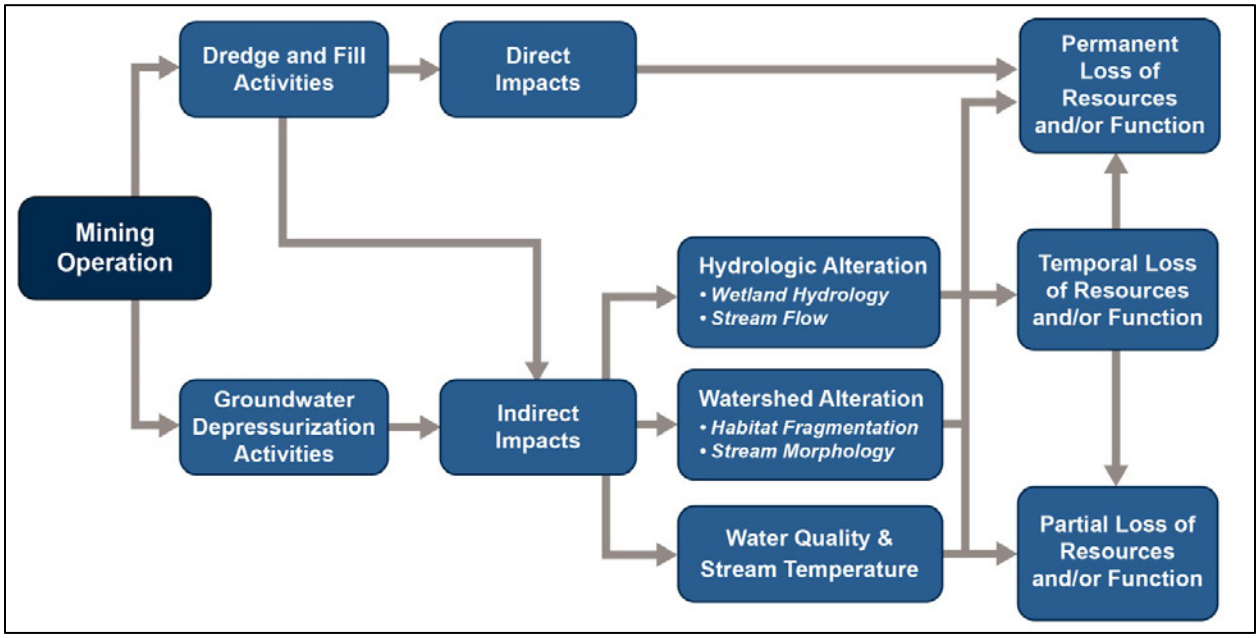

Figure 4.6-1 Overview of Direct and Indirect Impacts on Wetlands and Waters of the U.S. Associated with the Proposed Project

4.6.1 Methods

The methods used to quantify and evaluate impacts on Waters of the U.S. are outlined below. Also described is the method used to assess total functional loss associated with the impacts in order to ensure that adequate compensation is provided in accordance with the USACE and USEPA goal of no net loss of aquatic resources. Where feasible, this impact analysis takes into consideration the degree and duration of impacts for an accurate assessment of the compensation required for wetland losses.

Impacts on wetlands and other Waters of the U.S. were evaluated in terms of direct and indirect impacts under each alternative and for the active mining and post-mining/reclamation periods. The study area[2] is shown in Figure 4.6-2 for purposes of this impact analysis. Figure 3.6-1 also shows the study area for wetlands and other Waters of the United States. Figure 4.6-2 shows greater detail by including the numbered stream reaches in the study area that would be affected.

Two subareas were defined within the study area: within the Project boundary and outside the Project boundary. As described in Section 3.6, much more detailed and spatially accurate information was available on wetlands and Waters of the U.S. within the Project boundary (in the Project area) because they were formally delineated according to the USACE's Wetlands Delineation Manual (USACE 1987).

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[2] The limits of the study area were defined by the maximum zone of influence (in Mine Year 14) when potential drawdown from groundwater lowering activities could affect wetlands and streams outside of the Project boundary.

Outside the Project boundary, formal jurisdictional determinations were not available. These areas were evaluated through a desktop mapping exercise (interpretation of aerial photographs of wetlands) that relied on publicly available resources and databases. Although similar analyses were completed, the results are presented separately for wetlands within the Project boundary and outside the Project boundary because of the differences in the data sources.

4.6.2 Analysis of Direct Impacts

Direct impacts include the dredge and fill activities proposed within the construction footprint of the mine that would result in permanent loss of wetlands and stream resources. The wetlands and streams that would be directly affected by the proposed Project are shown in Figure 4.6-2. The figure distinguishes between areas of direct impacts (within the mine plan footprint) and areas of potential indirect impacts (within the study area).

Direct impacts were quantified based on the construction drawings provided in support of the proposed Project and a 50-foot disturbance area around all facilities beyond the planned mine footprint. An additional 450-foot direct disturbance area (a total of 500 feet) has been assumed around Champion Pit to accommodate access and staging areas for mining equipment. Except for the Champion Pit area, a 50-foot non-disturbance buffer would be maintained around all other wetlands and streams to preserve the integrity of these systems.

4.6.3 Analysis of Indirect Impacts

Wetlands and streams would be affected by a number of mining activities that could contribute to indirect impacts (hydrologic alterations, water quality impacts, and habitat fragmentation). Groundwater and surface water resources support the functions of wetlands and streams. Likewise, aquatic resources are supported by healthy function of wetlands and streams. Consequently, the impacts on all of these resources are interrelated.[3] Groundwater lowering generally would cause the most prevailing impact on these resources, but other activities would further contribute to degradation of the same systems. Therefore, this analysis addresses indirect impacts for each category (hydrology, watershed alterations, and water quality) to evaluate potential losses and mitigation requirements associated with the proposed Project. For purposes of this analysis, the indirect impact assessment addresses only the wetlands and stream resources located outside of the direct mine plan footprint, as depicted in Figure 4.6-2.

The analysis of indirect impacts relied on data from the groundwater and surface water analysis (outlined in Sections 4.3, “Groundwater Hydrology and Water Quality” and 4.4, “Surface Water Hydrology and Water Quality”) to evaluate hydrology, water quality, and temperature. Both hydrology and temperature were evaluated quantitatively and qualitatively to show potential impacts associated with measurable changes in groundwater table depths, streamflows, and water temperatures relative to baseline conditions. Water quality was evaluated qualitatively to address potential impacts from mining activities. Potential impacts associated with watershed alterations (such as habitat fragmentation and changes in stream morphology) were evaluated qualitatively. The following sections summarize the methods used for each assessment.

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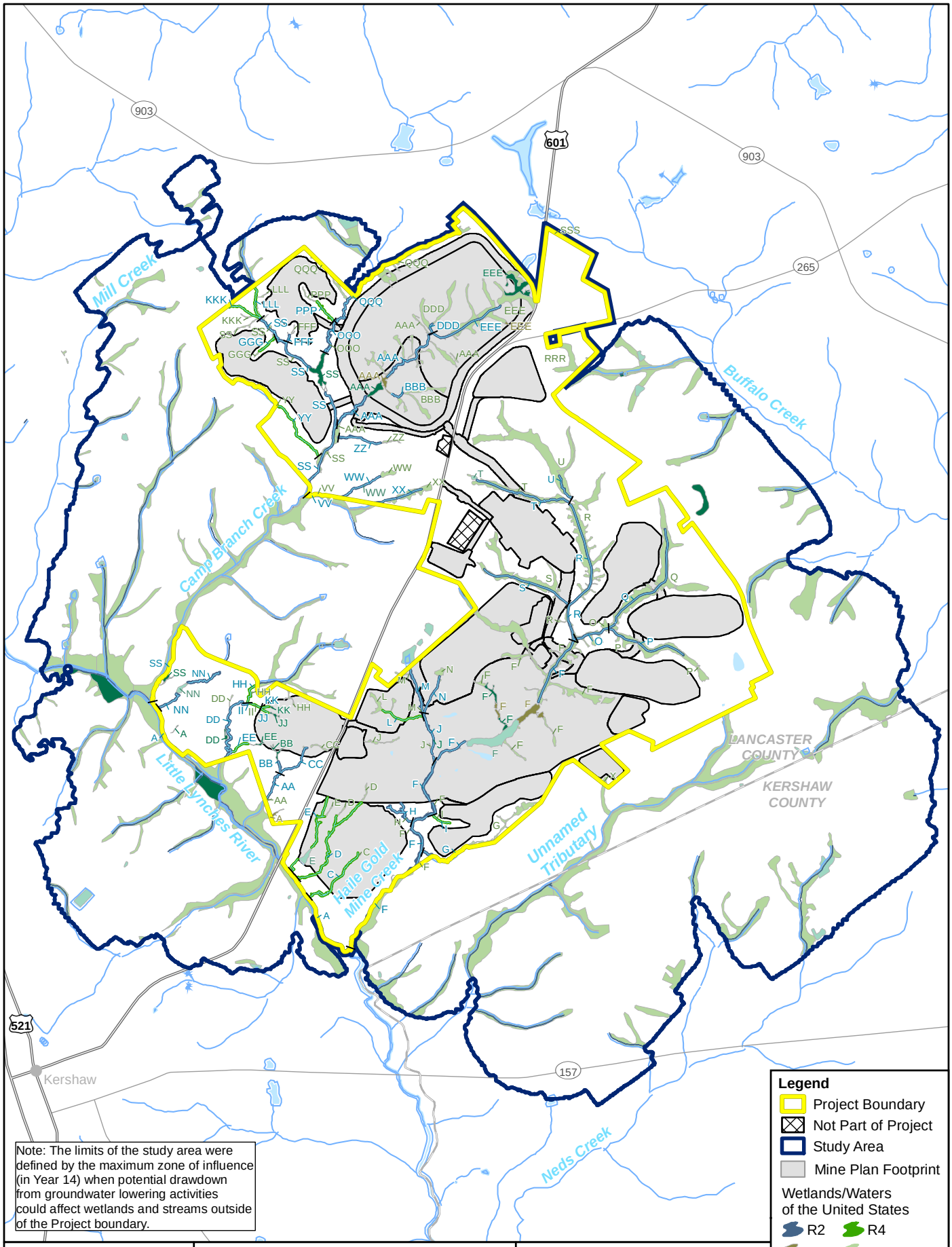
[3] Refer to impact discussions in Section 4.3, “Groundwater Hydrology and Water Quality”; Section 4.5, “Water Supply and Floodplains”; and Section 4.4, “Surface Water Hydrology and Water Quality.” Likewise, aquatic resources are interrelated, as impacts on wetland and stream habitats, whether direct or indirect from groundwater or surface water impacts, could cause direct impacts on the aquatic fauna using those systems (refer to Section 4.7, “Aquatic Resources”).



Note: The limits of the study area were defined by the maximum zone of influence (in Year 14) when potential drawdown from groundwater lowering activities could affect wetlands and streams outside of the Project boundary.

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Figure 4.6-2

Wetland and Stream Habitats in the Study Area in Proximity to the Mine Plan Footprint

0 1,500 3,000 Feet

0 500 1,000 Meters

Sources: ESRI 2008, Haile 2013, SCDNR 2013, USFWS 2013.

4.6.3.1 Hydrologic Alteration

Below is an overview of the methods used to evaluate indirect wetland and stream impacts associated with groundwater lowering activities and surface water alterations. Groundwater drawdown primarily was used to assess potential hydrologic impacts on wetlands, and baseflows were used to evaluate impacts on streams.

Groundwater

For purposes of this analysis, groundwater drawdown was evaluated for each year of the active mining phase (Mine Years 0–14) to evaluate the magnitude of drawdown specific to each wetland. The groundwater model also was used to evaluate recovery periods (post-mining) and the total duration of impacts for each wetland. Baseflows were evaluated in conjunction with drawdown because they are fed by groundwater and hydrate the wetlands through seepage. Drawdown and baseflows were evaluated in terms of annual averages, which take into consideration the wide range of seasonal variability in groundwater elevations. Groundwater drawdown specific to wetlands was evaluated only for those areas located outside of the direct mine footprint.

The potential for indirect impacts is largely tied to baseline conditions of the wetlands, proximity to the proposed dewatering activities, and the extent and duration of drawdown. For purposes of this impact analysis, there are too many variables and spatial uncertainty in the groundwater model to assume that any impacts would occur where groundwater drawdown measures less than 1 foot relative to the baseline elevations. However, any wetlands that are exposed to groundwater drawdown in excess of 1 foot for sustained periods could be indirectly affected. Drawdown in excess of 1 foot may result in temporal loss in wetlands, the extent of which depends on the magnitude and duration of drawdown. The potential for impact would increase relative to the extent and duration of drawdown. When active mining ceases, the groundwater table would be allowed to recover, in which case wetland function may return. However, some areas may experience permanent (or partial) loss of wetland resources depending on the extent and duration of drawdown. Permanent (or partial) losses may include functional loss, spatial loss (acreage), or changes in community structure.

Specific criteria were developed to evaluate potential for indirect wetland impacts based on the extent and duration of groundwater drawdown, as outlined in Table 4.6-1. The groundwater drawdown zones identified below are consistent with sensitivity thresholds established for wetland surface drawdown in Appendix K.

Given the complexity of the analysis, there are too many variables to define a clear relationship between the groundwater and surface hydrology (X feet of groundwater drawdown = X feet of drawdown at the surface). In most cases, it is unlikely that drawdown at the wetland surface would occur in direct proportion to groundwater drawdown. Regardless, the wetlands may respond negatively and quickly to groundwater lowering, and duration would be a factor. Although a permittee-responsible mitigation plan has been developed to address all direct and indirect impacts associated with the proposed Project (see Section 4.6.7), long-term monitoring is required to measure potential losses (spatial and functional) within wetlands that are being indirectly affected.

Table 4.6-1 Criteria Used in Evaluating Indirect Wetland Impacts from Groundwater Drawdown

Maximum Extent of Groundwater Drawdown	Duration of Drawdown	Potential for Indirect Impact	Permanent Change or Loss of Function[a]
≤1 foot	Indefinite	None	No change in wetland area or condition.
1–2 feet	1–3 years	Low	Possible but not likely. Nearly all changes reversible with restoration of original seepage, inundation and duration patterns.
	≥3–10 years	Low/ moderate	Possible. ▪ Change in function more likely than loss of area. ▪ Loss of obligate species with low drought tolerance; temporary encroachment of upland species. ▪ Opportunity for nuisance species to become established and persist, especially with watershed disturbance. ▪ Few shifts in fauna and original populations; levels would likely re-establish through expansion of residual population. ▪ Potential loss of wetland acreage depends on geology and relative importance of baseflow, interflow, and runoff; losses likely would be minor.
	≥10 years	Moderate	Possible. ▪ Loss of obligate species with low drought tolerance may be permanent if seed bank and propagules are lost. ▪ Opportunity for nuisance species to become established and persist, especially with watershed disturbance. ▪ Some plant community changes are likely to be permanent. ▪ Shifts in faunal communities are likely. ▪ Potential for loss of wetland acreage depends on geology and relative importance of baseflow, interflow, and runoff. ▪ If there are losses in area, they most likely would be minor.
2–5 feet	1–3 years	Moderate	Possible. ▪ Potential for permanent loss of species with narrow hydrological tolerances. ▪ Potential for change in seed bank and propagules with resulting potential for some change in plant community after hydrologic restoration. ▪ Minor opportunity for nuisance species to become established and persist, especially with watershed disturbance. ▪ Fauna are likely to recover. ▪ Loss of wetland acreage is unlikely.

Table 4.6-1 Criteria Used in Evaluating Indirect Wetland Impacts from Groundwater Drawdown (Continued)

Maximum Extent of Groundwater Drawdown	Duration of Drawdown	Potential for Indirect Impact	Permanent Change or Loss of Function[a]
2–5 feet (continued)	≥3–5 years	Moderate/ major	Likely. ▪ Species likely to be lost include characteristic wetland obligates. ▪ Potential for change in seed bank and likely loss of many propagules with resulting potential for some change in plant community even after hydrologic restoration. ▪ Some opportunity for nuisance species to become established and persist, especially with watershed disturbance. ▪ Most fauna are likely to recover either from reduced population levels or by recolonization, assuming habitat continuity. ▪ Potential for permanent change depends on geology and relative importance of baseflow, interflow, and runoff. ▪ Loss of wetland acreage is unlikely.
	≥5 years	Major	Highly likely. ▪ More species are likely to be lost, including many obligate and facultative species. ▪ Likely change in seed bank and likely loss of most propagules, resulting in some change in plant community even after hydrologic restoration. ▪ Some opportunity for nuisance species to become established and persist, especially with watershed disturbance. ▪ Some fauna dependent on reliable hydrology likely would be lost. ▪ Potential for permanent change depends on geology and relative importance of baseflow, interflow, and runoff. ▪ Loss of wetland acreage is likely, especially in upper slope locations.
≥ 5 feet	1 year	Moderate	Likely. ▪ Species likely to be lost during drawdown period include characteristic wetland obligates and some facultative species. ▪ Potential for change in seed bank and some loss of propagules, resulting in potential for some change in plant community. ▪ Some opportunity for nuisance species to become established and persist, especially with watershed disturbance. ▪ Most fauna are likely to recover by recolonization, assuming habitat continuity. ▪ Loss of wetland acreage is unlikely.

Table 4.6-1 Criteria Used in Evaluating Indirect Wetland Impacts from Groundwater Drawdown (Continued)

Maximum Extent of Groundwater Drawdown	Duration of Drawdown	Potential for Indirect Impact	Permanent Change or Loss of Function[a]
≥ 5 feet (continued)	2–3 years	Moderate	Likely. ▪ Species likely to be lost during drawdown period include characteristic wetland obligates and some facultative species. ▪ Likely loss of many wetland species in seed bank and most propagules, resulting in potential development of different plant communities after restoration of hydrology. ▪ Substantial opportunity for nuisance species to become established and persist, especially with watershed disturbance. ▪ Potential changes in soil conditions, including microbial changes and changes in forms of nitrogen present ▪ Most fauna are likely to recover by recolonization, assuming habitat continuity. ▪ Loss of wetland acreage is unlikely.
	≥3 years	Major	Very likely. ▪ Permanent shift to an upland plant community unless hydrology is restored. ▪ Substantial opportunity for nuisance species to become established and thrive, especially with watershed disturbance. ▪ Changes in soil conditions, including microbial changes and changes in forms of nitrogen present. ▪ Fauna would not recover unless hydrology recovers. ▪ Loss of wetland acreage is probable.

[a] Severity of change and functional loss increases with the duration of drawdown and would be permanent if drawdown is not eliminated.

Streamflow

The effects of groundwater drawdown also were evaluated for streams in terms of baseflow reductions. Much like the wetland hydrology, the streams are primarily fed from groundwater baseflows, with surface runoff from precipitation as a secondary source. Therefore, reductions in baseflows are expected as a result of groundwater drawdown. Baseflow reductions are likely to result in partial loss of stream resources (and/or function) but would not necessarily result in a permanent loss of resources. Reduced flows may alter flow regime, stream morphology, and stream order. In some cases, perennial streams may experience no-flow conditions during seasonal variations where they may function more as intermittent streams. Changes in runoff also can be expected as a result of surface water alterations in the contributing watershed, which would contribute to streamflow reductions (or in some cases, increased flows from the stream diversion activities). The surface water analysis is a better predictor for hydrologic regimes in streams than in wetlands.

Runoff flows and baseflows provide different functions relative to the stream channel and the aquatic organisms it supports. Baseflows tend to provide a more constant habitat for aquatic life, while runoff flows in sufficient quantities form the channel and move sediment. Alterations in baseflows would therefore affect habitat conditions and aquatic organisms, while impacts on runoff flows would increase

or decrease the amount of sediment that is eroded from channel banks or stored in the channel bed. Runoff flows also provide natural variability to flow conditions that, in turn, support various stages of aquatic life. Impacts of altered baseflows and runoff flows on aquatic organisms are discussed in Section 4.7, "Aquatic Resources."

The surface water analysis used for streams was developed to characterize baseline flow conditions across the site and to predict changes in annual average flow throughout all active mining phases. The flow analysis focused on streams, as they contain measurable data for surface water flows. Because streamflow is fed both by surface runoff and groundwater baseflows (from riparian wetlands and hill slopes), the model evaluated both components to determine total flows (annual averages). Because baseflow is the more constant source of flow for streams, this analysis focuses on baseflow reductions associated with groundwater lowering activities. These baseflows also were evaluated relative to groundwater drawdown to evaluate whether there is a correlation between the two that would further substantiate the likelihood of wetland impacts. Data from both the groundwater model and surface water analysis were used to evaluate relative changes in net flows relative to the baseline conditions established for each affected stream reach (see Section 3.6). These relative changes were evaluated for each year of the active mining phase (Mine Years 0–14) to determine peak impacts, and for the post-mining phases to determine the duration of impacts and to determine the point at which hydrology may be recovered.

Specific criteria were established to evaluate changes in baseflows for streams, as outlined in Table 4.6-2. Duration of the change also was considered for purposes of the stream analysis. However, given that streams are highly sensitive to changes in flow, any changes involving altered flow regimes that would last for more than 1 year likely would result in permanent effects on stream morphology.

Table 4.6-2 Criteria Used in Evaluating Indirect Stream Impacts from Baseflow Reductions and Changes in Total Flow

Percent Change in Average Annual Stream Baseflow (or Total Flows)	Degree of Indirect Impact	Changes That May Occur
<10%	Low	Potential changes in stream condition would likely be unnoticeable.
10–20%	Moderate	Some changes in streamflow may be seen during low-flow conditions. May result in partial loss of stream function and direct impacts on aquatic resources.
>20%	Major	The character of the stream would likely change during low-flow conditions, including channel width, depths, and reduction (or increase) in flow velocity. Changes in flow regime may occur (perennial systems may become seasonal).

Watershed Alteration

As described above, watershed alterations could substantially affect the hydrology of wetland resources; but the direct impacts from the mine footprint also could contribute to substantial changes in the watershed, resulting in habitat fragmentation and altered stream morphology. Habitat fragmentation was evaluated qualitatively in conjunction with groundwater lowering activities in the impacts summary (Section 4.6.4) as fragmentation is likely to exacerbate hydrologic alterations in both wetlands and streams. Habitat fragmentation and stream morphology also were evaluated in terms of the aquatic resources using these systems (see Section 4.7, "Aquatic Resources"). The direct impacts on wetlands and streams are considered a permanent loss of habitat for aquatic resources (as well as the aquatic resources inhabiting these areas). Likewise, any indirect impacts on wetlands and streams associated with habitat fragmentation or other alterations (e.g., streamflow changes) contributing to habitat loss or degradation

would directly affect the aquatic fauna inhabiting these systems. In some cases, changes in water quality and stream temperature also could directly affect the aquatic resources using these systems. These impacts are expected to result more in losses of function and partial loss of resources as opposed to a permanent loss of resources. However, the true extent of impact would need to be evaluated through long-term monitoring.

Water Quality

Water quality was evaluated for both groundwater and surface water through a combination of modeling and qualitative analysis following the methods outlined in Sections 4.3, "Groundwater Hydrology and Water Quality" and 4.4, "Surface Water Hydrology and Water Quality." The modeling efforts also considered changes in water temperature that may exacerbate water quality concerns. Some of these impacts (change in stream temperature) may occur as a result of groundwater lowering activities; and therefore, may be indirect.

Although the criteria for potential water quality impacts are clearly defined, Water Quality Certification would be granted by the SCDHEC under Section 401 of the CWA, which assumes that no effluent limits or water quality standards would be violated. As such, the Applicant has outlined a number of water quality assurances in Section 4.4 to ensure compliance with the Section 401 Water Quality Certification. Long-term monitoring would be required to identify potential water quality violations during mining operations and post-mining.

4.6.4 Direct Impacts on Wetlands and Other Waters of the United States

Direct impacts on wetlands and Waters of the U.S. would result from dredging and filling activities associated with construction of haul roads, mining pits, OSAs, the TSF, and the diversion structure on Haile Gold Mine Creek. Below is a summary of the direct impacts associated with each alternative.

4.6.4.1 No Action Alternative

Under the No Action Alternative, ongoing reclamation and closure would continue and no additional mining would take place. As a result, no adverse impacts on wetlands and Waters of the U.S. would occur. However, incremental beneficial impacts on wetlands and Waters of the U.S. would be expected. As reclamation is completed, the habitat quality and biological integrity of wetlands and Waters of the U.S. previously affected by mining activity would be expected to continue to improve. Wetlands not previously mined would remain largely unchanged under the No Action Alternative.

4.6.4.2 Applicant's Proposed Project

Active Mining Period

Under the proposed Project, 120.46 acres of wetlands and open waters and 26,460.54 linear feet of streams would be directly affected by dredge and fill activities associated with pit excavation and construction of the TSF, OSAs, haul roads, and Mill, and installation of the Haile Gold Mine Creek diversion structure. The direct impacts are shown in Figure 4.6-3. Impacts associated with construction of the TSF and mining pits would be the most encompassing. Construction of haul roads would involve filling wetlands and piping sections of streams to accommodate road crossings. These impacts would result in a permanent loss of wetland and stream resources. Impacts associated with wetlands and streams are summarized in Table 4.6-3 based on habitat type. Additional details specific to each impact area are provided in Appendix K.

Wetlands

The proposed Project would result in permanent impacts on 120.46 acres to wetlands and open waters: jurisdictional wetlands (109.47 acres) and impoundments (10.99 acres). Direct impacts are summarized in Table 4.6-3. Details are shown in Appendix A (Waters of the US Direct Impact Analysis Detailed Plan, ERC 2012). The impacts primarily would affect forested wetlands (93.24 acres); however, herbaceous wetlands (5.72 acres), shrub wetlands (10.51 acres) and man-made impoundments (10.99 acres) also would be directly disturbed. The jurisdictional impoundments are classified as other Waters of the U.S. and are identified as *reaches* in the USACE-approved jurisdictional determination (USACE 2012) because they were originally part of the stream system before being dammed and converted to impoundments. Details specific to each impact area are included in Appendix K.

Streams

Under the proposed Project, a total of 26,460.54 linear feet of streams would be permanently lost from direct mining impacts, as shown in Table 4.6-3. The majority of these impacts would affect perennial systems (17,444.89 linear feet) as opposed to seasonal streams or non-relatively permanent waters (non-RPWs) (9,015.65 linear feet). Furthermore, the majority of streams that would be affected by the proposed Project are characterized as 1st- and 2nd-order streams (16,761.90 linear feet). All other streams that would be affected by direct impacts are characterized as 3rd-order streams (4,589.25 linear feet) or non-RPWs (5,109.39 linear feet). Detail for these stream impacts are shown in Appendix A (Waters of the US Direct Impact Analysis Detailed Plan, ERC 2012).

Table 4.6-3 Summary of Direct Impacts on Wetlands and Other Waters of the United States by Impact Type

Mine Activity Area	Impact Type	Impacts on Jurisdictional Wetlands (acres)			Impacts on Jurisdictional Impoundments (acres)	Impacts on Jurisdictional Streams (linear feet)
		Forested	Herbaceous	Shrub		
Duckwood Tailings Storage Facility	Fill	46.34	1.22	7.19	0.00	6,214.15
Haul roads[a]	Fill	5.84	0.00	0.00	0.00	2,097.87
Haile Gold Mine Creek diversion structure	Fill	2.77	0.00	0.00	0.00	427.13
Overburden storage areas	Fill	17.01	0.00	0.00	1.48	9,000.42
Pit-related activities[b]	Dredge and fill	21.28	4.50	3.32	9.51	8,720.97
Total Direct Impacts		93.24	5.72	10.51	10.99	26,460.54
		109.47			**10.99**	**26,460.54**

[a] Includes haul roads for Holly and Hock Tailings Storage Facility borrow areas, Duckwood TSF, the Mill, and the James and Ramona overburden storage areas. All other roads associated with pits are lumped under "pit-related activities."

[b] "Pit-related activities" include all dredge and fill impacts associated with eight mine pits and haul roads, including the Mill Zone, Snake, Haile, Red Hill, Ledbetter, Chase, Champion, and Small Pits.

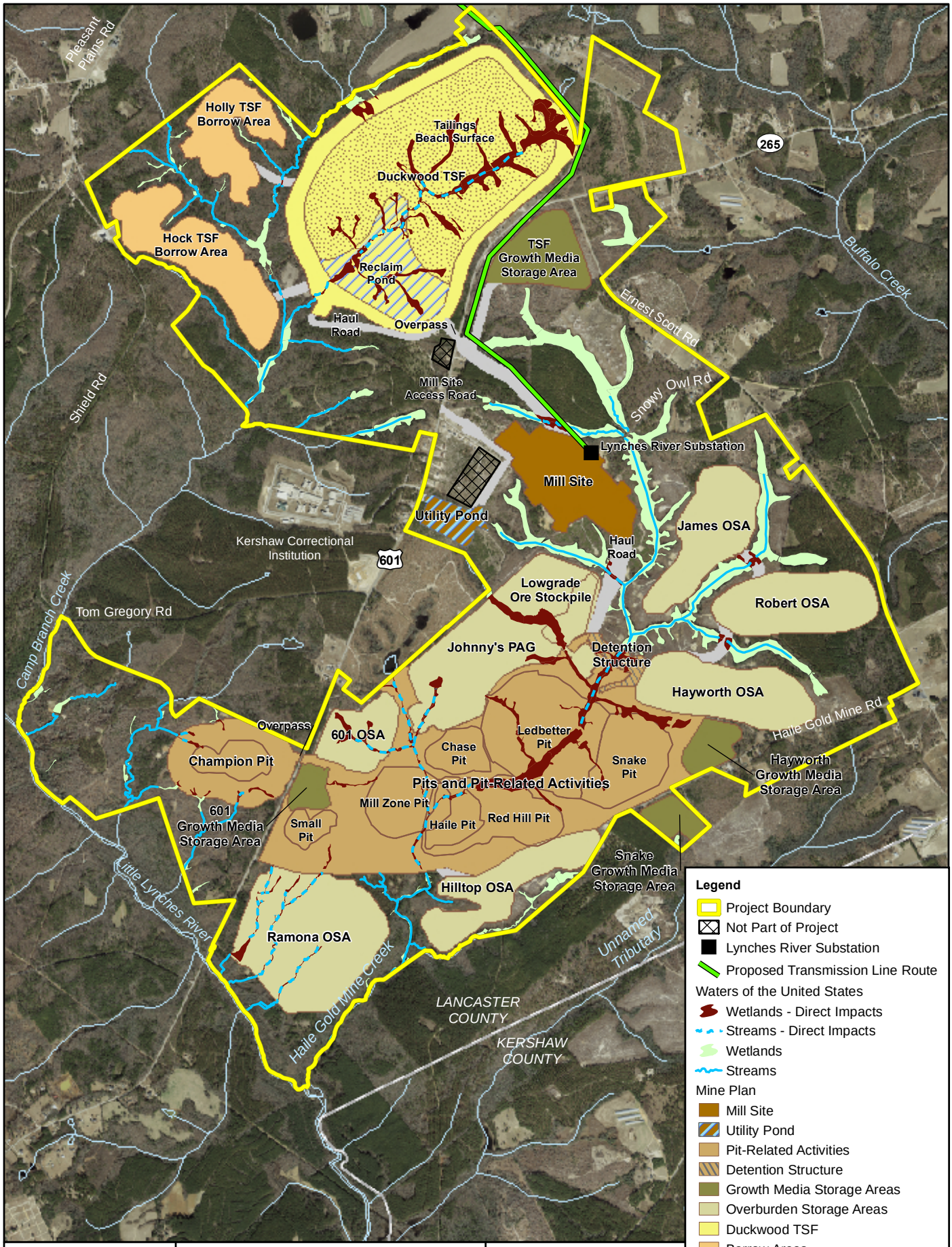

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Figure 4.6-3

Direct Impacts on Wetlands and Other Waters of the United States under the Applicant's Proposed Project

Post-Mining Period

No additional direct impacts are anticipated during reclamation or monitoring. Any areas within the footprint of proposed reclamation activities already would have been directly disturbed by dredge and fill activities during the active mining phase. Haile submitted a detailed Reclamation Plan (AMEC 2013) with a schedule of mining and reclamation activities (Appendix D). The plan outlines a number of activities intended to convert disturbed land to a stabilized condition that would provide for the long-term protection of land and water resources for post-mining land uses. Site reclamation would occur both during mining (concurrent reclamation) and after mining ceases (post-mining reclamation) (Appendix A).

During concurrent reclamation, while other pits are being mined, Haile, Mill Zone, Red Hill, and Chase Pits would be completely backfilled, and Snake Pit would be partially backfilled. Once active mining ceases, Ledbetter, Small, and Champion Pits would be allowed to refill with groundwater and surface water to form pit lakes and would be managed for acidity. The portion of Snake Pit that is not backfilled would form a lake that ultimately would become part of Ledbetter Pit Lake. All three pit lakes are expected to take approximately 20 to 25 years to fill. In addition, reclamation activities would also address the OSAs (Johnny's PAG and the OSAs with Green Class overburden), surface water management facilities, the TSF, Mill Site infrastructure, borrow areas, and other accessory facilities (including haul roads, utilities, pipelines, growth media storage areas, ore stockpiles, diversion structures, and weirs).

As part of these reclamation efforts, the central portion of the Haile Gold Mine Creek system would be minimally re-established to maintain hydrologic connectivity within the Haile Gold Mine Creek watershed. Some riparian wetlands are likely to re-establish in areas along these corridors where conditions allow (reclaimed grades, soils, and hydrologic conditions). The reclaimed corridors are depicted on the Post-Mining Land Use Map included in the Reclamation Plan (Appendix D). A wetland seed mix would be used where wetlands and riparian areas are part of reclamation, resulting in a community of palustrine emergent wetland vegetation that likely would transition into the more typical characteristic forested wetland community through natural successional processes (Haile 2013). In addition to the reclaimed stream corridors, substantial open-water habitat would be created as a result of the pit lakes associated with Ledbetter Pit, Champion Pit, and Small Pit.

4.6.4.3 Modified Project Alternative

The Modified Project Alternative is virtually the same as the Applicant's Proposed Project in terms of direct impacts on wetlands and other Waters of the U.S., except that a refined footprint for the Ramona OSA would avoid three headwater streams that are shown on Figure 4.6-3 within the footprint of the Ramona OSA. This alternative would eliminate 2.22 acres of wetland impacts and 7,111.22 linear feet of stream impacts, resulting in a total of 118.24 acres of direct impacts on wetlands and 19,349.32 linear feet of direct impacts on streams. This alternative provides for a 2-percent reduction in direct impacts on wetlands and a 27-percent reduction in direct impacts on streams.

Active Mining Period

During active mining, a total of 118.24 acres of direct impacts on wetlands and 19,349.32 linear feet of direct impacts on streams would be caused by dredge and fill activities necessary for pit excavation; construction of the TSF, OSAs, haul roads, and Mill; and installation of Haile Gold Mine Creek diversion structure. Modification of the Ramona OSA would substantially reduce direct impacts, particularly on streams.

Post-Mining Period

Post-mining/reclamation period impacts under the Modified Project Alternative would be the same as those for the Applicant's Proposed Project. No additional direct impacts on wetlands or streams would occur from dredge and fill activities during the post-mining period as areas being reclaimed would already have been disturbed by dredge and fill activities. The same reclamation activities would occur as outlined in the Haile Reclamation Plan (Appendix H), except that reclamation activities in the footprint of Ramona's OSA would be unnecessary under this alternative.

4.6.5 Indirect Impacts on Wetlands and Other Waters of the United States

Indirect impacts that could occur as a result of the proposed Project based on hydrologic alterations, watershed alterations, and water quality impacts are described below.

4.6.5.1 Hydrologic Alteration

No Action Alternative

Under the No Action Alternative, indirect impacts on wetlands and other Waters of the U.S. would not occur from hydrologic alterations.

Applicant's Proposed Project

Active Mining Period

Wetlands

Hydrologic alterations associated with wetlands are primarily tied to groundwater lowering activities, the results of which are outlined in Appendix K (see Summary of Indirect Impacts on Wetlands). This appendix summarizes the maximum extent of groundwater drawdown for each wetland and the total duration of drawdown within various drawdown zones for both the active mining and the post-mining recovery periods. The appendix also shows whether the groundwater table would fully recover within each wetland and references a number of other variables that indicate the potential for indirect impacts (Section 4.6.4).

As detailed in Table 4.6-4, the Applicant's Proposed Project could result in 982.58 acres of indirect impacts on wetlands where groundwater drawdown in excess of 1 foot would occur for sustained durations during both the active mining and post-mining periods. Of the potential indirect wetland impacts, 149.72 acres are associated with wetlands inside the Project boundary and 832.86 acres are associated with wetlands outside the Project boundary. When considering the potential indirect wetland impacts shown in Table 4.6-4, it should be noted that some of these areas are also identified as being affected by habitat fragmentation (Section 4.6.3.2). The indirect impacts summarized in Section 4.6.4 take into consideration all sources of indirect impacts.

Table 4.6-4 groups the wetlands in three categories of groundwater drawdown zones based on criteria outlined in Table 4.6-1. Any areas that experience less than 1 foot of drawdown were not considered as a potential impact. For areas that exceed 5 feet of groundwater drawdown, drawdown at the surface is likely to result in indirect wetland impacts. Drawdown in the more moderate zones (1–5 feet) also has potential for indirect impacts, and the potential increases with increasing duration of drawdown. It is unlikely that indirect impacts would occur with lower levels of drawdown (1–2 feet) occurring over shorter periods of time (<3 years). However, even in areas that are expected to maintain wetland function, prolonged

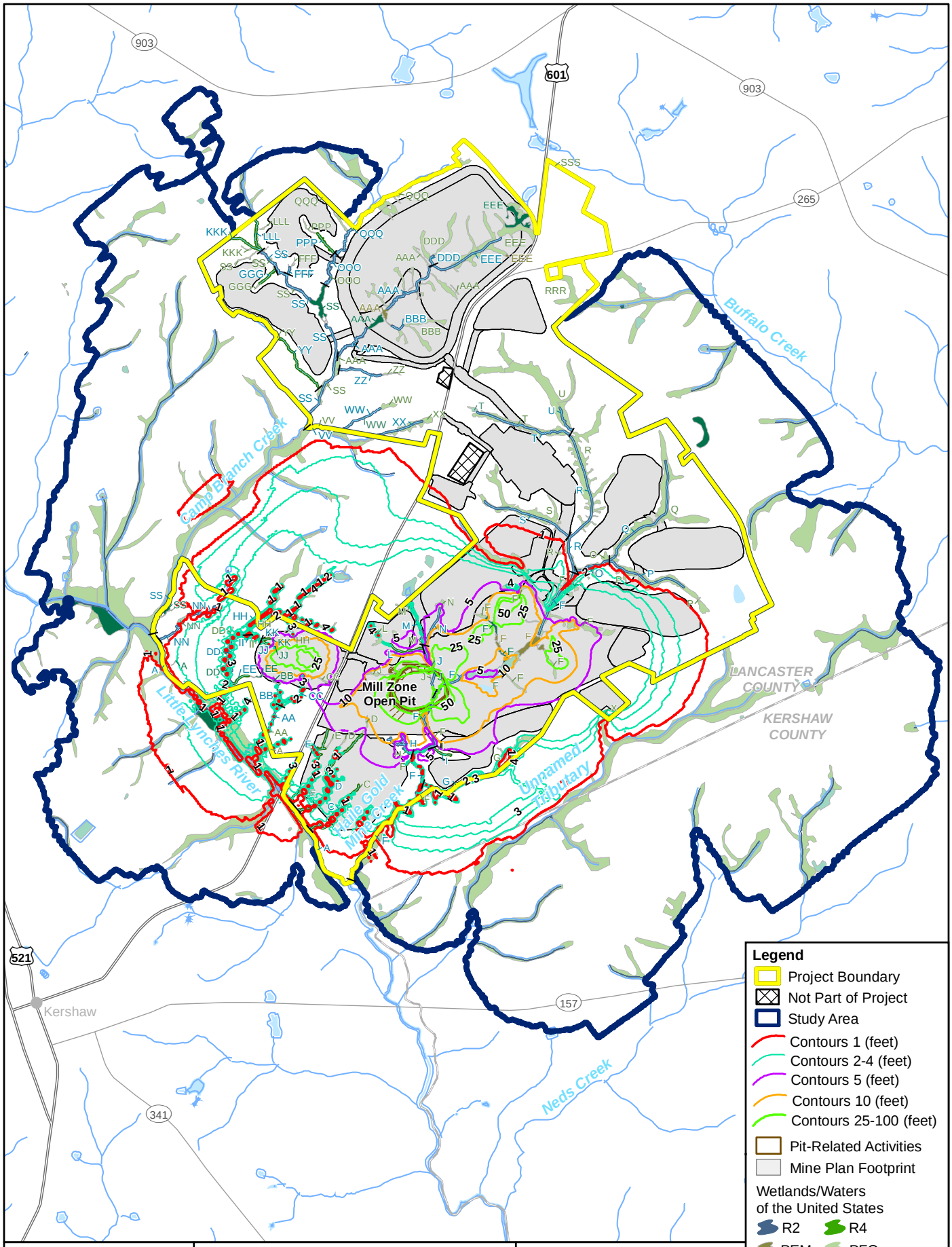
periods of change in the seasonal hydrologic regimes has the potential to cause permanent changes in wetland habitat and community structure. Long-term monitoring would be required to measure the true extent of functional or spatial losses.

Table 4.6-4 Summary of Potential Indirect Impacts on Wetlands and Open Waters Associated with Groundwater Lowering

Water Type	Habitat Type	Groundwater Drawdown		
		1–2 Feet of Groundwater Drawdown	2–5 Feet of Groundwater Drawdown	>5 feet of Groundwater Drawdown
Wetland	Forested	34.73	23.85	88.20
	Scrub-shrub	0.00	0.00	1.27
	Herbaceous	0.00	0.00	0.38
Other waters	Open water	0.90	0.00	0.39
Total Indirect Impacts inside Project Boundary		35.63	23.85	90.24
Wetland	Forested	241.60	376.43	168.39
	Scrub-shrub	0.00	4.96	9.24
	Herbaceous	0.00	0.00	0.00
Other waters	Open water	13.59	9.67	8.98
Total Indirect Impacts outside Project Boundary[a]		255.19	391.06	186.61
Total Indirect Impacts		290.82	414.91	276.85

[a] Any areas of potential impact identified outside of the Project boundary are based on interpretation of wetland lines in aerial photographs; therefore, acreages are approximate.

As shown in Appendix K, some wetlands may be subjected to as much as 100 feet of groundwater drawdown relative to baseline conditions. The extent of drawdown typically follows the sequence of pit excavation, and more drawdown generally would occur when the deeper pits are being excavated. The drawdown contour maps depict the expanding zone of influence associated with select years (Mine Years 0, 7, and 14) of active mining (Figures 4.6-4 through 4.6-6). Drawdown contour maps are also provided for each year of active mining (see Appendix K) consistent with groundwater contour maps provided in Section 4.3. The outermost zone of influence (the 1-foot-drawdown contour shown in red) overlaps the study area boundary on Mine Year 14 and was used to define the study area in which wetlands and streams could be potentially affected by the proposed Project.



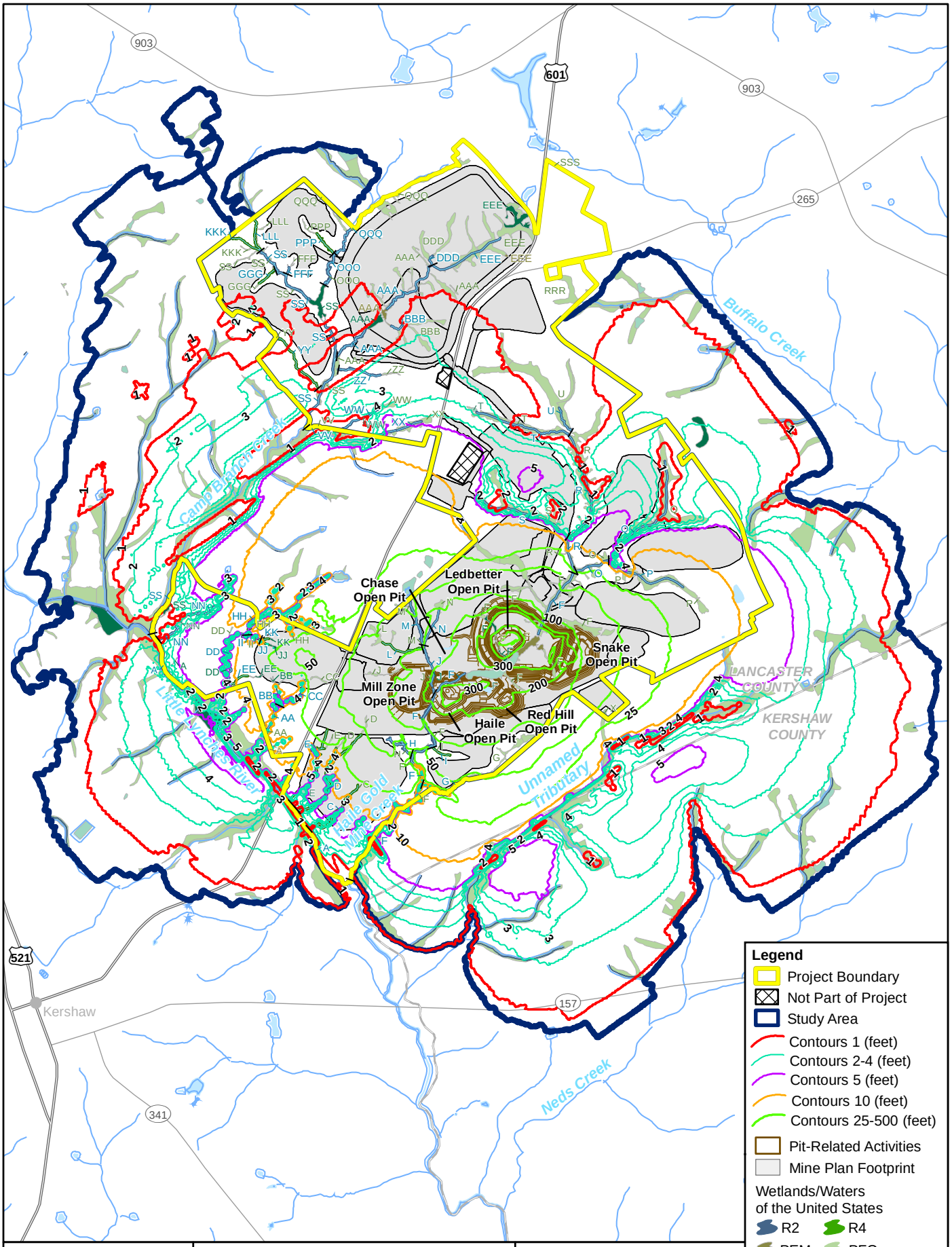
Haile Gold Mine Environmental Impact Statement
www.HaileGoldMineEIS.com

Figure 4.6-4

Groundwater Drawdown Contour Map (Mine Year 0)

0 1,500 3,000 Feet
0 500 1,000 Meters

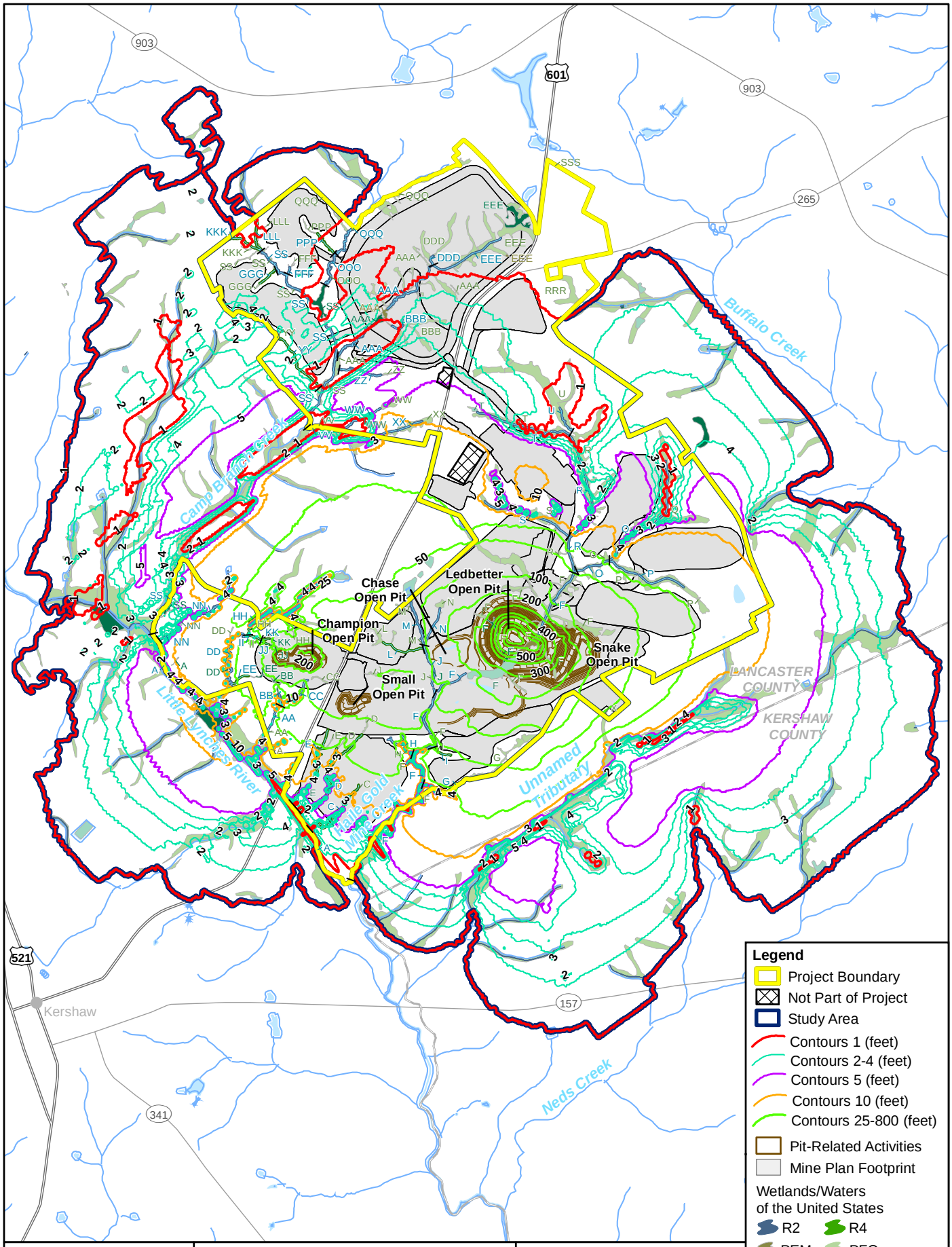
Sources: ESRI 2008, Haile 2013.



Haile Gold Mine Environmental Impact Statement
www.HaileGoldMineEIS.com

Figure 4.6-5

Groundwater Drawdown Contour Map (Mine Year 7)



Haile Gold Mine Environmental Impact Statement
www.HaileGoldMineEIS.com

Figure 4.6-6

Groundwater Drawdown Contour Map (Mine Year 14)

0 1,500 3,000 Feet
0 500 1,000 Meters

Sources: ESRI 2008, Haile 2013.

Drawdown contours also are shown in Figure 4.6-7 for Mine Year 14, when the maximum extent of drawdown would occur at the end of the active mining period. The extent of drawdown is closely correlated to proximity of the dewatering activity (as shown in Figure 4.6-8, where areas immediately surrounding the pit-related activities would be exposed to greater groundwater drawdown). Although surface runoff would persist in light of groundwater lowering activities, in most cases, the amount of runoff from precipitation would not be sufficient to recharge the wetlands. Likewise, the mining activities would result in substantial topographic changes that would alter the source of seepage supporting wetland hydrology. The hydrology for slope wetlands is primarily supported by groundwater. Any slope runoff from precipitation would not be sufficient to sustain the hydrologic regime typically found in these systems, and recharge of the groundwater table by precipitation may be inadequate to overcome the induced drawdown caused by dewatering activities. Any drawdown that eliminates water mounding under the hill that is the water source for the seepage would eliminate groundwater flows into the wetland (Stein et al. 2004). Topographic changes were considered in evaluating potential for indirect wetland impacts, as outlined in Appendix K.

The duration of drawdown also contributes to the extent of impact. Appendix K summarizes the duration (years) of drawdown within each zone of influence for both the active mining period and post-mining period. The appendix also summarizes the total duration of drawdown within the 1–5 foot zones and >5-foot zones, which includes both the active mining and post-mining periods. The purpose for distinguishing between these zones is to identify those areas with higher potential for indirect impacts (>5 feet). As shown in the appendix, any areas with greater than 5 feet of groundwater drawdown would experience drawdown for prolonged periods of time during active mining (>10 years), and this does not take into consideration the recovery period (post-mining). Areas subjected to lower levels of drawdown (1–5 feet) generally have shorter duration (<10 years) during active mining, as the majority of drawdown in these areas occurs in the range below 1 foot.

Streams

Indirect impacts on streams were evaluated based on baseflow reductions and surface water alterations, but were quantified based on changes in baseflows because they are critical to the baseline hydrologic regime of streams. Indirect impacts on streams are summarized in Appendix K based on changes in annual average baseflows. As shown in Table 4.6-5, a total of 80,483.35 linear feet of indirect stream impacts would occur as a result of hydrologic alterations from groundwater lowering activities and surface water alterations. Of the predicted indirect impacts on streams, 45,147.48 linear feet are associated with streams inside the Project boundary and 35,335.87 linear feet are associated with streams outside the Project boundary. These impacts are primarily tied to baseflow reductions. Runoff flows would decrease during mining in upper and lower Camp Branch Creek, the unnamed tributary near the western side of Champion Pit, all three tributaries covered by the Ramona OSA, and Haile Gold Mine Creek within and downstream of the mining area. Runoff flows would increase during mining in the unnamed tributary near the southern side of Champion Pit and in upper Haile Gold Mine Creek. Mine releases would increase flows in Haile Gold Mine Creek and the Little Lynches River downstream during mining.

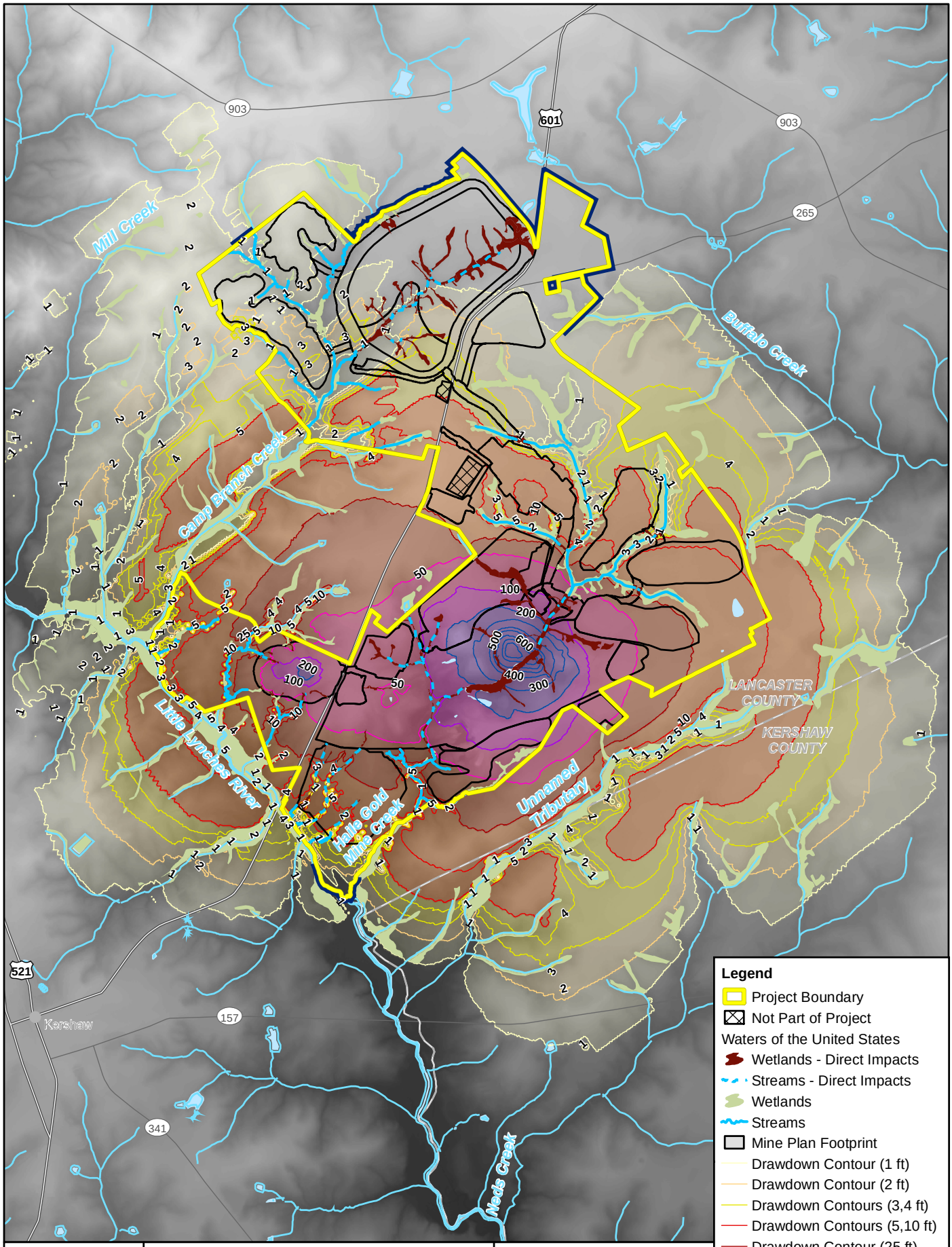


Figure 4.6-7

Drawdown Contours at Maximum Extent of Drawdown during Active Mining (Mine Year 14)

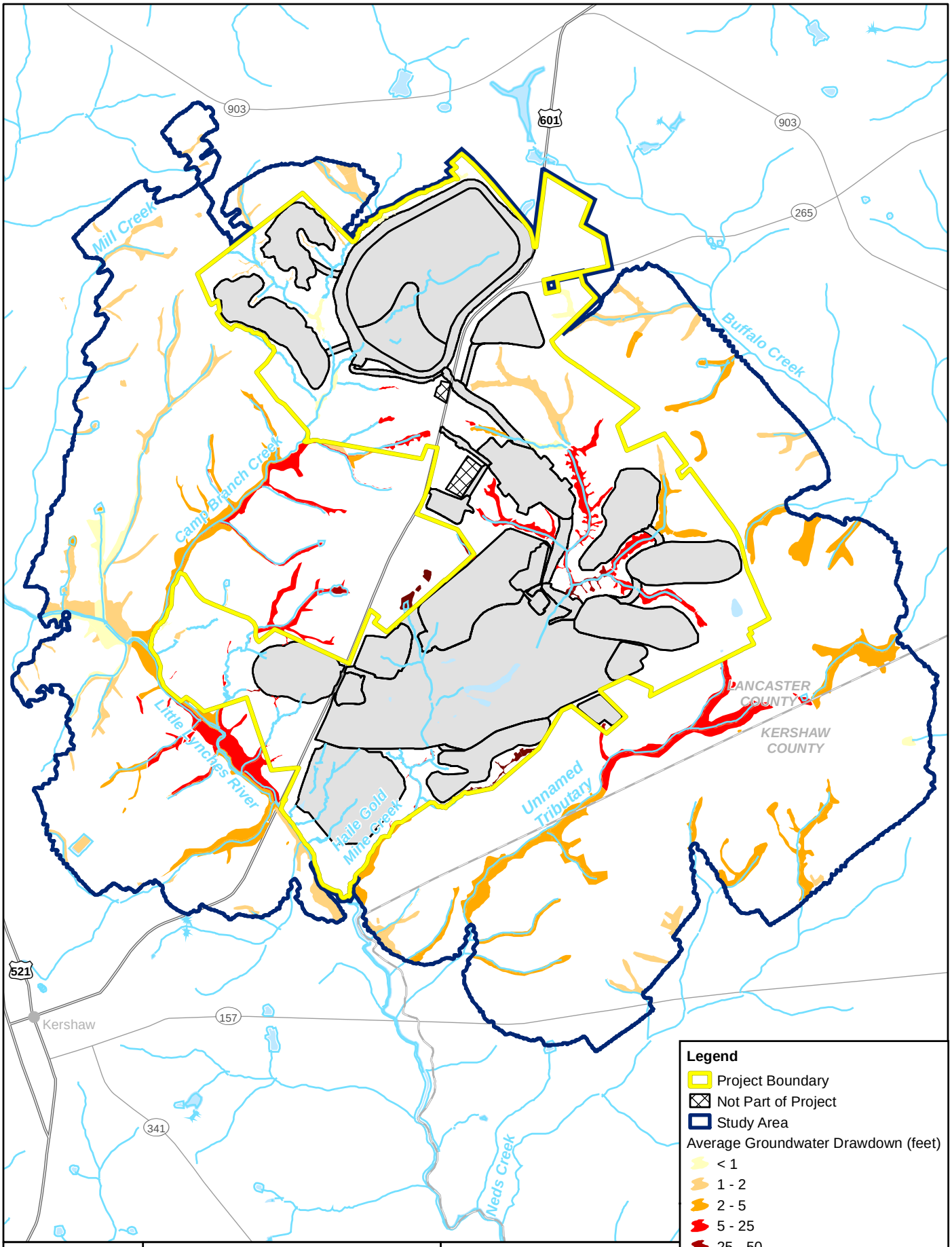


Figure 4.6-8

Maximum Extent of Average Groundwater Drawdown in Wetlands and Other Waters of the United States (Mine Year 14)

0 1,500 3,000 Feet

0 500 1,000 Meters

Sources: ESRI 2008, Haile 2013, SCDNR 2013.

Table 4.6-5 Summary of Potential Indirect Impacts Associated with Stream Baseflow Reductions

Streams Associated with the Project	Moderate Impacts (linear feet)	Major Impacts (linear feet)
Streams inside the Project boundary	3,591.50	41,555.98
Streams outside the Project boundary	8,457.97	26,877.90
Total indirect impacts	**12,049.47**	**68,433.88**

The indirect stream impacts shown in Table 4.6-5 are grouped based on criteria outlined in the "Methods" section. Any areas with less than a 10-percent change in flows were considered minor for purposes of this analysis. The impacts estimated for areas outside the Project boundary are approximate as streams were mapped through interpretation of aerial photographs, and measurements have not been formally verified in the field.

Similar to drawdown, the most substantial changes in streamflow would occur close to the dewatering activities and direct mining activities, as depicted in Figure 4.6-9. All indirect impacts identified for streams are associated with reduced flows—except for lower Haile Gold Mine Creek, which would experience substantial increases in flows from mine water releases and discharges from the stream diversion pipe. Drawdown also is considered given the correlation with baseflow reductions. The changes in baseflows outlined in Appendix K are annual averages and do not reflect seasonal variations. Results of the analysis show that none of the streams would lose complete flow in terms of annual averages. However, when seasonal variation is considered, some streams could experience sustained periods of no flow or low flow. This could result in a change in flow regime in which perennial streams may transition into seasonal (intermittent) systems. Changes in stream order also have the potential to occur from these changes in flow (e.g., 1st-order seasonal stream transitions to non-RPW). Depending on the extent of change, streamflow reductions (or increases) also could result in substantial changes in stream morphology by altering natural erosion and sedimentation patterns within the stream systems.

Duration is also a critical factor in evaluating indirect stream impacts, although streams have far less tolerance than wetlands. Therefore, any changes that would last for more than 1 year were considered permanent for purposes of this analysis. All baseflow changes would occur in conjunction with groundwater drawdown; and therefore, would occur throughout the active mining phase (through Mine Year 14). When considering the impacts outlined in Table 4.6-5, it should be noted that some of these reaches also were identified as being affected by habitat fragmentation (Section 4.6.3.2). All indirect impacts were summarized and evaluated cumulatively in Section 4.6.4.

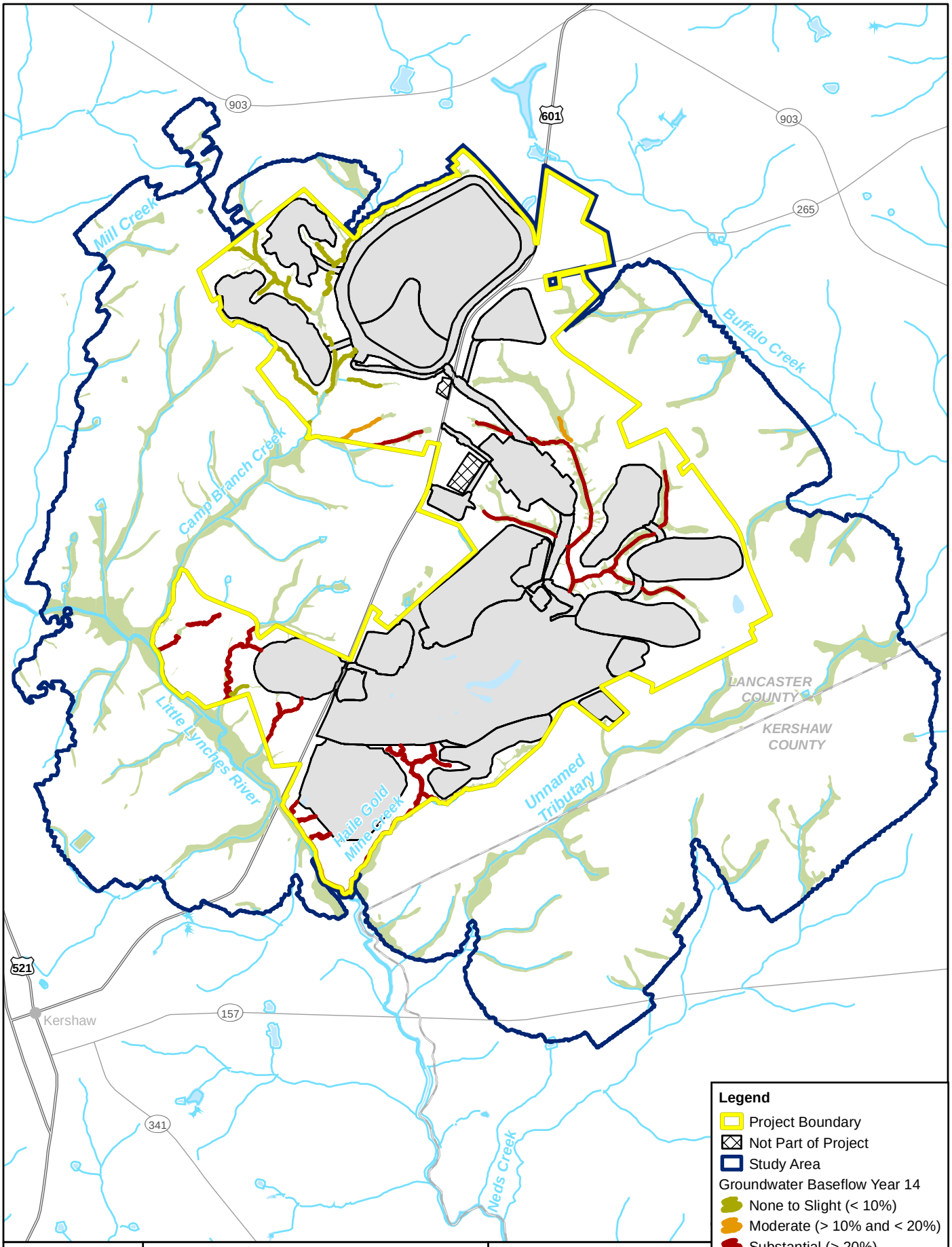


Figure 4.6-9

Maximum Extent of Annual Average Baseflow Reductions in Streams (Mine Year 14)

0 1,500 3,000 Feet

0 500 1,000 Meters

Sources: ESRI 2008, Haile 2013, SCDNR 2013.

Post-Mining Period

Groundwater lowering would cease at the end of the active mining period. Therefore, no additional wetland or stream impacts would occur as a result of drawdown and baseflow reductions during the post-mining period. However, the impacts sustained during active mining would persist during the post-mining/reclamation phase until the groundwater table recovers (see Appendix K). Recovery of the groundwater table would take substantially longer than the drawdown since it would occur naturally as opposed to being artificially pumped. The recovery period is driven by the extent of drawdown and other variables (geology, topography, slope, watershed position). Also, long-term topographic changes associated with mining and post-reclamation activities may result in permanent watershed alterations that either remove or divert mounding sources of seepage to wetlands and streams. As a result, this could prolong the recovery period for the groundwater table. A slight increase of surface runoff is expected throughout the Project area post-mining with the exception of the tributaries near Champion Pit. While this may improve flows for some of the streams, there would still be an overall decrease in total flows (relative to baseline conditions) within most of the reaches.

Hydrologic regimes of wetlands that are subjected to a lesser extent of drawdown (relative change) or shorter periods of drawdown may recover within 0–5 years following post-mining (after Mine Year 14). Likewise, hydrologic regimes of wetlands that are subjected to either a greater extent of drawdown or longer periods of drawdown would take several years to recover following completion of dewatering activities, and in some cases, decades before baseline conditions return. Some areas—particularly those anticipated to experience major drawdown—may not fully recover, or may take over 40 years. The recovery periods for wetlands and streams are summarized in Appendix K to show the duration of impact for consideration of temporal losses. Temporal losses ultimately could result in permanent functional losses, change in community structure, and in some cases, total loss of resources. Following groundwater recovery, it may take several years for wetland communities to re-establish, particularly where drawdown occurs long enough to allow colonization of upland and nuisance species. As detailed in Appendix K, the groundwater table would not recover in many cases at the end of Mine Year 54 (40 years post-mining) encompassing a total of 169.96 acres of wetlands (within the study area).

Post-mining recovery periods for the groundwater table and baseflows[4] are represented in Figures 4.6-10 and 4.6-11. As shown, the areas that are close to the dewatering activities around the pits would require the longest recovery periods (~40 years post-mining, Mine Year 54) and, in some cases, may not recover fully.

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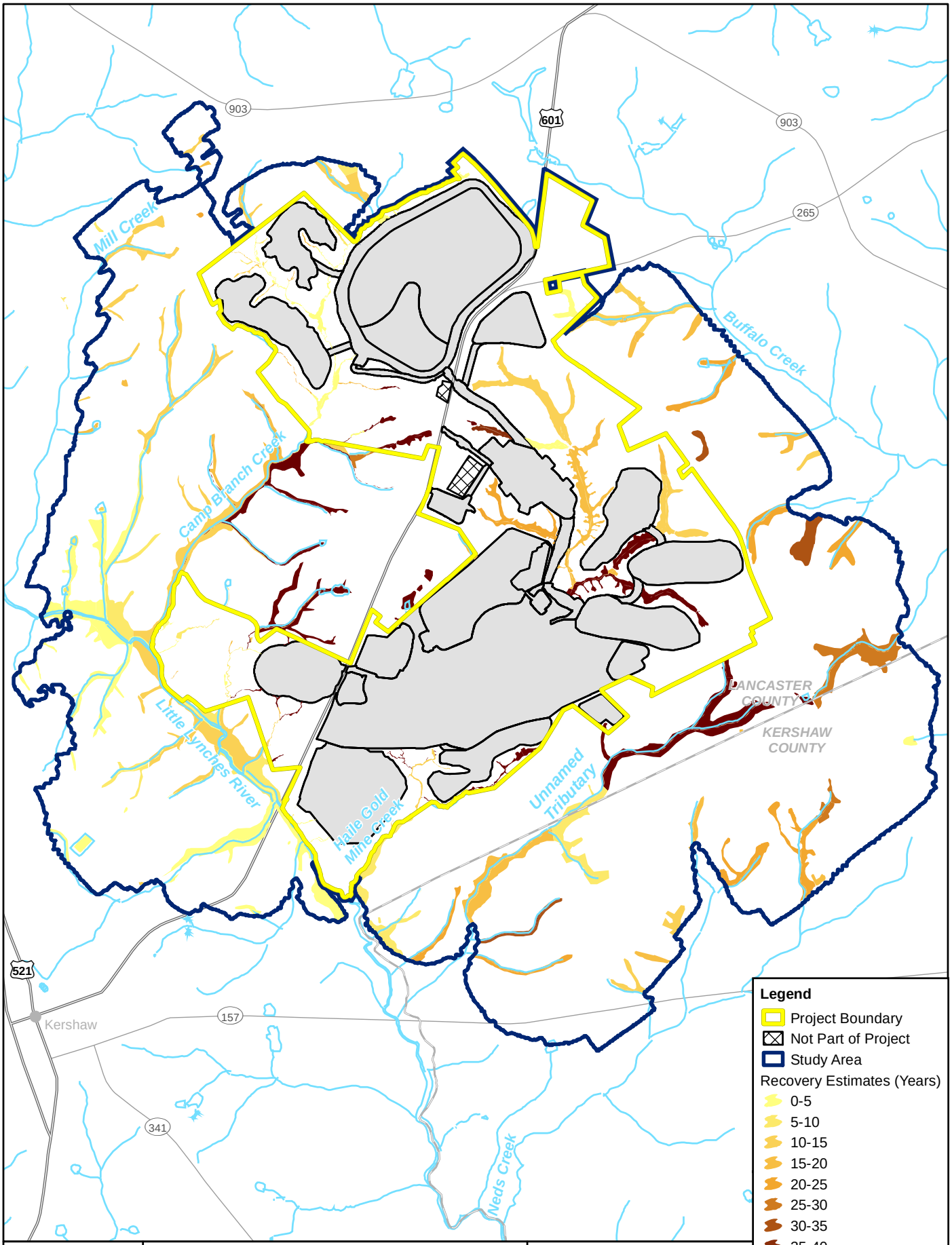
[4] Baseflow recovery estimates are provided only for wetlands and streams inside the Project boundary. The model did not address recovery of flows outside the Project boundary.



Haile Gold Mine Environmental Impact Statement

Figure 4.6-10

Post-Mining Recovery Periods for Groundwater Table

0 1,500 3,000 Feet

0 500 1,000 Meters

Sources: ESRI 2008, Haile 2013, SCDNR 2013.

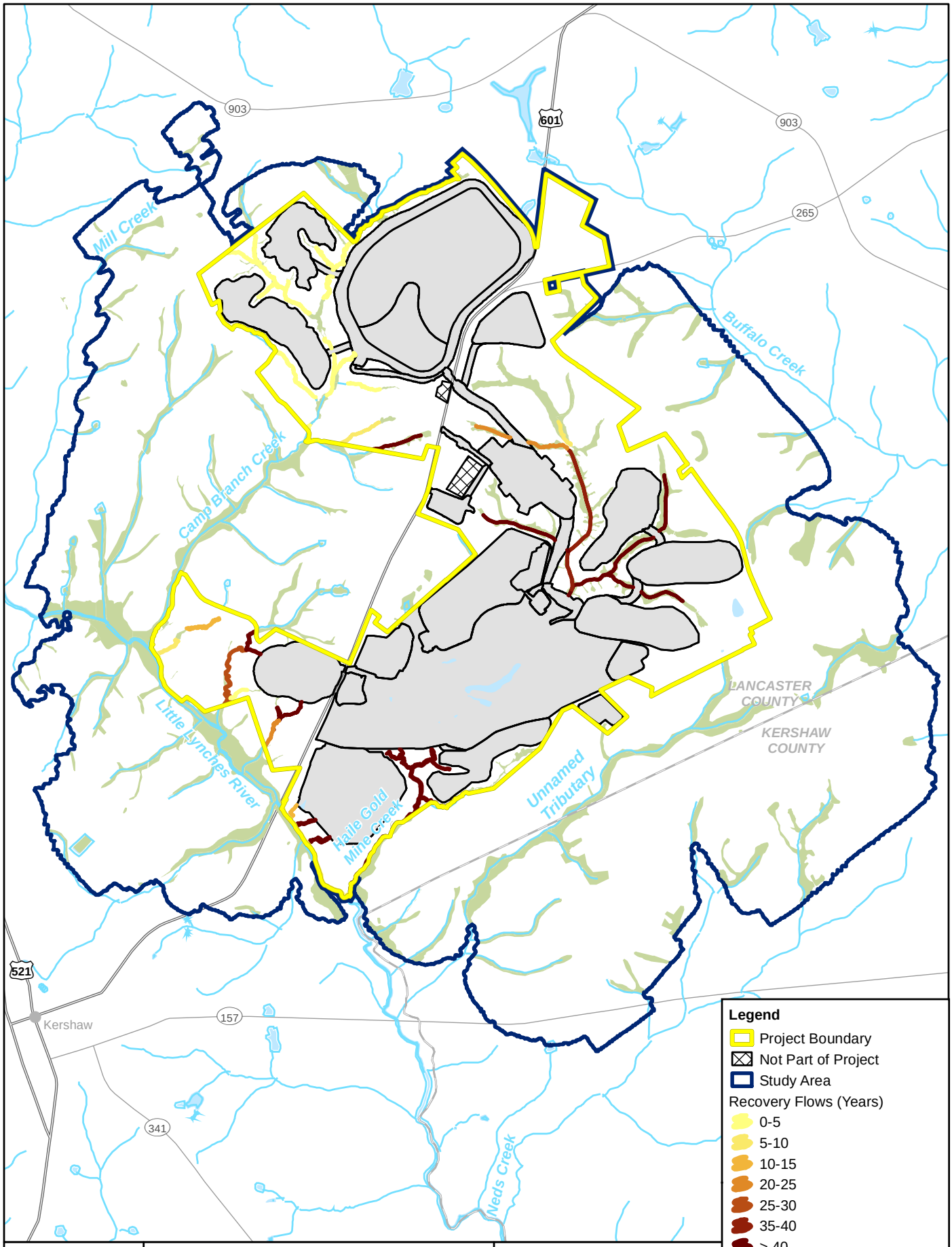


Figure 4.6-11

Post-Mining Recovery Periods for Baseflows

0 1,500 3,000 Feet

0 500 1,000 Meters

Sources: ESRI 2008, Haile 2013, SCDNR 2013.

Modified Project Alternative

Active Mining Period

Although the Modified Project Alternative would avoid direct impacts on streams in the footprint of the Ramona OSA (Figure 4.6-3), these areas would still be exposed to sustained periods of drawdown during mining activities because of their proximity to pit dewatering activities. Therefore, impacts related to baseflows associated with the Modified Project Alternative would essentially be the same as the impacts described for the Applicant's Proposed Project, except for the cause of the impacts. Baseflow impacts under the Modified Project Alternative are considered major and would equate to the same amount of loss as the direct impacts in the Applicant's Proposed Project. However, wetlands and streams can be expected to recover to the same extent as the groundwater table recovers. These impacts equate to 2.73 acres of indirect wetland impacts (open water and forested wetlands) from drawdown and 9,613.69 linear feet of indirect stream impacts from substantial changes in flow.

Post-Mining Period

Similar to the Applicant's Proposed Project, the Modified Project Alternative would not result in any additional indirect impacts during the post-mining/reclamation period. The groundwater table and flows would take a while to return to baseline conditions, similar to the recovery periods for the Applicant's Proposed Project. Therefore, temporal loss of wetland and stream functions is expected to continue during post-mining/reclamation and long-term phases of mine operations. However, after the water table recovers, some functions are expected to be restored in the streams within the footprint of Ramona OSA under this alternative, as opposed to the Applicant's Proposed Project, which would result in permanent impacts on these systems.

4.6.5.2 Watershed Alteration

Below is an overview of habitat fragmentation effects that are being considered for indirect impacts on wetlands and streams. Watershed alterations pertaining to topographic changes and surface water hydrology are addressed under "Hydrologic Alterations."

No Action Alternative

Under the No Action Alternative, indirect impacts on wetlands and other Waters of the U.S. associated with habitat fragmentation would not occur.

Applicant's Proposed Project

Active Mining Period

The majority of indirect impacts associated with watershed alterations would occur because of habitat fragmentation and changes in hydrology from direct mining activities. Habitat fragmentation is expected in both the upstream and downstream portions of the Applicant's Proposed Project, including upper Camp Branch Creek, upper Haile Gold Mine Creek, and lower Haile Gold Mine Creek.

Habitat fragmentation associated with upper Camp Branch Creek would result from the proposed activities in this area including the TSF, Holly and Hock TSF borrow areas, and large haul roads. The two haul roads would affect portions of upper Camp Branch Creek (200 linear feet each), which would be piped to maintain connectivity between upstream and downstream portions of the creek. Activities

associated with upper Camp Branch Creek are expected to moderately affect wetland and streams within this subwatershed.

The majority of upland habitats in the surrounding landscape would be removed, which could result in a loss of seed sources within the wetlands. Once the surrounding areas are converted to industrial uses, invasive species likely would colonize the edges of wetlands. These types of fragmentation effects are known to slow recovery after rehydration and provide the opportunity for highly adaptive, fast-growing species to colonize the wetlands. In addition, fragmentation is well documented to change habitat quality for many wetland-dependent wildlife species. Amphibians that depend on wetlands for reproduction and uplands for their adult stages would lose their adult habitats. The amount of "edge" of boundary between natural and disturbed areas would increase, and edge habitats are used by different species of birds than those occupying areas with continuous forest. Any species that requires natural streams and wetlands to complete its life cycle has the potential to experience inadequate habitat area, absence of specific required habitats, or isolation from other areas of habitat when connections are severed. Almost all animals that use stream corridors for travel or migration are likely to find the corridors narrower, potentially noisy, converted into culverts, or otherwise made less suited to their use. The overall effect of habitat fragmentation has been documented as less diversity of both plants and animals, and a shift from the original species composition to one that is more common and less dependent on specific habitat conditions.

Habitat fragmentation also is expected to occur in the upper and lower portions of Haile Gold Mine Creek. This is because pit-related activities would affect the central portion of this creek corridor, eliminating all wetlands and stream resources that otherwise would serve as corridors for aquatic organisms. The upper portion is expected to experience the most substantial impacts because connectivity would be severed from the downstream portion, except for the stream diversion pipe. Although hydrologic connectivity would be maintained through a stream diversion pipe, the pipe would extend over 12,000 linear feet. Aquatic organisms are not likely to use this structure, given its linear extent and lack of appropriate habitat inside the pipe. Consequently, aquatic organisms using the upper creek area would become isolated as they would no longer be able to interact with organisms in downstream systems. For the impact assessment, it was assumed that some aquatic organisms (e.g., the Sandhills chub) that currently use the upper reaches for critical portions of their life cycles could eventually die off if there is no opportunity for spawning and genetic exchange with other portions of the species population. A combination of inadequate water in the habitat areas coupled with the inability to recolonize could lead to elimination (NC Sandhills Conservation Partnership 2004; Rohde and Arndt 1991). The intensity of this impact would vary by species. The diversion structure also could alter upstream flows, stream morphology, and thermal regimes which could result in habitat changes not suitable for some aquatic species. In addition, a number of haul road crossings are proposed in the upper reaches that would be piped to maintain hydrologic connectivity. The pipes used for these haul roads would range from 260 to 614 linear feet. Given the habitat fragmentation concerns in the upper reaches, indirect impacts in this area have been designated as major.

Habitat fragmentation also is a concern for the downstream portion of Haile Gold Mine Creek because habitat connectivity would be severed from the upstream portion. The downstream portion also is expected to experience changes in stream morphology from increased velocity of flows and scouring generated from the pipe that would alter natural erosion and sedimentation patterns in the stream. The lower portion of the creek would maintain connectivity with downstream areas (Little Lynches River); therefore, indirect impacts in this area are designated as moderate. The downstream portion also is expected to experience localized changes in stream morphology associated with piping that may alter natural erosion and sedimentation patterns in the stream. In addition to the separation of upper and lower portions of Haile Gold Mine Creek, wetlands and streams would be fragmented by Johnny's PAG.

In addition to the fragmentation associated with the direct mine footprint, habitat fragmentation may occur from hydrologic alterations associated with groundwater lowering activities. Groundwater lowering could result in long-term or permanent loss of wetlands and streams, which could sever hydrologic connectivity within the corridors that otherwise would be connected under normal hydrologic regimes. Fragmentation from hydrologic alterations could occur in virtually every wetland and stream in the Project area (outside of the direct mine footprint) and in some cases outside of the Project boundary. Any loss of resources (spatial or functional) would be measured through long-term monitoring of water quality, thermal regimes, hydrology, vegetation, and aquatic organisms. These areas of potential impact generally overlap wetlands and streams that would be monitored for groundwater lowering impacts.

Post-Mining Period

Drainage channels would be minimally re-established as part of the reclamation efforts to partially restore the subwatersheds. Once the groundwater table recovers, flows in many streams are expected to recover to pre-mining levels, but the flow in some streams nearest the pits are unlikely to recover fully. Therefore, effects on the associated stream and floodplain habitats may be long term or permanent. Some riparian wetlands are likely to re-establish in areas along these corridors where conditions allow (reclaimed grades, soils, and hydrologic conditions). However, the full range of natural communities and habitat that may be required for long-term maintenance of some species may not return. This could be particularly important for species with specific habitat requirements. The reclaimed corridors are depicted on the Post Mining Land Use Map included in the Reclamation Plan (Appendix D).

Modified Project Alternative

Active Mining Period

The Modified Project Alternative would result in the same habitat losses as those described for the Applicant's Proposed Project, except for avoiding the streams within the footprint of the Ramona OSA as a result of reconfiguring the Ramona OSA. Although these reaches would be avoided, they would still be subject to major hydrologic impacts that could in turn adversely affect any habitat uses in the corridors, should the streams go dry from dewatering activities or be subject to pollutant discharges from upstream activities.

Post-Mining Period

Post-mining and reclamation activities associated with the Modified Project Alternative would involve the same activities as those described for the Applicant's Proposed Project, except for reclamation associated with the Ramona OSA under the proposed Project. Streams within the footprint of the Ramona OSA would be avoided under the Modified Project Alternative; therefore, no reclamation would be required, and habitat function is expected to be restored when groundwater levels and flows recover.

4.6.5.3 Impacts on Water Quality

As detailed in Section 4.4, "Surface Water Hydrology and Water Quality," active mining operations and post-mining/reclamation activities could result in water quality impacts that indirectly affect wetlands and streams and the aquatic resources inhabiting these areas. Water quality impacts were evaluated qualitatively as described in Section 4.4. Stream temperature changes also were evaluated as they could contribute to water quality impacts. Below is a summary of the potential water quality impacts associated with each alternative and each mining period. Long-term monitoring would be required to quantify potential impacts on water quality and stream temperature.

No Action Alternative

Under the No Action Alternative, indirect impacts on wetlands and others Waters of the U.S. would not occur from water quality impacts or stream temperature changes.

Applicant's Proposed Project

Active Mining Period

As summarized in Table 4.4-11 in Section 4.4, the Applicant's Proposed Project may result in water quality impacts in virtually all wetlands and streams in the Project area as a result of active mining operations, and in some cases, within downstream waters outside of the Project boundary. Impacts would primarily occur in Haile Gold Mine Creek, Camp Branch Creek, and the tributaries that flow into the Little Lynches River at the downstream end of the Project area. Water quality impacts also may occur in the downstream end of the Little Lynches River where it would receive waters from Camp Branch Creek, Haile Gold Mine Creek, and other small tributaries. Stream temperatures are expected to change during active mining, particularly in the upper and lower portions of Haile Gold Mine Creek, which may exacerbate potential water quality concerns.

Runoff from watershed disturbances could cause increased loads of sediment and sediment-associated pollutants, although sediment detention ponds would be used to minimize these effects. This is more of a concern for the borrow areas in upper Camp Branch Creek, where sediment detention ponds would not be used. Fugitive dust and air emissions from vehicles and heavy equipment also could increase sediment and pollutant loads. Direct discharges during mining could affect water quality in Haile Gold Mine Creek as well as the Little Lynches River downstream. Specifically, discharges from the water treatment plant and pit depressurization would likely increase pH as well as the concentrations of TSS, cyanide, arsenic, cadmium, copper, lead, zinc, and selenium in the stream. Alteration in the pH regime resulting from flow alterations, direct discharges, and eutrophication could affect chemical equilibrium, toxicological effects, and the solubility of metals. Interactions with backfilled pits and pit lakes also could affect water quality in these systems from increased concentrations of barium, calcium, manganese, nickel, sulfate, and zinc. In addition, the entire study area could be affected by failure of containment systems (Johnny's PAG, the TSF, and the Mill) or improper materials handling, except for the unnamed tributaries that drain to the Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek, Buffalo Creek, and the unnamed tributary southeast of the Project boundary.

Altered flow regimes from baseflow reductions could contribute to water quality impacts. Stream morphology changes would affect residence time and biological, chemical, and/or geochemical reactions in the streams. Decreased streamflows during dry, warm conditions could lower DO concentrations as water becomes warmer and flow volumes decrease. Increased temperatures also can be expected in waters that are piped aboveground, including the stream diversion pipe that releases into the lower portion of Haile Gold Mine Creek. Increased temperature could decrease DO concentrations and result in increased biological activity (growth, productivity, respiration, and decomposition), particularly during summer months when lower DO naturally occurs. These changes could indirectly affect wetlands and streams and would directly affect aquatic resources inhabiting these areas. Low DO can lead to mortality of aquatic fauna, changes in decomposition rates, and changes in a variety of chemical and biological processes. These increases in biological activity may be associated with changes generally linked to eutrophication,[5]

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[5] *Eutrophication* refers to excessive nutrients in a waterbody, usually caused by runoff of nutrients from the land. Such input stimulates algal blooms and bacteria growth, which contribute to depletion of oxygen in the water and formation of anoxic conditions, and eventually can lead to fish mortality.

such as increased algal growth and loss of water clarity—even in the absence of increased nutrient levels. Raised temperatures also can change biodiversity, lead to fish kills, cause malnutrition of aquatic organisms, and cause shifts in species composition (Kaushal et al. 2010; Langford 1990). Increased flows from the stream diversion pipe could cause scouring in the downstream portion of Haile Gold Mine Creek, leading to increased suspended materials in receiving waters.

Because water quality changes cannot be predicted quantitatively, indirect impacts associated with water quality and temperature changes would require long-term monitoring. Water quality monitoring would be required to ensure compliance with State water quality standards; any reaches that exhibit diminished water quality would be considered an indirect impact. The extent of impact would be determined based on the upstream origin of the impact and the downstream point at which water quality returns to ambient conditions. Monitoring protocols are outlined in Section 4.4, and several mitigation measures (e.g., runoff conveyances, sediment detention ponds, passive treatment cells, containment systems, and closed-loop treatment systems) would be implemented to avoid potential water quality impacts.

Post-Mining Period

Water quality impacts associated with the Applicant's Proposed Project during post-mining may occur in Haile Gold Mine Creek, Camp Branch Creek, the Little Lynches River, and its tributaries on the downstream side of the area within the Project boundary. Post-mining, disturbed areas would be reclaimed, and groundwater elevations eventually would rise to near-baseline levels. Runoff from reclaimed areas with failing slopes or reduced vegetative cover would contribute sediment and pollutants that may decrease water quality. Potential impacts from air emissions and dust would persist until roads are decommissioned and areas are re-graded and/or re-vegetated.

Discharges from the water treatment plant would continue to affect downstream water quality until seepage water is treated passively. Passive treatment cells would be used to treat seepage from Johnny's PAG and the TSF which could affect water quality in upper and lower Camp Branch Creek, Haile Gold Mine Creek, and the receiving waters of the Little Lynches River. Only small volumes of water would be released from these areas after treatment, and any discharges must meet State water quality standards; therefore, impacts are expected to be minor. The discharges would also be monitored in accordance with NPDES discharge permit requirements regulated by the SCDHEC. The concerns for potential failure of the containment systems at Johnny's PAG and the TSF would persist post-mining.

Water quality impacts could occur via groundwater migration through backfilled pits and pit lakes, surface discharges from Ledbetter Pit Lake, runoff from reclaimed areas with failing slopes or vegetative cover. Passive treatment cells, if not properly operated and maintained, may have discharges that could also affect water quality. Water that flows from pit lakes during the post-mining period could affect water quality in Haile Gold Mine Creek and the Little Lynches River due to changes in the quality of the underlying groundwater system (see Section 4.3 for a discussion of groundwater quality). Modeling results show that the proposed Project would result in elevated concentrations of calcium, sulfate, and TDS in the pit lakes during the post-mining period. After atmospheric equilibrium and ferrihydrite precipitation are accounted for, concentrations of antimony, manganese, sulfate, and thallium could increase in some downstream surface waters and exceed surface water standards after groundwater from the mining area reaches Haile Gold Mine Creek and the Little Lynches River. These parameters would require monitoring (at lower reporting limits) to detect potential impacts caused by the Project.

As summarized in Section 4.4 (Tables 4.4-8 through 4.4-10), no substantial stream temperature changes are anticipated during the post-mining/reclamation period for the Applicant's Proposed Project, although some change (such as those due to extended sun exposure) could persist until the adjacent streamside canopy returns to pre-mining levels.

Modified Project Alternative

Active Mining Period

As summarized in Section 4.4, water quality impacts associated with the Modified Project Alternative are the same as those outlined for the Applicant's Proposed Project, except for the three tributaries within the footprint of the proposed Ramona OSA and potential impacts associated with the Holly and Hock TSF borrow areas. These tributaries would remain in place and therefore would not be exposed to the same type of water quality concerns described for the Applicant's Proposed Project. Water quality concerns for these reaches would primarily originate from land disturbances associated with the pits and the reconfigured Ramona OSA, which could introduce polluted runoff into these streams. Likewise, stream temperature changes can be expected in these reaches as a result of baseflow reductions. The modified Holly and Hock TSF borrow areas may contribute additional sediment and associated pollutants to the Camp Branch Creek stream complex due to the placement of overburden at these locations. However, runoff conveyances and sediment detention ponds would be used to mitigate these impacts.

Post-Mining Period

Water quality and stream temperature impacts associated with post-mining/reclamation activities under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project, except for impacts related to the Ramona OSA and the Holly and Hock TSF borrow areas. Under the Modified Project Alternative, the three unnamed tributaries under the proposed Ramona OSA would remain in place and therefore would not require reclamation. The Holly and Hock TSF borrow areas would be used to store overburden material. During reclamation, the OSAs would be stabilized with vegetation, and water quality impacts associated with reclaimed OSAs likely would be minimal.

4.6.6 Impact Summary

Provided below is a summary of impacts on Waters of the U.S. associated with each alternative.

4.6.6.1 No Action Alternative

Under the No Action Alternative, ongoing reclamation and closure would continue and no additional mining would take place. As a result, no adverse impacts on wetlands and Waters of the U.S. would occur. However, incremental beneficial impacts on wetlands and Waters of the U.S. would be expected. As reclamation is completed, the habitat quality and biological integrity of wetlands and Waters of the U.S. previously affected by mining activity are expected to continue to improve. Wetlands not previously mined would remain largely unchanged under the No Action Alternative.

4.6.6.2 Applicant's Proposed Project

A summary of the combined direct and indirect impacts that would occur in wetlands and other Waters of the U.S. under the Applicant's proposed Project is provided in Table 4.6-5. Impacts are grouped according to type (e.g., forested wetlands, streams). Direct impacts are clearly defined in Section 4.6-3 based on dredge and fill activities proposed within wetlands and streams. The indirect impacts were quantified based on a qualitative assessment of groundwater and surface water and other critical variables that are considered to be contributing factors to indirect impacts. Variables evaluated for the indirect wetland impact analysis are outlined in Appendix K as follows: maximum extent of groundwater drawdown, duration of drawdown, water table recovery, geology, baseflow reductions, and watershed alterations (habitat fragmentation, long-term topographic change). Criteria were developed for each variable to distinguish between areas with no impacts and those with low, moderate, or high potential for

indirect impacts (Appendix K). These variables then were evaluated collectively to determine the combined indirect impact. The combined indirect impacts were grouped as major or moderate based on the exposure associated with these numerous variables. Likewise, indirect impacts on streams were evaluated based primarily on changes in baseflows, total flows, and habitat fragmentation concerns based on the criteria outlined in Appendix K. For purposes of this analysis, areas designated as having low potential are not included in Table 4.6-6. Although water quality and temperature changes also may contribute to indirect impacts, they were not taken into consideration in this summary because they cannot be quantified without long-term monitoring. Following the summary table is an indirect impacts discussion that addresses the variables considered in the analysis.

Table 4.6-6 Summary of Direct and Indirect Impacts on Wetlands and Other Waters of the United States under the Applicant's Proposed Project

Aquatic Habitat Type	Direct Impacts	Indirect Impacts (inside Project Boundary)		Indirect Impacts (outside Project Boundary)		Total Impacts
		Moderate	Major	Moderate	Major	
Forested (acres)	93.24	16.90	153.27	199.32	544.82	1,007.55
Scrub-shrub (acres)	10.51	4.25	1.27	0.00	14.20	30.23
Herbaceous (acres)	5.72	0.00	0.38	0.00	0.00	6.1
Open water impoundments (acres)	10.99	0.90	0.39	8.28	18.64	39.2
Wetlands and Open Water Subtotal (acres)	**120.46**	**22.05**	**155.31**	**207.60**	**577.66**	**1,083.08**
Streams (linear feet)	**26,460.54**	**25,273.31**	**40,917.73**	**8,457.97**	**27,838.49**	**128,948.04**

As described in the methodology section, any wetlands that exceed 1 foot of drawdown (or 10% change in baseflows for streams) are being considered as a potential indirect impact associated with groundwater lowering activities. Criteria outlined in Table 4.6-1 distinguish between various drawdown zones where the potential for indirect wetland impacts are considered to increase relative to the extent and duration of drawdown. Wetlands typically would tolerate drier conditions (<5 feet) for short periods of time (1–3 years) typical of natural drought periods. Lower levels of drawdown that occur for short periods of time were designated as having low potential for indirect impacts. When the duration exceeds the typical drought period (>3 years), temporal losses may start to occur. These temporal losses are more likely to return to baseline conditions when the withdrawals cease depending on the extent of impact. Visible changes in the community structure may start to occur in any areas that are exposed to drawdown for extended periods of time (temporal loss). Changes in the community structure would be an indicator of functional loss and may include loss of hydrophytic vegetation and seed bank, colonization by upland species and nuisance species, and some loss of aquatic resource habitat.

Drawdown in these 1–2-foot zones is anticipated to affect more of the wetland fringe (uppermost topographic positions of the wetland) where there is more separation between the groundwater table and the surface as opposed to the deeper portions where groundwater may be closer to the surface and would maintain some level of saturation or inundation in the wetland. Geology was considered as part of the drawdown analysis, and areas of higher topography where CPS is more prevalent at the surface were considered to be more susceptible to drawdown than the lower-lying saprolite areas. The severity of the effect is known to be affected by connectivity of the wetland to the underlying aquifer, season, and rainfall conditions; a combination of dry conditions during the growing season, low rainfall, and high connectivity with the aquifer would result in the greatest impacts. Wetland depth, presence or absence of organic soils, and geological variation are known to be important factors affecting the degree of impact (e.g., see Pyzoha et al. 2008; Stein et al. 2004). The species composition of a mature wetland canopy may

not change for decades or longer after hydrologic conditions change. However, composition of the understory may change rapidly and dramatically as aquatic species disappear, seeds of wetland species fail to germinate, and terrestrial species invade the system (Palanisamy and Chui 2012; Armentano et al. 2006).

Wetlands that are subjected to 2 to 5 feet of drawdown at the surface would be dry for sustained periods of time, with the exception of high rainfall events, and are likely to have moderate to major impacts depending on the duration. Likewise, any drawdown at the surface that exceeds 5 feet is expected to result in a total (or near complete) loss of wetland resources. These areas were designated as having major potential for indirect impacts. A two-foot reduction in the average groundwater table in a shallow wetland, such as a headwater seepage wetland—even allowing for seasonal variation, may result in the water table being below the root zone of most wetland plant species and may result in a major change in species composition. Relatively larger amounts of change in the wetland groundwater table would affect relatively deeper wetlands. Any soils with relatively high organic concentrations that are exposed for extended periods during the growing season would tend to decompose more rapidly leading to greater subsidence. Such changes tend to be slow to reverse upon the return of natural hydrology and may result in permanent shifts in wetland type (Haag and Pfeiffer 2012).

In addition to the drawdown analysis, other variables were taken into consideration such as watershed alterations (topographic changes, habitat fragmentation). Topographic change was considered as a source of indirect impacts on hydrology where up-gradient sources of seepage (mounding effects) were being removed or diverted. Habitat fragmentation also was considered, particularly for the upper portion of Haile Gold Mine Creek that would be severed from the downstream portion of the creek. Any wetlands or areas within this subwatershed were designated as areas with high potential for habitat fragmentation. Likewise, upper Camp Branch Creek and the lower portion of Haile Gold Mine Creek were designated as moderate areas of concern for habitat fragmentation.

Indirect impacts on streams were evaluated using baseflow reductions, changes in total flow, and habitat fragmentation concerns based on the criteria outlined in Table 4.6-2 and Appendix K. The results show that several reaches would be exposed to moderate or major changes in flow. Some reaches would experience a 100-percent reduction in baseflows for prolonged periods of time, but total streamflow would not be eliminated when surface runoff is taken into consideration. In most cases, there is still a reduction of total flows, except for lower Haile Gold Mine Creek where flow velocity would increase during mining because of the stream diversion pipe. The groundwater model does not distinguish between the seasonal variations in flow that could alter the overall flow regime of streams (e.g., perennial systems may flow intermittently).

These changes in flow regimes also can alter stream morphology, which would directly affect aquatic resources inhabiting these areas. Stream morphology changes can result in increased stream temperatures from altered residence times which could lower DO concentrations and lead to potential water quality impacts. Habitat fragmentation also was taken into consideration based on the qualitative assessment outlined in Section 4.6.3.2. Areas of moderate to high concern for habitat fragmentation are consistent with those identified for wetlands based on their relationships with the subwatersheds. Any activities that adversely affect streamflow regimes to the extent that hydrologic connectivity is severed with traditional navigable waters would be considered a complete loss of that resource, as it would no longer function as a tributary.

Areas exposed to more substantial impacts from drawdown levels, drawdown duration, or habitat fragmentation likely would be subject to more permanent losses in function. Once the groundwater table recovers, a wetland community would re-establish. But there could be substantial time lag before re-establishment with a probable permanent change in community structure relative to the baseline. In some

cases, the groundwater table would not recover by Mine Year 75, in which case, major indirect impacts were assumed.

4.6.6.3 Modified Project Alternative

When compared to the Applicant's Proposed Project, the Modified Project Alternative reduces direct impacts on wetlands and streams by 2.22 acres and by 7,111.1 linear feet, respectively. However, the avoided Waters of the U.S. within the Project area would be indirectly affected by groundwater drawdown. Consequently, total impacts on Waters of the U.S. under the Modified Project Alternative would equal the total impacts anticipated under the Applicant's Proposed Project.

Table 4.6-7 presents a summary of impacts on wetlands and other waters of the United States under each alternative.

4.6.7 Mitigation for Impacts on Wetlands and Other Waters of the United States

4.6.7.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included a number of additional avoidance and minimization measures for impacts on wetlands in the MMP for the proposed Haile Gold Mine (Appendix G) (also see Section 4.6.3.1). Additional avoidance and minimization measures are being provided specific to groundwater and surface water (hydrology and water quality) and aquatic resources, as outlined in Sections 4.3, 4.4, and 4.7. These measures include BMPs for stormwater, erosion control, spill prevention, dust suppression, and other features that are directly applicable to protection of wetlands and streams.

- Maintain a 50-foot wetland buffer around otherwise non-affected wetlands and streams within the Project boundary. This buffer area would be intended as an area of non-disturbance and would not be altered from the existing condition.
- Implement a long-term wetland monitoring plan.
- The Applicant has proposed that long-term monitoring of wetlands and streams would be conducted in several locations within the study area where indirect impacts are anticipated from groundwater lowering, habitat fragmentation, and potential impacts on water quality. Long-term wetland monitoring would include vegetation, soils, hydrology, and water quality following the methodologies outlined in the MMP (Appendix G) (Haile 2013). Much of the hydrology and water quality assessments would overlap monitoring efforts for groundwater and surface water. Supplemental data from groundwater and surface water monitoring efforts would be reviewed as part of the wetland monitoring to evaluate water table recovery relative to pre-mining levels. Wildlife monitoring data collected for wetland-dependent species and aquatic resources also would be evaluated as an indicator of habitat function and the overall health of the wetland resources and streams. The Applicant proposes long-term monitoring at 13 locations shown in Figure 3 of the MMP (Appendix G). The locations primarily cover upper Haile Hold Mine Creek and locations outside the Project boundary, including Buffalo Creek and an unnamed tributary located southeast of the Project boundary. As outlined in Section 4.6.7, it would be beneficial to monitor additional locations in the lower portion of Haile Gold Mine Creek, the upper and lower portions of Camp Branch Creek, Champion Branch Creek, and the receiving waters of the Little Lynches River on the downstream end of the Project.

Table 4.6-7 Summary of Impacts on Wetlands and Other Waters of the United States

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Dredging and filling of wetlands	Direct impacts on wetlands and other Waters of the U.S. from dredging and filling activities would not occur.	Direct impacts from dredge and fill activities for construction of pits, OSAs, and the TSF and haul roads would result in a permanent loss of 120.46 acres of wetlands and 26,460.54 linear feet of streams.	Direct impacts from dredge and fill activities for construction of pits, OSAs, and the TSF and haul roads would result in a permanent loss of 118.24 acres of wetlands and 19,349.32 linear feet of streams.
Hydrologic alteration	Indirect impacts on wetlands and other Waters of the U.S. would not occur from hydrologic alterations.	Indirect impacts which vary in duration and extent of drawdown estimated to be 758.38 acres of wetlands and 80,483.35 linear feet of streams from changes in hydrology caused by groundwater depressurization activities and surface water alterations.	Avoidance of direct impacts on streams within the footprint of Ramona OSA. However, these areas would still be exposed to sustained periods of drawdown during mining activities because of their proximity to pit dewatering activities. Baseflow impacts are considered to be major and would equate to the same amount of loss as the direct impacts of the Applicant's Proposed Project. However, some wetlands and streams can be expected to recover as the water table recovers.
Water quality	Indirect impacts on wetlands and others Waters of the U.S. would not occur from water quality impacts or stream temperature changes	Runoff from watershed disturbances could cause increased loads of sediment and sediment-associated pollutants, although sediment detention ponds would be used to minimize these effects. Fugitive dust and air emissions from vehicles and heavy equipment also could increase sediment and pollutant loads. Direct discharges from the water treatment plant and pit depressurization would likely increase pH as well as the concentrations of TSS, cyanide, arsenic, cadmium, copper, lead, zinc, and selenium in Haile Gold Mine Creek as well as the Little Lynches River downstream. Interactions with backfilled pits and pit lakes also could affect water quality in these systems from increased concentrations of barium, calcium, manganese, nickel, sulfate, and zinc.	Same as those outlined for the Applicant's Proposed Project, except for the three tributaries within the footprint of Ramona OSA and potential impacts associated with the Holly and Hock TSF borrow areas. These tributaries would remain and water quality concerns for these reaches would primarily originate from land disturbances associated with the pits and the reconfigured Ramona OSA, which could introduce stormwater runoff into these streams. During reclamation, water quality impacts associated with reclaimed OSAs likely would be minimal.

Table 4.6-7 Summary of Impacts on Wetlands and Other Waters of the United States (Continued)

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Stream temperature	No impact	Decreased streamflows during dry, warm conditions could lower DO concentrations as water becomes warmer and decreases in flow rate. Increased temperatures also can be expected in waters that are piped aboveground, including the stream diversion pipe that releases into the lower portion of Haile Gold Mine Creek. Increased temperature could decrease DO concentrations and result in increased biological activity. No substantial stream temperature changes are anticipated during the post-mining/reclamation period.	Same as the Applicant's Proposed Project, except that this alternative would avoid direct impacts to the three tributaries within the footprint of Ramona OSA. Stream temperature changes can be expected in these reaches as a result of baseflow reductions.
Habitat changes	Indirect impacts associated with habitat fragmentation would not occur.	Prolonged periods of change in the seasonal hydrologic regimes have the potential to cause permanent changes in wetland habitat and community structure. Habitat fragmentation is expected in both the upstream and downstream portions of the proposed Project site, including upper Camp Branch Creek, upper Haile Gold Mine Creek, and lower Haile Gold Mine Creek. Habitat changes would be measured through long-term monitoring of water quality, thermal regimes, hydrology, vegetation, and aquatic organisms.	Same as the Applicant's Proposed Project, except for avoiding the three tributaries within the footprint of Ramona OSA. These reaches would be subject to major hydrologic impacts that could in turn adversely affect any habitat uses in the corridors, should the streams go dry from groundwater drawdown or be subject to discharges from upstream activities.

4.6.7.2 Additional Potential Mitigation Measures

In addition to the measures proposed by the Applicant, the USACE will consider other potential mitigation measures to reduce the remaining impacts on wetlands and Waters of the U.S. associated with the proposed Project, as described below:

- Expand the long-term wetland monitoring locations to address lower Haile Gold Mine Creek, upper and lower Camp Branch Creek, Champion Branch Creek, and the receiving waters of the Little Lynches River.

4.6.8 Literature Cited

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4.7 Aquatic Resources

This section describes the potential impacts of the proposed Haile Gold Mine on aquatic resources in the study area, including stream fish and benthic macroinvertebrate communities, freshwater mussels and snails, the Sandhills chub and American eel, other biota dependent on aquatic habitats (e.g., amphibians and reptiles), and pit lake aquatic communities. Other sections have set the stage for this section by describing the changes that would occur in streamflow regime, water temperature, water quality, stream channel and habitats, and other factors that would influence the health and condition of these aquatic biological resources. This section describes the expected response of the biological communities to the stressors resulting from mining activities within the subwatersheds (see Figure 4.4-1) influenced by the proposed Project.

Section 4.6, "Wetlands and Other Waters of the United States" quantifies the direct and indirect impacts on wetlands and Waters of the U.S. caused by the proposed Project. This section considers those impacts but focuses on the remaining and largely indirect impacts on the fish, invertebrate, and amphibian biological resources of the streams and lakes; and the remaining largely indirect impacts on waterbodies (such as reduced streamflow or hydroperiods, increased or decreased water temperature regime, increased sedimentation, changes in water quality, increases in levels of some contaminants, and other changes that would result from mining activities). These impacts are referred to as "stressors."

A ***stressor*** is any agent that adversely affects an organism, population, or community. Commonly recognized stressors in aquatic biological communities include habitat alteration, flow regime alteration, degradation of water quality, invasive species, excessive nutrients, toxics, and suspended and deposited sediments.

The aquatic biological resources of streams in the study area and the pit lakes would be exposed, and would respond, to multiple stressors caused by watershed disturbance and mining activities (Niyogi et al. 2002; Townsend et al. 2008). A generalized relationship between stressors and aquatic ecosystem response is shown in (Figure 4.7-1).

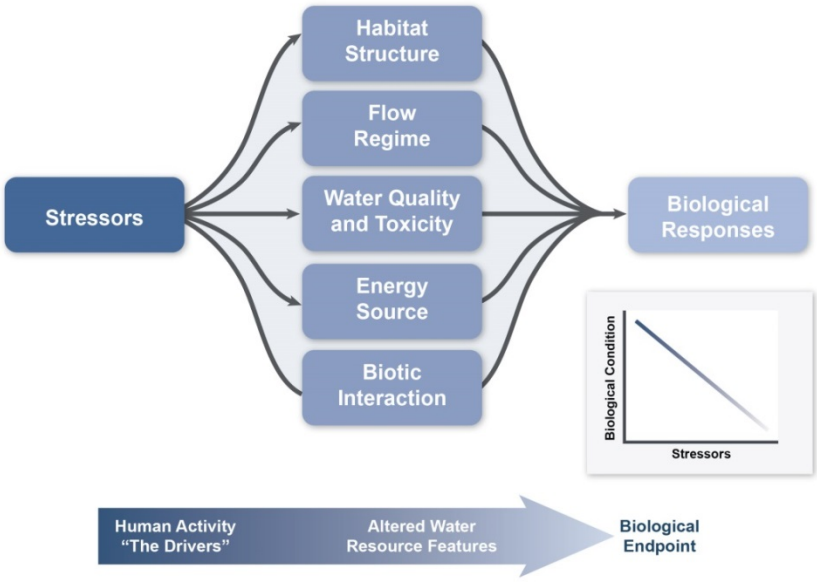

Figure 4.7-1 Stressor Response Relationships within Aquatic Communities

Source: Adapted from Montgomery County 2013.

4.7.1 Methods

The potential effects of the proposed Project and the alternatives on aquatic resources were characterized using a combination of quantitative and qualitative estimates of changes in streamflow, water temperature, area of watershed alteration, and loss of stream segments, as described in Section 4.4, "Surface Water Hydrology and Water Quality." These estimated effects were combined with qualitative consideration of such factors as changes in stream channel conditions, sedimentation, stormwater changes in water quality, and habitat fragmentation to estimate the probable impacts on the condition of aquatic biological communities.

Just as the presence, condition, and numbers of the types of fishes, insects, algae, plants, and other aquatic life are well documented to provide accurate information about the health of freshwater systems (Karr et al. 1986; Simon 2002), biological communities also have been shown to respond in relatively predictable ways to gradients of environmental impact within watersheds (Cranston 1990; Yoder and Rankin 1996; Simon 2002). These relatively well understood and documented responses to watershed stressors, summarized in Table 4.7-1, were combined with the matrix of watershed stressors that would occur in each subwatershed affected by the proposed Project to qualitatively characterize the likely impacts on aquatic community condition of mining and watershed disturbance from the proposed Project.

The approach used for the impact analysis was an impact characterization matrix that combined the quantitative and qualitative information on the potential extent and severity of aquatic stressors by subwatershed (Table 4.7-2). This approach allowed consideration of the multiple stressors that would occur in each watershed and characterization of the probable degree of biological response. Table 4.7-2 illustrates the extent of mining impact by the 16 subwatersheds, as each would be affected by the proposed Project, for four watershed stressors well established in aquatic resource science: the percent of basin disturbed, degree of hydrologic alteration, change in water temperature regime, and habitat fragmentation. See Section 4.4, "Surface Water Hydrology and Water Quality" for a description of the data that provided the basis for the impact ratings.

Table 4.7-2 describes the expected level of intensity for the stressors for each subwatershed that would result from a range of Project-related mining activities, including construction, land disturbance, stormwater flows, changes in runoff and groundwater contribution, and increased stream temperatures. These qualitative ratings were based on interpretation of data presented in Section 4.4. This information was used as the basis for qualitatively characterizing the expected biological response in the subwatersheds.

Section 3.7 describes the historical and recent biological monitoring of the fish and aquatic macroinvertebrate communities that was conducted within and in the vicinity of the Project boundary. Also described were the multi-metric biological measurements and bioclassification tools that were used to characterize the existing ecological health or condition (e.g., the biological condition) of various stream segments, repeated here for convenient reference (Table 4.7-3). These same concepts and biological condition descriptions are used in the impact analysis.

Table 4.7-1 Selected Stressors and Expected Change in Aquatic Biological Response

Watershed Stressor	Biological Response/Expected Changes
Percent of basin disturbed/developed	Many studies have documented an inverse relationship between the amount of developed or disturbed land as a percentage of the watershed and lowering of the biological integrity of the waterbody (Simon 2002). This lowering of the biological condition or health in response to watershed stressors is a result of fairly characteristic responses—loss of sensitive species; reduction in the relative abundance of insectivorous fish species; loss or lowering of the number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) species[1]; loss of top predators; increases in relative abundance toward more tolerant species and omnivores; and increases in disease and physical anomalies (Karr et al. 1986; Yoder and Rankin 1996; Simon 2002). The types of human watershed disturbances that have been shown to contribute to these patterns have included logging; agriculture; development; mining; increases in impervious surfaces and roadways; and other land uses or activities in a watershed, or a combination of land uses.
Hydrologic alteration	Numerous case studies and expert knowledge provide the scientific foundation for the understanding that alteration of the flow regime of streams (e.g., flow magnitude, frequency, and timing) induces a variety of ecological responses in stream systems (Bunn and Arthington 2002; Poff and Zimmerman 2010) that are mostly adverse, especially for stream fish communities. McManamay et al. (2013) reported that the majority of stream ecological responses to human-induced changes in flow in the South Atlantic Region were negative. Fish abundance, diversity, reproduction, and habitat consistently showed negative response to human-induced changes in flow regime. Lowering of baseflows and increases in periods with very low or no flow are particularly adverse (Rolls et al. 2012) and result in lowered water quality, higher water temperatures, and isolated habitats that stress aquatic communities.
Water temperature regime	Water temperature is an environmental factor that aquatic organisms are constantly subjected to; compared to other stressors that can be temporary, water temperature is always present to potentially affect aquatic organisms (Coutant 1976). Temperature is a major factor in fish and other aquatic populations that triggers physiological activities such as feeding, metabolic processes, distribution, reproduction, and general survival. Any human activities that can alter the thermal environment (e.g., deforestation, dams, and effluent discharges) also would trigger a change in aquatic populations (Coutant 1976). While aquatic communities can tolerate a range of non-lethal temperatures and can cope with natural changes within a system, rapid increases or decreases may result in a behavioral (e.g., habitat use, abundance and distribution, feeding, predation, and reproduction) or physiological response (Donaldson et.al. 2008). Rapid changes in temperature could result in extreme responses by aquatic organisms, which could lead to death.
Habitat fragmentation	Habitat fragmentation occurs when populations become isolated because the links between habitat patches have been lost. In streams, habitat fragmentation can occur as a result of diversions, dams, road crossings, and loss of hydrologic (flow) connectivity. Habitat fragmentation alters stream fish community structure in dendritic (branching) stream networks (Perkins and Gido 2012) and has been shown to produce spatially and genetically fragmented populations and to reduce biological diversity (Fluker et al. 2014). Reduced viability of freshwater biota may occur with cumulative headwater alteration, including for species that occupy a range of stream sizes, but for which headwater streams diversify the network of interconnected populations or enhance survival for particular life stages (Freeman et al. 2007). In addition to providing habitat, headwater connectivity to downstream segments affects viability of species that occupy, but are not restricted to, headwaters (Freeman et al. 2007).

[1] EPT species are easily identified and are commonly used as an indicator of water quality. In general, high quality streams have a greater number of these species (higher richness) and have fewer pollutants. The greater the pollution, the lower the richness of EPT species.

Table 4.7-2 Characterization Matrix for Indirect Impacts on Aquatic Resources

Subwatershed	Potential for Indirect Impact			
	Hydrologic Alteration	Thermal Alteration	Watershed Disturbance	Habitat Fragmentation and Connectivity
Buffalo Creek	Low	Low	Low	Low
Upper Camp Branch Creek	Moderate	Low	High	Moderate
Lower Camp Branch Creek	Moderate	Low	High	Low
Unnamed tributary near Camp Branch Creek	High	Low	Low	Moderate
Unnamed tributary West of Champion Pit	High	Moderate	Moderate	Moderate
Unnamed tributary South of Champion Pit	High	Moderate	High	Moderate
Unnamed tributaries by Ramona OSA	High	Moderate	High	Moderate
Upper Haile Gold Mine Creek	High	Moderate	High	High
Haile Gold Mine Creek in mined area	High	High	High	High
Lower Haile Gold Mine Creek	High	High	High	Moderate
Unnamed tributary southeast of the Project	High	Moderate	Low	Moderate
Little Lynches River upstream of Camp Branch Creek	Low	Low	Low	Low
Little Lynches River downstream of Camp Branch Creek	Low	Low	Low	Low
Little Lynches River downstream of Haile Gold Mine Creek	Low	Moderate	Low	Low

Notes:

Watershed Disturbance (Percent)

Low = <10%; *Moderate* = 10–20%; *High* = >20%

Hydrologic Alteration

Low = <8% change in baseflow and <1 foot groundwater drawdown; *Moderate* = 8–20% change in baseflow and 1–3 feet of groundwater drawdown; *High* = >20% change in baseflow and > 3 feet of groundwater drawdown

Thermal Alteration

Low = <1°F change; *Medium* = 1–5°F change; *High* = >5°F change

Habitat Fragmentation

Low = little or no fragmentation or loss of tributaries; no to low reduction in connectivity due to flow alteration; *Moderate* = some fragmentation or loss, disconnection from other streams; moderate to high reduction in connectivity due to flow alteration; *High* = disconnected from remainder of subwatershed; disconnected from downstream stream reaches; high reduction in connectivity due to flow alteration.

Table 4.7-3 Description of Bioclassification and Aquatic Life Use Support Classifications

Biological Condition or Bioclassification Score	Aquatic Life Use Support Classification	Description
Excellent or good	Fully supporting	Has functioning, sustainable biological assemblages (fish, macroinvertebrates, or algae) that have not been modified beyond the reference condition range.
Good-fair or fair	Partially supporting	Exhibits moderate modification of the biological community for at least one assemblage.
Poor	Does not support	Has at least one severely affected assemblage that indicates severe modification compared to the reference condition.

4.7.2 Impacts on Fish, Macroinvertebrates, and Aquatic Biological Condition

4.7.2.1 No Action Alternative

Under the No Action Alternative, monitoring of reclamation and closure would continue, and no additional mining would take place. The habitat quality in streams within the Project boundary previously affected by mining activities are expected to improve slowly over time following reclamation. This would occur as a result of improved vegetative stabilization, reduced erosion and sedimentation, improved water quality, and development of riparian and streamside cover and trees that would provide improved shading and stream water temperature stabilization. Particularly in the previously mined areas of Haile Gold Mine Creek, these changes eventually would result in development of natural land cover, forested stream buffers, less erosion and sedimentation, improved stream substrates, and generally improved stream conditions that would be typical of forested headwater streams of the Piedmont and Sandhills ecoregions.

Expected along with these changes would be small to moderate incremental improvements in the biological integrity of the streams over time, particularly in Haile Gold Mine Creek. These types of improvements in biological conditions have occurred to some extent following reclamation from past Haile Gold Mine site mining activities (Section 3.7).

Other subwatersheds in the study area, such as Camp Branch Creek, Buffalo Creek, the unnamed tributary southeast of the Project boundary, and the other sub-basins not previously mined, would remain largely unchanged under the No Action Alternative, subject to any future watershed development that may occur.

4.7.2.2 Applicant's Proposed Project

Active Mining Period

Under the proposed Project, the biological conditions of the streams and subwatersheds directly and indirectly affected by mining are expected to decline as a result of the stressors and their intensities, as shown in Table 4.7-2. In particular, upper and lower Haile Gold Mine Creek, upper Camp Branch Creek, the North Fork of Haile Gold Mine Creek within the mined area, the unnamed tributaries near the Ramona OSA, and the tributaries that drain the Champion Pit area would likely be degraded during the mining period to a fair or poor category of biological condition and may partially support or not support their designated uses. This would occur from multiple stressors on the aquatic community (Table 4.7-2), including a large percentage of their watershed area being disturbed, stormwater runoff, altered water temperatures, increased TSS and sediment loading, and other factors that would degrade stream habitat and water quality.

The most likely biological impacts, as described in Table 4.7-1, would include such changes as loss of sensitive insectivorous fish species, loss of EPT invertebrate taxa, and dominance by tolerant and omnivorous species. These changes would be expected even with implementation of the Applicant's proposed avoidance and minimization measures (e.g., no-disturbance buffers and stormwater BMPs) although these measures would reduce the intensity of the impacts of watershed development and mining activities. Examples of sensitive species and species of state conservation importance known to occur in the study area with the potential to be affected include the Sandhills chub (*Semotilus lumbee*), fireyblack shiner (*Cyprinella pyrrhomelas*), and sawcheek darter (*Etheostoma fusiforme*).

Upper Haile Gold Mine Creek in particular likely would experience a decline in its biological condition, probably to a fair or poor biological rating, through loss of connectivity, aquatic habitat loss, increased stream temperatures, and increased sedimentation. Upper Haile Gold Mine Creek would be essentially separated from its lower watershed, would be likely to go dry at some time during the active mining period during dry or drought conditions, and would drain a watershed considerably altered by OSAs. During most of the active mining period, upper Haile Gold Mine Creek would have no connection to downstream segments; therefore, loss of fish or fish species could not be replaced in part from upstream migration from downstream. Some fish species that may currently use the upper Haile Gold Mine Creek habitats during certain seasons would no longer have access to these headwater streams for the duration of the active mining period and potentially longer.

Lower Haile Gold Mine Creek also likely would experience a measurable decline in biological condition, but the profile of stressors would be somewhat different than for upper Haile Gold Mine Creek. The most substantial differences would be that lower Haile Gold Mine Creek would have a more altered water temperature regime, degraded water quality conditions, and increased sedimentation. The water temperature regime would be altered by changes in flow and the discharge of pit depressurization water. When excess pit depressurization water would be discharged, stream temperatures would be cooler than the existing condition in summer and warmer in winter. Flow and water temperature changes as a result of the discharge of pit depressurization water would be variable, and the flow of lower Haile Gold Mine Creek would periodically be higher or lower than the No Action Alternative. These temperature changes could affect the suitability of lower Haile Gold Mine Creek for some aquatic species, prevent or delay reproduction, or affect growth and survival of fish residing there. Some species may no longer inhabit lower Haile Gold Mine Creek because of the periodically altered water temperature regime.

Lower Haile Gold Mine Creek would receive the discharge from the water treatment plant. Although the NPDES permit would require that water quality standards be met, changes in water quality nevertheless would occur. Some of these changes may affect aquatic biota, especially sensitive fish, invertebrates, or amphibians. This may be particularly true with increases in TDS, sulfates, and total dissolved metals (see Section 4.4); these stressors have been strongly associated with biological degradation from agriculture, urban development, and mining (Vander Laan et al. 2013).

Other subwatersheds would be less intensely affected by the stressors associated with mining activity (Table 4.7-2) and would experience minor indirect impacts on their biological condition or health during the mining period. Subwatersheds such as Buffalo Creek, the Little Lynches River, and possibly lower Camp Branch Creek would experience stressor levels mostly at low intensity and therefore would be expected to be maintained at, or be lowered to, the good-fair or fair category of biological health. These subwatersheds may well continue to support their designated uses at the partially supporting level based on biological measures for the duration of the mining period. The biological conditions of the remaining subwatersheds (the unnamed tributary near Camp Branch Creek and the Unnamed Tributary southeast of the Project) likely would experience moderate impacts, primarily caused by hydrologic alteration and potential habitat fragmentation during the mining period.

Post-Mining Period

Concurrent site reclamation would be completed during mining according to the requirements of the South Carolina Mine Operating Permit and after mining ceases (Appendix A). Haile provided a schedule of mining and reclamation activities, as well as a description of how drainage channels and final grades would be reestablished. The impacts are considered major for upper Camp Branch Creek, Haile Gold Mine Creek, the unnamed tributaries near Champion Pit, and the three unnamed tributaries directly affected by the Ramona OSA. The impacts are moderate for lower Camp Branch Creek, the unnamed tributary near Camp Branch Creek, and the Unnamed Tributary southeast of the Project. Because no stream restoration activities are included under the proposed Project (the requirement of the Mine Operating permit requires only re-establishing drainage channels), the time period required for recovery of the stream system would depend on the type and severity of impact. Many years may be required before stream channels would become naturalized and biological conditions returned to near pre-mining levels. Streams channels that would be completely removed, rerouted, or diverted through pipe potentially would take the longest to recover from the considerable alteration.

After reclamation and closure, the habitat quality in streams affected by the proposed Project would be expected to improve over time. This would occur as a result of improved vegetative stabilization and vegetation succession, and development of riparian and streamside cover and trees that would provide improved shading and stream water temperature stabilization. Particularly in the previously mined areas of Haile Gold Mine Creek, these changes eventually would result in development of natural land cover, forested stream buffers, less erosion and sedimentation, improved stream substrates, and generally improved stream conditions more typical of forested headwater streams of the Piedmont and Sandhills ecoregions. Expected along with these changes would be small to moderate incremental improvements in the biological integrity of the streams over time, particularly Haile Gold Mine Creek. Improvements in stream channel conditions, instream habitats, and biological communities may take relatively few years in less affected streams; more affected streams may take many years or decades to return to their existing condition. Some streams, such as the middle and lower sections of Haile Gold Mine Creek, may never completely recover to pre-impact biological conditions during the foreseeable future.

4.7.2.3 Modified Project Alternative

Active Mining Period

Impacts on the watershed during the active mining period under the Modified Project Alternative would be very similar to those described for the proposed Project, except for impacts related to streams and aquatic habitats in the vicinity the Ramona OSA and the Holly and Hock TSF borrow areas. Under the Modified Project Alternative, the Ramona OSA would be designed to avoid the unnamed tributaries in that area and these streams would experience less intense stress (Table 4.7-2). These streams would still be affected by reduced baseflows and other stressors, and their biological condition likely would decline. Current biological conditions of the streams near the Ramona OSA are not known because they were not sampled. Based on the projected impacts, the biological condition may drop to fair or poor. Streams draining Holly and Hock TSF borrow areas would be similarly affected, but the addition of OSAs on the borrow areas would result in more intense temporary watershed disturbance and impacts of greater duration, and the runoff from the OSAs would concentrate stormwater flows, resulting in greater hydrologic modification.

Post-Mining Period

Impacts on the watershed during the post-mining period under the Modified Project Alternative would be very similar to those described for the proposed Project, except for impacts related to aquatic habitats in

the vicinity of the Ramona OSA and the Holly and Hock TSF borrow areas. These streams would still be affected by reduced baseflows and other stressors, and their biological condition likely would decline during the mining period. After reclamation and closure, the habitat quality in streams affected by the Modified Project Alternative would be expected to improve over time. This would occur as a result of improved vegetative stabilization and vegetation succession, completed runoff diversion structures, and general maintenance of structures throughout the post-mining period.

4.7.3 Impacts on Sandhills Chub and American Eel

Two South Carolina Priority Conservation Species of "highest" priority, the Sandhills chub and American eel (*Anguilla rostrata*), were found in various streams in the aquatic resources study area (Figure 4.7-2) and were the subject of comments by the SCDNR, USFWS, and other commentors. The potential impacts on these two fish species are discussed in this section. Other South Carolina Priority Conservation Species of "high priority" also are discussed. The remainders of the South Carolina Priority Conservation fishes were of "moderate" priority and are not discussed here in detail because they are generally common and abundant or widely distributed in South Carolina; impacts on these species would be similar to those described in Section 4.7.2.

Details on the occurrence and abundance of fish species in the study area streams is presented in Section 3.7.

4.7.3.1 Sandhills Chub

No Action Alternative

Under the No Action Alterative, impacts on aquatic systems would the same as described in Section 4.7.2. Monitoring reclamation and closure activities would continue, and no additional mining would take place. The habitat quality in streams within the Project boundary previously affected by mining activities would be expected to improve over time following reclamation. Expected along with these changes would be small to moderate incremental improvements in the biological integrity of the streams over time, particularly Haile Gold Mine Creek. Other stream basins in the study area, such as Camp Branch Creek, Buffalo Creek, the unnamed tributary southeast of the Project boundary, and the other sub-basins not previously mined, would remain largely unchanged under the No Action Alternative. These trends in improved stream condition in previously mined areas would be expected to result in a small beneficial effect on habitat and a potentially positive but small benefit on Sandhills chub, particularly those individuals using Haile Gold Mine Creek. The potential benefits to American eel would be small based on their existing distribution, which appears to be limited to the Little Lynches River downstream of the confluence with Camp Branch Creek.

Applicant's Proposed Project

Active Mining Period

Sandhills chub were found to be common throughout the study area, but were particularly abundant or dominant in certain headwater stream areas. The reasons for the variability and apparent patchiness of Sandhills chub abundance among streams is not understood, but sources indicate that they inhabit smaller tributaries and tend to thrive in streams that harbor few other competing species (Rohde and Arndt 1991; NatureServe Explorer 2012). This seems to be borne out in that their distribution and abundance in the study area is highest in areas with few other fish species.

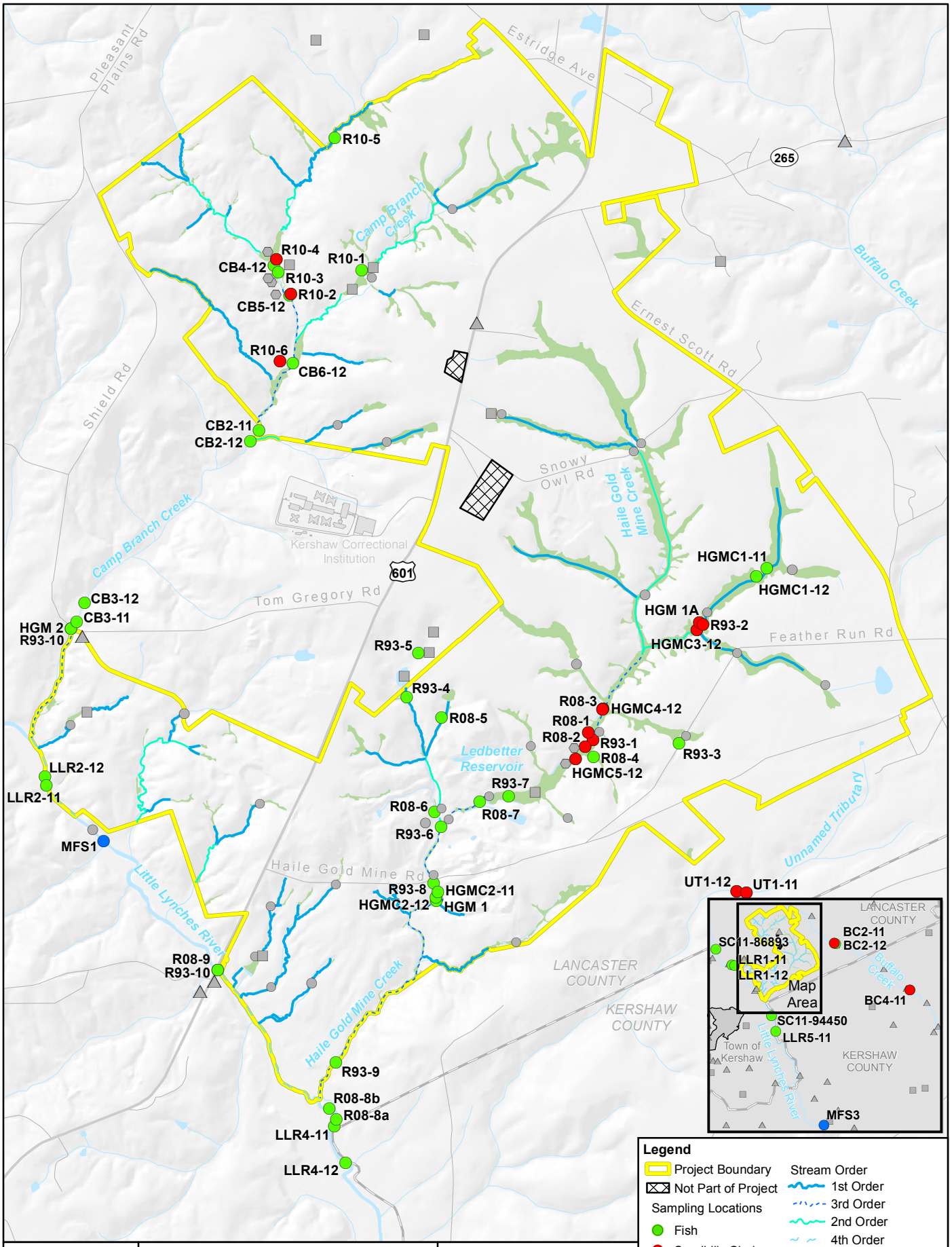

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Figure 4.7-2

Occurrence of Sandhills Chub and American Eel in Fish Surveys

Under the proposed Project, the permanent impacts on existing populations of Sandhills chub within Haile Gold Mine Creek and upper Camp Branch Creek are expected to be moderate to major. Middle Haile Gold Mine Creek would be excavated, and upper Haile Gold Mine Creek would be completely fragmented and isolated from downstream segments for many years. This condition, together with the flow reductions, higher stream temperatures, and potential water quality degradation, is expected to result in the loss of this intolerant, insectivorous species from upper Haile Gold Mine Creek. While lower Haile Gold Mine Creek would remain, flow and water temperature alterations and water quality degradation are expected to make this stream segment marginally acceptable or uninhabitable by Sandhills chub.

It is reasonable to expect that the outcome for the populations of Sandhills chub in upper Camp Branch Creek would be similar to those in Haile Gold Mine Creek. The upper reaches of Camp Branch Creek, seemingly the preferred habitat of the species in that subwatershed, would be considerably affected by mining activities and associated flow alteration, stormwater runoff, and the potential for increased suspended and streambed sediment. The habitat requirements of the Sandhills chub (clear, cool, small streams with sand and gravel substrates and clean gravel suitable for nest building) would likely not persist in upper Camp Branch Creek with the proposed extent of subwatershed alteration during the active mining phase. The headwaters of Camp Branch Creek likely would become marginally acceptable or uninhabitable by Sandhills chub, and the middle reaches of Camp Branch Creek do not currently appear to be preferred habitat.

Post-Mining Period

Much like the description provided for the “Post-Mining Period for Fish, Macroinvertebrates, and Aquatic Biological Condition” after reclamation and closure, the habitat quality in streams affected by the proposed mining activities would be expected to improve over time. Expected along with these changes would be small to moderate incremental improvements in the biological integrity of the streams over time, particularly Haile Gold Mine Creek. However, for Sandhills chub, it is unclear if these improvements would be enough to make these stream segments once again suitable for the species within the foreseeable future. The permanent impacts on Sandhills chub populations within Haile Gold Mine Creek would be major.

Modified Project Alternative

Active Mining Period

Impacts on the watershed during the active mining period under the Modified Project Alternative would be very similar to those described for the Applicant’s Proposed Project, except for impacts related to streams and aquatic habitats in the vicinity of the Ramona OSA and the Holly and Hock TSF borrow areas. The streams draining the Holly and Hock TSF borrow areas that are near stream segments currently inhabited by Sandhills chub would be similarly affected, but the addition of OSAs on the borrow areas would result in more intense temporary watershed disturbance impacts of greater duration, and the runoff from the OSAs would concentrate stormwater flows, resulting in greater hydrologic modification. However, because the headwaters of Camp Branch Creek would likely become marginally acceptable or uninhabitable by Sandhills chub under the proposed Project, the difference between these two alternatives may not be meaningful and the impacts would remain major during the active mining period.

Post-Mining Period

Impacts on the watershed during the post-mining period under the Modified Project Alternative would be very similar to those described for the proposed Project, except for impacts related to aquatic habitats in the vicinity of the Ramona OSA and the Holly and Hock TSF borrow areas. These streams would still be

affected by reduced baseflows and other stressors, and their biological condition likely would decline during the mining period. After reclamation and closure, the habitat quality in streams affected by the Modified Project Alternative would be expected to improve over time. This would occur as a result of improved vegetative stabilization and vegetation succession, completed runoff diversion structures, and general maintenance of structures throughout the post-mining period. In the long term, Sandhills chub populations could return to upper Camp Branch Creek, but only if some of the original source population remains or a hydrologic connection to a new source population.

4.7.3.2 American Eel

Applicant's Proposed Project

Active Mining Period

Despite considerable fish surveys in the study area, including specific efforts to detect migratory fish such as the American eel, the American eel was found only in the mainstem of the Little Lynches River. American eel are known to inhabit a wide variety of stream and river habitats, from small headwaters to large rivers. The American eel is said to occupy the broadest diversity of habitats of any fish species (Helfman et al. 1987 cited in USFWS 2011). Given this, it is unclear why American eel do not appear to be present in tributaries in the study area such as Haile Gold Mine Creek and Camp Branch Creek. This may be due to the habitat and water quality conditions in the study areas streams, or may reflect that specialized surveys for American eel and other seasonally migratory fishes were completed only in the Little Lynches River.

Based on the existing distribution of American eel in the Little Lynches River, the potential temporary effect of mining activity on the Little Lynches River is likely to be minor. In the Little Lynches River, impacts from mining would be considerably attenuated by the contribution of the larger watershed and the fact that hydrologic alteration at the point of the confluence with Haile Gold Mine Creek would be minor to moderate (Table 4.7-2). To the extent that American eel do in fact use the smaller streams of the study area, the impacts on American eel would be similar to those described in the section on fish, macroinvertebrates, and aquatic biological condition.

Post-Mining Period

The potential effect of mining activity on American eel in the Little Lynches River is likely to be minimal during the post-mining period. The potential exception would effects on the eel from water quality conditions after mine closure when groundwater affected by contact with the backfilled pit lakes would reach lower Haile Gold Mine Creek and the Little Lynches River. Potential impacts on water quality during the post-mining period are presented in Section 4.4.

Modified Project Alternative

Active Mining Period

Impacts on the watershed during the active mining period under the Modified Project Alternative would be very similar to those described for the Applicant's Proposed Project, except for impacts related to streams and aquatic habitats in the vicinity of the Ramona OSA and the Holly and Hock TSF borrow areas. However, because the American eel was not found in Camp Branch Creek or the unnamed tributaries near the Ramona OSA, the difference between these two alternatives may not be meaningful.

Post-Mining Period

No impacts on American eel populations would take place during the post-mining period under the Modified Project Alternative.

4.7.4 Impacts on Freshwater Mussels and Snails

4.7.4.1 No Action Alternative

Under the No Action Alternative, monitoring for reclamation and closure activities would continue, and no additional mining would take place; the habitat quality in streams within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation. Expected along with these changes would be small to moderate incremental improvements of the streams over time, particularly Haile Gold Mine Creek. These improvements may or may not ultimately result in habitat suitable for freshwater mussels in Haile Gold Mine Creek. Other subwatersheds in the study area, such as Camp Branch Creek, Buffalo Creek, the unnamed tributary southeast of the project boundary, and the other subwatersheds not previously mined, would remain largely unchanged under the No Action Alternative.

4.7.4.2 Applicant's Proposed Project

Active Mining Period

For the most part, streams in the aquatic resources study area supported few or no populations of freshwater mussels and snails. Under the proposed Project, the likelihood that freshwater mussels would colonize or inhabit subwatersheds directly and indirectly affected by mining would be expected to decline as a result of the stressors and their intensities shown in Table 4.7-2. In particular, during the mining period, upper and lower Haile Gold Mine Creek, upper Camp Branch Creek, the north fork of Haile Gold Mine Creek within the mined area, unnamed tributaries near Ramona OSA, and tributaries that drain the Champion Pit area would be less likely than they are now to provide suitable habitat necessary for freshwater mussels or snails. These species tend to be intolerant of habitat degradation, sedimentation, and reduced water quality. However, because few streams currently support freshwater mussels, the long-term potential impacts on mussels due to the proposed Project would be would be negligible.

Because surveys for mussels were not conducted in the other subwatersheds, such as the unnamed tributary near Camp Branch Creek, unnamed tributaries by Champion Pit, and unnamed tributaries near the Ramona OSA, it is not known whether any freshwater mussels are present. If mussels are present within these remaining subwatersheds, the potential for impacts on mussel populations that may occur there would be less because the remaining subwatersheds would be less intensely affected by the stressors associated with mining activity.

Other subwatersheds such as Buffalo Creek and the Little Lynches River would experience stressors at a low level; therefore, any mussel populations present should be largely unaffected.

Camp Branch Creek does support some Asiatic clam (*Corbicula fluminea*). During mining, conditions in upper Camp Branch Creek may become temporarily unsuitable due to flow alteration, increased sedimentation, and watershed disturbance. The Asiatic clam is less tolerant than native mussels to environmental fluctuations. This species is extremely sensitive to low oxygen conditions; consequently, its distribution is restricted to well-oxygenated streams and lake shallows. Based on hydrologic alteration and watershed disturbance, the Asiatic clam would experience moderate to major impacts in Camp Branch Creek.

Other species found within the Little Lynches River include the two-ridge rams-horn (*Helisoma anceps*) and pond snails (*Physa* sp.). These species may experience temporary minor impacts, mainly from minor hydrologic alteration, potential for increased sedimentation, and other factors that may result in periodic impacts on stream water quality. Any alteration of the fish community also could negatively affect the mussel community, based on similar physiological requirements for survival (Neves 1999). As described above, however, temporary impacts on fish communities in the Little Lynches River are expected to be minor.

Post-Mining Period

After reclamation and closure, the habitat quality in streams affected by the proposed mining activities would be expected to improve slowly over time, as described in Section 4.7.2. Some streams, such as middle and lower Haile Gold Mine Creek, may never completely recovery to pre-impact conditions during the foreseeable future, and would not be expected to support freshwater mussels.

4.7.4.3 Modified Project Alternative

Active Mining Period

Impacts on the watershed during the active mining period under the Modified Project Alternative would be very similar to those described for the Applicant's Proposed Project, except for impacts related to streams and aquatic habitats in the vicinity of the Ramona OSA and the Holly and Hock TSF borrow areas. Under the Modified Project Alternative, the Ramona OSA would be designed to avoid the unnamed tributaries in that area, and these streams would experience less intense stressors. Nevertheless, they would still be affected by reduced baseflows and other stressors, and they would not be expected to support freshwater mussels during the active mining period. Streams draining the Holly and Hock TSF borrow areas would be similarly affected, but the addition of OSAs on the borrow areas would result in more intense temporary watershed disturbance and impacts of greater duration; and the runoff from the OSAs would concentrate stormwater flows, resulting in greater hydrologic modification.

Post-Mining Period

Freshwater mussel populations would not be affected during the post-mining period under the Modified Project Alternative because no freshwater mussel species are known to inhabit the affected tributaries.

4.7.5 Impacts on Amphibians and Reptiles

4.7.5.1 No Action Alternative

Under the No Action Alternative, impacts on aquatic systems would be the same as described for the No Action Alternative in Section 4.7.2. Monitoring for reclamation and closure activities would continue, and no additional mining would take place. The habitat quality in streams within the Project boundary previously affected by mining activities would be expected to improve slowly over time following reclamation. Expected along with these changes would be small to moderate incremental improvements of the streams over time, particularly Haile Gold Mine Creek. Other stream basins in the study area, such as Camp Branch Creek, Buffalo Creek, the unnamed tributary southeast of the project boundary, and the other subwatersheds not previously mined would remain largely unchanged under the No Action Alternative.

Amphibian and reptile (herptile) populations would not be expected to change in any of the subwatersheds, except for Haile Gold Mine Creek. As time passed, habitats along Haile Gold Mine Creek

may be better able to support more amphibians and reptiles as it naturally transitions to a more natural stream with improved riparian conditions.

4.7.5.2 Applicant's Proposed Project

Active Mining Period

Under the proposed Project, the headwater streams, wetlands, and upland terrestrial habitat used by amphibians and reptiles would be directly and indirectly affected by mining. Some of the frog and salamander species found in Haile Gold Mine Creek and Camp Branch Creek use headwater wetlands to reproduce. Numerous amphibians spend their entire life within streams or wetlands, while others spend most of their time in terrestrial habitats, returning to water only to reproduce (Meyer et al. 2007). Reptiles such as snakes and turtles also use aquatic environments either partially or fully. Meyer et al. (2007) found that four genera of turtles and five genera of snakes use small streams in the Southeast. During the active mining period, upper and lower Haile Gold Mine Creek, upper Camp Branch Creek, the north fork of Haile Gold Mine Creek within the mined area, the unnamed tributaries near the Ramona OSA, and the tributaries that drain the Champion Pit area would be directly and indirectly affected. Therefore, in many areas these streams would be unlikely to support the necessary habitat resources for some herptile species. Most of the wetlands draining to these streams also would be adversely affected by filling or disconnecting from the downstream segments (see Section 4.6, "Wetlands and Other Waters of the United States" for additional discussion of wetlands).

Upper Haile Gold Mine Creek would essentially be isolated from the downstream section of the watershed, and habitat for many herpetological species would be fragmented and indirectly degraded. The core terrestrial habitat range for amphibians and reptiles is typically from approximately 300 to 600 feet (Semlitsch and Bodie 2003). Impacts on wetlands as described in Section 4.6 would result in indirect impacts on herptiles because of their inability to migrate to other suitable habitats and isolation of individuals. Overall, population connectivity is important for species that may not be directly affected by habitat loss or elevated mortality risks while dispersing (Cushman 2006).

Amphibian populations within lower Haile Gold Mine Creek and the Little Lynches River immediately downstream of Haile Gold Mine Creek would be moderately affected by changes to water quality during the mining period. While some of the predicted changes to water quality may be minor, the impact of multiple stressors on a community could be greater in amphibians than other taxa (Kerby et al. 2010).

Other subwatersheds would be less intensely affected by the stressors associated with mining activity, and the amphibians and reptiles inhabiting those subwatersheds would experience less impact. Subwatersheds such as Buffalo Creek, the upper Little Lynches River, and possibly lower Camp Branch Creek would experience stressor levels mostly at a low level of intensity, and temporary impacts on populations of amphibians and reptiles likely be minor.

Surveys for amphibians and reptiles were not conducted in the other smaller subwatersheds (unnamed tributaries near Camp Branch Creek, Champion Pit, and near Ramona's OSA), so it is unknown what species are present. Amphibians and reptiles using these remaining subwatersheds would likely be subject to intermediate impacts due to habitat fragmentation and hydrologic alteration.

Post-Mining Period

After reclamation and closure, the habitat quality in some wetlands and most streams affected by the proposed mining activities would be expected to improve over time. This would occur as a result of improved vegetative stabilization and vegetation succession, and development of riparian and streamside

cover and trees that would provide improved shading and stream water temperature stabilization. Many years may be required before stream channels would become naturalized and biological conditions returned to pre-mining levels. Streams channels that would be completely removed, rerouted, or established or diverted through pipe would potentially take the longest to recover from the considerable alteration. Once streams can be used again, populations of amphibians and reptiles that survived in more downstream sections of the watershed would begin to repopulate more upstream headwaters sections in the long term. Some instream populations of amphibians and reptiles, such as those living in middle and lower Haile Gold Mine Creek may not completely recover to pre-impact conditions during the foreseeable future and would experience permanent major impacts.

4.7.5.3 Modified Project Alternative

Active Mining Period

Impacts on amphibians and reptiles using the watershed during the active mining period under the Modified Project Alternative would be very similar to those described for the proposed Project, except for impacts related to wetlands, streams, and aquatic habitats in the vicinity the Ramona OSA and the Holly and Hock TSF borrow areas. Moderate impacts on amphibians and reptiles using the terrestrial and aquatic environments in these areas would be expected for the duration of the active mining period.

Post-Mining Period

Post-mining period impacts on herptiles populations under the Modified Project Alternative would be similar to the proposed Project except in the aquatic habitats in the vicinity of the Ramona OSA and the Holly and Hock TSF borrow areas. As these areas would not experience the same amount of watershed disturbance, herptiles populations may be able to use these areas more rapidly as they would be similar to natural conditions. These areas may become refuges for other populations of amphibians and reptiles in the Project boundary during the mining period, and they would gradually disperse during the post-mining period.

4.7.6 Impacts Related to Pit Lakes

4.7.6.1 No Action Alternative

Under the No Action Alternative, monitoring of reclamation and closure activities would continue, and no additional mining would take place. The habitat quality in existing pit lakes within the Project boundary may improve slowly over time following reclamation. The existing pit lakes currently support very limited biological communities and few fish species. This would be expected to continue unless some other management action was taken, such as stocking.

4.7.6.2 Applicant’s Proposed Project

Active Mining Period

Very few aquatic surveys were conducted in the man-made pit lakes (see Section 3.7) within the Project boundary. Ledbetter Reservoir was the only pit to be surveyed for fish, and only two tolerant fish species (bluegill and pirate perch) were collected. The four other pit lakes (Snake Pit, Gault Pit, Champion Pit, and West Champion Pit) may have similar fish assemblages, but no further information is available. Ledbetter Reservoir was the only man-made lake in which benthic macroinvertebrate surveys were completed; these were part of an NPDES permit requirement from previous mining activities. With very

few exceptions, Ledbetter Reservoir had an ALUS classification of “does not support” aquatic life (Figures 4.7-3 and 4.7-4).

During the active mining period, all aquatic communities would be expected to be permanently lost as all the existing pit lakes would be fully drained and excavated.

Post-Mining Period

After reclamation and closure, Champion Pit, Small Pit, and Ledbetter Pit would not be backfilled but would be reclaimed as pit lakes. Ledbetter Pit Lake would require the addition of lime for 13 years after filling while lime would be added to Champion Pit for 17 years. Water quality monitoring would occur in all three pit lakes throughout the reclamation period to ensure that they eventually meet applicable state water quality standards.

Haile has proposed no restocking any of the pit lakes with fish; therefore, there is little likelihood for populations to become re-established or recruit within any lake during the reclamation period. Ledbetter Pit Lake eventually would be connected to Haile Gold Mine Creek, possibly resulting in some fish moving into the pit lake. Periphyton, algal, and macroinvertebrate populations would be expected to repopulate the lakes in a shorter time period, but mainly with tolerant species and not until filling of the pit lakes is complete.

4.7.6.3 Modified Project Alternative

Active Mining Period

Impacts on pit lake aquatic resources during the active mining period under the Modified Project Alternative would be the same as those described for the Applicant’s Proposed Project.

Post-Mining Period

Impacts on pit lake aquatic resources during the post-mining period under the Modified Project Alternative would be the same as those described for the Applicant’s Proposed Project.

4.7.7 Impacts on Essential Fish Habitat

NMFS reviewed the proposed Project regarding compliance with the EFH provisions of the Magnuson-Stevens Act. In a letter dated March 25, 2011, the NMFS stated that the nearest estuarine habitat is over 100 miles from the proposed mine (NMFS 2011). Consequently, EFH would not be affected by any alternative.

4.7.8 Impact Summary

Table 4.7-4 provides a summary of impacts on aquatic resources under all alternatives.

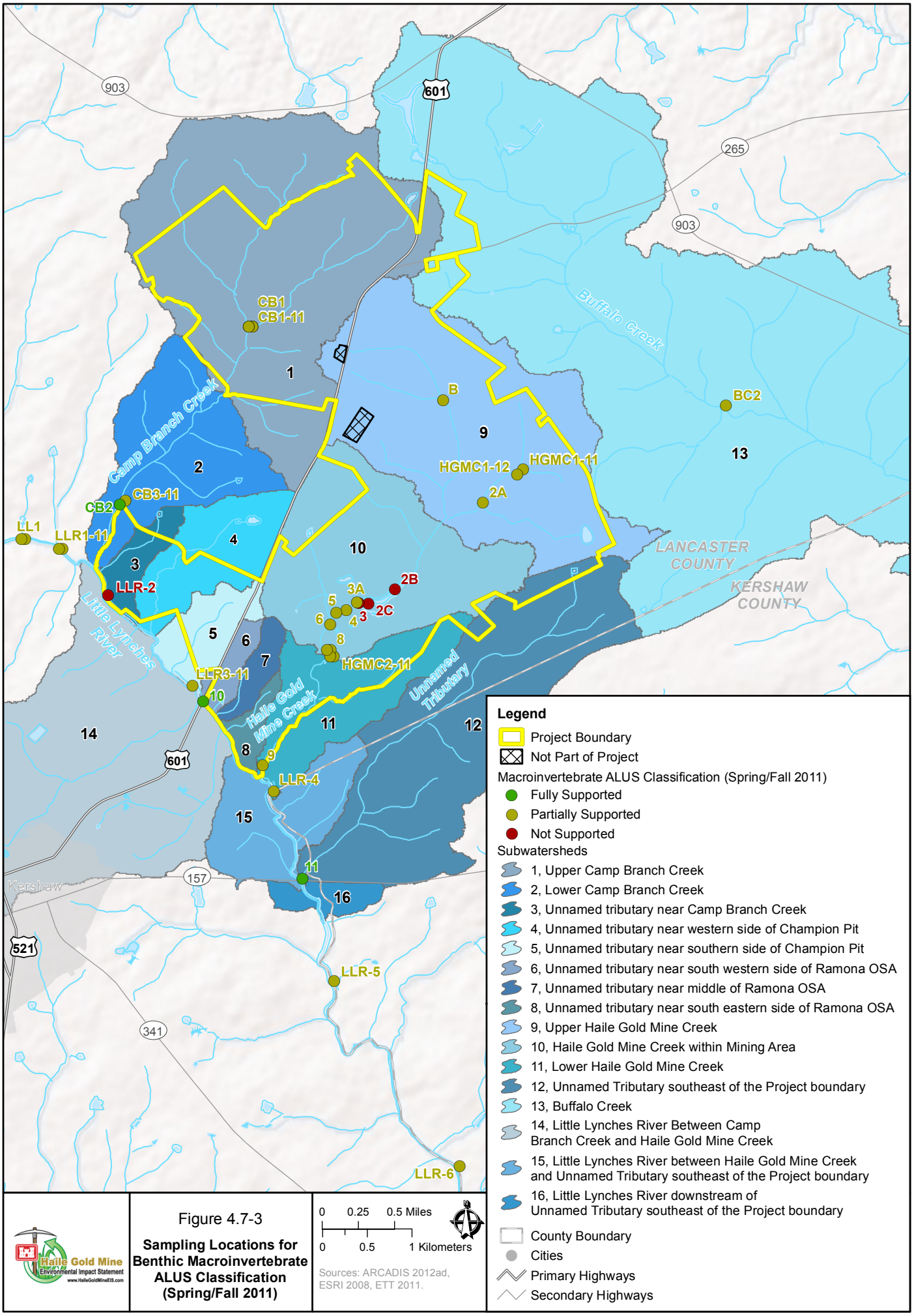

Figure 4.7-3

Sampling Locations for Benthic Macroinvertebrate ALUS Classification (Spring/Fall 2011)

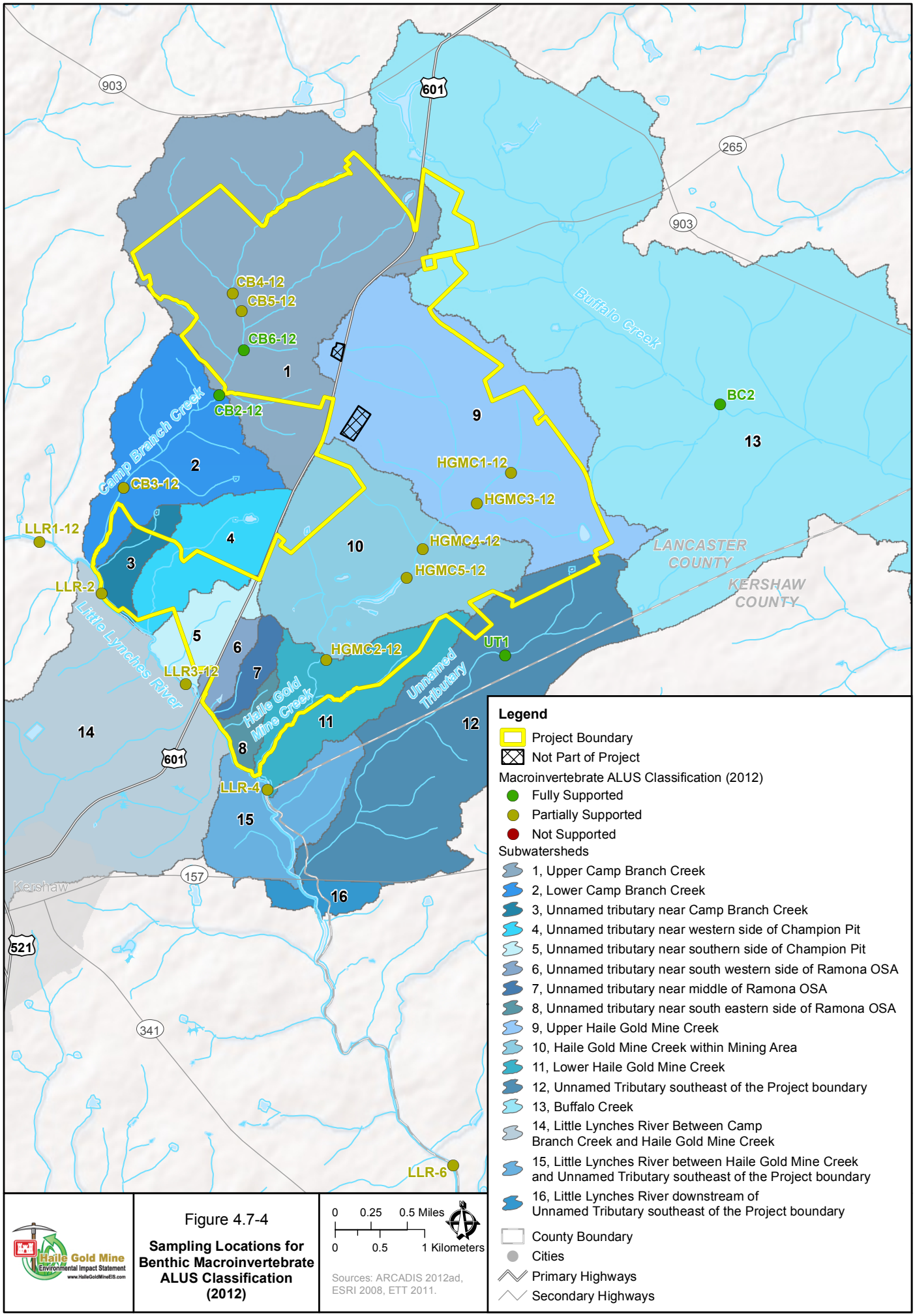

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Figure 4.7-4

Sampling Locations for Benthic Macroinvertebrate ALUS Classification (2012)

Table 4.7-4 Summary of Impacts on Aquatic Resources

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Stream fishes, macroinvertebrates, and biological condition	Reclamation and closure would continue and the habitat quality in streams with the project boundary previously affected by mining activities would be expected to improve slowly over time; expected along with these changes would be small to moderate incremental improvements in the biological integrity of Haile Gold Mine Creek. Other streams in the study area not previously affected by mining would remain largely unchanged subject to any watershed development that may occur.	The biological condition of the streams and subwatersheds directly and indirectly affected by mining would be expected to decline as a result of multiple stressors on the aquatic community including a large percentage of their watershed area being disturbed, stormwater runoff, altered water temperatures, increased total suspended solids and sediment loading; some of the most likely biological impacts would include such changes as loss of sensitive insectivorous fish species, loss of invertebrate taxa, dominance by tolerant omnivorous species, among others. The degree of impact on the biological health of stream communities would be greatest in more intensively developed subwatersheds, including upper and lower Haile Gold Mine Creek and upper Camp Branch Creek; other subwatersheds such as Buffalo Creek, upper Little Lynches River, and possibly Lower Camp Branch Creek would experience minor impacts on their biological condition or health.	Impacts of the Modified Project Alternative would be very similar to those described for the Applicant's Proposed Project, except for impacts related to streams and aquatic habitats in the vicinity the Ramona OSA and the Holly and Hock TSF borrow areas. Streams draining Holly and Hock TSF borrow areas would have more intense temporary watershed disturbance impacts of greater duration, and the runoff from the OSAs would concentrate stormwater flows, resulting in greater hydrologic modification. After reclamation and closure, the habitat quality in streams affected by the Modified Project Alternative would be expected to improve over time.

Table 4.7-4 Summary of Impacts on Aquatic Resources (Continued)

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Sandhills Chub and American Eel	Habitat quality in streams previously affected by mining activities would be expected to improve slowly over time; with small to moderate incremental improvements in the biological integrity of the streams. Improved stream conditions are expected to have a small beneficial effect on habitat on Sandhills chub, particularly individuals using Haile Gold Mine Creek. Small potential benefits to American eel based on existing distribution limited to the Little Lynches River downstream of the confluence with Camp Branch Creek. Other streams in the study area not previously affected by mining would remain largely unchanged subject to any watershed development that may occur.	Impacts on existing stream populations of Sandhills chub within Haile Gold Mine Creek and upper Camp Branch Creek would be moderate to major; middle Haile Gold Mine Creek would be excavated and upper Haile Gold Mine Creek would be completely fragmented and isolated from downstream segments for many years. Expected loss of Sandhills chub populations from upper Haile Gold Mine Creek due to flow reductions, higher stream temperatures, and potential water quality. Lower Haile Gold Mine Creek would become marginally acceptable or uninhabitable by Sandhills chub. Potential effects on American eel would be similar to those described in the section on fish, macroinvertebrates, and aquatic biological condition.	Similar to the Applicant's Proposed Project, with greater impacts to Sandhills chub habitats in upper Camp Branch Creek; however, since the headwaters of Camp Branch Creek would likely become marginally acceptable or uninhabitable by Sandhills chub under the proposed Project, the difference between these two alternatives may not be meaningful. Impacts to the American eel would be the same as for the Applicant's Proposed Project since was not found in Camp Branch Creek or the unnamed tributaries near the Ramona OSA.
Freshwater Mussels and Snails	Habitat quality in streams with the project boundary previously affected by mining activities would be expected to improve slowly over time. These improvements may or may not ultimately result in habitat suitable for freshwater mussels in Haile Gold Mine Creek. In the other sub-basins not previously mined, habitat for mussels and snails would remain largely unchanged, subject to any watershed development.	Freshwater mussels would be unlikely to colonize or inhabit subwatersheds directly and indirectly affected by mining, resulting in low impacts. Other subwatersheds such as Buffalo Creek and Little Lynches River would experience stressors at a low level, and therefore any mussel populations present should be largely unaffected.	Impacts would be very similar to those described for the Applicant's Proposed Project, except for impacts related to streams and aquatic habitats in the vicinity the Ramona OSA. The Ramona OSA would avoid filling unnamed tributaries and these streams would have experience less intense stressors, though they would still be affected by reduced base flows and other stressors and they would not be expected to support freshwater mussels.

Table 4.7-4 Summary of Impacts on Aquatic Resources (Continued)

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Amphibians and Reptiles (Herptiles)	Herptile populations would not be expected to change in any of the subwatersheds with the exception of Haile Gold Mine Creek. As time passed, habitats along Haile Gold Mine Creek may be better able to support more amphibians and reptiles as it naturally transitions to a more natural stream with improved riparian conditions.	Headwater streams, wetlands, and upland terrestrial habitat used by amphibians and reptiles would be directly and indirectly affected by mining. Upper Haile Gold Mine Creek would essentially be isolated from the downstream section of the watershed, and habitat for many herpetological species would be fragmented and indirectly degraded; impacts to wetlands would result in indirect impacts to herptiles due to their inability to migrate to other suitable habitats and isolation of individuals. Buffalo Creek, upper Little Lynches River, and possibly lower Camp Branch Creek would experience low stresses and populations of amphibians and reptiles would likely have only minor impacts. Herptiles using the remaining subwatersheds would likely be subject to intermediate impacts due to habitat fragmentation and hydrologic alteration.	Impacts on amphibians and reptiles would be very similar to those described for the proposed Project, except for impacts related to wetlands, streams, and aquatic habitats in the vicinity the Ramona OSA and the Holly and Hock TSF borrow areas. Moderate impacts to amphibians and reptiles using the terrestrial and aquatic environments in this area would be expected during the duration of the active mining period.
Pit Lakes	The habitat quality in existing pit lakes within the project boundary may improve slowly over time following reclamation. The existing pit lakes currently support very limited biological communities and few fish species. This would be expected to continue unless some other management action was taken such as stocking.	During the active mining period, all pit lake aquatic communities would be expected to be lost as all the existing pit lakes will be fully drained and excavated; after reclamation and closure, Champion Pit, Small Pit, and Ledbetter Pit would not be backfilled but would be reclaimed as pit lakes; fish populations are not likely to be reestablished in any pit lake without stocking; periphyton, algal, and macroinvertebrate populations would be expected to repopulate the lakes in a shorter time period, but mainly with tolerant species and not until the advanced stages of pit lake filling.	Impacts to pit lake during the active mining period under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.7.9 Mitigation for Impacts on Aquatic Resources

4.7.9.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included a number of avoidance and minimization measures. Haile has committed to these measures as a part of its proposed MMP (Haile 2013) (Appendix G). Measures relevant to aquatic resources include:

- Conduct post-mining reclamation and closure monitoring for purposes of ensuring continued compliance with permit requirements.
- Implement an aquatic community (fish and benthic macroinvertebrate) monitoring and reporting program during operations and post-mining.
- Design sedimentation ponds to treat runoff from growth media storage areas, OSAs, the Mill, Johnny's PAG, and the TSF.
- Implement 50-foot vegetative buffers around otherwise non-affected surface waters.
- Design storm ponds to allow animals a means of escape.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of avoidance and minimization measures for aquatic resources proposed by the Applicant is provided in Chapter 6. With implementation of the measures listed above, some of the short- and long-term impacts on flow, temperature, and water quality would be reduced.

4.7.9.2 Additional Potential Mitigation Measures

In addition to these measures, the USACE will consider other potential mitigation measures to reduce remaining impacts on aquatic resources from the proposed Project such as the following:

- During scoping, it was suggested that a relocation plan for the Sandhills chub be developed for the population found in Haile Gold Mine Creek.
- To preserve the known populations of Sandhills chub in the Little Lynches basin, translocate the populations within Camp Branch Creek, Haile Gold Mine Creek, and the unnamed tributary to the southeast of the Proposed Project to comparable waters nearby.
- To reduce the time required for benthic invertebrates and fish to recolonize portions of Haile Gold Mine Creek in the mined area after mining, plant the riparian zone with various age trees and native vegetation. Within the stream segments that were altered during mining, snags should be added to the water, riffles created, and the stream pattern, shape, and profile could be designed to be appropriate to the stream size and region.

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4.8 Terrestrial Resources

This section describes the potential impacts of the proposed Haile Gold Mine on terrestrial vegetation and wildlife resources[1] in the study area. Impacts on terrestrial vegetation include clearing and removal of large acreages of natural and previously disturbed terrestrial community types, potential impacts of groundwater drawdown on terrestrial vegetation, ongoing disturbance during mining (dust and invasive species), potential impacts on state-listed plant species, and reestablishment during reclamation of less diverse and productive terrestrial communities.

Potential impacts on terrestrial wildlife (birds and mammals) include temporary habitat loss and alteration; potential impacts on special-status species; ongoing disturbance during mining (dust, noise, and human activity); wildlife injury or mortality; and the potential for animals to be exposed to contaminants, including cyanide at the TSF.

Because many of these potential impacts would change over the course of mining and reclamation, many impacts are considered to be of greater duration than temporary, but not permanent, depending on how the land would be managed in the long term.

4.8.1 Methods

The type and severity of impacts on terrestrial resources depend on the characteristics of the disturbance (type, timing, and duration); where the disturbance occurs (the habitat type present and existing site characteristics); and the species present, and their sensitivity, habituation, and resilience to disturbance. Studies conducted by the Applicant document and characterize vegetation and wildlife resources in the Project area and were used to assess existing conditions. These references include:

- *Summary Report of Rare Plant Surveys Haile Gold Mine Properties, Lancaster and Kershaw Counties, South Carolina 2008–2010* (DuMond 2010).
- *Technical Memorandum Addressing Occurrences of Rare Plant Species of Kershaw and Lancaster Counties at Haile Gold Mine Properties, Lancaster County, South Carolina* (DuMond 2012).
- *Vegetation Community Mapping Report Haile Gold Mine Project* (ERC 2012).
- *Comprehensive Baseline Wildlife and Aquatic Resources Report for the Haile Gold Mine Site* (ARCADIS 2012) incorporating studies by Needham, Jernigan, & Associates (1993), Parnell (2008), and Needham Environmental, Inc. (2010).

The study area for terrestrial resources encompasses the Project area and land within approximately 0.5 mile of the Project boundary. Anticipated changes in the existing conditions for terrestrial resources in the study area under each alternative were identified and assessed quantitatively for resources for which quantitative data were available, including vegetation types, wildlife habitat, and raptor nests. For terrestrial resources where no quantitative data were available, impacts are described qualitatively.

Development and operations of the proposed Project require clearing and removal of vegetation in areas where mine pits, OSAs, the TSF, access roads, the Mill, and all other facilities would be located. Haile estimated the total disturbance area to be 2,612 acres (see Appendix A). This calculation does not account for 50-foot areas around mine components that are identified as areas of "additional disturbance" in the Section 404 permit application; Haile would try to avoid disturbance in this zone (areas where mine

[1] The discussion of wetlands is in Section 4.6, "Wetlands and Other Waters of the United States."

components abut wetlands, streams, or related buffers). For the terrestrial resources analysis, the total footprint of proposed mining activities is estimated at approximately 2,819 acres, including the 50-foot buffer around mine components that could be disturbed. Because the entire area within the 50-foot buffer is not likely to be disturbed, the amount of 2,819 acres over-estimates the expected area of disturbance for the proposed Project, and was used as the basis for calculating acreage of impacts.

4.8.2 Impacts

4.8.2.1 Vegetation Cover and Type

No Action Alternative

Under the No Action Alternative, the existing vegetation conditions in the study area generally would be expected to continue. The areas historically managed for agriculture and timber would continue to have vegetation characteristic of the stage of development of the crop or timber. Ongoing monitoring for reclaimed areas would continue in accordance with previous or ongoing permit requirements, and no additional mining associated with the proposed Project would occur.

Previously reclaimed areas would continue *vegetation succession*, the process by which species slowly replace one another as the community develops. Previous OSAs that are managed to prevent the development of large woody species would remain in an herbaceous scrub condition. The accumulation and subsequent decomposition of plant residues over time builds organic matter within soils and increases nutrient enrichment (Gairola and Soni 2010). Under the No Action Alternative, soil and habitat quality would likely improve for wildlife.

Applicant's Proposed Project

Table 4.8-1 and Figure 4.8-1 present the vegetation types within the study area that would be affected by clearing activities in preparation for mining. Approximately 34 percent (954 acres of the total area to be disturbed) would affect natural communities, including oak-hickory forest (617 acres, 21.9 percent), xeric Sandhills scrub (156 acres, 5.5 percent), slope wetlands[2] (140 acres, 5.0 percent), and small stream forest (40 acres, 1.4 percent). Small stream forest includes vegetated sites and flooded lowlands bordering small streams.

Approximately 67 percent of the total area to be disturbed (2,819 acres) would affect previously disturbed communities. Approximately 35 percent (985 acres) of the total area to be disturbed would be in modified managed upland vegetation-scrub regrowth from previous mining. This vegetation type includes most of the reclaimed area affected by previous mining activity. Approximately 323 acres (11.5 percent of the total area to be disturbed) would affect developed land. Developed lands include areas of low-intensity residential development, lawns, paved roadways, and historic mine facilities. Characteristics of the land type range from impervious (such as paved roadways), to planted lawns, to unvegetated mine features such as overburden stockpiles. Developed areas lack any significant natural vegetation communities (ERC 2012).

Vegetation would be re-established by reclamation activities in most of the vegetation communities that already have been subject to disturbance, including previous mining and other developments, and would

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[2] Wetlands and streams in the Project area and study area consist of headwater streams and riparian wetlands that are primarily considered slope wetlands (see Section 3.6, "Wetlands and Other Waters of the United States"). Impacts on these areas are discussed in Section 4.6.

be similar to, or potentially more diverse and productive than, the existing vegetation types found there. Impacts on vegetation in non-natural communities therefore would be temporary and minor.

Table 4.8-1 Vegetation Types in Natural Communities and Previously Disturbed Areas in the Project Area

Vegetation Type	Pit-Related Activities (acres)	OSAs (acres)	Duckwood TSF (acres)	Borrow Areas (acres)	Growth Media Storage Areas (acres)	Mill, Access Roads, Utility Pond, Detention Structure (acres)	Total Acres	Percentage of Total Disturbed Area (%)
Natural Communities								
Oak-hickory forest	95.7	97.7	304.4	92.2	14.7	12.7	617.4	21.9
Xeric Sandhills scrub	5.9	0.1	92.5	40.8	3.6	13.4	156.3	5.5
Slope wetlands	20.8	16.4	94.0	0.0	0.0	9.0	140.2	5.0
Small stream forest	18.6	13.5	7.2	0.0	0.0	1.0	40.3	1.4
Natural Communities Total							**954.2**	**33.8**
Land Use/Previously Disturbed Land[a]								
Managed tree plantation	0.2	67.9	90.9	0.0	0.0	9.0	168.0	6.0
Recently logged timberland	0.0	12.6	16.9	0.0	0.0	0.0	29.5	1.0
Modified managed upland vegetation-naturalized	35.4	94.2	7.6	0.0	24.6	20.9	182.7	6.5
Modified managed upland vegetation-scrub regrowth	218.8	393.1	195.7	18.8	68.2	90.4	985.0	34.9
Developed	233.3	36.1	0.2	0.0	0.9	52.5	323.0	11.5
Agriculture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open water[b]	20.4	1.4	0.0	0.0	0.0	0.0	21.8	0.8
Temporary access roads	6.2	3.5	120.7	21.9	0.0	2.3	154.6	5.5
Land Use/Previously Disturbed Land Total							**1864.6**	**66.5**
Total	**655.3**	**736.5**	**930.1**	**173.7**	**112.0**	**211.2**	**2,818.8**	**100.0**

Notes:

These calculations include the 50-foot areas around mine components that are identified as areas of "additional disturbance" in the Section 404 permit application.

[a] Previously disturbed land includes modified managed upland vegetation-scrub regrowth from previous mining, managed tree plantation and timberlands, developed land, agricultural land, pit lakes, and access roads.

[b] Open water includes pit lakes previously used for mining.

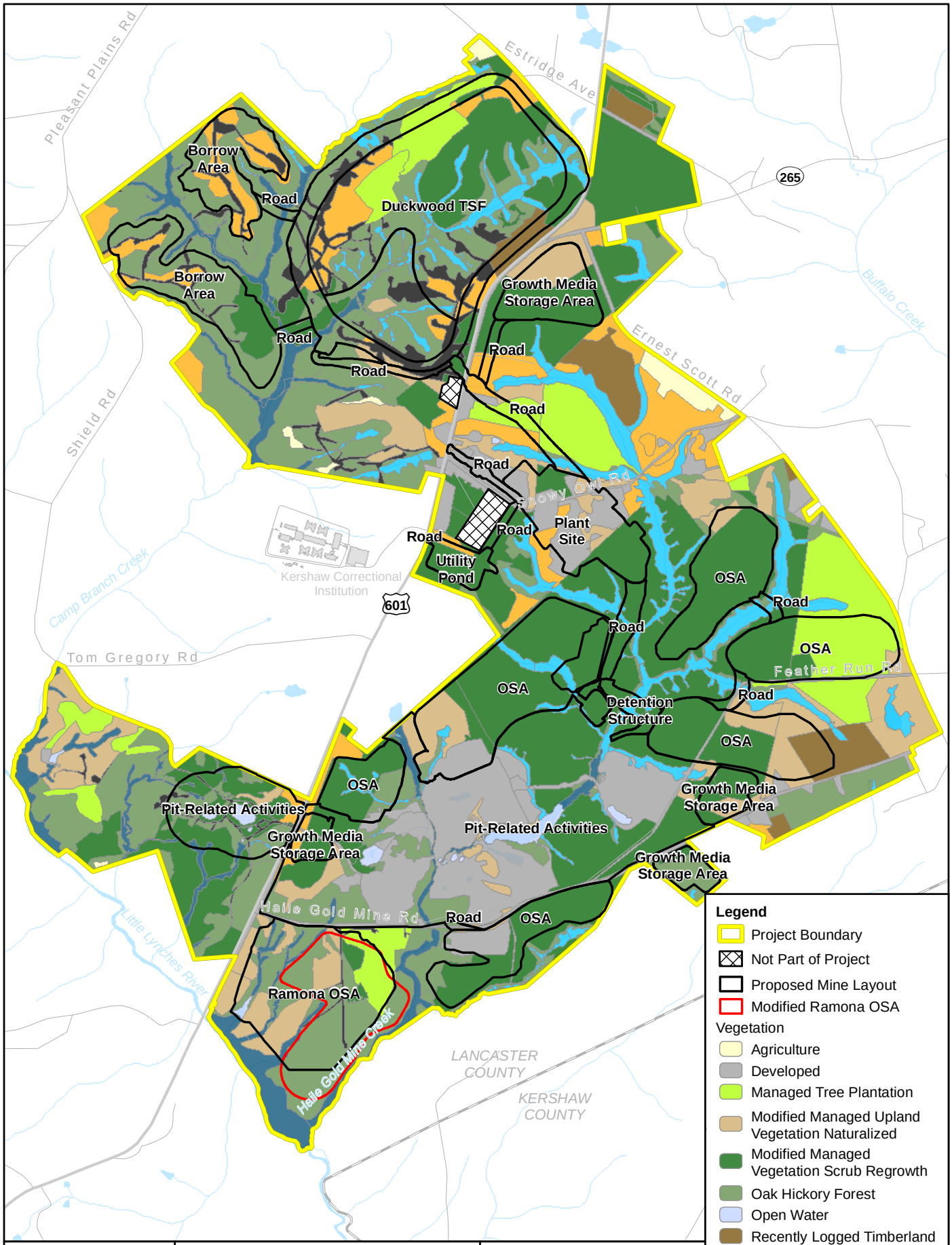

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Figure 4.8-1

Vegetation Types in Areas Disturbed by the Proposed Project and the Modified Ramona OSA

Vegetation in natural communities would be affected by the removal of trees and shrubs for preparation of mining and construction of facilities. The species composition in the natural communities to be disturbed would change from existing riparian, scrub, and forested areas to modified managed upland vegetation-scrub type vegetation post-mining. Previous reclamation and revegetation efforts at the mine have demonstrated that vegetation cover, although not of the same type as the natural communities, has been re-established on previously mined areas (Haile 2012). Vegetation cover similar to the modified managed upland vegetation-scrub regrowth type would be established on all disturbed areas, except for approximately 400 acres where herbaceous vegetation would be maintained and the area of the proposed pit lakes. Impacts on vegetation in natural communities would be temporary and moderate for areas that would not be maintained because vegetation would be allowed to re-establish. For areas where the vegetation would be maintained as grassland or scrub (on Johnny's PAG and the Duckwood TSF), the vegetation type and diversity would change, resulting in moderate, permanent impacts. Potential mitigation measures to reduce impacts on natural communities include using more diverse native seed mixes and replanting suitable locations with native trees and shrubs to provide more diverse vegetation communities post-mining, as described in the mitigation discussion below.

The removal of vegetation can cause increased erosion of soil on areas without the vegetative material to intercept rainfall, reduce runoff and stabilize soil, as addressed in Section 4.2, "Geology and Soils." Areas without well-established vegetation would be susceptible to invasion by weeds, including invasive or noxious species, because these species are typically adapted to primary succession on bare soil. However, no invasive or noxious weeds were found in previously reclaimed areas in the study area during surveys by DuMond (2010) from 2008 to 2010 (see Section 3.8), suggesting that this may not be of concern.

Disturbed areas would be reclaimed concurrent with operations when they are no longer needed for operation of the mine. The remaining areas would be reclaimed post-mining, as described in the Applicant's MMP (Haile 2013b) (Appendix G). The vegetation type ultimately present on reclaimed areas post-mining would likely resemble the modified managed upland vegetation-scrub regrowth type that currently occurs on 35 percent of the area that would be disturbed (Figure 4.8-2).

Studies carried out to compare reclaimed mine sites with undisturbed surrounding vegetation have shown that older reclaimed mine sites host a large percentage of the plant species found in the surrounding natural areas and may even host some rare species (Wade and Thompson 1993). The seeds of many plant species will disperse effectively on reclaimed mines if seed sources are accessible (if there is native vegetation close to the reclaimed site). Mechanisms for seed dispersal include wind, animals, and soil redistribution by the mining process. Storage and reuse of topsoil (growth media) may aid in the reclamation process by the storage of seeds; however, seeds lose viability when stored and the longer the storage period, the greater loss of viability (Holl et al. 2009). Wherever possible, therefore, the most recently removed growth media should be placed onto reclaimed sites to aid seed viability.

The choice of species used for reclamation appears to influence the plant species naturally colonizing reclaimed mines, as well as the rate at which those species colonize (Holl et al. 2009). Planting with less aggressive species allows a more rapid recovery of the native ecosystem than planting with aggressive groundcover species (Holl et al. 2009). Two seed mixes would be used to reclaim areas post-mining: a standard seed mix and a wetland seed mix, both of which would be certified as noxious-weed-free (Haile 2013a). The vegetation procedures planned for the Project area are based on industry standards, site-specific experience in South Carolina, and past reclamation success. The individual plant species in the proposed seed mix are generally known to establish quickly in South Carolina; as a mix, they are intended to complement each other in long-term establishment while ultimately developing a diverse native community (Haile 2013a).

Figure 4.8-2 Modified Managed Upland Vegetation-Scrub in Previously Disturbed Areas

Post-mining, disturbed areas that are reclaimed and subsequently unmanaged would continue vegetation succession much like the previously disturbed areas under the No Action Alternative. Successional species would likely include those found outside of the study area as seeds from the surrounding areas are dispersed and establish on reclaimed sites. For the long term, the vegetation in the study area is expected to continue succession, which would improve soil and habitat quality for wildlife.

In addition to the direct impacts of vegetation clearing, indirect impacts on vegetation may occur in some areas from groundwater lowering, which may reduce water availability to upland plant species. Impacts on wetland vegetation are presented in Section 4.6, "Wetlands and Other Waters of the United States." Response of terrestrial vegetation to reduced water availability depends greatly on the water requirements of individual plant species, their root depths, and tolerances. Plants with shallow root systems that require a fairly constant supply of water would be impacted to a greater extent than those which are more drought-tolerant or with deeper root systems. Impacts on vegetation from reduction in water availability may include stunted growth, greater susceptibility to disease (NCDENR 2009), and succession of more drought-tolerant species. Areas within 3 miles of the edges of the proposed mine pits that are currently used for timber harvesting also may experience effects on vegetation from reduced availability of groundwater. Impacts would depend on the actual timing and location of the groundwater lowering and the tolerance of the tree types.

Construction and operations of the mine would generate dust that could be dispersed beyond the areas cleared of vegetation. Section 4.16, "Air Quality" addresses dust generation and dispersion. Dust settling

on vegetation close to dust-generating activities (e.g., roads) may reduce cover and productivity of the vegetation through disruption of photosynthesis and reproduction processes. However, this would be a temporary impact and would be reduced through the use of dust suppression BMPs (see Section 4.16).

State-Listed Plant Species

Two state-listed plant species were found in the study area: heart-leaved foam flower (*Tierella cordifolia)* and nestronia (*Nestronia umbellula*). The one location of heart-leaved foam flower is outside of the area that would be disturbed by the proposed Project and would therefore not be directly affected (Figure 3.8-2). Nestronia is a relatively common shrub found at 16 locations along upper to middle slope habitats in dry woods dominated by several species of scrub oaks and pine (Figure 3.8-2). Thirteen of those locations would be directly affected by the proposed Project, and nestronia would be cleared during construction in those locations. The plant is a relatively common shrub in the region (DuMond 2012), and the impact on the regional population due to the proposed Project would be minor.

Modified Project Alternative

Impacts on vegetation associated with the Modified Project Alternative would be similar to those described for the Applicant's Proposed Project, except that the Modified Project Alternative would affect less vegetation by reducing the disturbance footprint of the Ramona OSA (Figure 4.8-2 and Table 4.8-2). The Modified Project Alternative would disturb approximately 47 acres less than the proposed Project, including a reduction of approximately 13 acres of small stream forest and 29 acres of modified managed upland vegetation (Table 4.8-2).

Impacts on vegetation in previously disturbed vegetation communities would be temporary and minor; impacts on vegetation in natural communities would be temporary and moderate for areas that would not be maintained, and would be permanent and moderate for areas that would be maintained. Over a long period of time post-mining, eventually there would be only minor differences between re-established vegetation areas under the Applicant's Proposed Project and the Modified Project Alternative.

Table 4.8-2 Comparison of Vegetation Disturbance in the Ramona OSA under the Applicant's Proposed Project and the Modified Project Alternative

Type to Be Disturbed	Applicant's Proposed Project (acres)	Modified Project Alternative (acres)
Developed	0.1	0
Managed tree plantation	17.9	16.0
Modified managed upland vegetation	40.1	11.2
Modified managed vegetation scrub regrowth	6.5	6.5
Oak hickory forest	82.3	80.5
Open water	1.4	0
Small stream forest	13.4	0.3
Temporary access road	3.5	3.2
Total	**165.2**	**117.8**

State-Listed Plant Species

Under the Modified Project Alternative, heart-leaved foam flower would not be directly affected (Figure 3.8-2). The Modified Project Alternative would affect the same locations of nestronia as the proposed Project, resulting in the same minor impact on the regional population.

4.8.2.2 Wildlife and Wildlife Habitat

No Action Alternative

Under the No Action Alternative, the existing habitat conditions for terrestrial wildlife in the study area generally would be expected to continue. The areas currently managed for agriculture and timber would continue to have habitats characteristic of the stage of development of the crop or timber. The existing habitats in the study area are fragmented due to previous developments (e.g., habitats adjacent to the Kershaw Correctional Institution), roads, mining, silviculture, agriculture, rural development, and infrastructure such as transmission lines (ARCADIS 2012). *Habitat fragmentation* refers to the division of large, contiguous blocks of habitat into smaller, more isolated parcels that are less suitable for wildlife. The areas currently being monitored for past mining activities would continue in accordance with previous permit requirements. No additional mining activity or impacts associated with the proposed Project would occur, and habitat would be expected to improve over time as vegetation continues to grow on previously disturbed areas.

Applicant's Proposed Project

Habitat fragmentation would result from removal of vegetation and loss of habitat during construction of the mine facilities, and from human disturbance during operation of the mine. Clearing activities would temporarily increase habitat fragmentation until reclamation and revegetation are accomplished. Except for Johnny's PAG and the Duckwood TSF, which would be maintained as herbaceous vegetation cover rather than woody species, and the areas that would become pit lakes, reclaimed areas would provide habitat similar to the modified managed upland vegetation-scrub regrowth type that is currently found on approximately 35 percent of the area to be disturbed. This would increase habitat connectivity in the long term, depending on future land management. Because the existing habitat in the study area is already fragmented, additional fragmentation during construction and operation of the proposed Project would cause a minor temporary impact on wildlife. After reclamation and revegetation, permanent post-mining impacts due to habitat fragmentation would be minor.

Birds

Vegetation clearing would result in direct minor impacts on avian habitat by eliminating existing vegetation until reclamation is accomplished, including habitat for birds protected under the MBTA. Reclaimed areas would provide habitat similar to the modified managed upland vegetation-scrub regrowth currently on approximately 35 percent of the total area to be disturbed once vegetation becomes established post-mining. Of all habitats surveyed, the highest number of bird species was observed in the previously disturbed habitat type, which was dominated by American crow, Carolina wren, and eastern towhee. These species also were dominant in all other habitats surveyed in the Project area. The reclaimed areas would provide habitat for re-establishment of avian species, including those protected under the MBTA, that were present in much of the Project area prior to mining.

Regarding impacts on raptors and other large birds, the facilities associated with the proposed Project largely would be at distances greater than 0.5 mile from the riparian corridors where raptor nests were found or where raptors would be expected to use the Project area. An exception is the Ramona OSA,

which would be within approximately 1,000 feet of the Little Lynches River. No red-shouldered hawks, red-shouldered hawk nests, other raptor or raptor nests were observed within this reach of the Little Lynches River riparian corridor. Given the lack of suitable nesting and foraging habitat throughout the Project area except along the margins of the Project boundary, and no observations of raptors or their nests within 0.5 mile of proposed facility structures, potential impacts on raptors and other large birds would be temporary and minor.

Indirect impacts on birds may include disturbance from human activities such as noise. Birds are expected to avoid construction areas and are highly mobile, able to move quickly away from disturbance. The distance avoided would depend on many factors, including the type, timing, season, and duration of human activity; the type of habitat adjacent to the activity; and the sensitivity and tolerance of the birds affected. The majority of bird species currently present (American crow, northern cardinal, mourning dove, blue jay, Carolina chickadee, and Carolina wren) commonly inhabit previously disturbed habitats. These common species are relatively abundant, and are adapted to living in close association with human activity and infrastructure. As such, indirect impacts on birds from human disturbance are expected to be temporary and minor.

Mammals

Vegetation clearing would result in direct minor impacts on wildlife habitat by eliminating existing vegetation until reclamation is accomplished. The species currently present are those that have adapted to using previously disturbed habitats, as demonstrated by their presence in these areas. These species would be expected to re-occupy reclaimed areas post-mining. Because most mammals observed (feral hog, white-tailed deer, coyote, raccoon, bat, and squirrel) during surveys in the Project area were found in the previously disturbed vegetation habitat type, which would be re-established post-mining, impacts on mammals from habitat loss would be temporary and minor.

The Applicant's Proposed Project could remove bat foraging habitats; however the impact would be minor, given the relative abundance of suitable habitat in the surrounding area compared to the availability of such habitat in the study area. In addition, forest clearing activities around the edges of the Project boundary may create new foraging habitats for bats.

Indirect impacts on mammals may include disturbance from human activities such as noise, and a reduction in water sources. Most of the species present in the study area occupy previously disturbed habitats, are relatively abundant common species, and are adapted to living in close association with human activity and infrastructure. As such, indirect impacts on wildlife from human disturbance are expected to be temporary and minor.

Water sources for wildlife would be affected when directly disturbed by mining activities and indirectly disturbed through groundwater lowering. This would occur simultaneously with loss of wildlife cover habitat. Impacts from loss of water sources in the study area are expected to be temporary and minor.

Priority Conservation Wildlife Species

Eight SCDNR priority conservation species have been observed in the study area: Acadian flycatcher, brown-headed nuthatch, eastern wood-pewee, field sparrow, prairie warbler, northern bobwhite, American kestrel, and little blue heron. These species were observed primarily in vegetation communities that had been subjected to previous disturbance. These species may be affected through direct loss of habitat and avoidance of adjacent habitat when portions of their habitat are removed or disturbed during construction and operation of the mine. However, given the limited presence of these species in the Project area, the fragmented condition of the existing habitat, and the availability of similar suitable

habitat in the region, the habitat loss would be a moderate impact on the individuals displaced but a minor impact on regional populations. Because the species currently occupy previously disturbed habitats in the Project area, it is likely that they would reoccupy habitat provided in the reclaimed areas post-mining.

Modified Project Alternative

Impacts on wildlife habitat associated with the Modified Project Alternative would be similar to those described for the Applicant's Proposed Project, except there would be 47 acres less disturbance from the modified Ramona OSA. Figure 4.8-2 and Table 4.8-2 show the differences in affected areas under the two project alternatives. The Modified Project Alternative would avoid impacts on approximately 13 acres of small stream forest and 29 acres of modified managed upland vegetation (Table 4.8-2).

4.8.2.3 Wildlife Disturbance and Potential Contamination

No Action Alternative

Under the No Action Alternative, Haile is expected to complete its reclamation and mine closure responsibilities and vacate the site, reducing the potential for contact between wildlife and road traffic and resulting in less potential for mortality. A very low level of potential contamination exists from previously disturbed and reclaimed mine features (such as Chase Hill Pad, see Figure 4.8-2) which has been lined and revegetated. The areas currently being monitored for past mining activities would continue in accordance with previous permit requirements. No additional mining activity or impacts associated with the proposed Project would occur.

Applicant's Proposed Project

Injury or mortality of mammals, birds, and other small animals could occur through direct contact with construction equipment, traffic, open pits, pit lakes, sediment/storage/retention ponds, and toxic materials. Impacts on wildlife from connected actions (such as the proposed transmission line) are discussed in Section 4.20. Wildlife would likely move away from the study area in the presence of human activity, which would decrease the potential for direct contact with construction equipment and traffic. In addition, large equipment would move slowly through the area, which would reduce the potential for collisions with wildlife. Haile also would enforce a low speed limit for all traffic on roads within the Project area. Direct impacts would occur only in the areas directly affected by construction activities. Although individuals could be affected, entire populations would not, resulting in minor temporary impacts on wildlife from contact with construction equipment.

Animals could fall into open mine pits, causing injury or mortality. This potential impact would be temporary and minor because the mine pits would be the location of much of the noise and human disturbance and therefore likely would be unattractive to wildlife. Post-mining, the pits would be backfilled or developed into pit lakes.

Wildlife could fall into pit lakes and may not be able to escape. This potential impact would be reduced with the creation of a sloping littoral shelf at the edges of pit lakes, as required by State permits. This may also increase vegetation diversity at the edges of pit lakes where riparian species may establish. This measure would be created at the end of mining but before the pits completed filling with water, at which time the appropriate elevation for the littoral shelves would be established.

The sediment detention ponds would be open to the air and thus accessible to wildlife that may be attracted by the presence of water. However, these would be dry the majority of the time and only hold water during a storm event. In addition, noise and human disturbance would make this area generally

unattractive to most wildlife, resulting in temporary and minor impacts. In addition, the sediment retention ponds would be designed to allow animals a means of escape, should they enter the ponds. Post-mining, these facilities would be demolished and salvaged or removed, and the sites would be regraded, resulting in no impacts on wildlife post-mining.

Cyanide is used in mining to extract gold from ores after crushing, grinding, and flotation, and could be a source of toxicity to wildlife. The potential exposure points for wildlife would be the pond in the TSF and any accidental release along the tailings slurry pipeline. Haile has committed to maintain a cyanide concentration of no more than 50 mg/L (50 ppm) weak acid dissociable (WAD)[3] cyanide that would be pumped to and stored in the TSF. Within the TSF, the concentration of cyanide would be less than 50 mg/L WAD cyanide and would be continuously reduced due to natural processes such as dissociation, photolysis and volatilization.

In general, wildlife could be exposed to cyanide through ingestion, inhalation, or skin contact (Ballantyne 1987). Cyanide exposure to wildlife could potentially occur through ingestion of or direct contact with water or sediment in the TSF, or prolonged inhalation of cyanide gas.

The International Cyanide Management Code (the Code) was developed to facilitate responsible use and management of cyanide in the gold mining industry (ICMI 2012). The limit of 50 mg/L WAD cyanide was assigned in the Code to protect wildlife that drink and forage within a TSF without the need for additional protective measures, although any additional measure that would protect wildlife is encouraged (ICMI 2006).

Three major forms of cyanide are found in gold mine TSFs: free cyanide, WAD cyanide complexes, and strong cyanide complexes. WAD cyanide is a more reliable measure for toxicity and is considered more biologically relevant than total cyanide because total cyanide includes stable compounds (e.g., ferrocyanide complexes) that do not contribute to toxicity (USEPA 1980; Eisler 1991).

There has been generally low mortality of most avian species at TSF ponds that maintain WAD cyanide concentrations below 50 mg/L; however, some deaths of migratory birds have been recorded below this level and sublethal effects have been documented in mallards and pigeons from water containing less than this concentration (Eisler and Wiemeyer 2004; Brasel et al. 2006) including sublethal effects such as panting, labored breathing, eye blinking, tremors, and lethargy (Cooper 2003, cited in NICNAS 2010). These results are from laboratory studies which are based on toxicity of sodium cyanide which completely dissociates in solution. In a TSF pond, some cyanide will volatilize, precipitate, and complex into forms that are not bioavailable, resulting in lower levels of effects. Some field studies of wildlife exposure to cyanide have shown no mortality at levels above 50 ppm WAD cyanide while others have indicated mortality at levels below this. Not all of the field studies are reliable due to inconclusive reasons for deaths of wildlife, amateur wildlife monitors, and no standard method of monitoring both wildlife and cyanide concentrations within a TSF.

Wildlife could use the TSF as a source of water and food, and as a resting area. Mammals and birds can be exposed to water at TSF ponds resulting in potential mortality. In birds and mammals, WAD cyanide dissociates in weak acid making it bioavailable and toxic to organisms. Therefore, cyanide might not be immediately toxic upon ingestion and will take time to dissociate in weak stomach acid to cause toxic effects (Eisler 1991). Cyanide is unlikely to bioaccumulate in the food chain because it is rapidly metabolized (USEPA 1985; Gensemer et al. 2007). Studies by Wiemeyer et al. (1986) showed that

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[3] WAD cyanide refers to metal cyanide complexes (combinations of cyanide with metals such as Zn, Cd, Cu, Hg, Ni, and Ag) that dissociate (separate) under weak acid conditions of pH 4.5 to 6.

injured birds that were alive after 60 minutes from exposure often survived due to rapid metabolism and detoxification of cyanide to thiocyanate. Organisms have the ability to process and detoxify cyanide reducing the impact of chronic effects. The MBTA, which protects migratory birds during migration, does not stipulate acceptable WAD cyanide concentrations; however, the Code level of 50 mg/L WAD historically has been adopted to meet treaty objectives (Kay 1990).

Because WAD cyanide is unlikely to bioaccumulate (NICNAS 2010), the risk of secondary exposure (by animals feeding or scavenging on other animals that have ingested low levels of cyanide) is minor. However, total reliance on WAD cyanide might not account for all cyanide available to wildlife. WAD cyanide includes only complexes that dissociate over pH 4.5, and gastric acid in some bird and mammal stomachs can dissociate complexes below pH 4.5, thus freeing the cyanide and making it bioavailable (Henny et al. 1994). In addition, for many of the gold mines in the deserts of the western United States, cyanide exposure to wildlife is a larger concern due to the lack of alternative water sources for drinking and resting areas for migrating birds and other wildlife (Henny et al. 1994). Because alternative drinking water sources to the TSF are available to wildlife within the Project boundary, wildlife exposure to cyanide due to limited water sources would be considerably less.

Risks to the environment from exposure to gaseous HCN are considered acceptable because hydrogen cyanide released into the atmosphere at the WAD cyanide levels estimated for the proposed Project (4.65 tpy) is unlikely to cause ecotoxicity (NICNAS 2010). (See Section 4.16, “Air Quality” for a discussion of fugitive emissions of HCN.) For many cases in the field where no wildlife deaths were reported with concentrations above the 50 mg/L WAD cyanide limit, secondary protection mechanisms were used around TSF ponds. Griffiths et al. (2009) conducted a field study based on a functioning TSF pond treated to reduce the WAD cyanide concentration and hyper-salinated to protect wildlife. No wildlife deaths were reported even when the WAD cyanide concentration in the influent spigot was over 50 mg/L WAD (69.7 mg WAD/L); no birds were reported to have drunk from the pond. Therefore, although a concentration of 50 mg/L WAD cyanide was protective to wildlife, secondary protection measures also were in place. Operations that released greater than 50 mg/L WAD cyanide have reported wildlife mortality, but these operations did not use primary or secondary protection mechanisms (Donato et al. 2007; Henny et al. 1994). The Sunrise Dome Central TSF also recorded over 50 mg/L WAD cyanide and reported no wildlife deaths, even with 1,096 wildlife visitations. The USFWS observed 17 mines in Nevada with cyanide in TSF ponds ranging from 8 to 216 mg/L WAD cyanide. Mortality was observed in only two ponds (with concentrations of 81 and 62 mg/L WAD cyanide). Because no mortality was observed at the other ponds, including those with higher concentrations of WAD cyanide, another factor might have deterred birds from the pond or the observed mortalities were not due to cyanide (Hagelstein and Mudder 2006).

There are also examples of wildlife deaths due to cyanide from TSF ponds where the concentration is below 50 mg/L WAD cyanide. Over a 2-year period at the Ridgeway Mine in South Carolina, 271 vertebrates were reported dead around the mine. Of these, 13 percent were mammals, 86 percent were birds, and the rest were reptiles and amphibians. Of the 25 mammals reported, 29 were bats (Clark et al. 1991). In Nevada, 9,512 dead wildlife were reported at gold mine TSFs in a 4-year period. Of these, 91 percent were birds (waterfowl, shorebirds, and perching birds), 7 percent were mammals (rodents, rabbits, bats, and carnivores), and 3 percent were amphibians and reptiles (Henny et al. 1994). Paradise Peak Mine in Nevada decreased cyanide levels in discharge into a TSF from 500 mg/L to less than 50 mg/L. Although bird mortalities were reduced by 97 percent, 26 mortalities were observed in 1 year, thus the lowered concentration did not protect all wildlife (Hagelstein and Mudder 2006). Although most studies have not determined the cause of these wildlife deaths, most mortalities are assumed to be from cyanide.

Most mines with high WAD cyanide concentrations (over 50 mg/L) with few to no wildlife deaths also implemented another method of protection such as maintaining a hypersaline TSF solution to discourage wildlife from drinking from the pond. Hypersaline solution is considered to have >50,000 mg/L TDS (NICNAS 2010). Wildlife will choose to not drink from hypersaline ponds and will find other sources of water. Other methods to exclude wildlife access to a TSF include installing fencing, noise deterrents, decoy wetlands, walls, berms, netting, and HDPE floating balls (Logsdon et al. 1999; Donato et al. 2007; Eisler and Wiemeyer 2004). HDPE balls prevent birds from being attracted to the pond and require no maintenance (Eisler and Wiemeyer 2004). Water hyacinths (*Eichhornia crassipes*) can be introduced to TSFs to accumulate cyanide with no negative effect on the plant; therefore, they have been a proposed as a mitigation technique of reducing cyanide in untreated wastewater (Eisler et al. 1999). Reducing the food sources in and around a TSF for foraging is important to reduce the contact time that organisms have with cyanide-contaminated water. Building alternative freshwater ponds for drinking sources located away from a TSF also help to deter the use of a TSF as a drinking source (NICNAS 2010). A gold mine in Africa decreased bird deaths from 554 in 2001 to 2 deaths in 2004 by creating alternative drinking pools, using noise deterrents, preventing access to ponds, and using HDPE balls (NICNAS 2010).

At the proposed Project, the TSF area would be fenced to prevent access to the area for many wildlife species. The Applicant would monitor for wildlife presence in the area and deter wildlife away from the area as necessary, as described in the MMP (Haile 2013b) (Appendix G). Haile has proposed to avoid any accumulation of substrate that may form islands in the TSF, to avoid attracting birds. Haile has proposed to deter birds away from the TSF with the use of air horns and more aggressive mechanical noises or pyrotechnics. Because these measures would not likely reduce all potential impacts on wildlife, and birds in particular, additional measures are considered in the mitigation discussion at the end of this section.

Post-mining, the TSF would be closed, using a dry closure approach, covered with a minimum of 2 feet of growth media, and revegetated. There would be little or no risk of cyanide exposure to wildlife after the TSF was reclaimed because the tailings would be contained and not exposed to the air. During reclamation, a process water treatment system would treat underdrainage from the TSF until the flows have diminished to a level where the outflow can be treated in a passive treatment system. This passive treatment system would resemble a wetland and may be attractive to wildlife. The levels of cyanide and other contaminants in this system would be evaluated as part of the permitting of the passive treatment wetland systems for the TSF and Johnny's PAG, and would be required by the SCDHEC to meet state water quality standards as part of the conditions of the NPDES discharge permit. Similar measures to avoid potential impacts on wildlife, and birds in particular, may need to be considered for the passive treatment facility.

Long-term impacts on wildlife at the regional population level from mortality during construction, operations, and reclamation of the mine would be minor for species that are common and occur throughout similar habitats surrounding the study area and throughout the region. The number of individual animals that may suffer mortality would represent a small portion of the regional population, limiting long-term impacts on wildlife at the regional population level. For species that are less common or rare, or for migratory species protected under the MBTA, the impacts could be moderate.

Modified Project Alternative

Impacts on wildlife from disturbance and potential contamination resulting in injury or mortality under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.8.1 Impact Summary

Table 4.8-3 presents a summary of impacts on terrestrial resources under each alternative.

Table 4.8-3 Summary of Impacts on Terrestrial Resources

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Vegetation cover and type	Previously disturbed and reclaimed vegetation communities would continue to change and mature over time, with improvements in plant and habitat diversity.	Approximately 2,819 acres of vegetation would be cleared, of which 67% would consist of previously disturbed vegetation communities. Species composition in natural areas would change from existing riparian, scrub, and forested areas to modified managed upland vegetation-scrub type post-mining. In the long term, vegetation communities would continue to change and mature over time, with improvements in plant and habitat diversity. Indirect impacts on vegetation, including effects on timber harvesting activities, from reduction in water availability may include stunted growth, greater susceptibility to disease and succession of more drought-tolerant species.	Same as Applicant's Proposed Project.
Sensitive plant species	Sensitive plant species would likely not be disturbed, depending on the future uses of the Haile property.	Loss of nestronia, a state-listed sensitive plant species, at 13 locations.	Same as Applicant's Proposed Project.
Wildlife and wildlife habitat	Wildlife habitat would be expected to slowly improve over time as vegetation continues to grow in previously reclaimed areas.	Temporary loss of wildlife habitat from removal of vegetation. Increase in habitat fragmentation until reclamation and revegetation are accomplished. Reclaimed areas would provide habitat for re-establishment of wildlife species that occurred prior to mining. Wildlife would temporarily avoid areas disturbed by construction activities and noise.	Same as Applicant's Proposed Project, but with removal of 47 fewer acres of wildlife habitat.

Table 4.8-3 Summary of Impacts on Terrestrial Resources (Continued)

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
State-listed wildlife species	State-listed wildlife species would likely not be disturbed, depending on the future uses of the Haile property.	Reclaimed areas would provide habitat for re-establishment of State-listed wildlife species that occurred prior to mining. Wildlife would temporarily avoid areas disturbed by construction activities and noise.	Same as Applicant's Proposed Project, but with removal of 47 fewer acres of wildlife habitat.
Disturbance of wildlife	As Haile completes its reclamation and closure responsibilities, there would be reduced potential for contact between wildlife and road traffic, resulting in less potential for mortality.	The potential exists for direct and indirect disturbance and mortality of wildlife during mine operations. This potential would be reduced considerably post-mining.	Same as Applicant's Proposed Project.
Potential contamination of wildlife	A very low level of potential contamination exists from previously disturbed and reclaimed mine features such as Chase Hill Pad.	Wildlife could be exposed to cyanide at the TSF during mine operations, resulting in potential mortality. The risk of secondary exposure is minor. Cyanide gas is unlikely to cause ecotoxicity. Little or no risk of cyanide exposure to wildlife after reclamation of the TSF.	Same as Applicant's Proposed Project.

4.8.3 Mitigation for Impacts on Terrestrial Resources

4.8.3.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included a number of avoidance and minimization measures in the design and plans for operating and managing the proposed Haile Gold Mine. Haile has committed to implementing many of these measures as a part of its proposed MMP (Haile 2013b) (Appendix G).

Applicant-proposed avoidance and minimization measures are summarized below:

- Follow the MBTA terms described in 16 USC 703(a).
- Implement an avian mortality reporting system.
- Install an 8-foot fence around all HDPE double-lined ponds and the TSF facility.
- Inspect and maintain all fencing around HDPE double-lined ponds and the TSF perimeter regularly.
- Monitor wildlife at all open retention structures.
- Visually survey transportation corridors in the Project area for signs of wildlife.
- Use skirting to enclose open spaces as necessary beneath raised structures.
- Limit the concentration of WAD cyanide in the TSF Reclaim Pond to a maximum of 50 ppm.

- Avoid exposed sediment "islands" in HDPE double-lined ponds as possible to reduce attraction to wildlife;
- Design and operate contact and process water ponds to restrict access, where necessary, and to provide a means of escape for trapped animals.
- Clear vegetation surrounding the perimeter of HDPE-lined ponds, and minimize infrastructure around open solution ponds and the TSF where practicable.
- Use seed mixes to promote diverse wildlife in areas undergoing final reclamation.
- During final grading of facilities during reclamation, leave occasional large boulders that are uncovered during sloping on the surface to provide microhabitats for wildlife and vegetation.
- Ensure that workers do not intentionally feed, harass, or approach wildlife.
- Follow posted speed limits for traffic in the Project area to reduce incidents with wildlife.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of avoidance and minimization measures for terrestrial resources proposed by the Applicant is provided in Chapter 6.

With implementation of the measures listed above, long-term impacts on wildlife at the local level would be temporary and minor to moderate, and would be negligible at the regional population level. Most of the species currently using the study area are common and occur throughout similar habitats surrounding the Project area and throughout the region. The small number of individual animals that may affected by the Applicant's Proposed Project or the Modified Project Alternative would represent a small portion of the regional population, limiting long-term impacts on wildlife at the regional population level.

4.8.3.2 Additional Potential Mitigation Measures

In addition to the measures proposed by the Applicant, the USACE will consider other potential mitigation measures to reduce the remaining impacts on wildlife from the proposed Project, as described below:

- To minimize long-term impacts on natural communities from reductions in vegetation type and diversity and to improve the time of recovery of reclaimed areas, replant suitable locations with diverse seed mixes and native trees and shrubs.
- To maximize seed viability in stored growth media, place the most recently removed topsoil onto reclaimed sites.
- To increase safety for wildlife and create potential riparian habitat, design and implement a sloping littoral shelf at the edges of pit lakes to increase fringing aquatic habitat for wildlife and safe access for wildlife to the water.
- To address potential wildlife mortality, a wildlife protection and mortality response plan could be developed in consultation with the USFWS and the SCDNR that would be incorporated into permits issued by the USACE and the SCDHEC. This plan should consider such measures as hypersaline TSF solution, decoy wetlands, netting, HDPE floating balls, water hyacinths, reducing the food sources in and around a TSF for foraging, and building alternative freshwater ponds to provide drinking sources away from a TSF.

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4.9 Federally Listed Species

This section describes potential impacts on species listed as threatened, endangered, or candidate by the USFWS under the ESA.

4.9.1 Impacts

As discussed in Section 3.9, no TEC species were found to be present in the study area. In addition, no designated or proposed critical habitat is present in the study area. The Joint Public Notice (January 28, 2011) included the following:

> *Pursuant to Section 7(c) of the Endangered Species Act of 1973 (as amended), the applicant has provided a protected species survey for the property associated with the activity described above. Based upon this report, the District Engineer has determined that the project is not likely to adversely affect any federally endangered, threatened, or proposed species or result in the destruction or adverse modification of designated or proposed critical habitat.* (USACE and SCDHEC 2011)

The USFWS concurred with the determination of "not likely to adversely affect" federally endangered, threatened or proposed species or their critical habitat:

> *We have reviewed the project for potential adverse impacts to federally protected species and critical habitat. Based on the information received, we concur with a determination that this project is not likely to adversely affect any federally protected species and/or designated or proposed critical habitat.* (USFWS 2011)

No additional information has indicated that listed species have been found in the Project area, the action has not been modified to include areas occupied by listed species or critical habitat, and new species have not been listed nor critical habitat determined during the interim that would be affected by the proposed Project.

In August 2012, the Applicant submitted a revised DA permit application to the USACE that included some additional in-parcels, increasing the total Project area by 45.9 acres. The USACE published a revised public notice on April 9, 2013, that included a determination of "not likely to adversely affect":

> *Pursuant to Section 7(c) of the Endangered Species Act of 1973 (as amended), the applicant has provided protected species surveys for the property associated with the activity described above. Based upon this report, the District Engineer has determined that the project is not likely to adversely affect any federally endangered, threatened, or proposed species or result in the destruction or adverse modification of designated or proposed critical habitat. This notice maintains consultation requirements with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service regarding federally protected species, No response was received from the USFWS.* (USACE 2013a)

More recent coordination with the USFWS (USACE 2013b) indicated that the USFWS concurrence with the determination of no adverse effect still stands.

Similarly, the No Action Alternative and the Modified Project Alternative would not cause impacts on TEC species or designated critical habitat.

Final coordination with the USFWS will occur prior to the Record of Decision.

4.9.2 Impact Summary

Table 4.9-1 presents a summary of effects under each alternative for federally listed species.

Table 4.9-1 Summary of Impacts on Federally Listed Species

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Federally listed species	No threatened, endangered, or candidate (TEC) species or their critical habitat occur within the proposed Project boundary; therefore, there would be no effect on TEC species.	No TEC species or their critical habitat occur within the proposed Project boundary; therefore, there would be no effect on TEC species.	No TEC species or their critical habitat occur within the proposed Project boundary; therefore, there would be no effect on TEC species.

4.9.3 Mitigation for Impacts on Federally Listed Species

4.9.3.1 Applicant's Proposed Avoidance and Minimization Measures

Because no TEC species or their critical habitats occur within the proposed Project boundary, no avoidance and minimization measures have been proposed by the Applicant. However, the Applicant's compensatory mitigation plan proposes acquisition of 698 acres at Rainbow Ranch, which includes USFWS-designated critical habitat for the Carolina heelsplitter. Acquisition of the properties and donation of the site to the SCDNR Heritage Trust Program, along with establishment of a $4.9 million endowment for projects benefiting the Carolina heelsplitter, would result in beneficial effects on TEC species.

4.9.3.2 Additional Potential Mitigation Measures

Because there would be no effect on TEC species or their critical habitat within the Project boundary, no additional mitigation measures are proposed. The USFWS has indicated that obligations under Section 7 of the ESA must be reconsidered if:

> …*(1) New information reveals impacts of this identified action that may affect listed species or critical habitat in a manner not previously considered, (2) this action is subsequently modified in a manner which was not considered in this assessment, or (3) a new species is listed or critical habitat is determined that may be affected by the identified action.* (USFWS 2011)

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4.10 Socioeconomics and Environmental Justice

4.10.1 Introduction

In addition to physical and environmental effects discussed elsewhere in Chapter 4, development, operation, and closure of the proposed mine has the potential to affect socioeconomic conditions in the Project area. Generally, the Project is expected to generate local and regional economic benefits over the life of the mine, as well as potential socioeconomic impacts on local communities. The potential economic benefits of the Project are attributed to gold production and its associated market value; project-level investment and spending in the local economy as the mine is developed, operated, and reclaimed; employment opportunities at the mine and wages paid to the local workforce; and the regional economic benefits that extend beyond the mine as local expenditures and labor income ripple throughout the economy based on linkages among industries and households (the multiplier effect).

The Project also would result in fiscal effects within the public sector as a result of changes in tax and other revenues and public service costs. In addition to the monetary impacts, the Project may affect local population levels, which in turn affect the demand for housing and public services. Regional housing and property values also could be affected by the projected economic growth from the Project and proximity to proposed mining activities. The analysis also considers the displacement of existing economic uses of Project lands, which would be foregone with mine development. Finally, environmental justice impacts could occur to minority and low-income people from potential economic effects of the Project. In summary, the following types of socioeconomic impacts have been analyzed for each alternative:

- Effects on gold production values and markets;
- Direct economic effects at Haile Gold Mine;
- Regional economic effects;
- Tax revenue effects;
- Population and housing effects;
- Property value effects;
- Economic effects from displaced land uses;
- Effects on public services; and
- Environmental justice effects, including disproportionate health or safety effects on children.

4.10.2 Methods

As described above, the economic effects of the Project are multi-faceted, and the methods used in the analysis vary depending on the type of impact being evaluated. This section provides an overview of the geographic and temporal scope of the analysis and the methods used to evaluate economic impacts.

4.10.2.1 Geographic Scope

The geographic scope of the economic analysis was driven by the location of proposed gold mining activity and the extent of inter-industry economic linkages with the mining sector. The direct economic effects of gold production would occur at the mine site located near the community of Kershaw in Lancaster County, South Carolina. For the regional economic analysis, the geographic scope extends across the broader four-county socioeconomics study area that encompasses Lancaster, Kershaw, Richland, and York Counties, as described in Section 3.10. An analysis of statewide economic effects

within South Carolina also was conducted. The regional and statewide economic analyses estimate the socioeconomic impacts of Haile Gold Mine activities that extend past Lancaster County. Exploration activities also may be occurring in these counties by the Applicant, but these activities are not included in this analysis as they are not directly related to the Project.

4.10.2.2 Temporal Scope

The economic analysis considers both short- and long-term effects, capturing the various Project phases. Short-term activities terminating at Project closure include mine development[1] (including permitting and site development occurring for approximately 3 years prior to active mining).[2] Long-term activities include mining operations (over the 14-year mining period), and post-mining reclamation (commencing soon after mining begins and extending for approximately 30 years). Based on substantial fluctuations in Project-level expenditures and employment requirements over time, the regional economic analysis was conducted on a year-by-year basis using financial forecasts provided by the Applicant. All monetary results are presented in constant 2010 dollars, unless otherwise noted.

4.10.2.3 Data Sources

The primary sources of information for the socioeconomic impact analysis were financial data and projections for the Project provided by the Applicant. This information serves as the foundation of the economic analysis presented in this section. Other supporting data, such as information on the gold industry and markets, were obtained from the USGS and trade associations. For the regional economic modeling, IMPLAN (IMpact Analysis for PLANning) software and data were used. This program quantifies trade flows among regions, regional purchase coefficients, and other industry-specific information; the model and supporting data were obtained from IMPLAN Group, LLC.

4.10.2.4 Technical Approach

The socioeconomic analysis is both quantitative and qualitative. Generally, the quantification of economic impacts was based on the information provided by the Applicant regarding the estimated spending on labor, materials, and services for the Project phases (Haile 2012a). Where data were not available or an impact did not warrant quantitative analysis, the impact was assessed qualitatively. Below is a summary of applicable methods organized by impact topic.

Gold Production and Markets

The value of gold production from Haile Gold Mine was based on the quantity of gold and silver to be extracted and the unit value (price) of these commodities in the marketplace. To estimate production values, the quantity of gold and silver to be extracted over time was multiplied by current commodity prices. Market effects were assessed qualitatively by evaluating anticipated production levels in the context of other local, regional, national, and international supplies, in conjunction with the global demand for gold. The market analysis focuses on the effects of Haile Gold Mine on market conditions.

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[1] Also referred to as *pre-production*.

[2] In this section, the first year of mining operations is referred to as Mine Year 1 (2015), with mining operations extending to Mine Year 14 (2028). The preceding 3 years of mine development (Pre-Production) are referred to as Mine Years -2 to 0, and include 2012, 2013, and 2014. The pre-production time period analyzed in this section is longer than in other sections as this section also includes the economic impact associated with permit preparation activities that began in 2012, in addition to impacts associated with site development.

Direct Economic Effects at Haile Gold Mine

The direct economic effects associated with mine development and operations, including the value of gold and silver production (the direct output), labor income, and employment, were estimated based on information provided by the Applicant. While all direct employment and associated labor income are earned within Lancaster County (and thus the four-county study area), not all of these benefits accrue to local study area residents. The size of the local employment base, skill requirements, and the distances to larger labor markets outside the study area (such as Charlotte, North Carolina) were used to identify the potential direct employment and income benefits that may accrue to residents in the study area.

Regional Economics

Building on these direct effects, the regional economic analysis measures total economic impacts in the study area based on inter-industry linkages across economic sectors affected by mining activities. The regional economic analysis was conducted using the IMPLAN model, which is based on the principles of input-output (I-O) analysis. I-O analysis is a means of measuring the flow of commodities and services among industries, institutions, and final consumers within an economy. I-O models capture all the monetary market transactions for consumption in a given time period, accounting for inter-industry linkages and the availability of regionally produced goods and services. The primary input for I-O analysis is the dollar change in purchases of products or services for final use; this is referred to as *final demand*. Industries respond to meet demands directly or indirectly by supplying goods and services to those industries, responding directly to final demand changes.

The primary metrics estimated by the IMPLAN model are output (or value of production), employment, and income multipliers across affected industries within a study area. In estimating impacts, the model considers direct,[3] indirect,[4] and induced[5] effects, which are based on the multiplier effect. In this context, a *multiplier* is a factor of proportionality that measures the additional economic activity generated in response to the initial influx of money within an economy.[6]

For this Project, both a four-county economic model covering Lancaster, Kershaw, Richland, and York Counties and a statewide (South Carolina) model were constructed using the 2010 IMPLAN dataset to estimate regional economic effects associated with the proposed Haile Gold Mine. The main drivers of regional economic activity are attributed to the magnitude and location of projected expenditures in support of the Project, including labor payroll; this information was provided by the Applicant. The Applicant provided information on the expected location (within the four-county study area, elsewhere in the state, or outside of the state) of Project expenditures. Economic impacts were analyzed based on this distribution of spending. The economic impact also was estimated based on IMPLAN data regarding the

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[3] *Direct effects* represent the impacts for the expenditures and/or production values specified as direct final demand changes.

[4] *Indirect effects* represent the impacts caused by the iteration of industries purchasing from industries resulting from the direct final demand changes.

[5] *Induced effects* represent the impacts on all local industries caused by the expenditures of new household income generated by the direct and indirect effects resulting from the direct final demand changes. Note that induced effects are based on the proportion of labor income that accrues to residents within the study area; Project in-commuters are assumed to spend their earnings outside of the study area.

[6] For example, a theoretical output multiplier of 1.5 in the mining industry indicates that every $1,000,000 of mining production (the direct output of this industry) supports a total of $1,500,000 in economic production throughout the economy (total output of all industries), including the initial $1,000,000 in mining output.

proportion of expenditures (by sector) that are typically spent within the four-county study area and the state, versus spent on imported goods and services. This provides a range of possible indirect and induced impacts of Project-related spending on goods and materials. The actual distribution of Project-related spending within the four-county study area, elsewhere in the state, or outside of the state will depend on several factors, including the relative availability, quality, and price of required materials and services in the local area versus other areas.

Projected annual expenditures within the four-county and statewide study areas were assigned to the applicable IMPLAN sector. The regional economic analysis was conducted on a year-by-year basis covering the expected life of the mine. The results of the regional economic analysis are presented by Project phase, namely mine development (pre-production) and mine operations. Based on the relatively small magnitude of spending and employment requirements, regional economic modeling was not deemed necessary for post-mining reclamation activities; these effects were assessed qualitatively.

Tax Revenues

Mining activity would generate a range of tax revenues for local and state governments, including sales, income, and property taxes. Estimates of sales tax revenues were based on projected expenditures subject to sales taxes and applicable sales tax regulations; this information was provided by the Applicant. Income tax revenues were forecasted using estimates of taxable corporate and labor income in conjunction with applicable income tax rates. Haile Gold Mine would not generate property taxes, but instead is subject to FILOT that are paid to Kershaw County. Estimated FILOT payments are based on an agreement established with Lancaster County dated December 1, 2008, pursuant to the Fee in Lieu of Tax Simplification Act (Title 22, Chapter 44, Code of Laws of South Carolina, 1976).[7] No royalty or severance payments are required for mining activities on private land in South Carolina.

Population and Housing

Changes in local population levels were estimated using information on direct employment at the mine, total regional employment, and the anticipated origin of employees and their families. In addition, local residents could leave the area as property is purchased by the Applicant; this potential was assessed qualitatively. Potential changes in local population levels were evaluated in the context of available housing stock proximate to the Project area.

Property Values

The effect of the Project on property values was evaluated qualitatively based on a comprehensive literature review on the subject, focusing on other mining and large industrial projects. This information was considered in the context of the proposed Project, including operating parameters, proximity to housing, and effects on local economic conditions.

Economic Effects from Displaced Land Uses

Existing land uses in the Project area were reviewed to determine whether any commercial activities occur in the Project area, such as timber production. The analysis focuses on whether the Project would result in displacement of any economically viable land uses that would result in losses in economic

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[7] See Lancaster Ordinance No. 964.

production. To the extent that commercial activity would be displaced, economic losses can be estimated based on the quantity of lost production (e.g., million board feet of timber) and related production values.

Public Services

Effects on public services and community infrastructure were evaluated based on coordination with service providers and their anticipated ability to serve the Project. In addition, public service agreements between the Applicant and local service providers were identified and reviewed. The analysis also assesses whether new or upgraded infrastructure would be required to meet Project demands, which could result in additional infrastructure costs. The public service costs attributed to the Project were assessed qualitatively. See also Section 2.3, "Connected Actions" for additional discussion of infrastructure requirements for the Project.

Environmental Justice

The environmental justice analysis evaluates whether minority or low-income people in the Project area would realize disproportionate adverse effects from both an environmental and economic perspective. Minority and low-income communities were screened based on the demographic profile of the region, including data on race and ethnicity and a range of income measures. To the extent that environmental justice communities of concern are present in the Project area, these population groups were evaluated in the context of socioeconomic impacts (presented in this section) and physical environmental impacts discussed elsewhere in this EIS. The objective was to determine whether these groups would be subject to disproportionate adverse effects of the Project, relative to the general population. The screening analysis was conducted at both the city/county and census tract level.

4.10.3 Impacts

4.10.3.1 Gold Production and Markets

Haile Gold Mine would produce gold and silver, both precious metals, having market values and direct economic output that would be a direct economic benefit of the Project (as discussed in Section 4.10.3.2). In addition, production at Haile Gold Mine would introduce a new source of gold and silver to the global market for precious metals. Conceptually, the Project may indirectly affect gold and silver prices based on supply and demand factors. The projected quantity and value of gold and silver production at Haile Gold Mine under the Project alternatives are presented in Table 4.10-1, which is followed by separate discussions for each alternative.

No Action Alternative

Under the No Action Alternative, ongoing monitoring activities associated with closure and reclamation of previous mining activity would continue within the Project area, but exploratory drilling would cease and the proposed Haile Gold Mine would not be developed. Therefore, under the No Action Alternative, there would be no production of gold and silver, and no production value would be attributed to mineral resource extraction. This would be similar to existing conditions, where no active mining is occurring. No impact would occur on gold and silver production values or markets.

Table 4.10-1 Projected Quantity and Value of Gold and Silver Production at Haile Gold Mine

Parameter	No Action Alternative		Applicant's Proposed Project		Modified Project Alternative	
	Annual Average	Total	Annual Average	Total	Annual Average	Total
Gold production (ounces) [a]	0	0	119,884	1,678,371	119,884	1,678,371
Silver production (ounces) [a]	0	0	106,796	1,495,142	106,796	1,495,142
Value of gold production ($ millions) [b]	$0.0	$0.0	$148.6	$2,080.7	$148.6	$2,080.7
Value of silver production ($ millions) [c]	$0.0	$0.0	$2.4	$34.2	$2.4	$34.2
Total production value ($ millions)	**$0.0**	**$0.0**	**$151.1**	**$2,114.9**	**$151.1**	**$2,114.9**

Notes:

Monetary values are reported in constant 2010 dollars.

Annual average and total values are provided for the mine production period (Mine Years 1 to 14).

[a] Represents projected volume of *recovered* metals at the mine site (measured in troy ounces).

[b] Gold values are based on the average annual gold price between 2008 and 2012 ($1,240 per ounce).

[c] Silver values are based on average annual silver prices between 2008 and 2012 ($23 per ounce).

Sources: M3 Engineering & Technology Corporation 2010; World Gold Council 2013; London Bullion Market Association 2013.

Applicant's Proposed Project

The Applicant's Proposed Project entails active mining of gold and silver over an approximately 14-year production timeframe.[8] In total, approximately 1.68 million ounces of gold would be recovered at the mine, averaging approximately 119,900 ounces annually. Silver production is estimated at 106,800 ounces annually and nearly 1.50 million ounces over the life of the mine. The estimated value of gold and silver production was based on historic market prices. Over the preceding 5-year period (2008 to 2012), the average price of gold and silver was approximately $1,240/ounce and $23/ounce, respectively (reported in 2010 dollars). Based on these figures, the total value of precious metals extracted from the Haile Gold Mine is expected to be $2.1 billion over the life of the mine, averaging approximately $151.1 million annually and peaking in Mine Year 1 at $216.6 million. Gold accounts for the largest share of production value, accounting for approximately 98.4 percent of the value of precious metals to be extracted at the mine. The value of precious metal production at Haile Gold Mine represents a major economic benefit of the Project during operation.

Gold production at Haile Gold Mine has the potential to indirectly affect the national and global gold markets. However, the projected gold production, approximately 119,900 ounces per year on average, would account for only approximately 0.1 percent of gold mining production globally and approximately 1.6 percent of gold mining production in the United States. Consequently, it is not likely that the gold produced by the Project would influence the national and international gold markets, and indirect effects on existing market prices and conditions would be negligible.

[8] Gold and silver would not be produced during the mine development (pre-production) and reclamation phases of the Project.

Modified Project Alternative

The Modified Project Alternative would entail the same level of gold and silver production as the Applicant's Proposed Project; therefore, effects on gold and silver production values and markets for this alternative would be the same as described for the Applicant's Proposed Project.

4.10.3.2 Direct Economic Benefits at Haile Gold Mine

The extent to which the economic benefits generated by the Project would be realized by local communities is an important issue raised during the public scoping process, based on the need for local jobs and economic growth. The direct economic benefits of the Haile Gold Mine would occur during Project development, operations, and post-mining reclamation. These benefits are driven by Project capital investment and ongoing spending, and the employment opportunities and wages paid to the Project workforce, which were forecasted by the Applicant. In turn, the direct economic benefits of the Project would generate additional economic activities in the local economy, which are addressed in Section 4.10.3.3.

No Action Alternative

Under the No Action Alternative, the Project would not be developed but ongoing monitoring activities would continue at the mine site for past mining activity. No economic benefits would be attributed to mine development or active mining of gold and silver resources under the No Action Alternative. However, ongoing monitoring activities associated with closure and reclamation of previous mining activities would continue to provide income and employment benefits to local workers. It is estimated that Haile would expend approximately $4.0 million over an 11-year period, with expenditures ranging from $104,000 to $1.3 million annually (Haile 2012b). The number of employees and related labor income associated with ongoing monitoring without the Project has not been quantified.

Applicant's Proposed Project

The Applicant's Proposed Project would generate direct economic benefits at Haile Gold Mine during all Project phases, including mine development (pre-production), operations, and post-mining reclamation. In total, projected spending over the life of the Project, excluding post-mining activities, is estimated to be nearly $1.1 billion, including expenditures on land acquisition, equipment and materials, and other goods and services ($822 million) and labor payments ($284.0 million). Most of the expenditures would occur during mining operations ($785.4 million, 71 percent of the total), with mine development accounting for 29 percent ($321.2 million). The Applicant expects that approximately $834 million in Project expenditures would occur within the State of South Carolina, with most of that spent within the four-county study area ($776.2 million). However, depending on the availability of the necessary goods and services, it is also feasible that Project-related spending in the study area may be lower. Using data on the proportion of goods and services required in the study area that are currently purchased from area businesses, local spending within the State of South Carolina may be closer to $542 million, with $413.3 million of this being spent in the four-county study area. The magnitude of these expenditures drive the indirect economic benefits of the Project presented below.

Mine Development Period

Table 4.10-2 shows the economic benefits associated with mine development, as measured by the labor income and employment.

Table 4.10-2 Direct Economic Benefits at Haile Gold Mine – Mine Development

Year	Mine Development		
	Output ($ millions) [a]	Labor Income ($ millions)	Employment (jobs)
2012 (Mine Year -2)	N/A	$0.0	0
2013 (Mine Year -1)	N/A	$6.1	50
2014 (Mine Year 0)	N/A	$37.9	340
2015 (Mine Year 1) [b]	N/A	$0.3	0
Annual average [c]	***N/A***	***$11.1***	***100***
Total	**N/A**	**$44.3**	**N/A**

Notes:

N/A = not applicable

Mine development includes initial capital costs and permitting activities required to construct the Project.

Monetary values are reported in constant 2010 dollars.

[a] The direct output value of construction projects, such as mine development, represents total Project value, which is not representative of economic benefits to the local economy; therefore, it is not reported here.

[b] Note that the economic activity in this table associated with Mine Year 1 is associated with mine development activities, and represents a different (and additive) economic impact to the economic activity presented in Table 4.10-2 related to mine operations.

[c] Annual average values correspond to the pre-production period (Mine Years -2 to 1).

Source: Haile 2012c.

Conceptually, the direct output value during mine development is the construction cost of the Project, which totals $321.2 million (spent over the 3-year development period and the first year of mining operations, during which time some site development continues). This $321.2 million includes expenditures for initial capital costs ($275.5 million) and permitting[9] ($45.7 million). As the direct cost of mine development (the value of the mine itself) does not represent an economic benefit to the local economy, it is not reported in Table 4.10-2.

The key drivers of construction-related economic benefits are the employment and related income supported by development of the mine. During mine development, approximately $44.3 million in labor income would be paid to mine employees and contractors, which fluctuate in number over the development period—reaching as high as 340 employees during the peak construction period. Average annual labor costs (including wages, benefits, and other employment costs) during mine development would be $112,600 per worker. Increases in employment and income directly supported at the Project site during mine development are considered short-term beneficial effects of the Project. All of this labor and income would be generated within the four-county study area, but not all workers are expected to be study area residents. An estimated 55 to 60 percent of mine development workers are anticipated to be local study area residents, while approximately 75 percent of workers are estimated to be state residents. Based on national data from the Bureau of Labor Statistics on construction employment wages, jobs held by four-county residents are anticipated to provide an average annual wage of over $40,000.

[9] Costs involved in permitting include field studies, desktop analyses, environmental assessments and other actions taken to obtain adequate information for permitting purposes,

Active Mining Period

Table 4.10-3 presents the direct economic effects of mining operations, which represents the period of active metal mining and processing at the mine (Mine Years 1 to 14). Mining operations include expenditures and labor supporting sustaining capital, operations, and general administrative (G&A) functions. The direct output value of mining operations is the value of gold and silver production. As noted above, the value of precious metals recovered at the mine is estimated to total over $2.1 billion over the life of the Project, averaging $151.1 million per year.

Table 4.10-3 Direct Economic Benefits at Haile Gold Mine – Mining Operations

Year	Mining Operations		
	Output ($ millions)	Labor Income ($ millions)	Employment (jobs)
2015 (Mine Year 1)	$216.6	$17.7	280
2016 (Mine Year 2)	$167.8	$19.9	290
2017 (Mine Year 3)	$204.7	$19.9	300
2018 (Mine Year 4)	$193.1	$22.5	340
2019 (Mine Year 5)	$164.2	$18.8	310
2020 (Mine Year 6)	$167.1	$20.3	350
2021 (Mine Year 7)	$184.4	$29.5	420
2022 (Mine Year 8)	$170.0	$19.0	320
2023 (Mine Year 9)	$201.8	$14.5	220
2024 (Mine Year 10)	$198.9	$14.1	220
2025 (Mine Year 11)	$135.5	$14.0	220
2026 (Mine Year 12)	$51.2	$12.0	190
2027 (Mine Year 13)	$48.5	$10.1	150
2028 (Mine Year 14)	$10.9	$7.5	150
Annual average[a]	***$151.1***	***$17.1***	***270***
Total	**$2,114.9**	**$239.7**	**N/A**

Notes:

N/A = not applicable

Project operations represent active mining.

Monetary values are reported in constant 2010 dollars.

[a] Annual average values correspond to the mining operations period (Mine Years 1 to 14).

Source: Haile 2012c.

The labor requirements to conduct mining activities are substantial as well. Direct employment at the mine would range from 150 to 420 employees annually, with a corresponding labor income of $7.5 to $29.5 million annually. The average annual labor payments (including wages and benefits) during mine operations would be $63,800 per worker. Increases in production (output), employment, and income would occur during mining operations. All of this labor and income would be generated within the four-county study area, but not all workers are expected to be study area residents. An estimated 75 to 96 percent of mine operations workers are anticipated to be local study area residents, while

approximately 90 to 97 percent of workers are estimated to be state residents. Based on national data from the Bureau of Labor Statistics on mining employment wages, jobs to four-county residents are anticipated to provide an average annual wage of over $40,000.

Post-Mining Period

Post-mining reclamation costs were estimated separately from the other phases of the Project presented above. Total expenditures for post-mining activities are estimated to be more than $34.7 million over an approximately 30-year period (Haile 2013a). The supporting labor requirements and labor income associated with post-mining reclamation would include 0 to 30 employees annually earning a total of $9.7 million. Increases in employment and income at the Project site during post-mining reclamation are considered long-term beneficial effects of the Project.

Modified Project Alternative

The Modified Project Alternative would entail comparable levels of expenditures and labor requirements as the Applicant's Proposed Project. Therefore, the direct economic benefits of this alternative would be similar to those described for the Applicant's Proposed Project, with several exceptions.

Use of the Holly and Hock TSF borrow areas in lieu of the Ramona OSA would result in increased costs and expenditures on certain items and decreases in others. In summary, the Modified Project Alternative would increase total transportation costs by approximately $17 million. In addition, construction of a haul road extension for the Duckwood TSF would involve additional costs (these costs have not been quantified). This alternative would not appreciably affect the direct employment and income benefits realized by mine workers.

4.10.3.3 Regional Economics

Implementation of the Project would not only support direct economic benefits as described above but also would generate additional economic benefits within the local economy based on linkages among industries and households. These linkages provide the framework for the flow of money, which begin with Project-related expenditures and wage payments that subsequently ripple across local industries and households generating additional economic activity. This is commonly referred to as the *multiplier effect*. The multiplier effect provides the basis to measure the indirect and induced economic effects of the Project. Collectively, the direct, indirect, and induced economic effects represent the total economic effects of the Project. The regional economic benefits generated within the four-county socioeconomics study area and South Carolina overall are presented below. Regional benefits are presented separately by Project phase.

As noted above, the analysis of regional economic impacts uses a range of estimates of possible Project-related expenditures that are spent in the local four-county and state-wide areas. The location of spending determines the size of the multiplier effect within a given region. Data from the Applicant on the expected location (within the four-county study area, elsewhere in the state, or outside of the state) of Project expenditures indicates a relatively high level of local spending, and an associated higher multiplier effect. Due to the relatively small size of the local economy relative to the size of the proposed Project and the fact that there are some relatively specialized labor skills, services, and material inputs to the Project that may not be available locally, a lower level of local spending was also analyzed. This lower level of spending is based on IMPLAN data regarding the proportion of expenditures (by sector) that are typically spent within the four-county study area and the state, versus spent on imported goods and services. This provides a range of possible indirect and induced impacts of Project-related spending on goods and materials. The actual location of Project-related spending and the associated total economic impacts

within the four-county study area, elsewhere in the state, or outside of the state will depend on several factors, including the relative availability, quality, and price of required materials and services in the local area versus other areas.

No Action Alternative

Under the No Action Alternative, ongoing monitoring activities would continue at the mine site, at a total cost of approximately $4.0 million over an 11-year period. On an annual basis, these expenditures range from $104,000 to $1.3 million per year (Haile 2012b). In addition to the income and employment benefits to local workers, local expenditures and employee spending would generate economic benefits to the local economy. These benefits have not been quantified but are expected to be minor compared to the regional Project benefits, based on the relative magnitude of expenditures under the No Action Alternative.

Applicant's Proposed Project

Mine Development Period

Table 4.10-4a presents the regional economic benefits in the four-county study area from development of the proposed Haile Gold Mine, which generally corresponds to the Pre-Production period. Expenditures made during mine development include initial capital and permitting costs, totaling $321.2 million. To the extent that these expenditures occur locally, they would generate regional economic benefits during mine development in the four-county study area. Specifically, mine development would result in an additional $70 to $140 million in output value across a range of support industries over the pre-production period; this reflects the indirect and induced economic effects of mine development.

More pertinent to the local economy and residents are the employment and income benefits that would be generated during the development phase of the Project. Mine development is expected to support an average of approximately 300 to 410 jobs during the pre-production period, including 100 jobs on site and 200 to 310 jobs in local support industries. The employment benefits would be substantially higher during the peak construction period (Mine Year 0), when approximately 780 to 1,060 total jobs would be supported by the Project.

In conjunction with the employment benefits of the Project, labor income levels across the regional economy would increase. The total labor income generated by the Project during the development phase is estimated to be $73.4 to $104.2 million, of which $44.3 million would be paid to contractors and employees at the Haile Gold Mine and $29.1 to $59.9 million would be paid to workers in local support industries. Both the employment and income benefits would terminate at the end of the pre-production period.

Table 4.10-4b presents the results for the statewide analysis of economic benefits generated during mine development. The direct economic effects are the same as those for the four-county study area because the direct effects capture activity at the mine site, which is unchanged. However, the total output, income, and employment benefits accruing to the State are larger because they represent a larger economy and capture relatively more spending and linkages among industries and households.

Table 4.10-4a Regional Economic Effects from Haile Gold Mine – Mine Development (Four-County Study Area)

Year	Output ($ millions) a			Labor Income ($ millions)			Employment (jobs)	
	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total
High Estimate								
2012 (Mine Year -2)	$2.5	$2.5	$0.0	$1.3	$1.3	0	20	20
2013 (Mine Year -1)	$45.4	$45.4	$6.1	$20.0	$26.1	50	380	440
2014 (Mine Year 0)	$81.3	$81.3	$37.9	$31.4	$69.2	340	720	1,060
2015 (Mine Year 1)	$13.3	$13.3	$0.3	$7.2	$7.5	0	130	130
Annual average [b]	***$35.6***	***$35.6***	***$11.1***	***$15.0***	***$26.0***	***100***	***310***	***410***
Total	**$142.4**	**$142.4**	**$44.3**	**$59.9**	**$104.2**	**N/A**	**N/A**	**N/A**
Low Estimate								
2012 (Mine Year -2)	$1.0	$1.0	$0.0	$0.5	$0.5	0	10	10
2013 (Mine Year -1)	$32.5	$32.5	$6.1	$14.1	$20.2	50	310	370
2014 (Mine Year 0)	$34.5	$34.5	$37.9	$13.6	$51.5	340	440	780
2015 (Mine Year 1)	$2.1	$2.1	$0.3	$0.9	$1.2	0	20	20
Annual average [b]	***$17.5***	***$17.5***	***$11.1***	***$7.3***	***$18.4***	***100***	***200***	***300***
Total	**$70.1**	**$70.1**	**$44.3**	**$29.1**	**$73.4**	**N/A**	**N/A**	**N/A**

Notes:

N/A = not applicable

Project development includes initial capital costs and permitting activities required to construct the Project.

Monetary values are reported in constant 2010 dollars.

[a] The direct output value of construction projects, such as mine development, represent total Project value, which is not representative of economic benefits to the local economy. Therefore, it is not reported here.

[b] Annual average values correspond to the pre-production period (Mine Years -2 to 1).

Source: Cardno ENTRIX (internal calculations from IMPLAN model).

Table 4.10-4b Regional Economic Effects from Haile Gold Mine – Mine Development (Statewide)

Year	Output ($ millions)			Labor Income ($ millions)			Employment (jobs)		
	Direct[a]	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total
High Estimate									
2012 (Mine Year -2)	N/A	$3.2	$3.2	$0.0	$1.7	$1.7	0	30	30
2013 (Mine Year -1)	N/A	$68.7	$68.7	$6.1	$29.5	$35.7	50	610	660
2014 (Mine Year 0)	N/A	$136.1	$136.1	$37.9	$48.8	$86.7	340	1,150	1,480
2015 (Mine Year 1)	N/A	$18.0	$18.0	$0.3	$8.9	$9.2	0	180	180
Annual average [b]	***N/A***	***$56.5***	***$56.5***	***$11.1***	***$22.2***	***$33.3***	***100***	***490***	***590***
Total	**N/A**	**$225.9**	**$225.9**	**$44.3**	**$88.9**	**$133.2**	**N/A**	**N/A**	**N/A**
Low Estimate									
2012 (Mine Year -2)	N/A	$16.2	$16.2	$0.00	$8.5	$8.5	0	170	170
2013 (Mine Year -1)	N/A	$52.1	$52.1	$6.10	$22.5	$28.6	50	460	510
2014 (Mine Year 0)	N/A	$90.2	$90.2	$37.90	$35.0	$72.9	340	810	1,150
2015 (Mine Year 1)	N/A	$3.1	$3.1	$0.30	$1.2	$1.5	0	30	30
Annual average [b]	*N/A*	*$40.4*	*$40.4*	*$11.10*	*$16.9*	*$27.9*	*100*	*370*	*470*
Total	**N/A**	**$161.6**	**$161.6**	**$44.30**	**$67.1**	**$111.4**	**N/A**	**N/A**	**N/A**

Notes:

N/A = not applicable

Project development includes initial capital costs and permitting activities required to construct the Project.

Monetary values are reported in constant 2010 dollars.

[a] The direct output value of construction projects, such as mine development, represent total Project value, which is not representative of economic benefits to the local economy. Therefore, it is not reported here.

[b] Annual average values correspond to the pre-production period (Mine Years -2 to 1).

Source: Cardno ENTRIX (internal calculations from IMPLAN model).

Active Mining Period

Table 4.10-5a presents the results of the regional economic analysis for the mining operations phase. As described above, the direct value of gold and silver production at the mine is estimated to be $2.1 billion over the life of the mine. Projected mining operations expenditures in the four-county study area would generate approximately an additional $160 to $450 million in economic production across local support industries over the life of the mine, or approximately $11.3 to $32.4 million annually. Similarly, approximately 370 to 540 total jobs, on average, would be created by the Project, including 270 jobs at the mine and 100 to 270 additional jobs in the local economy. Total labor compensation (including wages and benefits) associated with these jobs is estimated to be approximately $295.2 to $401.8 million. The majority of regional economic benefits associated with mining activity would occur over a 14-year period.

Table 4.10-5b presents the results for the statewide analysis of benefits generated during mining operations.

Post-Mining Period

The regional economic effects of post-mining reclamation activities have not been quantified. However, to the extent that these reclamation expenditures occur within the four-county study area and state, these regions would experience an increase in economic activity supporting additional employment and labor income, which would benefit local economic conditions throughout the reclamation period.

Modified Project Alternative

The Modified Project Alternative would entail comparable levels of expenditures and labor requirements as the Applicant's Proposed Project. Therefore, the regional economic effects of this alternative would be similar to those described for the Applicant's Proposed Project.

4.10.3.4 Tax Revenues

In addition to the regional economic benefits generated by the proposed Haile Gold Mine, the Project would affect tax revenues collected by local governments, while increasing the costs of providing additional public services to the Project. For this analysis, three main sources of tax revenues were evaluated: property taxes, sales taxes, and income taxes. No royalty payments or severance taxes would be generated by the proposed Project because these taxes are not applicable to mining operations on private land in South Carolina.

Table 4.10-5a Regional Economic Effects from Haile Gold Mine – Mining Operations (Four-County Study Area)

Year	Output ($ millions)			Labor Income ($ millions)			Employment (jobs)		
	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total
High Estimate									
2015 (Mine Year 1)	$216.6	$32.2	$248.9	$17.7	$11.6	$29.3	280	270	540
2016 (Mine Year 2)	$167.8	$39.0	$206.8	$19.9	$13.6	$33.5	2903	310	610
2017 (Mine Year 3)	$204.7	$34.3	$239.1	$19.9	$12.8	$32.7	300	300	600
2018 (Mine Year 4)	$193.1	$50.3	$243.4	$22.5	$17.8	$40.3	340	400	740
2019 (Mine Year 5)	$164.2	$34.9	$199.1	$18.8	$13.2	$32.0	310	310	620
2020 (Mine Year 6)	$167.1	$39.8	$206.9	$20.3	$15.4	$35.7	350	350	700
2021 (Mine Year 7)	$184.4	$79.2	$263.7	$29.5	$26.4	$55.8	420	570	990
2022 (Mine Year 8)	$170.0	$35.0	$205.0	$19.0	$13.3	$32.3	320	310	630
2023 (Mine Year 9)	$201.8	$23.2	$225.0	$14.5	$8.3	$22.7	230	200	420
2024 (Mine Year 10)	$198.9	$22.3	$221.2	$14.1	$7.9	$21.9	220	190	410
2025 (Mine Year 11)	$135.5	$21.9	$157.3	$14.0	$7.7	$21.7	220	190	400
2026 (Mine Year 12)	$51.2	$17.9	$69.1	$12.0	$6.1	$18.1	190	150	330
2027 (Mine Year 13)	$48.5	$15.6	$64.1	$10.1	$5.2	$15.2	150	130	270
2028 (Mine Year 14)	$10.9	$8.2	$19.2	$7.5	$2.8	$10.3	150	70	230
Annual average [a]	***$151.1***	***$32.4***	***$183.5***	***$17.1***	***$11.6***	***$28.7***	***270***	***270***	***540***
Total	**$2,114.9**	**$453.9**	**$2,568.8**	**$239.7**	**$162.1**	**$401.8**	**N/A**	**N/A**	**N/A**
Low Estimate									
2015 (Mine Year 1)	$216.6	$11.7	$228.3	$17.7	$4.1	$21.8	280	110	380
2016 (Mine Year 2)	$167.8	$14.1	$181.9	$19.9	$4.9	$24.8	290	130	420
2017 (Mine Year 3)	$204.7	$14.4	$219.1	$19.9	$5.2	$25.1	300	130	440
2018 (Mine Year 4)	$193.1	$17.4	$210.5	$22.5	$6.3	$28.8	340	150	490
2019 (Mine Year 5)	$164.2	$10.8	$175.0	$18.8	$3.8	$22.6	310	100	420
2020 (Mine Year 6)	$167.1	$13.0	$180.1	$20.3	$4.7	$25.0	350	120	470
2021 (Mine Year 7)	$184.4	$25.2	$209.6	$29.5	$8.7	$38.2	420	210	640
2022 (Mine Year 8)	$170.0	$10.9	$180.9	$19.0	$3.8	$22.8	320	100	420
2023 (Mine Year 9)	$201.8	$8.0	$209.8	$14.5	$2.8	$17.3	230	80	300
2024 (Mine Year 10)	$198.9	$7.9	$206.8	$14.1	$2.7	$16.8	220	80	290
2025 (Mine Year 11)	$135.5	$7.7	$143.2	$14.0	$2.7	$16.7	220	70	290
2026 (Mine Year 12)	$51.2	$6.7	$57.9	$12.0	$2.3	$14.3	190	60	250
2027 (Mine Year 13)	$48.5	$5.6	$54.1	$10.1	$1.9	$12.0	150	50	200
2028 (Mine Year 14)	$10.9	$4.2	$15.1	$7.5	$1.4	$8.9	150	40	190
Annual average [a]	***$151.1***	***$11.3***	***$162.3***	***$17.1***	***$4.0***	***$21.1***	***270***	***100***	***370***
Total	**$2,114.9**	**$157.5**	**$2,272.2**	**$239.7**	**$55.4**	**$295.2**	**N/A**	**N/A**	**N/A**

Notes:

N/A = not applicable

Project operations represent active mining.

Monetary values are reported in constant 2010 dollars.

[a] Annual average values correspond to the mining operations period (Mine Years 1 to 14).

Source: Cardno ENTRIX (internal calculations from IMPLAN model).

Table 4.10-5b Regional Economic Effects from Haile Gold Mine – Mining Operations (Statewide)

Year	Output ($ millions)			Labor Income ($ millions)			Employment (jobs)		
	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total
High Estimate									
2015 (Mine Year 1)	$216.6	$37.2	$253.9	$17.7	$12.7	$30.4	280	320	590
2016 (Mine Year 2)	$167.8	$45.2	$213.0	$19.9	$15.1	$34.9	290	370	670
2017 (Mine Year 3)	$204.7	$39.5	$244.2	$19.9	$14.1	$34.0	300	360	660
2018 (Mine Year 4)	$193.1	$54.7	$247.8	$22.5	$18.6	$41.0	340	450	790
2019 (Mine Year 5)	$164.2	$37.6	$201.8	$18.8	$13.6	$32.4	310	340	660
2020 (Mine Year 6)	$167.1	$42.8	$209.9	$20.3	$15.7	$36.0	350	390	740
2021 (Mine Year 7)	$184.4	$86.0	$270.4	$29.5	$27.6	$57.1	420	650	1,070
2022 (Mine Year 8)	$170.0	$37.7	$207.7	$19.0	$13.7	$32.7	320	350	670
2023 (Mine Year 9)	$201.8	$25.1	$227.0	$14.5	$8.6	$23.1	230	220	450
2024 (Mine Year 10)	$198.9	$24.2	$223.1	$14.1	$8.2	$22.3	220	210	430
2025 (Mine Year 11)	$135.5	$23.7	$159.2	$14.0	$8.1	$22.0	220	210	430
2026 (Mine Year 12)	$51.2	$19.5	$70.8	$12.0	$6.4	$18.5	190	170	350
2027 (Mine Year 13)	$48.5	$17.0	$65.5	$10.1	$5.5	$15.5	150	140	290
2028 (Mine Year 14)	$10.9	$9.1	$20.0	$7.5	$3.0	$10.5	150	80	240
Annual average [a]	***$151.1***	***$35.7***	***$186.7***	***$17.1***	***$12.2***	***$29.3***	***270***	***310***	***570***
Total	**$2,114.9**	**$499.4**	**$2,614.3**	**$239.7**	**$170.8**	**$410.5**	**N/A**	**N/A**	**N/A**
Low Estimate									
2015 (Mine Year 1)	$216.6	$15.9	$232.5	$17.70	$5.4	$23.1	280	130	400
2016 (Mine Year 2)	$167.8	$19.0	$186.8	$19.90	$6.4	$26.3	290	150	440
2017 (Mine Year 3)	$204.7	$19.2	$223.9	$19.90	$6.7	$26.6	300	160	460
2018 (Mine Year 4)	$193.1	$24.5	$217.6	$22.50	$8.5	$31.0	340	190	530
2019 (Mine Year 5)	$164.2	$14.5	$178.7	$18.80	$4.9	$23.7	310	130	440
2020 (Mine Year 6)	$167.1	$17.9	$185.0	$20.30	$6.3	$26.6	350	150	500
2021 (Mine Year 7)	$184.4	$34.7	$219.1	$29.50	$11.5	$41.0	420	250	670
2022 (Mine Year 8)	$170.0	$14.7	$184.7	$19.00	$5.0	$24.0	320	130	450
2023 (Mine Year 9)	$201.8	$10.6	$212.4	$14.50	$3.5	$18.0	230	90	320
2024 (Mine Year 10)	$198.9	$10.4	$209.3	$14.10	$3.5	$17.6	220	90	310
2025 (Mine Year 11)	$135.5	$10.2	$145.7	$14.00	$3.4	$17.4	220	90	310
2026 (Mine Year 12)	$51.2	$8.9	$60.1	$12.00	$3.0	$15.0	190	80	260
2027 (Mine Year 13)	$48.5	$7.4	$55.9	$10.10	$2.5	$12.6	150	60	210

Table 4.10-5b Regional Economic Effects from Haile Gold Mine – Mining Operations (Statewide) (Continued)

Year	Output ($ millions)			Labor Income ($ millions)			Employment (jobs)		
	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total
Low Estimate (continued)									
2028 (Mine Year 14)	$10.9	$5.5	$16.4	$7.50	$1.8	$9.3	150	50	200
Annual average [a]	***$151.1***	***$15.2***	***$166.3***	***$17.1***	***$5.2***	***$22.3***	***270***	***120***	***390***
Total	**$2,114.9**	**$213.4**	**$2,328.3**	**$239.7**	**$72.4**	**$312.1**	**N/A**	**N/A**	**N/A**

Notes:

N/A = not applicable

Project operations represent active mining.

Monetary values are reported in constant 2010 dollars.

[a] Annual average values correspond to the mining operations period (Mine Years 1 to 14).

Source: Cardno ENTRIX (internal calculations from IMPLAN model).

Table 4.10-6 presents estimated property tax and fee payments for the Project alternatives. Property taxes for the No Action Alternative were based on existing property tax assessments on lands within the Project boundary. For the Applicant's Proposed Project and Modified Project Alternative, fee payments were based on the FILOT agreement between Haile Gold Mine, Inc. and Lancaster County, established in December 2008 pursuant to the Fee in Lieu of Tax Simplification Act (Title 22, Chapter 44, Code of Laws of South Carolina, 1976).[10] The agreement stipulates that Haile would pay an annual fee to the County in lieu of ad valorem[11] property taxes based on meeting certain capital investment and job creation thresholds outlined in the agreement.[12] The FILOT agreement uses a 4-percent assessment ratio and a fixed millage rate[13] (246 mills). For this analysis, property tax and fee estimates were adjusted to reflect only the 4,552 acres of land within the Project boundary.[14]

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[10] See Lancaster Ordinance No. 964.

[11] An ad valorem tax is a tax based on the value of real estate or personal property.

[12] The agreement requires an investment of $150 million within 8 years (including certain pollution control equipment) and the creation of approximately 125 new full-time jobs.

[13] *Millage rate* refers to the amount of tax per thousand currency units of property value. A *mill* is one-thousandth of a currency unit.

[14] For the Project alternatives, the analysis assumes that all land within the Project boundary is covered by the fee-in-lieu-of-taxes (FILOT) agreement

Table 4.10-6 Estimated Property Taxes and Fees

Parameter	No Action Alternative		Applicant's Proposed Project[a]		Modified Project Alternative[b]	
	Annual Average	Total	Annual Average	Total	Annual Average	Total
Fee-in-lieu-of-taxes	N/A	N/A	$1,090,923	$17,454,764	$1,090,923	$17,454,764
Property taxes	$223,248	$3,571,963	N/A	N/A	N/A	N/A
Total taxes and fees	**$223,248**	**$3,571,963**	**$1,090,923**	**$17,454,764**	**$1,090,923**	**$17,454,764**

Notes:

N/A = not applicable

Property taxes and fees are based on a 16-year period including pre-feasibility (Mine Years -1 through 14).

Values were adjusted to reflect land within the Project boundary (4,552 acres).

[a] Based on the fee-in-lieu-of-taxes (FILOT) agreement between Haile Gold Mine, Inc. and Lancaster County.

[b] Based on the fee-in-lieu-of-taxes (FILOT) agreement between Haile Gold Mine, Inc. and Lancaster County.

Sources: Haile 2012d; Lancaster County 2008.

Table 4.10-7 presents estimated taxable sales and sales tax revenues generated by the Project alternatives. Estimated sales taxes are based on anticipated expenditures over time and by location, in conjunction with tax regulations outlined in the South Carolina Code of Laws. These sales taxes were estimated by the Applicant using their projected spending pattern by location of final purchase. The taxes presented in the table do not include the Applicant's estimated taxable sales from exploration activities, which are generally not directly related to the Project. As noted earlier, based on the existing expenditure patterns in the four-county study area and the State, Project-related spending in the four-county study area may be approximately two-thirds of the level estimated by the Applicant. Consequently, the sales tax receipts within the four-county study area may be lower than those estimated in the table (by approximately one-third). At the State level, Project expenditures may also be lower by up to approximately one-third. However, for expenditures occurring out of South Carolina, the state may still collect tax revenue through a use tax. The State of South Carolina levies a use tax equivalent to the 6 percent state sales tax, less any tax paid out of state to other jurisdictions, on taxable items purchased out-of-state. The value of total Project-related state sales tax receipts thus depends not only on the value of in-state purchases (which are subject to State sales tax), but also on the location of out-of-state purchases (which determines the level of revenue from the use tax).

Table 4.10-7 Estimated Taxable Sales and Sales Tax Revenues

Parameter	No Action Alternative	Applicant's Proposed Project		Applicant's Proposed Project with Modifications	
		Annual Average	Total	Annual Average	Total
Taxable Sales (Total)	Not estimated	**$1,131,000**	**$19,242,000**	**$1,131,000**	**$19,242,000**
Lancaster County		$1,132,000	$19,242,000	$1,132,000	$19,242,000
Kershaw County		$0	$0	$0	$0
Richland County		$0	$0	$0	$0
York County		$0	$0	$0	$0
Other South Carolina counties		$0	$0	$0	$0
Out of state		$0	$0	$0	$0
Sales Tax Revenues (Total)	Not estimated	**$84,000**	**$1,425,000**	**$84,000**	**$1,425,000**
Lancaster County		**$84,000**	**$1,425,000**	**$84,000**	**$1,425,000**
Kershaw County		$0	$0	$0	$0
Richland County		$0	$0	$0	$0
York County		$0	$0	$0	$0
Other South Carolina counties		$0	$0	$0	$0
Out of state		$0	$0	$0	$0

Note: Total values are based on a 17-year period, from Mine Years -2 to 14, including pre-production and active mining.

Source: Haile 2013b, modified to remove sales tax associated with exploration.

Estimated state income taxes to be paid to South Carolina are presented in Table 4.10-8. State income taxes would be paid both at the corporate and individual (worker) level. The state corporate income tax rate is 5.0 percent. The personal income tax rate in South Carolina is based on a marginal tax rate schedule that peaks at 7.0 percent for incomes exceeding $13,800 annually. Based on data from the Applicant indicating an estimated annual average salary of $68,800 paid to mine workers, the effective state income tax rate was calculated to be 6.3 percent.

The following discussion focuses on the Project fiscal effects for each alternative based on the information presented in Tables 4.10-6, 4.10-7, and 4.10-8.

Table 4.10-8 Estimated State Income Taxes

Parameter	No Action Alternative	Applicant's Proposed Project		USACE Modified Project Alternative	
		Annual Average	Total	Annual Average	Total
Corporate income tax	Not estimated	$1,072,761	$17,164,183	$1,072,761	$17,164,183
Personal income tax	Not estimated	$1,119,000	$17,904,000	$1,119,000	$17,904,000

Note: State income taxes were based on taxable income over the period from Mine Years -2 to 14.

Sources: M3 Engineering & Technology Corporation 2010; Cardno ENTRIX (internal calculations from IMPLAN model).

No Action Alternative

Under the No Action Alternative, no incremental sales or income tax revenues would accrue to local or state governments beyond those revenues generated by ongoing monitoring activities at the Project site (which have not been estimated). However, property taxes would continue to be assessed on parcels within the Project boundary. The estimated market (or appraised) value of the 4,552 acres within the Project boundary is approximately $19.3 million, resulting in Haile paying approximately $223,200 in property taxes to Lancaster County annually. It was assumed that property taxes would remain stable over time unless the properties are developed, which would result in fluctuations in market value and the assessment rate on these lands. Total property tax payments through Mine Year 14 (the end of mining operations) were estimated to be nearly $3.6 million, as presented in Table 4.10-6. Because property taxes would not change relative to existing conditions, no impact would occur.

Applicant's Proposed Project

As shown in Table 4.10-6, under the Applicant's Proposed Project, Haile would pay an estimated total of $17.5 million in fees pursuant to the FILOT agreement, cumulatively through the end of active mining operations (Mine Year 14), or nearly $1.1 million annually. FILOT fees would continue beyond the active mining period for a total of 30 years.

In addition, sales taxes paid by Haile would vary by Project phase. It is anticipated that no sales/use taxes would be paid on materials and equipment used during mine development,[15] except for some permitting-related costs. During mining operations, machinery and material handling equipment used in the mining process are tax-exempt, as well as costs related to maintenance of these items.[16] Purchases that would be subject to sales/use taxes during mining operations include consumables and repair parts for maintenance on equipment not directly used during the mining process.

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[15] S.C. Code Ann. §12-36-2120(67) exempts from sales and use tax construction materials used in the construction of a single manufacturing or distribution facility, or one that serves both purposes, with a capital investment of at least $100 million in real and personal property at a single site in the state over an 18-month period.

[16] S.C. Code Ann. §12-36-2120(17) exempts from sales and use tax machines used in manufacturing, processing, recycling, compounding, mining, or quarrying, if the machine is integral and necessary to the process. In addition, S.C. Code Ann. §12-36-2120(51) exempts from sales and use tax material handling equipment used in distribution or manufacturing (mining) facilities with a capital investment of at least $35 million in real and personal property at a single site over a 5-year period.

The Applicant estimates that the Project would generate taxable sales in South Carolina totaling $19.2 million over the life of the Project. As shown in Table 4.10-7, these taxable sales would generate approximately $1.4 million in sales tax revenues ($84,000 annually), all of which would be collected in Lancaster County.

Lastly, the Project would generate income tax revenues for the federal and state governments. For this analysis, only state income taxes are considered. As shown in Table 4.10-8, approximately $17.2 million in corporate income taxes would be paid to the State of South Carolina through the mining operations period (Mine Year 14); this is equivalent to $1.1 million annually. Labor income paid to workers at the mine would generate state income tax revenues. Labor payments to mine workers and contractors would total approximately $284.0 million over the life of the mine, which would generate approximately $17.9 million in state income tax payments (or $1.1 million per year).

Overall, the property, sales, and income taxes generated by the Project represent a beneficial effect during operation that would be realized by local governments.

Modified Project Alternative

The Modified Project Alternative would entail comparable levels of expenditures and labor requirements as the Applicant's Proposed Project; therefore, tax revenues generated under this alternative would be the same as those described for the Applicant's Proposed Project.

4.10.3.5 Population and Housing

The Project would support a local workforce that varies in size across phases (initial mine development, mining operations, and post-mining reclamation). Depending on the target labor pool that would be used to fill jobs, the Project may induce local population growth, temporarily and permanently, thereby resulting in an increased demand for local housing and other community resources.[17] There is also the potential for population displacement as available land (and housing) is purchased to accommodate the Project.

No Action Alternative

Under the No Action Alternative, the Project would not be implemented and the existing workforce supporting ongoing exploratory activities at Haile Gold Mine would not be required. Existing monitoring activities associated with closure and reclamation of previous mining activity would continue according to permit terms. As a result, existing Haile employees, totaling approximately 115 under existing conditions, would remain living in the region or relocate to find another source of employment. To the extent that workers continue to reside locally, there would be no effect on existing population levels and housing resources. Conversely, if mine workers and their families leave the region, population levels would decline relative to existing conditions, and housing vacancy rates would increase. This would represent a minor impact of the No Action Alternative during a17-year period (equivalent to the Project construction and operational periods).

Applicant's Proposed Project

Under the Applicant's Proposed Project, additional workers would be required during mine development, operations, and post-mining reclamation, which could result in increased population levels in the local

[17] See Section 4.10.3.8 for more information on effects to public services and community infrastructure.

area. During mine development, a maximum of approximately 340 workers and contractors are estimated to be required during the peak construction period. A significant proportion of the construction workforce is anticipated to come directly from the local area (four-county study area), while others would come from other parts of South Carolina, as well as from outside the state. Specifically, during this peak period, it is estimated that all but approximately 190 to 210 construction workers (approximately 55 to 60 percent of the peak construction workforce) would be existing residents of the four-county study area, which would not generate any additional population growth (assuming that residents of other counties in the study area would not relocate to Lancaster County). The remaining 130 to 150 jobs are expected to be filled by workers that would commute to the Project site regularly or temporarily relocate to the four-county study area until mine development is complete.[18] Because of the temporary nature of mine development, it is not likely that construction workers would permanently relocate with their families; therefore, it is estimated that the local population would increase by up to 150 people, which accounts for 0.2 percent of the existing population base in Lancaster County (76,700 residents). At the community level, however, population growth would be more significant. If all workers from outside the four-county study area relocated to either the Town of Kershaw or City of Lancaster, the local population would increase by 8.3 percent and 1.8 percent, respectively.

Construction workers likely would use local temporary accommodations to meet their housing needs, such as hotels, motels, and apartments.[19] As described in Section 3.10, 23 hotels and motels, with approximately 810 rooms, are within a 25-mile radius of the Project site that includes the communities of Kershaw and Lancaster in Lancaster County and the communities of Camden and Lugoff in Kershaw County. Based on average occupancy rates (57.8 percent), an average of approximately 340 rooms are estimated to be vacant throughout the year. If needed, local apartments also could be used to meet worker housing demands. Therefore, it appears that temporary housing resources would be sufficient to accommodate the workers temporarily relocating to the area to serve the Project, thereby alleviating the need for on-site housing resources. Construction-related housing demand would be a negligible impact of the Project.

The Project would generate demands for housing during mining operations. During mining operations, the Project is estimated to employ between 150 and 420 workers. Most of these workers (75 to 95 percent of the operations workforce) are expected to come from the four-county study area. Based on these figures, mining operations would bring up to approximately 20 to 105 new workers to Lancaster County during peak production periods. Assuming that these workers would permanently relocate to Lancaster County with their families, the City of Lancaster population could increase by up to approximately 260 people (3 percent).[20]

An increase in population during operations would generate demand for local housing over the Project timeframe. As explained above, the Project would draw up to 105 new households to the region to support operations activities. In 2010, approximately 32,700 housing units were located in Lancaster County, which included 2,990 vacant housing units countywide and 578 vacant housing units in the nearby communities of Lancaster and Kershaw. Based on these values, there appears to be sufficient vacancy in the local housing stock to accommodate Project-related housing demands. If needed, operational housing also would be available from local apartment complexes and in adjacent

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[18] For this analysis, it was conservatively assumed that all workers outside of Lancaster County would temporarily relocate near the Project, likely near the communities of Kershaw and Lancaster.

[19] No housing would be available at the Project site.

[20] Assumes an average of 2.49 persons per household in South Carolina (U.S. Census 2012).

communities. Increased local housing demand during Project mining operations would be a negligible impact.

The Project also could affect local population levels and housing resources, based on development of the mine site and displacement of existing housing. Approximately 44 of the parcels within the Project boundary included houses at the time they were purchased. All of these houses have been or would be demolished or sold and relocated prior to the start of construction. These 44 houses represent approximately 0.1 percent of the local housing stock in Lancaster County and 5.1 percent of the housing stock in the community of Kershaw. This is a negligible impact.

Modified Project Alternative

The Modified Project Alternative would entail comparable levels of employment at the mine site and throughout the regional economy as the Applicant's Proposed Project. The population and housing effects under this alternative would be the same as those described for the Applicant's Proposed Project.

4.10.3.6 Property Values

As with any large-scale change in land use, there is the potential that the Project would affect property values in the region. Factors that may positively influence property values include the development of a large employment base and benefits to the local economy from the Project. Conversely, factors that may adversely affect property values include nuisance-related effects associated with a large industrial project, such as noise, impairment of the visual and aesthetic quality of the local area, loss of rural character, and other potential environmental impacts. For this analysis, potential effects on local property values were assessed qualitatively based on a literature review of applicable studies summarized below.

Chmura Economics & Analytics (2011) conducted an economic analysis of the Chatham, Virginia uranium mine that was not yet operational. The study concluded that properties within a 5-mile radius of the mine were expected to experience a loss in property value ranging from 2 to 8 percent, with properties within a 2-mile radius experiencing the largest declines in property values. However, it was anticipated that the negative stigma and the associated impacts on property values near the mine would be temporary.

Controlling for other factors that influence property values, Erickcek (2006) statistically evaluated the effects of mining on property values near a gravel mining site in the Richland Township of Pennsylvania. The key finding of the study was that property values tend to increase as distance from gravel mines increases. In other words, there is a negative relationship between proximity to gravel mines and property values. Specifically, the study found that a residential property located 0.5 mile from a gravel mine would experience an estimated 20-percent reduction in value; 1 mile from the mine, a 14.5-percent reduction; 2 miles from the mine, an 8.9-percent reduction; and 3 miles from the mine, a 4.9-percent reduction. The study also indicated that property value impacts generally occurred at the time the mining operation was opened or shortly thereafter.

Similarly, for a mine in Queensland, Australia, Neelawala et al. (2013) found that property values within a 4-kilometer radius around Mount Isa increased by almost $14,000 AUS for every kilometer of increased distance from the mining and smelting facilities.

Qualitative analysis of a proposed frac sand mine and transportation route by Parker and Phaneuf (2013) concluded that the introduction of noise, industrial traffic congestion, and related nuisance factors such as dust and visual/aesthetic impacts would lower property values in various locations in the Pepin Lake region. Furthermore, there was a negative stigma surrounding the possible mine, as residents and local business owners believed that the industrial site would threaten their investments and community—

mainly by adversely affecting the natural amenities of the area, which were a major source of economic activity due to recreation and tourism.

Williams (2011) analyzed the impacts of surface coal mining on residential property values across a number of states using a hedonic pricing analysis. The study identified a negative relationship between coal mines and property values. The research also generally found that the impact on property values was higher if the property was located within 1 mile of a mine, versus several miles away.

Other studies have found a positive or neutral relationship between mining/industrial sites and property values. Analyses at Alaska's Wishbone Hill coal mine by two different realtors concluded that property values would either increase or stay the same, and neither predicted an adverse impact on property values (University of Alaska Anchorage 2011).

Similarly, Willingham Associates (2002) determined that the values of residential property and vacant land near aggregate mining operations in Ohio were not negatively affected close to mining sites. Willingham Associates (2002) noted that this conclusion includes the conscientious nature of mine operators and impact minimization measures (e.g., landscaping and control measures that would minimize dust and traffic). The study also acknowledged that residents realized that there were tradeoffs regarding living conditions anywhere, which further supported their conclusion.

No Action Alternative

Under the No Action Alternative, property values in the region may decline in response to foregone economic benefits and housing demand that are projected with the Project. If the local housing market has already capitalized these economic benefits and housing demand into property values, the No Action Alternative may result in declining home and land prices. To the extent that current property values have been unaffected by plans to develop the Haile Gold Mine and existing activity at the Project site, the No Action Alternative would not affect property values.

Applicant's Proposed Project

As described in the literature review above, development of mining operations can place both downward and upward pressures on local property values. The economic benefits that would be generated by the Project, including increases in employment opportunities and income at both the mine site and in the larger economy, could increase the demand for housing, thereby driving prices higher in the local real estate market. It is difficult to ascertain whether these factors have already been capitalized into existing market conditions in anticipation of the proposed Project. Conversely, development of the Project could result in nuisance-related effects, such as dust, noise, and degradation in the visual character of the surrounding landscape, which could in turn result in declining property values during operation. These adverse effects would tend to be localized close to the mine site and likely would affect only a small segment of the local housing stock. Further, the Project site has been used for mining in the past, which likely has been factored into existing market values.

Modified Project Alternative

The Modified Project Alternative would be comparable to the Applicant's Proposed Project, in terms of siting, design, and operations, and in terms of economic benefits. Therefore, the potential effects on property values under this alternative would be the same as those described for the Applicant's Proposed Project.

4.10.3.7 Economic Effects from Displaced Land Uses

The Project site historically has been used intermittently for mining. Mining and related activities are the only currently allowable land uses in the Project area under the existing mining zoning designation. If the zoning designation were to change, other potential land uses could occur in the area. For example, because some of the land within the Project boundary is forested, future timber production and sale is possible. At this time, as no other land uses are allowed and no mining is ongoing at the site, there are no identified displaced land uses in the Project area and no associated economic impacts.

No Action Alternative

Under the No Action Alternative, the proposed mine would not be developed; therefore, existing and potential future land uses within the Project boundary would not be displaced. No impacts would occur.

Applicant's Proposed Project

Following reclamation, potential future land uses could include agricultural, forestry, commercial, industrial or residential development, or limited recreational use opportunities. The actual future land use and the extent and type of future land use opportunities at the Project site are unknown at this time. Any potential land use, other than mining, would require changes to the current mining zoning by Lancaster County.

Some land within the Project boundary would be cleared to construct new facilities and engage in mining activities. Some of the areas targeted for clearing are forested land. Timber clearing would occur only on an as-needed basis. The proposed mine would not displace *existing* economic production on Project lands because the area is not currently being used for commercial timber purposes. Therefore, no loss in local economic production or jobs would result from Project development.

However, to the extent that forested areas are cleared, the Project would preclude *future* timber harvest in these areas. The quantity and quality of timber resources that would be affected by the Project are unknown, and it is speculative to predict whether future timber harvesting would occur absent the Project. Kershaw Industrial Park, which supports a range of businesses and services, would not be affected because it is located outside the Project boundary.

Modified Project Alternative

Effects on existing and future land uses within and adjacent to the Project area under the Modified Project Alternative would be comparable to those under the Applicant's Proposed Project. Therefore, the potential effects from displaced land uses under this alternative would be the same as those described for the Applicant's Proposed Project.

4.10.3.8 Public Services

As with most large development projects, the Haile Gold Mine would increase demand for a range of public services and require new infrastructure to serve the Project and its employees. This section addresses potential effects on education and schools, solid waste disposal, potable water supplies, wastewater disposal, electricity, and natural gas. Other public services related to the health and safety of local residents (law enforcement, fire protection, and emergency services) are addressed in Sections 3.18 and 4.18, "Health and Safety."

No Action Alternative

Without the Project, additional demand for local public services would not be generated. Therefore, the public services referenced above would not be affected under the No Action Alternative. No impact on public services would occur.

Applicant's Proposed Project

The Applicant's Proposed Project would increase the demand for public services based on operating requirements of the mine and the anticipated influx of workers that would increase local population levels. Public services required to serve the Project are addressed in Appendix A (Project Description), and projected changes in population due to workforce requirements are addressed in Section 4.10.3.5. Based on the number of Project workers that the Applicant anticipates hiring from areas outside of Lancaster County, it is estimated that population levels in Lancaster County could increase by a maximum of 150 persons during the pre-production period and up to 260 persons during active mining operations (105 mine workers and their family members). Population increases would depend on the proportion of these workers (and their families) that permanently relocate to Lancaster County. Currently, many residents of nearby counties commute to Lancaster County; therefore, the actual change in population may be lower than the number of non-resident workers.

Education and Schools

During mine development, most workers from outside the region would likely not relocate with their families to Lancaster County. This would limit the increase in the population of school-aged children. Therefore, effects on the local school system would be negligible. During the operations phase of the Project, up to approximately 105 workers with families may permanently relocate to Lancaster County to serve the Project, which would result in an increase of up to 86 school-aged children.[21] This represents a relatively small proportion (0.7 percent) of the total enrollment in the Lancaster County School District (11,928 students in 2011). Based on these figures, it is likely that local public schools would be able to accommodate any new students that would move into the region. Therefore, the direct effects on the local school system during operations would be negligible.

Solid Waste Disposal

The proposed Project would generate solid waste during mine development, including construction and demolition debris during facility construction. It also would generate municipal solid waste during all Project phases. As a commercial entity, the Applicant would need to contract with commercial haulers to dispose of Project waste. Further, solid waste generated by the Project would be disposed of differently, depending on the type of waste. Construction and demolition debris likely would be disposed of at the Mining Road Landfill, a Class II facility located in the Town of Kershaw. Although the capacity of the Mining Road Landfill is unknown, Lancaster County maintains an open disposal amount at this landfill with no contractual capacity, indicating that sufficient capacity likely would be available to meet the waste disposal needs during mine development. This impact is considered negligible.

For municipal waste, the Lee County Landfill, a Class III facility, would likely serve the Project. This landfill has an expected life of 15 to 17 years, which indicates that it could handle solid waste generated over the life of the Project. In addition, the Applicant has been coordinating with Lancaster County Public

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[21] Based on an average of 0.82 children (under 18) per family in South Carolina (U.S. Census 2004).

Works authorities regarding the solid waste disposal needs of the Project, and no concerns regarding disposal capacity have been identified. Consequently, construction and operational direct impacts associated with solid waste disposal would likely be negligible.

Modified Project Alternative

The Modified Project Alternative would generate comparable demands on public services as the Applicant's Proposed Project; therefore, effects on public services under this alternative would be the same as those described for the Applicant's Proposed Project.

4.10.3.9 Environmental Justice

As shown in Table 3.10-3, the population in Lancaster County is predominantly White (71.5 percent). Racial minorities make up the remaining 28.5 percent of the population, including the Black/African American population, which accounts for 23.8 percent of the population in the county. The relative proportion of minority populations in Lancaster County is lower than the four-county socioeconomics study area (39.9 percent) and the State of South Carolina overall (33.8 percent). At the census tract level, the minority population in CT 102 (the location of the proposed mine) is only slightly larger than Lancaster County overall and lower than the socioeconomics study area and the state. Generally, the data show that the minority population surrounding the Project boundary is not meaningfully greater than in the larger region. However, a distinct population group (Kershaw Correctional Institution inmates), located just west of the Project boundary in CT 102, was considered in the environmental justice analysis. In addition, a number of census tracts elsewhere in Lancaster County exhibit high rates of minority populations, such as CT 107 and CT 108 in the City of Lancaster. The minority populations in both of these census tracts exceed 50 percent; however, these tracts are located sufficiently distant from the Project boundary as not to be affected by site-specific environmental impacts. See Figure 3.10-12 for a map of the census tracts.

Key economic indicators of social well-being are presented in Table 3.10-4. At the regional level, the population in Lancaster County has relatively lower income levels (per capita income of $19,308) and higher unemployment (12.3 percent) and poverty rates (20.4 percent) compared to the socioeconomics study area and the state. At the census tract level, CT 102 has similar economic characteristics compared to Lancaster County, but is economically disadvantaged compared to the region and state based on higher unemployment and poverty rates and low per capita income levels. In addition, CT 9702 in Kershaw County, located immediately south of the Project, is characterized by relatively high unemployment and poverty rates and lower income levels. Based on these data, the population immediately surrounding the Project boundary and in Lancaster County overall are considered low-income populations, and therefore environmental justice communities of concern, which requires further evaluation in the context of the potential environmental and economic impacts of the Project.

This section also addresses EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks* (April 27, 1997), which instructs federal agencies to identify, assess, and address environmental health and safety risks from federal policies, programs, activities, and standards that may disproportionately affect children.

No Action Alternative

Under the No Action Alternative, the Project would not be developed, and none of the potential environmental impacts or economic benefits attributed to the Project would be realized. Therefore, there would be no environmental justice effects on minority or low-income populations in the region and no disproportionate health or safety effects on children.

Applicant's Proposed Project

As noted above, the population surrounding the Project boundary and residing in the greater Lancaster County area is characterized by relatively low income levels and high unemployment and poverty rates. The environmental and socioeconomic effects of the Project on these environmental justice communities of concern are addressed separately below.

The physical effects of the Applicant's Proposed Project with the potential to affect local populations include effects associated with air quality (see Section 4.16, "Air Quality"), noise and vibration (see Section 4.17, "Noise and Vibration"), and water supply (see Section 4.5, "Water Supply and Floodplains"), as well as general health and safety concerns attributed to natural events and emergency response capabilities of local service providers (see Section 4.18, "Health and Safety"). The Applicant's Proposed Project would result in increased generation of air pollutant emissions and noise and vibration. These effects would not exceed regulatory or health standards; therefore, local minority and low-income populations and children would not be subject to adverse health effects from Project operations. Local public service providers have indicated that they would be able to adequately respond to events in the Project area; therefore, minority and low-income populations and children residing near the Project would not experience a decline in service levels provided by law enforcement, fire protection, or emergency service agencies. For the impacts outlined above, the Project would not result in disproportionate adverse effects on children or minority or low-income populations surrounding the Project area, including Kershaw Correctional Institution inmates.

The Project would result in drawdown of groundwater levels in the vicinity of the Project area. As expected, groundwater drawdown would be greatest in the Project area and would decline with distance from the Project boundary. The inmates at the Kershaw Correctional Institution have been identified as an environmental justice community of concern. Groundwater levels near the facility would decline by approximately 10 to 50 feet. This drawdown may affect water levels in the groundwater well for the facility, thereby increasing pumping costs or potentially rendering the well unusable. The potential impact on groundwater levels would be temporary during mining, and water levels are expected to rebound some years after mining ends. Historically, this groundwater well provided potable water to the facility. The well is not being used currently, however, as the facility is now served by the municipal water supply system. Consequently, the groundwater drawdown would not adversely affect the well-being of inmates at the Kershaw Correctional Institution. Accordingly, the Project would not result in disproportionate adverse effects on minority or low-income populations based on changes in groundwater levels. No health or safety risks would result from the groundwater drawdown, and consequently no disproportionate effects on children are expected. In summary, the potential effects on environmental quality due to the Project are expected to result in minimal adverse effects on human health and safety, with no air quality or other health-related threshold exceeded even for sensitive populations such as children.

From an economic perspective, the Applicant's Proposed Project would result in a broad range of economic benefits in the Project area and in the larger four-county economy, as described in Sections 4.10.3.2 and 4.10.3.3, respectively. The direct benefits in the Project area in Lancaster County during Project development include up to 340 jobs for workers who would collectively earn $37.9 million in total compensation. In addition, the Project would generate economic benefits in the Project area during the operations phase of the Project, which are expected to occur over an approximately 14-year mining period. Collectively, mining operation would support 150 to 420 direct jobs and $7.5 to $29.5 million in labor compensation (wages and benefits) in the Project area. It is expected that three-quarters or more of these jobs would be filled by residents in the four-county study area (Lancaster, Kershaw, Richland, and York Counties). When considering the larger region, these direct benefits also would spur economic activity throughout the four-county study area. During peak production in Mine Year 7, the

Project would generate approximately 600 to 1,000 new jobs and $38 to $56 million in labor compensation in the four-county region.

The extent to which these direct and regional economic benefits would affect minority and low-income populations in the Project area is unknown. It is plausible that some of the construction and mining jobs would be filled by minority and low-income workers living near the mine in Lancaster County; however, these opportunities would be limited to workers with the required skill sets. It is more likely that the regional economic benefits generated throughout Lancaster County would benefit minority and low-income workers because these benefits would occur across a broader range of industries that are supported by a more diverse mix of workers. The fiscal benefits of the Project, including new tax and fee revenues, also could allow Lancaster County to provide additional or improved public services that would benefit all county residents. In summary, the economic and fiscal benefits of the Applicant's Proposed Project would likely result in environmental justice benefits and would not result in disproportionate adverse effects on the minority and low-income populations in the socioeconomics study area.

This analysis of environmental justice effects, including the evaluation of human health, social, and economic effects on minority and low income populations at the census tract level, is consistent with the demographic and environmental data and analysis available through the USEPA tool, NEPAssist.

Modified Project Alternative

The environmental and economic effects and therefore the potential environmental justice effects under the Modified Project Alternative would be the same as those of the Applicant's Proposed Project.

4.10.4 Impact Summary

The proposed Haile Gold Mine is a large-scale project that would generate a range of economic benefits based on the large capital investment and workforce requirements. A summary of the economic benefits of the Project are presented in Table 4.10-9a (for the four-county socioeconomics study area) and Table 4.10-9b (for the State of South Carolina overall). These benefits include those supported directly by Project-level spending, employment, and wages paid to workers; benefits also include the ancillary effects in the larger economy based on linkages among industries and households (the multiplier effect). In addition, the Project would generate substantial tax revenues at the local, county, and state levels.

Beyond the monetary benefits, the Project could affect local socioeconomic conditions based on a number of factors, including increases in population and related demands for housing and public services, changes in local property values, and environmental justice considerations. These impacts, although not quantified, need to be considered when evaluating the overall socioeconomic effects of the Project. Table 4.10-10 presents a summary of impacts for each alternative for the key socioeconomic issues evaluated in this section.

Table 4.10-9a Summary of Regional Economic Impacts under the Applicant's Proposed Project (Four-County Study Area) (Annual Average)

Project Phase	Output ($ millions)			Labor Income ($ millions)			Employment (jobs)		
	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total
Project development (2012–2015)	N/A	17.5-35.6	17.5–35.6	11.1	7.3-15.0	18.4–26.1	100	200-310	300–410
Operations (2015–2028)	$151.1	11.2-32.4	162.3–183.5	17.1	4.0-11.6	21.1–28.7	270	100-270	370–540

Notes:

N/A = not applicable

Monetary values are reported in constant 2010 dollars.

Source: Cardno ENTRIX 2013 (based on IMPLAN modeling).

Table 4.10-9b Summary of Regional Economic Impacts under the Applicant's Proposed Project (Statewide) (Annual Average)

Project Phase	Output ($ millions)			Labor Income ($ millions)			Employment (jobs)		
	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total	Direct	Indirect/ Induced	Total
Project development (2012–2015)	N/A	40.1–56.5	40.1–56.5	11.1	16.8-22.2	27.9–33.3	100	200-310	300–410
Operations (2015–2028)	$151.1	15.2–35.6	166.3–186.7	17.1	5.2-12.2	22.3–29.3	270	100-270	370–540

Notes:

N/A = not applicable

Monetary values are reported in constant 2010 dollars.

Source: Cardno ENTRIX 2013 (based on IMPLAN modeling).

Table 4.10-10 Summary of Impacts on Socioeconomics and Environmental Justice

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Effects on gold production values and markets	No production of gold and silver.	Increase in gold and silver production ($151.1 million annually).	Same as the Applicant's Proposed Project
Direct economic effects at Haile Gold Mine	Minor amounts of income and jobs supported at the mine.	Increase in income and jobs at the mine site; varies by Project phase.	Same as the Applicant's Proposed Project
Regional economic effects	Minor regional economic benefits in the local and statewide economies.	Increase in output (production), income, and jobs in the local and statewide economies.	Same as the Applicant's Proposed Project
Tax revenue effects	Minor effects on local tax revenues.	Increase in fee/tax revenues; FILOT fees ($1.1 million annually); sales taxes ($327,000 annually); and state income taxes ($2.5 million annually).	Same as the Applicant's Proposed Project
Population and housing effects	No effects on local population or housing.	Minor increases in population and demand for local housing.	Same as the Applicant's Proposed Project
Property value effects	Unknown	Unknown	Same as the Applicant's Proposed Project
Effects on public services	No effects on public services.	Increased demand for local public services.	Same as the Applicant's Proposed Project
Environmental justice effects	No adverse effects on environmental justice populations based on environmental or socioeconomic factors.	Beneficial effects on environmental justice populations from local and regional economic benefits (jobs and income).	Same as the Applicant's Proposed Project

4.10.5 Mitigation for Impacts on Socioeconomics and Environmental Justice

4.10.5.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included avoidance and minimization measures in the design and plans for operating and managing the proposed Project (Haile 2013b). Although none specifically address socioeconomic and environmental justice, some of the measures identified for other resources such as land use, transportation, visual resources, noise and vibration, water quality, air emissions, health and safety, and recreation, would apply to socioeconomics and environmental justice. The full list of avoidance and minimization measures proposed by the Applicant is provided in Chapter 6.

4.10.5.2 Additional Potential Mitigation Measures

The impacts on socioeconomics from the Applicant's Proposed Project are beneficial; therefore, no additional mitigation measures are proposed.

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4.11 Land Use

The land use impact analysis focuses on potential changes in land use and land ownership, consistency with local zoning ordinances, and potential impacts on prime and unique farmland in the Project area.

4.11.1 Methods

The impact analysis used GIS mapping information obtained from a variety of federal, state, and local sources; satellite imagery; and publicly accessible information available on the internet. Information on the size and location of various Project elements (including post-mining site reclamation activities) were compared to GIS mapping layers and satellite imagery to determine the type, magnitude, and duration of potential impacts.

4.11.2 Impacts

4.11.2.1 Changes in Land Use and Land Ownership and Consistency with Zoning

No Action Alternative

Under the No Action Alternative, there would be no immediate change to the existing land use in the Project area because it is currently zoned as "Mining District," and the only land use permitted on the site under this current zoning would be mining (Lancaster County 2013a). No impacts related to changes in land use or land ownership, or consistency with zoning and applicable land management plans would occur under the No Action Alternative.

Applicant's Proposed Project

Active Mining Period

During the active mining phase, approximately 2,612 acres of the 4,552 acres within the Project boundary would be directly affected by construction and operation of the various mining components, including mine pits, OSAs, the Mill, TSF, borrow areas, haul roads, and other related support facilities. Land within the Project area historically has been zoned R-45A (Rural Residential Intense Agricultural) and has been occupied by scattered rural residences; other historical land uses included timber operations, agriculture, and mining. As explained in Section 3.11, most of the land within the Project area was rezoned to I-2 Heavy Industry in 2009 and 2012. In 2013, land within the Project area was rezoned from I-2 to M, Mining District.

While development of the mine would convert large amounts of land not historically used for mining to mining-related uses, the Applicant's Proposed Project is consistent with the permissible uses in the Mining District zone. Section 2.1.6 of the Lancaster County UDO states that the purpose of the Mining District is to accommodate businesses engaged in extraction and processing of mineral materials (Lancaster County 2013a). It also should be noted that approximately 252 acres of the land within the Project area that would be disturbed by the Applicant's Proposed Project has previously been disturbed by past mining activities. Ownership of the Project area is not expected to change during the life of the Project.

Perimeter fencing has been installed along the boundary of the Project area to separate the mine from adjacent land uses. In addition, the landscaping requirements in the Lancaster County UDO would require a minimum 30-foot wide Type 4 buffer yard to block visual contact and create spatial separation between the mine and adjacent land uses (Lancaster County 2013b). The Type 4 buffer yard would be composed

of a vegetative screen of trees and shrubs that would help to reduce the amount of the light and noise from the mine that could potentially intrude upon adjacent properties.

Post-Mining Period

Land use impacts during the post-mining reclamation and monitoring phase would be similar to those described for the active mining phase. While site reclamation would occur in some areas within the Project boundary during the active mining phase, reclamation and monitoring activities would become the primary activity during the post-mining phase. During this phase, vegetation would be established over all portions of the site except for the pit lakes and associated high walls, and any roads or access areas needed for post-mining activities. The perimeter fencing and Type 4 buffer yard described above would remain in place during this phase to screen the mine from adjacent properties. No impacts from changes in land use or land ownership, or consistency with zoning and applicable land management plans, would occur under the Applicant's Proposed Project.

Haile identified potential future land use suitability following reclamation for the Project site in which portions of the Project site could provide potential future agricultural, forestry, commercial, industrial or residential development, or limited recreational use opportunities (Haile 2013a). Some areas within the Project boundary would have limited suitability for future land use opportunities, such as Johnny's PAG and the TSF area. Other OSA areas may have limited suitability for future land uses due to topography and slope limitations. The type and extent of future land use opportunities that would be provided in the Project area are unknown at this time. The post-reclamation land use and access would be specified in an SCDHEC-approved Reclamation Plan. In addition, any potential land use, other than mining, would require changes to the current zoning designation by Lancaster County.

Modified Project Alternative

Active Mining and Post-Mining Periods

Impacts on land use and land ownership and consistency with local zoning under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.11.2.2 Impacts on Special-Status Farmland

No Action Alternative

Under the No Action Alternative, undisturbed prime farmland and farmland of statewide and local importance within the Project area would remain undisturbed. No impacts on undisturbed prime and unique farmland would occur. Future mining activities proposed by others in the Project area would require a similar level of permitting and environmental review as the Applicant's Proposed Project.

Applicant's Proposed Project

Active Mining and Post-Mining Periods

During the active mining phase, approximately 186 acres of prime farmland, and an additional approximately 246 acres of farmland of statewide or local importance, would be disturbed within the Project boundary (Figure 3.11-3). The soil productivity, physical structure, and ecological function of these resources would be substantially altered during the active mining phase. The impacts on these resources would continue throughout the reclamation and monitoring phase. While reclamation activities would attempt to restore the physical, chemical, and biological characteristics of the soil and establish

vegetation across the site (except for the pit lakes and associated high walls, and roads or access areas needed for post-mining activities), the level of disturbance that would occur during the active mining phase would likely result in a permanent loss of these resources. Because most of the affected prime farmland and farmland of statewide and local importance is not currently used for cropland, and the amount of affected acreage would be small compared to the total amount of these resources in Lancaster County (64,821 acres and 55,147 acres, respectively), the long-term impact of converting 432 acres of special-status farmland to non-farm use would be minor.

Modified Project Alternative

Active Mining and Post-Mining Periods

Impacts on special-status farmland under the Modified Project Alternative during both the active mining phase and the reclamation and monitoring phase would be similar to those described for the Applicant's Proposed Project. However, the reduced size of the Ramona OSA under this alternative would affect 33 fewer acres of prime farmland, resulting in a total of 153 acres of prime farmland that would be disturbed. The amount of farmland of statewide or local importance that would be disturbed would be the same for both alternatives (246 acres). Because most of this farmland is not currently used for cropland, and the amount of affected acreage would be small compared to the total amount of these resources in Lancaster County, the long-term impact of converting 399 acres of special-status farmland to non-farm use would be minor.

4.11.3 Impact Summary

Table 4.11-1 presents a summary of impacts under each alternative for the key issues related to land use.

4.11.4 Mitigation for Impacts on Land Use

4.11.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included avoidance and minimization measures in the design and plans for operating and managing the proposed Project (Haile 2013b); these measures are summarized as follows:

- Use existing community infrastructure to avoid affecting additional lands in order to construct employee housing facilities and other amenities.
- Concentrate all land disturbances within a relatively compact mine-footprint-affected area.
- Perform concurrent and final reclamation.
- Return disturbed areas to a stable condition that can support a productive post-mining land use.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of avoidance and minimization measures for land use proposed by the Applicant is provided in Chapter 6.

4.11.4.2 Additional Potential Mitigation Measures

The proposed mining and reclamation activities under both action alternatives would be consistent with existing zoning, and impacts on designated farmland would be minor. As such, no additional mitigation measures are proposed for land use.

Table 4.11-1 Summary of Impacts on Land Use

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Changes in land use	No immediate change in land use; ongoing monitoring and maintenance activities would continue.	Approximately 2,612 acres within the Project boundary would be converted from past land uses to mining, consistent with the current zoning.	Same as the Applicant's Proposed Project
Change in land ownership	Applicant may sell some or all of the property within the Project boundary; the Haile-owned minerals laboratory at the Kershaw Industrial Park may be closed.	No change in ownership is anticipated for Project lands.	Same as the Applicant's Proposed Project
Consistency with zoning and land management plans	Consistent with the Lancaster County Mining District zoning designation and consistent with applicable land management plans.	Consistent with the Lancaster County Mining District zoning designation and consistent with applicable land management plans.	Same as the Applicant's Proposed Project
Impacts on special-status farmland	Undisturbed prime farmland and farmland of statewide and local importance would remain undisturbed.	Approximately 186 acres of prime farmland and approximately 246 acres of farmland of statewide or local importance would be disturbed and converted to non-agricultural uses.	Approximately 153 acres of prime farmland and approximately 246 acres of farmland of statewide or local importance would be disturbed and converted to non-agricultural uses.

4.11.5 Literature Cited

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4.12 Transportation

As discussed in Section 3.12, the Applicant's Proposed Project has the potential to (1) cause traffic congestion; (2) increase the possibility of vehicle conflicts or collisions at proposed vehicular access points, including a proposed driveway onto US 601 that would replace the existing Snowy Owl Road; and (3) increase wear and tear on highway surfaces.

4.12.1 Methods

The traffic analysis of existing and future conditions is based on the *Highway 601 & Haile Gold Mine Road Traffic Impact Study* (the TIS) (Haile 2013a). As noted in Section 3.12, the TIS incorporates procedures and standards established by the SCDOT, the state agency with jurisdiction over the transportation facilities in the study area. During development of the TIS, the SCDOT worked with the Applicant to define the transportation study area, which includes the three intersections that provide access to the Project area (see Figure 3.12-1). The SCDOT approved the TIS on July 3, 2013.

Traffic projections for the No Action Alternative are the assumed future traffic conditions without the Applicant's Proposed Project. Estimated traffic under the No Action Alternative assumes future traffic growth based on historical and current traffic volume trends in the transportation study area and on surrounding roadways. As discussed in Section III.A of the TIS, a conservative growth factor of 1 percent per year was assumed. The growth factor was uniformly applied to the existing July 2012 traffic counts. These factored volumes for the two baseline scenarios (2013 and 2020) represent the No Action Alternative. Because the No Action Alternative estimates future conditions based on historical trends, it provides a reasonable basis for estimating traffic associated with present and reasonably foreseeable future projects (Chapter 5).

Existing traffic data were collected for the TIS in July 2012. However, construction and operation of the Applicant's Proposed Project would occur in subsequent years. To provide a reasonable basis for measuring Project-related traffic effects, No Action Alternative baseline scenarios were created that correspond to the estimated periods for Project construction and operations activities. In the TIS, the No Action Alternative baseline scenario for measuring construction impacts assumed 1 year of growth from the time of the 2012 traffic counts and analyzed year 2013 conditions.[1] In the TIS, the No Action Alternative baseline scenario for operations impacts evaluated year 2020 conditions.[2]

The amount of new traffic resulting from mine construction and operations was determined using employment estimates furnished by the Applicant and traffic generation rates published by the Institute of Transportation Engineers, as documented in Section III.B of the TIS. The TIS evaluated potential Project-related effects on traffic congestion in terms of LOS, using methods contained in the *Highway Capacity Manual* (TRB 2010). Specifically, the analysis used the procedures contained in Chapter 19, Two-Way Stop-Controlled Intersections. The possibility of vehicle conflicts or collisions at proposed access points also is based on the TIS.

For potential impacts at intersections, new construction and operations trips, along with diverted existing trips, were assigned to intersections in the study area according to existing traffic patterns and the location

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[1] Although construction activities may occur after 2013, given that the intersection delays for the construction baseline (2013) are virtually identical to those for the operations baseline (2020) (refer to Table 4.12-1), the baseline scenario for construction provides an appropriate basis for measuring the Applicant's Proposed Project's near-term traffic effects.

[2] In the TIS, the peak for proposed operations is projected to occur between 2017 and 2021.

of the Applicant's Proposed Project access point. These trips then were combined with traffic from the corresponding No Action Alternative baseline scenarios (2013 and 2020) to develop traffic conditions under the Applicant's Proposed Project, and an intersection capacity analysis was performed.

Potential impacts on roadway surfaces were evaluated qualitatively based on the volume of additional truck traffic associated with mining and reclamation and monitoring activities given in the TIS, existing traffic counts given in the TIS, and a review of current roadway maintenance programs and practices.

4.12.2 Impacts

The Applicant's Proposed Project would result in direct impacts related to the following issues:

- Potential for traffic congestion;
- Potential conflicts at access points; and
- Roadway wear and tear.

The intensity of all transportation-related impacts, during both mining and reclamation and monitoring periods, would be negligible. The duration of impacts would be temporary for mine construction and long term for mining operations and reclamation and monitoring activities.

4.12.2.1 Potential for Traffic Congestion

The potential for traffic congestion from the Applicant's Proposed Project would be caused by the addition of new traffic and diversion of existing traffic due to street closures.

No Action Alternative

Table 4.12-1 presents an LOS summary for intersections in the study area for both the construction (2013) and operations (2020) baseline scenarios. As shown in this table, all intersections would maintain LOS A during both peak morning and afternoon hours. Comparing intersection delays under the No Action Alternative to those under existing conditions (Table 3.12-2) indicates that 2013 traffic would not result in any incremental increase in delay, while 2020 traffic would result in a maximum increase in delay of 0.2 second per vehicle. Based on this comparison, the No Action Alternative would result in a negligible permanent impact on traffic congestion.

Applicant's Proposed Project

Mining activities, including construction and operation of the Applicant's Proposed Project, would result in the addition of new traffic (both passenger vehicles and trucks) to streets and intersections in the Project vicinity. Mine construction and operation trip generation estimates are presented in Table 4.12-2. As shown in this table, Project construction is expected to generate a higher level of traffic than operations. Both the construction and operations scenarios would involve similar levels of truck traffic during peak commuting hours. It is estimated that, in 2013, a total of 396 auto and 34 truck mining-related trips would occur in the morning and 391 auto and 34 truck trips would occur in the evening. In 2020, an estimated total of 278 auto and 37 truck mining-related trips would occur in each of the morning and evening periods.

Also, because the Applicant's Proposed Project would close three open Lancaster County roads (Snowy Owl Road, Gene Lewellen Road, and Bumblebee Road [also known as Gary Road]) and one SCDOT-maintained road (Haile Gold Mine Road), some existing traffic would be diverted from their current

travel routes. The number of existing diverted trips would be 8 in the morning peak hour and 10 in the afternoon peak hour for construction, and 8 in the morning peak hour and 11 in the afternoon peak hour for operations.

Table 4.12-1 LOS Summary at Study Area Intersections for the No Action Alternative

Intersection		Traffic Control	Peak Hour	No Action Alternative Conditions	
				Delay[a]	LOS[b]
Construction Baseline Scenario (2013)					
1	US 601/Haile Gold Mine Road	One-way stop	A.M.	0.6	A
			P.M.	1.5	A
2	Haile Gold Mine Road/Existing Haile Gold Mine Entrance	Two-way stop	A.M.	6.0	A
			P.M.	5.7	A
3	US 601/Snowy Owl Road	One-way stop	A.M.	0.1	A
			P.M.	0.1	A
Operations Baseline Scenario (2020)					
1	US 601/Haile Gold Mine Road	One-way stop	A.M.	0.6	A
			P.M.	1.6	A
2	Haile Gold Mine Road/existing Haile Gold Mine Entrance	Two-way stop	A.M.	6.2	A
			P.M.	5.7	A
3	US 601/Snowy Owl Road	One-way stop	A.M.	0.1	A
			P.M.	0.1	A

[a] Delay is measured in seconds per vehicle.

[b] LOS calculations in the Traffic Impact Study were based on the methodology in TRB (2010) and performed using Synchro 8 intersection traffic analysis software.

Source: Haile 2013a.

As shown in Table 4.12-3, traffic delays at intersections would range from roughly 4 seconds per vehicle in the morning to 6 seconds per vehicle in the evening during construction and operation. However, conditions at the proposed US 601/ Haile Gold Mine Entrance driveway that are currently at a LOS A rating would remain at that level during both construction and operations morning and evening peak hours. Therefore, traffic-related impacts of the Applicant's Proposed Project would be negligible and temporary for construction, and negligible and long term for operations.

Table 4.12-2 Haile Gold Mine Construction and Operation Trip Generation Estimates

Scenario	Trip Direction and Time of Day	Employee Trips	Other Trips [a]		Construction Trips		Total	
		Autos	Autos	Trucks	Autos	Trucks	Autos	Trucks
Construction (2013)	Inbound A.M.	153	10	21	140	3	303	24
	Outbound A.M.	60	4	8	29	2	93	10
	Inbound P.M.	60	4	8	34	2	98	10
	Outbound P.M.	153	10	21	130	3	293	24
Operations (2020)	Inbound A.M.	178	11	25	N/A	N/A	189	25
	Outbound A.M.	84	5	12	N/A	N/A	89	12
	Inbound P.M.	84	5	12	N/A	N/A	89	12
	Outbound P.M.	178	11	25	N/A	N/A	189	25

Notes:

Reclamation and monitoring activities would involve substantially fewer employees than mining activities (i.e., construction or operations), and therefore would result in substantially less traffic generation.

[a] Other trips = 0.20 time employee trips and include the following types of trips: operational trips, vendor support and sales, other cars and light trucks (e.g., mail and deliveries), large truck deliveries, and non-scheduled trips to local businesses.

Source: Haile 2013a.

Table 4.12-3 LOS Summary at Study Area Intersections for Applicant's Proposed Project

Intersection[a]	Traffic Control	Peak Hour	Applicant's Proposed Project Conditions	
			Delay[b]	LOS[c]
Construction				
US 601/ Haile Gold Mine Entrance driveway (proposed intersection)	One-way stop	A.M.	4.3	A
		P.M.	6.9	A
Operations				
US 601/Haile Gold Mine Entrance driveway (proposed intersection)	One-way stop	A.M.	4.2	A
		P.M.	6.3	A

Notes:

LOS = level of service

Reclamation and monitoring activities would involve substantially less traffic generation than mining activities (i.e., construction or operations).

[a] Intersections 1 (US 601/Haile Gold Mine Road) and 2 (Haile Gold Mine Road/existing Haile Gold Mine Entrance) would be closed as part of the Applicant's Proposed Project.

[b] Delay is measured in seconds per vehicle.

[c] LOS calculations in the Traffic Impact Study were based on the methodology in TRB (2010) and performed using Synchro 8 intersection traffic analysis software.

Source: Haile 2013a.

In addition to potential delays caused by the addition of new trips and diversion of existing trips, roadway construction activities may cause localized travel delays. One-way traffic flagging operations would occur during construction and paving of the proposed mine entrance, and during placement of the overpass bridge girders across US 601 (Haile 2013b). This would involve providing a single lane of travel on US 601 through the construction zone, flag personnel temporarily stopping traffic in one direction of travel to allow motorists to pass through the construction zone in the opposite direction, and vice versa.

Mitigation is recommended to reduce the temporary impact of traffic congestion during construction and the long-term impact during operations. Mitigation measures include (1) developing and implementing a construction traffic management plan; and (2) developing, maintaining, and implementing a transportation phasing and management plan. A construction traffic management plan would address operation and staging of construction vehicles and equipment, and measures to minimize disruption to through-traffic on US 601 during construction of the proposed Haile Gold Mine Entrance driveway and the two proposed overpasses crossing US 601. A transportation phasing and management plan would ensure that necessary transportation improvements are in place to accommodate the Applicant's Proposed Project traffic during both construction and operations (the proposed Haile Gold Mine Entrance driveway would be in place before the existing entrance is closed and before construction truck traffic accesses US 601; and overpasses would be in place before operations traffic crosses US 601). All required plans and permits, including encroachment permits, would be processed through and approved by the SCDOT before construction begins.

With implementation of these measures, the potential temporary traffic congestion impacts during construction and long-term impacts during operations of the Applicant's Proposed Project would be negligible.

Reclamation and monitoring activities also would involve vehicular traffic on US 601 and the proposed Haile Gold Mine Entrance driveway. However, the number of employees involved in reclamation and monitoring activities would be substantially lower than during the construction and operations mining scenarios. Specifically, the number of employees would be reduced from 500 to 153 at the start of reclamation and monitoring activities, and the number of employees would continue to drop in subsequent years. Because traffic generation is based on the number of employees, the traffic congestion impact for reclamation and monitoring operations under the Applicant's Proposed Project would be negligible and long term.

Modified Project Alternative

Under the Modified Project Alternative, the size of the Ramona OSA would be reduced. The balance of Ramona OSA overburden material would be stored in the Holly and Hock TSF borrow areas. A reduction in the size of the Ramona OSA would be expected to result in a net reduction in the duration of construction and/or the number of employees required to build the Project. Therefore, it is anticipated that the transportation-related construction impacts of the Modified Project Alternative would generally be consistent with, or slightly lower than, those of the Applicant's Proposed Project. Accordingly, the traffic congestion impact related to construction of the Modified Project Alternative would be negligible and temporary.

Because the Holly and Hock TSF borrow areas are located on the opposite (western) side of US 601 from the Ramona OSA, the transport of overburden material to the borrow areas would require trucks to cross US 601. However, because these trucks would cross over US 601 via the proposed TSF overpass, no change in operations traffic is expected at the US 601/Haile Gold Mine Entrance driveway under the USACE Modified Project Alternative. With implementation of mitigation described above for the Applicant's Proposed Project, the traffic congestion impact under the USACE Modified Project Alternative would be negligible and long term.

4.12.2.2 Potential Conflicts at Access Points

Potential conflicts or collisions at access points would constitute a direct Project effect.

No Action Alternative

Under the No Action Alternative, no changes would be made to existing Project access points. However, the projected increase in traffic due to estimated growth may result in a slight increase in the likelihood of a conflict or collision at the existing access points. Therefore, the impact relative to conflicts at access points would be negligible and permanent.

Applicant's Proposed Project

As described above, the Applicant's Proposed Project would involve closing Snowy Owl Road, constructing a proposed access driveway onto US 601, and building two overpasses across US 601. A conceptual design of the proposed US 601/Haile Gold Mine Entrance driveway was developed by the Applicant and the SCDOT to facilitate the movement of large trucks into and out of this driveway (refer to Section VII of the TIS). This design provides turning radii and a separate southbound left-turn lane to minimize potential conflicts between trucks accessing the proposed driveway and through-trips on US 601. This improvement is expected to minimize the potential for conflicts or collisions at this intersection for both construction and operations.

Possible conflicts or collisions involving Project traffic crossing US 601 would be avoided through the construction and use of two proposed overpasses crossing US 601. Project traffic would use these overpasses to cross US 601 to access the Champion Pit and TSF.

The SCDOT has requested review and approval by the appropriate SCDOT office of all required plans for these improvements (SCDOT 2013a).With these planned improvements and coordination with the SCDOT, temporary construction impacts and long-term operations impacts related to conflicts at access points would be negligible.

Reclamation and monitoring transportation-related impacts under the Applicant's Proposed Project would be incrementally lower than mining transportation-related impacts due to the scaling back of employment. Therefore, reclamation and monitoring activities would result in a negligible long-term impact with respect to conflicts at access points.

Modified Project Alternative

Impacts related to potential conflicts at access points under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project for both mining (construction and operations) and reclamation and monitoring activities.

4.12.2.3 Roadway Wear and Tear

Impacts on roadway wear and tear would constitute a direct Project effect.

No Action Alternative

As discussed above, the construction (2013) and operations (2020) scenarios of the No Action Alternative assumed traffic growth at a rate of 1 percent per year. The projected increase in truck traffic would be expected to contribute to wear and tear on roadway surfaces. Given the relatively minor increase in truck traffic associated with the No Action Alternative, however, the potential roadway wear and tear impacts would be negligible and long term.

Applicant's Proposed Project

As indicated in Appendix B of the TIS, existing traffic counts on US 601 included 514 trucks in both directions of travel over a 24-hour period. During construction, the Applicant's Proposed Project would add 68 trucks per day to the surrounding street network. Of this total, 45 percent would travel north and 55 percent would travel south. Based on this distribution, the Applicant's Proposed Project would increase truck traffic south of Snowy Owl Road by 37 vehicles per day, resulting in an increase of 7.3 percent over the existing truck counts. During operations, the daily truck volume increase on this segment (41 trucks per day), would cause a 7.9-percent increase in truck traffic on US 601.

US 601 is maintained by the SCDOT. The SCDOT has designated the roadway as an approved overweight truck route that may accommodate permitted trucks with a gross vehicle weight of up to 100,000 pounds (SCDOT 2011a). Maintenance of US 601 and other SCDOT highways is funded primarily through motor fuel taxes (SCDOT 2013b). Since 2008, the SCDOT has used a planned pavement management strategy (involving preservation, rehabilitation, and reconstruction treatments) to proactively maintain facilities in the state (SCDOT 2012a). The SCDOT has indicated that US 601 is ranked fourth on the highway maintenance priority list within the administrative region (Engineering District 4) (SCDOT 2012b). The timing of the maintenance is dependent on the completion of higher-ranked projects.

Given the relatively low volume of truck traffic associated with the Applicant's Proposed Project, the designation of US 601 as an approved overweight truck route, ongoing and funded SCDOT maintenance activities, and US 601's ranking on the priority list, the addition of Project truck traffic during construction would result in a negligible temporary impact from wear and tear on US 601. Similarly, operations would result in a negligible long-term impact from roadway wear and tear on US 601. Further, the Applicant's Proposed Project is not expected to result in any maintenance needs that cannot be funded by the SCDOT.

The proposed Haile Gold Mine Entrance driveway would be constructed by the Applicant and provide access to and from the Applicant's Proposed Project via US 601. In accordance with the SCDOT's Access and Roadside Management Standards (SCDOT 2011b), the Applicant would be responsible for the ongoing maintenance of the driveway within the state right-of-way.

Mitigation is recommended to reduce the temporary impact of roadway wear and tear during construction and the long-term impact during operations. The Applicant should construct the proposed Haile Gold Mine Entrance driveway in accordance with the conceptual plan in the TIS, modified as necessary through plan development and approval by the SCDOT. The design of the proposed intersection and internal access roadway should account for the volume and weight of heavy vehicles accessing these facilities. All designs should be reviewed and approved by the SCDOT.

With implementation of this mitigation measure, the impact from pavement wear and tear related to the proposed Haile Gold Mine Entrance driveway would be negligible and temporary for construction, and negligible and long term for operations.

As described above, reclamation and monitoring activities would result in a substantial reduction in the number of employees present in the Project area, as compared to the operational scenario. This number would fall from 500 during peak operations to 153 in Mine Year 14. As truck traffic is a function of the employee count in the TIS, truck traffic would be expected to be reduced by the same proportion. Therefore, reclamation and monitoring activities would result in a negligible and long-term impact relative to pavement wear and tear.

Modified Project Alternative

As discussed above, traffic characteristics under the Modified Project Alternative are expected to be similar to those of the Applicant's Proposed Project. Therefore, the impacts would be the same. With implementation of the mitigation described for the Applicant's Proposed Project, the impact from pavement wear and tear related to the proposed Haile Gold Mine Entrance driveway would be negligible and temporary for construction, and negligible and long term for operations.

4.12.3 Impact Summary

Table 4.12-4 presents a summary of the potential transportation impacts for each alternative.

Table 4.12-4 Summary of Impacts on Transportation

	No Action Alternative	Applicant's Proposed Project	USACE Modified Project Alternative
Traffic congestion	Based on assumed future traffic growth rate of 1% per year, 2020 traffic would result in a maximum increase in delay of 0.2 second per vehicle at intersections. All intersections would maintain LOS A during both peak hours.	Increases in delays of up to 6 seconds per vehicle at intersections, compared to the No Action Alternative. All intersections would maintain LOS A during both peak hours. Localized travel delays from one-way traffic flagging during construction activities on roadways.	Same as, or slightly lower than, described for the Applicant's Proposed Project
Conflicts or collisions at access points	No changes to existing Project access points but potential for a slight increase in the likelihood of a conflict or collision at existing access points from a projected increase in traffic from estimated growth.	Closing Snowy Owl Road, constructing a proposed access driveway onto US 601, building two overpasses over US 601, and review and approval by the SCDOT of all required plans for improvements would minimize the potential for conflicts or collisions at intersections.	Same as described for the Applicant's Proposed Project
Roadway wear and rear	Assumed future traffic growth rate of 1% per year would contribute to wear and tear on roadway surfaces. Increases in truck traffic would be relatively minor.	Increases of 7.9% in truck traffic during construction and 7.3% during operations would cause wear and tear on US 601, an approved overweight truck route. The roadway is maintained by the SCDOT, with adequate funding available.	Same as described for the Applicant's Proposed Project

LOS = level of service

4.12.4 Mitigation for Impacts on Transportation

4.12.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included avoidance and minimization measures in the design and plans for operating and managing the Applicant's Proposed Project; these measures are summarized as follows (Haile 2013c):

- Concentrate all land disturbances within a relatively compact mine-footprint-affected area to minimize truck traffic on public roadways.
- Construct two bridges over US 601 (to TSF and Champion Pit).
- Restrict mining-related traffic to roads constructed in the Project area to minimize impacts on local infrastructure.
- Construct turning lanes for Project entrance.

- Stagger times of starting and ending shifts.
- Perform employee training.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of avoidance and minimization measures for transportation proposed by the Applicant is provided in Chapter 6.

4.12.4.2 Additional Potential Mitigation Measures

In addition to these measures, the USACE will consider a number of other potential mitigation measures to reduce other remaining impacts on transportation from the Applicant's Proposed Project:

- To reduce traffic congestion, develop and implement a construction traffic management plan to address operation and staging of construction vehicles and equipment, and measures to minimize disruption to through-traffic on US 601 during construction of the proposed Haile Gold Mine Entrance driveway and the two proposed overpasses crossing US 601.
- To reduce traffic congestion, develop, maintain, and implement a transportation phasing and management plan to ensure that necessary transportation improvements are in place to accommodate the Applicant's Proposed Project traffic during both construction and operations.
- To reduce roadway wear and tear, construct the proposed Haile Gold Mine Entrance driveway in accordance with the conceptual plan in the TIS, modified as necessary through plan development and approval by the SCDOT.

With implementation of the measures listed above, the potential temporary traffic congestion impacts and the impact from pavement wear and tear related to the proposed Haile Gold Mine Entrance driveway would be negligible.

4.12.5 Literature Cited

Haile. See Haile Gold Mine, Inc.

Haile Gold Mine, Inc. 2013a. Highway 601 & Haile Gold Mine Road Traffic Impact Study. August 27, 2012 (Revised April 2013).

Haile Gold Mine, Inc., 2013b. Response of Haile Gold Mine, Inc. to USACE's March 27, 2013 Request for Additional Information (RAI No. 4 – TT-01 to TT-09). April 25.

Haile Gold Mine, Inc. 2013c. Haile Avoidance and Minimization Efforts. December 19.

SCDOT. See South Carolina Department of Transportation.

South Carolina Department of Transportation. 2011a. South Carolina Overweight Truck Routes Map. Website: http://www.dot.state.sc.us/doing/doingPDFs/permits/TruckRouteMap_11x17.pdf. Accessed on July 30, 2013.

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South Carolina Department of Transportation. 2012a. SCDOT Highway Preservation. Website: http://www.scdot.org/doing/Pavement_Preservation/preservation.aspx. Accessed on November 28, 2012.

South Carolina Department of Transportation. 2012b. Mr. Todd Cook (District Maintenance, SCDOT Engineering District 4). Personal communication with Scott Barker (Cardno TEC) regarding highway maintenance procedures and the status of US 601 maintenance. December 5, 2012.

South Carolina Department of Transportation. 2013a. Letter to Campco Engineering, Inc., regarding the Haile Gold Mine Traffic Impact Analysis. July 1.

South Carolina Department of Transportation. 2013b. State Funding for Highways. Website: http://www.scdot.org/inside/highwaypolicy/statefunding.aspx. Accessed on July 30, 2013.

Transportation Research Board. 2010. Highway Capacity Manual, Volumes 1–3. Washington, DC.

TRB. See Transportation Research Board.

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4.13 Cultural Resources

This section discusses potential impacts on historic properties in the Cultural Resources Study Area. Historic properties include NRHP eligible, listed, and/or NRHP unevaluated cultural resources. Project-related activities have the potential to directly or indirectly affect the character or use of historic properties. Direct effects could result from excavation or demolition, and indirect effects could entail visual, auditory, or atmospheric changes. Potential visual effects may result from loss of shielding vegetation, removal of aspects of historic setting, or addition of non-historic elements to the landscape. Noise and vibration, infrastructure improvements, and stream erosion or groundwater changes related to Project activities may affect historic properties.

Impacts on historic properties would be possible from mining through reclamation and monitoring phases. Both direct and indirect effects may be short term or long term.

4.13.1 Methods

Historic properties were evaluated for their eligibility for listing in the NRHP using the criteria defined by the NHPA to evaluate the significance of a resource (see Section 3.13.1.1). Impact analysis requires consideration of the character-defining features of a historic property and protection of the characteristics that give that property its significance.

Direct effects are “caused by the action and occur at the same time and place” (40 CFR 1508.8). Examples of direct effects on historic properties include demolition of structures and any ground-disturbing activities within an archaeological site. Indirect effects are “caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable” (40 CFR 1508.8). Examples of indirect effects on historic properties include addition of visual elements to the landscape, erosion within an archaeological site, or structural damage from blasting-related vibrations.

Appendix C of 33 CFR Part 325 states that an undertaking would affect a historic property when the undertaking may alter the characteristics of the property that qualified the property for inclusion in the NRHP. “No effect” means that an undertaking would have no effect at all on a particular historic property. An “adverse effect” occurs when an undertaking alters the character-defining features of a particular historic property in such a way that would diminish the eligibility of the property for listing in the NRHP. “No adverse effect” applies when an undertaking would have an effect but not such that it would alter the characteristics that make a particular historic property eligible for listing in the NRHP. Appendix C of 33 CFR Part 325 also states that effects that would otherwise be found to be adverse may be considered not adverse when the historic property is of value only for its potential contribution to archaeological, historical, or architectural research; when such value can be substantially preserved through conducting appropriate research; and when such research is conducted in accordance with applicable professional standards and guidelines.

4.13.2 Impacts

4.13.2.1 Impacts on Historic Properties

Historic properties would be impacted during mining and during reclamation and monitoring activities, as described below. Appendix M provides additional information and tables related to historic properties.

No Action Alternative

Under the No Action Alternative, the Project area would remain in its current state, and the existing cultural resources would not be affected or significantly altered. Any future mine development at this location would require acquisition of permits and environmental approval and review.

The MOA between Haile and the SHPO (dated June 9, 2010) concerning data recovery at 38LA334 and 38LA335, and the MOA between Haile and the SHPO (dated November 16, 2010) concerning data recovery at 38LA291, 38LA361, and 38LA383 would remain in effect. These sites are eligible for listing in the NRHP or unevaluated, as described in Table 4.13-1.

Table 4.13-1 Potential Impacts on Historic Properties under All Alternatives

Site Number/ Name	Property Type	NRHP Eligibility[a]	Impacts		
			No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
38LA291	Archaeological site	Eligible	Data recovery would continue under current MOA	Adverse	Adverse
38LA334	Archaeological site	Eligible	Data recovery would continue under current MOA	Adverse	Adverse
38LA355	Archaeological site	Eligible	Data recovery would continue under current MOA	Adverse	Adverse
38LA361	Archaeological site	Eligible	Data recovery would continue under current MOA	None	None
38LA371	Archaeological site	Eligible	None	Adverse	Adverse
38LA383	Archaeological site	Eligible	Data recovery would continue under current MOA	Adverse	Adverse
38LA624	Archaeological site	Unevaluated[b]	None	Not yet evaluated[c]	Not yet evaluated[c]
38LA625	Archaeological site	Unevaluated[b]	None	Adverse	Adverse
38LA627	Archaeological site	Unevaluated[b]	None	Adverse	Adverse
38LA636	Archaeological site	Unevaluated[b]	None	Adverse	Adverse

Table 4.13-1 Potential Impacts to Historic Properties under All Alternatives (Continued)

Site Number/ Name	Property Type	NRHP Eligibility[a]	Impacts		
			No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
38LA637	Archaeological site	Unevaluated[b]	None	Adverse	Adverse
38LA638	Archaeological site	Unevaluated[b]	None	Adverse	Adverse
38LA640	Archaeological site	Eligible	None	Adverse	Adverse
38LA642	Archaeological site	Unevaluated[b]	None	Adverse	Adverse
38LA654	Archaeological site	Eligible	None	Adverse	Adverse
38LA660	Archaeological site	Unevaluated[b]	None	None	None
38LA664	Archaeological site	Unevaluated[b]	None	Not yet evaluated[c]	Not yet evaluated[c]
38LA665	Archaeological site	Unevaluated[b]	None	None	None
38LA666	Archaeological site	Unevaluated[b]	None	Adverse	Adverse
38LA673	Archaeological site	Unevaluated[b]	None	Not yet evaluated[c]	Not yet evaluated[c]
38LA679	Archaeological site	Unevaluated[b]	None	Not yet evaluated[c]	Not yet evaluated[c]
38LA690	Archaeological site	Unevaluated[b]	None	None	None
38LA706	Archaeological site	Unevaluated[b]	None	None	None
38LA716	Archaeological site	Unevaluated[b]	None	None	None
38LA726	Archaeological site	Unevaluated[b]	None	None	None
38LA727	Archaeological site	Eligible	None	None	None
265-1103 / Haile Gold Mine School	Building	Eligible	None	None	None

[a] Determination of eligibility made by the USACE with concurrence by the South Carolina State Historic Preservation Office.

[b] Additional information needed for USACE evaluation of this archaeological site. Additional information to be collected under the Memorandum of Agreement (MOA) that is being prepared for the Project.

[c] Additional archaeological testing may extend site boundary, which would result in a direct impact on this site. Additional testing to be completed under the MOA that is being prepared for this Project. Specific testing plans will be developed based on the protocols developed in the MOA and CRMP that are being prepared for this Project.

Applicant's Proposed Project

Historic properties that could be impacted by mining, reclamation, and monitoring activities under the Applicant's Proposed Project are listed in Table 4.13-1 and discussed below.

Active Mining Period

Under the Applicant's Proposed Project, construction of the 601 growth media storage area would directly and adversely affect an NRHP-eligible archaeological site, as would construction of the Duckwood TSF and the TSF growth media storage areas. Construction of haul roads would directly and adversely affect two NRHP-eligible archaeological sites. Construction of the new mine entrance has the potential to directly and adversely affect an unevaluated archaeological site; further archaeological testing would be required to confirm that the site extends into the mine entrance area of direct impact.

Excavation of each of the Champion, Haile, Ledbetter, Small, and Snake Pits would directly and adversely affect NRHP-eligible archaeological sites. Construction of the Holly TSF borrow area would directly and adversely affect one unevaluated archaeological site, while construction of the Hock TSF borrow area would directly and adversely affect five unevaluated archaeological sites. One additional unevaluated archaeological site might be directly affected by construction of the Hock TSF borrow area, but further investigation is needed to confirm that the site's boundaries extend into the borrow area. Construction of the Robert OSA would directly and adversely affect one, and possibly two, unevaluated archaeological sites; further investigation is needed to determine the boundaries of the second site. Construction of the James OSA would directly and adversely affect an NRHP-eligible archaeological site.

With the opening of pits and construction of storage areas, additional access roads would be built in the Project area. Construction of the Champion Pit overpass would directly and adversely affect two NRHP-eligible archaeological sites. Construction of haul roads during active mining would directly and adversely affect an additional NRHP-eligible archaeological site not affected during pre-production construction of facilities.

Diversion of Haile Gold Mine Creek during active mining would directly and adversely affect an NRHP-eligible archaeological site.

Activities associated with ore processing with the potential to directly affect historic properties, if present, would take place during pre-production construction of facilities. Construction of pipes for pumping byproducts (e.g., slurry) and reclaimed water, as well as possibly connecting to municipal water has the potential to directly affect historic properties through ground-disturbing activities.

Post-Mining Period

Historic properties are unlikely to be affected during reclamation activities as all reclamation activities would take place in previously mined areas. However, if activities associated with reclamation, such as transporting equipment, extended beyond previously disturbed areas, the potential to affect historic properties would exist. Impacts on historic properties during monitoring also are unlikely given that monitoring would be limited to surface water, groundwater, and stormwater runoff from the reclaimed areas.

Modified Project Alternative

Historic properties that could be destroyed by mining, reclamation, and monitoring activities under the Modified Project Alternative are listed in Table 4.13-1 and discussed below.

Mining Impacts

Potential direct impacts on historic properties during mining under the Modified Project Alternative would be the same as described for the Applicant's Proposed Project. Multiple unevaluated archaeological sites would be directly and adversely affected by construction of the Holly and Hock TSF borrow areas, but subsequent use of the Holly and Hock TSF borrow areas as OSAs would not add additional disturbance to these unevaluated sites. A reduction in the size of the footprint of the Ramona OSA would not reduce potential direct impacts on historic properties because no historic properties would be directly affected by construction of the Ramona OSA.

Post-Mining Period

Potential direct impacts on historic properties under the Modified Project Alternative during reclamation and monitoring would be the same as described for the Applicant's Proposed Project.

4.13.2.2 Visual, Auditory or Atmospheric Changes to Historic Properties

No Action Alternative

Under the No Action Alternative, the Project area would remain in its current state, and the cultural resources would not be affected or significantly altered. Monitoring of recovery efforts would be completed as required under previous permits, and the cultural resources would not be affected or significantly altered. Any future mine development at this location would require acquisition of permits and environmental approval and review.

Applicant's Proposed Project

Potential visual, auditory, or atmosphere changes to historic properties during mining, reclamation, and monitoring activities under the Applicant's Proposed Project are listed in Table 4.13-2 and discussed below.

Active Mining Period

A mine element in the viewshed of a historic property has the potential to cause a visual impact on historic properties in the permit area.

The Ramona OSA would be visible from four eligible archaeological sites. The 601 growth media storage area would be within the viewshed of three eligible archaeological sites. Johnny's PAG, the 601 OSA, TSF Overpass on US 601, the TSF growth media storage area, and the Mill also would be visible from NRHP-eligible and unevaluated archaeological sites. The TSF would be visible from one NRHP-eligible archaeological site and 10 unevaluated archaeological sites.

The current viewshed is not considered to be one of the characteristics contributing to the NRHP eligibility of archaeological sites potentially affected by the Project. Thus, for archaeological historic properties, visibility of a mine element within their viewshed would be considered "no adverse effect."

One unevaluated archaeological site is close enough to be potentially affected (not adversely) by construction-related noise, dust, and vibrations. Haul roads built during construction of facilities would affect NRHP-eligible and unevaluated archaeological sites visually and through the noise, dust, and vibrations generated during construction and use. The indirect impacts on archaeological sites from construction of haul roads would not cause adverse effects on historic properties. BMPs required during construction activities for the Project would minimize these short-term indirect effects.

The Hayworth OSA would be minimally visible from the NRHP-eligible structure, Haile Gold Mine School (265-1103); this would not be considered an adverse impact on the historic property.

Construction and use of the Holly and Hock TSF borrow areas also would introduce viewshed changes for eight unevaluated archaeological sites, which would be considered no adverse indirect impact on these historic properties.

Table 4.13-2 Potential Visual, Auditory, or Atmosphere Changes to Historic Properties under All Alternatives

Site Number/ Name	Property Type	NRHP Eligibility[a]	Impacts		
			No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
38LA291	Archaeological site	Eligible	Data recovery would continue under current MOA	Not adverse	Not adverse
38LA334	Archaeological site	Eligible	Data recovery would continue under current MOA	Not adverse	Not adverse
38LA355	Archaeological site	Eligible	Data recovery would continue under current MOA	Not adverse	Not adverse
38LA361	Archaeological site	Eligible	Data recovery would continue under current MOA	Not adverse	Not adverse
38LA371	Archaeological site	Eligible	None	Not adverse	Not adverse
38LA383	Archaeological site	Eligible	Data recovery would continue under current MOA	Not adverse	Not adverse
38LA624	Archaeological site	Unevaluated[b]	None	Not yet evaluated	Not yet evaluated
38LA625	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA627	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA636	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA637	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA638	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse

Table 4.13-2 Potential Visual, Auditory, or Atmosphere Changes to Historic Properties under All Alternatives (Continued)

Site Number/ Name	Property Type	NRHP Eligibility[a]	Impacts		
			No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
38LA640	Archaeological site	Eligible	None	Not adverse	Not adverse
38LA642	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA654	Archaeological site	Eligible	None	Not adverse	Not adverse
38LA660	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA664	Archaeological site	Unevaluated[b]	None	Not adverse	Not yet evaluated
38LA665	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA666	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA673	Archaeological site	Unevaluated[b]	None	Not yet evaluated	Not yet evaluated
38LA679	Archaeological site	Unevaluated[b]	None	Not yet evaluated	Not yet evaluated
38LA690	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA706	Archaeological site	Unevaluated[b]	None	None	None
38LA716	Archaeological site	Unevaluated[b]	None	None	None
38LA726	Archaeological site	Unevaluated[b]	None	Not adverse	Not adverse
38LA727	Archaeological site	Eligible	None	Not adverse	Not adverse
265-1103 / Haile Gold Mine School	Building	Eligible	None	Adverse	Adverse

[a] Determination of eligibility made by the USACE with concurrence by the South Carolina State Historic Preservation Office.

[b] Additional information is needed for USACE evaluation of this archaeological site. Additional information to be obtained under process outlined in the MOA that is being prepared for this Project.

The Champion Pit Overpass would be visible from two NRHP-eligible archaeological sites, and haul roads built during active mining would be visible from two NRHP-eligible archaeological sites. The overpass and haul roads would not cause an adverse visual impact on these historic properties.

The Mill site would be visible from one NRHP-eligible archaeological site and two unevaluated archaeological sites but would not be considered an adverse visual impact on historic properties.

One NRHP-eligible archaeological site and eight unevaluated archaeological sites would be close enough to mine elements to experience dust, noise, or vibrations during construction or use during active mining; these indirect effects on the archaeological sites would not be considered adverse.

Post-Mining Period

Some indirect impacts on historic properties may occur during reclamation activities, including visual, auditory, and atmospheric alterations. The use of equipment can cause visual changes and can introduce noise, vibration, and exhaust fumes to surrounding historic properties and unevaluated resources and sites.

Revegetation of the Hayworth OSA during reclamation and retention of trees along SR 188, which would shield the viewshed to the north from the school, may cause a long-term indirect visual effect on the Haile Gold Mine School (265-1103); however, would not be an adverse effect.

Modified Project Alternative

Potential visual, auditory, or atmosphere changes to historic properties during mining, reclamation, and monitoring activities under the Modified Project Alternative are listed in Table 4.13-2 and discussed below.

Active Mining Period

Under the Modified Project Alternative, activities that would occur during mining with the potential to affect historic properties indirectly would be largely the same as described for the proposed Project, with some minor differences. A reduction in the height of the Ramona OSA would reduce the potential indirect (visual) impact on historic properties. Use of the Holly and Hock TSF borrow areas as OSAs would have the potential to indirectly (visually) affect historic properties through the addition of sediment to the area, whereby views of and from the properties would be blocked. Additionally, the use of Holly and Hock TSF borrow areas as OSAs would introduce indirect visual effects on nearby historic properties, the effects of which would remain after construction of the borrow areas. None of these visual effects would be adverse for archaeological sites.

Post-Mining Period

Impacts on historic properties related to reclamation and monitoring activities under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.13.3 Impact Summary

Table 4.13-3 lists the potential impacts on cultural resources under all alternatives.

Table 4.13-3 Summary of Impacts on Cultural Resources

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Historic properties	Existing cultural resources would not be affected or significantly altered. Some properties would continue treatment under existing MOAs.	Adverse impacts to 14 NRHP eligible historic properties. Potential impacts to 4 NRHP unevaluated historic properties.	Same as the Applicant's Proposed Project.
Visual, auditory, or atmospheric changes to historic properties	No indirect impacts would occur to historic properties from mining activities.	Indirect impacts from loss of vegetation, removal of aspect of historic setting, addition of non-historic elements, noise, vibration, and infrastructure improvements. Potential visual, auditory, or atmosphere changes to 1 NRHP eligible historic properties during mining. Potential visual, auditory, or atmosphere changes to 3 NRHP unevaluated historic properties.	Same as the Applicant's Proposed Project.

4.13.4 Mitigation for Impacts on Cultural Resources

A Memorandum of Agreement (MOA) is being developed as part of the Section 106 consultation process. The MOA will be included as an appendix to the Final EIS. The MOA will outline the process for specific mitigation measures that would be developed and discussed in the Cultural Resources Management Plan (CRMP), also to be included in the Final EIS. A brief description of the CRMP is provided in Appendix M.

4.13.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included avoidance and minimization measures in the design and plans for operating and managing the proposed Project. Haile has committed to many of these measures as a part of the proposed MMP (Haile 2013) (Appendix G); these measures are summarized below:

- Perform Phase I surveys on all areas to be disturbed.
- Implement Cultural Resource Monitoring and Mitigation Plan.
- Implement Memorandum of Agreement.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of Applicant-proposed avoidance and minimization measures related to cultural resources is provided in Chapter 6.

4.13.4.2 Additional Potential Mitigation Measures

No additional mitigation measures are proposed for cultural resources.

4.13.5 Literature Cited

Haile. See Haile Gold Mine, Inc.

Haile Gold Mine, Inc. 2013. Haile Gold Mine Monitoring and Management Plan. September.

Memorandum of Agreement for Recovery of Significant Information from Archaeological Sites 38LA334 and 38LA355 between Haile Gold Mine, Inc. and the South Carolina State Historic Preservation Office, June 6, 2010, Haile-SCSHPO.

Memorandum of Agreement for Recovery of Significant Information from Archaeological Sites38LA291, 38LA361, and 38LA383 between Haile Gold Mine, Inc. and the South Carolina State Historic Preservation Office, Nov. 16, 2010, Haile-SCSHPO.

4.14 Visual Resources and Aesthetics

The Project area is located in a densely vegetated area, and the topography consists of gently sloping hills. Construction activities and mining operations at the proposed Haile Gold Mine may affect the visual character of the Project area in the short term during mining activities and in the long term following reclamation. Activities that would affect the visual character include pit excavation, overburden storage, and other changes to topography. In addition, Project structures, lighting, and vehicular traffic can affect visual resources. The magnitude of impacts on visual resources are influenced by the scale and location of the modifications (e.g., the amount of acreage cleared of vegetation); potential screening or visual obstructions (e.g., vegetation and topography); and proximity of key viewing areas, sensitive features, and public access features (e.g., parks, historic sites, and transportation corridors) to the Project area.

4.14.1 Methods

The study area for visual resources is defined as the area within the Project boundary, adjacent parcels, and viewing areas from where Project-related features and construction, operation, and maintenance activities have the potential to be visible. The potential visual effects of the proposed Project were assessed considering possible changes in the visual character of the existing landscape, the scenic integrity, and potential viewer sensitivity and viewing distance, defined as follows:

- **Landscape Character** – Consideration of the changes to the existing landscape character such as topography and landforms, vegetation, landscape features (water and exposed rock) and cultural modification or development.
- **Scenic Integrity** – Consideration of the extent to which the existing landscape was previously altered; and therefore, changes to the landscape would not be as readily apparent compared to a landscape that was unaltered and more natural in appearance.
- **Viewer Sensitivity and Viewing Distance –** Consideration of the potential number of viewers, the duration of the views, the context of the viewing setting, viewing distances, and viewer expectations. For example, viewers would be more sensitive to landscape changes to foreground and middleground views.

Critical viewing areas were identified and assessed in terms of potential visual impacts associated with the proposed Project at key viewing locations. To characterize existing key viewing locations, a desktop analysis and field assessment were conducted to identify potential KOPs within the visual resources study area. KOPs are critical viewing locations within the visual resources study area from which the Project could be seen by the public, such as roadways, public facilities, public recreation areas, or residences. KOPs were identified based on the potential of the Project to influence the visual character as seen from that viewpoint location or the location providing representative views of the landscape, such as along the roadway corridor.

A computer desktop analysis was conducted to identify potential KOPs within a digital elevation model based on existing and proposed topographic conditions within the study area. A field assessment was then conducted to determine whether the proposed Project area was visible from each of these potential KOP locations, considering potential viewer locations, existing vegetative conditions, area features, and topography. Photographs and visual characteristics of the KOPs in relation to the proposed Project were collected.

As a result of this assessment, 15 KOPs were identified with the potential to be affected by the proposed Project. The 15 KOPs were reviewed to identify those KOPS that provided representative views or critical viewing locations to further assess potential visual impacts. Accordingly, six KOPs were selected that

provide representative views of the most visible aspects of the Project as seen from viewing locations that typify visually sensitive locations. Appendix N provides additional detail regarding the KOP selection, descriptions and photographs of the 15 KOPs, and visual simulations and assessment of the six representative KOPs.

In addition to evaluating the potential visibility of the proposed Project from the initial 15 KOPs, a line-of-sight analysis was completed to determine whether Project features would be visible from the Forty Acre Rock Heritage Preserve and Wildlife Management Area (Preserve) during the span of the Project life. Line-of-sight profiles were created from the Preserve to two prominent Project features (the TSF and the Ramona OSA) for the existing topography, Mine Years 4, 7, and 14. Because the line-of-sight models do not account for existing vegetation or structures within the viewpoint, the results indicate greater visibility than would actually occur. Typically, the line of sight would be hampered by visual obstructions in the immediate foreground such as local topography, trees, and other vegetation. Actual visibility would be less than predicted by the line-of-sight model, and in some cases considerably less.

4.14.2 Impacts

4.14.2.1. Visual Effects from Proposed Mining Operations

No Action Alternative

Under the No Action Alternative, the Project area would remain in its current state, and the existing visual resources would not be affected or significantly altered; vegetation would continue to grow on previously reclaimed areas (Figure 4.14-1). Consequently, the visual resources under the No Action Alternative would be similar to those described for existing conditions.

Applicant's Proposed Project

Summary of Visual Resources and Aesthetics Impacts

Under the proposed Project, Haile would maintain a minimum 100-foot setback from property lines to the edge of any major Project facilities. Some stormwater or stream diversions would be located within 100 feet of the permit boundary line; however, Haile would maintain at least a 50-foot undisturbed buffer from the permit boundary line. Haile has installed fencing along the property line of the Project and proposes to construct a small perimeter road. The road would be used for security patrols for safety purposes to ensure that public access is restricted to the mine area. The land disturbance resulting from fence construction would be reseeded immediately to re-establish the buffer area.

The Project area is located in a densely vegetated area, and the topography consists of gently sloping hills. Consequently, the proposed Project and associated vegetative clearing and earth-moving measures would not be visible from many locations outside of the Project boundary, reducing the potential impacts on visual quality. The vegetation buffer along the highway is thinner near the parking area at the Kershaw Industrial Park along US 601, and the proposed Johnny's PAG would be visible in the distance, approximately 0.4 mile away. The Project would not be visible from downtown Kershaw, located south of the Project boundary, nor would it be visible from the Kershaw Correctional Institution parking lot, located in a valley approximately 0.8 mile south of the TSF. Furthermore, the Project would not be visible from the Haile Gold Mine Church parking lot, located along Haile Gold Mine Road at the easternmost corner of the Project boundary. Foreground vegetation that is approximately 40 feet tall would block potential views at this location, and the closest Project boundary would be 0.8 mile to the west.

Figure 4.14-1 Existing Reclaimed Overburden Sites

Haile has petitioned for the closure of 17 abandoned but not formally closed Lancaster County roads and the closure of three open Lancaster County roads: Snowy Owl, Gene Lewellen, and Bumblebee (also known as Gary Road). In addition, Haile is expecting to make application for the closure of SR 188 (Haile Gold Mine Road) through the mine area (see also Section 4.13, "Transportation"). With the proposed closure of several roadways in the Project boundary, such as Haile Gold Mine, Snowy Owl, Gene Lewellen, and Bumblebee Roads, the public viewing opportunities and associated potential visual impacts observed from these roadways would no longer occur. The majority of roadside views of the proposed Project would be along the segment of US 601 that passes directly through the Project boundary. View durations for motorists traveling along these roads would be short term and intermittent, reducing the potential visual impact. When approaching the Haile Gold Mine via US 601 from both the south and the north, the Project would not be visible until within 0.5 mile of the Project boundary due to tall, thick vegetation lining the road. Similarly, the proposed Project would not be visible while driving along other public roadways within the Project vicinity, such as Shield Road, Pleasant Plains Road, Payne Road, or SR 901, except where periodic breaks in the vegetation would provide fleeting views of the Project area.

The seven proposed OSAs used to store approximately 241 million tons of material generated from pit development would be developed in phases, depending on the associated pit excavations. All OSAs would be developed with 3:1 (horizontal: vertical) side slopes. The configuration of maximum side slope steepness and stockpile height minimizes the required footprint of the stockpile but may result in greater potential for visual impacts because the proposed OSAs would be designed to be as tall as possible while maintaining structural integrity. The OSAs would range from approximately 200 to 300 feet taller than the surrounding base elevation and would be visible from various locations along US 601 as the road passes through the Project area. However, as noted above, the OSAs would not be visible from US 601 beyond 0.5 mile from the Project boundary.

The OSAs would create short-term visual impacts during construction and mining operations, as the areas would be developed in phases. These areas would contrast with the surrounding natural vegetation; they

would be viewed by the public as large bare earth piles exceeding the height of surrounding vegetation. Because these OSAs would remain and not be flattened during the reclamation process, their additional height would create a long-term visual impact. However, as part of the reclamation process, all OSAs would be revegetated with growth media and seed mixes in accordance with an SCDHEC-approved revegetation plan. The long-term visual impact would result from changes in topography to the existing landscape. View durations of the OSAs for motorists traveling along the roads adjacent to the Project area would be temporary and intermittent, reducing the overall visual impact. See discussions under KOP 1 and KOP 15 in Appendix N for visual simulations and further assessment of the Ramona OSA, and see the discussion of Johnny's PAG under KOP 4 in Appendix N.

Haile proposes four growth media storage areas, all located within the Project boundary. The footprint of the 601 growth media storage area would be approximately 15 acres, and it would be visible from US 601. The TSF growth media storage area would be significantly larger, with a footprint of approximately 56 acres, and would be visible along a segment of US 601 and a segment of SR 265. The Hayworth and Snake growth media storage areas would be located adjacent to Haile Gold Mine Road, with footprints of approximately 19 and 13 acres, respectively. These two areas would be located in an area with no public viewing opportunities because of the proposed closure of Haile Gold Mine Road. Therefore, they would not be visible to motorists from the roadway and would not result in adverse visual impacts.

The TSF and 601 growth media storage areas would be visible from the adjacent public roadway corridors and would create short-term visual impacts during construction and mining operations. These areas would be used to temporarily store topsoil or other ground material removed prior to pit development until the material was used in construction of the TSF or trucked back to mined-out pits for backfill. At both the 601 and TSF growth media storage areas, the duration of views from the roadways by motorists would be short and would be behind the proposed 100-foot setback and vegetative buffer. Therefore, the visibility of these areas would be somewhat minimized because of the short duration of the potential views and the screening afforded by the vegetative buffer. The growth media storage areas would not create long-term visual impacts because the material piles would be used in reclamation and stabilizing the OSAs, Johnny's PAG, and the TSF.

The TSF site would be located along a segment of US 601 across from the TSF growth media storage area. The footprint of the TSF would range from 353 acres during production to 498 acres at Mine Year 8 and post-reclamation. The TSF embankment would be constructed to higher elevations during Mine Years 2, 4, and 7 by increasing the height and width of the embankment. The embankment would be developed with 3:1 (horizontal: vertical) exterior side slopes and would range from approximately 75 feet in height by Mine Year 2 to approximately 130 feet in height at Mine Year 8. At the location of the proposed TSF site, Haile would maintain existing pine trees and would install additional plantings, if necessary, to provide an approximately 100-foot-wide buffer along US 601 and along Duckwood Road to assist in visually screening the TSF. In addition, after construction is completed, Haile proposes to grade, revegetate, and stabilize the soil of the outside embankment of the TSF concurrently as the TSF increases in height. This concurrent reclamation would serve to enhance aesthetics and meet regulatory requirements.

The TSF area would be highly visible due to its large size and embankment height. The TSF would allow for more potential public viewers because it would be located adjacent to US 601 and Duckwood Road; however, because the viewers would be motorists traveling the roadways, the views would be relatively short. The grading and vegetation on the embankment would help to reduce the visual contrast of the TSF in relation to the surrounding landscape, and the vegetative and screening buffer would help to minimize adverse visual impacts associated with this facility.

Public views of of the proposed mining pits and the Holly and Hock TSF borrow areas would be limited, as these features would be located away from public roadways, or in an area where the topography or vegetative growth associated with the 100-foot setback would provide limited views to motorists along US 601. Because the topography consists of gently sloping hills and the vegetation is dense, few locations outside of the Project boundary in the vicinity of the Project would have sufficiently high elevations to provide aerial views of pit excavations. Five of the pit areas would be backfilled and revegetated during reclamation, and would return to their current state. Therefore, the long-term visual impacts at these pits would be limited. The three pits that would be transformed into pit lakes (that would take from approximately 20 to 25 years to fill) would create long-term visual changes from the current environment. However, they would not be visible to the public because all the proposed pit lakes would be located within the Project boundary. The pit lakes would likely enhance the visual aesthetics of the Project area by replacing barren excavated pits with lakes, thus reducing the visual contrast present during active mining.

Visual Impact Assessment of the KOPs

The potential visual impacts of the Applicant's Proposed Project were assessed considering possible changes in the visual character of the existing landscape, the scenic integrity, potential viewer sensitivity, and viewing distance. Figure 4.14-2 shows the locations of the KOPs, and Table 4.14-1 provides a summary of the potential visual impacts of the Applicant's Proposed Project on the existing visual character of the 15 KOP views. See Appendix N for further discussion of the KOP identification methods and for visual simulations and assessment of the representative KOPs.

A nearby prominent landscape feature and popular destination and recreation area, the Forty Acre Rock Heritage Preserve and Wildlife Management Area, is located approximately 3.5 miles northwest of the Project area. The Preserve has a hiking trail and is known for views of the surrounding landscape. The results of the line-of-sight analysis indicate that the proposed Project would not be visible from the highest elevations at the Preserve, largely because the line of sight would be obscured by landscape topography (not including trees and vegetation). The Project's tallest feature (the Ramona OSA) would not be visible because of distance (over 6.4 miles away from the Preserve) and intervening topography inhibiting the view. In Mine Year 14, when the TSF would reach its maximum height, it is possible that the TSF (3.5 miles southeast of the Preserve) would be visible during winter, when visual screening by vegetation is more limited. These distant Project views would be toward an area with existing cultural modifications, such as previously mined areas and the Kershaw Correctional Institution. Therefore, views from the Preserve would remain similar to existing conditions and would not be adversely affected by the proposed Project.

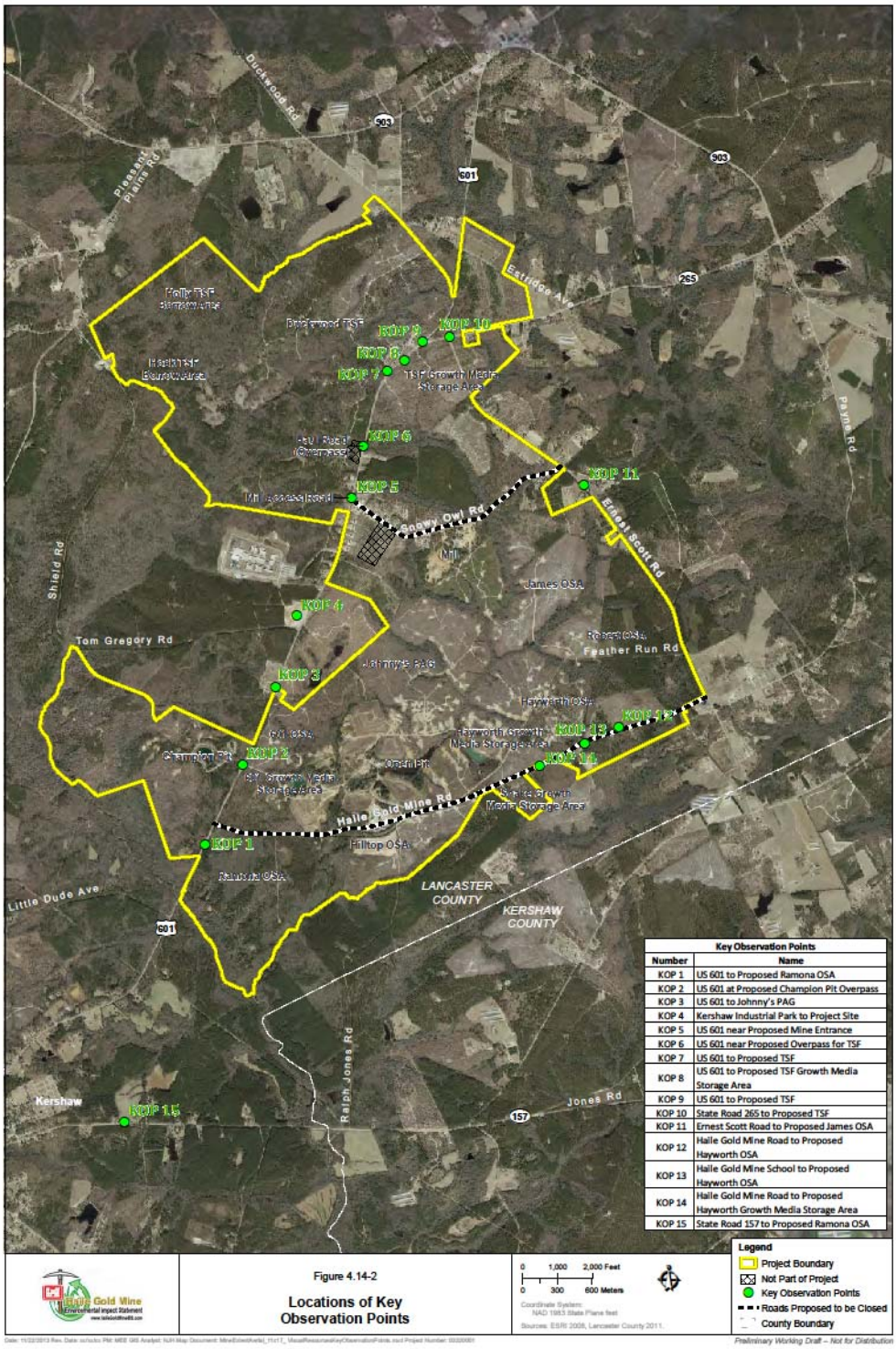

Figure 4.14-2 Locations of Key Observation Points

Table 4.14-1 Summary of Potential Visual Impacts of the Applicant's Proposed Project at Key Observation Points

Number	KOP Name	Potential Modifications and Impacts			
		Landscape Character	Scenic Integrity	Viewer Sensitivity	Summary
KOP 1	US 601 to proposed Ramona OSA	Moderate – modification of topography to include large OSA.	Minor – existing landscape has been modified from previous mining operations and roadway construction.	Moderate – limited because primary views would be from a roadway while traveling in a vehicle; OSA in proximity to the roadway.	Primary change would be to topography, with addition of an OSA in proximity to roadway. The vegetative berm would provide partial blockage of the OSA. Short-term impacts would be caused by vegetative clearing and lack of vegetation on the OSA. In the long term, the OSA would be revegetated and similar to color and textures of surrounding landscape; however topography changes would remain clearly visible.
KOP 2	US 601 at proposed Champion Pit overpass	Major – would alter the visual character of the existing roadway.	Minor – existing landscape has been modified from previous mining operations and roadway construction.	Moderate – motorists would travel directly under overpass; view of overpass would be dominant but of short duration.	The new overpass would result in a major visual change to the existing highway corridor, but views would be of relatively short duration and from an existing roadway corridor. Minor short-term effects during Project construction and operations; long-term visual impact if the overpass would remain post-mining and operations.
KOP 3	US 601 to Johnny's PAG	Minor – would provide only a distant view of Johnny's PAG.	Minor – existing landscape has been modified from previous mining operations.	Minor – limited because primary views would be from a roadway while traveling in a vehicle.	Roadside view along US 601 from a residence parcel, with distant views of the proposed Johnny's PAG. Would result in minor short-term and long-term impacts because of the viewing duration and distance.
KOP 4	Kershaw Industrial Park to Project area	Minor – would provide only a distant view of Johnny's PAG.	Minor – existing landscape has been modified from previous industrial and roadway construction.	Minor – distant views and view would be from Industrial Park (Haile facility) parking area.	View of the Project area from the parking area at the Kershaw Industrial Park along US 601 would provide a distant view of the proposed Johnny's PAG. Would result in short-term and long-term minor impacts because views by the public would be limited and distant.

Table 4.14-1 Summary of Potential Visual Impacts at the Key Observation Points (Continued)

Number	KOP Name	Potential Modifications and Impacts			
		Landscape Character	Scenic Integrity	Viewer Sensitivity	Summary
KOP 5	US 601 near proposed mine entrance	Minor – entrance would be similar in character to other entrance facilities along US 601.	Minor – existing landscape has been modified from previous mining operations.	Minor – limited because primary views would be from a roadway while traveling in a vehicle.	The proposed new Haile Gold Mine entrance would result in short-term minor impacts of cleared vegetation to construct the entrance and a long-term visual change in the existing area character, but the entrance would be comparable to entrances for other facilities along US 601.
KOP 6	US 601 near proposed overpass for TSF	Major – would alter the visual character of the existing roadway.	Minor – existing landscape has been modified from previous roadway construction.	Moderate – motorists would travel directly under the overpass; view of overpass would be dominant but of short duration.	The new overpass would result in major visual change to the existing highway corridor, but views would be of relatively short duration and from an existing roadway corridor. Minor short-term visual effects during Project construction and operations; long-term visual impact if the overpass would remain post-mining and operations.
KOP 7	US 601 to proposed TSF	Major – would alter the visual character due to large embankment along roadway.	Minor – portions of the existing vegetation have previously been cleared.	Major – primary views would be from roadway while traveling in a vehicle but for a relatively longer duration along a longer segment of the roadway.	TSF facility would result in approximately 500-acre footprint with an embankment along the perimeter of the facility that would range up to approximately 130 feet in height and would be visible along portions of US 601.
KOP 8	US 601 to proposed TSF growth media storage area	Moderate – would alter the visual character due to topography changes of storage area.	Minor – portions of the existing vegetation have previously been cleared.	Minor – limited because primary views would be from a roadway while traveling in a vehicle.	TSF growth media storage area would be visible from the roadway, but a thick vegetative buffer along the highway near the proposed TSF growth media storage area would help block views.
KOP 9	US 601 to proposed TSF	Moderate – would alter the visual character due to large embankment along roadway.	Minor – portions of the existing vegetation have previously been cleared.	Moderate – primary views would be from roadway while traveling in a vehicle but for a relatively longer duration along a longer segment of roadway.	Roadside view along US 601. A break in the vegetation buffer would allow clear views of the proposed TSF approximately 200 feet away.

Table 4.14-1 Summary of Potential Visual Impacts at the Key Observation Points (Continued)

Number	KOP Name	Potential Modifications and Impacts			
		Landscape Character	Scenic Integrity	Viewer Sensitivity	Summary
KOP 10	State Road 265 to proposed TSF	Minor – would alter only distant features of the landscape.	Minor – portions of the existing vegetation have previously been cleared.	Minor- limited because primary views would be from roadway while traveling in a vehicle.	View from Old Jefferson Highway (State Road 265) approaching the intersection of US 601. The proposed TSF would be visible in the distance, approximately 900 feet away.
KOP 11	Ernest Scott Road to proposed James OSA	Minor – would alter only distant features of the landscape.	Minor – existing landscape area has been modified from previous mining operations.	Minor – limited because primary views would be from roadway while traveling in a vehicle and.would alter only distant views.	Roadside view from Ernest Scott Road. The proposed James OSA would be visible in the distance, approximately 0.4 mile away.
KOP 12	Haile Gold Mine Road to proposed Hayworth OSA	Minor – would alter only distant features of the landscape.	Minor – existing landscape area has been modified from previous mining operations.	None –roadway would be closed to public traffic and therefore no public views.	Roadside view from Haile Gold Mine Road that is proposed to be closed. Vegetation has been previously cleared. The proposed Hayworth OSA would be visible in the distance, approximately 0.3 mile away.
KOP 13	Haile Gold Mine School to proposed Hayworth OSA	Minor – would alter only distant features of the landscape.	Minor – existing landscape area has been modified from previous mining operations.	None – roadway would be closed to public traffic and therefore no public views.	Roadside view from the vicinity of the historic Haile Gold Mine School on Haile Gold Mine Road that is proposed to be closed. The Hayworth OSA would be visible in the distance, approximately 0.3 mile away.
KOP 14	Haile Gold Mine Road to proposed Hayworth growth media storage area	Minor – would alter only distant features of the landscape.	Minor – existing landscape area has been modified from previous mining operations.	None – roadway would be closed to public traffic and therefore no public views.	Roadside view from Haile Gold Mine Road that is proposed to be closed. The proposed Hayworth growth media storage area would be visible in the distance behind tall vegetation, approximately 0.1 mile away.

Table 4.14-1 Summary of Potential Visual Impacts at the Key Observation Points (Continued)

Number	KOP Name	Potential Modifications and Impacts			
		Landscape Character	Scenic Integrity	Viewer Sensitivity	Summary
KOP 15	State Road 157 to proposed Ramona OSA	Minor – would alter only distant views.	Minor – existing landscape has been modified from previous mining operations.	Minor – limited because primary views would be from roadway while traveling in a vehicle.	Would alter only distant views and would not alter the visual character. A clearing in the vegetation would allow a very distant view of the proposed Ramona OSA, approximately 1.4 miles away.

Notes:

KOP = key observation point

OSA = Overburden storage area

TSF = Tailings storage facility

US 601 = US Highway 601

Minor — Minor changes to the landscape character would occur, but due to existing landscape modifications, and/or limited viewing sensitivity (limited potential viewers and short duration of viewing period) would result in only minor or negligible visual impacts on the existing character of the KOP view.

Moderate — Changes to the landscape would be more apparent and at a location where viewing sensitivity would be greater due to higher number of potential viewers and/or potential longer viewing duration, resulting in minor to moderate impacts on the existing visual character of the KOP view.

Major — Changes to the landscape character would be obvious and substantial, where the viewing sensitivity would be high and the changes to the existing landscape character would be great, resulting in major impacts on the existing visual character of the KOP view.

Short term — Duration of the impact would be shorter-term and finite because it would occur during Project operations would not be as evident following reclamation.

Long term — Duration of the impact would would remain post-Project operations and following implementation of proposed reclamation activities.

Modified Project Alternative

The Modified Project Alternative includes the use of the Holly and Hock TSF borrow areas as additional OSAs, offsetting the amount of overburden stored at the proposed Ramona OSA. Overall, the visual impacts under the Modified Project Alternative would be similar to those described for the Applicant's Proposed Project, except for the Holly and Hock TSF borrow area OSAs and the Ramona OSA. The maximum amount of overburden would be placed in the Holly and Hock TSF borrow area OSAs, with a 3:1 (horizontal: vertical) slope design and the maximum capacity of 24 million tons of overburden storage. The proposed Holly and Hock TSF borrow area OSAs would be built on average 100 feet higher than the existing terrain.

Use of the Holly and Hock TSF borrow areas for overburden storage would allow for a reduction in the size and footprint of the Ramona OSA by approximately 38 percent, which would reduce visual impacts compared to the Applicant's Proposed Project. The height of the Ramona OSA under the Modified Project Alternative would be on average 100 feet lower than under the Applicant's Proposed Project. Under the Modified Project Alternative, the heights of the Ramona OSA would range from 250 feet taller than the surrounding average base elevation on the north to 205 feet taller on the south. In addition, the Ramona OSA would be located approximately 1,100 feet away from US 601 compared to approximately 200 feet away from US 601 under the Applicant's Proposed Project. The increased distance from US 601 would lessen the visual impact of the Ramona OSA as viewed by the public, and the majority of the overburden piles would be shielded by roadside vegetation.

The decrease in size of the Ramona OSA would result in an increase in size of the Holly and Hock TSF borrow areas. Figure 4.14-3 shows a sample cross section of the Holly and Hock TSF borrow areas under existing conditions and the Modified Project Alternative. The proposed Holly and Hock TSF borrow area OSAs would be built higher than existing conditions after being filled to current grade. During active mining under the Modified Project Alternative, the total elevation of the overburden pile would reach its maximum height of approximately 100 feet. As such, the Holly and Hock TSF borrow area OSAs would be moderately visible from Pleasant Plains Road. The existing road corridor along Pleasant Plains Road is heavily forested, providing a vegetation buffer between the roadway and the Holly and Hock TSF borrow areas. In addition, the proposed Holly and Hock TSF borrow area OSAs would be bare until reclaimed, which would temporarily contrast with the surrounding green vegetation. This color contrast would add to the visual impact; however, the areas would be bare only during the active mining periods and would be revegetated during reclamation. In Mine Year 15 post-mining, the Holly and Hock TSF borrow area OSAs would remain 100 feet taller than the existing terrain, but the area would be revegetated and would blend in with the surrounding landscape. Therefore, the only long-term visual impact would be changes to topography.

The Modified Project Alternative would increase the number of OSAs to nine by using the Holly and Hock TSF borrow areas as OSAs. Except for the differences described above for the Ramona OSA and the Holly and Hock TSF borrow area OSAs, visual impacts associated with the OSAs would be the same as described for the Applicant's Proposed Project. All OSAs would create short-term visual impacts during construction and mining operations as the areas would be developed in phases. These areas would contrast with the surrounding natural vegetation, as they would be viewed by the public as large bare earth piles exceeding the height of surrounding vegetation. The OSAs would range from approximately 100 to 300 feet taller than the surrounding base elevation and would be visible from various locations along US 601 as the road passes through the Project area. However, as noted above, the OSAs would not be visible from US 601 beyond 0.5 mile from the Project boundary.

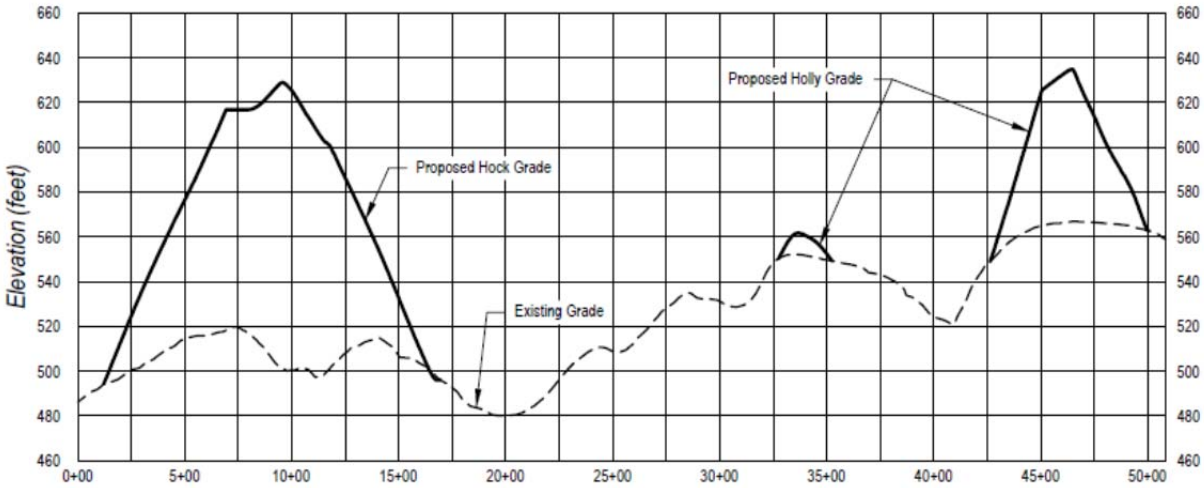

Figure 4.14-3 Cross Section for Holly and Hock TSF Borrow Area OSAs under Modified Project Alternative (x 4 vertical exaggeration)

The OSAs also would create long-term visual impacts because these storage areas would remain as permanent landscape features; therefore, their additional height would create a lasting visual impact. As part of the reclamation process, all of these areas would be revegetated with growth media and approved seed mixes, in accordance with a reclamation plan approved by the SCDHEC. Durations of views by motorists traveling along these roads would be temporary and intermittent, reducing the overall visual impact. As described for the Applicant's Proposed Project, the growth media storage areas would not create long-term visual impacts because the material piles would be used in reclamation and stabilizing storage sites (the OSAs, Johnny's PAG, and the TSF).

4.14.2.2. Visual Effects from Proposed Project Facilities and Construction Activities

No Action Alternative

Under the No Action Alternative, the Project area would remain in its current state, and the visual resources would not be affected or significantly altered; vegetation would continue to grow on previously distrurbed areas. Consequently, visual resources under the No Action Alternative would remain similar to those described for existing conditions.

Applicant's Proposed Project

Under the Applicant's Proposed Project, Haile would maintain a minimum 100-foot setback from property lines to the edge of any major Project facilities. In locations where stormwater or stream diversions would be located within 100 feet of the permit boundary line, Haile would maintain at least a 50-foot undisturbed buffer from the permit boundary line. This undisturbed buffer would help to block public views of the mining operations, including visual impacts from vehicles and equipment, new mining facilities and structures, and dust emissions, as described below.

Haile has installed a perimeter fence at the property line and proposed to construct a small perimeter road for security. The wire fence is approximately 5 feet high. Fencing would be most visible to the public

along US 601 and near the property line at the single public entrance to the mine (Haile 2012). The public entrance would be located at the intersection of Snowy Owl Road and US 601. This intersection would be improved to include a left-turn lane for southbound travelers along US 601 and a right-turn lane for northbound US 601 travelers. The entrance would be comparable to entrances for other facilities along US 601. The public would see an increase in Project-related vehicles in and out of the proposed new entrance.

The perimeter fencing installed along the boundary of the Project area visually separates the mine from adjacent lands. In addition, the landscaping specifications in the Lancaster County UDO require a minimum 30-foot wide Type 4 buffer yard to block visual contact and create spatial separation between the mine and adjacent lands (Lancaster County 2013). The Type 4 buffer yard would be composed of a very dense vegetative screen of trees and shrubs that would help to reduce the visual impact and the amount of light from the mine.

The presence of vehicles and equipment for Project construction and mining operations may cause a short-term visual impact. The equipment used includes hydraulic front shovels, wheel loaders, and 100-ton-capacity off-road mining vehicles. The majority of mining-related activities would be performed by off-road vehicles that would remain within the Project boundary and not use the public road network. This would minimize public views of construction activities. Haul roads would be constructed to connect pit areas, OSAs, and the primary crusher area. Employees coming to and from the mine could increase the amount of vehicle traffic on public roads, but these visual impacts would be short term and intermittent.

An overpass would be constructed over US 601 so that trucks could haul ore and overburden across the highway. This overpass would also serve as a utility corridor for piping drawndown groundwater to the process plant and contact water to the water treatment plant. The overpass and the trucks and equipment traveling across it would be directly visible to motorists on US 601, resulting in a short-term visual impact. Long-term visual impacts would occur in the event that the overpass structure would remain post-mining operations and reclamation; however, the visual impacts would be reduced as the number and frequency of trucks and equipment crossing the structure would be reduced. Following mine closure, if the overpass was removed, the KOP would return to similar visual character as the existing conditions. See Appendix N for further discussion of KOP 6; Appendix N provides visual simulations and further assessment of the US 601 overpass area.

Haile proposes a similar style of overpass structure for the Champion Pit crossing location, which is proposed to be constructed in Mine Year 9. The Champion Pit overpass would cause short-term and long-term visual impacts comparable to those described for the US 601 overpass. The Champion Pit overpass and the trucks and equipment traveling across to the Champion Pit would be directly visible to motorists on US 601.

Construction and operations could result in visible dust emissions. Haile would work with the SCDHEC to finalize the Fugitive Dust Control Plan, which would include control measures to minimize the generation of fugitive particulate matter emissions. The control plan would address site-specific operational and control measures that would be considered BMPs. The plan may include using a water spray system to suppress dust in ore feed streams and at transfer points, and using cartridge-type dust collectors to capture and control dust from reclaim feeders. See Section 4.16, “Air Quality” for further details on fugitive dust emissions.

Haile proposes to construct a number of new structures within the Project boundary. These new facilities include structures associated with ore processing, as well as an administration building, a truck shop and warehouse facility, a Mill maintenance building with showers and change rooms, a guard house and security gate, a fuel station, diesel fuel storage, a process chemical storage building, a mine operations

line-out building, and an electrical substation. The majority of these structures would be located in the new Mill area—immediately south of Snowy Owl Road, which Haile proposes to close. The nearest public road, US 601, is approximately 0.5 mile west of the new facilities. This distance and the vegetative buffer would obscure the proposed facilities from motorists on the highway. The proposed new facilities and structures would be comparable in visual character to structures that existed during past mining operations. Because of the location of these facilities and the limited viewing opportunities, along with the existing historical mining structures in the vicinity, no adverse visual impacts associated with these proposed structures are anticipated.

All construction and operations activities that would result in potential dust sources would be located within the Project boundary and would be screened by the vegetative buffer. The visible impacts potentially resulting from dust creation would be reduced through the aforementioned measures (Tetra Tech 2011). As such, short-term visual impacts of dust are likely to be minor. There would be no long-term visual impacts from dust because construction and operations activities that would be potential dust sources would no longer occur after active mining and reclamation activities have ceased.

Modified Project Alternative

The Project-related visual impacts under the Modified Project Alternative would be similar to those described for the Applicant's Proposed Project, except for increased vehicles and equipment for use of the Holly and Hock TSF borrow areas as OSAs. Approximately 24 million tons of overburden storage could be trucked to these locations for deposit. The equipment used would include hydraulic front shovels, wheel loaders, and 100-ton capacity off-road mining vehicles. The majority of mining-related activities would be performed by off-road vehicles that would remain within the Project boundary and would not use the public road network. This would minimize public views and visual impacts of the industrial activity.

4.14.2.3. Visual Effects from Proposed Project Lighting

No Action Alternative

Under the No Action Alternative, no Project facilities that would use lighting would be constructed; therefore, there would be no lighting impacts on visual resources. The visual resources under the No Action Alternative would be similar to existing conditions.

Applicant's Proposed Project

Haile Gold Mine has proposed general design criteria based on protocols followed in locations with a "Dark Sky Ordinance," which requires fully shielded (full cutoff) design on light fixtures to eliminate light discharge and glare into the open night sky (IDA 2013). Some specific design parameters that Haile proposes are listed below (Haile 2012):

- Parking lots would have high-pressure sodium full cutoff fixtures on 18-foot 6-inch standards, 16-foot poles, and 2-foot 6-inch concrete bases for an average of 0.5 foot candle.
- At the exterior of the large buildings, such as the Mill building, the warehouse, the Mill maintenance building, and the truck shop, 150-watt HPS wallpacks (wall-mounted lights) with full cutoff optics would be used. The full cutoff shields would restrict lumens1 at or below 90 degrees.

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[1] A measure of the total amount of visible light emitted by a source.

- At the exterior of smaller buildings, such as electrical buildings near the crusher, Mill building, reagent storage, and the refinery, 42-watt compact fluorescent light fixtures with full cutoff optics would be used.
- Conveyor walkways would have 100-watt HPS light fixtures with full cutoff, with an average of 10 foot candles.
- On the main access road, 100-watt fixtures on 35-foot poles would be spaced approximately 150 feet apart, for an average of 1 foot candle. Haile proposes no plans to light in-plant haul roads or roads between the mine and Mill.

The general design suggests that outside lighting would be HPS lamps and fixtures with full cutoff shields. Many of the fixtures would have no lumens above 85 degrees. Figure 4.4-4 illustrates the difference between full cutoff-shielded light and non-cutoff shielded light.

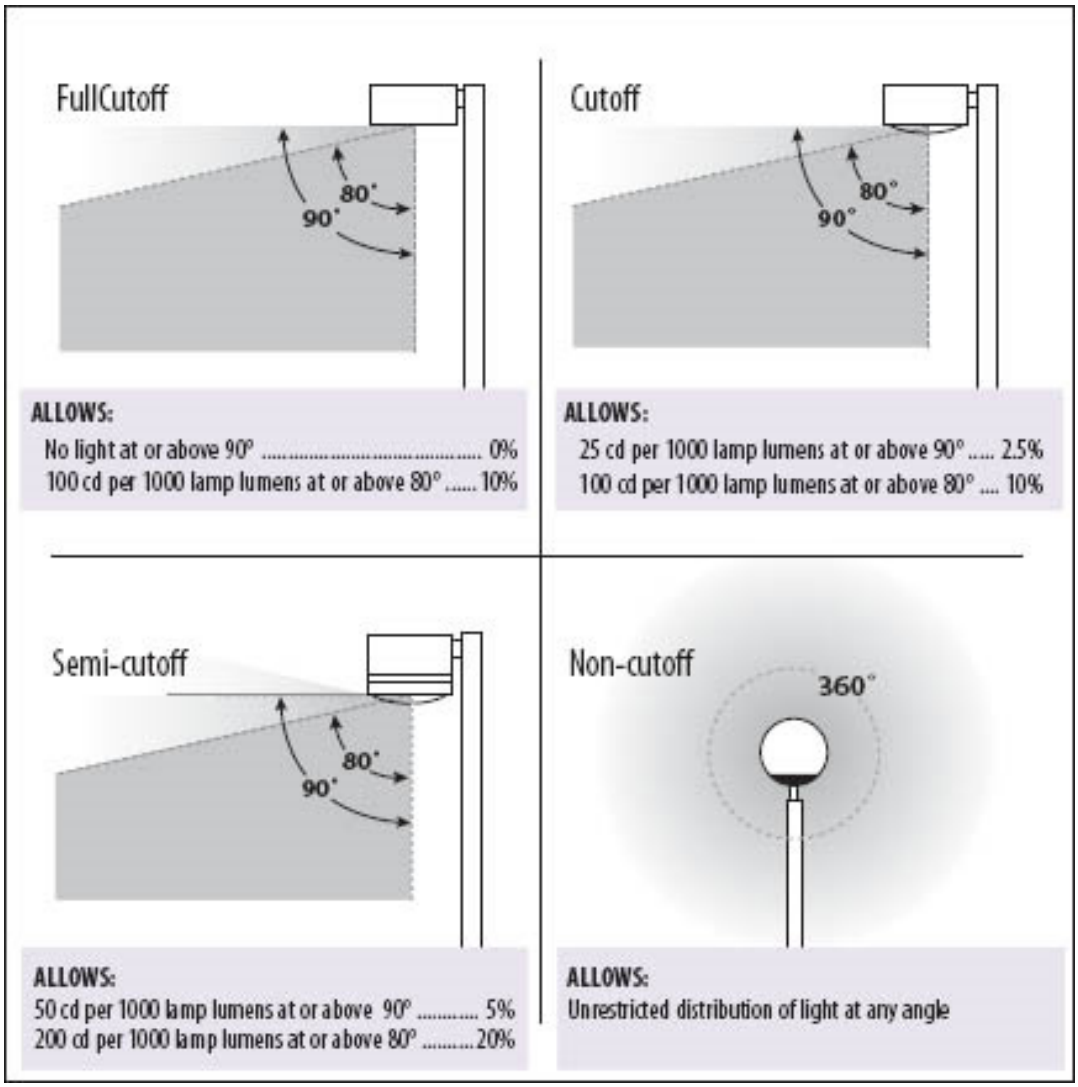

Figure 4.14-4 Example Lighting Elements and Light Distribution

Source: Lithonia Lighting 2013.

Expansion of the Haile Gold Mine and construction of associated facilities and lighting would increase levels of ambient light on and near the area (Genesis 2011). Haile would be required to follow exterior lighting requirements for mining per regulations under the UDO Conditional and Special Exceptional Uses Provisions as required by Lancaster County (Part I, Appendix B, Chapter 4, Section 4.1.16) (Lancaster County 2012). Direct effects during mining activity from increased light would be minimized by following specified requirements and by reducing light discharge and glare with the use of full cutoff-shielded lighting elements that do not allow light above the horizontal when possible (Genesis 2011). The full cutoff-shielded light would reduce negative impacts on the night-time environment, limiting light at or below 90 degrees (Lithonia Lighting 2013). No long-term ambient light impacts are anticipated because Project facilities would be demolished upon mine closure, and the majority of lighting features would be removed during reclamation.

Modified Project Alternative

The lighting requirements for facilities would not change under the Modified Project Alternative. Consequently, visual impacts from lighting under the Modified Project Alternative would be the same as described for the Applicant's Proposed Project.

4.14.3 Impact Summary

Table 4.14-2 presents a summary of potential impacts on visual resources and aesthetics under each alternative for the key issues.

4.14.4 Mitigation for Impacts on Visual Resources and Aesthetics

4.14.1.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included a number of avoidance and minimization measures in the design and plans for operating and managing the proposed Haile Gold Mine. Many of these measures have been committed to by Haile as a part of its proposed MMP (Haile 2013) (Appendix G) and are summarized as follows:

- Use vegetative set-back areas from public roadways.
- Use visual screening techniques.
- Use earth tones for major mine facilities.
- Implement dust control measures.
- Direct operating lights downward to shield light sources.
- Reduce outside lighting to the minimum amount allowed for safe operations and maintenance.
- Minimize facility heights, where feasible.
- Perform reclamation to approximate original topography where practicable.
- During final grading of facilities, occasional large boulders that are uncovered may be left to provide topographic diversity and to break the linear appearance of the final slope.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of Applicant-proposed avoidance and minimization measures for visual resources and aesthetics is provided in Chapter 6.

Table 4.14-2 Summary of Impacts on Visual Resources and Aesthetics

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Mining operations	The Project area would remain in its current state, and the visual resources would not be affected or significantly altered. Visual resources would be similar to those described for existing conditions.	Short-term visual impacts within 0.4 mile of area of active mining, with contrasting overburden piles exceeding existing terrain. Limited long-term visual impacts with reclaimed vegetation cover on OSAs and the TSF.	Same as the Applicant's Proposed Project, except decreased visual impacts from Ramona OSA because of its lower height. Additional topography changes to Holly and Hock TSF borrow areas, with increase in height.
Project facilities and construction activities	The Project area would remain in its current state, and visual resources would not be affected or significantly altered. Visual resources would be similar to those described for existing conditions.	Short-term visual impacts with construction of perimeter fencing, presence of construction vehicles and equipment, potential dust emissions, and new mining structures. Limited long-term visual impacts, including at the Forty Acre Rock Heritage Preserve, because facilities at the Project area would be re-graded, demolished, salvaged, or removed as appropriate.	Same as the Applicant's Proposed Project, except for an increase in vehicles and equipment for use of the Holly and Hock TSF borrow areas as OSAs.
Project lighting	No Project facilities that would use lighting would be constructed so there would be no additional lighting impacts on visual resources.	Short-term visual impacts as the Project would increase levels of ambient light on and near the Project area. No long-term ambient light impacts because Project lighting would be removed during reclamation activities.	Same as the Applicant's Proposed Project.

4.14.1.1 Additional Requirements to Reduce Visual Resources and Aesthetics Impacts

Additional requirements from policies that contain specific requirements and restriction standards that would reduce the potential visual impacts of the Applicant's Proposed Project are provided in Table 4.14-3, along with the expected outcome of such measures.

Table 4.14-3 Summary of Visual Resources and Aesthetics Management Requirements

Entity	Requirements	Proposed Project	Expected Outcome
South Carolina Department of Health and Environmental Control (SCDHEC)	Measures may be required to screen views of operations from public highways, parks, or residential areas, where the SCDHEC finds such screening to be feasible and desirable.	Haile would maintain a minimum 100-foot setback from property lines to the edge of any major Project facilities and maintain at least a 50-foot undisturbed buffer from the permit boundary line if stormwater or stream diversions would be located within 100 feet of the permit boundary line.	The proposed buffer would block public views of mining operations, including visual impacts from vehicles and equipment, new mining facilities, and structures.
Lancaster County Uniform Development Ordinance (UDO)	Requires a minimum 30-foot-wide Type 4 buffer yard to block visual contact and create spatial separation between the mine and adjacent lands (Lancaster County 2013). Exterior lighting requirements for mining operations under the UDO Conditional and Special Exceptional Uses Provisions (Part I, Appendix B, Chapter 4, Section 4.1.16 Lancaster County 2012).	The Type 4 buffer yard would be composed of a vegetative screen of trees and shrubs that would help to reduce the visual impact and the amount of light from the mine.	The proposed buffer would block public views of mining operations, including visual impacts from vehicles and equipment, new mining facilities, and structures.
South Carolina Mining Regulations	A minimum of 75-percent vegetative groundcover with no substantial bare spots is required post-reclamation.	Slopes would be revegetated with approved seed mixes and growth media, in accordance with an SCDHEC-approved reclamation plan.	The vegetative cover would be similar to the colors and textures of the surrounding landscape and would help to reduce visual impacts. However, topography changes would remain clearly visible.

4.14.2.4. Additional Potential Mitigation Measures

The proposed mining and reclamation activities under both action alternatives would result in short-term visual impacts from bare earth and construction activities. Limited long-term visual impacts would occur with reclaimed vegetation cover on OSAs and the TSF. No mitigation measures beyond those proposed by Haile are proposed for visual and aesthetic resources.

4.14.5 Literature Cited

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Lancaster County. 2012. Code of Ordinances, Unified Development Ordinance. Part I, Appendix B, Chapter 4, Conditional and Special Exceptional Uses, Section 4.1.16, *Manufacturing/Processing Uses*, 9. Exterior illumination. Website: http://library.municode.com/HTML/11128/level3/PTITHCO_APXBUNDEOR_CH4COSPEXUS.html#PTITHCO_APXBUNDEOR_CH4COSPEXUS_S4.1.29MIEXOP. Accessed on May 1, 2013.

Lancaster County. 2013. Lancaster County, South Carolina, Code of Ordinances. Appendix B Unified Development Ordinance. Website: http://library.municode.com/index.aspx?clientId=11128. Accessed on September 11, 2013.

Lithonia Lighting. 2013. Cutoff Lighting Classifications. Available online at: http://www.lithonia.com/micro_webs/nighttimefriendly/cutoff.asp. Accessed on September 13, 2013.

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4.15 Recreation Resources

The recreation resources impact analysis focuses on potential effects on publicly accessible recreation facilities and lands in the Project area and within approximately 15 miles of the Project boundary.

4.15.1 Methods

Project-related impacts on recreation resources generally were assessed qualitatively by considering the impacts caused by construction activities, mining operations, maintenance activities, and post-reclamation land use. The likely direct impacts on recreational use and access were considered, in addition to the potential indirect changes in the existing recreational setting and experience.

To specifically address the potential visibility of the proposed Project from the Forty Acre Rock Heritage Preserve, a line-of-sight analysis was completed to determine whether Project features would be visible during the span of the Project life, as discussed in Section 4.14, "Visual Resources and Aesthetics."

Compatibility with applicable recreation management plans also was assessed.

4.15.2 Impacts

4.15.2.1 Impacts on Public Recreation Resources

No Action Alternative

Under the No Action Alternative, the land privately owned by the Applicant would likely continue to be managed in a manner similar to existing conditions, and public recreation access would not be permitted, with the possible exception of limited lease hunting by a previous landowner. Ongoing reclamation monitoring would continue, but current exploratory bore-hole drilling to further define the extent of mineral reserves would cease. Because the Lancaster County zoning ordinance designates all Haile-owned property within the Project boundary as "Mining District," the only land use permitted on the site under the existing zoning would be mining (Lancaster County 2013). As such, there would be no change and no impacts on public recreation access and use under the No Action Alternative.

Applicant's Proposed Project

Active Mining Period

The Project area currently is closed to public access, with no public recreation opportunities. Perimeter fencing has been installed along the boundary of the Project area to separate the mine from adjacent land uses and to limit public access. Because the Project is located entirely on private property with no existing public recreation access to the property, the perimeter fence would not restrict access to any recreation resources that otherwise would be publically accessible. Moreover, no public recreation areas are located on parcels adjacent to the Project. There is the potential for dispersed recreation, including hiking, hunting, fishing, or boating, on the lands surrounding the Project area, including on the Little Lynches River. However, most of the lands near the Project that would be suitable for such activities are privately owned, and there are no known public recreation resources on these lands, with the exception of limited lease hunting. Therefore, adverse impacts on public recreation activities would be minor resulting from the proposed Project, compared to existing conditions.

The Project would not be visible from most locations outside the Project boundary, especially those farther than 0.5 mile from the Project site. A nearby prominent landscape feature and popular destination

and recreation area, the Forty Acre Rock Heritage Preserve and Wildlife Management Area, is located approximately 3.5 miles northwest of the proposed Project. The Preserve has a hiking trail and is known for views of the surrounding landscape. As discussed in Section 4.14, views from the Preserve would remain similar to those under existing conditions and would not be adversely affected by the proposed Project.

Other recreation areas are located 5 miles or more from the Project site, and the Project would not be visible at those distances. Overall, the Project would not adversely affect the recreation experience and scenic views from public recreation areas within the region. Furthermore, because of the distance of these public recreation areas from the Project area, air quality and mining noise likely would cause minimal to no effects on the visitor experience at public recreation areas in the region. The local transportation network, which is rural with low traffic volumes, does not provide direct access to public recreational areas. Therefore, the Project-related increases in traffic and road closures would not affect public recreation areas in the region.

Post-Mining Period

Haile identified potential post-reclamation land use suitability for the Project area (see Appendix A) and stated that portions of the Project area have the potential to provide limited recreational use opportunities. The actual post-reclamation land use, and the extent and type of recreational opportunities that would be available in the Project area, are unknown at this time. Because no public recreational access to the Project area exists, any future public recreational access and opportunities would result in enhanced recreational opportunities compared to existing conditions.

Some portions of the Project area likely would not be suitable or would have limited suitability for future recreational opportunities, such as Johnny's PAG and the TSF. However, the Ledbetter, Champion, and Small Pits would be reclaimed as pit lakes, with the potential for future recreational opportunities. Haile would construct a safety berm around portions of the pit lakes, and fences would be added during reclamation, along with signage warning of the hazards of the pit highwalls and pit lakes. These actions would provide safety measures in the event that any public recreational use and access would occur in these areas.

The post-reclamation land use and access would be specified in the Reclamation Plan, which would require review and approval by the SCDHEC, Division of Mining. In addition, any potential land use other than mining, including recreational opportunities and access, would require changing the current M, Mining zoning designation by Lancaster County to appropriate land use zoning and regulations for the proposed future land use.

Modified Project Alternative

Potential effects on public recreation resources under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.15.2.2 Consistency with Applicable Recreation Management Plans

The proposed Project and alternatives would be consistent with existing applicable recreation management plans, as summarized in Section 3.15.1, except for a potential conflict with the *South Carolina Thread Trail Master Plan* (Carolina Thread Trail 2011). As stated in *The Carolina Thread Trail Master Plan*, the proposed Kershaw Greenway segment of the South Carolina Thread Trail would pass through a portion of the Project west of US 601 and along US 601 just north of the mining area (see Figure 3.15-1).

No Action Alternative

As noted, *The South Carolina Thread Trail Master Plan* for Lancaster County proposes that the Kershaw Greenway segment of the Thread Trail pass through a portion of the Project area; the proposed segment would pass west of US 601 and along US 601 just north of the active mining area. The geographic extent of the potential conflict with the Thread Trail Plan is confined to the approximately 2.3-mile segment of the trail that would pass through the Project boundary. The area is dominated by scrub and forestland that was previously disturbed by mining features and that has been reclaimed and revegetated.

The Thread Trail Master Plan states that the trail "moves through active mining area, which may interfere with greenway trail development." The *South Carolina Thread Trail Master Plan* was approved in 2011. As of the writing of this EIS, the segment route has been only proposed, not finalized, and the timing and exact location of the trail segment development are unknown. Even if no active mining occurred in the planned segment, the Kershaw Greenway segment of the Thread Trail could not pass through the Project area without a conflict with the Mining District zoning designation.

Applicant's Proposed Project

As noted under the No Action Alternative, use of the Project area for recreation, including the proposed Kershaw Greenway segment of the Thread Trail, would conflict with the existing Mining District zoning designation in the Project area. Moreover, if the zoning conflict was resolved and the trail was not to be developed until reclamation, it is possible that it could pass through the Project area without conflicting with the Project.

Post-reclamation access to the site is not known at this time, and the location of the Thread Trail segment has only been proposed and has not been finalized. As such, it is not possible to fully predict the interaction between the proposed Thread Trail and the Haile Gold Mine Project. Changes in land use and zoning have occurred since development of the proposed Thread Trail Plan. Final implementation of the Thread Trail would need to consider current land use and existing zoning requirements in the placement of the trail way route. Therefore, no impacts on recreation resources would be associated with the proposed Project, and no conflict is anticipated regarding development of the South Carolina Thread Trail.

Modified Project Alternative

Potential conflicts with *The South Carolina Thread Trail Master Plan* under the Modified Project Alternative would be the same as described for the Applicant's Proposed Project.

4.15.3 Impact Summary

Table 4.15-1 presents a summary of potential impacts on recreation resources under each alternative.

Table 4.15-1 Summary of Impacts on Recreation Resources

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Public recreation resources	The Project area would remain closed to most public access, with no public recreation opportunities; therefore, no change from existing conditions.	During active mining, the Project area would be closed to all public access resulting in minor impacts to recreation resources. Post reclamation, potential benefits of future recreational opportunities in the Project area would depend on post-reclamation land use and public recreational access plans.	Same as the Applicant's Proposed Project.
Recreation management plans	*The South Carolina Thread Trail Master Plan* includes only proposed trail segments, and the location of the final trail likely would be routed to conform with compatible land use and zoning.	Same as the No Action Alternative.	Same as the No Action Alternative and the Applicant's Proposed Project.

4.15.4 Mitigation for Impacts on Recreation Resources

4.15.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included avoidance and minimization measures in the design and plans for operating and managing the proposed Project, as summarized below (Haile 2013):

- Return disturbed areas to a stable condition that can support a productive post-mining land use, including recreation.
- Construct a safety berm around pit lakes, install fences during reclamation, and provide signage warning of the hazards of the pit highwalls and pit lakes.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of avoidance and minimization measures for recreation resources proposed by the Applicant is provided in Chapter 6.

4.15.4.2 Additional Potential Mitigation Measures

The proposed mining and reclamation activities under both action alternatives would not result in anticipated adverse impacts on recreation resources within the Project area, and no anticipated conflict with area recreation management plans, including development of the South Carolina Thread Trail. Therefore, no mitigation is proposed for recreation resources.

4.15.5 Literature Cited

Carolina Thread Trail. 2011. Carolina Thread Trail Master Plan for Lancaster County Communities. Website: http://www.carolinathreadtrail.org/wp-content/uploads/2010/12/Lancaster-County-CTT-FINAL1.pdf. Accessed on October 30, 2012.

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Lancaster County. 2013. Ordinance No. 2013-1207. Lancaster County, South Carolina, Code of Ordinances, adopted April 8, 2013. Website: http://www.mylancastersc.org/vertical/sites/%7BA02FC01E-6C41-44F4-BE02-9B73FC0206C5%7D/uploads/2013-1207.pdf. Accessed on October 29, 2013.

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4.16 Air Quality

Haile Gold Mine would be actively mined for a total of approximately 15 years, using multiple open pits throughout the active mine life. Impacts on air quality may occur during the pre-construction, construction, mining ore processing, and tailings disposal activities for nearly the total mine life. In approximately Mine Year 6, post-mining, reclamation, pit filling, and closure monitoring activities would begin. Mining activities affecting air quality would include pit backfilling following mining with stripped overburden from successive pits, drilling and blasting in hard rock encountered during mining, excavating overburden material and hauling it to overburden stockpiles or to backfill other pits, and transporting ore for processing. Mining activities affecting air quality would include both physical and chemical separation techniques to isolate and concentrate the gold product.

4.16.1 Methods

As discussed in Section 3.16, the study area for potential air quality impacts is the Metropolitan Charlotte Interstate AQCR (Figure 3.16-1). As defined in the CAA (42 USC 7407), an *AQCR* is a contiguous area considered to have relatively uniform ambient air quality. An AQCR is treated as a single unit for reducing emissions and determining compliance with the NAAQS. This area was considered for each of the potential impact issues discussed in this section. Emissions were estimated using calculations (e.g., emission factors, material balance, or source test data) as appropriate to determine expected levels for the mining and processing activities described above. Those estimates were incorporated into modeling as required. The resultant emissions were compared with applicable federal, state, and local standards for protection of human health and the environment and for potential nuisance (also discussed in Section 3.16).

Air quality impacts were determined based on potential effects on ambient air quality conditions and on nearby sensitive receptors (Figure 3.16-2). Sensitive receptors with the greatest potential to be affected by emissions from the Project are located within and along the Project boundary, as they are the closest to the activities generating emissions. In general, emissions disperse with distance, depending on topography, meteorology, vegetation, and other factors. Consequently, receptors farther from the Project boundary would experience a lower risk of air quality impacts. In general, ground-level emission sources at or near receptors represent a worst-case scenario for air quality impacts because there is less opportunity for dispersion.

While the life of the mine can be separated into two main phases, mining impacts and reclamation and monitoring impacts, air quality emissions were calculated based on a worst-case scenario for all sources. The analysis assumes that all mining activities would be conducted in compliance with all applicable air quality regulations, including emissions limitations and reporting and operational requirements, as listed in the construction permit granted in October 2013 and in Section 3.16.1.

A detailed air quality impact analysis was conducted under the review of the SCDHEC as a part of the air quality permitting process (Haile 2012a). The permit application was submitted to the SCDHEC in August 2012, and the SCDHEC granted a construction permit in October 2013. To obtain SCDHEC approval, an air quality analysis or other information had to demonstrate that the Project would not interfere with maintenance of ambient air quality standards. Per SCDHEC *Air Quality Modeling Guidelines* (July 2001), modeling protocols are required only for sources undergoing a Prevention of Significant Deterioration (PSD) review and sources demonstrating compliance with Standard 3.1 (*Hospital, Medical, Infectious Waste Incinerators*). Neither of these circumstances applies to the proposed Project, which is considered a minor source (based on the Project's potential to emit). However, the

SCDHEC required modeling of minor source, non-fugitive[1] sources, along with calculations of emissions, as part of the permitting analysis.

Air dispersion modeling was conducted for criteria pollutants, as required by the SCDHEC, using the AERMOD modeling system to predict maximum pollutant concentrations in ambient air from mining emissions, for comparison with the PSD Class II Increment standards and the NAAQS.[2] The modeling followed the guidance and protocols in the *Air Quality Modeling Guidelines* (SCDHEC 2001a), *New Source Review Workshop Manual* (USEPA 1990), 40 CFR Part 51 Appendix W *Guideline on Air Quality Models* (Revised) (USEPA 2005), *AERMOD Guidance* (SCDHEC 2009, updated 2011), and meetings and correspondence with the SCDHEC. The modeling used standard USEPA methods and regulatory default options (Haile 2012a). In accordance with the state modeling guidance, only sources (or combined processes, such as the ore crushing and transfer circuits) emitting 1 pound per hour or more needed to be modeled.

The meteorological data and the digital terrain data are obtainable from the SCDHEC website for Lancaster County. The meteorological data provided on the website is preprocessed with AERMET and ready for use in the AERMOD air quality modeling program. The SCDHEC website also provides background concentrations for modeling purposes. Emissions that were modeled include PM_{10} and $PM_{2.5}$ from primary crushing operations, coarse ore storage, transport to the Mill, wet scrubber controlling the metal-removing cells, the carbon regeneration kiln, five sump pump engines, and the natural gas-fired thermal fluid heater. As required by the SCDHEC, emissions from sump pump engines and the thermal fluid heater also were modeled for CO, NOx, and SO_2. The modeled NOx impacts were converted to NO_2 using the Ambient Ratio Method (ARM) modeling guidance from the USEPA. Modeling was not required for fugitive emissions.

GHGs typically include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). The GHG emissions are multiplied by a global warming potential (GWP) to calculate the CO_2 equivalents (CO_2-e). The GWP is the ratio of heat trapped by one unit mass of the GHG to that of one unit mass of CO_2 and estimates how much each pollutant contributes to global warming. For example, the GWP of CO_2 is 1, while CH_4 has a GWP of 25 and N_2O a GWP of 298. The greater the GWP, the more warming potential of the gas. Methane's 100-year GWP is 25, meaning that methane would result in 25 times as much warming as an equivalent mass of carbon dioxide over a 100-year period. The USEPA revised some GWPs in the GHG Reporting Rule (USEPA 2014) for sources that are required to report GHG emissions. Haile Gold Mine is not required to report GHG emissions under this rule. The previous values were 21 for CH_4 (increased) and 310 for N_2O (decreased), and those values were used to determine air permitting emissions for the Project. The USEPA has indicated that, "The final GWP amendments will moderately change (in most cases increase) the emission totals for existing reporters of gases with revised GWPs, primarily methane and fluorinated GHGs" (USEPA 2014). As discussed under "Generation of Toxic and Hazardous Air Pollutants," the GHG emissions from the Project would be extremely small and would remain so even with incorporation of the revised GWPs. Because Haile Gold Mine is not required to report GHG emissions under the GHG Reporting Rule, and because the revised GWP increased for one gas and decreased for one gas, the original GHG estimates completed for air permitting purposes were used in this analysis.

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1 *Fugitive emissions* are unintended releases of gases, such as leaks, primarily from industrial activities, that do not pass through a stack, vent, chimney, or similar opening where they could be captured by a control device.

2 The AERMOD modeling system (AERMOD) includes AERMET, the meteorological data preprocessor, and AERMAP, the terrain data preprocessor.

4.16.2 Impacts

Potential impacts on air quality associated with Haile Gold Mine include generation and release of air toxics, fine particulate emissions, dust, minerals, and GHGs. Liquids waste in tailings dams, when dried in the atmosphere, also can serve as a source of dust. Airborne emissions may occur during each stage of the mine cycle, although in particular during exploration; development; construction; and operations, including reclamation and maintenance.

The principal sources of emissions from the proposed Project include the following:

- Criteria pollutant and GHG emissions from combustion of fuel in stationary and mobile equipment, use of electric equipment, and use of specific equipment for mining operations such as smelter equipment;
- Fugitive emissions and dust from blasting and from exposed surfaces such as tailings facilities, stockpiles, waste dumps, and haul roads; and
- Toxic and hazardous air pollutants (TAPs and HAPs) from operation of the carbon-in-leach (CIL) circuit, from the naturally occurring compounds in the ore, from reagent storage tank emissions, and from fuel combustion.

Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions (CEQ 2010) recommends that federal agencies consider (1) the effects of a proposed federal action on GHG emissions; and (2) the effects of climate change on a proposed federal action. These issues are discussed in Section 4.16.2.2.

4.16.2.1 Generation of Criteria Pollutants

No Action Alternative

Under the No Action Alternative, the USACE would not issue a DA permit and the proposed mine construction, operations, and reclamation activities would not occur. The Project area would be preserved in its current state, and air quality would not be affected or significantly altered. Activity at the site would be limited to monitoring and maintenance. The existing mine would continue to be restored and would return to a vegetated state. Any future mine development at the site would require new permits and environmental approval and review. Therefore, air quality under the No Action Alternative would be similar to that described for existing conditions.

Applicant's Proposed Project

Direct Emissions

Ore processing would result in direct (non-fugitive) emissions from crushing, handling, and separation activities; from storage and handling of fuel, chemicals, and materials used in the separation process; and from operation of emergency generators, pit dewatering sump pump engines, lighting systems, and the fire protection water pump engine (Haile 2012b). Mining would result in gaseous emissions from the following sources: emergency generator, natural gas-fired carbon regeneration kiln, natural gas-fired thermal fluid heater, diesel pump engines, and trailer-mounted lighting systems. Criteria pollutants (also referred to as *priority pollutants*) emitted would include VOCs, PM, NO_X, CO, and SO_2. The primary criteria pollutant emissions from mining would be PM emissions.

Lead is naturally occurring at very low concentrations in the ore and overburden at Haile Gold Mine. Based on assay results (Haile 2012a), the average lead content is approximately 0.0012 percent by weight (12 milligrams per kilogram [mg/kg]). Lead emissions were calculated using the same data for the PM emission calculations, assuming that lead would be present in particulate matter at the same concentration as in the ore and overburden. On this basis, lead emissions were estimated at less than 5 pounds per year, or approximately 0.0005 pound per hour. The estimated lead emissions are therefore below the State of South Carolina modeling exemption threshold of 0.114 pound per hour (SCDHEC 2010).

Table 4.16-1 shows the emissions calculated for direct criteria pollutant emissions and the major source limits. The calculations for controlled emissions[3] incorporated measures to reduce emissions, such as maintaining and operating equipment per manufacturer's recommendations and operating equipment under controlled conditions (Haile 2012b). Emissions from criteria pollutants, including lead from the sources described above, are relatively low but would be long term as they would last for the 15 years of active mining. Based on the small amount of emissions, the air quality impact within the AQCR from gaseous emission sources would be minor for the worst-case scenario evaluated here. Although mitigation would not be required to reduce emissions, Haile Gold Mine has incorporated many priority pollutant emission reduction strategies into the design of the Project, such as minimizing the impact area, conducting simultaneous reclamation activities, and phasing the mine development (Haile 2012a, 2012b).

Air Dispersion Criteria Pollutant Emissions

As required, background pollutant concentrations were added to the maximum modeled concentrations for all pollutants and compared with the NAAQS, as shown in Table 4.16-2. For the PSD Class II Increment, the modeled concentration without the added background concentration was compared to the PSD Class II Increment, as shown in Table 4.16-3.

Each maximum modeled impact for PM_{10} and $PM_{2.5}$ occurred at receptor locations along the eastern fence line northeast of the Mill. The CO 1-hour second-highest impact occurs on the eastern fence line east of the Mill, while the 8-hour second-highest impact occurs along the eastern fence line northeast of the Mill. The annual maximum NO_2 and SO_2 impacts and second-high 3-hour and 24-hour SO_2 impacts are along the southern fence line, while the 1-hour highest first-high concentration 5-year average for both NO_2 and SO_2 impacts occurs on US 601 near Haile Gold Mine Road.

Modeling results indicate that concentrations of all modeled pollutants were below the PSD Class II Increment and the NAAQS. Modeling assumptions used were conservative to provide a worst-case scenario and did not include control measures beyond regulatory requirements. The modeling results listed in Tables 4.16-2 and 4.16-3 exclude concentrations that may occur inside a facility, as those areas are not considered ambient air and are not required to meet NAAQS. In considering receptors within the privately owned property (property not owned by Haile Gold Mine), the modeling results also demonstrate compliance with NAAQS in these areas. The NAAQS analysis of maximum impacts from the mining operations demonstrates that operation of all the modeled sources would not cause or contribute to a violation of any NAAQS.

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[3] *Controlled emissions* incorporate measures to reduce emissions into the calculations, such as maintaining and operating equipment per manufacturer's recommendations and operating equipment under controlled conditions; *uncontrolled emissions* refers to emissions without these control measures incorporated into the calculations.

Table 4.16-1 Direct Criteria Pollutant Emissions

Criteria Pollutant	Uncontrolled Emissions (tons per year)	Controlled Emissions (tons per year)	Major Source Operating Permit Limit (tons per year)	Major Source Construction Permit Limit (tons per year)
Particulate matter (PM)	94.639	19.2546	100	250
Particulate matter (as PM_{10})	36.139	10.45	100	250
Particulate matter (as $PM_{2.5}$)	22.539	4.9646	100	250
Nitrogen dioxide (NOx)	69.37	62.087	100	250
Carbon monoxide (CO)	14.37	12.8048	100	250
Sulfur dioxide (SO_2)	17.876	17.389	100	250
Volatile organic compounds (VOCs)	3.34	2.66	100	250
Lead (Pb)	1.12E-04	N/A	N/A	250

Notes:

N/A = not applicable

Lead emissions were calculated using the same data for PM emissions, assuming that lead is present in particulate matter at the same concentration as in the ore and overburden.

The calculations for controlled emissions incorporated measures to reduce emissions, such as maintaining and operating equipment per manufacturer's recommendations and operating equipment under controlled conditions (Haile 2012a).

Sources: Haile 2012a, 2013a; SCDHEC 2013a.

The rate of emissions from the proposed mine operations, the effects of implemented environmental commitments (see discussion further below), and the existing local environment are expected to result in minor direct impacts on air quality. The nature of the sources and the local environment would result in a limited area of impact. Any air quality impacts that occur as a result of the proposed Project are considered long term, as they would last for the life of the Project (15 years of active mining). Although mitigation would not be required to reduce emissions, Haile has incorporated many priority pollutant emission reduction strategies into the design of the proposed Project, such as minimizing the impact area, conducting simultaneous reclamation activities, and phasing the mine development (Haile 2012a, 2012b).

Table 4.16-2 Criteria Pollutant Modeling Analysis

Pollutant	Averaging Period	Year	Location UTM-X (m)	Location UTM-Y (m)	Background Concentration (µg/m3)	Maximum Modeled Impact (µg/m3)	Total Concentration (µg/m3)	NAAQS (µg/m3)
Particulate matter (as PM_{10})	24-hour	5-year average	543,233.00	3,829,534.00	46.0	19.8	66.8	150
Particulate matter (as PM_{10})	Annual [a]	2006	543,233.00	3,829,534.00	17.3	0.59	17.89	50
Particulate matter (as $PM_{2.5}$)	24-hour	5-year average	543,250.30	3,829,521.90	24.0	1.2	25.2	35
Particulate matter (as $PM_{2.5}$)	Annual	5-year average	543,250.30	3,829,521.90	11.7	0.1	11.8	15
Nitrogen dioxide (NO_2)	1-hour[a]	5-year average	540,830.06	3,826,101.83	75.2	44.38	119.58	188
Nitrogen dioxide (NO_2)	Annual	5-year average	543,156.60	3,826,296.60	19.2	2.3	21.5	100
Carbon monoxide (CO)	1-hour	5-year average	543,650.40	3,828,945.00	2,022.8	13.0	2,035.8	40,000
Carbon monoxide (CO)	8-hour	5-year average	543,395.70	3,829,421.00	1,1412.2	4.7	1,416.9	10,000
Sulfur dioxide (SO_2)	1-hour [a]	5-year average	540,830.06	3,826,101.83	115.2	20.26	135.46	196
Sulfur dioxide (SO_2)	3-hour	5-year average	543,187.60	3,826,311,20	43.0	11.7	54.7	1,300
Sulfur dioxide (SO_2)	24-hour	5-year average	543,156,60	3,826,296.60	11.7	4.7	16.4	365
Sulfur dioxide (SO_2)	Annual	5-year average	543,156,60	3,826,296.60	2.2	0.8	3.0	80

Notes:

µg/m3 = micrograms per cubic meter; N/A = not applicable; UTM = Universal Transverse Mercator in meters (m), a projected coordinate system to provide locations on the surface of the Earth.

As required, background pollutant concentrations were added to the maximum modeled concentrations for all pollutants and compared with the NAAQS. For the PSD Class II Increment, the modeled concentration without the added background concentration was compared to the PSD Class II Increment.

Short-term concentrations are the highest sixth-high 5-year average for PM_{10} (24-hour); high second-high for CO (1-hour and 8-hour) and SO_2 (3-hour and 24-hour); and highest first-high 5-year average for $PM_{2.5}$ (24-hour), NO_2 (1-hour), and SO_2 (1-hour). Annual concentrations are highest concentrations in calendar year for PM_{10} and high 5-year average for $PM_{2.5}$, NO_2, and SO_2.

The NOx modeled impacts were converted to NO_2 impacts by using the Ambient Ratio Method (ARM). It converts the NOx impacts to NO_2 impacts by multiplying by 0.8 for the 1-hour and 0.75 for the annual averaging period.

[a] Because the annual PM_{10}, 1-hour NO_2, and 1-hour SO_2 standards were not required for modeling, they were not reviewed by the SCDHEC but are included here for informational purposes.

Sources: Haile 2012b, 2012c.

Table 4.16-3 Prevention of Significant Deterioration Modeling Analysis

Pollutant	Averaging Period	Year	Location UTM-X (m)	Location UTM-Y (m)	Maximum Modeled Impact (µg/m3)	PSD Class II Increment (µg/m3)
Particulate matter (as PM_{10})	24-hour	5-year average	543,233.00	3,829,534.00	20	30
Particulate matter (as PM_{10})	Annual	2006	543,233.00	3,829,534.00	1	17
Sulfur dioxide (SO_2)	3-hour	5-year average	543,187.60	3,826,311,20	5	512
Sulfur dioxide (SO_2)	24-hour	5-year average	543,156,60	3,826,296.60	1	91
Sulfur dioxide (SO_2)	Annual	5-year average	543,156,60	3,826,296.60	2	20

Modified Project Alternative

The Modified Project Alternative involves the use of the Holly and Hock TSF borrow areas as additional OSAs, offsetting the amount of overburden stored at the proposed Ramona OSA. Most air quality impacts under this alternative would be similar to impacts associated with the proposed Project, except for increased emissions from vehicles and equipment at the Holly and Hock TSF borrow area OSAs. Approximately 24 million tons of overburden storage could be hauled to these locations for deposit. However, these emissions would be offset by a decrease in emissions at the Ramona OSA. Proposed equipment includes hydraulic front shovels, wheel loaders, and off-road mining vehicles. Most activities would be conducted using off-road vehicles within the Project boundary and not public roads, and any emissions would remain localized in the immediate vicinity of the work being performed. Criteria pollutant emissions may increase based on the emission estimates in Table 4.16-1; however, any additional emissions would not exceed standards and the long-term direct impacts on air quality within the AQCR would remain minor.

4.16.2.2 Generation of Fugitive Emissions

No Action Alternative

Under the No Action Alternative, the USACE would not issue a DA permit and the proposed mine construction, operation, and reclamation activities and associated generation of fugitive emissions would not occur. Activity at the site would be limited to monitoring and maintenance and the generation of fugitive emissions under the No Action Alternative would be similar to those described for existing conditions.

Applicant's Proposed Project

Mining activities such as dumping, crushing, stockpiling, and transfer would generate fugitive dust emissions—the primary source of emissions associated with the proposed Project—and to a lesser extent, fugitive emissions of other non-particulate emissions (Haile 2012b). The PM impacts resulting from mining operations would be determined in large part by characteristics of the emission sources, transport region, and area of impact, including the following:

- Distance from sources to public access areas;
- Source physical characteristics;
- Magnitude of emissions;
- Meteorology;
- Geography; and
- Terrain and vegetation.

The specific ore processing sources resulting in fugitive dust leading up to the SAG mill would include the following:

- Primary crusher including load-in/load-out;
- Crusher conveyor transfer to the stockpile feed conveyor;
- Stockpile feed conveyor transfer to the coarse ore stockpile; and
- Stockpile reclaim conveyor transfer to the SAG mill.

Fugitive PM emissions would result from transport of ore and overburden from the pit to the crusher and overburden storage facilities in haul trucks. Trucks or front-end loaders would place material directly into the feed hopper where it would be crushed and screened, and then placed onto the appropriate conveyors. The transfer points in this process would be equipped with water sprays and, because they would be located within the confines of the reclaim tunnel, no PM emissions would be associated with this transfer point. Emissions also would be generated from the smelting furnace, carbon regeneration kiln, and the silos associated with the lime reagent storage and overburden lime system.

As the mine is operated as open pits, the activities that result in fugitive PM emissions would include drilling, blasting, hauling, material handling, maintenance, and support activities. The PM emissions would be below ground level and from non-buoyant (remaining at ground level) sources; this would reduce the amount of non-buoyant fugitive PM emissions that could be released or transported downwind. Therefore, potential impacts from fugitive PM emissions would be reduced by the physical characteristics of the mine pit.

An SCDHEC-approved Fugitive Dust Control Plan (FDCP) has been developed (Haile 2012a) that requires implementing operational and control measures considered BMPs. The FDCP includes detailed information addressing how fugitive PM would be minimized onsite.

Table 4.16-4 shows fugitive dust emissions for the proposed Project. The SCDHEC requires controlling fugitive PM emissions to avoid creating undesirable impacts. The fugitive PM impacts are measured against the opacity of the emissions (the ability of visible emissions to block light). The approved state air quality permit would include an operational plan to minimize fugitive PM emissions.

As defined in footnote 1, *fugitive emissions* are those unintended releases of gases, such as leaks, primarily from industrial activities that do not pass through a stack, vent, chimney, or similar opening where they could be captured by a control device. Fugitive emissions for several pollutants would occur during blasting operations. Blasting techniques would include electronic programmable delays and use of modern blasting agents that maximize blasting efficiency and minimize displacement of the blasted material, generation of fly rock, and vibration. A typical or average blast may encompass an area of approximately 35,000 square feet and use approximately 25 tons of a water-based gel emulsion blasting agent. The largest blast may use up to 35 tons of blasting agent. Fugitive emissions also would occur from pipes, valves, and connectors and from the reagent storage tanks from two primary components, Frother - MIBC (Aerofroth 70) and Flotation Promoter AERO 404. Table 4.16-5 shows non-particulate fugitive emissions from blasting activity; tank losses; and piping, valve, and connector losses.

Table 4.16-4 Fugitive Dust Emissions under the Applicant's Proposed Project

Mining Activity	Long-Term Controlled PM_{10} (tons per year) [a]	Long-Term Controlled $PM_{2.5}$ (tons per year)	Short-Term Controlled PM_{10} (pounds per hour) [b]	Short-Term Controlled $PM_{2.5}$ (pounds per hour)
Haul trucks	127.88	12.79	29.20	2.92
Blasting	8.34	0.48	5.96	0.34
Total fugitive dust	**136.22**	**13.27**	**35.15**	**3.26**

Notes:

Controlled emissions were calculated assuming that PM emissions from ore handling in the milling process would be controlled by enclosed or partially enclosed transfer points, water sprays, and pollution control devices.

[a] Long-term emissions are reported in tons per year.

[b] Short-term emissions are reported in pounds per hour.

Source: Haile 2012a.

Table 4.16-5 Non-Particulate Fugitive Emissions under the Applicant's Proposed Project

Mining Activity	NOx (tons per year)	CO (tons per year)	SO_2 (tons per year)	VOCs
Blasting	1.75	20.1	8.75	N/A
Loss from reagent storage tanks – flotation promoter AERO 404	N/A	N/A	N/A	18 pounds per year
Frother - MIBC (Aerofroth 70)	N/A	N/A	N/A	0.1 pound per year
Loss from valves, piping, and connectors - flotation promoter AERO 404	N/A	N/A	N/A	0.6 ton per year
Frother - MIBC (Aerofroth 70)	N/A	N/A	N/A	2.7 tons per year

Notes:

N/A = not applicable

Emissions from blasting would be controlled with environmental commitments, as discussed in text.

Sources: Haile 2012a, 2013a, 2013b.

Through implementation of the FDCP and additional measures committed to by Haile—including implementation of BMPs for minimizing dust, enclosing transfer points within the processes, using water sprays at all transfer points, locating processes below grade and within walls or skirts, using a wet scrubber in the carbon regeneration kiln, using baghouses and bin vent filters, limiting truck speed, maintaining roadways to minimize dust, and applying gravel wearing course[4] to roadways—generation of fugitive dust and the resulting opacity would be minimized (Haile 2012a, 2012b). Fugitive emissions also would be minimized from proper operation and maintenance of pipes, valves, and connectors. Impacts on air quality would be minor within the AQCR but are considered long term as they would last for the life of the Project (15 years of active mining).

Modified Project Alternative

The Modified Project Alternative involves the use of the Holly and Hock TSF borrow areas as additional OSAs, offsetting the amount of overburden stored at the proposed Ramona OSA. Most air quality impacts under this alternative would be similar to impacts described for the proposed Project, except for increased emissions from vehicles and equipment at the Holly and Hock TSF borrow area OSAs. Approximately 24 million tons of overburden storage could be hauled to these locations for deposit. However, these emissions would be offset by a decrease in emissions at the Ramona OSA. Proposed equipment includes hydraulic front shovels, wheel loaders, and off-road mining vehicles. Most activities would be conducted using off-road vehicles within the Project boundary and not public roads, and any emissions would remain localized in the immediate vicinity of the work being performed. Although fugitive dust and non-particulate fugitive emissions may increase based on emission estimates in Tables 4.16-4 and 4.16-5, any additional emissions would not exceed standards. Therefore, direct long-term air quality impacts within the AQCR would remain minor.

4.16.2.3 Generation of Greenhouse Gases and Effects of Climate Change

No Action Alternative

Under the No Action Alternative, the USACE would not issue a DA permit and the proposed mine construction, operation, and reclamation activities would not occur. Activity at the site would be limited to monitoring and maintenance and the associated generation of GHGs under the No Action Alternative would be similar to that described for existing conditions in Section 3.16. The effects of climate change also would be similar to that described for existing conditions (see Section 3.1, “Introduction and Physical Setting”).

Applicant’s Proposed Project

Direct Greenhouse Gases

Direct GHGs would be emitted from combustion sources used during mining activity. GHGs typically include CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs. Of the six GHGs, CO_2, CH_4, and N_2O would be emitted during mining activities and during operation of combustion sources. Table 4.16-6 shows calculated direct GHG emissions from stationary and mobile sources for the Project.

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[4] A *wearing course* for gravel roads requires a hard, even surface that must also be elastic to withstand traffic and weather. It must not produce dust and must be able to manage ground frost in winter where necessary.

Table 4.16-6 Direct Greenhouse Gas Emissions under the Applicant's Proposed Project (tons per year)

Equipment/Source	Carbon Dioxide (CO_2)	Nitrous Oxide (N_2O)	CH_4
Stationary Sources			
Natural gas-fired carbon regeneration kiln	1,156	0.02	0.02
Diesel emergency generator	591	N/A	0.32
Trailer-mounted lighting systems	93	N/A	N/A
Sump pump engines	9,546	N/A	N/A
Natural gas-fired thermal fluid heater	6,570	0.12	0.13
Fire water pump engine	53	N/A	N/A
Total stationary sources (tons per year)	**18,291**	**0.14**	**0.47**
Global warming potential	1	310	21
Total stationary sources (tons per year of CO_2-e)	18,034		
Total stationary sources (metric tonnes per year of CO_2-e)	16,360		
Mobile Sources			
Diesel-fueled mobile sources	46,373	40	117
Gasoline-fueled mobile sources	1,178	1	3
Total Mobile Sources	47,551	41	120

CO_2-e = carbon dioxide equivalents

N/A = not applicable

1 metric tonne = 1,000 kilograms or 2,204.6 pounds (1.1023 short tons)

Sources: Haile 2012b, 2013c.

Based on the calculated stationary source levels,[5] direct GHG emissions for the proposed Project would not be subject to either the Mandatory Reporting of Greenhouse Gases Rule or the PSD and Title V Greenhouse Gas Tailoring Rule (see Haile 2012a). The *Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions* (CEQ 2010) also would exempt the proposed Project from calculating and disclosing annual direct and indirect GHG emissions. Nevertheless, these emissions have been calculated and are included in Table 4.16-6 and in the following section regarding indirect GHGs. Direct impacts would be minor within the AQCR but are considered long term as they

[5] Federal actions that would produce 25,000 annual metric tonnes or less of CO_2-e GHG emissions are not required to report these emissions.

would last for the life of the Project (15 years of active mining) (Haile 2012b). The contribution of the Project to climate change through the direct release of GHGs is considered negligible.

As discussed under "Methods," the USEPA revised GWPs in its GHG Reporting Rule for sources required to report GHG emissions (as noted, Haile Gold Mine is not required to report GHG emissions). The original GHG estimates completed for air permitting purposes are used in this analysis, as shown in Table 4.16-6.

While mitigation would not be required to reduce emissions, Haile Gold Mine would incorporate measures to reduce GHG emissions, such as maintaining and operating equipment per manufacturer's recommendations and operating equipment under controlled conditions. Haile has incorporated many GHG emission reduction strategies into the design of the proposed Project, such as minimizing the impact area, conducting simultaneous reclamation activities, and phasing the mine development (Haile 2012a, 2012b).

Indirect Greenhouse Gases

Indirect GHG emissions result from equipment not owned or controlled by Haile but resulting because of the proposed Project. They include consumption of purchased electricity (the majority of indirect emissions), extraction and production of purchased materials and fuels, and other transport-related activities. Other sources might include employee travel, transmission and distribution losses of electricity from purchased power, and contracted services such as waste disposal.

Calculations of indirect emissions are not required for permitting purposes. Most sources of indirect GHG cannot be calculated based on a lack of information for the calculations. Using the World Resources Institute and World Business Council for Sustainable Development (2012) calculation tool, based on an estimated electrical load of 288 megawatt hours per day, estimated GHG emissions from electricity consumption are approximately 54,500 tpy (49,500 metric tpy) of CO_2-e, based on USEPA's 2009 Emissions & Generation Resource Integrated Database (eGrid) summaries.

The total direct and indirect GHG emissions from the Proposed Project equal approximately 65,940 metric tpy of CO_2-e. As a comparison, GHG emissions from only electrical production—not including any other stationary sources—in the Virginia, North Carolina, and South Carolina area equal 152,694,000 metric tpy of CO_2-e. Therefore, the proposed Project's GHG emissions are less than 0.04 percent of regional GHG emissions generated solely from electrical production. The contribution of GHG emissions from the Haile Gold Mine would result in minor indirect impacts that are considered long term as they would last for the life of the proposed Project (15 years of active mining). (Haile 2013c.) The contribution of the Project to climate change through the indirect release of GHGs is considered negligible.

Effects of Climate Change on the Project

Forecasts of climate change generally include rising sea levels, changes in average annual temperature, and changes in annual precipitation and the frequency of high rainfall events. As noted in Section 3.1, climate trends over the past 100 years in the Project area have shown a 0.5-°F lowering of annual average temperature and a 3-inch increase in precipitation (SCSCO 2013). Because the Haile Gold Mine is located at a distance from any coastal area and at several hundred feet above sea level, any change in sea level caused by climate change would not affect the Haile Gold Mine. The potential effects of other changes in climate are discussed below.

- **Temperature –** The recent trend has been a small reduction in average annual temperature. If an increase in average temperature were to occur, coupled with drought conditions, succession[6] in site vegetation could occur. This would not affect the Project during the active mining period because the gold mining operations are not dependent on vegetation or habitat resources. To the extent that increases or decreases in temperature trends are detected during reclamation, closure and post-closure monitoring could determine the need to select different plant species for revegetation. Selection of appropriate plant species that can be successfully cultivated is important to maintain slope stability and to minimize slope erosion wherever revegetation is undertaken.
- **Precipitation –** Increased frequency of high-precipitation events could lead to increased erosion and sedimentation in surface waters and effects on operations such as pit dewatering and TSF operational capacity. Design of all critical system components such as TSF storage capacity, stormwater management structures, and spill containment structures, have incorporated the projected maximum storm (high rainfall) events. These design safety factors are intended to accommodate high rainfall events in order to prevent effects on critical systems. Consequently, potential changes in precipitation rates related to climate change are not expected to affect Project operations, reclamation, or closure.
- **Flooding –** To the extent that construction and operations of the Project affect flood flows, increased episodic rainfall could increase flooding potential. However, Section 4.4, "Surface Water Hydrology and Water Quality" states that stream flows are expected to be reduced during active mining and would only partially recover in the post-mining period. To the extent that flows are reduced, some capacity would be available to accommodate higher flows during storm events. As described in Section 4.5, "Water Supply and Floodplains," all Project facilities are outside the 100-year regulated flood zone and above the 100-year flood elevation. Therefore the proposed Project would not be affected by climate changes related to the frequency of flood events in the flood zone.

Modified Project Alternative

Air quality impacts under the Modified Project Alternative would be similar to impacts associated with the proposed Project, except for increased GHG emissions from vehicles and equipment at the Holly and Hock TSF borrow area OSAs. However, these GHG emissions would be offset by a decrease in emissions at the Ramona OSA. Direct and indirect impacts within the AQCR related to GHGs would remain minor. The effects of climate change on Project construction, operations, and reclamation are expected to be the same as those described for the proposed Project.

4.16.2.4 Generation of Toxic and Hazardous Air Pollutants

No Action Alternative

Under the No Action Alternative, the USACE would not issue a DA permit and the proposed mine construction, operation, and reclamation activities would not occur. Activity at the site would be limited to monitoring and maintenance and the associated generation of toxic and hazardous air pollutants under the No Action Alternative would be similar to that described for existing conditions.

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[6] *Succession* means the process of a plant community gradually or rapidly evolving into a community of a different plant species.

Applicant's Proposed Project

The refining process, consisting of metals removal, smelting, and carbon regeneration, would generate emissions of non-criteria HAPs and TAPs. Negligible amounts of HAPs and TAPs also would be emitted from on-road and off-road combustion engines (Haile 2012a.) The CAA, amended in 1990, identified 189 HAPs to regulate, referring to pollutants, "known to cause or may reasonably be anticipated to cause adverse effects to human health or adverse environmental effects." HAPs may be emitted from both stationary and mobile sources. Federal HAPs are regulated by MACT standards and generally achievable control technology (GACT) standards. Currently, 187 federal HAPs are regulated, as caprolactam and methyl ethyl ketone were removed from the list. The SCDHEC has a health-based control program that regulates TAPs, some of which overlap with HAPs.

The potential sources of HAPs and TAPs emissions at the Mill are listed below and discussed in the following sections:

- HCN (a federal HAP and South Carolina TAP) emissions from the use of NaCN in the CIL circuit to leach gold and silver, and to promote removal of gold and silver in the carbon leaching operations;
- Naturally occurring mercury (Hg) and arsenic (As) contained in the ore or overburden (both As and Hg are federal HAPs and TAPs);
- Carbon disulfide (CS_2) (a federal HAP and TAP) formed through the breakdown of xanthates contained in the potassium amyl xanthate (PAX) reagent;
- Reagent storage tank emissions; and
- Emissions from fuel-burning sources.

HCN also would be released as fugitive emissions from the TSF.

Hydrogen Cyanide

The Mill

Emissions of HCN, a Category 1 (low toxicity) South Carolina TAP and federal HAP, were considered in the recent NESHAPs for Gold Mine Ore Processing and Production area sources. The USEPA 2011 rule for reporting GHG indicated that, with conservative assumptions, the estimated potential to emit for the largest of these sources (many times larger than Haile Gold Mine) ranged from 5 to 9 tpy of HCN. The USEPA reviewed the potential to emit for all the sources reviewed when preparing the revised GHG Reporting Rule. The USEPA determined that the potential to emit for the largest sources was below major source thresholds and recognized the implementation of source practices to minimize HCN emissions.

HCN could be emitted during the CIL process and the tailings impoundment, where the pH of the solution in the leaching process is necessary to both optimize gold recovery and prevent the formation of HCN. HCN also could be emitted from metal-dissolving cells and the carbon regeneration kiln.

HCN process fugitive emissions from the CIL tanks and CN recovery thickener are 0.12 ton per year, well below the level of 3 pounds per day that required modeling. Although there are no published emission factors for HCN emissions from metal-removing cells, associated tanks, and the carbon regeneration kiln, conservative estimates can be made from other mining sites. Using a conservative emission rate and annual operating hours, total emissions for the metal-removing cells, tanks, and regeneration kiln would be approximately 0.98 ton per year. This is well below the modeling threshold of 3 pounds per day. Impacts from HCN emissions within the AQCR would be minor but are considered long term as they would last for the life of the Project (15 years of active mining). Although mitigation

would not be required to reduce HCN emissions, Haile would minimize the formation of HCN by maintaining leach solution at a high pH—using solid NaCN and water to form a dilute NaCN solution and adding CaO and/or NaOH simultaneously when needed to maintain a minimum pH of 10 (Haile 2012a, 2012b).

Fugitive Hydrogen Cyanide Gas

HCN would be produced as fugitive emissions from volatilization processes occurring within the TSF. Volatilization is one of several forms of natural attenuation from wet or dry HCN sources, along with chemical and biological oxidation, hydrolysis, precipitation, complexation, and sorption. The rate of HCN volatilization can be affected by temperature, wind speed, turbulence of the water surface, mixing processes within the impoundment, and other chemicals present in the solution and their pH (Botz and Mudder 2000).

Fugitive emissions from the TSF are difficult to measure and estimate directly. Volatilization is sometimes indirectly estimated using calculations and modeling that compare HCN levels in solution over time, where all losses can be attributed to the attenuation processes listed above. Studies have found that HCN volatilization can account for up to 90 percent of HCN removal from solution in tailings impoundments, while the other attenuation processes or reactions account for the remaining 10 percent of loss. In a study on an inactive mine site, HCN concentrations in solution were measured over 1 year, with a decrease in HCN from 172 mg/l to 76 mg/l after 10 months. HCN also was calculated based on modeled losses, from 172 mg/l in January to 79 mg/l in December. Using the same model, it would be expected that HCN concentrations after 5 years would be reduced to 10 mg/L, attenuated by the processes previously listed (Botz and Mudder 2000). Other ways of estimated HCN emissions include calculations based on the amount of scrubbed HCN within the leach tank (Environment Australia 1998).

Fugitive emissions of HCN from the tailings at the Haile Gold Mine are not subject to the *Standard 8 – Toxic Air Pollutants*, under South Carolina Regulation 61-62.5. Emissions were estimated to be 4.65 tpy, using a conservative method that includes the results collected by the USEPA from three gold mines in Nevada, flux chamber data, and consideration of HCN levels from both wet and dry surfaces. Flow from the CN recovery thickener is pumped to the TSF through the CN destruction circuit, where CN is destroyed and residual free and WAD CN are oxidized to the nearly non-toxic form of cyanate, thus ensuring that CN concentration in the TSF is maintained below 50 ppm WAD CN. Estimates took into account management practices to control and monitor cyanide, such as that described above, to ensure that CN concentrations in the TSF would be below 50 ppm WAD cyanide and to manage volatilization to minimize emissions (Haile 2013d).

Some experience with fugitive HCN emissions from tailings deposition has been gained through air quality monitoring at the closed Ridgeway Gold Mine in Fairfield County, South Carolina. Volatile HCN emissions were monitored by the SCDHEC Air Quality Bureau for nearly a decade (1991–2000) at Ridgeway Gold Mine, where the CIL process was used for gold recovery (SCDHEC 2001b). HCN concentrations detected within 0.25 mile of Ridgeway's TSF (<1.0 ppm) were well below the OSHA 8-hour permissible work limit for HCN of 10 ppm (a conservative health-based standard). Gold production ceased at the Ridgeway Gold Mine in November 1999, and the TSF was capped in 2000. Pit lakes are currently filling, and the site is being maintained and monitored.

The concentration of WAD CN in tailings would be monitored during the life of the proposed mine pursuant to the SCDHEC Mine Operating permit. Higher concentrations of NaCN were used in ore processing at the Ridgeway Gold Mine. Because spent processing solution was discharged directly to the TSF (without use of a cyanide destruction circuit), greater volatilization of fugitive HCN occurred at the Ridgeway mine than is expected to occur at the proposed Haile Gold Mine.

Haile Gold Mine would perform air monitoring of HCN in accordance with the SCDHEC Air Construction permit granted to the facility, which requires the following, "Within 60 days of achieving normal operations, [Haile] shall test the tailings to confirm the concentration of HCN. The results of this test shall be submitted to the Bureau of Air Quality, Engineering Services Division." Should the tested concentration exceed the concentration estimated in the air permit application, Haile Gold Mine would be required to reevaluate the potential of tailings to volatilize HCN and would work with the SCDHEC to develop appropriate monitoring at that time. The SCDHEC may modify the air quality permit as needed.

Mercury

The mercury concentration in the Haile Gold Mine ore is low compared with ore from other parts of the United States and worldwide, averaging approximately 78 µg/kg. Mercury emissions associated with the refinery process, including the metal-removing cells, smelting furnace, and carbon regeneration kiln, have been estimated using emission factors in the *Draft Mercury Mass Balance and Emission Factor Estimates for Gold Ore Processing Facilities* (USEPA 2001), based on "typical ore" with a total mercury concentration of 20 mg/kg and adjusted using actual mercury concentration for site-specific emission factors. Estimated mercury emissions from the Mill are 0.05 pound of mercury per ton of concentrate, below the MACT standards established in NESHAPs, Subpart EEEEEEE, and below the South Carolina Air Toxics *de minimis* level and modeling threshold. As the sources are subject to the above-referenced MACTs, they are exempt from South Carolina *Standard 8 – Toxic Air Pollutants*. The mercury emissions shown in Table 4.16-7 include emissions for natural gas-fired equipment (carbon regeneration kiln and thermal fluid heater); however, these emissions are not subject to the MACT standard. Impacts from mercury emissions would be minor within the AQCR but are considered long term as they would last for the life of the Project (15 years of active mining). Although mitigation would not be required to reduce mercury emissions, Haile would use a mercury control reagent at the required concentrations to remove mercury from the process solutions by precipitating it as an insoluble organic sulfide.

Arsenic

Arsenic emissions are calculated as a small percentage of calculated PM emissions, assuming that arsenic would occur in particulate matter at a similar concentration to the ore overburden. Arsenic emissions were estimated at approximately 0.00066 ton per year/0.0036 pound per day. As *Standard No. 8 – Toxic Air Pollutants* requires calculation of total uncontrolled emissions, arsenic also was calculated from fuel-burning equipment. The total emissions shown in Table 4.16-7 are below the South Carolina *de minimis* level/modeling exemption threshold of 0.012 pound per day. Impacts from arsenic emissions would be minor within the AQCR but are considered long term as they would last for the life of the Project (15 years of active mining).

Carbon Disulfide

CS_2 results from the breakdown of compounds known as xanthates that are added at the flotation stage of ore processing. The breakdown is affected by pH and temperature, among other factors. Potassium amyl xanthate would be used at the mine. Emission factors from the Commonwealth of Australia were used to estimate CS_2 emissions from xanthate use. The CS_2 emissions were estimated at 0.17 pound per day or 0.03 ton per year, based on an expected throughput of 9,120 tons per day of ore and a PAX usage rate of 0.05 pound per ton. The CS_2 emissions shown in Table 4.16-7 are below the South Carolina *de minimis* level/modeling exemption of 1.8 pounds per day. Impacts from carbon disulfide emissions would be minor within the AQCR but are considered long term as they would last for the life of the Project (15 years of active mining).

Reagents

Emissions from the reagent storage tanks were considered negligible because of the low vapor pressures for the compounds contained. Reagents identified as containing HAPs include lead nitrate, sodium cyanide, and hydrochloric acid; reagents identified as containing TAPs include sodium cyanide, hydrochloric acid, sodium hydroxide; and sulfuric acid. Uncontrolled emissions were estimated at 5.2 pounds per year, while controlled emissions were estimated at 0.052 pound per year. Emissions from the sulfuric acid and sodium hydroxide tanks were estimated at 0.36 and 0.17 pound per year, respectively. These emissions are shown in Table 4.16-7. They are below the South Carolina *de minimis* levels of 0.12 pound per day for sulfuric acid and 0.6 pound per day for sodium hydroxide. Therefore, impacts from reagent emissions would be minor within the AQCR but are considered long term as they would last for the life of the Project (15 years of active mining). Although mitigation would not be required to reduce hydrochloric acid, Haile Gold Mine would use a caustic scrubber with a 99-percent control efficiency in the HCl storage tank to neutralize and eliminate HCl emissions from the tank.

Table 4.16-7 Hazardous and Toxic Air Pollutant Emissions

Pollutant	Plant-Wide Emissions (pounds per day)	South Carolina *de Minimis* Level (pounds per day)	Maximum Off-Site 24-Hour Concentration (µg/m3)	South Carolina MAAC (µg/m3)
Mercury (Hg)	0.0001	0.003	NR	0.25
Hydrochloric acid (HCl)	0.0001	2.100	NR	175
Hydrogen cyanide (HCN)	5.3836	3.000	13.5	250
Carbon disulfide (CS_2)	0.1707	1.800	NR	1,150
Arsenic (As)	0.0088	0.012	NR	NR
Sulfuric acid (H_2SO_4)	0.0010	0.120	NR	10
Sodium hydroxide (NaOH)	0.0005	0.600	NR	50
Total HAPs[a]	1.6 tons per year	--	--	--

Notes:

MAAC = maximum allowable ambient concentration

NR = not required

As, HCN, Hg, and CS2 are federal hazardous air pollutants (HAPs) as well as South Carolina toxic air pollutants (TAPs). Because they are federal HAPs, they are subject to maximum achievable control technology standards and are exempt from the South Carolina Department of Health and Environmental Control regulations for TAPs.

[a] HAPs may include HAPs other than those listed in the table; major source limits are 25 tons per year for all HAPs and 10 tons per year for any single HAP.

Sources: Haile 2012b, 2013d.

Combustion TAPs and HAPs

HAP and TAP emissions from the lighting system generators and the sump pump engines are shown in Table 4.16-7. All HAP and TAP emissions from the generators and engines are below 1,000 pounds per month and therefore are exempt from permitting requirements. The total HAP and TAP emissions would be negligible and below the major source thresholds of 10 tpy (for any single HAP) and 25 tpy (for total HAPs). Impacts from HAPs and TAPs would be minor within the AQCR but are considered long term as they would last for the life of the Project (15 years of active mining).

Modified Project Alternative

The Modified Project Alternative involves the use of the Holly and Hock TSF borrow areas as additional OSAs, offsetting the amount of overburden stored at the proposed Ramona OSA. Most air quality impacts under this alternative would be similar to impacts associated with the proposed Project, except for increased emissions from vehicles and equipment at the Holly and Hock TSF borrow area OSAs. Approximately 24 million tons of overburden storage could be hauled to these locations for deposit. However, these emissions would be offset by a decrease in emissions at the Ramona OSA. Proposed equipment includes hydraulic front shovels, wheel loaders, and off-road mining vehicles. Most activities would be conducted using off-road vehicles within the Project boundary and not on public roads, and any emissions would remain localized in the immediate vicinity of the work being performed. Negligible amounts of HAP and TAP emissions would result from the equipment. Any additional emissions would not exceed standards; therefore, long-term impacts on air quality within the AQCR related to HAP and TAP emissions would remain minor under this alternative.

4.16.3 Impact Summary

Table 4.16-8 presents a summary of potential air quality impacts for each alternative.

Table 4.16-8 Summary of Impacts on Air Quality

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Criteria pollutants	Air quality would not be affected or significantly altered and would be similar to that described for existing conditions.	Criteria pollutants emitted would include VOCs, PM, NOx, CO, and SO_2.The primary criteria pollutant emissions from mining would be PM emissions. Calculated criteria pollutants would be below major source thresholds. Modeled criteria pollutants would be below National Ambient Air Quality Standards and the Prevention of Significant Deterioration (PSD) Class II increment. minor direct impacts on air quality.	Impacts would be similar to the Applicant's Proposed Project, except for an increase in emissions from vehicles and equipment at the Holly and Hock TSF borrow area OSAs and decreased emissions from the Ramona OSA.

Table 4.16-8 Summary of Impacts on Air Quality (Continued)

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Fugitive PM emissions	The generation of fugitive PM emissions would occur from monitoring and maintenance activities similar to existing conditions.	Fugitive PM emissions (dust) would be generated from drilling, blasting, hauling, material handling, maintenance, and support activities. Fugitive emissions for several pollutants also would occur during blasting operations but would be reduced by the physical characteristics of the mine pit. Emissions would be minimized with avoidance and minimization measures.	Impacts would be similar to the Applicant's Proposed Project, except for an increase in fugitive PM emissions from vehicles and equipment at the Holly and Hock TSF borrow area OSAs and decreased emissions from the Ramona OSA.
Greenhouse gases	The generation of GHGs would occur from monitoring and maintenance activities similar to existing conditions.	Direct GHGs would be emitted from combustion sources used during mine operations. Indirect GHGs would be emitted from electricity used at the mine, waste management, and delivery vehicles. Direct GHGs would be below Mandatory Reporting of Greenhouse Gases Rule or the PSD and Title V Greenhouse Gas Tailoring Rule thresholds. The total direct and indirect GHG emissions from the Proposed Project equal approximately 65,940 metric tons per year of CO2-e.	Impacts would be similar to the Applicant's Proposed Project, except for an increase in GHG emissions from vehicles and equipment at the Holly and Hock TSF borrow area OSAs and decreased GHG emissions from vehicles and equipment at the Ramona OSA.
Toxic and hazardous air pollutants	The generation of toxic and hazardous air pollutants would occur from monitoring and maintenance activities similar to existing conditions.	Hazardous and toxic air pollutants (HAPs and TAPs), would be generated from the refining process, from lighting system generators, and from the sump pump engines. HCN would be emitted at the Mill and TSF and is estimated to be 4.65 tons per year. Monitoring for HCN would occur in collaboration with the SCDHEC. Calculated HAPs and TAPs would be below major source thresholds.	Impacts would be similar to the Applicant's Proposed Project, except for an increase in toxic and hazardous air pollutants from vehicles and equipment at the Holly and Hock TSF borrow area OSAs and decreased toxic and hazardous air pollutants from the Ramona OSA.

CO = carbon monoxide; CO_2-e = carbon dioxide equivalent; GHG = greenhouse gas; HAP = hazardous air pollutant; HCN = hydrogen cyanide; NAAQS = National Ambient Air Quality Standards; NOx = nitrogen oxide; OSA = overburden storage area; PM = particulate matter; PSD = Prevention of Significant Deterioration; SCDHEC = South Carolina Department of Health and Environmental Control; SO_2 = sulfur dioxide; TAP = toxic air pollutant; TSF = tailings storage facility; VOC = volatile organic carbon.

4.16.4 Mitigation for Impacts on Air Quality

4.16.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included avoidance and minimization measures in the design and plans for operating and managing the proposed Project, as summarized below (Haile 2012a, 2013e):

- Comply with air quality state construction and operating permit requirements, conditions, and reporting.
- Implement dust control measures, including using water sprays to minimize dust at all transfer points.
- Limit the concentration of WAD cyanide in the TSF Reclaim Pond to a maximum of 50 ppm.
- Implement a Fugitive Dust Control Plan.
- Limit haul truck speeds to 24 miles per hour or less.
- Maintain roadways for optimal aggregate surface.
- Apply gravel to roadways.
- Minimize the formation of HCN by maintaining leach solution at a high pH.
- Use a mercury control reagent at the required concentrations to remove mercury from the process solutions.
- Use caustic scrubber in the HCl storage tank to neutralize/eliminate HCl emissions.

The avoidance and minimization measures listed above have been considered in the preceding impact analysis. The complete list of avoidance and minimization measures for air quality proposed by the Applicant is provided in Chapter 6.

4.16.4.2 Additional Potential Mitigation Measures

All mining activities would be conducted to comply with all applicable air quality regulations, including the permitting requirements listed in Section 3.16.1. Potential air quality impacts from the proposed Project would be minimal, and mitigation of potential air quality impacts is not necessary to reduce emissions beyond those measures required in regulations and approved permit conditions. Consequently, no additional mitigation measures are proposed for air quality.

4.16.5 Literature Cited

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4.17 Noise and Vibration

Haile Gold Mine would be mined for approximately 12 years, using multiple open pits. The Project has the potential to generate noise throughout the active mine life, including pre-construction. Mining activities generating noise would include overburden removal and transportation to OSAs or completed pits for backfilling, drilling, blasting and transportation of ore to the Mill for crushing, ore processing, and tailings disposal. Noise also would be generated during mine closure and reclamation activities, including slope grading, soil amendment and seeding, creek reconstruction, maintenance of closed units, and post-closure monitoring.

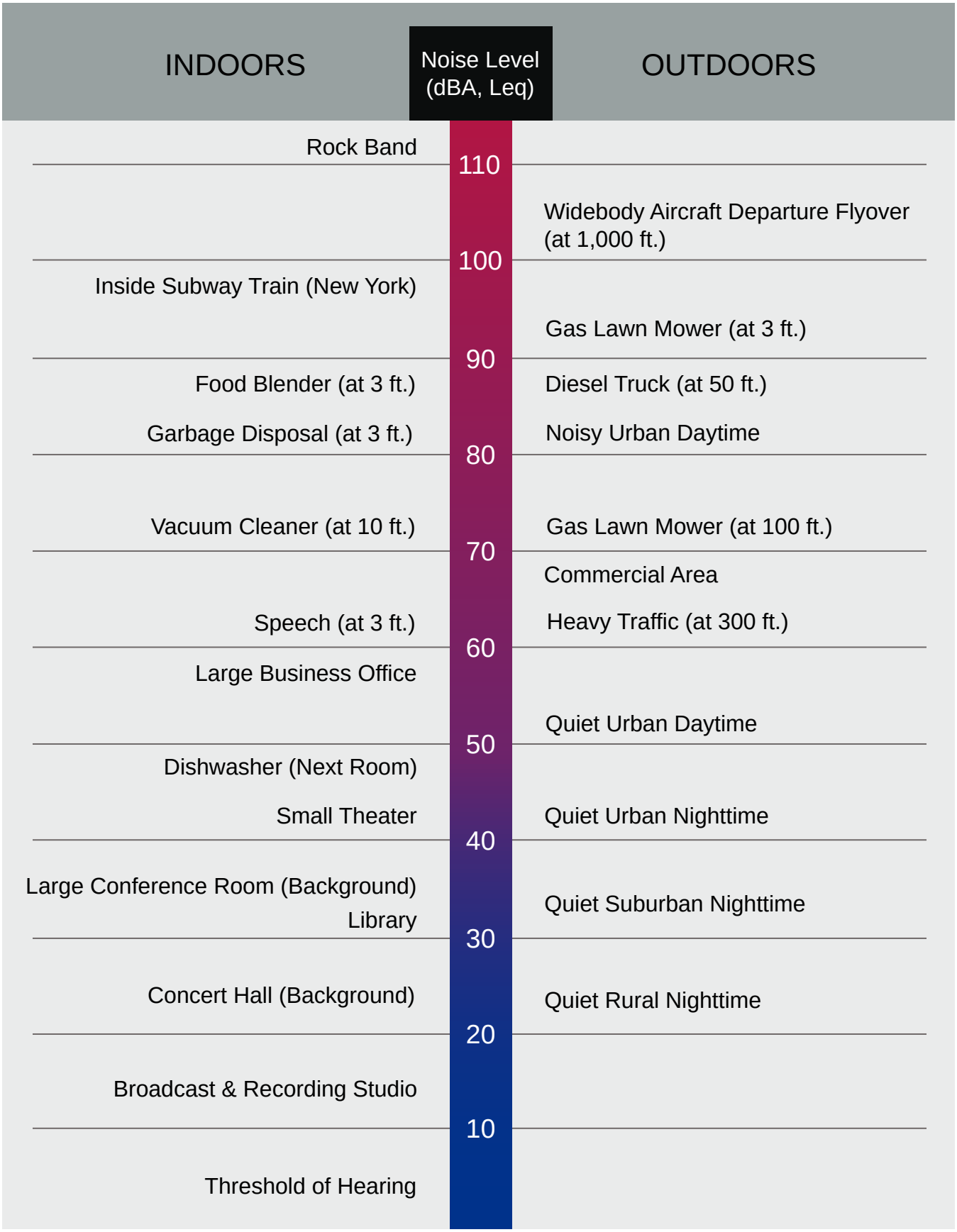
4.17.1 Methods

The potential for impacts on ambient noise conditions depends on the proximity of Project-related noise sources to sensitive receptors, typical noise levels associated with equipment, the potential for noise levels to interfere with daytime and nighttime activities, and the duration that sensitive receptors would be affected. As discussed in Section 3.17, sensitive receptors are land uses that can be more sensitive to noise based on the population groups present or activities involved (see Figure 3.17-3). The sensitive receptors with the greatest potential to be affected by noise contributions from the Project are located within and along the Project boundary, as they would be the closest to the activities generating noise. Noise levels decrease with distance, in addition to other factors such as vegetation and topography between the noise source and the receptor. Therefore, receptors farther from the Project boundary would experience a lower risk of noise levels and impacts. The study area for potential noise impacts encompasses the area within a 1-mile radius around the Project boundary, and the combined noise-level scenario was determined for noise generated for all mining processes within and along the Project boundary. Potential impacts from noise on nearby receptors was determined by comparing existing noise levels with the increase in noise levels expected from operation of the equipment and by comparing calculated or modeled results with applicable standards. Noise levels would vary based on the type of equipment operating and on the mine activity and phase. The analysis of noise-related impacts was based on a combined noise-level scenario with all sources operating simultaneously during the loudest mine phase. Consequently, any other scenario would result in lower noise levels. The noise model used to project operational noise considered 51 sources of noise operating simultaneously, including nine sources associated with ore processing.

A comparative evaluation between the expected noise levels for the Haile Gold Mine Project and the Ridgeway Mine operation was conducted based on noise monitoring results gathered at the Ridgeway Mine during operations and reclamation activities. Figure 4.17-1 depicts noise levels for common sounds.

4.17.2 Impacts

As discussed in Section 3.17, Project-related activities that would contribute most to the existing noise and vibration levels in the study area include on-road vehicles, off-road equipment, mobile equipment, stationary equipment, and blasting during the active mining period (including pre-production). Project-related noise associated with the post-mining period would be less than during active mining.



Haile Gold Mine Environmental Impact Statement
www.HaileGoldMineEIS.com

Figure 4.17-1

Noise Levels for Common Sounds

Source: Sacramento County Airport System 2014.

4.17.2.1 Noise from Mining Activities

No Action Alternative

Under the No Action Alternative, noise from general maintenance and monitoring of closure activities would continue similarly to the conditions documented by STS in fall 2010. However, the conditions documented in fall 2010 included noise from exploration drilling and reclamation activities. As of April 2013, most of the exploration drilling activity at the Haile Gold Mine had ceased, resulting in a decline in noise levels in the Project area. Absent the exploratory drilling and reclamation activities, the noise levels associated with general maintenance and monitoring of closure activities would continue to decline with time. Background ambient noise under the No Action Alternative would likely be similar to levels typical for this type of environment (generally below 75 dB) and the existing land uses (STS 2012).

Applicant's Proposed Project

Active Mining Period

Noise during active mining and development of mine facilities would result from operation of on-road and off-road mobile sources and vehicles and from stationary equipment used for ore processing. Noise measurements were collected at 10 locations in 2010 to determine the ambient noise conditions (Table 3.17-1). Table 4.17-1 shows the noise measurement locations with the peak noise levels collected in 2010 and the estimated noise levels from all mining noise sources except blasting (noise from blasting is analyzed in Section 4.17.2.3). It shows the increase in noise levels by comparing the 2010 existing noise levels with the estimated peak noise levels from mining activity. As shown in the table, barely perceptible or imperceptible increases of less than 5 dBA in noise levels would be expected at any receptor location when comparing the estimated noise levels from mining with ambient noise levels (see Section 3.17.1 for further discussion). Noise impacts on sensitive receptors would be long term, lasting for the duration of the Project. As noted, the peak Project-related noise levels would occur during mine development and active mining (through Mine Year 12).

The most stringent noise standards are in the Lancaster County Ordinance # 309 (as amended to include Section 4.1.29, *Mining and Extraction Operations*). Table 4.17-2 shows the maximum estimated noise levels from mining activity for residential and non-residential receptors near the mine, along the Project boundary, and within a 1-mile radius of the Project boundary. All predicted noise levels are below the Lancaster County standards. Locations of sensitive receptors are shown in Figure 3.17-3 and in Haile (2012a), *Noise Impact Analysis*, Appendices B and C.

Although mitigation measures would not be required to reduce noise levels to below applicable thresholds, Haile Gold Mine would incorporate Project design measures that would reduce noise, such as minimizing the impact area, conducting simultaneous reclamation activities, and phasing mine development. In addition, as the pit and bench areas of the mine are developed, it is expected that the elevation of mobile and drilling equipment would be lowered, and the developed berms would further reduce noise levels. The increased elevation of developed OSAs also may provide additional noise attenuation. Measures proposed for reduction of air emissions, such as locating processes subgrade, enclosing equipment, using walls and aprons around equipment, limiting truck speed, and maintaining roadways (Haile 2012a), also would reduce noise levels.

Table 4.17-1 Change in Noise Levels from Mining Activity at Receptor Locations

Receptor Location Description	Highest Measured Noise Level (dBA)[a]	Predicted Noise Level during Active Mining (dBA)	Difference in Noise Levels from Project (dBA)	Human Perception to Difference in Noise Levels
Haile Gold Mine Baptist Church	68	68	0	None
Kershaw Industrial Park	77	77	0	None
Corner of Gold Mine Highway (US 601) and Haile Gold Mine Road	57.9	60	2.1	Just perceivable
Along Haile Gold Mine Road	52.4	55	2.6	Just perceivable
Corner of Snowy Owl Road and State Road 219	54.1	56	1.9	Just perceivable
Residences along Snowy Owl Road	49.1	54	4.9	Just perceivable
Corner of Snowy Owl Road and Gold Mine Highway (US 601)	55.1	56	0.9	Undetected
Gold Mine Highway (US 601) and State Road 265	58	58	0	None
5099 Gold Mine Highway (US 601)[a]	74.5	74.5	0	None
Estridge Avenue and State Road 29-204 (Duckwood Road)[b]	79.4	79.4	0	None

Notes:

dBA = A-weighted decibel scale

See Figure 4.17-1 for noise levels associated with common sounds, Figure 3.17-3 for locations of sensitive receptors in the study area, and Figure 3.17-4 for noise measurement locations in the study area.

[a] The conditions documented in fall 2010 by South Technical Service (2012) included noise from exploration drilling and reclamation activities.

[b] Noise measurements taken at a different time than the other eight sites and not included in the locations shown in Figure 3.17.

Source: Haile 2012a.

Table 4.17-2 Mining Activity Noise Levels Compared with Lancaster County Noise Standards

Receptor Location Description[a]	Predicted Noise Level during Active Mining (dBA)	Lancaster County Residential Standards (dBA)	Below Noise Standards?
Receptor Location 1 (Haile Baptist Church)	51	62.9	Yes
Receptor Location 5 (Residences at corner of Snowy Owl Road and Gold Mine Highway)	57	62.9	Yes
Receptor Location 6 (Residences along Snowy Owl Road)	61	62.9	Yes
Receptor Location 7 (Gold Mine Highway at Route 265)	52	62.9	Yes
Receptor Location 8 (Snowy Owl Road and Route 219)	56	62.9	Yes
Receptor Location 9 (5099 Gold Mine Highway)	48	62.9	Yes
Project boundary Site # 11	51	62.9	Yes
Project boundary Site # 12	55	62.9	Yes
Project boundary Site # 13	50	62.9	Yes
Project boundary Site # 14	46	62.9	Yes
Project boundary Site # 15	56	62.9	Yes
Project boundary Site # 16	46	62.9	Yes
Project boundary Site # 17	56	62.9	Yes
Project boundary Site # 18	46	62.9	Yes
Project boundary Site # 19	46	62.9	Yes
Project boundary Site # 20	55	62.9	Yes
Project boundary Site # 21	52	62.9	Yes
Project boundary Site # 22	52	62.9	Yes
1-mile radius Site # 23	40	62.9	Yes
1-mile radius Site # 24	43	62.9	Yes
1-mile radius Site # 25	45	62.9	Yes

Table 4.17-2 Mining Activity Noise Levels Compared with Lancaster County Noise Standards (Continued)

Receptor Location Description[a]	Predicted Noise Level During Mining Activity(dBA)	Lancaster County Residential Standards (dBA)	Below Noise Standards?
1-mile radius Site # 26	44	62.9	Yes
1-mile radius Site # 27	45	62.9	Yes
1-mile radius Site # 28	43	62.9	Yes
1-mile radius Site # 29	42	62.9	Yes
1-mile radius Site # 30	40	62.9	Yes
1-mile radius Site # 31	39	62.9	Yes

Notes:

dBA = A-weighted decibel scale

Hz = Hertz

Noise measurements include both frequency in Hz and intensity (pressure) relative to normal atmospheric pressure. People respond more to higher frequencies than to lower frequencies. Sixty-three Hz is used here for Lancaster County standards.

[a] Locations of noise receptor locations are shown in Figure 3.17-4.

Source: Haile 2012a.

The Ridgeway Gold Mine is a site similar to the Project, located 20 miles northeast of Columbia, South Carolina and approximately 35 miles southwest of the Haile Gold Mine property. The Ridgeway Gold Mine was operated by the Kennecott Ridgeway Mining Company from December 1988 to November 1999 (Minerals Education Coalition 2013). The mine consisted of two open pits, processing facilities, and a TSF. The Ridgeway Gold Mine continues to undergo reclamation today.

Noise monitoring was conducted at the Ridgeway Gold Mine during operations, on a monthly basis from February 1989 to the transition to reclamation activities in November and December 1999. Noise monitoring data collected in 1992, 1995, 1996, and 1997 during active operations were reviewed. Noise levels during operation in 1989 varied by type and distance from the processing equipment operating; the highest noise level was recorded at 78 dB at a laydown yard, and the lowest noise level was recorded at 40 dB at an air quality monitoring station positioned at Highway 34 between the two pits at the mine. Noise measurements at the Ridgeway Gold Mine were taken during both operations and reclamation at locations that were closer to the two pits and the Mill at the Ridgeway Gold Mine than receptors would be to the pits and Mill proposed at the Haile Gold Mine. Taking into account the difference in distances from the noise source and the site-specific topographies, noise levels perceived by sensitive receptors at the Haile Gold Mine may be lower than the noise levels recorded for the Ridgeway Gold Mine.

Based on the noise levels shown in Tables 4.17-1 and 4.17-2 that were vetted with noise monitoring data at the Ridgeway Gold Mine, long-term noise-related impacts at the Haile Gold Mine would be minor.

Post-Mining Period

During the post-mining period, noise would occur from general maintenance and monitoring of closure activities and would be similar to the conditions documented by STS in fall 2010 that included reclamation activities. After reclamation activities have ceased and only monitoring occurs, background ambient noise would likely be similar to levels typical for this type of environment (generally below 75 dB) and the existing land uses (STS 2012).

Modified Project Alternative

The Modified Project Alternative involves the use of the Holly and Hock TSF borrow areas as additional OSAs, offsetting the amount of overburden stored at the proposed Ramona OSA. For most aspects of the Project, noise impacts under the Modified Project Alternative would be similar to those associated with the Proposed Project, except for noise from increased vehicles and equipment at the Holly and Hock TSF borrow area OSAs. Approximately 24 million tons of overburden storage could be hauled to these locations for deposit. Proposed equipment includes hydraulic front shovels, wheel loaders, and off-road mining vehicles. Most activities would be conducted using off-road vehicles within the Project boundary and not on public roads, and noise would be generated in the immediate vicinity of the work being performed. Although noise levels would increase under this alternative, the additional activity would not exceed standards based on the noise estimates in Table 4.17-1), and long-term noise-related impacts would remain minor.

4.17.2.2 Vibration from Mining Activities

No Action Alternative

Under the No Action Alternative, expected levels of vibration from the proposed Project would be similar to existing ambient conditions. Minimal equipment would be retained at the existing mine site such as backhoes and hedge hogs (similar to Bobcats) for conducting mowing and ditch/stormwater maintenance, and these would cause little or no increase in vibration. As of April 2013, all exploration drilling activity was ceased at the Haile Gold Mine, and this has decreased vibration.

Applicant's Proposed Project

Active Mining Period

Excess vibration can contribute to human annoyance and to structural damage. The greatest potential for perceptible vibration from mining activities would occur during blasting, as discussed in Section 4.17.2.3 below. Operation of on-road and off-road mobile sources during mining activities also would produce vibrations. To a lesser extent, vibrations would result from ore processing equipment. This vibration would be perceptible only in the immediate vicinity of the equipment, and sensitive receptors would not be affected.

Table 4.17-3 shows estimated vibration levels for mobile sources proposed for the Project. Vibration levels also were calculated for the nearest receptors based on distance and were compared with applicable standards for human annoyance and with structural damage thresholds. Estimated vibration levels at the nearest receptors would be below standards. Like noise, vibration decreases with distance. Therefore, the nearest receptors would represent the greatest potential impact, and receptors farther distant would perceive less vibration. Estimated mining-related vibration levels would range from 0.0002 to 0.038 PPV at the nearest receptors, far below the most conservative human annoyance standards and structural damage thresholds. Although minor to negligible, impacts from vibration would be long term and would

last for the duration of the Project. As noted, the peak levels of vibration would take place during the active mining period.

Table 4.17-3 Vibration Levels from Stationary and Mobile Sources during Active Mining

Vibration Source	Estimated Vibration Level (PPV in/sec at 25 feet)	Nearest Receptor (feet)	Estimated Vibration Level at Nearest Receptor (PPV in/sec)	Human Annoyance Threshold (PPV in/sec)	Structural Damage Threshold (PPV in/sec)
Haul truck/off-highway truck	0.076	50	0.038	0.60	0.75
Motor grader	0.003	500	0.0003	0.60	0.75
Excavator	0.003	500	0.0003	0.60	0.75
Drill rig	0.089	2,000	0.0002	0.60	0.75
Wheel loader	0.003	500	0.0003	0.60	0.75
Bull dozer	0.089	500	0.0089	0.60	0.75
Wheel dozer	0.089	500	0.0089	0.60	0.75

Notes:

in/sec = inches per second

PPV = peak particle velocity

Sources: Haile 2012b; ATS Consulting 2013; FTA 2006.

As discussed in Section 3.17, the USBM has established vibration thresholds to prevent damage to neighboring structures from blasting. These thresholds are dependent on a range of variables, including vibration frequency, distance of the structure from the blast, and the method of construction (USBM 1980a). Many states, including South Carolina, have promulgated a maximum vibration limit of 1.0 inch per second PPV for ground motion from surface blasting; this limit is based in large part on research by the USBM.

Post-Mining Period

During the post-mining period expected levels of vibration from the proposed Project would occur from equipment such as backhoes and hedge hogs (similar to Bobcats) for conducting reclamation and maintenance activities (mowing and ditch/stormwater maintenance), and these would cause little or no increase in vibration. Vibration impacts during the post-mining period would therefore be minimal.

Modified Project Alternative

The Modified Project Alternative involves use of the Holly and Hock TSF borrow areas as additional OSAs, offsetting the amount of overburden stored at the proposed Ramona OSA. For most aspects of the Project, vibration impacts under the Modified Project would be similar to impacts associated with the proposed Project, except for vibration from vehicles and equipment at the Holly and Hock TSF borrow area OSAs. Approximately 24 million tons of overburden storage could be hauled to these locations for

deposit. Proposed equipment includes hydraulic front shovels, wheel loaders, and off-road mining vehicles. Most activities would be conducted using off-road vehicles within the Project boundary and not on public roads, and vibrations would be generated in the immediate vicinity of the work being performed. Although vibration levels would increase, the additional activity would not exceed standards based on the estimated vibration levels in Table 4.17-3, and long-term impacts would remain minor.

4.17.2.3 Noise and Vibration from Blasting

No Action Alternative

Under the No Action Alternative, no noise or vibration would occur from blasting, and noise and vibration levels would not increase above the existing conditions.

Applicant's Proposed Project

Active Mining Period

Blasting is expected to be required in the following areas to remove rock: Mill Zone Pit, Snake Pit, Haile Pit, Red Hill Pit, Ledbetter Pit, Chase Pit, Small Pit, and Champion Pit (see Figure A-4 in Appendix A). Following removal of the growth media and the upper layer of overburden in the pits, drilling and blasting would be required to excavate the underlying bedrock. Rotary blasthole drills would be used to drill holes in the rock to allow blasting prior to the removal of overburden and ore. Drill holes approximately 6.5 inches in diameter, to a depth of 23 feet, are expected; but specifications may change because of site-specific ground and rock conditions.

Blast holes would be drilled approximately 14 feet apart in a pattern of typically 50 to 200 holes. Blasting would be conducted in a timed sequence to maximize rock fragmentation, minimize low-frequency vibrations, minimize fly rock, and protect the pit slopes from damage. The size of each detonation and the amount of explosives required would vary based on rock characteristics (Haile 2012c).

Potential impacts on nearby receptors and structures from blasting activity include ground-borne vibrations that can be felt and air-borne vibrations (referred to as *air overpressure*) that are perceived as noise.

Blasting Ground-Borne Vibrations

Ground-borne vibrations move away from blast locations in all directions, similar to ripples in a pond; however, movement in the ground cannot be seen and can only be recorded by seismic equipment. As the vibrations move farther away from the blasting site, the energy is dissipated and the vibrations weaken and eventually fall below perceptible levels. The rate at which ground vibration moves through rock and earth depends on the location and rock type; vibrations decrease very quickly near the source of the blasting, and move more slowly farther from the source. Therefore, most of the vibrations would occur at within the Project boundary, but a small amount of vibration may be perceptible at some distance from blast sites. Thresholds for human annoyance from vibration are at the lower end of the "strongly perceptible to mildly unpleasant" average response. Thresholds for structures were developed to protect the weakest portions of a structure, regardless of structure type, which is the plaster interior. Vibration thresholds are discussed further in Section 3.17.

Blasting Noise (Air Overpressure)

Blasting activity also results in air-borne vibrations, or air overpressure, which can be perceived as sound. Blasting seismographs use microphones to measure the changes in air pressure occurring as the air vibration passes to determine whether any applicable standards are exceeded. The air vibrations produced by blasting cause the normal air pressure to fluctuate, resulting in air overpressure (as in pressure over atmospheric pressure). Air vibrations from blasting are typically referred to as noise levels, but frequencies below the threshold of human hearing (called infrasonic) can affect structures, such as wind rattling a window. Structural damage from air overpressure is rare without window breakage, as glass is the weakest portion of a structure's exterior. Air overpressures from blasting rarely exceed 0.01 psi, approximately one one-hundredth of the overpressure that a window can safely withstand based on design. Thresholds for air overpressure are based on human reaction rather than structural damage.

Based on blasting research, the frequency where the most sound energy is located for a blast is at the 2 to 25 Hz range, below the level of human hearing. As blasting noise levels generally are very low frequency, the human ear does not detect the total energy associated with the activity. Research has been conducted on annoyance levels for sonic booms, and artillery fire was used to determine appropriate thresholds for human response.

Potential Impacts

Based on review of the mine plan and maps and the typical blast designs that might be used, ground and air vibration levels were estimated to determine any impacts on nearby receptors and structures from both vibration and air overpressure. Table 4.17-4 lists each pit that is expected to require blasting the nearest receptor and highest vibration and noise (air overpressure) levels expected for each pit, and the applicable standards. Calculations indicated that blasting would produce perceptible levels of ground vibration and air overpressure at receptor locations closest to the Project boundary. However, the projected ground and air vibration levels are similar to ambient levels experienced by structures on a daily basis and below the threshold levels known to cause cosmetic damage to structures. In addition, the predicted ground vibrations and air overpressures for all receptor locations are below the USBM criteria, the SCMA and Regulations, and the State of South Carolina – County of Lancaster Ordinance. Based on the projected ground and air vibration levels, impacts caused by ground or air vibrations during blasting activities at Haile Gold Mine would be minor on receptors and surrounding structures, and would last for the duration of the Project.

While mitigation measures would not be required to reduce vibration or noise levels from blasting to below applicable thresholds, Haile would incorporate measures to reduce vibration and noise during blasting. These measures include use of programmable electronic detonators, considered state-of-the art for the blasting industry. The detonators provide redundant safety features and flexibility in controlling low-frequency wavelengths produced by blasting based on allowing variability in delays between charges that control vibrations on the pit walls and nearby. Measures also include developing a monitoring and blasting plan in cooperation with the SCDHEC following selection of a contractor and prior to commencement of blasting. Haile and the selected contractor would review all blast vibration data and adjust, if necessary, the blast size and pattern to reduce ground-borne vibration and air overpressure (Haile 2012c). Mitigation intended to minimize air emissions, such as limiting truck speed and maintaining roadways, also would reduce vibration (Haile 2012a).

Table 4.17-4 Ground-Borne Vibration and Noise (Air Overpressure) from Blasting

Pit	Closest Receptor (feet)	Ground-Borne Vibration			Noise (Air Overpressure)		
		Estimated Vibration (PPV in/sec)	Threshold for Human Annoyance (in/sec)	Threshold for Structural Damage (in/sec)	Estimated Air Overpressure (psi)	Threshold for Human Annoyance (psi)	Threshold for Structural Damage (psi)[a]
Mill Zone Pit	1,869	0.1093	0.60	0.75	0.00182	0.01	0.01295
Snake Pit	2,428	0.0719	0.60	0.75	0.00136	0.01	0.01295
Haile Pit	2,770	0.0582	0.60	0.75	0.00118	0.01	0.01295
Red Hill Pit	2,300	0.0784	0.60	0.75	0.00145	0.01	0.01295
Ledbetter Pit	3,017	0.0508	0.60	0.75	0.00107	0.01	0.01295
Chase Pit	2,150	0.0874	0.60	0.75	0.00156	0.01	0.01295
Small Pit	2,615	0.0639	0.60	0.75	0.00126	0.01	0.01295
Champion Pit	1,942	0.1028	0.60	0.75	0.00175	0.01	0.01295

Notes:

in/sec = inches/second

PPV = peak particle velocity

psi = pounds per square inch

0.013 psi equals 133 dB. South Carolina did not promulgate an air overpressure limit because, if quarry blasts comply with the 1.0 inch per second PPV limit for ground motion, air over pressure would be less than 130 dB.

[a] Source: USBM 1980b.

Post-Mining Period

During the post-mining period, no noise or vibration would occur from blasting.

Modified Project Alternative

Noise and vibration impacts from blasting under the Modified Project Alternative would be the same as described for the Applicant's Proposed Project because no additional blasting would be required under the modified Project.

4.17.3 Impact Summary

Table 4.17-5 presents a summary of noise and vibration impacts under each alternative.

Table 4.17-5 Summary of Impacts on Noise and Vibration

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Noise from mining activities	Ambient noise would not be affected and would be similar to that described for existing conditions.	Noise would result from process equipment and from - road and off-road equipment used during mining. Noise levels would not exceed standards.	Impacts would be similar to the Applicant's Proposed Project, except for increased noise from vehicles and equipment at the Holly and Hock TSF borrow area OSAs.
Vibration from mining activities	Ambient vibration would not be affected and would be similar to that described for existing conditions.	Vibration would result from process equipment and from on-road and off-road equipment used during mining. Vibration levels would not exceed standards.	Impacts would be similar to the Applicant's Proposed Project, except for increased vibration from vehicles and equipment at the Holly and Hock TSF borrow area OSAs.
Noise and vibration from blasting	No noise or vibration would occur from blasting, and noise and vibration levels would not increase above the existing conditions.	Noise and vibration would result from blasting activity during mining. Vibration and noise levels from blasting would be below applicable standards.	Same as the Applicant's Proposed Project.

4.17.4 Mitigation for Noise and Vibration Impacts

4.17.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included avoidance and minimization measures in the design and plans for operating and managing the proposed Project (Haile 2012c, 2012d, 2013), and these are summarized as follows:

- Implement vegetative set-back areas from public roadways.
- Perform blasting with electronic programmable detonators to minimize ground vibrations.
- Perform blasting only during daylight hours.
- Use sound-attenuating devices on Mill equipment.
- Construct earthen berms on the OSA working benches.

- Use electric engine starters on mining equipment.
- Use rubber liners in grinding mills, where appropriate.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of Applicant-proposed avoidance and minimization measures related to noise and vibration is provided in Chapter 6.

4.17.4.2 Additional Potential Mitigation Measures

All mining activities would be carried out in compliance with all applicable noise and vibration regulations, as listed in Section 3.17.3. Potential noise and vibration impacts from the Applicant's Proposed Project would be minor, and mitigation of potential noise and vibration is not necessary to reduce levels to below regulatory standards. As such, no additional mitigation measures are proposed for potential noise and vibration impacts.

4.17.5 Literature Cited

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4.18 Health and Safety

Potential hazards related to Project facilities can include worker accidents and injuries from the operation of vehicles and equipment; contact with chemicals; drilling, blasting, and loud equipment; and other Project facilities such as pits and pit lakes. Natural hazards include high-wind events, excessive precipitation events, prolonged freezing conditions, and wildland fires. Potential hazard-related environmental impacts include damage to or flooding of Project facilities, pits, and equipment; tailings dam breaks; and facility failures. Potential emergency service response impacts include exceedance of the community's capacity to provide emergency responses.

4.18.1 Methods

Direct natural hazard impacts from the Project were measured using data from available published literature and historical records documenting the occurrence, response, and damage due to natural hazards. Indirect health and safety impacts were measured using the response history and records available for the public emergency response agencies (e.g., fire, emergency medical, and police) for the Town of Kershaw and Lancaster County.

4.18.2 Impacts

The potential for health and safety impacts are directly related to the actions taken by the Applicant during gold mining and processing. The natural hazards of the Project area influence the safety and stability of engineered components of mine facilities. The capacity of emergency response departments in the Project area influence the need for alternate emergency response plans.

4.18.2.1 Health Risks and Hazards related to Project Facilities

No Action Alternative

Under the No Action Alternative, the potential for direct worker health impacts from Project facilities and heavy equipment would be similar to the present risk potential. Ongoing exploratory drilling to further define the extent of mineral reserves would cease, and the potential risk to workers associated with exploratory activities also would cease. Ongoing monitoring of the reclaimed sites would continue in accordance with previous permit requirements. The existing worker health conditions in the Project area generally would be expected to continue.

Applicant's Proposed Project

The Applicant's Proposed Project would employ an estimated 704 workers during pre-production, 500 workers during peak production at the mid-point of operations, and 153 workers by the end of the 15-year mine plan. In 2009, 13,329 people were employed in the mining and natural resources industry in South Carolina. Table 4.18-1 summarizes the potential risks to the Project workforce for each of the three phases of work and assuming an annual average of 340 reportable injuries and illnesses, resulting in a loss of 180 days away from work, and 6 fatalities (see Section 3.18.2.1).

As shown in Table 4.18-1, the annual potential risks of injuries and illnesses to workers that would be employed for the proposed Project is estimated to be very low. To minimize the potential risks to workers, the Applicant has included a number of avoidance and minimization measures in the design and plans for operating and managing the proposed Haile Gold Mine, such as providing training for hazardous materials handling and placing appropriate signage during closure to warn of the hazards of the pit highwalls and pit lakes.

Table 4.18-1 Estimated Annual Potential Worker Injuries and Illnesses

Health Risk	Project Phase Worker Effects		
	Pre-Production	Peak Production	End of Production
Number of workers	704	500	153
Number of injuries or illnesses	18	13	4
Lost days from work	10	7	2

Note: Estimates are based on the estimated number of employees at the mine by phase and historical records of injuries and illnesses in the mining industry in 2009.

The potential risk of injury from Project facilities is considered low because of the design features of Project facilities, safety precautions and training measures that would be implemented by the Applicant, and compliance with safety guidelines.

Modified Project Alternative

The potential health risks from Project facilities under the Modified Project Alternative would be the same as described for the Applicant's Proposed Project.

4.18.2.2 Impacts from Natural Hazards

No Action Alternative

Under the No Action Alternative, the potential for direct impacts from natural hazards would not change from the present risk potential. Ongoing exploratory drilling to further define the extent of mineral reserves would cease and ongoing monitoring of the reclaimed sites would continue in accordance with previous permit requirements. The existing natural hazards conditions in the Project area generally would be expected to continue.

Applicant's Proposed Project

Under the Applicant's Proposed Project, the personnel, equipment, and mine facilities would be exposed to the open environment over a 15-year period and could be at risk from natural hazards in the Project area. Natural hazards include tornadoes and hurricanes, excessive precipitation, freezing conditions, and wildland fires. The risk of seismic events is discussed in Section 4.2, "Geology and Soils." Potential moderate to major direct or indirect impacts from natural hazards could be temporary or long term, depending on the severity of the event.

Tornadoes, Hurricanes, and Other High-Wind Events

The high wind speeds associated with tornadoes and hurricanes, even without the potential excessive precipitation impacts described in greater detail below, can cause major damage to facilities and property. The Applicant would comply with the Emergency Planning and Community Right-To-Know Act (EPCRA) throughout the life of the Project. If a high-wind event should occur, the Applicant would implement its Emergency Response Action Plan (ERAP)and coordinate as needed with local and regional emergency response officials and agencies. Although the mine facilities and equipment could be damaged by high winds, damages to mine facilities and equipment would not affect property outside the Project area, and the potential cost would be borne by the Applicant. A more likely and greater impact would be caused by excess precipitation and flooding in the Project area, as addressed below.

Based on data from the *Lancaster County Hazard Mitigation Plan* (Lancaster County 2012), the chances of a tornado or hurricane are relatively low. The long-term potential impact therefore is considered minor.

Excessive Precipitation

Potential temporary or long-term impacts, such as facility failures, tailings dam breaks, and flooding of Project equipment, facilities, and pits due to excessive precipitation are possible and could be moderate to major in intensity.

The Applicant has included design features to limit impacts in the event of a facility failure. Should a facility failure occur that would affect the tailings or process water pipelines, or should a prolonged unplanned power outage occur, overflow of fluids that requires treatment would drain to an HDPE-lined Process Event Pond (a pond designed to contain process water in the event of a failure), as described in the Project Description (Appendix A). Once the failures have been repaired, or power restored, the material in the Process Event Pond would be returned to the applicable area for processing. Water from a spill or incident that contacts processing reagents would be suitable for use in the closed-loop system, which includes use of process water from the TSF.

The Applicant has designed facilities to prevent potential impacts from excessive precipitation events. The Duckwood TSF would cover an area of approximately 524 acres and is engineered to withstand hydraulic stress, to prevent a tailings dam break. The TSF would be equipped with an HDPE liner with a collection system beneath, exposed tailings, and a supernatant reclaim pond at the base of the tailings beach. The TSF is designed to contain the PMP[1] event, including an additional 4 feet of freeboard[2] in the embankment to contain direct stormwater flows from the PMP event under maximum planned storage conditions. In the event that the water level exceeds the marked level, the additional 4 feet of freeboard would act as a buffer while the mine processes the excess solution and lowers the TSF water level.

In addition, the Applicant has developed an ERAP to reduce the potential for loss of life and injury, and to minimize property damage during an unusual or emergency event at the TSF, including a flood. The ERAP includes an overview for personnel roles and responsibilities. The ERAP includes methods to detect and evaluate the emergency condition, assess the situation, and determine the emergency level for notification and the procedures for communication and expected actions. The locations and contact information of any residents or structures that may be flooded if the TSF should breach are noted. A notification list provides emergency contact names and numbers for federal, state, and local agencies (Haile 2013a).

The Mill, chemical storage areas, and fuel storage areas are designed with the capacity and volume to hold and contain spills or leaks simultaneously with a 100-year, 24-hour storm event. These facilities are designed to capture all spills and direct material to a collection sump for cleanup and return of the spill to the closed-loop system for which it is best suited. If a facility is open to the sky, it has been designed to capture 110 percent of the largest container in that process area plus stormwater for a 100-year, 24-hour

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[1] A *PMP event* is defined by the American Meteorological Society as "the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage basin at a particular time of year" (AMS 1959). The PMP storm for the Haile Gold Mine site is calculated as 47.96 inches for a 72-hour event (Haile 2013a).

[2] *Freeboard* is the vertical distance between the horizontal crest of the embankment and the reservoir water level (Punmia et al 1992). It is a function of the facility design and is calculated in order to provide a factor of safety greater than that for which the facility is designed (Haile 2013a).

storm event. If a spill is greater than the facility's containment capacity, the overflow would be captured and flow into the adjacent Process Event Pond, as outlined in Section 4.19, "Hazardous Materials and Waste." The Process Event Pond was designed to act as a failsafe in the event that individual containment systems have insufficient capacity.

The Applicant would prepare Toxic Release Inventory Reports, to identify the types and quantities of chemicals stored onsite, and implement a Chemical Handling and Storage Plan and staff training to be better prepared to respond to unforeseen emergency situations. During the life of the mine, Haile also would develop and implement detailed pollution prevention plans for process chemical handling and mining operations in accordance with appropriate regulations, permits, BMPs, and codes.

To prevent flooding of pits, runoff would be captured in diversion channels that would route the stormwater into natural drainages. Collection channels would manage runoff that originated from non-PAG facilities, while sediment detention ponds would limit peak runoff rates. All collection channels and spillways have the capacity to convey a 100-year, 24-hour storm event. An NPDES General Permit for Stormwater Discharges from Construction Activities would be obtained by the Applicant, as required by the SCDHEC, Bureau of Water, Stormwater Permitting Section. Sump pumps would be used to remove rainfall and groundwater seepage into the pits.

Based on the data from the *Lancaster County Hazard Mitigation Plan* (Lancaster County 2012), the chances of an excessive precipitation event or flood occurring is relatively low. The long-term potential impact therefore is considered minor.

Freezing Conditions

The average winter temperature for the Project area is 50 °F; the coldest month is January, with an average temperature of 43 °F (AMEC 2012). Based on these weather conditions, prolonged freezing or impacts due to freezing conditions is unlikely. Potential moderate direct facility integrity and operational process impacts, and the resulting potential releases of untreated or hazardous discharges, from freezing conditions are unlikely to occur. Prolonged freezing may require operational changes at the TSF, slurry delivery pipeline, and mine facilities. To prevent blockages of pipes by inward ice growth, all surface pipework would be kept flowing full and at design conditions, or would be drained and left with valves open, depending on the need for the specific piping. For example, the tailings slurry pipelines on the embankment inner crest are designed to allow gravity drainage inward toward the basin and may be drained. Deposition at the TSF may be moved to points furthest from the supernatant pond during prolonged freezes, to maximize storage at each discharge point in the TSF.

Wildland Fires

Project facilities, equipment, vehicles, and personnel have the potential to cause wildland fires that could occur within or extend beyond the Project boundary. Potential temporary and moderate direct impacts from wildland fires are possible. Haile Gold Mine does not presently have fire protection water supplied to the site. If fire trucks were called to the site, Ledbetter Reservoir would be used as the water supply source. For Project facilities, the Town of Kershaw would supply fire protection water from an existing 250,000-gallon storage tank near the Kershaw Correctional Institution via a pipeline installed by Haile. While potential impacts from wildland fires are possible, Haile would install a fire protection water supply to fight wildland fires within the Project boundary. Wildland fires that occurred outside of the Project boundary would be fought by regional resources.

To reduce the risk of ignition of hazardous or toxic wastes, the Applicant has prepared a *Solid and Hazardous Waste Management Plan*, which outlines specific precautions and regulations (Haile 2011).

As specified by 40 CFR 265.176, the Solid and Hazardous Waste Management Plan requires that ignitable or reactive wastes not be stored any closer than 50 feet from the property fence line. MSHA regulations require that ignitable inside or outside storage wastes not be stored within 25 feet of a wood building, unless contained by a three-sided steel fire wall. The Applicant also requires all personnel to be trained in fire incident management. The ERAP addresses procedures in the event of an accident involving hazardous wastes at the mine. This portion of the *Solid and Hazardous Waste Management Plan* is designed to minimize hazards to human health or the environment from fires, explosions, or any unplanned releases of hazardous waste or hazardous waste constituents to the air, soil, or surface water. Included in the plan is contact information for emergency response and information on the location of fire extinguishers, which are inspected and tested regularly by the Applicant's Safety Department (Haile 2011).

Based on the data from the *Lancaster County Hazard Mitigation Plan* (Lancaster County 2012), wildland fires are a common occurrence throughout the county, and the chance of a wildland fire occurring within the Project boundary is possible. However, based on the protocols and response of the responding agencies (see below) and precautions taken by the Applicant, the risk of wildland fire is considered minor.

Modified Project Alternative

The potential direct impacts from natural hazards under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.18.2.3 Increased Demand for Emergency Response

No Action Alternative

Under the No Action Alternative, ongoing exploratory drilling to further define the extent of mineral reserves would cease, and the potential need for emergency responses associated with these activities also would cease. Ongoing monitoring of the reclaimed sites would continue in accordance with previous permit requirements. The existing conditions regarding the emergency response procedures in the Project area generally would be expected to continue. No additional emergency response would be required for mining activities associated with the proposed Project.

Applicant's Proposed Project

Potential moderate or major indirect impacts from increased demand for local or regional emergency response agencies would be temporary. The increased need for emergency responses by local or regional agencies due to medical, fire, hazardous material release, or other emergencies has the potential to exceed the community's capacity to provide the specified emergency response.

The Applicant has received letters from local emergency response agencies assuring that they are fully capable of handling all anticipated emergency response calls (Haile 2012). Until emergency response teams arrive, personnel within the Project boundary would assist in the emergency, in compliance with the safety training provided by the Applicant. Such training includes emergency response procedures, first aid/heat stress/cold weather awareness, fire incident management (fire incident control and fire extinguisher), and emergency procedures outlined in the Applicant's ERAP.

Based on documentation received by the Applicant from the individual emergency response agencies, the proposed Project is not likely to exceed the community's capacity to provide the specified emergency response.

Modified Project Alternative

The potential direct and indirect impacts from increased demand for emergency response under the Modified Project Alternative would be the same as described for the Applicant's Proposed Project.

4.18.3 Impact Summary

Table 4.18-2 presents a summary of potential health and safety impacts under each alternative.

4.18.4 Mitigation for Health and Safety Impacts

4.18.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has included a number of avoidance and minimization measures in the design and plans for operating and managing the proposed Haile Gold Mine. Haile has committed to implementing many of these measures as a part of its proposed MMP (Haile 2013b) (Appendix G). Applicant-proposed avoidance and minimization measures related to health and safety are summarized below:

- Provide around-the-clock security.
- Restrict access to the Project area.
- Use vegetative screens and fencing to minimize public interaction.
- Develop detailed pollution prevention plans for process chemical handling and mining operations in accordance with appropriate regulations, permits, best practices, and codes.
- Add cyanide only in the recycled, closed-loop process water to/from the Mill and the TSF.
- Comply with the EPCRA.
- Implement an Emergency Response Action Plan.
- Comply with NPDES permits, air permits, the Dam Safety permit, the SCDHEC Mining permit, the Floodplain permit, and building and sewer permits.
- Perform Toxic Release Inventory Reporting.
- Implement a Chemical Handling and Storage Plan.
- Comply with MSHA requirements.
- During reclamation, construct safety berms around any portions of the pit lakes that did not have berms during operations.
- Place appropriate signage during closure to warn of the hazards of the pit highwalls and pit lakes.
- Construct two bridges over US 601 to avoid impact on public safety by mine vehicle movement.
- Seal abandoned wells.
- Perform employee training.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of avoidance and minimization measures for health and safety proposed by the Applicant is provided in Chapter 6.

Table 4.18-2 Summary of Impacts on Health and Safety Impacts

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Project facility health risks and hazards	Negligible potential for injuries associated with ongoing monitoring required by previous permits.	Potential for injury from Project facilities reduced with appropriate training. Minor and temporary impact if an injury or illness.	Same as the Applicant's Proposed Project
Tornadoes, hurricanes, and other high-wind events	Existing potential for tornadoes, hurricanes, and other high-wind events and the associated damage to the Project area would continue.	Minor potential for damage to Project facilities and equipment from high-wind events.	Same as the Applicant's Proposed Project
Excessive precipitation	No potential for facility failures; tailings dam breaks; or flooding of mine facilities, pits, or equipment. Existing potential for flooding of the Project area from excessive precipitation events would continue.	Minor potential for facility failures; tailings dam breaks; and flooding of mine facilities, pits, or equipment from excessive precipitation events.	Same as the Applicant's Proposed Project
Freezing conditions	No potential freezing of mine facility components. Existing potential for freezing conditions in the Project area would continue.	Negligible potential for temporary operational changes needed at the Duckwood TSF, slurry delivery pipeline, and mine facilities due to ice formation within pipelines.	Same as the Applicant's Proposed Project
Wildland fires	Existing potential for damage from wildland fires in the Project area would continue.	Minor potential for moderate or long-term wildland fire damage.	Same as the Applicant's Proposed Project
Increased demand for emergency response	Potential for decreased demand for emergency response because exploratory activities would cease. No additional emergency response would be required for proposed mining activities.	Potential for negligible, short-term increased demand on local responders for emergency response.	Same as the Applicant's Proposed Project

4.18.4.2 Additional Potential Mitigation Measures

No additional mitigation measures are proposed for health and safety issues.

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4.19 Hazardous Materials and Waste

Construction activities and mining operations associated with the Project would involve the handling, use, and storage of potentially hazardous materials and waste. Issues related to hazardous materials and waste include potential human health risks from the use and handling of hazardous materials; accidental release of hazardous materials to the environment from storage within the Project boundary; accidental release of hazardous materials to the environment from transport within the Project boundary; and potential impacts from disposal of hazardous waste outside the Project boundary.

4.19.1 Methods

Potential impacts related to hazardous materials and waste were evaluated based on the chemical types, quantities, storage, and handling procedures of hazardous materials and waste in the Project area during the gold mining process. Impacts related to PAG waste rock and ore were evaluated using information from recent studies at the mine. These studies used chemical analyses to segregate the materials into specific categories that describe the overall acid generation potential and thus the potential to cause indirect chemical effects to the exposed waste rock and ore (Schafer 2013).

4.19.2 Impacts

The potential for hazardous materials and waste impacts is directly related to the actions taken by the Applicant during gold mining and ore processing. The chemical types and quantities of hazardous materials and waste dictate their use and handling, transport, storage and disposal locations. Proper handling and management of these materials are strictly monitored by federal and state regulations, as discussed in Section 3.19. The Applicant's Solid and Hazardous Waste Management Plan (Haile 2011) identifies how hazardous materials and waste would be managed in the Project area.

4.19.2.1 Impacts from Handling Hazardous Materials

No Action Alternative

Under the No Action Alternative, ongoing exploratory drilling to further define the extent of mineral reserves would cease, and the associated use and handling of hazardous materials and waste would be discontinued. Ongoing monitoring of the reclaimed sites would continue in accordance with previous permit requirements, which would require the use of some hazardous materials such as diesel fuel. There would be a low health risk from handling hazardous materials within the Project boundary under the No Action Alternative.

Applicant's Proposed Project

The duration and intensity of potential human health risks from the use and handling of hazardous materials and wastes depend on the types and quantities of hazardous materials and/or waste encountered, the method of encounter, and the length or duration of exposure. The types and quantities of hazardous materials would cause different effects based on their chemical compositions and would influence the degree of impact. Degree of impact would be affected by the exposure mechanism and duration such as ingestion, inhalation, or external contact through skin or mucus membranes. The effect from duration of exposure varies for different types of hazardous materials and does not have a standard measurement. Duration of exposure includes a single exposure event or repetitive exposure over a period of time. In general, greater exposure to a hazardous material yields a more severe impact.

The specific potential health risks associated with the hazardous materials and waste that would be used for the Project (see Section 3.19) can be located on each substance's material safety data sheet (MSDS). The USEPA defines the MSDS as "printed material concerning a hazardous chemical, or Extremely Hazardous Substance, including its physical properties, hazards to personnel, fire and explosion potential, safe handling recommendations, health effects, firefighting techniques, reactivity, and proper disposal" (USEPA 1996).

Hazardous materials would be handled by individuals whose jobs require handling or management of hazardous waste, or by individuals working at the hazardous waste storage areas on the Project site. Proper use and handling of hazardous materials and waste would reduce potential impacts on human health and environmental resources. The Applicant would implement training requirements and training courses at the Project site for management of hazardous materials and wastes, non-hazardous materials and wastes, and *universal wastes.*[1] Training would be conducted in compliance with the requirements of the federal hazardous waste regulation found in 40 CFR 262.34 (d)(5)(iii) *SQG Hazardous Waste Handling and Emergency Procedures Training*, and in 273.16 *Universal Waste Small Quantity Handlers Training*. Trained employees would provide waste management supervision for new hires until the new hires are trained. This training would be offered to new hires within 12 months of their initial employment at the facility and annually thereafter to all applicable personnel. Employees working within the Mill would be required to undergo safety training pursuant to the MSHA hazardous communication standards (29 CFR 1910.1200). The Applicant would provide training so that all employees have the understanding, knowledge, and skills to safely perform their assigned duties.

Training would be completed by a person knowledgeable in hazardous waste management procedures. The type and quantity of training given to each employee would be relevant to the employee's hazardous waste management tasks commonly part of his/her employment position. Training may be provided in separate areas as required (e.g., laboratory waste management). Types of training that would be provided to employees include training required by appropriate regulations, and would focus in detail on areas directly related to hazardous waste management and spill response measures in the Project area. All hazardous waste training records would be kept in the employee's training files for 3 years. A complete list of all training that would be required is provided in the Solid and Hazardous Waste Management Plan (Haile 2011).

Potential impacts on human health from handling of hazardous materials and waste are considered low because of the safety precautions and training measures that would be implemented by the Applicant.

Modified Project Alternative

Potential impacts from proper use and handling of hazardous materials and waste under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.19.2.2 Impacts from Storage of Hazardous Materials in the Project Area

No Action Alternative

Under the No Action Alternative, ongoing exploratory drilling to further define the extent of mineral reserves would cease, and associated storage of hazardous materials and waste would discontinue.

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[1] *Universal wastes* refer to hazardous wastes that are commonly used, including batteries, pesticides, mercury-containing equipment (e.g., thermostats) and lamps (e.g., fluorescent bulbs) (http://www.epa.gov/osw/hazard/wastetypes/index.htm).

Ongoing monitoring of the reclaimed sites would continue in accordance with permit requirements which would require the use of some hazardous materials such as diesel fuel. There would be a low risk of an accidental release of hazardous materials within Project boundary under the No Action Alternative.

Applicant's Proposed Project

The Project would require storage of potentially hazardous materials at the mine and ore processing facilities during mining operations over a 15-year period. Hazardous materials and waste would include mine processing fluids and reagents (e.g., cyanides, laboratory reagents, fueling materials, and related lubricants and solvents) and general administrative materials that would be used in various operations (e.g., fueling vehicles and ore processing).

Each of these hazardous materials has a different environmental fate (how long the chemical persists in the environment after its release). To avoid the potential for moderate to major direct and indirect impacts from an accidental release of hazardous materials, the Applicant has provided a Solid Hazardous and Waste Management Plan (Haile 2011) that would implement safety precautions related to storage of hazardous materials and waste. All hazardous material would be stored in designated hazardous waste storage areas. These areas would be properly identified, with posted signs containing wording with appropriate safety warnings (e.g., "No Smoking"). All hazardous waste storage areas would be maintained and operated to minimize the possibility of fire, explosion, or a release of hazardous waste to the air, soil, or surface water that could threaten human health or the environment.

Hazardous waste storage areas would be equipped with proper disposal containers, in compliance with USDOT specifications. Storage containers include, but are not limited to, biohazard bags and containers, various USDOT-approved drums (e.g., fiber, metal closed top, metal open top, and plastic open top), non-USDOT specification totes provided by the disposal facility, and USDOT specification cubic yard boxes. These containers would be packaged, labeled, and marked in compliance with applicable RCRA and USDOT regulations and the requirements of the treatment, storage, and disposal facilities. The waste containers would be inspected for proper, non-leaking condition of the containers; that all covers, bungs, and gaskets are tight and sealed; and that all required markings and labels are present.

Containment areas would be provided for each of the chemicals that would be used in bulk volume at the Project site (Figure 4.19-1). Containment structures are designed to hold 110 percent of the volume of the largest storage vessel for each chemical plus stormwater for a 100-year, 24-hour storm event if the facility is open to the sky. Separate containment areas for each storage vessel are part of the design; they would segregate the chemicals in the event of multiple simultaneous leakage or failures of the storage vessels.

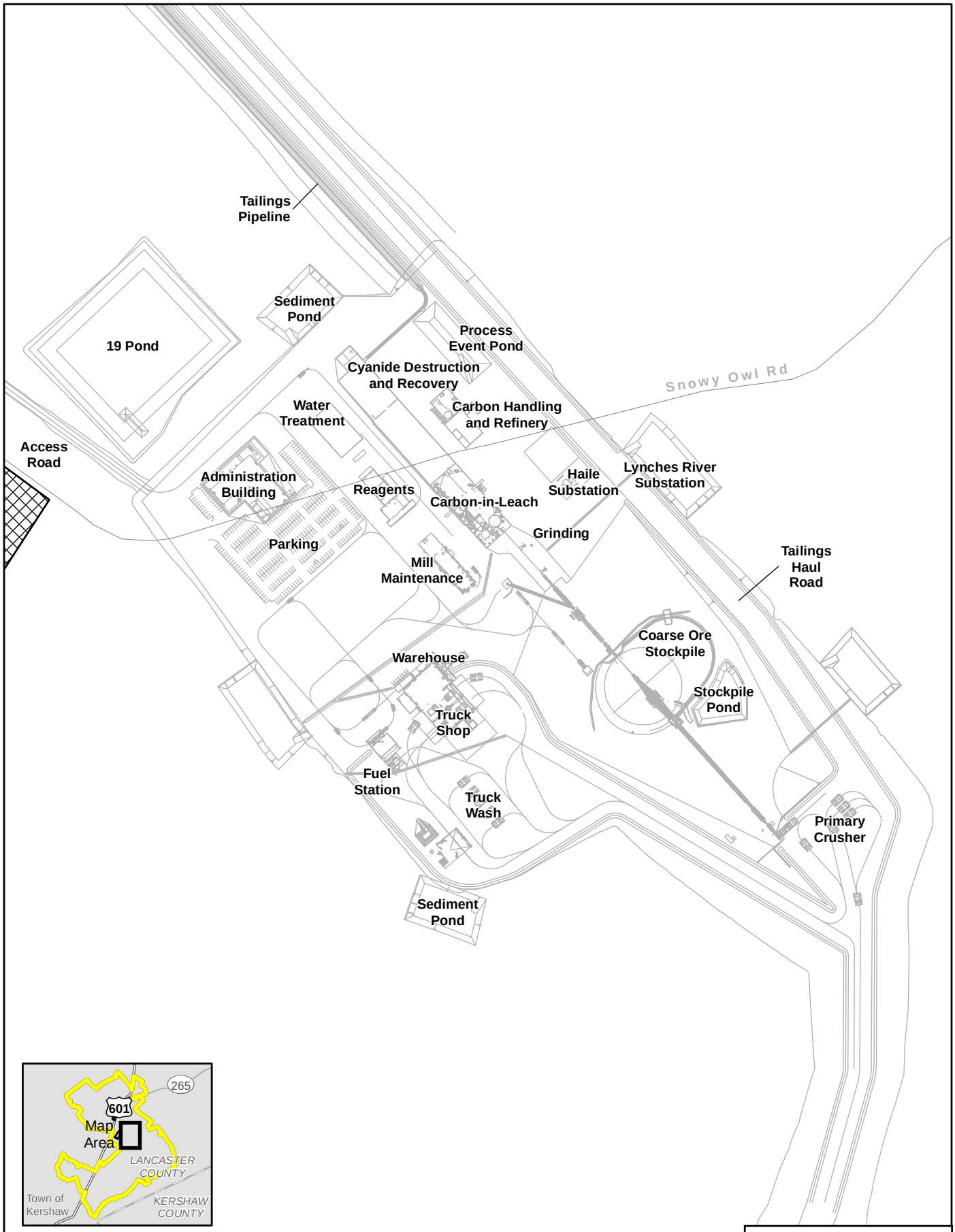

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Figure 4.19-1

Mill Site Plan

0 200 400 Feet
0 50 100 Meters

Coordinate System:
NAD 1983 State Plane feet

Sources: ESRI 2008, Haile 2012.

Legend

- Project Boundary
- Not Part of Project
- Mill Site
- County Boundary

Fueling materials would be stored in aboveground storage tanks at the plant site to support mining equipment operations. Materials would be stored in the truck shop and warehouse area. A fixed filling station would be used to service vehicles and some mining equipment. Related lubricants and solvents would be stored in the truck shop and warehouse area at the site. The Applicant currently has in place an SPCC Plan to prevent the release of oil into the environment. The SPCC Plan implements additional Project features and spill control measures, as required by the Oil Pollution Prevention Act (40 CFR 112).

In the event of a spill that exceeds a facility's containment capacity, the overflow would drain to a Process Event Pond, which is designed to act as a failsafe in the event that individual containment systems have insufficient capacity. The Process Event Pond would be an approximately 1.5-million-gallon capacity HDPE-lined pond to handle overflow events of fluids that require treatment. Once the failures have been repaired, or power restored, the material in the Process Event Pond would be returned to the applicable area for processing. Water from a spill or incident that contacts processing reagents would be suitable for use in the closed-loop system, which includes use of process water from the TSF.

Overall, the potential for an accidental release of hazardous material stored within the Project boundary is considered low due to the design features of Project facilities, safety guidelines and plans, personnel training, and transport and storage procedures.

Modified Project Alternative

Potential impacts from an accidental release of hazardous materials and waste stored within the Project boundary under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.19.2.3 Impacts from Transport of Hazardous Materials in the Project Area

This section addresses transport of hazardous materials in the Project area. The Hazardous Materials Transportation Act and the PHMSA regulate the transportation of hazardous materials by vendors outside the Project area.

No Action Alternative

Under the No Action Alternative, ongoing exploratory drilling to further define the extent of mineral reserves would cease, and associated transport of hazardous materials and waste would discontinue. There would be no risk of an accidental release of hazardous materials in the Project area associated with transport under the No Action Alternative.

Applicant's Proposed Project

Impacts from release of hazardous materials during transport within the Project boundary could be caused by a vehicular accident or pipeline breach. To prevent potential impacts due to vehicular accident, the Applicant would ensure that personnel operating equipment are properly trained as required by appropriate regulations. Haile would enforce a low speed limit for all traffic on roads in the Project area to reduce the potential for vehicular accidents.

The tailings slurry would be transported via pipeline along the TSF haul road to the TSF, where it would be discharged. Process water accumulated in the TSF Reclaim Pond would be transported back to the Mill through a return flow pipe. Potential impacts due to a breach in the pipeline system are possible but unlikely because the system is designed as double-contained pipeline, involving either a pipeline within a pipeline, or a pipeline within a lined containment structure or trench. Should a failure of the pipelines

occur, or in the event of a prolonged unplanned power outage, the material from the pipelines would drain to the Process Event Pond. Benches would be constructed along the interior embankment for secure placement of the pipeline.

An *Operations, Maintenance, and Inspection Manual* (AMEC 2012) has been prepared for the TSF. This manual serves as an operating guide for initial, normal, and emergency operating procedures for the TSF. The manual includes procedures for component failure, such as leakage through liners, blockage of pipeworks, and pump and pipeline failures. Daily, weekly, quarterly, and annual inspections and maintenance of the TSF and its operational components, including the pipeline, also are included in the manual.

Overall, the potential for an accidental release of hazardous material from transport within the Project boundary is low because of the design features of Project facilities, safety precautions and plans, and transportation requirements.

Modified Project Alternative

Potential impacts from an accidental release of hazardous materials and waste transported within the Project boundary under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.19.2.4 Impacts from Disposal of Hazardous Materials

No Action Alternative

Under the No Action Alternative, ongoing exploratory drilling to further define the extent of mineral reserves would cease, and associated disposal of hazardous materials and waste would discontinue. There would be no impacts from disposal of hazardous materials under the No Action Alternative.

Applicant's Proposed Project

Based on the proposed Project activities, Haile would be classified as a small-quantity generator of hazardous wastes; Haile would be required to file for a hazardous waste identification number from the USEPA, and register as a hazardous waste generator with the SCDHEC. The Applicant's Solid and Hazardous Waste Management Plan (Haile 2011) includes proposed methods for disposal of hazardous materials.

Disposal and transportation of hazardous materials to a location outside the Project boundary would comply with 40 CFR 262 Subparts B, C, and D, and the Applicant's company policy. Hazardous materials would be disposed of only in properly permitted treatment, storage, and disposal facilities. The approved hazardous waste containers would be transported out of the Project area by personnel trained as specified in 49 CFR 179 Subpart H and in a USDOT-approved transport vehicle for each specific classification of hazardous material. The Applicant would contract only with licensed and qualified vendors to transport hazardous materials to an appropriate disposal facility.

Potential impacts from disposal of hazardous waste are considered negligible because of the measures that would be implemented by the Applicant to ensure that hazardous materials and waste are properly disposed of.

Modified Project Alternative

The potential impacts from disposal of hazardous materials and waste under the Modified Project Alternative would be the same as those described for the Applicant's Proposed Project.

4.19.3 Impact Summary

Table 4.19-1 presents a summary of potential impacts related to hazardous materials and waste under each alternative.

Table 4.19-1 Summary of Impacts on Hazardous Materials and Waste

	No Action Alternative	Applicant's Proposed Project	Modified Project Alternative
Handling hazardous materials	Ongoing monitoring of the reclaimed sites would continue in accordance with previous permit requirements, which would require the use of some hazardous materials such as diesel fuel.	Training requirements and safety precautions would be in place to ensure proper handling of hazardous materials and waste, resulting in low potential impacts.	Same as Applicant's Proposed Project.
Storage of hazardous materials in the Project area	Ongoing monitoring of the reclaimed sites would continue in accordance with previous permit requirements, which would require the use of some hazardous materials such as diesel fuel.	Design features of Project facilities, safety guidelines and plans, personnel training, and storage procedures would reduce potential accidental releases of hazardous materials within the Project area, resulting in low potential impacts.	Same as Applicant's Proposed Project.
Transport of hazardous materials in the Project area	Ongoing exploratory drilling to further define the extent of mineral reserves would cease, and associated transport of hazardous materials and waste would discontinue.	Design features of Project facilities, safety precautions and plans, and transportation requirements would reduce potential accidental releases of hazardous materials within the Project area, resulting in low potential impacts.	Same as Applicant's Proposed Project.
Disposal of hazardous materials	Ongoing exploratory drilling to further define the extent of mineral reserves would cease, and associated disposal of hazardous materials and waste would discontinue.	Proper disposal measures are in place for disposal of hazardous materials outside of the Project boundary, resulting in negligible potential impacts.	Same as Applicant's Proposed Project.

4.19.4 Mitigation for Hazardous Materials and Waste Impacts

4.19.4.1 Applicant's Proposed Avoidance and Minimization Measures

The Applicant has incorporated Project design features and would implement safety training to minimize and reduce Project-related impacts related to hazardous materials that would be stored, transported, disposed of, and handled—and impacts related to storage and handling of PAG material. The Applicant's Solid and Hazardous Waste Management Plan (Haile 2011) identifies how hazardous materials and waste

on the Project site would be managed. Haile has committed to implementing many of these measures as a part of its proposed MMP (Haile 2013b) (Appendix G).

Applicant-proposed avoidance and minimization measures are summarized below:

- Implement a Solid and Hazardous Waste Management Plan.
- Implement an identification and approval process prior to bringing any hazardous material within the Project boundary.
- Implement an MSDS program.
- Obtain a USEPA identification number.
- Comply with RCRA and SCDHEC requirements for storage and handling of hazardous and toxic wastes.
- Implement waste minimization measures.
- Construct a building designed to store these materials prior to shipping outside of the Project boundary.
- Perform employee training.

These avoidance and minimization measures have been considered in the preceding impact analysis. The complete list of Applicant-proposed avoidance and minimization measures related to hazardous materials and waste is provided in Chapter 6.

4.19.4.2 Additional Potential Mitigation Measures

No additional mitigation measures are being proposed for impacts related to hazardous materials and waste.

4.19.5 Literature Cited

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USEPA. See U.S. Environmental Protection Agency.

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4.20 Connected Actions

Connected actions to the proposed Project include an interconnection to the electrical transmission grid and connections to the water, natural gas, and sewer utilities locally available. As noted in Section 2.3, provision of these interconnections is the purview of the providing utility and not the Applicant. When considering the potential impacts of the connected actions, it is acknowledged that design, construction, and operation details would be developed by the utility in accordance with relevant state and county regulatory requirements. As such, more detailed environmental assessment of the potential impacts of these proposed infrastructure facilities would be conducted by those agencies pursuant to regulatory requirements. In many cases, compliance with regulatory requirements mandates the use of avoidance and minimization measures and other BMPs to reduce environmental impacts. The evaluation of environmental impacts undertaken in this EIS assumes standard configuration and construction techniques for the overhead electric transmission line and burial of the pipeline connections for the remaining utilities.

4.20.1 Electric Transmission Line

Central Electric would construct a new 69 kV overhead power line and a 69 kV/24.9 kV substation to serve the proposed Project. The new connecting 69 kV line would be approximately 4.5 miles (7.2 kilometers [km]) long and would be routed along an existing power line and existing roads. This route would generally be the shortest route between the point of interconnection and the substation (see Figure 2-2). The transmission line would be constructed within a 70-foot-wide right-of-way and would generally run within or alongside the existing Duckwood Road and US 601 utility right-of-way. Haile would deed to the Lynches River Rural Electric Cooperative (LRREC) approximately 0.5 acre of land adjacent to the Mill Site for construction of the Lynches River substation.

In accordance with state regulation, Central Electric would conduct an environmental review process to assess potential impacts of the proposed electric transmission facilities on existing environmental resources, along with measures for avoidance or mitigation, in the event that impacts would occur. Potential impacts from construction and operation of the interconnecting electric transmission line and substation could include the following:

- **Geology and Soils –** Direct impacts on soils would result from vegetation clearing, grading, and compaction of soils by heavy equipment at the location of transmission towers during tower installation and stringing and tensioning conductors, and at the proposed substation site. Soils around the base of structures would be temporarily disturbed and may be compacted but would stabilize as vegetation becomes re-established on bare soils. To the extent that access roads for construction and inspection and maintenance are not available, additional grading and exposure of soils would occur during road construction. However, the road surface would be configured to prevent long-term erosion and impacts on water quality.
- **Water Resources –** A small area of bare soil would be temporarily exposed during construction at each transmission line structure site and at the proposed substation site. This may generate a small amount of temporary erosion but is unlikely to affect water quality in nearby streams. Development of needed construction and inspection and maintenance roads would include surface materials to minimize soil erosion and potential impacts on water quality.
- **Wetlands –** Transmission towers, access roads and substation site would be sited to avoid disturbance of wetlands.
- **Aquatic Resources –** Transmission towers, access roads and the substation site would not be located in or adjacent to aquatic resources. To the extent that increased erosion during runoff occurs, minimal

temporary impacts on water quality may result. However, BMPs typically are implemented during construction to minimize erosion, impacts on water quality, and impacts on aquatic resources.

- **Terrestrial Resources –** Clearing of the transmission right-of-way for safety and inspection and maintenance may include removal of trees and large shrubs, leaving only low-lying vegetation under the transmission line. In some locations, an access road may be required to support construction and maintenance and inspection activities. Impacts may include loss, alteration, and fragmentation of wildlife habitat; mortality of wildlife from construction and operations activities; mortality or injury of birds from electrocution and line strikes; and indirect disturbance of wildlife from construction activity and noise.
- **Federally Listed Species –** Typically, impacts on federally listed species are avoided by rerouting the transmission line route or conducting work outside of nesting and rearing seasons. It is likely that surveys for TEC species would be carried out during the environmental review process.
- **Socioeconomics –** Minor positive impacts on the regional economy may occur during construction through the local procurement of labor and materials, indirect employment, and payment of taxes. Because the construction workforce would be small and typically would already be in place, growth-inducing effects are unlikely from this construction activity.
- **Land Use –** Construction of the transmission line would cross approximately 37.9 acres within the right-of-way. Forested land would be the primary land use affected, as shown in Table 4.20-1, because trees within the right-of-way would be removed. All other land uses could coexist with the transmission line (except for the location of the transmission towers), and the existing use would not be affected.

Table 4.20-1 Land Use within the Transmission Line Right-of-Way

Land Use	Acres Affected
Forested land	14.2
Developed land	11.8
Grass/scrub shrub	5.7
Agricultural land	4.0
Waterbodies	1.5
Barren land	0.7
Total	**37.9**

Note: Acreages assume a 70-foot-wide right-of-way.

- **Transportation –** Increased truck traffic may result in minimal localized delays on roads used during construction of the transmission line.
- **Cultural Resources –** Typically, impacts on cultural resources are avoided by rerouting the transmission line route to avoid sensitive resources.
- **Visual Resources and Aesthetics –** Temporary impacts may occur from construction activities, including replacing structures, working on access roads, clearing vegetation, constructing the substation and storing construction equipment. Permanent impacts may occur from creation of a cleared linear corridor and the presence of transmission towers and conductors in the landscape.
- **Recreation Resources –** The transmission line is not proposed to be routed through any parks or other recreation amenities.

- **Air Quality –** Construction activities have the potential to increase particulate matter, CO, NO_X, and VOC emissions on a temporary, localized basis from the operation of heavy equipment.
- **Noise –** Construction activities would likely result in short-term and intermittent noise impacts as construction progresses along the transmission line right-of-way.
- **Health and Safety –** Potential health and safety impacts would be associated with the use of heavy equipment; construction traffic entering and traveling across the transmission line right-of-way; and potential exposure to hazardous materials, such as fuels and lubricants during construction.
- **Hazardous Materials and Waste –** Use of construction equipment containing hazardous materials (e.g., fuel, coolants, hydraulic fluids, brake fluids, and other chemicals) includes the potential for accidental release of toxic materials into the environment from improper use, storage, or disposal of these materials.

Central Electric would follow standard procedures for siting and construction of transmission projects to minimize impacts from the transmission line, and to be in compliance with 7 CFR 1794 and other relevant state and county requirements and regulations, as appropriate.

The design of substations and distribution and transmission lines for the Project would follow the guidelines established in the Rural Utilities Service (RUS) substation design and transmission line design handbooks (RUS 2001, 2009) and in the *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006* (APLIC 2006) for the protection of birds from electrocution and line strikes. With implementation of the avoidance and minimization measures committed to by the Applicant, along with the requirements of 7 CFR 1794 and other relevant state and county requirements and regulations, the proposed electrical transmission line likely would result in overall negligible impacts on environmental resources.

4.20.2 Supporting Infrastructure Facilities

The proposed connecting natural gas pipeline, potable water line, fire protection water line, sewage line, and associated tie-ins for these supporting infrastructure facilities are located almost entirely within existing roadway rights-of-way adjacent to the Project area (see Figure 2-3). Interconnection with these facilities would therefore result in limited impacts on environmental resources because of the highly disturbed nature of these areas. No wetland or stream impacts would occur from these facilities. It is anticipated that compliance with the requirements of relevant state and county requirements and regulations, and implementation of any appropriate avoidance and minimization measures and BMPs, the proposed supporting infrastructure facilities would result in overall negligible impacts on environmental resources.

4.20.3 Literature Cited

APLIC. See Avian Power Line Interaction Committee.

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Rural Utilities Service. 2001. Design Guide for Rural Substations. (RUS Bulletin 1724E-300.) U.S. Department of Agriculture. June. Website:

http://rurdev.sc.egov.usda.gov/SupportDocuments/UEP_Bulletin_1724E-300.pdf. Accessed on December 4, 2013.

Rural Utilities Service. 2009. Design Manual for High Voltage Transmission Lines. (RUS Bulletin 1724E-200.) U.S. Department of Agriculture, Rural Utilities Service, Electric Staff Division. May. Website: http://www.rurdev.usda.gov/SupportDocuments/UEP_Bulletin_1724E-200.pdf. Accessed on December 4, 2013.

RUS. See Rural Utilities Service.