Appendix P

Haile Gold Mine EIS

Comments Received on the Draft EIS

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APPENDIX P2

APPLICANT RESPONSES TO COMMENTS RECEIVED ON THE DRAFT EIS

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P2 APPLICANT RESPONSES TO COMMENTS RECEIVED ON THE DRAFT EIS

Appendix P2 contains the Applicant's responses to comment submittals received on the Draft EIS. The Applicant was provided with all comments (with personal information redacted in the case of public comments), and their responses were received by the USACE from May 22, 2014 through June 4, 2014. Table P2-1 contains a log of the Applicant's responses to comments made on the Draft EIS.

Table P2-2 Log of the Applicant's Response to Comments Received on the Draft EIS

Response Item No.	Response to Comment Submittal No	Response
A	4,7,12,46,49	Haile Response to Public Comments on Draft EIS
B	50	Haile Supplemental Response No. 1 to SELC Draft EIS Comments
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G	50	Haile's Response to SELC Exhibit B (Myers Report) May 22 2014
H	50	Exhibit 1 to SELC Comment No. 3, Analysis of Closure Model Baseflows
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J	59	Haile Response to USEPA Comments on Draft EIS
K	59	Exhibit 1 to USEPA Comment No 4, Composite Liner Systems Evaluation
L	61	Haile Response to NMFS Draft EIS Comments
M	60,80	Haile Response to USFWS and DOI Draft EIS Comments
N	70	Haile Response to SCDNR Comments on Draft EIS
O	71	Haile Response to Richland County Council Draft EIS Comments
P	79	Haile Response to COSCAPA Comments to Draft EIS

The following are copies of the Applicant's responses to comments on the Draft EIS.

Haile Gold Mine, Inc.'s Response to the Public Comments Received by the United States Army Corps of Engineers on the Haile Gold Mine Draft Environmental Impact Statement

Submitted June 4, 2014

Haile Gold Mine, Inc.'s (Haile) Response to the Public Comments Received by the United States Army Corps of Engineers (USACE) on the Haile Gold Mine Draft Environmental Impact Statement (DEIS) has been prepared to the best of Haile's ability, based upon information that is currently and reasonably available.

Public Comment No. 1. *The Draft EIS says, "The Duckwood TSF and Johnny's PAG would need to be maintained in an undisturbed condition for perpetuity ...." Talking of maintaining these facilities, as well as the ore leaching tailings pond "in perpetuity" is a fantasy. While the toxicity of the tailings and active ore will remain toxic essentially in perpetuity, human experience shows that even pharaohs' tombs do not receive attention in perpetuity. Archeologists are finding these facilities in Egypt, and probably elsewhere, which are less than 4000 years old. And, of course, they have been lost (not maintained) for thousands of years. This document should discuss a realistic endpoint to protection and monitoring and what the consequences would be. See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 2nd paragraph.

Haile's Response to Public Comment No. 1. Long-term monitoring of the site will be within the South Carolina Department of Health and Environmental Control's (SCDHEC) regulatory authority, and the DEIS appropriately discloses that any "endpoint" to such monitoring will be based upon site specific conditions at the time. *See also* Haile Response to Yasinsac Comment No. 16, submitted to the USACE on November 11, 2013.

Public Comment No. 2. *"... 60-millimeter HDPE geomembrane ..." 60 millimeters is almost 2-1/2 inches, an extremely thick piece of plastic. Is this correct? If so, is it possible to see a detail drawing of the cross-section of the membrane? See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 3rd paragraph.

Haile's Response to Public Comment No. 2. "60-mil HDPE geomembrane" is not an abbreviation for millimeters. A 60-mil HDPE geomembrane liner is approximately 0.06 inches or 1.5 millimeters thick.

Public Comment No. 3. *In section 2.5.2.8, Water Management Alternatives, there should be a discussion of preferentially using runoff from the Johnny's PAG for make-up for the ore/tailings processing. This is somewhat the most-contaminated runoff on the site, except tailings. Therefore, treatment and discharge of the water will lead to greater contaminant discharges from the treatment system to the stream than if this water is recycled with tailings water recycling so that other runoff from less-contaminated areas is treated and discharged. The improvement in the quality of the discharge would merit a segregated collection (piping) system to allow this runoff to be preferentially used as process water. See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 4th paragraph.

Haile's Response to Public Comment No. 3. *See* Haile Response to Yasinsac Comment No. 14, submitted to the USACE on November 11, 2013.

Public Comment No. 4. *In Table 2-15, regarding impacts, the discussion of groundwater impacts mentions lowering the water table at some points near the project boundary by 25-50 feet. It seems that this estimate does not consider the total lowering of the water table which might occur if wells just off the property boundary are in use. While no potable water well is expected, irrigation wells could be used without breaching the limitations considered by project information. Any such wells would likely have somewhat higher flow rates even than private potable water wells and would likely lead to much greater lowering of the water table than is stated above. Such irrigation wells are unregulated. See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 5th paragraph.

Haile's Response to Public Comment No. 4. There are two locations where the groundwater drawdown is projected to be in the 25 - 50 foot range near the project boundary: 1) West of project in the tracts of land along Hwy 601 (both east and west of Hwy 601), and 2) Southeast of the project between the project boundary and the Lancaster/Kershaw County line. Based upon a review of the Lancaster County GIS web site and Google Earth, there do not appear to be any agricultural lands (that would utilize high volume irrigation wells as suggested by the commenter) in these two areas. An estimated 95% of these lands are wooded. Woodland and timberland typically do not undergo irrigation. In addition, based upon review of the *Water Resources Inventory for Haile Gold Mine (Kennedy Consulting Services, LLC (August 6, 2013),* submitted to the USACE on August 7, 2013, there are three land tracts containing a combined total of 5 wells in these two areas. While the *Inventory* reflects that one of these wells is actively used to water pets and irrigate a garden at a residence, this is not the type of irrigation well that might impact the drawdown. In short, this is a moot comment because there are no irrigation wells (or wells capable of withdrawing large volumes of water) that could enhance the drawdown effects from the depressurization activities at Haile Gold Mine.

Public Comment No. 5. *In Table 2-15, it is mentioned that stream flows at the treated wastewater discharge will be reduced during mining and for some period after mining activity ceases. The stream is to be protected from mining discharges. Therefore, the NPDES permit issued for the mine must protect the stream at the reduced flow rates occurring during mining. See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 6th paragraph.

Haile's Response to Public Comment No. 5. Haile's NPDES permit is within the SCDHEC's regulatory authority, and will be protective of the environment.

Public Comment No. 6. *In Table 2-15, a comment says, "After traveling downgradient through the groundwater systems, interactions of groundwater with the backfilled pits could discharge to lower Haile Gold Mine Creek and the Little Lynches River, potentially exceeding water quality thresholds for certain constituents." Prior to and during backfiliing, alterations necessary to protect the stream from any such "threshold" exceedances should be made to the pits and the backfill. This could, for example, involve adding lime to the backfill. If there is no practical means to allow the groundwater discharge and still prevent stream standards violations, then groundwater pumping and treatment should be maintained to accomplish this in perpetuity (See*

discussion above about "in perpetuity".). See Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 7th paragraph.

Haile's Response to Public Comment No. 6. Backfilled pits will be amended with lime, or other suitable pH buffering material (referred to as lime or lime amendment). Projected constituent levels in groundwater do not warrant pumping and treating in perpetuity. *See* Haile Comment on DEIS Section 4.3.4.2, page 4.3-42, submitted to the USACE on May 8, 2014, for additional information on the projected constituents levels as noted in the DEIS.

Public Comment No. 7. *In Table 2-15, a comment says, "(i) Runoff from watershed disturbances related to construction and operation of Project facilities could cause increased sediment and sediment-associated pollutant loading to Waters of the U.S, although sediment detention ponds would be used to minimize these effects. (ii) Fugitive dust and air emissions from vehicles and heavy equipment also could increase stream sediment and pollutant loads in Waters of the U.S." The fugitive dust mentioned in the statement I designated (ii) above justifies requiring somewhat more-stringent requirements in the facility NPDES permit to control sediment from storm water ponds than is require by the S.C. construction storm water permit. Sediment is one of the most-severe causes of ecological disruptions in S.C. streams. See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 8th paragraph.

Haile's Response to Public Comment No. 7. Per Haile's comment on DEIS Section 4.4.2.4 at page 4.4-20, submitted to the USACE on May 8, 2014, the DEIS overstates potential impacts due to sedimentation as it does not reflect the fact that sedimentation ponds will also be located at the Holly and Hock TSF Borrow Areas. Regarding fugitive dust emissions, these will be adequately controlled pursuant to Haile's Air Permit. *See* Haile's Air Permit, Section D.11 (A) & (B), which was provided to the USACE as RAI 4-PD-04-b on October 31, 2013. As sedimentation and fugitive emissions are adequately addressed in Haile's General Stormwater permit for Industrial Activity and Air Permit, which are within SCDHEC's regulatory authority, current measures are protective the environment.

Public Comment No. 8. *In Table 2-15, a comment says, "Direct discharges from the contact water treatment plant and pit dewatering would likely increase pH and concentrations of total suspended solids, cyanide, arsenic, cadmium, copper, lead, zinc, and selenium in Haile Gold Mine Creek and the Little Lynches River downstream." For there being such a combination of metals in the treated wastewater of the mine, the stream can only be appropriately evaluated by instream biological monitoring requirements in the NPDES permit for the mine. See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 8th paragraph.

Haile's Response to Public Comment No. 8. It is not accurate to infer that any parameter with a permit limit will increase in receiving water, and instream biological monitoring should not be required by SCDHEC on this basis. *See* Haile Comment on DEIS, Section 4.4, page 4.4-19, submitted to the USACE on May 8, 2014.

Public Comment No. 9. *As Table 2-15 mentions that sizeable lengths of streams will be piped to bypass the mining operations, instream reaeration may be required in the pipes or near the end of those stream segments to assure maintenance of dissolved oxygen at or above the S.C.*

stream standard. *See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 10th paragraph.

Haile's Response to Public Comment No. 9. Existing dissolved oxygen levels measured during Haile's aquatic surveys show a wide variation among different reaches, but were generally above 5 mg/L, which is within levels that are typical for blackwater streams. State of South Carolina water quality standards identify a dissolved oxygen level of 4 mg/L as the lower limit for Class A (non-trout) water (USEPA 1988). Although Haile anticipates its dissipating structures will provide adequate aeration, Haile will initially monitor the dissolved oxygen levels prior to the water entering lower Haile Gold Mine Creek to ensure the effectiveness of the dissipation structures in aerating the water.

Public Comment No. 10. *As the tailings storage facility will be maintained and contain highly toxic material in perpetuity and the plastic liner used to protect groundwater has a finite and undefined functional life, leaks can be expected from the TSF. The TSF is located immediately adjacent to a stream, and the stream would be expected to be impacted, at some time, by the leakage. Therefore, instream biological monitoring in perpetuity of the stream adjacent to the TSF must be required to assure safe operation of the mine.* *See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, 11th paragraph.

Haile's Response to Public Comment No. 10. Instream biological monitoring in perpetuity is not required to assure safe operation of the mine. *See* Haile Response to EPA DEIS Comment No. 4, Composite Liner System Evaluation, submitted to the USACE on May 30, 2014.

Public Comment No. 11. *Proposed mitigation for the environmental damage caused by Haile GM is not adequate. The mitigation consists mainly of further protection of properties, much of which have existing protection of conservation easements. Environmental damage by the mine would consist of complete destruction (as wetlands) of about 120 acres of wetlands, elimination of another 758 acres of wetlands by conversion to dry land through lowered water tables (during mining and for some years afterward), and destruction of 5 to 6 miles of stream. The mitigation area, while totaling 4300 acres, does not include any significant amount of creation or recreation (rehabilitation) of wetlands.* *See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, paragraph 12a.

Haile's Response to Public Comment No. 11. Haile's proposed Mitigation Plan adequately mitigates for the direct and indirect impacts of the Project. *See* Haile Response to EPA DEIS Comments Nos. 9, 10 & 12, submitted to the USACE on May 30, 2014.

Public Comment No. 12. *Moreover, the 1100 plus acres of the Cook's Mountain tract are already protected by a conservation easement, so that this action by Haile Gold Mine does not noticeably improve the conservation status of that tract. No credit should be attributed to Haile Gold Mine for this tract.* *See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, paragraph 12b.

Haile's Response to Public Comment No. 12. Inclusion of Cook's Mountain in Haile's proposed Mitigation Plan provides significant conservation benefits. *See* Haile Response to SELC DEIS Comment No. 11, submitted to the USACE on May 30, 2014.

Public Comment No. 13. *Further, the proposed mitigation is greatly diminished in value as it largely does not occur in the basin of the streams affected, nor even in the same major river basin. Therefore, any aquatic, mobile species restricted to the basin of the mine are not protected or augmented at all by the proposed mitigation at Cook's Mountain or Goodwill Plantation, which make up more than 80% of the proposed area for mitigation. See* Public Comment Letter received May 05, 2014 7:0:57 PM by USACE, paragraph 12c.

Haile's Response to Public Comment No. 13. Haile's proposed Mitigation Plan adequately mitigates for the direct and indirect impacts of the Project. *See* Haile Response to EPA DEIS Comment No. 9, submitted to the USACE on May 30, 2014.

Public Comment No. 14. *In the article published by the local paper recently they stated, the impacts on cultural resources would occur where certain cultural resources would be eliminated by construction of the proposed project. Could you define what cultural resources would be eliminated? Does this mean a specific waterway, type of wildlife etc. See* Public Comment Letter received March 20, 2014 1:04 PM by USACE.

Haile's Response to Public Comment No. 14. As described in Section 4.13 of the DEIS, potential impacts to cultural resources include both historic and archeological sites within the Project boundary. Importantly, and as the DEIS reflects, unavoidable adverse impacts to historic properties eligible for listing on the National Register of Historic Places will be adequately mitigated pursuant to the Project Memorandum of Agreement and associated Cultural Resources Management Plan.

Public Comment No. 15. *It…states in the article on page 3, "But the report says no one within a two-mile radius of the project relies on wells for drinking water." We have been drinking from our well for over forty years. I would not take any amount of money for it. See* Public Comment Letter postmarked March 22, 2014 and received by USACE March 26, 2014.

Haile's Response to Public Comment No. 15. It is unclear where the referenced well is located. However, based upon consultation with SCDHEC, Haile understands that its state Mine Permit will require that it mitigate for any adverse impacts to private water supply that is determined to have been caused by the Project.

Public Comment No. 16. *How is protecting 4,400 acres, mainly in Richland County, going to help us, the ones whose land will be so horribly impacted? See* Public Comment Letter postmarked March 22, 2014 and received by USACE March 26, 2014.

Haile's Response to Public Comment No. 16. Nothing in the DEIS supports the commenter's statement that private land will be 'horribly impacted.' Haile's proposed Mitigation Plan adequately mitigates for the direct and indirect impacts of the Project. *See* Haile Response to EPA DEIS Comment No. 9, submitted to the USACE on May 30, 2014.

Public Comment No. 17. *The mitigation plan is inadequate. The total lack of restoration or enhancement seems to violate the "no net loss" principle. Further, the bulk of the mitigation assets are located outside the project river basin and/or ecoregion, another apparent violation of the intent of the CWA. I understand the value of high quality preservation, even outside the*

watershed. However, I believe the final mitigation package should be a combination of the original plan (in watershed restoration sites) coupled with the preservation sites. See Public Comment Letter received April 04, 2014 2:15 PM by USACE.

Haile's Response to Public Comment No. 17. Haile's proposed Mitigation Plan adequately mitigates for the direct and indirect impacts of the Project. *See* Haile Response to EPA DEIS Comments Nos. 9, 10 & 12, submitted to the USACE on May 30, 2014.

Public Comment No. 18. *This concern is regarding the current mitigation. This plan does not provide preservation of lands in the same water shed as the land being disturbed. See* Public Comment Letter received April 25, 2014 9:30 AM by USACE.

Haile's Response to Public Comment No. 18. Haile's proposed Mitigation Plan adequately mitigates for the direct and indirect impacts of the Project. *See* Haile Response to EPA DEIS Comment No. 9, submitted to the USACE on May 30, 2014.

Public Comment No. 19. *Mitigation in another watershed ignores the work of the 120.46 acres of wetlands in which they are located. There has been no measurement of their present impact on water quality or quantity, so the value of these wetlands cannot be compared to the value of wetlands in a different watershed. The effect of the loss of these wetlands for the future will be unknown. See* Public Comment Letter received May 06, 2014 4:46 PM by USACE.

Haile's Response to Public Comment No. 19. Haile's proposed Mitigation Plan adequately mitigates for the direct and indirect impacts of the Project. *See* Haile Response to EPA DEIS Comment No. 9, submitted to the USACE on May 30, 2014.

Public Comment No. 20. *In Section 4.2.2.1, Modification of Geology and Soils wetland soils are not discussed. Wetland soils cannot be replaced, not by excavation of the infill or any other method. At the very least, should you be determined to permit this Haile Gold Mine project to move forward, the plan should require constructed wetlands creation and maintenance into perpetuity. Section 6 of the Draft the issue is revisited. Wetlands cannot be rehabilitated, repaired, or restored. See* Public Comment Letter received May 06, 2014 4:46 PM by USACE.

Haile's Response to Public Comment No. 20. Haile's proposed Mitigation Plan adequately mitigates for the direct and indirect impacts of the Project. *See* Haile Response to EPA DEIS Comment No. 9, submitted to the USACE on May 30, 2014.

Haile Gold Mine, Inc.'s Supplemental Response No.1 to the Southern Environmental Law Center et al. Comments Received by the United States Army Corps of Engineers on the Haile Gold Mine Draft Environmental Impact Statement

Submitted May 30, 2014

Haile Gold Mine, Inc.'s (Haile) Supplemental Response No. 1 to the Southern Environmental Law Center (SELC) et al. Comments Received by the United States Army Corps of Engineers (USACE) on the Haile Gold Mine Draft Environmental Impact Statement (DEIS) has been prepared to the best of Haile's ability, based upon information that is currently and reasonably available.

SELC Comment No. 1. *[W]e recommend that the deficiencies noted in the DEIS be addressed in a revised DEIS. A revised DEIS should be made available to the public with another opportunity for comment before the Corps proceeds with a final EIS. See* SELC Comment Letter, p. 3, 2nd paragraph.

Haile Response to SELC Comment No. 1. The perceived 'deficiencies' referred to in this comment do not require a revised DEIS; rather, they are primarily based upon a misunderstanding of the text and documents on the part of the reviewer and thus may be adequately responded to by the USACE in its response to comments. Additionally, any difference in impacts remain within the parameters of impacts evaluated in the DEIS, as uncertainties in modeled impacts are appropriately disclosed therein.

SELC Comment No. 2. *The DEIS incorrectly assumes that all seepage from these acid-generating facilities [i.e., the TSF and Johnny's PAG] is eliminated upon completion of reclamation, and simply states that the seepage will be close to zero. Without adequate water balance modeling of the cover and consideration of potential failures, this is merely speculation. See* SELC Comment Letter, p. 4, 2nd paragraph. *See also* SELC, Exhibit B, page 2, 4th paragraph.

Haile Response to SELC Comment No. 2. The cover proposed for the TSF will consist of a geomembrane (60 mil HDPE) overlain by a suitable soil cover to protect the geomembrane from physical damage and to support vegetation. The TSF cover does not employ a GCL (geosynthetic clay liner) as suggested by Myers. A geomembrane does not have the susceptibility of damage due to weathering or root intrusion that a GCL would have. It is therefore unlikely that a geomembrane-based cover, as proposed, would allow more flux of water than the lower liner simply because there is much less hydraulic head on the upper liner and on the lower liner. As a consequence, it is unlikely that the long-term flux of water to the passive treatment system would exceed the capacity of the passive system.

The mass load model explicitly accounts for seepage through the basal liner (i.e., underlining) of the TSF and JPAG facilities. Leakage through the basal liner is more pertinent to the assessment of water quality effects than the performance of the cover, as stated by Myers. To the extent that draindown of interstitial water or infiltration through the cover exceeds the calculated liner leakage rate, the excess water would be collected and treated in the water treatment plant (and eventually the passive treatment cells).

Haile has performed calculated a predicted leakage rate for the basal liner of the TSF and JPAG facilities based on EPA protocols. See Exhibit 1 to SELC Comment No. 2, TSF and PAG Leakage Rate Analyses. (This Attachment was previously provided by Haile as Appendix E of the *Draft Post-Closure Water Quality Impacts Report* (Schafer, AMEC, and ERC, February 2013) (hereinafter Schafer, AMEC and ERC, 2013).) The underliner for Johnny's PAG has a predicted leakage rate of 0.18 gpm, and the underliner for the TSF has a predicted leakage rate of 0.31 gpm beneath the TSF Reclaim Pond and 0.09 gpm beneath the rest of the TSF (for a total of 0.4 gpm). (Just to clarify, page 86 of the narrative portion of that Report incorrectly stated that the leakage rate for the TSF underliner was 4.4 gpm.)

SELC Comment No. 3. [*SELC*] *believe[s] that modeling errors have led the Corps to underestimate the[] impacts to surrounding streams for two primary reasons. First, it is likely that the largest de-watering impacts to streams in the zone of impact will occur within the first couple of years after mine operations cease because groundwater drawdown will be at its maximum and will continue to expand in area as the pits – both lakes and backfilled areas – recover. During this time period, there will also be no de-watering discharge back into the downstream receiving waters to offset some of the baseflow reductions. See* SELC Comment Letter, p. 4, 2nd paragraph. *See also* SELC, Exhibit B, page 3, paragraph 1.

Haile Response to SELC Comment No. 3. The DEIS adequately discloses predicted impacts to surrounding streams. However, in order to respond more fully to this comment Exhibit 1 to SELC Comment No. 3, Analysis of Closure Model Baseflows provides supporting analysis of baseflow rates and mean total flows at different times during closure, which confirms that the periods assessed in the DEIS (including Year 12 of operations and Year 5 of closure) provide a good approximation of peak flow reductions. While flow reductions in some specific locations may be greater in the initial years of closure, differences are minor.

SELC Comment No. 4. *The DEIS does not provide an adequate comparison of the effects of this proposed project with the no action alternative. … The impacts of a mine include changes due to that mine over the no action alternative, but this DEIS utterly fails to present this comparison. So that the public can compare the changes with time, the DEIS should provide figures of predicted water quality parameters at the compliance point over time through operations and closure for both alternatives. Consideration of just a few times is inappropriate. … Schafer should provide a time series of load, especially for sulfate, from the end of mining to the time the system reaches steady state*." *See* SELC Comment Letter, p. 5, 1st paragraph. *See also* SELC, Exhibit B, Page 4, 1st paragraph and Page 25, 4th paragraph.

Haile Response to SELC Comment No. 4. While it may be possible to develop a continuous time series of predicted water chemistry in groundwater, this approach is unrealistic and confusing in a surface water system. At any point in time, a river or stream may consist of a proportion of water derived from groundwater contributions (e.g. baseflow) and another from surface runoff. These waters will vary in chemistry. The proportions of baseflow and surface runoff will vary erratically over short time periods (e.g. over hours to days). As a consequence, predicted chemistry would be erratic, and therefore would mask any potential effects from the mine. The presentation of water quality effects in *Preliminary Pit Lake Hydrology and Water Quality Results (Schafer Limited LLC,* December 11, 2013) (hereinafter Schafer 2013a), *Preliminary Little Lynches River Water Quality Results* (Schafer Limited LLC, December 13,

2013) (hereinafter Schafer 2013b), and related Schafer Technical Memoranda is far more clear in that it presents the predicted chemistry for specific flow durations (e.g. low flow and average flow conditions), which captures the low to median flow time periods when loads from the mine would have their greatest effect on water chemistry. Also, the analysis focuses on the time periods (e.g. Year 13) when cumulative loading from the mine facilities will be at their peak. It would not serve the public's interest to create a large number of potentially confusing graphs that would mostly serve to mask the effects of the mine contribution to overall chemical loading.

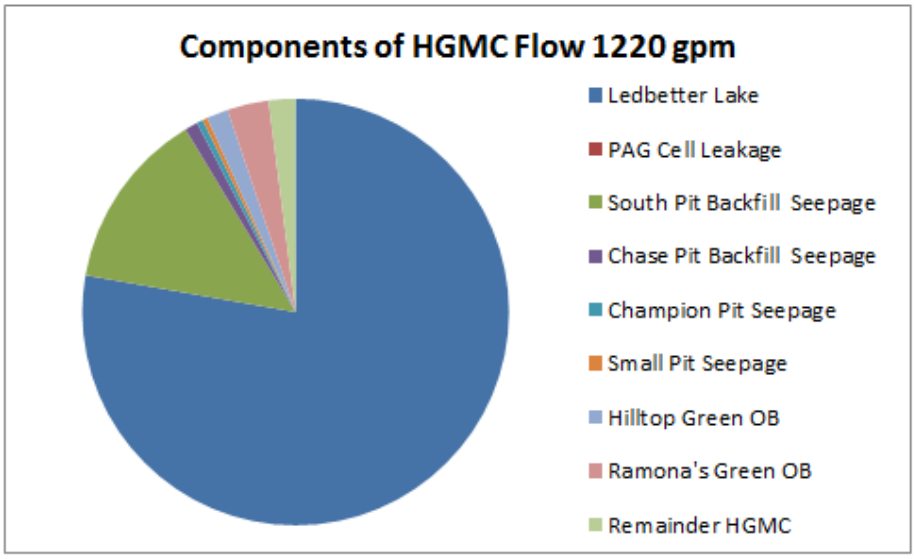
As requested, a series of time series were developed to show how the predicted water chemistry and flows vary through time in the water quality simulation. The two largest sources of flow and sulfate load from the mine are the Ledbetter Pit Lake and seepage from the South Pit backill. See Figures 1 and 2 below (Schafer 2013b). The Figures illustrate the predicted concentrations and loading for year 13 and year 75. In year 13, Ledbetter Pit Lake is the primary sulfate load while South Pit seepage dominates by year 75. (The sulfate loading in Schafer 2013b is a model solution using randomly selected stochastic variables while the sulfate loading below is an "expected value" based on median data inputs that are at the median of the input range. Consequently, the absolute amount of predicted sulfate mass may differ slightly.)

Predicted sulfate concentrations over time are shown for the Ledbetter Pit Lake and the South Pit backfill in Figure 3. Predicted sulfate in Ledbetter Pit Lake is the median value of the stochastic model runs. The predicted sulfate from the pit backfill zone was assumed to remain constant through time, which is conservative because concentrations are expected to decline as groundwater rinses the accumulated sulfate from the backfill zone. The interstitial water in the backfill is expected to be replaced every 16 years (Schafer, AMEC and ERC 2013). As a consequence, actual sulfate levels in the backfill should begin to decline about 12 to 16 years after refilling with groundwater:

> Page 91, Schafer, Amec and ERC 2013 - "Based on the volume of the backfill and the groundwater flux predicted in MODFLOW, the amount of time required or 1 pore volume of water to move through the backfill can be calculated (Table 20). Assuming 32 % porosity, 16 years will be required to rinse the South Pit and 21 years in Chase backfill. Effective porosity is usually less than 32 % so rinsing may progress more quickly. "

Predicted rinsing would occur more rapidly in the Cardno model.

The predicted loading to HGMC (Figure 4) was determined by multiplying the flow contribution to HGMC by the concentration. The highest combined loading occurs in Year 13 and Ledbetter is the most significant sulfate source from year 13 to year 32 after which South Pit seepage is the dominant sulfate source.



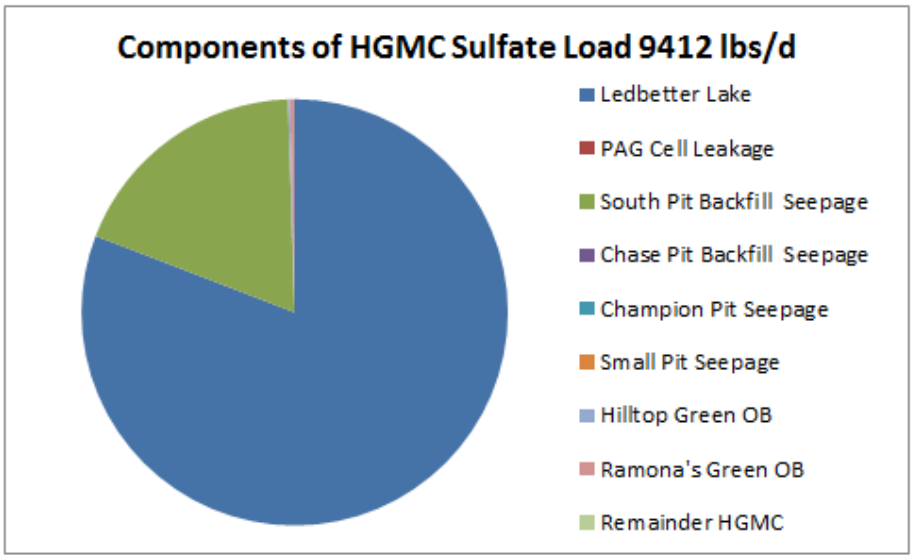


Figure 1. Contribution of flows and sulfate load in HGMC for Year 13.

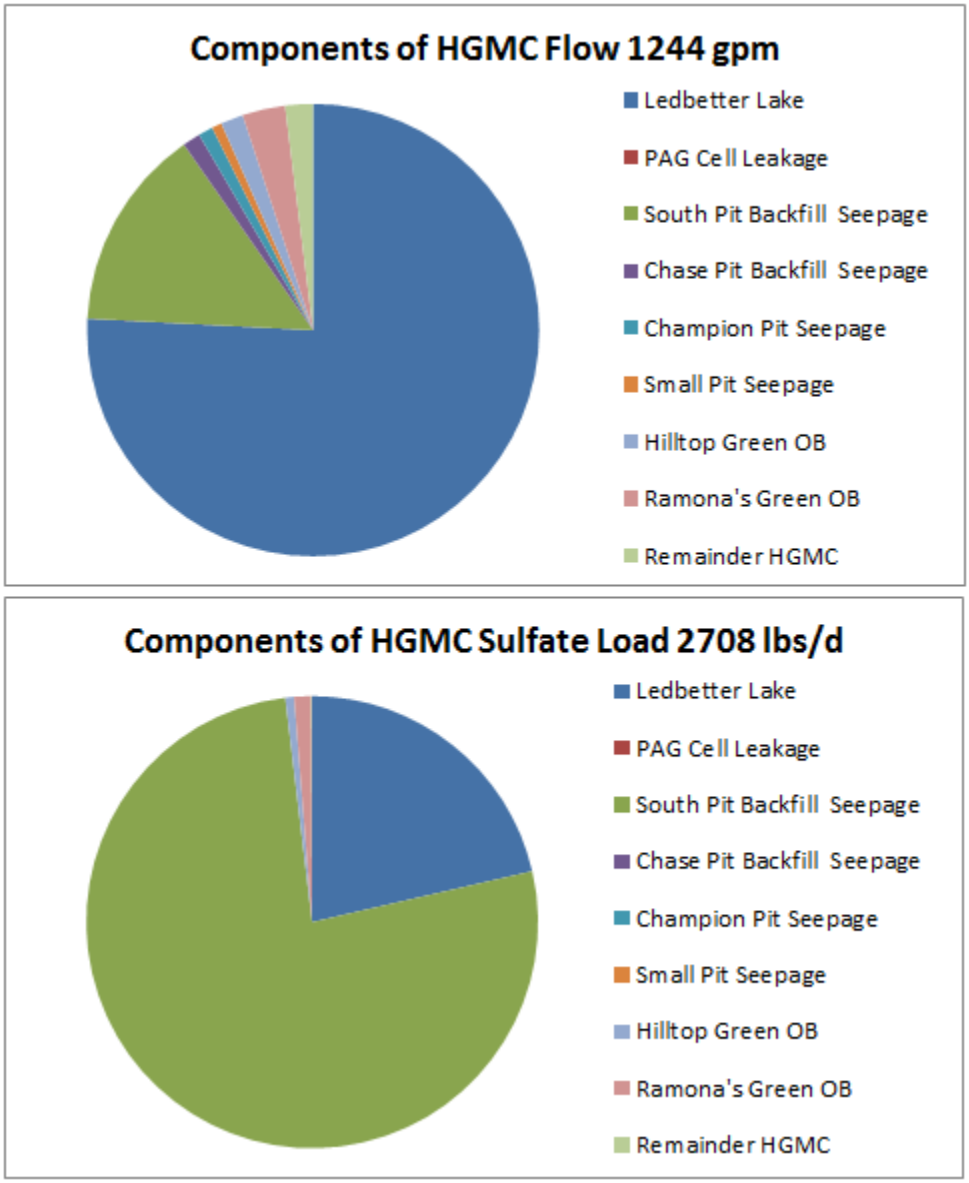


Figure 2. Contribution of flows and sulfate load in HGMC for Year 75.

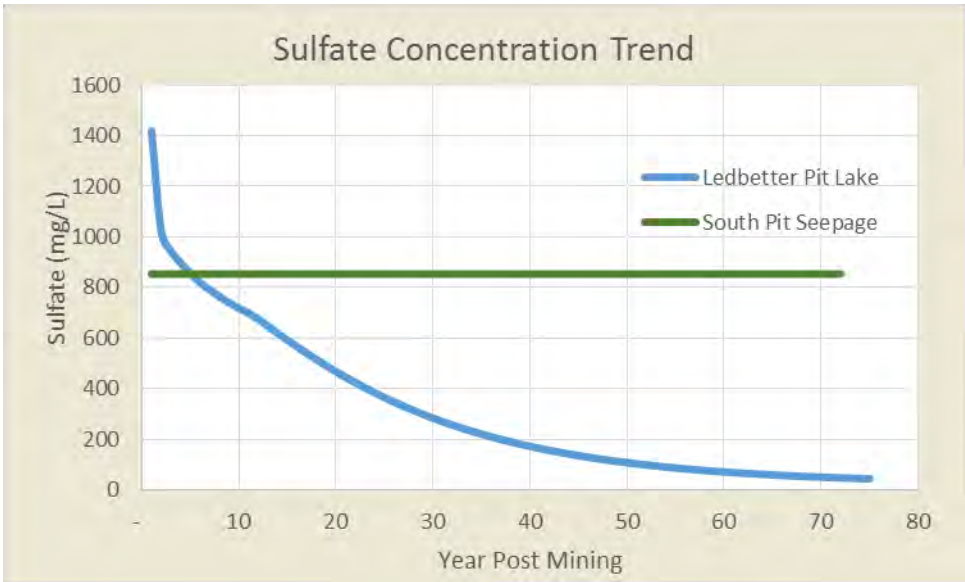


Figure 3. Predicted sulfate in Ledbetter Pit Lake and in South Pit seepage through time.

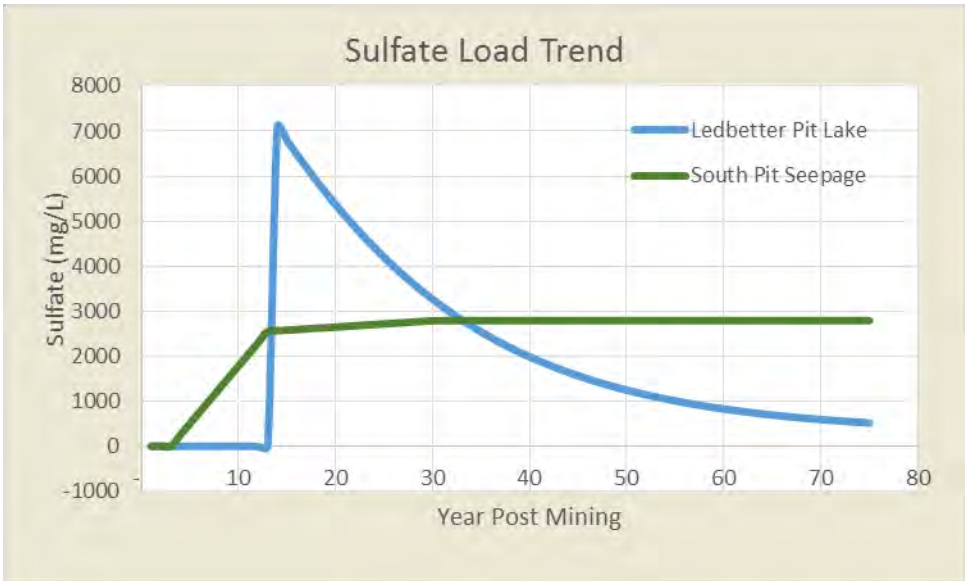


Figure 4. Predicted sulfate loads in HGMC from Ledbetter Pit Lake and South Pit seepage through time.

<u>SELC Comment No. 5.</u> *The DEIS assumes too much dilution of the loads leaving the sources and reaching the confluence point, and is not transparent with respect to which dilution factor is applied for each water quality parameter. Dilution results primarily from natural recharge on the site, but this DEIS does note account for the large portion of the mine site that will be covered with mine facilities and no longer contributing to* natural recharge . . . The water quality analysis at the confluence of Haile Gold Mine Creek and Little Lynches River should be redone correctly accounting for recharge and flows through the site. *See* SELC Comment Letter, p. 5, 2nd paragraph. *See also* SELC, Exhibit B, page 4, 4th and 5th paragraphs.

Haile Response to SELC Comment No. 5. The statement that the Surface Water mass Load model failed to properly account for dilution from the unmined watershed is untrue. The model does not overestimate the dilution from recharge in the watershed as stated by Myers. A few illustrations may serve to clarify this point. Figure 5 shows the components of flow in Haile Gold Mine Creek (HGMC) for year 13 and median (50%) flow.

For the pre-mining condition in HGMC, the median flow was estimated to be 1,109 gpm. For the post-mining conditions in Year 13, median flows in HGMC were estimated to be slightly higher at 1,220 owing to the slight increase in baseflow that occurs due to the effects of Ledbetter Pit Lake. Ledbetter serves as a drain, collecting contributions of groundwater and discharging much of this water to HGMC. This has the effect of increasing flow rates during median and low flow conditions. The effect is most pronounced at the lowest flow regimes.

The contribution of natural recharge used in the mass load model was only 24.91 gpm out of the total flow of 1,220 gpm. All remaining flows were derived from mine-related facilities including Ledbetter (953 gpm), South Pit seepage (166.8 gpm), and smaller amounts of flow from the Green Overburden Storage Areas, backfilled pits, and smaller pit lakes. For pre-mining conditions, of course, the entire flow in HGMC was assumed to represent natural recharge (1,109 gpm). So the modeled conditions reflect an 85 % reduction in recharge due to interception of groundwater by the mine facilities.

Figures 6 and 7 show similar results for the simulated HGMC water balance for the 10 % and 1 % flow duration in Year 13. The contribution of natural recharge was 0.39 gpm out of a total flow of 319 gpm for the 10 % flow duration and was 0.02 gpm out of a total flow of 176 gpm for the 1 % flow duration.

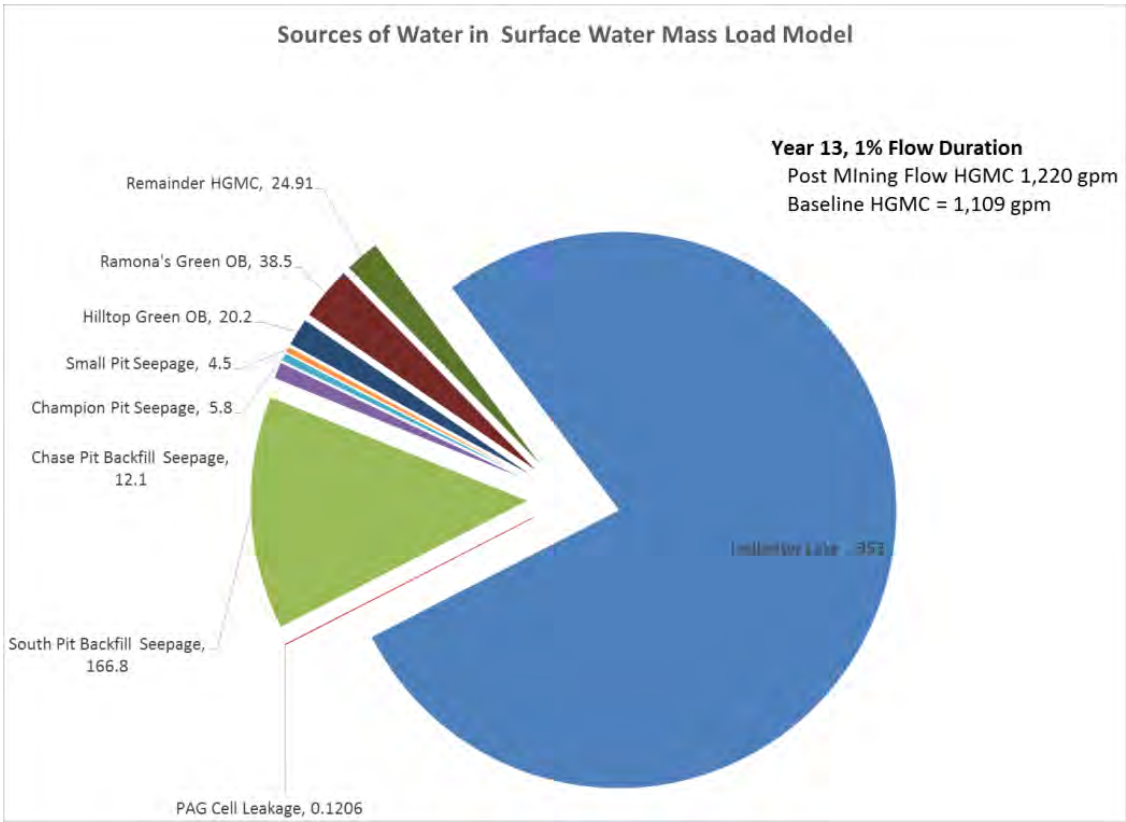


Figure 5. Modeled post-mining flows in HGMC for Year 13 and 50 % flow duration.

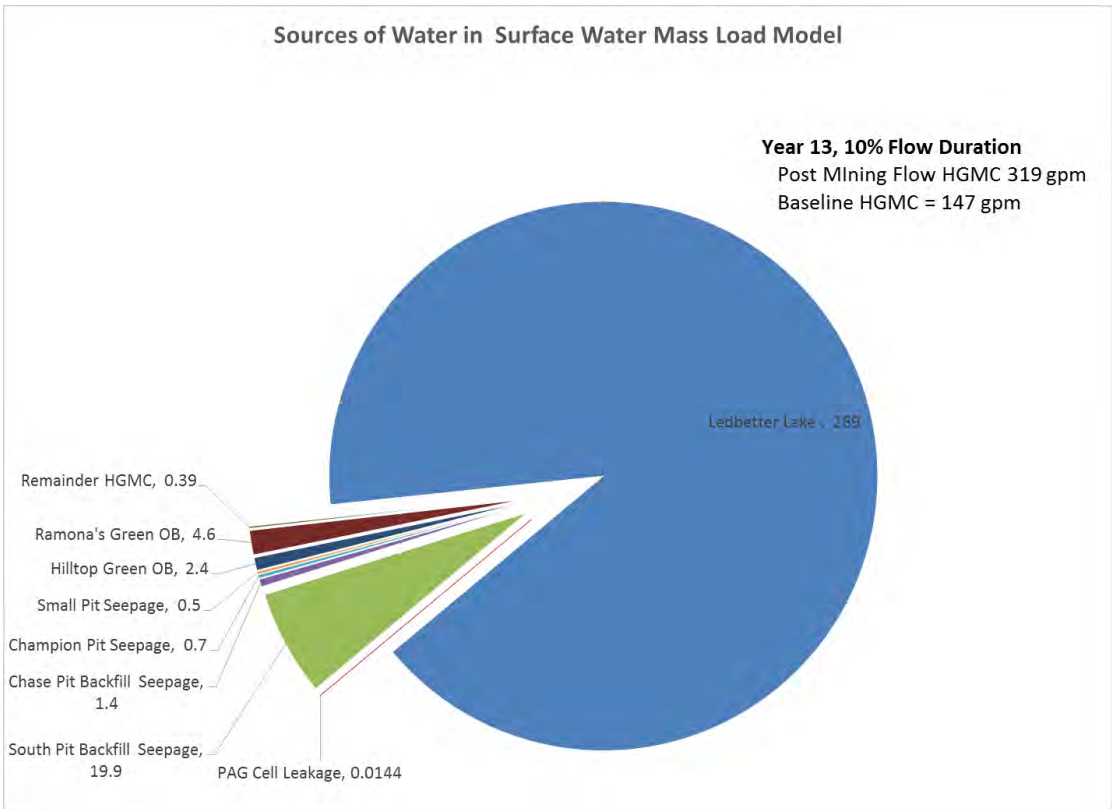


Figure 6. Modeled post-mining flows in HGMC for Year 13 and 10 % flow duration.

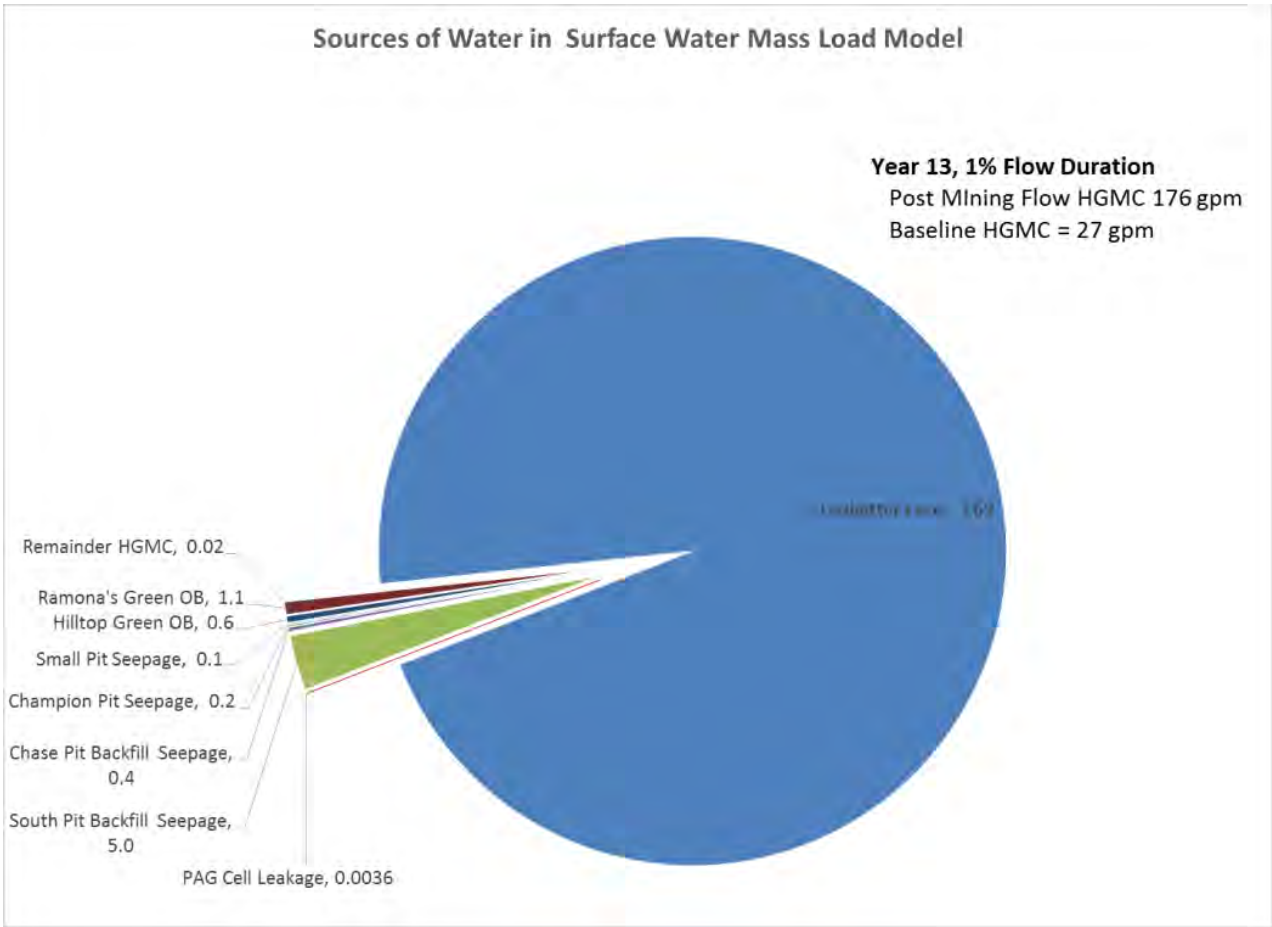


Figure 7. Modeled post-mining flows in HGMC for Year 13 and 1 % flow duration.

<u>SELC Comment No. 6.</u> *[SELC has] significant concerns about water quality impacts in light of the information presented in the DEIS. In discussing the cumulative impacts of the project, the DEIS acknowledges that "[w]ithin the watershed context of the upper Little Lynches River, the proposed Project and the alternatives have the potential to contribute incrementally to cumulative water quality degradation." DEIS at 5-12. Specifically, "[t]he proposed Project and alternatives have the potential to contribute additional loadings of nutrients, and at times low flows, which would contribute indirectly to additional biological oxygen demand downstream in the Little Lynches River." Id. Additionally, "[c]oncentrations 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." Id. at 4.4-19. Finally,"[d]ecreased streamflows during dry, warm conditions could lower dissolved oxygen concentrations as water becomes warmer and more stagnant," "affect[ing] nutrient transformations and algal growth and decay, leading to eutrophication 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." Id. at 4.4-20. See* SELC Comment Letter, p. 5-6.

Haile Response to SELC Comment No. 6. The SCDHEC discharge permit for the contact water treatment plant, referenced in the DEIS, appropriately deals with discharges, including potential cumulative impacts of discharges and seasonal changes to the receiving waters. Per Haile's comments on the DEIS (submitted May 8, 2014), the section cited in the SELC Comment Letter (re: watershed impacts) contained many misleading statements which were inconsistent with other parts of the DEIS. Haile also commented that it is inappropriate for the DEIS to suggest that water chemistry concentrations that are permissible under State programs will have adverse impacts to surface water quality. Specifically, Haile recommended the following language should be added after the sentence quoted above from DEIS, 4.4-19: "However, discharge from the water treatment plant would likely increase pH even though the pre-mining pH condition is lower than State standards (thereby improving the pH levels), and concentrations of arsenic, cadmium, copper, lead, mercury, zinc and selenium are expected to be below standards in either discharge stream. Importantly, these discharges will be regulated under an NDPES permit issued by SCDHEC."

Per Haile's comments on the DEIS at page 4.4-15 (submitted May 8, 2014), Haile believes that the DEIS is inaccurate in its assessment of temperatures in Haile Gold Mine Creek. Pit depressurization water will likely to be cooler than the receiving surface water during summer months. Traveling through pipes may heat this water, somewhat offsetting some of this difference; however; it is likely that the discharge will be cooler than the receiving water during summer months.

SELC Comment No. 7. *[The DEIS states:] "In 2004, Haile Gold Mine Creek was listed as impaired for aquatic life use because of low pH levels." Id. at 5-11, 12. It was then removed from the State's 303(d) impaired waters list in 2004 because "the State deemed that the low pH was caused by natural conditions." Id. The Corps should provide a more thorough explanation of what the "natural conditions" were that justified this delisting*. *See* SELC Comment Letter, p. 6, 2nd paragraph.

Haile Response to SELC Comment No. 7. Per Haile's Comments on the DEIS (submitted May 8, 2014), page 3-19.2, The HGMC site was not placed on the list. Rather, PD-344 on HGMC was placed on the list. EIS should be clarified to state: "In 1994, 2 years after mining ceased at the Project site, PD-334 on HGMC was placed on the State's list of impaired waters (Section 303[d] list) based on pH and toxics sampling results from monitoring station PD-334."

As provided in Haile Response to RAI 3-WQ-14, submitted to the USACE on Aug. 13, 2012, Haile stated:

> HGMC was originally listed on the 303(d) list for impaired waters in 1994; the reason as listed was 'pH, Toxics.' It is likely that the 'toxics' were tied to detections of several metals at PD-334, including chromium, copper, cyanide, iron, manganese, nickel, and zinc. Monitoring of HGMC at PD-334 was maintained by the state through 1998 and also by Kinross, and later Haile, during and beyond that time. In 2003, Haile supplied SC DHEC with twenty years of monitoring data on the low pH of the water upstream of the mine. HGMC was subsequently removed from the

303(d) list in 2004, reflecting the fact that the EPA and DHEC concurred that the low pH in the basin was a naturally occurring condition unrelated to mining activity.

SELC Comment No. 8. *[Quoting from the DEIS:] "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." DEIS at 4.4-15." See* SELC Comment Letter, p. 6, footnote 3.

Haile Response to SELC Comment No. 8. As noted in Haile's Comments on the DEIS (submitted May 8, 2014), Haile believes that the DEIS is inaccurate in its assessment of temperatures in Haile Gold Mine Creek. Pit depressurization water will likely to be cooler than the receiving surface water during summer months. Traveling through pipes may heat this water, somewhat offsetting some of this difference; however, it is likely that the discharge will be cooler than the receiving water during summer months. Haile believes the DEIS should be edited to more accurately represent anticipated temperature impacts and account for the likely cooling effect of the pit depressurization water. For this reason, Haile believes the comment by SELC is not accurate. For additional information on this, see Haile's Comments on the DEIS, page 4.4-15.

SELC Comment No. 9. *[I]n light of the disclosure in the DEIS that this proposal will impact approximately 1,100 acres of wetlands and 24 miles of streams, the proposed mitigation package simply does not offer enough wetland or stream mitigation to offset the negative aquatic impacts of this proposal. See* SELC Comment Letter, p. 7, 5th paragraph.

Haile Response to SELC Comment No. 9. Haile Response to EPA Comment No. 12 regarding ratios and rationale for ratios comparing proposed mitigation to project impacts.

SELC Comment No. 10. *"In general, the required compensatory mitigation should be located within the same watershed as the impact site, and should be located where it is most likely to successfully replace lost functions and services." 33 C.F.R. § 332.3(b)(1). While we recognize that the significant scale of the mine's environmental impacts may require an outstanding mitigation plan of statewide importance, we urge Romarco and the Corps to propose an augmented mitigation plan that would consider additional mitigation opportunities within the Lynches River watershed in order to protect the communities and ecosystems that will be most directly affected by the mine. See* SELC Comment Letter, p. 8, 2nd paragraph.

Haile Response to SELC Comment No. 10. *See* Haile Response to EPA Comment No. 9 regarding preservation as compensatory mitigation and watershed location, and Haile Response to EPA Comment No. 12 regarding ratios and rationale for ratios comparing proposed mitigation to project impacts.

SELC Comment No. 11. *[A]lthough we agree that the Cooks Mountain property has many significant ecological benefits, it is important to recognize that much of the property is already under conservation easement. According to Romarco's proposed plan, the Cooks Mountain property contains a total of 1,131.8 acres, of which approximately 1,100 acres are already protected under an easement held by Ducks Unlimited's Wetlands America Trust, Inc. Mitigation*

Plan (Appendix B) at 40. The Corps must carefully evaluate this component of the proposed mitigation plan to determine how much mitigation credit should be provided for preserving the additional 30+ acres of this property and adding the additional layers of protection for the other portion of the property. Although this property appears worthy for inclusion within the Heritage Trust Program, the Corps must also ensure that all aquatic impacts of the project are fully compensated. See SELC Comment Letter, p. 8, 3rd paragraph.

Haile Response to SELC Comment No. 11. The value provided by inclusion of Cook's Mountain in the Revised Mitigation Plan is significant. As stated in Haile's Revised Mitigation Plan at pp. 40-41.

> The existing conservation easement ("existing easement") for the Cook's Mountain site is held by the Wetlands America Trust, Inc. Wetlands America Trust is an entity that holds conservation easements for Ducks Unlimited.[1] Ducks Unlimited's primary goal is to conserve, restore and manage wetlands and associated habitat for North America's waterfowl. As such, the existing easement is primarily focused on maintaining aquatic resources for the benefit of waterfowl, and allowing certain recreational activities such as hunting, and development associated with those activities. In addition, the existing easement allows for limited residential development. The most important aspect of the existing easement is that it does not cover the entire site. There is a large parcel of land (30.75 acres) at the top of Cook's Mountain that is not included in the existing easement. This unprotected parcel is zoned RU Rural District, a classification that allows single family detached residential development.[2]
>
> The purpose of the existing easement is to retain the property's "natural, scenic, and open condition . . . for conservation purposes and to prevent any use of the Protected Property which will impact significantly or interfere with the conservation values of the Protected Property, its wildlife habitat, natural resources or associated ecosystem." Existing easement at 4. However, the existing easement reserves a number of rights that may either directly or indirectly impact ecological and cultural resources. Among other things, the easement reserves the right to construct five hunting cabins, two 4,000 square foot residential buildings and associated septic systems, roads, and utilities, docks, a two-acre landfill, a three-acre borrow pit, and "limited commercial or agricultural" use wells. Easement at 6-10. Under the easement, the impoundments are managed for waterfowl and the existing wetlands and water control structures can be replaced. Existing easement at 10. The easement reserves the right to conduct timber harvests and other agricultural activities including the use of chemical fertilizers. Easement at 10-11. Mineral rights are also currently reserved under the existing easement. Existing easement at 13.
>
> Under this mitigation plan, Haile will work with SCDNR and others to improve the protections on the Cook's Mountain Site, to be highly protective of ecological

[1] *See Wetlands America Trust*, available at: http://www.ducks.org/philanthropy/wetlands-america-trust.
[2] Richland County Code, § 26-86 RU Rural District.

and cultural resources, in particular aquatic resources, wildlife, and water quality. *See* Section 3.3, Site Protection. Whereas the current easement does not apply to a 31-acre parcel at the top of Cook's Mountain, the transfer to SCDNR of fee simple title will protect the entire site. No unprotected parcels subject to residential development and related infrastructure will remain on Cook's Mountain. This prohibition on unrestricted development and the likely secondary effects of such development such as utility and road infrastructure, for this 31-acre parcel located at the top of the local drainage area, provides innumerable benefits for habitat, water quality, recreation, and aesthetics.

In addition, the transfer to SCDNR will provide ecological uplift by providing more stringent restrictions on activities than those allowed under the existing conservation easement that currently have the potential to negatively impact ecological and cultural resources. The extensive forested wetland systems located at the site will be protected. The same is true for the network of streams and other watercourses located on the property. Without development in the surrounding catchment, the streams will maintain or be given the opportunity to regain their natural geomorphology. In turn, sediment loads from bank erosion may be reduced providing a local and regional water quality benefit.

Economically, the highest and best use of the site, before and as a reserved right under the existing conservation easement, is for timber production and recreational purposes. Timber assessments of the site document a value in excess of $1,000,000. Improperly managed, timber operations threaten soil stability and potentially can affect water quality of the onsite and downstream aquatic resources.

SELC Comment No. 12. *[I]n previous comments, we noted our objection to statements by Romarco saying that this proposed mitigation plan would adequately offset any future impacts resulting from permit amendments or new permit applications. ... We again urge the Corps to clarify that the proposed mitigation plan would not grant the company a "blank check" covering all future mining activities on the Haile property. See* SELC Comment Letter, p. 8, 4th paragraph.

Haile Response to SELC Comment No. 12. Haile's Revised Mitigation Plan is intended to fully compensate for all impacts of the Project as proposed, including, direct impacts to wetlands and streams within the identified project site as well as indirect impacts both within and outside of the identified Project site.

SELC Comment No. 13. *[I]t is clear that feasible alternative locations exist [within the Carolina Slate Belt region], and the Corps must consider this as part of its NEPA and CWA analyses. See* SELC Comment Letter, p. 10, 1st full paragraph.

Haile Response to SELC Comment No. 13. The USACE has more than satisfied the requirements of NEPA and CWA to consider reasonable and practicable alternatives in the Carolina Slate Belt region. As explained in the DEIS, at the time Haile purchased the Haile Gold Mine site, no sites within the Carolina Slate Belt region had comparable mineralization to that which was known to exist at the Haile site. SELC has identified no conflicting information, or

any specific alternative locations it believes the USACE should have considered. Although other mining companies are currently conducting *exploration* drilling activities in various locations within the Carolina Slate Belt region (Romarco ceased exploration drilling in 2013), none of these locations have comparable mineralization to that which is known to exist at the Haile site. As Haile has explained previously, without, *at a minimum,* known mineralization comparable to the Haile Gold Mine site, alternative locations within the Carolina Slate Belt region are neither reasonable nor practicable alternatives. For further discussion of this topic, see Haile Comment on DEIS, Executive Summary, ES-6, submitted on May 8, 2014; Haile Response to SELC's Comment No.1 on the USACE's Draft Preliminary Report on Alternatives Development and Evaluation (dated August 5, 2013), submitted to the USACE on October 25, 2013.

SELC Comment No. 14. *[T]he Corps' alternative analysis should consider future expansion of the Haile Gold Mine, as well as future mining projects at other locations that are in close proximity to the Haile property. See* SELC Comment Letter, p. 10, 2nd full paragraph.

Haile Response to SELC Comment No. 14. As SELC is aware, the USACE's alternatives analysis must consider only reasonably or practicable alternatives. With respect to possible future mining at the Haile Gold Mine site, including the possibility of underground mining, those events are speculative.[3] There is insufficient detail or specific information about such future mining to reasonably project what impacts such activities might have to allow for a meaningful comparison of alternatives. *See* 40 CFR § 1508.7, defining cumulative impacts. ("T]he impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other action. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." (emphasis added).) The mine plan associated with the current permit application includes 12 years of mining (with additional time before mining for construction of major facilities and two years after mining ceases for processing of the low grade ore stockpile).

With respect to both future mining at the Haile Gold Mine site and future mining projects at other locations that are in close proximity to the Haile property, the appropriate milestone at which additional mining activity is sufficiently "reasonably foreseeable" to be considered for purposes of NEPA is when a reserve is established via feasibility study and permitting is sought for such mining activity. For further discussion of this topic, see Haile Response to SELC's Comment No.1 on the USACE's Draft Preliminary Report on Alternatives Development and Evaluation (dated August 5, 2013), submitted to the USACE on October 25, 2013.

Moreover, future mining at the Haile location (and at any other location in the region) could not occur without additional review, through either modified or new permits, from the State and federal government. As a result, even if possible future mining could be reasonably described, there would be an opportunity for government review and approval before any such projected actions and impacts occurred. *See* Haile Response to SELC's Comment No.3.b on the USACE's

[3] Courts have recognized that "An environmental impact is considered 'too speculative' for inclusion in an EIS if it cannot be described at the time the EIS is drafted with sufficient specificity to make its consideration useful to a reasonable decision maker." *Dubois v. United States Dept. of Agriculture*, 102 F.3d 1273, 1286 (1st Cir. 1996).

Draft Preliminary Report on Alternatives Development and Evaluation (dated August 5, 2013), submitted to the USACE on November 11, 2013.

SELC Comment No. 15. *The Corps should reconsider the feasibility of underground mining methods, quantify the reduction in surface water impacts that would result from underground mining at these locations, and consider the possibility of employing some combination of open-pit and underground mining methods. If the Corps ultimately determines that underground mining methods do not represent reasonable alternatives to the proposed mining plan, the public should at least be provided with this information and have an opportunity to comment on the merits of such an approach. See* SELC Comment Letter, p. 11, 1st paragraph.

Haile Response to SELC Comment No. 15. Haile previously submitted a detailed analysis to the USACE regarding the practicability of underground mining at the Haile site, which the USACE considered and is part of the EIS Record, and which was appropriately summarized in the DEIS. *See* Haile Supplemental Response to RAI 2-AL-01 (submitted June 19, 2013); *see also* Haile Response to SELC's Comment No. 2 on the USACE's Draft Preliminary Report on Alternatives Development and Evaluation (dated August 5, 2013), submitted to the USACE on November 11, 2013. This underground mining analysis showed that substantially less gold would be mined using underground methods than using pits, due to the fact that not the entire reserve could be accessed using underground mining. *See* Exhibit RAI 2-AL-01-a (*Scoping Evaluation: Underground Stope Mine, Haile Gold Mine*, Independent Mining Consultants, Inc. (IMC), June 2013). Haile has previously provided the USACE with information demonstrating that extraction of less than the reserve would be poor stewardship of the mineralization and is disfavored in mineral law and policy. *See* Letter from Haile to USACE (dated Sept. 7, 2012). Based on the aforementioned analysis of underground mining, it was estimated that the underground mining alternative would generate revenue of approximately $324.0 million. Mining, processing and general and administrative costs (i.e., cash operating costs before reclamation) would equal approximately $205.8 million, and initial capital investment costs would equal approximately $205.9 million, totaling $411.7 million in costs (compared to $324.0 million in revenue) without even considering the additional costs associated with underground mining (such as reclamation and closure costs and income taxes), as well as sustaining capital costs. Based on these results, costs associated with the underground mining alternative far exceed revenue such that underground mining would not be economic.

Additionally, a combination of open pit and underground mining would not significantly reduce impacts to the environment as it would still: require that the pits be dewatered; generate large amounts of overburden that would need to be stored; and require construction of the major project facilities, including the Mill Site, Johnny's PAG and the TSF. Moreover, like underground mining alone, a combination of open pit and underground mining would decrease the amount of mineral reserve recovered and thus would not meet the project purpose and would not be practicable.

SELC Comment No. 16. *The DEIS should have considered the potential for a reduction in impacts associated with waste rock/overburden disposal through beneficial use of "green" (no PAG) waste materials for regional projects that require sand and gravel, such as development of road bedding material. See* SELC Comment Letter, p. 11, 2nd paragraph.

<u>Haile Response to SELC Comment No. 16.</u> Haile previously submitted a response to this same comment by SELC, which the USACE considered and is part of the EIS Record. *See* Haile Response to SELC's Comment No.3.e on the USACE's Draft Preliminary Report on Alternatives Development and Evaluation (dated August 5, 2013), submitted to the USACE on November 11, 2013. As stated therein:

Haile already plans to use Green overburden for construction on site within the Project Area. Haile will crush metavolcanics and the diabase dikes removed from the pits for the initial construction of roads and erosion controls, and will crush additional rock each year to fulfill the mine's continuing needs for this material for maintenance of roads and erosion controls and construction of any new roads and erosion controls. Use of this rock on site will reduce the amount of overburden space needed at a rate of approximately 100,000 tons per year initially, and this quantity will fluctuate depending on haul requirements and the condition of the roads.

Production of sand and gravel for transport and sale is not a viable alternative to on site storage of Green overburden for a number of reasons:

- There is currently a limited local market/need for sand and gravel, which is met by local granite mines. Other possible markets, such as Charlotte or Columbia, are more than 60 miles from the Haile site. The value of market grade sand and gravel is largely a factor of transportation costs, and the costs of transporting the tremendous volume of Green overburden at the Haile site to sufficiently sizeable markets would be prohibitive.

- Haile's Revised Permit Application (dated August 2012) already has reconfigured the majority of the Green OSAs (at a cost of approximately $7 million dollars) to avoid impacts to Waters of the United States. As a result, the beneficial commercial use of Green overburden would have to be large scale to translate into a material reduction in impacts to Waters of the U.S. Haile has looked at opportunities for further avoidance of Waters of the U.S. at the OSAs. As illustrated in Haile's alternatives analysis of using the Holly and Hock Borrow Areas for OSA Storage, a reduction of 23 million tons of overburden from the Ramona OSA is necessary in order to achieve a 2.15 acre reduction in wetland impacts and a 5,485 linear foot reduction in stream impacts. *See* Exhibit ALT-2, *Haile Comments on the USACE's Draft Preliminary Report on Alternatives Development and Evaluation* (dated August 5, 2013). Haile knows of no market large enough to accommodate crushed rock at this volume. Other OSAs that were not modified, such as the 601 OSA, do not offer avoidance opportunities because they are needed for operational purposes at their planned locations. More specifically, the vast majority of the material stored in 601 OSA is saprolite (with some sand) that is needed for Haile's construction of the TSF embankment – i.e., another form of on-site beneficial reuse.

- Whatever market does exist for beneficial reuse of Green overburden from the Haile Gold Mine would need to provide a constant demand that matches (or exceeds) the rate of Haile's generation of Green overburden. Otherwise, Green overburden necessarily will be stored for lengthy periods of time, causing impacts to Waters of the U.S. and

undermining the very purpose for establishing a distinct business unit within Haile to process and sell the Green overburden as construction material.

In summary, achieving reduction of overburden storage sufficient to materially reduce resource impacts by selling sand and gravel is not practicable. The limited amount of resource impacts that may be realized are more than offset by the burden of developing this separate line of business and the substantial risk that it would never result in reduced impacts. That said, if Haile can find a viable market for any of its overburden, crushed or otherwise, it will pursue such an opportunity. For purposes of mine permitting, however, this is not a reasonable alternative.

SELC Comment No. 17. *Alternatives that result in larger and less numerous waste rock piles should have been evaluated. See* SELC Comment Letter, p. 11, 2nd paragraph; *see also* SELC Comment Letter, Exhibit A, p. 8, 2nd paragraph.

Haile Response to SELC Comment No. 17. Haile's alternatives analyses, the USACE's evaluation and consideration of this analyses, and the DEIS all consider whether larger and less numerous overburden storage areas are practicable alternatives. As discussed in the DEIS (see page 2-17), Haile's original permit application reflects Haile's preference for larger OSAs, which are less costly to build and reclaim. However, in order to avoid impacts to Waters of the United States, in Haile's revised permit application (and Mine Plan), the Hayworth OSA was separated into two smaller OSAs, the Hayworth OSA and Robert OSA, and the Hilltop and James OSA were re-contoured and reduced in size – at an approximate cost to Haile of $7 million dollars. Thus, as reflected in Haile's revised permit application and Mine Plan, in determining how best to minimize impacts to Waters of the United States, the DEIS alternatives analysis considers whether fewer, larger OSAs are more practicable than more numerous, smaller OSAs. *See also* Haile's Alternative Webinar, provided to the USACE on Feb. 23, 2012.

SELC Comment No. 18. *[T]he DEIS' analysis of cumulative impacts and connected actions must take into account both the potential for the Haile Gold Mine to expand significantly in the future, as well as the potential that other mines will follow in its path. See* SELC Comment Letter, p. 12, 2nd paragraph; *see also* SELC Comment Letter, Exhibit A, p. 4, 2nd paragraph & p. 8, 3rd and 4th paragraphs.

Haile Response to SELC Comment No. 18. *See* Haile Response to SELC Comment No. 13, *supra.*

SELC Comment No. 19. *[W]e believe Romarco's proposed [reclamation] plan is insufficient. See* SELC Comment Letter, p. 12-13; *See* SELC Comment Letter, Exhibit A, p. 12 *et seq.*

Haile Response to SELC Comment No. 19. Haile and SCDHEC are engaged in active consultation regarding Haile's proposed Reclamation Plan, and the final Reclamation Plan will be approved by SCDHEC pursuant to its regulatory authority, and included as a component of Haile's state Mining Permit. SCDHEC regulations – which govern review, evaluation and acceptance of an applicant's proposed Reclamation Plan – are designed to be protective of the environment, and include consideration of the concerns raised by SELC, including: (1) adequate financial assurances in the event of an unplanned closure; (2) an adaptive management approach

regarding the appropriate time frame for post-closure monitoring; (3) and funding for long-term monitoring and maintenance costs. *See* South Carolina Code of Regulations Sections 89-80, 89-120, 89-140, 89-170, 89-180, 89-190, 89-200, 89-210, 89-220 & 89-330.

As SELC acknowledges in its comments, the entire Reclamation Plan is designed pursuant to an adaptive management approach. *See* SELC Exhibit A, p. 19, 3rd paragraph. As stated therein: "Importantly, however, DHEC and Haile will be better able to determine appropriate post-mining monitoring and management obligations, as well as the appropriate length of time for which these activities should occur, once reclamation activities are underway and more site-specific information is available." Reclamation Plan, p. 61. SELC's comments suggesting that the DEIS discussion of potential impacts / time frame should go beyond the 50 years (after mining ceases) currently addressed ignores the adaptive management component of Haile's proposed Reclamation Plan and that SCDHEC will retain regulatory authority over the Project site until Haile is granted bond release. As it is anticipated (based upon the design criteria of Haile's facilities, as well as modeled predictions of future impacts, among other factors) that impacts from the Project will decrease over time, the DEIS adequately describes the potential impacts for the proposed Project. Should unanticipated conditions develop concerning operations, closure or post-closure, Haile will work with SCDHEC to develop appropriate management and mitigation measures.

SELC's related comment regarding the need for SCDHEC to require financial assurance for long-term monitoring extending from 100 to 500 years, simply because this has been required at other hard rock mines, similarly ignores the fact that the appropriate amount of financial assurance required for a given Project must be tied to the specifics of that project. Haile's proposed Reclamation Plan identifies a reasonable time frame (based upon the design criteria of Haile's facilities, as well as modeled predictions of future impacts, among other factors) for long-term monitoring and maintenance costs. Additionally, Haile's proposed Reclamation Plan recognizes that certain obligations – such as protecting the closure system at Johnny's PAG and the TSF – will extend in perpetuity. SCDHEC is currently reviewing Haile's proposed time frame for bonding, and will identify the appropriate time frame (and amount of bond required) based upon the Project-specific information that is currently available. Based upon more specific information available at a future point in time, SCDHEC may subsequently shorten or extend this time frame and decrease or increase the amount of bond required. As noted above, SCDHEC and Haile are also currently discussing the most appropriate mechanism to provide for funding of certain costs in perpetuity.

SELC Comment No. 20. *The Corps should seek out information from other communities, particularly in the Western United States, on their economic and environmental experiences with cyanide gold mining. ... The Corps should also weigh the intrinsic value of gold, its uses, and the desirability of its extraction versus the suite of environmental and economic risks associated with this proposal. ... Prior to making a decision regarding whether this proposal is in the public interest, the Corps must first remedy the inadequacies in the DEIS, including the failure of the models to account for the full range of indirect impacts to aquatic resources, and provide the public with a meaningful opportunity to comment on a revised DEIS. See* SELC Comment Letter, p.14, 1st full paragraph.

Haile Response to SELC Comment No. 20. See Haile Response to SELC Comment No. 1 regarding alleged 'inadequacies' in the DEIS. Experiences of other communities and other gold mining projects are not relevant to the USACE's consideration of the Haile Gold Mine project and whether said project is in the public interest, as the public interest review for each project is dependent upon the unique features of that project. Relevant information regarding the value of gold and its uses is in the EIS Record. Potential economic and environmental impacts of the proposed Haile Project are adequately disclosed and discussed in the DEIS.

SELC Comment No. 21. *The Corps must address the obvious inadequacies in DHEC's ability to provide sufficient regulatory authority over a proposal of this type and scale and evaluate the implementation of additional protections during the mining, closure, and post-closure phases to address these deficiencies and protect the public and the environment.* See SELC Comment Letter, p.14, 3rd paragraph, & Exhibit A, p.2

Haile Response to SELC Comment No. 21. Regarding matters within SCDHEC's regulatory authority, it would not be appropriate for the USACE to attempt to "double-regulate" the Haile Project. SELC's comment is unwarranted and unfounded.

SELC Comment No. 22. *While it describes in detail the existing low income levels and high poverty rates, the DEIS does not acknowledge that the "boom and bust" cycle of mining may very well leave this region in a similar or worse position once the economic "boom" of the project is over. See* SELC Comment Letter, p.14, last paragraph.

Haile Response to SELC Comment No. 22. The DEIS satisfies NEPA requirements, and adequately discloses the anticipated economic impacts from the proposed Project.

SELC Comment No. 23. *The DEIS fails to address whether a diminished tax base – resulting from workers leaving – would be able to continue to support the infrastructure projects that will be built to support the mine during its operation, once the project is complete. See* SELC Comment Letter, p.15, 1st paragraph; *see also See* SELC Comment Letter, Exhibit A, p.2-3.

Haile Response to SELC Comment No. 23. The DEIS satisfies NEPA requirements, and adequately discloses the anticipated economic impacts from the proposed Project. Moreover, as noted in the DEIS, it is expected that the proposed Project will have a negligible impact to most existing public infrastructure. *See* DEIS, Sections 4.10.3.8 & 4.10.3.9.

SELC Comment No. 24. The DEIS should include a more comprehensive analysis and discussion of the predicted impacts and costs associated with development of the proposed Haile Gold Mine, including impacts to schools, emergency services, and increased infrastructure maintenance, in addition to the factors already discussed in the DEIS. The Corps should also rely upon regulations and guidance developed by communities that have experienced major hardrock mine development, such as Montana's Hard-Rock Mining Impact Act, to plan and mitigate for the socio-economic impacts of the Haile Gold Mine. SELC Comment Letter, p.15, 2nd full paragraph; *see also* SELC Comment Letter, Exhibit A, p.3.

Haile Response to SELC Comment No. 24. *See* Haile Response to SECL Comment No. 23.

SELC Comment No. 25. *The Corps must supplement a revised DEIS with a FMEA and AMP developed in cooperation with stakeholders and utilizing highly qualified independent experts.* SELC Comment Letter, p.15, 3rd full paragraph; *see also* SELC Comment Letter, Exhibit A, p.2, 3rd paragraph & p. 12, 3rd paragraph.

Haile Response to SELC Comment No. 25.

FMEA

The DEIS indicates that a Failure Mode Analysis was conducted, DEIS page 4.1-22, Section 4.1.7, so it appears that the USACE need not respond to this comment. However, Haile notes that Failure Modes Effect Analysis (FMEA) concepts are built into the design, construction, operation, and response planning for the Haile Gold Mine. Thus, SELC's implication that risk analyses have not been completed and that some form of additional analyses must be performed is incorrect.

Prudent and standard engineering principles and practices are utilized in the design of Haile's facilities along with rigorous review by local, state, and federal permitting agencies. The USACE's record contains all of this information, which is also presented in the DEIS, so there is no need to conduct any new analysis for the Final EIS.

For example, the Duckwood TSF was evaluated for seismic stability under two levels of design earthquake events: the Operation Basis Earthquake (OBE), magnitude 7.30, for the operational period of the facility, and the Maximum Design Earthquake (MDE), magnitude 7.38, for post-closure period. The associated performance requirement with an OBE is that the facility will operate with little or no damage, and without interruption of function. The associated performance requirement for an MDE is that the facility performs without catastrophic failure, such as uncontrolled release, although severe damage or economic loss may be tolerated. Slope stability analyses were conducted in support of the design of the Duckwood TSF embankment. The analyses examined the stability of the facility under both static and seismic loading condition for OBE and MDE scenarios.

Composite liner design that includes a minimum 12- inch layer of low permeable soil liner overlain with a 60 mil HDPE liner. The primary liner is the HDPE geomembrane. A rigorous construction quality assurance (CQA) and construction quality control (CQC) program will be undertaken to construct the most faultless liner possible.

Geotechnical investigations beyond general subsurface characterizations, includes identifying suspect zones that could affect the design intent of the proposed project elements and quantifying the engineering characteristics of the material to be used in construction. Geophysical investigations were conducted to determine the compressional wave (P-wave) and shear wave (S-wave) velocity in the shallow subsurface to assess the potential for geologic structures or soft soils that could affect the Duckwood TSF design performance.

Probable Maximum Precipitation (PMP) event, which is about 48 inches of precipitation over a 72 hour period, was incorporated into the TSF embankment design whereby at any given time the TSF can contain this event while maintaining a four foot freeboard. Water balance modeling was developed to aid in the design of the TSF and understand water management decision for safe operation of the facility. Multiple possible scenarios were modeled covering a range of potential occurrences. Results from these multiple realizations provide a range of potential outcomes allowing risk-based decision making. General stormwater management controls are designed to manage stormwater around the TSF and runoff from the outside embankment face.

A Dam Breach Analysis – i.e., the assessment of potential flood inundation from a hypothetical dam failure of the Duckwood TSF embankment – was completed as part of the TSF Dam Permit Application.

Operation, Maintenance and Inspection Manual is intended to serve as an operating guide for the Duckwood TSF. Initial, normal, and emergency operating procedures for the TSF are described in this manual. A contingency plan for emergency conditions and safety measures along with daily, weekly, and quarterly inspections, and annual inspection of the main embankment by a registered Engineer are set forth in the manual.

An Emergency Acton Plan (EAP) was developed to reduce the potential for loss of life and injury and to minimize property damage during an unusual or emergency event at the Duckwood TSF. The EAP is a five-step process: 1) Emergency Condition Detected; 2) Emergency Level Determination; 3) Notification and Communication; 4) Expected Actions; and 5) Termination and Follow-Up.

South Carolina DHEC reviewed Duckwood TSF design plans and specifications to ensure compliance with South Carolina Dams and Reservoirs Safety Act Regulations 72-1 thru 72-9, and issued Haile's Dams & Reservoirs Safety Permit (No. 29-0007) on October 7, 2013.

Adaptive Management

Adaptive Management Planning is built into Haile's monitoring and management for Haile Gold Mine. Thus, SELC's implication that Haile's monitoring and management lacks this "adaptive" element is misleading and incorrect. Adaptive management merely provides for a feedback mechanism so that the results of monitoring programs have an effect on future management of the system(s) being monitored. Therefore, the monitoring plans required by SCDHEC are adaptive by nature as SCDHEC and internal Haile management functions will provide for appropriate feedback actions in response to monitoring results.

HAILE SUPPLEMENTAL RESPONSES TO SELC - EXHIBIT A

SELC Comment No. 26. *The analysis performed in the DEIS to consider the potential impacts from the HGM should look into the future well beyond the 50 years currently contemplated to ensure the protection of human health and the environment is maintained throughout mine development, operations, closure and post-closure periods as identified in the following comments. Other modern mines with similar originally predicted impacts have post-closure*

periods of 100 to 500+ years. At the Golden Sunlight Mine, an open pit gold mine with acid drainage of similar size to the proposed HGM, original predictions similarly suggested a walk-away scenario, however later predictions showed that post-closure water treatment to mitigate impacts associated with acid drainage is potentially necessary for 10,000 years or more and long-term monitoring and maintenance has been incorporated into their reclamation and closure plan and financial assurance. SELC Comment Letter, Exhibit A, p.2, 1st paragraph.

Haile Response to SELC Comment No. 26. *See* Haile Response to SELC Comment No. 19, *supra*. In addition, it is important to clarify that the Golden Sunlight Mine is quite different than the Haile Gold Mine in that the operating plan, developed and permitted more than 30 years ago, did not employ any of the mitigation measures proposed for handling potentially acid generating (PAG) waste rock at the Haile Mine:

- PAG waste rock at Golden Sunlight is not separated from non-PAG as at Haile.
- PAG waste rock is not placed in a lined facility as at Haile.
- PAG waste rock is not placed in controlled lifts of less than 50 feet as proposed at Haile.
- The PAG waste repository will not be covered with geomembrane as at Haile.
- PAG waste constitutes a larger overall proportion of the waste rock at Golden Sunlight than at Haile.
- The waste rock tonnage (484 million tons, MDEQ 2013) is substantially greater than at Haile (241 million tons).

For these reasons, the comparison of Haile Gold Mine to Golden Sunlight is inappropriate. At Golden Sunlight, the closure plan anticipates collection and treatment of water in perpetuity, which is the main reason for the longer post-closure monitoring period.

MDEQ, 2013. Golden Sunlight Mine Amendment 015 To Operating Permit No. 00065 Final Environmental Impact Statement.

SELC Comment No. 27. *For example, the DEIS is based on designs that consider a 100-year storm event, however as noted by the DEIS, in 1990, tropical storm Marco passed over South Carolina, resulting in 120 dam failures statewide. See* SELC Comment Letter, Exhibit A, p. 2, 3rd bullet; *see also* SELC Comment Letter, p.15, 3rd full paragraph.

Haile Response to SELC Comment No. 27. This comment is generally incorrect. The two most significant structures that would capture rainfall and runoff from a large storm event are the Tailing Storage Facility (TSF) and the Diversion Dam. The TSF is designed to contain the full volume of water resulting from a General Storm Probable Maximum Precipitation (PMP) event while still maintaining four feet of residual freeboard. The Diversion Dam includes a spillway that is designed to pass 50% of the Local Storm PMP. For comparison, the 100-year produces 8.59 inches of rainfall in 24-hours. The General Storm PMP used for the TSF design produces 47.96 inches of rainfall in 72-hours while the 50% of the Local PMP used in the Diversion Dam Spillway Design generates 20.5 inches of rainfall in 6 hours. Ecological Resource Consultants,

Inc., 2012. Surface Water Existing Conditions Report, Haile Gold Mine Project – Lancaster County, South Carolina.

SELC Comment No. 28. *The DEIS should include a more comprehensive analysis and discussion of the predicted impacts and costs associated with development of the proposed Haile Gold Mine, including impacts to schools, emergency services and increased infrastructure maintenance, in addition to factors already discussed in the DEIS.* SELC Comment Letter, Exhibit A, p. 3, 3rd paragraph.

Haile Response to SELC Comment No. 28. *See* Haile Response to SECL Comment No. 23.

SELC Comment No. 29. *The USACE should rely upon regulations and guidance developed by other governmental programs to plan for and mitigate socioeconomic impacts from mining communities that have experienced major hardrock mine development, such as Sweet Grass and Stillwater Counties in Montana, to determine impacts associated with the proposed HGM and alternatives.* SELC Comment Letter, Exhibit A, p. 3, 3rd paragraph.

Haile Response to SELC Comment No. 29. *See* Haile Response to SECL Comment No. 23.

SELC Comment No. 30. *The predicted water quality impacts are highly conceptual and assume a relatively ideal outcome. In the best case presented, the last pit lake is projected to achieve water quality standards after 50 years of refilling and treating with lime as required. This period, during which active treatment of the pit lake is required, is typically considered the "closure" phase and extends until whenever water quality standards are achieved without significant operational or maintenance requirements. Post-closure monitoring, to confirm performance of mitigation and longer-term achievement of water quality and other standards, is typically performed for 30 years. The timeframe may be extended beyond 30 years, particularly where delayed onset of acid rock drainage (ARD) is predicted. As noted by Price (1998),4 one of the technical challenges of metal leaching and ARD assessment is the potential for significant delays in metal leaching and ARD onset.* See SELC Comment Letter, Exhibit A, p. 4, 4th paragraph.

Haile Response to SELC Comment No. 30. Predicted water quality impacts are neither "highly conceptual" nor do they assume a "relatively ideal outcome." The analysis of potential water quality impacts is completely quantitative, employs risk analysis to identify the sensitivity of outcomes to model assumptions, and uses very conservative assumptions. While concerns about a long lag time (Price 1998) before onset of ARD may be a valid generalized concern, it is not a valid concern at Haile. Humidity cell tests found that acidic conditions developed in all PAG materials within a few weeks of the onset of kinetic testing (Schafer 2012b).

SELC Comment No. 31. *The DEIS should recognize and require as additional mitigation best management practices for tailings facilities based on the Canadian Tailings Dam Management Guidelines and best available technologies based on current industry practice for the proposed project and consider additional mitigations to minimize potential impacts to water quality. In the case of the TSF pipelines, additional mitigation should be required including a leak detection system to ensure operational upsets are detected and addressed immediately, and also consider a*

requirement to bury the tailings slurry and return flow pipelines. SELC Comment Letter, Exhibit A, p. 5, 4th paragraph, p. 18, 5th paragraph & p. 19, 1st paragraph.

Haile Response to SELC Comment No. 31. Additional mitigation best management practices are not necessary in order to ensure the TSF design is protective of the environment. *See* Haile Response to EPA Comment No. 4, submitted on May 30, 2014. As previously stated by Haile in its Response to Additional Information Needs dated October 11, 2013, which was submitted to the USACE on November 15, 2013:

> The tailing slurry pipeline from the Mill to the TSF will be a double contained, above ground pipeline system (with the pipeline placed inside a containment pipe (double-walled), or the pipeline (single-walled) in an HDPE-lined ditch). … If the pipeline is in an HDPE-lined ditch, a leak in the pipeline will be apparent due to the presence of tailing solution in the HPDE-lined ditch. If Haile instead uses a pipeline inside a containment pipe, the spacers in the containment pipe [] will be slotted to allow any leakage to flow from one section to another and then ultimately to a HDPE-lined area (which would then flow into the Process Event Pond or Underdrain Collection Pond). At this HDPE-lined area, the double-walled pipeline will transition to a single-walled pipeline in an HDPE-lined ditch, allowing any tailing slurry in the outer containment pipe to exit into the HDPE-lined area. A leak in the pipeline will be apparent due to the presence of tailing solution in this HPDE-lined area. Mine personnel inspecting the pipeline will be in communication with the Mill control room, allowing the tailing slurry pumps to be shut down quickly if there is a problem observed. The Mill control room will be staffed any time there is tailing flowing from the Mill to the TSF, allowing the operators to shut down the pumps if they see a problem (such as a change in pressure in the pipes that is indicative of a problem). In addition, the operators at the Mill will have local control to shut down the tailing slurry pumps if they see a problem. Should a failure of the tailing pipeline occur, or in the event of a prolonged unplanned power outage, the material from the pipeline will flow to an HDPE-lined containment (either the Process Event Pond (approximately a 1.5 million gallon capacity) or the TSF Underdrain Collection Pond (approximately a 0.8 million gallon capacity)). Once the failures have been repaired, or power restored, the material in the HDPE-lined containment area would be returned to the cyanide recovery thickener or applicable area for processing.

Burying the tailing slurry pipeline would make leak detection more difficult, among other factors, and is not a practicable alternative.

SELC Comment No. 32. *The DEIS should consider the benefits of requiring a thicker liner in the case of this proposal given the prediction that tailings will be acid generating and require management into perpetuity and the proximity of the tailings facility to wetland and surface water resources. See* SELC Comment Letter, Exhibit A, at p. 5-6. *See also* SELC Comment Letter, p. 5-6.

Haile Response to SELC Comment No. 32. A thicker TSF liner is not necessary in order to ensure the TSF design is protective of the environment. *See* Haile Response to EPA Comment No. 4, submitted on May 30, 2014.

SELC Comment No. 33. *The DEIS should consider requiring secondary seepage detection and collection to ensure that any leakage from the primary containment system is detected and captured before impacting groundwater, as an additional mitigation measure. See* SELC Comment Letter, Exhibit A, at p. 6. *See also* SELC Comment Letter, p. 6, 2nd paragraph.

Haile Response to SELC Comment No. 33. Secondary seepage detection and collection at Johnny's PAG and/or the TSF is not necessary in order to ensure the design is protective of the environment. *See* Haile Response to EPA Comment No. 4, submitted on May 30, 2014. The TSF already employs a double lined design with a geomembrane underlain by low permeability saprolite material as a composite liner. The use of dual geomembrane liners is more protective of the environment than industry standard practice for tailings facilities. If dual geomembrane layers were used, a drainage layer or drainage geogrid would need to be placed between the two geomembranes, which would make the primary liner inherently more leaky. The rate of leakage through a geomembrane is strongly affected by the permeability of the foundation layer, which is why compacted low permeability layers are the preferred foundation for a TSF containment system.

The only reasonable application for dual geomembrane liners is in process ponds in which the exposed primary liner has inherently higher risk of puncture and the greater head from stored solutions would increase the leakage rate in event of a puncture. *See* DEIS, Appendix A, Project Description.

SELC Comment No. 34. *The USACE should take a more conservative approach to the development of a reclamation and closure plan and financial assurance estimate for this DEIS, and use more realistic rather than ideal reclamation and closure requirements and associated costs. The USACE and SCDHEC should consider and where appropriate use similar requirements to those used by federal and state agencies where hardrock mines are more commonly operated.* SELC Comment Letter, Exhibit A, p. 6-7.

Haile Response to SELC Comment No. 34. *See* Haile Response to SELC Comment No. 19, *supra.*

SELC Comment No. 35. *The DEIS should provide the actual slope of "the steepest overall angle" that was determined. The DEIS should explain why the steepest angle proposed was justified instead of a more moderate approach and should recognize that there is a risk with steep angle reclamation relative to erosion and revegetation success.* SELC Comment Letter, Exhibit A, p. 7, 5th paragraph.

Haile Response to SELC Comment No. 35. The "steepest overall angle" for reclaimed facilities at the Haile Project site is 3:1. *See* DEIS, Appendix H, Haile Reclamation Plan. This is in accordance with SCDHEC regulations, which consider the probability of reclamation success, in limiting the overall reclaimed angle to 3:1, unless special approval is received. See South Carolina Code of Regulations, Section 89-330. Criteria for Approval of Reclamation Plan and Completed Land Reclamation. Moreover, Haile's OSA slopes are reclaimed to 2.5:1 with intermediate catch benches between slopes to aid in erosion control. Thus, the reclaimed OSA, including the intermediate catch benches, yields the DHEC requirement of an overall slope of 3:1.

SELC Comment No. 36. *The DEIS should address how in-depth consultations with the project proponent and limited involvement by other regulatory agencies, and no substantive involvement by local government and public stakeholders, represents a rigorous analysis. The DEIS should similarly provide information on the qualifications of the participants other than the project proponent who participated in the alternatives analysis. The alternatives analysis in the DEIS should be further supplemented to include a full-range of alternatives incorporating input from multi-stakeholders and independent qualified experts in mine design.* SELC Comment Letter, Exhibit A, p. 8, 5th paragraph; *see also* SELC Comment Letter, Exhibit A, p. 7, 4th paragraph.

Haile Response to SELC Comment No. 36. As SELC is aware, opportunities for public involvement in the development of the USACE's alternative analysis and consideration of practicable alternatives have been provided throughout the DEIS process and fully satisfy NEPA requirements. Such opportunities include, but are not limited to, scoping, public meetings, publication of the USACE's Haile EIS Draft Preliminary Report - Alternatives Development and Evaluation on August 5, 2013 and related request for comments, and, most recently, through publication of the DEIS in March 2014 and request for comments.

SELC Comment No. 37. *The DEIS should provide supporting information to justify the protectiveness of the 50 foot buffer planned to ensure protection of adjacent wetlands and waters of the US. A 100-ft buffer should be considered as an alternative to the 50-ft buffer*. SELC Comment Letter, Exhibit A, p. 9, 2nd paragraph.

Haile Response to SELC Comment No. 37. The intent of the voluntary ~50 foot buffer proposed by Haile is to establish a physical boundary to prevent inadvertent encroachment of mining activities into otherwise non-impacted wetlands and streams within the Project site. Coupled with appropriate BMPs, the proposed buffer is sufficient to accomplish this purpose.

SELC Comment No. 38. [*T]he DEIS did not adequately evaluate a full range of alternatives including the following: Tailings deposition alternatives (paste and dry stack) to optimize water use and reduce potential impacts from tailings. See* SELC Comment Letter, Exhibit A, p. 9, 1st paragraph & 10, 1st bullet.

Haile Response to SELC Comment No. 38. Haile previously submitted a response to this same comment by SELC, which the USACE considered and is part of the EIS Record. *See* Haile Response to SELC's Comment No.3.e on the USACE's Draft Preliminary Report on Alternatives Development and Evaluation (dated August 5, 2013), submitted to the USACE on November 11, 2013. *See also* Haile Response to RAI 2-MO-06 (submitted on April 19, 2012) and Exhibit RAI 2-SH-05-l (submitted on April 19, 2012). As stated therein:

> [D]uring the past two decades there has been a considerable advance in the understanding of the physical and chemical processes which are active in tailing deposits. It has been recognized that alternative placement methods and impoundment operating procedures result in storage facilities with substantially different engineering properties. The dry stack (thickened or dry filtered tailing), paste backfill, and conventional tailing impoundment disposal methods have been

evaluated by Haile specifically to address the climatic conditions, the tailing engineering properties and tailing geochemical types for the Haile Project.

Haile offers the following brief assessment of the comment's suggestions regarding paste backfill and dry stack options.

PASTE BACKFILL

Paste backfill involves the use of tailing (>70% solids) mixed with appropriate proportions of cement and water that are transported underground by pipeline to fill mined-out areas. The term "paste" was coined to differentiate a tailing product with better dewatering and the addition of cement from the previously described hydraulic backfill. In some mining operations, tailing were dewatered and used as hydraulic backfill to provide a working surface for underground mining operations. To Haile's knowledge, paste backfill has not been used in open pit mining.

Haile has conducted a preliminary review for the paste backfill option that compared technical requirements, economics, environmental and closure issues. For the Haile Gold Mine, backfilling using the paste tailing material for the open pits is not a viable option because:

- Use of paste backfill for open pits below the water table (saturated conditions) currently does not have a track record for long-term durability and stability.
- Not all tailings are appropriate for creating a quality backfill paste that will flow properly and demonstrate the required strength properties.
- Industry experience indicates that ultra-fine grind tailings (Haile's process tailings) would be problematic in this use. They do not maintain a consistent mixture because they fail to retain water and they produce fine material run-off. The fineness of the Haile tailings would affect (increase) the water demand of the paste mix.
- The mineralogy, chemistry, and particle size distribution indicate that the Haile tailings are not suitable as paste backfill.
- The mill process uses a cyanide leach circuit in tanks for gold extraction; thus, like tailings commingled with overburden, storage of paste backfill in unlined mine pits introduces risks not affiliated with a lined disposal method.
- Given the wet climate in the region of the Haile Project and the need to consistently dewater the tailings, Haile would require a redundant, conventional tailing storage facility to address potential upsets. That is, tailings need to be dewatered and stored before converted to a paste, and would need to be stored until pits were ready for backfill. As a result, the impacts of a TSF would not be avoided.
- The increased capital cost and operational complexity of dry paste outweighs any potential operating savings.

THICKENED OR DRY FILTERED TAILING

A detailed analysis of dry filtered tailing vs. conventional tailing is included in Appendix F of the TSF Alternatives Report (AMEC 2009) (Exhibit RAI 2-SH-05-l). The following summarizes the information in that Report. Dewatering tailings will produce a filtered wet (saturated) and dry (unsaturated) cake that can no longer be transported by slurry pipeline due to its low moisture content. These filtered tailing or dry tailing are normally transported by conveyor or truck and deposited, spread and compacted to form an unsaturated free-stacks or in an impoundment. A typical moisture content of less than 20% is achieved by using a combination of belt, drum horizontal and vertical-stacked pressure plates, and vacuum filtration systems.

Haile developed a conceptual design in 2009 for a two-phase Dry Filtered Tailing Stack (DFTS) facility to store a startup impoundment area of 15 million tons with expansion to an ultimate impoundment area to store 30 million tons of dry-filtered tailing. The layout for the two-phase DFTS facility includes the thickener and filtration facility sited adjacent to the dry stack pad. Design criteria assumed that the tailing would be pumped from the mill area to the thickener and filtration facility at a solids content of 35%. The filter cake from the filter presses would be reduced to a moisture content of approximately 20%.

Two options were considered for the stacking of the filtered tailing including:

1. stacking using trucks and
2. stacking using a conveyor and radial stacker.

The basic pad design considered for the two options is the same with the exception that for the truck stack option a concrete-lined load out area for receiving filter cake from the filters was included in the cost estimate. For the conveyor option, a lined containment area was included for temporary storage of filtered tailing in case of a short-term conveyor outage.

<u>Dry Stack Pad Design Concept</u>

The basic dry stack pad design concept includes grading the existing ground surface through a cut-and-fill operation to drain towards the downgradient toe. A berm is provided at the pad perimeter to contain tailing and surface water. A 40-foot setback is provided between the pad perimeter berm and the toe of the tailing stack for placement of mine waste for tailing containment and reclamation. Components of the dry stack include:

- Grading for proper liner construction and drainage within the pad
- Groundwater drains in natural drainages
- 12-inch thick low-permeability soil liner
- 60-mil HDPE textured geomembrane liner
- Drains consisting of 3-inch corrugated perforated pipe (CPeP) with geotextile socks placed in a herringbone pattern connecting to primary drain pipes surrounded with drainage material wrapped with geotextile material

- An operation pond sized to contain the 2-year, 24-hour storm event for the 15-million ton facility footprint
- When the pad footprint is expanded to 30 million tons, a second event pond would be constructed for the 100-year, 24-hour storm event.
- Slurry pipeline consisting of a 12-inch pipe inside an 18-inch pipe for double containment
- Reclaim water will be pumped from the thickener and filter facilities to the process water tank located at the mill site. The pipeline consists of a 12-inch pipe inside an 18-inch pipe for double containment.
- A thickener would be used to reduce the solids content to 50 to 55 percent with the moisture content being further reduced to the 18 to 20 percent range using filter presses.

Truck Stack Option

For the truck stack option it was assumed that the filtered tailing would be conveyed from the filter presses to a concrete lined stockpile area having a capacity of 24 hours of production. The filtered tailing would be loaded on trucks from the stockpile area using a wheel loader and transported to the dry stack pad using 42-ton trucks. A D7 dozer would be provided at the dumpsite to spread and maintain the tailing surface.

Conveyor Stack Option

For the conveyor stack option it was assumed that the filtered tailing would be conveyed from the filter presses to a tripper conveyor sited along one side of the dry stack pad. A series of mobile conveyors (grasshoppers) would convey the tailing from the tripper to the deposition point on the pad where it will be stacked using a radial stacker. Equipment requirements for the stacking system were provided by Terra Nova Technologies, Inc. based on the production rate and a general description of the dry stack pad layout provided.

DRY STACK OPTION COSTS

- Appendix F (15 and 30 Million Ton Dry Stack Facility) of the 2009 AMEC TSF Alternatives Report (Exhibit RAI 2-SH-05-l) presents the basic design concept and estimated capital and operating costs. These costs form the basis of the alternatives analysis costs for the DFTS presented below.

Capital and Operating Cost Summary - Dry Filter Tailing Storage (DFTS)

Option	Cost for a 15 Mt DFTS ($ millions)	Additional Costs for 30 Mt (Expansion of DFTS) ($ millions)	Total Cost (to store 30 Mt) ($ millions)

Truck Stack Capital	$64.7	$9.3	$74.0
Conveyor Stack Capital	$69.4	$12.3	$81.7
Truck Stack Operating	$60.6	$60.6	$121.2
Conveyor Stack Operating	$40.5	$40.5	$81.0
Total DFTS Cost – Truck Option	$125.3	$69.9	$195.2
Total DFTS Cost– Conveyor Option	$109.9	$52.8	$162.7

- Costs for the 30 M ton conventional TSF (Site 2C in AMEC's 2009 Report, which was renamed Alternative 19 in the TSF Alternatives Analysis that Haile provided in the February 23, 2012 webinar with the USACE) were calculated using the same assumptions and design criteria as the DFTS analysis to compare overall costs, as presented below.

Capital and Operating Cost Summary- Conventional Tailing Storage (2009 Alternative 2C)

Option	**Cost for 15 Mt TSF ($ millions)**	**Additional Costs for 30 Mt (expansion of TSF) ($ millions)**	**Total Cost (to store 30 Mt) ($ millions)**
Conventional Tailing Capital	$83.6	$11.0	$94.6
Conventional	$4.0	$4.0	$8.0

Operating			
Total Conventional TSF Cost	$87.6	$15.0	$102.6

In summary, the conventional TSF costs are approximately $60 million less than a dry stack facility that uses a conveyor system and more than $90 million less than a dry stack facility that uses a trucking system.

Dry stack tailings storage would not only cost substantially more than conventional tailings storage, but would pose some serious technical concerns:

- Dry stack is typically used in arid climates where water conservation is crucial, and management of dry stack storage is relatively straightforward. South Carolina is not such a climate. Thus, the dry stack storage facility would require all the components of the conventional TSF with respect to process water containment.
- Having the ability to deal with off-specification material and still place tailing material in any weather condition would also require a backup system of an additional conventional TSF.
- The prospect of re-saturation and destabilization of the dry stacks due to South Carolina's high precipitation climate poses some serious operational challenges with filtration and dewatering plants, operation of conveyors and stackers (or trucks), and the need for backup systems for these. (These technical complications translate into higher operating costs, as well.)
- Due to the wet climate, the design of a DFTS facility would have to incorporate a robust surface water management system and possibly a covering liner to prevent major erosion or saturation of the "dry" stack. This would add cost and complexity to the operations.

TECHNICAL FEASIBILITY AND RELATIVE COST CONCLUSIONS

- Conventional, rotational slurry deposition of the tailing is a well-known and time-tested method. Dry stack and paste backfill do not have a proven "track record" for the ultra-fine grind materials Haile is proposing to produce. Haile decided to pursue conventional tailing storage based on the fact that the technology has been used successfully for several decades and in multiple climatic conditions throughout the world. The DFTS offers more technical and environmental challenges from an upset condition standpoint and from a maintenance perspective.

- Response to ambient meteoric conditions, and in particular during extreme rainfall events, would have to be managed carefully for a dry stack to be successful in the Haile project area. Relatively wet conditions with an annual average rainfall of 47 inches and a probable maximum precipitation of 48 inches

at the project could lead to issues with respect to containment, operability, and sustainability related to long-term geotechnical stability.

- A DFTS could lead to over $60 million in additional tailing storage costs for 30 million tons of tailings over the life of the mine. Increasing the DFTS to 40 million tons, would increase the additional costs even further.

- After review of the deposition methods available Haile has decided to pursue the conventional, rotational slurry deposition of the tailing due to the aforementioned safety, operability, environmental and geotechnical concerns with operating a thicken tailing dry stack facility.

In summary, based on the information that the USACE has, it is reasonable to screen out dry stack storage from further consideration as an alternative in the DEIS.

SELC Comment No. 39. [*T]he DEIS did not adequately evaluate a full range of alternatives including the following: Tailings design alternatives (different liner and drainage schemes) to optimize tailings drainage and containment. See* SELC Comment Letter, Exhibit A, p. 10, 2nd bullet.

Haile Response to SELC Comment No. 39. *See* Haile Response to EPA Comment No. 4, submitted on May 30, 2014.

SELC Comment No. 40. [*T]he DEIS did not adequately evaluate a full range of alternatives including the following: Alternative methods to address PAG (e.g., amendment, blending, additional backfill). See* SELC Comment Letter, Exhibit A, p. 10, 3rd bullet.

Haile Response to SELC Comment No. 40. Haile will be using amendment (with lime or limestone) as a component of the proposed plan for Yellow PAG rock placed as backfill into mine pits.

Blending was evaluated and dismissed by Haile because it was not considered as effective as placement of Red PAG in a lined facility and backfilling Yellow PAG (with amendment as needed) or placement in a lined facility. Blending would have been a lower cost alternative than what is in the proposed plan.

It is not clear what is meant by "additional backfill," but if this is meant to evaluate backfilling of the Ledbetter Pit as an alternative, it was considered by the USACE, and is not a practicable alternative. *See* Haile Response to RAI 2-AL-03, submitted to the USACE on April 19, 2012.

SELC Comment No. 41. [*T]he DEIS did not adequately evaluate a full range of alternatives including the following: OSA design to maximize reclamation success versus avoidance of wetlands. See* SELC Comment Letter, Exhibit A, p. 10, 5th bullet.

Haile Response to SELC Comment No. 41. Reclamation success versus avoidance of wetlands was appropriately considered in determining the overall 3:1 slope of the reclaimed OSAs in accordance with SCDHEC regulations. *See* Haile Response to SELC Comment No. 35, *supra*.

SELC Comment No. 42. *The DEIS should address common failures that occur despite permit requirements due to characterization and mitigation inadequacies and provide for additional mitigation measures in the form of a FMEA and AMP as discussed elsewhere in our comments. See* SELC Comment Letter, Exhibit A, p. 11, 1st paragraph, p. 20 2nd paragraph.

Haile Response to SELC Comment No. 42. *See* Haile Response to SELC Comment No. 25, *supra.*

SELC Comment No. 43. *The baseline data used in the DEIS evaluations should include all data including data collected in 2011 and 2012. See* SELC Comment Letter, Exhibit A, p. 11, 2nd paragraph.

Haile Response to SELC Comment No. 43. Per Haile's comments on the DEIS (submitted to the USACE on May 8, 2014), at page 3.3-14, Section 3.3.2.4, the DEIS "Trends in Groundwater Quality" Section is based on information provided in the *Baseline Hydrologic Report (Schlumberger, 2010)* only. However, additional baseline data was made available in the *Addendum to the Baseline Hydrologic Report (AMEC, 2012),* as reflected in Appendix I of the DEIS. As a result, Haile recommended that the EIS record should acknowledge the additional groundwater quality baseline data in the record and reflected in Appendix I of the DEIS. Haile's recommendation would adequately respond to SELC's comment.

SELC Comment No. 44. *Given that the surface water quality already exhibits impacts from historic mining, this DEIS should justify the assumption that water quality will improve after HGM is operated and reclaimed. Additionally, a summary of additional results compared to standards would be more useful in a table format. See* SELC Comment Letter, Exhibit A, p. 11, 3rd paragraph.

Haile Response to SELC Comment No. 44. Per Haile's Comments on the DEIS (submitted to the USACE on May 8, 2014) at page 3.4-32, Section 3.4.3.2, the conclusion that water quality already exhibits impacts from historic mining is not borne out by the data. A statistical evaluation of spatial trends in surface water quality was conducted on sample data collected by Haile from July 2010 – January 2012 and was presented in the *Addendum to Baseline Hydrologic Report (AMEC, 2012).* This evaluation compared surface water quality data collected in Haile Gold Mine Creek, Little Lynches River, Camp Branch Creek, and the unnamed tributary within the study area.

SELC Comment No. 45. *It is recommended that SCDHEC require a soil handling plan meeting the BLM's specifications together with any state- or site-specific requirements that would ensure proper removal, stockpiling and management of growth medium to support post-mining reclamation. See* SELC Comment Letter, Exhibit A, p. 13, 2nd paragraph.

Haile Response to SELC Comment No. 45. South Carolina Code of Regulations Section 89-140 (C) requires that topsoil sufficient to satisfy reclamation requirements shall be removed and stored in such a manner as to remain available for reclamation and shall not be carried away or covered up with other materials. Thus, 'soil handling' is within SCDHEC's regulatory authority

and will be a component of Haile's Mine Permit. Haile has proposed that underlying material capable of producing desirable reclamation and vegetation (i.e., growth media) at the Project site be stockpiled, revegetated, and protected in designated Growth Media Storage Areas until needed for reclamation. DEIS, Appendix H, Reclamation Plan.

SELC Comment No. 46. *A formal review of past reclamation practices, monitoring and evaluation of results should be performed and made available and the key observations made a part of the Reclamation Plan as well as integrated into HGM's overall reclamation approach. See* SELC Comment Letter, Exhibit A, p. 13, 4th paragraph.

Haile Response to SELC Comment No. 46. Haile's past reclamation practices, monitoring and evaluation of results has been made available to the USACE and is part of the EIS record. This information need not be included in the EIS or Haile's Reclamation Plan. *See* Haile Response to RAI 3-WQ-14, submitted to the USACE on August 13, 2012.

SELC Comment No. 47. *[T]he Reclamation Plan should recognize the limited extent to which test plots can be used to predict the requirements for "sustainable" vegetation. Also, the plan should define "sustainable" as it is used in this context and elsewhere in the document. See* SELC Comment Letter, Exhibit A, p. 14, 1st paragraph.

Haile Response to SELC Comment No. 47. Test plots during mining will be suitable predictors of whether sustainable vegetation is established. With respect to what is defined as "sustainable", SCDHEC Regulation 89-330 states: "The operator shall establish on a continuing basis the vegetative cover and soil stability appropriate to the area. Conservation practices essential for controlling both on-site and off-site erosion and siltation must be established. A minimum of seventy-five (75) percent vegetative ground cover, with no substantial bare spots, must be established and maintained into the second growing season. Where the Department finds that because of special soil conditions it is not feasible to establish a minimum of seventy-five (75) percent ground cover, it may approve a reclamation plan consistent with the original soil condition."

SELC Comment No. 48. *It is recommended that additional quality assurance and quality control (QA/QC) measures be required for the construction of the repositories and long-term monitoring of the sites (e.g. provision for 500-yrs) so as to ensure their success is proven. See* SELC Comment Letter, Exhibit A, p. 14, 4th paragraph.

Haile Response to SELC Comment No. 48. *See* Haile Response to EPA Comment No. 4, submitted on May 30, 2014. *See also* Haile Response to SELC Comment No. 19, *supra.*

SELC Comment No. 49. *We recommend requiring applicable requirements similar to those contained in NM 20.6.7.17 GENERAL ENGINEERING AND SURVEYING REQUIREMENTS to ensure that QA/QC critical to ensuring implementation of necessary oversight and procedures and general mitigation performance is incorporated into the project construction and operations. See* SELC Comment Letter, Exhibit A, p. 15, 2nd paragraph.

Haile Response to SELC Comment No. 49. *See* Haile Response to EPA Comment No. 4, submitted on May 30, 2014.

SELC Comment No. 50. *It is recommended that prior to any proposal to co-dispose of waste rock which contains significant metals content, additional testing be performed to address the effectiveness of the method with respect to the factors listed above. In addition, it is recommended that additional QA/QC measures be performed including additional characterization sampling during operations*. *See* SELC Comment Letter, Exhibit A, p. 16, 2nd paragraph & p. 18, 4th paragraph.

Haile Response to SELC Comment No. 50. To be clear, blending is not part of the proposed plan. If blending were to be proposed in the future, its use would require approval by regulatory agencies that oversee the mine. For further discussion of the Overburden Management Plan for ensuring proper segregation of Green, Yellow, and Red PAG material for proper handling, see Haile Response to EPA Comment No. 1, submitted May 30, 2014, discussing Haile's QA/QC protocol for managing overburden. During operations additional sampling and verification of overburden classification will be performed to ensure overburden is segregated and placed accordingly.

SELC Comment No. 51. *We recommend that the reclamation plan overburden classification be changed to use total rather than sulfide sulfur*. *See* SELC Comment Letter, Exhibit A, p. 16, 3rd paragraph.

Haile Response to SELC Comment No. 51. Sulfur fractionation has been used for about 35 years as the preferred means of assessing ARD risk. Sobek et al. (1978) developed the test method for assessing ARD risk by partitioning total sulfur into three fractions, namely, sulfate sulfur, sulfide sulfur, and residual sulfur. Sulfate sulfur is not considered acid generating, while only sulfide sulfur is considered to be acid generating by Sobek. Residual sulfur is not normally considered acid generating, but at Haile grouped it with sulfide sulfur for purposes of assessing acid generating potential (AGP). Therefore non-sulfate sulfur (e.g. residual plus pyritic sulfur) is used to assess AGP, which is more conservative than the approach suggested in Sobek (1978). Price (2009) considers the use of total sulfur as an example of "errors in Drainage Chemistry Prediction" on page 3-25 of his 2009 publication. Price says that use of total sulfur would overpredict the amount of material with the potential to generate acidic drainage.

Additionally, the GARD guide endorses use of sulfide sulfur or total sulfur for waste classification. The advantage of using total sulfur over sulfide sulfur at a particular mine depends on the nature of the sulfate minerals present. In a geochemical environment such as Haile, where sulfates are generally only significant in the oxide zone, there is no advantage to the use of total sulfur as sulfide sulfur based waste classification would be equally protective. This is the point made by Price, whose guidance is heavily relied upon in the GARD guide.

Price. 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND report 1.20.1

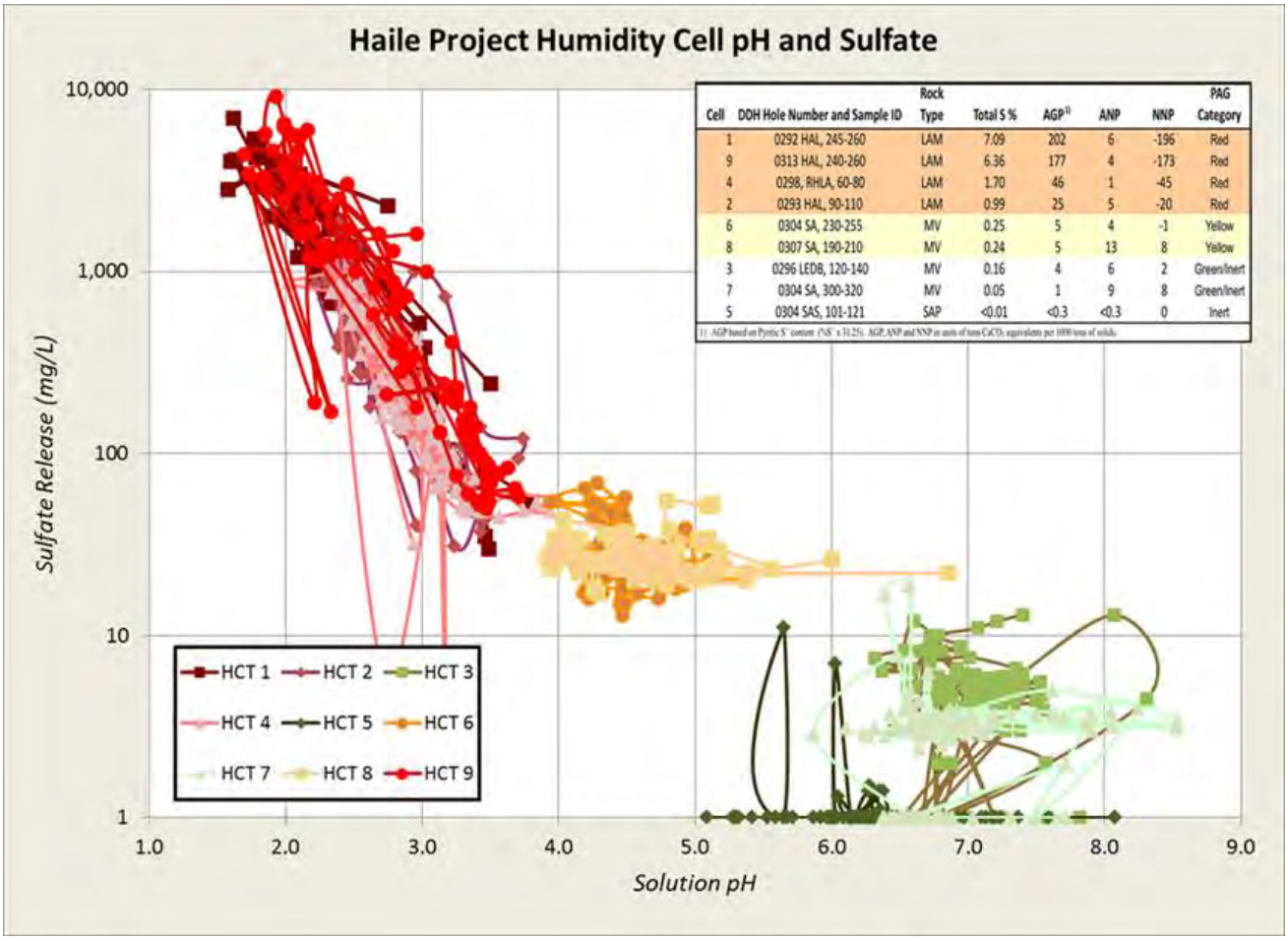
Sobek, A.A., Schuller, W.A., Freeman, J.R., and R.M. Smith, 1978. Field and Laboratory Methods Applicable to Overburdens and Minesoils. U.S. Environmental Protection Agency 600/2-78-054, Washington DC.

SELC Comment No. 52. *We recommend that the total S criteria be changed from "or" to "and" and that the NNP criteria be changed to NNP >20. See* SELC Comment Letter, Exhibit A, p. 16, 4th paragraph.

Haile Response to SELC Comment No. 52. The quote from the GARD guide provided in this comment – "Use of the NNP is not recommended for characterizing the future ARD potential" – appears to be in error. Based on a word search of GARD Chapter 4 on Characterization, Chapter 5 on Prediction and Chapter 6 on Prevention and Mitigation; there is no mention of the concept that, "Use of the NNP is not recommended for characterizing the future ARD potential."

There is no basis for the proposal to define PAG material based on all materials with an NNP of less than <+20 kg/t. This benchmark (NNP range from -20 to +20) sometimes is used to define an "uncertain" category of NNP results **when kinetic test results are lacking**. However, the proposed criteria in the Overburden Management Plan (Schafer 2010c) have been calibrated for site specific geochemical conditions using an extensive kinetic testing test program. The kinetic test results at Haile confirm that the criteria in the OMP correctly classify long-term behavior observed in kinetic tests (see Figure 6 from Schafer 2012b below). That Figure (below) shows that samples classified as Red or Yellow PAG or Green overburden had distinctly different leachate chemistry in kinetic tests and confirmed that Green overburden consists of samples that are both low in acid drainage and low in metal leaching risk.

Further, if the PAG criteria of NNP<+20 was used, the overall tonnage of PAG-classified material would increase by a factor of 3.7 from about 48.6 million tons (27.1 million tons Red PAG and 21.5 million tons Yellow PAG) to 184.1 million tons (based on 77% of Laminated Unit with NNP <+20, 61% of Metavolcanics, and 98% of saprolite and Coastal Plain sands). This would necessitate a complete re-design of the overburden facilities, would increase the overall waste footprint, would greatly increase mining costs and would not improve environmental performance.



Cell	DDH Hole Number and Sample ID	Rock Type	Total S %	AGP[1]	ANP	NNP	PAG Category
1	0292 HAL, 245-260	LAM	7.09	202	6	-196	Red
9	0313 HAL, 240-260	LAM	6.36	177	4	-173	Red
4	0298, RHLA, 60-80	LAM	1.70	46	1	-45	Red
2	0293 HAL, 90-110	LAM	0.99	25	5	-20	Red
6	0304 SA, 230-255	MV	0.25	5	4	-1	Yellow
8	0307 SA, 190-210	MV	0.24	5	13	8	Yellow
3	0296 LEDB, 120-140	MV	0.16	4	6	2	Green/Inert
7	0304 SA, 300-320	MV	0.05	1	9	8	Green/Inert
5	0304 SAS, 101-121	SAP	<0.01	<0.3	<0.3	0	Inert

1) AGP based on Pyritic S$^{=}$ content (%S$^{=}$ x 31.25). AGP, ANP and NNP in units of tons $CaCO_3$ equivalents per 1000 tons of solids.

Figure 6 from Schafer 2012b.

The criteria for overburden management developed in the OMP (Schafer 2010c) and supported by the geochemical baseline work (Schafer 2010a, 2010b, 2012a, and 2012b) are fully consistent with the development of site-specific geochemical classification criteria described in the GARD guide.

Section 5.4.16 (GARD)

> "Site-specific operational parameters and threshold values are established for waste classification (i.e., PAG vs. NPAG) based on regulatory requirements, literature, and the geochemical test program. Examples of commonly used operational parameters for waste rock management include the sulphur content (including total and sulphide sulphur), paste pH, NNP, net potential ratio (NPR), NCV, NAG test value, or NAG pH and metal content.
>
> Theoretical relationships, empirical data, and evaluation of analytical and logistical constraints should be used to establish screening or evaluation criteria. For example, if a quantitative relationship can be reliably established between ARD potential and sulphur content, a sulphur cutoff can be determined to segregate between PAG and non-PAG

waste rock. Similarly, if a relationship between metal leachability and metal content is identified, a metal concentration cutoff can be established to discriminate between material that will or will not affect receiving water quality. Sometimes a combination of methods is needed to classify problematic material, such as paste, pH, sulphur, and NPR."

Finally, we offer the following response in regards to the statement from Price "It is important to note that a %S cut-off should not be used as the only means of assessing ARD potential *unless the minimum NP value is known*" (emphasis added). A 0.2 % S (non sulfate S) cutoff is used to discriminate between Yellow PAG and Green overburden. The following graph in Figure 8 shows the AGP (red bars) and ANP (blue bars) for all samples of Green Overburden. As is readily apparent, the ANP is far greater than AGP for virtually all of the samples except for a handful of samples that have very low ANP and low AGP.

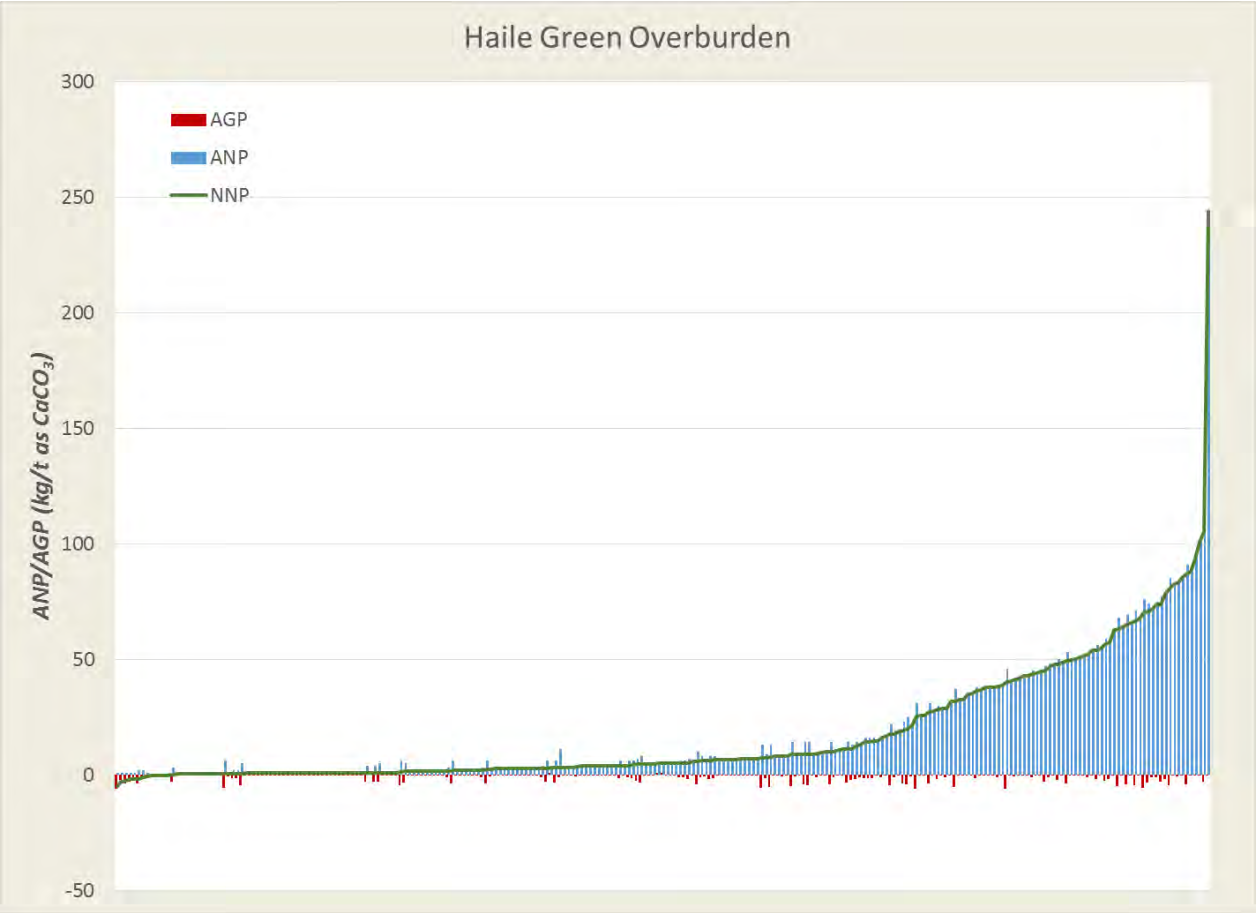


Figure 8. Comparison of AGP and ANP for Green Overburden samples.

<u>SELC Comment No. 53.</u> *It is recommended that the permit application be amended to specifically address potential nitrogen based discharges and that if potential for release is identified that the applicant be required to consider the use of non-nitrogen based explosives in whole or part. See* SELC Comment Letter, Exhibit A, p. 16, 5th paragraph.

Haile Response to SELC Comment No. 53. It is unclear as to what 'permit application' this comment is referring. Haile's Air Permit (Construction) considers the potential impacts of Haile's proposed explosives.

SELC Comment No. 54. *The Reclamation Plan should identify triggers for additional actions including monitoring and mitigation for unplanned outcomes. This should be done in the event the proposed waste management plan does not adequately result in prevention of and/or the necessary level of reduction of discharge*. *See* SELC Comment Letter, Exhibit A, p. 16-17.

Haile Response to SELC Comment No. 54. *See* Haile Response to SELC Comment No. 19, *supra.*

SELC Comment No. 55. *The Reclamation Plan should similarly provide a discussion of the uncertainty of the prediction basis for the proposed mitigation measures and provide a sensitivity analysis in the form of a FMEA and AMP as recommended elsewhere in these comments*. *See* SELC Comment Letter, Exhibit A, p. 18, 2nd paragraph.

Haile Response to SELC Comment No. 55. *See* Haile Response to SELC Comment No. 25, *supra.*

SELC Comment No. 56. *However, the description of the "green OSA's" does not include any similar provisions for growth media in the description. We assume this is an unintended omission from the Reclamation Plan, however if it is not, then the plan should provide detailed justification for this approach as it would not represent accepted best practice for hardrock mine reclamation in the U.S. See* SELC Comment Letter, Exhibit A, p. 18, 3rd paragraph.

Haile Response to SELC Comment No. 56. Per Haile's Reclamation Plan, Appendix D, page 7, Haile has proposed that the green OSAs be covered with six inches of growth media, prior to re-seeding.

SELC Comment No. 57. *The reclamation cost estimate should be revised to consider additional reclamation and closure scenarios including unplanned closure at the time of maximum reclamation liability to ensure adequate financial assurance is available for a third party contractor to complete mine closure and post-closure tasks under the direction of SCDHEC and cooperating agencies should the operator be unable to fulfill their commitments for planned mine closure. See* SELC Comment Letter, Exhibit A, p. 21, 2nd paragraph.

Haile Response to SELC Comment No. 57. *See* Haile Response to SELC Comment No. 19, *supra.*

SELC Comment No. 58. *A more conservative approach should be applied in the financial assurance estimate to determine reclamation requirements and associated closure costs with reliance on existing requirements used by other federal and state agencies where hardrock mines are commonly operated and bonded. See* SELC Comment Letter, Exhibit A, p. 21, 3rd paragraph.

Haile Response to SELC Comment No. 58. *See* Haile Response to SELC Comment No. 19, *supra.*

SELC Comment No. 59. *Reclamation and closure requirements and the related short and long-term costs for hard rock mines with associated acid mine drainage can range from $10 million to several hundred million dollars per mine, with costs closer to the $100-$500 million dollar range when water quality impacts such as acid mine drainage require water management and treatment into perpetuity (100 – 500 years is commonly considered in closure costs). See* SELC Comment Letter, Exhibit A, p. 22.

Haile Response to SELC Comment No. 59. No reference is provided for the suggestion that the projected range in reclamation costs ($10,000,000 to several hundred million) for mines without acid mine drainage requiring water management and treatment into perpetuity to $100,000,000 to $500,000,000 for mines with acid mine drainage requiring water management and treatment into perpetuity. These are not typical of industry costs. Furthermore, the reclamation and closure cost estimates developed by Haile, based on specific construction and operational requirements for the Haile site, are far more reliable than such wide-ranging and unsupported conjecture about costs.

SELC Comment No. 60. *The reclamation plan should be revised to more specifically define post-mining land use (PMLU) objectives at closure for the 2,612 acres of disturbed area. The current description of PMLU is too conceptual for determination of appropriate reclamation tasks, long-term monitoring and operation and maintenance requirements, estimated costs and financial assurance release criteria for a given mine feature or PMLU. See* SELC Comment Letter, Exhibit A, p. 22-23.

Haile Response to SELC Comment No. 60. Post-mining land use objectives for closure have been appropriately described in Haile's proposed Reclamation Plan and may be revised over time in consultation with SCDHEC, as appropriate, based upon additional site-specific information.

SELC Comment No. 61. *The reclamation plan should be revised to estimate tasks and costs at the time of maximum disturbance and reclamation liability. See* SELC Comment Letter, Exhibit A, p. 23, 2nd paragraph.

Haile Response to SELC Comment No. 61. *See* Haile Response to SELC Comment No. 19, *supra.*

SELC Comment No. 62. *The DEIS should require additional studies to refine the revegetation plan as mine operations proceed instead of relying upon the South Carolina Department of Natural Resources (SCDNR) and SCDHEC to develop study plans in future permits. See* SELC Comment Letter, Exhibit A, p. 23, 4th paragraph.

Haile Response to SELC Comment No. 62. NEPA regulations are procedural and do not expand the USACE's regulatory authority beyond that granted by statute. Any suggestion by SELC that the USACE should attempt to use NEPA to regulate issues within SCDHEC's regulatory authority is inappropriate.

SELC Comment No. 63. *Soil amendments and application of a seed mix should be required as part of the reclamation plan until it has been demonstrated through test plot evaluations that they will not be necessary to achieve the desired PMLU. See* SELC Comment Letter, Exhibit A, p. 23, 5th paragraph.

Haile Response to SELC Comment No. 63. South Carolina Code of Regulations Section 89-140 (C) requires that topsoil sufficient to satisfy reclamation requirements shall be removed and stored in such a manner as to remain available for reclamation and shall not be carried away or covered up with other materials. Thus, 'soil handling' is within SCDHEC's regulatory authority and will be a component of Haile's Mine Permit. Haile has proposed that underlying material capable of producing desirable reclamation and vegetation (i.e., growth media) at the Project site be stockpiled, revegetated, and protected in designated Growth Media Storage Areas until needed for reclamation. Haile believes test plot evaluations during mining will be adequate to determine whether soil amendment is also necessary.

SELC Comment No. 64. *The DEIS should consider alternative closure measures should pit backfill not be practicable under actual closure conditions, and rely upon adaptive management planning throughout the life of the project to modify closure requirements as appropriate. See* SELC Comment Letter, Exhibit A, p. 24, 2nd paragraph.

Haile Response to SELC Comment No. 64. As noted above in Haile Response to SELC Comment No. 14, the EIS need only consider reasonable or practicable alternatives, not speculative future "what if" scenarios. Sequencing of mine development and the availability of backfill materials has been carefully evaluated as an integral component of Haile's overall Mine Plan. Should alternative closure methods be required at some future time based upon unforeseen circumstances, Haile will work with SCDHEC to identify appropriate closure measures that are protective of the environment (i.e., closure and reclamation will follow an adaptive management approach). *See also* Haile Response to SELC Comment No. 19.

SELC Comment No. 65. *The reclamation plan needs to include a basis for the determination that these facilities will be ready to transition to passive treatment after 5 years of active water treatment post-closure as described for Johnny's PAG. See* SELC Comment Letter, Exhibit A, p. 24, 5th paragraph.

Haile Response to SELC Comment No. 65. Information responsive to this comment has already been provided by Haile. *See* Haile Supplemental Response to RAI 2-EN-03-a & -b, submitted to the USACE on May 11, 2012. As explained therein, passive treatment cells would substitute for active treatment of the flow (seepage) from the lined facility into its collection system, at a point in time in the future where such treatment was suitable. If passive treatment cells are designed and constructed in the future, the water quality will meet State standards applicable at the time. Thus, a difference in Haile's projected timeframe as to when Johnny's PAG and the TSF may be capable of transitioning from active to passive treatment is immaterial from an evaluation of potential impacts. However, in order to respond to SELC's comment, Haile is providing information that SCDHEC has requested in support of Haile's Mine Permit application, which confirms Haile's projection of when Johnny's PAG and the TSF may be able

to transition from an active to a passive treatment system. See Exhibit 1 to SELC Comment No. 65, Technical Memorandum on PAG Draindown (ERC, May 28, 2014), and Exhibit 2 to SELC Comment No. 65, Draft Draindown Rate Prediction for Haile TSF (Schafer Limited LLC, May 30, 2014).

SELC Comment No. 66. *The monitoring activities are only planned for 35 and 63 years after mining production begins, and are not planned for an adequate duration to ensure the ongoing management and maintenance of these acid generating waste facilities into perpetuity as committed by Haile in this DEIS, and to meet the requirements of the SCMA. Post-closure monitoring activities are planned to conclude before groundwater levels are predicted to return to steady state conditions. The DEIS needs to also consider additional tasks and costs with respect to monitoring and maintenance such as replacement of cover materials, revegetation and weed control, replacement of water management facilities and reagents, media, pipelines, etc. required to meet permit requirements. See* SELC Comment Letter, Exhibit A, p. 25, 2nd paragraph.

Haile Response to SELC Comment No. 66. *See* Haile Response to SELC Comment No. 19, *supra.*

SELC Comment No. 67. *The Duckwood TSF and Johnny's PAG would need to be maintained in an undisturbed condition for perpetuity to protect and maintain the integrity of the closure systems." (DEIS, p 2-10) … The DEIS should address how funding and enforcement would be provided for "perpetuity" or acknowledge that such guarantees cannot be made. See* SELC Comment Letter, Exhibit A, p. 25, 3rd paragraph.

Haile Response to SELC Comment No. 67. Regarding funding in perpetuity, s*ee* Haile Response to SELC Comment No. 19, *supra.*

SELC Comment No. 68. *The DEIS should prepare a revised cost estimate to determine adequate financial assurance in the event of bankruptcy or operational upset that requires closure tasks to be completed by the SDHEC and other cooperating agencies*. *See* SELC Comment Letter, Exhibit A, p. 26, 1st paragraph.

Haile Response to SELC Comment No. 68. *See* Haile Response to SELC Comment No. 19, *supra.*

HAILE SUPPLEMENTAL RESPONSE TO SELC - EXHIBIT B

SELC Comment No. 69. *Once mining ceases, up to 69 gpm would be diverted into the Ledbetter Pit for refill, although it could be higher. The DEIS does not explain how it could be higher. This affects the downstream flow rates on Haile Gold Mine Creek because there is no pit lake outflow. Once the pit lake is full, the creek would flow into and out of the pit. The DEIS implies that no diversion permit would be necessary, presumably because the pit lake would technically be part of the stream at that point. See* SELC Comment Letter, Exhibit B, at p. 3, 3rd paragraph.

Haile Response to SELC Comment No. 69. Sixty-nine gallons per minute (69 gpm) is the maximum rate that can be diverted from a surface water source without a South Carolina surface water withdrawal permit. In the event that Haile were to pursue a surface water withdrawal permit, Haile would need to leave minimum instream flows in Haile Gold Mine Creek but could divert the safe yield of the stream as defined by that State. The DEIS does consider the potential impacts of higher diversions. As stated in the first full paragraph of page 4.3.14, "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)."

SELC Comment No. 70. *This would also apply to stream temperature because stream temperatures during summer would be maximized at the time the baseflow is lowest; there would be no discharge to mitigate the high temperatures. See SELC Comment Letter, Exhibit B, at p. 4, 2nd paragraph.*

Haile Response to SELC Comment No. 70. During closure, piped diversions will be removed and the streams will be reclaimed. See DEIS, Appendix H. The DEIS considered heating of the water that is expected during operations as a result of these piped sections. Removal of these pipes will help reduce the temperature, helping to alleviate temperature concerns.

SELC Comment No. 71. *The DEIS also suggests that water quality results do not include any dilution, and then it says there is dilution at a 3:1 rate. The DEIS suggests that the water quality model "over-predicted concentrations of chemicals in groundwater" because there is no dilution with unaffected groundwater (DEIS 4.3-10). Then it describes how it used "Dilution in Predicting Groundwater Quality" (DEIS p 4.3-20). The last section in this review describes how they estimate dilution to be much too high, even with the choice of 3:1, but the DEIS is simply unclear as to whether the comparisons to standards rely on dilution or not. If it did, it is likely that the DEIS has grossly overestimated compliance with standards.* See SELC Comment Letter, Exhibit B, at p. 4, 6th paragraph.

Haile Response to SELC Comment No. 71. The intent of the analysis described in the DEIS was to predict what groundwater concentrations were likely to be at monitoring wells that will be located and drilled as part of the operational monitoring plan. (Put another way, the 3:1 dilution factor was used for purposes of generally predicting ground water chemistry only; the mass load model used to predict surface water quality assumed no dilution of the pollutant loadings from the various mine facilities when predicting surface water quality impacts.) The actual mixtures of background groundwater and mine contact water necessarily will depend on the exact location of proposed monitoring wells, well depth and screened depth, the nature of the upgradient mine facilities, the natural of groundwater movement, and the characteristics of the groundwater mixing zone. The analysis in *Clarification of Surface Water Quality Impact Model and Groundwater* (Schafer and Newfields, January 13, 2014) (hereinafter Schafer and Newfields 2014) used a range of dilution ratios (5:1 to 13:1) to represent these effects as described below. The DEIS used a lower bound dilution ratio of 3:1.

> "1.3 Use of Surface Water Model to Predict a Range of Groundwater Chemistry
>
> The chemical load prediction for backfill and other sources of subsurface loading used in the surface water model are not meant to predict actual groundwater concentrations, but

rather overestimate concentrations for a number of reasons. For example, the predicted backfill concentration accounts only for worst case release of soluble constituents due to water in direct contact with waste rock occurring within the interstitial pore space of the backfilled rock, and accounts for additional geochemical equilibrium reactions that would occur due to limestone addition and due to subsurface gaseous concentrations of carbon dioxide and oxygen. The backfill source term does not account for dilution with background groundwater, hydrodynamic dispersion and attenuation reactions that might occur downgradient of the mine pits, or the gradual rinse-out of the constituents due to groundwater flux. Each of these functions will occur at the Haile site, reducing the actual concentrations.

1.3.3 Predicted Groundwater Effects

The combined flows of contact water (280 gpm) were averaged and mixed with the total calculated groundwater flux at the Haile mine (3,944), which results in a 13:1 dilution ratio. Localized groundwater near the mine facilities may have a somewhat lower dilution ratio and higher concentrations. Therefore, a second predicted groundwater case was developed using a 5:1 dilution ratio. This lower dilution will yield higher predicted groundwater concentrations, which based on professional judgment may be more representative of localized groundwater downgradient of the mine facilities (e.g. in monitoring locations shown in the Haile Gold Mine Monitoring and Management Plan)."

SELC Comment No. 72. *Drawdown will affect wetlands if there is a connection, but if the wetland is perched there may be no or only a delayed impact. See SELC Comment Letter, Exhibit B, at p. 5, 5th paragraph.*

Haile Response to SELC Comment No. 72. Haile concurs. Wetland impacts presented in the DEIS provide an upper bound of potential wetland impacts and it is understood that other water sources contribute to wetland hydrology.

SELC Comment No. 73. *The DEIS should consider that any drawdown beneath a stream or wetland could have an effect. Wetlands that have little drawdown due to the presence of a stream but that are surrounded by drawdown away from the stream, should also be mapped as being indirectly affected.* See SELC Comment Letter, Exhibit B, at p. 5-6.

Haile Response to SELC Comment No. 73. The DEIS considered that all wetlands where the groundwater model predicted a drawdown of greater than one (1) foot as resulting in an indirect impact. Therefore, as a conservative approach any wetlands within areas of predicted groundwater drawdown of greater than 1-foot, regardless of other hydrologic inputs (i.e., runoff, precipitation or being perched) were considered indirectly impacted.

This indirect assessment is explained further in the DEIS Section 4.6.3.1, (page 4.6-5) which states" any wetlands that are exposed to groundwater drawdown in excess of 1 foot for sustained periods could be indirectly affected" and Section 4.6.5.1 (Page 4.6-14) which states that the "Applicant's proposed project could result in 982.58 acres of indirect impact on wetlands where the groundwater drawdown in excess of 1 foot would occur".

SELC Comment No. 74. *The DEIS includes multiple references to NewFields and Schafer (2013) which as described on page 4.3-43 is a memorandum concerning "Preliminary Haile Particle Tracking Results". The memorandum is just four pages plus 7 figures and concerns particle tracking. The DEIS cites it as describing pit refill (p 4.3-2, 4.3-8) including the time to fill the Ledbetter Pit (p 4.3-31), post closure mass load model (Id.), locating monitoring wells based on loads (Id.), as being the Post-Closure Water Quality Report (4.3-2, 4.3-10), a sensitivity analysis for pit lake modeling (p 4.3-13), dilution in groundwater quality calculation (p 4.3-20), as describing the starting conditions for simulating the post-mining period (p 4.3-23), and project impacts on groundwater quality (p 4.3-23). Newfields and Schafer (2013, p 1) states: " NewFields (2013) developed a model of groundwater recovery and pit lake filling using the Cardno groundwater model" (p 1). The memo does not even include a Literature Cited section so it is not possible to identify Newfields (2013). Newfields (2013) is also cited twice in the DEIS but there is no listing in the Literature Cited section. The DEIS apparently confuses documents and fails to list the most important one.*

The DEIS also references Schafer and Schlumberger Water Services (2011) regarding financial assurances for "proposed reclamation and closure activities" (4.1-22), but the Literature Cited includes a Schafer and Schlumberger (2013) titled Draft Haile Gold Mine Revised Post-Closure Water Quality Impact Evaluation. The date is wrong, but based on the title it is unclear whether this is the document for the citation. The Newfields and Schafer (2013) memorandum discussed in the previous paragraph refers to the "Schafer and Schlumberger 2011 report", but again provides no references. This is another example of the DEIS and accompanying documents providing very poor referencing.

More generally, the DEIS does a poor job of referencing modeling discussions and results. The discussion in the last two paragraphs provides just a couple of examples. For surface water flow and quality (Section 4.4, p 4.4-1), the DEIS lists Schaffer, AMEC, and ERC (2013), as being the basis for the results as affected by pit refilling. The rest of the discussion in the section regarding these issues is unreferenced, so the reader is left guessing which report a given calculation may result from. Because Schafer, AMEC, and ERC (2013) is based on a now-superseded groundwater model (pre-C-E), it would have used incorrect groundwater flows. Schafer and Newfields (2014), Schafer (2013b), Newfields (2013) and Newfields and Schafer (2013) appear to update the pit lake refill and quality modeling. The water quality subsection is much worse, with section 4.4.1.4 listing 14 references which "were used to assess impacts on stream water quality" (p 4.4-3). The reader cannot actually find where given calculations were made when provided simply with a long list of references which had been used.

The DEIS should be reedited to properly reference the technical supporting documents. See SELC Comment Letter, Exhibit B, at p. 6, 4th paragraph.

Haile Response to SELC Comment No. 74. Haile agrees that the references in the DEIS were incorrect. Several Tech Memos collectively describe the results of the revised Surface Water Impact Model. References should include:

- Schafer, AMEC, and ERC, 2013. Draft Haile Gold Mine Revised Post-Closure Water Quality Impacts Evaluation. February 2013. (*Includes the original Impact Analysis model and report that was based on the AMEC groundwater model. This report provides*

useful background information about the modeling approach and the site conceptual model but specific model results have been superseded by a series of Technical Memoranda that convey updated results based on the Cardno groundwater model.)

- Newfields and Schafer Limited, LLC, 2013. Memorandum: Preliminary Haile Particle Tracking Results, December 11. (*Describes the groundwater refilling stage model and particle tracking results.)*

- Schafer Limited LLC 2013a. Preliminary Pit Lake Hydrology and Water Quality Results. December 11, 2013. (*Provides water balance and water chemistry for the revised Ledbetter Pit Lake model.)*

- Schafer Limited, LLC. 2013b. Preliminary Little Lynches River Water Quality Results. December 13, 2013. (*Provides water chemistry results for the revised Little Lynches River surface water quality model.)*

- Schafer Limited, LLC. 2013c. Preliminary Water Quality Result Tables. December 16, 2013. (*Includes a more detailed listing of predicted water quality in tabular form.)*

- Schafer Limited, LLC. 2014. Clarification of Surface Water Quality Impact Model and Groundwater. January 13, 2014. (*Provides clarification of several elements of the model results including comparison to water quality standards and development of predicted groundwater concentrations.)*

SELC Comment No. 75. *The DEIS cites Newfields and Schaffer (2013) regarding pit lake recovery and many other things, as listed above. However, that memorandum is limited to particle tracking results. It provides a confusing description of the Particle Tracking Simulation. First it describes the "mass load model" which assumes that chemical loads reach the confluence of Haile Gold Mine Creek and the Little Lynches River, that there is no attenuation or transformation of chemical species, and that loads have zero travel time. The focus is on "water quality prediction at a downgradient compliance location". This mass load model description is not referenced. Then it implies that more detail on "chemical behavior at intermediate locations nearer the mine facilities" would be useful, but rejects a fate and transport model to assess chemical flux in lieu of a particle tracking analysis, calling it a "reasonable alternative" to "provide additional information about rate and direction of chemical flux". This is not correct because particle tracking only provides the paths along which a conservative substance flows; it does not provide a concentration at any point nor does it allow the estimation of a load. It does provide a travel time from the point of particle release to a receptor without consideration of dispersion. See* SELC Comment Letter, Exhibit B, at p. 23, 3rd paragraph.

Haile Response to SELC Comment No. 75. Haile agrees that the discussion of particle tracking in the DEIS is confusing. The purpose of particle tracking is to illustrate the direction and rate of groundwater flux, which can be taken as an approximation of the potential rate of transport of a soluble constituent in groundwater. Haile disagrees that the particle tracking routine substantially underestimates travel time; however, the surface water impact modeling

assumed zero travel time, and ignored the tendency for chemical reactions including attenuation to reduce loading to insure that predictions were conservative.

SELC Comment No. 76. *DEIS Figure 4.3-15 shows a useful breakdown of rock type by elevation. It would be more useful to show the amount of water entering the pit lake from each level with time since this is the input necessary to the model.*

The pit lake modeling should be redone accounting for water flow into the pits by geologic formation. See SELC Comment Letter, Exhibit B, at p. 25, 1st paragraph.

Haile Response to SELC Comment No. 76. Groundwater contributions to the pit lake were tracked separately for different components of the groundwater system in the pit lake model. An example of the detailed water balance follows (Figure 9) (Schafer 2013a).

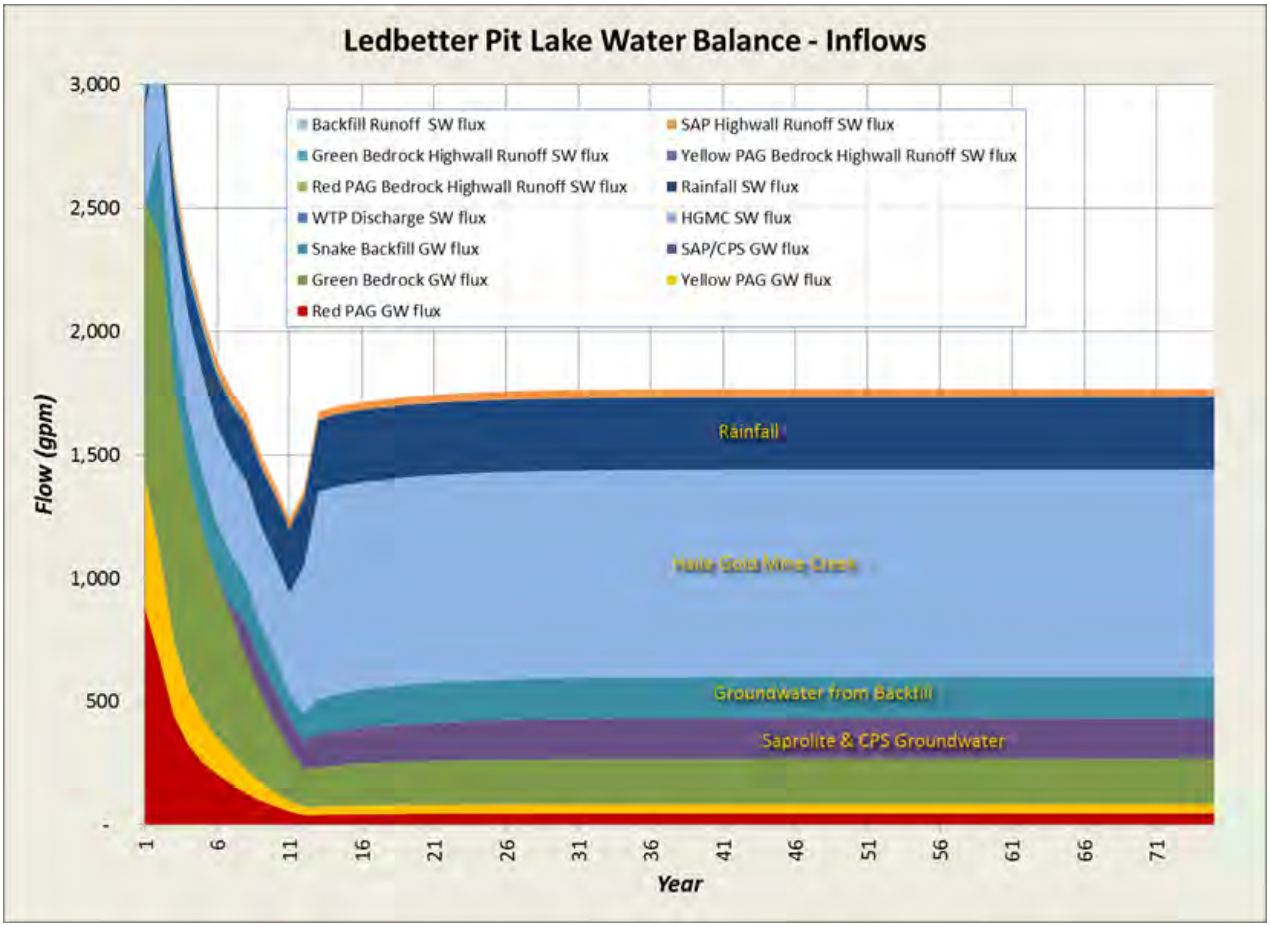


Figure 9. Pit lake water balance.

SELC Comment No. 77. *Schafer and Newfields (2014, p 8) claim that most seepage would be neutralized within feet of leaving the source without data or analysis. The only way this would occur is if the seepage is considered spread across the area of the source, an incorrect assumption because most of the seepage would concentrate at preferential flow paths so that the neutralizing capability would be used relatively quickly.*

Schafer and Newfields (2014, p 13 and 14) also emphasize that the mass balance estimates may be too high because they ignore geochemical reactions which could occur between the source and the point of interest. This could go both ways due to the aquifers being dewatered for 14 years or more. As the water table draws down, air, including oxygen, enters which could allow oxidation products to form. As the water levels recover or seepage from above encounters these products, they could be leached and add a source not previous considered in the analysis.

The DEIS should not rely on assurances that the presented analysis is conservative. See SELC Comment Letter, Exhibit B, at p. 26, 5th and 6th paragraphs.

Haile Response to SELC Comment No. 77. The predicted seepage rates from the TSF and JPAG facilities are 0.4 and 0.18 gpm respectively, as discussed above and supported with more detailed analysis in Exhibit 2 to SELC Comment No. 65. The nature of seepage from the lined facilities is through small imperfections spaced broadly over the entire facility footprint. As a consequence these flows would be distributed over a large area. Even if these flows were more concentrated, a significant amount of neutralization (for the JPAG solution), chemical precipitation, biotransformation (nitrate and ammonia), and sorption of metals would be expected over relatively small distances.

Aquifer dewatering is not expected to have a large influence on the chemistry of groundwater due to oxidation of sulfides in that portion of the groundwater that is drained. This is because the supply of oxygen would be extremely limited so deep in the groundwater system. Any chemical changes due to dewatering are expected to be small relative to other effects simulated in the model.

Haile Gold Mine, Inc.'s Supplemental Response No. 2 to the Southern Environmental Law Center et al. Comments Received by the United States Army Corps of Engineers on the Haile Gold Mine Draft Environmental Impact Statement

Submitted June 4, 2014

Haile Gold Mine, Inc.'s (Haile) Supplemental Response No. 2 to the Southern Environmental Law Center (SELC) et al. Comments Received by the United States Army Corps of Engineers (USACE) on the Haile Gold Mine Draft Environmental Impact Statement (DEIS) has been prepared to the best of Haile's ability, based upon information that is currently and reasonably available.

SELC Comment No. 78. *The concern regarding whether the DEIS considers the maximum potential drawdown discussed in the previous section also applies to streamflow quality. Just after mine dewatering ceases when baseflow may be at a minimum, the discharge of pollutants could be [at] a maximum . . . The DEIS should provide an analysis of streamflow water quality at the critical time period for baseflow reduction during pit lake recovery. See* SELC Comment Letter, Exhibit B, at p. 4, 3rd paragraph.

Haile Response to SELC Comment No. 78. The discharge of pollutants to Haile Gold Mine Creek will not be at "maximum" levels at any time during filling of Ledbetter Pit Lake. As a general principle, the groundwater that comprises baseflow has higher ion concentrations than runoff; as a result, reduced baseflow would tend to slightly reduce the annual average concentration of dissolved ions in surface water. Furthermore, at the time period noted in the comment, any pollutant load from mine facilities would be relatively small because: (1) pollutant loads from the backfilled pits will be relatively small when the groundwater baseflow is at a minimum (since conveyance of these chemical loads relies on groundwater flow); (2) no pollutant loads will be released from the surface outlet of Ledbetter Pit Lake (which is still filling until approximately Closure Year 13); and, (3) excess water from Johnny's PAG and the TSF (either collected run off or seepage) will be treated prior to discharge, thus minimizing loading from these sources. Consequently, the majority of the surface water in the basin during any period that drawdown continues immediately after cessation of depressurization would be receiving limited pollutant loading from mine facilities. In other words, lower Haile Gold Mine Creek would be predominantly comprised of surface runoff and treated water during this time.

Exhibit 1 to SELC Comment No. 2
(Haile Supplemental Response No. 1 to SELC DEIS Comments):

Estimated Leakage Rate Through Lined Facilities

(Note: This analysis was previously provided to the USACE as Appendix E of Schafer, AMEC and ERC 2013.)

Technical Memorandum

To: Haile Gold Mine Inc.

Project 74201263B

From: Amec Earth & Environmental, Inc.

Date: October 27, 2011

Re: Duckwood TSF Composite Liner Seepage Evaluation

AMEC Earth and Environmental (AMEC) has prepared this memorandum at the request of Haile Gold Mine, Inc. (Haile) to estimate the seepage through the liner of the proposed Tailing Storage Facility (TSF) located at the Haile Mine. The TSF includes four separate construction phases to accommodate the estimated 13-year life expectancy of the mine. The first phase of construction is planned to store approximately 7.5 million dry tons of tailings while the final stage will have a capacity of approximately 40 million dry tons of tailings. The basin floor and the upstream embankment face of the entire facility will be lined with 60-mil smooth high density polyethylene (HDPE) geomembrane, with the majority of the HDPE underlain by 1-foot of low-permeability soil. The basin will have an 18-inch thick drainage blanket with a network of perforated collection pipes to route effluent from the TSF. The total area of the lined basin and embankment area is approximately 14 million ft^2. The entire geomembrane-lined area was considered in the seepage analysis completed herein.

The objective of the drainage blanket and collection pipes is to reduce the hydrostatic head above the liner and convey effluent out of the the system. The drainage blanked has a hydraulic conductivity several magnitudes greater than the overlying tailings mass and when coupled with the internal drainage system, the hydraulic head overlying the geomembrane is quite low. Essentially, due to the large difference in hydraulic conductivity between the tailings and the drainage blanket, effluent is removed from the drainage material faster than the overlying tailings can replenish. However, location within the TSF basin has an effect on the anticipated hydraulic head overlying the composite liner system. The basin area underlying the supernatant pond will be subjected to constant seepage, while the basin area outside the limits of the supernatant pond is primarily unsaturated and seepage reporting to the base of the facility is intermittent. Therefore, when estimating the hydrostatic head above the basin composite liner system, a value of 1.5 and 0.5 feet was selected interior and exterior to the supernatant pond area, respectively.

For seepage to occur, defects in the liner must be present to allow the passage of effluent. A liner defect frequency of two circular defects per acre was selected as appropriate given the high level of anticipated construction quality control. Additionally, the permeability and thickness of the low permeability soil layer underlying the HDPE geomembrane directly affects the rate of infiltration. The proposed construction plans recommend a 12-inch thick low permeable soil layer with a hydraulic conductivity of 3.28×10^{-8} ft/sec (1×10^{-6} cm/sec) or less.

The quality of contact between the HDPE geomembrane and the underlying clay layer is a key factor governing the percolation rate through the clay layer because it establishes the size of the wetted area. Values developed by Giroud et al. (1989) ranged from 0.21 for good contact to 1.15 for poor contact. The contact quality factor (C_{qo}) used in this calculation was 0.21 as very high levels of construction quality control are anticipated.

The Giroud (1997) equation for estimating the rate of liquid migration through a composite liner system was used to calculate the maximum anticipated seepage emanating from the proposed Duckwood TSF.

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others require graphs to acquire one of the variables. Assuming circular defects, the seepage equation is as follows:

$$Q = C_{qo}\left[1 + 0.1(h/t_s)^{0.95}\right]a^{0.1}h^{0.9}k_s^{0.74}n$$

Where Q is the leakage rate through a defect, C_{qo} is the contact quality factor, h is the hydraulic head above the geomembrane, t_s is the thickness of the underlying clay layer, a is the area of the circular defect, k_s is the hydraulic conductivity of the underlying clay layer, and n is the number of defects per acre in the geomembrane.

The resulting seepage for the entire Duckwood TSF based on the assumptions stated above is estimated to be approximately 0.4 gpm (25.2 cm^3/sec) given good installation and quality assurance practices. The calculations are summarized in the attached spreadsheet.

Sincerely,
AMEC Earth & Environmental, Inc.

Carl Burkhalter, P.E.
Senior Associate

Attachment1 – Seepage Calculations

Attachment 1

Seepage Calculations

Geomembrane Leakage Rate Underlain by Relatively Low Permeability Soil

Project: Duckwood TSF
Client: Haile Gold Mine, Inc.
Facility: Supernatant Pond Area

Inputs
Outputs

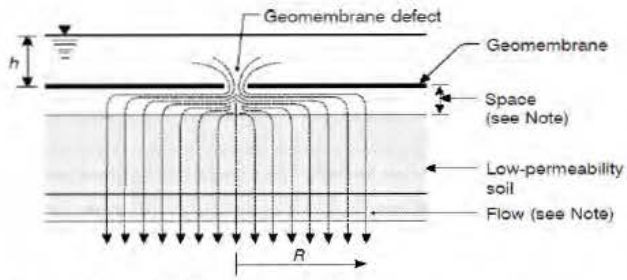

Figure 1. Liquid migration through a composite liner.

$$Q = C_{qo}\left[1 + 0.1(h/t_s)^{0.95}\right]a^{0.1}h^{0.9}k_s^{0.74}n \quad \text{(Giroud, 1997)}$$

Where: $n = \left(A/43{,}560\ ft^2\right) \times DefectsPer\ \ Acre$

$$a = \pi\left(d^2/4\right)$$

Typical Installation Damage [*1]

Installation Quality	Defects per Acre
Excellent	Up to 1
Good	1 to 4
Fair	4 to 10
Poor	10 to 20

Assume 2 Defects Per Acre

Contact Quality Factor, C_{qo} [*2]

Liner/Soil Contact	Factor (Circ. Defect)
Good	0.21
Poor	1.15

Assume 0.21 for Contact Quality

Inputs Defined:

Q = Leakage Rate
n = Number of Defects in Geomembrane[*1]
a = Area of Circular Defect
g = Acceleration of Gravity (32.2 ft/s^2 or 9.81 m/s^2)
h = Hydraulic Head Above Geomembrane
d = Diameter of Circular Defect
A = Area of Geomembrane Lined Facility
C_{qo} = Contact Quality Factor[*2]
k_s = Permeability of Underlying Soil Layer
t_s = Thickness of Underlying Soil Layer

Variable Inputs

English Units			Metric Units	
d (in)	0.444		d (m)	0.0113
A (ft^2)	7,532,460		A (m^2)	699,788
h (ft)	1.5000		h (m)	0.4572
k_s (ft/sec)	3.28E-08		k_s (m/s)	1.00E-08
t_s (ft)	1.0		t_s (m)	0.3

Calculated Values

English Units			Metric Units	
n	346		n	346
a (ft^2)	1.07E-03		a (m^2)	9.98E-05
Q (ft^3/s)	6.96E-04		Q (m^3/s)	1.97E-05

Conversion

$$1.97\text{E-}05\ \frac{m^3}{\sec} \times \frac{60\ \sec}{\min} \times \frac{264.1 gal}{m^3} = 0.31\ \frac{gal}{\min}$$

Assumptions

1. Above equations are for a circular defect with a diameter less than 25 mm.
2. The hydraulic head above the liner should be equal to or less than 3 m
3. The typical installation damage assumes a circular defect diameter of approxiately 3.5 mm given good to excellent quality control.

References

1. Giroud, J.P. 1997. "Equations for Caulculating the Rate of Liquid Migration Through Composite Liners Due to Geomembrane Defects". Geosynthetics International. Vol 4, Nos. 3-4, pp. 335-348.

Geomembrane Leakage Rate Underlain by Relatively Low Permeability Soil

Project: Duckwood TSF
Client: Haile Gold Mine, Inc.
Facility: Outside of Supernatant Pond Area

Inputs
Outputs

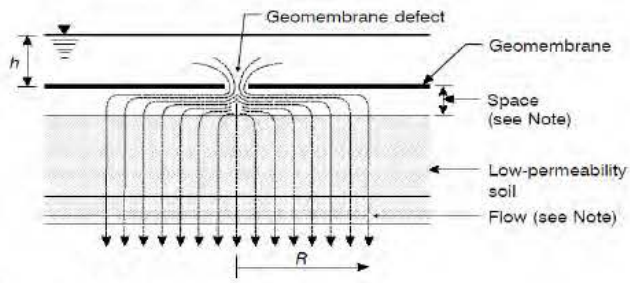

Figure 1. Liquid migration through a composite liner.

$$Q = C_{qo}\left[1 + 0.1(h/t_s)^{0.95}\right]a^{0.1}h^{0.9}k_s^{0.74}n \quad \text{(Giroud, 1997)}$$

Where: $n = \left(A/43{,}560\ ft^2\right) \times DefectsPer\ \ Acre$

$$a = \pi\left(d^2/4\right)$$

Typical Installation Damage [1]

Installation Quality	Defects per Acre
Excellent	Up to 1
Good	1 to 4
Fair	4 to 10
Poor	10 to 20

Assume 2 Defects Per Acre

Contact Quality Factor, C_{qo} [2]

Liner/Soil Contact	Factor (Circ. Defect)
Good	0.21
Poor	1.15

Assume 0.21 for Contact Quality

Inputs Defined:

Q = Leakage Rate
n = Number of Defects in Geomembrane[1]
a = Area of Circular Defect
g = Acceleration of Gravity (32.2 ft/s² or 9.81 m/s²)
h = Hydraulic Head Above Geomembrane
d = Diameter of Circular Defect
A = Area of Geomembrane Lined Facility
C_{qo} = Contact Quality Factor[2]
k_s = Permeability of Underlying Soil Layer
t_s = Thickness of Underlying Soil Layer

Variable Inputs

English Units		Metric Units	
d (in)	0.444	d (m)	0.0113
A (ft²)	6,467,540	A (m²)	600,854
h (ft)	0.5000	h (m)	0.1524
k_s (ft/sec)	3.28E-08	k_s (m/s)	1.00E-08
t_s (ft)	1.0	t_s (m)	0.3

Calculated Values

English Units		Metric Units	
n	297	n	297
a (ft²)	1.07E-03	a (m²)	9.98E-05
Q (ft³/s)	2.04E-04	Q (m³/s)	5.77E-06

Conversion

$$5.77\text{E-}06\ \frac{m^3}{\sec} \times \frac{60\ \sec}{\min} \times \frac{264.1\,gal}{m^3} = 0.09\ \frac{gal}{\min}$$

Assumptions

1. Above equations are for a circular defect with a diameter less than 25 mm.
2. The hydraulic head above the liner should be equal to or less than 3 m
3. The typical installation damage assumes a circular defect diameter of approxiately 1.13 cm given good quality control.

References

1. Giroud, J.P. 1997. "Equations for Caulculating the Rate of Liquid Migration Through Composite Liners Due to Geomembrane Defects". Geosynthetics International. Vol 4, Nos. 3-4, pp. 335-348.

Geomembrane Leakage Rate Underlain by Relatively Low Permeability Soil

Project: HGM EIS Support
Client: Haile Gold Mine, Inc.
Facility: Johnny's PAG - 6.4 M ft^2

Inputs
Outputs

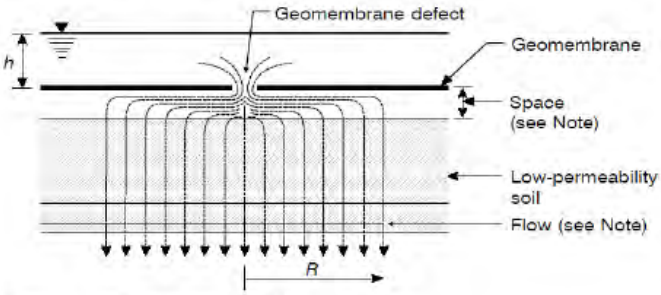

Figure 1. Liquid migration through a composite liner.

$$Q = C_{go}\left[1 + 0.1(h/t_s)^{0.95}\right]a^{0.1}h^{0.9}k_s^{0.74}n \quad \text{(Giroud, 1}$$

Where: $n = \left(A/43{,}560\ ft^2\right) \times DefectsPer\ \ Acre$

$$a = \pi\left(d^2/4\right)$$

Typical Installation Damage [*1]

Installation Quality	Defects per Acre
Excellent	Up to 1
Good	1 to 4
Fair	4 to 10
Poor	10 to 20

Assume 2 Defects Per Acre

Contact Quality Factor, C_{go} [*2]

Liner/Soil Contact	Factor (Circ. Defect)
Good	0.21
Poor	1.15

Assume 0.21 for Contact Quality

Inputs Defined:

Q = Leakage Rate
n = Number of Defects in Geomembrane[*1]
a = Area of Circular Defect
g = Acceleration of Gravity (32.2 ft/s^2 or 9.81 m/s^2)
h = Hydraulic Head Above Geomembrane
d = Diameter of Circular Defect
A = Area of Geomembrane Lined Facility
C_{go} = Contact Quality Factor[*2]
k_s = Permeability of Underlying Soil Layer
t_s = Thickness of Underlying Soil Layer

Variable Inputs

English Units			Metric Units	
d (in)	0.444		d (m)	0.0113
A (ft^2)	6,400,000		A (m^2)	594,579
h (ft)	1.0000		h (m)	0.3048
k_s (ft/sec)	3.28E-08		k_s (m/s)	1.00E-08
t_s (ft)	1.0		t_s (m)	0.3

Calculated Values

English Units			Metric Units	
n	294		n	294
a (ft^2)	1.07E-03		a (m^2)	9.98E-05
Q (ft^3/s)	3.94E-04		Q (m^3/s)	1.12E-05

Conversion

$$1.12\text{E-}05\ \frac{m^3}{\sec} \times \frac{60\ \sec}{\min} \times \frac{264.1\,gal}{m^3} = 0.18\ \frac{gal}{\min}$$

Assumptions

1. Above equations are for a circular defect with a diameter less than 25 mm.
2. The hydraulic head above the liner should be equal to or less than 3 m
3. The typical installation damage assumes a circular defect diameter of approxiately 3.5 mm given good to excellent quality control.

References

1. Giroud, J.P. 1997. "Equations for Caulculating the Rate of Liquid Migration Through Composite Liners Due to Geomembrane Defects". Geosynthetics International. Vol 4, Nos. 3-4, pp. 335-348.

Geomembrane Leakage Rate Underlain by Relatively Low Permeability Soil

Project: HGM EIS Support
Client: Haile Gold Mine, Inc.
Facility: Johnny's PAG - 6.4 M ft^2

Inputs
Outputs

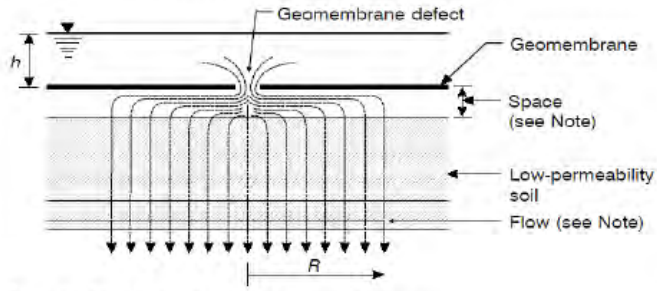

Figure 1. Liquid migration through a composite liner.

$$Q = C_{qo}\left[1 + 0.1(h/t_s)^{0.95}\right]a^{0.1}h^{0.9}k_s^{0.74}n \quad \text{(Giroud, 1997)}$$

Where: $n = \left(A/43{,}560\ ft^2\right) \times DefectsPer\ \ Acre$

$$a = \pi\left(d^2/4\right)$$

Typical Installation Damage [*1]

Installation Quality	Defects per Acre
Excellent	Up to 1
Good	1 to 4
Fair	4 to 10
Poor	10 to 20

Assume 2 Defects Per Acre

Contact Quality Factor, C_{qo} [*2]

Liner/Soil Contact	Factor (Circ. Defect)
Good	0.21
Poor	1.15

Assume 0.21 for Contact Quality

Inputs Defined:

Q = Leakage Rate
n = Number of Defects in Geomembrane[*1]
a = Area of Circular Defect
g = Acceleration of Gravity (32.2 ft/s^2 or 9.81 m/s^2)
h = Hydraulic Head Above Geomembrane
d = Diameter of Circular Defect
A = Area of Geomembrane Lined Facility
C_{qo} = Contact Quality Factor[*2]
k_s = Permeability of Underlying Soil Layer
t_s = Thickness of Underlying Soil Layer

Variable Inputs

English Units			Metric Units	
d (in)	0.444		d (m)	0.0113
A (ft^2)	6,400,000		A (m^2)	594,579
h (ft)	0.5000		h (m)	0.1524
k_s (ft/sec)	3.28E-08		k_s (m/s)	1.00E-08
t_s (ft)	1.0		t_s (m)	0.3

Calculated Values

English Units			Metric Units	
n	294		n	294
a (ft^2)	1.07E-03		a (m^2)	9.98E-05
Q (ft^3/s)	2.02E-04		Q (m^3/s)	5.71E-06

Conversion

$$5.71E\text{-}06\ \frac{m^3}{\sec} \times \frac{60\ \sec}{\min} \times \frac{264.1\,gal}{m^3} = 0.09\ \frac{gal}{\min}$$

Assumptions

1. Above equations are for a circular defect with a diameter less than 25 mm.
2. The hydraulic head above the liner should be equal to or less than 3 m
3. The typical installation damage assumes a circular defect diameter of approxiately 3.5 mm given good to excellent quality control.

References

1. Giroud, J.P. 1997. "Equations for Caulculating the Rate of Liquid Migration Through Composite Liners Due to Geomembrane Defects". Geosynthetics International. Vol 4, Nos. 3-4, pp. 335-348.

Applicant Response - E

Ecological Resource Consultants, Inc.
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Technical Memorandum

Date: **May 30, 2014**

To: **Johnny Pappas, Romarco Minerals**

From: **Troy Thompson**

Re: **PAG Draindown**

Introduction

The purpose of this memorandum is to provide a document that presents supporting information on the amount of draindown that is predicted from Johnny's PAG overburden storage area (Johnny's PAG) in order to confirm the projected timeframes in the DEIS as to when Haile anticipates that Johnny's PAG will be able to transition from active to passive treatment. Draindown from Johnny's PAG was calculated as part of the overall site wide water balance report (ERC 2013). Specifically, Section 6.1 of ERC 2013 presents precipitation inputs, and Section 6.2 presents evaporation losses that were used as part of the assessment of Johnny's PAG. Section 6.4 of the report describes the calculation methods used to track flow through Johnny's PAG.

Johnny's PAG is designed so that PAG material will be placed in lifts not more than 50 feet in height. The outside perimeter of each bench will contain a minimum 20 foot wedge of saprolite. During closure, the top of each bench will be covered with a 5-foot layer of compacted saprolite, a double-textured HDPE geomembrane, covered with two feet of growth media and revegetated. These measures will help minimize oxygen and meteoric water entry/infiltration into the pile. (For more detail on the Johnny's PAG design, see Appendix N of the 11/19/10 Mine Permit Application.)

The liner was assumed to be effectively impermeable, so no inputs of meteorological water to Johnny's PAG were assumed once the facility was closed.

Johnny's PAG Seepage and Closure Draindown

The amount of water predicted to seep through Johnny's PAG during operations and closure was calculated using Monte Carlo simulations during operations and closure. One thousand different equally likely precipitation scenarios were run through the model to provide a range of potential outcomes (ERC 2013). A graph showing seepage through Johnny's PAG that will be collected on the liner system that will be installed below Johnny's PAG and conveyed to the collection ponds is presented on **Figure 1**.

The bound of colors on the graph shows the range of anticipated outcomes. The top of the green shading represents the maximum amount of seepage predicted in any of the 1,000 model runs while the bottom of the green shading illustrates the minimum results of all 1,000 runs. Mean and median values are represented by the blue and red lines, respectively.

The distinct change in predicted values after approximately model month 170 represent the cutoff between operations and closure. Once Johnny's PAG is covered, meteorological water was no longer assumed to enter the system and Johnny's PAG was assumed to drain down. As is illustrated by the shape of the curve after closure, predicted draindown reduces in quantity relatively quickly but is expected to continue at small rates long after closure commences. Mean annual draindown values predicted by the model in select years after closure are presented in **Table 1**. Model results including the mean, median, 5th , 25th , 75th - and 95th percentile results by month are provided in **Appendix A**.

Figure 1 – Predicted Seepage and Closure Draindown from Johnny's PAG

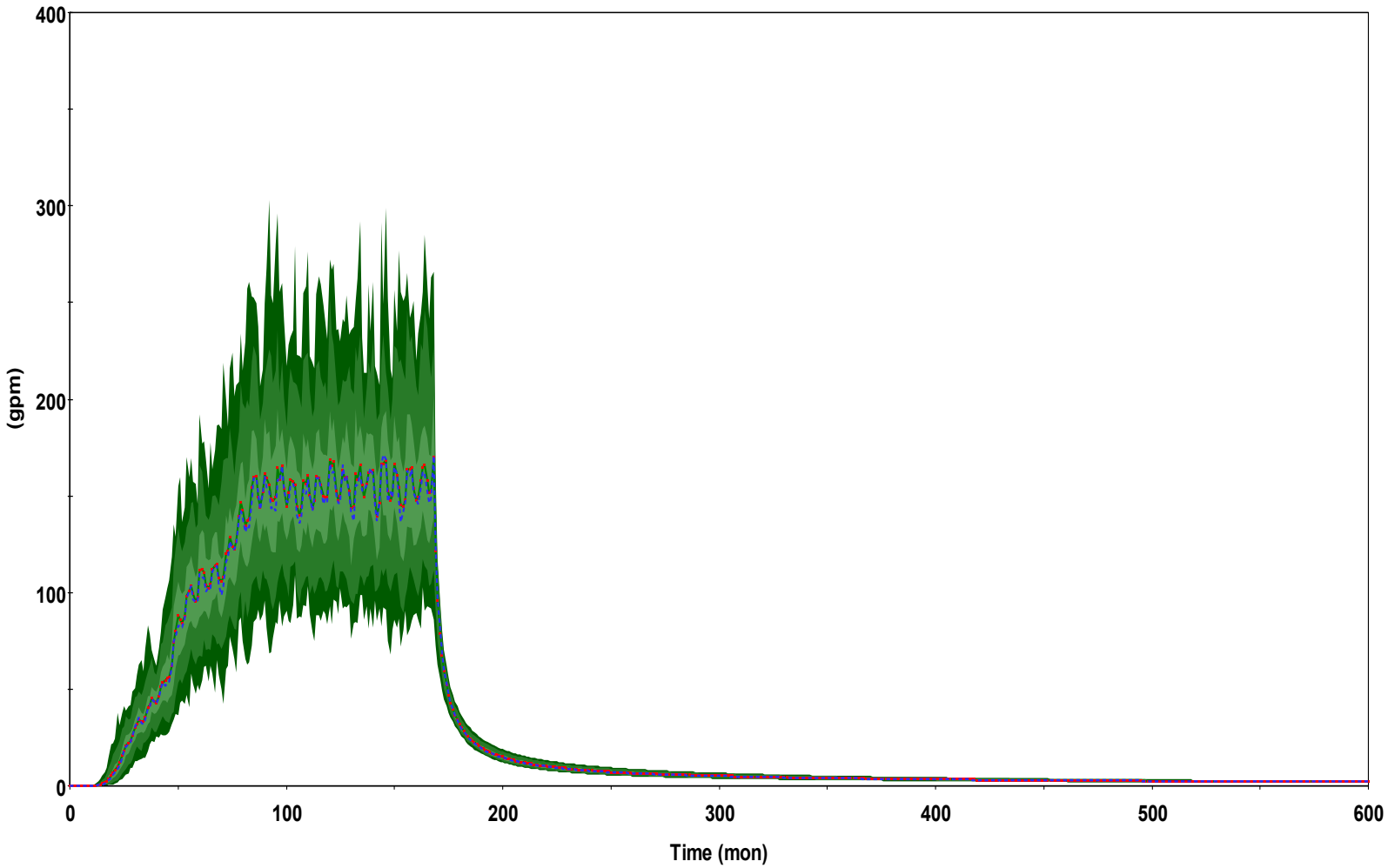

Table 1 – Predicted Mean Annual Draindown from Johnny's PAG during Closure

Closure Year	Mean Annual Draindown (gpm)
Closure Year 1	51 gpm
Closure Year 2	22 gpm
Closure Year 3	15 gpm
Closure Year 4	12 gpm
Closure Year 5	10 gpm
Closure Year 10	5 gpm
Closure Year 15	4 gpm
Closure Year 20	3 gpm
Closure Year 25	3 gpm

References

Ecological Resource Consultants, Inc. (ERC) (Dec 2013). Haile Gold Mine Revised Site Wide Water Balance Report.

Appendix A – Tabulated Results by Month

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	1
13	0	0	0	0	1	1
14	1	0	0	1	1	2
15	1	0	0	1	1	3
16	2	0	1	1	2	4
17	2	0	1	2	3	6
18	4	1	2	3	5	9
19	5	1	3	4	7	13
20	7	2	4	6	9	16
21	8	2	5	7	11	18
22	10	3	6	9	12	21
23	12	4	8	11	15	23
24	16	6	11	14	20	30
25	18	7	12	19	23	31
26	21	9	15	20	26	36
27	22	11	17	22	26	35
28	23	12	19	23	28	35
29	26	14	22	25	30	40
30	30	18	24	31	35	46
31	32	20	26	32	37	46
32	35	19	27	35	41	49
33	33	18	28	32	38	47
34	33	22	27	32	37	50
35	36	23	29	34	40	54
36	41	24	32	40	47	59
37	42	26	33	41	47	62
38	45	30	38	44	51	66
39	43	28	37	43	49	59
40	43	28	38	43	49	57
41	46	32	40	46	52	64
42	51	34	42	51	58	73
43	53	36	44	53	62	74
44	55	34	44	52	64	83

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
45	56	33	43	54	68	85
46	56	32	45	54	65	88
47	62	37	47	62	75	92
48	74	38	52	75	93	114
49	80	46	61	77	98	123
50	88	54	67	83	106	134
51	86	55	68	82	101	126
52	84	53	71	82	99	122
53	88	58	73	86	101	126
54	98	59	79	97	113	133
55	101	66	84	101	116	138
56	103	71	85	104	119	147
57	99	66	83	97	114	147
58	95	63	81	95	108	133
59	97	66	84	95	111	135
60	111	67	87	110	129	166
61	112	67	89	108	133	162
62	110	76	91	107	131	150
63	104	70	90	101	118	140
64	102	71	86	103	117	137
65	104	70	90	102	117	141
66	112	78	96	111	128	150
67	114	77	97	113	131	151
68	115	73	100	114	131	149
69	107	74	90	104	120	145
70	105	71	87	99	118	157
71	108	73	91	104	118	168
72	120	77	99	116	140	169
73	121	84	106	118	135	170
74	129	88	108	126	144	185
75	124	84	105	123	136	172
76	122	81	104	122	142	161
77	127	81	107	125	145	172
78	139	96	119	138	160	184
79	147	100	126	142	166	208
80	143	82	119	139	168	198
81	135	96	114	131	148	195
82	137	87	113	135	156	200
83	138	91	116	133	159	196
84	154	104	126	148	184	219
85	160	106	132	159	184	228
86	160	108	139	159	180	222
87	149	103	129	151	165	205
88	144	101	126	143	160	189
89	152	111	136	151	170	198

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
90	161	108	132	160	190	213
91	159	107	135	155	182	218
92	156	102	126	152	183	226
93	149	94	121	144	168	222
94	147	91	121	145	171	208
95	149	98	121	142	176	215
96	165	105	137	159	195	236
97	159	110	137	157	177	203
98	165	115	141	166	185	219
99	154	108	132	152	176	201
100	145	104	127	147	164	186
101	152	97	131	147	176	205
102	159	113	137	155	181	216
103	158	114	139	156	177	209
104	156	116	133	153	173	208
105	144	100	123	140	163	207
106	140	94	121	136	161	201
107	144	102	124	140	158	195
108	158	104	134	153	182	220
109	156	108	129	151	175	223
110	161	109	136	159	179	224
111	151	99	129	150	171	205
112	143	104	123	142	164	191
113	147	99	129	149	168	195
114	160	101	133	159	182	217
115	159	107	132	159	185	220
116	155	108	131	154	174	211
117	150	105	125	146	171	206
118	149	100	125	148	171	209
119	149	101	128	147	171	199
120	169	106	144	167	194	252
121	166	112	142	162	183	234
122	168	117	145	162	190	228
123	153	104	130	150	173	209
124	147	102	127	146	164	197
125	150	111	132	146	169	199
126	163	111	142	166	181	210
127	159	109	137	158	177	209
128	160	107	135	160	189	210
129	153	99	129	150	174	217
130	144	96	114	142	167	205
131	144	94	128	137	165	202
132	161	99	133	156	195	227
133	158	99	135	156	180	219
134	166	109	138	162	186	234

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
135	156	108	129	153	181	210
136	149	104	129	153	171	190
137	156	108	130	156	183	205
138	162	109	143	160	182	220
139	163	113	142	164	182	213
140	163	114	136	161	181	231
141	149	100	127	145	170	206
142	139	101	117	137	160	189
143	146	104	123	147	165	193
144	167	112	150	166	185	221
145	167	108	140	171	191	233
146	169	113	140	169	194	214
147	153	105	130	147	179	206
148	147	100	126	152	168	189
149	150	105	132	149	170	200
150	167	109	144	165	191	227
151	161	110	136	161	178	226
152	155	101	127	147	180	219
153	145	93	119	137	170	221
154	144	89	116	142	162	214
155	148	97	123	147	170	210
156	164	102	134	163	192	246
157	164	113	133	160	192	229
158	165	110	133	164	187	233
159	154	107	124	151	179	223
160	148	101	125	148	166	206
161	149	98	128	146	169	202
162	158	106	134	154	181	229
163	165	117	142	163	184	225
164	166	114	137	161	186	246
165	158	112	127	152	180	237
166	152	104	125	146	171	222
167	153	104	130	149	171	211
168	170	112	139	170	202	228
169	122	90	107	124	137	151
170	96	75	87	97	105	114
171	79	65	73	81	85	92
172	67	56	63	69	72	77
173	59	50	55	60	62	67
174	52	45	50	53	55	59
175	47	41	45	47	49	53
176	43	38	41	43	45	49
177	40	35	38	39	41	45
178	37	32	35	36	38	41
179	34	30	32	34	35	39

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
180	32	28	30	32	33	36
181	30	27	29	30	31	34
182	28	25	27	28	29	32
183	27	24	26	26	28	31
184	26	23	24	25	27	29
185	24	22	23	24	25	28
186	23	21	22	23	24	27
187	22	20	21	22	23	26
188	21	19	20	21	22	25
189	21	18	19	20	22	24
190	20	18	19	19	21	23
191	19	17	18	19	20	23
192	19	16	17	18	20	22
193	18	16	17	18	19	21
194	17	15	16	17	18	21
195	17	15	16	17	18	20
196	16	14	15	16	17	20
197	16	14	15	16	17	19
198	16	14	14	15	17	19
199	15	13	14	15	16	18
200	15	13	14	15	16	18
201	14	12	13	14	15	17
202	14	12	13	14	15	17
203	14	12	13	14	15	17
204	14	11	12	13	14	16
205	13	11	12	13	14	16
206	13	11	12	13	14	16
207	13	11	12	12	14	15
208	12	10	11	12	13	15
209	12	10	11	12	13	15
210	12	10	11	12	13	15
211	12	10	11	12	13	14
212	12	10	11	11	12	14
213	11	9	10	11	12	14
214	11	9	10	11	12	14
215	11	9	10	11	12	13
216	11	9	10	11	12	13
217	11	9	10	10	11	13
218	10	9	10	10	11	13
219	10	8	9	10	11	13
220	10	8	9	10	11	12
221	10	8	9	10	11	12
222	10	8	9	10	11	12
223	10	8	9	10	11	12
224	10	8	9	9	10	12

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
225	9	8	9	9	10	12
226	9	8	9	9	10	12
227	9	8	8	9	10	11
228	9	7	8	9	10	11
229	9	7	8	9	10	11
230	9	7	8	9	10	11
231	9	7	8	9	10	11
232	9	7	8	9	9	11
233	9	7	8	8	9	11
234	9	7	8	8	9	10
235	8	7	8	8	9	10
236	8	7	8	8	9	10
237	8	7	7	8	9	10
238	8	7	7	8	9	10
239	8	6	7	8	9	10
240	8	6	7	8	9	10
241	8	6	7	8	9	10
242	8	6	7	8	8	10
243	8	6	7	8	8	10
244	8	6	7	8	8	9
245	8	6	7	7	8	9
246	8	6	7	7	8	9
247	7	6	7	7	8	9
248	7	6	7	7	8	9
249	7	6	7	7	8	9
250	7	6	7	7	8	9
251	7	6	6	7	8	9
252	7	6	6	7	8	9
253	7	6	6	7	8	9
254	7	6	6	7	8	9
255	7	5	6	7	8	9
256	7	5	6	7	8	9
257	7	5	6	7	7	8
258	7	5	6	7	7	8
259	7	5	6	7	7	8
260	7	5	6	7	7	8
261	7	5	6	6	7	8
262	7	5	6	6	7	8
263	6	5	6	6	7	8
264	6	5	6	6	7	8
265	6	5	6	6	7	8
266	6	5	6	6	7	8
267	6	5	6	6	7	8
268	6	5	6	6	7	8
269	6	5	6	6	7	8

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
270	6	5	6	6	7	8
271	6	5	5	6	7	8
272	6	5	5	6	7	8
273	6	5	5	6	7	7
274	6	5	5	6	7	7
275	6	5	5	6	7	7
276	6	5	5	6	6	7
277	6	5	5	6	6	7
278	6	5	5	6	6	7
279	6	5	5	6	6	7
280	6	5	5	6	6	7
281	6	4	5	6	6	7
282	6	4	5	6	6	7
283	6	4	5	6	6	7
284	6	4	5	6	6	7
285	6	4	5	5	6	7
286	6	4	5	5	6	7
287	5	4	5	5	6	7
288	5	4	5	5	6	7
289	5	4	5	5	6	7
290	5	4	5	5	6	7
291	5	4	5	5	6	7
292	5	4	5	5	6	7
293	5	4	5	5	6	7
294	5	4	5	5	6	7
295	5	4	5	5	6	7
296	5	4	5	5	6	6
297	5	4	5	5	6	6
298	5	4	5	5	6	6
299	5	4	5	5	6	6
300	5	4	5	5	6	6
301	5	4	5	5	6	6
302	5	4	5	5	6	6
303	5	4	5	5	6	6
304	5	4	4	5	5	6
305	5	4	4	5	5	6
306	5	4	4	5	5	6
307	5	4	4	5	5	6
308	5	4	4	5	5	6
309	5	4	4	5	5	6
310	5	4	4	5	5	6
311	5	4	4	5	5	6
312	5	4	4	5	5	6
313	5	4	4	5	5	6
314	5	4	4	5	5	6

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
315	5	4	4	5	5	6
316	5	4	4	5	5	6
317	5	4	4	5	5	6
318	5	4	4	5	5	6
319	5	4	4	5	5	6
320	5	4	4	5	5	6
321	5	4	4	5	5	6
322	5	4	4	5	5	6
323	5	4	4	4	5	6
324	5	4	4	4	5	6
325	4	3	4	4	5	6
326	4	3	4	4	5	6
327	4	3	4	4	5	6
328	4	3	4	4	5	6
329	4	3	4	4	5	5
330	4	3	4	4	5	5
331	4	3	4	4	5	5
332	4	3	4	4	5	5
333	4	3	4	4	5	5
334	4	3	4	4	5	5
335	4	3	4	4	5	5
336	4	3	4	4	5	5
337	4	3	4	4	5	5
338	4	3	4	4	5	5
339	4	3	4	4	5	5
340	4	3	4	4	5	5
341	4	3	4	4	5	5
342	4	3	4	4	5	5
343	4	3	4	4	5	5
344	4	3	4	4	5	5
345	4	3	4	4	5	5
346	4	3	4	4	4	5
347	4	3	4	4	4	5
348	4	3	4	4	4	5
349	4	3	4	4	4	5
350	4	3	4	4	4	5
351	4	3	4	4	4	5
352	4	3	4	4	4	5
353	4	3	4	4	4	5
354	4	3	4	4	4	5
355	4	3	4	4	4	5
356	4	3	4	4	4	5
357	4	3	4	4	4	5
358	4	3	4	4	4	5
359	4	3	3	4	4	5

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
360	4	3	3	4	4	5
361	4	3	3	4	4	5
362	4	3	3	4	4	5
363	4	3	3	4	4	5
364	4	3	3	4	4	5
365	4	3	3	4	4	5
366	4	3	3	4	4	5
367	4	3	3	4	4	5
368	4	3	3	4	4	5
369	4	3	3	4	4	5
370	4	3	3	4	4	5
371	4	3	3	4	4	5
372	4	3	3	4	4	5
373	4	3	3	4	4	5
374	4	3	3	4	4	5
375	4	3	3	4	4	5
376	4	3	3	4	4	5
377	4	3	3	4	4	5
378	4	3	3	4	4	5
379	4	3	3	4	4	4
380	4	3	3	4	4	4
381	4	3	3	4	4	4
382	4	3	3	4	4	4
383	4	3	3	4	4	4
384	4	3	3	4	4	4
385	4	3	3	4	4	4
386	4	3	3	4	4	4
387	4	3	3	4	4	4
388	4	3	3	3	4	4
389	3	3	3	3	4	4
390	3	3	3	3	4	4
391	3	3	3	3	4	4
392	3	3	3	3	4	4
393	3	3	3	3	4	4
394	3	3	3	3	4	4
395	3	3	3	3	4	4
396	3	3	3	3	4	4
397	3	3	3	3	4	4
398	3	3	3	3	4	4
399	3	3	3	3	4	4
400	3	3	3	3	4	4
401	3	3	3	3	4	4
402	3	3	3	3	4	4
403	3	3	3	3	4	4
404	3	3	3	3	4	4

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
405	3	3	3	3	4	4
406	3	3	3	3	4	4
407	3	3	3	3	4	4
408	3	3	3	3	4	4
409	3	3	3	3	4	4
410	3	3	3	3	4	4
411	3	3	3	3	4	4
412	3	3	3	3	4	4
413	3	3	3	3	4	4
414	3	3	3	3	4	4
415	3	2	3	3	4	4
416	3	2	3	3	4	4
417	3	2	3	3	4	4
418	3	2	3	3	3	4
419	3	2	3	3	3	4
420	3	2	3	3	3	4
421	3	2	3	3	3	4
422	3	2	3	3	3	4
423	3	2	3	3	3	4
424	3	2	3	3	3	4
425	3	2	3	3	3	4
426	3	2	3	3	3	4
427	3	2	3	3	3	4
428	3	2	3	3	3	4
429	3	2	3	3	3	4
430	3	2	3	3	3	4
431	3	2	3	3	3	4
432	3	2	3	3	3	4
433	3	2	3	3	3	4
434	3	2	3	3	3	4
435	3	2	3	3	3	4
436	3	2	3	3	3	4
437	3	2	3	3	3	4
438	3	2	3	3	3	4
439	3	2	3	3	3	4
440	3	2	3	3	3	4
441	3	2	3	3	3	4
442	3	2	3	3	3	4
443	3	2	3	3	3	4
444	3	2	3	3	3	4
445	3	2	3	3	3	4
446	3	2	3	3	3	4
447	3	2	3	3	3	4
448	3	2	3	3	3	4
449	3	2	3	3	3	4

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
450	3	2	3	3	3	4
451	3	2	3	3	3	4
452	3	2	3	3	3	4
453	3	2	3	3	3	4
454	3	2	3	3	3	4
455	3	2	3	3	3	4
456	3	2	3	3	3	4
457	3	2	3	3	3	4
458	3	2	3	3	3	4
459	3	2	3	3	3	4
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483	3	2	2	3	3	3
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489	3	2	2	3	3	3
490	3	2	2	3	3	3
491	3	2	2	3	3	3
492	3	2	2	3	3	3
493	3	2	2	3	3	3
494	3	2	2	3	3	3

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
495	3	2	2	3	3	3
496	3	2	2	3	3	3
497	3	2	2	3	3	3
498	3	2	2	3	3	3
499	3	2	2	3	3	3
500	3	2	2	3	3	3
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503	3	2	2	3	3	3
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534	2	2	2	2	3	3
535	2	2	2	2	3	3
536	2	2	2	2	3	3
537	2	2	2	2	3	3
538	2	2	2	2	3	3
539	2	2	2	2	3	3

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
540	2	2	2	2	3	3
541	2	2	2	2	3	3
542	2	2	2	2	3	3
543	2	2	2	2	3	3
544	2	2	2	2	3	3
545	2	2	2	2	3	3
546	2	2	2	2	3	3
547	2	2	2	2	3	3
548	2	2	2	2	3	3
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551	2	2	2	2	3	3
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554	2	2	2	2	3	3
555	2	2	2	2	3	3
556	2	2	2	2	3	3
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565	2	2	2	2	2	3
566	2	2	2	2	2	3
567	2	2	2	2	2	3
568	2	2	2	2	2	3
569	2	2	2	2	2	3
570	2	2	2	2	2	3
571	2	2	2	2	2	3
572	2	2	2	2	2	3
573	2	2	2	2	2	3
574	2	2	2	2	2	3
575	2	2	2	2	2	3
576	2	2	2	2	2	3
577	2	2	2	2	2	3
578	2	2	2	2	2	3
579	2	2	2	2	2	3
580	2	2	2	2	2	3
581	2	2	2	2	2	3
582	2	2	2	2	2	3
583	2	2	2	2	2	3
584	2	2	2	2	2	3

	Johnny's PAG Seepage Water (Underdrain) (All Values in gpm)					
Month	**Mean**	**5%**	**25%**	**Median**	**75%**	**95%**
585	2	2	2	2	2	3
586	2	2	2	2	2	3
587	2	2	2	2	2	3
588	2	2	2	2	2	3
589	2	2	2	2	2	3
590	2	2	2	2	2	3
591	2	2	2	2	2	3
592	2	2	2	2	2	3
593	2	2	2	2	2	3
594	2	2	2	2	2	3
595	2	2	2	2	2	3
596	2	2	2	2	2	3
597	2	2	2	2	2	3
598	2	2	2	2	2	3
599	2	2	2	2	2	3
600	2	2	2	2	2	3

Memorandum

May 30, 2014

To: Mr. Johnny Pappas, Romarco Minerals

From: William M. Schafer, Schafer Limited LLC

Re: Draindown Rate Prediction - Haile TSF

Introduction

The reclamation and closure plan for the Haile Tailings Storage Facility (TSF) entails collection and treatment of residual process water from the TSF. The plan anticipates that conventional water treatment would be used when the process water flow rate is greater than about 10 to 20 gpm, and that a bioreactor system would be used when flow rates fall below this threshold.

The rate of flow from tailings facilities gradually declines through time as the tailings solids release excess water, which migrates to the drain system by unsaturated flow processes. The change in flow rate through time is known as a draindown curve. The potential flow rate and overall volume of process solution represented by the draindown curve is proportional to the area of the TSF. The Haile TSF will be constructed in three stages so that potential draindown flows and volumes will increase as each of the three stages are developed. The purpose of this Memorandum is to predict draindown curves for the three TSF stages. This data can be used for estimating water management costs as part of an overall reclamation and closure cost estimate.

Seepage Modeling

The bases for the seepage predictions are based on the geometry of the tailings impoundment, the hydrologic characteristics of tailings materials in different parts of the facility, the climate, and the reclamation approach and schedule. The tailings facility is shown in Figure 1.

The texture of tailings were generalized for two domains within the tailings; the beach and pool area. Tailings on the beach are deposited in a sub-aerial environment, are drained, and have an opportunity to dry after placement. Tailings on the pool remain under water (during mine life), and are typically finer-grained and less permeable than beach tailings. The hydraulic properties of beach tailings were based on tests conducted by Knight Piesold and material properties for the pool area were based on professional judgment.

In each seepage simulation, the water movement out of the tailings (e.g. seepage rate) was predicted during 14 years of operation, 5 years of initial reclamation to allow for consolidation (before cover placement), and 40 years after cover placement.

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The infiltration of water into the tailings determines the equilibrium water content the tailings will attain. The surface infiltration into the tailings (for Case A) was assumed to be 50 % of rainfall (24 in/yr) plus an additional 6 in/yr of seepage to account for drainage from saturated deposition areas. After tailings placement ceases but before placement of cover, the surface infiltration was assumed to be 20 in/yr. After geomembrane cover placement, the surface infiltration was limited to 0.1 in/yr. In Case B, lower initial infiltration rates of 20 in/yr and 12 in/yr were used for operations and year 0 through 5 of reclamation. The model used for the assessment was Vadose/W Basic, a 1-D code.

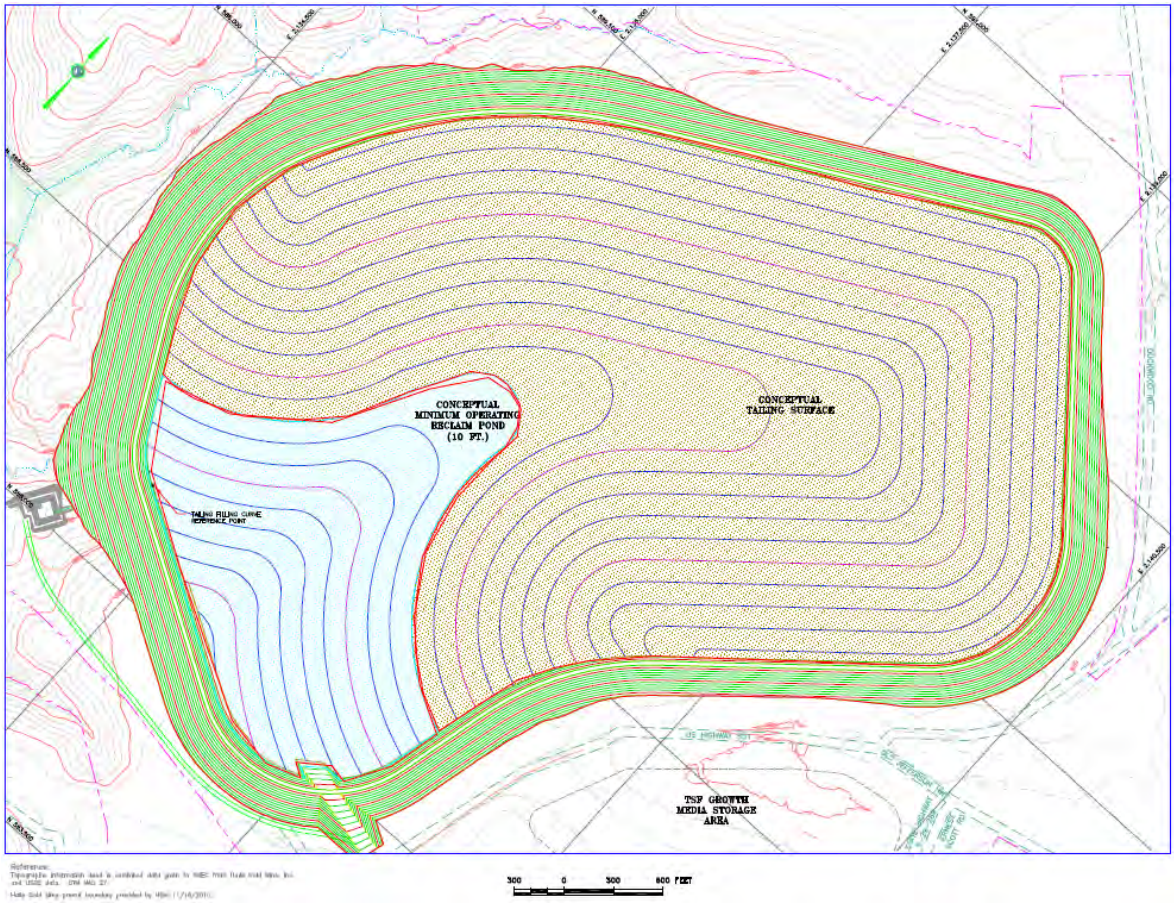

Figure 1. Haile tailings facility design.

Table 1. Seepage model set-up.

Seepage Model Calibration and Boundary Conditions

Case A

Facility Geometry
Exposed tailings 387.9 acres
Beach 310.5 acres
Pool 77.4 acres
Average tailings thickness 25m

Material Characteristics

Property	**Beach Area**	**Pool Area**
SWCC type curve	silty sand	silty clay
Sat water %	45%	45%
Hyd Cond (cm/s)	4×10^{-5}	1×10^{-7}

Flux Conditions

Stage	**Years**	**Flux**
1 (Operations)	10	30”/yr
2 (Prior to cover placement)	5	20”/yr
3 (Subsequent to covering)	50	0.1”/yr
3b (Soil cover)	50	7.2”/yr (15 % infiltration)

Case B

Reduce influx into beach area during operations to 20”/yr, and to 12”/yr during year 0-5 of reclamation

Seepage Modeling Results

Estimated draindown rates were predicted separately for the beach and pool areas as shown in Figures 2 and 3. The overall quantity of predicted draindown amounts to 33.7 % of the tailings weight, which is a conservatively high estimate of the water loss during draindown.

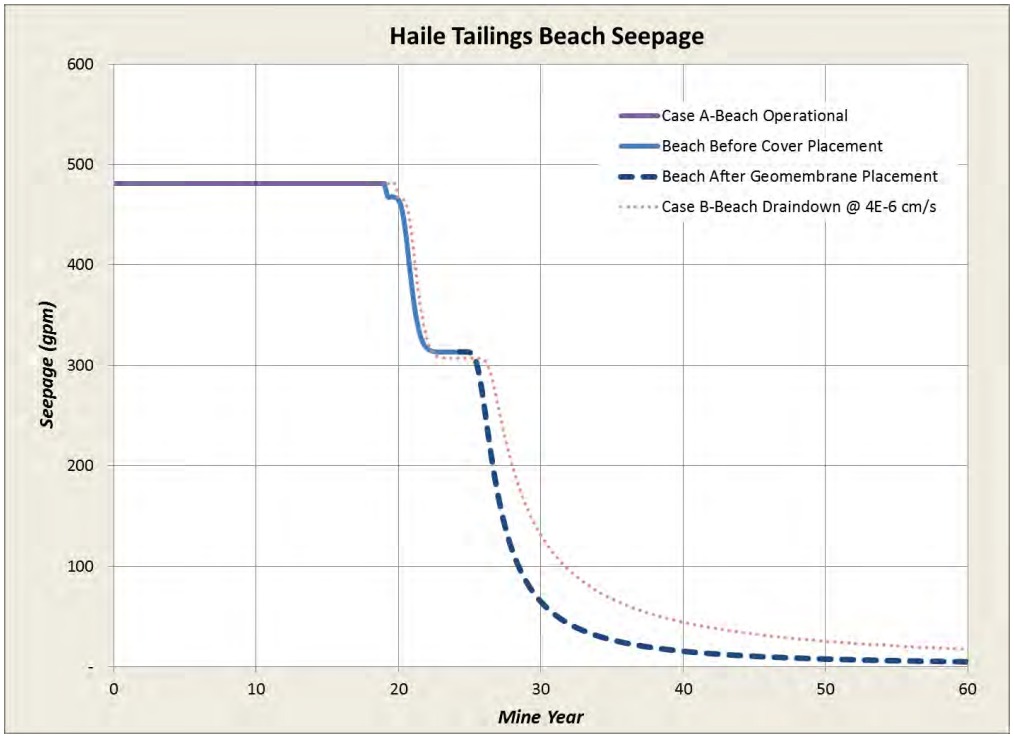

Figure 2. Seepage through beach tailings.

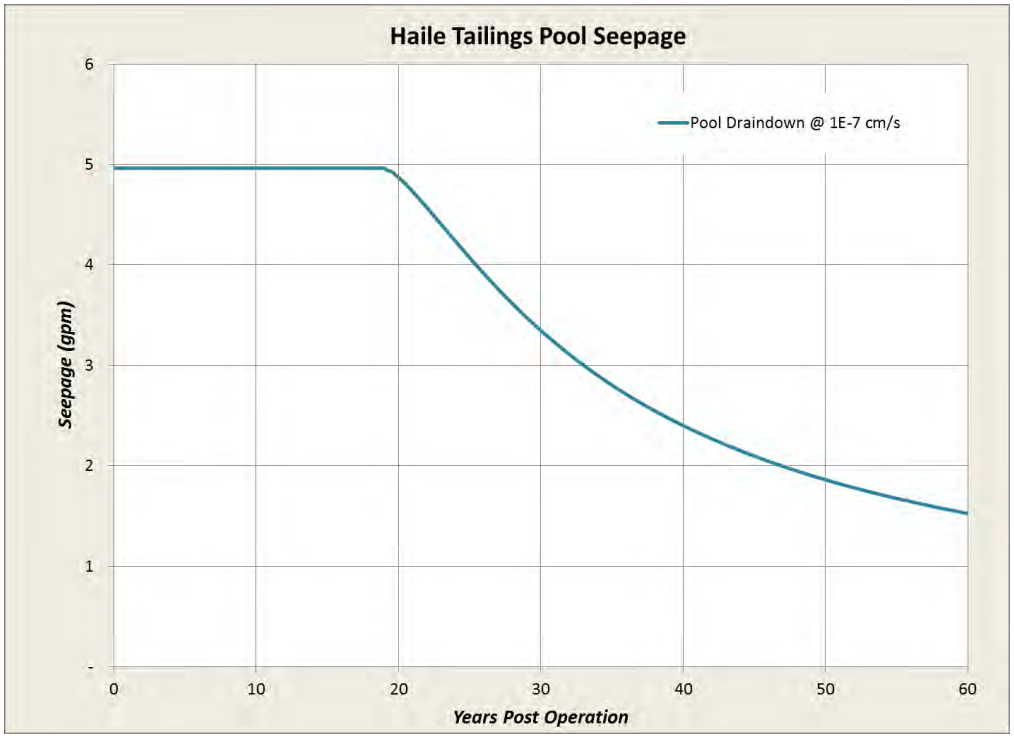

Figure 3. Seepage through pool area tailings.

Approach to Assessing Phased TSF Development

The proportional area of beach and pool areas was used to estimate combined draindown from the TSF that would result from early closure at year 3 and 5 compared to full build-out at year 8 (and closure starting in year 14). The vertical flux for beach and pool areas from the Vadose 1-D model runs were adjusted for beach and pool areas shown in Table 2 for each TSF stage and were also adjusted so that overall seepage volume over 50 years equaled 33.7 % of tailings weight. Actual draindown curves for year 3 and 5 may be more front-loaded than shown in Figure 4, but the overall total seepage volume should not differ from these estimates. The total volume of draindown that will require collection, and conventional treatment was calculated assuming that a bioreactor system could be employed when flows reach either 10 or 20 gpm (Table 3).

Table 2. Tailings tonnage, beach and pool areas for interim TSF stages.

Year	Tailings Dry Weight (million tons)	Pool Area (million square feet)	Beach Area (million square feet)
3	7.665	8.4	4.9
5	12.77	7.3	7.4
8	20.44	5.1	11.6

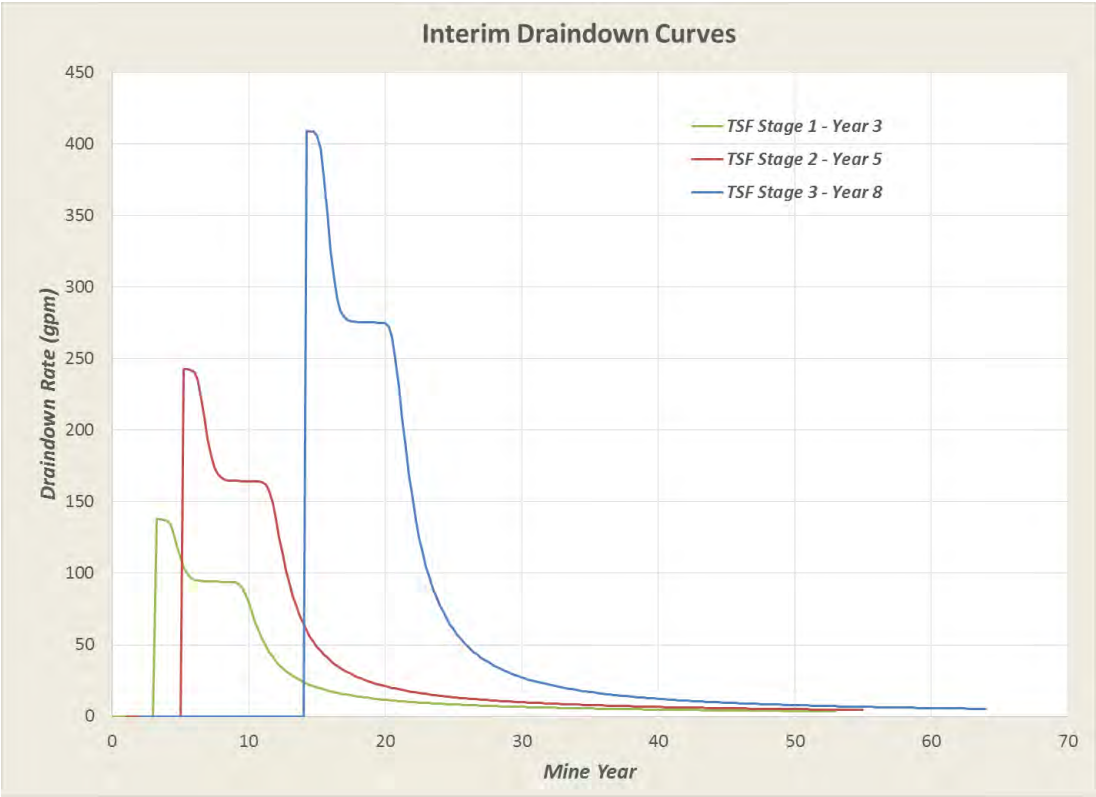

Figure 4. Combined beach and pool draindown rates for interim TSF shutdown.

Table 3. Estimated water treatment volumes for various interim TSF closure stages. Values in bold occur in years with average flow greater than 20 gpm.

Mine Year	TSF Stage 1	TSF Stage 2	TSF Stage 3
	Gallons/Yr (x1,000)		
1			
2			
3			
4	**36,178**		
5	**70,358**		
6	**56,934**	**63,680**	
7	**50,194**	**123,801**	
8	**49,525**	**99,585**	
9	**49,349**	**87,493**	
10	**48,620**	**86,406**	
11	**39,679**	**86,216**	
12	**27,231**	**85,019**	

Mine Year	TSF Stage 1	TSF Stage 2	TSF Stage 3
	Gallons/Yr (x1,000)		
13	**19,667**	**68,938**	
14	**15,239**	**46,494**	
15	12,425	**32,895**	**107,365**
16	10,501	**24,975**	**208,676**
17	9,111	**19,974**	**167,061**
18	8,062	**16,580**	**146,369**
19	7,243	**14,147**	**144,660**
20	6,587	**12,329**	**144,497**
21	6,049	**10,923**	**142,595**
22	5,600	9,807	**115,022**
23	5,219	8,901	**76,471**
24	4,892	8,151	**53,164**
25	4,606	7,521	**39,643**
26	4,356	6,984	**31,147**
27	4,133	6,522	**25,415**
28	3,935	6,118	**21,333**
29	3,756	5,764	**18,303**
30	3,594	5,450	**15,979**
31	3,447	5,169	**14,149**
32	3,313	4,918	**12,675**
33	3,190	4,691	11,466
34	3,076	4,485	10,459
35	2,971	4,297	9,607
36	2,874	4,125	8,879
37	2,784	3,968	8,250
38	2,700	3,822	7,701
39	2,621	3,688	7,219
40	2,548	3,564	6,792
41	2,478	3,448	6,412
42	2,413	3,340	6,071
43	2,352	3,240	5,765
44	2,294	3,145	5,487
45	2,239	3,057	5,235
46	2,187	2,974	5,005
47	2,138	2,895	4,795
48	2,091	2,821	4,602
49	2,046	2,752	4,423
50	2,004	2,685	4,259

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Haile Gold Mine, Inc.'s (Haile)
Response to Southern Environmental Law Center et al. (SELC) Comments on DEIS,
Exhibit B, Tom Myers Report

Comment Number	Section	Page	Paragraph	SELC Comment	Response
General Comment				SELC provides several comments on adequacy of field characterization data.	Haile acknowledges the importance of a data set that meets the project objectives and supports development of a credible numerical groundwater model and believe that sufficient data of appropriate accuracy and precision have been collected in support of the DEIS. An approximate accounting of the baseline data and routine monitoring data collected is provided below: • Extensive geologic characterization of the site using data collected from 1,167 exploratory drill holes; • Airlift yield and RQD measurements collected from exploration borings; • Installation of 82 wells to monitor groundwater conditions; • 5 long-term aquifer tests using an extensive network of observation wells, as well as associated step-drawdown tests (10-day test, 43-day test, 40 day test, and 11-day test at PW-09-01; 7-day test at PW-13-01) from 2009 through 2013; • 24 single well pumping tests conducted from 1994 through 2013; • 17 slug tests from 1994 through 2009; and • 7 downhole geophysical surveys in 2013.
General Comment				SELC asserts on several occasions that "critical errors" were made in the modeling.	Haile disagrees and feels that the DEIS groundwater model represents a reasonable numerical representation of the groundwater system based on a large set of site characterization data. The "critical errors" documented in the Myers review of the C-E model are instead related to the following: • Misunderstanding of the text and documents on the part of the reviewer; • Lack of documentation of data and analyses in the EIS and supporting documents performed by C-E; and • Model choices that could have been made differently, but that do not significantly affect the model predictions.
General Comment				SELC asserts that the groundwater model under predicts drawdown, which also leads to under-prediction of impacts to wetlands and surface water flow and quality.	Haile believes that review of the C-E model indicates that it is conservative for many reasons, including the following: • Hydraulic conductivity (K) and transmissivity (T) for the majority of the model is greater than or on the upper end of values determined from aquifer testing. This is evident in the simulation of the PW-13-01 test which over estimated drawdown at distal wells by up to 5 times, suggesting the model will over predict the extent of drawdown. • The way in which C-E simulated streams and rivers allows the drawdown to propagate beyond rivers and streams. In actuality, water leaking from streams and rivers may act as a hydraulic boundary and limit the extent of drawdown. • Specified flux boundaries simulated with MODFLOWS well package at the southern model boundary inhibit contribution of groundwater from the south. This boundary assignment forces impacts to be realized in streams and rivers within the model domain.

Comment Number	Section	Page	Paragraph	SELC Comment	Response
1	Streamflow Quantity	3	1	States: "However, the maximum impacts could occur after mine operations cease because the groundwater drawdown will be at its maximum and will continue to expand in area as the pits, both lakes and backfilled, recover."	The timing of maximum impacts following the cessation of mining has a negligible effect on the predicted extent and magnitude of groundwater drawdowns as shown on Figure 1. Figure 1 presents the 1-ft, 10-ft and 100-ft drawdown contours at the end of mining and 250, 1,000 and 2,500 days after mining. These contours show that some areas have virtually immediate recovery, while other areas continue to experience drawdown as the pits refill. Similarly, the time when the greatest baseflow depletions are predicted to occur is variable: in some reaches maximum baseflow depletion occurs at the end of mining; in many it occurs approximately 90 days after cessation of pumping; and in a few reaches it occurs 2 to 3 years after mining. Haile will be providing more specific information on impacts to flows resulting from baseflow depletions during the recovery period shortly.
2	Streamflow Quantity	3	2	States: "These include the fact that calibrated conductivity (K) values form a zone of low K around the streams which may minimize the impact of dewatering."	The model does not include a zone of low K around the streams. The streams are simulated within either layer 1 or 2 of the model. Stream and River Package boundaries simulated in layer 1 (the CPS unit) are surrounded by cells with a K of generally about 2 ft/day, which is similar to the K in other layer 1 cells. K values in cells surrounding Stream and River Package boundaries simulated in layer 2 are also similar to other cells in layer 2 that are not in close proximity to Stream and River Package boundaries.
3	Streamflow Quantity	3	2	States: "The stream boundaries limit the extent that drawdown expands in a given direction; this may not have occurred with proper modeling of the interactions between model layers 2 and 3.	K values assigned to layer 2 in the project area are appropriate ranging from 0.01 to 2 ft/day which is within the tested range of values for saprolite. Vertical K values for layer 3 are appropriate for saprock. For this reason, Haile believes that the simulation of hydraulic interactions between layers 2 and 3 is reasonable and representative of field conditions.
4	Streamflow Quantity	4	2	States: "The concern regarding whether the DEIS considers the maximum potential drawdown discussed in the previous section also applies to streamflow quality. Just after mine dewatering ceases when baseflow may be at a minimum, the discharge of pollutants could be a maximum and the impacts to the stream."	Refer to Haile's Response to SELC Comment No. 1.
5	Wetlands	5	1	States: "This means that dewatering will lower the water table under the wetlands or prevent groundwater from discharging into the streams. It also includes streams and wetlands from which surface water flow will be diverted due to mine facility construction. These indirect impacts have likely been underestimated for the same reasons discussed above regarding streamflow quantity."	Refer to Haile's Response to SELC Comment No. 1.
6	Wetlands	5	4	States: "The DEIS provides no really useful wetland data to assess whether groundwater drawdown will affect the wetland water levels. Pump tests might help, but the pump tests discussed elsewhere do not meet these needs."	Additional aquifer testing of PW-09-01 was performed over a 40-day period extending from January 31, 2012, to March 11, 2012, with the primary objective of observing the surface water-groundwater interactions, including responses measured in 12 wetland piezometers and at two adjacent monitoring surface water stations. These results were presented in the Addendum to the Baseline Hydrologic Characterization Report (AMEC, 2012). The results indicated that no discernible responses were observed in the shallow groundwater during the 40-day aquifer testing of PW-09-01 and that shallow groundwater levels respond primarily to precipitation events and longer-term climatic trends.

Comment Number	Section	Page	Paragraph	SELC Comment	Response
7	Data Adequacy	7		States: "Based on the observed fractures in bedrock, thin surficial aquifer, complex wetlands, and steep gradients, the Haile mine site requires more data because of the likely changeable properties."	This comment is a gross generalization and fails to acknowledge the considerable data collected to characterize the Haile site. Specifically, Haile has conducted the following characterization activities at the site: • Extensive geologic characterization of the site using data collected from 1,167 exploratory drillholes; • Airlift yield and RQD measurements collected from exploration borings; • Installation of 82 monitoring wells and piezometers to monitor groundwater conditions; • 5 long-term aquifer tests using an extensive network of observation wells, as well as associated step-drawdown tests (10-day test, 43-day test, 40 day test, and 11-day test at PW-09-01; 7-day test at PW-13-01) from 2009 through 2013; • 24 single well pumping tests conducted from 1994 through 2013; • 17 slug tests from 1994 through 2009; and • 7 downhole geophysical surveys in 2013. Haile recognizes the importance of a data set that meets the project objectives and supports development of a credible numerical groundwater model and believes that sufficient data of appropriate accuracy and precision have been collected in support of the DEIS.
8	Data Adequacy	7	Last	States: "Private wells are not a substitute for dedicated monitoring wells for many reasons, but mostly because they are simply not designed for monitoring and may span multiple layers so that water levels are a blend; also, their observed levels depend on the frequency of use . . . Additional piezometers, including three into bedrock, were also constructed for a 2013 pump test (C-E 2013, Table 4-3). It is unclear whether this data was used for calibration."	Private wells are not being considered as substitute for dedicated monitoring wells but are included in the groundwater dataset to supplement designated monitoring wells to provide additional water-level coverage. Water level data from the additional piezometers installed in 2013 for the monitoring of PW-13-01 aquifer test were used for model calibration.
9	Data Adequacy	8	2	States: "Because the transient effects to be caused by the proposed project are long term, both the temporal and spatial scales of the transient analysis are incorrect and generally not useful for this model site. The temporal data are simply not time consistent with the project to be simulated (Hill and Tiedeman 2007)."	The 40-day pumping test is a very long pumping test by industry standards. Generally a 24-hour test is sufficient for characterizing confined aquifers and a 72 hour test is sufficient for characterizing unconfined aquifers (Driscoll 2003). The two simulations of pumping tests do provide confidence in the model's ability to simulate the propagation of pumping stresses. Therefore, the transient simulations are appropriate and useful in demonstrating the model's ability to simulate pumping stresses.
10	Data Adequacy	8	3	States: "The piezometer data collected for the wetland analysis was not apparently utilized in the groundwater analysis. The groundwater analysis therefore does not include any apparent analysis of whether the wetland water levels are connected to the groundwater."	The installation details of the 12 wetland piezometers and the evaluation of data from these piezometers were presented in the Addendum to the Baseline Hydrologic Characterization Report (AMEC, 2012).
11	Data Adequacy	8	4	States: "There were two pump tests completed to parameterize the formations. They were completed correctly and provide useful initial information regarding the formation properties. However, they are very limited in spatial scale. The scale of a pump test extends only to the extent of the drawdown effects which may cover only a portion of a model cell. The temporal results, storage coefficients, are not representative of the time-scale of the project or of the areas likely to be affected.	As stated in the response to Comment No. 8 above, 5 long-term aquifer tests using an extensive network of observation wells, as well as associated step-drawdown tests (10-day test, 43-day test, 40 day test, and 11-day test at PW-09-01; 7-day test at PW-13-01) from 2009 through 2013. Model simulations of these aquifer tests performed on the PW-09-01 and PW-13-01 wells indicate that simulated drawdowns propagate distances that are much greater than

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					the width of one model cell. These two aquifer tests were not designed to show the impact that mine depressurization will have, rather the simulation of these tests shows how well the model reproduces the propagation of pumping stresses.
12	Data Adequacy	8	5	States: "In conclusion, the data collected and used for the hydrogeology analysis is insufficient for estimating the required dewatering rates, impacts of that dewatering, and the rates of groundwater and pit lake recovery and associated effects . . . The transient water level data, wetland data, pump test, and baseflow data are all relatively useless due to temporal or spatial factors.	As stated in the response to Comment No. 7, this comment fails to acknowledge the considerable data collected to characterize the Haile site. Further, as described in the responses to Comments No. 9 and 11, the transient model calibration to transient water-level data from collected from wetlands and monitoring networks installed adjacent to pumping wells demonstrates the model's ability to simulate pumping stresses.
13	Data Adequacy	8	1st bullet	States: "The data needs identified above should be remedied prior to claiming that the DEIS makes accurate predictions of the effects. Specifically, new data should (1) include more water level data over more of the study site, (2) transient data over a consist period of a least several years, preferably including a long-term pump test, and (3) synoptic streamflow measurement to accurately estimate baseflow around the site. Without these revisions, the groundwater modeling is too imprecise to be utilized for disclosure in the DEIS."	The USACE has determined that the Haile groundwater model is an appropriate tool for assessment of groundwater-related impacts in the DEIS and satisfies the requirements of NEPA. In making this determination, it was recognized that models are inherently simplifications of complex systems. The groundwater model as designed generally over predicts the extent of drawdown since the K/T values of the bedrock is on the high end of measured values. In addition, the river and stream boundaries were designed such that they do not provide an infinite supply of water that would bound the propagation of drawdown. As a result, the groundwater model is conservative in that it over predicts the magnitude and extent of drawdown and streamflow depletions. • Water level data have been collected at multiple depths across the permit area and beyond at over 100 sites excluding VWPs; • The 40-day pumping test is a "long-term pumping test;" and • Synoptic stream flow measurements would only provide estimated baseflow at the time of the measurements and would be approximate due to measurement error. The range in baseflow and the average baseflow would still be uncertain.
14	Hydrogeology	9	2	States: "Table 2-1 shows the range as 0.03 to 0.17, that is likely the correct value. These estimates are based on in-situ constant and falling head tests whereas the pump test gave a range of 0.15 to 1.39 ft/d. This is a good demonstration of scale effects for K, wherein the K becomes larger as the considered volume increases because large volumes have a better chance of being representative of the fractures in the volume (Schulz-Mackuch et al. 1999). C-E (2013) should have used the higher range as the limits in the model calibration as discussed below."	C-E did allow the range of K's used in the model to be greater. The model simulated K values of layer-2 (saprolite) ranges from 0.001 to 3 ft/day with the majority of mine pits within a region ranging from 0.5 to 1.4 ft/day.
15	Hydrogeology	9	3 - 4	States: "Because the bedrock could provide most of the dewatering water, depending on its characteristics, it should have been better characterized than was done by C-E (2013). The report indicates that three major fracture sets cross the site at orientations of northeast, northwest, and north-northwest with a nominal spacing of 100 to 300 feet between fractures. The report then states the "fracture pattern has not been extensively studied" (p 2-6). Such a fracture pattern could cause horizontal anisotropy, which means the horizontal K could be much higher parallel to the fractures than crosswise to them. This means the effects of dewatering could vary substantially with direction. The pump tests performed would provide little information regarding fractures if not designed	The reader misunderstood that the three fracture sets mapped were at the Brewer Mine not the Haile Mine. The authors did not ignore the Schlumberger Water Services (SWS) Haile Gold Mine Depressurization and Dewatering Feasibility Study (December 2010) and SWS Haile Gold Mine, Depressurization and Dewatering Feasibility Study: Volume 1 (January 2011). They did more analysis of field data using the extensive RQD data. Section 4.2 of the modeling report presents an analysis of RQD data analyzed via kriging algorithms in a Vulcan model. The RQD data were collected at 65,111 discrete intervals in 502 borings located across the site. This analysis showed a definite trend with depth but no notable lateral variations.

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				to do so. The report also cites a study suggesting there are more fractures at the contact between the overlying sap-rock and that there are three productive horizons, from 200 to 400, 600 to 800, and over 1000 feet below ground surface. Countering that they cite another study which did not find different horizons and that K was relatively constant to 1000 feet. The authors utilize the second study and ignore the different fracture horizons for the modeling effort. Different horizons could have substantial differences in flow among them, including water quality and source. Dewatering them could have different effects."	
16	Hydrogeology	10	1st full paragraph	States: "The report discusses additional well tests of existing boreholes on p 4-2; it is unclear how these differ from the tests discussed on p 2-6. Most of the single well tests demonstrated leaky artesian behavior with a relatively high K for bedrock. However, they do not tabulate these results. The 2013 pump test, detailed on pp 4-5, 6, demonstrated that the dikes were not flow barriers and that the saprolite was not a confining layer. It also demonstrated additional leaky artesian behavior. The pump test applies only in the area of the piezometers, but there is no reason to suspect that it is not broadly applicable to the site."	Haile agrees. Section 4.1 should include results of Single well Aquifer Tests. Section 4.6 should also document results of the PW-13-01 test. Recommended revisions to the Cardno modeling report Page 4-1 and 4-6 have been developed. (See Haile's Response to SELC DEIS Comments, Attachment 1, included below).
17	Revised Conceptual Model	10	1st and 2nd bullets	States: • "Nothing showed that sap-rock and upper bedrock had substantial horizontal fractures. In fact, they failed to verify or disprove the existence of fractures that might cause a horizontal anisotropy. • There is no reason to conclude the "lower bedrock was generally dense and tight." There was simply insufficient data collected to support such a conclusion.	• The RQD data clearly indicate a greater concentration of fractured rock at depths above 400 ft below ground surface (bgs). It is true that the direction of the fractures is not documented. • Similarly, RQD data collected from deeper bedrock indicate more competent, less fractured rock below 400 ft bgs. Further, out of the 17 single well aquifer tests completed in 2013, the tests in the three deepest wells had the two lowest K values of 0.0006 ft/d, 0.004 ft/d, and the third value of 0.03 ft/d was within the bottom six (New Table 4.1).
19	Revised Conceptual Model	10	4	States: "The DEIS (p 4.3-3) sets a level of about 400 feet in the bedrock as a dividing line between higher K shallow bedrock and lower K deeper bedrock. This dividing line is not supported by the new data collected for the DEIS; some studies cited by C-E (2013) directly counter this conceptualization.	The RQD data, which are dense and span a large portion of the site, clearly indicate more fractured rock (less intact or lower RQD values) at depths above 400 ft bgs.
20	Baseflow and Recharge	11	1st bullet	States: "The report should describe estimates of recharge at other sites in the area for comparison and consider the level of uniqueness in the estimate."	Overall recharge in the model is on the order of 20% of background precipitation. Although this is on the high end of other documented assessments, there was a desire to create a conservative simulation with regard to drawdown extent using the higher end K values. In doing so the higher recharge rate was necessary.
21	Baseflow and Recharge	12	1st bullet	States: "C-E should use a more appropriate method for estimating reach-by-reach baseflow than area proration."	Although the method for determining baseflow in the ungaged reaches is very generalized, C-E went above and beyond necessary calibration efforts by attempting to calibrate the model to flows in all 16 reaches. Since Hanging Rock is a gaged reach Haile does know that the flows calibrated to for Hanging Rock are appropriate. Furthermore, Haile provides in Haile's Response to SELC DEIS Comments, Attachment 2, additional average annual baseflow estimates generated using three additional USGS

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					streamflow stations. Baseflows at these three additional stations were estimated using both flow separation techniques applied directly to the measured flows and using basin proration based on the Hanging Rock Creek gage. The similarity of results obtained by these two methods illustrates that basin proration provides reasonable estimates of baseflow.
22	Baseflow and Recharge	12	2nd bullet	States: "C-E (2013) should complete synoptic streamflow measurements during baseflow periods to determine the extent of gaining and losing reaches, or the rate of gain experienced by reach. Fractures may control the groundwater discharge points. A synoptic flow data set, a commonly used tool in estimating baseflow by reach, would vastly improve the model calibration and improve the predictions of the effects of mine dewatering and should be included in the revised DEIS."	The USACE has determined that the Haile groundwater model is an appropriate tool for assessment of surface water impacts in the DEIS and satisfies the requirements of NEPA. In making this determination, it was determined by the USACE and their consultants that the basin proration method of estimated average baseflow conditions was adequate for the purposes of assessing surface water impacts. Further, synoptic stream gaging gives point in time quantification of stream flow/ baseflow with notable measurement error. Estimating average baseflow from this information may lead to similar levels of uncertainty in the target values.
23	Groundwater Model Structure	12	4	States: "They do not state whether model layers 2 through 6 were assumed to be confined or convertible. The upper layer is always unconfined, but if the water level falls below the top of a layer, it converts from confined to unconfined…"	All model layers were simulated as Type 3 convertible. Thus, the simulations were appropriate.
24	Groundwater Model Structure	13	1	States: "C-E should fix the modeling error identified in this paragraph and reestimate the drawdown and streamflow reductions."	All model layers were simulated as Type 3 convertible. Thus, the simulations were appropriate.
25	Groundwater Model Structure	13	2	States: "In MODFLOW, only recharge and wells are specified flux, but the authors do not specify which they use. The water balance summary in C-E (2013) Table 6-7 shows a flux boundary with inflow and outflow equal to 58,449 and -63,882 ft3/d. These flows do not appear consistent with the description of a specified flux boundary. The steady state head contours shown in C-E Figure 6-1 indicate that flow would cross the boundary in both directions, which makes it being a specified flux very unlikely. The flux shown in Table 6-7 is similar to that from a head-controlled flux boundary, such as a constant head or general head boundary in MODFLOW, which would allow flow into or out of the domain depending on the direction of the gradient. Therefore it is not clear how C-E conceptualized this boundary, but based on Table 6-7 it appears to simply balance the water balance. In other words, it allows whatever flow is necessary to enter or leave the domain without limit which facilitates attaining the targets at the stream reaches. If this is correct, it allows the recharge estimates discussed above to be non-unique. The specified flux boundary therefore is not well described and may not be representative of actual flow through that portion of the model domain at all."	The use of specified flux boundaries at this location, forces all impacts to be within the model domain (it does not allow for induced inflow at the model boundary from the simulated stress). As a result, the representation of this boundary in the model ensures that model behaves conservatively by ensuring that all impacts are within the model domain. <u>Clarifications on Model Set-up</u> The model uses the MODFLOW- Well package cells to simulate specified flux across the southern boundary. The MODFLOW- Well package cells simulate specified flux both into and out of the model. The assigned specified flux was based on the flux simulated to cross the same location in the previous larger scale model domain. Since the flow is specified it does not change between the calibrated steady state model and the predictive model.
26	Calibrated Parameter Values	14-15	Last	Discussion in the last paragraph on page 14 implies that the hydraulic conductivity distribution of layer 2 was designed to limit the extent of the cone of depression.	The distribution of K in layer 2 falls within measured ranges and was not adjusted to limit the predicted extent of the cone of depression. Model simulated horizontal hydraulic conductivity of layer 2 (saprolite) ranges from 0.001 to 3 ft/day with the majority of mine pits within a region ranging from 0.5 to 1.4 ft/day. Table 2-1 shows K values ranging from 0.03 to 1.39 ft/d from falling head and pumping tests. Layer 2 vertical hydraulic conductivity ranges from 0.0074 to 3 ft/d with the majority of mine pits having K values around 0.01 ft/d.

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27	Calibrated Parameter Values	16	Last	States: "K values in layer 3 are even more suspect, as shown in the snapshot of those properties (Figure 4). Layer3 is sap rock and Kh varies from 0.01 to 0.1 ft/d over most of the domain. Kh in this layer is lower than for other layers. An exception is an almost circular area just south of the project area in which Kh appears to be as high as 6 ft/d. Geologically, this is almost impossible but is often an artifact of PEST calibration if the modeler simply accepts the results. The vertical K shows the same circular area (Figure 5) but has values ranging from 0.6 to 6 ft/d over much of the domain, which means that Kv is significantly higher than Kh. This is geologically highly unusual and would cause zones of high vertical flow among layers. A combination of required baseflow and head levels near these areas probably causes the anomalies."	The horizontal hydraulic conductivity of layer 3 is on the low end of measured values; however, the vertical hydraulic conductivity is consistent with measured values in shallow bedrock. Although the use of Kv values that are higher than Kh values appears to be less representative of the saprock in most areas, the effect of this on the predicted extent of draw down appears to be minimal. Comparing the 1-ft, 5-ft, 50-ft, and 100-ft drawdown contours at year 14 between layer 5 and layer 2 indicates there is a very small difference in the magnitude and extent of drawdown and suggests that drawdown has not been minimized in the shallow model layers.
28	Calibrated Parameter Values	17	Last	States: "Layers 4 and 5 also show zonations with K varying up to two orders of magnitude, including areas where Kv exceeds Kh."	K does not vary by two orders of magnitude in layers 4 and 5; there is just over one order of magnitude variation. In fractured bedrock one would expect significant variation in hydraulic conductivity depending on the presence and connectivity of fractures at any given location. The horizontal K values of layers 4 and 5 range from 0.45 to 5.6 ft/day, with most of the site area in the 0.5 to 1 ft/day range. Vertical K ranges from 0.46 to 5.2 ft/day with most of the site area in the 0.5 to 1 ft/day range. These values are on the high end of field tested K.
29	Calibrated Parameter Values	19	2	States: "The final calibrated K values may decrease the effect the mine dewatering has on the nearby streams. Low K in upper layers will increase the gradient for flow to the pit dewatering and thereby decrease the extent of the drawdown. High vertical K values in the bedrock will allow water to be drawn from depth to replace that which is being drawn from the mine site. A drawdown 1000 feet below the surface does not show up as decreased baseflow."	As presented above, the K parameterization of layers 4 and 5 is conservative and allows for more horizontal propagation of drawdown than is likely to occur. Comparing the 1-ft, 5-ft, 50-ft, and 100-ft drawdown contours at year 14 between layer 5 and layer 2 shows a very small difference and do not suggest that drawdown has been minimized in the shallow model layers. Therefore, model simulated drawdowns at depth are indeed propagated to the surface and do indeed result in decreases to baseflow.
30	Model Calibration	19	4	States: "Each of these sets of water levels is inconsistent with the other sets. They do not represent a long-term average, which is what steady-state implies. The complete data set of observed water levels is improperly used and inappropriate for calibration."	Although an ideal calibration data set is one in which the measurements are collected at the same time or for the same period of time, it is acceptable to use a data set such as this especially in areas where there is not significant temporal variation.
31	Model Calibration	20	1	States: "This indicates they will over predict drawdown further from the Mine…Predicted drawdown is shown to be limited by the river boundaries, as well."	Haile agrees. This model will tend to over predict the extent of drawdown which again demonstrates the conservatism of model simulations. Further, one would expect drawdown to be somewhat diminished near sources of water such as streams, and therefore, this is not a shortcoming of the model.
32	Simulation of Mine Development	20	2	States: "The methods for simulating dewatering appear accurate, to the extent there are details to review. Using DRAIN boundaries to simulate dewatering is a commonly accepted practice. However, they do not describe how the conductance was set which makes the predictions hard to evaluate because the conductance controls the amount of water removed from the model.	Drain boundaries were assigned a conductance of 250 ft^3/ft.

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33	Simulation of Mine Development	20	3	States: "They set the DRAIN head five feet below the projected pit bottom. This means the water level will be lowered to five feet below the pit bottom. Because the DRAIN would establish a relatively flat water surface beneath the pit bottom, the projected water table would be very close to the bottom of the pits. This differs from reality because dewatering for this mine will likely require dewatering wells to be established around the perimeter of the pit. The water level in the center of the pit cannot be lower than the water level in the dewatering wells. Therefore, at the well, the water table must be drawn substantially below the bottom of the pit so that the cumulative drawdown from the wells will be below the bottom of the pit. This causes a much higher gradient for flow to the actual wells than to a DRAIN boundary with elevation set just below the bottom of the pit. Therefore, the dewatering estimates made using the DRAINs are likely too low."	Since the parameterization of this model with high end bedrock permeability is very conservative in regard to predicted extent of drawdown and predicted dewatering rates, Haile does not believe that these estimates of dewatering are too low. Further, it is not necessary to determine the exact location, depth, and pumping rate for dewatering wells in order to assess potential impacts associated with mine pit depressurization to satisfy the requirements of NEPA.
34	Simulation of Mine Development	21	2 - 4	States: "The figures showing drawdown contours in C-E Appendix 7b reveal a major conceptualization problem with the dewatering simulations. Figure 6 shows the drawdown contours at the end of mining, year 14, when the drawdown at the pits is most likely the deepest. The maximum drawdown exceeds 700 feet but less than a mile to the south it is only 1 foot, which occurs at the river reach 16. C-E Figure 7-3 shows that baseflow in this stream decreases about 50% due to dewatering from the baseflow target value of 640,800 ft3/d (C-E Table 6-3). This continued groundwater discharge to the stream means that the groundwater contours continue to slope toward the creek. C-E Figure 6-4 shows that steady state groundwater levels are 50 to 100 feet above the creek near reach 16. It was discussed previously that low K values near the mine site could cause the water table to slope steeply during dewatering. If K had been higher, dewatering would have lowered the water table more nearer the mine, possibly reversing the gradient or even lowering the water table to beneath the bottom of the RIVER reach. If that had occurred, the boundary would have lost flow at the rate of the conductance (since the effective gradient would be 1.0). The figures show that the streams limit the extent of the drawdown. As shown in Figure 6, RIVER boundaries occur across the model domain including on the mine site. The drawdown contours show water levels below the bottom of the pits, as simulated with the DRAIN boundaries. However, the drawdown near the RIVER boundaries on the southeast and southwest side of the mine site is just 1 foot but is higher beyond the river reaches due to drawdown extending beneath the rivers within the deeper layers. Drawdown continues beyond the rivers due to drawdown in deeper layers pulling water from overlying layers. Further south there is actually a 5-foot drawdown contour, which indicates that the river does not limit drawdown in the deeper layers. Neither the DEIS nor C-E present drawdown contours for deeper layers, so there is no way to assess the extent of drawdown effects in the bedrock."	• There is nothing abnormal about drawdown diminishing from 700 ft to 1 ft over a mile distance (5280 ft) under pumping conditions; this equates to a gradient of (699/5280 =0.13). During the pumping test at PW-13-01 drawdown was observed at 159.9 ft at the pumping well to 3.8 ft at a distance of 229.5 ft. This is a gradient of (156.1/229.5 =0.678). • Reach 16 is quite large and includes all of HGMC, the watershed southeast of the permit boundary, and a stretch of the Little Lynches catchment. It is anticipated that many of the streams in the more distal portions of reach 16 would still receive baseflow. • There is a small area of the model north and west of the Champion Pit where water levels are artificially quite high; this is likely the result of KHz and Kv values in this region being set too low in layer 3 and possibly in layer 2. However, water levels elsewhere are more appropriate. It is unlikely that this relatively small area greatly impacts the overall model predictions. • It is expected that drawdown would be somewhat diminished near sources of water (like streams and rivers); this is not a shortcoming of the model.

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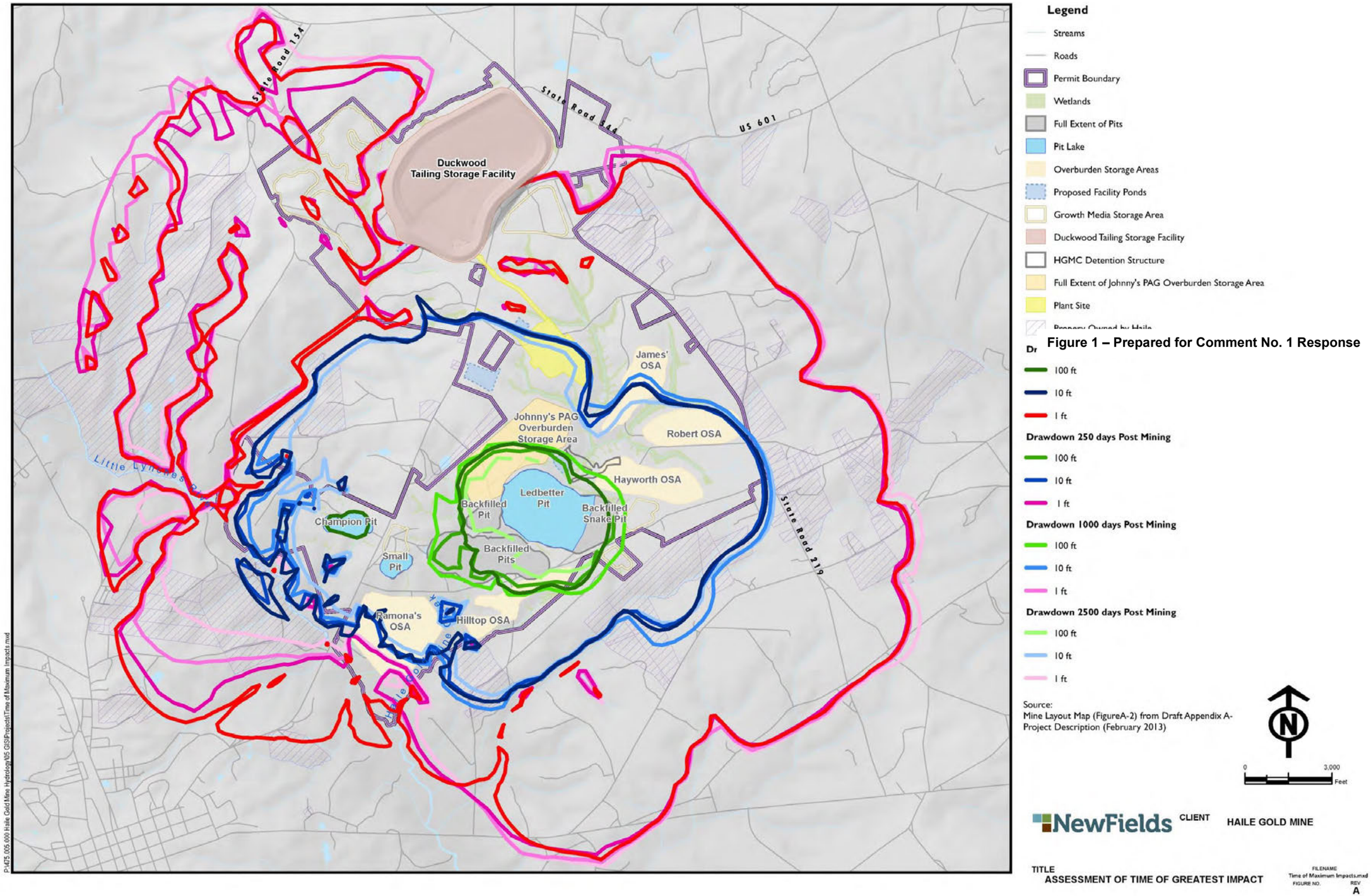
35	Simulation of Pit Lake Recovery and Particle Tracking	23	4	States: "It is common to set effective porosity equal to specific yield, but is most appropriate for media dominated by primary porosity (Stephens et al 1998). In fractured bedrock dominated by secondary porosity, the effective porosity could be much different. In the case of the Haile Gold Mine, it should be expected that individual particles would flow much faster through the connected fractures."	The referenced paper (Stephens et al 1998) is not an applicable reference because it does not assess whether specific yield is more appropriate for media dominated by primary porosity for particle tracking calculations. It assesses whether use of calculated or estimated values of effective porosity are best for solute transport analyses. The paper uses a sand and gravel aquifer as a case study. The methodology used for the Haile analysis applied effective porosity in bedrock ranging from (0.01 to 0.04) for the particle tracking analysis. In particle tracking effective porosity is used along with K values to calculate travel time. Groundwater velocity is proportional to K and inversely proportional to effective porosity. Since bedrock K is set conservatively, high the speed of simulated particle movement is likely conservatively high.
36	Simulation of Pit Lake Recovery and Particle Tracking	24	1	States: "They also changed hydraulic parameters in the backfilled pits to represent K and storativity in the pits. They selected a hydraulic K to "simulate coarse-grained poorly-sorted alluvial material" to have a K equal to 40 ft/d. This could be too high because it ignores the compaction that goes into backfilling a pit."	Comment noted; the value of K for backfill is unknown but is likely within an order of magnitude of the value assigned. The use of a higher estimate of K is more conservative.
37	Simulation of Pit Lake Recovery and Particle Tracking	25	Last	States: "1. The estimate of 3944 gpm of noncontact water for dilution is much too high. It is based on pre-mine steady state groundwater flow through the system (Schafer and Newfields 2014, p 5). Table 1 shows that 3595 gpm of the inflow results from recharge over an area shown on Figure 2. After mining, a large percent of that area (which is not given in the memorandum) becomes covered with mine facilities so that pre-mine recharge rates no longer apply. Additionally, Table 1 shows that 832 gpm passes through to downgradient groundwater and groundwater contours on Figure 2 indicate that some of that groundwater may not have contacted seepage so it also does not contribute to dilution."	The reader was mistaken. The memo cited -- Clarification of Surface Water Quality Impact Model and Groundwater Chemistry (Schafer and Newfields, January 13, 2014) – states the flow is based on the long term post mining flow conditions, not the pre-mine steady-state conditions.
38	Simulation of Pit Lake Recovery and Particle Tracking	25	Last	States: "2. For complete dilution to occur, the seepage would have to mix through the entire aquifer thickness. By using the groundwater inflow rate for the entire thickness of the model, Schafer and Newfields (2014) imply the groundwater flow is through the entire thickness of the groundwater model which was several thousand feet. Seepage would mix through at most the uppermost 100 feet of the aquifer so that it would not be diluted by the entire groundwater flow-through.	The reader was mistaken. The 2014 memo states the flow zone analyzed extends from ground surface to the bottom of model Layer 6, which incorporates the deepest portion of Ledbetter Pit (in the recovery model the original layer 6 was split in order to have the pit lake simulate the appropriate volume). Thus the bottom of layer 6 is coincident with the bottom of Ledbetter pit. The zone analyzed is not calculated for the entire model thickness and is not several thousand feet. Also, seepage out of the pit lakes, which are hundreds of feet deep, would mix with more than just the uppermost 100 feet of the aquifer.

REFERENCES

Driscoll, F.G. 2003 Groundwater and Wells second Edition. Johnson Screens. St. Paul Minnesota.

FIGURE 1


Legend
Streams
Roads
Permit Boundary
Wetlands
Full Extent of Pits
Pit Lake
Overburden Storage Areas
Proposed Facility Ponds
Growth Media Storage Area
Duckwood Tailing Storage Facility
HGMC Detention Structure
Full Extent of Johnny's PAG Overburden Storage Area
Plant Site
Property Owned by Haile
Dr
Figure 1 – Prepared for Comment No. 1 Response
100 ft
10 ft
1 ft
Drawdown 250 days Post Mining
100 ft
10 ft
1 ft
Drawdown 1000 days Post Mining
100 ft
10 ft
1 ft
Drawdown 2500 days Post Mining
100 ft
10 ft
1 ft
Source:
Mine Layout Map (FigureA-2) from Draft Appendix A-Project Description (February 2013)
0
3,000
Feet
NewFields
CLIENT
HAILE GOLD MINE
TITLE
ASSESSMENT OF TIME OF GREATEST IMPACT
FILENAME
Time of Maximum Impacts.mxd
FIGURE NO.
REV
A
State Road 154
State Road 344
US 601
Duckwood Tailing Storage Facility
James' OSA
Johnny's PAG Overburden Storage Area
Robert OSA
Hayworth OSA
Ledbetter Pit
Backfilled Pit
Backfilled Snake Pit
Backfilled Pits
Champion Pit
Small Pit
Ramona's OSA
Hilltop OSA
Little Lynches River
Haile Branch
State Road 219
P:\475.005.000 Haile Gold Mine Hydrology\05 GIS\Projects\Time of Maximum Impacts.mxd

HAILE'S RESPONSE TO SELC DEIS COMMENTS, ATTACHMENT 1
(PREPARED IN RESPONSE TO SELC COMMENT NO. 16, ABOVE)

Revise modeling report Page 4-1, Section 4.4 Paragraph1 with: *"…The data were analyzed using the AQTESOLV pumping test interpretation software to calculate the hydraulic conductivity of the aquifer and estimate the boundary conditions based on the type curve response.* Table 4-1 presents the estimated hydraulic conductivity values from these tests. Bedrock hydraulic conductivities ranges from 0.0006 to 0.5 ft/day with a geometric mean of 0.065 ft/day and saprolite hydraulic conductivity ranged from 0.03 to 9 ft/day. *All of the wells were fit to a Theis solution for confined aquifers and then fit to the type curve that relatively closely fit the time-drawdown plot. In general, the Theis curve fits were poor, indicating that the aquifers were not fully confined systems. Most of the wells followed leaky artesian type curves (Hantush), with one well (BMW-5) plotting as a dual porosity- (Moench) type aquifer…."*

NEW Table 4-1

Well	Well Depth (ft bgs)	Primary Lithology	Maximum Drawdown (ft)	Method	Transmissivity (ft2/day)	Length of Screen Interval (ft)	Hydraulic Conductivity (ft/day)
BMW-2	340	Bedrock - Metasediment	6.5	Hantush	10.22	30	0.3
BMW-5	150.7	Bedrock - Metasediment	2.5	Moench w/ Slab	NA	20	0.5
BMW-6	150.3	Bedrock - Metasediment	11.3	Hantush-Jacob	2.06	20	0.1
BMW-09-01	800	Metasediment / Diabase Dike	217.2*	Hantush-Jacob	0.283	480	0.0006
BMW-09-02	802	Metasediment / Altered Dike	209.7*	Hantush-Jacob	1.719	420	0.004
BMW-09-03	800	Metasediment / Meta Volcanic	70.3	Hantush-Jacob	15.13	520	0.03
BMW-10-01	178	Bedrock - Metavolcanic	12	Hantush-Jacob	9.442	40	0.2
BMW-10-02	130	Saprolite	6.3	Hantush-Jacob	226	25	9
BMW-10-03	160	Metasediment/Saprolite	113.5*	Hantush-Jacob	7.437	25	0.3
BMW-10-04	400	Bedrock - Metavolcanic	128.4	Hantush-Jacob	2.406	80	0.03
BMW-10-05d	400	Saprolite/Metasediment/Metavolcanic	165	Hantush-Jacob	3.734	200	0.02
BMW-10-05s	90	Saprolite / Metasediment	39.4*	Hantush-Jacob	1.51	60	0.03
DMW-1	45	Bedrock - Siliceous Argilite	32.7	Hantush-Jacob	2.873	10	0.3
DMW-2	88.5	Bedrock-Quartz Vein	14.9	Hantush-Jacob	4.95	10	0.5
DMW-6	30	Saprolite	5.1	Hantush-Jacob	4.715	10	0.5
DMW-8	38	Silty Weathered Saprolite	23.1	Hantush-Jacob	0.4366	10	0.04
DMW-9	29	Silty Weathered Saprolite	7.7	Hantush-Jacob	0.7581	10	0.08
* Water Level Fell Below Transducer							

Revise Modeling report Page 4-6, paragraph 4 with: "*The drawdown data were analyzed using the AQTESOLV pumping test analysis software* (Appendix 4h). *PZ-13-04, PZ-13-05, and PZ-13-06 fit the Theis confined solution, although it is likely that PZ-13-04 and PZ-13-06 may have followed an unconfined drawdown curve if they had not gone dry a short time after pumping started. PZ-13-05 and PZ-13-07 were deeper and were completed in the saprolite. These wells did not go dry and followed an unconfined aquifer solution, indicating that the saprolite behaved more like an aquifer than a confining unit. PZ-13-08, PZ-13-09, and PZ13-10 were completed in the bedrock. PZ-13-09 and PZ-13-10 followed a leaky artesian curve, indicating that the bedrock aquifer was acting as a porous media and receiving significant vertical flow through the saprolite and sap-rock units. PZ-13-08 followed a Moench dual porosity fracture flow drawdown curve, indicating that small portions of the bedrock are probably dominated by discrete fractures and locally behave as a fracture flow aquifer.* The bedrock transmissivity estimated from drawdowns in PW-13-01 and observation well PZ-13-09 is -----ft^2/day. This transmissivity results in an estimated hydraulic conductivity of ----ft/day."

---- Values estimated by C-E based on aquifer test data provided by Haile. Values not included in the DEIS, but should be added here.

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Technical Memorandum

Date: **May 28, 2014**

To: **Johnny Pappas, Romarco Minerals**

From: **Troy Thompson and James Koehler**

Re: **Analysis of Closure Model Baseflows**

Introduction

The purpose of this memorandum is to address comments made by Tom Myers in Exhibit B of the Southern Environmental Law Center (SELC) comments to the Draft Environmental Impact Statement (DEIS) (Myers 2014) suggesting that the maximum groundwater depressurization impacts of Haile Gold Mine would occur within the first couple of years after mine operations cease (see, e.g., page 4 of the Myers Report). The DEIS analysis evaluated three discrete time periods during closure to capture the temporal distribution of impacts: while Ledbetter Pit Lake is filling (Closure Year 5), just after Ledbetter Pit Lake is full (Closure Year 15), and after Ledbetter Pit Lake has been full for approximately 60 years (Closure Year 75). These three post-mining period were evaluated in addition to five periods during operations when impacts were evaluated.

In order to evaluate whether the original closure analysis presented in the DEIS provided a reasonable representation of anticipated impacts, Ecological Resource Consultants, Inc. (ERC) evaluated the average predicted baseflows determined by Newfields at quarterly intervals during the first year following cessation of mine operations and annually thereafter up to Closure Year 75. ERC then compared those baseflow numbers to the baseflow numbers for years previously analyzed that reflected highest baseflow changes (i.e., Mining Year 12 and Closure Year 5) to calculate the percentage difference in baseflow. ERC then identified those new time intervals with the highest percentage difference in change of baseflow – i.e., Closure Year 0.25 and Closure Year 3 – and completed a total flows analysis in order to determine the impacts at all Assessments Points in the project area at Closure Year 0.25 and Closure Year 3.

Analysis of Changes in Baseflow during Closure

Table 1 was created to visually quantify times of minimum and maximum baseflows at each stream Assessment Point during closure. Total flow is the sum of runoff and baseflow. Runoff in each year of

closure is essentially the same because runoff factors do not change significantly after the end of active mining. Therefore, for purposes of this comparative analysis, changes in baseflow are a good proxy for changes in total flows. **Table 1** shows the percent difference between Closure Year 5 baseflows, as calculated by the DEIS groundwater model, and baseflows at different times throughout closure. Positive values indicate baseflow at the given time period is greater than that predicted in Closure Year 5. Negative values indicate a baseflow less than that predicted in Closure Year 5. Cells highlighted in red represent the largest decrease in baseflow from Closure Year 5, or the time with the minimum flows. Cells highlighted in green represent the largest predicted baseflow levels.

Table 1. Percent Difference in Baseflows from Original Closure Year 5 (Closure Year 0.25 – Closure Year 25)

year	WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10	WS11	WS12	WS13	WS14	WS15	WS16
0.25	0.63%	-0.23%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.02%	3.16%	2.48%	[illegible]	5.49%	[illegible]	0.45%
0.5	0.00%	-0.82%	-11.22%	-30.87%	-27.56%	-11.40%	-9.14%	-5.56%	-4.99%	1.07%	1.43%	1.96%	-3.57%	7.87%	-2.28%	0.45%
0.75	-0.63%	-1.33%	-10.21%	-28.45%	-25.24%	-10.39%	-8.60%	-4.55%	-4.45%	-0.68%	0.62%	1.30%	-3.20%	6.23%	-2.13%	0.45%
1	-0.63%	-1.28%	-9.21%	-26.00%	-22.93%	-9.79%	-8.60%	-4.55%	-3.92%	-1.18%	0.09%	0.36%	-2.90%	4.87%	-2.01%	0.30%
2	[illegible]	[illegible]	-5.55%	-16.96%	-15.00%	-7.80%	-8.33%	-5.05%	-2.92%	-2.57%	-1.36%	-2.52%	-2.55%	-1.57%	-2.33%	0.15%
3	-0.63%	-0.87%	-3.28%	-10.97%	-9.51%	-6.10%	-8.06%	-5.56%	-1.82%	[illegible]	[illegible]	[illegible]	-1.93%	[illegible]	-2.21%	0.15%
4	-0.63%	-0.69%	-1.64%	-5.11%	-4.76%	-3.64%	-5.38%	-3.54%	-1.09%	-2.37%	-1.15%	-2.98%	-1.27%	-4.22%	-1.52%	[illegible]
5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6	0.63%	0.69%	1.51%	5.32%	4.88%	4.25%	6.99%	6.06%	1.15%	5.42%	1.11%	3.69%	1.41%	5.63%	1.76%	[illegible]
7	1.26%	1.37%	3.03%	10.76%	9.88%	8.78%	15.59%	12.12%	2.33%	12.65%	6.76%	10.75%	3.34%	12.52%	4.09%	[illegible]
8	1.26%	1.56%	4.41%	15.02%	14.76%	13.03%	25.00%	17.68%	3.15%	25.56%	16.85%	21.00%	5.47%	22.75%	6.91%	0.15%
9	1.89%	2.20%	5.67%	20.34%	19.02%	16.87%	34.41%	23.23%	4.21%	42.56%	35.53%	36.93%	8.54%	32.30%	10.50%	0.15%
10	2.52%	2.84%	6.81%	24.60%	23.17%	20.44%	43.82%	28.79%	5.23%	55.58%	51.31%	51.00%	11.33%	41.61%	13.79%	0.30%
11	3.14%	3.48%	7.82%	28.86%	26.83%	23.59%	52.69%	34.34%	6.22%	69.37%	81.54%	74.08%	15.37%	50.38%	18.10%	0.45%
12	3.14%	3.62%	8.83%	32.06%	29.27%	26.06%	61.02%	38.38%	6.75%	83.69%	127.50%	106.89%	20.45%	58.35%	23.21%	0.60%
13	3.77%	4.21%	9.58%	35.25%	31.71%	27.85%	68.01%	41.41%	7.50%	96.80%	168.53%	135.59%	25.09%	65.64%	27.90%	0.75%
14	4.40%	4.81%	10.21%	38.45%	34.15%	29.36%	73.66%	44.44%	8.22%	109.45%	210.79%	164.49%	29.73%	72.37%	32.52%	0.90%
15	4.40%	4.85%	10.72%	40.58%	35.37%	30.45%	78.23%	46.46%	8.49%	119.43%	236.75%	182.73%	32.51%	78.58%	35.50%	1.06%
16	4.40%	4.94%	11.22%	42.71%	36.59%	31.28%	81.18%	47.47%	8.76%	126.42%	249.17%	191.49%	33.97%	82.17%	37.10%	1.21%
17	5.03%	5.45%	11.48%	43.77%	37.80%	31.96%	83.60%	48.48%	9.21%	130.91%	256.66%	196.69%	35.04%	85.76%	38.37%	1.36%
18	5.03%	5.49%	11.73%	44.83%	39.02%	32.51%	85.48%	48.99%	9.36%	133.09%	260.89%	199.78%	35.59%	87.53%	39.01%	1.36%
19	5.03%	5.54%	11.98%	46.96%	39.02%	32.78%	86.83%	49.49%	9.51%	137.49%	266.92%	203.80%	36.27%	91.12%	39.95%	1.51%
20	5.66%	6.04%	12.23%	48.03%	40.24%	33.20%	88.17%	50.00%	9.94%	139.80%	270.64%	206.44%	36.96%	91.10%	40.53%	1.66%
21	5.66%	6.09%	12.36%	48.03%	40.24%	33.47%	88.98%	50.51%	9.98%	142.07%	273.97%	208.65%	37.33%	92.89%	41.04%	1.66%
22	5.66%	6.09%	12.61%	49.09%	40.24%	33.61%	89.78%	50.51%	10.06%	144.32%	277.97%	211.35%	37.77%	94.66%	41.59%	1.81%
23	5.66%	6.13%	12.74%	50.16%	41.46%	33.88%	90.59%	51.01%	10.17%	144.35%	279.11%	212.20%	37.97%	94.64%	41.76%	1.81%
24	5.66%	6.13%	12.74%	50.16%	41.46%	34.02%	91.13%	51.01%	10.18%	146.56%	282.59%	214.42%	38.29%	96.41%	42.21%	1.96%
25	6.29%	6.64%	12.86%	51.22%	41.46%	34.16%	91.67%	51.52%	10.56%	148.77%	285.69%	216.55%	38.87%	96.37%	42.70%	1.96%

Table 1, continued. Percent Difference in Baseflows from Original Closure Year 5 (Closure Year 26 – Closure Year 50)

year	WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10	WS11	WS12	WS13	WS14	WS15	WS16
26	6.29%	6.64%	12.99%	51.22%	41.46%	34.16%	91.94%	51.52%	10.57%	148.77%	286.34%	216.95%	38.93%	96.36%	42.75%	1.96%
27	6.29%	6.68%	13.11%	52.29%	41.46%	34.29%	92.20%	51.52%	10.63%	148.78%	287.04%	217.39%	39.04%	98.14%	43.02%	1.96%
28	6.29%	6.68%	13.11%	52.29%	41.46%	34.43%	92.47%	51.52%	10.64%	148.79%	287.77%	217.99%	39.13%	98.12%	43.10%	2.11%
29	6.29%	6.68%	13.11%	52.29%	42.68%	34.43%	92.74%	51.52%	10.67%	150.99%	290.40%	219.69%	39.40%	98.11%	43.32%	2.11%
30	6.29%	6.68%	13.24%	52.29%	42.68%	34.43%	93.01%	52.02%	10.68%	150.99%	290.95%	220.04%	39.45%	98.09%	43.36%	2.11%
31	6.29%	6.73%	13.24%	52.29%	42.68%	34.57%	93.01%	52.02%	10.74%	150.99%	291.30%	220.26%	39.53%	98.09%	43.43%	2.11%
32	6.29%	6.73%	13.24%	53.35%	42.68%	34.57%	93.28%	52.02%	10.77%	151.00%	291.42%	220.33%	39.56%	98.07%	43.45%	2.11%
33	6.29%	6.73%	13.24%	53.35%	42.68%	34.57%	93.28%	52.02%	10.77%	151.00%	291.79%	220.72%	39.62%	98.07%	43.50%	2.11%
34	6.29%	6.73%	13.37%	53.35%	42.68%	34.57%	93.28%	52.02%	10.77%	150.99%	291.95%	220.81%	39.63%	98.05%	43.51%	2.11%
35	6.29%	6.73%	13.37%	53.35%	42.68%	34.57%	93.55%	52.02%	10.78%	153.17%	294.41%	222.40%	39.86%	98.05%	43.71%	2.11%
36	6.29%	6.73%	13.37%	53.35%	42.68%	34.57%	93.55%	52.02%	10.78%	153.17%	294.58%	222.51%	39.87%	98.05%	43.72%	2.11%
37	6.92%	7.19%	13.37%	53.35%	42.68%	34.57%	93.55%	52.02%	11.06%	153.16%	294.53%	222.47%	40.08%	98.05%	43.89%	2.11%
38	6.92%	7.19%	13.37%	53.35%	42.68%	34.71%	93.55%	52.02%	11.06%	153.16%	294.71%	222.59%	40.10%	98.05%	43.91%	2.26%
39	6.92%	7.19%	13.37%	53.35%	42.68%	34.71%	93.55%	52.02%	11.06%	153.15%	294.88%	222.70%	40.11%	98.05%	43.92%	2.26%
40	6.92%	7.19%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.07%	153.15%	294.86%	222.68%	40.11%	98.05%	43.92%	2.26%
41	6.92%	7.19%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.07%	153.14%	294.83%	222.67%	40.11%	98.05%	43.92%	2.26%
42	6.92%	7.19%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.07%	153.14%	295.04%	222.80%	40.13%	98.05%	43.94%	2.26%
43	6.92%	7.19%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.07%	153.14%	295.01%	222.78%	40.13%	98.05%	43.93%	2.26%
44	6.92%	7.23%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.14%	294.99%	222.77%	40.15%	98.03%	43.95%	2.26%
45	6.92%	7.23%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.14%	294.99%	222.76%	40.15%	98.03%	43.95%	2.26%
46	6.92%	7.23%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.13%	295.19%	222.90%	40.16%	98.03%	43.96%	2.26%
47	6.92%	7.23%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.13%	295.19%	222.89%	40.16%	98.03%	43.96%	2.26%
48	6.92%	7.23%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.13%	295.19%	222.89%	40.16%	98.03%	43.96%	2.26%
49	6.92%	7.23%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.13%	295.16%	222.88%	40.16%	98.03%	43.96%	2.26%
50	6.92%	7.23%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.13%	295.16%	222.88%	40.16%	99.84%	44.14%	2.26%

Table 1, continued. Percent Difference in Baseflows from Original Closure Year 5 (Closure Year 51 – Closure Year 75)

year	WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10	WS11	WS12	WS13	WS14	WS15	WS16
51	6.92%	7.23%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.13%	295.16%	222.88%	40.16%	99.84%	44.14%	2.26%
52	6.92%	7.23%	13.37%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.13%	295.14%	222.86%	40.16%	99.84%	44.14%	2.26%
53	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.13%	295.14%	222.86%	40.16%	99.84%	44.14%	2.26%
54	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.12%	295.14%	222.86%	40.16%	99.84%	44.14%	2.26%
55	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	93.82%	52.02%	11.10%	153.12%	295.14%	222.86%	40.16%	99.84%	44.14%	2.26%
56	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.13%	295.37%	223.01%	40.19%	99.84%	44.16%	2.26%
57	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.37%	223.01%	40.18%	99.84%	44.16%	2.26%
58	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.37%	223.01%	40.18%	99.84%	44.16%	2.26%
59	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.37%	223.01%	40.18%	99.84%	44.16%	2.26%
60	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.37%	223.01%	40.18%	99.84%	44.16%	2.26%
61	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.37%	223.01%	40.18%	99.84%	44.16%	2.26%
62	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
63	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
64	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
65	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.37%	223.01%	40.18%	99.84%	44.16%	2.26%
66	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
67	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
68	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
69	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
70	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
71	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
72	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
73	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
74	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%
75	6.92%	7.23%	13.49%	53.35%	42.68%	34.71%	94.09%	52.02%	11.10%	153.12%	295.34%	222.99%	40.18%	99.84%	44.16%	2.26%

Note: Some cells with an apparent maximum value are not shaded. This is because of slight differences not shown due to rounding.

The results presented in **Table 1** show that the largest positive deviations in baseflows (illustrated by the green cells) were captured by the Closure Year 75 analysis. This is evidenced by the fact that the largest positive deviations from Closure Year 5 (highlighted in green) are the same, or nearly the same, as the percent deviation noted in Closure Year 75. For example, in Watershed 10 (WS10), the largest positive deviation from Closure Year 5 was 153.17% and it occurs during Closure Year 35. In Closure Year 75, the percent difference from Closure Year 5 is 153.12%. This demonstrates that the original analysis conducted by ERC in Closure Year 75 captures (within 0.05%) the maximum increase in total flows in Watershed 10. Similar results in other watersheds show that Closure Year 75 was an appropriate choice to model the effects of maximum increases in total flows.

Cells shown in red in **Table 1** contain the maximum decrease in baseflows. In the majority of watersheds, the largest decreases occur in Closure Year 0.25 (1st quarter of closure) and Closure Year 3. For example, in Watershed 4 (WS4), Closure Year 0.25 baseflow is 34.30% less than Closure Year 5 baseflow. In Watershed 14 (WS14), Closure Year 3 baseflow is 5.49% less than in Closure Year 5. This indicates that it is possible that the years evaluated in the DEIS were not representative of the peak flow

impacts. For this reason, ERC has conducted an analysis for flows in two additional times during closure (Closure Year 0.25 and Closure Year 3) to evaluate changes in total flows. Changes in total flows at these time periods were then compared with time periods evaluated in the DEIS to assess the adequacy of the years selected for the DEIS.

Total Flows Analysis during Closure

Based on the results discussed above, an analysis was conducted to evaluate total flows at each Assessment Point during Closure Year 0.25 and Closure Year 3. The methodology used to conduct the analysis is the same as described in Sections 4.4, J-5 and J-6 of the DEIS (USACE) and in ERC 2013. For Closure Year 0.25, output from the ground water model during that time was used as the baseflow component of total flow. For runoff, land use categories, areas, and composite runoff factors from the DEIS Mining Year 12 analysis were used. This makes the analysis conservative in the direction of maximum flow reductions since it assumes no reclamation since the end of active mining. No excess pit depressurization was included as it will cease with mining. For Closure Year 3, output from the ground water model during that year was used as the baseflow component of total flow. For runoff, land use categories, areas, and composite runoff factors from the DEIS Closure Year 5 analysis were used. This is appropriate as reclamation activities would have been on-going for a significant duration by this point in time.

In order to quantify changes, total flows from the new analysis (Closure Year 0.25 and Closure Year 3) were compared to total flows from the original DEIS analysis (Mining Year 12 and Closure Year 5). **Table 2** presents the average annual flow predicted at the various Assessment Points for these time periods. **Table 3** presents the results as a percentage change from Closure Year 5 total flows as a way to quantify differences. In **Table 3**, values highlighted in orange represent areas where total flows in Closure Year 0.25 and Closure Year 3 are outside the range of flows previously calculated for Mining Year 12 and Closure Year 5 by between 3% and 5%. Red highlights indicate areas where total flows in Closure Year 0.25 and Closure Year 3 are outside the range of flow values previously presented for Mining Year 12 or Closure Year 5 by more than 5%. It is important to note that the percentage of change in flow values for either of the new Closure Years analyzed (i.e. Closure Year 0.25 or Closure Year 3) at each Assessment Point must fall outside the range of values bounded by Mining Year 12 and Closure Year 5 to be highlighted orange or red. If the values do not sufficiently deviate from this range (i.e. they fall between the Mining Year 12 and Closure Year 5 values or are outside of that range by less than 3%), the new flow values (and associated impacts) are deemed to have been sufficiently captured by the prior assessment of flows (and associated impacts) from the original DEIS analysis. **Figure 1** presents a map of the project area and Assessment Points used in the DEIS analysis (USACE) that correspond to the Assessment Points presented in **Tables 2** and **3**.

Table 2. Total Flows during Selected Years (cfs)

AP	Cardno Subbasin	Active Mining Year 12 Total Flows[1] (cfs)	Closure Year 0.25 Total Flows[2] (cfs)	Closure Year 3 Total Flows[2] (cfs)	Closure Year 5 Total Flows[1] (cfs)
A	1. Upper Camp Branch Creek	2.89	2.88	3.13	3.14
B	2. Lower Camp Branch Creek	3.95	3.94	4.19	4.21
C	17. Little Lynches River upstream of Camp Branch Creek	34.6	34.6	34.6	34.6
D	3. Unnamed tributary near Camp Branch Creek	0.16	0.15	0.16	0.16
E	4. Unnamed tributary near eastern side of Champion Pit	0.29	0.28	0.31	0.32
F	5. Unnamed tributary near southern side of Champion Pit	0.20	0.20	0.19	0.20
G	6. Unnamed tributary near north eastern side of Ramona OSA	0.12	0.12	0.13	0.14
H	7. Unnamed tributary near middle of Ramona OSA	0.08	0.08	0.11	0.11
I	8. Unnamed tributary near south western side of Ramona OSA	0.07	0.06	0.08	0.08
J	14. Tributaries to Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	2.18	1.91	2.03	2.04
K	NA	41.7	41.4	41.8	41.9
L	9. Upper Haile Gold Mine Creek	1.65	1.59	1.53	1.54
M	10. Haile Gold Mine Creek within Mining Area	6.77	1.92	1.98	1.98
N	11. Lower Haile Gold Mine Creek	7.34	2.49	2.57	2.60
O	NA	49.0	43.9	44.4	44.5
P	15. Little Lynches River between Haile Gold Mine Creek and unnamed tributary southeast of the Project boundary	0.87	0.89	0.91	0.91
Q	NA	49.9	44.8	45.3	45.4
R	12. Unnamed tributary southeast of the Project boundary	1.52	1.49	1.42	1.45
S	16. Little Lynches River downstream of unnamed tributary southeast of the Project boundary	0.38	0.38	0.38	0.38
T	NA	51.8	46.6	47.1	47.3
U	13. Buffalo Creek	11.3	11.2	11.2	11.2

Note: Baseflow values greater than or equal to 10 are rounded to the nearest tenth. All others are rounded to the nearest hundredth.

1. Original DEIS total flows analysis (USACE)
2. New ERC analysis

Table 3. Percent Difference in Total Flows from DEIS Closure Year 5 Analysis

AP	Cardno Subbasin	Active Mining Year 12 Total Flows[1] (cfs)	Closure Year 0.25 Total Flows[2] (cfs)	Closure Year 3 Total Flows[2] (cfs)	Closure Year 5 Total Flows[1] (cfs)
A	1. Upper Camp Branch Creek	-8.0%	-8.1%	-0.4%	0.0%
B	2. Lower Camp Branch Creek	-6.2%	-6.5%	-0.5%	0.0%
C	17. Little Lynches River upstream of Camp Branch Creek	0.0%	0.0%	0.0%	0.0%
D	3. Unnamed tributary near Camp Branch Creek	-4.6%	-6.4%	-1.9%	0.0%
E	4. Unnamed tributary near eastern side of Champion Pit	-7.9%	-11.5%	-3.8%	0.0%
F	5. Unnamed tributary near southern side of Champion Pit	-1.3%	-3.6%	-4.5%	0.0%
G	6. Unnamed tributary near north eastern side of Ramona OSA	-10.8%	-15.7%	-3.7%	0.0%
H	7. Unnamed tributary near middle of Ramona OSA	-25.3%	-28.1%	-3.2%	0.0%
I	8. Unnamed tributary near south western side of Ramona OSA	-19.6%	-26.7%	-1.5%	0.0%
J	14. Tributaries to Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek	6.7%	-6.5%	-0.9%	0.0%
K	NA	-0.5%	-1.3%	-0.2%	0.0%
L	9. Upper Haile Gold Mine Creek	7.1%	3.0%	-1.0%	0.0%
M	10. Haile Gold Mine Creek within Mining Area	241.1%	-3.0%	-0.4%	0.0%
N	11. Lower Haile Gold Mine Creek	182.2%	-4.5%	-1.2%	0.0%
O	NA	10.2%	-1.5%	-0.2%	0.0%
P	15. Little Lynches River between Haile Gold Mine Creek and unnamed tributary southeast of the Project boundary	-3.8%	-1.8%	-0.3%	0.0%
Q	NA	9.9%	-1.5%	-0.2%	0.0%
R	12. Unnamed tributary southeast of the Project boundary	4.7%	2.5%	-2.4%	0.0%
S	16. Little Lynches River downstream of unnamed tributary southeast of the Project boundary	-1.5%	-0.5%	-0.3%	0.0%
T	NA	9.6%	-1.3%	-0.3%	0.0%
U	13. Buffalo Creek	0.5%	0.3%	0.1%	0.0%

1. Original DEIS total flows analysis (USACE)
2. New ERC analysis

Figure 1. Map of Haile Gold Mine Project Site and Assessment Points used in DEIS Analysis

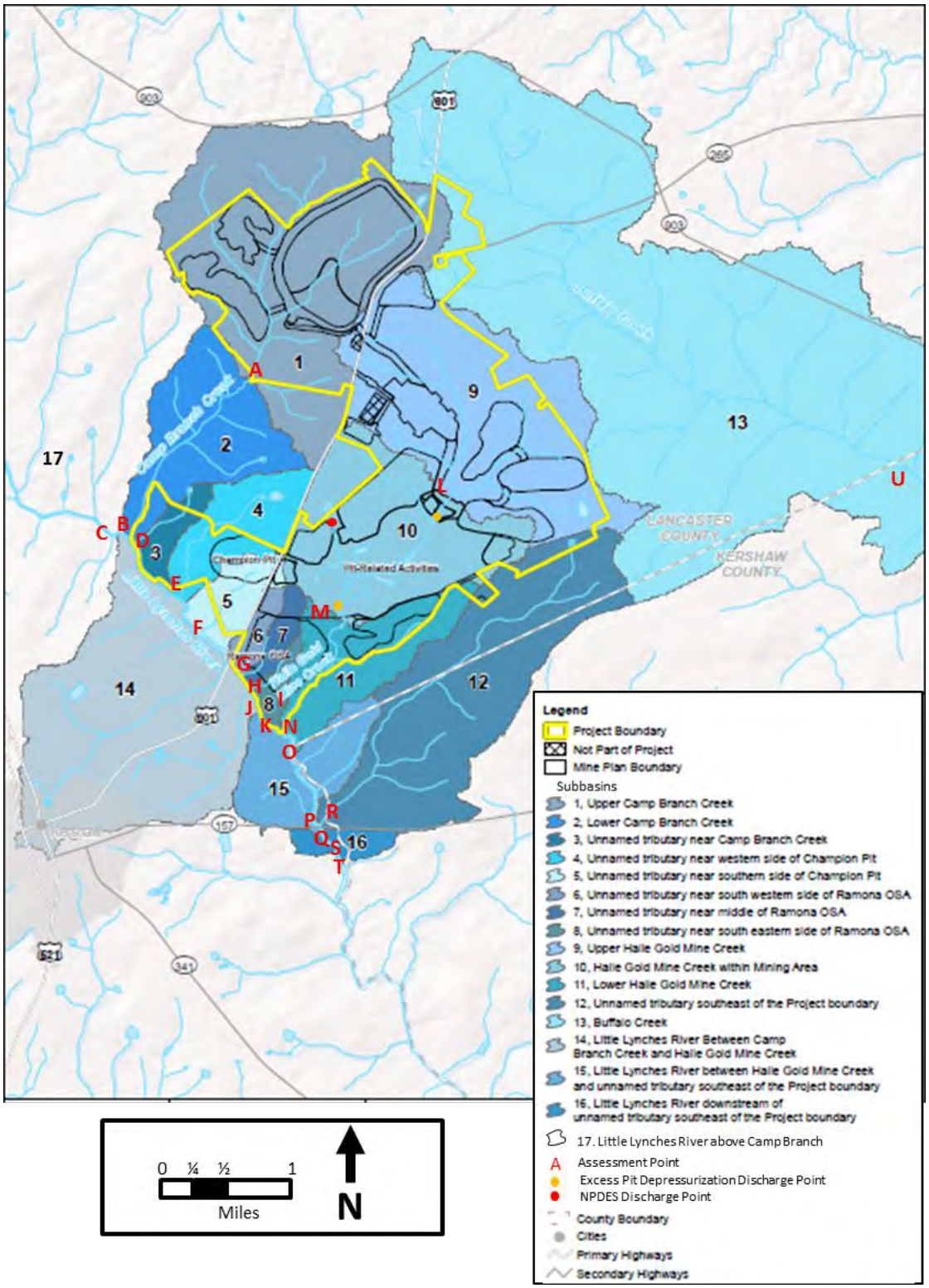


Table 3 can be viewed as a range of total flows where the new analysis (in the middle two columns) is bounded by the original DEIS analysis (in the outer columns). Where values in the middle two columns fall within, or nearly within, the range of values in the outer columns, the original analysis has captured the maximum impacts at that particular Assessment Point. For example, at Assessment Point S, the values for Mining Year 12 and Closure Year 5 are -1.5% and 0.0%, respectively. The values for Closure Year 0.25 and Closure Year 3 are -0.5% and -0.3%, respectively. In other words, in Mining Year 12, total flows are predicted to be 1.5% less than in Closure Year 5; in Closure Year 0.25, total flows are predicted to be 0.5% less than in Closure Year 5; and during Closure Year 3, total flows are predicted to be 0.3% less than in Closure Year 5. This means that the impacts in Closure Year 0.25 and Closure Year 3 are within the range of impacts predicted in Mining Year 12 and Closure Year 5. Since Mining Year 12 was evaluated as part of the original DEIS analysis, it is reasonable to conclude that, at Assessment Point S, the original DEIS analysis at Mining Year 12 and Closure Year 5 captures the most significant impacts on total flows.

At most Assessment Points, the percent change in total flows in Closure Year 0.25 and Closure Year 3 (when compared to Closure Year 5) are less than the percent change in total flows in Mining Year 12 or exceed the percent change by less than 3%. As an example, at Assessment Point A, total flows predicted in Closure Year 0.25 are 8.1% less than total flows in Closure Year 5 while total flows predicted in Mining Year 12 are 8.0% less than total flows predicted in Closure Year 5. This means the original analysis of total flows at Assessment Point A reasonably captured the total flows for Closure Year 0.25, which were only 0.1% (or 0.003 cfs) higher than flows in Mining Year 12.

At five Assessment Points, flow impacts in either Closure Year 0.25 or Closure Year 3 are outside the range of impacts bounded by Mining Year 12 and Closure Year 5 by between 3% and 5%. These values are highlighted in orange in **Table 3.** At two Assessment Points, flow impacts in Closure Year 0.25 are outside the range of impacts bounded by Mining Year 12 and Closure Year 5 by more than 5%. These values are highlighted in red in **Table 3**. Thus, impacts during the greatest flow reduction period for these Assessment Points were not fully assessed. However, such additional flow impacts are minor. For instance, at Assessment Point J, total flows in Closure Year 0.25 are 6.7% less than total flows in Closure Year 5. This represents an absolute difference of approximately 0.13 cfs. At Assessment Point I, which is the other location where flow changes were predicted to exceed 5%, the predicted magnitude of flow change is on the order of 0.01 cfs.

The areas with the greatest differences include the unnamed tributary near the southeast side of Ramona OSA (Assessment Point I) and the western (right hand) tributaries to the Little Lynches River between Camp Branch Creek and Haile Gold Mine Creek (Assessment Point J). At Assessment Point I, total flows in Closure Year 0.25 are predicted to be 7.1% less than during Mining Year 12 (reduction of 0.01 cfs). At Assessment Point J, total flows in Closure Year 0.25 are predicated to be 6.5% less than in Closure Year 5 (reduction of 0.13 cfs). These maximum flow changes are on the order of 7% and occur at areas outside the Haile Gold Mine Creek drainage.

It is important to note that downstream of the Haile Gold Mine project area (all Assessment Points from O through T), results from the new analysis at Closure Year 0.25 and Closure Year 3 are less than 3% different than from results of the original DEIS analysis.

References

Ecological Resource Consultants, Inc. (ERC) (Dec 2013). Supplemental Surface Water Direct and Indirect Flow Impact Assessment Report.

Myers, Tom (May 8, 2014) Review of the Hydrogeological Aspects of the Draft Environmental Impact Statement Haile Gold Mine, Lancaster County, South Carolina. Southern Environmental Law Center.

U.S. Army Corps of Engineers (USACE). 2014. Draft Environmental Impact Statement for the Haile Gold Mine Project. Charleston District. Prepared by Cardno ENTRIX. March.

Haile's Response to SELC DEIS Comments
Attachment 2

Ecological Resource Consultants, Inc.
35715 US Hwy. 40, Suite D204 ~ Evergreen, CO ~ 80439 ~ (303) 679-4820

Technical Memorandum

Date: May 22, 2014

To: Johnny Pappas, Romarco Minerals

From: Troy Thompson and James Koehler

Re: Analysis of Basin Proration as a Method for Estimating Average Annual Baseflow

Introduction

The purpose of this memorandum is to address comments made by Tom Myers in Exhibit B of the Southern Environmental Law Center (SELC) comments to the Draft Environmental Impact Statement (DEIS) (Myers 2014) regarding the use of baseflow from Hanging Rock Creek as a means to estimate baseflows at other locations within the domain of the groundwater model. In his review of the DEIS, Myers states that basin proration cannot be used to accurately determine average annual baseflow. Ecological Resource Consultants, Inc. (ERC) prepared this memo to show that the method used to estimate baseflows for the groundwater model based on observed data from the Hanging Rock Creek gage is a reasonable way to approximate these flows.

The Cardno ENTRIX groundwater model assumed baseflows at various streams within their model domain could be approximated using a technique known as basin proration. Basin proration assumes that the flow at an ungaged location can be estimated using data from a gaged location and multiplying the known flow by the relative basin size of the unknown and the known flow location. In order to show that this technique generates reasonable results, ERC completed an analysis of three additional regional USGS flow gages that show that the amount of baseflow at all of the regional stations is similar. As all gaged drainages show a similar amount of baseflow per square mile, basin proration is a reasonable way to estimate baseflows at ungaged locations.

Methodology

To determine the efficacy of using basin proration as a method for estimating average annual baseflow in the project area, several U.S. Geological Service (USGS) stream flow gages in the area of Haile Gold Mine were analyzed (USGS). Using the Automated Digital Filter Method (ADFM), total flows recorded at each of the gages were divided into the component parts of runoff and baseflow. Given that some

gages had incomplete flow records, only years where 100% of days had daily streamflow observations were used. The equation of the ADFM used to separate total flows into baseflow and runoff is:

$$q_t = \beta * q_{t-1} + \frac{(1+\beta)}{2} * (Q_t - Q_{t-1}) \quad (1)$$

where:

q_t= filtered surface runoff at time *t* (one day)
q_{t-1}= filtered surface runoff at time *t*-1 (previous day)
Q_t = original unfiltered stream flow at time *t* (one day)
Q_{t-1} = original unfiltered stream flow at time *t*-1 (previous day)
β = filter parameter (selected as 0.925 based on Arnold and Allen, 1999).

$$b_t = Q_t - q_t \quad (2)$$

where:

b_t= filtered base flow at time *t* (one day)
Q_t = original unfiltered stream flow at time *t* (one day)
q_t= filtered surface runoff at time *t* (one day)

Average annual baseflow at Hanging Rock Creek and each of the three additional gages were determined by averaging the daily separated baseflow measurements. In **Table 2** below, these results are listed under the column heading "Average Annual Baseflow, ADFM."

Next, average annual baseflow at each of the three additional gage locations were estimated using basin proration and flow estimates from the Hanging Rock Creek gages. Hanging Rock Creek gage was used as the reference basin because it was used in the DEIS. Basin proration is computed using the following equation:

$$b_x = b_{HRC} \text{ x } \left(\frac{A_x}{A_{HRC}}\right) \quad (3)$$

where:

b_x = prorated average annual baseflow at gage "x" (cfs)
b_{HRC} = average annual baseflow at Hanging Rock Creek gage from baseflow separation (cfs)
A_x = drainage area above gage "x" (sq mi)
A_{HRC} = drainage area above Hanging Rock Creek gage (sq mi)

In **Table 2** below, these results are listed under the column heading "Average Annual Baseflow, Basin Proration from Hanging Rock Creek."

Finally, estimates of average annual baseflow from each method were compared. This comparison, expressed as the percent difference between the two estimates, appears in **Table 2** under the column heading "% Difference."

USGS Gage Sites

All USGS stream gages within a 20-mile radius of the project area were selected for this analysis. Using this criterion, three additional gages were identified as a way to check flows from the Hanging Rock Creek site. This approach was meant to limit the extent of the analysis to basins in the vicinity of the mine and the groundwater model in question. **Figure 1** shows the locations of each gage and the Haile Gold Mine project area. The red circle denotes a 20-mile radius around the project area. **Table 1** presents pertinent data about each gage.

Figure 1. Locations of USGS Gages Used in this Analysis and the Haile Gold Mine

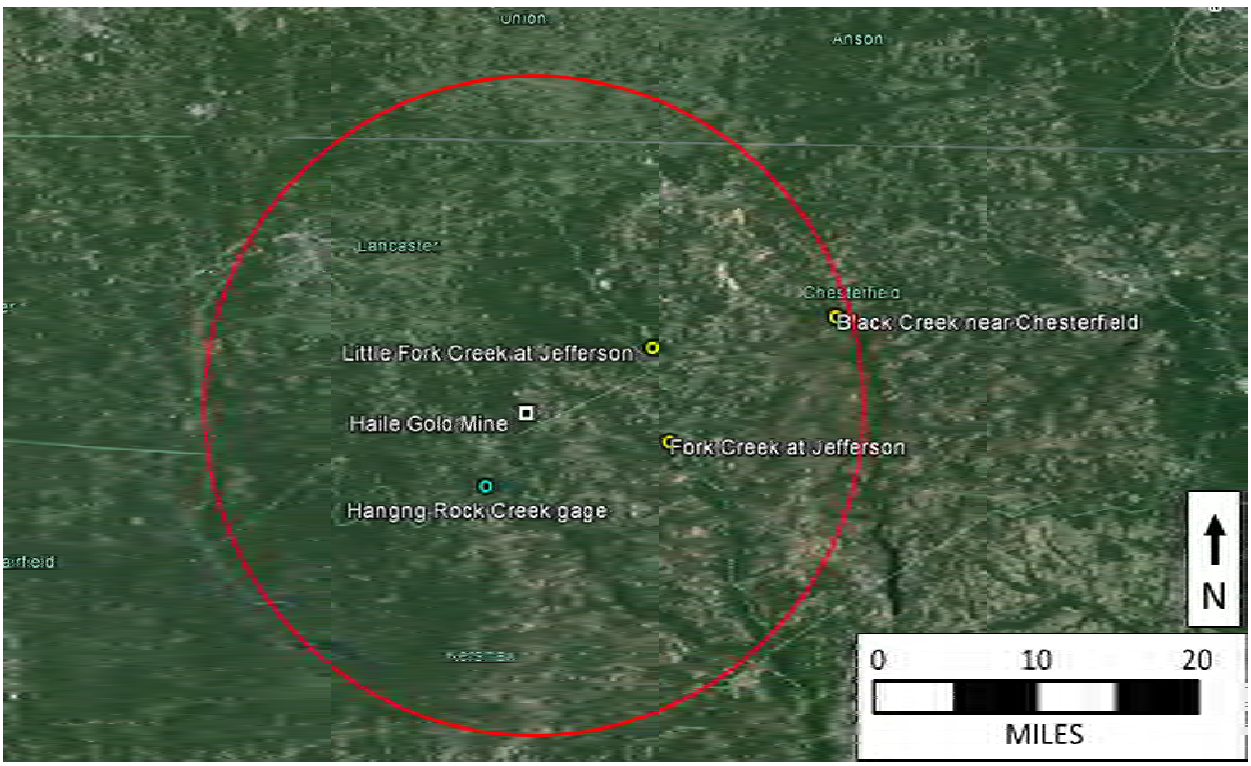


Table 1. USGS Gage Data

Basin	USGS Gage #	Period of Complete Records	Years of Complete Records	Drainage Area (mi^2)	Distance from Haile Gold Mine (mi)
Hanging Rock Creek near Kershaw, SC	02131472	1981-2002	22	23.9	5.1
Little Fork Creek at Jefferson, SC	02131320	1991-1999 2009-2011	12	15.0	8.5
Fork Creek at Jefferson, SC	02131309	1977-1996	20	24.3	8.8
Black Creek below Chesterfield, SC	02130840	2006-2009 2010-2013	8	51.7	19.5

Results

Table 2 presents the results of this analysis: a comparison of estimated average annual baseflows from ADFM and basin proration methods.

Table 2. Comparison of Average Annual Baseflows by Method

Basin	Drainage Area (mi^2)	Average Annual Baseflow, ADFM (cfs)	Average Annual Baseflow, Basin Proration using Hanging Rock Creek[1] (cfs)	% Difference
Hanging Rock Creek near Kershaw, SC	23.9	15.16	NA	NA
Little Fork Creek at Jefferson, SC	15.0	9.43	9.51	0.9%
Fork Creek at Jefferson, SC	24.3	16.92	15.41	-9.8%
Black Creek below Chesterfield, SC	51.7	29.44	32.78	10.2%

1. Hanging Rock Creek gage is the reference basin for this calculation.

Table 2 shows the average annual baseflow at each of the four sites as calculated by the ADFM method. For the three additional sites, it also shows the average annual baseflow that was predicted using data from the Hanging Rock Creek site and a basin proration estimate and the difference between this estimate and the measured flows. For the Little Fork Creek site, the average annual baseflow estimate based on data recorded at the site itself is 9.43 cfs. Estimating baseflows at this site using Hanging Rock Creek data and the basin proration technique yields an estimate of 9.51 cfs. These values are within 1%

of each other. Baseflow estimates at Fork Creek are 16.92 cfs from flows measured at the site and 15.41 cfs when estimated using Hanging Rock Creek and basin proration. At Black Creek, baseflow estimates are 29.44 cfs from site measurements and 32.78 cfs when estimating baseflows using Hanging Rock Creek data and basin proration. Baseflow estimates using the basin proration technique at these two stations are within approximately 10% of measured flows.

The similarities in average baseflows measured at the three USGS sites to the baseflows that were estimated using data from Hanging Rock Creek and the basin proration technique confirm that the basin proration method is a reasonable way to estimate baseflows in the vicinity of the mine. This suggests that in the absence of detailed field measurements, basin proration is a reasonable approach for estimating average annual baseflows in the project area.

References

Arnold, J.G., and Allen, P.M. 1999. Automated Methods for Estimating Baseflow and Ground Water Recharge from Streamflow Records. Journal of the American Water Resources Association, Vol. 35, No. 2, pages 411-424.

Ecological Resource Consultants, Inc, (ERC) (Jun 27, 2012). Surface Water Existing Conditions Report.

Myers, Tom (May 8, 2014) Review of the Hydrogeological Aspects of the Draft Environmental Impact Statement Haile Gold Mine, Lancaster County, South Carolina. Southern Environmental Law Center.

USGS. Current Water Data for the Nation (http://waterdata.usgs.gov/nwis/rt/).

Haile Gold Mine, Inc.'s Response to the United States Environmental Protection Agency Comments Received by the United States Army Corps of Engineers on the Haile Gold Mine Draft Environmental Impact Statement

Submitted May 30, 2014

Haile Gold Mine, Inc.'s (Haile) Response to the United States Environmental Protection Agency (EPA) Comments Received by the United States Army Corps of Engineers (USACE) on the Haile Gold Mine Draft Environmental Impact Statement (DEIS) has been prepared to the best of Haile's ability, based upon information that is currently and reasonably available.

EPA Comment No. 1. *Designs for inlet, dams, and other engineered structures should comply with the latest applicable engineering standard and the standards should be clearly posted and cross-referenced throughout the body of the report as well as the appendix. The average annual precipitation data used to calculate the height of freeboard should be adjusted to include peak precipitation events from catastrophic events such as hurricanes. See* EPA Comment Letter at p. 4, 5th paragraph.

Haile Response to EPA Comment No. 1. Haile believes that its engineering designs meet the criteria EPA notes. Haile analyzed the required height of the North Fork Hail Gold Mine Creek diversion structure using the 100-yr design event. This is appropriate for this structure as it has a piped outlet and will not store any water during normal conditions. Haile Gold Mine staff confirmed that adjustment can be made so that the freeboard noted in the EPA comment exists. Furthermore, Haile will construct safety berms along the haul road that sits on the diversion structure. These safety berms will be constructed based on MSHA regulations and will be five (5) feet high across the haul road/diversion structure. Coupled with the slight increase in road elevation, the safety berms will provide a total of eight (8) feet of freeboard above the 100-year storm level.

EPA Comment No. 2. *Table 1 – Green Overburden: There is a strong cost incentive to maximize the fraction (~80% at the mine's 12th year of operation – see Fig. 6) of the low-treatment cost Green Overburden. Considering that it will remain untreated and that the containing piles won't be lined, and considering the complex structural relations among the different overburden fractions, how would ROMARCO ensure that the Green Overburden ["Less than 0.2 % sulfide S or NNP > 0 (or NAG pH > 4.5)"] does not get mixed with fractions of Yellow or Red Overburden? How would quality control be implemented on a daily basis to ensure such separation? More detailed geologic information is needed to support the presumable ease of practically field-establishing the boundaries among the different overburden types. See* EPA Comment Letter at p. 5, 4th full paragraph (bullet i).

Haile Response to EPA Comment No. 2. See Haile's Response to EPA Comments (submitted to USACE June 30, 2013). As stated therein:

Haile has taken extensive steps to properly distinguish between Red, Yellow and Green overburden to ensure that the material is properly managed. Haile has performed extensive advanced testing to support the mineralogical composition at the site, based on humidity cell tests (HCTs) of actual core samples across the site. This testing also is discussed at length in the

Haile Baseline Geochemistry Report (Schafer, October 2008 / Revised November 2010 for Phase I Testing) and its three [Addenda] to Baseline Geochemistry Report[s] (Schafer, November 2010 for Phase II Testing, March 2012, and January 2013). Projected quantities of Red, Yellow and Green overburden are based on this advanced testing.

Haile does not anticipate that the division between Red, Yellow and Green overburden can be based solely on field (visual) methods. This is why an *Overburden Management Plan* was developed that describes sampling and analytical procedures for classification (Schafer, November 2010). During the mining phase of the Project, an overburden material testing program will be used to classify individual blocks (generally, 25x25x25 feet) of overburden as Red, Yellow or Green. The testing program will be conducted on pulps of samples collected for assay tests or from grab samples expressly collected for this purpose.

Based on geological information and testing, the upper Saprolite is geochemically inert and non-acid-generating. (The Saprolite zone will likely be excavated without drilling and no drillhole sampling will occur.) The deepest 50 feet of Saprolite will be sampled for geochemical testing using grab samples on a spacing that approximates the testing frequency used for bedrock (e.g. 40 to 50 foot grid spacing). Bedrock samples will be selected at a frequency of not less than 1 in 10 samples from the assay pulps (e.g. the material left over from pulverized borehole chips that were used for gold assays).

All geochemical samples (e.g., assay pulps or grab samples) will be tested using Leco analysis to determine the total sulfur or the sulfide sulfur using the Net Carbonate Value (NCV) method (Bucknam 1997). One of two supplementary procedures will be used to refine material classification. Either the ANP will be determined using Leco inorganic carbon analysis (Bucknam 1997) or a net acid generation (NAG) pH test will be used (Stewart 2004).

Contrary to the implication in the question, Haile has a strong economic incentive to properly classify all materials. Overburden storage capacity is based on proper classification of overburden, reflected in the extensive work that Haile has already conducted to analyze overburden based on testing. Indiscriminate placement of Yellow or Red overburden into the Green overburden piles could cause water quality problems, which could result in additional burdens and remedial costs for the company.

References:

Schafer Limited LLC. 2010a. Haile Gold Mine – Baseline Geochemistry Report. Report to Romarco Minerals. 64 pgs plus attachments.

Schafer Limited LLC. 2010b. Haile Gold Mine - Addendum to Baseline Geochemistry Report. Report to Romarco Minerals. 22 pgs plus attachments.

Schafer Limited LLC. 2010c. Haile Overburden Management Plan. Report to Romarco Minerals. 10 pgs plus attachments.

Schafer Limited LLC. 2012a. Haile Gold Mine – 2nd Addendum to Baseline Geochemistry Report. Report to Romarco Minerals. 24 pgs plus attachments.

Schafer Limited LLC. 2012b. Haile Gold Mine – 3rd Addendum to Baseline Geochemistry Report. Report to Romarco Minerals. 16 pgs plus attachments.

EPA Comment No. 3. *More information about the type of geomembrane is needed. There is a concern that an 80 mil (sheet type) geomembrane might be accidently perforated by jagged overburden fragments. See* EPA Comment Letter at p. 5, 5th full paragraph (bullet ii).

Haile Response to EPA Comment No. 3. *See* Haile's Response to EPA Comments (submitted to USACE June 30, 2013). As stated therein: Haile will construct a composite liner system where an 80-mil thick HDPE geomembrane liner along with a minimum layer of one foot of low permeability soil beneath the 80-mil HDPE liner. In addition, Haile will be placing a minimum of two feet of sand cover over the top of the 80-mil HDPE liner as a protective cushion between the PAG material and the HDPE liner to prevent accidental perforation by jagged overburden fragments. *See also* DEIS, Appendix A, Project Description, Figure A-19, for a design drawing of the PAG liner, and Haile Response to EPA Comment No. 4, *infra*.

EPA Comment No. 4. *More information is needed as to the permeability of the [saprolite] layers and how effective will it be as a sub-liner, assuming that the geomembrane liner's integrity might be compromised due to inadvertent puncturing? See* EPA Comment Letter at p. 5, 6th paragraph.

Haile Response to EPA Comment No. 4. Information regarding the permeability of the saprolite layers and how effective it will be as a sub-liner is already part of the EIS Record and adequately disclosed in the DEIS. However, in order to respond to this comment, Haile has summarized and confirmed the information in the EIS record. *See* Haile's Composite Liner Systems Evaluation, enclosed as Exhibit 1 to EPA Comment No. 4.

EPA Comment No. 5. *The effective use of a saprolite cap as an effective 'oxygen inhibitor' is questionable, as long as its permeability is not low enough to prevent infiltration by direct rainfall and runoff. See* EPA Comment Letter at p. 5, 7th full paragraph.

Haile Response to EPA Comment No. 5. The effectiveness of a compacted saprolite layer as a means of reducing oxygen supply to sulfide enriched Red or Yellow PAG waste in Johnny's PAG Facility is based on several factors. The proposed use of saprolite layers are a secondary mitigation, aimed at reducing the rate of sulfide reaction, but the primary mitigation measure in Johnny's PAG Facility is the use of a geomembrane liner to collect seepage and a geomembrane cover to restrict long-term recharge of water.

Saprolite will have less overall porosity and much smaller pore spaces than coarse end-dumped waste rock. As a consequence, the saprolite layers are expected to restrict the supply of oxygen to a diffusion process, whereas oxygen may be supplied through coarse rock by both diffusion and thermally-driven air advection. Diffusion of oxygen can be estimated from Ficks Law (Hillel 1998) where diffusive mass flux (J in cm^2/s) is the product of the diffusion coefficient (D_{air} in cm^2/s), times the concentration gradient (equation [1]).

$$-J_D = D_{air} \frac{\delta C}{\delta X} \qquad [1]$$

The saprolite layer will reduce diffusion of oxygen in two ways. First, the effective diffusion rate of a gas in a porous media is proportional to the air-filled porosity (Hillel 1998). Compacted saprolite will have a lower porosity than waste rock and a higher residual water content and will therefore have much lower air-filled porosity than waste rock. The lower air-filled porosity equates to a lower diffusivity when saprolite is used. Also, the diffusion path length (δX) will be much longer when saprolite is used, so that the term ($\frac{\delta C}{\delta X}$) will become much smaller.

<u>Reference:</u>

Hillel, Daniel (1998-09-09). Environmental Soil Physics: Fundamentals, Applications, and Environmental Considerations (Kindle Locations 6880-6883). Elsevier Science. Kindle Edition.

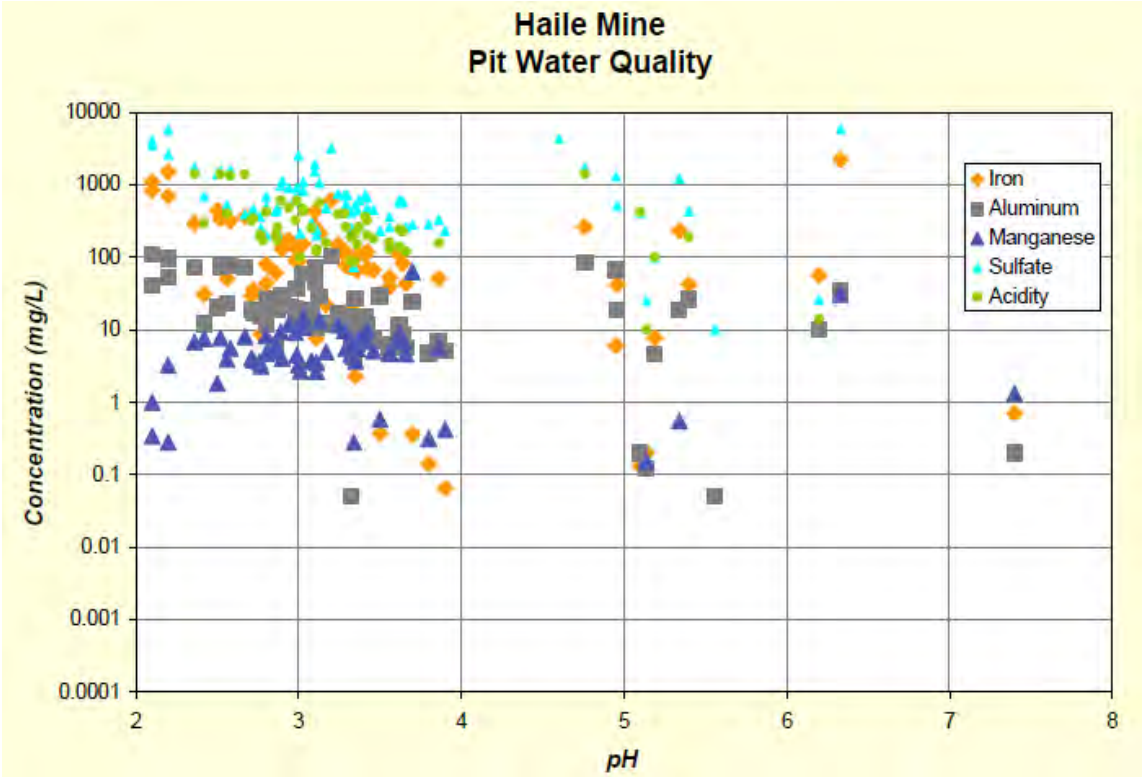
<u>EPA Comment No. 6.</u> *A more detailed plan should be presented in the FEIS, as to the separation of the overburden layers and the integrity and ability of the geomembranes to prevent punctures as well as, a contingency plan [that] addresses the process that will be undertaken in the event of a puncture or loss of liner integrity. More hydrological data is needed in reference to the [saprolite] layers permeability (K), and how it will be used in the sub-liner and caps. This type of information should be summarized in the body of the report. See* EPA Comment Letter at p. 6, 1st paragraph.

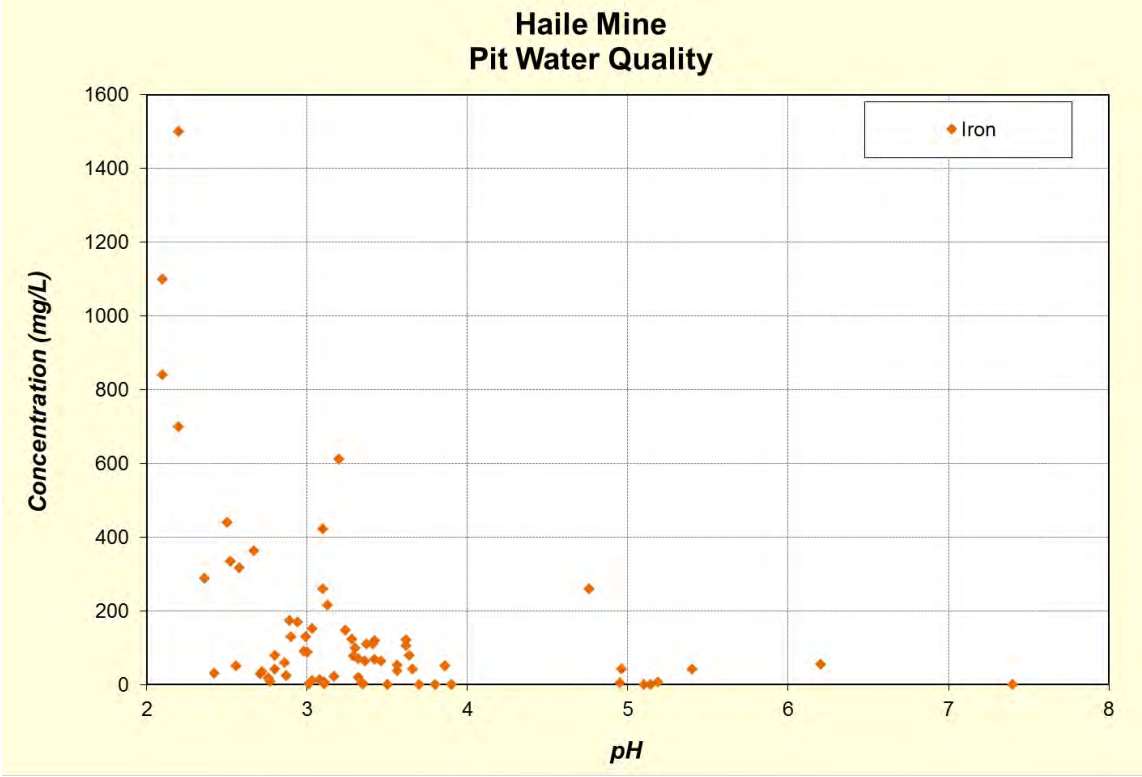
<u>Haile Response to EPA Comment No. 6.</u> *See* Haile Response to EPA Comment No. 4. Haile believes that the USACE's record includes this information, which need not be presented in any greater level of detail in the final EIS. With respect to a contingency plan that addresses the process that will be undertaken in the event of a puncture or loss of liner integrity, Haile will have groundwater monitoring wells strategically placed (locations of wells will be determined in coordination with SCDHEC) which will provide early warning of a loss of liner integrity. Should a loss of liner integrity occur, Haile will work with SCDHEC to develop appropriate responses measures.

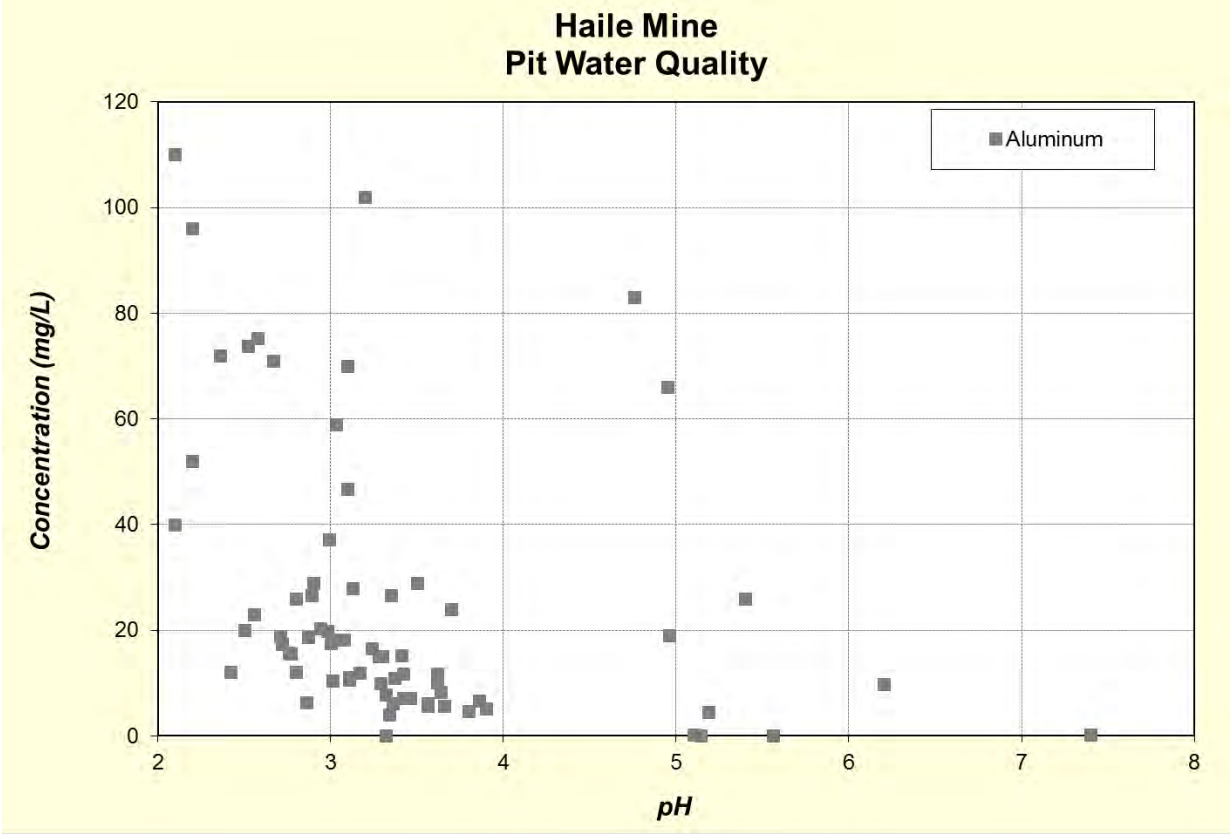
<u>EPA Comment No. 7.</u> *Fig. 3 should be more representative for presenting measured mining pit Acidity values on a plot depicting the concentrations of iron, aluminum, manganese, and sulfate versus pH vs. concentration levels. Moreover, using a log scale for concentrations distorts the strong effect of water acidity on the concentration levels of the solutes. A linear concentration scale would be more representative and, if necessary, generate a separate plot for each of the constituents. See* EPA Comment Letter at p. 6, 4th paragraph.

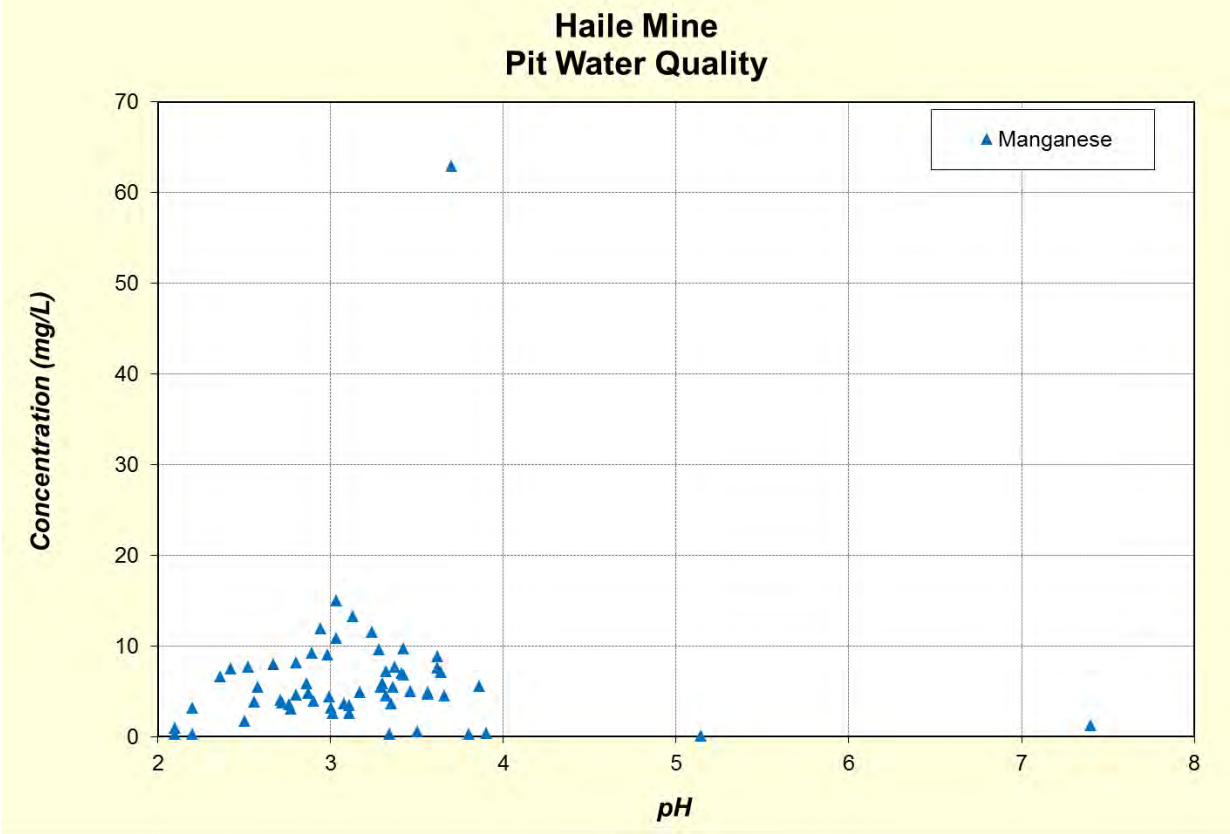
<u>Haile's Response to EPA Comment No. 7.</u>

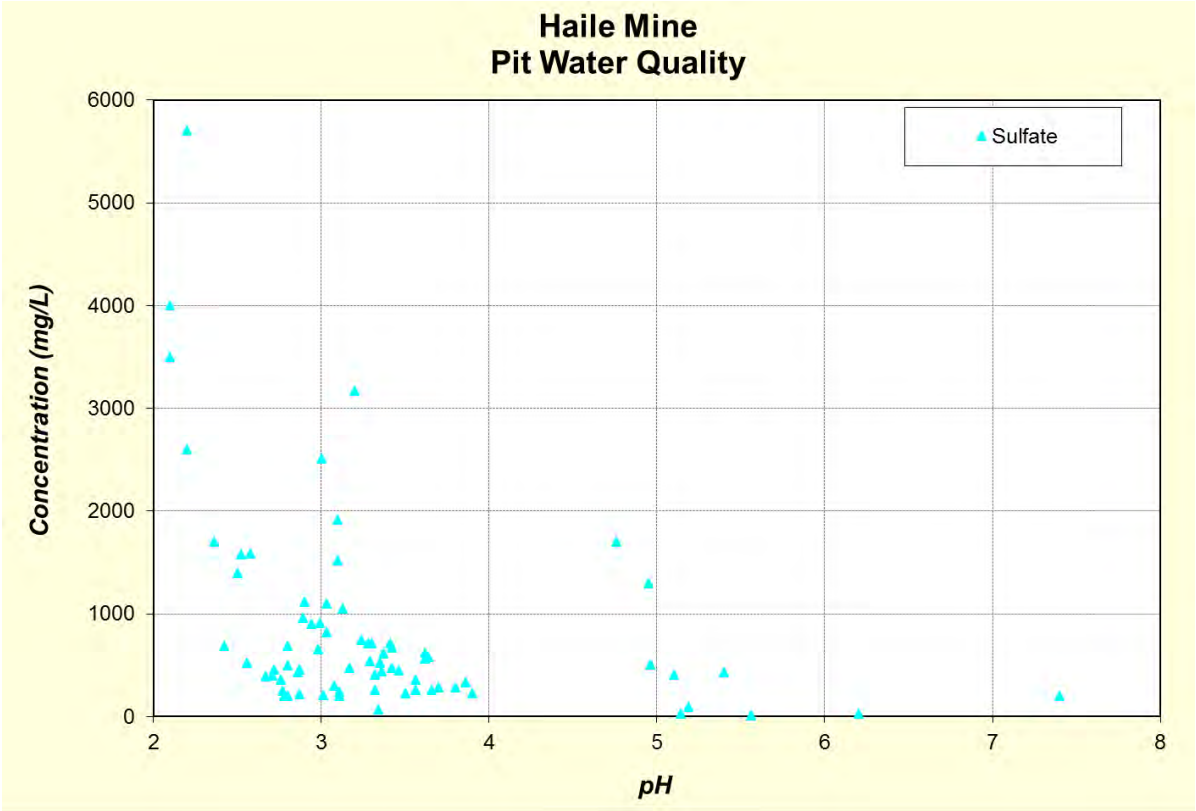
Figure 3 (below) from the Draft Post-Closure Water Quality Impacts Report (Schafer, AMEC and ERC, February 2013) plots the iron, aluminum, manganese, sulfate and acidity values measured in historic pit lakes at Haile against pH. Five new graphs of this data are included showing each individual constituent plotted against pH on an arithmetic y-axis scale. Haile believes that the USACE's record includes this information, which need not be presented in any greater level of detail in the final EIS.

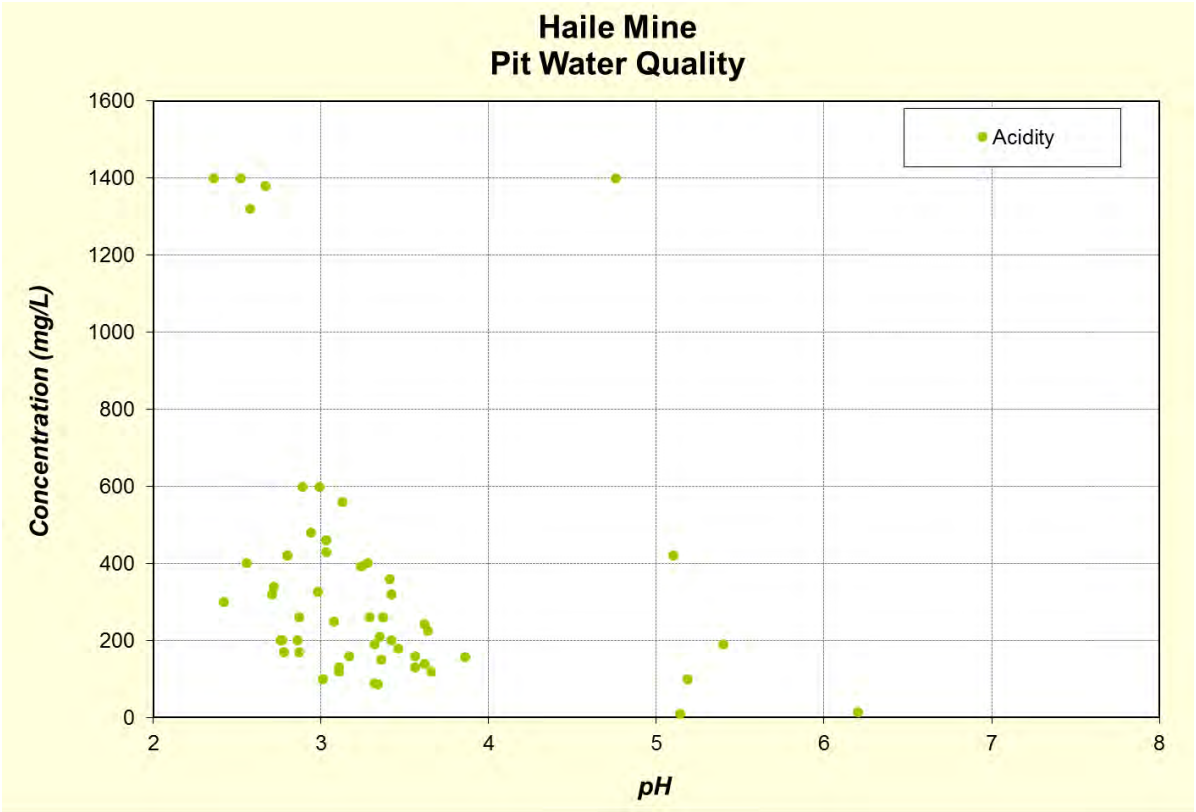

Haile Mine
Pit Water Quality
Concentration (mg/L)
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
2
3
4
5
6
7
8
pH
Iron
Aluminum
Manganese
Sulfate
Acidity


Haile Mine
Pit Water Quality
Concentration (mg/L)
1600
1400
1200
1000
800
600
400
200
0
2
3
4
5
6
7
8
pH
Iron


Haile Mine
Pit Water Quality
Aluminum
Concentration (mg/L)
pH
0
20
40
60
80
100
120
2
3
4
5
6
7
8


Haile Mine
Pit Water Quality
Manganese
Concentration (mg/L)
pH
0
10
20
30
40
50
60
70
2
3
4
5
6
7
8


Haile Mine
Pit Water Quality
Sulfate
Concentration (mg/L)
6000
5000
4000
3000
2000
1000
0
2
3
4
5
6
7
8
pH


Haile Mine
Pit Water Quality
Acidity
Concentration (mg/L)
1600
1400
1200
1000
800
600
400
200
0
2
3
4
5
6
7
8
pH

Reference:

Schafer, AMEC, and ERC. 2013. Draft Haile Gold Mine Revised Post-Closure Water Quality Impacts Evaluation. February 2013. 109 pgs plus attachments.

EPA Comment No. 8: *"The Wateree River shoreline is not included in stream linear footage calculations as preservation because without control of both shorelines, preservation cannot be ensured." See* EPA Comment Letter at p. 7, 1st paragraph.

Haile Response to EPA Comment No. 8: The Mitigation Plan preserves the Wateree River shoreline, not the entire Wateree River; shoreline preservation provides habitat and water quality benefits to the River. The USACE Charleston District Guidelines for preparing a Compensatory Mitigation Plan (Guidelines) provide for consideration of one or both stream sides in calculating stream mitigation credits. There is great value in protecting one side of a significant river system such as the Wateree. The Cooks Mountain and Goodwill Plantation properties, located on the easternmost shoreline of the Wateree River, represent the only developable river frontage from US Hwy 76 north for over five miles. The westernmost shoreline consists of a broad, forested, bottomland wetland system and floodplain, regulated and protected under section 404 of the Clean Water Act (CWA). The Wateree River adjacent to these properties is greater than 200' in width. Additionally, given the ongoing land conservation efforts in the Cowasee Basin Focus Area and the additional momentum to that effort Haile's Mitigation Plan will provide, it is reasonable to anticipate that some of the lands on the western shoreline, as well as upstream and downstream of the mitigation properties, may be protected in the future.

EPA Comment No. 9: *"Within the 2008 Mitigation Rule, preservation as compensatory mitigation may be authorized, but the Rule sets out five very specific requirements that must be met before preservation will be considered. 33 CFR 332.3(h). As with all mitigation authorized under the 2008 Mitigation Rule, preservation is tied to being within the same watershed." See* EPA Comment Letter at p. 7, 3rd paragraph.

Haile Response to EPA Comment No. 9:

Background Information:

The Haile Gold Mine project site (the Project) is located within the Lynches River Watershed (HUC 03040202) and EPA Level III Piedmont and Southeastern Plains ecoregions. One of the objectives of mitigation for the project was to develop a Plan that would be consistent with the scope of the project and provide ecological benefits to the region. Haile's evaluation of mitigation options for this project has used the 2008 Mitigation Rule to evaluate and propose adequate and appropriate mitigation on a similar regional scale. Haile believes that the Revised Mitigation Plan is consistent with the 2008 Mitigation Rule.

Haile submitted a joint permit application to the USACE and South Carolina Department of Health and Environmental Control (SCDHEC) in December, 2010. As no mitigation banks are present in the service areas of the project, Haile's application included a proposed Permittee Responsible Mitigation (PRM) Plan. The PRM Plan was revised in May, 2011. The proposed 2011 PRM Plan included the Rainbow Ranch tract and multiple smaller parcels with potential restoration opportunities within the Lynches River Watershed that were owned by a number of different

individuals and/or entities. During the EIS process, reviewing state and federal agencies and environmental organizations raised questions and concerns regarding the feasibility and appropriateness of the PRM Plan, particularly the numerous fragmented sites, and advised Haile that they believed it was appropriate and that they would prefer a PRM Plan focused on "outstanding aquatic resources," consistent with the scale and regional impacts of the Project. With the assistance of, and in coordination with, the resource agencies and environmental organizations, Haile began to identify and evaluate alternative mitigation sources centering on outstanding aquatic resources. This effort was directed by the scope and complexity of the Project and agency comment and input received during the Environmental Impact Statement (EIS) process.

This process culminated in Haile's Revised Mitigation Plan (July 2013). The Revised Mitigation Plan embodies protection for regionally outstanding aquatic resources as compensatory mitigation for all impacts that may occur as result of the proposed Project. The USACE offered this Revised Mitigation Plan to the public for comment in July 2013.

Additionally, The Revised Mitigation Plan (July 2013) provides an explanation of the process of identifying potential mitigation sites, which is summarized here. This process was followed to demonstrate the significance of the mitigation sites in accordance with the requirements of the Regulations. Potential, alternative mitigation sites were identified, evaluated and selected based upon criteria established by the S.C. Legislature in 1976 under Section 51-17 of the S.C. Code of Laws, the Heritage Trust Program. To be considered for the Heritage Trust Program, candidate lands must include:

- Significant natural areas containing relatively undisturbed ecosystems, unique landforms, threatened, endangered or unique plant or animal habitats or other unusual or outstanding scientific, educational, aesthetic or recreational characteristics; or
- Outstanding examples of historic or archaeological heritage.

From a baseline of suitability for the Heritage Trust Program, a search for and evaluation of potential sites within the Lynches River Watershed was conducted. Regional conservation goals were considered as a factor to evaluate potential sites within the watershed. Sites that would provide a "conservation corridor" by proximity to other protected lands were preferred as such locations can maximize watershed benefits. From this search, the previously identified Rainbow Ranch tract was selected as a candidate site. Additional sites within the Lynches River Watershed were limited by size and/or availability, and no other candidate sites were identified.

Recognizing the need for additional mitigation and in coordination with the environmental and resource agencies, Haile expanded the search to include sites in the EPA designated ecoregion. This is consistent with agency comments received on the 2011 PRM Plan, recommending consideration of ecoregion in mitigation site selection. Expanding the search to the appropriate ecoregion, the Cooks Mountain and Goodwill Plantation properties were identified as outstanding resources within the Wateree River Watershed (HUC 03050104, EPA Level III Southeastern Plains Ecoregion) and were selected as candidate sites.

Importantly, before Haile submitted its Revised Mitigation Plan, the South Carolina Department of Natural Resources (SCDNR) assisted in coordinating an effort to determine the level of consensus for including these two out-of-watershed tracts into Haile's revised mitigation plan. Specifically, beginning in November 2012, and going into the summer of 2013, with the permission of Haile,

SCDNR began organizing tours of the out-of-watershed tracts. During this time, approximately 20 trips were organized that included approximately 65 individuals. Each field day lasted an entire day and included a comprehensive examination of the natural resource features of the Cooks Mountain and Goodwill Plantation tracts. A focus was on quality, not just quantity, of wetlands and whether the properties could be described as outstanding and ecologically significant and worthy of protection through a mitigation opportunity for the proposed Project's impacts. It was carefully explained to all participants that the sites were out-of-watershed from the proposed Project impacts. This led to Haile submitting its Revised Mitigation Plan in July.

We note that by letter of September 16, 2013, the SCDNR supported the Revised Mitigation Plan and concurred that mitigation sites within the watershed, with the exception of Rainbow Ranch, were not available. Indeed, SCDNR conducted its own investigation for mitigation sites (see Letter from SCDNR to USACE (dated Sept. 16, 2013)) and determined that none existed. Having met the threshold criteria for approving mitigation sites outside of the watershed, the SCDNR letter provides detailed information on why Cooks Mountain and Goodwill Plantation serve landscape level, regional ecological needs. Goodwill Plantation and Cook's Mountain are located within the COWASEE Basin Focus Area, a conservation initiative formed in 2005 by a partnership of private landowners, conservation organizations, land trusts and government agencies. Together, these tracts comprise over 1,500 acres of wetland and nearly 6 miles of high quality streams and riparian habitat.

Rainbow Ranch is a natural fit for inclusion into the adjacent Forty Acre Rock Heritage Preserve, a high quality habitat deemed worthy of protection under South Carolina Heritage Trust Program, and the privately owned Carolina Heelsplitter Conservation Bank. Rainbow Ranch's inclusion into the Forty Acre Rock Heritage Preserve will increase the size of the Preserve by over 30%, and in concert with the $4.9 million endowment pledged by Haile for heelsplitter restoration, represents one of the most unique and important features of the Revised Mitigation Plan and will provide for a first-of-its-kind program to benefit an imperiled species.

As the Revised Mitigation Plan provides, Haile evaluated each of the sites under consideration (in and out of watershed) based upon more specific criteria, including, among others:

- Size and location
- Wetlands, streams and upland habitat offered
- Natural quality or level of disturbance of property
- Threat of destruction or adverse modification
- Designation of special value
- Availability
- Ability to accomplish perpetual protection and management.

The Revised Mitigation Plan explains in great detail how the three sites meet each of these criteria. Based upon this site selection and evaluation process, the Rainbow Ranch, Cooks Mountain and Goodwill Plantation properties were selected.

In summary, to the maximum extent practicable, the compensatory mitigation plan proposed by Haile provides "in-kind" mitigation to offset proposed impacts at the Project site, in that the proposed mitigation sites contain resources that are 1) the same functional classification as impacted resources (e.g., Cowardin Classification or Stream Order), 2) within the same watershed or ecoregion as impacted resources 3) located within the same or similar landscape as the impacts associated with

Haile Gold Mine; and 4) outstanding and ecologically significant on a regional scale. Haile has demonstrated that the mitigation sites will contribute to the aquatic resources of the watersheds within which they sit.

Haile Specific Response to EPA Comments:

The 2008 Mitigation Regulation grants the District Engineer authority and discretion to determine the appropriate mitigation for impacts authorized under a Section 404 permit. As EPA notes, "in general" the required mitigation should be in the same watershed. 33 CFR 332.3(b). Haile believes that the Regulations clearly contemplate that it is appropriate for the District Engineer to authorize mitigation in a different watershed or the Rule would not say "in general." Importantly, the Regulations do not set different criteria for in-watershed or out-of-watershed mitigation. Where the District Engineer finds that out-of-watershed mitigation is appropriate, he or she should consider the needs of the watershed in which the mitigation is sited. This applies whether the out-of-watershed mitigation consists of restoration or preservation.

EPA's comment was drawn from and slightly alters the portion of the Regulations that authorize preservation, introducing the concept that mitigation is limited to the impacted watershed. However, Section 332.3(h), which provides guidelines for acceptance of preservation as mitigation, does not require the mitigation sites to be in the "impacted watershed." The definitions of "watershed" and "watershed approach" (33 C.F.R. 332.2) are not limited to the impacted watershed. The District Engineer is authorized to consider mitigation located beyond the watershed of the impacts (see Section 332.3(b)), but when doing so, should look at the needs of the watershed in which the proposed mitigation sits. Notably, EPA suggested use of ecoregions as a criteria for mitigation siting in its comments on Haile's initial PRM mitigation plan. See Letter from EPA to USACE dated March 25, 2011. The Revised Mitigation Plan compensatory mitigation is sited within the same ecoregion as the Project.

As stated in 33 C.F.R. 332.3(a), "When evaluating compensatory mitigation options, the district engineer will consider what would be environmentally preferable." In other words, the District Engineer need not analyze how "out of watershed" mitigation contributes to the sustainability of the impacted watershed if the out-of-watershed mitigation is environmentally preferable. When the circumstances, as here, warrant selection of some (not all) mitigation sites outside of the impacted watershed, the District Engineer can consider the contribution of the mitigation plan to the ecoregion or other appropriate landscape level zone.

This is why the Revised Mitigation Plan provides substantial information about the ecoregion of the impacts as well as the watershed needs of the watersheds in which the mitigation sites sit, including Rainbow Ranch (in the same watershed as the impacts) and Cooks Mountain and Goodwill Plantation (in different watersheds but the same EPA ecoregion.) It is also why the Revised Mitigation Plan provides ample information about the lack of large, consolidated and available mitigation sites within the watershed of the impacts. Haile provided information about the importance of each of the mitigation sites to the watersheds in which they sit, including information about adjacent properties, ecological corridors and habitats. This information meets the standards of the 2008 Mitigation Regulations for consideration of watersheds, for authorizing preservation as mitigation, for authorizing some of the mitigation to occur outside of the watershed of the impacts, and for authorizing the overall environmentally preferable mitigation. Accepting that it is within the District Engineer's discretion to authorize mitigation outside of the impacted watershed, Haile's

Mitigation Plan discusses and satisfies each of the five elements required for preservation, as requested by the EPA in its comments on the DEIS.

Conclusion:

Haile's Revised Mitigation Plan (July 2013) responds to criticisms and concerns expressed with its initial PRM mitigation plan, was developed in coordination with the environmental and resource agencies, is fully in accord with the 2008 Mitigation Rule, and warrants the District Engineer exercising his discretion in approving the two out-of-watershed mitigation sites.

As proposed, the Revised Mitigation Plan is found to be environmentally preferable. Section 4.0 of the 2008 Mitigation Rule is met by "preservation of an outstanding aquatic resource that is determined to be important to the long term success and sustainability of the surrounding watershed…". Consistent with this aspect of the Rule, the Heritage Trust Program was established "to provide for the inventorying, preservation, use and management of unique and outstanding natural or cultural areas and features…". The Revised Mitigation Plan documents that the proposed tracts are Significant Natural Areas, which, therefore, are eligible for inclusion in the Heritage Trust Program and are consistent with the 2008 Mitigation Rule.

EPA Comment No. 10: *"Due to the majority of the mitigation being out of the impacted watershed, the EPA believes the preservation should be done in conjunction with restoration projects. The EPA understands that restoration projects are planned by the South Carolina Department of Natural Resources after the lands are transferred to the Heritage Trust Program. However, to fully evaluate the mitigation plan, the EPA requests the 12 elements specified in the mitigation rule including: objectives, site selection, site protection instrument, baseline information, determination of credits, mitigation work plan, maintenance plan, performance standards, monitoring requirements, long-term management plan, adaptive management plan, and financial assurances." See* EPA Comment Letter at p. 8, 3rd paragraph.

Haile Response to EPA Comment No. 10: As stated in Haile Response to EPA Comment No. 2 *supra*, Haile believes the compensatory Revised Mitigation Plan, as proposed, is in full compliance with the 2008 Mitigation Rule and does not require a restoration component. However, as acknowledged by the EPA, SCDNR has stated that it plans to incorporate restoration activities on the mitigation properties as a component of its long term maintenance and management plans once the properties are transferred into the Heritage Trust Program. Significantly, the Revised Mitigation Plan includes financial commitments by Haile to SCDNR of $4.5 million for maintenance and management of the mitigation properties, including wildlife enhancements or other resource enhancements/restoration consistent with the Heritage Trust Program. Additionally, the mitigation plan provides $4.9 million specifically for projects benefitting the endangered Carolina Heelsplitter which may also result in enhancement/restoration of aquatic resources. It is the understanding of Haile that implementation of restoration activities will be accomplished as a component of SCDNR's management under the Heritage Trust Program.

EPA Comment No. 11: *"While the EPA believes the mitigation plan may be adequate to compensate for all unavoidable impacts…", EPA recommends "A robust monitoring plan should be implemented to ensure the true impacts are documented…" and provides for "additional mitigation review," if necessary. See* EPA Comment Letter at p. 8, 4th paragraph.

Haile Response to EPA Comment No. 11: Haile has submitted a draft wetlands monitoring plan as part of the DEIS, which Haile is currently working to finalize with the USACE. The draft monitoring program is designed to document the actual, indirect impacts to on-site and adjacent wetlands and streams during the relevant time period. This monitoring plan will provide the necessary information to allow for additional mitigation review, as appropriate.

EPA Comment No. 12: *The EPA stated that the mitigation plan "could adequately mitigate for the impacts of the project" however, the EPA recommended that mitigation ratios and the rationale for those ratios be provided and included in the final EIS. See* EPA Comment Letter at p. 8, 5th paragraph.

Haile Response to EPA Comment No. 12: The USACE may decide that its final rationale for approving mitigation should be based on qualitative rather than quantitative (ratio) factors. The significance and value of conserving and appropriately managing the mitigation properties is far greater than the quantity of aquatic resources. Each of these properties has been evaluated based upon a rigorous set of criteria established by the SC Legislature for inclusion in the Heritage Trust Program. Individually and collectively the selected sites, as detailed in Haile's Mitigation Plan, include/provide relatively undisturbed ecosystems, unique landforms, protected or unique plant or animal habitats, outstanding scientific, educational, aesthetic or recreational characteristics and outstanding examples of historic or archaeological heritage. The benefits to the public are significant, including potential public access to over 4,300 acres of upland and aquatic resources for recreation, education and research. The benefits to the watershed likewise far exceed the preservation of aquatic resources, which is considerable, by including over 2,800 acres of upland/riparian enhancement. The 2008 Mitigation Rule recognizes that buffers adjacent to aquatic resources are of value as mitigation at 33 CFR 332.3(i). The Charleston District Guidelines also acknowledge that the protection of streams and wetlands by establishing buffers is *important to* maintain the integrity of aquatic systems. Additionally, a study conducted by the Wetlands Regulatory Assistance Program, US Army Research and Development Center (ERDC-TN-WRAP-01-06, May 2008) determined that buffers adjacent to aquatic resources provide physical and ecological functions and "are a critical element of the overall aquatic ecosystem in virtually all watersheds." Additionally, each of these mitigation properties is an important and significant addition to ongoing regional conservation efforts.

For informational purposes only, the ratios of aquatic resource preservation compared to Haile's proposed direct impacts are as follows:

Wetlands: 1,561.31 Acres ÷ 120.46 Acres = 13 to 1
Streams: 118,561 LF ÷ 26,460.54 LF = 4.5 to 1

The indirect impacts identified in the DEIS are uncertain and temporary and reclamation of the site post mining will allow functions and services temporarily affected during the mining process to recover. Importantly, and as Haile noted in its Comments on the DEIS (submitted to the USACE on May 8, 2013), aquatic resources on adjacent properties have not been delineated but are only estimates of acreage and linear footage that may be affected. Based upon comparisons of estimated resources to delineated resources within the Project site, estimates of indirect impacts to resources on adjacent tracts are likely overstated. The DEIS recognizes that even the potential for indirect impacts on wetlands and streams is greatly reduced as distance from the point of pumping increases.

EPA Comment No. 13. *Real time monitoring needs to be conducted throughout the mining life of the project including pre, post and active mining. To evaluate the changing environmental conditions of the mine, the monitoring results needed to be provided to SCDHEC, USACE and EPA for evaluation of the monitoring data. See* EPA Comment Letter at p. 9, 3rd full paragraph.

Haile Response to EPA Comment No. 13. Haile has proposed monitoring throughout the mining life of the project, including pre, post and active mining. See DEIS, Appendix G, Monitoring and Management Plan. Haile will submit monitoring results in accordance with permit requirements.

EPA Comment No. 14. *As more data is collected over time to fully characterize the waste rock and tailings, the International Network for Acid Prevention's (INAP) guidance should be used so that the characterization is consistent with international standards. The Global Acid Rock Drainage (GARD) guide encourages acid rock drainage testing for the life of mines using static and kinetic testing. At present, it is unclear the extent of metal mobility at the proposed mine and whether the designs and proposed treatment will be able to mitigate adverse metal mobility. See* EPA Comment Letter at p. 9, 4th and 5th full paragraphs.

Haile's Response to EPA Comment No. 14. The proposed criteria in the Overburden Management Plan (Schafer 2010c) have been calibrated for site specific geochemical conditions using an extensive kinetic testing test program. The kinetic test results at Haile confirm that the criteria in the OMP correctly classify long-term behavior observed in kinetic tests (see Figure 6 from Schafer 2012b below). The Figure shows that samples classified as Red or Yellow PAG or Green overburden had distinctly different leachate chemistry in kinetic tests and confirmed that Green overburden consists of samples that are both low in acid drainage and low in metal leaching risk.

Further, if the PAG criteria of NNP<+20 was used, the overall tonnage of PAG-classified material would increase by a factor of 3.7 from about 48.6 million tons (27.1 million tons Red PAG and 21.5 million tons Yellow PAG) to 184.1 million tons (based on 77% of Laminated Unit with NNP <+20, 61% of Metavolcanics, and 98% of saprolite and Coastal Plain sands). This would necessitate a complete re-design of the overburden facilities, would increase the overall waste footprint, would greatly increase mining costs and would not improve environmental performance.

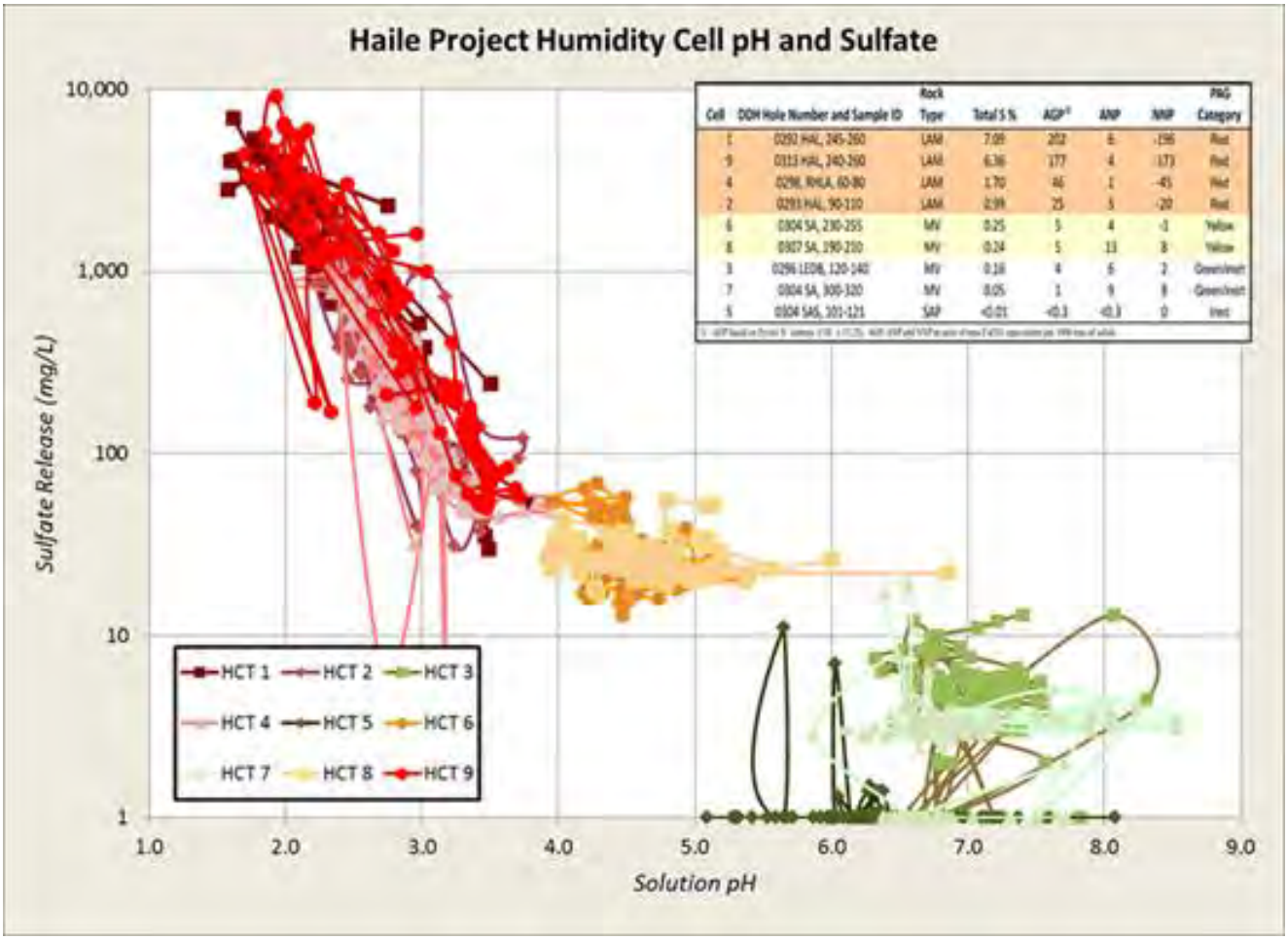


Figure 6 from Schafer 2012b.

Criteria to be used by Haile Gold Mine will be consistent with the Global Acid Rock Drainage (GARD), which was a work product of a project funded by the industry consortium, International Network for Acid Prevention (INAP). The criteria for overburden management developed in the Overburden Management Plan (Schafer 2010c) and supported by the geochemical baseline work (Schafer 2010a, 2010b, 2012a, and 2012b) are fully consistent with the development of site-specific geochemical classification criteria described in the GARD guide.

Section 5.4.16 (GARD)

> "Site-specific operational parameters and threshold values are established for waste classification (i.e., PAG vs. NPAG) based on regulatory requirements, literature, and the geochemical test program. Examples of commonly used operational parameters for waste rock management include the sulphur content (including total and sulphide sulphur), paste pH, NNP, net potential ratio (NPR), NCV, NAG test value, or NAG pH and metal content.
>
> Theoretical relationships, empirical data, and evaluation of analytical and logistical constraints should be used to establish screening or evaluation criteria. For example, if a

quantitative relationship can be reliably established between ARD potential and sulphur content, a sulphur cutoff can be determined to segregate between PAG and non-PAG waste rock. Similarly, if a relationship between metal leachability and metal content is identified, a metal concentration cutoff can be established to discriminate between material that will or will not affect receiving water quality. Sometimes a combination of methods is needed to classify problematic material, such as paste, pH, sulphur, and NPR."

The Overburden Management Plan describes the extensive geochemical testing that Haile will conduct during mine operation (Schafer 2010c). Also, the metal leaching risk of various types of overburden at Haile are fully described in Schafer 2010a (page 55 to 60) and Schafer 2010b (page 13 to 19).

References:

Schafer Limited LLC. 2010a. Haile Gold Mine – Baseline Geochemistry Report. Report to Romarco Minerals. 64 pgs plus attachments.

Schafer Limited LLC. 2010b. Haile Gold Mine - Addendum to Baseline Geochemistry Report. Report to Romarco Minerals. 22 pgs plus attachments.

Schafer Limited LLC. 2010c. Haile Overburden Management Plan. Report to Romarco Minerals. 10 pgs plus attachments.

Schafer Limited LLC. 2012a. Haile Gold Mine – 2nd Addendum to Baseline Geochemistry Report. Report to Romarco Minerals. 24 pgs plus attachments.

Schafer Limited LLC. 2012b. Haile Gold Mine – 3rd Addendum to Baseline Geochemistry Report. Report to Romarco Minerals. 16 pgs plus attachments.

EPA Comment No. 15. *The NPDES permits should be caveated to address the changing conditions during and post mining operations that reflect state and federal water quality standards, as well as, how exceedances of the permit will be enforced. See* EPA Comment Letter at p. 9, 6th full paragraph.

Haile's Response to EPA Comment No. 15. NPDES permits are within SCDHEC's regulatory authority, and are protective of the environment; Haile will comply with the terms and conditions of its NPDES permits.

EPA Comment No. 16. *Throughout the report and including the appendices, there are several descriptions of the tailing ponds (overburden storage areas) that differ from each other. We recommend one formal description in the body of the report and that description be cross referenced throughout the report and appendices to clearly indicate which of the eight ponds will be filled, partially filled and those that will become lakes. See* EPA Comment Letter at p. 10, 1st full paragraph.

Haile's Response to EPA Comment No. 16. The DEIS accurately describes the pits and the plans for backfilling and otherwise reclaiming the mining pits. As stated in Haile's proposed Reclamation Plan: "The identified reserve at the Haile Gold Mine Site will be extracted from eight mine pits: Mill Zone, Snake, Haile, Red Hill, Ledbetter, Chase, Champion and Small. The final excavation of Mill Zone, Haile, and Red Hill will form the South Pit complex, while Snake and Ledbetter will intersect to form the Ledbetter-Snake Pit complex. The three remaining pits, Chase, Champion and Small will remain as separate pits. Mill Zone, Haile, Red Hill, and Chase Pits will be completely backfilled with overburden, and the Snake Pit will be partially backfilled with overburden and reclaimed to facilitate post mining land uses." … "Ledbetter, Champion and Small Pits will not be backfilled during operations and will be reclaimed as pit Lakes. As noted above, the portion of Snake Pit that is not backfilled will also be reclaimed as a lake which would become part of the Ledbetter Pit Lake." DEIS, Appendix H, Haile's proposed Reclamation Plan, pp. 13 & 17. To the extent that the DEIS might have been confusing, Haile would recommend that the above description be cited as the correct description in the FEIS.

NewFields
Perspective. Vision. Solutions.

TECHNICAL MEMORANDUM

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To: **Catherine Clark, Haile Gold Mine, Inc.**

From: **Nicholas Rocco & Carl Burkhalter, NewFields LLC.**

Project: **Haile Gold Mine**

Project No: 475.0042.001

Subject: **Composite Liner Systems Evaluation**

Date: 29 May 2014

Public comments to the Draft Environmental Impact Statement (DEIS) for the proposed Haile Gold Mine Project included statements related to the low-permeability soil liner material designated to be used in the composite liner system for both the Duckwood Tailing Storage Facility (TSF) and Johnny's Potentially Acid Generating Overburden Storage Area (Johnny's PAG). The native saprolite material on site has been characterized for geotechnical properties and deemed suitable for use as the soil liner material.

The primary basis of the received comments regarding the liner systems for the TSF and Johnny's PAG relate to the performance of the soil liner should the integrity of the HDPE geosynthetic liner be compromised over time. Additional comments included the request for additional information regarding the permeability of the saprolite and how effective this material will be as a soil liner.

This technical memorandum summarizes:

1. A discussion of the laboratory testing procedures and permeability results for geotechnical characteristics of the native saprolite;
2. The design criteria for the soil liner material and design objectives for the composite liner systems;
3. The discussion of the technical specifications for construction quality control and construction quality assurance designated for the construction of the composite liner system to ensure the resulting high quality soil liner that will meet performance objectives; and
4. Discussion of the regulations and guidelines used to develop the proposed state-of-the-practice and industry standards designs for the composite liner systems at Haile.

1.0 GEOTECHNICAL CHARACTERIZATION OF THE SAPROLITE MATERIAL

Previous site and laboratory geotechnical investigations have been performed for Haile by AMEC and Knight Piésold, respectively. Discussion of the geotechnical investigations, laboratory testing program, subsurface conditions, the results of the soil permeability testing and engineering analyses for the TSF design are summarized in AMEC's Duckwood Tailing Storage Facility - Detailed Design Report, dated August 31, 2012 (hereinafter AMEC 2012) which was previously submitted to the USACE on 10/2/12 as a component of Haile's state Dam Permit Application.

The analyses were completed on natural saprolitic materials obtained from geotechnical borings and test pits excavated within the footprints of the facilities and potential borrow sites. Relevant discussion, figures, drawings, tables and appendices from AMEC 2012 are noted below with further discussion of the results following after the list of bulleted items.

- Chapter 3 presents the detailed discussion on the geotechnical investigations and laboratory testing;
- Chapter 4 presents the detailed TSF design including the basin liner system;
- Appendix A presents geotechnical borings and test pits logs. Locations for test pits where samples were collected are shown on Drawing A110 and Figure 3.1. Stratigraphic sections of the TSF showing the distribution of the saprolite are shown on Figures 3.2 and 3.3. The relevant AMEC test pit logs describing the geotechnical characteristics and sample intervals utilized in the lab testing as provided by Haile Gold Mine, Inc. are included hereto as Attachment 1 for ease of reference.
- Appendix B presents laboratory test results. Soil Index Testing is included as Appendix B.1 and are summarized on Tables 3.3 and 3.4. Flexible and Rigid Wall Permeability test results are summarized on Table 3.7 and presented in Appendix B.4. Copies of the relevant AMEC tables and test data as provided by Haile Gold Mine, Inc. are included hereto as Attachment 2 for ease of reference.
- Appendix E presents the Technical Specifications for component designs. The technical specifications for "Earthworks Materials and Construction" and "Geomembrane Materials and Installation" are included. These specifications define the following:
    - The requirements for the earthworks construction activities and cover the quality of materials, control and record tests, test methods and test frequencies; and

- The requirements for geomembrane manufacturing, installation quality control including trial welds, field seaming, inspection, testing, repair procedures and certification.

Soil Liner Material Characteristics

General discussions on the laboratory and field testing are found in AMEC 2012 in Chapter 3. As noted in the report, soils in the shallow stratigraphic layers are known in descending order as Coastal Plain Sands (CPS) underlain by saprolitic material. Weathered bedrock characterized as "saprock" underlies the CPS and saprolite and grades unconformably into contact with bedrock.

The CPS is predominately classified as clayey or silty sand (SC or SM) with lenses of non-plastic, well- or poorly-graded sand with silt (SP or SW-SM) per the Unified Soil Classification System (USCS).

Underlying the CPS is the saprolitic material. The majority of the saprolitic soils classified predominately as lean, low-plasticity clay (CL) and silt (ML) per USCS. The tested samples contained varying amounts of sand, and if present in sufficient quantity altered the USCS classification to clayey sand (SC) or silty sand (SM).

For Johnny's PAG design, similar saprolite materials will be used for the low-permeability soil liner material. Johnny's PAG area is also underlain by CPS and saprolite material. The soil liner material for Johnny's PAG will be sourced from saprolite areas with similar properties as those tested for the TSF. This technical memorandum discussion is applicable for both facilities.

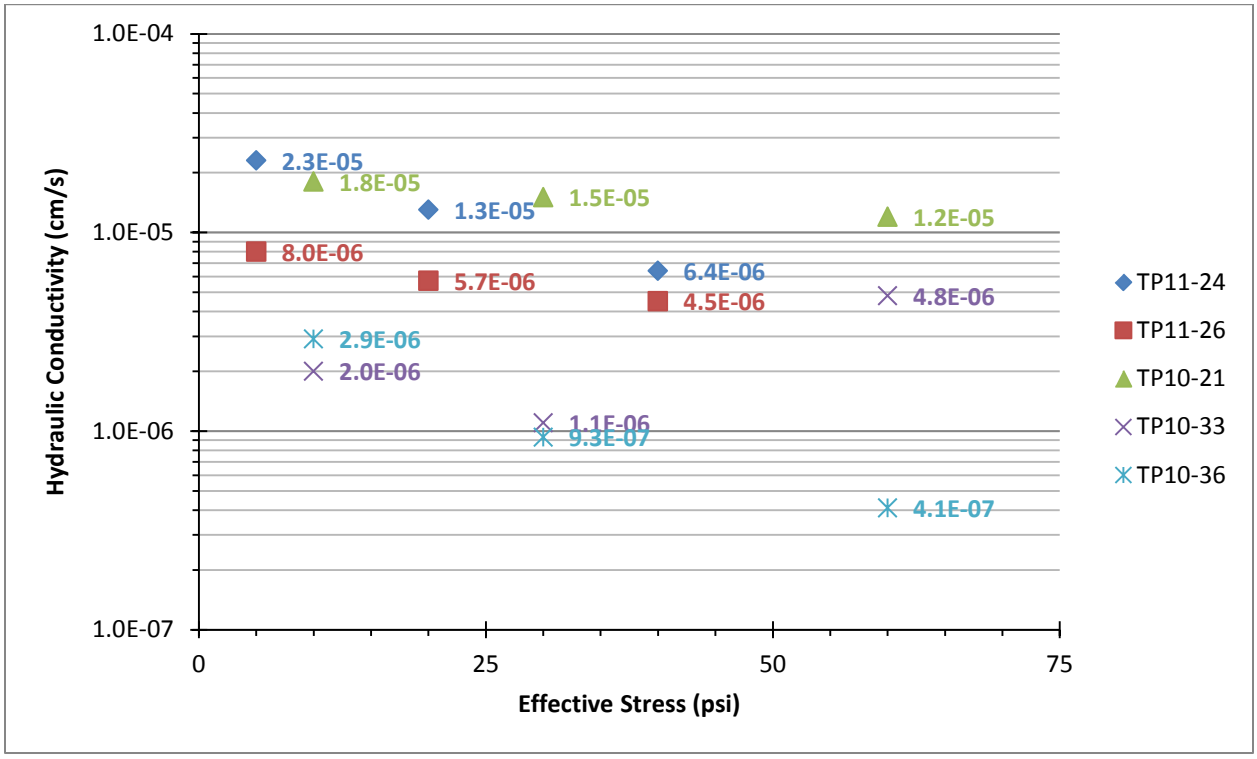
Laboratory Permeability Testing

Laboratory permeability testing is discussed in AMEC 2012 sections 3.3.5 and 3.3.6. Flexible wall permeability tests were performed following American Society for Testing Materials (ASTM) Method D5084. Rigid wall permeability tests followed USBR Method 5600. In general, the flexible wall permeability test is more applicable to saturated, cohesive soils such as the low-permeability soil liner and the rigid wall test is more applicable to higher permeability aggregates and drainage materials such as the CPS.

Flexible wall tests were performed on remolded soil samples of saprolite obtained during the excavation of the test pits with similar properties to the specification for soil liner material. Samples were remolded to a specified density and moisture content based on the maximum dry density and optimum moisture content as determined with Modified Proctor (ASTM D1557) compactive effort and in general accordance with the field compaction criteria detailed in the Technical Specifications. Permeability measurements were obtained for five different soil specimens classifying as saprolite, at isotropic confining water pressures exerted on the exterior

of the sample to mimic *in situ* loading conditions from the tailing of 5 to 60 pounds per square inch (psi).

The variation in permeability with increasing effective stress was determined and results are plotted in the figure below for the saprolite soils.



Results of the laboratory measurements indicate that the permeability decreased with increasing effective stress, as expected, and the measured permeability ranged from a maximum of $2x10^{-5}$ cm/sec to a minimum of $4x10^{-7}$ cm/sec. The geometric mean provides a representative description of the average permeability for a suite of measured data (Applied Hydrogeology, 4th ed., by C.W. Fetter), and for these laboratory results the average permeability of the re-compacted saprolite is $5x10^{-6}$ cm/sec.

2.0 COMPOSITE LINER DESIGN

Both the TSF and Johnny's PAG rely on a state-of-the-practice and industry standards for composite liner design consisting of the following components from the bottom up:

- A 12-inch thick, fine grained (>20% passing the #200 sieve) low-permeability soil material compacted to 95% of maximum dry density as determined by ASTM D1557. An

acceptable moisture content of optimum to 3 percent over optimum is required, which will aid in reducing the permeability of the compacted layer.

- A 60 mil or 80 mil High Density Polyethylene (HDPE) geomembrane liner for the TSF and Johnny's PAG, respectively.
- An engineered solution collection system (underdrain) consisting of an 18- or 24-inch thick drainage or cushion layer and a network of collection piping sized to minimize and maintain the hydraulic head on the composite liner.

Construction of the TSF and Johnny's PAG facilities will commence with the footprint being cleared and grubbed of timber, vegetation and stockpiling of the growth media. Subsequent foundation preparation will consist of basin grading to promote drainage and develop a level working surface for placement of the soil liner material. The saprolitic soil liner material will be dumped, spread, moisture conditioned and compacted to a specified 95% of the maximum dry density to form the 12-inch thick low-permeability layer. Because the soil liner material has at least 20% of particles passing the #200 sieve (opening size is 0.074 millimeters, or 0.0029 inches), this layer provides an excellent bedding foundation for the HDPE geomembrane and will reduce the possibility of geomembrane punctures from the subgrade.

The primary liner for both facilities is the HDPE geomembrane. HDPE has a proven track record in the mining industry for the durability and long-term integrity of successfully containing mining and waste solutions. Haile has previously provided information to the USACE from the Geosynthetic Institute showing that 500 plus years, when buried, is a reasonable life expectancy for HDPE liners (see Exhibit RAI 4-EN-04-a, submitted on 5/21/13) and that Johnny's PAG and the TSF are expected to experience minimal soil erosion over time (see Haile's Soil Erosion Modeling Report, submitted as Exhibit RAI 4-EN-05 on 8/15/13). A rigorous CQA/CQC program will be undertaken by the geomembrane liner manufacturer, installer, general contractor, engineer and owner to construct the most faultless liner possible.

To ensure the performance of the composite liner and enhance the environmental performance of the facility the overlying drainage layer and underdrain collection pipe system will reduce the hydraulic head on top of the liner. The low-permeability soil layer will serve to reinforce the protection component of the HDPE geomembrane.

Performance as a Leakage Barrier

The hydraulic performance of the composite liner system can be evaluated using standard accepted leakage models. Empirical modeling and field observations (Giroud and Badu-Tweneboah 1992; Giroud 1997) have resulted in the "Giroud Equation" for estimating leakage through a hole in the geomembrane portion of a composite liner. The basis for the equation is

referenced in the U.S. EPA Technical Manual (1993) and is used for predicting landfill leachate generation (Designer's Forum, GSE World, by Richard B. Erickson, Richard Thiel, P.E., and Gregory N. Richardson, P.E., Ph.D.).

AMEC previously completed a leakage analysis using the Giroud Equation to estimate leakage through a properly constructed composite liner (Giroud, J.P. 1997, "Equations for Calculating the Rate of Liquid Migration through Composite Liners Due to Geomembrane Defects), which was submitted to the USACE as Appendix E to Haile's Draft Post-Closure Water Quality Impacts Evaluation (Feb. 2013) on March 17, 2013. AMEC's estimated leakage results for the entire TSF basin was approximately 0.4 gallons per minutes (gpm) assuming, 2 defects per acre, good contact between the HDPE and soil, a 1-foot thick layer of $1x10^{-6}$ cm/sec material underlies the HDPE, and 1.5 feet of hydraulic head is ponded above the HDPE below the reclaim water pond area with 0.5 feet outside the limits of the pond area.

Sensitivity Analysis of Leakage Analysis Parameters

NewFields performed a parameter sensitivity analysis by simulating the impact of changes to material properties and hydraulic head on the predicted leakage values. Two cases were analyzed utilizing the same assumptions as AMEC:

1. Evaluating the change in the permeability value "k" for the soil liner material and the change in the thickness of the soil liner material with a constant 1.5-foot hydraulic head above the liner, and
2. Evaluating the change in the permeability value "k" for the soil liner material and the change in the hydraulic head on top of the liner system in the pond.

The sensitivity analysis consisted of systematically varying the two parameters over a range of reasonable estimates and reviewing the magnitude of change in predicted leakage. The magnitude of change represents the sensitivity of the parameter. The purpose of the analysis was to demonstrate the effectiveness of the low-permeability soil liner material.

Results for the TSF analysis are summarized in the table below for Case 1 and Case 2, respectively:

Case 1 – Parameter Sensitivity
Soil Liner Material Permeability and Soil Liner Thickness

Soil Liner Material Permeability (k)	Soil Liner Thickness		
	1 foot	1.5 feet	2 feet
$1x10^{-4}$ cm/sec	12.19 gpm	11.77 gpm	11.55 gpm
$1x10^{-5}$ cm/sec	2.22 gpm	2.14 gpm	2.10 gpm
$1x10^{-6}$ cm/sec	0.40 gpm	0.39 gpm	0.38 gpm
$1x10^{-7}$ cm/sec	0.08gpm	0.07 gpm	0.07 gpm

The results of this case analysis indicate that while the leakage is reduced with a decrease in the permeability of the soil liner material, there is not a significant reduction in leakage with an increase in the thickness of the soil liner.

As discussed above and based on laboratory testing, the average permeability of the re-compacted saprolite is expected to be in the 10^{-6} cm/sec range. For a soil liner material with this range of permeability, the predicted leakage volume should be considered minimal.

If during construction, minor, discontinuous locations along the composite liner were characterized with a 1 foot thick soil liner permeability as high as $2x10^{-5}$ cm/sec, the maximum measured lab value in the TSF design report, maintaining 1.5 feet of hydraulic head in the pond area and 0.5 feet outside the pond would result in a total leakage rate of less than 3 gpm, which should still be considered a minimal leakage rate.

The Case 2 sensitivity analysis was performed to evaluate the effect of the hydraulic head on the liner system for a range of soil liner permeabilities on the predicted leakage rates, and results are listed in the following table.

Case 2 – Parameter Sensitivity
Soil Liner Material Permeability and Soil Liner Hydraulic Head above Liner

Soil Liner Material Permeability (k)	Hydraulic Head Above Liner		
	1.5 feet	2 feet	3 feet
$1x10^{-4}$ cm/sec	7.47 gpm	10.06 gpm	15.60 gpm
$1x10^{-5}$ cm/sec	1.76 gpm	2.23 gpm	3.24 gpm
$1x10^{-6}$ cm/sec	0.40 gpm	0.42 gpm	0.61 gpm
$1x10^{-7}$ cm/sec	0.05 gpm	0.06 gpm	0.10 gpm

The results of this case analysis indicate that while it remains that the predicted leakage rate is reduced with a decrease in the permeability of the soil liner material, the potential leakage rates are more a function of the hydraulic head on the liner rather than the soil liner thickness.

As discussed above, an integral part of the composite liner systems design for the TSF and Johnny's PAG facilities is the incorporation of the underdrain collection systems. The underdrain collection system drainage layer, piping diameters, and pipe spacing are designed to maintain a minimal hydraulic head on the liner.

Lower total leakage results would be expected for Johnny's PAG because the lined area is smaller; approximately 7 million square feet for Johnny's PAG versus 14 million square feet for the TSF.

3.0 CONSTRUCTION QUALITY CONTROL AND QUALITY ASSURANCE

In order to obtain and create an effective low-permeability soil layer for both the TSF and Johnny's PAG, a rigorous construction quality control and quality assurance (CQA/CQC) program will be undertaken to ensure the soils meet the technical specifications. The technical specifications can be referenced in AMEC 2012. AMEC Specification 1263B-SP-EW001-0, Section 5 discusses the CQA/CQC for the soil liner material.

AMEC Specification 1263B-SP-GS001-B, sections 2.1 and 3.2, detail the quality control program for the construction and installation of the HDPE geomembrane liner materials. The plan specifies the observations and tests to be used to ensure that the construction of the liner systems meets all design criteria, plans and specifications.

Haile Construction Management contract documents for persons responsible for overseeing the CQA/CQC program will include the following identification and approval elements for:

1. Field and laboratory testing equipment proposed to be used;
2. Procedures for observing and testing the liner, subgrade, liner bedding, and other liner system construction material (also included in the technical specifications);
3. Protocol for verification of any manufacturers' quality control testing and procedures (also included in the technical specifications);
4. Procedures for reviewing inspection test results and field and laboratory sampling results;
5. Actions to be taken to replace or repair liner material, subgrade, liner bedding or other liner system construction materials should deficiencies be identified; and,
6. Procedures for reporting all inspections and test data for review and evaluation.

After completion of the installation, the liner installer will certify the installed material and the manufacturer will guarantee the HDPE materials according to industry standards. The on-site, 3rd party CQA Engineer experienced in liner systems construction and installation will maintain records and observe all testing of the liner materials and field seams. All liner system testing and evaluation reports for liner construction and installation, including modifications and replacements will be included in the overall Record of Construction Report, reviewed and stamped by a South Carolina Registered Professional Engineer (SCPE).

4.0 REGULATION COMPARISON

The Haile Gold Mine TSF is designed based on the State of Nevada, Department of Environmental Protection, Bureau of Mining Regulation and Reclamation NAC Chapter 445A for Water Control. Nevada Administrative Code (NAC) Section 445A.437 covers the minimum design for Tailings Impoundments and is reproduced below:

NAC 445A.437 Minimum design criteria: Tailings impoundments. *(NRS 445A.425, 445A.465)*

1. A tailings impoundment must utilize a system of containment equivalent to:

(a) Twelve inches of recompacted native, imported, or amended soils which have an in place recompacted coefficient of permeability of no more than 1x10-6 cm/sec; or

(b) Competent bedrock or other geologic formations underlying the site which has been demonstrated to provide a degree of containment equivalent to paragraph (a).

2. An alternate level of containment may be required by the Department for all of the tailings impoundment or for a portion thereof after considering the following factors:

(a) The anticipated characteristics of the material to be deposited;

(b) The characteristics of the soil and geology of the site;

(c) The degree to which the hydraulic head on the impoundment liner is minimized;

(d) The extent and methods used for recycling or detoxifying fluids;

(e) Pond area and volume;

(f) The depth from the surface to all groundwater; and

(g) The methods employed in depositing the impounded material.

(Added to NAC by Environmental Comm'n, eff. 9-1-89)—(Substituted in revision for NAC 445.24368)

Nevada has more gold mine tailing storage facilities that use cyanide processing than any other state. The majority of the recently permitted facilities have used HDPE liners, with a prepared subgrade that have demonstrated a degree of containment equivalent to paragraph 1.(a) above, i.e., 12-inches of less than $1x10^{-6}$ cm/s soil. Nevada has no geomembrane requirement if the 12-inches of soil liner material meets the permeability value. The Duckwood TSF design meets and exceeds the all the NAC requirements listed above.

In the comments to the DEIS some members of the public suggested the TSF be designed to New Mexico or Canadian Guidelines. New Mexico has not developed regulations for tailing storage facilities for gold processing. The regulations quoted in the public comments refer to copper facilities. New Mexico Administrative Code (NMAC) 20.6.7.22 is specific to copper tailings storage facilities and does not require any liner, only downstream groundwater collection wells. The Duckwood TSF design exceeds the NMAC copper tailings storage facility requirements.

Some public comments also recommended requirements that Haile follow the "Canadian Dam Safety Guidelines 2007" suggesting that "they are considered the standard for best practice worldwide". These guidelines have been developed by the Canadian Dam Association (CDA) for conventional water dams, specifically hydroelectric generating facilities that incorporate design components and operations such as concrete embankments and spillways that are designed to

discharge designated storm events without damage. The Haile TSF is a no-discharge facility and tailings storage facilities operate under different criteria and management systems than a conventional water dam. While the document is a good reference with suggested "good practice" methodologies, it is by no means the "standard for best practice worldwide." There are presently three countries that are the main driving force behind current international tailings management guidance. These are Canada, Australia and South Africa, all of which have active mining industries and a large number of tailing storage facilities (Davies 2001). Multiple international guidelines are available for review in the mining industry to provide information on safe and environmentally responsible design and management of tailing storage facilities.

Common within all guidelines are the design, engineering analyses, and risk and safety assessments including:

- Site selection and characterization (development of design criteria and alternatives)
- Geotechnical characterization (drill holes, test pits and sample acquisition for laboratory testing)
- Engineering Analyses
    - Seismic Hazard Analysis
    - Meteorological, Hydrology and Hydraulics
    - Stability Analyses
- Engineering Design
- Dam Safety Analysis and Assessment
- Operations, Inspection and Maintenance
- Dam Breach Analysis
- Emergency Action Plans

The Haile TSF has been designed to state of the practice and industry standards considering multiple international guidelines, regulations and design manuals, such as those of the U.S. Bureau of Reclamation, U.S. Environmental Protection Agency and the U.S. Army Corp of Engineers.

As discussed above, The Mining Association of Canada (MAC) has developed "A Guide to the Management of Tailings Facilities." The guide was prepared by the Canadian mining community and covers each stage of tailing management from design through construction, operations and then closure and reinforces the integrated nature of each element (Brehaut 1998). Section D discusses the design of TSFs and mentions consideration of environmental controls and management of risk, but does not make specific recommendations for basin lining materials. The Haile Gold Mine TSF design is consistent with the MAC guidelines.

The public comments also mention recommendations to follow the New Mexico General Engineering and Surveying Requirements for construction quality control and quality assurance (CQA/CQC) procedures during construction of the TSF liner system. NMAC 20.6.7.17 C. (1) (b) details the Liner system CQA/CQC procedures. AMEC technical specifications 1263B-SP-EW001-B (Earthworks Materials and Construction) and 1263B-SP-GS001-B (Geomembrane Materials and Installations) meet and exceed all aspects of the New Mexico requirements. Attachment 3 provides a copy of these technical specifications previously provided by Haile Gold Mine, Inc. for ease of reference.

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AMEC Earth & Environmental, Inc. (2009) "Haile Gold Mine Tailing Storage Facility Seismic Hazard Assessment" submitted December 4, 2009.

AMEC Earth & Environmental, Inc. (2010) "Tailing and Process Water Management Bankable Feasibility Study" submitted November 19, 2010.

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AMEC Earth & Environmental, Inc. (2013) "INTERIM Overburden Storage Area and Site Wide Storm Water Management Plan Design Report" submitted March 1, 2013.

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State of Nevada, Department of Environmental Protection, Bureau of Mining Regulation and Reclamation NAC Chapter 445A for Water Control. Nevada Administrative Code (NAC) Section 445A.437

State of New Mexico, Administrative Code, Environmental Protection, Water Quality – Groundwater Protection Supplemental, Permitting Requirements for Copper Mines. Water Quality Control Commission [20.6.7.17 NMAC-N 12/1/13].

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ATTACHMENT 1

AMEC

TEST PIT LOGS FOR

PERMEABILITY TESTING SAMPLES

TEST PIT LOG

Test Pit: TP11-26

Project: Haile Detailed Design

Project No.: 74201263B

Location: Duckwood TSF
Date: 3/15/11
Surface Conditions: Native Vegetation
Contractor:
Equipment Type:
Logged By: B. Nelson

Northing: 587557.56
Easting: 2134824.85
Ground Elevation: 538.63
Depth to GW (ft) : NE
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 14.0

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS ML		SD	TOPSOIL, organics and silty sand, fine grained, loose, non-plastic, moist, dark brown	
						SILT, trace gravel to 1/2", subangular, loose, low plasticity, moist, brown, chalky	
					LD	Density increased to dense, plasticity increased to high, color changed to light yellow	Gradation (G=0%, S=2%, F=98%) Atterberg (PL=30, LL =37, PI=7) Flex Wall Permeability (k=6.1e -6)
5							
10						Color changed to mottled - white and yellow	
					SD	Machine Limits at 14.0'	

TEST PIT LOG

Test Pit: TP11-25

Project: Haile Detailed Design

Project No.: 74201263B

Location: Duckwood TSF
Date: 3/15/11
Surface Conditions: Native Vegetation
Contractor:
Equipment Type:
Logged By: B. Nelson

Northing: 585393.26
Easting: 2134655.66
Ground Elevation: 490.39
Depth to GW (ft) : NE
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 8.5

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS			TOPSOIL, organics and silty sand, fine grained, loose, non-plastic, moist, dark brown	Gradation (G=19%, S=55%, F=26%) Atterberg (PL=20, LL =28, PI=8) Flex Wall Permeability (k=1.1e - 6cm/sec)
			SC		LD	Clayey SAND with gravel	
			CL			Lean CLAY, with sand and gravel to 1", medium dense, medium plasticity, moist, brown	
			SC		SD	Clayey SAND, trace gravel up to 1", claystone, very dense, low plasticity, slightly moist, brown, black and yellow	
5						Refusal at 8.5'	

TEST PIT LOG

Test Pit: TP11-24

Project: Haile Detailed Design

Project No.: 74201263B

Location: Duckwood TSF
Date: 3/15/11
Surface Conditions: Native Vegetation
Contractor:
Equipment Type:
Logged By: B. Nelson

Northing: 585746.54
Easting: 2135124.48
Ground Elevation: 510.43
Depth to GW (ft) : NE
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 14.0

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS		SD	TOPSOIL, organics and silty sand, fine grained, loose, non-plastic, moist, dark brown	
			ML			SILT, very sandy and silty, medium stiff, low plasticity, yellowish brown Consistency increased to very stiff, moist, color changed to mottled - yellow, white and purple, chalky	
					SD		
5					LD		Gradation (G=0%, S=8%, F=92%) Atterberg (PL=33, LL =48, PI=15) Flex Wall Permeability (1.4E-5cm/sec)
10			ML			SILT, some weathered claystone, shale-like	
					SD	Refusal at 14.0'	

TEST PIT LOG

Test Pit: TP11-15

Project: Haile Detailed Design

Project No.: 74201263B

Location: Duckwood TSF
Date: 3/14/11
Surface Conditions: Native Vegetation
Contractor:
Equipment Type:
Logged By: B. Nelson

Northing: 587816.13
Easting: 2136870.72
Ground Elevation: 551.36
Depth to GW (ft) : 15.0
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 16.0

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			SM SP		SD	Silty SAND, fine grained, topsoil and organics, loose, non-plastic, moist, dark brown	
						Poorly graded SAND, Coastal Plain Sands, fine grained, subangular, loose, non-plastic, moist, brown	
			SP-SC			Poorly graded SAND with clay, gravel to 1/2", poorly graded, fine to medium grained, subangular, very dense, medium plasticity, moist, mottled - red, white and yellow	
5					SD		
			SP-SM		SD	Poorly graded SAND with silt, fine to coarse grained, density decreased to dense, plasticity decreased to low plasticity, moisture increased to very moist, color changed to light red and white	Gradation (G=1%, S=87%, F=11%) Atterberg (PL=18, LL =21, PI=3) Direct Shear (c=1018 psf, φ=27°) Flex Wall Permeability (k=1.6e - 3cm/sec)
10							
			SP-SM		SD	Poorly graded SAND with silt, moisture increased to wet, color changed to yellowish brown	
15	▼						
			SP-SM			Poorly graded SAND with silt, sloughing sidewalls at 16.0', test pit abandoned	

TEST PIT LOG

Test Pit: TP11-02

Project: Haile Detailed Design

Project No.: 74201263B

Location: Tailing Pipeline Corridor
Date: 3/18/11
Surface Conditions: Native Vegetation
Contractor:
Equipment Type:
Logged By: B. Nelson

Northing: 582452.53
Easting: 2140243.03
Ground Elevation: 530.33
Depth to GW (ft) : 12.0
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 14.0

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS			TOPSOIL, organics and silty sand, fine grained, loose, non-plastic, moist, dark brown	
			SP			Poorly graded SAND, slightly silty, fine grained, loose, low plasticity, moist, brown	
5			SC			Clayey SAND, poorly graded, fine to medium grained, dense, medium plasticity, very moist, mottled - red, yellow with white clay lenses	
			SC		LD	Clayey SAND	Gradation (G=0%, S=78%, F=21%) Atterberg (PL=18, LL =35, PI=17) Flex Wall Permeability (k=2.9e 4cm/sec)
10					SD	Moisture increased to wet, color changed to yellow and light brown	
						Sloughing sidewalls at 14.0', test pit abandoned	

TEST PIT LOG

Test Pit: TP10-36

Project: Tailing and Process Water Management

Project No.: 94201263A

Location:
Date: 7/16/10
Surface Conditions:
Contractor: Haile Gold Mine
Equipment Type: John Deere 200C LC Excavator
Logged By: A. Frias

Northing: 540797
Easting: 3829708
Ground Elevation:
Depth to GW (ft) : NE
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 25'

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS MH		SD	TOPSOIL Elastic SILT, trace of fine grained sand, medium plasticity, moist, medium dense, reddish brown	SD from 0.5'-3'
					LD	Color change to mottled (light brown, reddish brown, light gray and black)	LD from 3'-25' Gradation (G=1%, S=6 %, F=93) Atterberg (PL=39 LL=54 PI=15) Flex Wall Permeability (k=1.5e -5cm/sec)
5							
10							
15							
20							
25						End of test pit at 25'	

TEST PIT LOG

Test Pit: TP10-33

Project: Tailing and Process Water Management

Project No.: 94201263A

Location:
Date: 7/17/10
Surface Conditions:
Contractor: Haile Gold Mine
Equipment Type: John Deere 200C LC Excavator
Logged By: A. Frias

Northing: 540113
Easting: 3830068
Ground Elevation:
Depth to GW (ft) : 12'
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 17'

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS			TOPSOIL	
			SM			Silty SAND, fine to medium grained sand, non-plastic, moist, dense, light brown	
5			CL		LD	Lean CLAY, trace fine grained sand, medium plasticity, moist, dense, mottled (light brown, white and black)	LD from 6'-13'
10							Groundwater encountered at 12'
			MH		SD	Elastic SILT, clayey, slightly sandy, fine grained sand, high plasticity, moist, very hard, mottled (green, light green, light brown and white)	SD from 13'-17' Gradation (G=0%, S=10 %, F=90) Atterberg (PL=35 LL=53 PI=18) Flex Wall Permeability (k=1.2e - 6cm/sec)
15							
						End of test pit at 17'	

TEST PIT LOG

Test Pit: TP10-27

Project: Tailing and Process Water Management

Project No.: 94201263A

Location:
Date: 7/19/10
Surface Conditions:
Contractor: Haile Gold Mine
Equipment Type: John Deere 200C LC Excavator
Logged By: A. Frias

Northing: 540882
Easting: 3830742
Ground Elevation:
Depth to GW (ft) : 18'
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 22'

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS			TOPSOIL	
			SM			Silty SAND, fine grained sand, non-plastic, medium moist, loose, light brown	
5			SC			Clayey SAND, clay nodules, fine to medium grained sand, low plasticity, moist, medium dense, light reddish brown	Gradation (G=0%, S=86 %, F=14) Atterberg (PL=11 LL=21 PI=10) Rigid Wall Permeability (k=1.8e - 3cm/sec)
10							
15							
	▼					Fine to coarse grained sand, very moist, light yellow with gray and red clay nodules	Groundwater encountered at 18'
20							
						End of test pit at 22'	

TEST PIT LOG

Test Pit: TP10-21

Project: Tailing and Process Water Management

Project No.: 94201263A

Location:
Date:
Surface Conditions:
Contractor: Haile Gold Mine
Equipment Type: John Deere 200C LC Excavator
Logged By: A. Frias

Northing: 541135
Easting: 3830355
Ground Elevation:
Depth to GW (ft) : NE
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 23'

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS			TOPSOIL	
			SM		SD	SILT, some sand and gravel to 3/4", fine to coarse grained sand, non-plastic, medium moist, medium dense, light brown	SD from 0.5' to 1.5'
			CL-ML		LD	Silty lean CLAY, low to medium plasticity, moist, dense, mottled (tan, light brown and brown)	LD from 1.5' to 11.5' Gradation (G=0%, S=2 %, F=98) Atterberg (PL=28 LL=33 PI=5) Flex Wall Permeability (k=1.4e - 6cm/sec)
5					HD		HD at 7'
10					LD	Color change to mottled (white, light brown and red)	LD from 11.5'-23'
15							
20							
						End of test pit at 23'	

TEST PIT LOG

Test Pit: TP10-16

Project: Tailing and Process Water Management

Project No.: 94201263A

Location:
Date: 7/7/10
Surface Conditions:
Contractor: Haile Gold Mine
Equipment Type: John Deere 200C LC Excavator
Logged By: A. Frias

Northing: 586206.35
Easting: 2138230.21
Ground Elevation: 586206.35
Depth to GW (ft) : NE
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 22'

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS			TOPSOIL	
			SM		LD	Silty SAND, fine grained sand, non-plastic, slightly moist, loose, light brown	LD from 1'-6' Gradation (G=0%, S=77 %, F=23) Rigid Wall Permeability (k=8.1e - 4cm/sec)
5			CL		LD	Lean CLAY, medium plasticity, moist, dense, mottled (white and reddish brown)	LD from 6'-9'
10			SP-SC		LD	Poorly graded SAND with clay, fine to medium grained sand, low plasticity, moist, dense, mottled (red, light brown and white)	LD from 9'-20'
15							
20			SP-SM		SD	Poorly graded SAND with silt, fine to medium grained sand, non-plastic, moist, medium dense, white	SD from 20'-22'
						End of test pit at 22'	

TEST PIT LOG

Test Pit: TP10-07

Project: Tailing and Process Water Management

Project No.: 94201263A

Location:
Date: 7/9/10
Surface Conditions:
Contractor: Haile Gold Mine
Equipment Type: John Deere 200C LC Excavator
Logged By: A. Frias

Northing: 589175.04
Easting: 2136596.46
Ground Elevation: 565.3
Depth to GW (ft) : 16'
Depth to Bedrock (ft) : NE
Total Pit Depth (ft) : 22'

Depth in Feet	Water Levels	USCS Graphic	USCS	Sample Location	Sample Type	Field Description	Remarks
0			TS			TOPSOIL	
			SP		SD	Poorly graded SAND, trace silt, fine to medium grained sand, non-plastic, medium moist, loose, light brown	SD from 0.5'-6.5'
5			SC		LD	Clayey SAND, fine to medium grained sand, medium plasticity, moist, dense, brown	LD from 6.5'-16' Gradation (G=0%, S=88%, F=12%) Atterberg (PL=18, LL =36, PI=16) Direct Shear (c=15psf, φ=32°) Rigid Wall Permeability (k=2.2e -4cm/sec)
10							
15			SP		SD	Poorly graded SAND, trace silt, fine to medium grained sand, non-plastic, very moist to wet, medium dense, light gray	SD from 16'-22' Groundwater encountered at 16'
20							
						End of test pit at 22'	

ATTACHMENT 2

AMEC

LABORATORY PERMEABILITY

TESTING RESULTS

Table 3.4
Haile Gold Mine, Inc.
Tailing Storage Facility
Test Pit Index Testing

				Sieve Analysis - Percent Passing														Atterberg Limits		
Sample Location	**Depth (ft)**	**Material Description**	**USCS**	**3"**	**2"**	**1.5"**	**1"**	**3/4"**	**1/2"**	**3/8"**	**#4**	**#10**	**#20**	**#40**	**#60**	**#100**	**#200**	**Plastic Limit**	**Liquid Limit**	**Plasticity Index**
Knight Piesold Laboratory																				
2011																				
TP11-11	4' &14'	Clayey Sand	SC	-	-	-	-	-	-	-	100.0	98.6	88.6	63.8	43.4	35.0	30.5	22	38	16
TP11-15	9'-16'	Poorly Graded Sand with Silt	SP-SM	-	-	-	-	100.0	99.9	99.5	98.6	90.6	64.3	34.3	19.2	13.1	11.3	18	21	3
TP11-22	3.5'-5' & 6.5'	Clayey Sand	SC	-	-	-	-	-	100.0	99.6	98.2	89.3	76.8	53.9	34.7	28.5	26.0	22	39	17
TP11-24	6'-11'	Silt	ML	-	-	-	-	-	-	-	100.0	99.7	98.6	97.4	96.1	94.6	92.1	33	48	15
TP11-26	3'	Silt	ML	-	-	-	-	-	-	-	100.0	99.9	99.8	99.7	99.5	99.1	98.1	30	37	7
TP11-27	4' & 12'	Silty Sand with Gravel	SM	-	-	100.0	95.2	90.9	87.7	86.0	83.6	80.3	73.9	64.6	56.8	52.3	48.5	27	35	8
AMEC Laboratory																				
2011																				
Sample Location	**Depth (ft)**	**Material Description**	**USCS**	**2"**	**1.5"**	**1"**	**3/4"**	**1/2"**	**3/8"**	**#4**	**#8**	**#10**	**#16**	**#30**	**#50**	**#100**	**#200**	**Plastic Limit**	**Liquid Limit**	**Plasticity Index**
TP11-06	6'-8'	Poorly Graded Sand with Silt	SP-SM	-	-	-	-	-	-	100.0	99.9	-	95.8	74.2	35.3	12.0	5.5	NP	NV	NP
TP11-07	3'-7'	Silty Sand	SM	-	-	-	-	-	100.0	99.9	-	99.5	97.7	81.2	46.6	23.0	15.5	NP	NV	NP
TP11-12	5'-8'	Clayey Sand	SC	-	-	-	-	-	100.0	99.7	-	95.0	87.9	66.1	33.9	22.2	19.5	17	28	11
TP11-14	6'	Clayey Sand	SC	-	-	-	-	-	-	100.0	96.5	-	69.6	41.3	22.9	20.5	19.2	27	50	23
TP11-17	10'-15'	Clayey Sand	SC	-	-	-	-	-	-	100.0	99.9	-	99.5	97.7	74.1	34.7	26.9	16	30	14
TP11-18	16'-17'	Well-graded Sand with Silt	SW-SM	-	-	-	-	-	100.0	96.7	83.0	-	58.3	34.1	17.1	10.9	9.1	NP	NV	NP
TP11-20	6'	Well-graded Sand with Clay	SW-SC	-	-	-	-	-	100.0	99.1	90.5	-	69.6	51.8	25.8	13.1	7.1	27	45	18
TP11-23	3'-7'	Silty Gravel with Sand	GM	100.0	93.9	92.0	84.8	69.0	61.2	45.5	39.0	-	31.6	25.5	21.1	18.1	15.6	33	40	7
TP11-25	1'-2'	Clayey Sand with Gravel	SC	100.0	99.0	98.1	96.0	92.9	92.9	80.9	-	47.7	43.8	37.5	32.2	28.7	26.1	20	28	8
2010																				
TP10-6	1'-6'	Silty Sand	SM	-	-	-	-	-	-	-	100.0	99.9	96.6	74.7	39.4	17.2	12.4	NP	NP	NP
TP10-7	6.5'-16'	Clayey Sand	SC	-	-	-	-	-	-	100.0	99.9	98.3	85.0	46.2	18.1	16.1	15.5	18	36	18
TP10-16	1'-6'	Silty Sand	SM	-	-	-	-	-	-	-	100.0	99.7	96.7	80.3	49.0	30.1	23.1	NP	NP	NP
TP10-19	8.5'	Clayey Sand	SC	-	-	-	-	-	-	100.0	99.8	99.2	91.5	64.8	37.2	30.2	28.6	22	41	19
TP10-21	1'-11.5'	Silt	ML	-	-	-	-	-	-	-	100.0		100.0	99.8	99.7	99.4	98.2	28	33	5
TP10-27	5'-18'	Clayey Sand	SC	-	-	-	-	-	-	-	100.0	98.3	89.2	63.7	24.7	14.9	14.0	11	21	10
TP10-33	13'-17'	Elastic Silt	MH	-	-	-	-	-	-	-	100.0	97.4	95.0	93.2	91.7	91.1	90.2	35	53	18
TP10-35	12'-15'	Fat Clay	CH	-	-	-	-	-	-	-	100.0	100.0	99.4	97.7	96.2	95.3	93.8	28	61	33
TP10-36	3'-25'	Elastic Silt	MH	-	-	-	100.0	99.4	99.3	99.1	98.8	98.4	97.8	97.1	96.4	95.3	93.1	39	54	15
TP10-40	1.5'-8.5'	Sandy Silt with Gravel	ML	-	-	-	100.0	99.8	98.5	96.9	78.3	67.5	61.5	58.5	56.4	55.9	55.2	36	49	13

Notes:
NP - Non-Plastic
NV - Non-Viscous

Table 3.7
Haile Gold Mine, Inc.
Tailing Storage Facility
Flexible and Rigid Wall Permeability Testing

Flexible Wall Permeability Testing									
Sample Location	Depth (ft)	Material Description	USCS	Remold / Test Data			Hydraulic Conductivity (cm/sec)		
				Dry Density (lb/ft^3)	Moisture (%)	Confining Pressures (lb/in^2)			
2011									
TP11-24	6'-11'	Silt	ML	90.6, 89.7, 88.8	15.8	5, 20, 40	2.30E-05	1.30E-05	6.40E-06
TP11-02	6'	Clayey Sand	SC	110.5	10.5	5	2.90E-04		
TP11-25	1'-2'	Clayey Sand with Gravel	SC	124.75	10	5, 20	1.79E-06	4.27E-07	
TP11-26	3'	Silt	ML	95.8, 94.9, 94.0	12.5	5, 20, 40	8.00E-06	5.70E-06	4.50E-06
TP11-15	9'-16'	Poorly Graded Sand with Silt	SP-SM	107.9, 108.7, 109.6	7.9	40, 60, 80	1.70E-03	1.50E-03	1.60E-03
2010									
TP10-21	1'-11.5'	Silt	ML	93.4, 94.0, 94.6	15.4	10, 30, 60	1.80E-05	1.50E-05	1.20E-05
TP10-33	13'-17'	Elastic Silt	MH	84.5, 84.3, 84.5	25.9	10, 30, 60	2.00E-06	1.10E-06	4.80E-07
TP10-36	3'-25'	Elastic Silt	MH	84.0, 84.0, 84.0	22.6	10, 30, 60	2.90E-06	9.30E-07	4.10E-07

Notes:

1. Tap water was used as the permeant.

Rigid Wall Permeability Testing									
Sample Location	Depth (ft)	Material Description	USCS	Remold / Test Data			Hydraulic Conductivity (cm/sec)		
				Dry Density (lb/ft^3)	Moisture (%)	Normal Stresses			
2010									
TP-07	6.5'-16.0'	Clayey Sand	SC	98.0	10.2	5, 20, 414	2.90E-04	2.10E-04	1.50E-04
TP-16	1.0'-6.0'	Silty Sand	ML	109.7	5.2	5, 20, 414	8.90E-04	8.00E-04	7.30E-04
TP-27	5.0'-18.0'	White Clayey Sand	SC	106.4	8.1	5, 20, 414	1.90E-03	1.60E-03	1.40E-03

Appendix B.4

Flexible and Rigid Wall Permeabilities

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.11
BORING NO.	TP11-24	LAB NO. :	L2011-027
DEPTH	6-11'	SAMPLE ID:	2011-027-160
SAMPLE NO.		TEST STARTED :	05/21/11
SAMPLE TYPE	Remolded	TEST FINISHED :	05/27/11
CONF. PRESSURE. (psi)	5	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	161.58	188.09
Wt. Wet Soil & Pan (g)	623.00	246.09
Wt. Dry Soil & Pan (g)	565.05	196.90
Wt. Moisture Lost (g)	57.95	49.19
Wt. of Pan Only (g)	197.60	58.00
Wt. of Dry Soil (g)	367.45	138.90
Moisture Content %	15.8	35.4
Wet Density (pcf)	104.9	125.7
Dry Density (pcf)	90.6	92.9

Init. Diameter (in)	1.933	(cm) 4.910
Init. Area (sq in)	2.935	(sq cm) 18.933
Init. Height (in)	2.000	(cm) 5.080
Height Change (in)	-0.020	(cm) -0.051
Consol. Height (in)	2.020	(cm) 5.131
Area After Consol. (sq in)	2.821	(sq cm) 18.200

Vol. Before Consol. (cu ft)	0.00340	Specific Gravity 2.71
Vol. Before Consol. (cc)	96.2	Assumed? NO
Change in Vol. (cc)	2.8	
Cell Exp. (cc)	0.0	Init. Saturation 50.5
Vol. After Consol. (cc)	93.4	Init. Void Ratio 0.877
Vol. After Consol. (cu ft)	0.00330	Final Saturation 100.0
Effective Porosity %	46.45	Final Void Ratio 0.822
Pressure Difference (psi):	0.00	
C =	0.10319	Buret Constant, a 0.318
k, cm/s = (C/t)*log(h1/h2)		Buret Stand 13

Permeability Test Trials

Time min.	Cap Elevation cm	Pedestal Elevation cm	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.00	42.9	1.0	41.9	41.9	
3.00	41.0	2.9	38.1	38.1	2.4E-05
12.00	34.8	9.0	25.8	25.8	2.4E-05
5.00	33.0	10.8	22.2	22.2	2.2E-05
5.00	31.4	12.4	19.0	19.0	2.3E-05
11.00	28.7	15.0	13.7	13.7	2.2E-05
			Avg.of Last 4 Rdgs.		2.3E-05
			Max.Hyd.Gradient:	+	7.8

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 90.0 pcf @ 16.1% moisture.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.11
BORING NO.	TP11-24	LAB NO. :	L2011-027
DEPTH	6-11'	SAMPLE ID:	2011-027-160
SAMPLE NO.		TEST STARTED :	05/21/11
SAMPLE TYPE	Remolded	TEST FINISHED :	05/27/11
CONF. PRESSURE. (psi)	20	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	161.58	184.59
Wt. Wet Soil & Pan (g)	623.00	242.59
Wt. Dry Soil & Pan (g)	565.05	196.90
Wt. Moisture Lost (g)	57.95	45.69
Wt. of Pan Only (g)	197.60	58.00
Wt. of Dry Soil (g)	367.45	138.90
Moisture Content %	15.8	32.9
Wet Density (pcf)	103.8	123.1
Dry Density (pcf)	89.7	92.6

Init. Diameter (in)	1.933	(cm)	4.910
Init. Area (sq in)	2.935	(sq cm)	18.933
Init. Height (in)	2.020	(cm)	5.131
Height Change (in)	-0.020	(cm)	-0.051
Consol. Height (in)	2.040	(cm)	5.182
Area After Consol. (sq in)	2.801	(sq cm)	18.072

Vol. Before Consol. (cu ft)	0.00343	Specific Gravity	2.71
Vol. Before Consol. (cc)	97.1	Assumed?	NO
Change in Vol. (cc)	3.5		
Cell Exp. (cc)	0.0	Init. Saturation	49.4
Vol. After Consol. (cc)	93.6	Init. Void Ratio	0.895
Vol. After Consol. (cu ft)	0.00331	Final Saturation	100.0
Effective Porosity %	46.98	Final Void Ratio	0.827
Pressure Difference (psi):	0.00		
C =	0.10494	Buret Constant, a	0.318
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	13

Permeability Test Trials

Time min.	Cap Elevation cm	Pedestal Elevation cm	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.00	42.2	1.7	40.5	40.5	
7.00	39.7	4.2	35.5	35.5	1.4E-05
16.00	35.3	8.5	26.8	26.8	1.3E-05
10.00	33.1	10.7	22.4	22.4	1.4E-05
12.00	31.0	12.8	18.2	18.2	1.3E-05
16.00	28.8	15.0	13.8	13.8	1.3E-05
18.00	26.9	16.9	10.0	10.0	1.4E-05
			Avg.of Last 4 Rdgs.		1.3E-05
			Max.Hyd.Gradient:		7.3

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 90.0 pcf @ 16.1% moisture.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.11
BORING NO.	TP11-24	LAB NO. :	L2011-027
DEPTH	6-11'	SAMPLE ID:	2011-027-160
SAMPLE NO.		TEST STARTED :	05/21/11
SAMPLE TYPE	Remolded	TEST FINISHED :	05/27/11
CONF. PRESSURE. (psi)	40	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	161.58	182.59
Wt. Wet Soil & Pan (g)	623.00	240.59
Wt. Dry Soil & Pan (g)	565.05	196.90
Wt. Moisture Lost (g)	57.95	43.69
Wt. of Pan Only (g)	197.60	58.00
Wt. of Dry Soil (g)	367.45	138.90
Moisture Content %	15.8	31.5
Wet Density (pcf)	102.8	119.5
Dry Density (pcf)	88.8	90.9

Init. Diameter (in)	1.933	(cm)	4.910
Init. Area (sq in)	2.935	(sq cm)	18.933
Init. Height (in)	2.040	(cm)	5.182
Height Change (in)	-0.020	(cm)	-0.051
Consol. Height (in)	2.060	(cm)	5.232
Area After Consol. (sq in)	2.826	(sq cm)	18.233

Vol. Before Consol. (cu ft)	0.00346	Specific Gravity	2.71
Vol. Before Consol. (cc)	98.1	Assumed?	NO
Change in Vol. (cc)	2.7		
Cell Exp. (cc)	0.0	Init. Saturation	48.4
Vol. After Consol. (cc)	95.4	Init. Void Ratio	0.914
Vol. After Consol. (cu ft)	0.00337	Final Saturation	99.0
Effective Porosity %	47.50	Final Void Ratio	0.861
Pressure Difference (psi):	0.00		
C =	0.10504	Buret Constant, a	0.318
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	13

Permeability Test Trials

Time min.	Cap Elevation cm	Pedestal Elevation cm	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.00	42.5	0.4	42.1	42.1	
23.00	38.9	4.2	34.7	34.7	6.4E-06
46.00	33.3	9.6	23.7	23.7	6.3E-06
42.00	29.8	13.1	16.7	16.7	6.3E-06
48.00	27.0	15.9	11.1	11.1	6.5E-06
74.00	24.4	18.4	6.0	6.0	6.3E-06
			Avg.of Last 4 Rdgs.		6.4E-06
			Max.Hyd.Gradient:		7.3

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 90.0 pcf @ 16.1% moisture.

Flexible Wall Permeability
ASTM 5084-03, Method C

Project	Haile Tailings Storage Facility Design	Project No.	74201263B0
Lab No.	11-168-07	Date of Test	5/10/2011
Sample No.	TP11-02	Tested By:	MC
Location	6'	Checked By	KE

Type of Sample	*Remold*				
Sample Specific Gravity	*2.4*		Specific Gravity Assumed?		*Yes*
Initial Dry Density (lbs/ft^3)	*110.47*		Final Dry Density (lbs/ft^3)		*110.20*
Initial Moisture Content (%)	*10.50*		Final Moisture Content (%)		*18.4%*
Moisture Density Test	*ASTM D1557*				
Maximum Dry Density (lbs/ft^3)	*122.2*		Optimum Moisture Content (%)		*10.5%*
Remolded Compaction (%)	*90*		± Optimum Moisture Content (%)		7.9
Initial Sample Height (cm)	*7.62*		Final Sample Height (cm)		*7.59*
Initial Sample Diameter (cm)	*7.28*		Final Sample Diameter (cm)		*7.28*
Initial Saturation	95.00		Final Saturation		*100%*
Manometer Diameter (cm)	large	2.00	small	1.00	
Backpressure (psi)	0.00				
Confining Pressure (psi)	*5 PSI*				

Average K_{sat} (cm/sec) ***2.90E-04***

Notes:

Sample Rock Corrected

0.3 %+#4 99.7 %-#4

Tap water used as permeant.

Flexible Wall Permeability
ASTM 5084-03, Method C

Project	Haile Tailings Storage Facility Design	Project No.	74201263B0
Lab No.	11-168-16	Date of Test	5/10/2011
Sample No.	TP11-25	Tested By:	MC
Location	1'-2'	Checked By	KE

Type of Sample	*Remold*				
Sample Specific Gravity	*2.4*		Specific Gravity Assumed?		*Yes*
Initial Dry Density (lbs/ft^3)	*124.75*		Final Dry Density (lbs/ft^3)		*124.85*
Initial Moisture Content (%)	*10.00*		Final Moisture Content (%)		*13.7%*
Moisture Density Test	*ASTM D1557*				
Maximum Dry Density (lbs/ft^3)	*131.7*		Optimum Moisture Content (%)		*10.0%*
Remolded Compaction (%)	*95*		± Optimum Moisture Content (%)		3.7
Initial Sample Height (cm)	*7.62*		Final Sample Height (cm)		*7.62*
Initial Sample Diameter (cm)	*7.28*		Final Sample Diameter (cm)		*7.28*
Initial Saturation	95.00		Final Saturation		*100%*
Manometer Diameter (cm)	large	2.00	small	1.00	
Backpressure (psi)	0.00				
Confining Pressure (psi)	*5 PSI*				

Average K_{sat} (cm/sec) ***1.79E-06***

Notes:

Sample Rock Corrected

19.1 %+#4 80.9 %-#4

Tap water used as permeant.

Flexible Wall Permeability
ASTM 5084-03, Method C

Project	Haile Tailings Storage Facility Design	Project No.	74201263B0
Lab No.	11-168-16	Date of Test	5/11/2011
Sample No.	TP11-25	Tested By:	MC
Location	1'-2'	Checked By	KE

Type of Sample	*Remold*				
Sample Specific Gravity	*2.4*		Specific Gravity Assumed?		*Yes*
Initial Dry Density (lbs/ft^3)	*124.75*		Final Dry Density (lbs/ft^3)		*125.48*
Initial Moisture Content (%)	*10.00*		Final Moisture Content (%)		*13.7%*
Moisture Density Test	*ASTM D1557*				
Maximum Dry Density (lbs/ft^3)	*131.7*		Optimum Moisture Content (%)		*10.0%*
Remolded Compaction (%)	*95*		± Optimum Moisture Content (%)		3.7
Initial Sample Height (cm)	*7.62*		Final Sample Height (cm)		*7.58*
Initial Sample Diameter (cm)	*7.28*		Final Sample Diameter (cm)		*7.28*
Initial Saturation	95.00		Final Saturation		*100%*
Manometer Diameter (cm)	large	2.00	small	1.00	
Backpressure (psi)	0.00				
Confining Pressure (psi)	*20 PSI*				

Average K_{sat} (cm/sec) ***4.27E-07***

Notes:

Sample Rock Corrected

19.1 %+#4 80.9 %-#4

Tap water used as permeant.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.11
BORING NO.	TP11-26	LAB NO. :	L2011-027
DEPTH	3'	SAMPLE ID:	2011-027-161
SAMPLE NO.		TEST STARTED :	05/20/11
SAMPLE TYPE	Remolded	TEST FINISHED :	05/26/11
CONF. PRESSURE. (psi)	5	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	538.60	626.39
Wt. Wet Soil & Pan (g)	664.10	771.90
Wt. Dry Soil & Pan (g)	612.00	612.00
Wt. Moisture Lost (g)	52.10	159.90
Wt. of Pan Only (g)	196.60	145.51
Wt. of Dry Soil (g)	415.40	466.49
Moisture Content %	12.5	34.3
Wet Density (pcf)	107.9	130.1
Dry Density (pcf)	95.8	96.9

Init. Diameter (in)	2.880	(cm)	7.315
Init. Area (sq in)	6.514	(sq cm)	42.028
Init. Height (in)	2.920	(cm)	7.417
Height Change (in)	-0.029	(cm)	-0.074
Consol. Height (in)	2.949	(cm)	7.490
Area After Consol. (sq in)	6.220	(sq cm)	40.133

Vol. Before Consol. (cu ft)	0.01101	Specific Gravity	2.65
Vol. Before Consol. (cc)	311.7	Assumed?	YES
Change in Vol. (cc)	11.1		
Cell Exp. (cc)	0.0	Init. Saturation	53.1
Vol. After Consol. (cc)	300.6	Init. Void Ratio	0.771
Vol. After Consol. (cu ft)	0.01062	Final Saturation	100.0
Effective Porosity %	42.06	Final Void Ratio	0.708
Pressure Difference (psi):	0.00		
C =	0.06799	Buret Constant, a	0.317
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	11

Permeability Test Trials

Time min.	Cap Elevation cm	Pedestal Elevation cm	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.00	42.3	1.6	40.7	40.7	
3.00	41.4	2.7	38.7	38.7	8.3E-06
15.00	37.3	7.0	30.3	30.3	8.0E-06
12.00	34.6	9.8	24.8	24.8	8.2E-06
13.00	32.3	12.1	20.2	20.2	7.8E-06
			Avg.of Last 4 Rdgs.		8.0E-06
			Max.Hyd.Gradient:		5.3

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 94.1 pcf @ 15.8% moisture.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.11
BORING NO.	TP11-26	LAB NO. :	L2011-027
DEPTH	3'	SAMPLE ID:	2011-027-161
SAMPLE NO.		TEST STARTED :	05/20/11
SAMPLE TYPE	Remolded	TEST FINISHED :	05/26/11
CONF. PRESSURE. (psi)	20	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	538.60	614.39
Wt. Wet Soil & Pan (g)	664.10	759.90
Wt. Dry Soil & Pan (g)	612.00	612.00
Wt. Moisture Lost (g)	52.10	147.90
Wt. of Pan Only (g)	196.60	145.51
Wt. of Dry Soil (g)	415.40	466.49
Moisture Content %	12.5	31.7
Wet Density (pcf)	106.8	126.7
Dry Density (pcf)	94.9	96.2

Init. Diameter (in)	2.880	(cm)	7.315
Init. Area (sq in)	6.514	(sq cm)	42.028
Init. Height (in)	2.949	(cm)	7.490
Height Change (in)	-0.029	(cm)	-0.074
Consol. Height (in)	2.978	(cm)	7.564
Area After Consol. (sq in)	6.205	(sq cm)	40.033

Vol. Before Consol. (cu ft)	0.01112	Specific Gravity	2.65
Vol. Before Consol. (cc)	314.8	Assumed?	YES
Change in Vol. (cc)	12.0		
Cell Exp. (cc)	0.0	Init. Saturation	52.0
Vol. After Consol. (cc)	302.8	Init. Void Ratio	0.788
Vol. After Consol. (cu ft)	0.01069	Final Saturation	100.0
Effective Porosity %	42.63	Final Void Ratio	0.720
Pressure Difference (psi):	0.00		
C =	0.06883	Buret Constant, a	0.317
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	11

Permeability Test Trials

Time min.	Cap Elevation cm	Pedestal Elevation cm	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.00	42.2	1.4	40.8	40.8	
9.00	40.2	3.4	36.8	36.8	5.7E-06
7.00	38.8	4.8	34.0	34.0	5.6E-06
12.00	36.6	7.0	29.6	29.6	5.8E-06
13.00	34.5	9.0	25.5	25.5	5.7E-06
25.00	31.3	12.2	19.1	19.1	5.8E-06
			Avg.of Last 4 Rdgs.		5.7E-06
			Max.Hyd.Gradient:		5.1

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 94.1 pcf @ 15.8% moisture.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.11
BORING NO.	TP11-26	LAB NO. :	L2011-027
DEPTH	3'	SAMPLE ID:	2011-027-161
SAMPLE NO.		TEST STARTED :	05/20/11
SAMPLE TYPE	Remolded	TEST FINISHED :	05/26/11
CONF. PRESSURE. (psi)	40	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	538.60	607.89
Wt. Wet Soil & Pan (g)	664.10	753.40
Wt. Dry Soil & Pan (g)	612.00	612.00
Wt. Moisture Lost (g)	52.10	141.40
Wt. of Pan Only (g)	196.60	145.51
Wt. of Dry Soil (g)	415.40	466.49
Moisture Content %	12.5	30.3
Wet Density (pcf)	105.8	121.9
Dry Density (pcf)	94.0	93.5

Init. Diameter (in)	2.880	(cm)	7.315
Init. Area (sq in)	6.514	(sq cm)	42.028
Init. Height (in)	2.978	(cm)	7.564
Height Change (in)	-0.029	(cm)	-0.074
Consol. Height (in)	3.007	(cm)	7.638
Area After Consol. (sq in)	6.319	(sq cm)	40.772

Vol. Before Consol. (cu ft)	0.01123	Specific Gravity	2.65
Vol. Before Consol. (cc)	317.9	Assumed?	YES
Change in Vol. (cc)	6.5		
Cell Exp. (cc)	0.0	Init. Saturation	50.8
Vol. After Consol. (cc)	311.4	Init. Void Ratio	0.806
Vol. After Consol. (cu ft)	0.01100	Final Saturation	100.0
Effective Porosity %	43.19	Final Void Ratio	0.769
Pressure Difference (psi):	0.00		
C =	0.06824	Buret Constant, a	0.317
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	11

Permeability Test Trials

Time min.	Cap Elevation cm	Pedestal Elevation cm	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.00	41.5	0.9	40.6	40.6	
7.00	40.3	2.2	38.1	38.1	4.5E-06
16.00	37.8	4.7	33.1	33.1	4.3E-06
10.00	36.3	6.2	30.1	30.1	4.7E-06
12.00	34.8	7.7	27.1	27.1	4.3E-06
16.00	33.0	9.4	23.6	23.6	4.3E-06
18.00	31.2	11.3	19.9	19.9	4.7E-06
			Avg.of Last 4 Rdgs.		4.5E-06
			Max.Hyd.Gradient:		5.2

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 94.1 pcf @ 15.8% moisture.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.11
BORING NO.	TP11-15	LAB NO. :	L2011-027
DEPTH	9-16'	SAMPLE ID:	2011-027-156/157
SAMPLE NO.		TEST STARTED :	06/03/11
SAMPLE TYPE	Remolded	TEST FINISHED :	06/09/11
CONF. PRESSURE. (psi)	40	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	573.00	631.70
Wt. Wet Soil & Pan (g)	573.00	778.60
Wt. Dry Soil & Pan (g)	531.10	678.00
Wt. Moisture Lost (g)	41.90	100.60
Wt. of Pan Only (g)	0.00	146.90
Wt. of Dry Soil (g)	531.10	531.10
Moisture Content %	7.9	18.9
Wet Density (pcf)	116.4	129.4
Dry Density (pcf)	107.9	108.8

Init. Diameter (in)	2.869	(cm)	7.287
Init. Area (sq in)	6.465	(sq cm)	41.708
Init. Height (in)	2.900	(cm)	7.366
Height Change (in)	0.022	(cm)	0.056
Consol. Height (in)	2.878	(cm)	7.310
Area After Consol. (sq in)	6.463	(sq cm)	41.698

Vol. Before Consol. (cu ft)	0.01085	Specific Gravity	2.6
Vol. Before Consol. (cc)	307.2	Assumed?	Yes
Change in Vol. (cc)	2.4		
Cell Exp. (cc)	0.0	Init. Saturation	40.7
Vol. After Consol. (cc)	304.8	Init. Void Ratio	0.504
Vol. After Consol. (cu ft)	0.01076	Final Saturation	100.0
Effective Porosity %	33.51	Final Void Ratio	0.492
Pressure Difference (psi):	0.00		
C =	0.18564	Buret Constant, a	0.920
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	3

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	48.5	0.6	51.7	51.7	
0.3	43.2	6.5	39.6	39.6	1.4E-03
0.3	38.3	11.3	29.2	29.2	1.6E-03
0.3	34.6	15.0	21.2	21.2	1.7E-03
0.3	32.0	17.7	15.4	15.4	1.7E-03
			Avg.of Last 4 Rdgs.		1.7E-03

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 108.0 pcf @ 8.0% moisture.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.11
BORING NO.	TP11-15	LAB NO. :	L2011-027
DEPTH		SAMPLE ID:	2011-027-156/157
SAMPLE NO.		TEST STARTED :	06/03/11
SAMPLE TYPE	Remolded	TEST FINISHED :	06/09/11
CONF. PRESSURE. (psi)	60	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	573.00	629.60
Wt. Wet Soil & Pan (g)	573.00	776.50
Wt. Dry Soil & Pan (g)	531.10	678.00
Wt. Moisture Lost (g)	41.90	98.50
Wt. of Pan Only (g)	0.00	146.90
Wt. of Dry Soil (g)	531.10	531.10
Moisture Content %	7.9	18.5
Wet Density (pcf)	117.3	129.8
Dry Density (pcf)	108.7	109.5

Init. Diameter (in)	2.869	(cm)	7.287
Init. Area (sq in)	6.465	(sq cm)	41.708
Init. Height (in)	2.878	(cm)	7.310
Height Change (in)	0.022	(cm)	0.056
Consol. Height (in)	2.856	(cm)	7.254
Area After Consol. (sq in)	6.469	(sq cm)	41.740

Vol. Before Consol. (cu ft)	0.01077	Specific Gravity	2.6
Vol. Before Consol. (cc)	304.9	Assumed?	Yes
Change in Vol. (cc)	2.1		
Cell Exp. (cc)	0.0	Init. Saturation	41.6
Vol. After Consol. (cc)	302.8	Init. Void Ratio	0.493
Vol. After Consol. (cu ft)	0.01069	Final Saturation	100.0
Effective Porosity %	33.00	Final Void Ratio	0.482
Pressure Difference (psi):	0.00		
C =	0.18404	Buret Constant, a	0.920
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	3

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	48.0	1.5	50.2	50.2	
0.3	42.7	6.8	38.8	38.8	1.4E-03
0.3	38.6	10.9	29.9	29.9	1.4E-03
0.3	35.1	14.4	22.4	22.4	1.6E-03
0.3	32.5	17.0	16.7	16.7	1.5E-03
			Avg.of Last 4 Rdgs.		1.5E-03

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 108.0 pcf @ 8.0% moisture.

FLEXIBLE WALL PERMEABILITY TEST
ASTM D 5084-03
Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.11
BORING NO.	TP11-15	LAB NO. :	L2011-027
DEPTH		SAMPLE ID:	2011-027-156/157
SAMPLE NO.		TEST STARTED :	06/03/11
SAMPLE TYPE	Remolded	TEST FINISHED :	06/09/11
CONF. PRESSURE. (psi)	80	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	573.00	613.10
Wt. Wet Soil & Pan (g)	573.00	760.00
Wt. Dry Soil & Pan (g)	531.10	678.00
Wt. Moisture Lost (g)	41.90	82.00
Wt. of Pan Only (g)	0.00	146.90
Wt. of Dry Soil (g)	531.10	531.10
Moisture Content %	7.9	15.4
Wet Density (pcf)	118.2	133.8
Dry Density (pcf)	109.6	115.9

Init. Diameter (in)	2.869	(cm)	7.287
Init. Area (sq in)	6.465	(sq cm)	41.708
Init. Height (in)	2.856	(cm)	7.254
Height Change (in)	0.022	(cm)	0.056
Consol. Height (in)	2.834	(cm)	7.198
Area After Consol. (sq in)	6.159	(sq cm)	39.739

Vol. Before Consol. (cu ft)	0.01068	Specific Gravity	2.6
Vol. Before Consol. (cc)	302.6	Assumed?	Yes
Change in Vol. (cc)	16.5		
Cell Exp. (cc)	0.0	Init. Saturation	42.6
Vol. After Consol. (cc)	286.1	Init. Void Ratio	0.481
Vol. After Consol. (cu ft)	0.01010	Final Saturation	100.0
Effective Porosity %	32.49	Final Void Ratio	0.400
Pressure Difference (psi):	0.00		
C =	0.19181	Buret Constant, a	0.920
k, cm/s = (C/t)*log(h1/h2)		Buret Stand	3

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	46.3	2.8	47.0	47.0	
0.3	41.4	8.1	36.0	36.0	1.5E-03
0.3	37.5	12.2	27.3	27.3	1.5E-03
0.3	34.3	15.3	20.5	20.5	1.6E-03
0.3	32.0	17.8	15.3	15.3	1.6E-03
			Avg.of Last 4 Rdgs.		1.6E-03

General Test Notes:
1) Tap water was used as the permeant.
2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.
3) Target remolding parameters: 108.0 pcf @ 8.0% moisture.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.10
BORING NO.	TP-21	LAB NO. :	L2010-91
DEPTH	1-11.5'	SAMPLE ID:	2010-91-15
SAMPLE NO.		TEST STARTED :	10/25/10
SAMPLE TYPE	remolded	TEST FINISHED :	10/29/10
CONF. PRESSURE. (psi)	10	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	398.44	447.30
Wt. Wet Soil & Pan (g)	398.44	642.90
Wt. Dry Soil & Pan (g)	345.20	540.80
Wt. Moisture Lost (g)	53.24	102.10
Wt. of Pan Only (g)	0.00	195.60
Wt. of Dry Soil (g)	345.20	345.20
Moisture Content %	15.4	29.6
Wet Density (pcf)	107.8	122.0
Dry Density (pcf)	93.4	94.2

Init. Diameter (in)	2.422	(cm) 6.152
Init. Area (sq in)	4.607	(sq cm) 29.724
Init. Height (in)	3.057	(cm) 7.765
Height Change (in)	0.020	(cm) 0.051
Consol. Height (in)	3.037	(cm) 7.714
Area After Consol. (sq in)	4.597	(sq cm) 29.660

Vol. Before Consol. (cu ft)	0.00815	Specific Gravity 2.712
Vol. Before Consol. (cc)	230.8	Assumed? No
Change in Vol. (cc)	2.0	
Cell Exp. (cc)	0.0	Init. Saturation 51.4
Vol. After Consol. (cc)	228.8	Init. Void Ratio 0.813
Vol. After Consol. (cu ft)	0.00808	Final Saturation 100.0
Effective Porosity %	44.85	Final Void Ratio 0.798
Pressure Difference (psi):	0.00	
C =	0.27600	Buret Constant, a 0.922
k, cm/s = (C/t)*log(h1/h2)		

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	0.7	49.3	52.5	52.5	
10.0	2.8	47.2	48.0	48.0	1.8E-05
6.0	4.0	46.0	45.4	45.4	1.9E-05
8.0	5.4	44.6	42.3	42.3	1.7E-05
37.0	11.1	39.1	30.2	30.2	1.8E-05
			Avg.of Last 4 Rdgs.		1.8E-05

General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

3) Target remolded density = 96.6 pcf at 15.3% moisture content.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.10
BORING NO.	TP-21	LAB NO. :	L2010-91
DEPTH	1-11.5'	SAMPLE ID:	2010-91-15
SAMPLE NO.		TEST STARTED :	10/25/10
SAMPLE TYPE	remolded	TEST FINISHED :	10/29/10
CONF. PRESSURE. (psi)	30	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	398.44	445.80
Wt. Wet Soil & Pan (g)	398.44	641.40
Wt. Dry Soil & Pan (g)	345.20	540.80
Wt. Moisture Lost (g)	53.24	100.60
Wt. of Pan Only (g)	0.00	195.60
Wt. of Dry Soil (g)	345.20	345.20
Moisture Content %	15.4	29.1
Wet Density (pcf)	108.5	122.2
Dry Density (pcf)	94.0	94.6

Init. Diameter (in)	2.422	(cm) 6.152
Init. Area (sq in)	4.607	(sq cm) 29.724
Init. Height (in)	3.037	(cm) 7.714
Height Change (in)	0.020	(cm) 0.051
Consol. Height (in)	3.017	(cm) 7.663
Area After Consol. (sq in)	4.607	(sq cm) 29.725

Vol. Before Consol. (cu ft)	0.00810	Specific Gravity 2.712
Vol. Before Consol. (cc)	229.3	Assumed? No
Change in Vol. (cc)	1.5	
Cell Exp. (cc)	0.0	Init. Saturation 52.2
Vol. After Consol. (cc)	227.8	Init. Void Ratio 0.801
Vol. After Consol. (cu ft)	0.00804	Final Saturation 100.0
Effective Porosity %	44.49	Final Void Ratio 0.790
Pressure Difference (psi):	0.00	
C =	0.27358	Buret Constant, a 0.922
k, cm/s = (C/t)*log(h1/h2)		

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	1.0	49.5	52.4	52.4	
6.0	2.4	48.2	49.5	49.5	1.9E-05
39.0	8.1	42.8	37.5	37.5	1.4E-05
11.0	9.5	41.5	34.6	34.6	1.5E-05
79.0	16.6	35.0	19.9	19.9	1.4E-05
			Avg.of Last 4 Rdgs.		1.5E-05

General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.10
BORING NO.	TP-21	LAB NO. :	L2010-91
DEPTH	1-11.5'	SAMPLE ID:	2010-91-15
SAMPLE NO.		TEST STARTED :	10/25/10
SAMPLE TYPE	remolded	TEST FINISHED :	10/29/10
CONF. PRESSURE. (psi)	60	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	398.44	439.80
Wt. Wet Soil & Pan (g)	398.44	635.40
Wt. Dry Soil & Pan (g)	345.20	540.80
Wt. Moisture Lost (g)	53.24	94.60
Wt. of Pan Only (g)	0.00	195.60
Wt. of Dry Soil (g)	345.20	345.20
Moisture Content %	15.4	27.4
Wet Density (pcf)	109.2	123.8
Dry Density (pcf)	94.6	97.2

Init. Diameter (in)	2.422	(cm)	6.152
Init. Area (sq in)	4.607	(sq cm)	29.724
Init. Height (in)	3.017	(cm)	7.663
Height Change (in)	0.020	(cm)	0.051
Consol. Height (in)	2.997	(cm)	7.612
Area After Consol. (sq in)	4.516	(sq cm)	29.134

Vol. Before Consol. (cu ft)	0.00804	Specific Gravity	2.712
Vol. Before Consol. (cc)	227.8	Assumed?	No
Change in Vol. (cc)	6.0		
Cell Exp. (cc)	0.0	Init. Saturation	53.0
Vol. After Consol. (cc)	221.8	Init. Void Ratio	0.790
Vol. After Consol. (cu ft)	0.00783	Final Saturation	100.0
Effective Porosity %	44.12	Final Void Ratio	0.742
Pressure Difference (psi):	0.00		
C =	0.27728	Buret Constant, a	0.922
k, cm/s = (C/t)*log(h1/h2)			

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	2.6	49.6	50.8	50.8	
18.0	5.1	47.3	45.6	45.6	1.2E-05
19.0	7.4	45.1	40.7	40.7	1.2E-05
8.0	8.3	44.3	38.9	38.9	1.2E-05
17.0	10.1	42.6	35.1	35.1	1.2E-05
			Avg.of Last 4 Rdgs.		1.2E-05

General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.10
BORING NO.	TP-33	LAB NO. :	L2010-91
DEPTH	13-17'	SAMPLE ID:	2010-91-17
SAMPLE NO.		TEST STARTED :	10/20/10
SAMPLE TYPE	remolded	TEST FINISHED :	10/29/10
CONF. PRESSURE. (psi)	10	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	385.65	421.46
Wt. Wet Soil & Pan (g)	385.65	535.00
Wt. Dry Soil & Pan (g)	306.42	419.96
Wt. Moisture Lost (g)	79.23	115.04
Wt. of Pan Only (g)	0.00	113.54
Wt. of Dry Soil (g)	306.42	306.42
Moisture Content %	25.9	37.5
Wet Density (pcf)	106.3	115.1
Dry Density (pcf)	84.5	83.7

Init. Diameter (in)	2.408	(cm)	6.116
Init. Area (sq in)	4.554	(sq cm)	29.381
Init. Height (in)	3.035	(cm)	7.709
Height Change (in)	-0.005	(cm)	-0.013
Consol. Height (in)	3.040	(cm)	7.722
Area After Consol. (sq in)	4.586	(sq cm)	29.592

Vol. Before Consol. (cu ft)	0.00800	Specific Gravity	2.7
Vol. Before Consol. (cc)	226.5	Assumed?	Yes
Change in Vol. (cc)	-2.0		
Cell Exp. (cc)	0.0	Init. Saturation	70.1
Vol. After Consol. (cc)	228.5	Init. Void Ratio	0.996
Vol. After Consol. (cu ft)	0.00807	Final Saturation	100.0
Effective Porosity %	49.89	Final Void Ratio	1.013
Pressure Difference (psi):	0.00		
C =	0.27691	Buret Constant, a	0.922
k, cm/s = (C/t)*log(h1/h2)			

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	1.4	48.6	51.0	51.0	
197.0	5.6	44.4	41.9	41.9	2.0E-06
76.0	7.1	43.0	38.8	38.8	2.0E-06
88.0	8.6	41.5	35.5	35.5	2.0E-06
63.0	9.6	40.5	33.4	33.4	2.0E-06
			Avg.of Last 4 Rdgs.		2.0E-06

General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

3) Target remolded density = 85.5 pcf at 25.8% moisture content.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.10
BORING NO.	TP-33	LAB NO. :	L2010-91
DEPTH	13-17'	SAMPLE ID:	2010-91-17
SAMPLE NO.		TEST STARTED :	10/20/10
SAMPLE TYPE	remolded	TEST FINISHED :	10/29/10
CONF. PRESSURE. (psi)	30	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	385.65	418.73
Wt. Wet Soil & Pan (g)	385.65	532.27
Wt. Dry Soil & Pan (g)	306.42	419.96
Wt. Moisture Lost (g)	79.23	112.31
Wt. of Pan Only (g)	0.00	113.54
Wt. of Dry Soil (g)	306.42	306.42
Moisture Content %	25.9	36.7
Wet Density (pcf)	106.1	115.8
Dry Density (pcf)	84.3	84.7

Init. Diameter (in)	2.408	(cm) 6.116
Init. Area (sq in)	4.554	(sq cm) 29.381
Init. Height (in)	3.040	(cm) 7.722
Height Change (in)	0.033	(cm) 0.084
Consol. Height (in)	3.007	(cm) 7.638
Area After Consol. (sq in)	4.581	(sq cm) 29.560

Vol. Before Consol. (cu ft)	0.00801	Specific Gravity 2.7
Vol. Before Consol. (cc)	226.9	Assumed? Yes
Change in Vol. (cc)	1.1	
Cell Exp. (cc)	0.0	Init. Saturation 69.9
Vol. After Consol. (cc)	225.8	Init. Void Ratio 0.999
Vol. After Consol. (cu ft)	0.00797	Final Saturation 100.0
Effective Porosity %	49.98	Final Void Ratio 0.989
Pressure Difference (psi):	0.00	
C =	0.27420	Buret Constant, a 0.922
k, cm/s = (C/t)*log(h1/h2)		

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	0.1	49.7	53.6	53.6	
12.0	0.2	49.5	53.2	53.2	1.0E-06
14.0	0.4	49.3	52.8	52.8	1.2E-06
48.0	1.0	48.7	51.5	51.5	1.0E-06
59.0	1.8	47.9	49.8	49.8	1.1E-06
44.0	2.2	47.3	48.7	48.7	1.0E-06
1228.0	13.2	36.8	25.5	25.5	1.0E-06
			Avg.of Last 4 Rdgs.		1.1E-06

General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.10
BORING NO.	TP-33	LAB NO. :	L2010-91
DEPTH	13-17'	SAMPLE ID:	2010-91-17
SAMPLE NO.		TEST STARTED :	10/20/10
SAMPLE TYPE	remolded	TEST FINISHED :	10/29/10
CONF. PRESSURE. (psi)	60	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	385.65	417.73
Wt. Wet Soil & Pan (g)	385.65	531.27
Wt. Dry Soil & Pan (g)	306.42	419.96
Wt. Moisture Lost (g)	79.23	111.31
Wt. of Pan Only (g)	0.00	113.54
Wt. of Dry Soil (g)	306.42	306.42
Moisture Content %	25.9	36.3
Wet Density (pcf)	106.3	116.2
Dry Density (pcf)	84.5	85.2

Init. Diameter (in)	2.408	(cm) 6.116
Init. Area (sq in)	4.554	(sq cm) 29.381
Init. Height (in)	3.035	(cm) 7.709
Height Change (in)	0.037	(cm) 0.094
Consol. Height (in)	2.998	(cm) 7.615
Area After Consol. (sq in)	4.569	(sq cm) 29.481

Vol. Before Consol. (cu ft)	0.00800	Specific Gravity	2.7
Vol. Before Consol. (cc)	226.5	Assumed?	Yes
Change in Vol. (cc)	2.0		
Cell Exp. (cc)	0.0	Init. Saturation	70.1
Vol. After Consol. (cc)	224.5	Init. Void Ratio	0.996
Vol. After Consol. (cu ft)	0.00793	Final Saturation	100.0
Effective Porosity %	49.89	Final Void Ratio	0.978
Pressure Difference (psi):	0.00		
C =	0.27411	Buret Constant, a	0.922
k, cm/s = (C/t)*log(h1/h2)			

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	0.7	49.1	52.3	52.3	
117.0	1.5	48.4	50.7	50.7	5.3E-07
925.0	6.4	43.7	40.3	40.3	4.9E-07
103.0	6.9	43.2	39.2	39.2	5.2E-07
89.0	7.3	42.9	38.4	38.4	4.3E-07
92.0	7.7	42.5	37.6	37.6	4.9E-07
			Avg.of Last 4 Rdgs.		4.8E-07

General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.10
BORING NO.	TP-36	LAB NO. :	L2010-91
DEPTH	3'-25'	SAMPLE ID:	2010-91-17
SAMPLE NO.		TEST STARTED :	10/25/10
SAMPLE TYPE	remolded	TEST FINISHED :	11/04/10
CONF. PRESSURE. (psi)	10	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	379.68	415.00
Wt. Wet Soil & Pan (g)	379.68	609.50
Wt. Dry Soil & Pan (g)	309.80	504.30
Wt. Moisture Lost (g)	69.88	105.20
Wt. of Pan Only (g)	0.00	194.50
Wt. of Dry Soil (g)	309.80	309.80
Moisture Content %	22.6	34.0
Wet Density (pcf)	102.9	118.2
Dry Density (pcf)	84.0	88.2

Init. Diameter (in)	2.422	(cm)	6.152
Init. Area (sq in)	4.607	(sq cm)	29.724
Init. Height (in)	3.050	(cm)	7.747
Height Change (in)	-0.049	(cm)	-0.124
Consol. Height (in)	3.099	(cm)	7.871
Area After Consol. (sq in)	4.317	(sq cm)	27.856

Vol. Before Consol. (cu ft)	0.00813	Specific Gravity	2.7
Vol. Before Consol. (cc)	230.3	Assumed?	Yes
Change in Vol. (cc)	11.0		
Cell Exp. (cc)	0.0	Init. Saturation	60.5
Vol. After Consol. (cc)	219.3	Init. Void Ratio	1.007
Vol. After Consol. (cu ft)	0.00774	Final Saturation	100.0
Effective Porosity %	50.17	Final Void Ratio	0.911
Pressure Difference (psi):	0.00		
C =	0.29987	Buret Constant, a	0.922
k, cm/s = (C/t)*log(h1/h2)			

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	0.4	49.7	53.2	53.2	
31.0	1.4	48.7	51.1	51.1	2.9E-06
52.0	3.0	47.1	47.6	47.6	2.9E-06
56.0	4.6	45.5	44.2	44.2	2.9E-06
100.0	7.2	43.0	38.7	38.7	2.9E-06
123.0	10.0	40.3	32.7	32.7	2.9E-06
			Avg.of Last 4 Rdgs.		2.9E-06

General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.10
BORING NO.	TP-36	LAB NO. :	L2010-91
DEPTH	3'-25'	SAMPLE ID:	2010-91-17
SAMPLE NO.		TEST STARTED :	10/25/10
SAMPLE TYPE	remolded	TEST FINISHED :	11/04/10
CONF. PRESSURE. (psi)	30	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	379.68	404.00
Wt. Wet Soil & Pan (g)	379.68	598.50
Wt. Dry Soil & Pan (g)	309.80	504.30
Wt. Moisture Lost (g)	69.88	94.20
Wt. of Pan Only (g)	0.00	194.50
Wt. of Dry Soil (g)	309.80	309.80
Moisture Content %	22.6	30.4
Wet Density (pcf)	102.9	121.1
Dry Density (pcf)	84.0	92.9

Init. Diameter (in)	2.422	(cm) 6.152
Init. Area (sq in)	4.607	(sq cm) 29.724
Init. Height (in)	3.050	(cm) 7.747
Height Change (in)	0.015	(cm) 0.038
Consol. Height (in)	3.035	(cm) 7.709
Area After Consol. (sq in)	4.187	(sq cm) 27.017

Vol. Before Consol. (cu ft)	0.00813	Specific Gravity 2.7
Vol. Before Consol. (cc)	230.3	Assumed? Yes
Change in Vol. (cc)	22.0	
Cell Exp. (cc)	0.0	Init. Saturation 60.5
Vol. After Consol. (cc)	208.3	Init. Void Ratio 1.007
Vol. After Consol. (cu ft)	0.00735	Final Saturation 100.0
Effective Porosity %	50.17	Final Void Ratio 0.815
Pressure Difference (psi):	0.00	
C =	0.30280	Buret Constant, a 0.922

k, cm/s = (C/t)*log(h1/h2)

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	1.2	48.8	51.4	51.4	
50.0	1.7	48.2	50.2	50.2	1.0E-06
47.0	2.1	47.8	49.4	49.4	8.1E-07
49.0	2.6	47.3	48.3	48.3	9.9E-07
101.0	3.5	46.2	46.1	46.1	9.9E-07
1015.0	11.1	38.9	30.0	30.0	9.3E-07
438.0	13.4	36.6	25.1	25.1	9.1E-07
			Avg.of Last 4 Rdgs.		9.3E-07

General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

FLEXIBLE WALL PERMEABILITY TEST

ASTM D 5084-03

Falling Head/Increasing Tailwater Pressure

CLIENT:	AMEC		
PROJECT:	Haile Gold Mine	PROJECT NO. :	DV108-130.10
BORING NO.	TP-36	LAB NO. :	L2010-91
DEPTH	3'-25'	SAMPLE ID:	2010-91-17
SAMPLE NO.		TEST STARTED :	10/25/10
SAMPLE TYPE	remolded	TEST FINISHED :	11/04/10
CONF. PRESSURE. (psi)	60	SATURATED TEST:	YES

MOISTURE/DENSITY DATA	BEFORE TEST	AFTER TEST
Wt. Soil + Moisture (g)	379.68	396.50
Wt. Wet Soil & Pan (g)	379.68	591.00
Wt. Dry Soil & Pan (g)	309.80	504.30
Wt. Moisture Lost (g)	69.88	86.70
Wt. of Pan Only (g)	0.00	194.50
Wt. of Dry Soil (g)	309.80	309.80
Moisture Content %	22.6	28.0
Wet Density (pcf)	102.9	123.3
Dry Density (pcf)	84.0	96.3

Init. Diameter (in)	2.422	(cm)	6.152
Init. Area (sq in)	4.607	(sq cm)	29.724
Init. Height (in)	3.050	(cm)	7.747
Height Change (in)	0.059	(cm)	0.150
Consol. Height (in)	2.991	(cm)	7.597
Area After Consol. (sq in)	4.096	(sq cm)	26.427

Vol. Before Consol. (cu ft)	0.00813	Specific Gravity	2.7
Vol. Before Consol. (cc)	230.3	Assumed?	Yes
Change in Vol. (cc)	29.5		
Cell Exp. (cc)	0.0	Init. Saturation	60.5
Vol. After Consol. (cc)	200.8	Init. Void Ratio	1.007
Vol. After Consol. (cu ft)	0.00709	Final Saturation	100.0
Effective Porosity %	50.17	Final Void Ratio	0.750
Pressure Difference (psi):	0.00		
C =	0.30507	Buret Constant, a	0.922

k, cm/s = (C/t)*log(h1/h2)

Permeability Test Trials

Time min.	Cap Elevation cc	Pedestal Elevation cc	Elevation Head cm	Total Head cm	Permeability k cm/sec
0.0	0.3	49.1	52.7	52.7	
180.0	1.2	48.2	50.8	50.8	4.6E-07
247.0	2.2	47.1	48.5	48.5	4.1E-07
927.0	5.8	43.5	40.7	40.7	4.2E-07
237.0	6.6	42.8	39.1	39.1	3.8E-07
240.0	7.4	41.9	37.3	37.3	4.4E-07
			Avg.of Last 4 Rdgs.		4.1E-07

General Test Notes:

1) Tap water was used as the permeant.

2) Back pressure saturation continued until 'B' parameter a minimum of 0.95.

Knight Piésold CONSULTING

Constant Head Permeability

USBR 5605 - Amended

Project	*Haile Gold Mine TSF*	*Project No.*	*DV108-130.10*
Lab No.	*L2010-91*	*Date of Test*	*10/11/10*
Sample No.	*TP-07*	*Tested By*	*jhk*
Location	*6.5-16.0'*	*Checked By*	*jdb*

Specimen Data

Target Dry Density, pcf	108	Wet Sample Wt. + Tare, lbs.	20.876
Target Density, t/m^3		Tare, lbs.	0.000
Moisture Content, %	10.2	Wet Sample Wt., lbs.	20.876
Mold Diameter, in.	8.02	Sample Length, in.	5.950
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	300.6
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.1739
Depth to Mold Bottom, in.	8.590	Wet Density, pcf	120.0
		Initial Depth to Plate, in.	2.640
Normal Stress Range, psf	144 700 2900 5800		

Permeability Trial Data

Normal Stress, psf	144			Head, cm	6.1
Avg. Depth to Plate, in.	2.710	Consolidated Length, in.	5.880	Wet Density, pcf	121.4

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	49.83	1260.0	0.040	3.0E-04
2	33.98	840.0	0.040	3.0E-04
3	52.1	1320.0	0.039	3.0E-04
4	31.71	780.0	0.041	3.1E-04
5	45.3	1140.0	0.040	3.0E-04
Averages			0.040	3.0E-04

Permeability Trial Data

Normal Stress, psf	700			Head, cm	6.1
Avg. Depth to Plate, in.	2.760	Consolidated Length, in.	5.830	Wet Density, pcf	122.5

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	29.45	780.0	0.038	2.8E-04
2	124.58	3120.0	0.040	3.0E-04
3	192.53	4980.0	0.039	2.9E-04
4	90.6	2340.0	0.039	2.9E-04
Averages			0.039	2.9E-04

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Constant Head Permeability

USBR 5605 - Amended

Project	Haile Gold Mine TSF	Project No.	DV108-130.10
Lab No.	L2010-91	Date of Test	10/11/10
Sample No.	TP-07	Tested By	jhk
Location	6.5-16.0'	Checked By	jdb

Specimen Data

Target Dry Density, pcf	108	Wet Sample Wt. + Tare, lbs.	20.876
Target Density, t/m^3		Tare, lbs.	0.000
Moisture Content, %	10.2	Wet Sample Wt., lbs.	20.876
Mold Diameter, in.	8.02	Sample Length, in.	5.950
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	300.6
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.1739
Depth to Mold Bottom, in.	8.590	Wet Density, pcf	120.0
		Initial Depth to Plate, in.	2.640
Normal Stress Range, psf	144 700 2900 5800		

Permeability Trial Data

Normal Stress, psf	2900			Head, cm	6.1
Avg. Depth to Plate, in.	2.790	Consolidated Length, in.	5.800	Wet Density, pcf	123.1

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	52.1	1620.0	0.032	2.4E-04
2	52.1	1860.0	0.028	2.1E-04
3	47.57	1800.0	0.026	2.0E-04
4	44.77	1500.0	0.030	2.2E-04
5	49.83	1920.0	0.026	1.9E-04
Averages			0.028	2.1E-04

Permeability Trial Data

Normal Stress, psf	5800			Head, cm	6.1
Avg. Depth to Plate, in.	2.830	Consolidated Length, in.	5.760	Wet Density, pcf	124.0

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	47.57	2520.0	0.0189	1.4E-04
2	95.13	4800.0	0.0198	1.5E-04
3	56.63	3000.0	0.0189	1.4E-04
4	54.36	2400.0	0.0227	1.7E-04
5	45.3	2340.0	0.0194	1.4E-04
Averages			0.0199	1.5E-04

General Notes:
1) Tap water was used as permeant.
2) Flow conditions may vary depending on the particle distribution in the field.
3) The sample was allowed to saturate overnight prior to initializing flow trials.
4) Target remolding parameters = 108.0 pcf @ 10.2% moisture.

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Constant Head Permeability

USBR 5605 - Amended

Project	Haile Gold Mine TSF	Project No.	DV108-130.10
Lab No.	L2010-91	Date of Test	10/11/10
Sample No.	TP-16	Tested By	jhk
Location	1-6.0'	Checked By	jdb

Specimen Data

Target Dry Density, pcf	109.7	Wet Sample Wt. + Tare, lbs.	20.244
Target Density, t/m^3		Tare, lbs.	0.000
Moisture Content, %	5.2	Wet Sample Wt., lbs.	20.244
Mold Diameter, in.	8.02	Sample Length, in.	6.030
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	304.6
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.1763
Depth to Mold Bottom, in.	8.590	Wet Density, pcf	114.8
		Initial Depth to Plate, in.	2.560
Normal Stress Range, psf	144 700 2900 5800		

Permeability Trial Data

Normal Stress, psf	144			Head, cm	5.5
Avg. Depth to Plate, in.	2.620	Consolidated Length, in.	5.970	Wet Density, pcf	116.0

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	108.72	960.0	0.113	9.6E-04
2	86.07	720.0	0.120	1.0E-03
3	165.35	1440.0	0.115	9.7E-04
4	74.75	660.0	0.113	9.6E-04
5	135.9	1140.0	0.119	1.0E-03
Averages			0.116	9.8E-04

Permeability Trial Data

Normal Stress, psf	700			Head, cm	5.5
Avg. Depth to Plate, in.	2.710	Consolidated Length, in.	5.880	Wet Density, pcf	117.8

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	95.13	900.0	0.106	8.8E-04
2	178.94	1680.0	0.107	8.9E-04
3	156.29	1440.0	0.109	9.0E-04
4	199.32	1860.0	0.107	8.9E-04
5	86.07	780.0	0.110	9.2E-04
Averages			0.107	8.9E-04

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Constant Head Permeability

USBR 5605 - Amended

Project	Haile Gold Mine TSF	Project No.	DV108-130.10
Lab No.	L2010-91	Date of Test	10/11/10
Sample No.	TP-16	Tested By	jhk
Location	1-6.0'	Checked By	jdb

Specimen Data

Target Dry Density, pcf	109.7	Wet Sample Wt. + Tare, lbs.	20.244
Target Density, t/m^3		Tare, lbs.	0.000
Moisture Content, %	5.2	Wet Sample Wt., lbs.	20.244
Mold Diameter, in.	8.02	Sample Length, in.	6.030
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	304.6
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.1763
Depth to Mold Bottom, in.	8.590	Wet Density, pcf	114.8
		Initial Depth to Plate, in.	2.560
Normal Stress Range, psf	144 700 2900 5800		

Permeability Trial Data

Normal Stress, psf	2900			Head, cm	5.5
Avg. Depth to Plate, in.	2.780	Consolidated Length, in.	5.810	Wet Density, pcf	119.2

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	92.87	960.0	0.097	8.0E-04
2	88.34	900.0	0.098	8.1E-04
3	167.61	1740.0	0.096	7.9E-04
4	97.4	960.0	0.101	8.4E-04
5	77.01	840.0	0.092	7.5E-04
Averages			0.097	8.0E-04

Permeability Trial Data

Normal Stress, psf	5800			Head, cm	5.5
Avg. Depth to Plate, in.	2.840	Consolidated Length, in.	5.750	Wet Density, pcf	120.4

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	129.11	1440.0	0.0897	7.3E-04
2	99	1080.0	0.0917	7.5E-04
3	79.28	900.0	0.0881	7.2E-04
4	158.55	1740.0	0.0911	7.4E-04
5	172.14	1920.0	0.0897	7.3E-04
Averages			0.0900	7.3E-04

General Notes:
1) Tap water was used as permeant.
2) Flow conditions may vary depending on the particle distribution in the field.
3) The sample was allowed to saturate overnight prior to initializing flow trials.
4) Target remolding parameters = 109.7 pcf @ 5.2% moisture.

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Constant Head Permeability

USBR 5605 - Amended

Project	Haile Gold Mine TSF	Project No.	DV108-130.10
Lab No.	L2010-91	Date of Test	10/15/10
Sample No.	TP-27	Tested By	jhk
Location	5-18.0'	Checked By	jdb

Specimen Data

Target Dry Density, pcf	106.4	Wet Sample Wt. + Tare, lbs.	20.171
Target Density, t/m^3		Tare, lbs.	0.000
Moisture Content, %	8.1	Wet Sample Wt., lbs.	20.171
Mold Diameter, in.	8.02	Sample Length, in.	6.030
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	304.6
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.1763
Depth to Mold Bottom, in.	8.590	Wet Density, pcf	114.4
		Initial Depth to Plate, in.	2.560
Normal Stress Range, psf	144 700 2900 5800		

Permeability Trial Data

Normal Stress, psf	144			Head, cm	1.5
Avg. Depth to Plate, in.	2.580	Consolidated Length, in.	6.010	Wet Density, pcf	114.8

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	117.78	1560.0	0.076	2.4E-03
2	131.37	1680.0	0.078	2.4E-03
3	92.87	1200.0	0.077	2.4E-03
4	110.99	1380.0	0.080	2.5E-03
5				
Averages			0.078	2.4E-03

Permeability Trial Data

Normal Stress, psf	700			Head, cm	1.5
Avg. Depth to Plate, in.	2.650	Consolidated Length, in.	5.940	Wet Density, pcf	116.2

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	142.7	2280.0	0.063	1.9E-03
2	97.4	1560.0	0.062	1.9E-03
3	115.52	1800.0	0.064	2.0E-03
4	101.93	1680.0	0.061	1.9E-03
5	199.32	4020	0.050	1.5E-03
Averages			0.062	1.9E-03

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Constant Head Permeability

USBR 5605 - Amended

Project	Haile Gold Mine TSF	Project No.	DV108-130.10
Lab No.	L2010-91	Date of Test	10/15/10
Sample No.	TP-27	Tested By	jhk
Location	5-18.0'	Checked By	jdb

Specimen Data

Target Dry Density, pcf	106.4	Wet Sample Wt. + Tare, lbs.	20.171
Target Density, t/m^3		Tare, lbs.	0.000
Moisture Content, %	8.1	Wet Sample Wt., lbs.	20.171
Mold Diameter, in.	8.02	Sample Length, in.	6.030
Mold Area, in.^{2}	50.52	Sample Volume, in.^{3}	304.6
Mold Area, ft^2	0.3508	Sample Volume, ft^3	0.1763
Depth to Mold Bottom, in.	8.590	Wet Density, pcf	114.4
		Initial Depth to Plate, in.	2.560
Normal Stress Range, psf	144 700 2900 5800		

Permeability Trial Data

Normal Stress, psf	2900			Head, cm	1.5
Avg. Depth to Plate, in.	2.690	Consolidated Length, in.	5.900	Wet Density, pcf	116.9

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	38.51	780.0	0.049	1.5E-03
2	83.81	1620.0	0.052	1.6E-03
3	77.01	1500.0	0.051	1.6E-03
4	217.44	4260.0	0.051	1.6E-03
5				
Averages			0.051	1.6E-03

Permeability Trial Data

Normal Stress, psf	5800			Head, cm	1.5
Avg. Depth to Plate, in.	2.730	Consolidated Length, in.	5.860	Wet Density, pcf	117.7

Trial No.	Q cc	Time sec	Flow cc/sec	Permeability k, cm/sec
1	63.42	1380.0	0.0460	1.4E-03
2	67.95	1440.0	0.0472	1.4E-03
3	140.43	3000.0	0.0468	1.4E-03
4	117.78	2460.0	0.0479	1.5E-03
5				
Averages			0.0470	1.4E-03

General Notes:
1) Tap water was used as permeant.
2) Flow conditions may vary depending on the particle distribution in the field.
3) The sample was allowed to saturate overnight prior to initializing flow trials.
4) Target remolding parameters = 106.4 pcf @ 8.1% moisture.

ATTACHMENT 3

AMEC TECHNICAL SPECIFICATIONS

1263B-SP-EW001-0 Earthworks Materials and Construction

and

1263B-SP-GS001-0 Geomembrane Materials and Installation

HAILE GOLD MINE, INC TAILING STORAGE FACILITY KERSHAW, SOUTH CAROLINA **PROJECT NO.: 74201263B0**	**SPECIFICATION** TECHNICAL SPECIFICATIONS FOR EARTHWORKS MATERIALS AND CONSTRUCTION	PAGE 1 OF 28 **DOC. NO.:** 1263B-SP-EW001-B **DATE:** (ORIGINAL) 11/15/10 **REVISION:** B **DATE:** 08/31/12

THIS TITLE SHEET IS THE FIRST PAGE OF THE DOCUMENT AND IS A RECORD OF EACH ISSUE OR REVISION.

		APPROVALS				
REV	DATE	DESIGN MANAGER	PROJECT MANAGER	ORIGINATOR	PAGES	REMARKS
A	11/15/2010	JNM	DTW	RLA	28	Issued for Permitting
B	08/31/2012	JNM	CJB	RLA	28	Issued for TSF Detailed Design

☒ ENTIRE DOCUMENT ISSUED THIS REVISION

☐ REVISED PAGES ONLY ISSUED THIS REVISION

DOCUMENT ISSUED FOR:

☐ REVIEW AND COMMENT
☐ CLIENT APPROVAL
☐ INQUIRY/BID
☒ DESIGN
☐ PURCHASE
☐ CONSTRUCTION

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1.0 INTRODUCTION

This specification defines the requirements for the earthwork construction activities for the Haile Gold Mine, Inc (Haile or HGMI) Tailing Storage Facility. The specifications set forth in this document cover the quality of materials and workmanship for earthworks construction.

Any alternatives or exceptions to this specification shall be submitted in writing to the Owner or its designated representative(s) and or agent(s) and shall be approved by the Engineer.

1.1 Definition of Terms

- "Owner" is defined as HGMI or any of its authorized representative(s) and or agent(s).
- "Engineer" is defined as the Consultant or Engineering Company responsible for the detailed design or any of its authorized representative(s) and or agent(s).
- "Contractor" is defined as the party(s) that has executed the contract agreement for the specified Work with the Owner or its authorized representative(s) and or agent(s).
- "Specifications" are defined as this document, all supplemental addenda, and any modifications furnished by the Owner, the Engineer, or others that apply to the Work.
- "Drawings" are defined as the Drawings for the HGMI Tailing Storage Facility furnished by the Owner, Engineer, or others that apply to the Work.
- "Site" is defined as the Haile Project Mine site being developed by the Owner and where the Work is to be completed as described in these Technical Specifications and detailed on the Drawings.
- "Contract" is defined as the document executed by the Owner or its authorized representative(s) and or agent(s) with the Contractor to complete specified portions of the Work.

- "Work" is defined as the entire completed construction or the various separately identifiable parts thereof required to be furnished as shown on the Drawings and as described in the Specifications and Contract Documents.

- "Modifications" are defined as changes made to the Specifications or the Drawings that are approved by Owner and Engineer in writing, after the Specifications and Drawings have been issued for construction. These also refer to changes to design elements in the field to account for unforeseen conditions.

- "Plant" is defined as all equipment, supplies, accommodations, temporary offices, etc., required to complete the Work.

- "Units" In general, these Specifications and the Drawings will utilize English units, however metric units will be used when appropriate.

2.0 LANDSCAPE PRESERVATION

2.1 General

The Contractor shall exercise care at all times to preserve the natural landscape and shall conduct operations so as to prevent unnecessary damage, scarring or defacing of the natural surroundings in the vicinity of the work. Movement of personnel and equipment within the site disturbance, site access roads, and easements provided for access to the work shall be performed in a manner to prevent damage to the property.

2.2 Historic and Archaeological Data

There are historic and archaeological sites and artifacts known to exist within the work area. The known sites will be identified to the Contractor and the Contractor shall make its personnel and any subcontractors personnel aware of such areas and the restrictions associated with these areas. Not withstanding, should the Contractor or any of its Subcontractors discover evidence of artifacts of possible scientific, historic, or archaeological significance, within the work area they shall notify the Owner immediately.

2.3 Protection of Wetlands

There are jurisdictional wetlands within the work area. The known sites will be identified to the Contractor. The Contractor shall exercise care at all times to preserve the wetlands and shall conduct operations so as to prevent damage to the areas that will not be disturbed by the facility construction.

3.0 SURFACE WATER MANAGEMENT PLAN

The Contractor shall review the available surface runoff and subsurface data for the project site and evaluate the surface and subsurface conditions at the project site with respect to required diversion and dewatering requirements. During the construction period, the Contractor will be responsible for constructing and maintaining any temporary ditches, channels, and or ponds required to protect the works and control surface water flows as well as limit sediment transport outside the limits of the work as directed by the Owner.

The Contractor shall prepare a surface water management plan that will allow construction of all the project elements as detailed on the design drawings. The plan shall detail the materials, equipment pumps, piping, cofferdams, channels, and other components necessary to complete the construction and control sediments.

4.0 EARTHWORKS

This section presents the technical requirements for the earthworks construction.

4.1 Earthwork Specifications

4.1.1 Clearing and Grubbing

The natural ground surface is to be cleared and stripped of all organic and objectionable materials to the limits shown on the Drawings or as required by the Engineer to facilitate construction. The limits of stripping shall generally extend approximately 10 feet outside of the Work activity areas as shown on the Drawings. Any clearing and stripping beyond the limits shown on the Drawings, or as required by the Engineer, shall be subject to the approval of the Owner.

The area shall be cleared of all trees, shrubs, undergrowth, deadwood, rocks larger than one-foot (1') in diameter and other debris. As necessary trees shall be felled, lopped and cut to lengths suitable for removal from the site.

All stumps, the main root ball, and roots systems from the cleared trees and shrubs shall be removed. Removal of root systems shall continue until all roots larger than ½ inch in diameter are removed unless approved otherwise by the Owner and Engineer

Clearing and grubbing will be carried out using whatever method is deemed necessary, providing it is consistent with producing an acceptable end result as determined by the Owner and the Engineer.

Disposal of all surface debris, trees and shrubs shall be as defined in the contract documents and as designated by the Owner. The contractor shall not burn or bury any debris or material from clearing or grubbing operations unless expressly approved in writing by the Owner.

The contractor shall be responsible for maintaining the cleared work area in a condition free from additional vegetation growth for the duration of the project. The use of herbicides to discourage plant growth shall not be allowed unless approved by the owner.

4.1.2 Topsoil Stripping

Once the natural ground surface has been cleared and stripped of all organic and objectionable materials to the limits shown on the Drawings or as required by the Engineer the topsoil shall be removed. All usable topsoil, as determined by the Engineer, shall be properly placed in a storage area shown on the Drawings or as designated by the Owner.

Stripping shall mean the removal of topsoil, which shall be defined as soil of any gradation or degree of plasticity that contains significant quantities of visually identifiable plant matter, sod, roots, or humus as determined by the Engineer. Over much of the tailing facility and associated construction areas, stripping will consist of removal of the small root system not removed with the clearing and grubbing operation and vegetation cover with limited removal of surface soil (approximately 24 inches). In areas where the topsoil extends to depths greater than 24 inches, the excavations shall extend to a greater depth as directed by the Owner. The stripped material shall be hauled to growth media storage areas as shown on

the Drawings or as directed by the Owner. Stripped surface soils and vegetation suitable for use for future reclamation purposes shall be stored separately from material viewed as unsuitable for reclamation purposes.

Topsoil stripping will be carried out using whatever method is deemed necessary, providing it is consistent with producing an acceptable end result as determined by the Owner and the Engineer.

After stripping of the required area, the surface shall be treated as specified on the Drawings or in the Technical Specifications. Prior to any surface treatment on a stripped area, the Engineer shall be notified to inspect the stripped area and designate the method of treatment required for continuance of Work. A survey shall be taken of the area if necessary to determine quantities and or for verification of lift or layer thickness.

4.1.3 Foundation Preparation (General)

Once the work area has been stripped to the satisfaction of the Engineer, the surface shall be prepared before any overlying materials are added. All work areas shall be graded according to the limits shown on the Drawings. It is anticipated that there will be areas of both cut and fill to bring the grading of the work area to the elevations specified in the Drawings.

Areas that are to be filled shall have the exposed surface scarified to a depth of approximately 8 inches, moisture conditioned, and compacted to 95 percent of the maximum dry density as determined by ASTM D1557 to ensure a good foundation is provided for the first lift of fill. (Note: The Engineer may waive this requirement if the exposed surface soils without manipulating will provide a firm, non-yielding surface for fill placement, in which case the surface shall be lightly scarified, moisture conditioned and the first layer of fill placed).

All areas that require cut to achieve the rough grade which is not in rock and which has overlying construction shall be scarified to a depth of approximately 8 inches, moisture conditioned, and compacted to 95 percent of the maximum dry density as determined by ASTM D1557 unless waived by the Engineer.

Cut surfaces on which there is no overlying construction such as road and channel slopes, in general, do not require scarification, moisture conditioning, or compaction.

Areas of unsuitable material as determined by the Engineer shall be excavated to the limits designated by the Engineer and replaced with compacted random fill and or the area re-contoured to tie into the adjacent designed contours as directed by the Engineer.

All boulders and cobbles located at the surface and or partially exposed either in a finish cut or fill area that could be detrimental to the overlying construction shall be removed as directed by the Engineer.

Areas with material suitable for use as “Prepared Subgrade” or “Low Permeability Layer” as determined by the Engineer shall be excavated to the limits designated by the Engineer, placed into designated storage areas, and replaced with compacted fill and or the area re-contoured to tie into the adjacent designed contours as directed by the Engineer.

4.1.4 Foundation Preparation (Diversion Channels)

Channel cut and fill areas, in general, shall be prepared as indicated above and as per the following:

All areas that require cut to achieve the rough grade within the channel flow area that is not in rock shall be scarified to a depth of approximately 8 inches, moisture conditioned, and compacted to 95 percent of the maximum dry density as determined by ASTM D1557.

Areas to receive geotextile shall be free of angular particles and hard objects that may damage the geotextile. Smooth drum finishing rollers shall be used to smooth the surface to embed small stones and rocks into the soil matrix. Where excessive coarse material is exposed at the surface, rock removal by appropriate methods or other surface finishing as directed by the Engineer will be required.

Channel areas to receive geomembrane shall be finished in accordance with Section 4.1.9 “Finished Surface Preparation of Areas to Receive Geomembrane Lining” unless directed otherwise by the Engineer.

4.1.5 Excavations and Borrows

Excavation methods, techniques, and procedures shall be developed with consideration to the nature of the materials to be excavated and shall include all precautions that are necessary to preserve, in an undisturbed condition, all areas outside the lines and grades shown on the Drawings or as required by the

Engineer. Excavation, shaping, etc., shall be carried out by whatever method is considered most suitable, providing it is consistent with producing an acceptable result as determined by the Engineer.

No excavation beyond the lines and grades shown on the Drawings or as required by the Engineer shall be completed without the prior approval of the Owner. If such additional excavation is done without the prior approval of the Engineer and, in the opinion of the Engineer, requires backfilling in order to complete satisfactorily the Work, such backfilling shall be approved by the Engineer and shall be completed at the Contractor's cost. The Contractor shall protect and maintain all excavations until such time as the adjacent placement or overlying placement of material has been completed.

The Contractor shall coordinate borrow activities with the Engineer to allow the sampling and testing of materials prior to their excavation. The Contractor shall allow the Engineer adequate time to evaluate potential borrow materials. Materials recovered from borrow areas that meet the specified requirements for construction materials shall be stockpiled or placed in fill areas as directed by the Engineer. Unsuitable or excess materials shall be hauled to waste or to storage areas.

The materials obtained from borrow pits shall be selected to ensure that the gradation requirements for the various construction materials are achieved and that the materials are as homogeneous as possible. Care shall be taken to avoid cross-contaminating different types of materials.

On-site borrow areas shall be developed within the limits shown on the Drawings or as required by the Owner. Should the Contractor wish to develop additional borrow sources, the Contractor shall receive written approval from the Owner prior to proceeding. Approval by the Owner may require that subsurface investigations be carried out to obtain samples as are required by the Engineer to make an appropriate assessment of the suitability of the borrow materials in the area for the intended use.

Borrow pit operations shall be subject to the approval of the Owner and Engineer and shall avoid waste of any suitable construction material therein. Clearing and stripping of any borrow area is to be completed with all salvageable topsoil stored in growth media storage areas designated on the Drawings or as directed by the Owner. Each borrow area shall be developed with due consideration for drainage and runoff from the excavated surfaces so as not to cause erosion of the adjacent terrain. Each borrow area shall be excavated in near-horizontal layers and in such a manner that water will not collect and pond

except as approved by Owner. Before being abandoned, the sides of any borrow areas outside the Work area shall be brought to stable slopes (not steeper than 2.5H:1V) with slope intersections rounded and contoured to provide a natural, neatly graded appearance.

Waste and growth media storage areas shall be leveled, trimmed, and shaped to prevent the occurrence of ponding and concentrations of surface runoff and to provide a neat appearance. Finished slopes of the waste and growth media storage areas shall be graded to 2.5H:1V for interim reclamation. All surface water runoff shall be directed to available natural drainage courses.

4.1.6 Groundwater Collection Drains

Groundwater collection drains shall be installed in the locations as shown on the drawings or as directed by the Engineer. Once the work area has been dewatered, cleared, grubbed and stripped of topsoil the area will be inspected by the Engineer to determine the need and required limits for groundwater collection drains. Generally this inspection will be a visual inspection however some excavation of test holes may be incorporated into the inspection to identify the limits of the groundwater collection system and also areas where unsuitable material removal may be required before construction of the drain system.

For areas within the limits of any groundwater collection drain that requires the removal of unsuitable material a determination will be made by the Engineer once the unsuitable material has been removed as to whether the area requires to be backfill to achieve the necessary drain profile or if the adjacent area can be re-contoured to tie into the adjacent designed contours.

Construction of the drains shall be in general accordance with the typical cross-section(s) shown on the drawings with such modifications as required by the Engineer during installation to suit the field conditions.

The lines and grades will be determined, by the Engineer in the field, to suit the existing ground conditions. The minimum slope of the trench bottom shall be 0.25 percent.

The drain outlet(s) shall be covered with a removable screen that has a maximum of ½ inch openings.

4.1.7 Fill Materials

All material used for fill shall be loaded and hauled to the placement site, dumped, spread, and leveled to the specified layer thickness. Fill shall be moisture conditioned if required and compacted to form a dense integral fill per the Technical Specifications and the approval of the Engineer. Care shall be taken at all times to avoid segregation of the material being placed and, if required by the Engineer, all pockets of segregated or undesirable material shall be removed and replaced with material which matches the surrounding material. All oversize material shall be removed from the fill material either prior to it being placed or after it is dumped and spread but prior to compaction.

For most construction conditions, the fill is to be constructed in near horizontal layers with each layer being completed over the full length and breadth of the zone before placement of subsequent layers. Each zone shall be constructed with materials meeting the specified requirements and shall be free from lenses, pockets, and layers of materials that are substantially different in gradation from the surrounding material in the same zone, as determined by the Engineer.

Except in areas approved by the Engineer, where space is limited or as otherwise specified, fill shall be placed by routing the hauling and spreading units approximately parallel to the axis of fill. The hauling equipment shall be routed in such a manner that they do not follow in the same paths but spread their travel routes evenly over the surface of the fill.

Moisture conditioning is the operation required to increase or decrease the moisture content of material to within the specified limits. If moisture conditioning is necessary, it may be carried out by whatever method the Contractor deems is suitable, provided it produces the moisture content specified in these Technical Specifications or designated by the Engineer. The moisture shall be distributed uniformly throughout each layer of material being placed immediately prior to compaction. Measures shall be adopted as are necessary to ensure that the designated moisture content is preserved after compaction until the overlying layer is placed.

All particles having dimensions that interfere with compaction in the fill as determined by the Engineer shall be removed from the zone in which they were placed either prior to or during compaction.

The rolling pattern for compaction of all zone boundaries or construction joints shall be such that the full number of roller passes required in one of the adjacent zones, or on one side of the construction joint, extends completely across the boundary or joint.

Minor deviations from the material properties and gradation limitations specified in the Sections below may be acceptable, subject to the review and approval of the Engineer.

4.1.7.1 Random Fill

Material for compacted random fill shall consist of all types of material free of vegetation and other deleterious materials that can be compacted to the satisfaction of the Engineer and must be placed in the lift thickness specified.

The random fill material will have a wide range of Unified Soil Classifications and may contain significant variations in gradation and compaction properties. Random fill will be placed in areas where the material is not required to be of uniform character and engineering properties

Materials containing large size rock or cobbles, and gravel from required excavations may be used subject to the Engineer's approval and provided the rock be reasonably graded such that large void spaces do not result. Further, the maximum size rock shall be no larger the 2/3 the lift thickness.

Random fill may be obtained from required excavations within the work elements or outside borrow areas designated by the Owner.

4.1.7.2 Low Permeability Soil Layer and Liner

Low permeability material shall consist of an inorganic fine-grained silt and clay or sandy and gravelly silt and clay material obtained from on or near-site borrow areas or generated from the pit and stockpiled by the Owner. The material shall be compacted to 95 percent of maximum dry density, as determined by ASTM 1557.

The material gradation shall be as follows:

Sieve Size	Passing (%)
6 inch	100
#4	55-100
#200	20-70

Laboratory testing shall be completed on all low permeability zone sources prior to placement. The material shall be classified and compared to the material properties used in the design.

Some oversize materials, on the order of 6 to 12-inches, will be present in the materials. Removal of oversize materials will be necessary to meet the requirements of the material gradation and to meet the specifications for the requirement of the finished surface.

4.1.7.3 Chimney / Blanket Drain

The fill for the embankment chimney/blanket drain will generally be coastal plain sands from on site borrows. The transition zone material will be placed in conjunction with the random fill placement.

Sieve Size	Passing (%)
1”	100
#4	50-100
#50	20-40
#200	0-12

Laboratory testing shall be completed on the chimney/blanket drain material prior to placement compared to the material properties used in the design.

4.1.7.4 Drainage Layer

The drainage layer material lies directly above the HDPE geomembrane liner. The purpose of this layer is to provide a cover above the HDPE geomembrane to facilitate drainage in the basin. The drainage layer shall consist of acceptable processed or natural silty sands or sandy silts with varying amounts of

gravel. The drainage layer material shall be free of large gravel particles, debris, or any other material that has the potential to damage the underlying geomembrane.

The material gradation shall be as follows:

Sieve Size	Passing (%)
1½ in.	100
½ in.	70-100
#200	5-50

The drainage layer shall have a maximum plasticity index of 12 as determined by ASTM 4318.

4.1.7.5 Drainage Aggregate

The drainage layer material shall consist of acceptable processed or natural gravel material. The materials shall be composed of hard, durable stone particles reasonably free from thin, flat, and elongated pieces.

The material either produced on the site from a natural rock deposit, through a crushing and screening operation, or produced off-site and transported to the Site by the Contractor shall meet the following gradation limits:

Sieve Size	Passing (%)
1½ in.	100
¾ in.	70-100
# 4	5-50
#200	0-8

Material used for drainage aggregate may be approved by the Engineer by visual inspection if the rock is determined to be sound and durable. However, if in the Engineer's opinion, the material is marginal or unacceptable, the Engineer may have performed one or more of the following laboratory tests on representative samples of the drainage material in order to assess the quality of the drainage material.

Drainage Material Laboratory Tests

Test Description	Test Method	Specification Requirement
Los Angeles Abrasion	ASTM C 535	50% Loss Maximum (after 500 revolutions)
Sodium Sulfate or Magnesium Sulfate Soundness	AASHTO T 104 or ASTM C88	10% Maximum Loss (after 5 cycles)
Soundness by Freezing and Thawing	AASHTO T 103	10% Maximum Loss (after 12 cycles)
Slake Durability	ASTM 4644	Classification as Type 1

Moisture conditioning will not be required when placing drainage layer materials.

4.1.7.6 Pipe Bedding and Pipe Backfill

Backfill culverts shall consist of gravel, sand, or sandy silt. Gravel and sand shall consist of a well-graded mixture of stone fragments, gravel, and sand and shall meet the requirements of AASHTO M145, Classification A-1 or A-3. Sandy silt soil shall consist of moderately plastic granular material and shall meet the requirements of AASHTO M145, Classification A-2-4 or A-2-5, with a maximum No. 200 content of 35 percent and maximum Plasticity Index (PI) of 10. The backfill material shall be free of organic material or frozen clumps and have the following typical characteristics:

	Classification			
	A-1	**A-2-4**	**A-2-5**	**A-3**
Sieve Size	**Percent Passing**			
4 in.	100	100	100	100
3 in.	90 min	90 min	90 min	90 min
No. 10	--	--	--	--
No. 40	50 max	--	--	51 min
No. 200	25 max	35 max	35 max	10 max
Liquid Limit	--	40 max	41 min	--
Plasticity Index	6 max	10 max	10 max	NP
Typical Material Type	Stone fragments, gravel, and sand	Silty or clayey gravel with sand		Fine sand

4.1.7.7 Riprap

Riprap shall be placed on prepared surfaces at the locations as shown on the Drawings.

Riprap shall be hard, angular, durable, and reasonably well graded rock and shall be free of overburden, spoil, organic, or other deleterious material. Rounded stone is not acceptable. The riprap shall generally conform to the following gradation requirements as determined by ASTM C136.

D_{50} = 6 in.

Sieve Size	Passing (%)
12 in.	100
6 in.	35-55
3 in.	0-20

D_{50} = 12 in.

Sieve Size	Passing (%)
24 in.	100
12 in.	35-55
6 in.	0-20

D_{50} = 18 in.

Sieve Size	Passing (%)
30 in.	100
24 in.	50-70
18 in.	35-50
6 in.	2-10

4.1.7.8 Road Wearing Course

The roadway wearing surface is to be constructed using select mine-waste material or suitable natural gravels from an on-site borrow.

Wearing course shall generally conform to the following gradation requirements as determined by ASTM C136 and C117.

Wearing Course Aggregate

Sieve Size	Passing (%)
4 inch	100
¾ inch	50-70
No. 4	35-50

No. 16	15-40
No. 200	2-10

The plasticity index for wearing course materials shall be no greater than 15.

4.1.8 Fill Placement and Compaction

All fill materials shall be placed and compacted in accordance with the Drawings and the requirements set forth in the following sections:

4.1.8.1 Random Fill

Random fill material shall be placed in lifts not to exceed 12 inches in compacted lift thickness. This material shall be compacted to 95 percent of the maximum dry density as determined by ASTM D1557. The moisture content of the material shall be maintained at 2 percent below to 3 percent above optimum moisture content. Slight variations from the specified moisture range may be acceptable subject to the acceptance of the Engineer and provided the required compacted densities are achieved. The random fill material shall be compacted with appropriate compactive equipment capable of achieving compaction through the full thickness of the lift layer.

4.1.8.2 Low Permeability Soil Layer and Liner

The low permeability material shall be placed in lifts not to exceed 12 inches compacted lift thickness. This material shall be compacted to 95 percent of the maximum dry density as determined by ASTM D1557. The moisture content of the material will be maintained at optimum to 3 percent above optimum moisture content. Slight variations from the specified material gradation, moisture range and compaction requirements may be acceptable subject to the acceptance of the Engineer and provided it is demonstrated that the required compaction is achieved. The low permeability layer material shall be compacted using a sheepsfoot compactor. Smooth drum finishing rollers shall be used to smooth the surface to remove the tracks from the sheepsfoot rollers and to embed small stones and rocks into the soil matrix.

The Contractor shall protect the finished surface of the alluvial bedding from desiccation cracking between placement activity and coverage by the Geomembrane Installer. Areas that exhibit desiccation

cracks in excess of ¾ inch in depth shall be reworked prior to geomembrane placement. The surface of the low permeability layer material adjacent to the geomembrane shall be prepared in accordance with Section 4.1.9.

4.1.8.3 Chimney/Blanket Drain

Chimney/Blanket Drain material shall be placed, moisture conditioned, and compacted in accordance with the random backfill requirements under Section 4.1.7.1.

4.1.8.4 Drainage/Protective Layer

Drainage/Protective layer material shall be placed with extreme care as not to damage the underlying geomembrane. This is generally done by hauling the material with small haulage units that preferably exert less than 80 psi of ground force. The material shall be spread with a low ground pressure crawler type tractor or equivalent. The material shall be placed at a minimum compacted lift thickness of 12 inches. At no time shall equipment operate directly on the surface of the geomembrane. The working surface during placement of the drainage/protective layer material shall be maintained at least 12 inches above the geomembrane surface. Proposed methods and equipment to be utilized in protective layer placement shall be reviewed and approved by the Engineer prior to the commencement of the Work.

The drainage/protective layer material shall be placed during the cooler times of the day or during the evening where the geomembrane lays relatively flat. As ambient air temperature increases, wrinkles in the HDPE geomembrane will develop due to thermal expansion. Placement of drainage/protective layer will cease if the wrinkles become large enough to fold over itself or causes a crease to form when covered with the material.

To minimize the effect of wrinkles, the drainage/protective layer shall be placed in an uphill direction and /or parallel to the contours. Except as necessary for construction and the safety of the Works, anchor trenches shall not be filled until several cycles of expansion and contraction have occurred.

4.1.8.5 Drainage Aggregate

The material shall be dumped and spread by small crawler type tractor or blade. The material shall be placed in a minimum lift thickness of 12 inches. Special attention shall be given to the material being

placed over pipework and placement over the geomembrane shall be done as detailed in Section 4.1.8.4. All oversized material will be removed by whatever means necessary to ensure no damage to the underlying pipework or geotextile. Because of the thickness of the drainage aggregate and the potential crushing of the underlying piping, vehicle traffic on the drainage gravel shall be minimized and restricted to roadways and other areas where the possibility of damage is minimal. Proposed methods and equipment to be utilized in the placement of drainage gravel, shall be reviewed and approved by the Engineer prior to commencement of the Work

4.1.8.6 Pipe Bedding and Pipe Backfill

Backfilling shall be done as soon as possible after culvert installation. Suitable backfill material free from large lumps, clods, or rocks shall be placed alongside the structure in loose layers not exceeding 8 inches thick to provide a berm of compacted earth on each side of the pipe or structure (where applicable) a minimum of 5 feet wide or the width of the pipe diameter. (whichever is lesser). Each 8-inch layer shall be moisture-conditioned, if required to facilitate compaction, and compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D1557.

Prior to adding each new layer of loose backfill material until a minimum of 12 inches cover is obtained, an inspection shall be made of the inside periphery of the structure (where applicable) for local or unequal deformation caused by the backfilling operation. Only hand-operator tamping equipment shall be allowed within vertical planes 3 feet beyond the horizontal projection of the outside surfaces of the structure (or as recommended by the culvert or structure manufacturer or designer). No heavy earthmoving equipment shall be permitted over the structure until a minimum of 3 feet of compacted fill has been placed over the top of the structure (or such cover as recommended by the culvert manufacturer or designer).

Backfill material shall not be placed against any concrete foundation, abutment, wing wall, or culvert until the concrete has been in place at least seven days or the compressive strength of the concrete is 75 percent of the required 28-day strength. On structures that are not permanently supported laterally and that cannot tolerate horizontal movement, internal bracing or support should be placed during backfill operations.

4.1.9 Finished Surface Preparation of Areas to Receive Geomembrane Lining

Areas to receive geomembrane lining shall be free of angular particles over ¾-inch diameter and hard objects that may damage the geomembrane. Where excessive coarse material is exposed at the surface, rock removal by appropriate methods or other surface finishing as directed by the Engineer will be required. In areas with depressions or loose material, the contractor shall cover the area with a cushion of fine-grained sand or with screened random fill material (passed over ½-inch mesh screen) or equivalent.

4.1.10 Compaction Equipment

Sufficient compaction equipment, of the types and sizes specified herein, shall be provided as necessary for compaction of the various fill materials. If alternative equipment is to be used, a submittal shall be made to the Engineer for approval of the equipment, and the submittal shall give complete details of such equipment and the methods proposed for its use. The Engineer's approval of the use of alternative equipment will be dependent upon completion of suitable test fills, to the satisfaction of the Engineer, to confirm that the alternative equipment will compact the fill materials to the specified density.

Compaction equipment shall be maintained in good working condition at all times to ensure that the amount of compaction obtained is a maximum for the equipment. The Contractor shall provide the Owner and Engineer a list of proposed compaction equipment to be used before commencing Work.

4.1.10.1 Smooth Drum Vibratory Roller

Smooth drum vibratory rollers shall be equipped with a suitable cleaning device to prevent the accumulation of material on the drum during rolling. Each roller shall have a total static weight of not less than 20,000 pounds at the drum when the roller is standing on level ground. The drum shall be not less than 60 inches in diameter and 78 inches in width. The vibration frequency of the roller drum during operation shall be between 1,100 and 1,500 vibrations per minute, and the centrifugal force developed by the roller, at 1,250 vibrations per minute, shall not be less than 38,000 pounds.

For compaction by the vibratory roller, a single coverage shall consist of one pass of the roller. A minimum overlap of 12 inches shall be maintained between the surfaces traversed by adjacent passes of the roller drum. During compaction, the roller shall be propelled at 2 miles per hour (mph) or lesser speed

approved by the Engineer. The power of the motor driving the vibrator shall be sufficient to maintain the specified frequency and centrifugal force under the most adverse conditions that may be encountered during the compaction of the fill. Propulsion equipment for the roller shall be adequate to propel the roller at speeds up to 4 mph.

4.1.10.2 Tamping-Foot ("Sheepsfoot") Roller

The fill may be required to be compacted with a tamping-foot "sheepsfoot" roller. The sheepsfoot roller shall be self-propelled and fully ballasted with a standard tamping-foot design developing 5,000 pounds in weight per linear foot of width at rest on level ground or equivalent as approved by the Engineer.

4.1.10.3 Special Compactors

Special compactors shall be used to compact materials that, in the opinion of the Engineer, cannot be compacted properly by the specified larger vibratory roller because of location or accessibility.

Special compaction measures shall be adopted such as hand-held vibratory compactors or other methods approved by the Engineer to compact fill in trenches, around structures, and in other confined areas that are not accessible to the larger vibratory roller or tamping-foot roller. Such compaction shall be to the specified density for the particular material.

5.0 QUALITY CONTROL

5.1 General

The Engineer will take samples of fill materials and perform gradation, moisture content, Atterberg Limits, and field density tests on the compacted fill and any other tests that the Engineer considers necessary to ensure that the fill being placed meets the specified requirements. The results of the tests carried out by the Engineer will be final and conclusive in determining compliance with the Technical Specifications. Test Methods are listed in Table 1 of Section 5.5.

Each lift of fill will be approved by the Engineer prior to placement of further fill. Sufficient time shall be allowed by the Contractor for the Engineer to carry out the required test work and interpret the test results in order to determine the acceptability of each lift. Cooperation shall be given by the Contractor, to the

Owner and the Engineer, for taking samples or making tests, and such assistance shall be rendered as is necessary to enable sampling and testing to be carried out expeditiously.

Tests carried out by the Engineer will be performed in accordance with the latest principles and methods prescribed by the American Society for Testing and Materials (ASTM) and other such recognized industry standards. The tests shall include Control and Record Tests.

5.2 Control Tests

Tests for gradation, moisture content, moisture density relationship, and other tests, where applicable, will be made by the Engineer on samples of fill materials taken from borrow areas and on the fill after spreading and prior to compaction at frequencies sufficient to ensure that the fill material is in full compliance with the Technical Specifications.

5.3 Record Tests

The Engineer will conduct field density, moisture content, and other tests on the compacted in- place fill and will obtain samples of the compacted fill for related laboratory testing at such frequency as the Engineer considers necessary to determine that the compacted fill is in full compliance with the Technical Specifications.

5.4 Quality Control Construction Tolerances

The Contractor shall construct the various aspects of the tailing storage facility and related works to the lines and grades shown on the Drawings, or as required by the Engineer, within the following tolerances:

- All drainage material locations shall be constructed such that the dimensions at any location within the zone shall not be less than those shown on the Drawings.
- The maximum permissible combined horizontal and vertical deviation of the perimeter boundaries of the tailing storage facility and solution channels from the lines and grades shown on the Drawings or as required by the Engineer shall be 12 inches.
- The finished surface or the leach pads prepared shall not deviate vertically by more than 4 inches than the lines and grades shown on the drawings.

- The finished surface of the drainage materials shall not deviate vertically by more than 8 inches than the lines and grades shown on the drawings.

- The elevation and width of the stability and perimeter berm crests shall not be less than the dimensions shown on the Drawings or required by the Engineer.

All pipes shall be constructed to the following tolerances:

- Alignment and grade shall not deviate more than 5 percent of the nominal diameter of the pipe from a straight line between control points.

5.5 Testing Frequencies

The Engineer will carry out frequent quality control and assurance tests as described above to determine compliance of the Work with the Technical Specifications. The latest edition of standard procedures will be used for all activities, and in general, these will be adopted from recognized organizations such as the American Society of Testing and Materials (ASTM). The following tables outline the test methods and the minimum testing requirements for the project:

Table 1 – Test Methods

Test	Type of Test	Test Method (ASTM)
C1, R1	Atterberg limits	D4318
C2, R2	Moisture content	D2216
C3, R3	Particle size distribution	D422 [a]
C4, R4	Laboratory compaction	D1557
R5a	Nuclear density	D2922
R5b	Sand cone	D1556
C6, R6	Laboratory permeability	D5084

Notes:
C = Control Tests; R = Record Tests
[a] Hydrometer tests down to the 2-micron size will be carried out as directed by the QC Engineer but will generally not be required; all samples to be wash graded over a #200 sieve.

Table 2 – Test Frequency – Foundation Preparation

Test	Type of Test	Frequency (1 per)
R1	Atterberg limits	Soil type/500,000 ft²
C2, R2	Moisture content	100,000 ft²
C3, R3	Particle size distribution	Soil type/500,000 ft²
C4, R4	Laboratory compaction	Soil type
R5a	Nuclear density	100,000 ft²
R5b	Sand cone or water replacement density	1/30 Nuclear density test

Note: Required number of tests shall be determined by whichever method of determining the frequency requires the most tests.

Table 3 – Test Frequency – Random Fill (General)

Test	Type of Test	Frequency (1 per)
R1	Atterberg limits	10,000 yd³
C2, R2	Moisture content	2,000 yd³
C3, R3	Particle size distribution	10,000 yd³
C4, R4	Laboratory compaction	Soil type/75,000 yd³
R5a	Nuclear density	2,000 yd³
R5b	Sand cone or water replacement density	20,000 yd³

Note: Required number of tests shall be determined by whichever method of determining the frequency requires the most tests.

Table 4 – Test Frequency – Random Fill (Embankment)

Test	Type of Test	Frequency (1 per)
R1	Atterberg limits	50,000 yd³
C2, R2	Moisture content	5,000 yd³
C3, R3	Particle size distribution	50,000 yd³
C4, R4	Laboratory compaction	Soil type/150,000 yd³
R5a	Nuclear density	5,000 yd³
R5b	Sand cone or water replacement density	50,000 yd³

Note: Required number of tests shall be determined by whichever method of determining the frequency requires the most tests.

Table 5 – Test Frequency – Low Permeability Materials

Test	Type of Test	Frequency (1 per)
R1	Atterberg limits	Lesser of soil type/10,000 yd³
C2, R2	Moisture content	2,000 yd³
C3, R3	Particle size distribution	10,000 yd³
C4, R4	Laboratory compaction	Lesser of soil type/100,000 yd³
R5a	Nuclear density	2,000 yd³
R5b	Sand cone density	20,000 yd³
R6	Laboratory permeability	200,000 yd³

Table 6 – Test Frequency – Chimney/Blanket Drain

Test	Type of Test	Frequency (1 per)
R1	Atterberg limits	10,000 yd³
C2, R2	Moisture content	5,000 yd³
C3, R3	Particle size distribution	10,000 yd³
C4, R4	Laboratory compaction	Minimum 1 per Soil type/100,000cy
R5a	Nuclear density	5,000 yd³
R5b/R5c	Sand cone or water replacement density	50,000 yd³

Table 7 – Test Frequency – Drainage Layer Material

Test	Type of Test	Frequency (1 per)
R1	Atterberg limits	7,500 yd³
C3, R3	Particle size distribution	7,500 yd³

Note: Sample sizes to be sampled in accordance with ASTM standards.

Table 9– Test Frequency – Drainage Aggregate Material

Test	Type of Test	Frequency (1 per)
C3, R3	Particle size distribution	7,500 yd³

Note: Sample sizes to be sampled in accordance with ASTM standards.

Table 10 – Pipe Bedding and Pipe Backfill

Test	Type of Test	Frequency (1 per)
R1	Atterberg limits	Soil type/5,000 yd^3 or 1 per structure
C2, R2	Moisture content	1,000 yd^3
C3, R3	Particle size distribution	5,000 yd^3 or 1 per structure
C4, R4	Laboratory compaction	Soil type/25,000 yd^3
R5a	Nuclear density	Greater of 2 per major foundation or 500 yd^3 [a]
R5b	Sand cone density	1 per each 20 nuclear density tests

Note:
[a] Frequency of testing for backfill for minor foundations shall be determined by the Project Field Engineer.

HAILE GOLD MINE, INC TAILING STORAGE FACILITY KERSHAW, SOUTH CAROLINA **PROJECT NO.: 74201263B0**	**SPECIFICATION** TECHNICAL SPECIFICATIONS FOR GEOMEMBRANE MATERIALS AND INSTALLATION	PAGE 1 OF 20 **DOC. NO.:** 1263B-SP-GS001-B **DATE:** (ORIGINAL) 11/15/2010 **REVISION:** B **DATE:** 08/31/2012

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1.0 GENERAL

This specification defines the requirements for geomembrane materials, installation, and quality control for the Haile Gold Mine, Inc (HGMI or Owner) Tailing Storage Facility.

Any alternatives or exceptions to this specification shall be submitted in writing to the Owner or its designated representative with the bid.

2.0 GEOMEMBRANE

The geomembrane used for the Haile Gold Mine Project tailing storage facility shall be High-Density Polyethylene (HDPE) 60-mil nominal thickness unless otherwise designated on the Drawings.

2.1 Manufacturer's Quality Control

The HDPE geomembrane shall be a high quality formulation containing approximately 97-percent polymer and 3-percent carbon black with antioxidants and heat stabilizers. It shall be resistant to ultraviolet (UV) rays. All resin shall be hexene-based, consist of all virgin material from the same manufacturer, shall not be intermixed, and no reclaimed polymer may be added to the resin. The manufacturing process shall not use more than 10 percent rework. If rework is used, it must be similar HDPE to the parent material.

The geomembrane material shall comprise HDPE material manufactured of new, first-quality products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures as applied to the mining industry. The material shall be produced as to be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. The geomembrane is to be supplied in roll form. Each roll is to be identified with labels indicating roll number, thickness, length, width, and manufacturer's name.

The geomembrane manufacturer shall be ISO 9000/2000 certified. The manufacturer's laboratory must be certified by Geosynthetic Accreditation Institute (GAI)/Laboratory Accreditation Program (LAP) for the tests being performed and shall have a third-party independent quality assurance program. The third party shall perform the required tests at the required frequency as stated in this specification or at such frequency as is mutually agreed by the Owner, the Engineer, and the manufacturer at the time of award.

All test results shall be provided to the Owner, and the rolls of material shall be clearly identified and correlate to the test results.

Extrudate rod or bead material shall be made from the same type of resin as the geomembrane and be from the same resin supplier as the resin used for manufacture of the geomembrane.

The material shall be warranted against manufacturer's defects as well as degradation due to UV light for exposed areas for a minimum of 20 years from the date of installation or as mutually agreed prior to award of the contract for supply between the Owner and the geomembrane manufacturer. This warranty shall cover the cost of material, freight and duties, handling, labor, and equipment to replace the defective or failed material.

2.2 Submittals Post-Award

The manufacturer shall furnish the following product data, in writing, to the owner prior to shipment of the geomembrane material:

- Resin data including the following:
  - Certification stating that the resin meets the specification requirements and that it is all from the same manufacturer
  - Statement certifying no reclaimed polymer is added to the resin
  - Copy of quality assurance/quality control certificates issued by resin supplier
- Geomembrane roll/extrudate rod and bead material:
  - Copy of quality assurance/quality control certificates issued by the geomembrane manufacturer and the third-party independent quality assurance tester
  - Certification that the geomembrane material delivered to the project complies with these specifications

- Certification that extrudate rod or bead is from one manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane rolls.

2.3 HDPE Material Properties

The material supplied as smooth or textured HDPE shall conform to the standards outlined in Tables 1A and 2A.

3.0 GEOMEMBRANE INSTALLATION

3.1 General

The HDPE geomembrane shall be installed on the areas shown on the Drawings or as directed by the Engineer.

Prior to deployment of geomembrane, the Installer shall inspect and accept, with the Engineer and the Owner, all surfaces on which the geomembrane is to be placed. The surface on which the geomembrane is to be installed shall be free of sharp particles, rocks, or other debris to the satisfaction of the Engineer, the Owner, and the Installer. Sharp objects shall be removed by raking, sweeping, or handpicking as necessary.

The Installer shall supply the Engineer with panel layouts of the liner that must be approved by the Engineer prior to commencing the Work. It is the Installer's responsibility to submit timely proposals (allowing a minimum of two weeks for approval).

Installation of the geomembrane shall be performed under the direction of a field engineer or supervisor who has installed a minimum of 10,000,000 square feet of flexible geomembrane material. The geomembrane shall be placed over the prepared surfaces using methods and procedures that ensure a minimum of handling. Adequate temporary and permanent anchoring devices and ballasting shall be provided to prevent uplift and damage due to winds. The Installer is solely responsible for the safety of his operations including decisions regarding deployment in adverse weather conditions and the amount of temporary anchoring and ballasting required.

To the extent possible, seams shall be oriented parallel to the slope of the ground. The panels shall be secured temporarily with sandbags or other approved ballasting method to hold them in place until the field seams have been completed and the geomembrane has been permanently anchored.

The Installer shall take into account that frequent high winds may result in delays. The Installer shall take all necessary measures to ensure that each panel is sufficiently ballasted to prevent damage or movement by wind. Fusion of panels and repairs will only be permitted under weather conditions allowing such work, and within the warranty limits of the Geomembrane Manufacturer, as approved by the Owner and the Engineer.

Horizontal field seams on slopes shall be kept to a minimum. Horizontal seams on steep slopes shall be avoided where possible by cutting the liner at a 45-degree angle. Generally, horizontal seams are to be no closer than 10 feet from the toe of the slope. Horizontal seams shall be made by lapping the uphill material over the downhill material. Panels shall be shingled in a manner that prevents water from running beneath the liner.

The geomembrane shall be installed in a relaxed condition and shall be free of tension or stress upon completion of the installation. The installed geomembrane shall contain sufficient slack material to allow for thermal expansion and contraction. Individual wrinkles should take the form of undulations in the liner but should not be large enough for the material to fold over itself.

During installation, the Installer shall give each field panel an “identification” code number consistent with the layout plan. The Engineer shall agree upon the numbering system. The Installer shall update the layout plan as each panel is installed to show the location of each panel. A field panel is defined as the area of geomembrane that is to be seamed in the field (roll or portion of a roll cut in the field).

Individual panels of geomembrane material shall be laid out in a pattern that will produce the least number of seams. The material shall be overlapped prior to welding. Extreme care shall be taken by the Installer in the preparation of the areas to be welded. The joint interface shall be cleaned and prepared according to procedures laid down by the material manufacturer and approved by the Engineer. Seaming shall not take place unless the panel is dry and clean. All sheeting shall be welded together by thermal methods.

Any area showing damage due to excessive scuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of geomembrane. The cost of replacing or repairing the geomembrane shall be borne solely by the Installer.

No “fish mouths” will be allowed within the seam area. Where “fish mouths” occur, the material shall be cut, overlapped, and an overlap extrusion weld applied.

Geomembrane panels must have a finished overlap of 4 to 6 inches for double-wedge welding seams and minimum 6 inches for extrusion welding seams. Notwithstanding this provision, sufficient overlap shall be provided to allow peel tests to be performed on any seam.

Handling and storage of the geomembrane material shall be in accordance with the manufacturer’s printed instructions. Persons walking or working on the geomembrane shall not engage in activities or wear shoes that could damage the geomembrane.

An adequate number of handling equipment, welding apparatuses, and test equipment shall be maintained on site to avoid delays due to problems with equipment failures.

3.2 Geomembrane Installation Quality Control

3.2.1 General

The Installer shall submit a copy of his Quality Control Manual to the Engineer through the Owner prior to the start of installation of any geomembrane. If there are discrepancies between this specification and the Installer’s Quality Control Manual, the more stringent requirements will apply unless determined otherwise by the Engineer.

The Installer shall be fully responsible for carrying out all quality control tests on the geomembrane and shall do so to the satisfaction of the Engineer and in accordance with this Specification and the Installer’s Quality Control Manual. On-site physical nondestructive and destructive testing shall be completed on all joints to ensure that watertight uniform seams are achieved on a continuous basis as installation proceeds. At the time of bid submission, details shall be provided by the Installer that set forth the method proposed for both destructive and nondestructive testing of seams. The Engineer shall approve these methods prior to the Installer commencing the Work. Visual inspection alone is unacceptable.

Fusion of panels and repairs will only be permitted under weather conditions allowing work that is in conformance to the Specifications and within the warranty limits imposed by the manufacturer and to the approval of the Engineer.

At a minimum, the Installer's field installation test program shall consist of periodic visual observations and continuity and strength tests as defined in the following subsections.

3.2.2 Trial Welds

Trial welds shall be completed to verify the performance of the welding equipment and operator prior to performing production welds. No welding equipment or operator shall perform production welds until equipment and operator have successfully completed a trial weld. The following procedures shall be followed for trial welds:

- Make trial welds under the same surface and environmental conditions as the production welds, i.e., in contact with subgrade and similar ambient temperature.
- Minimum of two trial welds per day per welding apparatus – one made prior to the start of work and one completed at mid-shift or for every 5 hours of seaming operations.
- Cut five 1-inch-wide-by-6-inch-long test strips from the trial weld.
- Quantitatively test specimens for peel adhesion and then for bonded seam strength (shear).
- Trial weld specimens shall pass when the results shown in Table 3A is achieved in both peel and shear tests and:
    - The break, when peel testing, occurs by Separation in the Plane of the sheet (SIP), not through adhesion failure separation (AD).
    - The break is ductile.
- Repeat the trial weld, in its entirety, when the trial weld samples fail in either peel or shear as defined on Table 3A, footnote 2.

3.2.3 Field Seaming

The Contractor shall have at least one master welder who will provide direct supervision over other welders as necessary.

- The welding equipment shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the material to ensure changes in environmental conditions will not affect the integrity of the weld.
- The seam area shall be cleaned of dust, mud, moisture, and debris immediately ahead of the welding apparatus.
- The seam overlaps shall be aligned consistent with the requirements of the welding equipment being used. A 4- to 6-inch overlap shall be used for double wedge welded seams and 6-inches for extrusion welded seams unless approved otherwise by the Engineer.
- Seaming shall not proceed when the ambient air temperature or adverse weather conditions jeopardize the integrity of the geomembrane installation.
- Extrusion welding apparatus shall be purged of heat-degraded extrudate before welding.
- The double-wedge fusion welding process shall be used unless alternate methods are approved by the Engineer. Extrusion welding will be permitted to weld short seams, to repair small areas, where double-wedge welding is not feasible, and where test samples have been removed.

3.2.4 Field Seam and Panel Inspection and Testing

3.2.4.1 Nondestructive Testing and Inspection

The Installer shall perform visual inspections of deployed and welded HDPE panels to identify defects, damage, or protrusion of sharp objects that may affect the integrity of the geomembrane. Defective or damaged areas will be marked and repaired according to the Technical Specifications and the guidelines in the Installer's Quality Control Manual.

A quality control technician or field engineer acting for the Installer shall inspect each seam, marking his initials and date inspected at the end of each panel. Any area showing a defect shall be marked and repaired in accordance with the applicable repair procedures.

3.2.4.2 Continuity Testing

A maximum effort shall be made to install a perfect geomembrane liner. This implies that all seams completed in the field, patches, and extrusions shall be tested and recorded. All failures shall be isolated and repaired as directed by the Engineer. A general testing procedure is included as follows:

- Test all field seams and patches with interseam pressure, vacuum box, spark tester, or other approved methods. Pressure and vacuum testing are discussed in following subsections.
- Isolate and repair all areas indicating any leakage. Retest the repair.

Interseam Pressure Testing. Test procedure for interseam pressure for seams (for double-wedge welding only):

- Seal both ends of the seam to be tested by applying heat to the end of the seam via a heat gun until flow temperature is achieved. Clamp off the ends and let cool.
- Insert a pressure gauge/needle assembly into the end of the seam and seal.
- Pressurize the air channel between the two seams to between 30 and 35 psi. Following pressure stabilization, take the initial pressure reading, hold the pressure a minimum of 3 minutes, and take a second reading.
- The allowable leak down for the seam is 3 psi.
- If the pressure does not drop below the maximum allowable 3 psi, open the air channel at the end away from the pressure gauge. Air should rush out and the pressure gauge should register an immediate drop in pressure, indicating that the entire length of seam has been tested. If this does not happen, either the air channel is blocked or the equipment is faulty, and the test is not valid.

- Enter the results of the leak test on the appropriate document, indicating either a passed or a failed seam. If the seam fails, the repair work and subsequent testing should be recorded on the same document.

- Repair the area where the pressure gauge/needle assembly was installed and where the air was released.

Vacuum-Box Testing. The proposed test procedures are as follows:

- Mix a solution of liquid detergent and water and apply an ample amount to the area to be tested. If a seam contains excess overlap or loose edges, it must be trimmed before testing.

- Place a translucent vacuum box over the area and apply a slight amount of downward pressure to the box to seat the seal strip to the liner.

- Apply a vacuum of 3 to 5 psi for a minimum of 15 seconds to the area. Any leaks will become visible by large bubbles.

- Enter the results of the leak test on the appropriate document, indicating either a passed or a failed seam. If the seam fails, the repair work and subsequent testing should be recorded on the same document.

Spark Testing. Extrusion welded patches, cap, etc., in lieu of being vacuum-box tested, may be “spark” tested. The basic procedures for spark testing are as follows:

- The seam shall be prepared for extrusion welding in accordance with the installer’s procedures.

- Just prior to applying the extrusion bead, a small-gauge copper wire is placed into the seam. An 18-gauge bare copper wire usually works well. The wire should be grounded at one end and placed at the edge of the top sheet of the overlap seam. Tucking the wire under the edge of the top sheet will help hold the wire in place during welding, but this should be done prior to grinding to avoid the risk of contamination of the weld area.

- Apply the extrudate bead as normal, and allow the weld to cool.

- Energize the spark tester, and move the electrode wand near a grounding source to determine the maximum length of spark that can be generated. Adjust the output voltage setting until the spark length exceeds the greatest potential leak path distance. This is typically the diagonal distance form the embedded wire to the edge of the weld bead at a "T" joint.

- Once the output voltage has been set, testing may be started. Testing is performed by passing the electrode over the seams with the electrode in contact with the membrane and/or the extruded weld bead. The audible and visual indication of a spark provides the determination of a potential leak path.

- If a potential leak is detected, the area can be repaired by grinding and re-welding. Applying additional weld beads adjacent to the leaking weld is not an acceptable repair technique. This will only lengthen the leak path to the extent that the spark tester may not be capable of generating a spark of sufficient length to breach the lengthened gap.

- After grinding and re-welding, the seam must be retested. If there is still an indication of a potential leak (spark), it may be required to apply a patch over the entire area.

3.2.4.3 Destructive Testing

Peel and shear seam strength testing shall be carried out on samples of seams removed from the installed panels. For these tests, the following procedures shall be followed:

- Coupon sampling of all field seams, including patches and repair areas, shall be taken by cutting perpendicular to the seams a sample approximately 36 by 12 inches. This sample shall be cut into three 12-by-12-inch samples and labeled with the date and location, and individually marked "Owner Sample," "QA/QC Sample," and "Lab QA/QC Sample." The frequency and location shall be determined by the Engineer but shall not be less than one sample per 500 feet of field seams. These coupons shall be tested on site for peel and shear seam strength and thickness in accordance with D6392.

- Heat-welded seams shall be allowed to cool or warm to about 70°F prior to testing. Solvent seams, when used, shall be allowed to cure according to the manufacturer's recommendations. Additionally, at the Engineer's option, approximately 10 percent of the coupons (size 1 by 6 inches) shall be sent to an independent laboratory for confirmation testing. Should the lab and field tests conflict, installation shall halt until the conflict is resolved to the satisfaction of the Engineer.

The Engineer will continuously inspect the installation of the HDPE liner to ensure that the procedures specified in this section are adhered to fully.

Weld specimens shall pass when the results shown in Table 3A is achieved in both peel and shear tests and as follows:

- The break, when peel testing, occurs by Separation In the Plane of the sheet (SIP) not through adhesion failure separation (AD).
- The break is ductile.

In the event of a failing test result, the following procedures shall be used:

- The Installer shall follow one of two options:
  - Reconstruct the seam between any two passed test locations, or
  - Trace the weld to an intermediate location at least 10 feet or to where the seam ends in both directions from the location of the failed test. Once the failing limits of the seam are isolated, that portion of the seam shall be reconstructed or capped.

  Seams welded prior to and after the failed seam using the same welding device and/or operator shall be tested.

3.2.5 Repair Procedures

Damaged or defective geomembrane or seam areas failing a destructive or non-destructive test shall be repaired. The Installer shall be responsible for repair of damaged or defective areas. The repair method shall be decided by the Installer but must be agreed upon by the Engineer. Procedures available include the following:

- Replacement: Remove damaged geomembrane or unacceptable seam and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.
- Patching: Used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.
- Abrading and Re-Welding: Used to repair small seam sections.
- Capping: Used to repair large lengths of failed seams.
- Flap Welding: Used to extrusion-weld the flap (excess outer portion) of a fusion weld in lieu of a full cap.

In addition, the following procedures shall be observed:

- Surfaces of the polyethylene that are to be repaired by extrusion welds shall be lightly abraded to ensure cleanliness.
- All geomembrane shall be clean and dry at the time of repair.
- Extend patches or caps at least 6 inches for extrusion weld and 4 inches for wedge weld beyond the edge of the defect, and round corner of patch material. The edges of all patches are to be beveled.

Furthermore, repair verification shall be performed as follows:

- Number and log each patch repair.

- Non-destructively test each repair using methods specified in this Specification.

3.3 Certification

At the completion of the geomembrane installation, the Installer shall provide the Owner with a certification stating that the geomembrane was installed and tested in accordance with the Specifications together with a report of the test results. The certification shall be provided to the Owner prior to the demobilization of the installation personnel from the site unless agreed otherwise by the Owner. The report of the test results shall be provided in hard copy and digital format to the Owner and the Engineer not later than 30 days after the installation work has been completed.

3.4 Completion

At the completion of the installation, the Installer shall provide a set of as-built drawings showing the actual geomembrane panel layout, seams, location of destructive test samples, and the location of major repairs including repaired seams and capped areas. The as-built panel layout must be submitted in hard copy and digital format to the Owner and the Engineer not later than 30 days after the installation work has been completed.

TABLE 1A – HDPE GEOMEMBRANE, SMOOTH

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. avg.) ▪ Lowest individual of 10 values	D5199	Nominal -10%	Nominal -10%	Nominal -10%	Nominal -10%	Nominal -10%	Nominal -10%	Nominal -10%	Per roll
Density mg/L (min.)	D1505/D792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lbs
Tensile Properties [1] (min. avg.) ▪ Yield strength ▪ Break strength ▪ Yield elongation ▪ Break elongation	D6693 Type IV	63 lbs/in 114 lbs/in 12% 700%	84 lbs/in 152 lbs/in 12% 700%	105 lbs/in 190 lbs/in 12% 700%	126 lbs/in 228 lbs/in 12% 700%	168 lbs/in 304 lbs/in 12% 700%	210 lbs/in 380 lbs/in 12% 700%	252 lbs/in 456 lbs/in 12% 700%	20,000 lbs
Tear Resistance (min. avg.)	D1004	21 lbs	28 lbs	35 lbs	42 lbs	56 lbs	70 lbs	84 lbs	45,000 lbs
Puncture Resistance (min. avg.)	D4833	54 lbs	72 lbs	90 lbs	108 lbs	144 lbs	180 lbs	216 lbs	45,000 lbs
Stress Crack Resistance [2]	D5397 (Appendix)	300 hrs	300 hrs	300 hrs	300 hrs	300 hrs	300 hrs	300 hrs	Per GRI-GM10
Carbon Black Content (range)	D1603 [3]	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	20,000 lbs
Carbon Black Dispersion	D5596	Note [4]	Note [4]	Note [4]	Note [4]	Note [4]	Note [4]	Note [4]	45,000 lbs
Oxidative Induction Time (OIT) (min. avg.) [5] a) Standard OIT --OR-- b) High Pressure OIT	 D3895 D5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	200,000 lbs
Oven Aging at 85°C [5, 6] a) Standard OIT (min. avg.) - % retained after 90 days --OR-- b) High Pressure OIT (min. avg.) - % retained after 90 days	D5721 D3895 D5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	Per each formulation

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
UV Resistance [7]	GM11								Per each formulation
a) Standard OIT (min. avg.)	D3895	N.R. [8]	N.R. [8]	N.R. [8]	N.R. [8]	N.R. [8]	N.R. [8]	N.R. [8]	
--OR--									
b) High Pressure OIT (min. avg.) - % retained after 1,600 hrs [9]	D5885	50%	50%	50%	50%	50%	50%	50%	

1 Machine direction (MD) and cross-machine direction (XMD) average values should be based on five (5) test specimens each direction.
- Yield elongation is calculated using a gauge length of 1.3 inches.
- Break elongation is calculated using a gauge length of 2.0 inches.

2 The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

3 Other methods, such as D4218 (muffle furnace) or microwave methods, are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.

4 Carbon black dispersion (only near spherical agglomerates) for ten (10) different views: Nine (9) in Categories 1 or 2 and one (1) in Category 3.

5 The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

6 It is also recommended to evaluate samples at 30 and 60 days to compare with the 90-day response.

7 The condition of the test should be 20-hour UV cycle at 75°C followed by 4-hour condensation at 60°C.

8 Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV-exposed samples.

9 UV resistance is based on percent-retained value regardless of the original HP-OIT value.

TABLE 2A – HDPE GEOMEMBRANE, TEXTURED

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. avg.) ▪ Lowest individual of 10 values	D5994	Nominal (-5%) -10%	Nominal (-5%) -10%	Nominal (-5%) -10%	Nominal (-5%) -10%	Nominal (-5%) -10%	Nominal (-5%) -10%	Nominal (-5%) -10%	Per roll
Asperity Height mils (min. avg.) [1]	GM 12	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	10 mil	Every 2nd roll [2]
Density mg/L (min.)	D1505/D792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lbs
Tensile Properties [3] (min. avg.) ▪ Yield strength ▪ Break strength ▪ Yield elongation ▪ Break elongation	D6693 Type IV	63 lbs/in 45 lbs/in 12% 150%	84 lbs/in 60 lbs/in 12% 150%	105 lbs/in 75 lbs/in 12% 150%	126 lbs/in 90 lbs/in 12% 150%	168 lbs/in 120 lbs/in 12% 150%	210 lbs/in 150 lbs/in 12% 150%	252 lbs/in 180 lbs/in 12% 150%	20,000 lbs
Tear Resistance (min. avg.)	D1004	21 lbs	28 lbs	35 lbs	42 lbs	56 lbs	70 lbs	84 lbs	45,000 lbs
Puncture Resistance (min. avg.)	D4833	54 lbs	72 lbs	90 lbs	108 lbs	144 lbs	180 lbs	216 lbs	45,000 lbs
Stress Crack Resistance [4]	D5397 (App.)	300 hrs	300 hrs	300 hrs	300 hrs	300 hrs	300 hrs	300 hrs	Per GRI-GM10
Carbon Black Content (range)	D1603 [5]	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	20,000 lbs
Carbon Black Dispersion	D5596	Note [6]	Note [6]	Note [6]	Note [6]	Note [6]	Note [6]	Note [6]	45,000 lbs
Oxidative Induction Time (OIT) (min. avg.) [7] c) Standard OIT --OR-- d) High Pressure OIT	D3895 D5885	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	200,000 lbs
Oven Aging at 85°C [7, 8] c) Standard OIT (min. avg.) - % retained after 90 days --OR-- d) High Pressure OIT (min. avg.) - % retained after 90 days	D5721 D3895 D5885	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	Per each formulation

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
UV Resistance [7]	GM11								
c) Standard OIT (min. avg.)	D3895	N.R. [8]	N.R. [8]	N.R. [8]	N.R. [8]	N.R. [8]	N.R. [8]	N.R. [8]	Per each formulation
--OR--									
d) High Pressure OIT (min. avg.) - % retained after 1,600 hrs [9]	D5885	50%	50%	50%	50%	50%	50%	50%	

[1] Of 10 readings; 8 out of 10 readings must be ≥ 7 mils, and the lowest individual reading must be ≥ 5 mils

[2] Alternate the measurement side for double-sided textured sheet.

[3] Machine direction (MD) and cross-machine direction (XMD) average values should be on the basis of five (5) test specimens each direction.
- Yield elongation is calculated using a gauge length of 1.3 inches.
- Break elongation is calculated using a gauge length of 2.0 inches.

[4] P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.

The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

[5] Other methods, such as D4218 (muffle furnace) or microwave methods, are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.

[6] Carbon black dispersion (only near spherical agglomerates) for ten (10) different views: Nine (9) in Categories 1 or 2 and one (1) in Category 3.

[7] The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

[8] It is also recommended to evaluate samples at 30 and 60 days to compare with the 90-day response.

[9] The condition of the test should be 20-hour UV cycle at 75°C followed by 4-hour condensation at 60°C.

[10] Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV-exposed samples.

[11] UV resistance is based on percent-retained value regardless of the original HP-OIT value.

TABLE 3A – SEAM STRENGTH AND RELATED PROPERTIES OF THERMALLY BONDED SMOOTH AND TEXTURED HDPE GEOMEMBRANES

Geomembrane Nominal Thickness	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Hot Wedge Seams [1]							
Shear strength [2], lb/in.	57	80	100	120	160	200	240
Shear elongation at break [3], %	50	50	50	50	50	50	50
Peel strength [2], lb/in.	45	64	76	91	121	151	181
Peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams							
Shear strength [2], lb/in.	57	80	100	120	160	200	240
Shear elongation at break [3], %	50	50	50	50	50	50	50
Peel strength [2], lb/in.	39	52	65	78	104	130	156
Peel separation, %	25	25	25	25	25	25	25

[1] Also for hot air and ultrasonic seaming methods

[2] Value listed for shear and peel strengths are for four out of five test specimens; the fifth specimen can be as low as 80% of the listed values

[3] Elongation measurements should be omitted for field testing

Haile Gold Mine, Inc.'s Response to the National Marine Fisheries Service's Comments Received by the United States Army Corps of Engineers on the Haile Gold Mine Draft Environmental Impact Statement

Submitted May 30, 2014

Haile Gold Mine, Inc.'s (Haile) Response to the National Marine Fisheries Service's (NMFS) Comments Received by the United States Army Corps of Engineers (USACE) on the Haile Gold Mine Draft Environmental Impact Statement (DEIS) has been prepared to the best of Haile's ability, based upon information that is currently and reasonably available

National Marine Fisheries Service Comment No. 1. *NMFS recommends the applicant remove the old mill dam between Camp Branch and Haile Gold Mine Creek and create riffles in the river and creeks where dissolved oxygen levels are low. See* NMFS Comment Letter at p. 3, 1st paragraph.

Haile's Response to National Marine Fisheries Service Comment No. 1. The old mill dam structure was built by Springs Industries Inc., known now as Springs Global, and used to take water from Little Lynches River for their textile mill. This structure is not associated with past mining activities at Haile, but instead, associated with past textile activities. Springs Global appears to pride itself on environmental responsibility. See Springs Global, Environmental Responsibility, *available at* http://www.springs.com/springsglobal2013/web/conteudo_en.asp?idioma=1&conta=44&tipo=46434. Thus, if NMFS wishes to have this structure removed and the immediate section of Little Lynches River restored, it would seem more appropriate for NMFS to contact Springs Global with this request.

As for the request by NMFS to create riffles in the river and creeks where dissolved oxygen levels are low, the request is unclear as to whether NMFS is asking Haile to create riffles in the creeks or whether NMFS is asking Haile to compensate for any decreased oxygen levels as a result of operations.

In either case, the request to create riffles in the streams is not feasible from a practicability standpoint because the request would entail replacement of existing stream substrates to support such a habitat feature, and the changes in habitat structure as a result would significantly change the existing aquatic communities. Aquatic surveys between 2011 and 2013 have shown that the in-stream habitats for Haile Gold Mine Creek, Camp Branch Creek, and Little Lynches River have very limited habitat structure. Predominant substrate in streams throughout the Site consists primarily of sands and silts (ARCADIS 2012a). Habitat structure is largely composed of "run habitat" with essentially an absence of riffles and an extremely low frequency of pools. Existing pools were characterized as uniformly sand or mud with few to no root mats or submerged vegetation. Channels showed little to no sign of being altered but showed relatively little sinuosity, and sediment deposition throughout the channels was moderate to heavy with sand bars observed in some locations. Riparian vegetation was abundant, but there was very little epifaunal substrate (i.e., "snag" habitats and large woody debris) due to the highly erodible substrate composition of the channels.

Creation of riffle habitats essentially would mean removal and reengineering of the existing bottom substrate, which would significantly and negatively impact the existing fish and

macroinvertebrate communities that are adapted to and thriving in these types of blackwater stream systems.

Further, existing dissolved oxygen levels measured during the aquatic surveys show a wide variation among different reaches, but were generally above 5 mg/L, which is within levels that are typical for blackwater streams. State of South Carolina water quality standards identify a dissolved oxygen level of 4 mg/L as the lower limit for Class A (non-trout) water (USEPA 1988).

References:

ARCADIS. 2012a. Comprehensive Baseline Wildlife and Aquatic Resources Report for the Haile Gold Mine Site Lancaster County, South Carolina Revision: July 20, 2012.

ARCADIS. 2012b. Spring 2012 Aquatic Resource Surveys Report. Prepared for Haile Gold Mine, Inc. June 19.

USEPA. 1988. State water quality standards summary: South Carolina. EPA/440/5-88-076. Office of Water Regulations and Standards, Washington, D.C.

National Marine Fisheries Service Comment No. 2. *NMFS recommends the applicant be required to continue annual fish monitoring within the study area in accordance with the* Aquatic Resources Study Plan. *See* NMFS Comment Letter at p. 3, 1st paragraph.

Haile's Response to National Marine Fisheries Service Comment No. 2. Haile has proposed a surface water quality monitoring plan as part of its Monitoring and Management Plan. The proposed monitoring includes surface water quality, geomorphology, and surface water flow and water level monitoring. These parameters will provide early warning of water impacts and a means of identifying contaminant sources to assist in identifying contingency actions that will be employed. Thus, the proposed Monitoring and Management Plan should provide adequate monitoring and assessment of any potential impacts to the aquatic community. However, if fish monitoring is determined to also be necessary, then Haile proposes that the frequency of monitoring should consider a step-down approach, such as annual monitoring during pre-production (construction phase), then every two years until the monitoring frequency can be reduced or completely eliminated based upon review of the data and discussion with SCDHEC and SCDNR. Additionally, Haile proposes that the locations of the annual monitoring should coincide with a subset of locations proposed in the Monitoring and Management Plan rather than the Aquatic Study Plan. Such locations should be determined through consultation between SCDHEC, SCDNR and Haile.

Haile Gold Mine, Inc.'s Response to the United States Fish and Wildlife and United States Department of the Interior Comments Received by the United States Army Corps of Engineers on the Haile Gold Mine Draft Environmental Impact Statement

Submitted May 30, 2014

Haile Gold Mine, Inc.'s (Haile) Response to the United States Fish and Wildlife (FWS) and the United States Department of the Interior (DOI) Comments Received by the United States Army Corps of Engineers (USACE) on the Haile Gold Mine Draft Environmental Impact Statement (DEIS) has been prepared to the best of Haile's ability, based upon information that is currently and reasonably available.

U.S. Fish and Wildlife Service Comment No. 1. *[T]here are examples of numerous wildlife deaths due to cyanide from TSF ponds where the concentration is below 50 mg/L WAD cyanide. As described in the Draft Environmental Impact Statement developed for the Haile Gold Mine Project by the U.S. Army Corps of Engineers, over a 2-year period at the Ridgeway Mine in South Carolina, 271 vertebrate deaths were reported around the mine. Of these, 13 percent were mammals (mostly bats), 86 percent were birds, and only 1 percent were reptiles and amphibians. Migratory bird deaths at HGM could be even greater than those experienced at the Ridgeway Mine, as the tailings facility at Ridgeway was smaller than the one currently proposed for Haile Gold Mine (HGM). See* FWS Comment Letter at p. 2, 1st paragraph.

Haile Response to U.S. Fish and Wildlife Service Comment No. 1. Haile suggests that this comment is based on a faulty premise, i.e., assuming that there were controls for WAD cyanide at the Ridgeway Mine. As the South Carolina Department of Health and Environmental Control (SCDHEC) can confirm, the Ridgeway Mine was neither required by its state Mine Operating Permit nor did it voluntarily maintain the CN WAD in its tailings pond to less than 50 ppm. Haile has enclosed a copy of Ridgeway's Mine Operating Permit as Haile Response to FWS Comment No. 1, Exhibit 1.

In contrast, Haile has committed to maintain CN WAD in the Duckwood TSF Reclaim Pond to less than 50 ppm. As stated in Haile's comments on the DEIS, Haile maintains that the statement in the DEIS that exposure to a WAD CN concentration of less than 50 mg/L in a TSF will cause sublethal effects on avians is not supported by the literature, as summarized below.

Moreover, the cited sources do not support the comment. Eisler and Wiemeyer (2004) and Brasel et al. (2006) did not document sublethal effects in mallards and pigeons containing water less than 50 mg/L WAD CN. Eisler and Wiemeyer (2004) is a review paper that briefly discusses, but does not cite, a case of sublethal effects to mallards given a low dose of free cyanide. Brasel et al. (2006) gavaged pigeons with 0.2 mg free cyanide per kg body weight of the bird to study sublethal effects on pigeon flight times; the correlation between this dose and a concentration of 50 mg/L WAD CN in a TSF is unclear, as the units of exposure are different, as is the chemical form of cyanide.

Cooper (2003), as cited in NICNAS (2010), identified a low observed effect level for pigeons and mallards of 0.4 mg free cyanide (CN) per kg body weight. The test organisms had been gavaged with up to 80 mg/L CN (the specific dose is not reported). Again, direct correlation

between the NICNAS (2010) summary and exposure in a TSF is unclear as stated, both due to the form of cyanide administered and the laboratory dose as it would relate to exposure in a TSF.

Of the citations listed in these sentences, only Cooper (2003), as cited in NICNAS (2010), cites the form of cyanide administered to test organisms, which was in the form of potassium cyanide, not sodium cyanide.

Neither Eisler and Wiemeyer (2004) nor NICNAS (2010) are laboratory toxicity studies.

U.S. Fish and Wildlife Service Comment No. 2. *The [FWS] deems it necessary to implement a cyanide monitoring protocol, including how, where, and when (frequency) cyanide concentrations will be monitored to ensure that they are maintained at the anticipated concentration. See* FWS Comment Letter at p. 2, 3rd paragraph.

Haile Response to U.S. Fish and Wildlife Service Comment No. 2. Haile has committed to maintaining the WAD cyanide in the TSF Reclaim Pond to less than 50 ppm. In connection with Haile's state Mining Permit, Haile is currently engaged in discussions with SCDHEC regarding how, where, and when (frequency) cyanide concentrations will be monitored to ensure that the TSF Reclaim Pond WAD cyanide levels are maintained below 50 ppm. Haile understands from communications with SCDHEC that such monitoring will be a condition of its state Mining Permit, which is within SCDHEC's regulatory preview, and will include provisions protective of the environment.

U.S. Fish and Wildlife Service Comment No. 3. *In order to avoid and minimize impacts to trust resources, including migratory birds, the [FWS] recommends implementation of a wildlife protection and mortality response plan. This plan should be developed in consultation with the [FWS] and the South Carolina Department of Natural Resources and should be incorporated into, or a condition of, the mine modification permit issued by the South Carolina Department of Health and Environmental Control. This plan should address secondary and physical protective measures, as well as avian monitoring and reporting requirements. See* FWS Comment Letter at pp. 2-3, 1st paragraph.

Haile Response to U.S. Fish and Wildlife Service Comment No. 3. Per DEIS, Appendix G, Monitoring and Management Plan, Haile is committed to ensuring compliance with federal laws protecting avian species, as well as fencing the TSF and contact water ponds, maintaining WAD cyanide in the TSF Reclaim Pond to <50 ppm, monitoring the TSF and contact water ponds for wildlife, and recording any wildlife mortalities that occur therein. Haile will work closely with the SCDNR, SCDHEC Mining, and USFWS to refine this monitoring plan, as needed, to the satisfaction of the agencies and permittee. Given all of the controls planned, the expense of a third party inspector is not warranted. Haile intends to train those employees that have avian monitoring responsibilities in the identification of migratory birds. Haile anticipates that avian mortalities will be collected, reported, preserved and, if warranted following discussions with the state or federal agency, sent to an appropriate laboratory in order to determine the cause of death.

With respect to secondary protection measures, Haile's proposed wildlife protection measures (i.e., an 8 foot fence around the TSF and maintaining the TSF Reclaim Pond at less than 50 ppm WAD cyanide) are adequate at protecting wildlife from cyanide exposure, such that additional or secondary protection measures are not warranted. In addition, as Haile noted in its comments on the DEIS, Section 4.8.3.2, page 4-16:

> [H]ypersaline solution is not appropriate or necessary. It is sometimes used where there is high (over 50 mg/L) WAD cyanide; however, Haile has measures to maintain the WAD cyanide in the TSF Reclaim Pond at or below 50 mg/L. In addition, magnesium present in hypersaline solution has a buffering effect against lime that could cause the normal operating pH in the process to be between 9.0 and 9.5 instead of over 10.0. This could result in more HCN gas volatilization and could pose a potential safety hazard. Also, gold leach rate, and thus recovery, could be less because hypersaline solution has reduced oxygen solubility compared to nonsaline solution. Hypersaline solutions also have elevated chloride levels and can result in corrosion of stainless steel equipment and piping. This would require undesired and costly maintenance. Additionally, chlorides can react with silver to form insoluble silver chloride salts. This could result in lower silver recovery for Haile and impact project economics. Finally, hypersaline solution has been known to be deleterious to pyrite flotation which is a key unit operation. Haile suggests that netting is maintenance intensive and not practical; HDPE balls are costly for little benefit; water hyacinths would be a source for food; and fake wetlands would attract wildlife to an area that is not attractive. As a result, the potential additional mitigation measures should not be applied.

U.S. Department of the Interior Comment No. 1. *[T]here are examples of numerous wildlife deaths due to cyanide from TSF ponds where the concentration is below 50 mg/L WAD cyanide. As described in the Draft Environmental Impact Statement developed for the Haile Gold Mine Project by the U.S. Army Corps of Engineers, over a 2-year period at the Ridgeway Mine in South Carolina, 271 vertebrate deaths were reported around the mine. Of these, 13 percent were mammals (mostly bats), 86 percent were birds, and only 1 percent were reptiles and amphibians. Migratory bird deaths at HGM could be even greater than those experienced at the Ridgeway Mine, as the tailings facility at Ridgeway was smaller than the one currently proposed for Haile Gold Mine (HGM). See* DOI Comment Letter at p. 2, 3rd paragraph.

Haile Response to U.S. Department of the Interior Comment No. 1. See Haile Response to FWS Comment No. 1, *supra*.

U.S. Department of the Interior Comment No. 2. *The [DOI] deems it necessary to implement a cyanide monitoring protocol, including how, where, and when (frequency) cyanide concentrations will be monitored to ensure that they are maintained at the anticipated concentration. See* DOI Comment Letter at p. 2, 5th paragraph.

Haile Response to U.S. Department of the Interior Comment No. 2. See Haile Response to FWS Comment No. 2, *supra*.

U.S. Department of the Interior Comment No. 3. *The Final EIS should include, as part of the proposed project, a wildlife protection and mortality response plan. This plan should consider such measures as hypersaline TSF solution, decoy wetlands, netting, HDPE floating balls, water hyacinths, reducing forage food sources in and around the TSF, and building alternative freshwater ponds to provide drinking sources away from the TSF. See* DOI Comment Letter at p. 3, 3rd paragraph.

<u>Haile Response to U.S. Department of the Interior Comment No. 3.</u> See Haile Response to FWS Comments No. 1 - 3, *supra*.

Haile Gold Mine, Inc.'s Response to the South Carolina Department of Natural Resources Comments Received by the United States Army Corps of Engineers on the Haile Gold Mine Draft Environmental Impact Statement

Submitted May 30, 2014

Haile Gold Mine, Inc.'s (Haile) Response to the South Carolina Department of Natural Resources (SCDNR) Comments Received by the United States Army Corps of Engineers (USACE) on the Haile Gold Mine Draft Environmental Impact Statement (DEIS) has been prepared to the best of Haile's ability, based upon information that is currently and reasonably available.

SCDNR Comment No. 1. *DNR encourages the consideration of practicable, monitoring-based adaptive management strategies that may minimize the spatial and temporal impacts to ground and surface water resources particularly when and if maximum depressurization overlaps with drought. See* SCDNR Comment Letter at p. 6, 1st paragraph.

Haile Response to SCDNR Comment No. 1. Haile will work with the SCDNR to develop practicable monitoring-based management strategies that may minimize the spatial and temporal impacts to ground and surface waters resources, particularly when and if maximum depressurization overlaps with drought, as appropriate.

Haile Gold Mine, Inc.'s Response to Richland County Council, Richland County Council Chairman Norman Jackson, and Richland County Councilman Kelvin Washington Comments Received by the United States Army Corps of Engineers on the Haile Gold Mine Draft Environmental Impact Statement

Submitted June 4, 2014

Haile Gold Mine, Inc.'s (Haile) Response to Richland County Council, Richland County Council Chairman Norman Jackson and Richland County Council Councilman Kelvin Washington Comments Received by the United States Army Corps of Engineers (USACE) has been prepared to the best of Haile's ability, based upon information that is currently and reasonably available.

Richland County Council Comment No. 1. *Richland County requests before the transfer of the mitigation properties (Cook's Mountain and Goodwill Plantation), the South Carolina Department of Natural Resources will ensure that fair and equitable access will be guaranteed for every citizen wishing to utilize the properties after the public use has been determined. See* Richland County Council Comment Letter at p. 1, paragraph (2).

Haile Response to Council Chairman Norman Jackson Comment No. 1. Haile Gold Mine, Inc. (Haile) believes that determination of "fair and equitable access" to mitigation properties that will be owned and managed by the South Carolina Department of Natural Resources (SCDNR) is a matter of state law and practice, which does not require further analysis in the federal EIS.

The objective of Haile's proposed Mitigation Plan is to mitigate for all of the impacts associated with the construction and operation of the Haile Gold Mine project site, by assuring that outstanding aquatic resources, as well as cultural and historic resources, are preserved and a significant endowment is provided to the SCDNR for maintenance and management for the benefit of regional aquatic functions. An endowment totaling $4.5 million will be provided to SCDNR for maintenance and management of the sites. An additional amount of $4.9 million will be provided to SCDNR specifically for projects for the benefit of the heelsplitter mussel. Under the Mitigation Plan, outstanding aquatic resources will become part of South Carolina's Heritage Trust Program, removed from any threat of development and preserved for the benefit of the regional environment. Access and management consistent with state law and practice is not a Haile responsibility.

Richland County Council Chairman Norman Jackson Comment No. 1. *The proposed compensatory mitigation appears to include very little restoration, enhancement, or replacement of substitute resources or environments and is inconsistent with 33 CFR Part 332 as well as no net loss goals for wetlands. An exception to requiring restoration and/or enhancement in the proposed mitigation plan should not be approved. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 1, paragraph (1)(i).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 1. *See* Haile Response to EPA DEIS Comment Nos. 9 & 10, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 2. *Neither the DEIS or the proposed mitigation plan describes the amount or type of wetland and stream credits required by the SOP to mitigate the mining activities or the compensation calculations associated with proposed mitigation plan. These credit calculations should be provided in the EIS and in the mitigation plan. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 1, paragraph (1)(ii).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 2. The USACE Charleston District Guidelines for preparing a Compensatory Mitigation Plan (Guidelines) do include a methodology for calculating required credits; however, the credit calculation provisions of these guidelines are not applicable to a project of the scope and scale of the Haile Gold Mine. *See also* Haile Response to EPA DEIS Comment No. 9, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 3. *[T]he USACE should include [] potential restoration and enhancement activities* apriori *in the mitigation plan. To do otherwise is inconsistent with 33 CFR 332. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 1, paragraph (1)(ii).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 3. *See* Haile Response to EPA DEIS Comment Nos. 9 &10, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 4. *Permittee Responsible Mitigation should have and is generally required to have specific plans for restoration and enhancement activities including monitoring to demonstrate the effectiveness and functional lift resulting from these activities. No such plans are included in the DEIS or the proposed HGM mitigation plan. Without defined restoration and monitoring plans it is difficult to compare the proposed compensatory activities with the proposed impacts from the mine. See* Richland County Council Chairman Norman Jackson Comment Letter at pp. 1-2, paragraph (1)(iii).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 4. *See* Haile Response to EPA DEIS Comment Nos. 9 & 10, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 5. *The lack of any specificity of potential restoration or enhance plans brings into question the protection which should be afforded the cultural resources located in the floodplain of Goodwill Plantation. Numerous canals and dikes hand-dug by enslaved persons formerly used for the cultivation of rice are located in the floodplain. Any potential restoration activities must avoid these areas. The USACE should require specific plans on how this important cultural history be protected. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 2, paragraph (1)(iv).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 5. Protection and preservation of cultural resources is part of the mission of The Heritage Trust Program and will be a consideration in any restoration activities implemented by DNR. *See also*

Haile Response to EPA DEIS Comment Nos. 9 & 10, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 6. *The proposed $4.5 million dollar endowment to SCDNR for the three mitigation properties is inadequate to properly manage, maintain and restore the properties. No financial data has been provided to demonstrate that SCDNR has the financial capacity to manage the properties once the endowment (approximately $100,000 per year for each property) ends in 15 years. This is especially important given dwindling State budgets in recent years. Additionally, any memorandum of understanding between the USACE, HGM and the owner of lands set aside for mitigation must have adequate financial protections in the case of falling gold prices and/or mine closure. Consistent with 33 CFR 332, the USACE must require SCDNR to show other sources of State-funds managed by SCDNR to demonstrate the ability to meet the requirements of Section 332.4, (11) and (13) above and beyond those provided to SCDNR in the endowment from HGM. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 2, paragraph (1)(vi).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 6. *See* Haile Response to EPA DEIS Comment No. 10, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 7. *As stated in the DEIS, the compensatory mitigation plan claims to provide benefits to downstream water quality. The compensatory mitigation plan lacks the detail and requisite monitoring to quantify functional lift or benefits to downstream water quality at the mitigation properties in Richland County, or on the watershed or landscape level. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 2, paragraph (1)(vii).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 7. At the mitigation sites (and at the Haile Gold Mine site) there will be vegetated buffers to protect wetlands and streams. Riparian buffers adjacent to aquatic resources have been found by the USACE to be an important element of aquatic systems. The Charleston District Guidelines acknowledge the value of riparian buffers in maintaining the integrity of aquatic systems, "forested riparian zones are essential to stream system function, channel stability and maintenance of water quality and in-stream habitat." *See also* Haile Response to EPA DEIS Comment No. 12, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 8. *Large portions of the compensatory mitigation tracts are not within the same watershed (i.e. Cook's Mountain and Goodwill Plantation – Catawba-Wateree River Basin) as the mine impacts (Pee Dee River Basin) and therefore do not seem relevant to the goals of the CWA, NEPA, the SOP, or the proposed landscape scale mitigation which is to be watershed based. As requested in 2, ii above, The USACE should provide information on any location or other compensation factors applied to the proposed out-of-basin mitigation and how these impacted the required credit calculations. See* Richland County Council Chairman Norman Jackson Comment Letter at pp. 2-3, paragraph (1)(viii).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 8. *See* Haile Response to EPA DEIS Comment No. 9, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 9. *All of Cook's Mountain is already protected by a conservation easements and cannot be developed with the exception of four parcels totaling 18.6 acres located at the top of the Cook's Mountain; approximately 2.0 percent of the Cook's Mountain property. Therefore, further protection of Cook's Mountain will provide little, if any, additional or substitute resources, functional lift, water quality or habitat improvements which are required elements of any mitigation plan. Further, SCDNR plans on cutting timber from this site (consistent with the current conservation easement) which could adversely impact water quality in the Wateree River. Please explain the net water quality benefits (if any) between the current conservation easement and SCDNR's preservation plan which includes timber cutting. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 3, paragraph (1)(ix).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 9. *See* Haile Response to EPA DEIS Comment No. 10 & Haile Response to SELC DEIS Comment No. 11, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 10. *Other development threats to Goodwill Plantation in the mitigation plan are significantly overstated since no water or sewer infrastructure is currently available in the area and is unlikely to be available. The suggested development potential is inconsistent with and contrary to the Lower Richland Master Plan recently approved by Richland County Council. Both Cook's Mountain and Goodwill Plantation are within the Cowasee Basin Focus area which is to be preserved under the master plan. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 3, paragraph (1)(x).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 10. Haile's Mitigation Plan identifies potential development threats to the mitigation properties. The Goodwill Plantation property is located approximately 15 miles east of the City of Columbia, adjacent to the Wateree River and includes approximately 1500 upland acres. The property is adjacent to US Hwy 76/378, a four lane highway and ± 15 miles from I-77. The property is currently zoned RU in Richland County which provides for agriculture uses and low density residential development.

The future of the Goodwill Plantation property in private ownership is far from certain. The SC Budget and Control Board Office of Research and Statistics projects population growth in the state of 17.9% through 2030. South Carolina actively recruits and is attractive to new and expanding industry and commerce with relatively low labor costs and corporate taxes and excellent highway, rail and port access. The US Department of Commerce Bureau of Economic Analysis ranks South Carolina as the 12th fastest growing state economy in the nation and tied with North Carolina as the fastest growing state on the east coast.

Given this projected population growth and subsequent demand for economic growth and development in South Carolina, large accessible land tracts within close proximity to an urban labor force will continue to attract attention and be evaluated by residential, industrial and commercial development interests.

Richland County Council Chairman Norman Jackson Comment No. 11. *The July 19, 2013 Joint Public Notice stated 120.46 acres of jurisdictional, freshwater wetlands and 26,460 linear feet of streams would be impacted by the mine. The DEIS (Table 4.6-6) now indicates total*

(direct and indirect) impacts on 1,083 acres of wetlands and 128,948 linear feet of streams. A total of 733 acres (76%) of the indirect wetlands impacts and 68,758 linear feet (67%) of the indirect stream impacts are classified as major. It is my opinion the proposed HGM mitigation plan is inadequate to compensate for both the direct and indirect impacts and should be significantly modified (by requiring restoration and enhancement) or rejected, especially given the 10-fold increase in wetlands impacts and five-fold increase in stream impacts stated in the DEIS compared to the original direct impacts. See Richland County Council Chairman Norman Jackson Comment Letter at p. 3, paragraph (1)(xi).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 11. *See* Haile Response to EPA DEIS Comment No. 12, submitted to the USACE on May 30, 2014.

Richland County Council Chairman Norman Jackson Comment No. 12. *I question the rational for using only four counties (Lancaster, York, Kershaw and Richland Counties) in the regional economic analysis. Please provide the rational for including only four counties and why other adjacent counties such as Chester, Chesterfield, Fairfield, Darlington, Lee and Sumter are not included. I am also requesting the specific reason(s) why Richland County was included and whether or not the location of the proposed landscape-scale mitigation properties in Richland County was a deciding factor for inclusion. See* Richland County Council Chairman Norman Jackson Comment Letter at pp. 3-4, paragraph (2)(i).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 12. The regional economic analysis in the DEIS is not limited to only four counties, as suggested in this comment. As stated in the DEIS, "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." DEIS, p. 4.10-1 & -2. The USACE has additional regional economic information in the DEIS Record that extends beyond Lancaster, York, Kershaw and Richland Counties. *See* Haile Response to RAI 2-SE-01-g, Regional Analysis – Economic Impact of the Haile Gold Mine, provided to the USACE on September 7, 2012.

Richland County Council Chairman Norman Jackson Comment No. 13. *I am requesting Table 4.10-4a and Table 4.10-5a be revised to include specific information on the economic effects (output, labor and employment) in each of the four counties included in the regional analysis. The composite data are insufficient to determine the direct and indirect benefits to each county from the mine development and operation. These composite data are also insufficient to determine the direct and indirect economic effects (if any) associated with the proposed mitigation plan component in Richland County (Cook's Mountain and Goodwill Plantation). Inclusion of individual county data would (1) provide a partial answer to my comment concerning why the regional analysis included the selected four counties and (2) is consistent with the data format in Table 4.10-7, Estimated Taxable Sales and Sales Tax Revenue. Comparison of County-level economic effects (output, labor and employment) and tax data will*

provide an improved understanding of the socio-economic and EJ benefits associated with the mine. See Richland County Council Chairman Norman Jackson Comment Letter at p. 4, paragraph (2)(iv).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 13. The regional economic analysis in the DEIS satisfies Executive Order 12898, EPA's Draft Final Guidance for Assessing Environmental Justice in Regulatory Analysis and NEPA disclosure requirements, and need not include all of the information in the EIS Record relied upon by the USACE.

Richland County Council Chairman Norman Jackson Comment No. 14. *The DEIS should include a comparison of the direct and indirect county-level economic impacts from Chapter 4 with the regional economic data contained in 3.10.3 Regional Economy. This would enable an analysis of the significance of the economic benefits of mine development and operations with the current county-level economic data. For example, Table 3.10-6b, Employment by Industry in the Study Area and State, shows a total employment of 417,162 in 2009. Comparing these data to the estimated employment in Table 4.10-9a indicates total employment resulting from the mine is approximately one-tenth of one percent of the 2009 employment in the study area. In fact, the Target Corporation alone – "a 1.8-million square-foot regional distribution center located in Lugoff" has 580 employees, an amount equal to the maximum estimated direct and indirect employment resulting from the mine. See* Richland County Council Chairman Norman Jackson Comment Letter at pp. 4-5, paragraph (2)(v).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 14. The regional economic analysis in the DEIS satisfies Executive Order 12898, EPA's Draft Final Guidance for Assessing Environmental Justice in Regulatory Analysis and NEPA disclosure requirements, and need not include a comparison of the direct and indirect county-level economic impacts from Chapter 4 with the regional economic data contained in 3.10.3 Regional Economy.

Richland County Council Chairman Norman Jackson Comment No. 15. *Based on the requirements of Executive Order 12898 and EPA's Interim Guidance, it is my opinion that the proposed mitigation properties in Richland County must provide benefits to the EJ communities in Richland County. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 5, paragraph (3)(i).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 15. E.O. 12898 states, in relevant part, that: "[e]ach Federal agency shall conduct its programs, policies, and activities that *substantially affect human health or the environment*, in a manner that ensures that such programs, policies, and activities do not have the effect of *excluding persons* (including populations) from participation in, *denying persons (including populations) the benefits of*, or subjecting persons (including populations) to discrimination under, such programs, policies, and activities, because of their race, color, or national origin." (E.O. 12898, Sec. 2-2) (emphasis added). Per EPA's Interim Guidance, "When impacts or benefits will not be quantified or disaggregated by race/ethnicity or income, analysts should present information that is insightful with regard to potential EJ concerns (e.g., basic demographic information, and evidence of differential exposure)." E.O. 12898, EPA's Interim Guidance and NEPA do not require that the proposed

mitigation properties provide benefits to EJ communities, as suggested in this comment, only that the USACE consider whether any benefits from these properties will be equally available to EJ communities in Richland County as non-EJ communities in Richland County. As the DEIS discloses that the mitigation properties will be transferred to the SCDNR and managed pursuant to the SC Heritage Trust Program, this adequately addresses any EJ concerns and satisfies NEPA disclosure requirements.

Richland County Council Chairman Norman Jackson Comment No. 16. *The USACE should quantify the benefits to the EJ communities in the study area in the EIS. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 6, paragraph (3)(ii).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 16. Per EPA's Interim Guidance, "When impacts or benefits will not be quantified or disaggregated by race/ethnicity or income, analysts should present information that is insightful with regard to potential EJ concerns (e.g., basic demographic information, and evidence of differential exposure)." As the DEIS discloses that the mitigation properties will be transferred to the SCDNR and managed pursuant to the SC Heritage Trust Program, this adequately addresses any EJ concerns and satisfies NEPA disclosure requirements.

Richland County Council Chairman Norman Jackson Comment No. 17. *[T]he proposed mitigation plan should be rejected or amended to provide benefits to the study area, particularly to Richland County's EJ communities near the Cook's Mountain and Goodwill Plantation mitigation sites. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 6, paragraph (3)(ii).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 17. *See* Haile Response to Richland County Council Chairman Norman Jackson Comment No. 15, *supra.*

Richland County Council Chairman Norman Jackson Comment No. 18. *Table 3.10-3, Table 3.10-4 and Table 3.10-5 fail to provide any census tract-level data for Richland County. Such data should be included since numerous census tracts in Lower Richland County contain EJ and low-income communities. EPA-EJView also indicates EJ communities in Lower Richland have been negatively impacted by prior environmental permitting including, but not limited to, landfills, a coal-fired power plant with a leaking ash pond, a paper mill, a wastewater treatment plant and a nuclear fuel processing facility, Superfund and RCRA sites. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 6, paragraph (3)(iii).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 18. Per EPA's Interim Guidance, "When impacts or benefits will not be quantified or disaggregated by race/ethnicity or income, analysts should present information that is insightful with regard to potential EJ concerns (e.g., basic demographic information, and evidence of differential exposure)." As the DEIS concludes that there are no potential EJ concerns from the Haile Gold Mine project, which is sited based upon the location of the gold mineralization, the DEIS need not provide census tract-level data for Richland County.

Richland County Council Chairman Norman Jackson Comment No. 19. *Because of the mitigation properties located in Lower Richland County, these data must be included to*

demonstrate benefits to those communities consistent with Executive Order 12898 and EPA's Interim Guidance. Richland County includes Columbia, numerous academic institutions and significant business enterprises. Therefore including county-level census data for Richland County fails to accurately quantify the EJ communities in ***Lower Richland*** *near the mitigation properties. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 6, paragraph (3)(iv).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 19. *See* Haile Response to Richland County Council Chairman Norman Jackson Comment Nos. 15 & 18, *supra.*

Richland County Council Chairman Norman Jackson Comment No. 20. *I am of the opinion these properties and the mitigation plan can provide significant direct and indirect economic development benefits to Richland County and the State from ecological and heritage-based tourism similar to those derived from Congaree National Park. In addition, the County is actively promoting eco and heritage-based tourism as a part of the Lower Richland Master Plan. Coupled with the County's recent purchase of approximately 1,800 acres of wetlands and streams at Mill Creek (Congaree River Basin), Mill Creek, Cook's Mountain, Goodwill Plantation and the Congaree National Park could provide significant synergies for eco and heritage tourism to the EJ communities in Lower Richland. In no way does the use of mitigation properties for eco and heritage tourism detract from the conservation values of the properties or negatively impact any restored wetlands or streams. Based on the limited information provided by SCDNR on how these properties will be used and managed, it seems unlikely such benefits could accrue even under the Heritage Trust Program. See* Richland County Council Chairman Norman Jackson Comment Letter at p. 7, paragraph (3)(v).

Haile Response to Richland County Council Chairman Norman Jackson Comment No. 20. *See* Haile Response to Richland County Council Chairman Norman Jackson Comment Nos. 15 & 18, *supra.*

Richland County Councilman Kelvin Washington Comment Nos. 1-20. These comments are the same as provided by Richland County Chairman Norman Jackson, *supra.*

Haile Response to Richland Councilman Kelvin Washington Comment Nos. 1-20. *See* Haile Response to Richard County Council Chairman Norman Jackson Comments Nos. 1-20, *supra*.

Haile Gold Mine, Inc.'s Response to the Council of South Carolina Professional Archaeologists Comments Received by the United States Army Corps of Engineers on the Haile Gold Mine Draft Environmental Impact Statement

Submitted May 30, 2014

Haile Gold Mine, Inc.'s (Haile) Response to the Council of South Carolina Professional Archaeologists (COSCAPA) Comments Received by the United States Army Corps of Engineers (USACE) on the Haile Gold Mine Draft Environmental Impact Statement (DEIS) has been prepared to the best of Haile's ability, based upon information that is currently and reasonably available.

Council of South Carolina Professional Archaeologists (COSCAPA) Comment No. 1. *We encourage the USACE to continue consultation with the State Historic Preservation Office and the Catawba Indian Nation (which is a cooperating agency for this undertaking) in order to identify reasonable measures that will mitigate adverse effects to site types that can be uniquely addressed by the resources within the Haile Gold Mine project area. We recommend that the final CRMP address this issue and the identification of sites within a mitigation bank, as well as explain how any mitigation bank or alternate form of mitigation would effectively compensate for the loss of information caused by the destruction of sites within the project area. See* COSCAPA Comment Letter at p. 1, 4th paragraph.

Haile Response to COSCAPA Comment No. 1. At the time the DEIS was published, Haile had proposed a compensatory cultural resources management and mitigation plan (CRMMP) as an alternative to traditional data recovery oriented mitigation for certain sites on the Project site. Since the DEIS was published, based upon consultation with South Carolina State Historic Preservation Office (SHPO) and the USACE, Haile will follow the traditional course of data recovery oriented mitigation. On this basis, it appears that COSCAPA's comments regarding alternative mitigation have been addressed.

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APPENDIX P3

APPLICANT RESPONSES TO SCDHEC REQUEST FOR INFORMATION FOR SECTION 401 CERTIFICATION

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P3 APPLICANT RESPONSES TO SCDHEC REQUEST FOR INFORMATION FOR 401 CERTIFICATION

Appendix P3 contains the Applicant's response to the SCDHEC Information Request on the Haile Gold Mine application for a Section 401 Water Quality Certification.

HAILE GOLD MINE, INC.

June 9, 2014

VIA ELECTRONIC TRANSMISSION
AND OVERNIGHT DELIVERY

Alicia Rowe
Project Manager
Water Quality Certification and Wetlands Section
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201

Re: SAC 1992-24122-4IA; Haile Gold Mine; Water Quality Certification
Request for Information

Dear Ms. Rowe:

This letter provides Haile Gold Mine, Inc.'s (Haile's) Response to the South Carolina Department of Environmental Control (SCDHEC) Information Request on the Haile Gold Mine application for a Section 401 Water Quality Certification, letter dated May 12, 2014. These responses have been prepared to the best of Haile's ability, based upon information that is currently and reasonably available.

SCDHEC Information Request No. 1: *Based on the water quality models performed by Schafer Limited, LLC, there is a possibility that some constituents may exceed State water quality standards in Ledbetter Pit Lake after it has been filled and begins releasing surface water flows to Haile Gold Mine Creek downstream of the pit lake. Please provide an adaptive management plan that will explain monitoring and management options for assuring that the water quality of flows released to Haile Gold Mine Creek from Ledbetter Pit Lake will meet State water quality standards.*

Haile's Response to SCDHEC Information Request No. 1: An adaptive management element will be added to the Haile Monitoring and Management Plan for the Ledbetter Pit Lake system. Adaptive Management is a structured and data-driven decision process that employs monitoring and modeling (if appropriate) to manage environmental systems.

7283 Haile Gold Mine Road, P.O. Box 128, Kershaw, South Carolina 29067 USA
Telephone (803) 475-1220, Facsimile (803) 475-2317

For the Ledbetter Pit Lake system, water chemistry predictions have been developed for various years after mining ends and the Pit Lake begins to fill with meteoric water and groundwater. The reclamation and closure plan assumes the following:

- Flow from upper Haile Gold Mine Creek (HGMC) will be diverted around the Ledbetter Pit Lake during filling, with anywhere from 69 to 400 gpm of water allowed to run into the Pit Lake to accelerate filling (so long as such diversion leaves the requisite minimum in-stream flow in HGMC required by South Carolina surface water withdrawal regulation).
- Lime or limestone will be added to Ledbetter Pit Lake as needed to maintain neutral pH conditions.
- After Ledbetter Pit Lake is full, all water in upper HGMC will flow through the lake.

The Ledbetter Pit Lake is expected to fill and begin outflow to Haile Gold Mine Creek in about 13 years after groundwater depressurization ceases. When outflow from Ledbetter Pit Lake begins, the main predicted water chemistry changes in HGMC (from its baseline condition) are:

- pH and alkalinity will increase;
- Calcium and sulfate will increase to about 279 and 647 mg/L, respectively, and TDS will increase to about 1,048 mg/L; and
- Other major ions and some metals will increase above baseline levels found in HGMC.

Given the potential uncertainty in predictive models, the following adaptive management measures are proposed.

Water quality monitoring of Ledbetter Pit Lake will be conducted each year for the first three years of filling and then every third year until Ledbetter Pit Lake is nearly full. When Ledbetter Pit Lake is within 2 years of initial outflow, quarterly monitoring will be initiated, and all results will be reported annually. The Pit Lake water level, volume (calculated), and basic water quality parameters (pH, EC, temperature, depth, and dissolved oxygen) will be logged vertically using a Hydroprobe or similar device. Water samples will be collected from four or more depths including, at a minimum, the following:

- Upper foot,
- Base of epilimnion if stratification is evident (otherwise 10 feet),
- Upper hypolimnion if stratification is evident (otherwise 50 feet), and
- Approximately five feet above the base of the lake.

Samples will be analyzed for pH, total dissolved solids, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, boron, fluoride, nitrate, orthophosphate, silica, aluminum, antimony, arsenic, barium, cadmium, copper, iron, lead, manganese, mercury, nickel, selenium, thallium, and zinc. Metals will be analyzed in their dissolved and total recoverable form. In addition, for surface water samples collected 1 year prior to initial outflow from Ledbetter Pit Lake, Whole Effluent Toxicity (WET) tests will be performed using suitable test organisms.

A hydrologic model and water quality model will be re-calibrated based on updated hydrologic information (e.g. Modflow model) and water quality data three years after filling begins and again one year prior to outflow.

If any constituents in the surface samples of Ledbetter Pit Lake collected one year prior to outflow exceed water quality criteria and fail the WET test, then an evaluation will be conducted to identify the potential toxicity and to develop methods to either eliminate the toxicity or delay outflow from the pit lake. Measures that can be used to delay or avoid outflow would include:

- entirely diverting upper HGMC around the Ledbetter Pit Lake,
- pumping a portion of the Ledbetter Pit Lake water to a water treatment system or polishing pond, or
- pumping and land-applying water from the Ledbetter Pit Lake.

Once outflow from Ledbetter Pit Lake begins, the surface water in Ledbetter Pit Lake will be added as a routine monitoring point to the surface water monitoring program. If water quality exceedances occur downgradient of the Pit Lake, the depth sampling, modeling and WET testing described above will be conducted to assess the nature of the causes of water quality degradation. Appropriate response measures will be determined in cooperation with SCDHEC. Until the water quality in Ledbetter Pit Lake has achieved satisfactory levels for a sufficient period of time, as an adaptive management measure, Haile is committed to leaving the Haile Gold Mine Creek diversion in place in the event that Haile needs to reverse the Haile Gold Mine Creek pass through of Ledbetter Pit Lake to a full (or partial) diversion around the Pit Lake while any water quality issues in the Pit Lake are resolved.

SCDHEC Information Request #2: *Please provide an explanation of how the outlet structure for the discharge of depressurization well water into Haile Gold Mine Creek will be designed to ensure proper aeration of the water before it reaches the stream.*

Haile's Response to SCDHEC Information Request No. 2: The following response has been prepared by Haile for the above request. For reference, and as included in the DEIS, Appendix A, the proposed designs of the two types of outlet structures are shown below:

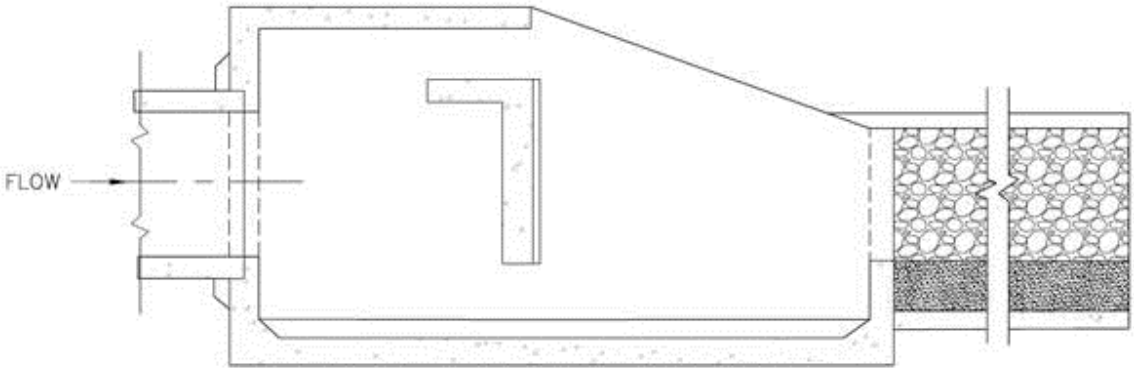
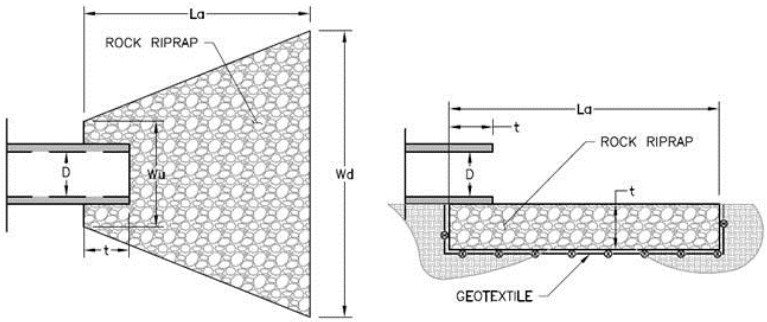


Figure A-40 Diversion Pipe Energy Dissipation

Source: Haile Gold Mine, Inc. 2013

Note: Dimension of individual impact basins to follow USBR sizing recommendations



ROCK OUTLET PROTECTION APRON DIMENSIONS						
CULVERT SIZE D (IN)	ROCK SIZE d_{50} (IN)	APRON LENGTH La (FT)	UPSTREAM WIDTH Wu (FT)	DOWNSTREAM WIDTH Wd (FT)	THICKNESS t (IN)	QUANTITY (TONS)
12	6	12	3	13	12	15
18	9	16	4.50	18	24	20
21	9	18	5	20	24	35
24	9	20	6	22	24	60

Figure A-37 Typical Apron Design for the Depressurization Tanks and the Contact Water Treatment Plant NPDES Outfalls

Source: Haile Gold Mine, Inc. 2013.

Both of the outlets illustrated above were designed primarily to achieve energy dissipation. Despite this primary objective, the diversion pipe energy dissipater will aerate the water in two ways. The water that comes out the end of the pipe will strike against the baffle, which will aerate the water. The apron outfall is intended to slow down and spread out the water so that is it less erosive to downstream areas; this will also provide additional aeration. The exact quantification of the amount of aeration from either of the two outlets is not possible *a priori*, as

oxygenation amounts will be dependent on as-built dimensions and other factors such as outflow rate and ambient temperature.

It also should be noted that aeration will occur before the water reaches the energy dissipation structure, as a result of the process of pumping and conveying the water to the energy dissipation structure. Specifically, the pumped water will be conveyed in a pipeline to the open top holding tank where it will be dropped into the top part of the tank, providing further aeration prior to being released via the designed energy dissipation structure.

For a period of time when the system is first operating, Haile will monitor the dissolved oxygen levels prior to the water entering lower Haile Gold Mine Creek to ensure the effectiveness of the dissipation structure in aerating the water from the depressurization wells.

Existing dissolved oxygen levels measured during Haile's aquatic surveys show a wide variation among different reaches, but were generally above 5 mg/L, which is within levels that are typical for blackwater streams. State of South Carolina water quality standards identify a dissolved oxygen level of 4 mg/L as the lower limit for Class A (non-trout) water (USEPA 1988).

References:

AMEC. 2012. Addendum to the Baseline Hydrologic Characterization Report. June 27.

ARCADIS. 2012a. Comprehensive Baseline Wildlife and Aquatic Resources Report for the Haile Gold Mine Site Lancaster County, South Carolina Revision: July 20, 2012.

ARCADIS. 2012b. Spring 2012 Aquatic Resource Surveys Report. Prepared for Haile Gold Mine, Inc. June 19.

Schlumberger. 2010. Haile Gold Mine Baseline Hydrologic Characterization Report. November.

USEPA. 1988. State water quality standards summary: South Carolina. EPA/440/5-88-076. Office of Water Regulations and Standards, Washington, D.C.

SCDHEC Information Request #3: *It is our understanding that post-closure water quality predictions for onsite surface waters can be estimated from the existing water quality models performed for the project. Please provide estimated water quality predictions for Haile Gold Mine Creek between Ledbetter Pit Lake and Haile Gold Mine Creek's confluence with the Little Lynches River.*

Haile's Response to SCDHEC Information Request No. 3:

Mass Load Model Description

A surface water predictive model was developed to evaluate potential water quality changes that may occur in the Little Lynches River (LLR) after mine closure (Schafer, AMEC and ERC 2013). Subsequently, the groundwater model used as input to the surface water model was revised. Consequently, the surface water model was also revised. Results of the revised modeling are described in a series of Technical Memoranda (Newfields and Schafer Limited 2013, and Schafer Limited 2013a, 2013b, 2013c, and 2014 - see Annotated References below).

This modeling provided a conservative estimate of water quality just below the confluence of Haile Gold Mine Creek (HGMC) and the LLR, based on the assumptions that all pollutant loadings from mine facilities would reach this assessment point immediately (rather than via transport over time) and without any dilution, attenuation, or dispersion.

Estimating Water Quality in Haile Gold Mine Creek

SCDHEC has asked Haile to provide estimated water quality upstream of the confluence of HGMC and the LLR. Existing models can be used to predict water chemistry at two locations in HGMC: 1) just below the outflow from Ledbetter Pit Lake where all of the surface water in HGMC is derived from the Pit Lake, and 2) HGMC just above its confluence with the LLR.

Model Interpretation

The mass load model does not account for chemical transformations that are likely to occur during transport. Ignoring these effects will tend to cause the mass load model to overestimate concentrations for those ions that may undergo transformations. Oxidation of subsurface waters that enter stream channels will tend to reduce iron and manganese concentrations due to redox effects. Nitrate is likely to undergo biological transformations that limit its transport in surface water. Highly acidic water, such as the Johnny's PAG seepage, will undergo neutralization reactions that remove most of its dissolved chemical mass within a short distance of the Johnny's PAG facility. Consequently, nitrate and metal ion concentrations are most likely to be overestimated in the mass load model. The pit lake model accounts for these chemical effects.

Modeled estimates of ion concentration that were within three times the minimum analytical detection level (MDL) were assumed to be less than detection in all simulations. The MDL is the lowest concentration in water that can be detected using accepted analytical methods. When an ion is less than the MDL, it means that it cannot be detected in the sample. Rather than report the concentration as zero, standard practice is to report the concentration as less than the MDL. However, when the model results were interpreted, the MDL value used for each constituent was assumed to be three times the analytical laboratory MDL for two reasons.

First, the Ledbetter Pit Lake is one of the primary post-closure sources of water and chemical loading in HGMC. Water entering the pit undergoes evaporation, and when there is net evaporation, soluble ions increase so that an adjustment to the detection level is needed (see insert below). For example, if water flowing into the pit lake was less than detection at an MDL of <1 mg/L and then underwent evaporation that caused a 50% volume reduction, the calculated concentration would become <2 mg/L, even though this value is higher than the original MDL.

The second reason for the adjustment to the MDL is because of the way that the chemistry of certain pit lake components and overburden seepage waters was calculated. A series of empirical equations were developed that relate ion concentration to pH level. These equations were derived from on-site water quality samples that represent a wide range in pH (Figure 1). Three equations were developed for each constituent corresponding to the upper and lower bounds and the central tendency of the pH-ion concentration trends. In order to produce conservative model predictions, the upper bound model was used for all metals. In Figure 1 for arsenic, it is apparent that the measured arsenic was less than the MDL for most samples above a pH of 3.5 at Haile. Various samples had an MDL of either <0.01 mg/L (older data) or <0.005 mg/L (newer data). However, in this pH range, the upper bound model yields estimated arsenic values closer to 0.08 to 0.09 mg/L, which is 16 to 18 times the MDL value of 0.005 mg/L. So

even though the assigned arsenic concentration was 0.08 mg/L, it should be understood to be <0.08 mg/L because arsenic in this pH range is not detectable in Haile waters. Based on these factors, which tend to increase the estimated values of constituents that are at the MDL, it is reasonable to assume that predicted values in the model that are three times the MDL (or less) should be interpreted as "non detectable."

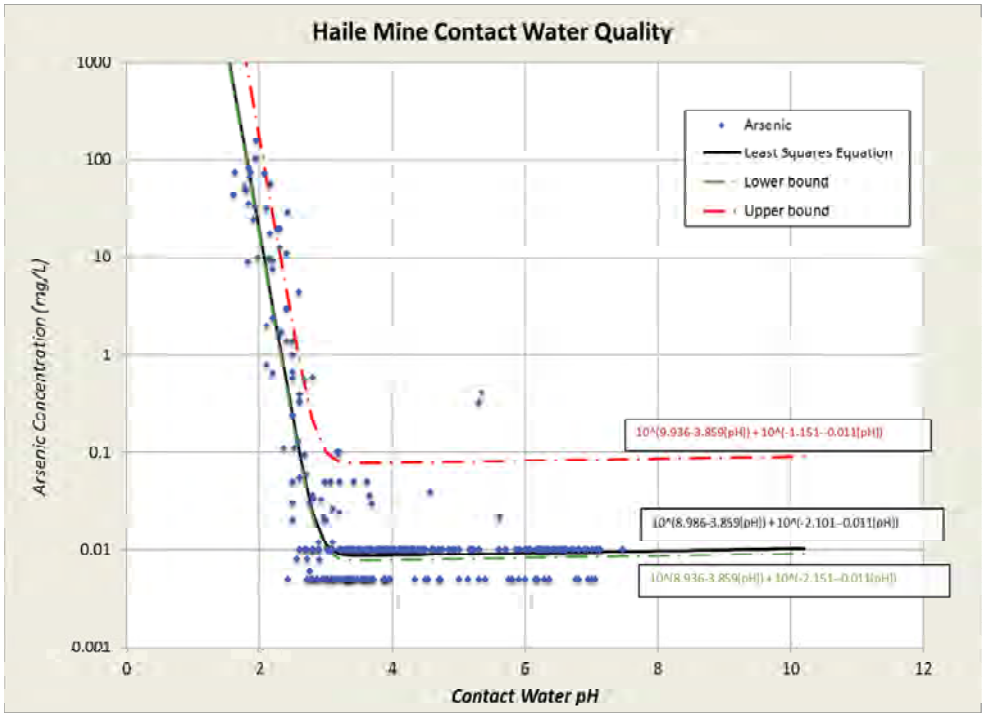


Figure 1. pH/arsenic concentrations at Haile and equations derived to describe lower bounds, upper bounds and central tendency of the pH-concentration trends.

Accounting for Oxidizing Conditions, Mineral Precipitation and Sorption in Mass Load Model Results

The effect of oxidation on the ion concentrations predicted by the mass load model was evaluated by employing a geochemical model (e.g. PHREEQC) to assess the effect of equilibrium between the predicted water quality and atmospheric oxygen and carbon dioxide. Equilibration with atmospheric gases is expected to occur in a surface water environment even though it was not originally simulated in the mass load model. The equilibration reactions were simulated in PHREEQC by:

- entering the simulated HGMC concentrations simulated in the mass load model into PHREEQC;
- allowing the model to adjust the sulfate concentration to achieve an overall ion charge balance;
- equilibrating the water with atmospheric carbon dioxide at $10^{-3.5}$ atmospheres partial pressure;

- equilibrating the water with atmospheric oxygen at a fugacity that would achieve a target redox of 400 mv at a pH of 7 ($10^{-28.08}$ atmospheres) – the pH plus pe (i.e., redox potential) was held constant at 13.78 for waters that differed from pH 7;

- equilibrating the water with the same solids that were permitted to form in the pit lake model; and

- allowing constituents in the water to sorb onto any ferrihydrite that may form in the step above using the same model assumptions as were used in the pit lake model.

Conditions Simulated

A variety of surface water flow conditions and time periods were simulated for HGMC below Ledbetter Pit Lake and just above the confluence of HGMC and LLR. Water chemistry in HGMC just below Ledbetter Pit Lake is not expected to change at different flow regimes owing to the mixing that will occur in the Pit Lake. Consequently, the Ledbetter Pit Lake model results for years 13, 30 and 75 were used to estimate the water chemistry for this reach (Table 1).

For the reach of HGMC just above its confluence with LLR (Table 1), water chemistry was predicted for median flow, average annual low flow and 7Q10 flow (minimum 7-day averaged flow that occurs once in 10 years). These flow regimes were estimated from the 50th, 5th and 1st percentile on a flow frequency curve. Details on the model development can be found in Schafer, AMEC and ERC and Schafer 2013b. Simulations were completed for years 13, 30 and 75.

Table 1. Simulations used to assess water chemistry in Haile Gold Mine Creek below Ledbetter Pit Lake and just above the Little Lynches River confluence.

Simulation	Reach	Time	Flow Frequency
Runs 51-59 (Pit Lake) [1]	HGMC below Ledbetter	Year 13	All
Runs 51-59 (Pit Lake)	HGMC below Ledbetter	Year 30	All
Runs 51-59 (Pit Lake)	HGMC below Ledbetter	Year 75	All
Run 0 (baseline)	Baseline HGMC	Pre-Mine	Average
Run 1	HGMC at LLR	Year 13	50% (median flow)
Run 2	HGMC at LLR	Year 13	5% (annual low flow)
Run 3	HGMC at LLR	Year 13	1% (7Q10 flow)
Run 4	HGMC at LLR	Year 30	50% (median flow)
Run 5	HGMC at LLR	Year 30	5% (annual low flow)
Run 6	HGMC at LLR	Year 30	1% (7Q10 flow)
Run 7	HGMC at LLR	Year 75	50% (median flow)
Run 8	HGMC at LLR	Year 75	5% (annual low flow)
Run 9	HGMC at LLR	Year 75	(7Q10 flow)

1 – Ledbetter Pit Lake runs 51 to 59 were stochastic simulations – the median result was used above

Predicted Water Quality – HGMC below Ledbetter Pit Lake

Water quality results for the reach of HGMC below Ledbetter Pit Lake are the same as for the pit lake model (Table 2 Schafer 2013a). Concentrations of calcium, sulfate and TDS showed the largest increases in HGMC below Ledbetter Pit Lake relative to baseline chemistry. These constituents reflect reaction products of neutralized acid rock drainage, with sulfate derived from pyrite oxidation, and calcium from lime added for pH control. Many other major ions including magnesium, sodium, bicarbonate, and nitrate increased by at least three-fold relative to baseline chemistry but predicted concentrations remain below 10 mg/L (to 86 mg/L for bicarbonate in year 13). Potassium, chloride, boron, fluoride, phosphate and silica remained close to baseline concentrations for HGMC.

Predicted concentrations for most metals were below the simulation quantitation limit except for barium, iron, manganese, thallium and zinc. Predicted barium remained within a factor of three of baseline chemistry while the remaining metals had predicted concentrations that were more than three times baseline levels in some years.

Table 2. Average predicted water quality in Haile Gold Mine Creek below Ledbetter Pit Lake for Years 13, 30 and 75.

Constituent (mg/L)	**Baseline HGMC**	**HGMC below Ledbetter Pit Lake**		
	Run 0	**Year 13**	**Year 30**	**Year 75**
pH (S.U.)	4.71	7.25	6.05	5.36
Total Dissolved Solids	38	**1,048**	**440**	102
Calcium	1	**279**	**110**	**12**
Magnesium	0.4	**5.6**	**3.4**	**1.8**
Sodium	1.5	**7.4**	**5.2**	4.1
Potassium	1.0	1.8	1.2	0.8
Alkalinity, HCO3	5	**86**	**16**	11
Sulfate	5	**647**	**285**	**46**
Chloride	5.0	4.7	3.9	3.3
Boron	0.1	0.1	0.1	0.1
Fluoride	1.0	0.0	0.0	0.0
Nitrate as N	0.1	**0.9**	**0.5**	0.2
Orthophosphate	0.1		0.1	

Constituent (mg/L)	Baseline HGMC	HGMC below Ledbetter Pit Lake		
	Run 0	Year 13	Year 30	Year 75
		0.1		0.1
Silica	7.9	18.3	14.4	12.5
Aluminum	0.252	0.004	0.008	0.049
Antimony	0.005	0.015	0.008	0.003
Arsenic	0.003	0.000	0.001	0.003
Barium	0.012	0.022	0.018	0.015
Cadmium	0.001	0.000	0.000	0.000
Copper	0.005	0.000	0.002	0.005
Iron	0.2	0.0	**1.7**	**1.1**
Lead	0.002	0.000	0.000	0.000
Manganese	0.015	**1.425**	**0.652**	**0.192**
Mercury	0.0002	0.0002	0.0002	0.0002
Nickel	0.004	0.009	0.009	0.005
Selenium	0.003	0.000	0.001	0.002
Thallium	0.001	**0.004**	0.002	0.001
Zinc	0.024	0.023	**0.076**	**0.104**

Constituents in gray are below detection level
Constituents in red are more than 3 times the background level

Predicted Water Quality – HGMC just above the LLR

Results in this section are based on mass load model results prior to adjustment for geochemical equilibrium of the simulated water with atmospheric oxygen and carbon dioxide, mineral precipitation and sorption (see next section for discussion of these effects). Predicted concentrations of major ions in lower HGMC just above the confluence with the LLR were similar to results for HGMC below Ledbetter Pit Lake, and water chemistry in HGMC did not vary significantly between different flow regimes. This is because Ledbetter Pit Lake dominates stream water chemistry from the lake to the confluence with LLR, especially in year 13 (Table 3) and 30 (Table 4). By year 75 (Table 4), water quality emanating from Ledbetter Pit Lake will become more similar to baseline HGMC so water chemistry shows improvement through time. At low flows in year 75, predicted water chemistry in HGMC at LLR was better than at median flows.

Predicted metal behavior in HGMC at the LLR was mostly similar to HGMC below Ledbetter Pit Lake except that predicted antimony, arsenic, and nickel were slightly higher owing to simulated mass contributions from other mine facilities such as the backfilled pits.

Table 3. Average predicted water quality in Haile Gold Mine Creek just above the confluence with Little Lynches River for year 13 (Runs 0 to 3).

Constituent (mg/L)	No Action	HGMC above LLR, Year 13		
	Run 0	Run 1 (median flow)	Run 2 (annual low flow)	Run 3 (7Q10 flow)
pH (S.U.)	4.71	6.30	7.15	7.18
Total Dissolved Solids	38	**1,104**	**1,105**	**1,105**
Calcium	1	**281**	**288**	**288**
Magnesium	0.4	**5.3**	**5.6**	**5.6**
Sodium	1.5	**7.2**	**7.3**	**7.3**
Potassium	1.0	1.8	1.8	1.8
Alkalinity, HCO3	5	**112**	**110**	**110**
Sulfate	5	**636**	**644**	**644**
Chloride	5.0	4.6	4.7	4.7
Boron	0.1	0.1	0.1	0.1
Fluoride	1.0	0.2	0.1	0.1
Nitrate as N	0.1	0.3	0.1	0.1
Orthophosphate	0.1	0.0	0.0	0.0
Silica	7.9	20.1	18.8	18.7
Aluminum	0.252	0.234	0.058	0.051
Antimony	0.005	**0.016**	**0.016**	**0.016**
Arsenic	0.003	**0.010**	0.003	0.002
Barium	0.012	0.020	0.021	0.021
Cadmium	0.001	0.001	0.001	0.001
Copper	0.005	0.005	0.001	0.001
Iron	0.2			

Constituent (mg/L)	No Action	HGMC above LLR, Year 13		
	Run 0	Run 1 (median flow)	Run 2 (annual low flow)	Run 3 (7Q10 flow)
		2.7	**0.7**	0.6
Lead	0.002	0.003	0.001	0.001
Manganese	0.015	**1.216**	**1.365**	**1.371**
Mercury	0.0002	0.0002	0.0002	0.0002
Nickel	0.004	**0.016**	0.011	0.011
Selenium	0.003	0.001	0.000	0.000
Thallium	0.001	**0.005**	**0.004**	**0.004**
Zinc	0.024	0.030	0.025	0.025

Constituents in gray are below detection level
Constituents in red are more than 3 times the background level

Table 4. Average predicted water quality in Haile Gold Mine Creek just above the confluence with Little Lynches River for runs 7 to 12.

Constituent (mg/L)	Year 30			Year 75		
	Run 4 (median flow)	Run 5 (annual low flow)	Run 6 (7Q10 flow)	Run 7 (median flow)	Run 8 (annual low flow)	Run 9 (7Q10 flow)
pH (S.U.)	5.81	5.93	5.93	5.46	5.43	5.43
Total Dissolved Solids	615	501	489	340	170	165
Calcium	**145**	**120**	**117**	**69**	**28**	**27**
Magnesium	**3.6**	**3.4**	**3.4**	**2.4**	**2.0**	**2.0**
Sodium	**5.6**	**5.3**	**5.3**	**4.8**	4.3	4.3
Potassium	1.3	1.2	1.2	1.0	0.9	0.9
Alkalinity, HCO3	**50**	**33**	**32**	**41**	**23**	**23**
Sulfate	**360**	**303**	**297**	**178**	**83**	**80**
Chloride	4.0	3.9	3.9	3.6	3.4	3.4
Boron	0.1	0.1	0.1	0.1	0.1	0.1
Fluoride	0.2	0.1	0.0	0.2	0.1	0.1
Nitrate as N	0.3	0.1	0.1	0.2	0.1	0.1
Orthophosphate	0.1	0.1	0.1	0.1	0.1	0.1

Silica	17.2	15.1	14.9	15.7	13.4	13.3
Aluminum	0.339	0.192	0.178	0.270	0.114	0.110
Antimony	0.010	0.009	0.008	0.007	0.004	0.004
Arsenic	**0.027**	**0.023**	**0.022**	**0.014**	0.007	0.007
Barium	0.017	0.018	0.018	0.015	0.015	0.015
Cadmium	0.001	0.001	0.001	0.001	0.001	0.001
Copper	0.009	0.006	0.006	0.009	0.006	0.006
Iron	**5.7**	**4.4**	**4.3**	**3.8**	**2.1**	**2.1**
Lead	0.003	0.001	0.001	0.003	0.001	0.001
Manganese	**0.615**	**0.638**	**0.639**	**0.273**	**0.218**	**0.216**
Mercury	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Nickel	**0.015**	0.011	0.010	0.012	0.007	0.007
Selenium	0.002	0.001	0.001	0.003	0.002	0.002
Thallium	0.003	0.002	0.002	0.002	0.001	0.001
Zinc	0.071	**0.076**	**0.077**	**0.090**	**0.100**	**0.100**

Constituents in gray are below detection level
Constituents in red are more than 3 times the background level

After adjusting water chemistry for equilibrium reactions that are likely to occur in an oxidizing system such as surface water, several constituents (including iron, lead, arsenic, copper and hydrogen ion activity (inverse log of pH)) decreased by 90 % (Figure 2). Many constituents (including barium, manganese, bicarbonate, zinc, phosphate, nickel and selenium) decreased by 20 % or more. Corrected results for water chemistry are shown in Tables 5 and 6. After equilibrium reactions, both predicted metals and major ions were similar for both HGMC reaches. With few exceptions, predicted results are below or near water quality criteria.

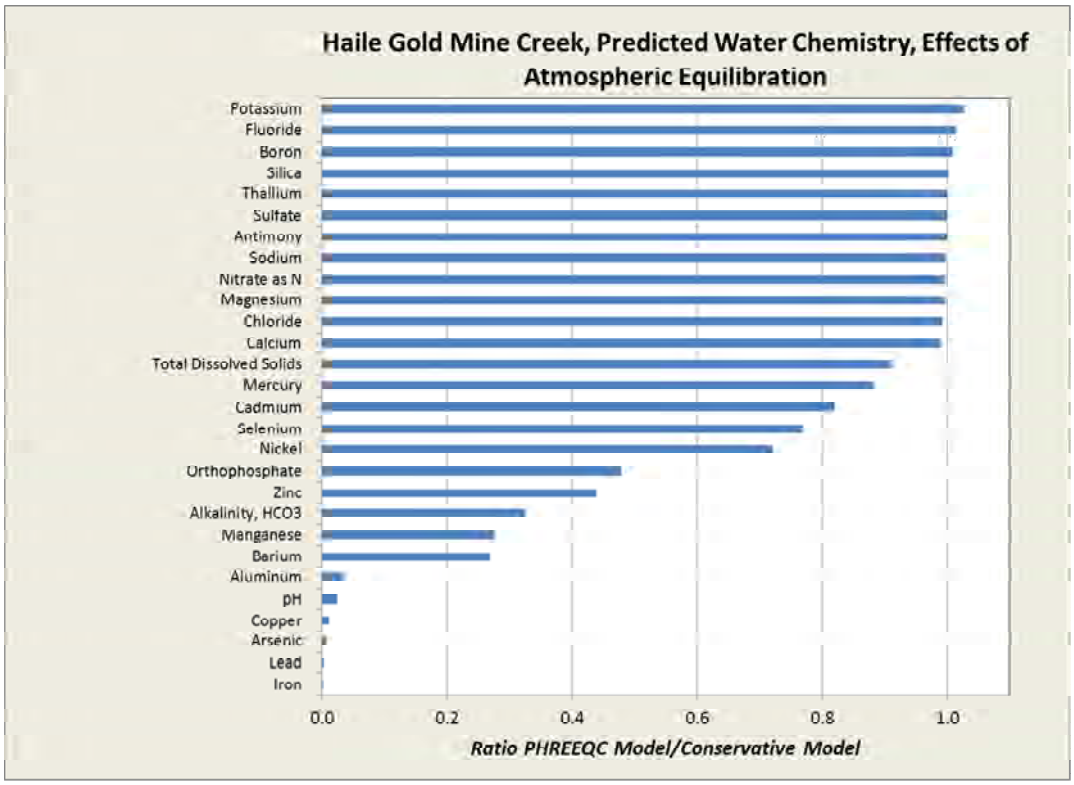


Figure 2. Ratio of predicted water quality in Haile Gold Mine Creek just above the confluence with Little Lynches River with and without geochemical equilibrium effects.

Table 5. Average predicted water quality equilibrated in PHREEQC for Haile Gold Mine Creek just above the confluence with Little Lynches River for runs 0 to 3.

Constituent (mg/L)	No Action	Year 13, Initial Outflow		
	Run 0	Run 1 (median flow)	Run 2 (annual low flow)	Run 3 (7Q10 flow)
pH (S.U.)	4.69	7.90	7.91	7.91
Total Dissolved Solids	20	**1,007**	**1,007**	**1,007**
Calcium	0.5	**278**	**270**	**270**
Magnesium	0.4	**5**	**6**	**6**
Sodium	2	**7**	**7**	**7**
Potassium	1.0	2	2	2
Alkalinity, HCO3	1.0	**36**	**37**	**37**
Sulfate	5.0	**636**	**645**	**645**
Chloride	5.0	4.6	4.7	4.7
Boron	0.1	0.1	0.1	0.1
Fluoride	1.0	0.2	0.1	0.1
Nitrate as N	0.1	0.3	0.1	0.1
Orthophosphate	0.1	0.0	0.0	0.0
Silica	8	20	19	19
Aluminum	0.252	0.008	0.008	0.008
Antimony	0.005	**0.016**	**0.016**	**0.016**
Arsenic	0.003	0.000	0.000	0.000
Barium	0.012	0.005	0.005	0.005
Cadmium	0.000	0.001	0.001	0.000
Copper	0.0050	0.0001	0.0001	0.0001
Iron	0.2025	0.0002	0.0002	0.0002
Lead	0.00150	0.00001	0.00001	0.00001
Manganese	0.015	**0.336**	**0.326**	**0.326**
Mercury	0.0002	0.0002	0.0002	0.0002
Nickel	0.004	0.012	0.011	0.011
Selenium	0.003	0.001	0.000	0.000
Thallium	0.001	**0.005**	**0.004**	**0.004**
Zinc	0.024	0.013	0.020	0.020

Constituents in gray are below detection level
Constituents in red are more than 3 times the background level

Table 6. Average predicted water quality equilibrated in PHREEQC for Haile Gold Mine Creek just above the confluence with Little Lynches River for runs 7 to 12.

Constituent (mg/L)	Year 30			Year 75		
	Run 4 (median flow)	Run 5 (annual low flow)	Run 6 (7Q10 flow)	Run 7 (median flow)	Run 8 (annual low flow)	Run 9 (7Q10 flow)
pH (S.U.)	6.77	6.86	6.84	5.38	5.31	5.31
Total Dissolved Solids	**539**	**455**	**446**	**273**	**134**	**130**
Calcium	**145**	**120**	**117**	**69**	**28**	**27**
Magnesium	**4**	**3**	**3**	**2**	**2**	**2**
Sodium	**6**	**5**	**5**	**5**	4	4
Potassium	1	1	1	1	1	1
Alkalinity, HCO3	**4**	**4**	**4**	1	1	1
Sulfate	**360**	**303**	**297**	**178**	**83**	**80**
Chloride	4.0	3.9	3.9	3.6	3.4	3.4
Boron	0.1	0.1	0.1	0.1	0.1	0.1
Fluoride	0.2	0.1	0.1	0.2	0.1	0.1
Nitrate as N	0.3	0.1	0.1	0.2	0.1	0.1
Orthophosphate	0.0	0.0	0.0	0.0	0.0	0.0
Silica	17	15	15	16	13	13
Aluminum	0.005	0.004	0.005	0.175	0.098	0.091
Antimony	0.010	0.009	0.008	0.007	0.004	0.004
Arsenic	0.000	0.000	0.000	0.006	0.004	0.004
Barium	0.007	0.008	0.008	0.011	0.015	0.015
Cadmium	0.001	0.001	0.001	0.001	0.001	0.001
Copper	0.0002	0.0001	0.0002	0.0071	0.0053	0.0053
Iron	0.0021	0.0017	0.0018	0.0505	0.0587	0.0591
Lead	0.00000	0.00000	0.00000	0.00028	0.00020	0.00020
Manganese	**0.615**	**0.639**	**0.639**	**0.273**	**0.218**	**0.216**
Mercury	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
Nickel	**0.015**	0.010	0.010	0.012	0.007	0.007
Selenium	0.001	0.001	0.001	0.002	0.002	0.002
Thallium	0.003	0.002	0.002	0.002	0.001	0.001
Zinc	0.057	0.062	0.063	**0.090**	**0.100**	**0.100**

Constituents in gray are below detection level
Constituents in red are more than 3 times the background level

Annotated Reference List

Schafer, AMEC, and ERC. 2013. Draft Haile Gold Mine Revised Post-Closure Water Quality Impacts Evaluation. February 2013. (*Includes the original Impact Analysis model and report that was based on the AMEC groundwater model. This report provides useful background information about the modeling approach and the site conceptual model but specific model results have been superseded by a series of Technical Memoranda that convey updated results based on the Cardno groundwater model.)*

Newfields and Schafer Limited, LLC. 2013. Memorandum: Preliminary Haile Particle Tracking Results, December 11, 2013. (*Describes the groundwater refilling stage model and particle tracking results.)*

Schafer Limited LLC 2013a. Preliminary Pit Lake Hydrology and Water Quality Results. December 11, 2013. (*Provides water balance and water chemistry for the revised Ledbetter Pit Lake model.)*

Schafer Limited, LLC. 2013b. Preliminary Little Lynches River Water Quality Results. December 13, 2013. (*Provides water chemistry results for the revised Little Lynches River surface water quality model.)*

Schafer Limited, LLC. 2013c. Preliminary Water Quality Result Tables. December 16, 2013. (*Includes a more detailed listing of predicted water quality in tabular form.)*

Schafer Limited, LLC. 2014. Clarification of Surface Water Quality Impact Model and Groundwater. January 13, 2014. (*Provides clarification of several elements of the model results including comparison to water quality standards and development of predicted groundwater concentrations.)*

SCHDEC Information Request #4: *The comment period for the DEIS ended on Friday. May 9, 2014. The WQD has received copies of the comments received by the USACE during the comment period, and understands that the USACE has provided Haile Gold Mine, Inc. with copies as well. Please provide your response to these comments.*

Haile's Response to SCDHEC Information Request No. 4: Haile's Response to the DEIS comments received by the USACE has been provided to the SCDHEC via email and DVD on May 22 and 30, and June 4, 2014.

SCDHEC's May 12, 2014 letter also identified two items that are not information requests. It stated that SCDHEC "will need confirmation" from the USEPA and the USACE that the proposed mitigation plan meets the requirements of the 2008 Federal Compensatory Mitigation Rule. It also noted that, to date, there has been no resolution of the USEPA letters that designated the streams and wetlands at the proposed project site as Aquatic Resources of National Importance (ARNIs). SCDHEC states that this will need to be resolved before the WQD can complete its review of the proposed Project. Haile understands that these two items are under active review by the federal agencies. Respectfully, Haile suggests that, since this is not information that Haile can provide, the 180 day time period for review of an application cannot be stopped pending receipt of this information. All of the information requested from Haile for processing Haile's application for Section 401 Water Quality Certification has been provided, and the time for processing Haile's application should recommence upon SCDHEC's receipt of this letter and enclosed information.

If there are any questions regarding this transmittal, please contact me at 803-396-9700.

Sincerely,

Johnny Pappas
Director of Environmental Affairs
Romarco Minerals, Inc.

cc: Marianna DePratter (SCDHEC Mining and Reclamation Program)
Richard Darden, PhD (USACE)
Paul Leonard (Cardno ENTRIX)
Alison Uno (Cardno ENTRIX)
McLane Evans (Cardno ENTRIX)
Kelly Laycock (EPA)

APPENDIX P4

COMMENTS RECEIVED ON THE HAILE GOLD MINE MITIGATION PLAN

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P4 COMMENTS RECEIVED ON THE HAILE GOLD MINE MITIGATION PLAN

Appendix P4 contains a record of comments received from governmental agencies regarding the Haile Gold Mine Mitigation Plan (Haile's Mitigation Plan; previously referred to as the CMP in the Draft EIS).

South Carolina Department of
Natural Resources

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Alvin A. Taylor
Director
Robert D. Perry
Director, Office of
Environmental Programs

September 16, 2013

Dr. Richard L. Darden
U.S. Army Corps of Engineers
Charleston Regulatory Office
69-A Hagood Avenue
Charleston, South Carolina 29403

REFERENCE: Haile Gold Mine Mitigation Plan, SAC 1992-24122-41A, July 9 2013

Dear Dr. Darden,

Personnel of the South Carolina Department of Natural Resources (DNR) have reviewed the referenced plan which was provided for public review on July 19, 2013. DNR offers the following comments.

Background

The proposed reopening of Haile Gold Mine (Project) would impact approximately 120.46 acres of wetlands and 26,460.54 linear feet of streams designated by the United States Army Corps of Engineers (USACE), Charleston District (District) as waters of the United States (waters of the U.S.). These impacts have been reduced significantly by Haile Gold Mine, LLC (Applicant) through revisions to the original mine plan, which would have impacted approximately 160.81 acres of wetlands and 38,775 linear feet of streams. DNR appreciates the Applicant's efforts to avoid and minimize impacts to the greatest practicable extent, and agrees the Applicant's proposed mine plan represents the least damaging alternative that meets the Project's purpose.

The 2008 USACE and United States Environmental Protection Agency Mitigation Rule (Rule) and the USACE Charleston District Guidelines For Preparing A Compensatory Mitigation Plan, October 7, 2010 Revision (Guidelines) establishes an hierarchy for compensatory mitigation which requires, in order, purchase of established Mitigation Bank Credits, provision of In-Lieu-Fee Program Credits or Permittee Responsible Mitigation (PRM).

Due to the absence of mitigation banks or in-lieu-fee programs within the service area of the Project, the Applicant proposed a PRM conceptual mitigation plan (CMP) when the Project originally was public noticed on January 28, 2011. DNR commented on March 30, 2011 and relative to the CMP commended the applicant, in part, by noting:

> *. . . the proposed conceptual mitigation plan . . . [is] within critical habitat for the federally endangered Carolina heelsplitter (Lasmigona decorate). The Applicant also proposes to preserve 758 acres of land adjacent to Forty-Acre Rock Heritage Preserve.* [1]

The CMP was revised in May 2011 (Revised CMP). Upon review of the Revised CMP, DNR in correspondence of June 30, 2011 raised a number of concerns. Of note, DNR stated:

> *DNR recognizes the Revised CMP is conceptual in nature; however, there is significant uncertainty regarding proposed mitigation sites, as some sites are still under negotiation. The Revised CMP makes reference to 3 additional sites that may become a part of the plan (Big Sandy Add-Ons, Fork Creek and the Lindsay tract) while others may be removed from consideration. The Revised CMP indicates that mitigation sites may be protected with restrictive covenant where it is not possible to secure a conservation easement, presumably because these lands are not under the control of the Applicant. Restrictive covenants are not an appropriate protective mechanism and are generally not acceptable for large mitigation projects. In some areas 50-75 feet of buffer is proposed. Minimum average buffer width should be at least 150 feet. Less than 25% of the overall proposed linear feet of stream restoration can be described as in-kind (15,269 linear feet). As calculated by the Applicant, required credits are estimated to be 296,396 stream and 1,842 wetland credits. The amount of credit proposed in the Revised CMP is barely more than the minimum required (106% stream, 105% wetland).* ***For a project having this amount of impact to waters of the United States, DNR believes that substantially more mitigation should be required for the proposed project because the Mitigation Guidelines should only be used as a general reference for impact calculations as it is not designed to adequately enumerate the required mitigation for projects having large impacts*** [emphasis added].[2]

Subsequently, DNR had several meetings with the Applicant's agents to discuss aspects of the Revised CMP. In all of our conversations with the Applicant's agents we stressed the unusual, non-routine nature of the Project's proposed impacts, and we urged that the ultimate mitigation plan should be equally non-routine and not rely on the Charleston District Standard Operating Procedure for evaluating impacts to waters of the U.S. We urged that a PRM project be developed such that it contained elements of significance, considered a landscape scale approach meshing with established conservation priorities, focused on outstanding resources and included public use opportunities to benefit South Carolina.

DNR indicated satisfaction with the Rainbow Ranch component of the Revised CMP. Rainbow Ranch is adjacent to Forty Acre Rock Heritage Preserve, a high quality habitat deemed worthy of protection under the South Carolina Heritage Trust Program,[3] and the privately owned Carolina Heelsplitter Conservation Bank.[4] We pointed out that the Revised CMP's restoration component,

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[1] See: March 30, 2011 DNR correspondence (Perry) to LTC Jason A. Kirk and Ms. Heather Preston.
[2] See: June 30, 2011 DNR correspondence (Frampton) to LTC Jason A. Kirk and Ms. Heather Preston.
[3] South Carolina Code of Laws §51-17-10.
[4] http://www.fws.gov/charleston/pdf/Heelsplitter/Carolina%20Heelsplitter_ConservationBank_FactSheet.pdf. Last accessed September 9, 2013.

which focused on fragmented stream and wetland restoration projects adjacent to multiple privately owned agricultural lands, to be unacceptable. DNR expressed concern that the proposed restoration was fraught with multiple shortcomings including issues of habitat and spatial fragmentation, concern over long-term stability and compliance, complicated monitoring, general uncertainty, the potential for contention over performance and the high likelihood of litigation that would grind the Project to a halt. Notwithstanding these issues, even under the best of circumstances, the Revised CMP would not be able to meet a landscape need and could not be deemed to include restoration or protection of outstanding resources. Adjacent agricultural practices likely would continue to impact restored streams and wetlands, and predictably would result in fragmented restoration and protection of wetlands and stream reaches that, all things considered, are average in terms of resource value providing limited utility in achieving meaningful water quality improvements within the watershed. Additionally, the Revised CMP would have provided for no public use benefits.

The DNR consultation approach continued to stress the need for a plan that would provide for ecological benefits commensurate with the scale and magnitude of the proposed impacts. We believe a strict adherence to the Guidelines, in the case of very large projects with large documented effects, is not appropriate and not of sufficient benefit to offset impacts. There clearly was a need for a plan that would protect high quality, outstanding resources at the landscape scale. DNR, on its own, investigated mitigation opportunities within the watershed that might meet this need. Considerable effort was expended within the Upper Lynches River Watershed to identify such opportunities. We determined the upper watershed to be characterized by complex landownership pattern comprised of many landowners and relatively small tracts where agricultural practices have created numerous impacts. Further, even individual stream reaches in the upper watershed are characterized by multiple landowners where the streams themselves often form property boundaries. We could not locate opportunities where anything like a landscape need could be met and where the sites could be made available. DNR explored opportunities in the lower Lynches River Watershed as well. Not until we had completed these efforts did DNR look outside the watershed for opportunities that we believed would meet the compensatory mitigation need.

The Rule provides the District Engineer (DE) the discretion to consider mitigation opportunities in adjacent watersheds where mitigation may have a "greater likelihood of offsetting project impacts" or are "environmentally preferable." [5] Mitigation through preservation may be accepted so long as the following criteria are met:

- Resources to be preserved provide important physical, chemical and biological functions and contribute significantly to the ecological sustainability of the watershed,
- The DE determines preservation is appropriate and practicable,
- Resources to be preserved are under threat of destruction or adverse modification, and
- The proposed preservation sites will be permanently protected by a third party conservation easement or title transfer to a state resource agency or land trust.[6]

[5] (33 C.F.R. § 332.3(b)(6)).
[6] 33 C.F.R. § 332.3(f).

Further, the Rule provides that preservation alone may compensate for permitted impacts "where preservation has been identified as a high priority using the watershed approach...." [7] The Rule also acknowledges "public interest" factors in mitigation planning. [8]

Haile Gold Mine Mitigation Plan Version July 9, 2013

During its search for appropriate opportunities that would meet these criteria, DNR advised the Applicant that the properties known as Goodwill Plantation and Cook's Mountain both in Richland County and located within the Wateree River Watershed, were available. We suggested to the Applicant that they explore these opportunities. Subsequently, the Applicant revised and resubmitted its mitigation plan.[9] On July 19, 2013, the Charleston District published the Applicant's mitigation plan (Revised Plan). The objective of the Revised Plan is stated as:

> *. . . to mitigate for all of the impacts associated with the construction and operation of the Haile Gold Mine project site, by assuring that outstanding aquatic resources, as well as cultural and historic resources, are preserved and significant endowment is provided to the South Carolina Department of Natural Resources for maintenance and management for the benefit of regional aquatic functions.*

Thus, the Revised Plan would mitigate for all impacts to aquatic resources that would occur within the 4,552-acre project boundary of the proposed mine. Any future mining outside the currently proposed boundary would require additional, future analysis of potential effects and commensurate mitigation as then determined necessary.

The Revised Plan proposes the following:

- Preservation of the property known as Rainbow Ranch, which is adjacent to the Forty Acre Rock Heritage Preserve,
- Preservation of the Goodwill Plantation property (1,048.1 acres of wetlands and 30,706 lf of streams), and
- Preservation of Cooks Mountain (485.1 acres of wetlands and 28,292 lf of streams)

The Applicant intends that these sites be titled fee simple to DNR to be incorporated into the Heritage Trust Program and managed as Heritage Preserves in accordance with a Dedication Agreement. The Heritage Trust Program was established in 1976 under §51-17-10 of the South Carolina Code of Laws to protect lands with unique and outstanding natural and cultural features. The Heritage Trust Program protects in perpetuity natural areas that contain unique landforms to include threatened, endangered, or unique plant or animal habitats, outstanding historic or archaeological features, or other unusual or outstanding scientific, educational, aesthetic or recreational characteristics. These properties all meet that legislative definition, and protection under the South Carolina Heritage Trust Act utilizes a long-term protection instrument that arguably is of a higher standard, e.g., protection by the State of South Carolina, than a

[7] 33 C.F.R. § 332.3(h)(2).
[8] 33 C.F.R. §332.1(d).
[9] http://www.hailegoldmineeis.com/pdf/Haile_Revised_Mitigation_Plan_dated_July_9_2013.pdf. Last accessed Sept. 9, 2013.

conservation easement held by a qualified third party or other jurisdiction. In addition, the Applicant proposes to provide $4.5 million for the maintenance and management of these sites, including activities such as wildlife enhancement and restoration. An endowment of $4.9 million also will be provided for projects to benefit the endangered Carolina heelsplitter (*Lasmigona decorata*).

The Revised Plan provides a detailed accounting of the outstanding natural and cultural resources of each tract and the threats incurred by land use practices such as less-than-optimum forest and agriculture management, urban sprawl and residential development all of which substantially contribute to diminished water quality. Inclusion of the Rainbow Ranch property into Forty Acre Rock Heritage Preserve would protect 28.11 acres of wetlands and 19,714 lf of streams, increasing the area of the local Heritage Preserve by 30 percent, and it would protect federally designated critical habitat for the endangered heelsplitter mussel. Goodwill Plantation and Cook's Mountain are located within the COWASEE Basin Focus Area, a conservation initiative formed in 2005 by a partnership of private landowners, conservation organizations, land trusts and government agencies. Together, these tracts comprise over 1,500 acres of wetland and nearly 6 miles of high quality streams and riparian habitat.

DNR agrees with the Revised Plan and its objectives. The plan meets the Rule's criteria of preservation mitigation as it encompasses outstanding resources based on rigorous scientific and technical analysis. The South Carolina Heritage Trust Act and the DNR Heritage Trust Program constitute the highest order of long-term protection that can be provided by state government. The proposed endowment for long-term management is an outstanding financial trust that will allow DNR to manage the properties in a holistic, ecological manner and provide ample opportunities over the long-term to restore and enhance wetlands and streams on all three tracts.

DNR is uniquely qualified to serve as the long-term steward of the properties through its highly trained, professional staff of wildlife, fisheries, hydrology, forestry, archaeology, botany and other scientists. Further DNR staff is skilled at facilitation of a wide variety of public use programs to include, but not be limited to: fishing including fishing rodeos for youth, hunting (a variety of species will be available for hunting on all three tracts) to include programs and dates for youth hunting only, appreciative uses such as bird watching and nature study, educational programs such as Take One Make One© and Archery in Schools©, as well as hunter safety and general nature study.

We anticipate the development and execution of a Memorandum of Agreement (MOA) with the USACE and the South Carolina Department of Health and Environmental Control that will be the anchor for long-term stewardship. We expect the MOA will provide DNR with a limited number of reserved rights which will be entirely consistent with preserving the essential character of the tracts already identified as outstanding resources. For instance, one such reserved right would be to allow timber harvesting on select units of the tracts whereby the long-term ecological objective, if approved by the regulatory agencies, could be to plug ditches, restore hydrology and restore preferred bottomland hardwood species. Also DNR will have the opportunity to convert select uplands to longleaf pine (*Pinus palustris*), reducing fragmentation of this important habitat for the benefit of endangered, threatened and rare species and state species of concern, and restoring the historical ecotype to the landscape. These habitats are fire

dependent, and DNR has the professional staff trained in the planning and implementation of prescribed fire for ecosystem management.

Rainbow Ranch is a natural fit for inclusion into the adjacent Forty Acre Rock Heritage Preserve. In concert with the endowment pledged for heelsplitter restoration, this represents one of the most unique and important features of the plan, and will provide for a first-of-its-kind program to benefit an imperiled species. This component of the plan has direct importance to the upper part of the watershed of impact where development pressures are impinging on heelsplitter habitat. In the absence of a significant program to offset heelsplitter habitat impacts, development interests in the upper part of the watershed are likely to impede restoration goals for the heelsplitter as well as delay or forestall routine and otherwise smaller-scale permitting of impacts to waters of the U.S. due to impacts to endangered species habitat. Finally, the South Carolina Code of Laws §50-3-180, Mitigation Trust Fund presents an appropriate vehicle to manage and disperse the total $9.4 million endowment pledged by the Applicant. The Trust Fund has adequate monitoring and safeguard provisions ensuring deposited funds are spent only as prescribed and approved.

Summary

DNR appreciates that the Applicant has proposed a compensatory mitigation that sets a new and high standard for non-routine projects that would result in significant impacts to waters of the U.S. We further appreciate the opportunity to review and comment on the plan. Our opinion is that the plan is acceptable and commensurate with the scope and scale of the Project's anticipated effects.

If your offices require any additional information regarding these comments, please contact Vivianne Vejdani at vejdaniv@dnr.sc.gov or 803.734.4199.

Sincerely,

Bob Perry
Director, Office of Environmental Programs

c: Kelly Laycock – USEPA
Pace Wilber – NMFS
Jay Herrington – USFWS
Heather Preston – DHEC
Kent Coleman – DHEC
Alvin A. Taylor
Breck Carmichael
Vivianne Vejdani

United States Department of the Interior

FISH AND WILDLIFE SERVICE
176 Croghan Spur Road, Suite 200
Charleston, South Carolina 29407

January 23, 2014

Lt. Colonel John T. Litz
District Engineer
U.S. Army Corps of Engineers
69A Hagood Avenue
Charleston, SC 29403-5107

Attn: Dr. Richard Darden

Re: Haile Gold Mine, Revised Mitigation Plan, Lancaster County, South Carolina
FWS Log No. 2011-CPA-0059

Dear Colonel Litz:

The U.S. Fish and Wildlife Service (Service) submits these comments regarding the revised mitigation plan dated July 9, 2013, for the proposed Haile Gold Mine in Lancaster County, South Carolina. The applicant submitted a mitigation plan with the U.S. Army Corps of Engineers (USACE) permit application which was placed on public notice by the USACE in January 2011. A revised mitigation plan was submitted by the applicant in May 2011. However, the revised mitigation plan of May 2011 was considered insufficient to offset resource impacts from the gold mine construction due to several factors including an uncertainty of land acquisition, unsatisfactory protection measures, and deficient buffer widths adjacent to streams.

The Service recognizes that the 2008 USACE and United States Environmental Protection Agency Mitigation Rule (Rule) and the USACE Charleston District Guidelines For Preparing A Compensatory Mitigation Plan (Guidelines), October 7, 2010, sets forth a hierarchy for compensatory mitigation. Mitigation for impacts should first be accomplished through the purchase of established mitigation bank credits, followed by in-lieu-fee program credits, and then permittee responsible mitigation (PRM). As there are no mitigation banks or in-lieu-fee programs in the project's service area, the applicant was required to develop a PRM.

In order to assist the applicant and their agents in the development of an acceptable PRM, the Service, South Carolina Department of Natural Resources (SCDNR), and other resource agencies met with the applicant on several occasions. Our focus was to develop a landscape-scale plan to offset significant resource impacts of the gold mine project, rather than the

piecemeal approach characteristic of the previous plan. Through our meetings and site visits, the revised mitigation plan of July 9, 2013, was developed that included acquisition and preservation of three large tracts of land which would satisfactorily offset project impacts. These tracts include the Rainbow Ranch Property in Lancaster County (a component of the applicant's May 2011 plan), Goodwill Plantation in Sumter County, and Cooks Mountain in Richland County.

The Service finds this new mitigation plan of July 9, 2013, will provide superior ecological benefits over previous plans, particularly in consideration of the scale of the proposed impacts, both direct and indirect. While the current plan may not precisely adhere to the Rule or Guidelines, the Service also recognizes that the Rule grants the USACE District Engineer discretion to consider opportunities in adjacent watersheds where mitigation may have a "greater likelihood of offsetting project impacts" or are "environmentally preferable." We find the superior benefits obtained by the acquisition and preservation of the above properties is sufficient for the District Engineer a take discretionary action in the Haile Gold Mine project.

In consideration of the mitigation plan of July 9, 2013, the Service agrees that the proposed acquisition of the three tracts of land and their subsequent protection by SCDNR via inclusion into the Heritage Trust Program is appropriate and as such, offers no objection to the current PRM submitted by the applicant. If you should need further clarification regarding these comments, please contact our project manager Ms. Morgan Wolf at (843) 727-4707 ext. 219 or Mr. Mark Caldwell at (843) 727-4707 ext. 215, and reference FWS Log No. 2011-CPA-0059.

Sincerely,

for Thomas D. McCoy
Acting Field Supervisor

TDM/MAC

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