



GREENS CREEK MINE

Final

Environmental Audit

January 2019

Hecla Greens Creek Mining Company

Juneau, Alaska



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Abbreviations and Acronyms

AAC	Alaska Administrative Code
ABA	Acid Base Accounting
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
APDES	Alaska Pollutant Discharge Elimination System
ARD	acid rock drainage
Audit Team	HDR Audit Team
AWQS	Alaska Water Quality Standards
CaCO ₃	calcium carbonate
COD	Certificate of Approval to Operate a Dam
COMD	Certificate of Approval to Modify a Dam
DST	dry short tons
EAP	Emergency Action Plan
EPA	U.S. Environmental Protection Agency
FCS	flow control structure
FWMP	Fresh Water Monitoring Plan
gpm	gallons per minute
GPO	General Plan of Operations
GPS	global positioning system
HDPE	high-density polyethylene
HGCMC	Hecla Greens Creek Mining Company
ICP	inductively coupled plasma
IMP	Integrated Monitoring Plan
IWMDP	Integrated Waste Management and Disposal Plan
KCB	Klohn Crippen Berger
MOU	memorandum of understanding
NID	National Inventory of Dams
NNP	Net Neutralization Potential
NOV	Notice of Violation
O&M	Operations and Maintenance
OPMP	ADNR Office of Project Management and Permitting
PSI	Periodic Safety Inspection
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RPA	Reclamation Plan Approval
SCADA	supervisory control and data acquisition
SOP	standard operating procedure
SPCC	Spill, Prevention, Control, and Countermeasure
SRCE	Standard Reclamation Cost Estimator
tCaCO ₃ /kt	tons of CaCO ₃ per kiloton
TDF	Tailings Disposal Facility
ug/L	micrograms per liter



USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
VWP	vibrating wire piezometer
WMP	Waste Management Permit
WQS	Water Quality Standards
WRMP	Waste Rock Management Plan
WW	Wet Well

1.0 Purpose and Objectives

HDR Engineering, Inc., conducted an environmental compliance audit of Greens Creek Mine, located on Admiralty Island near Juneau, Alaska for the Hecla Greens Creek Mining Company (HGCMC), the Alaska Department of Natural Resources (ADNR) and Alaska Department of Environmental Conservation (ADEC). This report outlines the audit purpose and approach, findings, any systematic observations, and recommendations for consideration during the future renewal process for applicable permits and approvals.

Greens Creek Mine Waste Management Permit (WMP) and Reclamation Plan Approval (RPA) require an environmental audit prior to renewal. The audit is to be an objective, systematic, and documented review of the conditions, operations, and practices related to permit requirements and facility management conducted under these authorizations. A prior environmental audit was completed at the mine in 2009.

The environmental compliance audit for the Greens Creek Mine was conducted to compare and evaluate facility operations against applicable permits and state regulations. Program areas and permits included in the audit scope are summarized in Table 1 and Table 2. The audit results will be used by HGCMC and the State of Alaska to assist in updating, renewing, or issuing authorizations and permits; in updating policies, plans, and procedures; and in determining compliance with permits and authorizations.

The objectives of the audit were as follows:

- Assess the facility's environmental compliance performance.
- Identify potential corrective actions or noncompliance observations.
- Identify common or systematic environmental issues across the facility.
- Provide an overall assessment of environmental performance, including recommendations for resolving system-wide areas of noncompliance.
- Provide an overall assessment of, and recommendations for, agency oversight.
- Assess the adequacy of financial assurance for reclamation, closure and long-term operation, maintenance, and inspection of post-closure facilities.

2.0 Permits and Authorizations

The HDR Audit Team (Audit Team) was composed of the following personnel:

- Paul McLarnon, Project Manager/Solid Waste Specialist
- Molly Reeves, CPG, Senior Hydrogeologist
- Michael Murray, PhD, Resources Group Manager/Reclamation and Soils Specialist
- Nicholas LaFronz, P.E., Senior Geotechnical Section Manager



The Audit Team reviewed the state permits and authorizations listed below in Table 1 and Table 2. These authorizations represent the main regulatory drivers for the mine's environmental management program.

Table 1. Environmental Permits/Approvals Included in the Audit

Program Area/Permit	Site Location	Permit	Issue Date	Expiration Date
Waste Management Permit	Tailings Disposal Facility (TDF); Site 23; Underground mine workings; Inactive waste rock disposal sites (Sites 1350, C, D, and E); Pond 7; freshwater monitoring sites, reclamation and financial responsibilities.	2014DB0003	August 11, 2014	August 10, 2019
Reclamation Plan Approval	Reclamation and Closure Plan and Financial Assurance	J20142682	August 11, 2014 (amended August 14, 2014)	August 10, 2019
Certificate of Approval to Operate a Dam	Pond 7/10 Dam System	Temporary Certificate FY2018-18-AK00316	April 19, 2018	December 31, 2019
Certificate of Approval to Modify a Dam	Sand Pit Dam	FY2019-04-AK00317	July 31, 2018	December 31, 2019

Table 2. General Plan of Operations Appendices Reviewed as Part of the Audit

Monitoring /Management Plan	Facility	Date
Appendix 1 Integrated Monitoring Plan	TDF; Site 23; Inactive waste rock disposal sites (Sites 1350, C, D, and E); Pond 7; Freshwater monitoring sites	November 2014
Appendix 3 Tailings Disposal Facility Management Plan	Tailings Disposal	April 2018
Appendix 7 Integrated Waste Management and Disposal Plan	Mine Site	June 2014
Appendix 11 Waste Rock Management Plan	Site 23 and Inactive Waste Rock Sites	June 2014
Appendix 14 Reclamation and Closure Plan and associated Appendix B Basis of Cost Estimate	Mine Site	June 2014 (revisions 2016 and 2018)

As agreed to by HGCMC, ADNR, and ADEC, environmental related permits and plans not covered by the Audit Team review include:

- Alaska Pollutant Discharge Elimination System (APDES) Water Discharge Permit (AK0043206)
- Water Use Authorizations
- U.S. Environmental Protection Agency (EPA) Hazardous Waste
- Spill, Prevention, Control, and Countermeasure (SPCC) Plan
- U.S. Army Corps of Engineers (USACE) 404 Permit
- Potable Water Supply
- Sewage Treatment

- Toxics Release Inventory
- Federal Aviation Permits
- ADEC Air Quality Control Permit

HGCMC provided information to the Audit Team as requested to facilitate record auditing primarily while on-site. Key permits and related documents were obtained from the ADNR and ADEC project files prior to the field audit. HGCMC provided additional correspondence items as requested. The implementation of each of the document terms was checked during the field audit and found to be generally in compliance. However, it should be noted that there is an open enforcement action between the HGCMC and ADNR associated with Ponds 7 and 10 located at the Tailings Disposal Facility (TDF). This is an ongoing process and the ADNR has issued a Temporary Certificate of Approval to Operate a Dam (COD) containing permit stipulations that address their compliance concerns, to which HGCMC is actively responding. The Audit addresses HGCMC's compliance with the Temporary COD. However, any analysis beyond what is contained in the Temporary COD are outside of the Audit's scope of analysis.

3.0 Approach and Methodology

The audit methodology can be generally broken into three main tasks: pre-audit activities, on-site audit, and post-audit reporting.

3.1 Pre-audit Activities

The pre-audit activities were performed prior to the facility visits. Activities included review of available project permits and plans and participation in a project kickoff meeting prior to the on-site visits.

Permit and Plan Review. The intention of the preliminary review was to obtain a high-level understanding of the applicable permits and plans in place at the time of the permit review. The Audit Team gathered available permits, plans, and agency authorizations from online resources, ADEC and ADNR office visits, and HGCMC directly.

Project Kickoff Conference Call. A project kickoff conference call was performed on July 12, 2018, with the mine permitting team composed of the ADNR, ADEC, Alaska Department of Fish and Game (ADF&G), U.S. Forest Service (USFS) Tongass Office, HGCMC Environmental Lead, HGCMC Environmental Engineer, and Audit Team. This meeting provided a general overview of the assessment process, scope of permits, historical limitation of the audit (April 2014) and authorizations that the audit would address, and overall project schedule.

3.2 On-site Audit Activities

The Audit Team performed an on-site audit of the Greens Creek Mine on July 23–25, 2018, and participated in the following: on-site kickoff meeting, site walk-through, review of provided documents, and interviews.

On-site Kickoff Meeting. Upon arrival at the site, the Audit Team attended a site-specific safety training and a site meeting to introduce HGCMC Environmental staff to the Audit Team. The purpose of the meeting was to review the scope and purpose of the audit, introduce personnel involved in conducting the audit, and outline the schedule for the audit for tours and interviews with key personnel responsible for compliance programs and reporting.

On-site Walk-through. The Audit Team participated in a tour of the mine guided by the HGCMC Environmental Manager, Christopher Wallace. During the walk-through, the Audit Team viewed facilities and activities specific to the environmental permits, dam safety permits, and operational and monitoring elements of the various facilities. Field observations were discussed with the site personnel during the site walk-through and interviews. In addition to the mine site-wide tour, individual Audit Team members toured specific facilities with Environmental Team personnel with operational knowledge of the facilities and operations.

Facilities that were inspected included the following:

- TDF
- Site 23 / Pond 23 Waste Rock Storage Facility
- Ponds 7 and 10
- Inactive Waste Rock Disposal Sites
 - Site 1350 (in reclamation)
 - Sites C, D, and E
- Fresh Water Monitoring Sites (specifically visited 48, 54, and 9)
- Borrow Sites
- On-site Laboratory
- Environmental Sample Preparation Room
- Test Reclamation Sites
- Mill Reagent Storage Areas
- TDF Water Treatment Plant
- Waste Accumulation Areas
- Used Oil Storage Areas
- Secondary Containment Structures

Interviews. The Audit Team conducted interviews with HGCMC Mine representatives with responsibilities of overseeing environmental regulatory requirements. The purpose of these interviews was to obtain an understanding of the environmental programs and procedures for compliance with permits and plans, and to assess how well those programs are understood and implemented.

Records and Document Review. The Audit Team reviewed applicable permits and reports that were readily available and organized on-site. The auditors made observations of operational activities within the context of applicable permits and environmental requirements, taking note of any compliance gaps. Additional documents that were reviewed included but were not limited to waste logs; inspection logs; sampling field notes and chain of custodies; monthly, quarterly and annual compliance reports; biological monitoring reports; reclamation and financial responsibilities; SPCC Plan; Pond 7/10 Operations and Maintenance (O&M) Program manual (draft revised/updated November 2017); Pond 7 Periodic Safety Inspection (PSI) report (January 2018); and Pond 7/10 Dam – Pond 10 First Fill Plan (undated).

Briefing Sessions. The Audit Team met with Environmental Team personnel on a daily basis. The auditors reviewed the day's progress, asked questions, and discussed specific observations with mine site staff.

3.3 Post-audit Activities

Following the audit, a close-out meeting was held via teleconference with the HGCMC Environmental Team on August 8, 2018, to discuss observations and findings. The Audit Team interviewed various agency personnel, primarily those who manage the WMP, financial assurance, biological sampling programs, and compliance with ADNR dam safety permit requirements for monitoring and reporting.

4.0 Interviews

4.1 Agency Interviews

The Audit Team interviewed agency personnel regarding the following aspects of the audit purpose and HGCMC's permits:

- Audit scope;
- Identify various aspects of the authorizations to understand the intent of permit language;
- Request additional reporting or correspondence;
- Request a status update on submitted documents;
- Gather information regarding the agency perspective on mine compliance and ongoing ability to meet obligations and agency requests and gauge adequacy of state oversight; and
- Evaluate the effectiveness of ongoing monitoring programs.

The regulatory agency personnel were of significant help to the Audit Team on all of these accounts. Table 3 lists the interviews with agency personnel conducted by the Audit Team and includes a brief summary of the interaction.



Table 3. Audit Interviews with Agency Personnel

Name	Agency or Company	Date	Summary
Allan Nakanishi	ADEC	8/13/2018	Topics included many elements of the WMP, including the concept of elective monitoring versus ambient conditions monitoring versus permit limit monitoring, quarterly versus annual reporting content, ADEC's review of geotechnical site data, permit non-compliance reporting triggers, geochemistry of quarry walls, wildlife stress, etc.
Kate Kanouse	ADF&G	7/19/2018 & 9/21/2018	Conducted telephone interviews regarding biological sampling methods, results and recent changes to sample site 48 as a result of changes in stream channel locations.
Brent Martellaro	ADNR	7/17/2018	Email exchange on DNR issues/concerns on the mine reclamation and financial assurance. DNR's main concerns: Growth Media – volume updates, sources, and appropriate costing.
Mr. Charles F. Cobb, P.E., Dam Safety Engineer	ADNR Division of Mining, Land, & Water Dam Safety & Construction Unit	9/7/2018	<p>Discussion about the Special Conditions contained in Attachments A and B to the Pond 7/10 Dam System Temporary Certificate of Approval to Operate a Dam (COD) No. FY2018-18-AK00316 (April 19, 2018; ADNR, 2018b). The Special Conditions included in Attachments A and B to the COD, in particular the requirement for an independent engineering review of the Pond 7/10 Dam System and appurtenant works, reflect ADNR Dam Safety & Construction Unit's fundamental concerns about the permitting, design, and operation of the Pond 7/10 Dam System and appurtenant works. A Status of Compliance letter was sent to HGCMC in May 2017 (ADNR, 2017). Subsequent to HGCMC's response to the letter, a Notice of Violation (NOV) letter was issued to HGCMC in February 2018 (ADNR, 2018a). Because of the existing active NOV, Mr. Cobb was unable to discuss the Pond 7/10 Dam System and appurtenant works in any detail.</p> <p>Subsequent to the phone interview, Mr. Cobb provided to the Audit Team (in response to formal request via a completed State of Alaska, Division of Mining, Land and Water, File Review Request form) copies of the Status of Compliance and NOV letters.</p>

4.2 Mine Interviews

The Audit Team interviewed various HGCMC Mine personnel who are responsible for environmental management program tasks. Table 4 lists the interviews and brief summaries of the interview purpose.

Table 4. Audit Interviews with HGCMC Mine Personnel

Name	Role	Date	Summary
Chris Wallace	Environmental Manager for the mine site	7/23–24/2018 & 8/7/2018	Completed an initial tour of the site with the Audit Team and was available for questions throughout the on-site visit as well as following the on-site visit. Discussed HGCMC compliance with the requirements/conditions in the Temporary COD for Pond 7/10 Dam System and appurtenances (including the TDF) and associated recordkeeping.
Gunnar Fredheim	Environmental Technician	7/24/18	Completed a mine tour focusing on secondary containment, waste storage, inactive and active mine waste disposal sites, and biological sampling sites. Additionally, interviewed regarding water sampling procedures and note taking.



Table 4. Audit Interviews with HGCMC Mine Personnel

Name	Role	Date	Summary
David Landes	Senior Environmental Engineer	7/25/2018	All environmental monitoring implementation (site selection, sample procedures, calibration, handling, shipping, data validation), Quality Assurance Project Plan (QAPP), permit requirements, reporting, tour of the Fresh Water Monitoring Plan (FWMP) sites, internal monitoring sites, and environmental sampling shack.
Clint Colasanti	Production Geologist	7/24/2018	Discussed the geology department protocols for classification of waste, sampling, and handling waste rock for verification of visual classification; analysis of verification samples; and training of staff.
Amy Lamonica	Assay Lab Superintendent	7/24/2018	Toured the lab; reviewed the standard operating procedure (SOP) for the Acid Base Accounting (ABA) analysis, and discussed the quality control data quality objectives for the ABA analysis; and reviewed procedure for sampling receipt, handling, and laboratory analysis of both waste rock from the production geologists and tailings from the mill.
Dale Butikofer, PE	Senior Civil Engineer	7/24/2018 & 7/25/2018	Discussed HGCMC responses to recommendations in the Periodic Safety Inspection Report (Klohn Crippen Berger [KCB], 2018a). Includes group discussion with Chris Wallace and Dale Butikofer to discuss the TDF Management Plan as well as compliance conditions for the TDF and Sand Pit.

5.0 Compliance with Permits and Authorizations

5.1 Waste Management Permit

The WMP addresses waste disposal at active sites, including the TDF, Site 23, underground mine workings, and inactive waste disposal sites. It also includes permit stipulations associated with Pond 7, fresh water monitoring sites, hazardous chemical storage and containment, surface water containment systems used to prevent the discharge of wastewater, reclamation, closure activities, and financial responsibility.

The permit also includes General Conditions related to site access and inspection, information access, adverse impact, permit renewal, pollution prevention, and other general conditions. This section (Section 5.0) describes the facilities (active and inactive), monitoring activities, compliance reporting, and operational procedures that are pertinent to the WMP.

5.1.1 Active Waste Disposal Facilities

The Greens Creek Mine operates three active disposal sites consisting of the following:

Tailings Disposal Facility (TDF) – The TDF is a lined disposal facility¹ with a permitted footprint of approximately 68 acres (excluding pond systems). The primary function of the TDF is the disposal of dry stack tailings that are produced by the Mill. The Mill at the Greens Creek Mine generates approximately 1,800 dry short tons (DST) of filter-pressed tailings per day, which equates to approximately 650,000 DST annually. Tailings from the Mill are dewatered in a

¹ Approximately 65 percent of the TDF is lined.

filter press, approximately 50 percent of the tailings are mixed with cement and hauled back into the mine as backfill. The other 50 percent of the tailings are trucked to the TDF for permanent disposal (Hecla 2017 Annual Report; HGCMC, 2018a). According to the WMP, the TDF must be designed, operated, and reclaimed as a waste containment facility, preventing any discharge of solid or liquids according to tailings facility standard operating procedures (SOPs) and reclamation and closure plan.

The General Plan of Operations (GPO) includes several plans as appendices that stipulate the waste disposal and monitoring program management:

- Integrated Monitoring Plan (IMP)
- Integrated Waste Management and Disposal Plan (IWMDP)
- Tailing Disposal Facility Management Plan (TDF Management Plan)
- Waste Rock Management Plan (WRMP)

HGCMC appears to be generally in compliance with the WMP with regard to the TDF; however, recommendations by the Audit Team are provided below.

The IWMDP describes geochemical monitoring of the tailings, both at the Mill and TDF, and states that if any changes are seen in the geochemical results of the analysis for tailings, additional sampling and analysis are conducted as determined necessary. In reporting geochemical results in the quarterly or annual reports, there appear to be stated values for tailings with no comparison to baseline tailings characterization to determine if any changes are seen. For example, the reader of the 2016 Annual Report can review that tailings, as sampled at both the Mill and TDF have high acid generating potential according to acid base accounting (ABA) results (net neutralization potential <-100 tonnes calcium carbonate (CaCO₃) equivalent per 1,000 tonnes material and NPR<2). However, the reader is unable to compare this to historical samples or baseline tailings characterization. It is recommended that past geochemical data and baseline data be provided for comparison in reporting.

Further, WMP Section 2.1.2.7 required that water quality at Fresh Water Monitoring Plan (FWMP) monitoring stations associated with the TDF must not exceed Alaska Water Quality Standards (AWQS). If an AWQS is exceeded for a given parameter, then corrective action as designated in Section 2.5.3 of the WMP must be implemented. The downgradient monitoring wells are important because the TDF has the potential to be acid generating. The FWMP stations downgradient of the TDF are currently in non-compliance for low pH and low alkalinity relative to the AWQS. These stations are all sited in organic rich peat sediments and are thus believed to be representative of natural background peat water quality. Results from these sites do not appear to be changing over time and tailings underdrain pH values do not appear to be decreasing over the long term; thus, HGCMC is likely correct that these conditions are background conditions. However, it is recommended that similar site conditions in an undisturbed setting be identified to collect background water quality for comparison.

Fugitive dust emissions from the TDF is a concern for surface water quality and is identified for monitoring in Section 2.3.1.11 of the WMP. Since 2011, HGCMC has been monitoring fugitive

dust emissions from the TDF using 10-liter atmospheric depositional pails mounted approximately 1.3 meters off the ground. Five atmospheric depositional pail systems have been deployed 50 to 100 meters from the base of the dry stack tailings pile. Results from the analysis show that the deposition is seasonal with fugitive dust emissions occurring primarily in winter under cold, dry desiccating conditions with moderate wind speeds from the north or northeast. These conditions typically occur for short periods between mid-December and late February (see *Active Tailings and Production Rock Site 2017 Annual Report* for data).

HGCMC has implemented numerous abatement measures, including the use of water, minimizing active placement areas of tailings during the winter months, and windscreens. In addition, HGCMC is looking at placing cover material prior to winter months in those areas most susceptible to wind erosion. HGCMC is also evaluating the use of sprinkler sets for applying water to reduce dust.

HGCMC is following the requirements in the WMP by conducting monitoring, implementing abatement measures (experimenting with various options), and reporting results. The Audit Team recommends that they continue to evaluate abatement options and consider cover material in those areas most susceptible to wind. With appropriate planning for tailings and cover placement prior to winter, it should be possible to minimize tailings dust emissions.

Site 23 – The WMP lists Site 23 as an active disposal site and stipulates that it must be designed, operated, and reclaimed as a waste containment facility, preventing any discharge of solids or liquids. At closure or before, all waste rock contained in Site 23 will be relocated either to the TDF or to the underground workings for final disposal. Since the contents of Site 23 are not located at the site for the purposes of permanent disposal, the Audit Team recommends that Site 23 be described in the WMP as an active waste storage facility. Additionally, the WMP states that Site 23 is 11 acres in size, and the 2017 Annual Report states that the site boundary for Site 23 covers approximately 18 acres. It is recommended that the overall size of Site 23 be clarified as well as the area within Site 23 that is permitted to receive waste rock.

Production rock (also referred to herein as waste rock) is managed by following the WRMP, which developed the following rock classification system based on the rock potential to generate acid:

- Class 1: This material has a Net Neutralization Potential (NNP) > 100 tons CaCO₃/1,000 tons. No special handling is required.
- Class 2: This material has a NNP value between 100 and -100 tons CaCO₃/1,000 tons.
- Class 3: This material has a NNP value between -100 and -300 tons CaCO₃/1,000 tons.
- Class 4: This material has a NNP value less than -300 tons CaCO₃/1,000 tons and is kept underground as fill.

The rock is classified by a Production Geologist at the underground blast face or muck pile based on visual characteristics. The visual signs include estimation of percent pyrite and percent calcium carbonate. The Audit Team interviewed Production Geologist, Clint Colasanti, who described the visual estimation process and described that any uncertainty in content of

these minerals is weighted conservatively, meaning a higher rock class is assigned. In addition, verification sampling and analysis is performed. Chip samples from the headings are submitted to SGS Laboratory for analysis of ABA. All Class 4 waste rock is retained underground. Laboratory results come back months later, and comparisons to the visual classification recorded are completed and verification accuracy is reported in annual reports to ADEC. In 2017, 36 percent of the time the correct class was visually determined, 56 percent was overestimated, and 8 percent was underestimated out of a total of 39 samples. The samples are allowed to accumulate and are analyzed approximately twice per year. The Audit Team recommends a more frequent comparison for verification so that if issues were observed they could be discovered sooner, as well as the addition of data quality objectives to the WRMP, for example establishing a maximum acceptable percent of underestimated classified samples.

Underground Mine Workings – The underground mine began operation in 1989. Structural fill in the mine is provided by cemented tailings and residual tailings that are trucked to the TDF. Production rock is managed according to the WRMP through classification of the waste rock based on the potential to generate acid, with the most reactive (Class 4) rock being disposed of underground. Most of the workings are below the 920 portal elevations, the elevation of which is just above Greens Creek at the upper end of the site; therefore, most of the workings are below the valley of Greens Creek.

The Underground Mine Workings may accept waste rock, tailings, inert solid wastes such as scrap metal, empty plastic containers, settable solids from sumps, inert non-putrescible domestic solid waste, and other wastes as authorized in Section 2.1.2 of the Solid Waste Permit permitted to be disposed of in underground workings. Section 2.1.4.1 provides a list of waste that may *only* be disposed of in the Underground Workings. This implies that the wastes listed in Section 2.1.4.1 may not be disposed of elsewhere. However, according to the WMP many of those same wastes are also approved for disposal in the TDF. The Audit Team recommends that the solid waste permit clarify what waste may be disposed of in both the TDF and the Underground Workings.

At the time of the audit, a study had been initiated primarily to understand the hydrology of the underground mine at closure and possible spill points from the workings, which could include: faults, drill holes, and portals. The study had not progressed sufficiently to evaluate possible management requirements for the mine water at closure. Current inflows to the mine are low, indicating that low flows may be expected from the mine at closure. However, water quality will be degraded by contact with oxidized Class 4 waste rock and mine walls leading to requirements for long-term treatment of outflows. In the absence of modeling to predict flows and geochemical contributions, the need for and duration of treatment following flooding of the mine is unknown and could last for years to many decades depending on flow quantity and sources of loadings within the mine. Continuation of the study on the underground mine hydrology and chemistry is recommended to confirm assumptions used in the Reclamation Plan and Financial Assurance as it is anticipated that the water quality in the mine will be unacceptable for discharge without treatment.

5.1.2 Inactive Waste Rock Disposal Sites

Inactive waste rock sites consist of Sites 1350, C, D, and E. Each site is described in the WMP with acreage, but no limitations were established for size or tonnage. All of the waste rock in these sites will eventually be removed and placed either underground or in the TDF for final disposal. Partial removal of waste rock from Site 1350 was moved in 2014, thus exposing the waste rock to weathering and impacts to water quality from the site have been observed. Monthly reporting to ADEC includes notification of exceedances of cadmium, zinc, and alkalinity for Site 13 (drainage off inactive waste rock area 1350). Corrective actions have been implemented, and monitoring results since 2014 show a trend of improving water quality.

There may be potential for native soils beneath the rock fill at these inactive waste rock sites to contain products of waste rock weathering. The current practice for waste rock removal (as described for Site 1350) appeared to be removal down to the native soil as determined by exposed tree stumps, followed by removal of the upper surficial layer of native materials with the objective of limiting leaching of residual oxidation products. It may be appropriate to consider geochemical monitoring of surface exposed native material at the time of waste rock removal to determine if upper native materials should also be removed to limit leaching of these weathering products when they are exposed.

Sites C and D are in proximity to each other on the B-Road and are somewhat adjacent to Site 23. Site E is located approximately 3.5 miles west of Sites C and D. The surfaces (e.g., cap) of these sites are being used for various support operations such as road material storage and vehicle and conex container storage. The current use of these sites did not appear to be exposing waste or jeopardizing the containment integrity of the inactive sites.

5.1.3 Corrective Actions and Compliance Reporting

Sections 2.5.2 and 2.5.3 of the WMP address corrective actions and require notifications to ADEC based on triggers. Section 2.5.2 of the WMP states that the permittee shall notify ADEC when a statistically significant increase (SSI) in a constituent concentration above the background water quality in any of the water sampling locations is discovered. This is common to many mine permits; however, HGCMC does not have any monitoring sites with background water quality established. Section 2.5.3 states that the permittee shall notify ADEC when a SSI in concentration is discovered at a water monitoring station or if noncompliance with a requirement set out in Sections 2.1 or 2.2 is discovered. Sections 2.1.2.7 and 2.1.3.3 state that water quality in FWMP monitoring stations associated with the TDF and Site 23 must not exceed Water Quality Standards (WQS). Therefore, Section 2.5.3 appears to be calling an SSI over the WQS as the trigger for notification. However, it is not typical statistical protocol to use an SSI over a single regulatory value as a trigger. Typically, an exceedance of the WQS is a trigger or SSI over a statistically produced background data set. It is recommended that permit revisions be considered that would clarify the trigger for reporting, WQS, or SSI.

The WMP required quarterly and annual reporting of monitoring. HGCMC is compliant with all quarterly and annual reporting deadlines. It is HDR's understanding of agency reporting expectations that quarterly reports should cover all monitoring results available during the quarter, and annual reports include the 4th quarter of monitoring plus provide a review of the

overall monitoring for the year and general trends and observations during the year for all monitoring conducted throughout the year. With that approach, the annual report could be reviewed to see a consolidated accounting of all monitoring. The WMP does not specify what should be included quarterly versus annually. While HGCMC is compliant by reporting all monitoring conducted either quarterly or annually, it appears that the HGCMC quarterly and annual reports include different types of monitoring such that review of the annual report and not the quarterly reports would not provide a reviewer the full picture of what is monitored. In addition, some monitoring completed on a quarterly frequency (e.g., ABA geochemistry) are only analyzed semi-annually or annually and then reported annually. It is recommended that the permit revision clarify expectations for inclusions of quarterly and annual reporting.

5.2 Monitoring

Section 2.3 of the WMP states that the IMP dated June 2014² submitted by HGCMC and approved by the ADNR is incorporated into the permit. The following sections discuss the Audit Team's review and subsequent findings of the HGCMC monitoring program.

5.2.1 Geochemical Monitoring

Section 2.3.1.6 of the WMP requires geochemical monitoring of overburden, construction rock, waste rock, and tailings to ensure that there is low potential for the production of leachate that is acidic or contains levels of metals that would contaminate surface or groundwater. The IMP includes a geochemical monitoring plan for all of the required materials. In addition, while not called out in the WMP, HGCMC reports on geochemical monitoring of the quarry walls, which is conducted at 5-year intervals, and surface water monitoring at pits on an irregular frequency in the Inactive Production Rock Sites and Quarries Annual Reports. They were last monitored in 2013. The IMP includes "quarries" in the title of Table 3-1 for the internal monitoring program but the detail about what monitoring is completed at the quarries is the geochemical monitoring of construction rock on an "as necessary prior to use" frequency. The footer of Table 3-1 of the IMP implies quarry walls are monitored once every 5 years, but the footer is tied to monitoring associated with Site 23 and therefore is not well defined. The IMP does not describe or list in table format the 5-year monitoring of quarry walls that is being reported, nor the surface water monitoring at the pits. Therefore, it is recommended the IMP be revised to more clearly define the geochemical monitoring of quarry pit walls and the water quality monitoring of quarry/pit sites.

In the 2013 Annual Report, the results of the elective monitoring of pit walls were described as: "Pit 405 and Pit 174 have significant exposures of potentially acid generating rock and produced several samples with acidic rinse pH." Because of the acid generating potential of some quarry walls, it is recommended that the permit revision consider formal incorporation of geochemical monitoring of pit walls and associated surface water monitoring sites. The annual reports include surface water monitoring data from quarry pits. In 2017, data had been collected from pit 6, pit 174, and pit 7. However, no explanation is provided for the reason why those pits were

² The June 2014 IMP was updated in November 2014, and approved, to be consistent with the terms of the permit as required by Part 1.2.1.

sampled and not others. In the 2017 report, it appears that pit 405 had not been sampled since 2009; however, values from 2015 appear in the 2016 report for the same sample site.

The WMP Section 2.3.1.9 requires water flow and management monitoring to account for process water discharged to Pond 7, process water recycled to the mill, storm water entering Pond 7, flow under the TDF into Pond 7, water levels in piezometers, and meteorology. The Audit Team reviewed the Annual Reporting and the 2018 Site Water Balance provided by HGCMC. The piezometer levels are recorded and reported annually, as well as monthly flows of treated discharge from the TDF underdrain collection system and Pond 7. The Water Balance section (Section 7.4) of the Annual Report describes that “about 50% of the process water is recycled through the mill and the remainder (approximately 500 gallons per minute [gpm] long-term average) is sent to Pond 7 for further treatment”; however, no flow data is provided in reports. No data is reported for stormwater entering Pond 7. It is recommended that flow data for these elements be provided as an appendix in annual reporting to comply with the WMP monitoring requirement. Alternatively, the WMP could be revised to reflect anecdotal percentages of flows are an appropriate level of reporting.

5.2.2 Fresh Water Monitoring Program (FWMP)

The FWMP is being implemented and reported in compliance with the WMP. HGCMC submits a monthly letter reporting on any non-compliance, which includes the list of FWMP sites and constituents that exceeded AWQS. Most of these sites, with the exception of Site 13 (at inactive waste rock site 1350), are being reported by HGCMC as being consistent with baseline water quality at the site and thus non-compliance is not a result of facility impacts. Specifically, low pH and low alkalinity is found at Sites 9, 27, 29, 32, and 60.

HGCMC has established “baseline” for Sites 27, 29, and 32 in the FWMP Annual Reports. These sites have been monitored since the beginning of tailings placement. While the baseline established is useful for analysis, the baseline period is well after the TDF operation and thus the baseline data cannot be said to represent pre-operational, natural “background” conditions. The current baseline data set was established only for conductivity, alkalinity, and zinc. Data for those parameters over the period of record do appear to be stable for a significant amount of time in the early stages of TDF operation. It is recommended that a baseline be developed for additional parameters, including pH since it is a parameter currently reported as being in non-compliance with AWQS. The FWMP data may be better compared (SSI) against a baseline threshold value than the current practice of comparing to AWQS, which are not suited for the peat sediments.

5.2.3 Internal Monitoring of Waste Rock

The IMP Sections 3.0 and 4.0 describe an internal monitoring program. The IMP states that data generated by the IMP effort are “not compliance monitoring.” While these monitoring efforts do not have permit monitoring limits, there are specific monitoring requirements in the WMP that require monitoring as described within Sections 3.0 and 4.0 of the IMP. For example, the WMP Section 2.3.1.6 requires geochemical monitoring of waste rock and tailings; however, the monitoring description of the waste rock and tailings geochemistry monitoring are included within the internal monitoring program (not compliance monitoring) of the IMP. Because this

monitoring is specifically required in the WMP, it is not elective and is therefore necessary for permit compliance. It is recommended that the IMP be revised to accurately reflect the difference between elective monitoring (e.g., lysimeters and finger drains), ambient conditions monitoring without limits (e.g., water levels, stability, and ABA testing), and permit limits monitoring (FWMP). It is recommended that all reference to kinetic testing be removed from the IMP because that type of geochemical analysis is not being completed.

Tailings and Production Rock Annual Reports provide a table for production rock disposal tonnage and volume. It is understood that the tonnage is monitored in two different ways, survey at the waste disposal facility and truck counts from the mine department. The column headings in Table 5.2.a are difficult for the reader to understand. It appears that summing the last four columns should match the "From UG Truck Counts (tons)" column because the last four columns were also from truck count, just broken up by production rock class; however, the values are different by approximately 9,000 tons over the year. It is recommended that the heading labels be edited for a reader to better understand or a footnote added or text added to better explain the values.

According to the IMP Table 3-1, groundwater will be monitored at Site 23 annually. Groundwater is not reported for the site after 2014. Curtain drain data is provided annually, which represents under facility groundwater. But there is no data provided for the "3 monitoring wells at Site 23 and D" that the annual report says are monitored. The Annual Report says to see the 2014 Annual Report and that the current year data is consistent with past years. This implies it was monitored and not reported. This monitoring is considered elective; however, all monitoring data is required to be reported. It is recommended that the IMP be revised if HGCMC does not intend to monitor and report groundwater annually.

According to the IMP Table 3-1, surface water at Site 23 will be monitored annually. There are no surface water monitoring sites reported in annual reports after 2014. The annual report says for detailed analysis of water quality within Site 23/D refer to the Tailings and Production Rock 2014 Annual Report and states that the current results are consistent with past years. This implies it was monitored and not reported. This monitoring is considered elective; however, all monitoring data is required to be reported. It is recommended that the IMP be revised if HGCMC does not intend to monitor and report surface water annually.

In the annual reporting of the geochemistry of waste rock, it is recommended that the reports be revised to clarify that the samples labeled "23C-xxx" are from the Site 23 waste rock.

Section 2.3.1.6 of the WMP requires geochemical monitoring of overburden, construction rock, waste rock, and tailings to ensure that there is low potential for the production of leachate that is acidic or contains levels of metals that would contaminate surface or groundwater. According to Section 3.1.1 and Table 3-1 of the IMP, waste rock samples from Site 23 will be analyzed for inductively coupled plasma (ICP) annually. No waste rock ICP data is provided in quarterly or annual reports. While on-site, an Audit Team member observed the ICP data from SGS Laboratory Reports; therefore, it is recommended it be added to the reporting or the IMP be revised to remove that analysis from the geochemical methods. Further, ICP data should be reported for all materials listed in WMP 2.3.1.6 to be compliant. Alternatively, should baseline

geochemical characterization of these materials determine that metals leaching is of low concern, an updated permit could be edited to remove the “contains levels of metals” portion of the requirement, leaving only monitoring for ABA.

In the Annual Active Tailings and Production Rock Report the curtain drain and finger drain water quality data are provided. Site 57 data should be included in the same report to compare against the curtain drain data provided. For example, dissolved zinc has concentrations in one curtain drain (317) that are between 4,000 and 10,000 micrograms per liter (ug/L). These values are an order of magnitude higher than the other curtain drains, which raises the question of upgradient groundwater quality. That curtain drain is also an order of magnitude higher concentration than the upgradient groundwater at Site 57 (after checking the FWMP report). The finger drains have concentrations of dissolved zinc up to 2,000 ug/L. The curtain drain shallow groundwater collected and sent to treatment and downgradient surface water of Greens Creek near Site 23 is not showing any increase in zinc from shallow groundwater discharge to the creek. There is no finding of non-compliance; however, it is recommended that HGCMC and ADEC continue to review zinc in the downgradient monitoring points at Site 23 for any trends over time. Since waste rock ICP data is not reported, there is no way for a reviewer to track the potential for metals leachate (zinc) from the waste rock.

According to the IMP Table 3-1, Lysimeter L1 at Site 23 is supposed to be sampled annually. There is not data in the annual report nor quarterly reports and no explanation as to why. However, finger drains are monitored that likely provide similar data. It is recommended that the lysimeter sampling be removed from the IMP to better reflect current elective monitoring practices.

According to the IMP Table 3-1, composite soil cover monitoring will be conducted quarterly or annually (moisture probes, water levels, tipping buckets (WQ), lysimeters). No data is provided in annual or quarterly reports for composite soil cover monitoring. It is recommended that the IMP be revised to reflect current elective monitoring practices.

According to the IMP Table 3-1, groundwater at inactive waste rock sites will be monitored annually. No groundwater data was reported for Site E in 2017 Inactive Production Rock Annual Report, though monitoring wells are provided on the map included in the report. It is recommended that the IMP be revised to reflect current elective monitoring practices.

5.2.4 Internal Monitoring of Tailings

According to Section 4.1.1 and Table 4-1 of the IMP, tailings samples from the TDF will be analyzed for ICP annually. No tailings ICP data is provided in quarterly or annual reports. While on-site, an Audit Team member observed the ICP data from SGS Laboratory Reports; therefore, it is recommended it be added to the reporting or the IMP be revised to remove that analysis from the geochemical methods.

The Active Tailings and Production Rock Sites 2017 Annual Report (HGCMC, 2018a) does not include any ABA data from samples collected at the TDF, as required per the IMP. The tailings ABA data that is reported (Section 4.2.3 of the Annual Report) states that the samples collected at the TDF had an average acid potential of 426 tons of CaCO₃ per kiloton (tCaCO₃/kt) and stated

the annual averages for neutralization potential and net neutralization potential (referencing Table 4.2.d). However, the data in Table 4.2.d is monthly tailings ABA data collected at the mill filter press, not from the TDF. The 2016 annual report does report both the monthly ABA data from the tailings collected at the mill and the ABA data from samples collected at the TDF (Attachment E); however, the text description of which is which is incorrect.

According to the IMP Table 4-1, surface water at the TDF will be monitored annually. There are no surface water monitoring sites reported in Active Tailings and Production Rock Site annual reports. Surface water monitoring sites 9, 60, and 609 are FWMP monitoring surface water in drainages south of the TDF and reported in the FWMP Annual Reports. The IMP Table 4-1 addresses internal monitoring of surface water sites (not FWMP sites) and therefore implies that there is surface water monitoring at sites in addition to the three FWMP sites conducted annually. This monitoring is considered elective by HGCMC; however, all monitoring data is required to be reported. It is recommended that the IMP be revised if HGCMC does not intend to monitor and report surface water annually.

According to the IMP Table 4-1, groundwater will be monitored at the TDF annually. Tailings area underdrain water quality data is provided in annual reports, but no upgradient or downgradient groundwater data is reported for the site and it is assumed that the underdrains represent TDF pore water/leachate, not groundwater for the area. This groundwater monitoring is considered elective; however, it is recommended that the IMP be revised if HGCMC does not intend to monitor and report groundwater annually, or better communicate what the underdrain data represents for the area.

The IMP Section 4.0 describes the monitoring of the TDF facility. The text of the IMP Section 4.1.1 states that monitoring of the tailings in-situ material (older placed material) will be sampled by collecting a minimum of six samples from the oldest pile surfaces for analysis of NP, AP, and NNP every 5 years until final closure of the tailings facility. The IMP Table 1-1 is consistent by showing a 5-year sampling frequency. The IMP Table 4-1 shows that in-situ sampling of tailings is done annually. The IWMDP does not address the in-situ sampling.

Similarly, the monitoring protocols for tailings samples at the TDF and tailings samples from the Mill are not consistent across all of the GPO appendices. The IWMDP includes a requirement for ABA analysis of quarterly tailings samples (5 kilograms), while the IMP Sect 4.1.1 says six samples will be collected annually from the TDF in place; the IMP Tables 1-1 and 4-1 call for tailings to be sampled monthly and every 5 years; and the Tailings Management Plan calls for sampling of Mill tailings load-out sampling for ABA, paste pH, and ICP. It is the Audit Team's understanding that tailings from the Mill are monthly composites from daily samples for ABA, samples from the TDF are sampled quarterly for ABA and once annually for ABA and ICP, and in-situ tailings older material samples from the TDF are sampled every 5 years for ABA.

Therefore, it is recommended that the GPO appendices (IMP, IWMDP, WRMP, and Tailings Management Plan) be updated to reflect current monitoring conditions and be consistent across the documents. The Audit Team observed that tailings samples and waste rock samples that are sampled quarterly are sent to contract laboratories once or twice a year and only reported annually. It is also recommended that the IMP clarify how often the analysis should be

conducted and reported, and recommended that reporting be more in line with monitoring frequency (e.g., quarterly samples analyzed and reported quarterly).

5.2.5 Quality Assurance / Quality Control Program

It is recommended that the Quality Assurance Project Plan (QAPP) be updated to reflect all labs that complete analyses in the IMP, including the geochemistry sampling. The on-site laboratory analyzes the Mill tailings for ABA and the SGS laboratory analyzes the TDF tailings for ABA and ICP. The production rock for ABA and ICP and these laboratories should be added as well as the discussion of sampling, sample handling, data quality, and reporting associated with these geochemistry samples.

The Audit Team interviewed the water quality samplers and reviewed the field log books for sampling. It appears that the groundwater sampling protocol in the QAPP is not the methodology being followed in the field. The field log books did not state the equipment or method for well purging, nor record the field parameters during the purging process to document that the parameters had stabilized. It is recommended text be added to clarify the target stabilization expected, such as “Stabilization is achieved after three successive readings are within ± 0.1 for pH, ± 10 mV for ORP, $\pm 5\%$ for specific conductance, $\pm 10\%$ for DO, and <10 NTU for turbidity. Sampling may begin once the well has stabilized.”

The QAPP does not address the use of pressure transducers and data loggers for the measurement and recordation of water levels in piezometers. It is recommended that, at a minimum, the frequency of data download from the data loggers and reference to a separate SOP be included. The QAPP or the SOP should describe the data collection programming of the data logger; the equipment, frequency, and process for data download; where data will be stored and how it will be managed; how data drift will be reviewed and corrected; how data will be corrected for barometric pressure; etc.

The QAPP Table 4 lists specific training requirements and states that written record must be made for training of all new personnel. HGCMC could not produce any records of training and therefore it is recommended that a training file be initiated.

It is recommended that HGCMC update the QAPP to provide direction for the statistical analysis and reporting, whether direct comparisons of concentrations to the AWQS or calculations of SSIs over a baseline.

The data validation procedures described in the QAPP and completed by Synectics for HGCMC are only completed on the FWMP monitoring. According to HGCMC, there is no data validation performed on the Internal Monitoring. Sampling completed under the “internal monitoring” or geochemistry do not appear to have quality controls. It is recommended that there be more clarification in the QAPP regarding what quality control sampling is conducted for the internal sampling program (versus the FWMP) and what the acceptance criteria limits are if they are held to a different standard than FWMP.

5.2.6 Laboratories and Sample Analysis Procedures

On-site Environmental Laboratory

HGCMC maintains an on-site laboratory that is used for assay testing and also for ABA for the tailings samples collected at the Mill. The Audit Team conducted an assessment of the laboratory.

The laboratory management, operations, and waste management were found to be within general acceptable practices for environmental testing laboratories. Since the laboratory provides ABA data for permit compliance, it is recommended that the QAPP be updated to reflect the on-site laboratory's testing activities, sample handling, and general quality assurance/quality control (QA/QC) associated with the ABA testing in compliance with the IMP.

The laboratory manager provided the Audit Team with a copy of the Modified-Sobek ABA method. While the method provides sufficient details for the analysts to run the test, no method citation is provided. Furthermore, it is recommended that the lab method be revised to incorporate quality control in the process. For example, the lab has two laboratory control standards to assess method accuracy; however, there are no data quality thresholds.

The waste rock segregation program relies on visual classification of the rock into classes, followed up by analysis of muck samples for ABA. The analysis is not conducted in the on-site laboratory. It is submitted to SGS Laboratory by the laboratory superintendent after receipt of the samples from the production geologists.

Sample Preparation Shack

The Audit Team inspected the environmental sampling room (also known as the Water Room). The Water Room is used for storage of laboratory supplied sample containers, coolers for samples, refrigerator for temporary storage of samples and reagents, freezer for ice, storage of reagents, storage and calibration of field meters (e.g., pH meter), storage of sample preservative chemicals (e.g., nitric acid), and storage of field sampling equipment and supplies. In general, the building was clean, with equipment and supplies well maintained. HDR observed coolers pre-packed with bottle kits for sampling, including the double bagging prescribed in the QAPP for the FWMP samples. HDR observed the field meters and calibration logs for field meters, example Chain of Custody forms, and reviewed that all of the calibration standards were not expired. The calibration logs for field equipment were evidence that field meters were calibrated before each sampling event. Through discussion with the Senior Environmental Engineer, it was discovered there are no established acceptance criteria for the calibration check (e.g., meter reads +/-5 percent of standard after calibration). It is recommended that the calibration check acceptance criteria be easily identifiable in the QAPP and a sign be posted in front of the meter calibration station for personnel.

While the QAPP described protocols for some sampling, it is recommended that HGCMC create a master SOP list for environmental sampling and tests. This list should be included in the QAPP and also made available in the sample preparation shack. Furthermore, appropriate sampling, sample handling, and field equipment SOPs should be maintained in a binder at the shack and made available to field personnel.

5.2.7 Biological Monitoring

Aquatic Habitat

The WMP Section 2.3.1.5 requires biological monitoring in Greens Creek and Tributary Creek. Section 5.0 of the IMP describes the rationale and methods that are to be used to document the continued health of the aquatic communities. HGCMC is required to measure juvenile fish abundance; whole body concentrations of cadmium, copper, mercury, lead, selenium, silver and zinc in fish tissue as well as periphyton biomass estimated by Chlorophyll-a; and abundance and community structure of benthic invertebrates.

The FWMP Section 5.0 states that the role of the biological monitoring program is to ensure the continued use of Greens Creek and its tributaries by fish and other aquatic species and to document the continued health of all levels of the biological community consisting of primary productivity, invertebrate communities, and fish. Biological monitoring should also detect early changes to the aquatic community that may result from changes in water chemistry, through either surface or groundwater inputs to the system.

Since 2001, the ADF&G has completed the biological monitoring studies in Greens Creek and Tributary Creek for HGCMC as required by the WMP and approved FWMP. This partnership provides the ADF&G an opportunity to gather and review data, and help identify, assess, and resolve issues that could affect aquatic resources near the mine site (ADF&G, 2018).

The Aquatic Biomonitoring Program completes the following studies:

- Periphyton biomass, estimated by Chlorophyll-a concentrations;
- Benthic macro invertebrate density and community composition;
- Juvenile fish populations and fish condition; and
- Whole body juvenile fish (Dolly Varden char) element concentrations.

In addition to the parameters mentioned above, water quality field measurements for temperature, pH, conductivity, and stream flow are collected during each monitoring event.

Beginning in 2001 and through 2017, sample sites have consisted of the following:

- Greens Creek Site 48, reference site located upstream of mining activities;
- Greens Creek Site 54, downstream of mine activities; and
- Tributary Creek Site 9, downstream of the TDF.

In late 2017, the Greens Creek watershed experienced a high flow event that diverted the segment of stream channel containing Greens Creek [Sample] Site 48, causing Site 48 to go dry. As a result of this condition and prior to the 2018 sampling event, ADF&G Habitat Biologists established a new reference sampling site identified as Site 63, which is located downstream of Site 48. Similar to Site 48, the new site (i.e., Site 63) is located downstream of Big Sore Creek and upstream of mining activities. However, unlike Site 48, 1350 Creek flows (water quality impacted by Site 1350) into the Site 63 sampling reach (Kanouse and Zutz, 2018). According to

ADF&G, this was unavoidable due to limited suitable sampling areas that were still located downstream of Big Sore Creek, but still upstream of mining activities, as was the case with Site 48 prior to the site going dry. Results for the new sampling site (Site 63) will be compared to the results from the previous sample site (i.e., Site 48) but some considerations will be made with respect to the fact that biological diversity and abundance may be somewhat different because sampling is occurring immediately downstream of the newly formed stream channel (personal communication with Kanouse, September 2018).

The most recent biological monitoring report contains the results from the 2017 sampling event and represents the current data, and should be used to analyze data from previous years (Zutz, 2018).

Results from the 2017 sampling event were generally within the ranges observed in previous years for each of the three individual sites. Results from comparisons among the sample sites are also provided. However, the report noted that comparisons for Chlorophyll-a concentrations, benthic macro invertebrate density, and fish populations only occurs between Sites 48 and 54. Comparisons to Site 9 data do not occur because of a difference in aquatic habitat, which results in an effect to productivity. As such, only element concentrations are compared among all sample sites.

Comparisons of the Greens Creek data among sample sites found that results followed trends for Chlorophyll-a concentrations, benthic macro invertebrate density, and fish populations. The 2017 data comparisons among the Greens Creek and Tributary Creek sites for juvenile fish element concentrations found that the Site 9 mean ranks for silver, mercury, lead, and zinc concentrations were significantly different than the mean ranks for Sites 48 and 54. Additionally, the Site 9 mean ranks for cadmium and selenium were significantly different than the mean ranks for Site 48.

Other than natural variability, observed in the sampling results from the 2017 biological monitoring, results were generally unremarkable and provided no indication of declining fish use or changes to aquatic communities attributable to the project.

The biological sampling program is meeting the associated WMP conditions as well as the stated role for the biological sampling program contained in the FWMP. Recommendations for the program moving forward are to conduct relative abundance sampling for juvenile fish as opposed depletion sampling. The reasons for this recommendation are twofold. The assumptions for depletion sampling requiring a closed sample population, equal probability of capture, and no trap avoidance after each pass are challenging to implement in the field and difficult to prove, which adds uncertainty to the population estimate. Secondly, the WMP states that fish abundance should be determined, not fish population. Given that there is an 18-year period of record for the fish sampling program, the use of relative abundance estimates following similar sampling methods (i.e., 1.5-hour baited minnow trap saturation within the sample reach) should provide an adequate measure of continued fish use in Greens and Tributary Creeks; allow data comparisons to previous year sampling results; and, in consideration with the other sampling parameters, detect changes to the aquatic community.

Wildlife

The WMP Section 2.3.1.10 requires monitoring for signs of stress to wildlife associated with facility activities. This requirement is nondescript and difficult to comply with; therefore, it is recommended that this monitoring requirement be removed from future permit revision.

5.2.8 Geotechnical Monitoring

Geotechnical monitoring is performed by the HGCMC Environmental Department, Water Operations, and Technical Services staff at the Pond 7/10 Dam System and appurtenance works, the TDF, and the Site 23 Waste Rock Storage Facility, as described in the following section.

Pond 7/10 Dam System Monitoring

Monitoring of the Pond 7/10 System utilizes surface monuments installed on dam embankments, which consist of global positioning system (GPS) survey targets mounted on an all-thread rod embedded in concrete. These monuments are surveyed via GPS method for horizontal position and elevation by the HGCMC Technical Services survey lead. The Pond 7 surface monuments are surveyed annually, and the Pond 10 monuments presently are surveyed monthly. HGCMC indicated that it will reduce the frequency of readings of the Pond 10 surface monuments once a baseline data record is established. Cumulative survey data is collected in an Excel spreadsheet by Technical Services and updated with new readings.

Visual inspections of the Pond 7/10 Dams are performed weekly by HGCMC Water Operations, and an inspection checklist is prepared. The inspection records are reviewed and approved by an Environmental Department Senior Civil Engineer. The Audit Team viewed a notebook of compiled inspection checklists during the visit. In response to a recommendation in the most recent PSI report (Klohn Crippen Berger [KCB], 2018a), visual inspection of the sacrificial high-density polyethylene (HDPE) geo-membrane surrounding the Pond 7/10 flow control structure (FCS) for evidence of scour or damage was added to the weekly visual inspection checklist by HGCMC in 2018. The 2018 PSI report also recommended that HGCMC complete a visual condition assessment of the Pond 7 inlet channel Reno mattresses and assess whether maintenance or repair of the mattresses are required. HGCMC indicated that in summer 2019, they plan to divert water to Pond 10 and drain-down Pond 7, clean sediment from Pond 7, and assess the condition of the Reno mattresses at the inlet channel.

Automated continuous data collection via a supervisory control and data acquisition (SCADA) system is performed for the Pond 7/10 System and TDF wet wells by HGCMC Water Operations and Environmental staff. Wet well water levels, inflow and pump discharge data, and pump operating times, including for the Pond 7/10 and TDF underdrain system return flow, are continuously collected by the SCADA system and/or by cumulative pump hour-meter readings. The wet wells downgradient of the ponds intercept groundwater flow below the pond liners and intercepted by the underdrains within the foundation layer, and potential leakage through the pond liners into the foundation layer underdrains. Wet wells below the TDF collect intercepted leachate outflows from the TDF (flow through the tailings pile to the pile base). Wet Wells (WWs) A and 3 are not connected to the SCADA system. Flows that reach WW A pass through and report to WW 14. WW 3 pump hour-meter readings are recorded bi-weekly by HGCMC

environmental technicians. WWs 10, 11, 12, 13, 14, 15, and 16 are all continuously monitored on the SCADA system for flows. More recently constructed wet wells collect both below-liner flows (from the underdrain pipe network within the prepared foundation layer) and above-liner leachate outflows, from the TDF draining to a common wet well. The required WMP quarterly reporting includes data for the combined flows to the wet wells.

Vibrating wire piezometers (VWPs) installed within the Pond 7/10 foundation layer underdrain system (beneath the pond HDPE geo-membrane liners) measure the piezometric pressure head in the foundation below the pond liners and are automatically read every 6 hours with a Campbell Scientific data logger. Data is also periodically downloaded from the logger by HGCMC Environmental Department staff. The pressure head data are loaded into an Excel spreadsheet for analysis and reporting. The 2018 PSI report (KCB, 2018a) recommended that HGCMC and the Engineer of Record monitor and review readings from VWP PZ-P7-05-01 (located at the southeast corner of the bottom of Pond 7) monthly and identify potential causes of a pore pressure rise, taking into consideration groundwater trends in the surrounding areas. HGCMC indicated that the pressure head readings for PZ-P7-05-01 have been steady and pose no cause for concern. HGCMC indicated that they plan to contact the Engineer of Record (KCB) to discuss the PSI report recommendation and review the need to revise VWP action thresholds.

The first fill of Pond 10 was completed in May/June 2018 and reporting of the first fill activity and data is in progress by HGCMC. The report is anticipated to be submitted to the ADNR in August 2018. Approximately 2 months of Pond 10 leak detection system data had been collected as of the Audit Team site visit, and data collection was indicated by HGCMC to continue for several more months before establishing a baseline leakage rate for the primary liner/leak detection system. The baseline leakage rate is anticipated to be included in an update to the Pond 7/10 O&M Program manual.

The Audit Team found that the geotechnical monitoring of the Pond 7/10 Dam System and appurtenant works as currently being performed by HGCMC is adequate and in conformance with the requirements of the Pond 7/10 O&M Program manual and the Tailings Disposal Facility Management Plan (Appendix 3 to the Plan of Operations; HGCMC, 2018b).

Tailings Disposal Facility (TDF)

Open standpipe piezometers and VWPs internal to the TDF are read continuously (every 6 hours) using a Campbell Pacific data logger, and the data is downloaded monthly by the HGCMC Environmental Department staff. "Historic" pneumatic piezometers within the TDF and standpipe piezometers are manually read and recorded by HGCMC Environmental Department staff six to eight times per year.

As noted above, underdrain return flows from the TDF underdrain system are monitored at WW A, for which flows pass through and report to WW 14, and at WW 3, for which flow-rates are recorded using pump cumulative hour-meter readings. WWs 10, 11, 12, 13, 14, 15, and 16 are monitored using the SCADA system for auto collection and reporting of flow data.

HGCMC Surface Operations Technical Services staff perform quarterly in-place dry density (relative compaction) tests of the placed tailings within the TDF, along with occasional correlation checks performed by a KCB materials technician. As indicated in the 2017 WMP Quarterly Reports, HGCMC used a combination of a dynamic cone penetrometer, nuclear density gauge, and sand cone tests for verification of the compacted tailings density. The objective was to use multiple test methods to develop a calibration for the nuclear density gauge for future testing. However, HGCMC indicated that the nuclear gauge method may not provide accurate density data in the tailings, apparently due to the tailings mineralogy. However, it is important to note that this method is still being evaluated. Example quarterly test records were not viewed by the Audit Team during the site visit.

Site 23 Waste Rock Storage Facility

Monthly visual inspections of Site 23 are performed by the HGCMC Environmental Department, and Surface Operations performs daily and weekly inspections as part of regular work shift activities. Monthly inspection checklists are prepared by HGCMC.

The Site 23 surface survey monuments and inclinometers are read and recorded quarterly. HGCMC Environmental Department staff read the inclinometers and the HGCMC Technical Services survey lead reads the surface survey monuments. Site 23 finger drain and curtain drain flows, water levels in open-standpipe piezometers wells, and newer VWP's installed exterior to the inclinometer casings are read and recorded by the HGCMC Environmental Department staff on a monthly basis.

Geotechnical Monitoring Recommendations

Based on our understanding of the geotechnical monitoring program and results for the Pond 7/10 Dam System and appurtenance works, the TDF, and the Site 23 Waste Rock Storage Facility, and as discussed in the 2018 PSI report (KCB, 2018a), the Audit Team's recommendations are as follows:

- Results of monitoring of the Pond 7/10 Dam System surface survey monuments, as summarized in the 2018 PSI report (KCB, 2018a) and discussed with HGCMC, do not appear to indicate stability issues with the Pond 7/10 Dams, with the caveat that as indicated above, the baseline record of observations for the Pond 10 Dam has not yet been established.
- The apparent pore pressure rise indicated by piezometer (VWP PZ-P7-05-01) within the southeast corner of the Pond 7 bottom underdrain system should be evaluated by the Engineer of Record (KCB), compared to groundwater level trends in the surrounding area such as Pond 10 and the S3P1 expansion area, and the potential cause identified.
- The Engineer of Record (KCB) should review the action thresholds and reading frequencies for the Pond 7/10 foundation layer underdrain system VWP's and make recommendations.
- It is unknown if action threshold readings have been established by HGCMC for the open standpipe piezometers, VWP's and "historic" pneumatic and open standpipe piezometers, and underdrain return flows within the TDF, relative to potential effects on

TDF stability by elevated pore pressures and groundwater levels. It is recommended that the Engineer of Record (KCB) review the relevant stability analyses and the cumulative piezometer data, and then establish action threshold levels of pore pressure or hydrostatic head.

5.3 Waste Rock Management Plan

The Audit Team reviewed the WRMP (November 2014) and compared it against other Plans and against mine activities. The WRMP is a well written plan that allows HGCMC the ability to track the geochemistry of the waste rock on-site. The WRMP has a few statements that appear to be older practices at the mine and do not reflect current activities. For example, the WRMP states that chip samples collected for verification of the visual classification will be analyzed at the in-house laboratory, and it is the Audit Team's understanding that these samples are submitted to SGS Laboratory. In addition, the monitoring section of the WRMP is not consistent with the IMP. Therefore, an update to the WRMP to line up with all monitoring described in the IMP and IWMDP is recommended. It is also recommended that the WRMP include data quality objective for the verification sampling comparison against visual classification.

5.4 Integrated Waste Management and Disposal Plan

The Audit Team reviewed the IWMDP (June 2014) and compared it against other Plans and against mine activities. Section 4.23.1 of the IWMDP describes waste rock co-disposal requirements, including waste rock to tailings ratios for co-disposal. During the field audit, the Audit Team discussed co-disposal with the Environmental Staff and found that there are currently no co-disposal ratios or specific protocols used. In addition, the IWMDP states that weathered waste rock moved to the TDF will be limed if acidic, which the Audit Team believes may be an older procedure. There appears to be a number of older procedures described in the IWMDP; therefore, it is recommended that the Plan be updated to reflect current practices and also to be consistent with monitoring and practices described in the other GPO appendices.

The IWMDP states that if any changes are seen in the geochemical results of the analysis for the development rock or tailings, additional sampling and analysis are conducted as determined necessary. In reporting geochemical results, there appear to be stated values for waste rock and tailings with no comparison to baseline characterization to determine if any changes are seen. For example, the reader of the 2016 Annual Report can read that tailings, as sampled at both the Mill and TDF have high acid generating potential according to ABA results (net neutralization potential <-100 tonnes CaCO₃ equivalent per 1,000 tonnes material). However, the reader is unable to compare this to historical samples or baseline tailings characterization. It is recommended that baseline data be provided for comparison in reporting.

Some discrepancies between the QAPP and IWMDP were described earlier in the report (Section 5.1.8, Monitoring Program) and are not restated in this section.



5.4.1 Waste Management Priorities

The IWMDP lists five priorities that the mine should consider to prevent and/or minimize waste generation. These five priorities are:

1. The potential of materials excavated, mined, or milled to adversely affect water quality;
2. Waste source reduction;
3. Recycling;
4. Waste treatment; and
5. Waste disposal.

The IWMDP goes on to list several strategies the mine is to follow to accomplish the five priorities listed above. The waste prevention/minimization strategies from the IWMDP are listed below (see Table 5) along with the observed practices at the mine.

Table 5. Compliance with Waste Prevention and Minimization Strategies

Waste Prevention/Minimization Strategy	Audit Finding
Geochemical characterization of materials to be excavated, mined, or milled.	The mine is following the geochemistry monitoring plan, though some recommendations and updates should be considered; see Section 5.0.
Operations that generate waste would be reviewed to identify opportunities for reducing waste and the opportunities would be implemented whenever possible.	The mine facility employs a full-time staff position dedicated to environmental coordination and compliance. One of responsibilities for the Environmental Staff is to identify and reduce waste generation at the site.
The properties for materials would be reviewed prior to purchase, and every effort would be made to minimize the use of hazardous materials and those that would be classified as hazardous waste once they can no longer be used for their intended purpose.	The mine appeared to be following this strategy. The mine is considered a Very Small Quantity Generator of hazardous waste (≤ 220 pounds/month).
Methods for reusing and recycling materials would be promoted and implemented whenever possible to reduce waste.	All municipal solid waste generated by surface operations is shipped off-site for disposal, and reasonable efforts were being made to reduce the volume of waste generated and to recycle or reuse materials where possible. This included, but is not necessarily limited to, recycling oxygen and acetylene bottles, repairing tires, recycling batteries and scrap metal, and utilizing used oil for heat recovery.
Non-hazardous solid wastes that are permitted for disposal on-site would be disposed of at on-site, permitted, solid waste landfills regulated by ADEC and in accordance with 18 Alaska Administrative Code 60 or applicable HGCMC permits.	Non-hazardous solid waste disposal at the mine site was limited to the waste eligible for underground disposal per Section 2.1.4 of the WMP.
Materials that cannot be managed on-site would be sent off-site to appropriate facilities for recycling, reuse, treatment, and/or disposal.	Materials that cannot be managed on-site, such as kitchen wastes, is frozen and temporarily stored on-site until such time that it can be shipped off-site for disposal.

5.4.2 Purchasing of Materials

The IWMDP provides guidance on the procedures for the purchase of materials that consists of the following:

- Minimize the generation of hazardous wastes by avoiding the purchase of materials that would be regulated as hazardous wastes when the materials are no longer required for their intended purpose.
- To the extent practical, materials will be purchased in containers (e.g., totes or drums) that can be returned to the vendor.

- The Material Safety Data Sheets for new materials to be purchased will be reviewed to ascertain if the materials require special management under the Resource Conservation and Recovery Act, Emergency Planning and Community Right to Know Act, Comprehensive Environmental Responsibility and Compensation Liability Act, Clean Air Act, and Toxic Substances Control Act (see EPA's "List of Lists").
- For materials requiring special handling and/or that would be classified as a hazardous waste if disposed, HGCMC is to evaluate if a suitable substitute is available that is considered "less hazardous." Less hazardous includes: a waste that would not be classified as a hazardous waste if disposed, would not require special handling under the above-noted Acts, would generate less waste when disposed, can be reused or recycled, or is generally considered to have less of an impact on the environment (e.g., a material with less discharges to the environment when treated and/or disposed).

The Audit Team found that the mine is generally following the procedures above. The incentive to minimize the purchase of materials that, once used, could become hazardous waste is influenced by the requirement and associated cost of shipping all hazardous waste off-site for disposal. As a result, the Environmental Staff track incoming and outgoing materials, including chemicals that could become part of the mine's waste stream. This information helps to ensure proper characterization of the materials for disposal, recycling, or reuse. The mine also coordinates, where it is practicable, to return materials to vendors.

5.4.3 Waste Minimization

The IWMDP provides a number of efforts to minimize waste generation and as well as recycling and reuse of materials, which the Audit Team found HGCMC to be implementing. Some examples of methods listed in the IWMDP include:

- *The use of primarily eco-friendly solvents in parts washers (e.g., Orange-Sol™ or SimpleGreen®).* When asked, Environmental Staff at the mine did not know if only eco-friendly solvents were being used in parts washers.

Information provided by Environmental Staff after the site visit stated that some of the parts washers use eco-friendly solvents whereas others use hydrocarbon based solvents. Regardless of the solvent use, spent solvents and the residuals from parts washers are collected and disposed of off-site through Waste Management.

- *The use of low mercury, fluorescent lamps ("green end cap") and recycling of lamps and bulbs.* The use of low mercury, fluorescent lamps ("green end cap") and recycling of lamps and bulbs is occurring on-site. Used fluorescent lamps are managed as a Universal Waste and shipped off-site for disposal.
- *Recycling or reuse of materials such as antifreeze, batteries, reusable light vehicle tires, scrap metal, and used oil.* Antifreeze, batteries, and scrap metal are shipped off-site for disposal or recycling. Used oil is burned on-site for heat recovery purposes.
- *Returning containers to vendors or recycling them as scrap metal, which prevents the need for disposal of containers in landfills; appropriate container management, including the provision of secondary containment and proper labeling.* Containers at the mine

were well managed. This was evidenced by the observation that they were labeled, there appeared to be a minimal number of containers, and containers present were being used for a specific purpose.

- *The prevention of mixing of hazardous wastes with non-hazardous wastes through waste segregation, established procedures, and personnel training.* Observations at the time of the audit did not find that mixing hazardous waste with non-hazardous waste was occurring. All waste types were segregated and labeled. Based on interview conversations with the Environmental Staff, training occurs with personnel on an annual basis and immediately with new employees. If employees are not sure what do with any particular waste material, they are instructed to contact the Environmental Staff.

During the site visit, it was noted that used oil is being used as a fuel source for heat recovery purposes. On-site Environmental Staff stated that this oil was being tested to determine if hazardous waste characteristics are present.

5.4.4 Waste Segregation

According to the IWMDP, waste management at Greens Creek Mine should include appropriate segregation of wastes to ensure they are properly managed according to the applicable regulations and the specific waste handling procedures as described below:

- *All camp waste (e.g., putrescible food waste, paper products) is placed in a storage building at the incinerator.* The audit found that the mine is no longer operating an incinerator. All putrescible food waste, paper products, and other camp waste are placed in a refrigerated container and stored on-site (frozen) until such time that it shipped off-island for disposal. It is recommended that the IWMDP be modified to reflect this practice.
- *Inert wastes destined for the TDF or disposal underground will be taken directly to these locations or placed in specific areas such as the Remuck bays for temporary storage prior to disposal.* The Audit Team observed this practice is occurring on-site.
- *Hazardous wastes are placed in containers at Satellite Accumulation Areas or placed in containers appropriately labeled and brought directly to a Hazardous Waste Accumulation Area.* The Greens Creek Mine is considered by the EPA to be a Very Small Quantity Generator of Hazardous Waste³. At the time of the on-site audit, only one 5-gallon bucket of hazardous waste was observed at the Satellite Accumulation Area, and it was appropriately labeled and dated.
- *Universal Wastes (e.g., lamps, batteries, and mercury-containing equipment) will be placed in containers at Universal Waste Accumulation Areas according to the procedures outlined in WMP.* The Audit Team inspected the Universal Waste Accumulation Area, located within a steel building. Items such as used lead acid

³ Very Small Quantity Generators may not accumulate more than 1,000 kilograms (2,205 pounds) of hazardous waste at any time.

batteries, alkaline batteries, and florescent light bulbs were observed in the Universal Waste Accumulation Area.

- *Materials to be recycled will be placed in segregated containers designated for the specific type of material and managed as outlined in Section 4.0.* Materials such as lead acid batteries and scrap metal were observed by the Audit Team in segregated containers and labeled accordingly.

5.4.5 On-site Waste Management

Solid waste management facilities include: inert solid waste landfills (underground), temporary storage areas (i.e., Remuck bays) and frozen camp waste, and the TDF. The Audit Team found that HGCMC was compliant with on-site solid waste management requirements.

Inert solid waste that is generated underground is disposed of underground and backfilled with paste. Some inert solid waste generated as a result of surface operations is transported underground for disposal.

During the audit, the IWMDP was reviewed with mine staff for the purpose of determining if the current procedures for waste management on-site were consistent with the procedures contained in the waste management plan. It is important to note that the IWMDP was written in 2014 and it was found that some procedures contained in the plan have been modified “in practice” and did not always align with what is in the IWMDP. The reasons for these changes appear to be driven in large part by practicability, based on the actual versus the initially anticipated waste management operations and methods that were written into the waste management plan. At the time of the Audit, Environmental Staff were actively completing an update of the IWMDP to reflect current waste management and disposal practices.

5.4.6 Secondary Containment of Fuel and Hazardous Substances

The Greens Creek Mine contains a number of above ground storage tanks that contain various petroleum products and chemicals necessary to support operations of the overall facility. According the WMP Section 2.2.2, HGCMC shall provide and maintain secondary containment for all chemical mix tanks containing hazardous or toxic materials and new piping associated with that tankage. Secondary containment is considered to be 110 percent of the largest tank within a containment area or the total volume of manifolded tanks. The permittee must design and install secondary containment structures in a manner that ensures that solid waste and leachate will not escape from the structures. To prevent such discharges, facilities shall be maintained in good working condition at all times by the permittee. The audit included a review of the secondary containment measures contained in the SPCC Plan, which is only required to account for the storage and containment of petroleum and non-petroleum based oils; therefore, it does not account for reagent storage in the Mill.

During interviews with mine staff, the Audit Team confirmed that the mine maintains written communication with ADEC regarding engineering changes to the Mill and waste treatment processing, including the introduction of any new chemicals into the Mill process or waste treatment streams.

Secondary containment of Mill process reagents was inspected during the audit. The reagents were located in a covered area in the Mill building, stored in tanks that appeared to be in good working order, and contained within separate curbed concrete containment areas. Reagent material that is captured in the curbed containment area is used in the milling process or is captured in the floor drain system and sent to the water treatment plant at the Mill. The Audit Team found that concrete curbing that is used for the secondary containment of reagents used in the milling process is in need of repair. The concrete curbing has deteriorated in some places such that in the event of a reagent spill, containment would be questionable. At one location the curbing was removed so that what appeared to be a heater could be installed under an area where Mill reagents are stored (see Photograph 16 in Appendix A). The Audit Team recommends that the containment curbing for Mill reagents be assessed and repaired as necessary so that 110 percent containment is achieved.

While on-site, the Audit Team surveyed the above-ground bulk fuel storage facilities, other above-ground storage tanks, drum storage areas, recently installed pipelines at the Mill, as well as the SPCC Plan. The results of the audit found that HGCMC is in compliance with Section 2.2.2 Secondary Containment and Section 2.2.4 Fuel and Hazardous Substances as included in the WMP.

The Audit Team reviewed the ADEC Spills Database from April 2014 through August 2018. The majority of spills were small in volume, generally ranging from 2 to 9 gallons, and generally resulting from the failure of hydraulic hoses on heavy equipment where secondary containment is not practicable.

5.5 Certificate to Operate Dam

5.5.1 Pond 7/10 Dam System

The ADNR issued a Temporary COD for the Pond 7 Dam, Pond 10 Dam and respective appurtenance works (referred to as the Pond 7/10 Dam System) (ADNR, 2018b), which includes the following attachments:

- Attachment A – Special Conditions, and
- Attachment B – Scope of Work for Independent Review of Pond 7/10 Dam System.

It is noted that the Audit Team reviewed previous CODs for the Pond 7 Dam and appurtenant works, which were issued by the ADNR during the term of the current Waste Management Permit and Reclamation and Closure Plan. Requirements of the ADNR's 2013 and 2017 CODs are consistent with the current COD, but otherwise are superseded by more extensive requirements of the current COD. Collectively, the attachments to the Temporary COD include both specific operational requirements and specific requirements for independent engineering review of the Pond 7/10 Dam System. They also, incorporate operation, monitoring, inspection, and maintenance of the system and appurtenance works in accordance with the procedures described in the Operations and Maintenance Program for Pond 7/10 (Revised November 2017). Each Special Condition and referenced O&M Program requirement is listed below, along

with the Audit Team's review activity and audit of HGCMC compliance with the permit requirement.

COD Attachment A Special Conditions:

1. *Inspections of Pond 7/10 Dam System in accordance with the requirements of the Pond 7/10 O&M Program:* Visual inspections of the Pond 7/10 Dams and appurtenance works are performed weekly by HGCMC Water Operations, and an inspection checklist is prepared. The inspection records are reviewed and approved by an Environmental Department Senior Civil Engineer and maintained by the Environmental Department. In response to a recommendation in the most recent PSI report (KCB, 2018a), visual inspection of the sacrificial HDPE geomembrane surrounding the Pond 7/10 FCS for evidence of scour or damage was added to the weekly visual inspection checklist by HGCMC in 2018. The 2018 PSI report also recommended that HGCMC complete a visual condition assessment of the Pond 7 inlet channel Reno mattresses and assess whether maintenance or repair is required. HGCMC indicated that in summer 2019, they plan to divert water to Pond 10 and drain-down Pond 7, clean sediment from Pond 7, and assess the condition of the Reno mattresses at the inlet channel and repair or replace as needed. The Audit Team viewed typical completed Pond 7/10 inspection checklists during the visit.

In accordance with the TDF Management Plan (Appendix 3 of the General Plan of Operations; HGCMC, 2018b), monthly visual checks of the facility are performed when operations are in process, using the monthly visual inspection checklist in the TDF Management Plan. HGCMC staff also indicated that daily and weekly visual inspections are made as part of operations and for which an inspection checklist is not prepared. Environmental staff perform the monthly inspections, and Surface Operations staff perform the daily and weekly inspections as part of regular work shift activities. HGCMC Environmental staff prepare the monthly checklists. Typical completed inspection checklists were viewed by the Audit Team during the site visit.

Special inspections of the Pond 7/10 Dam System and the TDF are made by an HGCMC Surface Operations Engineer following severe storms and floods, increases in seepage, change in seepage water quality, or seismic activity. HGCMC indicated that no special events that required special inspections have occurred since 2014.

2. *Limit Pond 10 to temporary storage of storm-water overflow during the period of the Temporary COD approval:* HGCMC indicated that limiting Pond 10 to temporary storage of storm-water overflow is anticipated to change following reporting to the ADNR of the first fill testing of Pond 10, and pending revisions to the O&M Program specifically regarding the leak detection and recovery system for Pond 10.
3. *2018 work for the Stage 3 Phase 1 Expansion of the TDF during the period of the Temporary COD approval, including Pond 10 first fill, and punch list items from previous construction inspections:* HGCMC indicated that the Pond 10 first fill was performed in May–June 2018. Minor mechanical system punch list items have been addressed, with

the exception of installation of louvers for a ventilation system. The Pond 10 first fill report is in progress by HGCMC and is anticipated to be submitted to the ADNR in August 2018.

HGCMC indicated that as of the date of the site visit, about 2 months of Pond 10 primary liner leak detection system leakage data had been collected. HGCMC indicated that leakage data collection will continue for several more months before settling baseline leakage rates. When established, the baseline leakage rate will be included in the Pond 7/10 O&M Program.

4. *Submit to the ADNR all existing geotechnical reports, instrumentation plans/data reports, engineering design evaluations and reports (seepage, stability, and deformation), construction completion reports and independent reviews developed since January 2009 (pending), and future work for the TDF including the Stage 3 Phase 1 Expansion:* HGCMC indicated that the TDF documents have already been submitted to the ADNR, including for the Stage 3 Phase 1 Expansion area.
5. *Provide to the ADNR the most current water balance, design reports, run-off calculations, construction as-builts, stage-storage curves and O&M plans for collection ponds, and wet wells and other appurtenant works that contribute flow to the Pond 7/10 Dam System:* HGCMC indicated that the 2018 Site Water Balance (EDE Project Number GCM1706) was submitted to the ADNR in June 2018. It is understood from HGCMC that since the site visit, existing water system reports have been submitted to the ADNR Dam Safety and Construction Unit.
6. *Provide for an Independent Engineering Review of the Pond 7/10 Dam System, in accordance with the requirements of Attachment B of the Temporary COD, during the period of the Temporary COD approval, including a verbal report of preliminary findings to the ADNR by November 2018 and final written report to the ADNR by March 1, 2019:* HGCMC indicated that the Independent Review Engineer (IRE; Golder Associates) is under contract with HGCMC, Golder engineer's qualifications were submitted to and approved by the ADNR, and Golder visited the site during the week of July 16, 2018. It is understood that the verbal report by the IRE (Golder) was made to the ADNR on December 7, 2018. HGCMC further indicated that a hold point was included in the 2018 construction schedule for the TDF underdrain system (in accordance with the Attachment A Condition #7) to accommodate the field observations by the Golder engineer during the week of July 16, 2018.
7. *Update the O&M Program manual and develop an O&M manual for the Pond 7/10 Dam System, including an Emergency Action Plan, during the period of the Temporary COD approval:* HGCMC indicated that the next version of the O&M Program manual is planned to be issued in the first or second quarter of 2019. The program manual will be tailored for the facility operators' use, including all sources of water reporting to Pond 7/10, piezometer and surface monument threshold readings, action levels, and actions and communications in response to exceedances of thresholds (in the form of a revised expanded Table 7 in the O&M Program manual). According to HGCMC, the revised

O&M Program manual also will include an Emergency Action Plan for the Pond 7/10 Dam System.

8. *Beginning in 2019, submit to the ADNR an annual instrumentation report for the Pond 7/10 Dam System, including data for thermistors, piezometers, lysimeters, inclinometers, (pond) water levels, surface flows and pipe flows, underdrain flows, underdrain water quality data, leak detection system flows, survey monuments, and meteorological station data:* HGCMC indicated that the first annual instrumentation report will be submitted by March 31, 2019. HGCMC indicated that instrumentation data for the various instruments may be presented in both graphical and tabular formats.
9. *Beginning in 2019, submit to the ADNR an annual water management plan, including the information specified in Temporary COD Attachment A, Special Condition 10 for Pond 7, Pond 10, and the TDF:* HGCMC indicated that the 2018 Water Balance report was submitted in June 2018 (EDE, 2018). HGCMC indicated that this water management plan will be submitted to the ADNR in 2019 and noted that Special Condition 10 also includes the volume of placed tailings and the forecast of tailings placement relative to remaining storage capacity of the TDF. HGCMC indicated that the water balance input files will need to be updated as part of the 2019 submittal.
10. *Beginning in 2019, submit to the ADNR an annual performance report for the Pond 7/10 Dam System, prepared by a qualified engineer, including results of visual inspection and photographs, review and evaluation of routine inspection and maintenance reports, and review and evaluation of monitoring data (annual instrumentation report data plus any additional data that is available at time of field inspection):* This requirement will be waived by the ADNR in each year that a PSI is performed and is deferred for 2018 if the Independent Engineering Review required by Special Condition 7 of the Temporary COD is performed. HGCMC indicated that the initial annual performance inspection and report has been deferred to 2019, as the Independent Engineering Review was performed in accordance with the Temporary COD Special Condition 7.
11. *Perform the PSI of the Pond 7/10 Dam System no later than July 2020; perform subsequent PSIs at 3-year intervals as required for a Class II dam (significant hazard potential dams and appurtenant works):* The most recent PSI for Pond 7 and appurtenant works was performed by the Engineer of Record (KCB) in July 2017, approximately 5 years after the previous inspection in June 2012. A revised draft of the PSI report was issued by KCB in January 2018 (KCB, 2018a). The 2018 PSI report included seven recommendations, most of which concerned inspections and monitoring, and are detailed below. HGCMC indicated that the next 3-year interval PSI is scheduled for 2020.
12. *Maintain an Emergency Action Plan (EAP) for the Pond 7/10 Dam System in accordance with requirements for a Class II dam; exercise the EAP according to the schedule in Special Condition 13 of the COD:* HGCMC indicated that the EAP is in development and will be included in the Pond 7/10 Dam System O&M Program manual, to be submitted to the ADNR in the first or second quarter of 2019.

13. *Notify the ADNR in the event that EAP is activated, or within 24 hours in the event of any significant problems that could affect safety of the Pond 7/10 system:* HGCMC indicated that special inspections of the Pond 7/10 Dam System and the TDF are made by an HGCMC Surface Operations Engineer following severe storms and floods, and in response to increases in seepage, change in seepage water quality, or seismic activity. HGCMC indicated that no special events that required special inspections have occurred since 2014.
14. *Obtain separate certificate of approval from the ADNR for any modifications or major repairs of the Pond 7/10 Dam System.*
15. *The Mine Reclamation Plan must include requirements for operation, abandonment, or removal of the Pond 7/10 Dam System:* Details of the mine reclamation and closure and financial assurance are discussed in Section 5.5.

5.5.2 Periodic Safety Inspections – Pond 7 Dam System and Appurtenant Works

A PSI of the Pond 7 Dam and appurtenant works was performed by KCB in July 2017, and a revised draft of the PSI report was issued by KCB in January 2018 (KCB, 2018a). The PSI report included seven recommendations. Detailed below are the recommendations by KCB and response actions by HGCMC.

- *PSI-R-01 – Obtain approval from the ADNR to commission the Flow Control Structure and Pond 10 per Alaska dam safety regulations:* HGCMC confirmed that approval was obtained from the ADNR as covered by the Temporary COD – Pond 7/10 Dam System, dated April 19, 2018 (ADNR, 2018b).
- *PSI-R-02 – HGCMC and the Engineer of Record should review readings from PZ-P7-05-01 monthly and identify potential causes for the recent pore pressure rise, taking into consideration groundwater trends in the surrounding areas:* HGCMC indicated that the PZ-P7-05-01 pressure head readings are steady without unusual spikes, such that there is no cause for concern. HGCMC further indicated that review of the readings by the Engineer of Record (KCB) has not been performed.
- *PSI-R-03 – Review the need to revise piezometer thresholds, following the completion of PSI-R-02:* HGCMC indicated that they will contact the Engineer of Record (KCB) to further discuss this recommendation. HGCMC further indicated that revision of the piezometer thresholds by the Engineer of Record (KCB) has not been performed (see related recommendation PSI-R-02).
- *PSI-R-04 – Add reference to inspecting the sacrificial HDPE geomembrane surrounding the Flow Control Structure for signs of scour and/or damage to the weekly visual inspection form:* HGCMC confirmed that this inspection item was added to the updated weekly inspection form.
- *PSI-R-05 – Review Pond 7 flood routing and water balance as design hydrology assumptions change based on the site-wide hydrology review:* HGCMC confirmed that

the Pond 7 flood routing and water balance have been reviewed and updated based on the site-wide hydrologic analysis.

- *PSI-R-06 – Incorporate the suggested edits into the O&M manual:* These are completed for the most part and will be reflected in the new Pond 7/10 Dam System O&M Manual, which is to be submitted to the ADNR in the first or second quarter of 2019.
- *PSI-R-07 – Complete a visual condition assessment of the Pond 7 inlet channel Reno mattresses to assess whether maintenance or repair is required:* HGCMC will divert water to Pond 10 and drain down Pond 7, which will be cleaned of sediment, and the condition of the Reno mattresses will be addressed. HGCMC indicated that the drain-down is to occur in 2019 or 2020.

5.5.3 Sand Quarry Sand Pit Dam

The ADNR Dam Safety and Construction Unit issued a Certificate of Approval to Modify a Dam (COMD) in July 2018 (ADNR, 2018b). The ADNR-issued COMD for the Sand Pit Dam includes the requirement that modifications to the dam and appurtenant works be performed in accordance with the Stage 3 Phase 1 Tailings Expansion Sand Pit Spillway Re-Design, prepared by KCB (KCB, 2018b). Status of completion of these modifications is unknown at this time. HGCMC indicated that they plan to continue to manage and dewater the Sand Pit Dam pond, maintain the site for overburden storage, and then use the site as a source of reclamation material. HGCMC plans to eventually re-grade the area.

The HGCMC Environmental Department performs island-wide visual inspections of facilities on monthly basis, including the Sand Pit Dam at the Sand Quarry on the A-Road. Visual inspections are for storm water management and include adequacy of site drainage, evidence of cracks, sloughing on slopes, and erosion. Survey monuments were installed along the Sand Pit Dam and are being monitored monthly for elevation and horizontal position.

5.6 Reclamation and Closure Plan and Approval

5.6.1 Regulatory Setting for Reclamation, Closure, and Long-Term Care

Mine closure and reclamation activities, including reclamation and closure plan approval and financial assurance, is overseen by the ADNR's Division of Mining, Land and Water under Alaska Statutes, Chapter 27.19 (Reclamation) and Alaska Administrative Regulations in 11 Alaska Administrative Code (AAC) 97 (Mining Reclamation).

HDR's reclamation and financial assurance portion of the environmental audit focused on Hecla's Greens Creek, *General Plan of Operations, Appendix 14: Reclamation and Closure Plan*, dated June 2014, and amendments. The ADNR approved the plan on August 11, 2014 (Reclamation Plan Approval - J20142682). The ADNR discovered an error in the August 11, 2014, approval document and modified it in an amended letter dated August 14, 2014 (the original approval referred to an April 2014 *Reclamation and Closure Plan*, but it should have been June 2014 plan). The effective date for plan approval is August 11, 2014, to August 10, 2019. The plan was also approved by the USFS through a memorandum of understanding

(MOU) with the ADNR (the original MOU is dated June 30, 2014, and was modified on January 23, 2015).

The Audit Team focused on the following reclamation/closure items:

- Review conditions and status of Reclamation Plan Approval (J20142682);
- Evaluate adequacy of approved reclamation plan; and
- Evaluate adequacy of approved financial assurance.

5.6.2 Reclamation and Closure Plan Approval (J20142682)

HDR reviewed the ADNR's Reclamation Plan Approval requirements and HGCMC's status in meeting the approval conditions. Table 6 summarizes pertinent requirements and status. Table 7 summarizes plan amendments that HDR identified and related activities requiring changes in bonding since 2014.

Table 6. Reclamation Plan Approval (J20142682) Conditions and Status

#	Requirements/HDR Audit Questions	Status
Financial Assurance		
1	Approval by the ADNR and USFS of financial assurance mechanism. Documentation needs to be approved by the ADNR no later than 60 days after Reclamation Plan Approval.	Total financial amount approved is \$68,918,907. Two bonds accepted by USFS Bond#K08399190 \$22,845,688 and Bond #929589455 \$32,500,000 (\$55,345,688), September 25, 2014. This represents the reclamation phase. Alaska holds the post closure bond for \$13,573,219. Financial assurances have been updated since September 2014 and are described in Table 7. HDR did not find records of ADNR bond numbers.
Terms of Plan Approval		
3	Any changes in Reclamation Plan must be approved by ADNR Changes (amendments since 2014)?	See Table 7.
Authorized Officer		
4	Authorized officer for HGCMC (Changes since 2014, ADNR notified?)	No change since 2014.
Monitoring Plan		
5	Are state and federally required monitoring results submitted to the ADNR no later than 60 days following the last day of each quarter?	Yes
Closures (Temporary/Permanent)		
6	Notification to Authorized Officer in writing of temporary or permanent closure.	No closures have occurred
Erosion Standards		
7	Erosion features must be stabilized and inspections completed to verify rills and gullies do not persist.	Disturbed areas inspected by HDR showed stabilization in place.
Cultural		
6	Have any burial or human remains been discovered during mining activities under this approval (2013 to current).	None reported by HGCMC.
Maps		
7	Submit to ADNR annual map.	Part of annual reports and up to date.

Table 6. Reclamation Plan Approval (J20142682) Conditions and Status

#	Requirements/HDR Audit Questions	Status
Inspection and Entry		
8	ADNR and ADEC inspections between 2014 and current. Documentation of inspections.	Inspections have been conducted by the ADNR and USFS; inspections mostly focused on operations. Some reclamation has occurred on-site and, where observed by ADNR, ADEC, and USFS, are described in the inspection reports or field visit notes (on file http://dnr.alaska.gov/mlw/mining/largemine/greenscreek/).
Modifications		
9	Amendments to the Reclamation Plan Amendments may, at the discretion of the ADNR, require bond review and update.	See Table 7 regarding modifications since 2014.

Table 7. Amendments to 2014 Reclamation Plan

#	Items	Status
1	Amendment to reclamation plan J20142682.2. HGCMC revealed certain haulage of waste rock had been omitted in the original 2014 bond estimate. HGCMC recalculated bond for an additional \$3,912,280, giving a total of \$72,831,187.	Approved by the ADNR, December 7, 2016.
2	2018 update by HGCMC to address changes in material source costs (importing material) and also changes in costs for Pond 10. Estimated increase was \$15,189,496.	Approved by the USFS (letter to HGCMC) August 15, 2018. ADEC concurred via emailed August 16, 2018, and ADNR concurred via email August 20, 2018.

5.6.3 Waste Management Permit Review

Per the permit:

2.7.3 Closure of the waste disposal facilities will be complete when the following criteria are met:

2.7.3.1 Department-approved covers are installed on the 1350 portal area, 920 portal area including the mill site, Sites C, D, and E, Site 23, TDF, and drainage channels are constructed and stable;

2.7.3.2 A stable vegetative cover is established on the waste rock, re-contoured areas, and other infrastructure or other facilities as prescribed in reclamation and closure plan approved by the Department and incorporated by reference into this permit; and

2.7.3.3 The Department determines that active water treatment is no longer required for any water discharged from the facility.

Part 2.7.3.1 is not consistent with the *Reclamation and Closure Plan*. HGCMC's intent is to have a cover for the TDF only. Waste materials from the portal areas 1350 and 920; Sites C, D, E, and 23; and related channels will be removed and placed either in the mine (underground) or in the TDF. With waste materials removed, these areas can be reclaimed through standard methods described in the plan. It is recommended that Part 2.7.3.1 be revised in the next permit update.

5.6.4 Reclamation and Closure Plan Review

The Waste Management Permit addresses reclamation and closure requirements for the mine. The permit references and incorporates the 2014 Hecla Greens Creek *General Plan of Operations*, Appendix 14: *Reclamation and Closure Plan* (June 2014), financial responsibility, and mine termination (closure).

The *Reclamation and Closure Plan* sets performance goals applicable to interim, concurrent, and final reclamation and also addresses post closure monitoring. Overall, HDR finds the plan to be complete and comprehensive. Updates to the plan are required for the permit renewal process and are further noted below.

The *Reclamation and Closure Plan* and financial responsibility cover the following mine related facilities:

- TDF and associated ponds
- Underground mine workings
- 920 mill and portal area
- Waste rock dumps (active and inactive): Site 23, 1350, 960, C, D, and E; the plan is to move waste dump materials either to the underground workings or to the TDF for final disposal
- Roads – 1350, Access A, and Access B
- Hawk Inlet and Marine Loadout Area
- Young Bay dock facility
- Utilities – power line
- Growth media stockpile areas and borrow areas

Waste rock storage – HGCMC's plan is to not leave waste rock above ground at time of closure; rather, the rock will be placed back into the underground mine or will be placed in the lined and covered TDF. Given that some waste rock is acid generating, this will alleviate long-term concerns of acid rock drainage (ARD) from reclaimed and closed dumps. The following is a list of dumps:

- Site 23 is active and has a leachate and stormwater collection system. This was the only active waste rock site at the mine at the time of the on-site audit. This site also has a lined pond (23 Pond) that collects leachate and stormwater from the waste rock dump and this water is pumped to the TDF treatment system. Pond D is further downgradient and it picks up additional curtain drain water associated with Site 23.
- Site 1350 and portal area (former dump site) waste rock was moved to Site 23 for temporary storage but has since been hauled underground for disposal, and the site has been reclaimed.
- Sites C and D waste rock will be removed and placed underground or at the TDF.

- Site E waste rock was being actively moved to the TDF at the time of the site visit.

Borrow Sources – HGCMC has a number of borrow sources on-site that will require reclamation or are currently being reclaimed. HDR viewed Pit 7, the sand quarry, Pit 174, and Pit 6. Stabilization measures (hydroseeding, broadcast seeding, and placement of growth media) have been implemented for Pit 7 and the sand quarry, and in general appear to be working, as HDR observed little or no evidence of erosion on sloped hillsides. HGCMC indicated that it plans to minimize use of borrow areas (not create new borrow sources), which means it will rely more on imported materials for final reclamation and closure activities (cover material for TDF). This will need to be addressed in the updated *Reclamation and Closure Plan* for permit renewal.

920 Portal and Mill Area – This area will be reclaimed by removing all buildings and related structures, and possibly removing some surface material if it has the potential for ARD. Material with the potential to generate acid would be placed underground or at the TDF. Pond A collects stormwater and mine water, which is then conveyed to the TDF.

Modeling estimated that portal 920 would begin to seep (would be flooded) 50 years after mine closure. This seepage water will be conveyed to the pond system at the TDF for storage and batch treatment. Thus, this water seepage, collection, and batch treatments represent long-term treatment (perpetuity). The timing of when water will appear from the portal, the quality of that water, and the volume of water are all important factors for understanding financial assurance adequacy. The TDF environmental impact statement (EIS) evaluated the adequacy of this model prediction. HDR recommends that with each permit renewal, the adequacy of the water model be re-assessed. Given that the mine is in full operations and that site geology, hydrogeology, and water balances are now better understood than when the modeling was first completed, an update of the modeling (or at a minimum a verification statement from HGCMC that the model predictions are still valid, and assumptions have not substantially changed since the last model) is warranted.

Tailings Disposal Facility (TDF) – This site is active and continues to grow in size, per design. The water treatment facility is located at the TDF and treats stormwater and leachate not only from the TDF, but also from upstream sources (Site 23 and the Mill area). The TDF contains water storage ponds 7 and 10. The TDF will be closed in place with a cover. This is the only facility for which HGCMC is planning an engineered cover.

Growth Media – HGCMC defines growth media as a material that supports vegetation following reclamation. In its *Reclamation and Closure Plan*, HGCMC states that “topsoil” is not necessary for successful re-vegetation of disturbed areas on-site. HGCMC keeps an inventory of reclamation stockpiles to document their locations (map in the *Reclamation and Closure Plan*). At the time of the site visit, the table and map in the plan were outdated and HGCMC did not have an updated inventory. HDR recommends that HGCMC update this inventory for the revised *Reclamation and Closure Plan* in 2019 and that an updated inventory table be part of the annual report on reclamation (see Section 5.6.2).

As stated in the plan, “additional growth media needed to complete reclamation will be imported from off-island sources as needed for cover cap construction and reclamation.” The additional

cost of importing media was included in the 2018 cost update submitted to the ADNR. For the permit renewal, HDR recommends that HGCMC provide an update of total areas requiring growth media and quantities of material (including needed for the TDF cover based on the current design). A materials mass balance should be provided that shows growth media and cover material available on-site versus what needs to be imported. Imported material needs to be priced appropriately as this is a costly item and can greatly influence cost estimates. The July 13, 2018, cost estimate that HGCMC developed and submitted to ADEC provides insight, where on-site source area (1.4-mile trip) was estimated at \$22/cubic yard versus imported material (barged in to site) at \$50/cubic yard (more than double the costs).

5.6.5 Review of Reclaimed Areas and Specific Plant Community Goals

HDR assessed reclamation of the 1350 portal area. This area was a former waste rock area, where the rock was moved to Site 23 for temporary storage (the waste rock will go either underground in the mine or in the TDF). The area has been re-contoured and has had a drainage system established, which shows evidence of minimal reseeding and little or no top soil. HGCMC has indicated that “top soil” is not necessary for the vegetation to re-establish itself quickly in unconsolidated material. HDR’s review of the 1350 portal area supports HGCMC statements on vegetation establishment, with minimal topsoil and even limited active re-seeding. The vegetation re-establishment in the 1350 portal area was strong, with good vegetative coverage with desirable plant species within several years. HDR did not do a formal vegetative survey, rather this a qualitative assessment of site conditions based on experience with reclamation projects. The area showed minimal erosion and runoff (Photograph 1).



Photograph 1: 1350 Portal area reclamation (July 23, 2018). The area has good ground cover of native vegetation that is in its first and second years.

In Section 6.2.2, Specific Plant Community Goals, in the *Reclamation and Closure Plan*, HGCMC quantitatively defines revegetation success as having met the following conditions:

- The total vegetative cover (including live biomass of perennial species, litter, and standing dead) in each re-vegetation area is equal to or exceeds 80 percent aerial cover, with 90 percent statistical confidence limit;
- The density of actively growing trees is within 80 percent of target levels contained in the approved reclamation plan, with a 90 percent statistical confidence;
- The reclaimed wetland and plant meadow areas have approximately 90 percent total cover with graminoids and herbal species (e.g., *Deschampsia cespiosa*, *Lupinus nootkatensis*, *Sanguisorba canadensis*); and
- The reclaimed upland forest areas have a mixed conifer stand of at least two species of trees and one species of shrubs present with a mixed stand of approximately 222 trees per acre.

This is a very prescriptive definition of re-vegetation success, more than HDR sees in many reclamation plans. Because there is concurrent reclamation occurring at the mine, the Audit Team recommends that as part of the updated *Reclamation and Closure Plan*, HGCMC conduct vegetation surveys of reclaimed areas and determine if it is feasible to meet these goals. Following such surveys, HGCMC should determine whether to either keep these criteria or modify them with justification for such modifications. Another approach is to establish undisturbed reference sites and re-vegetation test plots to evaluate re-vegetation performance for reclaimed areas. From this evaluation, a mutual release criteria could be established.

5.6.6 Review of Annual Reports for Reclamation and Financial Assurance

Per the Waste Management Permit under Section 2.4.3 – Annual report, the permittee shall “address the adequacy of the financial responsibility including, but not limited to, significant changes in reclamation activity costs, concurrent reclamation, expansion or other changes to the operation of the facility.”

HGCMC provided a summary update of reclamation activities and adequacy in the 2017 annual report entitled, *Active Tailings and Production Rock Site 2017 Annual Report* (April 15, 2018). For 2017, HGCMC stated in the annual report:

HGCMC has conducted a review of the adequacy of the financial responsibility and based upon the review is updating the bond calculation in the Standard Reclamation Cost Estimator (SRCE) model. HGCMC will provide a letter detailing the changes to the SRCE model along with an updated model by 15 July 2018. Once approved by the agencies HGCMC will provide financial instruments to cover the increase.

HGCMC provided a Waste Management Permit Annual Bond Evaluation letter to ADEC on July 13, 2018, where it recommended a bond increase due to need to import materials, changes in cover material thickness requirements for the TDF, and cost for Pond 10.

HDR reviewed HGCMC’s annual reports for 2014 through 2017. The permit requires an assessment of adequacy, which HGCMC did in the updated costs for the 2017 report but did not do in the previous reports (2014 to 2016).

HDR recommends that HGCMC provide a standalone section in the annual report that summarizes reclamation activities and addresses financial assurance for the entire mine (i.e., take this discussion out of the TDF section of the annual report). The annual report should also include an update on materials inventory, as described in Section 5.5.4.

5.7 Financial Responsibility

5.7.1 Reclamation and Closure Costs Estimation

Per Alaska Statutes Chapter 27.19 (Reclamation) and Alaska Administrative Regulations in 11 AAC 97 (Mining Reclamation), the permittee shall provide the ADNR with an individual financial assurance to ensure the faithful performance of the requirements of the approved reclamation plan. Table 8 summarizes reclamation and closure costs (including post closure) for 2014, 2016, and 2018 updates. The cost schedule assumes 4 years for reclamation activities and, to present long-term costs and maintenance, calculates costs for 100 years following closure as a proxy for perpetuity.

Table 8. Reclamation/Closure Cost Estimate and Bond Evaluation Since 2014

Items	2014 Original ¹	2016 Update	2018 Update
Earthwork/Recontouring	\$19,988,098	\$22,574,448	\$33,085,274
Revegetation/Stabilization	\$222,403	\$222,403	\$222,403
Detox/Water Treatment/Disposal	\$22,058,609	\$22,058,609	\$22,058,609
Structure, Equipment, Facility Removal, Misc.	\$3,845,716	\$3,845,716	\$3,845,716
Monitoring	\$5,637,134	\$5,637,134	\$5,637,134
Construction Management & Support	\$350,886	\$350,886	\$350,886
Closure Planning, G&A, and Human Resources	\$16,328,391	\$16,328,391	\$16,328,391
Direct Totals	\$68,431,237	\$71,017,587	\$81,528,413
Indirect Costs	\$28,227,886	\$29,294,755	\$33,630,470
Grand Total²	\$96,659,123	\$100,312,342	\$115,158,883

¹ Costs presents labor, equipment, materials, mobilization/demobilization.

² Costs represents estimated reclamation/closure costs assuming 4 years for closure and 100 years as a proxy for perpetuity of water treatment and maintenance. Total financial assurance are based on net-present value assuming annual rate of return of 3.97 percent and inflation of 2.31 percent.

The total proof of financial assurance is less than the total amounts shown in Table 8, as it accounts for real rate of return, which in 2014 was set at 3.97 percent, but also accounts for inflation, which in 2014 was set at 2.31 percent. The total proof of financial responsibility was set as follows (2014 original):

- \$55,345,688 for reclamation – bond held by the USFS
- \$13,573,219 for Long-Term Care – bond held by the ADNR and ADEC

- Total \$68,918,907 (2014)

Thus, this total amount generates the principle necessary to provide funding in perpetuity (100-year cycles). The total proof of financial responsibility for the 2016 update was approved at \$72,831,187.

The ADNR approved the bond for \$68,918,907 on August 14, 2014. The USFS accepted proof of financial responsibility on September 25, 2014. Approval was updated in 2016 with an increase in bond amount to \$72,831,187. The increase accounts for additional waste rock disposal that was not accounted for in 2014. The 2018 increased cost accounts for importing (off-island) drain material rather than using on-site sources (see July 13, 2018, letter from HGCMC's Christopher Wallace to David Kahan, ADEC). The bond estimate update was approved by the USFS (letter to HGCMC) on August 15, 2018. The ADEC concurred with the update via email on August 16, 2018, and the ADNR concurred with the update via email on August 20, 2018.

5.7.2 Reclamation and Closure Cost Estimation

HGCMC used the Standard Reclamation Cost Estimator (SRCE) for the 2014, 2016, and 2018 reclamation and closure costs presented in Table 8. Cost estimate assumptions are presented in Section 9.0 and in Appendix B of the *Reclamation and Closure Plan*. The SRCE is a Nevada cost estimator (series of spreadsheets in Microsoft Excel format) that provides a consistent basis for estimating reclamation and closure costs for mining operations in Nevada with the goal of ensuring consistency among users and regulators. The estimator can be applied to other states, and it provides a good platform for cost estimation that is growing in popularity with both the mining and regulator communities.

The State of Alaska is required to obtain financial assurances to ensure that the approved reclamation tasks are completed in the event HGCMC fails to perform the necessary tasks as outlined in the reclamation and closure plan. The Reclamation Plan Approval requires that the environmental audit evaluate the adequacy of the approved financial assurance.

HGCMC prepared the 2014 plan and estimated reclamation costs (2014, 2016, and 2018) in accordance with standard engineering cost estimation procedure, which are consistent with methods commonly used by industry as well as state and federal agencies (using the SRCE platform). Costs for individual reclamation tasks are based on unit costs to support a third-party reclamation under varying years. General cost sources are as follows (from Section 9.0 and Appendix B in the plan):

- Labor rates – Alaska Department of Labor and Workforce Development, Division of Labor Standards and Safety's *Laborers' & Mechanics' Minimum Rates of Pay* (Pamphlet 600) (Alaska "Little Davis-Bacon")
- Material costs – Local vendors, 2011 RS Means Heavy Construction Cost Data, Western Edition.
- Productivity data and calculations – Caterpillar Handbook. Edition 36, for productivity calculations; 2011 RS Means Heavy Construction Cost Data

Most of the above-referenced cost sources have been updated since 2014. HGCMC used older versions of the above-referenced documents for the 2014 estimate (according to HGCMC this is due to the time lag between bond calculation submittal and agency approval); however, it did use an inflation factor that accounted for changes in time. For the 2019 update, HDR recommends that HGCMC use the most current references to update costs.

HDR did not “re-estimate” the financial assurance estimates created by HGCMC; instead, HDR spot checked calculations, verified assumptions listed in the plan, and evaluated the overall adequacy of the approved financial assurance.

Assumptions, reclamation tasks, and associated costs are listed in the plan. HDR identified concerns regarding several of these assumptions and recommendations for 2018 updates listed in the plan, mostly relating to closure and reclamation uncertainties. The following lists HDR’s greatest concerns:

- Long-term water treatment in perpetuity as it relates to volume of water, storage of water, and treatment requirements. Updating (or re-verifying) the hydrologic/water quality model for water seepage from the underground mining is recommended.
- Growth media and cover material mass balance updates, especially as it relates to estimating material that will need to be imported to the mine to support closure, as import costs are doubled to using on-site sources.

5.7.3 Cost Estimation Approach

The Audit Team reviewed the approved 2014 and 2018 financial assurance estimates. Overall, the cost estimate approach appears to be complete and consistent with mine activities reviewed during the audit. HGCMC customized the SRCE to fit their needs by creating 20 user sheets. The spreadsheet contains a table of contents that defines each of the user sheets, and these user sheets contain many of the details and assumptions. HDR recommends the following for the 2019 updated plan relating to cost estimation:

- Provide greater explanation of assumptions in Appendix B, including referencing where in the SRCE model these items can be found. One option is to list the user files in Appendix B and provide greater detail about what each user file includes. Appendix B includes some of this information, but it is still difficult to follow.
- Back up assumptions with citations in the user sheets. For example, user sheet 4 is the water treatment summary, which lists water flow in gallons per minute (gpm) for the 1350 drain (main sump) and is 25 gpm from year 0 to year 100. The fact that 25 gpm is collected and treated is important for cost purposes, but where did this estimate come from? Appendix B references Petros GeoConsulting 2014, but user sheet 4 provides no references; is this the reference? Add a reference column in the SRCE, where the citation is provided (e.g., reference specific study, EIS, or best professional judgment). This will aid in overall review of the 2019 plan and associated SRCE model.

5.7.4 Indirect Costs

The State of Alaska has published several documents on cost estimation approaches, including the following:

- *Draft Mine Closure and Reclamation Cost Estimation Guidelines*, dated December 2013 (ADNR/ADEC, 2013)
- *Mine Closure and Reclamation Cost Estimation Guidelines: Indirect Cost Categories* (ADNR/ADEC and prepared by DOWL, April 2015).

The first document remains in draft form and has not been adopted as official policy. The goal of the guidance is to provide consistent methodology for estimating the amount of financial assurance required for mine closure and the regulatory agencies to use when reviewing the closure cost estimates. The second document supplements the 2013 draft guidelines in that it assesses the variability that drives the ranges of indirect costs observed with reclamation and closure projects, and then makes recommendations about what changes the ADNR/ADEC should consider in order to improve the accuracy of the indirect costs portion of the guidelines.

The following discussion focuses on indirect costs, compares recommended indirect costs with HGCMC estimates, and makes recommendations for the 2019 update.

The ADNR/ADEC define the following seven indirect cost categories for reclamation and closure:

- Contractor Profit – Calculated as revenue gained from reclamation/closure activities after accounting for contractor expenses, costs, and taxes.
- Contractor Overhead – Contractor overhead refers to all ongoing business expenses not including or related to direct labor, direct materials, or third-party expenses that are billed directly to a project.
- Performance and Payment Bond – Bond to protect owner (in this case, the state) from contractor failure to perform contracted scope of work and also to cover payment to subcontractors and others receiving payments from the contractor. State of Alaska statutes (AS 36.25.010) require both a performance bond and a payment bond for construction of projects administered by the State of Alaska.
- Insurance – Liability insurance taken out by the contractor and required by the state.
- Contract Administration – Cost incurred by the state (and cooperating federal agencies, if applicable) to oversee reclamation and closure activities.
- Engineering Re-design – Typically involves updating the mine's reclamation and closure plan and plan of operations. Often done to provide sufficient details to obtain bids from contractors for mine site reclamation and closure. Generally performed by an independent engineer contracted with the state.

- Contingency – Accounts for unknown or unforeseen costs arising during the reclamation and closure work. The two types of contingency costs are related to the scope of work and contractor bids.

Other indirect costs often observed by HDR in reclamation cost estimates (i.e., may show up in direct costs, or are not accounted for) include the following:

- Inflation proofing – Additional anticipated project costs due to general economic inflation are sometimes (USFS Guide, 2004) included in the indirect cost category when determining the total estimated reclamation and closure cost. This is more often shown below direct and indirect costs since inflation adjustments should account for both types of costs.
- Mobilization/demobilization – Typically, these costs are included in direct costs (except for USFS guidelines [*Training Guide for Reclamation Bond Estimation and Administration, 2004*] indicate these should be included as indirect costs).

In 2013, HGCMC, ADNR/ADEC, and USFS had a series of meetings to discuss and develop recommended indirect costs. These are reflected in the 2014 indirect costs used in HGCMC's plan. HDR compared 2014 HGCMC indirect costs calculations to the indirect costs recommended by DOWL to the ADNR/ADEC in the *Draft Mine Closure and Reclamation Cost Estimation Guidelines* (DOWL recommended edits in Appendix A, April 2015) (Table 9).

Table 9. Comparison of Indirect Cost Percentages for Reclamation/Closure Costs between 2014 HGCMC and ADNR/ADEC Guidelines

Indirect Costs Category	2014 HGCMC	DOWL Recommendations ¹
	Percent of indirect costs	
Contractor Overhead and Profit	15	4 to 8 (OH) 6 to 10 (profit)
Performance and Payment Bond	3.0	2.5 to 3.5
Insurance	0.5	1.5 (labor)
Contract Administration	3.5	5 to 9
Engineering Re-design	2.75	3 to 7
Contingency	6.5 (scope) 6.5 (bid)	6 to 11 (scope) 4 to 9 (bid)
Inflation Proofing (apply to both direct and indirect costs)	2.31(year)	An inflation factor based on Anchorage CPI average over previous 5 years, and compounded for next 5 years
Mobilization/Demobilization	Part of direct costs	Part of direct costs

¹ Appendix A in *Mine Closure and Reclamation Cost Estimation Guidelines: Indirect Cost Categories*, prepared by DOWL for ADNR/ADEC, April 2015.

In summary, HGCMC's 2014 indirect costs estimates and assumptions are generally consistent with ADNR/ADEC draft guidelines and industry standards. As such, these indirect numbers are appropriate for the 2019 plan.

5.7.5 Reclamation of Pond 7/10 Dam System

HGCMC has a temporary COD for Ponds 7 and 10 at the TDF (April 2018). The permit states:

16. The requirements for operation, abandonment or removal of the Pond 7/10 Dam System must be included in each revision of the detailed mine reclamation plan. Sufficient funds for these requirements must be identified and included in the financial assurance required per: AS 27.19.020-040; 11 AAC 97.200-450; 11 AAC 93.171(d); 11 AAC 93.171(f)(2)(C); 11 AAC 93.171(f)(4)(F); and 11 AAC 93.172(a)(6)(C); other applicable Alaska laws; and the Memorandum of Understanding between the Alaska Department of Natural Resources, Alaska Department of Environmental Conservation and the U.S. Department of Agriculture, Forest Service Concerning Reclamation/Closure/Post-Closure Bonding for the Greens Creek Mine (June 30, 2014), or any revisions thereof. Submit a copy of associated sections of the Reclamation Plan and financial assurance instrument to the Dam Safety and Construction Unit of the Department during each review and revision cycle.

HGCMC's *Reclamation and Closure Plan* anticipates that these ponds would be used for post closure storage of water for treatment (perpetuity). The 2014 plan does address these ponds and the conditions above are met. However, HGCMC is reminded to submit a copy of appropriate plan sections and financial assurance instrument to the Dam Safety and Construction Unit of the ADNR, as described above.

6.0 Reliability and Integrity of Information Relating to Environmental Reporting and Compliance

Field observations and interviews with mine personnel were completed as well as the review of monitoring results to determine the reliability of reported information. Based on the Audit Team's assessment, the reliability and integrity of the environmental reporting and compliance information is reasonable. The Audit Team reviewed the QAPP, sampling protocols, reports, data quality, and waste management plan. The Greens Creek Mine maintains a complex environmental monitoring program, including a waste rock characterization program that goes beyond what is required by the WMP. The staff is well organized, knowledgeable, and well trained on the environmental management procedures. The Environmental Manager engages with staff on a daily basis and has a long period of institutional knowledge of mine site operations. The Audit Team recognized an overall high level of knowledge and dedication on maintaining compliance.

With respect to reporting and compliance, clarity could be added to quarterly reports with respect to background characterizing conditions, and inconsistencies between quarterly reports and annual reports could be reduced. This could also be addressed by revising permits to clarify reporting expectations (see Section 9.0). The WRMP could be modified to be consistent with all monitoring described in the IMP and IWMDP.

7.0 Adequacy of State Oversight to Protect State Resources

The Audit Team interviewed agency representatives and reviewed correspondence, permits, annual reports, and inspection reports from the ADNR, ADEC, and ADF&G. The inspection reports summarize their inspection tours and any findings or observations and provides photographs. The primary topics covered by the inspections include construction activities for Pond 10 and the flow control system linking to Pond 7, secondary containment, biological sampling, the TDF, and closed disposal sites. The regulatory staff for the mine are knowledgeable and have a good understanding of mining methods, mitigation measures, and state regulations.

The Audit Team recommends that the WMP be updated to reflect current on-site waste management practices and disposal facility conditions. Additionally, revisions to the WMP should be considered that would clarify the trigger for reporting WQS or SSI occurrences. The current monitoring program is completed in accordance with permit conditions. However, there would be a greater level of certainty for the protection of state resources if WQS and SSI over background water quality conditions were more clearly defined.

8.0 Adherence with Pollution Prevention Strategy

The IWMDP defines pollution prevention priorities that the mine is using to prevent and minimize the generation of waste (see Section 5.3). The Audit Team observed that the following practices and pollution prevention strategies are occurring:

- Excavated, mined, or milled materials undergo geochemical characterization.
- Operations that generate waste are reviewed by mine site staff to identify opportunities for reducing waste. For example, materials entering on-site are reviewed to minimize the use of hazardous materials and potential generation of hazardous waste.
- The reuse and recycling of materials is occurring where practicable.
- The disposal of solid waste is occurring according to permit conditions, and materials that cannot be adequately managed on-site are shipped off-site for disposal, reuse, or recycling.
- Secondary containment is being maintained for oil and fuel, hazardous materials, and chemicals. However, some maintenance is needed for the secondary containment of reagent storage at the Mill.

The TDF is a lined disposal facility with a permitted footprint. The primary function of the TDF is the disposal of dry stack tailings that are produced by the Mill. Tailings from the Mill are dewatered in a filter press, and approximately 50 percent of the tailings are mixed with cement and hauled back into the mine as backfill. The other 50 percent of the tailings are trucked to the TDF for permanent disposal. The TDF is designed, operated and will be reclaimed as a waste containment facility, preventing any discharge of solids or liquids according to tailings facility

SOPs and the Reclamation and Closure Plan. Water that enters the TDF by means of precipitation is captured by the liner system then transported via an underdrain system to the water treatment plant, where it is treated to meet AWQS prior to discharge.

The Reclamation and Closure Plan sets performance goals applicable to interim, concurrent, and final reclamation, and addresses post closure monitoring. The mine has developed preliminary test plots to gauge revegetation conditions. The 1350 portal area has been re-contoured and had a drainage system established. Vegetation in the 1350 portal area is flourishing, with a strong coverage of desirable plant species. Other elements of the closure plan include the relocation of the contents of Sites 23, C, D, and E to the TDF.

Production rock is managed by following the WRMP, which includes a rock classification system based on the potential for acid generation, with rock having the greatest potential for acid generation remaining underground for disposal purposes. HGCMC conducts a waste rock geochemical monitoring program that provides a check on the rock classification and permanent storage. There is a risk of the geochemical monitoring results not being understood and examined; however, as long as the results of the geochemical monitoring are being examined and the laboratory check on the visual classification show high accuracy, HGCMC is adhering to the approved ARD prevention strategy.

9.0 Conclusions and Recommendations

9.1 Overview

The Audit Team reviewed programs under the WMP; Reclamation and Closure Plan approval, including financial assurance; and the COD. The Greens Creek Mine is generally in compliance with operations and reporting for the current authorizations. However, the Audit Team has recommendations for improved environmental management of the facility that include refining background geochemical and water quality analyses, updates to language in the WMP, QAPP and IMP revisions for purposes of clarity and consistency, suggestions for improvements to internal waste rock monitoring, and recommendations to strengthen the Reclamation and Closure Plan as well as assumptions associated with financial assurance.

It is important to note that HGCMC Environmental Department staff is extremely knowledgeable, well-trained, and attentive in operating a complex environmental management program. It was notable by the Audit Team that the Environmental staff has a long period of institutional knowledge for the facility, which adds to the level of reliability of the environmental practices at the facility. HGCMC maintains a very sophisticated monitoring program that attempts to go above and beyond permit requirements, which is of value to the larger protection of resources.

9.2 General Recommendations

Routine coordination and communication between HGCMC and the ADNR Office of Project Management and Permitting (OPMP) consists of participation in bi-weekly teleconferences as well as an annual meeting. While on-site, HGCMC staff conveyed to the Audit Team that

operations at the mine could benefit from more frequent site visits by technical personnel from the ADNR and/or ADEC, which would increase situational awareness of operations, the TDF expansion project, monitoring activities, and future plans. The Audit Team recommends that the ADNR, ADEC, and HGCMC evaluate the practicability of increasing the frequency of agency technical staff site visits.

The following is a consolidated list of recommendations from prior sections in the report.

Waste Management Permit (WMP)

- 1) **TDF** – The IWMDP describes geochemical monitoring of the tailings, both at the Mill and at the TDF, and states that if any changes are seen in the geochemical results of the analysis for tailings, additional sampling and analysis are conducted as determined necessary. In reporting geochemical results in the quarterly and annual reports, there appears to be stated values for tailings with no comparison to baseline tailings characterization or trends to determine if any changes are seen.
- 2) **TDF** – The FWMP stations downgradient of the TDF are currently in non-compliance for low pH and low alkalinity relative to the AWQS. Results from these sites do not appear to be changing over time, and tailings underdrain pH values do not appear to be decreasing over long-term; therefore, HGCMC is likely correct that these conditions are background conditions. However, it is recommended that similar site conditions in an undisturbed setting be identified to collect background water quality for comparison and trends for downgradient water quality and tailings underdrain of pH and alkalinity and certain metals be monitored closely in quarterly reporting.
- 3) **TDF** – Continue to evaluate abatement options to control fugitive dust emissions and consider cover material in areas most susceptible to wind. With appropriate planning for tailings and cover placement prior to winter, it should be possible to minimize tailings dust emissions.
- 4) **Site 23** – Since the contents of Site 23 are not located at the site for the purposes of permanent disposal, the Audit Team recommends that Site 23 be described in the WMP as an active waste storage facility.
- 5) **Site 23** – The WMP states that Site 23 is 11 acres in size. The 2017 Annual Report states that the site boundary for Site 23 covers approximately 18 acres. It is recommended that the overall size of Site 23 be clarified as well as the area within Site 23 that is permitted to receive waste rock.
- 6) **Site 23** – Waste rock chip samples are allowed to accumulate and are analyzed approximately twice per year. The Audit Team recommends a more frequent comparison and reporting for verification as well as the addition of data quality objectives to the WRMP.
- 7) **Underground Workings** – Section 2.1.4.1 of the WMP provides a list of waste that may *only* be disposed of in the underground workings. This implies that the wastes listed in Section 2.1.4.1 may not be disposed of elsewhere. However, according to the WMP many of those same wastes are also approved for disposal in the TDF. The Audit Team

recommends that the solid waste permit clarify what waste may be disposed of in both the TDF and the Underground Workings.

- 8) **Underground Workings** – Continuation of the study on the underground mine hydrology and chemistry is recommended to confirm assumptions used in the Reclamation Plan and Financial Assurance, as it is anticipated that the water quality in the mine will be unacceptable for discharge without treatment after flooding.
- 9) **Monitoring** – The IMP does not describe or list in table format the 5-year monitoring of quarry walls that is being reported, nor the surface water monitoring at the pits. Therefore, it is recommended the IMP be revised to more clearly define the geochemical monitoring of quarry pit walls and the water quality monitoring of quarry/pit sites. Because of the acid generating potential of some quarry walls, it is recommended that the permit revision consider formal incorporation of geochemical monitoring of pit walls and associated surface water monitoring sites.
- 10) **Monitoring** – The Water Balance section (Section 7.4) of the Annual Report describes that “about 50% of the process water is recycled through the mill and the remainder (about 500 gpm long term average) is sent to Pond 7 for further treatment”; however, no flow data is provided. No data is reported for stormwater entering Pond 7. It is recommended that flow data for water balance elements be provided as an appendix in annual reporting to comply with the WMP monitoring requirement. Alternatively, the WMP could be revised to reflect anecdotal percentages of flows are an appropriate level of reporting.
- 11) **Corrective Actions and Compliance Reporting** – It is recommended that permit revisions be considered that would clarify the trigger for noncompliance reporting (WQS, SSI).
- 12) **Corrective Actions and Compliance Reporting** – The HGCMC quarterly and annual reports include different types of monitoring such that review of the annual report, and not the quarterly reports, would not provide a reviewer the full picture of what is monitored. In addition, some monitoring completed on a quarterly frequency (e.g., ABA geochemistry) are only analyzed semi-annually or annually and then reported annually. It is recommended that the permit revision clarify expectations for inclusions of quarterly and annual reporting.
- 13) **FWMP** – HGCMC has established “baseline” for Sites 27, 29, and 32 in the FWMP Annual Reports. These sites have been monitored since the beginning of tailings placement. While the baseline established is useful for analysis, the baseline period is well after the TDF operation and thus the baseline data cannot be said to represent pre-operational natural “background” conditions. The current baseline data set was established only for conductivity, alkalinity, and zinc. Data for those parameters over the period of record do appear to be stable for a significant amount of time in the early stages of TDF operation. It is recommended that a baseline be developed for additional parameters, including pH since it is a parameter currently reported as being in non-compliance with AWQS. The FWMP data may be better compared against a baseline

threshold value than the current practice of comparing to AWQS, which are not well suited for the peat sediments.

- 14) **Internal Monitoring of Waste Rock** – It is recommended that the IMP be revised to accurately reflect the difference between elective monitoring (e.g., lysimeters and finger drains), ambient conditions monitoring without limits (e.g., water levels, stability, and ABA testing), and permit limits monitoring (FWMP). It is recommended that all reference to kinetic testing be removed from the IMP because that type of geochemical analysis is not being completed.
- 15) **Internal Monitoring of Waste Rock** – Tailings and Production Rock Annual Reports provide a table for production rock disposal tonnage and volume. It is understood that the tonnage is monitored in two different ways, survey at the waste disposal facility and truck counts from the mine department. The column headings in Table 5.2.a are difficult for the reader to understand. It appears that summing the last four columns should match the "From UG Truck Counts (tons)" column, because the last four columns were also from truck count, just broken up by production rock class; however, the values are different by approximately 9,000 tons over the year. It is recommended that the heading labels be edited for a reader to better understand or a footnote added, or text added to better explain the values.
- 16) **Internal Monitoring of Waste Rock** – According to Section 3.1.1 and Table 3-1 of the IMP, waste rock samples from Site 23 will be analyzed for ICP annually. No production rock (also known as waste rock) ICP data is provided in quarterly or annual reports. While on-site, an Audit Team member observed the ICP data from SGS Laboratory Reports; therefore, it is being analyzed and is recommended to be added to the reporting or the IMP be revised to remove that analysis from the geochemical methods.
- 17) **Internal Monitoring of Waste Rock** – It is recommended that HGCMC and ADEC continue to review zinc in the downgradient monitoring points at Site 23 for any trends over time. Because waste rock ICP data is not reported, there is no way for a reviewer to track the potential for metals leachate (zinc) from the waste rock.
- 18) **Internal Monitoring of Tailings** – It is recommended that ICP data be added to quarterly or annual reports or the IMP be revised to remove that analysis from the geochemical methods.
- 19) **Internal Monitoring of Tailings** – According to IMP Table 4-1, surface water at the TDF will be monitored annually. There are no surface water monitoring sites reported in Active Tailings and Production Rock Site annual reports. The IMP Table 4-1 addresses internal monitoring of surface water sites (not FWMP sites) and therefore implies that there is surface water monitoring at sites in addition to the three FWMP sites conducted annually. This monitoring is considered elective by HGCMC; however, all monitoring data are required to be reported, and it is recommended that the IMP be revised if HGCMC does not intend to monitor and report surface water annually.
- 20) **Internal Monitoring of Tailings** – According to the IMP Table 4-1, groundwater will be monitored at the TDF annually. Tailings area underdrain water quality data is provided in

annual reports; however, no upgradient or downgradient groundwater data is reported for the site, and it is assumed that the underdrains represent TDF pore water/leachate, not groundwater for the area. This groundwater monitoring is considered elective; however, it is recommended that the IMP be revised if HGCMC does not intend to monitor and report groundwater annually, or better communicate what the underdrain data represents for the area.

- 21) **Internal Monitoring of Tailings** – With the exception of the Appendix 3 Tailings Disposal Facility Management Plan dated July 2018 (HGCMC, 2018b), it is recommended that the GPO appendices (IMP, IWMDP, and WRMP) be updated to reflect current monitoring conditions and be consistent across the documents. It is also recommended that the IMP clarify how often the analysis should be conducted and reported, and it is recommended that reporting be more in line with monitoring frequency (e.g., quarterly samples analyzed quarterly and reported quarterly).
- 22) **QAPP** – It is recommended that the QAPP be updated to reflect all labs that complete analyses in the IMP, including the geochemistry sampling.
- 23) **QAPP** – The QAPP does not address the use of pressure transducers and data loggers for the measurement and recordation of water levels in piezometers. It is recommended that, at a minimum, the frequency of data downloaded from the data loggers and reference to a separate SOP be included. The QAPP or SOP should describe the data collection programming of the data logger, equipment, frequency and process for data download, where data will be stored and how it will be managed, how data drift will be reviewed and corrected, how data will be corrected for barometric pressure, etc.
 - a. It is recommended that the QAPP add information regarding contingencies during sampling, what to do if sampling sites are inaccessible, how to document frozen conditions on field data sheets and in the database, how to document dry conditions in the database, etc.
 - b. The QAPP Table 4 lists specific training requirements and states that written record must be made for training of all new personnel. HGCMC could not produce any records of training; therefore, it is recommended that a training file be initiated.
 - c. It is recommended that HGCMC update the QAPP to provide direction for the statistical analysis and reporting, whether direct comparisons of concentrations to the AWQS or calculations of SSIs over a baseline.
- 24) **QAPP** – The data validation procedures described in the QAPP and completed by Synectics for HGCMC are only completed on the FWMP monitoring. According to HGCMC there is no data validation performed on the Internal Monitoring. Sampling completed under the "internal monitoring" or geochemistry do not appear to have quality controls. It is recommended that there be more clarification in the QAPP regarding what quality control sampling is conducted for the internal sampling program (versus the FWMP) and what the acceptance criteria limits are if they are held to a different standard than the FWMP.

- 25) **QAPP** – It is recommended that the QAPP be updated to reflect the on-site laboratory’s testing activities, sample handling, and general QA/QC associated with ABA testing in compliance with the IMP.
- 26) **QAPP** – It is recommended that the calibration check acceptance criteria be easily identifiable in the QAPP and a sign be posted in front of the meter calibration station for personnel. While the QAPP described protocols for some sampling, it is recommended that HGCMC create a master SOP list for environmental sampling and tests. This list should be included in the QAP and also made available in the sample preparation shack.
- 27) **Laboratories and Sample Analysis Procedures** – It is recommended that the lab method be revised to incorporate quality control in the process. The lab has two laboratory control standards to assess method accuracy; however, there are no data quality thresholds.
- 28) **Geotechnical Monitoring** – Results of monitoring of the Pond 7/10 Dam System surface survey monuments, as summarized in the 2018 PSI report (KCB, 2018a) and discussed with HGCMC, do not appear to indicate stability issues with the Pond 7/10 Dams, with the caveat that as indicated above, the baseline record of observations for the Pond 10 Dam has not yet been established.
- 29) **Geotechnical Monitoring** –The Engineer of Record (KCB) should review the action thresholds and reading frequencies for the Pond 7/10 foundation layer underdrain system VWP’s and make recommendations.
- 30) **Biological Sampling** – It is recommended that relative abundance sampling for juvenile fish be conducted as opposed to depletion sampling.
- 31) **Biological Sampling** – The WMP Section 2.3.1.10 requires monitoring for signs of stress to wildlife associated with facility activities. This requirement is nondescript and difficult to comply with; therefore, it is recommended that this monitoring requirement be removed from future permit revisions.
- 32) **IWMDP** – There appear to be a number of older procedures described in the IWMDP. It is recommended that the Plan be updated to reflect current monitoring and waste management practices. The IWMDP should also be updated to be consistent with monitoring and practices described in the other GPO appendices.
- 33) **Secondary Containment** – The Audit Team recommends that the containment curbing for Mill reagents be assessed and repaired as necessary, so that 110 percent containment is achieved.

Certificate of Approval to Operate a Dam (COD)

The design of Pond 10 and the Pond 7/10 flow control structure (as a modification of Pond 7) was completed in 2014, and construction was completed in 2017. Currently the Pond 7 Dam, and the Pond 10 Dam and appurtenant works, are being operated under a Temporary COD issued by the ADNR in April 2018. Additionally, the ADNR is requiring that HGCMC undertake corrective actions in accordance with an associated timeline of compliance for the construction and operation of the Pond 10 Dam and Sand Pit Dam.

At the time of the Environmental Audit, the Audit Team determined that HGCMC is working closely with the ADNR to comply with the requirements of the Temporary COD for the Pond 7/10 Dam System. HGCMC is currently meeting the requirements of the Temporary COD, as well as implementing the corrective actions within the timeline required by the ADNR. It is recommended that HGCMC, ADNR OPMP, and the ADNR Dam Safety and Construction Unit maintain an elevated level of communication and coordination to ensure that the corrective actions that are currently being employed by HGCMC meet the ADNR's expectations to resolve the violations within the desired timeframe.

Reclamation Plan Approval and Financial Assurance

- 1) **Closure of Waste Disposal Facilities** – Section 2.7.3 of the WMP is not consistent with the *Reclamation and Closure Plan*. HGCMC's intent is to have a cover for the TDF only. Waste materials from the portal areas 1350 and 920; and Sites C, D, E, and 23; and related channels will be removed and placed either in the mine (underground) or in the TDF. With waste materials removed, these areas can be reclaimed through standard methods described in the plan. It is recommended that Section 2.7.3.1 be revised in the next permit update.
- 2) **Growth Media** – HGCMC defines growth media as a material that supports vegetation following reclamation. In their *Reclamation and Closure Plan*, HGCMC states that "topsoil" is not necessary for successful re-vegetation of disturbed areas on-site. HGCMC keeps an inventory of reclamation stockpiles to document their locations (map in the *Reclamation and Closure Plan*). At the time of the site visit, the table and map in the plan were outdated, and HGCMC did not have an updated inventory. It is recommended that HGCMC update this inventory for the revised *Reclamation and Closure Plan* in 2019 and an updated inventory table be part of the annual report on reclamation.
 - a. It is recommended that HGCMC provide an update of total areas requiring growth media and quantities of material (including that needed for the TDF cover based on the current design). A materials mass balance should be provided that shows growth media and cover material available on-site versus what needs to be imported. Imported material needs to be priced appropriately as this is a costly item and can greatly influence cost estimates. The July 13, 2018, cost estimate that HGCMC developed and submitted to the ADEC provides insight where on-site source area (1.4-mile trip) was estimated at \$22/cubic yard versus imported material (barged to site) at \$50/cubic yard (more than double the costs).
- 3) **Reclaimed Areas and Specific Plant Community Goals** – The Audit Team recommends that as part of the updated *Reclamation and Closure Plan*, HGCMC conduct vegetation surveys of reclaimed areas and determine if it is feasible to meet these goals. Following such surveys, HGCMC should determine whether to keep these criteria or modify them with justifications. Another approach is to establish undisturbed reference sites and re-vegetation test plots to evaluate re-vegetation performance for reclaimed areas. From this, a mutual release criteria could be established.

- 4) **Annual Reports for Reclamation and Financial Assurance** – It is recommended that HGCMC provide a standalone section in the annual report that summarizes reclamation activities and addresses financial assurance for the entire mine (i.e., take this discussion out of the TDF section of the annual report). The annual report should also include an update on materials inventory, as described in Section 5.5.4.
- 5) **Reclamation and Closure Costs Estimation** – HGCMC prepared the 2014 plan and estimated reclamation costs (2014, 2016, and 2018) in accordance with standard engineering cost estimation procedures, which are consistent with methods commonly used by industry as well as state and federal agencies (using the SRCE platform). Costs for individual reclamation tasks are based on unit costs to support a third-party reclamation under varying years. Most of the referenced cost sources have been updated since 2014. It is unclear why HGCMC used older versions of the above-referenced documents for the 2014 estimate, even if it did use an inflation factor that accounted for changes in time. HDR recommends that HGCMC use the most current references to update costs for the 2019 update.
- 6) **Reclamation and Closure Costs Estimation** – Assumptions, reclamation tasks, and associated costs are listed in the Reclamation and Closure Plan. HDR identified concerns regarding several of these assumptions and recommendations for 2018 updates listed in Section 9 SRCE of the plan, mostly relating to closure and reclamation uncertainties. The following lists HDR’s greatest concerns:
 - a. Long-term water treatment in perpetuity as it relates to volume of water, storage of water, and treatment requirements. Updating (or re-verifying) the hydrologic/water quality model for water seepage from the underground mining is recommended.
 - b. Growth media and cover material mass balance updates, especially as it relates to estimating material that will need to be imported to the mine to support closure, as import costs are double using on-site sources.
- 7) **Cost Estimation** – HDR recommends the following for the 2019 updated plan relating to cost estimation:
 - a. Provide greater explanation of assumptions in Appendix B, including referencing where in the SRCE model these items can be found. One option is to list the user files in Appendix B and provide greater detail about what each user file includes. Appendix B includes some of this information, but it is still difficult to follow.
 - b. Back up assumptions with citations in the user sheets. For example, user sheet 4 is the water treatment summary, which lists water flow in gpm for the 1350 drain (main sump) and is 25 gpm from year 0 to year 100. That 25 gpm is collected and treated is important for cost purposes. But where did this estimate come from? Appendix B references Petros GeoConsulting 2014, but user sheet 4 provides no references; is this the reference? Add a reference column in the SRCE, where the citation is provided (e.g., reference specific study, EIS, or best profession judgment). This will aid in overall review of the 2019 plan and associated SRCE model.

10.0 References

- ADNR (Alaska Department of Natural Resources). 2017. Status of Compliance with Terms and Conditions of *Certificate of Approval to Operate a Dam*, Pond 7 Dam (AK00307), letter to Hecla Greens Creek Mining Company, ADNR Division of Mining, Land & Water, Water Resources Section, May 9.
- ADNR. 2018b. Temporary Certificate of Approval to Operate a Dam, Pond 7/10 Dam System, National Inventory of Dams ID #AK00307 and #AK00316, Division of Mining, Land and Water, Dam Safety and Construction Unit, April 19.
- ADNR. 2018c. Certificate of Approval to Modify a Dam, Sand Pit Dam National Inventory of Dams (NID) ID# AK00201, Division of Mining, Land and Water, Dam Safety and Construction Unit, July 31.
- ADNR. 2018a. Notice of Violations of the Alaska Water Use Act, Dam Safety Statutes and Pertinent Regulations at Greens Creek Mine, letter to Hecla Greens Creek Mining Company, ADNR Division of Mining, Land & Water, Water Resources Section, February 26.
- EDE. 2018. Hecla Greens Creek Mine, 2018 Site Water Balance, EDE Project Number GCM1706, June 2018.
- HGCMC (Hecla Greens Creek Mining Company). 2014a. Hecla Greens Creek General Plan of Operations, Appendix 1: Integrated Monitoring Plan (IMP). November 2014. Prepared in conjunction with = SRK Consulting, Inc., Anchorage, AK.
- HGCMC. 2014b. Hecla Greens Creek Mining Company General Plan of Operations, Appendix 7: Integrated Waste Management and Disposal Plan. June 2014. Prepared by SRK Consulting, Inc., Anchorage, AK.
- HGCMC. 2014c. Hecla Greens Creek Mining Company General Plan of Operations, Appendix 11: Waste Rock Management Plan. November 2014.
- HGCMC. 2014d. Hecla Greens Creek General Plan of Operations, Appendix 14: Reclamation and Closure Plan. June 2014. Prepared by SRK Consulting, Inc., Anchorage, AK.
- HGCMC. 2015. Hecla Greens Creek Mining Company General Plan of Operations, Appendix 3: Tailings Disposal Facility Management Plan. February 2015.
- HGCMC. 2018a. Hecla Greens Creek Mining Company Active Tailings and Production Rock Site 2017 Annual Report. April 15, 2018. Prepared by SRK Consulting, Inc., Anchorage, AK.
- HGCMC. 2018b. Hecla Greens Creek Mining Company General Plan of Operations, Appendix 3: Tailings Disposal Facility Management Plan, July 2018.

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- Kanouse, Kate. Memorandum to Timothy, Jackie. Alaska Department of Fish and Game. Alaska Department of Fish and Game. July 16, 2018.
- Kanouse, Kate. Memorandum to Timothy, Jackie. Alaska Department of Fish and Game. Alaska Department of Fish and Game. July 17, 2018.
- Kanouse, Kate. Zutz, Johnny. Memorandum to Timothy, Jackie. Alaska Department of Fish and Game. Alaska Department of Fish and Game. September 7, 2018.
- KCB (Klohn Crippen Berger). 2018a. Hecla Greens Creek, Greens Creek Mine Pond 7, Periodic Safety Inspection, revised draft. January 25, 2018.
- KCB. 2018b. Stage 3 Phase 1 Tailings Expansion Sand Pit Spillway Re-Design (letter report). July 13, 2018.
- Kennecott Greens Creek Mining Company. 2004. Greens Creek Mine General Plan of Operations, April 2004 (Rev. 1, 01/19/2006).
- Zutz, J. 2018 Aquatic biomonitoring at Greens Creek Mine, 2017. Alaska Department of Fish and Game, Technical Report No. 18-01, Douglas, AK.



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Appendix A

Site Photographs

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Photograph A-1: Tailings Disposal Facility Stage 3 expansion area foundation and lined collection ditch (looking north).



Photograph A-2: Tailings Disposal Facility reclaimed slopes.



Photograph A-3: Tailings Disposal Facility foundation and lined collection ditch (looking north-northwest).



Photograph A-4: Pond 10 Culvert Spillway, Gabion Inlet Structure and Access Ramp (looking east).



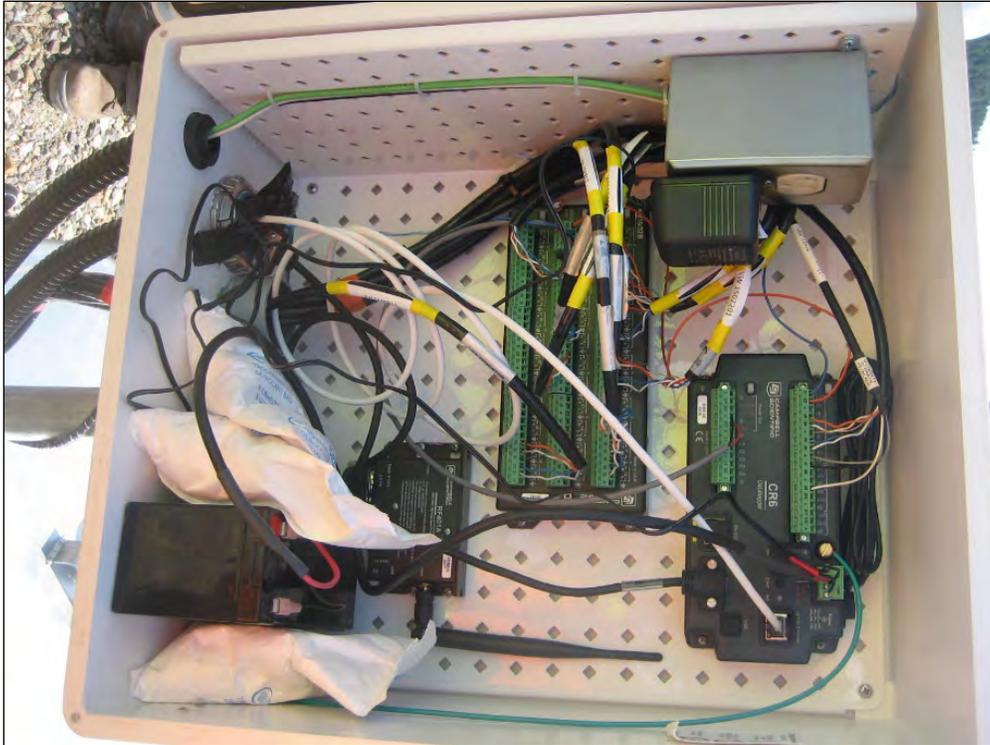
Photograph A-5: Pond 10.

Hecla
GREENS CREEK

Pond 10 (Pak Bus: 296)

MUX Channel	VW Serial #	IP #	VW Tip Elev. (feet)
1	104818	15	124.32
2	1502184	16	123.89
3	1502197	17	137.50
4	1502201	18	120.64
5	104801	18A	120.64
6	104807	18B	120.64
7	104819	18C	120.64
8	1502198	19	121.98
9	1400855	NA	barometry, offset 1022.477
10			
11			
12			
13			
14			
15			
16	1400855	NA	barometry, corr

Photograph A-6: Pond 10 Vibrating Wire Piezometers instrument information in data logger cabinet.



Photograph A-7: Pond 10 vibrating wire piezometers Campbell Scientific data logger cabinet.



Photograph A-8: Site 23 Waste Rock Tailing Storage Facility finger drain outlets and lined collection ditch at toe (looking north).



Photograph A-9: Site 23 Waste Rock Tailing Storage Facility finger drain outlet and lined collection ditch at toe (looking northwest).



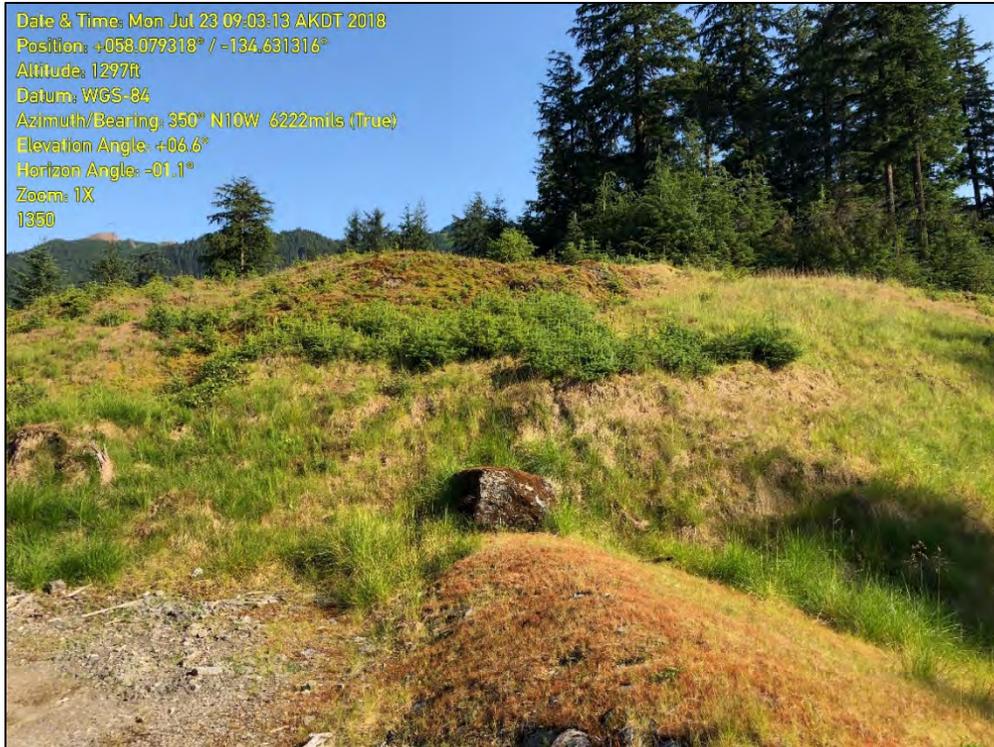
Photograph A-10: Pond area above the Sand Pit Dam (looking north).



Photograph A-11: Sand Pit Dam at the Sand Quarry, surface survey monuments in the foreground and background, crest of dam to the right (looking north).



Photograph A-12: Reclamation area at the 1350 Portal.



Photograph A-13: Reclamation area at the 1350 Portal.



Photograph A-14: Waste segregation.



Photograph A-15: Used oil storage area.



Photograph A-16: Secondary containment at the Mill, needs repair.



Photograph A-17: Cardboard press.



Photograph A-18: Frozen garbage prior to shipping off-site.

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