AuRico Metals

KEMESS UNDERGROUND PROJECT

# Mine Site Water Management Plan

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# DOCUMENT TRACKING

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# Mine Site Water Management Plan

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# ACRONYMS AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

| | |
|---|---|
| **AuRico** | AuRico Metals Inc. |
| **BC** | British Columbia |
| **BCWQG** | British Columbia Water Quality Guidelines |
| **EAC** | Environmental Assessment Certificate |
| **EAO** | Environmental Assessment Office (British Columbia) |
| **EMA** | *Environmental Management Act* |
| **EMC** | Environmental Monitoring Committee |
| **EMP** | Environmental Management Plan |
| **EMS** | Environmental Management System |
| **ENV** | Ministry of Environment |
| **FLNRO** | Ministry of Forests, Lands and Natural Resource Operations (British Columbia) |
| **GSM** | Groundwater and Seepage Monitoring |
| **HWDD** | High Wall Diversion Ditch |
| **IDZ** | Initial Dilution Zone |
| **KLV** | Kemess Lake Valley |
| **QA/QC** | Quality Assurance/Quality Control |
| **KS** | Kemess South |
| **KUG** | Kemess Underground |
| **MA** | *Mines Act* |
| **MEM** | British Columbia Ministry of Energy and Mines |
| **ML/ARD** | Metal Leaching and Acid Rock Drainage |
| **MMER** | Metal Mining Effluent Regulations |
| **MOE** | British Columbia Ministry of Environment |
| **MR** | Metals Removal |

| | |
|---|---|
| **MSP** | Mill Sediment Pond |
| **MSWMP** | Mine Site Water Management Plan |
| **NAG** | Non Acid Generating |
| **PLC** | Programmable Logic controller |
| **SBEB** | Science Based Environmental Benchmarks |
| **SCSP** | Southern Collection System Pond |
| **SeCP** | Selenium Collection Pond |
| **SOP** | Standard operating procedure |
| **STP** | Sewage Treatment Plant |
| **TSF** | Tailings Storage Facility |
| **WCD** | Western Collection Ditches |
| **WCSP** | Western Collection System Pond |
| **WDD** | Western Diversion Ditch |
| **WDS** | Water Discharge System |
| **WRD** | Waste Rock Dump |
| **WTP** | Water Treatment Plant |

# 1. PURPOSE AND OBJECTIVES

The purpose of the Mine Site Water Management Plan (MSWMP) is to provide guidance for the management of non-contact and contact water. The plan covers the surface water management, groundwater management, water treatment, and safe discharge aspects of water management during the life of mine.

This MSWMP will be used in conjunction with the Selenium Management Plan (Appendix 7-O), Fish and Aquatic Effects Monitoring Plan (Appendix 8-A), Surface Erosion Prevention and Sediment Control Plan (Appendix 7-Q), Subsidence Effects and Terrain Monitoring Plan (Appendix 7-P), Waste and Refuse Management Plan (Appendix 7-R), and ML/ARD Characterization and Management Plan (Appendix 7-L).

This MSWMP addresses the following objectives:

- maintain regulatory compliance in water management;
- avoid and/or minimize environmental effects by establishing environmental protection measures;
- supply and retain water for mine operations;
- identify the monitoring programs required for implementation of this plan; and
- coordinate water management activities with relevant management and monitoring plans.

# 2. PLANNING

## 2.1 ROLES AND RESPONSIBILITIES

### 2.1.1 Environmental Manager

The Manager of Environment will be responsible for the development, application, and monitoring of an effective Environmental Management System (EMS) and array of relevant Environmental Management Plans (EMPs) and communications with government and community, including Aboriginal groups.

The Environmental Manager will:

- interact and direct on-site Environmental Specialists and Technicians to fulfill environmental management responsibilities and tasks;
- audit internally and contractors for compliance with Sustainability Management System and EMP requirements; and
- design, implement and report programs and procedures to fulfill the EMPs for internal sustainability, Permit or regulatory commitments.

Specific mine site water management and monitoring responsibilities include:

- implementation of this MSWMP;
- being aware of the legislative and permit requirements during construction and operations to maintain Project compliance with regulatory requirements;
- monitoring and reporting activities that may have an effect on water; and
- providing training and awareness programs to all site personnel for competency.

### 2.1.2 General Manager

The on-site General Manager will carry line-function accountability for the Project's health and safety and environmental performance. The General Manager will instruct and approve the on-site systems and resources, by delegation to line-function personnel and with the support and advice of the Process Plant Manager and Mining Manager for planning, oversight, monitoring, and reporting. The General Manager has responsibility overall for the construction and operation of the Project, and responsibility for on-site environmental monitoring and compliance relating to construction and operation activities. The General Manager will:

- be aware of the components of this plan and how the proposed mining activities and disturbances will affect mine site water management;
- allocate adequate resources to enable implementation of this MSWMP;
- be responsible for implementing correction actions, external reporting, adaptive management and continuous improvement; and
- be accountable for the overall environmental performance of the mine, including the outcomes of this MSWMP.

### 2.1.3 Process Plant Manager and Mining Manager

The Process Plant Manager and Mining Manager will have the functional responsibility for all matters related to health and safety and environmental management for their specific areas and will provide line-function accountability to the General Manager. The Process Plant Manager and Mining Manager will:

- interact via a staff-function role with relevant on-site personnel that have specified environmental management responsibilities; and
- submit compliance reports to the General Manager.

The role and span of responsibility of the Process Plant Manager and Mining Manager may be a component of a broader portfolio that encompasses the management of health and safety of the Project. A scheduled and systematic system of support and monitoring of environmental performance are maintained and follow approved EMPs and conditions, and include compiling, reviewing, and seeking approval from the General Manager, Environmental Manager (or line-function delegate) for environmental management method statements and work instructions.

#### 2.1.4 Environmental Specialists and Environmental Technicians

The Environmental Specialists will be responsible for implementing the various EMPs and permit monitoring measures for the Project. They are under the direction of, and are accountable to the Environmental Manager. The Environmental Specialists will:

- complete the day-to-day tasks to fulfill the EMPs' obligations, sample collection, onsite monitoring and reporting; and
- perform environmental monitoring roles during all phases of the Project.

Environmental Technicians will complete tasks as directed to support responsibilities of the Environmental Specialists and Environmental Manager.

#### 2.1.5 Employees and Contractors

A safety and environmental orientation will be developed for AuRico personnel and contractors involved in the Project and will include the water management actions specific to the activity in which they will be involved. A key component of this orientation is a clear explanation of each individual's role and responsibility in the management of water at the Project.

The Employee and Contractors will be aware of this plan and be knowledgeable of how their individual actions may affect mine site water management.

#### 2.1.6 Qualified Professional

Qualified Professionals will be contracted by AuRico when specialized expertise is required. A qualified professional is a person who has training, experience and expertise in a discipline relevant to the field of practice set out in the condition or regulation, and is registered with the appropriate professional organization, is acting under that organization's code of ethics and is subject to disciplinary action by that organization.

### 2.2 COMPLIANCE OBLIGATIONS

#### 2.2.1 Legislation and Regulations

The following provincial and federal legislation and guidelines are relevant to managing the Project's water:

- BC *Environmental Management Act* (SBC 2003b) – Regulates the discharge of air contaminants, liquid effluent, and refuse into the environment, and regulates the management of hazardous wastes.
- *BC Mines Act (*RSBC 1996g) – Provides guidance and approvals for all Project activities on the mine site; requires designs and details for water management structures, water storage, and water treatment facilities as well as the source, use, and water balance for water required in the operation.

- Health, Safety, and Reclamation Code for Mines in British Columbia (BC MEMPR 2017) – Requires a plan for the environmental protection of land and watercourses during the construction and operational phases of the mining operation.
- *Fisheries Act* (RSC 1985b) – Provides Fisheries and Oceans Canada with the responsibility to ensure sufficient flows for fish by preventing permanent alteration to, or destruction of fish habitat.
- Canada *Water Act* (RSC 1985a) – Regulates the construction of works for the purposes of diverting, storing, or using water, or causing changes in and about a stream for any purpose.
- BC *Water Act* (RSBC 1996h) – Administers the allocation and management of surface waters in British Columbia. It is the primary legislation for regulating surface water diversion, storage, and use, and managing water quality.
- Metal Mining Effluent Regulations (MMER, 2012) – Stipulates and details the requirements for environmental effects monitoring if effluent (greater than 50 $m^3$/day) or deleterious substances are released into a receiving waterbody.

### 2.2.2 Provincial Environmental Assessment Certificate and Federal Decision Statement Conditions

AuRico Metals was granted an Environmental Assessment Certificate (EAC, #M17-01) on March 13, 2017 that included a series of conditions associated with the EAC #M17-01. Along with the Fish and Aquatic Effects Monitoring Plan (Appendix 8-A), this MSWMP addresses conditions #15, 16, 21, 23 and 28. These conditions are copied below for reference:

<u>EAC Condition #15 – Feasibility Study for Tailings Beach</u>

*Prior to construction of the tailings beach, the Holder must retain a Qualified Professional to conduct geochemical characterization to determine whether subaerial tailings are suitable for the tailings beach and determine what final beach configuration options are available. This study must include standard and appropriate static and kinetic testing procedures of Black Lake intrusives and Takla lithologies. This study must determine the volume of sand that can be generated as suitable subaerial beach material during the final years of Operations.*

*The Holder must provide the results of the study to Aboriginal Groups and MEM within 30 days of the completion of the study and discuss the results of the study, and the justification for the closure beach width with the EMC identified in condition 12.*

<u>EAC Condition #16 – Water Management</u>

*During Construction, Operations and Closure:*

a) *The Holder must treat effluent from the Project tailings storage facility for metals and selenium as required to ensure downstream water quality, as monitored in accordance with paragraph (b) of this condition meets:*
   i) *the British Columbia Water Quality Guidelines (BCWQG); or*
   ii) *Science Based Environmental Benchmarks (SBEB), if accepted by ENV for one or more contaminants.*

b) *The Holder must monitor surface water quality downstream of the point of discharge of the Project tailings storage facility at a location determined by a Qualified Professional, in consultation with ENV and Aboriginal Groups, to be suitable for monitoring.*

c) *Despite paragraph (a) of this condition, the Holder may exceed the BCWQG or SBEB referred to in that paragraph if the Holder:*

   i) *notifies ENV, EAO and Aboriginal Groups within 48 hours of any results identifying an exceedance being received from the testing facility; and*

   ii) *takes measures to meet downstream water quality as described in (a) and (b) in the manner directed, within the time period required, and using.*

<u>EAC Condition #20 – Amazay Lake Monitoring Plan</u>

*The Holder must retain a Qualified Professional to develop a plan for monitoring water quality of Amazay Lake. The plan must be developed in consultation with FLNRO, MEM, ENV and Aboriginal Groups.*

*The plan must include at least the following:*

a) *Surface Water Quality Monitoring*

   i) *Monitoring locations on Amazay Lake and its tributaries;*

   ii) *Frequency of monitoring;*

   iii) *Plan to compare water quality monitoring results collected prior to Operations with water quality monitoring results collected during Construction, Operations, Closure and Post-closure;*

   iv) *Consideration of conditions when the monitoring may not be required; and*

   v) *Adaptive management if the monitoring indicates adverse effects on surface water quality due to the Project as determined by a Qualified Professional.*

b) *Groundwater Quality Monitoring to detect potential groundwater movement from the underground cave/subsidence zone towards Amazay Lake:*

   i) *Monitoring locations;*

   ii) *Monitoring methods (e.g. overburden or shallow bedrock; dataloggers in groundwater monitoring wells);*

   iii) *Frequency and duration of monitoring;*

   iv) *Methods for which the monitoring results must be incorporated into the closure plans; and*

   v) *Adaptive management if the monitoring indicates adverse effects on groundwater quality due to the Project as determined by a Qualified Professional.*

*The Holder must provide this draft plan to FLNRO, MEM, ENV, Aboriginal Groups and EAO for review a minimum of 45 days prior to the planned commencement of Construction.*

*The Holder must not commence Construction until the plan has been approved by EAO, unless otherwise authorized by EAO.*

*The plan, and any amendments thereto, must be implemented to the satisfaction of a Qualified Professional throughout all Project phases to the satisfaction of EAO.*

EAC Condition #21 – Staged Discharge

> *During Construction, the Holder must retain a Qualified Professional to ensure that the water discharged from the Project tailings storage facility to Attichika Creek is staged on a monthly basis to a volume proportional to the Attichika Creek monthly streamflow and the discharge is restricted to the open water months.*

This MSWMP also addresses the conditions of the federal decision statement issued on March 9, 2017, under Section 54 of the *Canadian Environmental Assessment Act, 2012*. Conditions #3.3.2, 3.4, 3.5, 3.6, and 3.7.1 of the decision statement are copied below for reference:

Decision Statement Condition 3.3.2

> *3.3.2 Collect and treat all waters affected by the Designated Project that do not meet the requirements of the Metal Mining Effluent Regulations and subsection 36(3) of the* Fisheries Act*, as applicable, prior to the affected waters being deposited in waters frequented by fish.*

Decision Statement Condition 3.4

> *3.4 The Proponent shall install hydraulic plugs in the declines before the underground mine is flooded to direct seepage from the flooded underground mine towards East Cirque Creek.*

Decision Statement Condition 3.5

> *3.5 The Proponent shall, in a manner that complies with the Metal Mining Effluent Regulations and subsection 36(3) of the* Fisheries Act*, discharge water from the tailings storage facility into Attichika Creek during construction and the first year of operation such that flow rates downstream of the discharge location are within the range of minimum and maximum flow rates naturally occurring in Attichika Creek, and shall only discharge water into Attichika Creek during open water months.*

Decision Statement Condition 3.6

> *3.6 The Proponent shall divert all runoff from the East Pit quarry into the tailings storage facility during construction and operation.*

Decision Statement Condition 3.7.1

> *3.7.1 Monitor quality of water discharged in Attichika Creek during the dewatering of the Kemess South Pit and treat that water to meet the requirements of subsection 36(3) of the* Fisheries Act.

Decision Statement Condition 3.7.2

> *The Proponent shall monitor surface water quality in Amazay Lake and groundwater movement between the subsidence zone identified by the Proponent during the environmental assessment and Amazay Lake.*

Decision Statement Condition 3.7.4

> *The Proponent shall monitor changes in water quality in Waste Rock Creek and the tailings storage facility, including changes in selenium concentrations.*

### 2.2.3 Permit Conditions

#### *2.2.3.1 PE15335*

AuRico has submitted an application to amend its effluent discharge permit (PE 15335). Effluent discharge quantity and quality will be in compliance with the conditions of the amended permit.

#### *2.2.3.2 M206*

*Surface and Ground Water Management and Monitoring*

a) *The Permittee shall implement the Mine Site Water Management Plan (Ref. 13) and an updated plan shall be submitted by August 15, 2018, to the satisfaction of the Chief Inspector. The Permittee shall track changes to surface water, seepage, and groundwater quality and quantity on the mine site. The program shall be capable of providing early warning about the onset of ARD or an increase in contaminant loading.*

b) *No significant changes shall be made to the Mine Site Water Management Plan without the written approval of the Chief Inspector. Significant changes include removal of monitoring sites, or changes to monitored parameters.*

c) *Detection limits shall be sufficient to compare to water quality standards and permit requirements established by the British Columbia Ministry of Environment.*

d) *An effective QA/QC program for the surface water, groundwater and seepage monitoring programs shall be included and implemented as part of the Mine Site Water Management Plan. This shall include detection limits, performance criteria that define acceptable levels of precision and accuracy, and reporting of any missed sampling events.*

e) *Monitoring results of surface water, groundwater, and seepage quality and quantity shall be kept up to date in a dedicated database available for review by an Inspector of Mines. Water quality monitoring results, including interpretation of results, shall be reported and assessed in the Annual Reclamation Report. Any significant changes or trends in water quality or quantity results shall be discussed, and those that require additional evaluation and management shall be identified in the report.*

f) *The Permittee shall include a table comparing relevant monitoring and testwork data to source term concentrations used in water quality predictions in the Annual Reclamation Report. The implications of the results to source term refinement, water quality mitigation and adaptive management shall be discussed in the report.*

### 2.2.4 Guidelines and Best Management Practices

Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits (BC MEM and MOE 2016) lists the water management and safe discharge items to be included or referenced in the MSWMP. These items are shown in Table 2.2-1. For the items that are not directly included in this MSWMP, Table 2.2-1 provides reference to sections of the permit application where this information is provided.

Best management practices include separating of non-contact and contact water, re-using contact water, and minimizing freshwater make up needs. These practices are described in Sections 4 and 5 of this MSWMP.

**Table 2.2-1. Water Management Items based on Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits (BC MEM and MOE 2016)**

| Item | Location in Permit Application | Comments |
|---|---|---|
| Geotechnical stability and hydraulic capacity assessments should be provided for all water storage structures, water diversions, interceptors and sediment-retention structures. Proposed monitoring and maintenance programs should also be described | Chapter 3 (Section 3.6); Surface Erosion Prevention and Sediment Control Plan (Appendix 7-Q); Section 6 of this plan | Design criteria and drawings are provided in Section 3.6 of the permit application (Mine Facility Designs and Development). Surface Erosion Prevention and Sediment Control Plan (Appendix 7-Q) provides monitoring for sediment and erosion. Section 6 of this plan describes flow monitoring. |
| A water balance for each relevant structure | ERM (2017) | The water balance model is documented in ERM (2017) of the permit application. |
| Geotechnical, hydrologic, and hydraulic stability assessments for all water diversions, interceptors and sediment retention structures | Chapter 3 (Section 3.6) | Design criteria and drawings are provided in Section 3.6 of the permit application (Mine Facility Designs and Development) |
| Preliminary designs of sediment control ponds and diversion structures | Chapter 3 (Section 3.6) | Design criteria and drawings are provided in Section 3.6 of the permit application (Mine Facility Designs and Development) |
| Details on use of existing drainages | Section 4 of this plan and ERM (2017) | A summary is provided in Section 4 of this plan. Details are available in the water balance model report (ERM 2017). |
| Surveillance and maintenance of the water-management structures | Section 6 of this plan; Surface Erosion Prevention and Sediment Control Plan (Appendix 7-Q); | Surface Erosion Prevention and Sediment Control Plan (Appendix 7-Q) provides monitoring for sediment and erosion. Section 6 of this plan describes flow and treatment monitoring. |
| Proposed water sources for the mine, detailing the watershed or source area boundary for the water supply, and providing hydro-geologic information (location, capture zone, yield, water quality, etc.) for all groundwater sources to be utilized | Section 4 of this plan; Lorax (2017a); Lorax (2017b); ERM (2017) | Surface water and groundwater are described in detail in Lorax (2017a, 2017b). Section 4 of this plan describes the flow pathways and uses. Further details are available in the water balance model report (ERM 2017). |
| Design of conveyance system for the water treatment plant | Chapter 3 (Section 3.6) | Design criteria and drawings are provided in Section 3.6 of the permit application (Mine Facility Designs and Development) |
| Design of any groundwater seepage mitigation or interception structures | Chapter 3 (Section 3.6) | Design criteria and drawings are provided in Section 3.6 of the permit application (Mine Facility Designs and Development) |
| Description of any flow augmentation measures that might be required during low-flow periods to compensate for any induced streamflow losses to groundwater | n/a | n/a |

*(continued)*

**Table 2.2-1. Water Management Items based on Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits (BC MEM and MOE 2016; continued)**

| Item | Location in Permit Application | Comments |
|---|---|---|
| Appropriate contingency planning | Section 5 of this plan | Contingencies pertinent to surface and groundwater management, water treatment, and safe discharge are provided in /Section 5 of this plan. |
| Analysis of impacts if the contingencies fail | Mine Emergency Response Plan (Appendix 7-A) | Described in the Mine Emergency Response Plan (Appendix 7-A) |
| Potential impacts of mining and waste discharges on the source water quality, and relevant conditions from the regional health authority for well construction and the water system's operation; | Chapter 6 (Section 6.5 and 6.8) | Effects on surface water quality and human health are assessed in Sections 6.5 and 6.8 of the permit application. |
| An assessment of upset conditions (e.g., extreme flow conditions, icing, etc.) on the performance of the Water Management Plan; | Section 5 of this plan | Mitigation measures related to icing, extreme flow are described in Section 5 of this plan. |
| Contingencies required to mitigate potential impacts of upset conditions and potential impacts related to failure of identified contingencies | Section 5 of this plan | Contingencies are described in Section 5 of this plan. |
| Include the delineation of the watershed or source area boundary upstream of the proposed water intake (if surface water, including a spring) or capture zone (if on a well). | Lorax (2017c, 2017d) | Surface water is not used as a source of water. Groundwater modelling results are provided in Lorax (2017c, 2017d) |
| If the source is a water supply well, provide the details of the well's location and construction, yield and water quality testing and the source of the groundwater in relation to the geological units | Section 4.3 of this plan | Information regarding water supply wells is provided in Section 4.3 of this plan. |
| Identify and discuss any potential impacts of the proposed mining and waste discharge activities on the mine water source and use. | Chapter 6 (Sections 6.4 and 6.5) | Effects on surface and groundwater water quantity and quality are assessed in Sections 6.4 and 6.5 of the permit application. |
| Identify any relevant conditions in the permits from the regional health authority for the wells construction and the water system's operation | n/a | New wells are not constructed. |

*(continued)*

**Table 2.2-1. Water Management Items based on Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits (BC MEM and MOE 2016; completed)**

| Item | Location in Permit Application | Comments |
|---|---|---|
| A safe discharge plan should propose discharge limits (volumes and concentrations) that ensure no acute toxicity to aquatic organisms at the point of discharge and no chronic toxicity beyond the edge of the IDZ. This is achieved by back-calculating discharge concentration and volume limits using contaminant-specific WQGs, WQOs or science-based environmental benchmarks as values in the mass balance model. | Chapter 5 (Section 5.3.7) | |
| For groundwater, ensure groundwater use downstream is not compromised and no chronic toxicity occurs in surface waters as surface water recharge occurs. Note: This information may form the basis for terms or conditions incorporated into the EMA effluent discharge permit. | Chapter 6 (Sections 6.4, 6.5, and 6.8) | Effects on surface and groundwater water quantity and quality, and human health are assessed in Sections 6.4, 6.5, and 6.8 of the permit application. |
| Describe emergency procedures for pollution control system malfunctions/upsets, and contingency plans (e.g., contingency storage for water requiring treatment). Contingency plans for chemical and fuel storage areas should also be included. | Mine Emergency Response Plan (Appendix 7-A) and Section 5 of this plan | Emergency procedures are described in the Mine Emergency Response Plan (Appendix 7-A). Contingencies are provided in Section 5 of this plan. |

# 3. SUPPORT

## 3.1 Training and Awareness

Mine site personnel and contractors will be provided with training on the importance of mine site water management and relevant contents of the MSWMP consistent with the roles and responsibilities identified in Section 2.1 of this plan.

## 3.2 Internal and External Communication

The Managers are responsible for communicating changes or updates to the Plan internally to all Project employees, contractors, and visitors. The Safety, Health, and Environmental specialists will inform the Managers of their compliance and monitoring findings in a monthly report.

The results of any required reporting will be communicated externally on an annual basis through the production of an annual report. AuRico will participate in meetings and initiatives requested by EAO and FLNRO, as necessary.

## 3.3 Supporting Documentation

At this time, there are no supporting documents associated with this plan. Additional documents including, but not limited to, standard operating procedures may be added on an as needed basis and listed here in subsequent versions of the plan.

# 4. WATER MANAGEMENT INFRASTRUCTURE

## 4.1 Overview of Water Management Components

This section describes the flow pathways and function of the water management components of the Project (Figure 4.1-1). Design criteria and specifications (including drawings), as well as geotechnical, hydrologic, and hydraulic assessment for water management infrastructure, including diversion ditches, pipes, pumps, spillways, and ponds are provided in Chapter 3 of the Joint *Mines Act* and *Environmental Management Act* permits application (Joint MA/EMA Application). Existing drainages (including catchment area maps) and a brief introduction of climate and flow conditions are also described.

Conceptual water management schematics during Construction, Operations, Closure, and Post-Closure are shown in Figures 4.1-2 to 4.1-7. Flow rates and predictive water quality related to these conceptual diagrams are provided in the water balance and water quality modelling reports (ERM, ERM 2018).

The MSWMP for the Project integrates with and benefits from existing Kemess South (KS) water management features and strategies. The existing system is flexible and expandable and provides for the efficient management of water for various operating conditions. Specific aspects of the existing KS water management system are potable water supply, sewage treatment plant, freshwater diversion ditches, and contact water diversion and collection. Figure 4.1-8 distinguishes water management features that are addressed in existing permits from those requiring permit amendments.

Water management infrastructure related to surface water, groundwater, water treatment, and safe discharge are described in the following sections.

## 4.2 SURFACE WATER MANAGEMENT

### 4.2.1 KUG TSF

The Project is located in a net-positive water balance environment. During Operation (in approximately Year 7), the East Dam, a tailings retention dam, will be constructed on the east end of the KUG TSF. The East Dam will be progressively raised to elevation 1,275 m to accommodate storage requirements within the KUG TSF. An open channel spillway with an invert at elevation 1,271 m will be constructed during the Closure phase (Figure 4.1-1).

Tailings deposition in the KUG TSF will be mostly sub-aqueous, and partly sub-aerial. The subaerial tailings deposition (673,300 t above the final water elevation; AMEC 2016, personal communication) will create a tailings beach. The area of the tailings beach during different Project Years is shown in Table 4.2-1. In accordance with EAC Condition #15 (see Section 2.2.2 of this plan), geochemical feasibility of sub-aerial tailings needs to be completed.

**Table 4.2-1. Tailings Beach Area in KUG TSF**

| Mine Year | Surface Area ($m^2$) |
|---|---|
| 1 | 0 |
| 3 | 217,000 |
| 8 | 172,000 |
| 10 | 396,000 |
| 13 | 500,000 |
| 13+ | 500,000 |

*Reference: AMEC (2016), personal communication*

Table 4.2-2 shows the current elevation-storage-area relationship for the KUG TSF prior to tailings deposition.

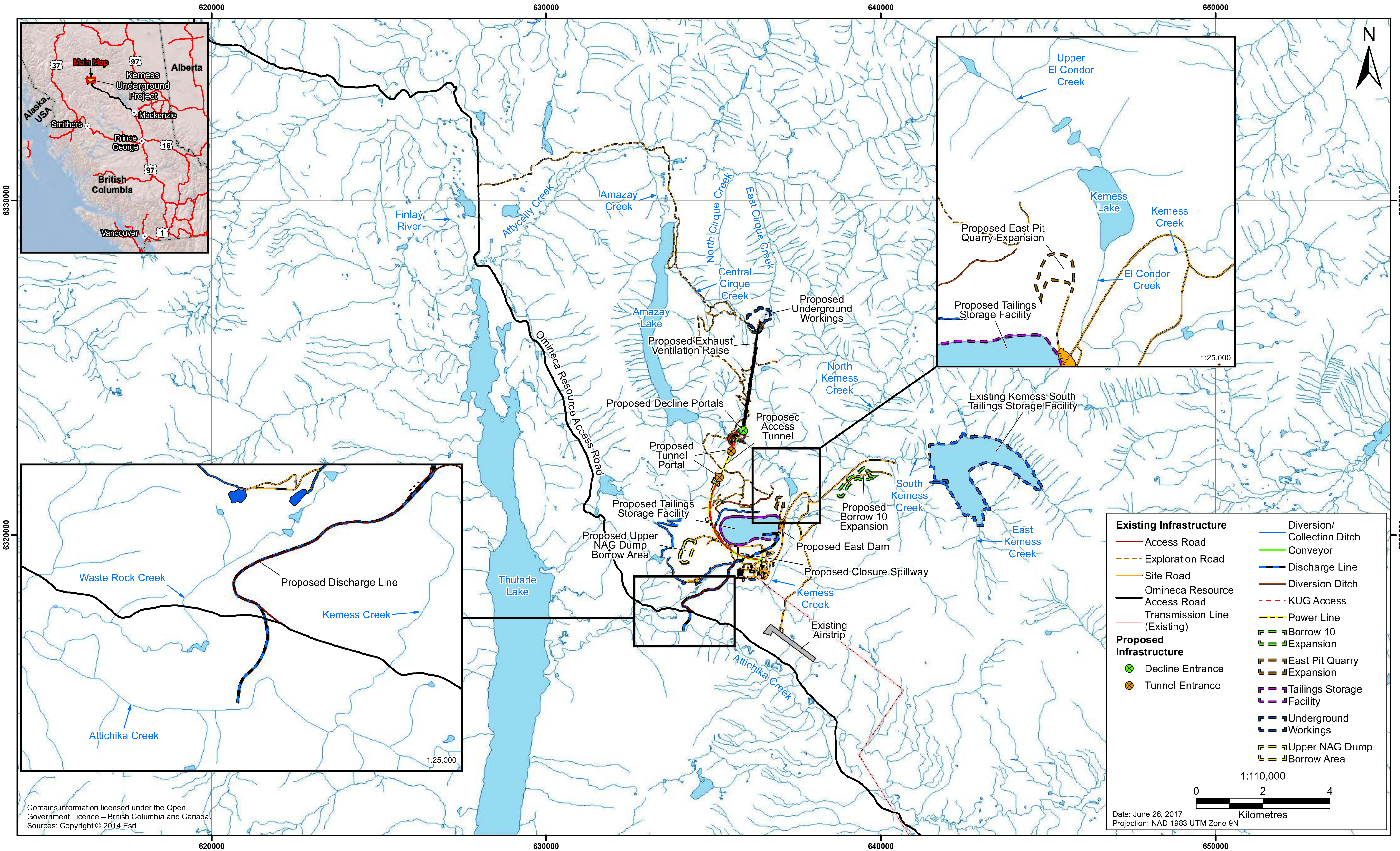
**Table 4.2-2. Elevation-Storage-Area Curve for KUG TSF**

| Elevation (m) | Surface Area ($m^2$) | Volume($m^3$) |
|---|---|---|
| 1,127 | 0 | 0 |
| 1,150 | 30,000 | 350,000 |
| 1,175 | 390,000 | 7,000,000 |
| 1,200 | 550,000 | 19,000,000 |
| 1,225 | 750,000 | 35,000,000 |
| 1,250 | 980,000 | 57,000,000 |
| 1,271 | 1,100,000 | 79,000,000 |

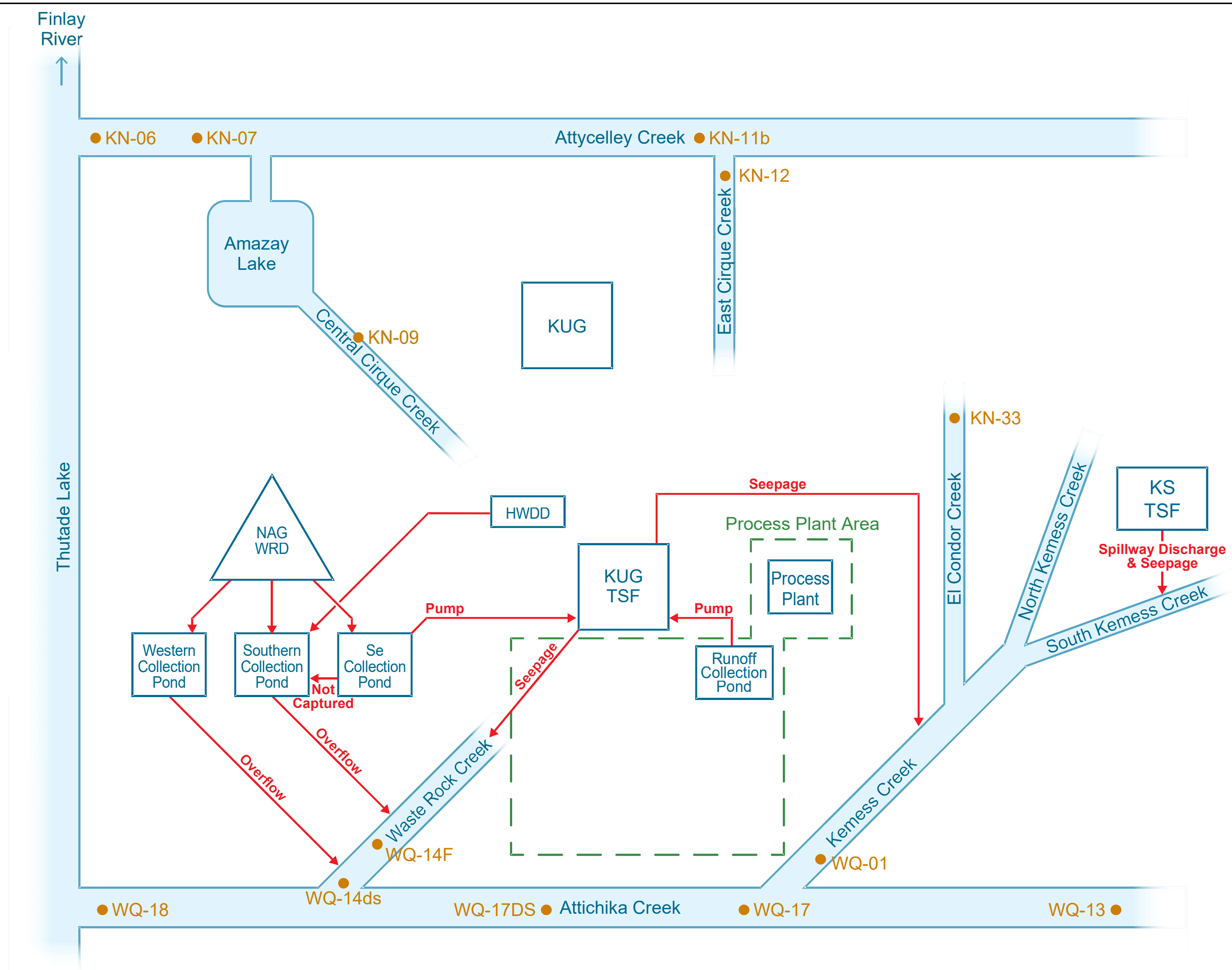
*Reference: ERM (2017)*

Figure 4.1-1

**Overview of Existing and Proposed Infrastructure and Waterbodies in the Project Area**



## Figure 4.1-2
## Conceptual Model for Water Management in Year -4 (Construction)

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## Figure 4.1-3
## Conceptual Model for Water Management in Years -3 to -1 (Construction)

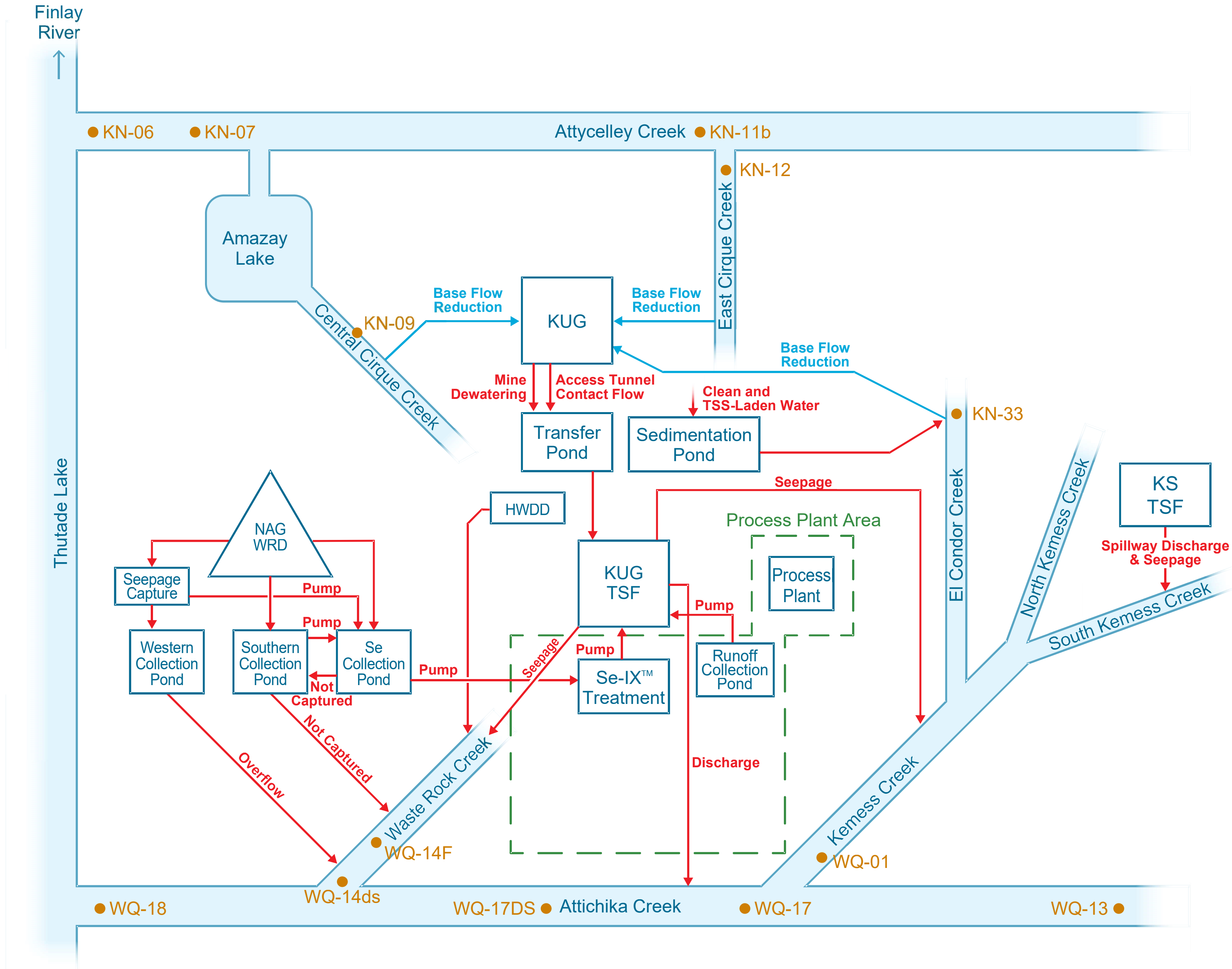
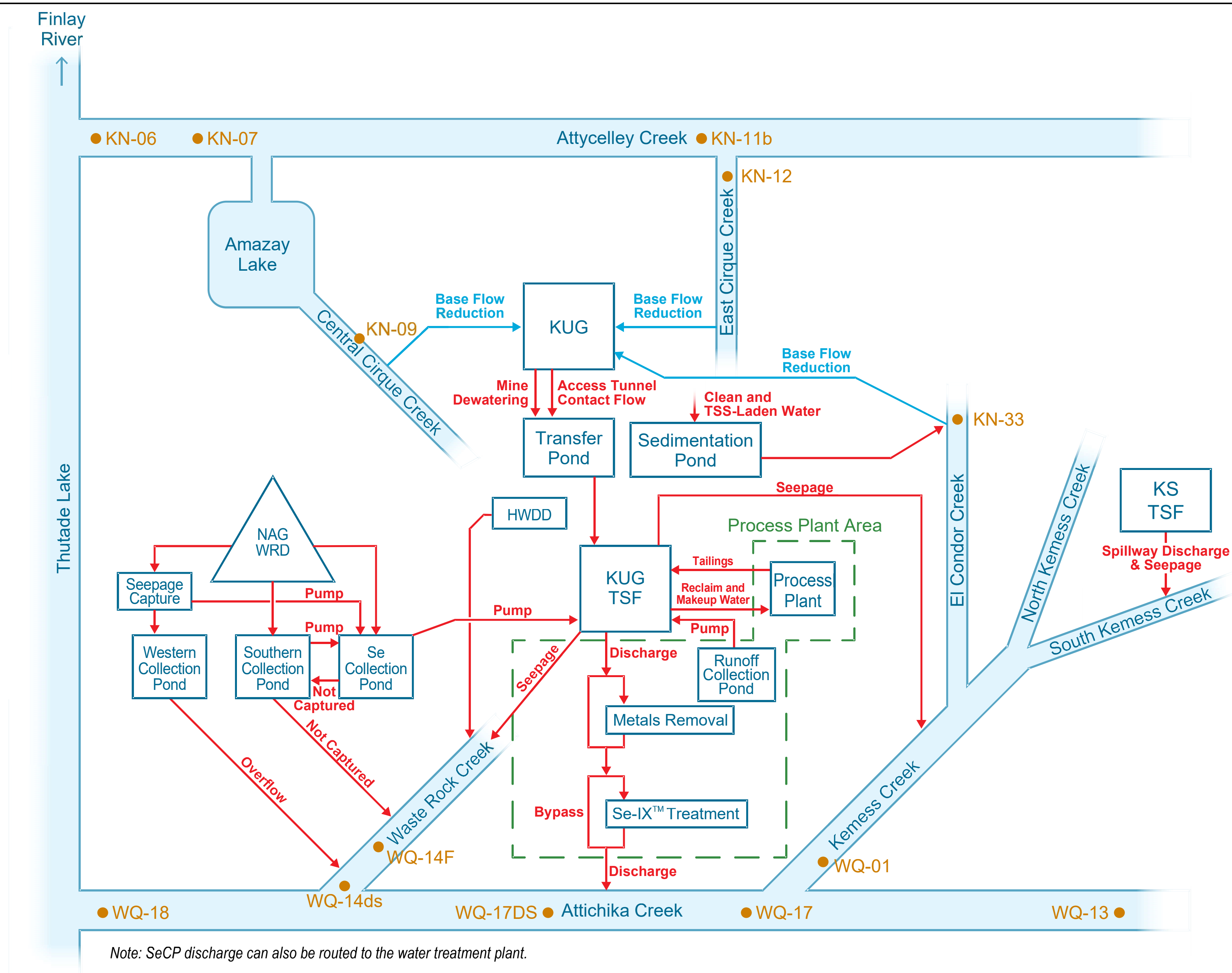


**Figure 4.1-4**

**Conceptual Model for Water Management in Year 1 (Operations)**




*Note: SeCP discharge can also be routed to the water treatment plant.*

## Figure 4.1-5

## Conceptual Model for Water Management in Years 2 to 13 (Operations)

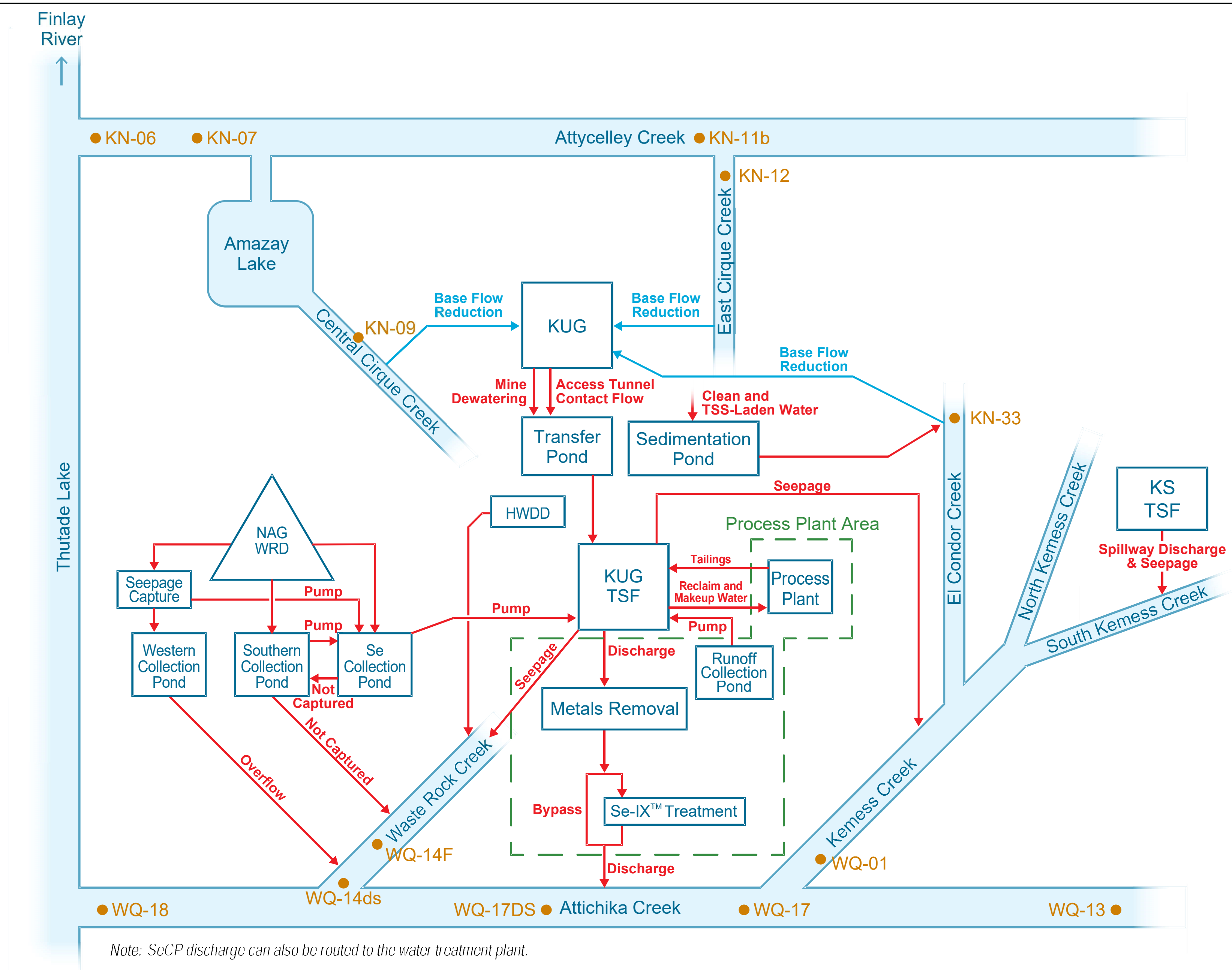
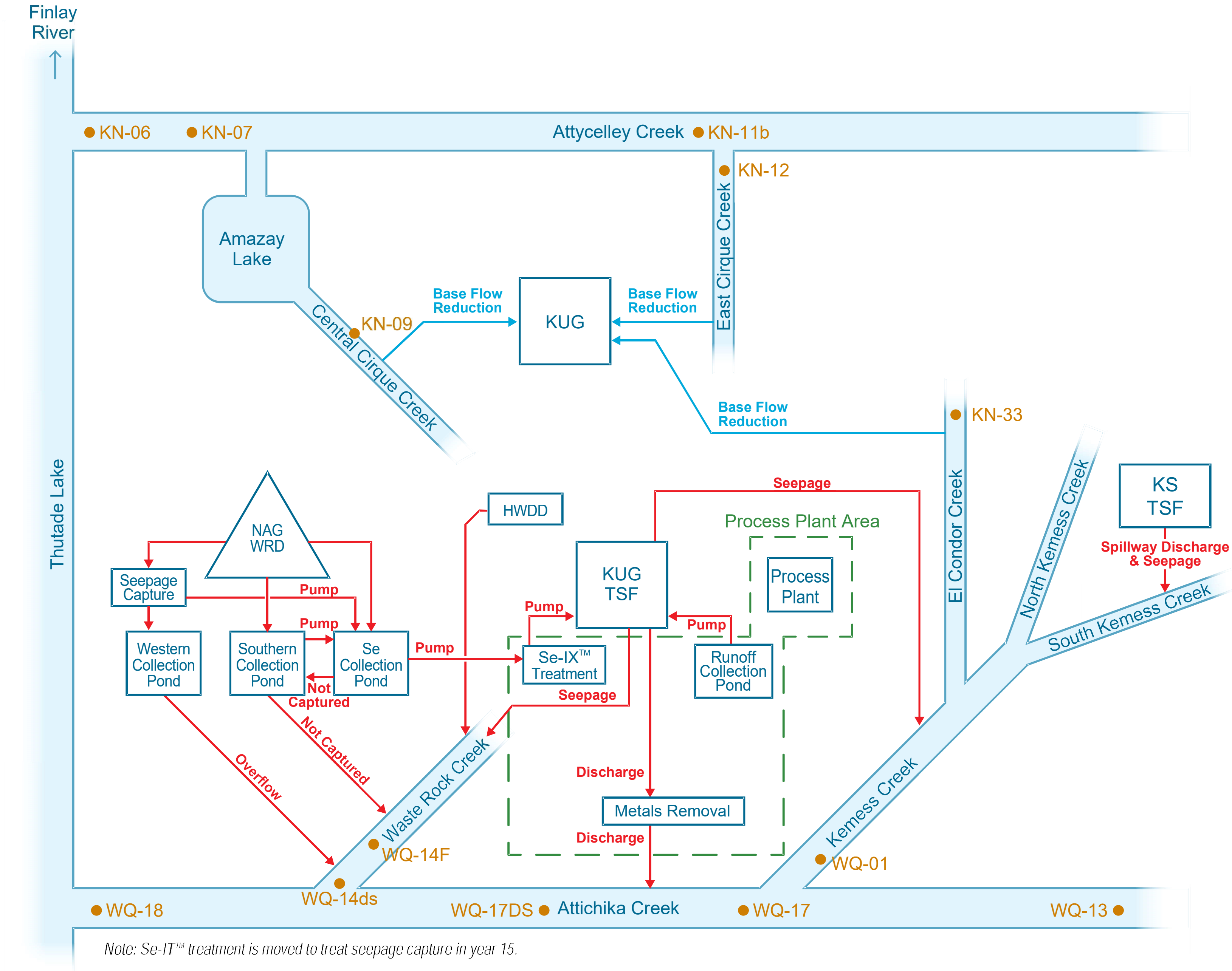


**Figure 4.1-6**

**Conceptual Model for Water Management in Years 14 to 19 (Closure)**




Note: Se-IT™ treatment is moved to treat seepage capture in year 15.

Figure 4.1-7

**Conceptual Model for Water Management after Year 19 (Post-Closure)**

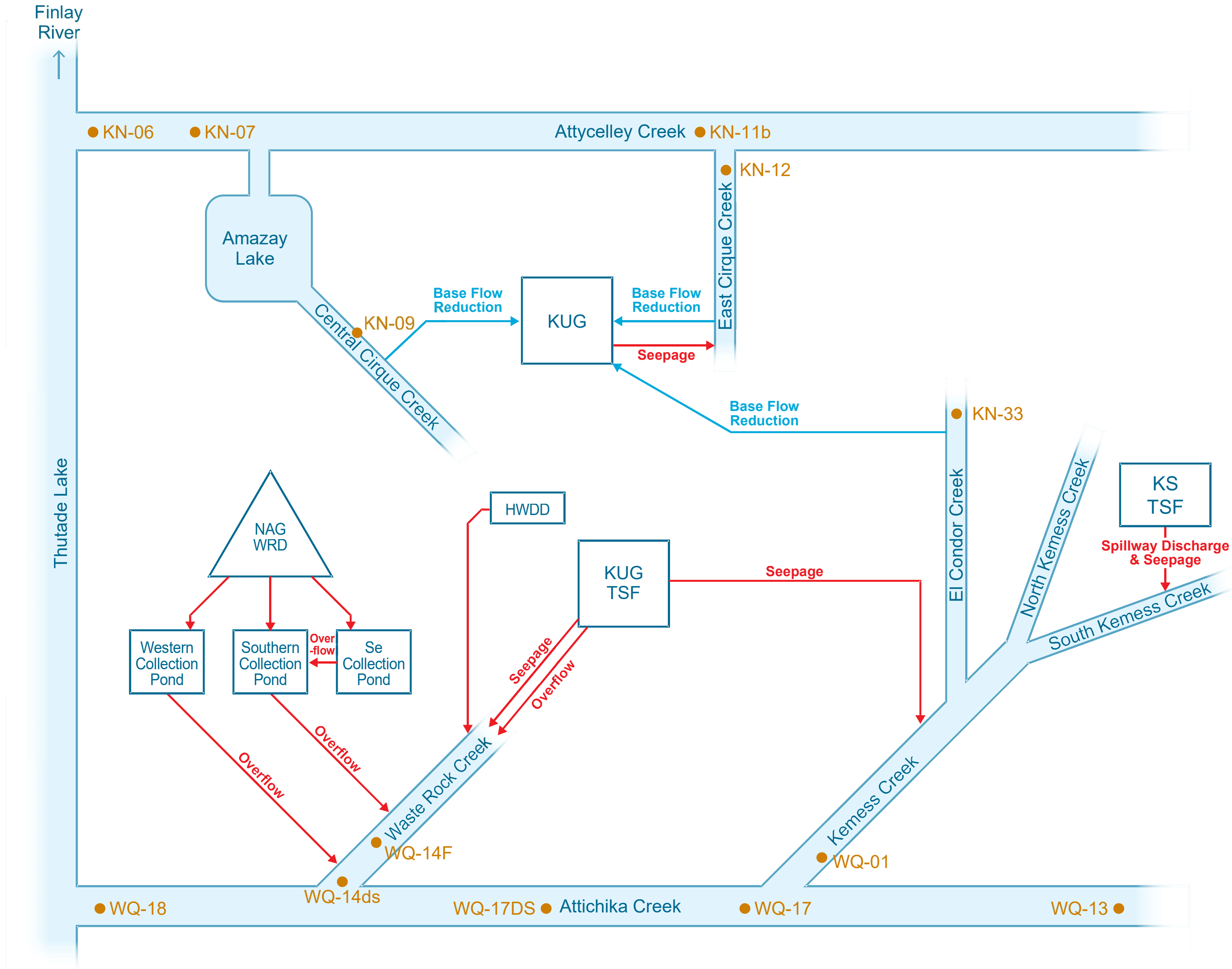
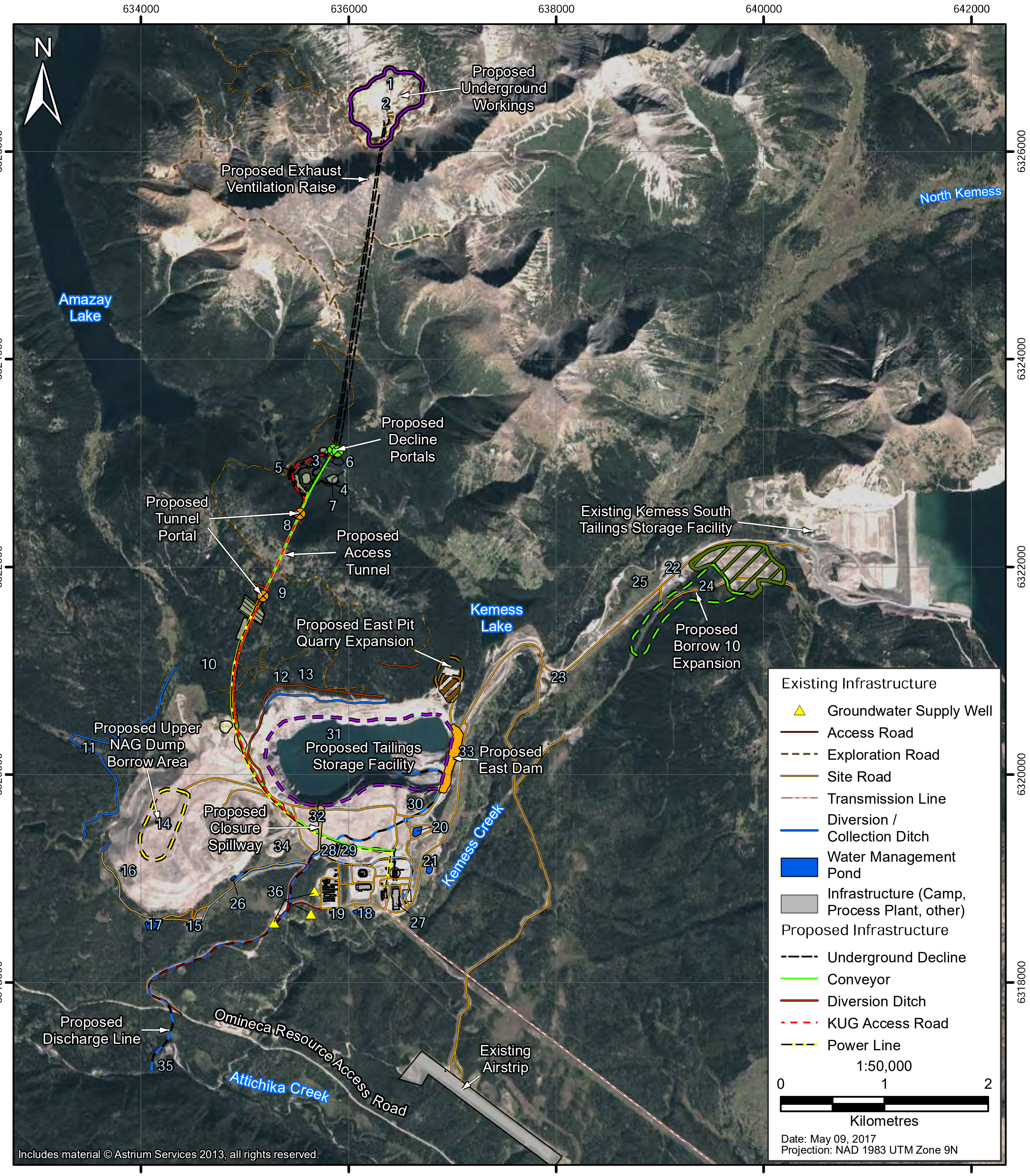


**Figure 4.1-8**

## Kemess Underground Project Water Authorizations Map




| ID | Water Mgmt Feature, project component or Activity | Provincial Permit/Authorization Requirements | New permit or permit amendment |
|---|---|---|---|
| 1 | Underground Mine sumps and pumps | *Water Sustainability Act, Mines Act* | - Potential new S.7 water licence for groundwater extraction and beneficial use<br>- Amendment to M206<br>- Likely to be listed within the amendment to PE15335 |
| 2 | Closure of the underground workings | *Mines Act* | - None at this time, addressed through future amendments to M206 and PE15335 |
| 3 | KLV Transfer Pond and Pumphouse | *Mines Act* | - Amendment to M206<br>- Likely to be listed within the amendment to PE15335 |
| 4 | Runoff Collection Ditches | *Mines Act* | - Amendment to M206<br>- Likely described as contribution to S.7 water licence for KLV sedimentation pond |
| 5 | Diversion Ditches | *Mines Act* | - Amendment to M206<br>- Likely described as contribution to S.7 water licence for KLV sedimentation pond |
| 6 | KLV sedimentation pond | *Mines Act, Environmental Management Act, Water Sustainability Act* | - Amendment to M206<br>- Amendment to PE15335<br>- New S.7 water licence for diversion and storage |
| 7 | Instream Works: Construction of spillway for KLV sedimentation pond to Upper El Condor Creek | *Mines Act, Water Sustainability Act* | - Amendment to M206<br>- New S.7 water licence for storage, same as for sedimentation pond |
| 8 | North portal diversion ditch | *Mines Act* | - Amendment to M206<br>- Likely described as contribution to S.7 water licence for KLV sedimentation pond |
| 9 | South portal diversion ditch | *Mines Act* | - Amendment to M206 |
| 10 | KUG Access road and tunnel, roadside ditches | *Mines Act* | - Amendment to M206 |
| 11 | Western diversion ditch | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 12 | Highwall diversion ditch (existing, part of southern collection system) | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 13 | Highwall diversion ditch (Proposed, (existing, part of southern collection system) | *Mines Act, Environmental Management Act* | - Amendment to M206<br>- Likely to be listed within the amendment to PE15335 |
| 14 | NAG WRD | *Mines Act* | - Addressed in existing permits |
| 15 | Southern collection system pond | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 16 | Western collection system (ditches) | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 17 | Western collection system pond (WCSP) | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 18 | Mill Sedimentation Pond | *Mines Act, Environmental Management Act* | - Amendment to M206<br>- Amendment to PE15335 |
| 19 | Sewage treatment and discharge | *Environmental Management Act* | - Amendment to PE15335 |
| 20 | Process pond | *Mines Act, Water Sustainability Act* | - Addressed in existing M206 permit<br>- New S.7 water licence |
| 21 | Pumphouse #1 pond | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 22 | Pumphouse #2 pond | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 23 | Dump pond #4 | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 24 | Borrow 10 area ditches | *Mines Act* | - Addressed in existing permits |
| 25 | BXL runoff collection ponds | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 26 | Selenium collection pond | *Mines Act, Environmental Management Act* | - Addressed in existing permits |
| 27 | Process Plant | *Mines Act* | - Amendment to M206 |
| 28 | Se Removal WTP | *Mines Act* | - Amendment to M206<br>- May be described in amendment to PE15335 |
| 29 | Se and Metals Removal WTP | *Mines Act, Environmental Management Act* | - Amendment to M206<br>- Amendment to PE15335 |
| 30 | KUG TSF dewatering facility | *Mines Act, Environmental Management Act* | - Amendment to M206<br>- Amendment to PE15335 |
| 31 | KUG TSF | *Mines Act* | - Amendment to M206<br>- May be described in amendment to PE15335 |
| 32 | KUG TSF (south pit wall) | *Mines Act, Environmental Management Act* | - Amendment to M206<br>- Amendment to PE15335 |
| 33 | KUG TSF (East Dam) | *Mines Act, Environmental Management Act* | - Amendment to M206<br>- Amendment to PE15335 |
| 34 | KUG TSF (Spillway, post-closure) | *Mines Act, Environmental Management Act* | - None at this time, addressed through future amendments to M206 and PE15335 |
| 35 | Instream works: Installation of diffuser into Attichika Creek | *Water Sustainability Act* | - New S.12 authorization for changes in and about a stream |
| 36 | Groundwater Supply Well | Water Sustainability Act | - New S.7 water licence for groundwater extraction and beneficial use |

The water balance model was run under a series of precipitation scenarios to predict water levels in the KUG TSF through the life of mine plan. Details of the water balance modelling scenarios and results are available in ERM (2017). Minimum, maximum, and average of water levels based on these scenarios are shown in Figure 4.2-1.

### 4.2.2 East Pit Quarry

Currently, runoff from the East Pit Quarry reports to KS Pit (KUG TSF) and this area is represented as a catchment area reporting to the KS Open Pit/KUG TSF within the site wide water balance and water quality model. This pattern will continue throughout KUG development. Most flow is captured by gravity, and the rest is collected in a ditch that reports to Dump Pond 1 which is then pumped to the KUG TSF.

### 4.2.3 Non-Acid Generating Waste Rock Dump

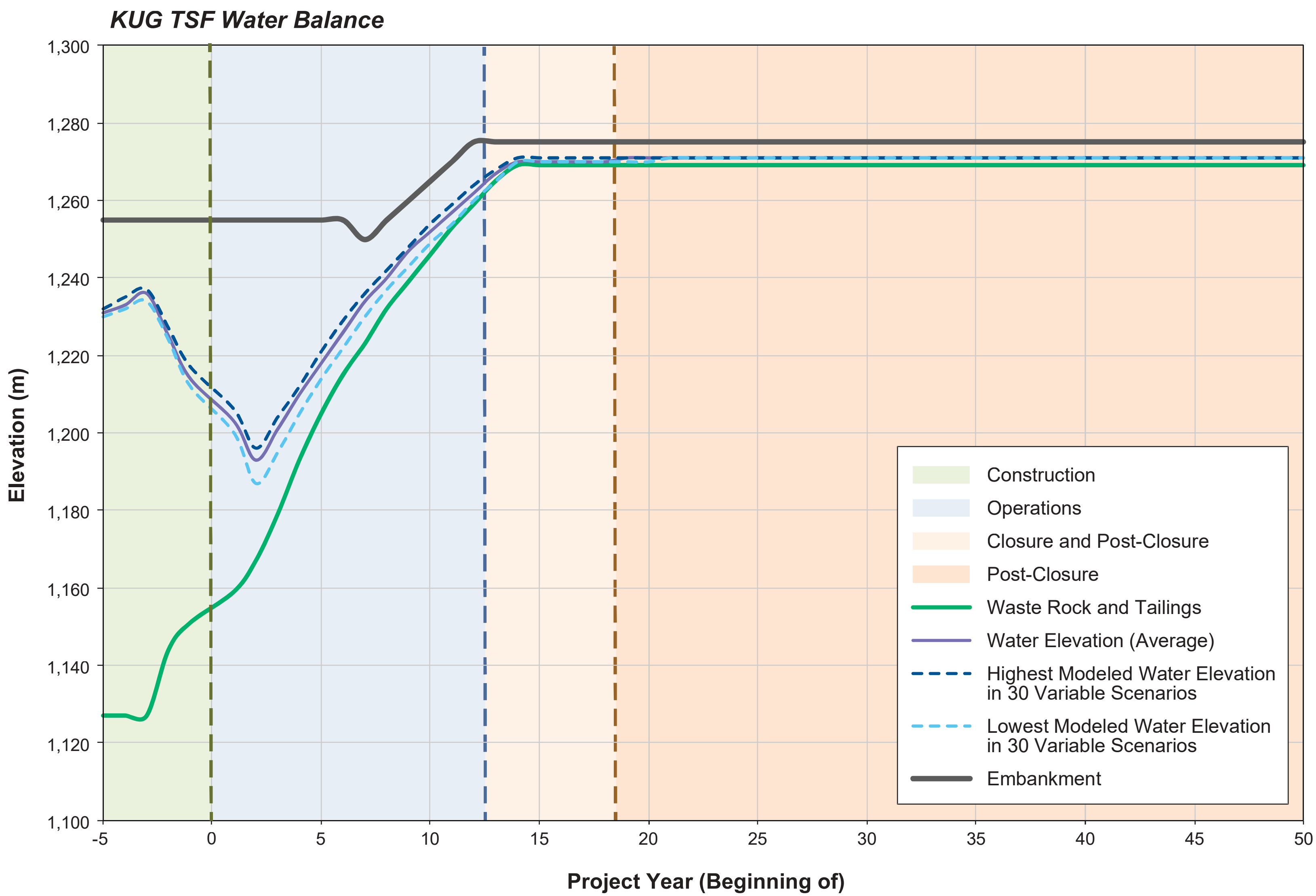
Flow pathways into Waste Rock Creek, non-contact water diversions, and collection ponds (SeCP, SCSP and WCSP) are described below.

The water management system of the existing Non-Acid Generating Waste Rock Dump (NAG WRD) described below is conceptually presented in Figure 4.2-2. A map of the area surrounding the NAG WRD is presented in Figure 4.2-3. Assumptions for the water management within the NAG WRD system are:

- The Western Diversion Ditch (WDD) was constructed with the intention of diverting the upper reaches of Waste Rock Creek around the footprint of the NAG WRD. In addition to the WDD, there are now two additional diversions that reduce flow into the NAG WRD area, being the River Jordan and OB1 Diversion. The River Jordan captures runoff on the northwest side of the NAG WRD and directs it to the WDD. The combined WDD and River Jordan flow is diverted to the Western Collection Ditch (WCD) to augment flow in Waste Rock Creek These diversions will continue to function through the life of mine.
- The River Jordan and OB1 diversions are located just upslope of the NAG WRD and divert water around NAG WRD. The River Jordan joins the bottom of the WDD, while the OB1 Diversion and the High Wall Diversion Ditch (HWDD) join the Eastern Diversion Ditch (EDD).
- The WCD connects the bottom of the WDD to the Western Collection System Pond (WCSP), allowing flows in the WDD to be diverted to the Western Collection System Pond WCSP.
- Non-contact water upslope of the NAG WRD and not captured by the WDD, River Jordan and OB1 Diversion, mixes with runoff from the NAG WRD, and exits the dump via six pathways: the WCD, seep SP7, seep S13-2, seep SP8, or seep WR-S3.
- Flow from the WCD and seep SP7 is collected in the WCSP, flow from seep S13-2 is collected in the Southern Collection System Pond (SCSP), flow from seeps SP8 and WR-S3 is collected in the Se Collection Pond (SeCP).

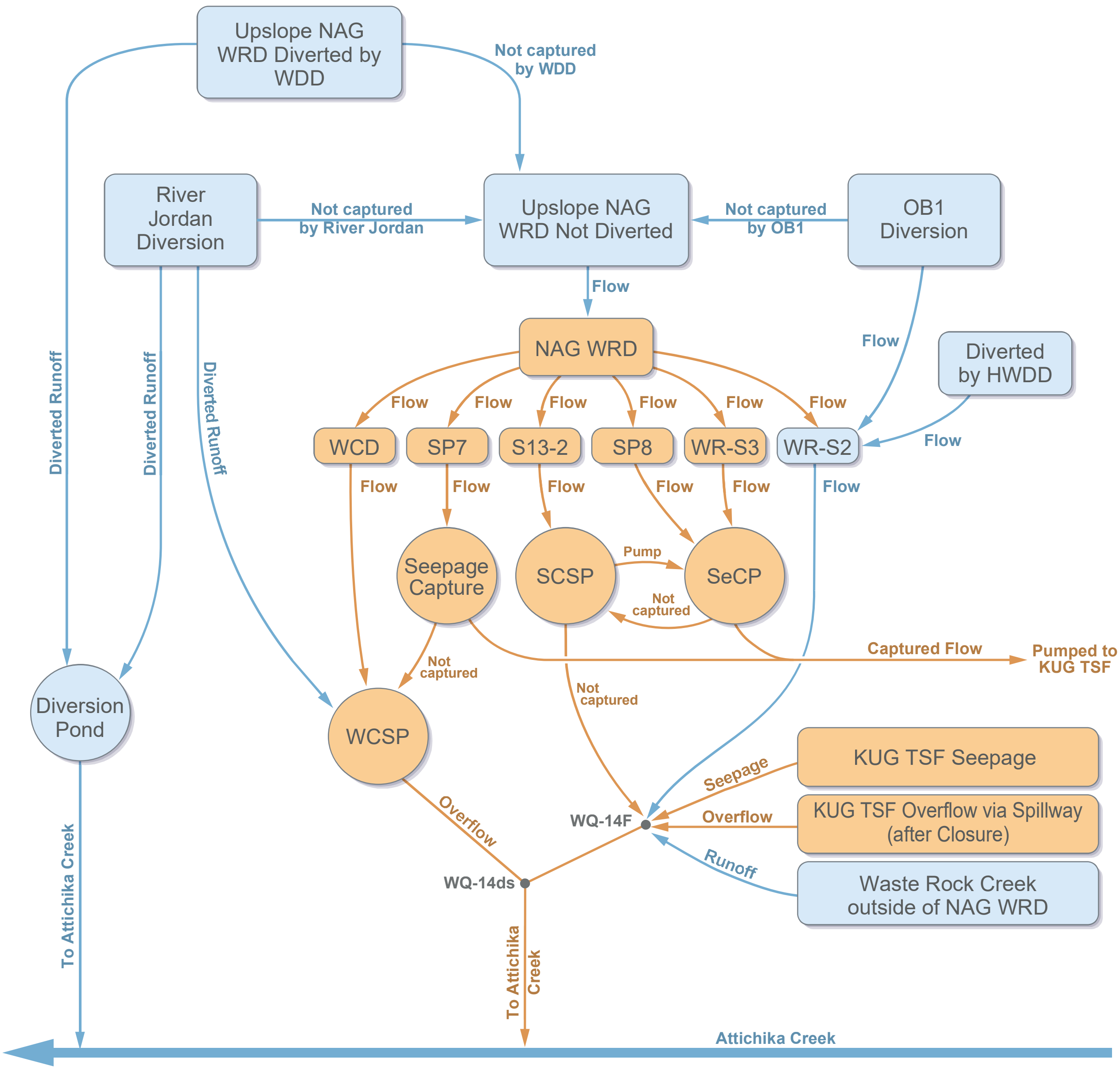
**Figure 4.2-1**

**Predicted Water and Solid Elevations within the KUG TSF during Different Phases of the Project**



# Conceptual Representation of Flow Pathways within the NAG WRD System

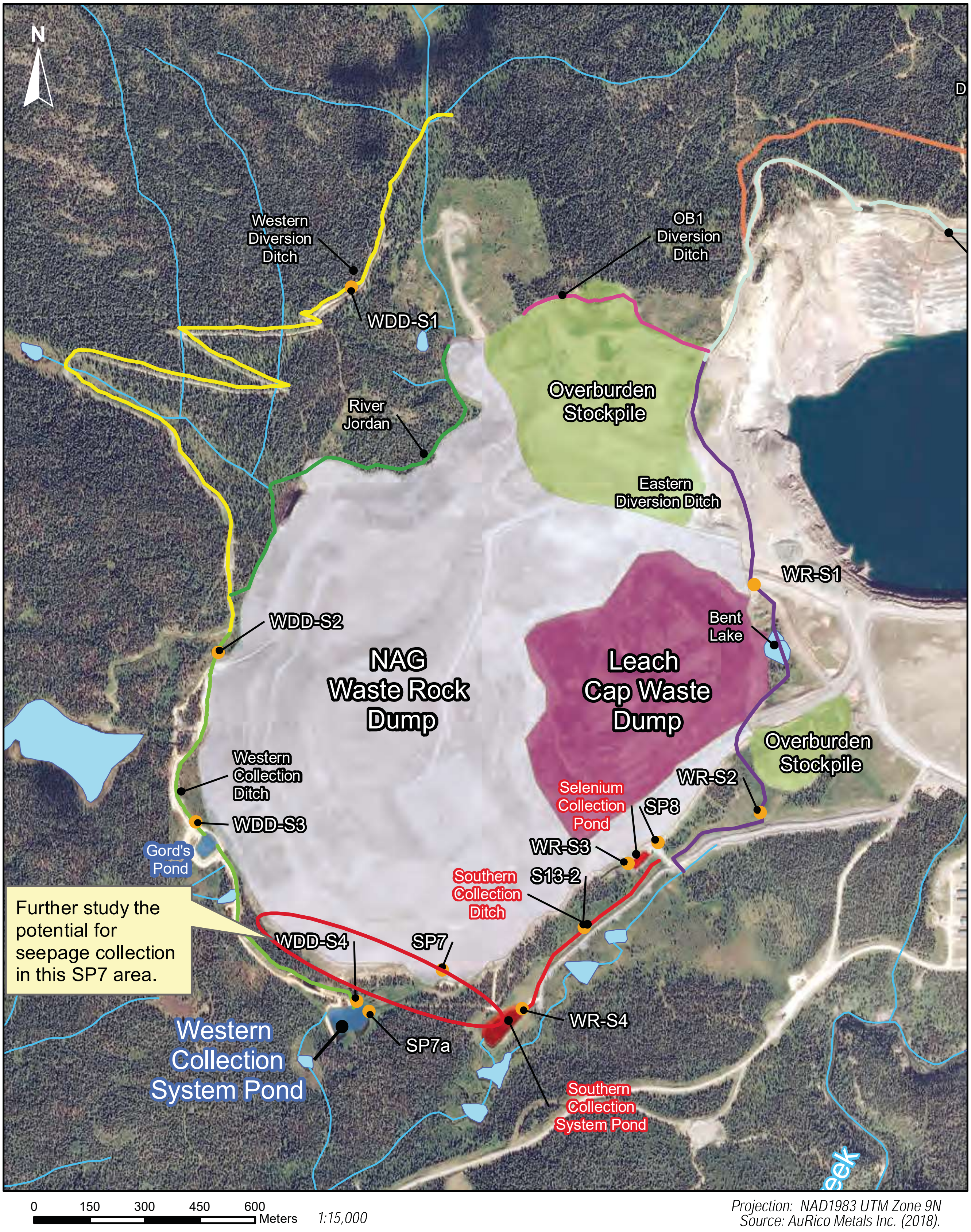
ERM




| | | | |
|---|---|---|---|
| (blue arrow) | Unloaded Flow | SCSP | Southern Collection System Pond |
| (orange arrow) | Loaded Flow | TSF | Tailings Storage Facility |
| HWDD | High Wall Diversion Ditch | WCSP | Western Collection System Pond |
| KUG | Kemess Underground | WDD | Western Diversion Ditch |
| NAG | Not Acid Generating | WRD | Waste Rock Dump |
| SeCP | Selenium Collection Pond | | |

**Figure 4.2-3**

**Seep Monitoring Locations at the Kemess South Non-Acid Generating Waste Rock Dump Area**



- The HWDD will divert runoff to Waste Rock Creek via the EDD and the Waste Rock Creek wetlands, as per the Selenium Management Plan. The diversion is currently split into two sections due to a highwall slump in the north west corner of the KUG TSF. The western portion continues to function passively while the eastern portion drains into a sump which is then pumped to operating western portion and ultimately reports to Waste Rock Creek from May-Sept. Runoff from the downslope catchment of this diversion ditch drains into the KUG TSF. During Construction, the western portion of the HWDD will be rebuilt farther upslope from existing eastern portion of the HWDD and the KUG TSF, and will be extended further east. Water will be diverted passively to Waste Rock Creek from the expansion, while the original eastern portion will continue to drain to the sump and be pumped to the western portion.
- The SCSP will serve as a collection pond for water from seep S13-2. From there, water will be pumped to the SeCP, water treatment plant or to the KUG TSF.
- Water collected in the SeCP is pumped into the KUG TSF. A seepage capture system is planned to capture seepage from seeps SP7 and S13-2 and direct it into the SeCP, with completion scheduled for late 2019. Pumping from the SeCP into the KUG TSF will continue during the Construction, Operations and Closure phases of the Project. Based on the updated GoldSim modeling of Waste Rock Creek (ERM 2018), it is expected that pump rates in Table 4.2-3 are sufficient to manage the SeCP through Closure. A pump system capacity of 65 L/s will be used to transfer the SeCP water to the KUG TSF.
- Water collected in the WCSP passively overflow into Waste Rock Creek. The SCSP is planned to be used as a collection pond to capture seeps SP7 and S13-2.

**Table 4.2-3. Average Pump Rates from NAG WRD (L/s)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pump rates used in the model[1] | 7 | 6 | 5 | 4 | 60 | 45 | 30 | 28 | 27 | 24 | 13 | 9 |

*[1] Based on modeled inflows to SeCP (ERM 2018)*

### 4.2.4 Kemess Lake Valley

The Kemess Lake Valley (KLV) water management system separates contact water requiring treatment, including groundwater inflows from the Access Tunnel and dewatering of the underground mine (see Section 4.3.1 and 4.3.2 of this plan), from non-contact runoff and contact runoff requiring only TSS removal. Water management facilities will be established in the KLV area as follows (see Sections 3.1.2.3 and 3.6.13.2.8 in Chapter 3 of the Joint MA/EMA Application):

- Temporary water handling facilities to handle contact water requiring treatment and provide water for triple decline development;
- KUG mine dewatering: KUG dewatering pipeline, KLV transfer pond and KLV dewatering pumphouse; transferring KUG mine water to the KUG TSF;
- KLV non-contact water diversion ditches;
- KLV contact water collection ditches; and

- KLV contact water collection ponds comprising the KLV transfer pond (for water requiring pumping to the KUG TSF and subsequent treatment) and KLV sedimentation pond (for water requiring settling prior to discharge to El Condor Creek).

In addition to the groundwater flows (Section 4.3.1 of this plan), surface runoff from a 2.5 ha catchment will flow into the Transfer Pond.

#### 4.2.5 Process Water

Process water, estimated at 16.5 $Mm^3$/year, will be sourced from the KUG TSF.

#### 4.2.6 KS TSF

The KUG Project does not include any changes to the existing KS TSF components or affect their operations.

### 4.3 GROUNDWATER MANAGEMENT

#### 4.3.1 Access Tunnel

The access tunnel is approximately 865 m long and connects the access road from the KS area to the KLV area (Figure 4.1-1; see Section 3.6.13.1.6 in Chapter 3 of the Joint MA/EMA Application for details). This access tunnel will have minimum dimensions of 5.5 m wide by 6.3 m high to allow movement of all required personnel, equipment and materials/consumables through the tunnel. Construction of the tunnel is expected to start in Year -4 and break through into the KLV area in Year -3.

Inflow rates to the access tunnel have been estimated using an analytical solution developed by Lei (1999) based on hydraulic conductivity results from packer tests conducted along the tunnel route by AMEC. At full buildout, the tunnel is expected to produce a steady state flow rate of 2 L/s.

#### 4.3.2 Underground Mine

The dewatering system design for Kemess underground was carried out by Tetra Tech (2012). The following provides a summary of the salient components of that report.

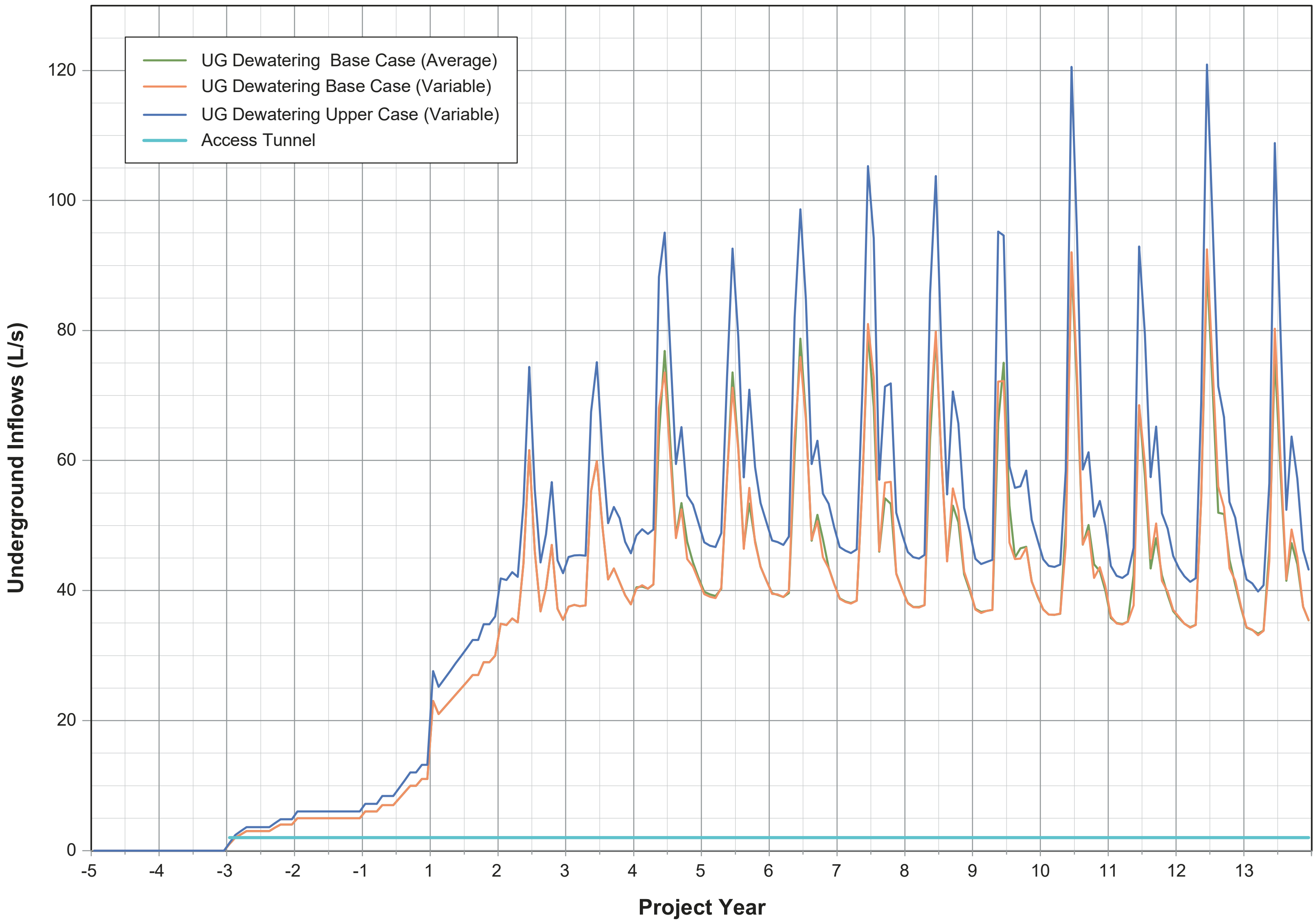
The dewatering facility will be located at the lowest elevation of the underground mine, being the 1,082 mRL, which is the low point on the ventilation-drainage level; allowing gravity drainage to the two main sumps. Each sump comprises settling and clean water zones, with each clean water zone having at least two hours capacity.

Water inflow estimates have been developed using a numerical hydrogeological model, covering all stages of the mine life from initial decline development, through cave development, to cave breakthrough to surface (Figure 4.3-1; see also Appendix 2-H: Groundwater Model for the Kemess Underground Mine). Maximum inflow is estimated to occur when the cave zone is at its maximum extent. Peak monthly flow rates are anticipated to occur in June. The upper bound June flow rates are conservatively estimated at 120 L/s, while base case estimates predict average June flow rates on the order of 93 L/s.

**Figure 4.3-1**

**Groundwater Inflow Estimates for the Cave Zone throughout Construction and Operations**

ERM



Annual average underground inflow rates are estimated to range from 45 to 50 L/s for the base case model simulations and 55 to 63 L/s for the upper case. In addition, Tetra Tech (2012) estimated mining process water inflow (e.g. drill water, etc.) of 13 L/s.

Based on estimated inflows, two 574 kW pumps will be installed in the pump chamber. During peak inflow (120 L/s, upper case), one pump will need to run for 10 h followed by 2 h idle, removing 88 L/s against a 400 m head. During steady-state inflow (50 L/s base case), one pump will need to run for 1.7 h followed by 2 h idle, removing 92 L/s against a 411 m head. As such, one pump and one sump will always be on standby. For both situations, a 200 mm pipe is required for dewatering, delivering water to the dewatering transfer pond adjacent to the conveyor decline portal, with the pipe located in the conveyor decline. Settled water will then be transported to the KUG TSF via a 200 mm pipeline installed on the overland conveyor structure.

Lorax (Appendix 2-H) has also estimated inflow to the KUG workings of 1,230 L/s over 24 h for the 100-year storm event; being an extreme worst case. This number was derived from peak flow envelope curves where conservative peak flows may be predicted using drainage area as an input (Appendix 2-A). The data informing the peak flow envelope curves correspond to events occurring predominantly during the last week of May or within the month of June; and thus reflect peak rain on snow and snowmelt events. One pump running full-time will take just under 13 days to dewater the ventilation level. It may be possible to dewater using both pumps, reducing the dewatering period to less than eight days, although in-pipe water velocity increases to 4.1 m/s which is considered excessive. The ventilation-drainage level has a water storage capacity of ±89 ML, which with ongoing dewatering during a 100-year event is considered adequate to handle the total 106 ML inflow.

Total capacity for a single sump is approximately 4 h at a steady-state inflow rate of 50 L/s, providing initial storage in the event of a failure of the standby sump. Thereafter, the ventilation-drainage level would be used for water storage.

During initial decline development, estimated maximum water inflow is 5 to 6 L/s. As such, 9.6 kW face (diaphragm) pumps and 43 kW staged (centrifugal) pumps will be used for dewatering. The staged pumps will be located in redundant re-muck bays in the access decline.

At closure decline plugs will be installed approximately halfway along the triple decline with bulkheads constructed at the portal. Plugs have been widely used in mining operations with demonstrated success at withstanding large head differentials. Seepage, if observed at all, is anticipated through the wall rock and not through the plug itself. According to Lang (1999), for well-designed plugs in favorable ground conditions, seepage rates of less than 0.5 L/s are easily achievable measured 20 m downstream of the plug, with occasional drips measured at the plug itself. Therefore, the upper limit of seepage expected to bypass the triple decline plugs is 1.5 L/s.

#### 4.3.3 KUG TSF Seepage

The design of the KUG TSF calls for a final pond elevation of 1,270 metres above sea level (masl), the elevation of the spillway invert. Geologic information indicates that fill (sand and gravel) and glaciofluvial sand and gravel overburden is present along the western area of the south wall of the TSF with the overburden-bedrock contact close to or above the final pond elevation (Appendix 2-I:

Groundwater Model for the Tailings Storage Facility). The primary seepage pathway from the TSF is through the more permeable overburden; this is anticipated to occur if the pond elevation becomes high enough to saturate the overburden deposits.

To evaluate the potential implications of permeable flow paths from the KUG TSF, seepage estimates have been calculated along the south wall. The widely-used industry standard finite-element software FEFLOW model code v.6.2 by DHI-WASY was used to develop a two-dimensional (2-D), cross-sectional steady-state numerical model to estimate seepage losses and pathways of mine contact water through the south wall of the KUG TSF (Appendix 2-I).

Seepage estimates were determined for two discrete portions of the south wall: (1) the portion corresponding with bedrock surface elevations above the final pond elevation along cross-section A-A′; and (2) the portion corresponding with bedrock surface elevations below the final pond elevation along cross-section B-B′ (Figure 4.3-2). Cross-section A-A′ was developed to represent the average conditions of stratigraphy, hydraulic properties, and boundary conditions along a predicted flow path perpendicular to the south wall, while cross-section B-B′ was developed to account for potential higher rates of seepage through the more permeable overburden if the TSF pond elevation were high enough to saturate overburden deposits. Seepage simulations were conducted along cross-section B-B′ which intersects the lowest bedrock surface elevation along the south wall at DDSSD-11-01 (1,269.2 masl) (Figure 4.3-2). The overburden at this point is approximately 1 m below the final pond elevation of 1,270 masl, which results in a more conservative seepage estimate. The overburden at Section B-B was considered to be stratified glaciofluvial sand and gravel. Seepage simulations along cross-section B-B′ (Base Case B-B′) were applied to a wall length of approximately 300 m, which corresponds with the distance between BHSSD-11-01 and BHSSD-11-02, the closest drill holes east and west of DDSSD-11-01 (the lowest bedrock surface elevation along the south wall). The Base Case result for cross-section A-A′ was applied to the remainder of the south wall length of 1,450 m. The model domains for cross-sections A-A′ and B-B′ were discretized into five zones summarized in Table 4.3-1.

**Table 4.3-1. Seepage Model Zones**

| | Cross-Section A-A′ | | | Cross-Section B-B′ | | |
|---|---|---|---|---|---|---|
| | | Depth Below Overburden-Bedrock Contact | | | Depth Below Overburden-Bedrock Contact | |
| Layer | Thickness (m) | From (m) | To (m) | Thickness (m) | From (m) | To (m) |
| Tailings | 160 | - | - | 160 | - | - |
| Overburden | 10-25 | - | - | 10-25 | - | - |
| Fractured Bedrock | 24 | 0 | 24 | 80 | 0 | 80 |
| Moderately Fractured Bedrock | 110 | 24 | 134 | 80 | 80 | 160 |
| Competent Bedrock | varies | 134 | bottom | varies | 160 | bottom |

[1] *The thickness of competent bedrock varies along the cross-sections due to decreasing ground surface elevation from north to south.*

The seepage analysis of cross-section A-A′ (Base Case A-A′) indicated that the water table was located within the fractured bedrock downstream from the TSF. The water table rose into the overlying overburden further downstream, forming a seepage face approximately 160 m upgradient from Kemess Creek. Most seepage from the TSF flowed within the fractured and moderately fractured bedrock, which were characterized by the highest hydraulic conductivities.

The seepage analysis of cross-section B-B′ (Base Case indicated that the water table was located within the overburden at the south wall, dropping slightly to align with the overburden-bedrock contact, and then rising into the overburden zone, forming a seepage face approximately 50 m up gradient from Kemess Creek. Most seepage from the TSF flowed within the overburden and fractured bedrock, which were characterized by the highest hydraulic conductivities.

The model results for Base Case A-A′ and B-B′ are presented in Table 4.3-2 for various mine years and tailings and water level elevations in the KUG TSF. For operations (year 1 to approximately 7), total seepage rates through the KUG TSF south wall are estimated to be between 0.6 and 1.4 L/s. Later in operations, as water elevations rise in the TSF, seepage rates of approximately 3.5 L/s are anticipated. At closure, total seepage rates along the south TSF wall are estimated to be on the order of 5 L/s (Table 4.3-2).

The predicted seepage fluxes through the KUG TSF south wall are reasonably comparable to previously predicted seepage inflows into KS pit during operations, which simulated a pit dewatering scenario for a smaller section of wall and much larger hydraulic gradient. Seepage modelling of the KS pit in 2003, predicted seepage inflows of approximately 4.0 L/s along a 600 m wide section of the south (west) wall (Knight Piésold 2003). The predicted seepage inflow was considered to be in reasonable agreement with observed seepage inflows into the KS pit.

In the event that seepage rates are higher than anticipated or water quality in the TSF is poorer than predicted, several possible contingency measures to limit seepage through the south wall were also investigated. Recognizing that the majority of seepage is expected to occur within the overburden, the effect of installing a 5 m wide by 300 m long cutoff trench containing tailings and intersecting the overburden layer was modeled as a contingency in cross-section B-B′. Two scenarios within this contingency were considered using assumed hydraulic conductivities of the tailings material of 5.0E-07 and 5.0E-08 m/s. Only under lower hydraulic conductivity conditions did significant reduction (~25%) in seepage fluxes occur relative to the no mitigation scenario (Table 4.3-3). A second contingency was modeled that considered the development of a tailings beach in front of the south wall to prevent direct contact of TSF water with the south wall. For this contingency, the tailings beach was assumed to be 100 m wide and extending in front of the south wall in the vicinity of cross-section B-B′. Modeled seepage fluxes indicated a potential reduction in seepage rates on the order of 40% to 45% (Table 4.3-3). The need for implementation of these contingencies will be informed by results from the monitoring of the TSF water quality throughout operations (Section 6.1) as well as groundwater monitoring proposed for the TSF (Section 6.2).

Seepage analyses for the East Dam were conducted by AMEC (2012) and this work estimated a seepage rate of approximately 0.4 L/s through the East Dam and underlying bedrock (for a dam length of 720 m). Seepage below and through the dam will be collected in an existing pond (proposed East Dam seepage collection pond) at the downstream toe of the East Dam. The existing pond will be expanded to the south as required during dam raising as the toe of the East Dam begins to encroach. Seepage flows collected in the pond will be directed via existing ditch to Pumphouse #1 and associated pond (dump pond #1) where it will be pumped back to the KUG TSF.

**Figure 4.3-2**
**Bedrock Surface Elevations at KUG TSF**

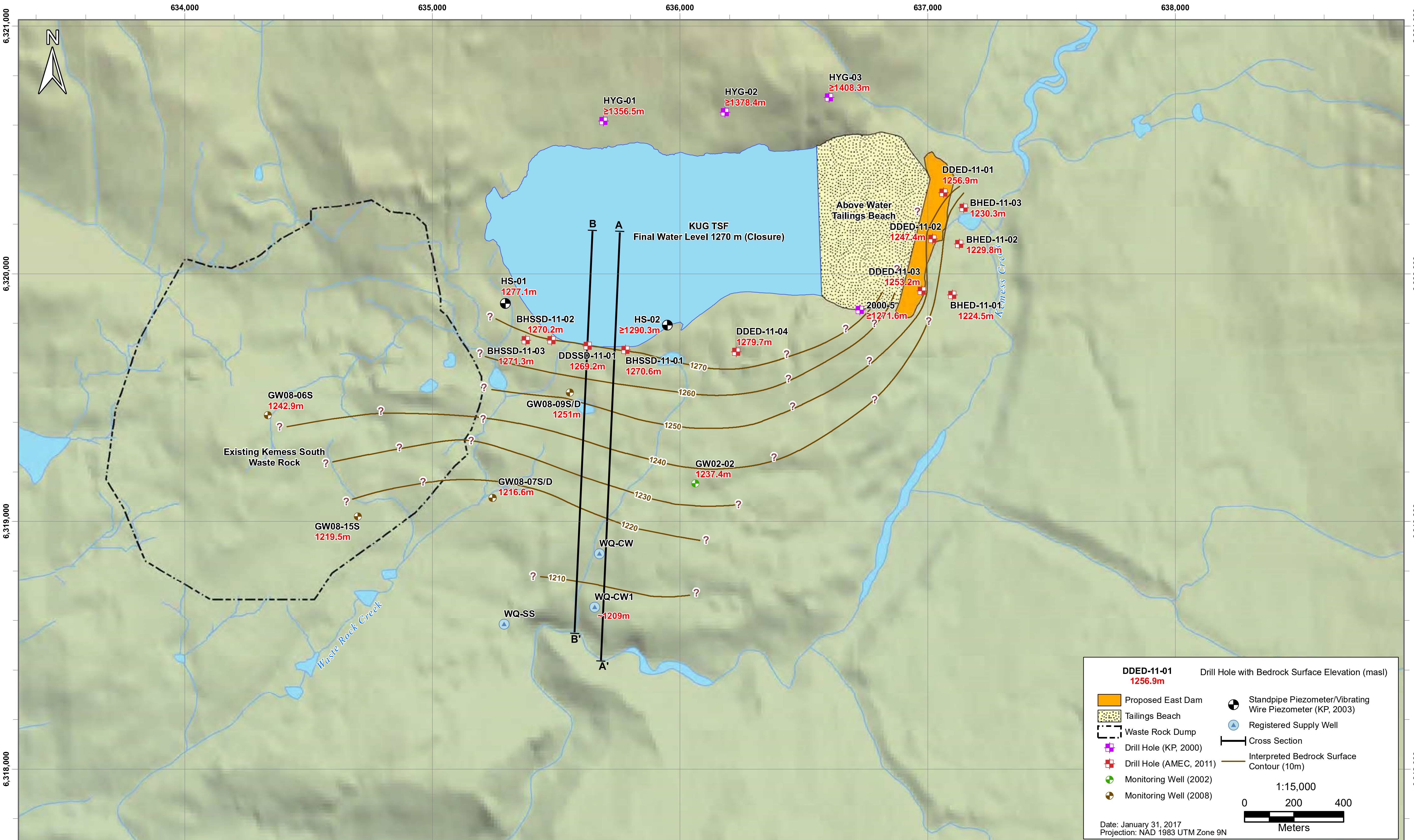


**Table 4.3-2. Seepage Estimates through the KUG TSF South Wall (Construction to End of Operations and Closure)**

| Scenario | Mine Year | TSF Solids Level (masl) | TSF Water Level (masl) | Hydraulic Conductivity (m/s) | | | | | Seepage Rate per Unit Width (L/s/m) | Wall Length (m) | Discrete Seepage Rate[2] (L/s) | Total Seepage Rate[3] (L/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Tailings | Overburden[1] | Fractured Bedrock | Moderately Fractured Bedrock | Competent Bedrock | | | | |
| Base Case A-A′ | -3 | 1,133.47 | 1,235.66 | 5.0E-07 | 1.0E-08 | 1.0E-07 | 5.0E-08 | 1.0E-08 | 2.2E-04 | 1,450 | 0.3 | 1.4 |
| Base Case B-B′ | -3 | 1,133.47 | 1,235.66 | 5.0E-07 | 1.0E-05 | 9.3E-08 | 5.9E-08 | 1.0E-08 | 3.6E-03 | 300 | 1.1 | |
| Base Case A-A′ | 1 | 1,164.88 | 1,208.72 | 5.0E-07 | 1.0E-08 | 1.0E-07 | 5.0E-08 | 1.0E-08 | 9.3E-05 | 1,450 | 0.1 | 0.6 |
| Base Case B-B′ | 1 | 1,164.88 | 1,208.72 | 5.0E-07 | 1.0E-05 | 9.3E-08 | 5.9E-08 | 1.0E-08 | 1.5E-03 | 300 | 0.5 | |
| Base Case A-A′ | 6.5 | 1,217.29 | 1,236.04 | 5.0E-07 | 1.0E-08 | 1.0E-07 | 5.0E-08 | 1.0E-08 | 2.2E-04 | 1,450 | 0.3 | 1.4 |
| Base Case B-B′ | 6.5 | 1,217.29 | 1,236.04 | 5.0E-07 | 1.0E-05 | 9.3E-08 | 5.9E-08 | 1.0E-08 | 3.7E-03 | 300 | 1.1 | |
| Base Case A-A′ | 13 | 1,267.54 | 1,268.48 | 5.0E-07 | 1.0E-08 | 1.0E-07 | 5.0E-08 | 1.0E-08 | 3.5E-04 | 1,450 | 0.5 | 3.5 |
| Base Case B-B′ | 13 | 1,267.54 | 1,268.48 | 5.0E-07 | 1.0E-05 | 9.3E-08 | 5.9E-08 | 1.0E-08 | 9.9E-03 | 300 | 3.0 | |
| Base Case A-A′ | Closure | 1,267.9 | 1,270 | 5.0E-07 | 1.0E-08 | 1.0E-07 | 5.0E-08 | 1.0E-08 | 3.8E-04 | 1,450 | 0.5 | 4.9 |
| Base Case B-B′ | Closure | 1,267.9 | 1,270 | 5.0E-07 | 1.0E-05 | 9.3E-08 | 5.9E-08 | 1.0E-08 | 1.5E-02 | 300 | 4.4 | |

*Notes:*

[1] *An anisotropy ratio of Kh/Kv = 2 was applied to the overburden material in Base Case B-B′; all other materials had anisotropy ratios of 1.*

[2] *The discrete seepage rate corresponding to cross-section A-A′ was estimated for a wall length of 1,450 m, while the discrete seepage rate corresponding to cross-section B-B′ was estimated for a wall length of 300 m.*

[3] *The total seepage rate estimate is the sum of the discrete seepage rates corresponding to cross-section A-A' (1,450 m wall length) and cross-section B-B' (300 m wall length).*

**Table 4.3-3. Seepage Estimates at Closure through the KUG TSF South Wall Employing Contingencies**

| Scenario | Mitigation | TSF Solids Level (masl) | TSF Water Level (masl) | Hydraulic Conductivity (m/s) Tailings | Overburden[1] | Fractured Bedrock | Moderately Fractured Bedrock | Competent Bedrock | Seepage Rate per Unit Width (L/s/m) | Wall Length (m) | Discrete Seepage Rate[2] (L/s) | Total Seepage Rate[3] (L/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Base Case A-A′ | *None* | *1,270* | *1,267.9* | *5.0E-07* | *1.0E-08* | *1.0E-07* | *5.0E-08* | *1.0E-08* | *3.8E-04* | *1,450* | *0.5* | - |
| Base Case B-B′ | *None* | *1,270* | *1,267.9* | *5.0E-07* | *1.0E-05* | *9.3E-08* | *5.9E-08* | *1.0E-08* | *1.5E-02* | *300* | *4.4* | *4.9* |
| Base Case B-B′ | Cutoff Trench[4] | 1,270 | 1,267.9 | 5.0E-07 | 1.0E-05 | 9.3E-08 | 5.9E-08 | 1.0E-08 | 1.3E-02 | 300 | 4.0 | 4.6 |
| Base Case B-B′ | Cutoff Trench[5] | 1,270 | 1,267.9 | 5.0E-07 | 1.0E-05 | 9.3E-08 | 5.9E-08 | 1.0E-08 | 1.0E-02 | 300 | 3.0 | 3.6 |
| Base Case B-B′ | Spigot Tails along South Wall[6] | 1,270 | 1,267.9 | 5.0E-07 | 1.0E-05 | 9.3E-08 | 5.9E-08 | 1.0E-08 | 7.6E-03 | 300 | 2.3 | 2.8 |

*Note:*

[1] *An anisotropy ratio of Kh/Kv = 2 was applied to the overburden material in Base Case B-B′; all other materials had anisotropy ratios of 1.*

[2] *The discrete seepage rate corresponding to cross-section A-A′ was estimated for a wall length of 1,450 m, while the discrete seepage rate corresponding to cross-section B-B′ was estimated for a wall length of 300 m.*

[3] *The total seepage rate estimate is the sum of the discrete seepage rates corresponding to cross-section A-A' (1,450 m wall length) and cross-section B-B' (300 m wall length).*

[4] *Contingency assumes installation of a 5 m wide by 300 m long cutoff trench filled with tailings at an assumed hydraulic conductivity of 5.0E-07 m/s.*

[5] *Contingency assumes installation of a 5 m wide by 300 m long cutoff trench filled with compacted tailings at an assumed hydraulic conductivity of 5.0E-08 m/s.*

[6] *Contingency assumes depositing a tailings beach of 100 m width along the South Wall with an assumed hydraulic conductivity of the tailings of 5.0E-07 m/s.*

### 4.3.4 Potable Water Supply Wells

There are three existing potable water supply wells that have supplied KS operations in the past and continue to be operated today. These wells include WQ-CW, WQ-CW1 and WQ-SS (Table 4.3-4). A map showing locations of these wells is provided in Section 6.2 of this plan.

**Table 4.3-4. Summary of Water Supply Wells**

| | | UTM Coordinates (NAD 83) | | |
|---|---|---|---|---|
| Station ID | Well Tag Number[1] | Easting (m) | Northing (m) | Description |
| WQ-CW | 88098 | 635673 | 6318882 | Original camp well |
| WQ-CW1 | 88338 | 635638 | 6318662 | New camp well initiated in 2007 |
| WQ-SS | 88131 | 635281 | 6318576 | Security shack well |

[1] *Well record in the BC Wells Database (BC MOE 2014).*

WQ-CW, the original camp well, supplied a camp population exceeding 300 personnel through to the beginning of 2007. Flow rates from WQ-CW were observed to decline from ~14 US GPM to 8 US GPM over the period of March 2006 to February 2007. At times, water supply to the camp was supplemented by the security shack well (WQ-SS) at rates less than 5 US GPM. After observing declining production at WQ-CW, the mine commissioned the new camp well WQ-CW1.

WQ-CW1 currently supports the small site staff (approximately 6 people) for care and maintenance of the site. WQ-SS is also intermittently operated. From previous production history, WQ-CW1 is well positioned to meet future camp demands where populations are anticipated to be between 350 and 400 personnel.

## 4.4 Water Treatment

The KUG project water treatment plant (WTP) is designed to remove contaminants from impacted surface water streams. The feed water source and effluent destination vary by project phase as follows:

- During the Construction phase, feed water will be pumped from the SeCP, treated and discharged to the KUG TSF or to Attichika Creek.
- During the Operation and Closure phases, feed water will be either SeCP or KUG TSF water, pumped to the transfer pond and gravity fed to the WTP. Treated water will be pumped to Attichika Creek.

Predicted feed water compositions are based on historical data for the SeCP and KUG TSF predictions from ERM/Lorax water quality modelling (see Section 4.1.6 of permit application and ERM 2017) and are shown in Table 4.4-1. Effluent quality predictions are based on BQE experience in other water treatment plants, as well as lab and piloting work and project-specific effluent quality requirements from ERM. The effluent quality predictions are discussed in more detail in the *KUG WTP Design Report* (BQE 2017).

## Table 4.4-1. Construction and Operation Phase Feed Water Compositions and Effluent Quality Predictions

| Constituents | Selenium Collection Pond (Construction Phase) | | | KUG TSF (Operations Phase) | | | Effluent Quality Targets (mg/L) |
|---|---|---|---|---|---|---|---|
| | Mean (mg/L) | 95th Percentile (mg/L) | Maximum (mg/L) | Mean (mg/L) | 95th Percentile (mg/L) | Maximum (mg/L) | |
| Alkalinity[(a)] | 108 | 327 | 327 | 108 | 327 | 327 | Feed |
| Alkalinity[(b)] | 104 | 120 | 120 | 104 | 120 | 120 | Feed |
| TSS | 1.75 | 7.52 | 22.5 | - | - | 250 | <10 |
| Bromide | 0.00496 | 0.0989 | 0.661 | 5 | 8.75 | 10.3 | Feed |
| Chloride | 0.963 | 1.85 | 2.19 | 103 | 171 | 201 | <600 |
| Fluoride | 0.0993 | 0.121 | 0.215 | 4.82 | 8.49 | 9.97 | Feed |
| Ammonia | 0.006 | 0.0115 | 0.0256 | 1.3 | 1.75 | 1.89 | Feed + 0.4 mg/L[3]<br>Feed + 0.2 mg/L[4] |
| Nitrite | 0.000999 | 0.00392 | 0.00579 | 0.232 | 0.314 | 0.33 | Feed - 0.1 mg/L[3]<br>Feed - 0.03 mg/L[4] |
| Nitrate | 6.87 | 14.1 | 17.4 | 6.75 | 9.76 | 11.1 | Feed - 0.45 mg/L[3]<br>Feed - 0.15 mg/L[4] |
| Phosphate | 0.00179 | 0.00579 | 0.0137 | 0.122 | 0.15 | 0.15 | Feed |
| Sulphate | 142 | 162 | 180 | 1671 | 1755 | 1755 | Feed + 170 mg/L[3]<br>Feed + 40 mg/L[4] |
| Ag[2] | 2.48E-06 | 3.1E-06 | 3.85E-06 | 8.42E-05 | 0.000139 | 0.000163 | ≤0.0001 |
| Al[2] | 0.00817 | 0.0455 | 0.126 | 0.481 | 0.56 | 0.578 | ≤0.1 |
| As[2] | 0.000627 | 0.000738 | 0.000917 | 0.00776 | 0.0101 | 0.0114 | ≤0.005 |
| B | 0.013 | 0.0174 | 0.0213 | 0.325 | 0.54 | 0.637 | Feed |
| Ba | 0.0868 | 0.102 | 0.116 | 0.119 | 0.14 | 0.144 | Feed |
| Be | 4.96E-06 | 5.01E-06 | 9.53E-06 | 0.000279 | 0.000433 | 0.000509 | Feed |
| Bi | 2.48E-06 | 3.15E-06 | 6.79E-06 | 0.000314 | 0.000507 | 0.000601 | - |
| Ca | 70 | 84.6 | 93.6 | 664 | 749 | 766 | - |
| Cd[2] | 2.48E-06 | 1.04E-05 | 2.05E-05 | 0.002 | 0.00314 | 0.00365 | ≤0.001 |
| Co[2] | 4.66E-05 | 9.79E-05 | 0.000175 | 0.00492 | 0.00584 | 0.00619 | ≤0.04 |
| Cr[2] | 4.96E-05 | 0.000101 | 0.000215 | 0.00174 | 0.00267 | 0.00313 | ≤0.005 |
| Cu[2] | 0.00122 | 0.00192 | 0.00273 | 0.0364 | 0.0544 | 0.0631 | ≤0.006 |
| Fe[2] | 0.00668 | 0.047 | 0.21 | 0.45 | 0.656 | 0.721 | ≤0.35 |
| Hg | 4.58E-06 | 0.000005 | 5.17E-06 | 4.22E-05 | 6.19E-05 | 7.16E-05 | - |
| K | 0.58 | 0.694 | 0.774 | 129 | 224 | 264 | - |
| Li | 0.00306 | 0.00487 | 0.00653 | 0.0441 | 0.0706 | 0.0829 | - |
| Mg | 4.04 | 5.71 | 7.29 | 12.2 | 13.2 | 13.6 | - |
| Mn[2] | 0.00191 | 0.0134 | 0.0424 | 0.82 | 1.24 | 1.3 | ≤0.5 |
| Mo[2] | 0.00832 | 0.0109 | 0.0166 | 0.557 | 0.907 | 1.07 | ≤0.05 |
| Na | 71 | 80.5 | 88.9 | 615 | 1019 | 1199 | - |
| Ni[2] | 0.000091 | 0.000217 | 0.000365 | 0.0173 | 0.026 | 0.0306 | ≤0.025 |
| Pb[2] | 4.5E-06 | 3.62E-05 | 0.000135 | 0.00251 | 0.00355 | 0.00373 | ≤0.025 |

*(continued)*

**Table 4.4-1. Construction and Operation Phase Feed Water Compositions and Effluent Quality Predictions (completed)**

| Constituents | Selenium Collection Pond (Construction Phase) | | | KUG TSF (Operations Phase) | | | Effluent Quality Targets (mg/L) |
|---|---|---|---|---|---|---|---|
| | Mean (mg/L) | 95th Percentile (mg/L) | Maximum (mg/L) | Mean (mg/L) | 95th Percentile (mg/L) | Maximum (mg/L) | |
| Sb[2] | 0.000125 | 0.000172 | 0.00022 | 0.00858 | 0.0108 | 0.012 | ≤0.01 |
| Se[1,2] | 0.0626 | 0.0815 | 0.0975 | 0.0486 | 0.0748 | 0.0856 | ≤0.002 |
| Si | 3.69 | 4.25 | 5.33 | 20.4 | 29.6 | 34.5 | - |
| Sn | 9.43E-05 | 9.95E-05 | 0.000134 | 0.00653 | 0.0102 | 0.012 | - |
| Sr | 0.756 | 0.873 | 0.998 | 8.46 | 9.98 | 10.3 | - |
| Ti | 0.000248 | 0.00147 | 0.0029 | 0.011 | 0.0172 | 0.0202 | - |
| Tl | 9.92E-07 | 1.21E-06 | 1.66E-06 | 0.000277 | 0.000348 | 0.000403 | - |
| U | 0.000765 | 0.00127 | 0.0016 | 0.0116 | 0.0182 | 0.0214 | Feed |
| V | 0.000616 | 0.00104 | 0.00148 | 0.0118 | 0.0164 | 0.0174 | Feed |
| Zn[2] | 0.000218 | 0.00101 | 0.00486 | 0.089 | 0.13 | 0.147 | ≤0.033 |

*Notes*

[1] *Selenium is present in two forms: selenite and selenate. This figure is the total selenium.*

[2] *Denotes "targeted constituent"*

[3] *Estimate when only Selen-IX running (no dilution effect from metals removal).*

[4] *Estimate when both Selen-IX and metals removal circuits are running.*

[(a)] *Alkalinity of observed water quality of the tails fluids (2004-2007) (Personal Communication, AuRico Metals).*

[(b)] *Alkalinity of observed water quality of the KS TSF (2004-2007) (Personal Communication, AuRico Metals).*

### 4.4.1 Treatment Process

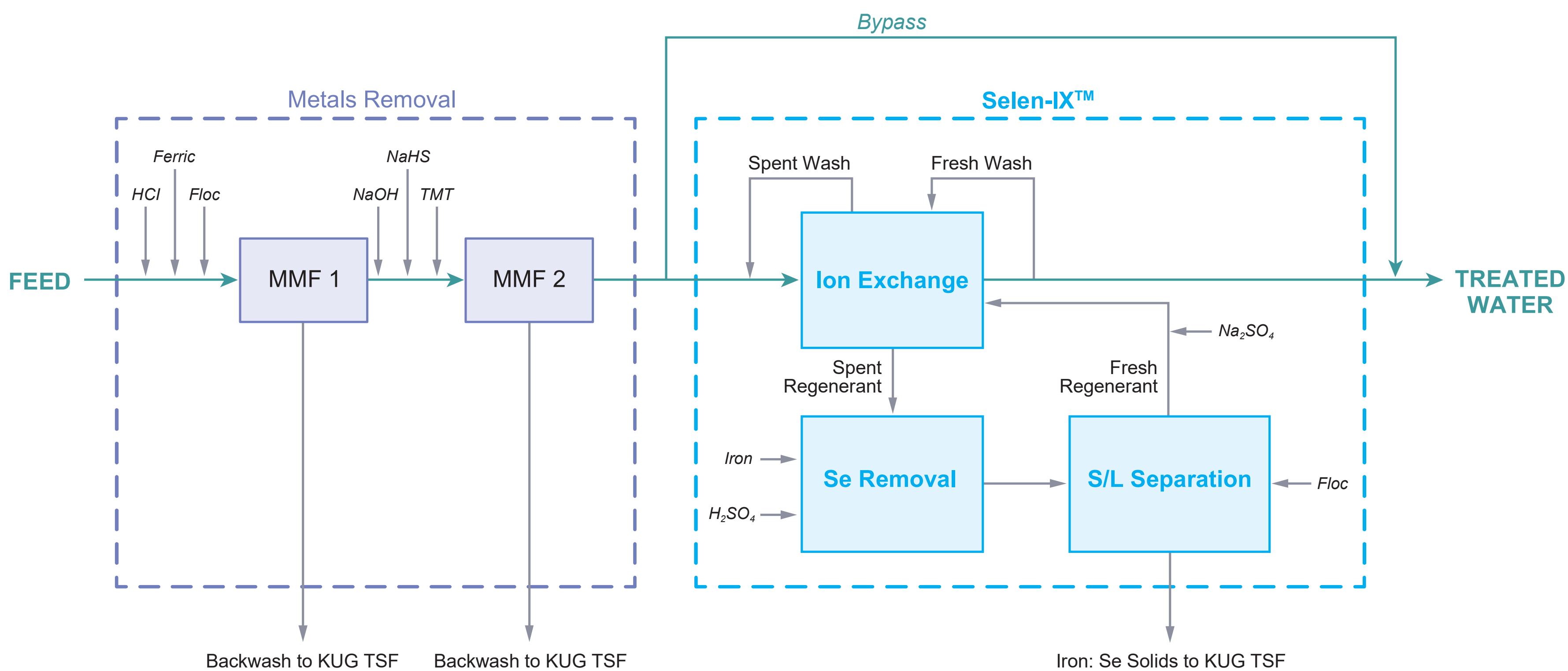
The water treatment process comprises two distinct systems and is shown in Figure 4.4-1:

- A metals precipitation and filtration system (MR Treatment Plant) to treat all of the constituents denoted as "targeted constituent" in Table 4.4-1 except selenate selenium
- BQE's Selen-IX™ selenium ion exchange system to treat the selenate selenium (Selen-IX™ Treatment Plant)

Metals Removal Treatment

The metals removal treatment process involves two stages of reagent addition and multimedia filtration to precipitate the metals out of solution. The first stage involves pH-controlled ferric co-precipitation, followed by a second stage involving pH-controlled sulphide precipitation. The multimedia filters are periodically backwashed, which removes the precipitates from the filters. The backwash reports back to the KUG TSF and solids contained in the backwash will co-deposit with tailings at the bottom of the TSF.

## Figure 4.4-1
## Water Treatment Plant Block Flow Schematic



Subsequent GoldSIM modelling after initial design of the water treatment plant has predicted higher concentrations of manganese than the previous model results. If these higher predicted levels (i.e., greater than 0.5 mg/L) eventuate, manganese removal during Operations will be required. BQE (2018) considered different manganese removal options and recommended that the following changes be incorporated into the existing water treatment plant design to enhance the manganese removal capability if required:

- Installation of one additional metering pump and injection port to allow for ferric iron addition downstream of all of the other reagent injection ports but still upstream of the second metal removal stage filters; and
- Installation of one additional chemical dosing system and injection point for liquid addition upstream of the feed HCL injection point.

If manganese concentrations of higher than 0.5 mg/L are observed in the KUG TSF water, ferric iron and/or strong oxidant will be injected at these points.

Selen-IX™ Treatment

The next stage of treatment is Selen-IX™, which selectively removes selenium to below 2 µg/L prior to discharge into the environment. The overall process comprises two main parts including ion exchange and electrochemical reduction and precipitation of selenium. Both of these process parts are purely physico-chemical and insensitive to water temperature. The first stage of the system uses a strong base anion exchange resin in the sulphate form to selectively remove selenium from water. Once the resin is saturated with selenium, the resin is regenerated using sodium sulphate brine solution. During regeneration, selenium loaded on the resin is stripped off the resin into a small volume of the sodium sulphate brine containing selenium at the concentration of at least one order of magnitude higher than the incoming plant feed.

The selenium-rich brine then enters the second part of the process where selenium is reduced and concurrently precipitated with iron released from iron anodes inside electrocells. The iron:selenium solids are then separated from the brine solution in a clarifier. The clarifier overflow is recycled back to the ion exchange regeneration stage while the underflow solids are dewatered in a conventional plate and frame filter press. The dewatered iron-selenium solids will be stockpiled prior to process plant operation and then blended with the tailings during process plant operation for deposition in the KUG TSF.

The WTP process and design criteria is described in detail in the *KUG WTP Design Report* (BQE 2017).

### 4.4.2 WTP Flow Rates

Table 4.4-2 shows the design and operating flow rates of the WTP during various operational phases. The operating flow rates were determined by the water quality model (ERM 2017). During years -3 to -1 of the Construction Phase, the selenium removal plant will operate year-round. During the Operations Phase, both the selenium and metals removal circuits will operate seasonally, during May through October only.

**Table 4.4-2. WTP Flow Rates**

| Process Circuit | Design Flow Rate (L/s) | Operating Flow Rate (L/s) | | |
|---|---|---|---|---|
| | | Construction Phase | Operations Phase | Closure |
| Metals Removal | 187 | 0 | 170 | 170 |
| Selenium Removal | 75 | 4-65 | 65 | 65 |

## 4.5 SAFE DISCHARGE

### 4.5.1 KUG Discharge into Attichika Creek

With development of the KUG Project, starting in Year -3, water in the KUG TSF will be discharged to Attichika Creek, to create sufficient capacity for the life of mine tailings production and waste rock storage. A water discharge system (WDS), consisting of a barge with on-board pumps (to be a refurbished and repurposed barge used in the KS mine operation) and a network of pipelines, will supply water from the KUG TSF to the following destinations:

- the process water pond which, in turn, supplies the process plant;
- the water treatment plant (WTP), where the KUG TSF water will be treated for removal of selenium and dissolved metals and then sent via pipeline to a diffuser in Attichika Creek; and
- directly to Attichika Creek via a diffuser to disperse the flow into the creek.

The plan and drawings of the WDS as well as key components of the system are provided in Section 3.6.13 of the Joint MA/EMA Application (Figures 3.6-58 to 3.6-66). A summary of planned discharge rates is provided in Table 4.5-1. Effluent discharge is planned from the KUG TSF to Attichika Creek during the months of May through October through the Construction and Operations phases. The discharge pattern is grouped into two distinct periods of the Project:

- Construction phase plus Year 1 of Operations: during this period the discharge to Attichika Creek is primarily intended to remove existing, unneeded water from the KS Open Pit so it can be used as the KUG TSF. Planned discharge rates (Table 4.5-1) are based on a variable monthly pattern that follows the natural intra-year variation of flow in Attichika Creek; and
- Operations and Closure phases, Years 2 to 19: up to 187 L/s of water from the KUG TSF will be discharged to Attichika Creek during May to October (Table 4.5-1).

Water from the KUG TSF is discharged to Attichika Creek through a diffuser. Design criteria and drawings for the discharge system, including the pipes, pumps, and diffuser, are provided in Section 3.6 of the Joint MA/EMA Application.

**Table 4.5-1. Planned Discharge Rates from KUG TSF into Attichika Creek**

| Project Phase | Project Year | Annual Discharge Volume (Mm³) | Treatment of the KUG TSF Discharge | | Monthly Discharge Rate (L/s) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Se-IXTM | Metals Removal (MR) | Jan - Apr | May | Jun | Jul | Aug | Sep | Oct | Nov - Dec |
| Construction | -4 | 0 | n/a | n/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | -3 | 10.4 | No[1] | No | 0 | 560 | 950 | 881 | 541 | 503 | 492 | 0 |
| | -2 | 10.4 | No[1] | No | 0 | 560 | 950 | 881 | 541 | 503 | 492 | 0 |
| | -1 | 10.4 | No[1] | No | 0 | 560 | 950 | 881 | 541 | 503 | 492 | 0 |
| Operations | 1 | 10.4 | Partial[2] | Partial[3] | 0 | 560 | 950 | 881 | 541 | 503 | 492 | 0 |
| | 2 to 13 | 2.4 | Partial[2] | Yes[4] | 0 | 134 | 170 | 170 | 153 | 145 | 146 | 0 |
| Closure | 14 to 19 | 2.4 | Partial[2,5] | Yes[4] | 0 | 134 | 170 | 170 | 153 | 145 | 146 | 0 |
| Post-Closure | 20+ | 0 | n/a | n/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Notes:*

[1] *Water pumped from the Selenium Pond to the KUG TSF passes through the Se-IX™ treatment.*

[2] *Up to 65 L/s of the KUG TSF discharge will be treated for Se; any discharge in excess of 65 L/s will bypass the Se-IX™ treatment.*

[3] *Up to 170 L/s of the KUG TSF discharge will be treated for metals removal; any discharge in excess of 170 L/s will bypass the metals removal treatment.*

[4] *The metals removal treatment plant has sufficient capacity to treat the planned KUG TSF discharge (i.e., 170 L/s).*

[5] *Water pumped from the Selenium Pond to the KUG TSF passes through the Se-IX™ treatment starting in Year 15.*

Volume and concentration of discharge into Attichika Creek will be in compliance with conditions of the amended effluent discharge permit PE-15335. At the time of writing, it is assumed that the conditions of such a permit will be based on discharge limit calculations to avoid acute toxicity to aquatic organisms at the point of discharge and chronic toxicity beyond the edge of the Initial Dilution Zone (IDZ; 200 m downstream of effluent discharge; ERM 2018). Minimum dilution ratios required to meet the receiving environment benchmarks at the end of IDZ were calculated (ERM 2018) based on Equation 1 and Tables 4.5-2 and 4.5-3. These minimum required dilution ratios are summarized in Tables 4.5-4 and 4.5-5.

$$\frac{F_B}{F_E} = \frac{C_E - C_{GL}}{C_{GL} - C_B} \quad \text{[Equation 1]}$$

where:

$F_B$ = portion of Attichika Creek streamflow that mixes with effluent at the end of the IDZ (L/s). This mixing flow is 70% of total Attichika Creek flow (ERM 2017)

$F_E$ = effluent discharge rate (L/s)

$C_E$ = concentration of the parameter in effluent (mg/L)

$C_{GL}$ = receiving environment WQG-AL for the parameter (mg/L; from Table 4.5-2)

$C_B$ = background concentration: median baseline concentrations (Table 4.5-3) are used as priori, and updated based on weekly sampling results (mg/L)

The minimum required dilution ratios (Tables 4.5-4 and 4.5-5) and 90% exceeded $F_B$ (Table 4.5-6) were used in Equation 1. Results, i.e., possible discharge rates based on 90% exceeded flows, are summarized in Table 4.5-7, and described here. In addition to meeting the minimum required dilution ratio, discharge rates presented in Table 4.5-7 would remain within 10% of background streamflow in Attichika Creek (Table 4.5-6).

**Table 4.5-2. Receiving Environment Benchmarks Used in the Derivation of Discharge Limits**

| Parameter | Receiving Environment Benchmark (mg/L) |
|---|---|
| Fluoride | 0.791 |
| Nitrite | 0.02 |
| Sulphate | 128 or 218 |
| Dissolved aluminum | 0.05 |
| Dissolved cadmium | 0.000078 to 0.00011 |
| Total chromium | 0.001 |
| Total copper | 0.002 |
| Total selenium | 0.002 |

*Notes:*
*Benchmarks for all parameters except fluoride are the BC MOE long-term average WQG-AL. For fluoride, the benchmark is the BC MOE short-term maximum WQG-AL. Temperature-, pH-, and hardness-dependent guidelines were calculated based on monthly background conditions at WQ-17.*

### Table 4.5-3. Baseline Parameter Concentrations in Attichika Creek at WQ-17

| Parameter | May | June | July | August | September | October |
|---|---|---|---|---|---|---|
| Fluoride | 0.037 | 0.039 | 0.040 | 0.042 | 0.048 | 0.045 |
| Nitrite | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Sulphate | 6.2 | 6.8 | 7.3 | 9.0 | 14 | 8.1 |
| Dissolved aluminum | 0.037 | 0.012 | 0.011 | 0.008 | 0.008 | 0.018 |
| Dissolved cadmium | 0.0000053 | 0.0000025 | 0.0000038 | 0.0000025 | 0.0000025 | 0.0000025 |
| Total chromium | 0.00025 | 0.00010 | 0.00012 | 0.00008 | 0.00010 | 0.00010 |
| Total copper | 0.0015 | 0.00084 | 0.00082 | 0.00073 | 0.00069 | 0.00076 |
| Total selenium | 0.00016 | 0.00017 | 0.00015 | 0.00015 | 0.00016 | 0.00016 |

*Notes:*
*All concentrations are in mg/L.*
*Baseline data for all parameters except fluoride was from site WQ-17. Baseline data for fluoride was the model baseline data from the node IDZ 200 m.*

### Table 4.5-4. Effluent Discharge Limits for the Construction Phase and Year 1 of the Operations Phase

<table>
<tr><th rowspan="2">Month</th><th rowspan="2">Maximum Discharge Rate for All Months (L/s)</th><th rowspan="2">Minimum Required Dilution Ratio by Month [a]</th><th>Effluent Quality Discharge Limits by Month (mg/L)</th><th colspan="6">Effluent Quality Discharge Limits for All Months (mg/L, dissolved)</th></tr>
<tr><th>$SO_4$</th><th>$NO_2$</th><th>Al</th><th>Cd</th><th>Cr</th><th>Cu</th><th>Se</th></tr>
<tr><td>May</td><td rowspan="6">950</td><td>12</td><td>2,760</td><td rowspan="6">0.12</td><td rowspan="6">0.30</td><td rowspan="6">0.0006</td><td rowspan="6">0.007</td><td rowspan="6">0.010</td><td rowspan="6">0.014</td></tr>
<tr><td>June</td><td>7</td><td>931</td></tr>
<tr><td>July</td><td>7</td><td>929</td></tr>
<tr><td>August</td><td>7</td><td>1,604</td></tr>
<tr><td>September</td><td>7</td><td>1,573</td></tr>
<tr><td>October</td><td>7</td><td>1,610</td></tr>
<tr><th>Month</th><th>Maximum Short-term Discharge Rate (L/s)</th><th>Minimum Required Dilution Ratio by Month [a]</th><th>Proposed Effluent Quality Discharge Limits by Month (mg/L)</th><th colspan="6">Proposed Effluent Quality Discharge Limits for All Months (mg/L, dissolved)</th></tr>
<tr><td>All months</td><td>1,000</td><td>As above</td><td>As above</td><td colspan="6">As above</td></tr>
</table>

*Notes:*
[a] *Minimum required dilution ratio = mixing portion of receiving environment stream flow : effluent discharge rate.*
*Abbreviations: $SO_4$ = sulphate, $NO_2$ = nitrite, Al = aluminum, Cd = cadmium, Cr = chromium, Cu = copper, Se = selenium.*

Using this approach, the lower (or higher) stream flows are, the lower (or higher) effluent discharge rates will be correspondingly such that the minimum dilution ratio is maintained. A frequency analysis on seven-day-averaged flows was conducted, and the 90% exceeded flow (i.e., the flow that will be exceeded 90% of the time during a long-term period) for $F_B$ is shown in Table 4.5-6.

## Table 4.5-5. Effluent Discharge Limits for the Operations Phase Years 2 to 13

| Month | Maximum Discharge Rate for All Months (L/s) | Minimum Required Dilution Ratio by Month[a] | Effluent Quality Discharge Limits by Month (mg/L) Se | Effluent Quality Discharge Limits for All Months (mg/L, dissolved) F | $SO_4$ | Al | Cd | Cr | Cu |
|---|---|---|---|---|---|---|---|---|---|
| May | 170 | 25 | 0.054 | 19 | 2,784 | 0.3 | 0.002 | 0.02 | 0.017 |
| June | | 22 | 0.045 | | | | | | |
| July | | 21 | 0.043 | | | | | | |
| August | | 21 | 0.043 | | | | | | |
| September | | 21 | 0.044 | | | | | | |
| October | | 22 | 0.044 | | | | | | |
| **Month** | **Maximum Short-term Discharge Rate (L/s)** | **Minimum Required Dilution Ratio by Month [a]** | **Proposed Effluent Quality Discharge Limits by Month (mg/L)** | **Proposed Effluent Quality Discharge Limits for All Months (mg/L, dissolved)** | | | | | |
| All months | 187 | As above | As above | As above | | | | | |

*Notes:*
*[a] Minimum required dilution ratio = mixing portion of receiving environment stream flow : effluent discharge rate.*
*Abbreviations: Se = selenium, F = fluoride, $SO_4$ = sulphate, Al = aluminum, Cd = cadmium, Cr = chromium, Cu = copper*

## Table 4.5-6. Frequency Analysis of Seven-Day-Averaged Flows in Attichika Creek

| Parameter | Parameter | May | June | July | August | September | October |
|---|---|---|---|---|---|---|---|
| $F_U$ | 50% exceedance | 14.50 | 28.80 | 14.87 | 6.77 | 6.36 | 6.06 |
| | 90% exceedance | 3.63 | 15.36 | 8.12 | 4.04 | 3.69 | 3.77 |
| $F_B$ | 50% exceedance | 10.22 | 20.31 | 10.49 | 4.78 | 4.49 | 4.27 |
| | 90% exceedance | 2.56 | 10.83 | 5.72 | 2.84 | 2.60 | 2.66 |

*Notes:*
*Seven-day-averaged flows are transposed (based on drainage area) from long-term daily streamflow time series available for Kemess Creek and Attichika Creek (WQ-01 and WQ-13; Lorax 2017a).*
*$F_U$ = Total Attichika Creek flow (seven-day-averaged) upstream of effluent discharge.*
*$F_B$ = Portion of Attichika Creek flow (seven-day-averaged) that mixes with effluent at the end of IDZ.*
*$F_B$ = 70% $F_U$ (ERM 2018).*
*50% exceedance: during a long-term period, seven-day-averaged flows are expected to exceed this value 50% of days.*
*90% exceedance: during a long-term period, seven-day-averaged flows are expected to exceed this value 90% of days.*

**Table 4.5-7. Discharge Rates Possible 90% of Time without Exceeding Water Quality Guidelines at the End of IDZ**

| Project Phase | Project Year | Annual Discharge Volume (Mm³) | Treatment of the KUG TSF Discharge | | Monthly Discharge Rate (L/s) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Se-IX™ | Metals Removal (MR) | Jan - Apr | May | Jun | Jul | Aug | Sep | Oct | Nov - Dec |
| Construction | -4 | 0 | n/a | n/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | -3 | 8.3 | No[1] | No | 0 | 226 | 950 | 812 | 404 | 369 | 377 | 0 |
| | -2 | 8.3 | No[1] | No | 0 | 226 | 950 | 812 | 404 | 369 | 377 | 0 |
| | -1 | 8.3 | No[1] | No | 0 | 226 | 950 | 812 | 404 | 369 | 377 | 0 |
| Operations | 1 | 8.3 | Partial[2] | Partial[3] | 0 | 226 | 950 | 812 | 404 | 369 | 377 | 0 |
| | 2 to 13 | 2.2 | Partial[2] | Yes[4] | 0 | 97 | 170 | 170 | 136 | 119 | 122 | 0 |
| Closure | 14 to 19 | 2.2 | Partial[2,5] | Yes[4] | 0 | 97 | 170 | 170 | 136 | 119 | 122 | 0 |
| Post-Closure | 20+ | 0 | n/a | n/a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Notes:*

*Possible discharge rates, based on minimum required dilution in Attichika Creek. Confidence level is 90%, i.e., 90% of the time streamflows in Attichika Creek allow for these possible discharge rates.*

[1] *Water pumped from the Selenium Pond to the KUG TSF passes through the Se-IX™ treatment.*

[2] *Up to 65 L/s of the KUG TSF discharge will be treated for Se; any discharge in excess of 60 L/s will bypass the Se-IX™ treatment.*

[3] *Up to 170 L/s of the KUG TSF discharge will be treated for metals removal; any discharge in excess of 170 L/s will bypass the metals removal treatment.*

[4] *The metals removal treatment plant has sufficient capacity to treat the KUG TSF discharge (i.e., 170 L/s).*

[5] *Water pumped from the Selenium Pond to the KUG TSF passes through the Se-IX™ treatment starting in Year 15.*

In practice, the flows will most likely be higher than the 90% exceeded flow. Therefore, it is expected that higher discharge rates can be used without exceeding the water quality guidelines or affecting water quantity. AuRico will monitor the background flow in Attichika Creek, and based on Equation 2, or similar dilution ratio conditions to be described in the permit PE-15335, can adjust the discharge volume.

### 4.5.2 Sewage Treatment Plant Discharge into KUG TSF

The Sewage Treatment Plant (STP) treats the waste water produced by the camp and discharges the treated water into the Mill Sediment Pond (MSP). Expected discharge rates from the STP are based on 230 L/person/day and are presented in Table 4.5-8. In addition, surface runoff from the Plant Site (45 ha), including runoff from stockpiles (10.9 ha), is collected in the MSP. The MSP water is pumped into the KUG TSF.

The STP discharge into the MSP and pumping the MSP water into the KUG TSF are assumed to end at Post-Closure.

**Table 4.5-8. Sewage Treatment Plant Annual Discharge Volume**

| Mine Year | STP Discharge $m^3$/year |
|---|---|
| -4 | 6,210 |
| -3 | 8,855 |
| -2 | 14,720 |
| -1 | 19,320 |
| 1 | 17,710 |
| 2 | 19,090 |
| 3 | 18,860 |
| 4 | 18,630 |
| 5 | 16,330 |
| 6 | 13,800 |
| 7 | 14,030 |
| 8 | 12,880 |
| 9 | 13,570 |
| 10 | 13,340 |
| 11 | 13,110 |
| 12 | 12,650 |
| 13 | 11,040 |
| 14 | 2,990 |
| 15 | 1,955 |
| 16 | 1,265 |
| 17 | 1,265 |
| 18 | 1,265 |
| 19 | 1,265 |
| 20+ | 0 |

*Reference: AuRico (2016), personal communication*

#### 4.5.3 Discharge to WRC

Water treatment and discharge to Attichika Creek will continue until water quality concentration in the KUG TSF is sufficient to allow direct discharge to Waste Rock Creek. This will require additional amendment to effluent discharge authorization that will result in discharge criteria being established for approximately 1 $Mm^3$/year of water at that time; eventual discharge from the KUG TSF to Waste Rock Creek at Post-Closure will be in accordance with the permit conditions.

Discharges to WRC from the NAG WRD and existing Kemess South water management network are described in Section 4.2.2 of this plan and in the Selenium Management Plan (AuRico 2018).

#### 4.5.4 Implications for Potable Water Wells

The groundwater model (Lorax 2017d) estimates travel times from the KUG TSF to Kemess Creek and potable supply wells as described in Section 4.3.4 of this plan. A monitoring program for these wells is provided in Section 6.2 of this plan.

# 5. ENVIRONMENTAL PROTECTION MEASURES AND CONTINGENCY

## 5.1 OVERVIEW OF MITIGATION MEASURES AND CONTINGENCIES

A series of environmental protection / mitigation measures are described in this section. These mitigation measures will address the EAC and Federal Decision Statement conditions, and comments received during the regulatory engagement meetings for Permitting. Further, available contingencies are provided for situations where water conditions (e.g., water level in the KUG TSF) are different from those predicted by the models.

The mitigation measures and contingencies pertinent to water management are summarized in Tables 5.1-1 and 5.1-2, and described in the following sections.

**Table 5.1-1. Water Management Mitigation Measures**

| Concern | Mitigation |
|---|---|
| **Surface Water** | |
| Alteration of drainage pathways | Underground panel cave mining removes the need for an open pit and associated diversions. Diversion ditches (i.e., HWDD and WDD) will be used. KS Open Pit will be used as the KUG TSF. Diversion structures will be decommissioned at Closure. |
| Freshwater withdrawal | Process water for the mill operation will be sourced from the KUG TSF to remove the requirement for makeup water from freshwater sources. |
| Mixing contact and non-contact water | Extension and improvement of the HWDD will divert more non-contact water around the KUG TSF.<br>At the KLV area, clean water and TSS-Laden water that only requires TSS removal are separated from contact water requiring treatment. |

*(continued)*

## Table 5.1-1. Water Management Mitigation Measures (continued)

| Concern | Mitigation |
|---|---|
| **Surface Water** *(cont'd)* | |
| Storage capacity of the KUG TSF | Water level in the KUG TSF will be monitored, and compared to predicted water levels. Significant differences can trigger re-evaluation of the water balance model (Section 8 of this plan). |
| Effects of extreme low flow conditions on the performance of the MSWMP | Discharge into Attichika Creek only occurs during the open water season to avoid under-ice discharge into Attichika Creek.<br>The KUG TSF has the capacity to contain 100-year-wet annual runoff without a need to change the planned discharge rates. During Construction and early Operations, the KUG TSF has the capacity to contain water for several years without the need to discharge. |
| **Groundwater** | |
| Reduction of baseflow in creeks draining the underground development | Plugs will be installed in each of the triple declines to maximize re-flooding of the mine and reduce baseflow reduction in post-closure |
| Closure flow from decline | Plugs will be located in area of favorable ground conditions to promote high performance. These locations will be informed by data collection during decline construction. Plugs will be designed with sufficient factor of safety to prevent possible failure. Bulkheads will be constructed at triple decline portal to limit seepage from the development to KLV. |
| Groundwater pathways to Amazay Lake | Position of plugs along the decline will be optimized according to predictions from the groundwater model and observations during decline development such that contact water flow paths will be forced to daylight in East Cirque Creek. |
| Seepage through the KUG TSF south wall | Monitor groundwater quality in the overburden and underlying fractured bedrock between the KUG TSF and downstream water supply wells and Kemess Creek to provide early detection of seepage from the KUG TSF. If warranted, contingency measures to reduce seepage from the TSF (see the Groundwater section of Table 5.1-2) or year-round treatment to reduce concentrations in the KUG TSF (see the Water Treatment section of Table 5.1-2) will be implemented. |
| Seepage through the East Dam | Seepage flows collected in the pond will be directed via existing ditch to Pumphouse #1 and associated pond (dump pond #1) where it will be pumped back to the KUG TSF. |
| **Water Treatment** | |
| Equipment failure prevents plant from operating | Installed spare feed/effluent pumps; Critical equipment spares will be warehoused; Qualified Professionals will operate the water treatment plant. |
| First industrial scale Selen-IX installation – commissioning may take longer than expected | Initial operation of Selen-IX will treat water from the selenium collection pond and discharge to TSF. Long commissioning time will not impact timing of water discharge to environment |

*(continued)*

### Table 5.1-1. Water Management Mitigation Measures (completed)

| Concern | Mitigation |
|---|---|
| **Safe Discharge** | |
| Alter baseline streamflow regime in Attichika Creek | Limit the discharge to the open water season, and follow the natural hydrograph when greater discharge volumes occur during Construction |
| Potential acute or chronic toxicity in the receiving environment | Establish discharge limits and receiving environment objectives that take into account the relevant guidelines, having ability to stage discharge to various flow conditions, and use of monitoring (effluent and receiving environment) to implement contingency measures as needed to remain within established limits. Water quality monitoring in the KUG TSF (Section 6.1-1 of this plan), Water Treatment Effluent (Section 6.1-3 of this plan), and receiving environment (Fish and Aquatic Effects Monitoring Plan) to be conducted to inform whether any contingency measures (Table 5.1-2) or adaptive management (Chapter 8 of this plan) is warranted. |
| Low flow conditions in Attichika Creek | If the streamflow in Attichika Creek is lower than average conditions, discharge to Attichika Creek will be reduced to meet achieve the minimum required dilution ratio. |

### Table 5.1-2. Water Management Contingencies

| Uncertainty or Concern | Contingency |
|---|---|
| **Surface Water** | |
| Blockage or functioning problem of non-contact water diversion ditches. | Diversions can be rebuilt before the next freshet as informed by routine inspection. |
| Higher than expected Se or other parameters in project discharges | Management measures specific to selenium loadings to the WRC from the NAG-WRD are addressed in the Selenium Management Plan (AuRico 2017). |
| Higher than expected Se or other parameters in KUG TSF | Se-IX treatment plant is insensitive to feed selenium concentration. Therefore, higher than expected selenium concentrations can be removed down to discharge targets for the portion of the KUG TSF discharge that receives Se-IX treatment.<br>The WTP (including Se-IX treatment) can be operated year-round with discharge back to the KUG TSF during winter to reduce the concentrations within the KUG TSF applicable to discharge as part of planned Operations phase by-pass of Se-IX treatment. |
| Exceeding effluent discharge limits (concentrations) | Contingency measures available to reduce KUG TSF discharge concentrations include: running the water treatment plants year-round with discharge back to the KUG TSF during winter; reducing or suspending discharge in order to achieve effluent discharge limits; increasing water treatment capacities; and ultimately shutting down operations in the underground mine to reduce dewatering and ore production. |
| **Groundwater** | |
| Higher than expected seepage from South Wall (if receiving environment water quality is exceeding objectives); | If receiving environment water quality exceeds objectives, available options include installation of a low permeability trench (using tails / other materials) intersecting high hydraulic conductivity overburden immediately south of the KUG TSF and/or construction of a tailings beach blinding the KUG TSF south wall to reduce downstream seepage. |
| Higher than expected flows into the underground development | Significant conservatism is currently assumed in the upper case groundwater inflow estimate. However, there remains additional capacity for storage in the TSF as well as the ability to increase treatment rates should periods of higher groundwater inflows be experienced. |

*(continued)*

## Table 5.1-2. Water Management Contingencies (continued)

| Uncertainty or Concern | Contingency |
|---|---|
| **Groundwater** *(cont'd)* | |
| Closure plug leakage/ failure | High pressure grouting of surrounding wall rock can reduce seepage bypass around the plug. |
| Longer than expected underground flooding time (and increased ARD) | If the development has not already captured the ephemeral creek flanking the cirque, then this creek can be diverted into the development to assist reflooding. |
| Higher than expected loads to East Cirque Creek in post-closure | Planned groundwater monitoring within the subsidence zone during filling/flooding will be used to determine if water quality is poorer than anticipated. Injection of lime slurry from injection wells could be used to neutralize and precipitate metals (most notably Cu and Zn). |
| Failure of groundwater dewatering pumps | Water will be stored in lower mine workings until pumping restored |
| **Water Treatment** | |
| Water balance under-predicts amount of water needing treatment | Plant design flow rate is 10% and 30% above maximum planned operating flow rate for metals removal and selenium removal respectively |
| Water model under-predicts contaminant concentrations in feed | Se-IX is insensitive to feed selenium concentration. Reagent dosages can be adjusted in metals removal plant and continue to meet treatment targets. Year round operation of the Se-IX and Metals Removal treatment with pump back to KUG TSF through winter; Adjustable reagent dosages in metals removal plant |
| Treatment plant is producing effluent not meeting targets | Recycle off-spec effluent back to KUG TSF |
| Mechanical shutdown of WTP | The feed and effluent pumps have installed spares; additional critical spare parts will be stored in on-site inventory. Storage capacity to contain water exists in the KUG TSF. In the event of a water treatment plant (WTP) shutdown during the Construction and Operations phases, the KUG TSF can contain water between 5 months up to 5 years under standard operating conditions without overflowing. During the Closure phase, the KUG TSF can contain water for less than 1 month up to 9 months under standard operating conditions without overflowing. In the event that the WTP is shutdown for a length of time that would cause the KUG TSF to overflow, contingency options include discharging at a lower rate that continues to meet water quality guidelines in the receiving environment, stopping pumping from the NAG WRD seepage capture system to reduce inflows to the KUG TSF, or allowing the KUG TSF to overflow to Waste Rock Creek. |
| **Safe Discharge** | |
| Higher than expected water level in KUG TSF (this could be the result of a suite of causes including, higher than expected precipitation, runoff, or groundwater inflow into the underground mine). | In the first half of Operations, the KUG TSF has sufficient capacity to contain several years of inflow without discharge into Attichika Creek. This window (i.e., from beginning of Construction until mid-Operation) is long enough to observe the water level in KUG TSF. If observed water levels are higher than predicted water levels, several contingency measures can be considered. These measures can include: a) potential for bypass of plant to be blended with plant discharge during high flows, if receiving environment flow and permit conditions allow; b) extend the discharge period to shoulder months (April and November) if receiving environment flow and permit conditions allow; c) increase the water treatment plant capacity; and d) shutting down the Operation and flooding the underground mine (as a last resort). |

*(continued)*

**Table 5.1-2. Water Management Contingencies (completed)**

| Uncertainty or Concern | Contingency |
|---|---|
| **Safe Discharge** *(cont'd)* | |
| Longer than expected water quality issues in KUG TSF (i.e., longer than expected closure period) | If the KUG TSF water quality at the end of Closure, does not meet the predicted estimates, the Closure phase treatment can continue (i.e., continue treatment of the KUG TSF discharge) until the water quality in KUG TSF has improved. Other Post-Closure options could be discharging to Attichika or Kemess Creek which have higher dilution capacity, or covering the tailings beach. |
| Unacceptable water quality in the KLV area at closure | If surface runoff in the KLV area is not acceptable for release into El Condor Creek at Closure, water transfer into the KUG TSF will continue until water quality is acceptable. |
| KUG TSF pump shutdown | Use KUG TSF for water storage until pump operation resumed. Redundant pumps. |
| Underground mine pump(s) failure | One of two installed pumps will provide sufficient capacity for regular operation. In extreme cases, water will be stored in lower mine workings (being ventilation level drifts). |

## 5.2 SURFACE WATER

Surface disturbance is the primary driver of impacts to surface water, and has the potential to alter streamflow magnitude and timing. The Project is unique in this regard, in that the existing infrastructure of the closed KS Mine allows the Project to be developed with a minimum of additional surface disturbance.

Many of the key mitigation strategies employed to minimize the impacts of the development are inherent in the Mine Plan. The two primary components of the Mine Plan and the resultant mitigation of potential impacts to surface water are listed below:

- Underground panel cave mining:
  - Removes the requirement for surface water diversion ditches around an open pit, and the alterations to watershed boundaries and flow regimes.
- Use of the pre-existing KS open pit as the KUG TSF for the Project.
  - This further reduces the potential impact on surface water quantity and timing by eliminating the need for a purpose built tailings impoundment, which often requires alterations to existing drainage systems.
- The diversion ditches (HWDD and WDD) are already in place, and flow alterations resulting from the KUG Project are expected to be minimal when compared to the current condition (i.e., HWDD will be extended and improved).
- Process water for the mill operation will be sourced from the KUG TSF to remove the requirement for makeup water from freshwater sources.

Actions will be taken to avoid, control or mitigate potential environmental effects of the Project. The MSWMP supports the application of the mitigation measures listed below and summarized in Table 5.1-1.

- Extension and improvement of the HWDD to divert non-contact runoff from a larger catchment area around the KUG TSF and into the Waste Rock Creek;
- Separation of clean water and TSS-laden water that only requires TSS removal from contact water requiring treatment;
- maintenance of existing KS sediment ponds and construction of new sediment ponds in the KLV area to reduce sediment loadings;
- store contact water in the KUG TSF, and reuse contact water for process water when possible;
- schedule and implement a monitoring program (see Section 6.2.1 of this plan) to confirm that water levels in the KUG TSF are consistent with predicted water levels; revisit the water balance model after five years; and revise the discharge patterns if warranted;
- discharge into Attichika Creek during the open water season to avoid icing effects on performance of the discharge system and to minimize the effects on winter flows;
- Maintaining capacity in the KUG TSF to contain 100-year-wet annual runoff without a need to change the planned discharge rates; and
- integrate diversion structures into the surrounding landscape at Closure.

Uncertainty associated with water management can cause surface water conditions different from those predicted by the water balance and water quality model (ERM 2017). Contingency measures for such conditions are summarized in Table 5.1-2.

## 5.3 GROUNDWATER

The Project is anticipated to affect groundwater quantity and quality in both the area of the underground development and the KUG TSF. A 3-D numerical groundwater model of the underground (Lorax 2017c) has been developed to assess:

- Dewatering rates for the mine during the construction and operational phases;
- Changes in baseflows to streams influenced by mine dewatering and reflooding;
- Flow paths and fluxes of mine contact water to the receiving environment during and following reflooding of the mine; and
- Reflooding of the mine.

As indicated in Table 5.1-1, the main groundwater mitigation associated with the underground development is the establishment of hydraulic plugs in the triple decline. These plugs will allow the development to reflood which will limit oxidation of the cave zone material, and thereby:

- Limit generation of acid rock drainage from the development;

- Limit impacts to baseflow in creeks surrounding the development; and
- Constrain contact water pathways from the development to the East Cirque drainage, thus preserving water quality in Amazay Lake.

As indicated in Table 5.2-2, there are several contingency measures in place should the groundwater system and/or mitigation measures not perform as anticipated. Related to underground dewatering rates, these contingencies include:

- Design of a pumping system with sufficient redundancy to handle conservative upper case dewatering rates; and
- Storage within the underground workings to accommodate inflows associated with exceptional events (i.e. 1:100 year storm event).

There are several groundwater contingencies related to closure of the mine, which include:

- Enhanced factor of safety to be used in decline plug design and construction to ensure long-term stability and imperviousness to seepage;
- Opportunity to optimize plug location and construction methods based on observations during decline development and validation of groundwater model through construction and operations;
- Bulkhead construction at triple decline portal to limit seepage from the development to the KLV;
- Assisted reflooding of the mine via diversion of ephemeral creek into the development (if it is not already captured) should reflooding rates be slower than predicted; and
- Potential injection of lime slurry into cave zone should groundwater quality in the development be poorer than anticipated.

A groundwater model has also been developed for the KUG TSF area in order to estimate seepage losses from the facility and travel times to receptors (Kemess Creek and potable supply wells). Actions will be taken to avoid, control or mitigate potential environmental effects of the Project. As summarized in Table 5.1-1, the groundwater monitoring plan supports the application of the mitigation measures as follows:

- Implementation of a groundwater and seepage monitoring program (Section 6.2 of this plan) to initiate monitoring in areas where pre-Construction conditions have not been characterized between the KUG TSF and downstream surface water and drinking water receptors;
- Assessment of groundwater flowpaths along the overburden-bedrock contact and in underlying bedrock to provide early detection of seepage from the KUG TSF before impacting surface water and drinking water receptors; and
- Validation and recalibration of the groundwater model as required.

Uncertainty associated with the characterization of the groundwater system may result in groundwater conditions different from those predicted by the KUG TSF groundwater model (Lorax 2017d). Contingency measures for such conditions are summarized in Table 5.1-2.

## 5.4 WATER TREATMENT

Concerns with plant availability are mitigated by incorporating installed spares for plant feed and effluent pumps. By doing so, if there is a pump failure of the primary pump, the spare pump can be brought online within minutes in order to minimize downtime. Other process pumps and process equipment/instrumentation will have either full replacements or repair kits stored in the KUG warehouse to facilitate quick replacement.

Another potential concern is that the KUG WTP will be the first full-scale implementation of the Selen-IX process. Although the process has been successfully piloted several times, and the scale up methodology for the associated process equipment is well understood, there is concern with any new process that commissioning time may take longer than anticipated. This risk is mitigated by operation during the Construction Phase of the project receiving water from the SeCP at substantially lower than the design capacity of the plant and discharging to the KUG TSF instead of to Attichika creek. This will allow an extended commissioning time without affecting environmental compliance.

Table 5.1-1 summarizes the above-noted mitigation measures related to water treatment.

A higher than expected water level in the KUG TSF could result from a suite of causes including higher than expected precipitation, runoff, or groundwater inflow into the underground mine. If the water level is higher than expected, then the WTP may be required to treat more flow than the 170 L/s and 65 L/s operating flow rates used in the site water balance for the Se-IX and MR plant, respectively. Plant design flow rates are 10% and 15% above maximum planned operating flow rate for metals removal and selenium removal respectively as a contingency for additional water requiring treatment.

Although the WTP design basis is conservative and used the 95$^{th}$ percentile predictions of feed contaminant concentrations, higher than expected contaminant concentrations can be tolerated by the WTP while still maintaining target effluent concentrations. Selen-IX in particular has been shown in previous piloting work to be insensitive to doubling of feed concentrations of selenium while maintaining effluent quality.

As a final contingency, if the WTP effluent is suspected to be off-spec, flow can be redirected to the KUG TSF via return pumps sized to handle the full design flow rate of the WTP.

Table 5.1-2 describes the above-noted contingencies related to water treatment.

## 5.5 SAFE DISCHARGE

Project design criteria to meet the end-of-pipe and receiving environment water quality objectives are the primary mitigation applied to all project discharges including the KUG TSF discharge into Attichika Creek through Closure, KUG TSF overflow (via spillway) to Waste Rock Creek at Post-Closure, KLV Sediment Pond discharge to El Condor at Closure, and contact water seepage into Kemess, Waste Rock, and East Cirque creeks. Discharge from the KUG TSF into Attichika Creek is the Project's primary discharge with potential water quantity and quality implications. Mitigation measures related to safe discharge are summarized in Table 5.1-1.

During Construction, when water quality parameters in the KUG TSF are acceptable, greater volumes of KUG TSF water can be discharged into Attichika Creek without exceeding the receiving environment water quality objectives (see Section 4.5.1 of this plan). Discharge is limited to the open water season May to October) and varies monthly to: 1) meet the minimum required dilution ratio described in Section 4.5.1 of this document, and 2) follow the natural hydrograph and negates potential effects on Attichika Creek streamflow rates. During wet, average, and even dry years, discharge rates can be greater than those presented in Table 4.5-7. Monitored streamflow in Attichika Creek, and concentration of parameters of interest in Attichika Creek and KUG TSF, can be used with Equation 1, to identify KUG TSF discharge rates into Attichika Creek without exceeding the discharge limits.

During Operations and Closure, water in the KUG TSF requires treatment prior to discharge to Attichika Creek. In order to minimize the potential effects on water quantity and quality in Attichika Creek, and fully utilize the water treatment plant, an average treatment and discharge rate of 170 L/s is planned, with a maximum authorized limit of 187 L/s. The aforementioned methodology will be used to inform necessary reduction in the discharge to meet the receiving environment objectives.

Water quantity and quality conditions can be different from those predicted by the water balance and water quality model (ERM 2017). Contingency measures for safe discharge under such conditions are summarized in Table 5.1-2.

## 5.6 TRIGGER ACTION RESPONSE PLAN

A proposed Trigger Action Response Plan (TARP) related to effluent discharge is presented here.

### 5.6.1 Triggers

Triggers under the TARP include numerical threshold levels below end-of-pipe permit discharge limits and/or receiving environment objectives that trigger specific responses in order to avoid non-compliance with permitted end-of-pipe discharge limits or exceedance of receiving environment objectives in Attichika Creek. These threshold levels are hereafter referred to as ‘Level 1 Triggers’ and ‘Level 2 Triggers’.

- **Level 1 Triggers:** Indicate an “alert” level. If a Level 1 Trigger is exceeded, this will result in further investigation into the cause of the threshold exceedance and increased monitoring. These investigations may indicate that the observed trend is temporary or caused by a known activity or may indicate the need to implement readily available contingencies, and initiate forward planning, including engineering design, for more complex contingency implementation.
- **Level 2 Triggers:** Indicate an “action” level, at which point contingencies will be implemented that are designed to reduce values below Level 1 triggers based on the results of the investigations completed in response to Level 1.

### 5.6.2 Trigger Criteria

Trigger criteria are summarized in Table 5.6-1 and Table 5.6-2 and are inclusive of all parameters with discharge limits as per the screening process outlined in Section 4.5.

**Table 5.6-1. Level 1 and Level 2 Trigger Thresholds, Construction and Year 1 of Operations**

| Parameter | Units | Level 1 Trigger | | Level 2 Trigger | | Proposed Discharge Limits (End of Pipe) | WQGs (IDZ-200m) |
|---|---|---|---|---|---|---|---|
| | | Effluent Quality | IDZ-200m[1] | Effluent Quality | IDZ-200m[1] | | |
| $SO_4$ | mg/L | 743 | 174 | 882 | 207 | Varies[2] | 218 |
| $NO_2$ | mg/L-N | 0.096 | 0.016 | 0.11 | 0.019 | 0.12 | 0.02 |
| Al | mg/L | 0.24 | 0.040 | 0.29 | 0.05 | 0.3 | 0.05 |
| Cd | mg/L | 0.00048 | 0.000090 | 0.00057 | 0.00012 | 0.0006 | 0.000106 – 0.000165 |
| Cr | mg/L | 0.0056 | 0.00080 | 0.0067 | 0.00095 | 0.007 | 0.001 |
| Cu | mg/L | 0.008 | 0.0017 | 0.0095 | 0.0020 | 0.010 | 0.002 – 0.00285 |
| Se | mg/L | - | - | 0.0139 | 0.0019 | 0.014 | 0.002 |

*Notes:*
*[1] For hardness-dependent guidelines, IDZ-200m trigger values were calculated based on average value of applicable water quality guideline during periods of discharge (May through October).*
*[2] Varies monthly: May = 2,760 mg/L, June = 931 mg/L, July = 929 mg/L, August = 1,604 mg/L, September = 1,573 mg/L, and October = 1,610 mg/L.*
*- = no trigger proposed*

**Table 5.6-2. Level 1 and Level 2 Trigger Thresholds, Years 2 through 13 of Operations**

| Parameter | Units | Level 1 Trigger | | Level 2 Trigger | | Proposed Discharge Limits (End of Pipe) | WQGs (IDZ-200m) |
|---|---|---|---|---|---|---|---|
| | | Effluent Quality | IDZ-200 m[1] | Effluent Quality | IDZ-200 m[1] | | |
| $SO_4$ | mg/L | 2,227 | 174 | 2,644 | 207 | 2,784 | 218 |
| F | mg/L | 15 | 0.83 | 18 | 0.99 | 19 | 0.959 – 1.2 |
| Al | mg/L | 0.24 | 0.04 | 0.29 | 0.05 | 0.3 | 0.05 |
| Cd | mg/L | 0.0016 | 0.00009 | 0.0019 | 0.00012 | 0.002 | 0.000106 – 0.000165 |
| Cr | mg/L | 0.016 | 0.0008 | 0.019 | 0.00095 | 0.02 | 0.001 |
| Cu | mg/L | 0.014 | 0.0017 | 0.016 | 0.0020 | 0.017 | 0.002 – 0.00285 |
| Se | mg/L | - | | 0.041 | 0.0019 | Varies[2] | 0.002 |

*[1] For hardness-dependent guidelines, IDZ-200m trigger values were calculated based on average value of applicable water quality guideline during periods of discharge (May through October).*
*[2] Varies monthly: May = 0.054 mg/L, June = 0.045 mg/L, July = 0.043 mg/L, August = 0.043 mg/L, September = 0.044 mg/L, and October = 0.044 mg/L.*
*- = no trigger proposed*

The trigger criteria are defined as follows:

- Level 1 triggers:
  - Observed effluent water quality is 80% of permitted discharge limit (end-of-pipe) for any parameter; or

  - Observed water quality at the end of the IDZ Attichika Creek (IDZ-200m) is 80% of applicable BC water quality guideline for the Protection of Aquatic Life for any parameter:
- Level 2 Triggers:
  - Observed effluent toxicity failure (less than 50% survival at 100% effluent concentrations) in *Daphnia* and/or Rainbow trout tests;
  - Observed effluent water quality is 95% of proposed end-of-pipe discharge limit for any parameter; or
  - Observed water quality at the end of the IDZ Attichika Creek (IDZ-200m) is within 95% of applicable BC water quality guideline for the Protection of Aquatic Life for any parameter.

Note, for selenium concentrations, a level 1 trigger has been proposed for the receiving environment (only at IDZ-200m). A level 1 trigger based on selenium end-of-pipe concentrations is not proposed as selenium does not have an associated short-term WQG and is only identified as requiring an end-of-pipe permit discharge limit as it is of special interest in effluent for the Project (i.e., selenium is not screened as COPC as per the process outlined in Section 5.3.7 of the MA/EMA Application). Currently the end-of-pipe discharge limit for selenium is considered protective of the receiving environment, given that it is back-calculated in order to achieve the BC Long-term average (i.e., "chronic") water quality guidelines during low-flow conditions. A level 2 trigger based on selenium end-of-pipe concentrations is proposed as presented in Tables 5.6-1 and 5.6-2.

#### 5.6.3 Trigger Response

If a Level 1 or Level 2 Trigger is exceeded, the Environmental Manager will be notified immediately. The Environmental Manager will then initiate appropriate actions for each trigger level. Management responses are described in this section.

<u>Level 1 Trigger Exceedance</u>

If any Level 1 Trigger is exceeded the following management actions will be initiated and/or implemented:

1. Additional confirmatory samples will be collected immediately;
2. Monitoring frequency at WQ-17 (upstream of the diffuser) and IDZ 200m (downstream of diffuser) will be increased from monthly to weekly (laboratory) and weekly to daily (field measurements) until level 1 trigger level is no longer exceeded;
3. Investigation into cause will be initiated immediately; and
4. Notify KUG Environmental Monitoring Committee (EMC) and keep them apprised of investigation and results.

If results obtained in 1 through 3, above, indicate that the exceedance was short-term and levels return to below Level 1 trigger thresholds then no further action is necessary. Monitoring frequency will return to normal following 2 weeks with readings below Level 1 Trigger values.

Records of each Level 1 Trigger exceedance will be kept and will be made available to regulators and First nations upon request.

Level 2 Trigger Exceedance

If any Level 2 Trigger is exceeded the following will be initiated and/or implemented, in order of escalation:

1. Management actions 1 through 4 required for a Level 1 Trigger exceedance;
2. Reducing or suspending discharge in order to achieve effluent discharge limits;
3. Review and update minimum dilution ratio requirements and discharge limits calculations, using available monitoring data, (as described in Section 4.5.1);
4. Review contingency measures identified in Section 5.1 against results from investigation into Trigger 1 exceedance to identify relevant contingency and commence preparations to implement further identified contingency(ies); and
5. Following implementation of any contingency(ies), continue with increased monitoring frequency until readings fall below Level 1 Trigger values.

Records of each Level 2 Trigger exceedance will be kept and will be made available to the EMC, regulators and First Nations upon request.

### 5.7 Emergency Preparedness and Response

The Mine Emergency Response Plan (AuRico 2017) and its associated procedures will recognize, and evaluate hazards to the environment, health and safety risks, surface infrastructure, and underground operations and infrastructure. This will evaluate risk levels and responses and actions to be taken if those levels are reached. This will trigger corrective, preventive, or mitigation actions. A team of key personnel will be identified to respond if triggers are met or exceeded. The team will ensure that the correct action is taken and that all affected groups are aware of any events.

# 6. MONITORING

The monitoring program to support this MSWMP includes:

- Surface water flows (Section 6.1.1);
- Water level and quality in the KUG TSF (Section 6.1.1 and Section 6.1.2).
- Receiving environment surface quality (Section 6.1.2);
- Groundwater levels and quality (Section 6.2); and
- Effluent volumes and quality (Sections 6.3 and 6.4).

Monitoring requirements for surface and groundwater quantity and quality are primarily driven by:

- EAC and Federal Decision Statement conditions;
- requirements of other management plans (e.g., Fish and Aquatic Effects Monitoring Plan);
- mitigation and contingency measures and adaptive management listed in this plan; and
- conditions of the effluent discharge permit and MMER.

All monitoring will comply with permit requirements.

## 6.1 SURFACE WATER MONITORING

This section describes the surface water quantity monitoring program, as well as surface water quality monitoring in the receiving environment. Water quality monitoring for the water treatment plant feed and effluent (i.e., end-of-pipe) is provided in Section 6.3 of this plan.

### 6.1.1 Surface Water Quantity

Water containment structures, pump houses, and pipelines associated with the Project will be routinely monitored to ensure that water management performance objectives are being met. Through regular inspections of water management features, maintenance issues can be identified and addressed. Diversion ditches will be inspected for snow/ice accumulation prior to freshet, and cleared if necessary to ensure proper functioning. Inspections of the diversion channels, sedimentation ponds, storage ponds, seepage ponds, and the diffuser in Attichika Creek will be conducted following extreme precipitation or runoff events. Visual observations of water management structures and systems can be incorporated into other relevant monitoring programs in accordance with permit conditions.

Currently the Project has 11 hydrometric monitoring stations (Figure 6.1-1). From these stations, five stations will be monitored during Construction, Operations, and Closure to confirm and verify the predicted effects, and implement mitigation measures (Table 6.1-1). These are: WQ-01 (Kemess Creek), WQ-13 (Attichika Creek), KEM-02 (Attycelley Creek), KEM-03 (East Cirque Creek), and KEM-07 (Central Cirque Creek). Monthly streamflow monitoring will be conducted at the KN-12 monitoring station in East Cirque Creek, and a similar station in Central Cirque Creek (CCC-1; see Figure 6.2-2) located downstream of the gossan area to monitor the local streamflow alterations predicted to occur as a result of underground development.

A hydrometric monitoring station in Attichika Creek downstream of the effluent discharge location (Table 6.1-1; ATT-IDZ) will replace and improve hydrometric data collection from WQ-01 and WQ-13. Further, a hydrometric station will be installed at the ORAR culvert to monitor flows in Waste Rock Creek (Table 6.1-1; WRC-1). In addition, the KUG TSF overflow into Waste Rock Creek will be monitored at Post-Closure (Table 6.1-1).

In addition to routine monitoring stations, East Cirque Creek and Central Cirque Creek will be subjected to longitudinal surveys of flow and in-situ parameters (T, EC, pH, +/-ORP, +/-DO) during the Construction period to identify zones of groundwater-surface water interaction along each watercourse. Streamflow measurements will be made using a combination of salt dilution and current meter methods. The longitudinal stream surveys will include a series of monitoring points along the full length of both Central and East Cirque Creeks. The monitoring points will be selected considering factors which may indicate gaining or losing reaches such as breakpoints in stream gradient, areas where the thickness or type of overburden changes and locations where any known faults or discontinuities that intersect the channels. Once in the field, these locations may be altered, or additional sites monitored as warranted based on observations (e.g., changes in conductivity, visual quality of water, noticeable changes in discharge volumes over short reaches, etc.). The surveys are proposed to be conducted during a low-flow period during the late-summer (mid-July to late-August), and again in the autumn (October), prior to development of a deep alpine snowpack. Ideally, a third longitudinal survey would be made in March of the following year to better define the recession limb of the baseflow component, but this will be subject to site access and safety considerations, both related to snowpack in the watersheds.

Monthly monitoring of water level in the KUG TSF will be used to: 1) verify water balance modelling predictions, and 2) implement the mitigation measure described in Section 5.4 of this plan to optimize the KUG TSF discharge into Attichika Creek.

### 6.1.2 Surface Water Quality

The surface water quality monitoring program is designed to be an extension of the Fish and Aquatic Effects Monitoring Plan (FAEMP), presented in Appendix 8-A. The MSWMP and FAEMP have been designed to be consistent with the requirements and objectives of an Environmental Effects Monitoring (EEM) program as required by the MMER as well as EAC and EA decisions conditions (see Section 2.2.2). The specific purposes of these monitoring programs are to provide information on the aquatic receiving environment necessary to achieve the following goals:

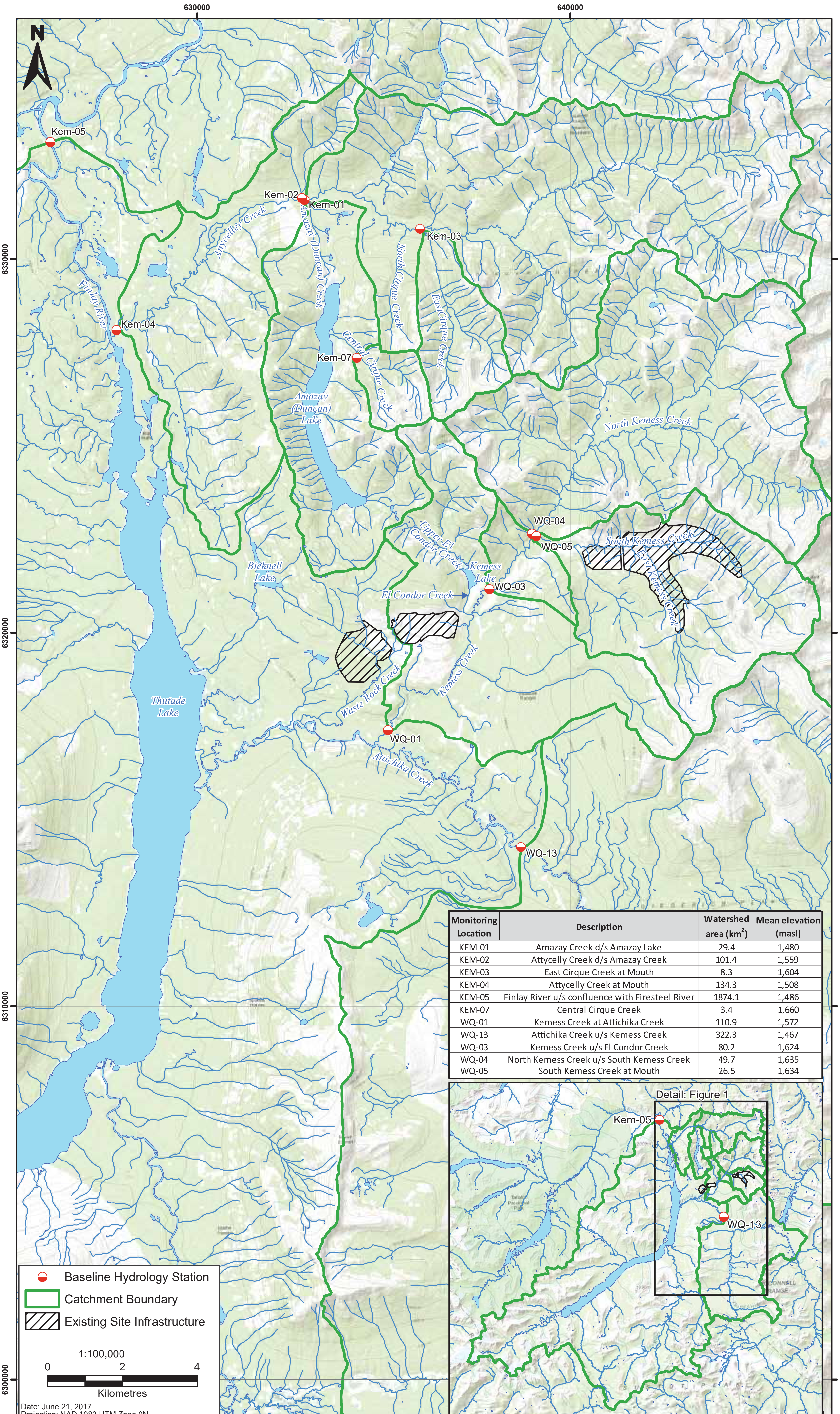
- detect Project-related effects on the aquatic ecosystem components (including water quality);
- confirm water quality predictions and assessment as presented in Chapters 5 (Discharges and Treatment) and Chapter 6 (Effects Assessment);
- meet permit and regulatory requirements for effluent and receiving environment quality;
- assess the performance of mitigation and management measures; and
- provide the necessary feedback and information for the adaptive management of potential Project-related effects.

The *Environmental Management Act* – Effluent Discharge Permit #PE15335 is an existing authorization associated with exploration and mining activities including monitoring and requirements of aquatic ecosystem parameters. The Effluent Discharge Permit #PE15335 requires monthly water quality sampling, weekly effluent sampling, and toxicity testing; the frequency, timing, and parameters required under this existing permit, have been incorporated into the overall FAEMP and MSWMP described in section below as well as Appendix 8-A.

**Figure 6.1-1**

**KUG Project Hydrometric Network**

LORAX ENVIRONMENTAL




| Monitoring Location | Description | Watershed area ($km^2$) | Mean elevation (masl) |
|---|---|---|---|
| KEM-01 | Amazay Creek d/s Amazay Lake | 29.4 | 1,480 |
| KEM-02 | Attycelly Creek d/s Amazay Creek | 101.4 | 1,559 |
| KEM-03 | East Cirque Creek at Mouth | 8.3 | 1,604 |
| KEM-04 | Attycelly Creek at Mouth | 134.3 | 1,508 |
| KEM-05 | Finlay River u/s confluence with Firesteel River | 1874.1 | 1,486 |
| KEM-07 | Central Cirque Creek | 3.4 | 1,660 |
| WQ-01 | Kemess Creek at Attichika Creek | 110.9 | 1,572 |
| WQ-13 | Attichika Creek u/s Kemess Creek | 322.3 | 1,467 |
| WQ-03 | Kemess Creek u/s El Condor Creek | 80.2 | 1,624 |
| WQ-04 | North Kemess Creek u/s South Kemess Creek | 49.7 | 1,635 |
| WQ-05 | South Kemess Creek at Mouth | 26.5 | 1,634 |

**Table 6.1-1. Surface Water Quantity Monitoring Program during Construction, Operations, Closure, and Post-Closure**

| Water Body | Station ID | Existing or New Station | Coordinates | | Monitoring Parameter | Frequency of Streamflow Monitoring | | | | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Easting (m) | Northing (m) | | Construction | Operations | Closure | Post-Closure | |
| Kemess Creek | WQ-01 | Existing | 635,126 | 6,317,400 | Streamflow | C | C | C | n/a | Monitor to confirm and verify the predicted effects, i.e., Project effects on the KLV flows, and KUG TSF seepage into Kemess Creek. These effects are year-round. In addition, streamflow monitoring during the open-water season can be used, along with WQ-13 flows, to estimate streamflow in Attichika Creek at the effluent discharge location. |
| Attichika Creek | WQ-13 | Existing | 638,676 | 6,314,291 | Streamflow | C[1] | CO[1] | CO[1] | n/a | Streamflow monitoring during the open-water season can be used, along with WQ-01 flows, to estimate streamflow in Attichika Creek at the effluent discharge location. |
| Attichika Creek | ATT-IDZ | New | 633,805 | 6,317,112 | Streamflow | C[1] | CO[1] | CO[1] | n/a | Monitor to confirm and verify the predicted effects, i.e., KUG TSF discharge into Attichika Creek. These effects occur during the open-water season (May to October). When a reliable rating curve is established at this new station, WQ-13 is no longer used. |
| East Cirque Creek | KEM-03 | Existing | 636,041 | 6,330,791 | Streamflow | C | C | C | C | To confirm and verify the predicted effects, i.e., year-round baseflow reductions and additions. Monitoring continues into Post-Closure until predicted baseflow addition is verified. |
| East Cirque Creek | KN-12 | New | 636,709 | 6,327,373 | Streamflow | M | M | M | n/a | Monitor stream flows, specifically low flow conditions as a proxy for baseflow in the upper reaches of East Cirque Creek. |
| Central Cirque Creek | KEM-07 | Existing | 634,268 | 6,327,368 | Streamflow | C | C | C | n/a | To confirm and verify the predicted effects, i.e., year-round baseflow reductions |
| Central Cirque Creek | CCC-1 | New | 635,738 | 6,326,698 | Streamflow | M | M | M | n/a | Monitor surface water in the upper reaches of Central Cirque Creek, at the toe of the gossan. |
| Attycelley Creek | KEM-02 | Existing | 632,840 | 6,331,646 | Streamflow | C | C | C | n/a | Monitor to confirm and verify that effects of the Project on baseflow are not significant. |

*(continued)*

**Table 6.1-1. Surface Water Quantity Monitoring Program during Construction, Operations, Closure, and Post-Closure (completed)**

| Water Body | Station ID | Existing or New Station | Coordinates | | Monitoring Parameter | Frequency of Streamflow Monitoring | | | | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Easting (m) | Northing (m) | | Construction | Operations | Closure | Post-Closure | |
| Waste Rock Creek | WQ-14ds | New | 633,741 | 6,317,776 | Streamflow | C | C | C | C | Monitor surface water flow in Waste Rock Creek |
| KUG TSF Spillway | - | New | TBD | TBD | Streamflow | n/a | n/a | n/a | C | KUG TSF overflow to the Waste Rock Creek via spillway will be monitored. |
| KUG TSF | - | New | TBD | TBD | Water Level | M | M | M | M | |

*Notes:*
*C = continuous monitoring during the open-water season and monthly monitoring when the streams are ice covered; CO = continuous monitoring during the open-water season; M = monthly monitoring.*
*TBD = to be determined; n/a = not monitored.*
*Coordinates reference UTM (NAD 83 Zone 09N).*
[1] *Station WQ-13 is needed until a reliable rating curve is established at the new station on Attichika Creek at the effluent discharge location (ATT-IDZ).*

#### 6.1.2.1 *Study Area, Locations and Frequency*

The MSWMP study area will comprise those areas potentially influenced by Project activities in the Mine Site Area (exposure) and areas beyond potential Project influences (reference). The primary Project activities that could affect the aquatic environment, and thus were considered in the water quality monitoring program design, include:

- diverted non-contact water,
- discharges from the KLV sediment pond;
- contact flows associated with the subsidize zone; and
- discharges and seepage from the KUG TSF.

Surface water quality monitoring sites and monitoring frequency for the MSWMP (see Table 6.2-1) build on monitoring sites identified in the FAEMP (Table 8.3-4 of Appendix 8-A) and have been designed to incorporate the monitoring required under existing permits. Further, the components of the monitoring program are intended to provide sufficient temporal coverage to collect representative data during the most ecologically relevant periods and, as applicable, sample and data collection for the separate components of the MSWMP and FAEMP will be coordinated to ensure data are cotemporaneous, which reduces the potential for cofounding factors in subsequent analyses.

Note, proposed surface water quality monitoring in Attycelley Creek and Amazay Lake watersheds (potential contact flows subsidence zone) is outlined in the Amazay Lake Monitoring Plan (Section 6.4), and has contributed to the FAEMP Adaptive Management Program (see Appendix 8-A). An annual selenium monitoring reporting program, including provincially-mandated studies of physical (water and sediment quality) and biological (fish tissue, periphyton, and benthic invertebrates) is presented in Section 8.3.4.2 of Appendix 8-A. Effluent characterization studies as required by the MMER are described in Appendix 8-A and Section 6.3, below.

Water quality locations monitored during Construction, Operations, and Closure periods are described in Table 6.1-2 and shown in Figure 6.1-2. Stream water quality samples will be collected monthly, except for sampling at the far-field monitoring site (Thutade), which will be sampled quarterly. The timing of quarterly sampling is designed to capture representative periods during winter low-flow conditions, freshet, summer low flow, and the increased streamflows in fall. During the current pre-Construction phase, water quality is monitored 12 times per year. During the four years of the Construction phase and 13 years of the Operations phase, water quality will also be monitored 12 times per year. During the six years of the Closure phase water quality will be adaptively managed and re-evaluated for FAEMP and MSWMP monitoring and EEM requirements. Initially, the monitoring and reporting schedule during the Closure phase will be set to the previous Operations phase schedule, but may be subject to changes as the Project transitions from the Closure phase and into the Post-Closure phase.

Monthly monitoring of concentrations in the KUG TSF will occur during Construction, Operations, and Closure periods will be used to: 1) verify water quality modelling predictions, and 2) implement the mitigation measure described in Section 5.4 of this plan to optimize the KUG TSF discharge into

Attichika Creek. Effluent monitoring sites required for Authorization #PE15335 under the provisions of the *Environmental Management Act* (2003) are described in Appendix 8-A; will be conducted at the point of discharge as required for effluent monitoring (see Table 6.1-2).

The number of replicate samples for each monitored component is informed by guidance documents and by a statistical power simulation. As a starting point, the sampling design considered five replicates (BC MOE 2012).

#### *6.1.2.2 Surface Water Quality Parameters Monitored*

Dissolved oxygen, temperature, TSS, turbidity, and pH measurements will be collected in the field to characterize the physical and chemical environment of the stream sites. Table 6.1-3 details the laboratory water quality parameters to be monitored under the MSWMP, including the parameters requiring current effluent discharge permits.

#### *6.1.2.3 Quality Assurance/Quality Control*

Replicate samples will be collected from a subset of all samples collected to quantify environmental variability and analytical consistency, with a minimum of one duplicate sample per sample set. Travel and field blanks will be collected to detect potential sources of contamination. Field instruments will be calibrated regularly according to the manufacturer's specifications and calibration logs will be maintained.

Quality assurance/quality control (QA/QC) principles will follow those outlined in guidance documents throughout the field sample collection and laboratory analysis phases (BC MOE 2012; Environment Canada 2012; Clark 2013). All water quality samples will be collected by qualified personnel using suitable sampling equipment (e.g., acid-rinsed sampling bottles). Samples will be preserved (where applicable) in appropriate containers and transported and stored following accepted procedures. Chain-of-Custody forms will be used to track the samples and analyses will be conducted by an accredited laboratory. Data quality will be verified by screening for potential data entry errors.

Data analysis will be conducted using established and standardized workflows, and analytical results will be cross-checked and validated. Data will be entered into suitable electronic databases (e.g., MS Access), checked for quality control, and stored for at least the life of mine. Data will be entered in a format and program that allow for comparison between years and storage in a single file format for each type of survey or monitoring activity. Data that have undergone QA/QC will be compiled and all cumulative data will be transferred for storage to the appropriate agency. Statistical hypothesis testing will be validated using power analysis and any other relevant methods.

Internal quality audits will be conducted to record and analyze quality issues and will be subjected to quality assurance procedures for documenting, tracking, and resolving QA/QC issues. The annual reports will include detailed descriptions of the analytical methods, including the relevant validation and QC procedures.

**Surface Water Quality Monitoring Locations**

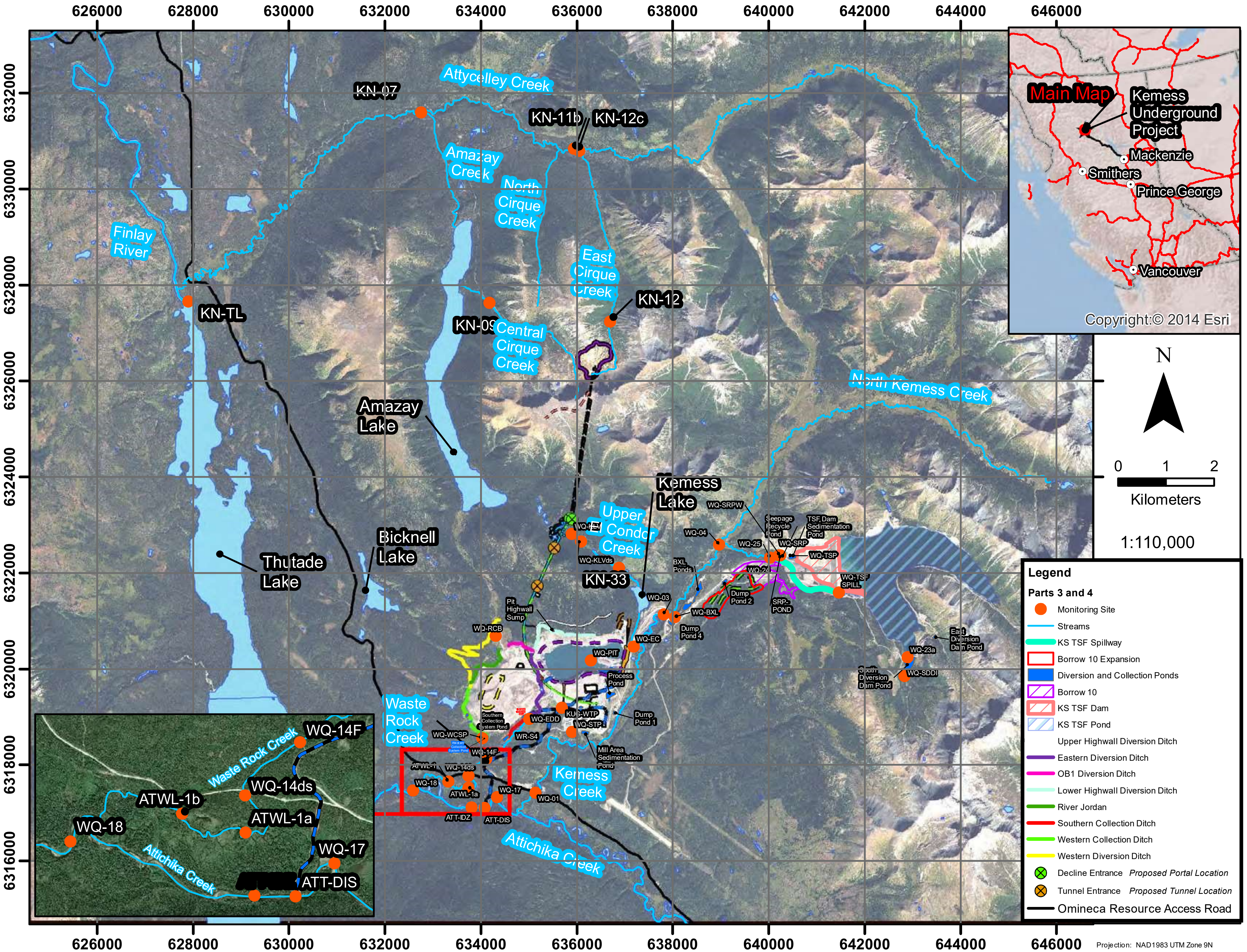


**Table 6.1-2. Surface Water Quality Monitoring Program during Construction, Operations, Closure**

| Type of Sampling | Site | Site Description and Rationale | Frequency of Monitoring | | | Monitoring Requirement/ Rationale |
|---|---|---|---|---|---|---|
| | | | Field Measurements | Laboratory Analysis [3] | 5-in-30 Days[3] | |
| **Attichika Creek / Waste Rock Creek Watershed** | | | | | | |
| Discharge | WR-S4 | Southern Collection System Discharge | - | Monthly | | KS permit PE15335 |
| | WQ-WCSP | Western Collection System Pond Discharge | Weekly [2, 6] | Monthly [5] | | KS permit PE15335 |
| | KUG-WTP | d/s of metal and selenium treatment | Weekly [2, 6] | Monthly | | |
| | ATT-DIS | KUG TSF effluent discharge to Attichika Ck - end of pipe | Weekly [2, 6] | Monthly | | |
| | ATT-IDZ [1] | Attichika Creek 0.2 km d/s of KUG TSF discharge | Weekly [2, 6] | Monthly | Freshet and Fall | Receiving environment attainment site on Attichika Creek, downstream of site charges |
| Surface Water | WQ-13 | Attichika Creek 30 m downstream of ORAR bridge (same as EEM-13 in FAEMP) | Weekly [2, 9] | Quarterly | | KS permit PE15335 |
| | WQ-17 | Attichika Creek 0.8 km downstream of Kemess Creek | Weekly [2, 9] | Monthly | | KS permit PE15335 |
| | WQ-18 | Attichika Creek approx. 100 m downstream of Waste Rock Creek wetland Outflow | Weekly [2, 10] | Monthly | | KS permit PE15335 |
| | WQ-14F | Waste Rock Creek 250 m upstream of ORAR at flume | Weekly [2,4] | Monthly [5] | | Monitored as per Condition 3.7.4, predicted to receive seepage form the KUG TSF |
| | WQ-14ds | Waste Rock Ck at ORAR crossing | Weekly [2,4] | Monthly | | |
| | WQ-RCb | Reference site upstream of Waste Rock Dump | Weekly [2, 7] | Quarterly | | KS permit PE15335 |
| | ATWL-1 | Attichika Wetland approx. 600 m d/s of WRC outlet | - | Monthly | | KS permit PE15335 |
| | ATWL-1a | Attichika Wetland approx. 100 m d/s of WRC outlet | - | Monthly | | KS permit PE15335 |
| Proposed for MSWMP | WQ-13 | Same as EEM-13 in the FAEMP (Appendix 8-A) | Weekly [9, 11] | Monthly | Freshet and Fall | Reference location. Upstream of influences of both potential Project effects, as well as influences of the former KS Mine |
| | WQ-17 | Attichika Creek 0.8 km downstream of Kemess Creek | Weekly [9, 11] | Monthly | Freshet and Fall | On Attichika upstream of the diffuser, but downstream of the confluence of Kemess Creek; included as a measure to assess potential cumulative effects of the Project and the former KS Mine |
| | WQ-14F | Waste Rock Creek 250 m upstream of ORAR at flume | Weekly [4, 11] | Monthly [5] | | Monitored as per Condition 3.7.4, predicted to receive seepage form the KUG TSF |
| | WQ-18 | Same as EEM-18 in the FAEMP (Appendix 8-A) | Monthy [11] | Monthly | | Far-field exposure site on Attichicka Creek; located downstream of discharges to Attichicka Creek and Waste Rock Creek wetland Outflow. |
| | Thutade Lake | Thutade Lake, downstream of confluence with Attichika Creek | Quarterly[11] | Quarterly | | Regional surface water quality monitoring location |
| | WQ-EDD | Eastern Diversion Ditch ds/ of HWDD and Bent Lake Discharge | | Monthly | | |
| | WQ-STP | Sewage Treatment Plant effluent discharge to Mill Area Sedimentation Pond | | | | |
| **Kemess Creek Watershed** | | | | | | |
| Discharge | WQ-23a | Plunge Pool discharge to south Kemess Creek at South Dam Chamber | Weekly [2, 4] | Quarterly | | KS permit PE15335 |
| | WQ-SRP | Seepage recycle pond toe drain discharge at V-notch weir | Weekly [2, 4] | Monthly | | KS permit PE15335 |
| | WQ-SRPW | Seepage recycle pond artesian well discharge | - | Quarterly (if discharging) | | KS permit PE15335 |
| | WQ-Pit | open water pit (proposed KUG TSF) | - | Quarterly | | KS permit PE15335 |
| | WQ-BXL | BXL Creek Discharge at V-notch weir, 30 m upstream of Kemess Creek | Weekly [2, 4] | Quarterly | | KS permit PE15335 |

*(continued)*

**Table 6.1-2. Surface Water Quality Monitoring Program during Construction, Operations, Closure (completed)**

| Type of Sampling | Site | Site Description and Rationale | Frequency of Monitoring | | | Monitoring Requirement/ Rationale |
|---|---|---|---|---|---|---|
| | | | Field Measurements | Laboratory Analysis [3] | 5-in-30 Days[3] | |
| **Kemess Creek Watershed** *(cont'd)* | | | | | | |
| | SRP-Pond | Discharge from Seepage Recycle Pond | Weekly [2, 4] | Monthly [5] | | KS permit PE15335 |
| | WQ-TSF Spill | Kemess South Tailings Storage Facility Discharge and Spillway Weir | Weekly [2, 4] | Monthly [5] | | KS permit PE15335 |
| Surface Water | WQ-01 | Kemess Creek 10 m downstream fo ORAR Bridge | Weekly [2,7] | Monthly | | KS permit PE15335 |
| | WQ-03 | Kemess Creek 10 m d/s ok Kemess Arch and u/s of the Kemess South closure pit spillway discharge location | Weekly [2,7] | Monthly | | KS permit PE15335 |
| | WQ-04 | North Kemess Creek 10 m upstream of South Kemess creek | Weekly [2,8] | Quarterly | | KS permit PE15335 |
| | WQ-25 | South Kemess Creek 100m downstream of Mill Creek | Weekly [2,7] | Monthly [5] | | KS permit PE15335 |
| | WQ-EC | El Condor Creek downstream of main haul road | Weekly [2,7] | Quarterly | | KS permit PE15335 |
| | WQ-SDDI | South Arm Creek upstream of South Diversion Pond | Weekly [4] | Quarterly | | KS permit PE15335 |
| | WQ-KLV | KLV sedimentation pond Discharge | Weekly [4] | Monthly [5] | | |
| | WQ-KLVds | El Condor Ck up stream of Kemess Lake | Monthly [5] | Monthly [5] | | |
| Proposed for MSWMP | WQ-01 | Kemess Creek 10 m downstream fo ORAR Bridge, | Weekly [11,7] | Monthly | | Predicted to receive seepage from the KUG TSF |
| | KN-33 | El Condor Creek, upstream of Kemess Lake | Weekly [11] | Quarterly | | Water management facilities will be established in the Kemess Lake Valley Area; downstream of the KLV sedimentation pond to discharge to El Condor Creek |
| | WQ-Pit | aligns with historical sampling site WQ-pit, open water pit (proposed KUG TSF) | - | Monthly (Construction) Quarterly (Operations thorugh Closure) | | KS permit PE15335, Monitored to validate model predictions, confirm water is of acceptable quality to discharge without treatmetn during the Construction Phase |
| **Additional FAEMP Amazay Lake and Attycelley Creek** | | | | | | |
| Surface Water | DCB-1 | Amazay Creek upstream of Attycelley Creek Confluence | Monthly | Monthly | | See Appendix 8-A, Adaptive Management Trigger |
| | KN-07 | Attycelley Creek downstream of the Duncan Creek confluence | Quarterly | Quarterly | | |
| | KN-12 | East Cirque Creek upstream of the confluence with Unnamed Tributary | Quarterly | Quarterly | | |
| | KN-TL | Thutade Lake | Quarterly | Quarterly | | |
| | ECB-1 | East Cirque Creek upstream of Attycelley Creek | Monthly | Monthly | | See Appendix 8-A, Adaptive Management Trigger |
| | KN-11b | Attycelley Creek downstream of East Cirque Creek | Monthly | Monthly | | See Appendix 8-A, Adaptive Management Trigger |

*Notes:*

*All monitoring will comply with permit requirements*

*MSWMP = Mine Site Water Management Plan*

*WRC = Waste Rock Creek*

*IDZ = initial dilution zone*

[1] *Effluent monitoring sites required for Authorization #PE15335 under the provisions of the* Environmental Management Act *(2003) are described in Appendix 8-A; weekly water sampling will be conducted at this site as required for effluent monitoring.*

[2] *Field parameters includes Field Turbidity and Temperature. Sampling is only conducted between May 1 and Sept. 30 at all stations save WQ-14F, which occurs throughout the year*

[3] *Conductivity, pH, ammonia, nitrate, nitrite, total nitrogen, chloride, orthophosphate, total dissolved phosphorus, alkalinity, hardness, sulphate, total and dissolved metals (must include selenium); see Tabke 6.1-3 for detailed paramter list.*

[4] *Sampled daily for turbidity if field turbidity exceeds 20 NTU.*

[5] *Additional biweekly TSS and Turbidity samples between May 1 and Sept 30, except at WQ-14F which is sampled biweekly throughout the year.*

[6] *Sampled daily for turbidity if field turbidity exceeds 50 NTU.*

[7] *Sampled daily for turbidity if field turbidity exceeds 10 NTU.*

[8] *Sampled daily for turbidity if field turbidity at WQ-03 exceeds 10 NTU.*

[9] *Sampled daily for turbidity if field turbidity at WQ-01 exceeds 10 NTU.*

[10] *Sampled daily for turbidity if field turbidity at WQ-14F exceeds 30 NTU.*

[11] *Field parameters includes Field Turbidity, Temperature, pH and dissolved oxygen (DO). Sampling is only conducted between May 1 and October 30 at all stations save WQ-14F, which occurs throughout the year*

**Table 6.1-3. Laboratory Water Quality Parameters**

| Physical and Chemical Parameters | Nutrients | Total and Dissolved Metals | |
|---|---|---|---|
| Conductivity | Ammonia | Aluminum (Al) | Lithium (Li) |
| Total Hardness | Nitrate | Antimony (Sb) | Manganese (Mn) |
| pH | Nitrite | Arsenic (As) | Mercury (Hg) |
| Total Alkalinity | Total Phosphorus | Barium (Ba) | Molybdenum (Mo) |
| Total Suspended Solids | Dissolved Ortho-phosphate | Beryllium (Be) | Nickel (Ni) |
| Turbidity | | Boron (B) | Selenium (Se) |
| Temperature | | Cadmium (Cd) | Silver (Ag) |
| Dissolved Oxygen | | Chromium (Cr) | Thallium (Tl) |
| **Anions** | | Cobalt (Co) | Titanium (Ti) |
| Chloride (Cl) | | Copper (Cu) | Uranium (U) |
| Fluoride (F) | | Iron (Fe) | Vanadium (V) |
| Sulphate ($SO_4$) | | Lead (Pb) | Zinc (Zn) |

All formal documents and reports will follow version-control procedures with revision tracking and version numbers. Version control information will be required for all documents and data that are issued, and approval will be given and tracked before issue. Designated personnel will coordinate preparation, review, and distribution, as appropriate, of the data and reports required for regulatory purposes.

The iterative QA/QC procedures will continuously improve the effectiveness of the monitoring to detect Project-related effects in the aquatic environment. These QA/QC processes will be important in the overall adaptive management of Project effects, and will support the goals of the Project to minimize, mitigate, and/or manage potential adverse effects on the environment.

## 6.2 GROUNDWATER AND SEEPAGE MONITORING

### 6.2.1 Overview

The groundwater and seepage monitoring (GSM) program consists primarily of monitoring groundwater quantity (levels, gradients and flows) and groundwater quality in key areas across the Project, as well as monitoring for seepage of mine contact water from the panel cave, underground mine workings and TSF during the Construction, Operations, Closure and Post-Closure Phases. Existing monitoring stations, in addition to new proposed locations are included in the GSM program.

The main monitoring objectives during Construction and Operations are to continue collection of groundwater quantity and quality data to better understand seasonal groundwater fluctuations and characterize the effects of dewatering, construction activities, and mine operations on the groundwater system. Monitoring will be initiated in areas where pre-Construction conditions have not been characterized (e.g. outside the expected surface influence of the panel cave, downstream from the portals area, and between the TSF and downstream surface water and drinking water receptors). Groundwater data collection will continue during Closure and Post-Closure to monitor and evaluate water level recovery and reflooding time, the equilibrium water level in the panel cave, the effectiveness of decline plugs, seepage of mine contact water, effects to East Cirque and Central Cirque creeks, and to confirm completion of reclamation objectives. Groundwater data will also be used to validate the groundwater model and inform future updates, as required (Section 6.2.3).

With the exception of one well nest to be completed at closure, the new monitoring wells are planned to be initiated during the first or second year of construction. Table 6.2-1 outlines benchmarks for baseline data collection and model updates based on the most current mine construction schedule. Should the mine construction schedule change, monitoring wells will be initiated so that one year of baseline data can be collected prior to groundwater impacts from mining being realized. One full year of data will be collected from baseline monitoring wells prior to the first update of the 3D numerical groundwater model. The first groundwater model update will occur after partial advancement of the declines, with delivery of results approximately 9 months prior to caving.

**Table 6.2-1. Suggested Timeline for Baseline Groundwater Data Collection and KUG Groundwater Model Update**

| Project Year | Mine Activity | Action Item |
|---|---|---|
| -4 | Access tunnel 50% complete | |
| -3 | Access tunnel complete, decline portals constructed and declines started by end of year | New well installations and initiation of baseline data collection Q3; initiate decline data collection |
| -2 | Declines progressed | Decline data collection; start KUG model update end Q3 |
| -1 | Declines progressed | Deliver KUG model update start Q2 |
| 1 | Initiate undercutting and caving | |

### 6.2.2 Construction and Operation Phase Monitoring

#### *6.2.2.1 Objectives*

Table 6.2-2 outlines the proposed groundwater and seepage monitoring (GSM) program for Kemess Underground during Construction and Operations Phases and includes project phase and monitoring locations, parameters, frequency, and rationale. One year of seasonal groundwater samples at all baseline monitoring stations is planned (Figure 6.2-1), with continued monitoring of selected existing stations, in addition to proposed new monitoring locations during Construction and Operations (Figures 6.2-2 and 6.2-3). New monitoring wells are proposed in several areas to complement the existing monitoring network, specifically outside the expected surface influence of the panel cave and down gradient from the underground mine, decline portals and TSF. Specific objectives of the GSM program during Construction and Operations are:

**Table 6.2-2. Groundwater Quality and Quantity and Seepage Monitoring Program during Construction and Operations Phases**

| | | Coordinates[1] | | Project Phase | | Monitored Parameters and Frequency | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Location | Station ID | Easting (m) | Northing (m) | Construction | Operations | Water Level[2] | Field Parameters[3] | Physical Parameters, Anions, & Nutrients[4] | Metals[5] | Flow[6] | Rationale |
| **KUG Mine** | | | | | | | | | | | |
| One Year of Seasonal Groundwater Samples | all baseline stations[7] | - | - | X | | C/Q | Q | Q | Q | | Monitor groundwater levels, gradients, and quality in existing overburden and bedrock wells monitored as part of the KUG Hydrogeology Baseline (Lorax 2017b) for one year of seasonal samples prior to commencement of Operations. |
| East Cirque Creek Sentinel Stations | DH-03-14A | 636,691 | 6,327,008 | X | X | C | Q | Q | Q | | Monitor groundwater levels, gradients, and quality in the overburden and bedrock downstream of the underground mine along East Cirque Creek. |
| | DH-03-14B | 636,691 | 6,327,008 | X | X | C | Q | Q | Q | | |
| | MW-03 | 636,699 | 6,326,952 | X | X | C | Q | Q | Q | | |
| | Kem3 | 636,041 | 6,330,791 | X | X | | | | | C | Monitor stream flows, specifically low-flow conditions as a proxy for baseflow in East Cirque Creek. |
| | KN12 | 636,709 | 6,327,373 | X | X | | M | M | M | M | Monitor stream flows, specifically low flow conditions as a proxy for baseflow in the upper reaches of East Cirque Creek. |
| | ECC Transect | n/a | n/a | X | | | O | O | O | O | Longitudinal survey to establish losing and gaining reaches along the length of East Cirque Creek |
| Central Cirque Creek Sentinel Stations | DH-03-16 | 634,440 | 6,327,423 | X | X | C | Q | Q | Q | | Monitor groundwater levels and quality northwest of the underground mine in Central Cirque Creek. |
| | MW-07A | 635,827 | 6,326,655 | X | X | C | Q | Q | Q | | Monitor groundwater levels and quality in bedrock at the toe of the gossan in Central Cirque Creek. |
| | MW-07B | 635,827 | 6,326,655 | X | X | C | Q | Q | Q | | |
| | Kem7 | 634,279 | 6,327,395 | X | X | | | | | C | Monitor stream flows, specifically low-flow conditions as a proxy for baseflow in Central Cirque Creek. |
| | CCC-1 | 635,738 | 6,326,698 | X | X | | M | M | M | M | Monitor surface water in the upper reaches of Central Cirque Creek, at the toe of the gossan. |
| | CCC Transect | n/a | n/a | X | | | O | O | O | O | Longitudinal survey to establish losing and gaining reaches along the length of Central Cirque Creek |
| Bedrock Wells outside the Surface Influence of the Panel Cave | MW-04A | 636,640 | 6,326,765 | X | X | C | Q | Q | Q | | Monitor groundwater levels, gradient and quality outside the surface influence of the panel cave to establish pre-operations conditions and monitor drawdown during mine dewatering. Well pairs planned adjacent to East Cirque Creek and along ridges between East Cirque and Central Cirque and to the south. |
| | MW-04B | 636,640 | 6,326,765 | X | X | C | Q | Q | Q | | |
| | MW-05A | 636,521 | 6,326,138 | X | X | C | Q | Q | Q | | |
| | MW-05B | 636,521 | 6,326,138 | X | X | C | Q | Q | Q | | |
| | MW-06A | 636,029 | 6,326,456 | X | X | C | Q | Q | Q | | |
| | MW-06B | 636,029 | 6,326,456 | X | X | C | Q | Q | Q | | |
| Bedrock Wells along the Declines | KN-11-02 | 635,701 | 6,323,327 | X | X | C | | | | | Monitor groundwater levels and gradients in the vicinity of the declines. |
| | KN-11-04 | 635,798 | 6,323,425 | X | X | C | | | | | |
| | KN-11-08 | 636,007 | 6,324,912 | X | X | C | | | | | |
| | KN-11-12 | 635,984 | 6,325,185 | X | X | C | | | | | |
| | KN-11-17 | 635,937 | 6,324,194 | X | X | C | | | | | |
| | KN-11-19 | 635,982 | 6,325,185 | X | X | C | | | | | |
| Discharge from Underground Workings | Outflow to KLV T. Pond | TBD | TBD | X | X | | M* | M* | M* | D | Monitor outflows from the decline and underground workings. Information to be used to determine water balance for declines. |
| Make-up water for Decline Development | TBD | TBD | TBD | X | | | M* | M* | M* | D | Monitor make-up water, if used, to supply the face drill during decline development. Samples to be collected at surface, prior to delivery to drills. Information to be used to determine water balance for declines. |

*(continued)*

**Table 6.2-2. Groundwater Quality and Quantity and Seepage Monitoring Program during Construction and Operations Phases (continued)**

| Monitoring Location | Station ID | Coordinates[1] Easting (m) | Northing (m) | Project Phase Construction | Operations | Monitored Parameters and Frequency Water Level[2] | Field Parameters[3] | Physical Parameters, Anions, & Nutrients[4] | Metals[5] | Flow[6] | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **KUG Mine** (*cont'd*) | | | | | | | | | | | |
| Discharge from Access Tunnel | TBD | - | - | X | X | | M | M | M | D | Monitor outflows from the access tunnel. |
| Upper El Condor Creek | DH-03-02A | 636,074 | 6,322,711 | X | X | C | Q | Q | Q | | Monitor groundwater levels and quality in the overburden and bedrock downstream from portal area infrastructure within the Upper El Condor Creek catchment. |
| | DH-03-02B | 636,075 | 6,322,709 | X | X | C | | | | | |
| | MW-02 | 635,980 | 6,322,761 | X | X | C | Q | Q | Q | | |
| | UEC-1 | 636,590 | 6,322,660 | X | X | | M | M | M | C | Monitor stream flows, specifically low-flow conditions, as a proxy for baseflow in Upper El Condor Creek. |
| Amazay Lake Sentinel Wells | MW-01A | 635,302 | 6,323,107 | X | X | C | Q | Q | Q | | Monitoring groundwater levels and quality in the overburden and bedrock downstream from portal area infrastructure within the Amazay Lake catchment. |
| | MW-01B | 635,302 | 6,323,107 | X | X | C | Q | Q | Q | | |
| Bedrock Well East of KUG Mine | KN-11-06 | 638,200 | 6,325,208 | X | X | Q | | | | | Monitor groundwater levels east of the KUG Mine to inform the groundwater model. |
| **KUG TSF** | | | | | | | | | | | |
| One Year of Seasonal Groundwater Samples | all baseline stations[8] | - | - | X | | Q | Q | Q | Q | | Monitor groundwater levels, gradients, and quality in existing overburden and bedrock wells monitored as part of the KUG Hydrogeology Baseline (Lorax 2017b) for one year of seasonal samples prior to commencement of Operations. |
| Overburden and Bedrock Wells in the Vicinity of the TSF | GW02-01 | 636,025 | 6,319,153 | X | X | Q | Q | Q | Q | | Monitor groundwater quality down gradient of the TSF where influence from the previous Kemess South operations have been observed. |
| | GW02-02 | 636,062 | 6,319,154 | X | X | Q | Q | Q | Q | | |
| | GW02-03 | 635,791 | 6,319,117 | X | X | Q | Q | Q | Q | | |
| | GW08-05S | 635,048 | 6,319,519 | X | X | Q | Q | Q | Q | | |
| | GW08-07S | 635,242 | 6,319,095 | X | X | Q | Q | Q | Q | | |
| | GW08-09S | 635,554 | 6,319,521 | X | X | Q | Q | Q | Q | | |
| | GW08-09D | 635,554 | 6,319,521 | X | X | Q | Q | Q | Q | | |
| | MW-12A | 637,355 | 6,320,631 | X | | C | Q | Q | Q | | Determine unimpacted background water quality upgradient of the KUG TSF along Kemess Creek. |
| | MW-12B | 637,355 | 6,320,631 | X | | C | Q | Q | Q | | |
| | MW-11A | 637151 | 6319969 | X | X | C | Q | Q | Q | | Monitor downstream groundwater levels and quality at the overburden-bedrock contact and in bedrock between the east end of the TSF and Kemess Creek. |
| | MW-11B | 637151 | 6319969 | X | X | C | Q | Q | Q | | |
| | MW-08A | 635326 | 6319632 | X | X | C | Q | Q | Q | | Monitor downstream groundwater levels and quality at the overburden-bedrock contact and in the bedrock between the west end of the TSF and Waste Rock Creek. |
| | MW-08B | 635326 | 6319632 | X | X | C | Q | Q | Q | | |

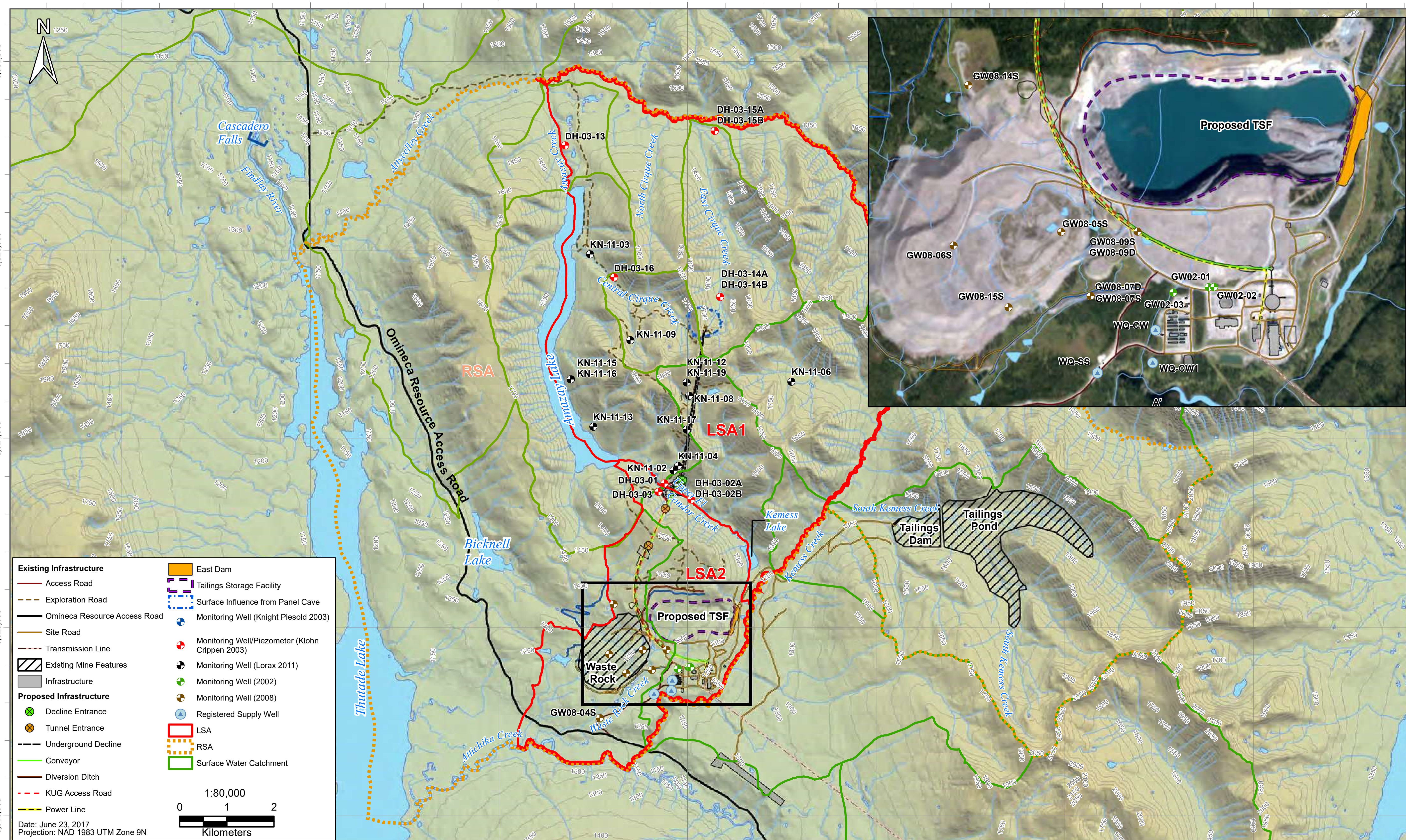
*(continued)*

**Table 6.2-2. Groundwater Quality and Quantity and Seepage Monitoring Program during Construction and Operations Phases (completed)**

| Monitoring Location | Station ID | Coordinates[1] Easting (m) | Northing (m) | Project Phase Construction | Operations | Monitored Parameters and Frequency Water Level[2] | Field Parameters[3] | Physical Parameters, Anions, & Nutrients[4] | Metals[5] | Flow[6] | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **KUG Mine** (*cont'd*) | | | | | | | | | | | |
| Drinking Water Sentinel Wells | MW-09A | 635695 | 6319116 | X | X | C | Q | Q | Q | | Monitor downstream groundwater levels and quality at the overburden-bedrock contact and in bedrock between the TSF and water supply wells WQ-CW and WQ-CW1. |
| | MW-09B | 635695 | 6319116 | X | X | C | Q | Q | Q | | |
| | MW-10A | 635,673 | 6,318,882 | X | X | C | Q | Q | Q | | Monitor downstream groundwater levels and quality at the overburden-bedrock contact and in bedrock between the TSF and water supply well WQ-SS. |
| | MW-10B | 635,673 | 6,318,882 | X | X | C | Q | Q | Q | | |
| | WQ-CW | 635,673 | 6,318,882 | X | X | C | Q | Q | Q | D | Monitor groundwater levels, quality and flow rates at the water supply wells. |
| | WQ-CW1 | 635,638 | 6,318,662 | X | X | C | Q | Q | Q | D | |
| | WQ-SS | 635,281 | 6,318,576 | X | X | C | Q | Q | Q | D | |
| Waste Rock Creek | WRC-1 | 633,730 | 6,317,850 | X | X | | M | M | M | M | Monitor stream flows, specifically low-flow conditions, as a proxy for baseflow in Waste Rock Creek. |

*Notes:*
*KUG = Kemess Underground; TSF = Tailings Storage Facility; TBD = to be determined; C = continuous monitoring; D = daily monitoring; Q = quarterly monitoring, M = monthly monitoring; M* = monthly monitoring or 1 sample per 100 m of decline advancement (whichever is more frequent), O = three surveys total times with late summer low flow conditions, late fall (October) and winter (March) low flow, subject to accessibility and safety requirements.*
[1] *Coordinates reference UTM (NAD 83 Zone 09N). Co-ordinates for new monitoring stations are approximate and subject to ground truthing.*
[2] *Groundwater levels measured continuously (recorded automatically) with pressure transducers equipped with dataloggers. Groundwater levels measured quarterly (manually with a water level meter).*
[3] *Field parameters include pH, temperature, specific conductance, oxidation reduction potential and dissolved oxygen measured using low-flow sampling methods with a flow-through cell and multi-parameter probe.*
[4] *Physical parameters include TSS, TDS, turbidity, conductivity, hardness, pH, alkalinity. Anions include Br, Cl, F, SO4, sulphide. Nutrients include nitrate, nitrite, total N, TKN, total ammonia, total P, ortho-phosphate, TOC and DOC. Analysed by a certified analytical laboratory.*
[5] *Total and dissolved metals by ICPMS (complete scan); analysed by a certified analytical laboratory.*
[6] *Stage recorded continuously with pressure transducers equipped with dataloggers. Mine discharge flows measured hourly with a totalizer.*
[7] *Baseline monitoring stations at KUG Mine include DH-03-02A, DH-03-02B, DH-03-13, DH-03-14A, DH-03-14B, DH-03-15A, DH-03-15B, DH-03-16, KN-11-02, KN-11-04, KN-11-06, KN-11-08, KN-11-09, KN-11-12, KN-11-13, KN-11-15, KN-11-16, KN-11-17 and KN-11-19 (does not include KN-11-03 which is damaged).*
[8] *Baseline monitoring stations at the KUG TSF include GW02-01, GW02-02, GW02-03, GW08-04S, GW08-05S, GW08-06S, GW08-07S, GW08-09S, GW08-09D, GW08-14S, WQ-CW, WQ-CW1 and WQ-SS (does not include GW08-07D and GW08-15S which are damaged).*

**Figure 6.2-1**
**Baseline Groundwater Monitoring Locations at Kemess Underground**

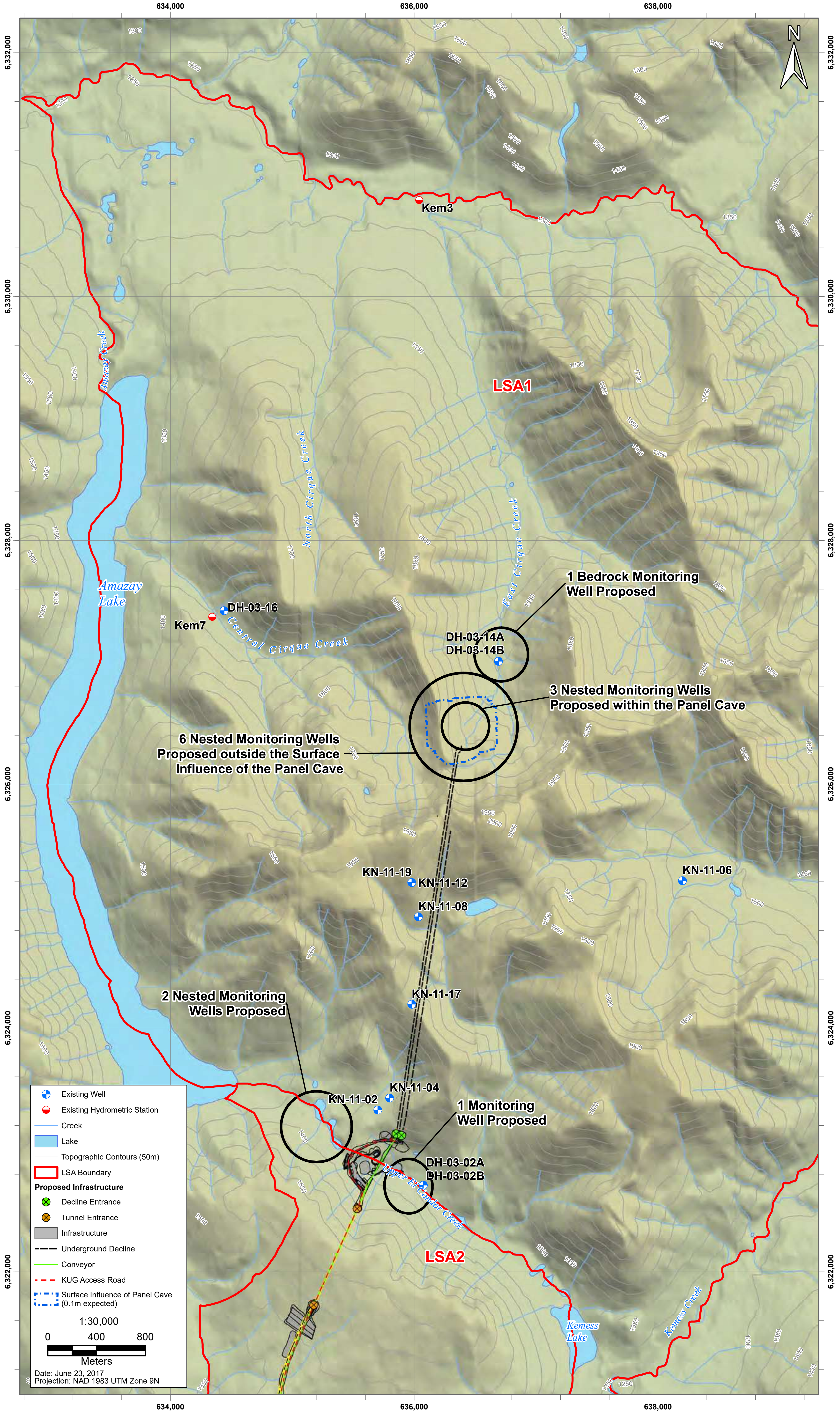





P:\@Drafting\Kemess\Drafting Figures\MXD\GW Monitoring Plan\Figure 6-1_KUG Baseline GW Monitoring_20170623.mxd

**Figure 6.2-2**

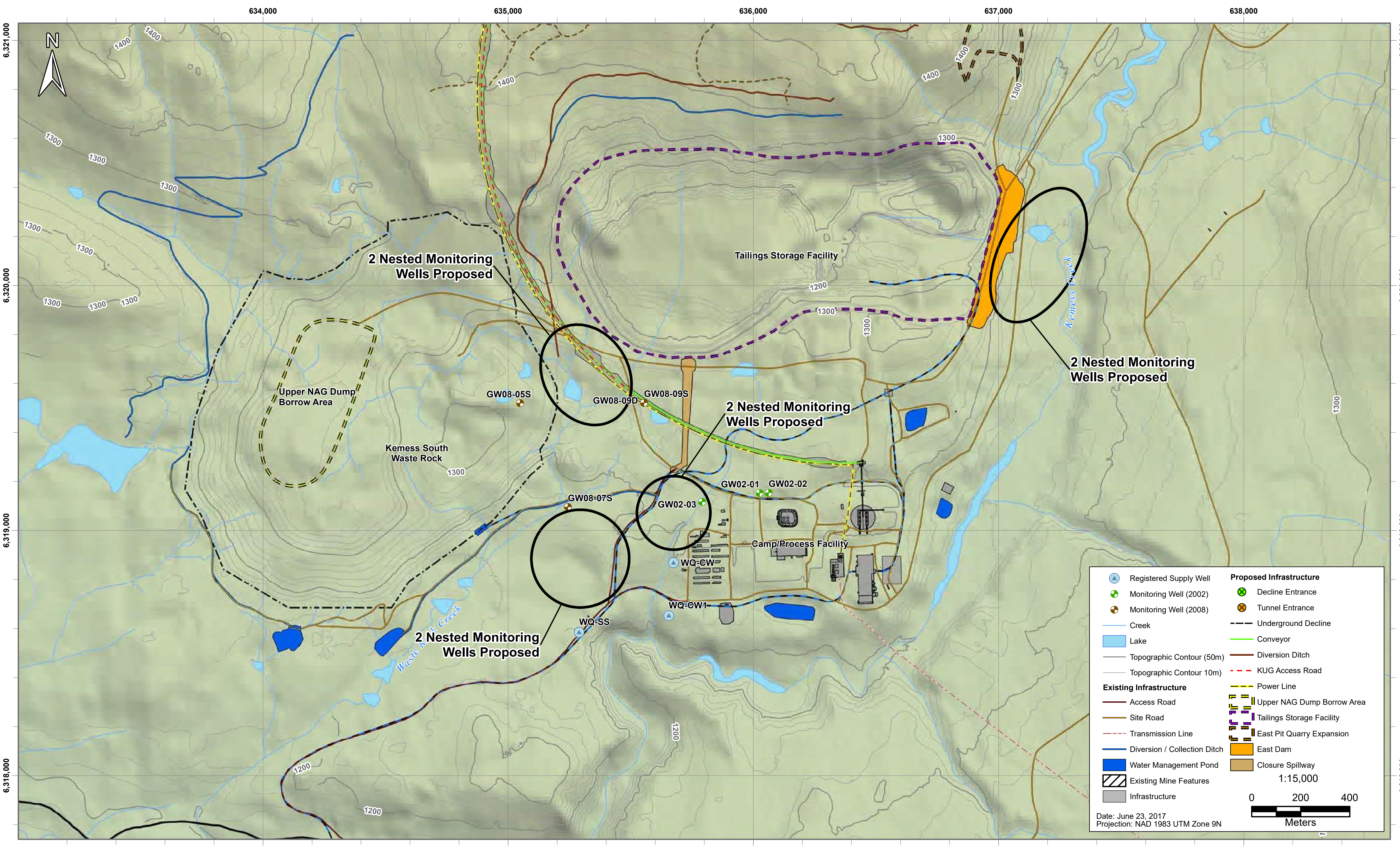
**Existing and Proposed Groundwater Monitoring Locations at Kemess Underground Mine**






P:\@Drafting\Kemess\Drafting Figures\MXD\GW Monitoring Plan\Figure 6-2_KUG GW Monitoring_20170623.mxd

## Figure 6.2-3
## Existing and Proposed Groundwater Monitoring Locations at Kemess Underground Tailings Storage Facility



KUG Mine

- Collect one year of seasonal groundwater samples at existing and new baseline monitoring wells prior to commencement of Operations to augment the groundwater baseline record.
- Collect baseline, pre-Operations groundwater quantity and quality data in overburden and bedrock downstream of portal area infrastructure in the Upper El Condor Creek and Amazay Lake catchments.
- Monitor discharge from the underground workings to assess predicted dewatering rates and to forecast mine outflows.
- Assess groundwater drawdown in the vicinity of the panel cave and along the declines during mine dewatering.
- Assess groundwater flowpaths from the underground mine, evaluate model predictions, and forecast impacts to East Cirque Creek and Central Cirque Creek during mine dewatering.
- Assess groundwater flowpaths from the portals area to detect effects from mining operations and predict potential impacts to Amazay Lake and Upper El Condor Creek.
- Validate the groundwater model and update with new data (levels, gradients and discharge) that becomes available during Operations to evaluate effects on predicted Post-Closure flowpaths. Provide, at least six months prior to the commencement of cave gallery construction, an updated numerical groundwater model, to the satisfaction of the Chief Inspector. The updated model will incorporate the results of the Groundwater and Seepage Monitoring Plan.
- Model validation/updates will be undertaken every five years, beginning in 2022, as part of the Mine Plan and Reclamation Program update, or more frequently as necessary to inform mine planning and mitigation design and engineering.

KUG TSF

- Collect one year of seasonal groundwater samples at all wells monitored as part of the KUG Hydrogeology Baseline (Lorax 2017b) prior to commencement of Operations to augment the groundwater baseline record.
- Collect baseline, pre-Operations groundwater level and quality data at proposed new monitoring wells at the overburden-bedrock contact and in the underlying bedrock between the KUG TSF and downstream Kemess Creek, Waste Rock Creek and water supply wells.
- Assess groundwater quality upgradient of the influence of KUG TSF along Kemess Creek where no data is available.
- Assess groundwater quality downgradient of the KUG TSF where previous effects from Kemess South operations have been observed.
- Assess groundwater quality at the water supply wells to improve understanding of existing conditions/trends and to ensure protection of drinking water.

- Assess groundwater flow paths from the KUG TSF, along the overburden-bedrock contact and in bedrock, to provide early detection of seepage from the KUG TSF before impacts reach downstream Kemess Creek, Waste Rock Creek and water supply wells.
- Provide, 90 days prior to the start of tailings deposition, an updated groundwater model for the KUG-TSF area, to the satisfaction of the Chief Inspector. The updated model shall include a report detailing the results of an assessment of the existing groundwater impacts within the vicinity of the KUG-TSF, including an assessment of loadings from the former PAG waste rock stockpile to the south of the facility.
- Validate and update the groundwater model, if required.

#### *6.2.2.2 Monitoring Well Locations and Methods*

Figure 6.2-2 presents existing and proposed monitoring locations in the vicinity of the underground. Three nested well pairs are planned outside the surface influence (0.1 m expected) of the panel cave: 1) adjacent to East Cirque Creek to the northeast; 2) along the ridge between East Cirque and Central Cirque; and 3) along the ridge south of the panel cave. These wells will be positioned to monitor groundwater drawdown and recovery, since the underground development will act as a large scale hydraulic test. Several wells will also serve to establish background groundwater quality. One deep bedrock well is planned near DH-03-14A/B to improve understanding of vertical gradients downstream of the underground mine. Three nested monitoring wells are planned following closure within the panel cave; see Section 6.2.3 for details. Two nested wells are planned in the overburden and bedrock downstream of the portals area infrastructure towards Amazay Lake, while one bedrock well is planned downstream of the portals area in the Upper El Condor Creek catchment.

Figure 6.2-3 presents existing and proposed monitoring locations in the vicinity of the KUG TSF. Five nested monitoring well pairs are proposed downstream from the KUG TSF: 1) Upgradient of the KUG TSF along the Kemess Creek Valley; 2) between the East Dam and Kemess Creek; 3) between the KUG TSF and Waste Rock Creek; 4) between the KUG TSF and water supply wells WQ-CW and WQ-CW1; and 5) upstream of water supply well WQ-SS. These nested well pairs will be installed at the overburden-bedrock contact, which has been identified as a potential preferential flow path for KUG TSF seepage, and in the underlying bedrock.

Preliminary design details for new monitoring locations are provided in Table 6.2-3 and are subject to change based on field observations. The majority of the proposed monitoring wells will be installed during Construction to allow sufficient time to assess current conditions prior to commencement of mining activities. Three of the monitoring wells listed in Table 6.2-3 will be initiated upon mine closure and are discussed in Section 6.2.3. The groundwater monitoring network will remain in place during Operations and Closure to facilitate evaluation of effects resulting from mining activities and to inform Closure plans.

**Table 6.2-3. Suggested Installation Details for Monitoring Wells to be Initiated Prior to Mining**

| Station ID | Mine Area | Completion Timing | Coordinates[1] Easting (m) | Northing (m) | Target Depth[2,3] (m) | Screened Lithology | Packer Tests[4] | Monitoring Location |
|---|---|---|---|---|---|---|---|---|
| MW-01A | LSA1 | Pre-mine | 635,302 | 6,323,107 | 75 | Bedrock | x | West of Triple Decline Portal |
| MW-01B | LSA1 | Pre-mine | | | 50 | Overburden | | |
| MW-02 | LSA1 | Pre-mine | 635,980 | 6,322,761 | 75 | Bedrock (deep) | x | Portal/KLV |
| MW-03 | LSA1 | Pre-mine | 636,699 | 6,326,952 | 150 | Bedrock (deep) | x | East Cirque Creek (near DH-03-14) |
| MW-04A | LSA1 | Pre-mine | 636,640 | 6,326,765 | 150 | Bedrock (deep) | x | Northeast of the surface influence (0.1 m expected) of the panel cave and adjacent to East Cirque Creek |
| MW-04B | LSA1 | Pre-mine | | | 50 | Bedrock (shallow) | | |
| MW-05A | LSA1 | Pre-mine | 636,521 | 6,326,138 | 150 | Bedrock (deep) | x | Along the ridge south of the surface influence (0.1 m expected) of the panel cave |
| MW-05B | LSA1 | Pre-mine | | | 75 | Bedrock (shallow) | | |
| MW-06A | LSA1 | Pre-mine | 636,029 | 6,326,456 | 150 | Bedrock (deep) | x | West of the surface influence (0.1 m expected) of the panel cave, along the ridge between East Cirque and Central Cirque |
| MW-06B | LSA1 | Pre-mine | | | 75 | Bedrock (shallow) | | |
| MW-07A | LSA1 | Pre-mine | 635,827 | 6,326,655 | 150 | Bedrock (deep) | x | Toe of gossan in Central Cirque Creek. |
| MW-07A | LSA1 | Pre-mine | | | 75 | Bedrock (shallow) | | |
| MW-08A | LSA2 | Pre-mine | 635,326 | 6,319,632 | 70 | Bedrock | x | Down gradient from the TSF between the TSF and Waste Rock Creek |
| MW-08B | LSA2 | Pre-mine | | | 20 | OVB/BR contact | | |
| MW-09A | LSA2 | Pre-mine | 635,695 | 6,319,116 | 75 | Bedrock | x | Down gradient from the TSF between the TSF and water supply wells WQ-CW and WQ-CW1 |
| MW-09B | LSA2 | Pre-mine | | | 25 | OVB/BR contact | | |
| MW-10A | LSA2 | Pre-mine | 635,302 | 6,318,885 | 80 | Bedrock | x | Down gradient from the TSF between the TSF and water supply well WQ-SS |
| MW-10B | LSA2 | Pre-mine | | | 30 | OVB/BR contact | | |
| MW-11A | LSA2 | Pre-mine | 637,151 | 6,319,969 | 70 | Bedrock | x | Down gradient from the TSF between the East Dam and Kemess Creek |
| MW-11B | LSA2 | Pre-mine | | | 20 | OVB/BR contact | | |
| MW-12A | LSA2 | Pre-mine | 637,355 | 6,320,631 | 70 | Bedrock | x | Kemess Creek Valley Northeast of KUG TSF |
| MW-12B | LSA2 | Pre-mine | | | 20 | OVB/BR contact | | |
| VWP1 | LSA2 | Pre-mine | 635,465 | 6,320,750 | 150 | Bedrock | | KS Pit (KUG TSF) north; 2 sensors |

*(continued)*

**Table 6.2-3. Suggested Installation Details for Monitoring Wells to be Initiated Prior to Mining (completed)**

| Station ID | Mine Area | Completion Timing | Coordinates[1] Easting (m) | Northing (m) | Target Depth[2,3] (m) | Screened Lithology | Packer Tests[4] | Monitoring Location |
|---|---|---|---|---|---|---|---|---|
| VWP2 | LSA2 | Pre-mine | 636,489 | 6,320,661 | 150 | Bedrock | | KS Pit (KUG TSF) north; 2 sensors |
| VWP3 | LSA2 | Pre-mine | 636,100 | 6,319,829 | 100 | Bedrock | | KS Pit (KUG TSF) west; 2 sensors |
| VWP4 | LSA2 | Pre-mine | 635,190 | 6,320,499 | 50 | Bedrock | | KS Pit (KUG TSF) south; 2 sensors |
| MW-13A | LSA1 | Closure | TBD | TBD | 400 | Bedrock | | Within cave zone |
| MW-13B | LSA1 | Closure | TBD | TBD | 150 | Bedrock | | Within cave zone |
| MW-13C | LSA1 | Closure | TBD | TBD | 40 | Bedrock | | Within cave zone |

*Notes:*

*[1] Proposed station coordinates are approximate and will require ground truthing.*

*[2] Proposed well target depths and screened intervals are based on available information and may be revised based on actual field conditions.*

*[3] Target depths were estimated based on available information from nearby monitoring wells and/or drill holes (i.e., overburden thickness and Broken Zone depth) as per KUG Project Baseline Hydrogeology report (Lorax, 2017).*

*[4] Recommended frequency of packer tests in shallow (75 m or less) and deep (150 m) monitoring well locations is 3 and 6 tests per hole, respectively, subject to hole conditions.*

New monitoring wells will be completed as conventional wells using 2” Schedule 80 PVC with 0.010” slot size for screened intervals. Recommended screened interval lengths for shallow (75 m or less) and deep (>75 m) are six and 12 meters, respectively, but are subject to the discretion of the supervising hydrogeologist. Screened intervals will be backfilled with filter sand and isolated from the upper portions of the borehole with a bentonite seal. A bentonite-cement grout is recommended for backfilling the annulus above the seal. Packer testing is recommended for the deep drill hole at nested monitoring locations completed prior to mining. Recommended frequency of packer tests in shallow (75 m or less) and deep (150 m) monitoring well locations is 3 and 6 tests per hole, respectively, subject to hole conditions.

Monitoring of wells will be conducted using the same methods as documented in the KUG Hydrogeology Baseline (Lorax 2017b). Groundwater levels will be measured manually with a water level meter or automatically with dedicated pressure transducers equipped with data loggers. Groundwater samples will be collected approximately quarterly (unless indicated otherwise in Tables 6.2-1 and 6.2-2). The exact timing of groundwater sampling should coincide with observed seasonal groundwater level fluctuations (high, medium and low water levels) and will be informed by groundwater level and surface water flow measurements.

#### *6.2.2.3 Decline and Access Tunnel Monitoring*

Monitoring of inflows during decline development can improve the current understanding of the groundwater flow regime (permeability and water quality) in the deeper bedrock. Both quantity and quality of discharge from the access tunnel and triple declines will be monitored during construction and operations.

The access tunnel will be advanced using conventional drill and blast tunnel excavation. This method uses drill jumbos (referred to as face drill rigs). Drill water sourced from development of the tunnel but may use local surface contact water sources for make-up if required. Excess flows from the access tunnel will be pumped to KUG TSF. The excess flows to the KUG TSF will be monitored to help inform future water quality modelling.

The triple declines will be advanced using conventional drill and blast tunnel excavation. This method uses drill jumbos (referred to as face drill rigs). Drilling fluid will be water which will be sourced from triple decline dewatering with excess water pumped to the Kemess Lake Valley (KLV) transfer pond and make-up water, if required, provided from local surface contact water sources. The decline water balance will be constrained through daily monitoring of a flow totalizer on the outflow line to the KLV transfer pond. The make-up water flows will be monitored to determine the contribution from groundwater and surface water sources, this will inform future groundwater modelling.

Outflow water quality samples will be collected at surface from the dewatering system prior to discharging into the KLV transfer pond that will handle contact water from the triple declines development. Sampling will be conducted regularly as the triple declines are advanced (approximately every 100 m or monthly, whichever is more frequent), as well as opportunistically when significant groundwater inflows are encountered (e.g., when the declines intersect a transmissive feature). The construction/drilling personnel will be asked to track occurrence of significant water bearing features and report these to environmental personnel in a timely fashion.

If significant groundwater inflows are encountered during triple decline development, potential follow-up investigations may be required. These investigations could include additional drilling, hydraulic testing (e.g., packer tests) and installation of groundwater instrumentation (monitor wells and/or vibrating wire piezometers). In addition to monitoring groundwater levels and quality in any potential new installations, flow accretion surveys (flow and water quality), if feasible depending on actual drainage conditions within the decline tunnels, could help identify sections with significant inflows. Potential follow-up investigations could also include radioisotope analyses (e.g., tritium and carbon 14) of inflow samples to evaluate mean residence times associated with groundwater inflows. Residence time estimates could help assess groundwater inputs (young versus old groundwater) and lead to an improved understanding of the groundwater flow regime in the deeper bedrock.

### 6.2.3 Closure and Post-Closure Phase Monitoring

The GSM program for Closure and Post-Closure is outlined in Table 6.2-4 (Figures 6.2-2 and 6.2-3). Specific objectives of the GSM program during Closure and Post-Closure are:

<u>KUG Mine</u>

- Assess groundwater level recovery, mine reflooding time, and the equilibrium water level in the panel cave.
- Assess groundwater recovery along the declines during mine flooding.
- Assess groundwater flowpaths from the underground mine, evaluate model predictions, and forecast impacts to East Cirque Creek and Central Cirque Creek during mine reflooding.
- Assess groundwater flowpaths from the portals area to detect effects and predict potential impacts to Amazay Lake and Upper El Condor Creek.
- Monitor for potential seepage from the declines and evaluate the effectiveness of the decline plugs.

<u>KUG TSF</u>

- Assess groundwater quality down gradient of the KUG TSF where previous effects from Kemess South operations have been observed.
- Assess groundwater flow paths from the KUG TSF, along the overburden-bedrock contact and in bedrock, to provide early detection of seepage from the KUG TSF before impacts reach downstream Kemess Creek, Waste Rock Creek and water supply wells.
- Asses seepage predictions to Waste Rock Creek, Kemess Creek and the water supply water wells.
- Assess groundwater quality at the water supply wells to ensure protection of drinking water during Closure.
- Validate and update the groundwater model, if required.

**Table 6.2-4. Groundwater Quality and Quantity and Seepage Monitoring Program during Closure and Post-Closure Phases**

| | | Coordinates[1] | | Project Phase | | Monitored Parameters and Frequency | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Location | Station ID | Easting (m) | Northing (m) | Closure | Post-Closure[2] | Water Level[3] | Field Parameters[4] | Physical Parameters, Anions, & Nutrients[4] | Metals[6] | Flow[7] | Rationale |
| **KUG Mine** | | | | | | | | | | | |
| East Cirque Creek Sentinel Stations | DH-03-14A | 636,691 | 6,327,008 | X | X* | C | Q | Q | Q | | Monitor groundwater levels, gradients, and quality in the overburden and bedrock downstream of the underground mine along East Cirque Creek. |
| | DH-03-14B | 636,691 | 6,327,008 | X | X* | C | Q | Q | Q | | |
| | MW-03 | 636,699 | 6,326,952 | X | X* | C | Q | Q | Q | | |
| | Kem3 | 636,041 | 6,330,791 | X | X | | | | | C | Monitor stream flows, specifically low-flow conditions as a proxy for baseflow in East Cirque Creek. |
| | KN12 | 636,709 | 6,327,373 | | | | M | M | M | M | Monitor stream flows, specifically low-flow conditions as a proxy for baseflow in the upper reaches of East Cirque Creek. |
| Central Cirque Creek Sentinel Stations | DH-03-16 | 634,440 | 6,327,423 | X | X | C | Q | Q | Q | | Monitor groundwater levels and quality northwest of the underground mine in the Central Cirque Creek drainage. |
| | MW-07A | 635,827 | 6,326,655 | X | X* | C | Q | Q | Q | | Monitor groundwater levels and groundwater quality in bedrock at the toe of the gossan in Central Cirque Creek |
| | MW-07A | 635,827 | 6,326,655 | X | X* | C | Q | Q | Q | | |
| | Kem7 | 634,279 | 6,327,395 | X | X | | | | | C | Monitor stream flows, specifically low-flow conditions as a proxy for baseflow in Central Cirque Creek. |
| | CCC-1 | 635,738 | 6,326,698 | X | X | | M | M | M | M | Monitor stream flows, specifically low-flow conditions as a proxy for baseflow at the toe of the gossan in Central Cirque Creek. |
| Bedrock Wells outside the Surface Influence of the Panel Cave | MW-04A | 636,640 | 6,326,765 | X | X* | C | Q | Q | Q | | Monitor groundwater levels, gradient and quality outside the surface influence of the panel cave to monitor recovery after Operations. Well pairs planned adjacent to East Cirque Creek and along ridges between East Cirque and Central Cirque and to the south. |
| | MW-04B | 636,640 | 6,326,765 | X | X* | C | Q | Q | Q | | |
| | MW-05A | 636,521 | 6,326,138 | X | X* | C | Q | Q | Q | | |
| | MW-05B | 636,521 | 6,326,138 | X | X* | C | Q | Q | Q | | |
| | MW-06A | 636,029 | 6,326,456 | X | X* | C | Q | Q | Q | | |
| | MW-06B | 636,029 | 6,326,456 | X | X* | C | Q | Q | Q | | |
| Bedrock Wells within the Panel Cave | MW-13A | TBD | TBD | X | X* | C | Q | Q | Q | | Monitor groundwater levels, gradients and quality at multiple levels in the cave zone during reflooding. |
| | MW-13B | TBD | TBD | X | X* | C | Q | Q | Q | | |
| | MW-13D | TBD | TBD | X | X* | C | Q | Q | Q | | |
| Bedrock Wells along the Declines | KN-11-02 | 635,701 | 6,323,327 | X | X | C | | | | | Monitor groundwater levels and gradients in the vicinity of the declines. |
| | KN-11-04 | 635,798 | 6,323,425 | X | X | C | | | | | |
| | KN-11-08 | 636,007 | 6,324,912 | X | X | C | | | | | |
| | KN-11-12 | 635,984 | 6,325,185 | X | X | C | | | | | |
| | KN-11-17 | 635,937 | 6,324,194 | X | X | C | | | | | |
| | KN-11-19 | 635,982 | 6,325,185 | X | X | C | | | | | |
| Seepage from Decline Plugs | TBD | - | - | X | X | | TBD | TBD | TBD | TBD | Monitor potential seepage from the plugged declines by conducting seepage surveys or with shallow monitoring wells. |
| Seepage from Access Tunnel Plug | TBD | - | - | X | X | | TBD | TBD | TBD | TBD | Monitor potential seepage from the plugged access tunnel by conducting seepage surveys or with shallow monitoring wells. |

*(continued)*

**Table 6.2-4. Groundwater Quality and Quantity and Seepage Monitoring Program during Closure and Post-Closure Phases (completed)**

| Monitoring Location | Station ID | Coordinates[1] | | Project Phase | | Monitored Parameters and Frequency | | | | | Rationale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Easting (m) | Northing (m) | Closure | Post-Closure[2] | Water Level[3] | Field Parameters[4] | Physical Parameters, Anions, & Nutrients[5] | Metals[6] | Flow[7] | |
| **KUG Mine** (*cont'd*) | | | | | | | | | | | |
| Upper El Condor Creek | DH-03-02A | 636,074 | 6,322,711 | X | X | C | Q | Q | Q | | Monitor groundwater levels and quality in the overburden and bedrock downstream from portal area infrastructure within the Upper El Condor Creek catchment. |
| | DH-03-02B | 636,075 | 6,322,709 | X | X | C | | | | | |
| | MW-02 | 635,980 | 6,322,761 | X | X | C | Q | Q | Q | | |
| | UEC-1 | 636,590 | 6,322,660 | X | X | | M | M | M | C | Monitor stream flows, specifically low-flow conditions, as a proxy for baseflow in Upper El Condor Creek. |
| Amazay Lake Sentinel Wells | MW-01A | 635,302 | 6,323,107 | X | X | C | Q | Q | Q | | Monitoring groundwater levels and quality in the overburden and bedrock downstream from portal area infrastructure within the Amazay Lake catchment. |
| | MW-01B | 635,302 | 6,323,107 | X | X | C | Q | Q | Q | | |
| Bedrock Well East of KUG Mine | KN-11-06 | 638,200 | 6,325,208 | X | X | Q | | | | | Monitor groundwater levels east of the KUG Mine to inform the groundwater model. |
| **KUG TSF** | | | | | | | | | | | |
| Overburden and Bedrock Wells in the Vicinity of the TSF | GW02-01 | 636,025 | 6,319,153 | X | X | Q | Q | Q | Q | | Monitor groundwater quality down gradient of the TSF where influence from the previous Kemess South operations have been observed. |
| | GW02-02 | 636,062 | 6,319,154 | X | X | Q | Q | Q | Q | | |
| | GW02-03 | 635,791 | 6,319,117 | X | X | Q | Q | Q | Q | | |
| | GW08-05S | 635,048 | 6,319,519 | X | X | Q | Q | Q | Q | | |
| | GW08-07S | 635,242 | 6,319,095 | X | X | Q | Q | Q | Q | | |
| | GW08-09S | 635,554 | 6,319,521 | X | X | Q | Q | Q | Q | | |
| | GW08-09D | 635,554 | 6,319,521 | X | X | Q | Q | Q | Q | | |
| | MW-11A | 637151 | 6319969 | X | X | C | Q | Q | Q | | Monitor downstream groundwater levels and quality at the overburden-bedrock contact and in bedrock between the east end of the TSF and Kemess Creek. |
| | MW-11B | 637151 | 6319969 | X | X | C | Q | Q | Q | | |
| | MW-08A | 635326 | 6319632 | X | X | C | Q | Q | Q | | Monitor downstream groundwater levels and quality at the overburden-bedrock contact and in the bedrock between the west end of the TSF and Waste Rock Creek. |
| | MW-08B | 635326 | 6319632 | X | X | C | Q | Q | Q | | |
| Drinking Water Sentinel Wells | MW-09A | 635695 | 6319116 | X | X | C | Q | Q | Q | | Monitor downstream groundwater levels and quality at the overburden-bedrock contact and in bedrock between the TSF and water supply wells WQ-CW and WQ-CW1. |
| | MW-09B | 635695 | 6319116 | X | X | C | Q | Q | Q | | |
| | MW-10A | 635,673 | 6,318,882 | X | X | C | Q | Q | Q | | Monitor downstream groundwater levels and quality at the overburden-bedrock contact and in bedrock between the TSF and water supply well WQ-SS. |
| | MW-10B | 635,673 | 6,318,882 | X | X | C | Q | Q | Q | | |
| | WQ-CW | 635,673 | 6,318,882 | X | | C | Q | Q | Q | D | Monitor groundwater levels, quality and flow rates at the water supply wells. |
| | WQ-CW1 | 635,638 | 6,318,662 | X | | C | Q | Q | Q | D | |
| | WQ-SS | 635,281 | 6,318,576 | X | | C | Q | Q | Q | D | |
| Waste Rock Creek | WRC-1 | 633,730 | 6,317,850 | X | X | | M | M | M | M | Monitor stream flows, specifically low-flow conditions, as a proxy for baseflow in Waste Rock Creek. |

*Notes:*
*KUG = Kemess Underground; TSF = Tailings Storage Facility; TBD = to be determined; C = continuous monitoring; D = daily monitoring; Q = quarterly monitoring*
*[1] Coordinates reference UTM (NAD 83 Zone 09N). Co-ordinates for new monitoring stations are approximate and subject to ground truthing.*
*[2] Monitoring frequency in Years 1 to 5 of Post-Closure will be quarterly, decreasing to bi-annually in Years 6 to 10 of Post-Closure and annually in Years 10 to 40 of Post-Closure.. Wells marked with an asterisk (*) will be monitored biannually from Years 1 through 30 of Post-Closure, and annually Years 30 to 40 Post Closure.*
*[3] Groundwater levels measured continuously (recorded automatically) with pressure transducers equipped with dataloggers. Groundwater levels measured quarterly (manually with a water level meter).*
*[4] Field parameters include pH, temperature, specific conductance, oxidation reduction potential and dissolved oxygen measured using low-flow sampling methods with a flow-through cell and multi-parameter probe.*
*[5] Physical parameters include TSS, TDS, turbidity, conductivity, hardness, pH, alkalinity. Anions include Br, Cl, F, SO4, sulphide. Nutrients include nitrate, nitrite, total N, TKN, total ammonia, total P, ortho-phosphate, TOC and DOC. Analysed by a certified analytical laboratory.*
*[6] Total and dissolved metals by ICPMS (complete scan); analysed by a certified analytical laboratory.*
*[7] Stage recorded continuously with pressure transducers equipped with dataloggers. Mine discharge flows measured hourly with a totalizer.*

Three nested monitoring wells are planned following closure within the panel cave at depths of approximately 40 m, 150 m and 400 m to evaluate panel cave flooding, flooding time and the Post-Closure water table equilibrium (Table 6.2-4). Safe installation of these wells will be important and confirmation that the ground had stabilized within the cave zone would be required.

### 6.2.4 Groundwater Model Updates

Two numerical models of groundwater flow have been developed for the Project including a 3-D FEFLOW model of the underground development and 2-D cross-sectional FEFLOW models for the KUG TSF.

The KUG groundwater model will be validated in transient (seasonal) mode and recalibrated (if required) based on new data collected during the construction period according to the timeline outlined in Table 6.2-1. Subsequent updates of the KUG groundwater model are planned every five years thereafter during Operations. The type of data and its importance to the KUG groundwater model are outlined in Table 6.2-5. The groundwater modeler will use professional judgement to determine whether recalibration of the groundwater model is required based upon the following criteria:

- Incorporation of water levels from new observation points causes a significant deterioration of the normalized root mean square error (NRMSE);
- Transient water level responses to seasonal recharge are not reasonably simulated using a more refined recharge time series;
- New baseflow measurements from existing stations (Kem-3, Kem-7) indicate that modeled ranges presented in the Application are significantly underestimated;
- Baseflow measured at new, upstream stations in East Cirque Creek and Central Cirque Creek are not reasonably simulated by the model; and
- Decline dewatering and surrounding water level responses are not reasonably simulated by the groundwater model.

Updates to the KUG TSF model will be informed by data collected downgradient of the TSF through installation of new monitoring wells and water level and flow data collected from the pumping wells. Monitoring well water level responses to TSF dewatering will also be considered. These data will largely be used to evaluate the appropriateness of hydraulic conductivity values and unit thicknesses assumed in the model (Section 4.3.3). The KUG TSF model may be updated should the data indicate that current modeling assumptions are not conservative. Delivery of this update, if required, will be timed to coincide with delivery of the KUG model update.

### 6.2.5 Seep Monitoring at the Non-Acid Generating Waste Rock Dump

Seep monitoring at the NAG WRD will also be conducted per Table 6.2-6 to satisfy the requirements of the Selenium Management Plan.

**Table 6.2-5. Construction Data Collection and Implications for KUG Groundwater Model Updates**

| Information | Significance to KUG Model | Practical Implications |
|---|---|---|
| a) Observed seasonal groundwater levels in existing and proposed new monitoring wells in the study area, including the East and Central Cirque Creek drainages | • Confirm the location and magnitude of groundwater divides between East Cirque Creek, Central Cirqe Creek and Upper El Condor Creek. | • Confinement of contact water fluxes from the development to East Cirque Creek is, in part, controllled by groundwater divides between the drainages<br>• When used in tandem with other information, groundwater levels (and therefore divides) can be used to evaluate the appropriateness of recharge and hydraulic conductivity values used in the area of interest which has implications for mine dewatering and reflooding rates |
| | • Confirm water levels and gradients surrounding the proposed development | • Additional monitoring in the vicinity underground footprint can be used to verify and improve model calibration (if required) through adjustment of recharge and hydraulic conducitivty. Both parameters influence mine dewatering and reflooding rates. |
| | • Confirm magnitude of seasonal groundwater level fluctuations in and around the development | • Groundwater fluctuations in and around the development can be used to evaluate the appropriateness of recharge and storage values applied in the area of interest which ultimately effect predictions of mine inflows and reflooding times. This would be evaluated through transient runs of the baseline groundwater model. |
| b) observed monthly streamflow (and inferred groundwater contributions) in East Cirque Creek, Central Cirque Creek and Upper El Condor Creek | • Confirm appropriateness of baseflow targets used for model calibration | • Baseflow generated in East Cirqe Creek and Central Cirque Creek used used to evaluate appropriateness of recharge and hydraulic conductivity values used in the area of interest which has implications for mine dewatering rates and reflooding time. |
| | • Identification and quantification of gaining and losing reaches of drainage reaches in area of interest | • Recharge to the groundwater system from upper reaches of East Cirque and Central Cirque Creek could contribute to underground dewatering rates. Although this is anticipated to be small, this term has not been explicitly included in the current model version.<br>• This would improve understanding of potential groundwater flowpaths from the development to surface water receptors and allow for verification that these flowpaths are captured by the groundwater model. |
| | • Quantification of flows in the Ephemeral Creek | • The Ephemeral Creek is inferred to be captured into the development (PY4 onward) and a flow term has been derived based on drainage area and the flow record in East Cirque Creek at Kem-03. More accurate quantification of this term would allow for refinement of underground dewatering rates and reflooding times. |

*(continued)*

**Table 6.2-5. Construction Data Collection and Implications for KUG Groundwater Model Updates (completed)**

| Information | Significance to KUG Model | Practical Implications |
|---|---|---|
| | • Include additional baseflow targets in the model calibration | • Measurement of stream flow, specifically low flows as a surrogate for baseflow, in Upper El Condor Creek and new stations in upper reaches of East Cirque Creek and Central Cirque Creek, can provide additional points for model validation and/or re-calibration through adjustment of recharge and hydraulic conductivity. |
| c) Initial dewatering observations during access tunnel development | • Provides an indication of shallow bedrock permeability | • The access tunnel has not been simulated in the current groundwater model. The flow rates for the Acces Tunnel was developed using an analytical solution based on K values measured in the field. Measured flow rates can be used to verify the K value of bulk rock and may be used to adjust shallower (<200 m) bedrock K used in the groundwater model. |
| d) Dewatering observations and water level responses during triple decline development | • Provides an indication deeper bedrock permeability and potential preferential flow paths (fractures) along the declines. | • Advancement of the triple declines allows for direct observation of bulk rock responsiveness to dewatering stresses closer to the cave zone. This can be used to refine hydraulic conductivity and recharge estimates in the area of interest. Moreover, observations of ground conditions in the decline itself can be used to confirm suitability of plug location, which feeds into updates of the closure groundwater model. |
| e) Hydraulic testing results from new monitoring locations located in and around the propsed development | • Confirms appropriateness of hydraulic conductivity values in the area of interest | • Bedrock hydraulic conductivity strongly influences mine dewatering rates, mine reflooding times and the post-closure flow field. Hydraulic testing data, water levels and baseflow allow for refinement of model recharge rates. |

**Table 6.2-6. Seep Monitoring Locations at the Non-Acid Generating Waste Rock Dump**

| Site Name | Easting | Northing | Elevation (m) | Frequency |
|---|---|---|---|---|
| EXPITS1 | 635,800 | 6,319,146 | 1,261 | Monthly |
| EXPITS2 | 636,131 | 6,319,138 | 1,260 | Annual |
| SP7 | 634,349 | 6,318,693 | 1,224 | Annual |
| SP8 | 634,937 | 6,319,040 | 1,235 | Monthly |
| WDD-S1 | 634,102 | 6,320,551 | 1,346 | Annual |
| WDD-S2 | 633,768 | 6,319,558 | 1,260 | Annual |
| WDD-S3 | 633,679 | 6,319,096 | 1,226 | Annual |
| WDD-S4 | 634,117 | 6,318,608 | 1,207 | Annual |
| WR-S1 | 635,199 | 6,319,742 | 1,268 | Monthly |
| WR-S2 | 635,215 | 6,319,121 | 1,244 | Monthly |
| WR-S3 | 634,856 | 6,318,983 | 1,226 | Monthly |
| WR-S4 | 634,566 | 6,318,589 | 1,223 | Monthly |
| S13-2 | 634,736 | 6,318,809 | 1,248 | Monthly |

## 6.3 WATER TREATMENT MONITORING

There will be over 140 instruments connected to the water treatment plant programmable logic controller (PLC), that will monitor and record process parameters in real time. On-line monitoring instruments salient to the overall water management plan are:

- Metals removal plant feed flow rate;
- Selenium removal plant feed flow rate;
- Multimedia filter backwash flow rate;
- Effluent to Attichika creek flow rate;
- Effluent to KUG TSF flow rate;
- Effluent pH; and
- Effluent turbidity.

In addition to the on-line monitoring instruments, there are numerous automated sample valves that will collect composite samples for chemical analysis in the plant HACH spectrophotometer, as well as key samples to be sent off-site on a weekly basis for validation at a third party analytical lab. These sample points include:

- Plant feed;
- Selenium removal plant feed; and
- Effluent.

Analysis of the samples will be for all regulated elements and compounds. Table 6.3-1 contains sampling frequency of the above-noted parameters.

**Table 6.3-1. Water Treatment Plant Parameter Monitoring and Frequency**

| | Monitoring Parameter | Frequency of Monitoring | | | | | Rationale |
|---|---|---|---|---|---|---|---|
| | | Commissioning | Construction | Operations | Closure | Post-Closure (WTP not Operational) | |
| Metals removal plant feed | Flow rate | C | N/A[1] | C | C | N/A | Monitoring continuous as instrumentation is installed in-line and connected to plant PLC. |
| | All regulated constituents (ICP and IC) | D | W | W | W | N/A | Will be used to develop correlations between continuously monitored plant performance indicators with effluent quality during commissioning. |
| Multimedia filter backwash | Flow rate | C | C | C | C | N/A | Monitoring continuous as instrumentation is installed in-line and connected to plant PLC. |
| Metals removal plant effluent | Flow rate | C | N/A[1] | C | C | N/A | Monitoring continuous as instrumentation is installed in-line and connected to plant PLC. |
| | All regulated constituents (ICP and IC) | D | W | W | W | N/A | Will be used to develop correlations between continuously monitored plant performance indicators with effluent quality during commissioning. |
| Selenium removal plant feed | Flow rate | C | C | C | C | N/A | Monitoring continuous as instrumentation is installed in-line and connected to plant PLC. |
| | All regulated constituents (ICP and IC) | D | W | W | W | N/A | Will be used to develop correlations between continuously monitored plant performance indicators with effluent quality during commissioning. |
| | Selenium speciation | Q | Q | Q | Q | N/A | To confirm relative percentage selenite and selenite |
| Selenium removal plant effluent | All regulated constituents (ICP and IC) | D | W | W | W | N/A | Will be used to develop correlations between continuously monitored plant performance indicators with effluent quality during commissioning. |
| | Selenium speciation | Q | Q | Q | Q | N/A | To confirm relative percentage selenite and selenite |
| WTP Effluent (to TSF or Attichika) | Flow rate / pH / Turbidity | C | C | C | C | N/A | Monitoring continuous as instrumentation is installed in-line and connected to plant PLC. |
| | All regulated constituents (ICP and IC) | D | W | W | W | W | Correlations between effluent quality and internal process parameters and benchtop HACH tests will be developed during commissioning. |

*Notes:*
*[1] WTP not operational during construction phase.*
*C = Continuous; D = Daily (24 hour composite sample); W = Weekly (7-day composite sample); Q = Quarterly.*

The analytical laboratory at the water treatment plant will be equipped with the following:

1. Beakers, graduated cylinders and general laboratory dishes;
2. Micro pipettes for accurate measurement of small quantities of solutions;
3. pH and ORP probes and calibration solutions and reagents;
4. Analytical balance (0.1 g) for accurate reagent measurement;
5. Stir plate and stir bars for reagent preparation and mixing; and
6. Hach spectrophotometer, measurement vials, and reagents.

Two of the most important parameters in the water treatment plant that impact the degree of contaminant removal from the water are pH and ORP. The plant is equipped with industrial in-line pH and ORP probes that will be calibrated by the operators on a daily basis. However, the laboratory probes will be periodically used to verify the accuracy of plant probes that will help ensure targets of treatment are met.

A Hach spectrophotometer will also be available at the lab that will allow measurement of certain elements that will be used as proxies to confirm the plant is operating according to specifications. These elements include copper, zinc and iron (Hach standard analytical methods 8506/8026, 8009, 8008, respectively).

The HACH instrument will be used to guide operation of the plant and the analytical results generated by this machine cannot be used for compliance purposes. Samples that are required to confirm effluent contaminant concentrations will be shipped to a third party accredited laboratory such as ALS Environmental or Maxxam Analytics for analysis.

It is anticipated that AuRico will be installing an ICP-MS instrument when mill operation commences, which will provide fast confirmation of the concentrations of all metals in effluent (and other) streams without the lag associated with shipping to an off-site third party lab. It is also important to note that prior to mill operation (project years -3 to -1), plant effluent will be discharging to the TSF and not the environment, making the lag associated with effluent testing off-site acceptable.

Refer to the *KUG WTP Design Report* (BQE 2017) for a detailed description of plant instrumentation and monitoring.

## 6.4 AMAZAY LAKE MONITORING PLAN

Table 6.4-1 provides details of the Amazay Lake Monitoring Plan in relation to EAC Condition 20 (described in Section 2.2.2).

Surface water quality monitoring results collected prior to Operations will be compared with any surface water quality monitoring results collected during Construction, Operations, Closure, and Post-closure. Quality assurance/quality control (QA/QC) and data analysis will follow Section 6.1.2.3.

**Table 6.4-1. Water Quality Monitoring in the Amazay Lake Monitoring Plan**

| Monitoring Locations | Frequency and Duration of Monitoring |
|---|---|
| **Surface Water Quality Monitoring on Amazay Lake and its Tributaries** | |
| Central Cirque Creek (Inlet 6) | Once during early Construction phase of the Project; annually during Operations, Closure, and Post-Closure |
| Amazay Lake (Water Quality Node) | Once during early Construction phase of the Project; annually during Operations, Closure, and Post-Closure |
| Amazay Lake (LS1) [1] | Once during early Construction phase of the Project; annually during Operations, Closure, and Post-Closure |
| Amazay Lake (LS2) [1] | Once during early Construction phase of the Project; annually during Operations, Closure, and Post-Closure |
| Amazay Creek (KN-08) | Once during early Construction phase of the Project; annually during Operations, Closure, and Post-Closure |
| **Groundwater Quality Monitoring** | |
| MW-01A | Quarterly monitoring during Construction and Operations, Closure, and Post-Closure phases |
| MW-01B | Quarterly monitoring during Construction and Operations, Closure, and Post-Closure phases |

*Note:*
[1] *Historical sampling locations from the proposed Kemess North open-pit mining project (2003 to 2006). Locations represent the deepest point of each basin of the lake.*

As described in Section 8.3.7.2 of the Fish and Aquatic Effects Monitoring Plan (FAEMP), Amazay Lake water quality data collected under the Amazay Lake Monitoring Plan will be integrated into the FAEMP as a key trigger for a fish and aquatic habitat Adaptive Management Monitoring Program. Adaptive management will be implemented if the surface water quality monitoring indicates adverse effects on surface water quality due to the Project as determined by a Qualified Professional.

As described in Section 6.2.2.2, monitoring of groundwater wells associated with Amazay Lake (i.e., MW-01A and MW-01B) will be conducted using the same methods as documented in the KUG Hydrogeology Baseline (Lorax 2017b). Groundwater levels will be measured manually with a water level meter or automatically with dedicated pressure transducers equipped with data loggers. Groundwater samples will be collected quarterly. The exact timing of groundwater sampling should coincide with observed seasonal groundwater level fluctuations (high, medium and low water levels) and will be informed by groundwater level and surface water flow measurements.

The groundwater monitoring results will be used to inform the Closure Plan. Specific methods for this will be developed prior to closure.

An Adaptive Management Monitoring Program will be triggered if the groundwater monitoring indicates adverse effects on groundwater quality due to the Project, as determined by a Qualified Professional.

AuRico will not commence Construction until the Amazay Lake Monitoring Plan has been approved by EAO, unless otherwise authorized by EAO.

The Amazay Lake Monitoring Plan, and any amendments thereto, will be implemented to the satisfaction of a Qualified Professional throughout all Project phases to the satisfaction of EAO.

### 6.5 SAFE DISCHARGE

The monitoring requirements for safe discharge are covered in Sections 6.1 to 6.3 of this plan and in other management plans (Selenium Management Plan and Fish and Aquatic Effects Monitoring Plan).

### 6.6 QUALITY ASSURANCE / QUALITY CONTROL

The process of data collection in the field are quality controlled through the use of trained personnel and a system of pre- and post-field checks to ensure that consistent, repeatable data are being gathered. All personnel will have necessary training for the activities being conducted.

Quality assurance/quality control (QA/QC) measures for monitoring activities will be employed by:

- following SOPs during establishment of monitoring and measurement activities;
- using standardized forms for data collection;
- reviewing data entry for errors and following of accepted data analysis procedures; and
- including a discussion in monitoring reports of any issues identified during QA/QC procedures and assessing the effectiveness of the plan and identifying adaptive management measures as required.

Quality control and quality assurance of field sampling will be based on the British Columbia Field Sampling Manual (Clark 2002). Quality assurance and quality control procedures specific to surface water quality monitoring are detailed in Section 6.1.2.3.

## 7. REPORTING AND RECORDKEEPING

### 7.1 REPORTING

The Environmental Manager or other designated person will be responsible for overseeing surface water monitoring, maintaining records of inspections, reporting in accordance with permit and approval conditions, and providing guidance on modifying the program as required.

Information collected through application of the MSWMP will be included in relevant reports prepared annually and as required to meet external and internal needs. Mine site water reports may contain the following:

- description of record keeping of monitoring data and analyses (e.g., a description of the analyses that were performed, detection limits used, and QA/QC procedures);
- monitoring results, comparison against applicable water quality objectives and guidelines and interpretation;

- identification of any emerging negative environmental trends likely attributable to the Project identified by monitoring; and
- description of proposed revisions to the MSWMP to address emerging negative trends, or to adjust monitoring programs, if required.

Reporting of surface water management activities will be conducted in accordance with all permit and approval conditions. Any non-compliances resulting from the Project's activities will be communicated to regulatory authorities, as required.

### 7.1.1 Monitoring Reporting

AuRico will assume the responsibility of data management and record-keeping of monitoring results. Data will be entered into suitable electronic databases and have quality control checks completed upon receipt of results. Data will be entered in a format and program that allows for comparison between years, and will be stored in a single file format for each type of survey or monitoring activity. Monitoring data will be stored for the life of the mine and be made available for review upon request.

The information gathered during surface water, groundwater, and water treatment plant monitoring will be summarized annually. Annual reports will be produced and submitted in accordance with the Permit specifications. The report will provide a summary of monitoring results and an assessment of compliance with the Permit, including a summary of any mitigation actions applied to rectify non-compliances where required. The report will provide results of monitoring described in Section 6 of this plan.

### 7.1.2 Compliance Reporting

Information from reporting described in Section 7.1.1 of this plan will be incorporated as needed into other general compliance reports in which AuRico will prepare under various authorizations such as the EAC, Decision Statement, and effluent discharge permits.

### 7.1.3 Incident Reporting

Incidents related to mine site water, including any surface water quality related complaints, will be reported internally to the Environmental Manager. External reporting will be completed, as required, by the Director, Environment.

## 7.2 RECORDKEEPING

### 7.2.1 Monitoring Results

Record keeping is conducted by designated personnel. Data are entered into suitable electronic databases, checked for quality control and assurance purposes, and stored. Data are entered in a format and program that allow for comparison over time and storage in a single file format for each type of survey or monitoring activity. Designated personnel will coordinate preparation, review, and distribution of the data and reports required for regulatory purposes.

AuRico will assume the responsibility of data management and record-keeping of monitoring results. Data are entered into suitable electronic databases and have quality control checks completed upon receipt of results. Data are entered in a format and program that allows for comparison between years, and are stored in a single file format for each type of survey or monitoring activity. Monitoring data are stored for the life of the mine and be made available for review upon request.

Standard operating procedures (SOPs) will be established for environmental data collection as needed. SOPs will cover all aspects of data collection, data processing, data QA/QC, and data management. SOPs will include duplicate sampling, relevant blanks, chain-of-custody procedures, and recordkeeping. SOPs will be reassessed and updated when necessary, as part of the iterative QA/QC process.

#### 7.2.2 Audits

Results of any internal and external audits and inspections will be kept on site and made available for inspection by regulatory authorities as required.

#### 7.2.3 Continuous Improvement

Annual reviews of the MSWMP will be conducted internally with the mindset of continually improving the program. Continuous improvement measures could include implementing new technology as it becomes available, streamlining processes and/or any other measures to improve the program.

To achieve continual improvement, an iterative process of planning, doing (implementing), checking, and acting is undertaken. Such a management approach is typically applied in the following manner:

- planning – during which objectives are established and processes defined that accord with the company's ethos (represented in the Environmental Policy);
- doing (implementing) – during which the defined processes (or actions) are carried out;
- checking – during which the processes carried out are monitored, measured against the objectives (including legal obligations), and reported; and
- acting – during which additional actions are undertaken, if necessary, to achieve continual improvement in the company's environmental performance (may require revising high-level planning, i.e., policy).

#### 7.2.4 Incident Response Records

Incident response records are stored for a minimum of five years and made available for review upon request.

# 8. EVALUATION AND ADAPTIVE MANAGEMENT

Adaptive management means identifying and addressing MSWMP components that are shown to be not functioning as intended. This could be as a result of ineffective mitigation measures, practical implementation of plan requirements or in response to changes in requirements or Project conditions. Scenarios related to water management where adaptive management may be required include:

- reoccurring exceedance of compliance requirements;
- reoccurring and substantive exceedance of ambient standards and objectives;
- significant increasing trend in contaminant concentrations;
- multiple incidents in any given year; or
- substantive regulatory changes and/or technological advances.

It is expected that as the Project moves through the Construction and Operations phases, refinements and updates to the water balance and water quality model will be done periodically (e.g., every five years) and if observed water levels in the KUG TSF are substantially higher than modelled levels. These updates and refinements will be incorporated in the MSWMP.

Adaptive management can also include additional protection measures mentioned in Section 5 of this plan. Additionally, adaptive management can include updates to this plan in terms of roles and responsibilities, training and/or supporting documents.

The cycle of mitigation activities, monitoring and evaluation, and instituting new mitigation activities if required, will provide adaptive management of water related issues identified and arising as a result of the Project.

Monitoring data will also be used to provide feedback to modify the surface water management measures implemented at the site, if required. This plan is designed to be adaptive, effective, and achievable in both the short and long term. Components of the MSWMP may need to be revised over the life of the Project based on regulatory changes and/or technological advances.

# 9. PLAN REVISION

The MSWMP is a "living document" and components of the plan may be revised over the life of the Project. The MSWMP may be updated as frequently as annually, or not at all. Any revisions of MSWMP will be implemented following a review by stakeholders and an opportunity for response by AuRico.

AuRico will conduct an annual (or as necessary) evaluation of the efficacy of mitigation and management activities and of monitoring activities. This plan may be updated as frequently as every year, or not at all, if the mine plan and methods for mitigation and monitoring are found to be robust.

## 9.1 NOTIFICATION AND CONSULTATION REQUIRED UPON PLAN REVISION

Any proposed modifications made to the MSWMP will be communicated to the Environmental Monitoring Committee, including members of regulatory authorities and First Nations. The Environmental Monitoring Committee will be provided with an opportunity to comment on the proposed revisions before revisions are implemented.

# 10. QUALIFIED PROFESSIONALS

Under the direction of AuRico Metals Inc., a team of consultants have supported preparation of this management plan. This management plan has been prepared and reviewed by, or under the direct supervision of, the following qualified professionals:

Sections 4.1, 4.2, 4.5, 5.1, 5.2, 5.5, 6.1, and 6.4
Prepared by:

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Sections 4.3, 5.3, and 6.2
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Jordi Helsen, M.Sc., P.Geo.
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Sections 4.4, 5.4, and 6.3
Prepared by:

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David Kratochvil, Ph.D., P.Eng.
President and CEO, BQE Water

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Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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