Mount Nansen Site

Tailings Facility and Associated Structures

Operation Maintenance and Surveillance Manual

April 16, 2014

Government of Yukon

Energy, Mines and Resources

Assessment and Abandoned Mines

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Operation Maintenance and Surveillance Manual – Record Tables

The following tables shall be maintained by the responsible parties

Record of Operation Maintenance and Surveillance Manual Holders

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<u>*Note:*</u> *The Operation Maintenance and Surveillance Manual is not currently in these locations, as a final version of this document has not yet been produced.*

Record of Revisions to Operation Maintenance and Surveillance Manual

Date	Reason	Person Requesting Change	Position	Signature
Nov. 16/16	***Update personnel information***	***Jeff Moore***	***Project Officer***	

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1. Introduction

This Operation Maintenance and Surveillance (OMS) Manual for the tailings storage facility and related infrastructure at the Mount Nansen Site (the Site) has been developed by Yukon Government, Assessment and Abandoned Mines (AAM). This OMS Manual provides a documented framework for actions in order to ensure the safe operation, maintenance, and surveillance of the facility. The OMS Manual is a live document in that it will regularly require updating; Information will be updated at a minimum of once per year, as well as at every change in critical personnel or contractors, and changes in procedures or conditions on-site.

As per the Canadian Dam Association Dam Safety Guidelines (2007), this document includes:

- A site description;
- Operation information including roles and responsibilities, water management and flow control gauging and emergency systems;
- Maintenance information for all major facilities and infrastructure on site; and
- Surveillance information including inspections, instrumentation, response to unusual conditions, and documentation and follow-up.

2. Site Description

The Mount Nansen Site is a former gold and silver mine in the Yukon. The site is currently in the care and maintenance stage and is undergoing closure planning. The Mount Nansen property is located approximately 45 km west of Carmacks, Yukon, and 180 km north of Whitehorse, Yukon. The Site is within the traditional territory of the Little Salmon/Carmacks First Nation. The Mount Nansen road is an all-weather public road that connects the site to the North Klondike Highway in Carmacks. Yukon Government, Highways and Public Works maintains the Mount Nansen Road up to the site property boundary. The Site is powered by diesel-fueled generators and associated infrastructure is maintained by the on-site operator. Telephone communication is available via satellite telephone as well as cellular telephone (CDMA only) assisted by a signal booster located within the Site camp facilities. Internet communication is available through a satellite dish antenna at the residence. The Site is managed by Yukon Government, Energy Mines and Resources (EMR), AAM.

The Site does not currently operate under the authority of a water license; however current activities are authorized under a minister's determination issued by the Department of Environment. This document allows AAM, under section 37 (1) of the Yukon *Waters Act, "…to take any reasonable measures to prevent, counteract, mitigate, or remedy any resulting adverse effect on persons, property, or the environment…"*

At this time the tailings pond holds little water, with a small ponds visible on the retained tailings. Staff gauges have been installed in the Tailings Pond and the Seepage Pond with markers on each indicating the maximum operating level for quick visual inspection.

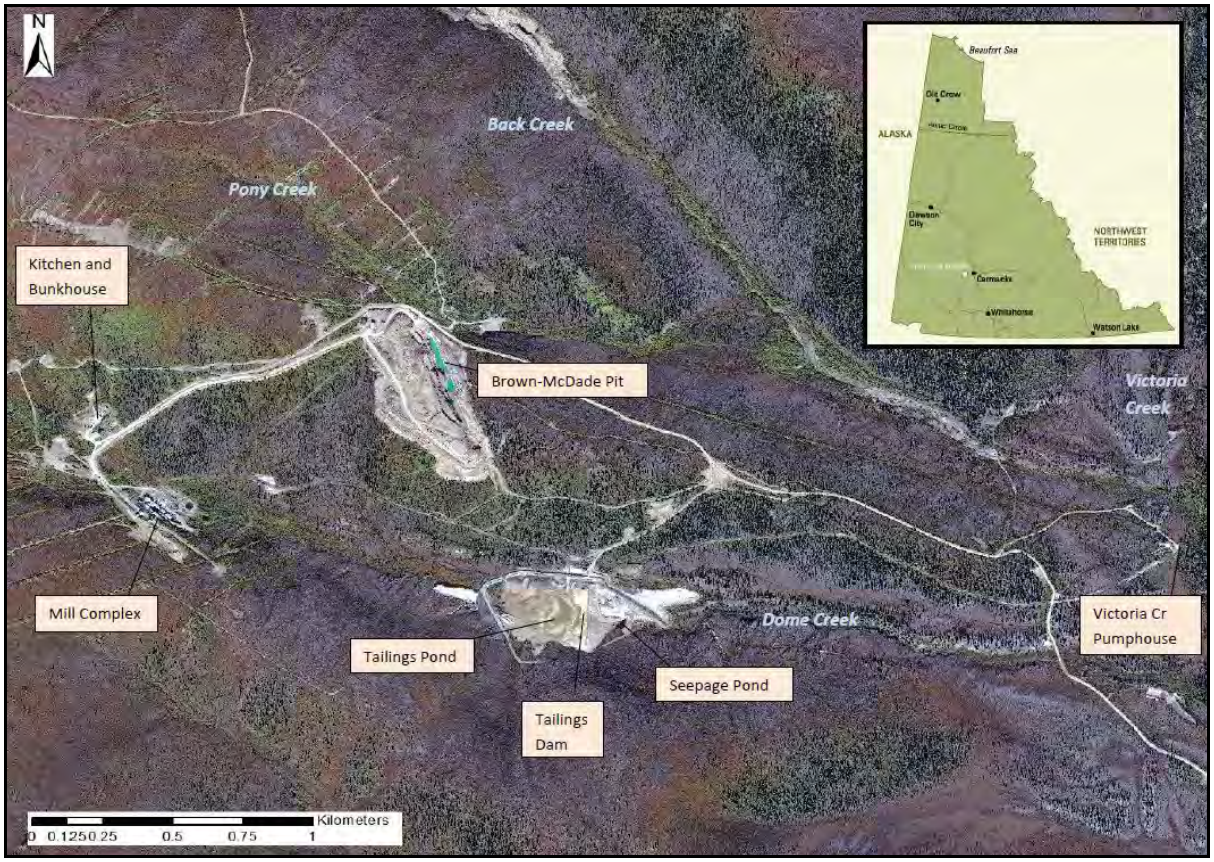

Figure 1 – Mount Nansen Site Layout

There are three major structures associated with the tailings facility at the Mount Nansen Site: the tailings dam, the seepage pond dam and the diversion channel berm/ditch. All of the structures are of prime importance where failure of any of the structures constitutes an emergency that must be addressed through the procedures and processes within the Emergency Response and Preparedness Plan (ERPP).

The facility was designed by Klohn Crippen Consultants Ltd. and was constructed from May through to October, 1996, by Ketza Construction Pacific Ltd. Klohn Crippen also provided construction management. Some questions exist regarding the stability of the dam foundation due to poor construction practice which has rendered the structure more susceptible to degradation due to the presence of permafrost within the area.

The Site is located within the Dome Creek drainage area, which is part of the water shed that leads to the Yukon River; Dome Creek connects to Victoria Creek, which connects to the Nisling River, which connects to the Donjek River, which connects to the White River, which ultimately connects to the Yukon River.

A diversion channel intercepts Dome Creek upstream of the tailings pond and directs the water to release it to the original Dome Creek channel downstream of the seepage pond. All structures were constructed on a permafrost base which is subject to melting.

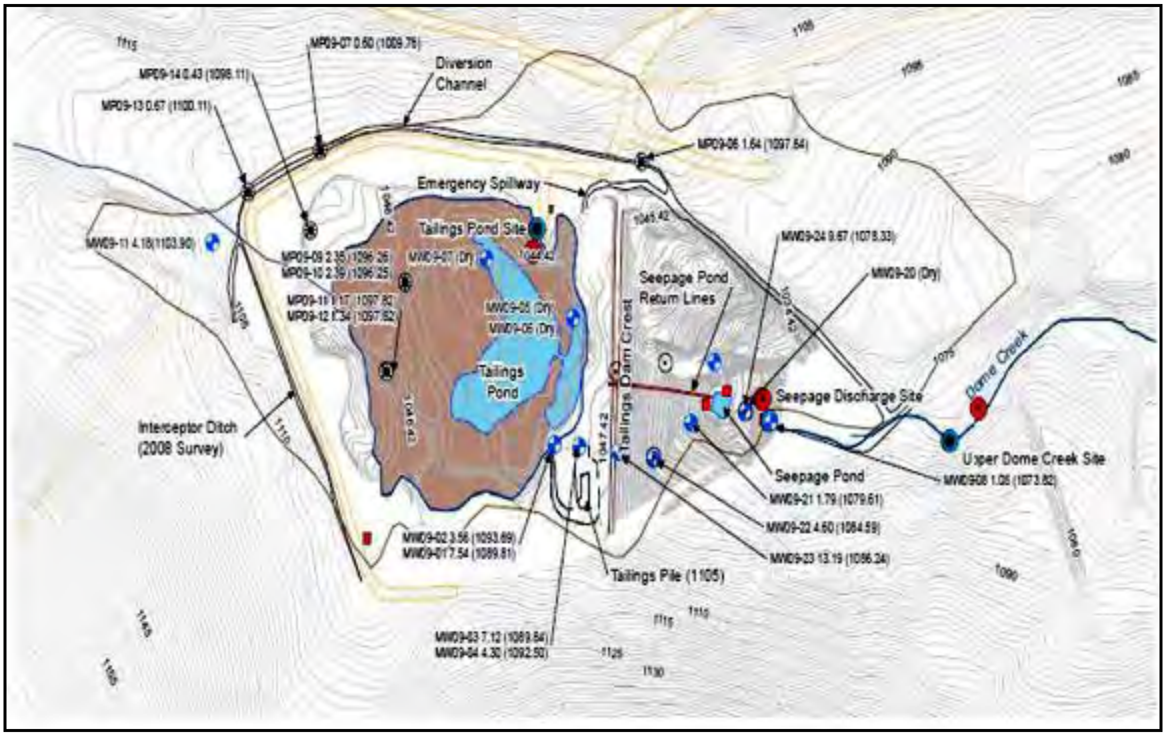

Figure 2 – Water Wells in the Tailings Pond Area

The tailings pond seeps into the seepage pond. Flow that is pumped from the seepage pond is monitored by a flow meter at the pump, and is discharged immediately down gradient of the tailings dam. The flow rate of water from the seepage pond provides a good indication of the possibility of excess seepage from the tailings dam and thus may be a good indicator of failure of the dam subgrade through melting permafrost. The melting permafrost may provide a larger conduit for the flow, and hydraulic conductivity increases with melting because a property of frozen ground is that hydraulic conductivity is very low.

The Site is in a remote location with no nearby year-round residents. Site operations personnel are familiar with the site and conduct daily inspections; therefore they are aware of potential dangers and should there be an emergency they would likely be the first to be aware of it and to take appropriate action (i.e. as per the Emergency Response and Preparedness Plan). Personnel authorized to access the site (i.e. including AAM staff, consultants and contractors) must report to the office prior to entering the Site. Upon entering the Site, all authorized personnel are provided with a site familiarization document, are required to attend the Site operator's site orientation & safety training and sign a liability release form. Authorized personnel are also provided with means of communicating with site operations personnel (i.e. via VHF radio) for check-in purposes and to advise of identified concerns. Access to the Site is restricted to those people who are authorized, as indicated by signs posted around the Site. All non-authorized people are asked to leave by the site operator. The highest risks to human safety in relation to the tailings facility is the area immediately downstream of the tailings dam; although the likelihood of non-authorized people being there is low (i.e. in the case of an emergency) given the site security checks conducted by the site operator throughout the day. Authorized personnel may access this area, although they are aware of the dangers, and should there be any signs or any events that increase the likelihood of an emergency they will be informed to not access this area.

Risks to travellers along the public Mount Nansen Road is low given that Dome Creek intersects this road approximately 1.6 km downstream of the tailings dam and the effects of an emergency are unlikely to extend that far.

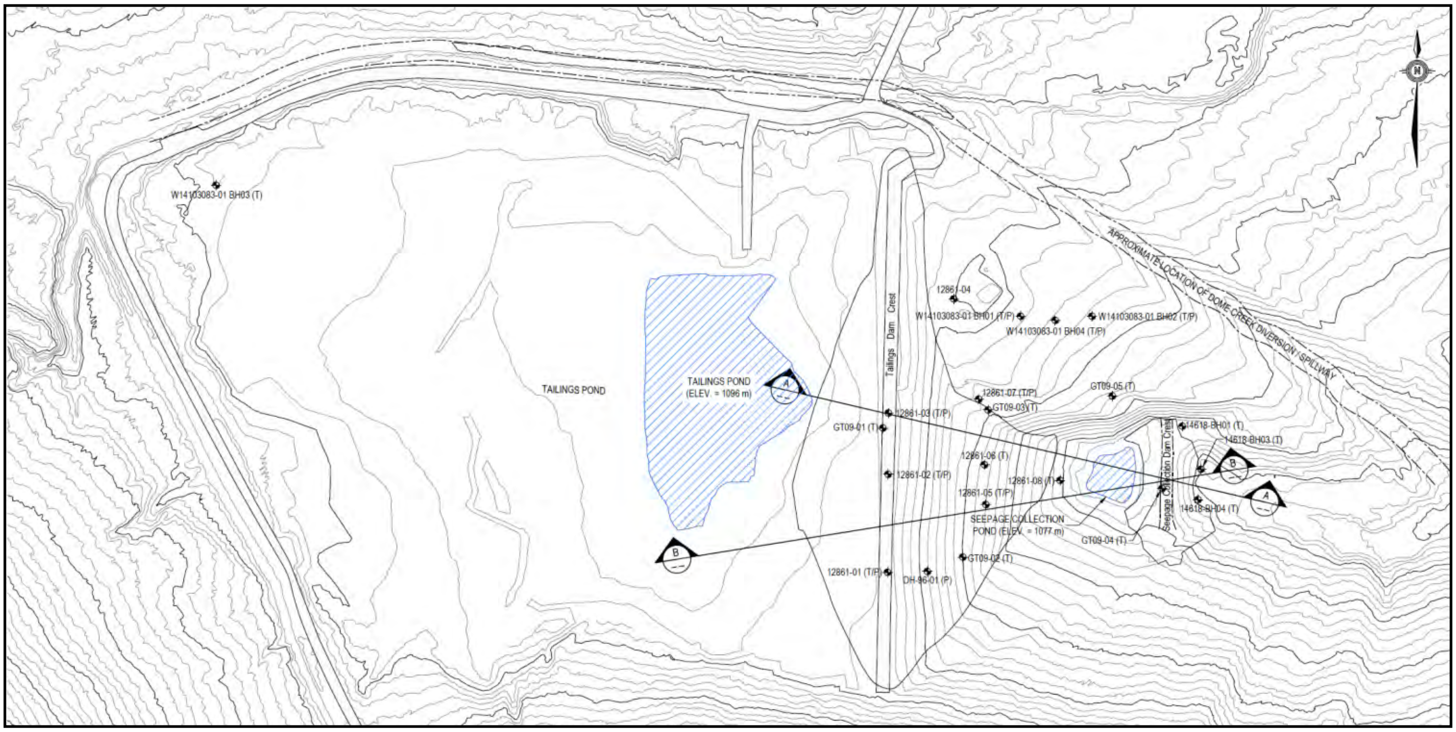

Figure 3 – Tailings Pond Area Instrumentation

2.1. Facility Components

The structures and equipment that currently comprise the water management systems on site are:

- Tailings pond including dam and spillway;
- Seepage pond and dam;
- Dome Creek diversion channel and interceptor ditch;
- Seepage pond pump and associated piping;
- Flow monitoring equipment;
- Access roads and bridge;
- Power supply and backup power supply equipment; and
- Instrumentation.

2.1.1. Tailings Pond, Dam and Spillway

The tailings pond, which was constructed over the summer of 1996, is a mill tailings impoundment area which allowed the collection of all process water and mill effluent including environmentally hazardous materials. Maximum reservoir design elevation is 1,097.8 m above sea level (ASL); recent water elevations have been well below this level.

The tailings impoundment dam is approximately 240 m long and the crest is 6 m wide. The maximum dam height is 18.5 m. The tailings dam is a compacted earth structure that includes a geosynthetic clay liner on the upstream side which extends to elevation 1,098.8 m ASL. The original design volume of the tailings pond was 240,000 m^3. The maximum water elevation for the tailings dam is 1,097.8 m ASL; this is the same elevation as the emergency spillway.

The emergency spillway is a total of 119 m long and was constructed outside the north end of the dam. The grade at construction was -0.1% from 55 m upstream of centerline of the tailings dam (intake) to 50 m downstream of centerline. Intake elevation or maximum reservoir elevation is 1,097.8 m ASL and the exit invert elevation (i.e. at the end of the diversion channel) is 1,067.1 m ASL.

Summary of Design and Operating Elevations		
Mount Nansen Tailings Facility, YT		
Tailings Dam:		
Crest of Dam (m)		1099.6
Top of Geocomposite Liner (m)		1098.8
Emergency Spillway Invert (m)		1097.8
Maximum Operating Level (m)		1097.8
Water Level May 25/12 (m)		1096.0
	Actual Freeboard (m)	3.6
	Below Max. Operating Level (m)	1.8
Seepage Collection Dam:		
Crest of Dam		1079.1
Top of 38 mil Arctic Liner		1078.7
Maximum Operating Level		1078.1
Water Level May 25/12		1077.5
	Actual Freeboard (m)	1.6
	Below Max. Operating Level (m)	0.6

Figure 4 – Design and Operating Elevations

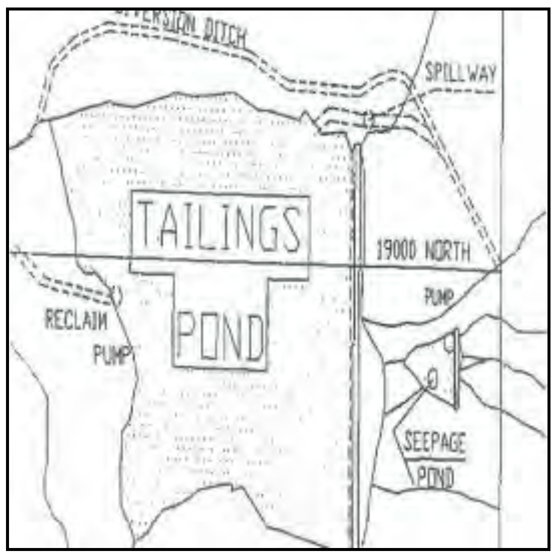

Figure 5 – Plan view of tailings facility at construction

2.1.2. Seepage Control Dam

The seepage control dam is approximately 50 m long; the crest elevation is at 1,079.1 m ASL and has a crest width of 7 m. Maximum safe water elevation for this dam is 1 m below the crest at 1,078.1 m ASL. The seepage collection dam was reconstructed in 2000 and contains a frozen key trench stabilized by two thermosyphons that were installed parallel to the dam centerline.

2.1.3. Diversion Channel/Interceptor Ditch

The diversion channel and interceptor ditch system is located within the Dome Creek watershed. Dome Creek flows into the system from the north past the mill area. The creek is diverted around the tailings dam by an excavated channel which starts at the north-western side of the tailings pond, follows the northern embankment of the dam, and reconnects to Dome Creek downstream of the seepage control dam. The diversion channel and the emergency spillway share a channel for the last 290 m. The grade to the intersection with the spillway was - 0.1% when constructed. The channel was originally lined with 300 mm of < 75 mm screened gravel; however, various maintenance activities have disturbed the screened gravels and their presence is not currently obvious. The diversion channel requires silt to be cleaned out on a regular basis in the summer and fall and ice to be removed as it tends to build up during the winter. Both silt and ice restrict water flow.

2.1.4. Seepage Pond

The seepage pond was constructed in 1996 as a part of the overall construction project. The structure was reconstructed in 2000 and thermosyphons were added to the dam structure to maintain permafrost. The purpose of the pond is to intercept any water that seeps under the tailing dam. The seepage pond protects the tailings pond by removing the water seeping under the dam. In the event that pumping was to stop, the seepage pond dam would likely wash out potentially resulting in failure of the tailings dam.

Water is decanted by an electric powered pumping system that transfers the water from the pond to the original Dome Creek channel downstream of the pond. The pumping system is located within a small pump-house located over top of a vertical culvert type sump within the pond. Flow is regulated by the site operations personnel using a simple system of bypass valves.

The importance of the pumping process demands that backup pumping system be in place. Mount Nansen provides backup pumping in three different ways to ensure that water level is not exceeded: a gas powered portable pump, a portable generator (i.e. as an alternate source of power for the current pump), an electrical powered pump, and a syphon system.

2.1.5. Flow Monitoring Equipment

Effluent flow from the seepage pond is monitored through an inline flow measuring instrument that is located within the pump-house. Diversion channel flows are measured as part of the hydrometric program.

2.1.6. Access Roads and Bridge

The access road to the tailings facility approaches from the north side of the valley from two sources; the Mount Nansen public road and a route which passes along the Brown-McDade Pit. Where the road crosses the diversion channel a bridge is used. The bridge is approximately 9 m long and is constructed of a wood deck over steel beams that rest on cement lock blocks at both ends. The bridge was rehabilitated in 2011.

2.1.7. Power Supply and Associated Infrastructure

The entire site is powered by three diesel-fuelled generators located in steel sea can type structures near the mill. Electricity is generated at 480 volts and transformed up to 4160 volts for distribution around the Site. Each of the generators has the capacity to power the Site on their own. Distribution consists of overhead lines and transformers at various drop points.

2.1.8. Instrumentation

Conditions around the site are monitored by the instrumentation installed within the dams and the surrounding area. Instrumentation includes thermistors, piezometers and monitoring stations.

2.2. Communication

Satellite, internet, cellular and VHF radio communications systems have been established at the site. The VHF system does not have the range to provide communication outside the general area and is only used on-site. Telephone service is provided through cellular phone communication (CDMA cell phones only). Satellite telephones are used as an emergency backup. Internet can also be used to communicate although its reliability may be an issue.

2.3. Site Access Routes

Site access is provided by the Mount Nansen Road from Carmacks. There are two access routes to access the tailings facility, one from the mill and camp site and the other from the Mount Nansen road approximately 2 km from the mill and camp.

2.4. Public Safety

The site operator is responsible for the safety of all authorized personnel on-site. All Yukon Workers' Compensation and Health and Safety rules are adhered to and authorized personnel are equipped with the appropriate safety gear. The general public is not allowed on site and will be turned away as part of the site security provisions.

2.5. Site Security

Site access is restricted to only those authorized; unauthorized people are informed to leave site. The site operator provides security services by patrolling the site regularly and administering safety and security processes. Upon entering the Site, all authorized personnel are provided with a site familiarization document, are required to attend the site operator's site orientation & safety training and sign a liability release form.

2.6. Water Quality & Monitoring

The site operator provides monthly water sampling and analysis from the seepage pond. The water monitoring wells are monitored on a yearly basis. Results are reported to AAM in the monthly report; AAM reviews them and assesses whether further action should be taken.

3. Operation

3.1. Roles and Responsibilities

The site operator is responsible for his and any other authorized personnel on site (i.e. includes site operations staff and management personnel, AAM personnel, contractors, and consultants). Reporting is provided to AAM.

The site operator is responsible for all on site operations including making immediate decisions required during an emergency, as well as ensuring all documentation is up to date and all procedures of the OMS Manual are followed. The site operator provides all services with respect to the Site Operations Manual and his contract.

AAM is responsible to ensure that the site operator has adequate information and training to allow for good decision making, and provides management and oversight of the facility. AAM is also responsible ensuring that the site operator follows the terms of the contract including all requirements of the OMS Manual and other manuals. AAM is the first line of communication in the case of an unusual event and is responsible for further communications outside the area immediately affected by the emergency. Figure 6 below illustrates the reporting process.

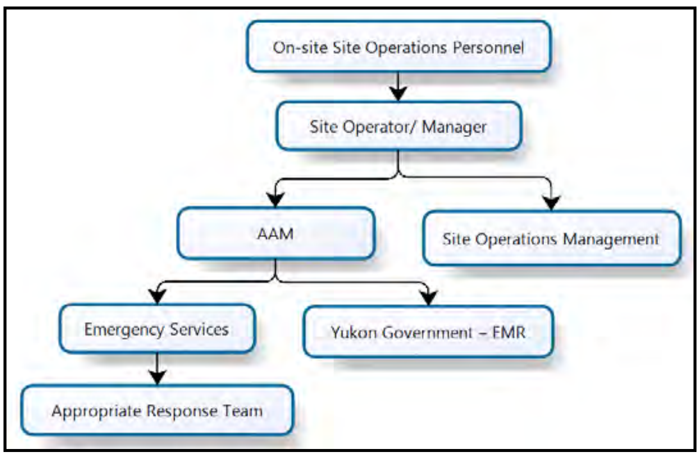

Figure 6 – Reporting Flow Chart

3.2. Training

AAM will provide a workshop for on-site personnel to whom the OMS Manual is relevant. The workshop will cover the contents of the OMS Manual, focusing on operational aspects of the seepage pumping system, dams and diversions, the thermistors and piezometers, as well as surveillance techniques. All on-site personnel must attend this workshop and any change in personnel will require that the incoming individual attend a subsequent workshop.

3.3. Water Management/ Flow Control

Three sources of water are managed at the Mount Nansen Site; that from Dome Creek, which is directed around the tailings facility by the diversion channel, the seepage pond and the tailings pond. The management of these waters is critical due to the erosional susceptibility of the tailings facility components (i.e. sand) where excessive rainfall and melting conditions heighten the water management requirements. Inadequate water management could lead to the functional failure of facility components (e.g. north abutment, dam crest, and dam toe).

Feature	Length(m)
Spillway	119
Interceptor Ditch	323
Diversion Channel	785
Dam Crest	240

Figure 7 – Approximate Feature Lengths

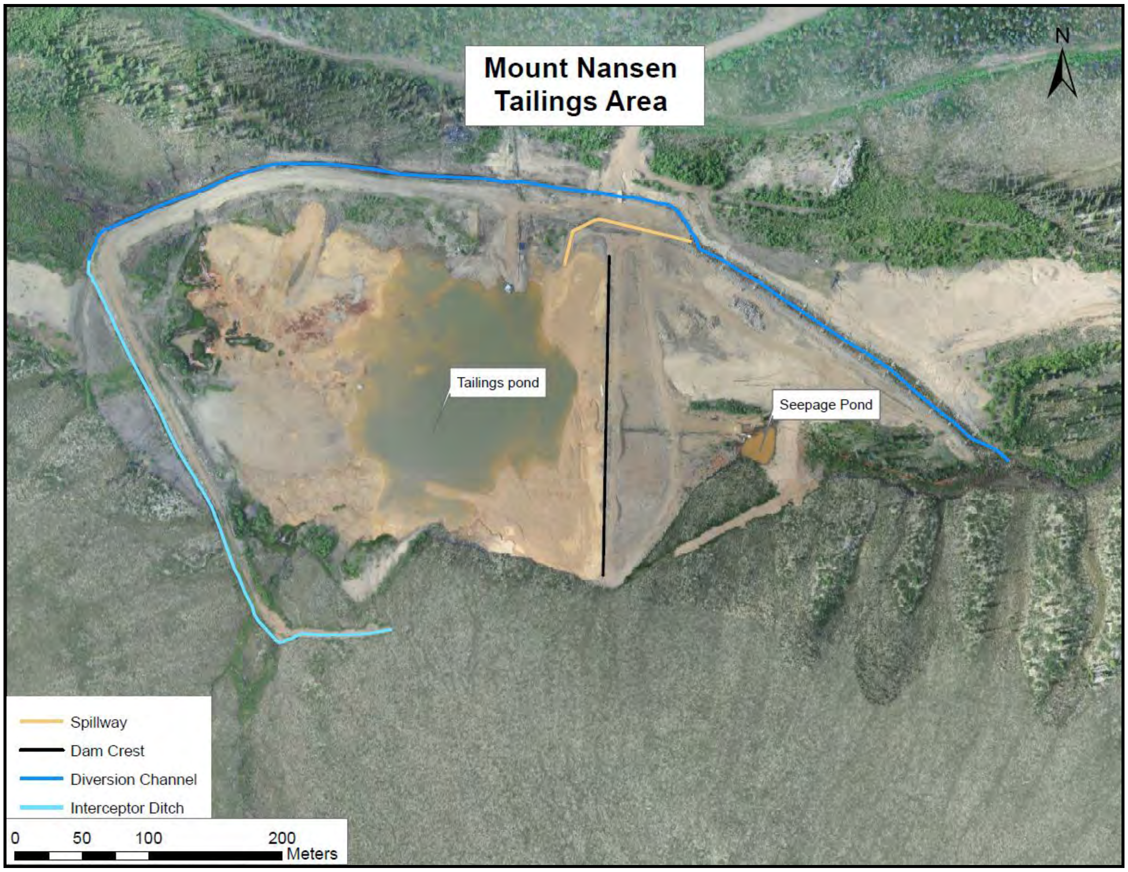

Figure 8 – Tailings Facility Water Management Features

3.3.1. Diversion Channel/ Interceptor Ditch

The diversion channel diverts water which originates from the portion of the Dome Creek watershed upstream of the tailings facility and includes water intercepted from the south west of the facility (i.e. from the interception ditch). The interception ditch starts at the south west point of the facility and ends at the northwest corner; the diversion channel begins at the end of the interception ditch and continues until its confluence with the seepage pond outflow. The interception ditch intercepts water from around the south west side of the pond.

Flow in the diversion channel fluctuates seasonally and with precipitation events. This is not regulated other than management of the blockages in the channel.

The diversion channel requires monitoring of silt deposition (i.e. through inspections) during the summer and ice buildup during winter, particularly along the section from the start of the spillway confluence of Dome Creek to the intersection with the spillway. Anomalies and observations must be recorded in the daily report. Silt buildup interrupts flow by reducing the grade of the channel between the Dome Creek confluence and the bridge. Silts are to be monitored and removed in the spring and fall or whenever the volume of deposition has an effect on the flow. Reduction in the velocity of flow will result in further deposition of bed-load as well as a higher likelihood of freezing the bottom of the channel and thus the buildup of Aufeis.

Ice buildup is a significant problem during freezing temperatures due to the presence of Aufeis. Aufeis builds when surface flow freezes in successive layers. If the Aufeis builds to the level of the berm along the diversion channel it is likely to result in water overtopping and eroding the berm. The berm is constructed of sandy material and is subject to very rapid erosion. Erosion of the berm could result in failure of the berm and the direction of water towards the tailings pond. The tailings are known to contain hazardous materials such as arsenic, which could contaminate water downstream. If this remains unchecked it is possible that the pond fills with water and releases the potentially contaminated water to the environment through the spillway. Although this scenario is unlikely due to volume capacity available within the pond to capture water; this provides some time to mobilize equipment to reduce the pond level before it reaches maximum safe water level in the pond (1,097.8 m ASL). The amount of time available is dependent on the volume of water flowing into the pond. It is unlikely that the dam could overtop given current conditions; unless the spillway were blocked and a large amount of water were to enter the pond.

3.3.2. Seepage Pond

Water flow is measured by the flow meter in the piping system at the seepage pond. Flow is recorded daily and pump water flow is adjusted as required to maintain pond equilibrium. Measurements are entered into the database and reported to AAM in the weekly report. Anomalies in flow volumes such as spikes or gradual increases or decreases must be noted and immediately reported to the site operator. This information must be passed to AAM immediately for assessment and resulting action.

Flow from the seepage pond is regulated through a series of valves within the pumping system. The valves are adjusted when needed to maintain the level of the pond. To reduce the flow from the pond a bypass valve is opened and the flow through valve is closed. The procedure is reversed if the pond level is observed to be rising.

A staff gauge has been installed in the seepage pond; this gauge is read daily and the readings are included in the weekly report to AAM.

Although the Mount Nansen Site does not currently operate under any licence, water samples are taken monthly and analyzed for compliance with the discharge parameters of the previous water licence. In the event that a sample does not meet the criteria the water may be pumped back to the tailings pond until it meets release requirements. The water analysis results, once available, are immediately reported to AAM for discussion and follow up. Water has been treated in the past, however it has met discharge criteria since 2004 and therefore no treatment has been required or has taken place since that time.

3.3.3. Tailings Pond

The tailings pond provides a source of water to the seepage pond through seeps upstream. The tailings pond does not receive direct surface water, although it acts as the confluence for a multitude of underground sources which collect in the tailings pond. Inflows include precipitation and subsurface flow input from the surrounding terrain. Tailing pond levels have remained consistent over the past several years and appear to have reached equilibrium through evaporation and seepage. Thus, it appears to remain consistent through makeup by ground water and precipitation, evaporation and dissipation through the seepage pond.

A staff gauge has been installed in the tailings pond; this gauge is read daily and the readings are included in the weekly report to AAM.

3.4. Operating Procedures

3.4.1. Normal Operations

Flow volumes within the expected levels are what are considered normal operation conditions. During those periods the above discussed processes shall be followed. These include the twice-daily inspections of all tailings and water management facilities and data recording. Seepage and tailings pond water level and flow monitoring will be required as indicated, along with adjustment of pump flow volumes through the valve system in the seepage pond pump house.

3.4.2. Flood or Drought Operations

Flood or drought operation conditions occur when recorded flow volumes lie outside the expected range indicated by the trend of data previously recorded by AAM and its consultants. In the event of a flood or drought situation, flow volumes, water levels and observed abnormal events must be recorded more frequently for reporting to AAM.

The seepage dam is not equipped with an overflow structure; therefore it is critical that water is pumped down, with heightened effort applied during abnormally high flow conditions. An overtopping event must be avoided as this will likely erode the dam and cause damage to the thermosyphon system, which would have negative consequences for tailings dam stability, and would be very expensive and time consuming to repair. In the event of an unexpected rise in the water elevation at the seepage pond the following steps should be taken:

1. The decant pump flow must be increased to full flow volume of water.
2. The backup pumping systems must be set up and started.
3. In the event that the backup pumping systems are not able to maintain the water level and an overtopping event is imminent, a controlled release may be possible with the assistance of heavy equipment.

4. If a release occurs, the on-site personnel must monitor the length of time the release occurs, take photographs, and attempt to estimate the velocity and volume of the water. If it is possible a water sample should be collected. AAM will submit this information to the regulatory authorities.

3.4.3. Emergency Operations

Some conditions which may lead to a failure of systems and structures and/or which could constitute an emergency include but is not limited to:

- Failure of a major structure such as the diversion channel berm, tailing or seepage dam;
- Failure of major equipment such as electrical generating equipment or pumping equipment;
- Slope failure having the potential to cause dam or berm failure;
- Blockage of the diversion channel which may cause the berm to fail;
- Sudden increase in seep volume occurrences which could lead to dam failure;
- Rapid increase or unexplained cloudy appearance of seepage water;
- Natural disasters such as earthquakes or high precipitation events; and
- Potential environmental contamination such as contaminated water at discharge, contaminated water seeps or tailings entering water courses (e.g. if sampled water suddenly becomes contaminated and does not meet the release threshold).

In the event of an emergency the site operator must immediately follow the instructions in the ERPP. The ERPP is at designated locations on site and is to be kept immediately available to personnel. All personnel are to be familiar with the plan.

3.4.4. Unusual Operations

Unusual operations are those that fall outside the expected levels of what is being monitored. This could include abnormal either high or low flows of water, abnormal movement or changes in physical conditions or any condition which could cause an abnormal condition (i.e. a weather pattern or an event on site). Identification of an unusual condition may require some knowledge of the site and normal operating conditions.

Failure of any of the systems on site such as power supply, pumping or other critical activity processes would also be considered unusual conditions. In the event of an unusual condition the operator shall first advise AAM of the current or impending circumstance. The operator will be required to monitor the condition very closely and may be asked to take action.

3.4.5. Records (Logs)

Site operations include monthly data collection from 8 piezometer locations and 19 thermistor locations (note some are piezometer/ thermistor combined locations). The Site Operations Manual includes a detailed procedure on reading the instruments as well as a map of the location of each instrument. Data is recorded and submitted to AAM with the site monthly report. AAM maintains a database that is updated upon receipt of new data. The data is provided to a geotechnical engineer once a year for review and analysis. Examples of data recorded include flow (twice daily), water elevations (daily) and an entire visual site inspection (twice daily).

3.5. Control Systems

3.5.1. Supervisory Control Systems

A variety of control systems have been put in place to allow the site operator to monitor conditions. Both the site operator and AAM will monitor the readings and assess any irregularities that may become apparent.

Supervisory controls include:

- Staff gauges in ponds including high water level marking;
- Monthly calibrations of seepage flow meter;
- Weather station data recording;
- Flow monitors;
- Activity records;
- Site security (24 hours a day, 365 days a year)
- Health and safety records;
- Water sampling activities;
- Fuel usage;
- System maintenance records; and
- Records of inspection tours.

3.5.2. Emergency Control Systems

In the event of an unusual condition that could turn into an emergency, critical equipment may require alternate systems to ensure continued operation and aversion of a disaster. These systems must be maintained and available to the site operator at all times. The seepage pond pumping system has backup systems in place to ensure that the pond is maintained at the appropriate level.

The backup systems for this facility include:

- Gas powered pump that is prepared for quick connection to system;
- Gas powered generator to power existing or alternate pump;
- Electrical powered sump pump;
- Syphon system;
- Power failure alarm; and
- Heavy equipment and personnel available 24 hours per day.

4. Maintenance

Maintenance of site facilities is critical for its safe and continuous operation as well as to ensure the integrity of the site components. The objectives of the maintenance program are to review and identify maintenance requirements, execute corrective measures, and repair all facility components as required.

4.1. Dams, Spillway and Diversion Channel

Erosion and settlement of the embankments of the dam could occur; however as this occurs it should be repaired. Rain, thaw and wear can all contribute to erosion, and thaw of underlying permafrost can result in some settlement. Minor settlement areas are maintenance issues and should be identified and resolved as these may become bigger problems pending the location and depth of the settlement. Settlements on the dam surface cause issues when rain pools on the surface and water infiltrates the dam structure. Any new or previously unnoticed depressions on the surface of the dam or any other structure must be recorded, photographed and measured. This is especially critical in the Mount Nansen location due to the underlying permafrost. In the event of permafrost degradation, there is a possibility of “piping” to occur within the structure. Piping would be particularly hazardous to the stability of the dam because any water passing through the foundation will result in further melting of the permafrost, eventually causing catastrophic failure. Depressions in the surface of any structure should be investigated to determine the cause and then repaired. If the depression turns out to be caused by a subsurface failure it will require further investigation to determine the cause and the repairs required. AAM should be notified immediately and an engineering consultant should be contacted to review the situation and site documentation in order to determine a plan of action.

The berm along the diversion channel is subject to settlement and as such is exposed to overtopping at low spots. Settlement of the berm lowers the effective level of the berm, which reduces the capacity for ice buildup. Ice buildup will cause the diversion channel to lose capacity and thus increase the possibility of overtopping the berm. Settlement along the berm should be noted and AAM should be informed; a plan for repair should be developed and implemented. Overtopping the berm would cause erosion and result in water entering the tailing pond. An overtopping event could result in erosion of critical portions of the tailings dam and eventual failure of the dam. This event must be avoided.

If fresh erosion channels on any surface are observed, AAM should be notified immediately. A plan for repairs required should be developed and implemented quickly to prevent further concentration of water in that location. The source of water creating erosion should also be investigated and corrected.

Silt and ice should be removed regularly to maintain the channel flow. Materials removed from the channel shall be placed into the tailings pond rather than to the north side of the bank. It is important that the ice under the bridge be removed before the ice level reduces the clearance between the bridge and the ice.

Drawdown of the seepage pond should occur on a yearly basis to assess the buildup of solids on the bottom of the pond and identify and monitor the seeps of water flowing into the pond. This activity should be coordinated with the geotechnical engineer.

The emergency spillway must be kept clear of ice. Materials removed from this area are to be pushed to the east so as to be out of the way.

Vegetation growth should be controlled on the surface of the dams. Plants need to be removed before the root systems have an opportunity to penetrate into the dam structure. This should be completed every year before the plants go to seed.

Burrowing animals can present a problem to a dam's integrity in that they can create holes and tunnels within the structure. These animals should be discouraged or removed from the dam as soon as the presence is obvious.

4.2. Flow Measurement Equipment

The seepage pond is equipped with a flow meter within the pumping system. It is important that the flow meter operate properly because it provides the main data by which seepage from the tailing dam is monitored. The meter is battery powered with an internal charging system powered by the impeller so no outside power source is required.

Flow should be checked monthly at the outlet of the pipe to verify that the flow meter is providing accurate data. This is done by placing a quantified bucket (i.e. buckets holding capacity is known) under the outlet of the hose and timing how long it takes to fill it. The capacity of the bucket divided by the length of time to fill it provides a flow measurement. Due to uncertainty and inaccuracy, the process should be repeated 5 times and the average number used to assess the flow. This number should be compared to the values shown by the flow meter to determine accuracy of the meter.

Precipitate can build up on the vanes of the impeller resulting in a lower flow indication by the meter. This can be confirmed by removing the meter from the system and visually verifying buildup on the impeller. Some cleaning of the impeller may be required; however care must be taken to ensure the impeller is not damaged. The flow meter may need to be sent to the manufacturer for repairs if the buildup is significant. In the event that the flow meter stops working it is likely that the impeller has been stopped by a foreign object. In this case, the meter must be removed from the system and the object removed from the impeller. Care must be taken when re-assembling the system that the gaskets are clean and placed correctly to prevent water leaks.

4.3. Pumping and Piping System

The pump at the seepage pond is an electric powered unit that is located on the floor of the seepage pond pumphouse. Water is drawn approximately 2 m up from the water surface, pumped through an assortment of valves and the flow meter, finally discharging immediately downstream of the seepage pond dam. The piping is subject to precipitate buildup and therefore sections must be replaced with cleaned sections on a regular basis. Cleaning is achieved by shaking previously replaced dry pipes by hand in order to dislodge the buildup; the pipes are PVC, so they flex easily. In the event that cleaning is not complete it may be necessary to dispose of that section of pipe.

4.4. Roads and Bridge

Roads must be kept in a condition which allows access to all areas of the site by heavy equipment as well as maintenance and emergency vehicles. It is important to ensure that ditches remain clean, erosion damage is repaired and the surface remains smooth for traveling. Winter maintenance requires that snow be plowed, any ice buildup be removed and roads sanded where the surface becomes slippery.

The bridge across the diversion channel provides all season access to the main components of the tailings facility and as such is a critical component of the infrastructure on site. Steam pipes have been installed under the bridge to reduce ice buildup. The ice must be removed before freeboard under the bridge reaches one meter. This is achieved by hooking the on-site steamer to the steam pipes and running the steamer until the ice is sufficiently reduced and water flow occurs at the bottom of the channel. Alternative methods of ice removal include excavating by hand with a pick and shovels, cutting the ice with a steamer or heating the area under the bridge with a space heater.

Snow must not be allowed to build up on the surface of the bridge. This can be removed with the on-site snowplow or by hand. Care must be taken not to damage the bridge components when plowing snow. The signs at each end of the bridge are particularly fragile and should be repaired as soon as convenient if damaged.

4.5. Power Supply and Distribution System

The likelihood of a failure of any part of the system is much reduced by the maintenance measures in place and the available backup systems. The Site Operations Manual outlines electrical generator maintenance schedules and switch out procedures.

The electrical distribution system consists of several kilometers of overhead power line as well as a variety of transformers, breakers and switching systems. Power is generated by three diesel powered electrical generators located near the mill facility. Each one of the generators is capable of operating the site. The generators are switched out at maintenance intervals. The daily site tour should monitor the electrical distribution facilities and note any irregularities that may be apparent.

Specific conditions to look for include:

- Excessive heat from any connection or transformer;
- Smoke or other vapour from any part of the system;
- Trees or obstructions crossing the lines;
- Abnormal events around any electrical object; and

- Operational failure of any part of the system.

AAM should be advised in the event of any of these conditions.

5. Surveillance

The principal objective of the Mount Nansen surveillance program is to identify any conditions of concern (i.e. which could compromise the integrity of the structure) prior to becoming a problem. Early identification of those conditions allows them to be addressed in a timely manner.

The program focuses on three areas of interest:

1. Stability and deformation of the embankments.
2. Thermal conditions within the seepage and tailings dams.
3. The quantity and quality of the seepage from the tailings and seepage dams.

Regular visual monitoring is critical to identify potential problems with the earth structures. Visual inspections should be completed on both the structures and the surrounding landforms. Inspections are broken into two categories; operational and formal.

5.1. Operational Inspections

It is important for the site operations personnel to be familiar with the structures and any conditions that may change over time. Operational inspections are performed twice daily by site operations personnel. The purpose of the inspection is to identify any changes in the condition of the structure that may have an effect on its performance or may signal its deterioration (e.g. settlement, seeps, etc.). If a condition is deemed to be serious, AAM shall be notified and a qualified geotechnical engineer will be brought to site to inspect the structure. Site operations personnel will be trained in the identification of hazardous conditions and will provide details of any changes in site conditions to AAM upon observation. Observations made during the inspection will be recorded, photographed and measured prior to notification. Previously identified conditions will be recorded, photographed and measured on a weekly basis to identify changes in the condition and will be forwarded to AAM for analysis by a qualified geotechnical engineer.

5.2. Formal Inspections

5.2.1. Formal Dam Safety Review

The most recent formal dam safety review assessment was completed in 2002 and the next inspection is scheduled to be completed in 2013. Formal reviews are generally completed at ten year intervals. The review consists of a full assessment of the site by a qualified and experienced geotechnical engineer. A report is generated with recommendations for management and maintenance of the facility.

5.2.2. Bi-Annual Review

Bi-Annual review of the data collected on site should be completed by a qualified geotechnical engineer familiar with the site. AAM should make the following data available to the engineer:

1. Thermal data
2. Piezometric data
3. Flow data
4. Water elevation data
5. Water quality data
6. Observations

Concerns resulting from the annual review should be addressed by a visit to site and a detailed inspection. Bi-annual inspection by geotechnical engineer is conducted every year around freshet and prior to winter. Structures are visually inspected and a report is issued detailing the observations and actions required when applicable. It should be noted that Mount Nansen tailings facility is currently not classified.

5.2.3. Daily Inspections

These are carried out daily and assess daily changes and monitor the conditions at the facility on a daily basis. Weekly reports are submitted to AAM who review the data and other information collected for consistency and unusual changes. A daily inspection form is included in Appendix A outlining the details of the daily observations.

5.3. Dam Instrumentation

Thermistors and piezometers have been installed in the tailings and seepage dams to monitor ground temperatures and pore-water pressure within these structures. Figure 3 indicates the locations and type of monitoring instruments. Temperature and pore-water pressure readings are collected monthly by site operations personnel. In addition, a full set of readings will be taken during the formal geotechnical inspection. All personnel who are assigned to read the thermistors and piezometers must be suitably trained.

5.4. Response to Changing Conditions

Twice daily inspections are intended to provide consistent surveillance of the site with any changing conditions noted and discussed in the daily report. In the event of a change in conditions that could have a short-term effect on the functionality of the dam, it is important to make AAM aware of the situation immediately.

Some potential conditions that may be considered of immediate concern are as follows:

- Water flow increase;
- Increase in water elevation;
- Seeps;
- Blockage within the diversion;
- Large settlement or subsidence of the dam crest or slopes;

- Cracks in the dam crest or slopes;
- Bulging on the downstream slope;
- Sinkhole on the crest, slope or tailings beach;
- Surface erosion, animal burrows or unusual vegetation patterns on the dam;
- Changes in seepage conditions on the downstream slope or at the toe of the dam. This includes seepage rates, changes in coloration of seepage water or suspended solids, from either seepage exiting on the slopes or from the abutments;
- Ruptures, leaks or large settlement in any pipeline particularly near the dam;
- Presence of suspended solids or siltation;
- Erosion of the diversion channels or spillways;
- Excessive seepage losses through the diversion ditches into the impoundment; and
- Changes in alignment of power poles, and pipelines.

When a change in condition is observed and reported it is imperative that the condition not be repaired prior to the geotechnical engineer's review of the location.

5.5. Documentation and Follow-up

The collation and analysis of operation, maintenance, and surveillance data will be shared between AAM and an engineering consultant retained by AAM. The site operator is responsible for performing and documenting operational inspections as well as collecting seepage flow, ground temperature and pore-water data. The consultant will review the information during the formal geotechnical inspection or more frequently if required. AAM will enter the ground temperature, piezometer, flow, and observations data collected by the site operator into a database. Plots of the ground temperature data will be generated as part of the formal geotechnical inspection process.

References

- Canadian Dam Association, Dam Safety Guidelines 2007.
- Mount Nansen Operations and Maintenance Manual, Government of Yukon, Energy Mines and Resources, Assessment and Abandoned Mines, Version 1.2, November 30, 2012.
- Mount Nansen Summary Data Report, Department of Indian Affairs and Northern Development, Whitehorse, Yukon. EBA Engineering Consultants, September 2002.
- Construction Report, Mount Nansen Seepage Control Dike and Spillway Upgrading, Department of Indian Affairs and Northern Development, Whitehorse, Yukon, EBA Engineering Consultants, March, 2003.
- Dam Safety Assessment Mount Nansen Tailings Facility Near Carmacks, EBA Engineering Consultants, May, 2002.
- Mount Nansen Tailings Facility Construction Report May to October 1996, Klohn Crippen Consultants Ltd., December 12, 1996.
- 2011 Geotechnical Inspection of Earth Structures Mount Nansen Mine, EBA A Tetratech Company, March 13, 2012.

Appendices

Appendix A: Daily Inspection Form

Feature	Item	Repairs	Comments
Access Roads	Ice/Snow Buildup		
	Ditches Clear of Debris		
	Erosion		
Bridge	Surface is Clear of Snow/Ice		
	Ice Buildup Under		
Diversion Channel	Ice/Silt Buildup		
	Flow Condition		
	Berm Condition		
	Freeboard		
Spillway	Ice/ Sediment Blockage		
	Freeboard		
Tailings Dam	Erosion		
	Depressions		
	Slumping		
	Seeps		
	Animals		
	Vegetation		
Tailings Pond	Water Elevation Staff Gauge		
	Seeps		
	Unusual Observations		
	Water Color (i.e. suspended sediment)		

Feature	Item	Repairs	Comments
Seepage Dam	Erosion		
	Depressions		
	Slumping		
	Seeps		
	Animals		
Seepage Pond	Access		
	Pump		
	Flow		
	Electrical		
	Water Elevation Staff Gauge		
	Seeps		
	Water Color (i.e. suspended sediment)		
	Unusual Observations		
Electrical	Heat		
	Smoke		
	Operating		
	Obstructions		
	Lines		
Generators	Operation		
	Maintenance		
Security	Trespassers		