MEMO

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Subject	**Mount Nansen Remediation Project** **Data Gap Analysis**		

1.0 INTRODUCTION

AMEC Environment and Infrastructure, in association with Associated Engineering, has been retained by the Yukon Government, Department of Energy, Mines and Resources - Assessment and Abandoned Mines (AAM) to carry out the detailed design of the Mount Nansen Remediation Project (MNRP). Early design tasks for the MNRP were authorized under Task Authorizations AMEC-001 and AMEC-002 and included the preparation of three memorandums: a data gap analysis, a site investigation (SI) plan to address the data gaps, and a Design Basis Memorandum (DBM) for design.

This memorandum presents the results of the data gap analysis based on the project reports provided by AAM and information and understanding gained through a site visit and kickoff meeting between the design team and the project partners held in Whitehorse on 10 and 11 April 2013.

2.0 PROJECT OVERVIEW

Mount Nansen has been the site of mining exploration activity and/or active mining since the 1940s. The most extensive stage of mining occurred between November 1996 and February 1999 in the Brown-McDade Open Pit. It involved construction of the existing tailings dam and deposition of approximately 300,000 m^3 of tailings (LORAX 2011) within the tailings impoundment. A waste rock storage area containing approximately 500,000 m^3 of waste rock (Altura, R73 2009) was also created adjacent to the Brown-McDade Open Pit. Earlier periods of mining contributed to smaller amounts of tailings, some of which are still present near the mill site, and localized zones of waste rock at the mill site and elsewhere on the site. Other site infrastructure includes the mill and camp facilities as well as various ancillary structures, power lines and pipelines.

In 1999, mining was halted because it was no longer economical, and sulphide ore was being mined in contravention of the water licence. The company operating the Mount Nansen property was put into receivership in March 1999. By September 1999, the appointed receiver-manager abandoned the project and the property reverted to government control. The site is now managed by AAM. In 2000, Strathcona Mineral Services Limited completed a review of the Mount Nansen site and concluded that there was nothing of economic interest and that the site should be remediated.

In support of site remediation, many studies and investigations have been carried out over the past decade to define the closure objectives and to explore various closure options. Detailed discussion of the closure objectives can be found in Yukon Government 2008 and SRK 2011. Generally, the key overall goal of the project is to remediate the site to reflect its original form, traditional and pre-mining land use, and natural appearance in a way that protects both human health and safety and the environment in a cost effective manner.

The final remediation alternatives study (LORAX 2011) presented technical information regarding four remediation options. The options were evaluated by representatives of Yukon Government, Aboriginal Affairs and Northern Development Canada (AANDC) and Little Salmon / Carmacks First Nation (LSCFN). Option 4 has since been selected as the remediation option for the MNRP.

A site plan showing the current condition at the Mount Nansen site is included in Figure 1. The selected remediation plan involves the following key features:

- relocating the tailings and underlying affected soils from the existing tailings impoundment to the Open Pit (~300,000 m^3);
- removing the main tailings dam and downstream seepage dam;
- relocating mineralized waste rock to the Open Pit;
- backfilling the Open Pit so that the tailings are located above the groundwater table and a stable final surface and topography is provided;
- developing a management method for the water currently in the tailings facility and Open Pit and for the short term seepage from the backfilled pit;
- covering the Open Pit area with an engineered low infiltration cover to maintain “dry conditions within the tailings deposit”;
- providing hydrogeological containment to the backfilled Open Pit to minimize seepage from the waste rock and tailings;
- remediating the mill area including building demolition, removing the rail tanker, restoring the water course, removing mineralized rock (~6,500 m^3), removing hazardous waste, removing historic tailings (~2,000 t), decommissioning historic settling ponds, remediating underground workings, improving water quality and, if shown to be necessary, remediating the old landfill;
- remediating the camp area including demolishing existing buildings except those required for maintenance following closure, and removing hazardous waste;
- decommissioning all non-public roads, where not required for future monitoring;
- removing existing infrastructure (power lines, pipelines, sediment ponds, ancillary buildings, etc.);
- treating hydrocarbon contaminated soils;

- backfilling and remediating exploration trenches and disturbed areas as appropriate;
- decommissioning the Victoria Creek pump house, including sealing the existing artesian well; and
- creating a remediated landscape that complements the natural topography and vegetation.

3.0 OBJECTIVES OF GAP ANALYSIS

The technical work on the MNRP carried out to date by a variety of consultants was intended to support conceptual level design and analyses so that the various options under consideration could be compared on an equal basis. Necessarily, there were many assumptions made in the various assessments that, while appropriate for conceptual evaluations, require validation for more detailed design. In addition, there will be a need for new analyses and assessments in support of detailed design.

The objective of the gap analysis is, therefore, to identify information that is considered necessary to complete 30% and 60% design and to provide input to the Yukon Environmental and Socio-economic Assessment Board (YESAB) application, but that is not available in the reference information provided by AAM. The site investigation required to gather the data needed to fill in the gaps was then identified and is presented under separate cover (AMEC 2013).

It should be noted that some of the gaps identified are more critical than others. Depending on the level of risk and uncertainty that is acceptable, some gaps may be filled by analyses and assumptions while others require additional site investigation. The intent of the gap analyses presented herein is not only to identify site investigation needs but also to present an understanding of the issues that require consideration during design. It should also be noted that, as is typical for all projects, information needs may change as more work is carried out and a more in depth understanding of the issues and data available is obtained. The level or quality of the information required may also be adjusted based on final objectives and priorities.

4.0 GAP ANALYSIS PROCEDURES

A significant volume of data was provided by AAM in the form of an electronic library containing approximately 155 reports. Many of the reports contained multiple files. Although a thorough review of the information was attempted, it was not possible to read each report in detail. It is likely that when design is undertaken and the available data is actually used and assessed in more detail, additional reports requiring review and/or additional data gaps will be identified.

The LORAX 2011 Option Report was considered to be the main reference document and the data review focused on the Option 4 and Common Element concepts presented therein. The report and AMEC's original proposal were also relied upon to identify specific design issues and key assumptions and uncertainties that require consideration. Once the key issues were thus

identified, an understanding of the data required to assess the issues was developed to focus the review. Relevant reports were identified based on title and/or consultant since there were no keyword or summary searches available for the reports. Attempts were made to determine the quality and adequacy of the data available, but the scope of the current effort does not include a detailed assessment of the data. The main objective was simply to identify what data is available. A comparison of the data available to what is currently considered to be required was then made to identify gaps in the available information. Given the complex and inter-disciplinary nature of this project, it is possible that further information needs will be identified.

The gap analysis procedure is reflected in the data gap analysis tables appended to this memorandum which present a listing of:

- the design objective being considered;
- the data required;
- the data available;
- the quality and coverage of the data;
- the data gaps identified; and
- general comments.

5.0 DOCUMENT ORGANIZATION

The gap analysis is presented in the following subsections broken down by discipline. Many of the remediation activities are interdisciplinary and, therefore, issues related to remediation of the Open Pit for example are included in various disciplines. For each discipline, an overview of the scope of work is presented followed by a summary of the general status of the information available and the main data gaps identified. A list of all the documents reviewed and detailed documentation of the gap analysis are appended in table format for each discipline following the main text of this memorandum. The information is organized as follows:

Section 6:	Geotechnical
Section 7:	Hydrology
Section 8:	Hydrogeology
Section 9:	Surface Water Quality
Section 10:	Infrastructure and Revegetation
Section 11:	Site Characterization
Section 12:	Drafting
Tables: 6.1 to 11.1	Reports reviewed
Tables: 6.2 to 11.2, A1	Gap analyses details
Figures 1 to 3	Historic Investigations

6.0 GEOTECHNICAL

6.1 Overview of Task Scope of Work

Many of the geotechnical components of the MNRP are related to the relocation of the tailings and other materials to the Open Pit and removal of the tailings dams. The intent of Option 4 is to achieve dry tailings in a configuration that does not require ongoing monitoring or treatment. The conceptual design presented in LORAX 2011 includes a non-mineralized waste rock platform in the bottom of the pit constructed to an elevation above the long term groundwater level. Tailings will be placed above this platform. Additional waste rock and other materials that require containment would be placed above the tailings. An engineered cover will be constructed over the waste rock surface to limit infiltration. With this option, ML/ARD will be controlled by minimizing contact between water and the tailings which will allow “maintenance of dry conditions within the tailings deposit” (LORAX, R88, 2011). The conceptual configuration will be evaluated and possibly optimized or modified as part of detailed design. If of acceptable quality, the fill material in the tailings dam and seepage collection dam will be reused as borrow material for general remediation activities, otherwise it will be placed in the Open Pit.

The following activities have been identified to complete the design and recommendations for the tailings relocation:

- Identify optimal relocation strategy for the tailings, particularly including consideration of the current tailings conditions and the desired tailings backfill properties.
- Quantify and characterize the volume of waste rock that is required to be or can be placed in the Open Pit and design waste rock placement and configuration to provide stability.
- Assess the stability and integrity of the tailings and tailings dam during removal of the tailings.
- Develop a method to allow safe removal of the dams.
- Develop recommendations to allow safe access to the Open Pit during construction.
- Design the Open Pit backfill configuration to provide acceptable long term stability including consideration of:
    - the tailings requirements to meet project objectives with regards to water quality; and
    - the desire to avoid a structure that would be classified as a dam.
- Predict the behaviour of the backfilled Open Pit including consolidation, permeability and permafrost regime as input to both the cover design and groundwater flow / water quality model.
- Design a cover to provide a long term solution that limits infiltration to the tailings.

- Provide input regarding the restoration of the tailings area including the potential for thermo-erosion during remediation activities, the potential rate and effects of freeze back of the talik and other permafrost related issues.

Most of the tasks listed above rely on a good understanding of the tailings and waste rock characteristics and behaviour. The waste rock material is expected to be generally dry and competent. It is, therefore, expected that it can be excavated and placed relatively easily and that it has the potential to provide physical stability to the tailings. The geotechnical tailings properties, however, are more uncertain and will be a main driver of many of the design decisions. A key component of the work is, therefore, to characterize the tailings from a geotechnical perspective to provide input to the geotechnical design and other disciplines.

With regards to remediation activities on the wider site, geotechnical issues include:

- Long term waste rock area stability.
- Borrow material availability and location.
- Location of a new landfill (if required).

6.2 Information Reviewed

The reports reviewed as part of the geotechnical gap analysis are presented in Table 6.1, appended.

6.3 Summary of Data Gap Analysis

A detailed documentation of the data gap analyses completed for the geotechnical components of the project is tabulated in Table 6.2 appended. Historic investigations at the tailings facility are presented in Figure 1.

The tailings characteristics affect the tailings relocation methods and considerations, the design and performance of the pit backfill, the cover design, and the magnitude of groundwater seepage. Because of their nature, the tailings are expected to present design challenges and, therefore, geotechnical characterization of the tailings was a main focus of the gap analysis. There are sufficient visual descriptions of the tailings samples collected to date to allow a general characterization of the tailings but there is a lack of definitive quantitative data. It appears that the tailings are mainly in an unfrozen state and that the water table may be below the pond level (i.e., the pond may be a perched water body). This is consistent with the ability for previous site investigation activities to access the middle of the pond and the relative ease with which samplers appear to have been advanced over a significant depth of tailings. There is, however, a lack of data with regards to the saturation levels in the tailings above the groundwater level, and the density or consistency and moisture content below the water level. There are very few geotechnical test results available and none available with regards to in-situ strength or the state of the tailings. While properties can be assumed for design purposes, there is currently no report that could be generated to characterize the tailings that could then be provided to a contractor for bidding purposes.

It appears that the most practical method identified for relocating the tailings is the excavation of partly frozen tailings material over the winter season. This method seems to have been the basis for the cost estimate produced (LORAX 2011 Appendix C10, AECOM 2009a) and appears to be generally compatible with the overall state of the tailings as currently understood. Wintertime haul and place methods would be expected to result in the placement of frozen blocks of tailings within a partly saturated to saturated matrix placed in a relatively uncontrolled and uncompacted manner. This has the potential to result in relatively large post placement movements. This judgement is consistent with Appendix C1 of LORAX 2011 which states that "considerably more settlement could occur if the tailings are placed in a frozen state with large void spaces and it may also take considerably longer for thaw induced settlement to occur".

The relocation method described above appears to conflict with some of the discussion reported for the Option 4 tailings relocation. The tailings are to be "maintained in a dry condition to the extent possible" with an engineered low infiltration cover as a key design element to minimize infiltration. Conceptually the design included a geomembrane liner in the cover and a self-supporting tailings deposit placed with a sloped surface. This would require a tailings deposit with fairly low differential settlement and reasonable strength and thus appears to imply that control may be required on tailings placement. Comments in AECOM 2009b mention placement of dewatered or dry tailings and the water quality modelling has assumed dry tailings. The need to have a self-supporting sloped tailing surface and various comments about dry or partly dewatered tailings do not appear consistent with the placement of partly frozen tailings in the wintertime. If the understanding stated above is correct, then this would appear to be a significant data gap.

An initial step in the design will thus be to determine what requirements exist with regards to the tailings deposit placed in the Open Pit from both a stability and water quality perspective. The tailings relocation method and the requirements for the placed tailings properties then need to be made consistent with one another. A requirement to meet specific tailings placement criteria would likely necessitate summer work and would likely include dewatering / drying of at least a portion of the tailings. This may require more effort and cost than currently estimated. If, however, the cover design or management plan can be modified to accommodate significant differential and ongoing settlement then winter tailings excavation and placement may be a viable option. A better understanding of the feasibility, cost and priorities of these competing issues is required.

The required tailings placement characteristics also affect the type of information and level of assessments required for detailed design. In addition, the required level of information depends on the contractual strategy and cost estimate certainty desired for remediation activities. As an example, the current level of information related to tailings characterization would allow development of a general excavation procedure. The condition of the tailings, however, would not be fully defined and an experienced contractor able to adapt to changing conditions would be required. This would increase the risk of extras and change orders during construction. This may, however, be balanced by the reduced cost of the required site investigation effort. It is understood that YG, AANDC and LSCFN would like to reduce risk and uncertainty during

construction. Ongoing discussion of the balance between site investigation effort and level of uncertainty will be required. The program that is completed will need to prioritize efforts so that the data gathered is sufficient to support the technical feasibility of the proposed design to the permitting bodies.

The tailings dam and seepage dam areas, including both the dam materials and underlying native soils have significantly more quantitative data available and based upon a high level review of the data there does not seem to be any significant geotechnical data gaps. The possible exception to this is the extent of the talik beneath the tailings impoundment. The existing thermal regime in the Dome Creek area would benefit from further assessment in order to develop appropriate relocation methods and mitigation measures with regards to thermo-erosion, particularly during the period between relocation and final site remediation. There is a geochemical data gap with regards to how much of the dam and underlying or surrounding native material is of an acceptable quality to be left in place or reused as borrow material for remediation activities and how much requires relocation to the Open Pit. This information is required as an input to the geotechnical work and is discussed in Section 11.0.

Waste rock material makes up a significant volume of the backfilled material; however, from a geotechnical perspective is not currently considered a critical design issue. The nature of the material suggests that the waste rock should be competent and will act to provide physical stability to the backfilled configuration. Geotechnical design is expected to proceed on the basis of general index testing. A significant amount of geochemical characterization is required to identify the volume of waste rock material that requires containment in the Open Pit as discussed in Section 11.0.

With regards to the Open Pit characterization, there is an information gap in terms of the current thermal regime in the Open Pit. The temperatures in the area are currently influenced by the Open Pit and will change once the area is reclaimed. In order to understand how the temperatures may change and to assess the impacts this may have on the performance of the pit backfill and any seepage, the current regime and particularly the extent of influence of the Open Pit needs to be better understood. There is also limited data regarding the actual condition of the Pony Creek adit and bulkhead. Pending confirmation of the conditions, the work completed to date regarding Open Pit stability appears to be adequate. The hydrogeology of the Open Pit including seepage paths and water levels is discussed in Section 8.0.

A study of potential borrow areas has been carried out (EBA 2009). There is no source of fine grained material available within the order in council (OIC) site boundary. Three potential sources of fine grained material were identified within several kilometres of the public site access road. These locations require field confirmation as well as material characterization, delineation and quantification. Within the OIC boundary there are sources of sand and coarser material although these sources will also require confirmation and delineation.

The detailed gap analysis presented in Table 6.2 was based on complete characterization of the tailings materials and assessments for the various geotechnical sub-disciplines. The level of effort required to address the issues will vary with the specific design options selected and the defined level of acceptable risk. In some cases, analyses and estimated parameters may be acceptable while in others, site specific data may be required. A summary of the key data gaps as currently understood is presented below. The data gaps and requirements may be modified based upon a better understanding of the objectives and priorities for the MNRP and as design work is advanced and issues are better understood.

- Definition of the requirements for the backfilled tailings and waste rock to satisfy the project objectives with regards to water quality and physical stability.
- Pit backfill configuration options to avoid a structure that would be classified as a dam given material balance and material properties.
- Confirmation of cover requirements.
- Geotechnical tailings characterization.
- Geotechnical characterization of waste rock and waste rock area.
- Identification of the tailings relocation methods (removal and placement) that will provide the required tailings properties and assess potential implications relative to assumptions and costs for Option 4.
- Volume and type of material that requires storage in the Open Pit (requires geochemical characterization) and material balance with available storage volume.
- Thermal regime at the Open Pit to assess the long term state of the relocated tailings.
- Long term water level in the pit.
- Adit conditions to allow safe access if required.
- Thermal regime in Dome Creek and impact on remediation activities.
- Characterization, delineation and quantification of identified borrow sources.

7.0 HYDROLOGY

7.1 Overview of Task Scope of Work

The purpose of overall site hydrological analysis is to understand the unique hydrological characteristics of the site that will affect the hydrotechnical design. Hydrological factors to be evaluated will include:

- watershed characteristics;
- climatic parameters (such as extreme temperatures, design storms);
- local and regional watercourses;
- natural drainage patterns (flow paths, both temporal and spatial);

- effects on watercourses that have been caused by the project; and
- effects on watercourses that will be caused by construction and post-construction.

Typical hydrological characteristics of local and regional watercourses such as mean annual hydrographs, and mean, minimum and maximum monthly and annual flows will be evaluated. Flood frequency analysis for high flow events will be used for sizing hydraulic structures.

Understanding the effects of extreme cold temperatures on the design of hydraulic structures at the site is particularly important. An example of such an effect is glaciations, or the build-up of ice in creeks or diversion channels, which could block water flow thus reducing the design capacity of the channel. This has the potential to cause ice jamming and flooding of diversion channels.

7.2 Information Reviewed

The documents which have been reviewed to identify the type of hydrology/hydrotechnical information and data contained in the report are listed in Table 7.1.

7.3 Summary of Data Gap Analysis

Data gaps identified for the hydrotechnical design for the Mount Nansen site have been identified in Table 7.2.

Most of the data gaps, such as hydrographs and flow rates for various design conditions, can be filled by more detailed hydrological and hydraulic analysis of the site as identified in Table 7.2. Details regarding watershed characteristics, particularly upstream and downstream of Dome Creek segments which will be used as the template for stream restoration at the mill and tailings will require site observations. The site investigation required for the identified segments will include detailed survey of several stream cross-section and the channel alignment, channel pattern, riparian vegetation and sampling of stream sediments. Similarly information regarding the channel forming soil and sediment characteristics will require site observation and will benefit from information synthesized from the geotechnical characterization of Dome Creek, based largely on existing data.

If non-acid generating waste rock of a suitable nature cannot be provided, alternate borrow sources for riprap (e.g., for channels and other surface water control structures) will be required. Similarly if the dam material, which was originally sourced from the alluvial Dome Creek deposits, cannot be reused to reconstruct Dome Creek, additional borrow sources will have to be identified.

8.0 HYDROGEOLOGY

8.1 Overview of Task Scope of Work

The hydrogeology task involves improving the conceptual groundwater flow model to a level sufficient for a detailed design. Groundwater flow has to be quantified in support of the site water balance and water quality model in order to confirm the impact of the MNRP on the environment. Long term active treatment is not acceptable for remediation and closure planning and therefore the hydrogeological task also aims to provide containment of tailings and other affected materials where required.

Hydrogeological support will be required to facilitate remediation design the assessment and permitting processes, plus groundwater quality monitoring associated with the remediation activities. The main hydrogeology tasks include:

- quantifying groundwater movement into and out of the Open Pit. It is proposed that this include an assessment of major faults intersecting the Open Pit lower levels, plus the Pony Creek adit, as documented in the pit walls (Brown McDade Pit Assessment at the Mount Nansen Site, EBA Engineering 2012(R177));
- quantifying groundwater reporting to the Open Pit that originates from Pony Creek, moving from the creek bed, via shallow bedrock, into the north wall of the Open Pit;
- identifying long-term, pit water levels, to support a design elevation, i.e., boundary between waste rock and ‘perched’ tailings, for implementation of Option 4 and keeping tailings above the pit water table;
- quantifying groundwater flow and quality leaving the Open Pit, hydraulically down-gradient, i.e., northeast of the Open Pit and south, between the Open Pit and tailings pond area. It is proposed that multi-level, rapidly-responding equipment be installed for groundwater movement and quality quantification;
- quantifying general groundwater-surface water interaction for Dome Creek and Pony/ Back Creeks, in terms of base flow, identifying discharge (losing) and recharge (gaining) creek stages and contaminant flux entering the creeks;
- identifying point-source underground mine workings water that may be degrading groundwater quality in the Dome Creek upper watershed, i.e., the Huestis adit, reportedly of limited underground extent; plus other potential point-sources at the old landfill and mine mill areas; and
- decommissioning former water supply well(s), at Victoria Creek.

The documentation available for each of these design items was reviewed to identify data gaps and identify what site investigation is required in 2013.

8.2 Information Reviewed

The reports reviewed in the preparation of the hydrogeology data gap analysis are listed in Table 8.1, appended.

8.3 Summary of Data Gap Analysis

The hydrogeological data gaps identified in Table 8.2 have been listed in a generally descending order of currently-perceived importance for remedial design and approval documentation. Conceptual design drawings (LORAX 2011, Drawing 5.7-1) indicate a conceptual elevation for the top of the waste rock platform, prior to tailings placement (El. 1190 m). A more detailed water balance model, specific to the Open Pit involving updates to input terms for the currently-selected Option 4 with geosynthetic cover will be required to confirm or update this elevation.

Limited shallow and deeper regional groundwater monitoring for the Open Pit has been implemented on the north side of the Open Pit. The south side of the Open Pit, however, has not been studied to-date and appears to be a significant groundwater pathway for water leaving the pit and ultimately entering the Dome Creek watershed. For design and approval of the Open Pit as a containment facility, the deeper groundwater system between the Open Pit and tailings pond must be quantified in terms of contaminant flux entering the tailings area and talik feature under the pond.

Groundwater-surface water interaction has not been evaluated to-date with respect to Dome and Pony/Back Creeks. This interaction and contribution of groundwater flow and quality to surface waters needs to be assessed, given the water quality leaving the site boundaries and potential impacts to the receiving waters of Victoria Creek.

9.0 SURFACE WATER QUALITY

9.1 Overview of Task Scope of Work

A primary driver of the remediation option selection process was the predicted water quality at the site. Specific surface water quality evaluations and water treatment criteria that have to be considered are as follows:

- high arsenic in the tailings;
- regular and typical guideline exceedances for metals (including reference sites);
- potential acid generating effects, including seeps from waste rock;
- poor water quality in the pit lake;
- contaminated runoff in waste and mill areas; and
- water seeps from conduits such as adits.

Previous studies have evaluated existing water quality in the tailings pond, the tailings seepage pond, the Open Pit pond, and to a limited extent, the tailings porewater. Parameters of concern include:

- Total suspended solids (TSS),
- Cyanide,
- Sulphate, and
- Metals.

The water quality data has to support several tasks as follows:

- revise the current site water quality model to estimate water quality before, during and after remediation activities;
- water quality simulations during dam removal, tailings relocation, pit lake remediation, etc.;
- design and recommendations for water quality mitigation measures during remediation work;
- water management plan including consideration of water quality monitoring design and maintenance plan during and post-construction:
    - pit water quality management;
    - seepage to Pony Creek;
    - runoffs to Pony Creek, Back Creek and Dome Creek;
    - water quality monitoring design and recommendation for post-remediation program;
    - reporting and working documents preparation; and
    - assistance and participation in regulatory submissions and technical inquires.

In addition, a water treatment component is included in the planned remediation activities for Option 4. Water treatment may be required for the following bodies of water:

- existing Brown-McDade Open Pit pond (1 pond volume including both north and south portions);
- existing tailings pond;
- existing ponds at the mill site;
- existing tailings seepage pond;
- tailings porewater (during dewatering and preparation for transfer to the Open Pit); and
- potentially pit water (as a contingency measure if predicted source characteristics are exceeded or if tailings are placed in a wet/frozen condition and need to dewater in pit).

9.2 Information Reviewed

The reports provided by AAM listed in Table 9.1 (appended) were reviewed.

9.3 Summary of Data Gap Analysis

The data gap analysis is presented in Table 9.2. In general, past site investigations have provided vast spatial and temporal surface water quality data in Pony Creek, Back Creek, Dome Creek and Victoria Creek. However, some of the parameters were analyzed at high detection limits that are above existing guidelines (e.g., aluminum reported at below 0.2 mg/L when the CCME guideline considering pH is 0.1 mg/L).

Data gaps exist and are related to more specific and targeted data for water quality modelling for remediation activities, pit lake water treatment options and planning, short-term (remediation) and long-term monitoring design.

The water quality model developed and run for option selection does not represent differences in drainage area surfaces including natural watersheds or in different type of facilities and their hydrological and hydrogeological features. There is no differentiation in surface runoff coefficients between drainages (natural and site facilities), no account for evaporation from ponds and pit and thus, no water balance for these water bodies accounted for in the model. Water quality inputs were roughly quantified and no surface-groundwater interactions were considered in the model nor were potential leachate from tailings and waste rock area.

The current water quality model has to be revised and a water and mass balance model for the site has to be developed and run for different temporal snapshots for Option 4. The snapshots have to be developed using the remediation plan and post-remediation conditions.

It appears that insufficient data are collected for site affected areas, particularly where surface runoff can occur (mill area, waste rock area, tailings, and adits). This component of the gap analysis will be covered as a result of geochemical additional studies (see Section 11.3).

Current, post mining data on bottom sediment quality in creeks was not available at the time of writing and is, therefore, listed as a data gap. It is understood that sediment chemistry data gathered post mining is available and this will be reviewed prior to the field program to assess the need for additional sampling.

A water quality data survey during low flow conditions is necessary to delineate the location of major inputs from site components by way of seepage and surface groundwater interaction. Another survey during a rainfall event and/or the 2013 freshet event is proposed to follow effects on surface runoff quality from site components. Both surveys have to be focused on studying spatial differentiation between sub-catchments and different types of land use in order to support a refinement of the site water balance and water quality model.

10.0 INFRASTRUCTURE LANDFORMS AND REVEGETATION

10.1 Overview of Task Scope of Work

The infrastructure and revegetation scope of the MNRP generally involves site grading, demolition, landform engineering and restoration. The aim is to provide a final site topography that will provide functionality with regards to stability, surface water management and erosion and that will aesthetically complement the existing landscape. The task is based on the goal of remediating the landscape to reflect its original form, traditional and pre-mining land use, and natural appearance in a way that protects the environment. More specifically, the following issues will be considered:

- closure of site roads while maintaining the status of the primary public road and site roads required for monitoring;
- closure of site trails;
- remediation of exploration trenches;
- building demolition;
- removal and remediation of miscellaneous infrastructure;
- remediation of miscellaneous clearings;
- requirements for borrow material with regards to required material characteristics and volumes for regrading and creation of final landforms;
- remediation of borrow areas;
- site grading;
- development of new landfill;
- pre-disturbance and traditional land use;
- pre-disturbance and adjacent vegetation ecology;
- baseline mapping;
- vegetation, soils and wildlife baseline conditions;
- surficial material characteristics;
- topography and substrate drainage;
- seed and plant source material; and
- revegetation techniques for the Yukon.

Miscellaneous infrastructure generally includes common site infrastructure and facilities such as power supply infrastructure, piping, core storage areas, the septic system at the camp and mill, and minor structures or debris. The major structures for demolition on-site are the mill area, camp and various ancillary buildings. The miscellaneous infrastructure will be removed and

properly disposed of. It is expected that the majority of demolition debris will be disposed of on-site or recycled although this will be confirmed during future design work. Potential recycling materials are heavier steel building elements, crushed concrete and brick, wood that has not been painted or contaminated by hydrocarbons after nails and bolts have been removed. Specifications will identify recycling potential and waste management performance criteria.

The site has extensive networks of roads and trails, most of which will be decommissioned as part of this project to prevent future use. The primary access road to the site is intended to remain open to the public. Exploration trenches surround the project site and require closure primarily from a safety aspect. If there are no obvious signs of contamination, the material associated with these trenches will be used as backfill. If there are indications of contamination such as soil staining or signs of metal leaching, the material will be characterized and/or removed as appropriate.

Borrow areas required for remediation activities have yet to be identified (see Section 6.0). The extent of borrow areas will be greatly influenced by the required volume of fill as well as the material which is available through the characterization of the tailings and tailing dams. Upon determination of further design work, preliminary volumes would be obtained to determine the impacted areas of proposed borrow sources.

Removal of the tailings and dams will be an interdisciplinary effort to develop a constructible plan consistent with the objectives of the various aspects of the project. Many issues related to the removal of the tailings and dams were discussed in Section 6.0. Once the tailings and dams are removed, the area can then be reinstated for drainage, natural slopes and restored.

All of the affected areas and features are to be regraded to minimize erosion and encourage natural vegetation restoration, provide pleasing future aesthetics, long term stable slopes and safety. The site grading task will be one of later items to take shape during the design as many other disciplines on the project will be required to provide input.

Throughout the project site there are also small, miscellaneous clearings which will require remediation. Remediation may likely involve minor grading and planting as determined during a formal inventory and measurement.

Revegetation will be an interdisciplinary effort to develop a construction plan consistent with the objectives of the various aspects of the project. A remediation plan will be written based on the information available from the site investigation and discussion with AAM.

10.2 Information Reviewed

Reports reviewed for the data gap analysis are listed in Table 10.1. The reports included information regarding general site conditions, relevant survey information for the project, remediation options, and revegetation projects in the Yukon.

10.3 Summary of Data Gap Analysis

Table 10.2 presents the gap analysis completed for the infrastructure and revegetation task. In addition to the assessments and investigations directly required for this task, input from the geotechnical, surface hydrology, geochemistry, and hydrocarbon and other hazardous material characterization is required to develop the site grading and revegetation plan.

Many of the data gaps include confirmation and more detailed inventories of items and areas requiring removal, demolition and/or regrading. These can be readily filled by a site visit and ground truthing of reported conditions to provide design quantities of the various materials requiring removal, recycle, demolition and/or on-site disposal. Site reconnaissance is planned for the summer of 2013 to quantify the material on-site and characterize the debris material. In general, buildings have been assessed for hazardous materials though some additional confirmation and quantification is required. A site visit will also provide field confirmation of topography to allow the landform engineer to develop sketches of desired landform shape that characterizes the greater landscape. This will provide a target form for the final “aesthetic” of the site. Additional information regarding traditional use could help direct end land use.

With regards to revegetation, the data gaps pertain to appropriate spatial coverage and quantity information regarding vegetation species present and abundance, ground cover in disturbed areas, characterization of substrate, quantity and quality of topsoil, and wildlife use within and around the site. The terrestrial (wildlife, vegetation and soils/substrate) information can be gathered during the site investigation. Collaboration will allow more detailed information regarding substrate materials and revegetation potential can also be gathered from other discipline site investigations.

Once the investigations have been completed, landform, grading and revegetation plans can be developed and the demolition material disposal locations finalized.

11.0 SITE CHARACTERIZATION

11.1 Overview of Task Scope of Work

The site characterization task is focused on the site geochemistry, and presence of hazardous materials and hydrocarbon impacted soils. The gap analysis was, therefore, carried out to identify potential gaps in knowledge considering the current information and the ongoing collection of data as they relate to these areas of focus. In particular, the following items were considered:

<u>Geochemistry:</u>

- mapping and characterization of mineralized material (Potential Acid Generation (PAG)/Non Acid Generation (NAG), volumes distribution, etc.) in the waste rock area, Open Pit, mill/camp, roads, and old ore transfer site;

- mapping and characterization low grade ore at the waste rock area, near Open Pit and mill area;
- mapping and characterization of tailings at mill/camp area and riparian areas;
- geochemical characterization of tailings in the Dome Creek tailings storage facility;
- geochemical characterization of native materials below tailings in the Dome Creek valley; and
- geochemical characterization of potential borrow materials.

Hazardous Materials:

- confirm past inventories location, composition and volume of hazardous materials on the site (e.g., in mill and camp building);
- delineate the environmental quality and extent of all areas of known releases of hazardous materials on-site;
- plan for the removal of all hazardous materials and contaminated soils from the site and manage appropriately (e.g., in mill and camp building);
- characterize the rail tanker contents and develop a removal plan; and
- assess if there is migration of contaminants from the existing landfill area near the mill building.

Hydrocarbon Impacted Soils:

- systematic site wide assessment for hydrocarbon contaminated soil (particularly at camp/mill, Ketza yard and along roads) which would consist of visual observation to identify areas of surficial staining followed by characterization and the preparation of a plan for removal/disposal; and
- locate, identify, quantify and prepare a plan for removal/disposal of all fuel storage equipment.

11.2 Information Reviewed

Table 11.1 appended summarizes the reports that were reviewed during the data gap analysis. Figures 2 and 3 show historical geochemistry sampling undertaken at the tailings impoundment, Open Pit, waste rock area, mill site areas, and along the pit to mill haul road.

11.3 Summary of Data Gap Analysis

Geochemistry:

Some geochemical mapping and characterization has been completed on-site, however, further work is required as presented in Table 11.2.

Additional samples and laboratory testing are recommended from the west lower, south and east pile sectors within the McDade waste rock pile, the haul road near the mill area, and the old ore stockpile at the upper mill platform area. In addition, sampling of historical ponds and riparian areas is recommended within the settling ponds.

The lower Huestis Adit should be investigated to determine if it may be contributing significant metal loads to Dome Creek. This should be done through water sampling of the lower Huestis Adit discharge. Water sampling of the Webber Adit outflow is also recommended to assess if there is significant contaminant sources that may contribute to the site.

Acid rock drainage (ARD) / metal leaching (ML) characterization of the native soils underlying the tailings impoundment, the materials in the tailings dam, and the materials near the tailings seepage pond were not included in previous ARD investigations. Sampling and testing are recommended for those materials.

The results of these geochemistry programs will provide the data required for a more thorough remediation plan and delineation of material requiring relocation to the Open Pit.

Hazardous Materials Impacted Materials:

Non-hydrocarbon or tailings impacted materials have not been systematically assessed across the site. Specific releases found in the historic reports include:

- metals contamination in wood chips in the educor area;
- metals contaminated sediment across the mill complex;
- cyanide slurry release in 1996;
- antifreeze release in 1998; and
- metals contaminated soil in the mill, SAG, polish pond and Ketza areas.

These areas require updated soil characterization and where contamination is observed, delineation of the vertical and horizontal extent of contamination. The field work would require shallow soil and material sampling for initial characterization with deeper soil samples and potentially groundwater samples depending on the observed extent.

Hazardous Materials inventories should be compiled and then confirmed and updated by a new site inspection. Where new information identifies conflicts with the existing information, additional sampling by a qualified professional will be required. In addition, sampling of the rail tanker and the mixing tanks outside the mill will also need to be completed.

The results of these programs will provide the data required for a more thorough remediation plan and a management plan can be finalized to address hazardous materials at the site in accordance with regulatory requirements.

Contaminants from the former landfill area next to the Mill Building may be migrating off-site. Material samples should be collected and analyzed from strategic points down gradient of the landfill area. If contaminants are found to be migrating, a plan will then be required to remediate the former landfill area and dispose of its contents in accordance with regulatory requirements.

The product in the Rail Tanker should be identified through sampling by a qualified professional. The products in all the tanks on-site should be quantified. A plan will then be required to empty the tank and remove the tank and its content from the site in accordance with regulatory requirements.

Hydrocarbon Impacted Soils:

Further study is required to confirm potential hydrocarbon contamination issues on-site. Areas will be selected for characterization based on documented contamination and visual observation of soil staining. For all assessed areas that do indicate hydrocarbon contamination, options for material removal and disposition will be assessed. The plan will also include conducting confirmatory sampling once the material is removed, to confirm successful remediation.

Areas of potential hydrocarbon contamination that have been identified based on project documentation which require characterization are:

- material near the former Ketza Shop;
- material near two reported historical spills;
- material adjacent to transformer storage;
- material adjacent to drums in the warehouse stockpile;
- stained soil within the generator building;
- stained soil near the AST in the warehouse;
- stained soil near the waste oil barrel, adjacent to the diesel tank containment;
- stained soil on the upper road to the Semi-Autogenous Grinding (SAG) Building; and
- oil sludge in the mill building.

The historical use of hydrocarbons on roads for dust suppression should be assessed through sampling. The contents of four on-site sumps or basins (three in the generator building and one in the upper mill building) and the oil sludge in the mill building should be sampled, characterized, and quantified.

The results of these programs will provide the data required for a more thorough remediation plan. The development of the remediation plan will include an assessment of whether on-site treatment would be more cost effective than removal and treatment off-site.

12.0 DRAFTING

12.1 Overview of Task Scope of Work

Drafting includes spatial data modelling and analysis and integration and management of LiDAR datasets. It also involves the development of digital models to allow volume estimates as well as preparation of figures, drawings, and site plans.

12.2 Information Reviewed

The information provided by AAM on 1 January 2013 and 1 March 2013 was reviewed and is summarized in Table 12.1.

12.3 Summary

Table 12.2 summarizes the data provided by the AAM with regards to drafting. From a review of the files, the data coverage appears sufficient to meet the team's needs from AutoCAD and GIS perspectives with the following exceptions:

- contour or DEM data below the current pond elevation in the pit;
- digital contours of original ground, before construction of the tailings impoundment, excavation of Open Pit or placement of waste rock; and
- bathymetry data of tailings surface has not been provided (this is referred to in the EBA report, Appendix F).

13.0 SUMMARY OF DATA GAP ANALYSIS

A significant amount of work has been completed to date for the MNRP in order to develop several alternatives to a conceptual level and to allow a relative comparison of the options. By necessity, this required a variety of assumptions. With the selection of Option 4 as the remediation option, many of those assumptions now require confirmation, and more detailed analyses. In addition, the requirements and priorities of the various disciplines need to be integrated to develop a consistent and practical remediation plan.

Specific data gaps identified by discipline have been summarized herein. As a general overview, the following broad data gaps were identified:

- reconciliation of the requirements for the pit backfill and in particular with regards to the tailings as determined by the Option 4 objectives with the relocation method;
- confirmation of reported site conditions;
- identification of the optimal relocation methods for the tailings and dams (including consideration of the interaction between the removal and placement methods);
- geotechnical characterization of tailings and waste rock;

- physical and chemical characterization of tailings and waste rock from a soils and revegetation perspective (e.g., texture, coarse fragment content, pH);
- additional geochemical characterization of waste rock, ore stockpile, historical tailings ponds and riparian area, Huestis adit seepage, Pony Creek adit, and the tailings and seepage dam materials;
- systematic assessment of non-hydrocarbon or tailings impacted soils across the site;
- assessment of the hazardous material operations and storage areas;
- characterization of potential hydrocarbon contamination locations;
- open pit thermal characterization and assessment;
- water quality measurements during specific flow conditions;
- bottom sediment quality;
- improvements to the site water quality model;
- characterization of site groundwater regime and in particular near the Open Pit;
- characterization of the shallow and deeper regional groundwater flow on the south side of the Open Pit;
- evaluation of the groundwater-surface water interaction in Dome and Pony/Back Creeks;
- characterization of watershed and channel;
- characterization and observation of the surrounding natural landscape to allow development of final landform aesthetics;
- vegetation composition in surrounding landscape as a plant material source; and
- wildlife use within and adjacent to the site.

14.0 PATH FORWARD

The site investigation required to address the data gap identified herein is presented in AMEC 2013. Given the realities of access conditions and effort, it is likely that the site investigation to fill in all of the gaps identified will be quite expensive. Priorities based on the level of uncertainty caused by the data gap and the potential benefit of site investigation will have to be identified through discussions with AAM.

The gap analyses presented herein will necessarily be refined as more detailed assessments of the data are made and design work begins. As with any site investigation program, the program developed for Mount Nansen will employ a phased approach, allowing for flexibility to accommodate conditions actually encountered during the site investigation and an improved understanding of data needs.

REFERENCES

AECOM. 2009a. Mount Nansen – Pit Disposal – Tailings Transport Methods for Alternative 4MEM-091118-Tailings Transport Methods Memo MEM-091118-Placement Scenarios to Alistair Kent, December 3, 2009. In LORAX 2010, Mount Nansen Options for Closure, Draft (R70).

AECOM. 2009b. Mount Nansen – Alternatives for Pit Disposal (as part of Alternative 4), Memo MEM-091118-Placement Scenarios to Alistair Kent, December 3, 2009. In LORAX 2010, Mount Nansen Options for Closure, Draft.

Altura. 2009. Brown McDade Waste Rock Pile Mount Nansen Mine Site Yukon, Geochemical Characterization, Report prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources Government of Yukon, February 2009.

AMEC. 2013. 2013 Site Investigation Plan – Mount Nansen Remediation Project, Draft, memo to Josée Perron, 28 March 2013.

EBA. 2009. Mt. Nansen Mine Reclamation Terrain Mapping and Materials Search, Report submitted to Government of Yukon Energy, Mines and Resources Assessment and Abandoned Mines Branch, September 2009.

LORAX Environmental Services Ltd. 2011. Mount Nansen Options for Closure, Report prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources Government of Yukon, July 2011.

SRK Consulting. 2011. Mount Nansen Closure Options Evaluation, Report prepared for Government of Yukon, September 2011.

Yukon Government. 2008. Options for Closure of the Mt. Nansen Mine, Technical Review Report by Energy, Mines, and Resources, Yukon Government, July 2008.

TABLES

INFORMATION REVIEWED

Table 6.1: Information Reviewed for Geotechnical Gap Analysis

Report ID	Title	Author	Year
R01	A Review of the Mt Nansen Property	Strathcona Mineral Services Ltd	2000
R02	Dam Safety Assessment, Summary Data Report Sept 2002	EBA Engineering	2002
R03	Geotechnical Data Review Report	EBA Engineering	1999
R04	Assessment of Chemical Tests Stability	CANMET, Kwong	2002
R07	Historical Review, Site Assessment and Field Program Version 2 Final Report	Conor Pacific	2000
R08	Dam Instrumentation Data and Assessment	EBA Engineering	2004
R10	Mt. Nansen Risk Assessment, Conceptual Closure Plan and Cost Estimation	EBA Engineering	2004
R11	Construction Report - Nansen Seepage Control Dyke & Spillway Upgrading	EBA Engineering	2003
R12	Dam Safety Assessment Tailings Facility	EBA Engineering	2002
R14	Mt Nansen Project Overview	BYG	1994
R19	Initial Environmental Evaluation Vol. 1	T.W. Higgs Associates	1994
R20	Initial Environmental Evaluation Mt Nansen Development Vol. 2	T.W. Higgs, BYG	1995
R21	Review of Tailings Relocation Projects & Methodology	Brodie Consulting	2003
R24	Hydrogeological Field Investigation same as R88 LORAX, Appendix E Hydrogeological Characterization	AECOM	2009
R25	Water Balance for Tailings Ponds	Gartner Lee	2006
R27	Mineralogy of Tailings	J.L. Jambour	2005
R33	Instrumentation Data Review, Tailings & Seepage Collection Dams	EBA Engineering	2006
R37	Phase 1 - Tailings Pond Impound Area; Phase II - Mill Waste Rock Site Cover & Veg Pilot Project	Kearah Environmental	2006
R46	Tailings Facility Construction Report	Klohn-Crippen	1996

Table 6.1: Information Reviewed for Geotechnical Gap Analysis

Report ID	Title	Author	Year
R48	Tailings Impoundment Final Design Report	Klohn-Crippen	1995
R50-51	Pony Creek Adit Bulkhead and Specifications	SRK	2006-07
R59	Initial Environmental Evaluation Mt Nansen Development Addendum Report	T.W. Higgs, BYG	1995
R61-62	Dam Safety Assessment of the Tailings Dam	Klohn-Crippen	1999-2000
R66	Tailings Porewater	LORAX Environmental	2008
R70	Supporting file MEM-091118 – "Pit Disposal - Tailings Transport Methods Alternative 4", "Spillway for Alternative 3", "Pit Disposal Scenarios – Consolidation of Tailings (Alternative 4"): • supporting file MEM-091118 Tailings relocation • supporting file MEM-091118, Placement • supporting file MEM-091118, Tailings consolidation • supporting file MEM-091118, Cover Options	AECOM	2010
R72	Mt. Nansen Mine Closure Cost Assessment	Brodie Consulting	1998
R83	Geotechnical Inspection of Earth Structures Mt Nansen Mine	EBA Engineering	2011 - 2012
R85	Tailings Relocation	AECOM	2011
R86	Snow Survey Program 2011-2012	EDI	2012
R88	Closure Options Report (particularly sections regarding Option 4, Common Closure Elements and Appendix C, Appendix B and Appendix E)	LORAX Environmental	2011
R89	Overview of Mt. Nansen Closure Alternatives Characterization	AECOM	2010
R92	Arctic Gold and Silver Tailings Site Monitoring Reports, 2003-2008	INAC	2008
R93	Mt Nansen Tailings Dam 2008 Geotechnical Inspections	AECOM	2008
R95	Mount Nansen Instrumentation Inspections and Installation	EBA Engineering	2012
R97	Mt Nansen Closure Alternatives, Water Balance, Water Quality Model	GOMM Engineering	2011

Table 6.1: Information Reviewed for Geotechnical Gap Analysis

Report ID	Title	Author	Year
R98	Mt Nansen Mine Reclamation Options Study	Brodie Consulting	2002
R100	Fall 2012 Geotech Drilling and Inst. Install Program	EBA Engineering	2012
R105	Characteristics of Impounded Tailings at Mt. Nansen, Implications for remediation	Kwong, CANMET	2003
R106	Mt Nansen Mine Reclamation Terrain Mapping and Materials Search	EBA Engineering	2009
R117	Conceptual Assessment of Low Infiltration Cover Options for the Mt Nansen Project	Golder	2010
R119	Preliminary report on bedrock geology of the Mount Nansen area, portions of NTS 115I/13	Elizabeth Westberg and Steve Israel, (Yukon Geological Survey)	2012
R120	Evaluation of Mine Waste Disposal in Pit	Brodie Consulting	1998
R158	GW Level & Slug test Oct. 2011, 2012	Norwest Corporation	2012
R159	Groundwater & Surface Water Sampling Field Report - Sept-Oct 2011	LORAX Environmental	2011
R160	Mount Nansen Closure Synopsis of Remediation Field Work; Sept 2011	Altura	2011
R162	Mount Nansen Closure Synopsis of Remediation Field Work; Oct 2011	Altura	2011
R133	Mt Nansen Closure Plan Options (2010); same as [2] Appendix B Geochemical Characterization 2012	LORAX Environmental	2010, 2012
R177	Brown-McDade Pit Assessment at the Mount Nansen Site	EBA Engineering	2012

Table 7.1: Information Reviewed for Hydrotechnical Gap Analysis

Report ID	Title	Author	Year
R64	Brown McDade Hydrological & Hydrogeological Investigation	Gartner Lee	2008
R11	Construction Report - Nansen Seepage Control Dyke & Spillway Upgrading	EBA Engineering	2003
R115	Reclamation Plan-Amendment to Water Licence QZ94-004-Correspondence	BYG	1995-8
R12	Dam Safety Assessment Tailings Facility	EBA Engineering	2002
R13	Tailings Storage Study, Feasibility Design	Klohn-Crippen	1994
R133	Mount Nansen Closure Plan Options Evaluation, Oct 2010 Draft	LORAX Environmental	2010
R15	Environmental Update Report for the Mt. Nansen Gold Project	Norecol Environmental Consultants	1989
R150	Summary of Geotechnical Services for Mount Nansen, Glaciation at MN Diversion	EBA Engineering	2012
R19	Initial Environmental Evaluation Vol. 1	T.W. Higgs Associates	1994
R20	Initial Environmental Evaluation Mt Nansen Development Vol. 2	T.W. Higgs, BYG	1995
R25	Water Balance for Tailings Ponds	Gartner Lee	2006
R40	Updated Water Licence Application Vol. 1	BYG	1995
R47	Tailings Impoundment Feasibility Design Update	Klohn-Crippen	1995
R48	Tailings Impoundment Final Design Report	Klohn-Crippen	1995
R49	Mt Nansen Site Specific Water Quality Investigation	EDI	2009
R59	Initial Environmental Evaluation Mt Nansen Development Addendum Report	T.W. Higgs, BYG	1995
R71	Mt Nansen Hydrologic Monitoring Report and Data, 2011-12	EDI	2012
R78	Mt Nansen 2010 Hydrology Monitoring Report	AECOM	2011
R79	Glaciation of Dome Creek Diversion Channel	Boreal Engineering	2011

Table 7.1: Information Reviewed for Hydrotechnical Gap Analysis

Report ID	Title	Author	Year
R86	Snow Survey Program, 2011-2012	EDI	2012
R88	Mt Nansen 2010-11 Final Closure Options Report	LORAX Environmental	2011
R89	Overview of Mt. Nansen Closure Alternatives Characterization	AECOM	2010
R97	Mt Nansen Closure Alternatives, Water Balance, Water Quality Model	GOMM Engineering	2011
R99	Mt Nansen Mine Site Melt Estimates for a Man-Made Snowpack	Soilcon Laboratories	2000
n/a	Surface Water Investigations	EDI	2013
n/a	LiDAR 2012 Report and LiDAR Data including Ortho-Image	BGC	2013
n/a	Mount Nansen Weather Data	EDI	2005-2012
n/a	Mt Nansen Hydrologic Monitoring Report and Data 2012-13	EDI	2012
n/a	Surface Water Investigation reports	EDI	

Table 8.1: Information Reviewed for Hydrogeology Gap Analysis

Report ID	Title	Author	Year
R009	Brown McDade Hydrological	GLL	2004
R011	Seepage Control Dyke	EBA Engineering	2003
R024	Hydrogeological Field	AECOM	2009
R056	Desktop Hydrogeological	GLL	2007
R064	Hydrogeological Site Char	GLL	2008
R088	Closure Options Report	LORAX Environmental	2011
R088	Closure Options Report, App. A	LORAX Environmental	2011
R088	Closure Options Report, App. E	LORAX Environmental	2011
R102	Groundwater Monitoring Report (2012)	EBA Engineering	2012
R142	Exploration Program Summary Report	DYG Natural Resources	1995
R158	GW Level and Slug Test	Norwest	2012
R159	Ground and Surface Water	LORAX Environmental	2012

Table 9.1: Information Reviewed for Water Quality Gap Analysis

Report ID	Title	Author	Year
R88	Mount Nansen - Options for Closure (with Appendices B; C – selectively, and Appendix F)	LORAX Environmental	2011
R26	Effluent Quality Analysis Report	Vista Engineering	1998
R30	Brown McDade Pit Summer Monitoring	Gartner Lee Ltd	2004
R49	Mt. Nansen Site Specific Water Quality Investigation	EDI Environmental	2009
R66	Tailings Porewater	LORAX Environmental	2008
R74	Pre Development Study of Water Quality, Sediments and Benthic Fauna of Selected Stream in the Mount Nansen Area, Yukon, Prior to the B.Y.G. Natural Resources Project. Regional Program Report 95-03	D. Davidge and P. Bellantyne	1995
R78	Mount Nansen Hydrology Monitoring	AECOM	2011
R89	Mount Nansen - Options for Closure (with Appendices B; C, and F)	LORAX Environmental	2011
R159	Groundwater and Surface Water Sampling	LORAX Environmental	2012
n/a	Mount Nansen Monthly Surface Water, Meteorology Report	EDI	2013
R91	Chemical Analysis Report	ALS	2001
R97	Mount Nansen Closure Alternatives Water Balance/Water Quality Model	Gomm Environmental Engineering Consulting	2011
R139	Mt. Nansen Surface Water Quality Baseline Characterization	AECOM	2009
R112	Bathymetric Analysis of Mt. Nansen Tailings Pond	EDI	2005
R139	Mt. Nansen Surface Water Quality Baseline Characterization	AECOM	2009

Table 9.1: Information Reviewed for Water Quality Gap Analysis

Report ID	Title	Author	Year
R159	Field Report – Groundwater & Surface Water Sampling- 25 Sep. – 1 Oct. 2011	LORAX Environmental	2011
R177	Brown-McDade Pit Assessment at the Mount Nansen Site	EBA Engineering	2012
n/a	Monthly Water Quality Reports, EDI Environmental (April – December 2012)	EDI Environmental	2012
n/a	Mount Nansen Site Interim Data Report: Surface Water and Meteorological Monitoring, 2012-2013 DRAFT	EDI Environmental	2013

Table 10.1: Information Reviewed for Infrastructure, Landform and Revegetation Gap Analysis

Report ID	Title	Author	Year
R07	Historical Review, Site Assessment and Field Program Version 2 Final Report	Conor Pacific	2000
R14	Mount Nansen Project Overview	BYG	1994
R15	Environmental Update Report for the Mount Nansen Gold Project	Norecol Environmental Consultants	1989
R19	Initial Environmental Evaluation Vol. 1	T.W. Higgs Associates	1994
R20	Initial Environmental Evaluation Mount Nansen Development Vol. 2	T.W. Higgs, BYG	1995
R36	Mine Site Reclamation Report	Arctic Alpine Reclamation Group	2006
R38	Hazardous Materials Inventory and Site Assessment	Kearah & Weri	2006
R39	Human Health Screening Level Risk Assessment	SENES Consultants	2003
R52	Bridge Rehab	Associated Engineering	2011
R63	Review of Environmental and Reclamation Issues at the Mount Nansen Mine	Eric Denholm, Strathcona Mineral Services	2000
R69	Bioengineering Works	EDI Environmental Dynamics Inc.	2008
R77	Options for Closure of Mount Nansen Mine, Technical Review Version	AAM	2008
R88	Closure Options Report	LORAX Environmental	2011
R89	Overview of Mount Nansen Closure Alternatives Characterization	AECOM	2010
R98	Mount Nansen Mine Reclamation Options Study	Brodie Consulting	2002
R104	Mt Nansen Hazardous Materials Classification	EBA Engineering	2011
R105	Characteristics of Impounded Tailings at Mt. Nansen, Implications for remediation	Kwong, CANMET	2003
R114	Brown McDade Waste Rock Pile, Ecological Restoration Strategy	Altura	2009

Table 10.1: Information Reviewed for Infrastructure, Landform and Revegetation Gap Analysis

Report ID	Title	Author	Year
R115	Reclamation Plan-Amendment to Water Licence QZ94-004-Correspondence	BYG	1995-8
R130	Limited Phase 2 Environmental Site Assessment Draft Rev 2	Kearah Environmental	2008
R133	Mount Nansen Closure Plan Options (2010); same as [2] Appendix B Geochemical Characterization 2012	LORAX Environmental	2010, 2012
R148	A Review of Several Yukon Revegetation Projects and Techniques	EDI Environmental Dynamics Inc.	2009
R151	Trench Mapping and Sampling Report	Carlyle	1997
R160	Mount Nansen Closure: Synopsis of Field Work LORAX Proposal J907-7 / YG Contract #C00010368	Altura Environmental Consulting	2011
R162	Mount Nansen Closure: Synopsis of Remediation Field Work – LORAX Proposal J987-1 / YG Contract #C00010821	Altura Environmental Consulting	2011
R170	Load Rating of Mt. Nansen Bridge and Diversion Chanel	Associated Engineering	2012
R173	Complete Site Survey	Yukon Engineering Services	2012
n/a	LiDAR 2012 Report and LiDAR Data including Ortho-Image	BGC	2013
	Hazardous Material Removal 2012	KBL	2013

Table 11.1: Information Reviewed for Site Characterization Gap Analysis

Report ID	Title	Author	Year
R04	Assessment of Chemical Stability of Impounded Tailings	CANMET	2002
R07	Mount Nansen Mine Site, Historical Review, Site Assessment and Field Sampling Program, Final report Version 2, June 2000	Conor Pacific	2000
R11	Construction Report – Mount Nansen Seepage Control Dyke & Spillway Upgrading	EBA Engineering	2003
R20	Initial Environmental Evaluation Mt Nansen Development Vol. 2	T.W. Higgs, BYG	1995
R21	Review of Tailings Relocation Projects & Methodology	Brodie Consulting	2003
R30	Brown McDade Pit Summer Monitoring Data Summary Report	Gartner Lee	2005
R32	Mount Nansen Bioremediation Assessment	LORAX Environmental	2006
R36	Mine Site Reclamation Report	Arctic Alpine Reclamation Group	2006
R38	Hazardous Materials Inventory and Site Assessment	Kearah & Weri	2006
R39	Human Health Screening Level Risk Assessment	SENES Consultants	2003
R46	Tailings Facility Construction Report	Klohn-Crippen	1996
R47	Tailings Impoundment Feasibility Design Update	Klohn-Crippen	1995
R48	Tailings Impoundment Final Design Report	Klohn-Crippen	1995
R57	Ecological Risk Evaluation Level 1, Custodial Input Section	SENES Consultants	2003
R63	Review of Environmental and Reclamation Issues at the Mt Nansen Mine	Eric Denholm, Strathcona Mineral Services	2000
R66	Mt Nansen Tailings Porewater Assessment	LORAX Environmental	2008

Table 11.1: Information Reviewed for Site Characterization Gap Analysis

Report ID	Title	Author	Year
R70	Mt Nansen Closure Alt Char	AECOM	2010
R73	Brown McDade Waste Rock Pile Mount Nansen Mine Site, Yukon, Geochemical Characterization, February 2009	Altura Consulting Environmental	2009
R77	Options for Closure of Mt Nansen Mine, Technical Review Version	AAM	2008
R80	Mt Nansen Options For Closure, App. B. Geochemical Characterization	LORAX Environmental	2011
R82	Summary of Estimated Closure Costs Mt Nansen Mine Site	AECOM	2011
R85	Tailings Relocation	AECOM	2011
R88	Mt Nansen 2010-11 Final Closure Options Report	LORAX Environmental	2011
R89	Overview of Mt. Nansen Closure Alternatives Characterization	AECOM	2010
R91	Chemical Analysis Report	EBA Engineering	2001
R92	Arctic Gold and Silver Tailings Site Monitoring Reports, 2003-2008	INAC	2008
R93	Mt Nansen Tailings Dam 2008 Geotechnical Inspections	AECOM	2008
R98	Mt Nansen Mine Reclamation Options Study	Brodie Consulting	2002
R104	Mt Nansen Hazardous Materials Classification	EBA Engineering	2011
R105	Characteristics of Impounded Tailings at Mount Nansen, Yukon Territory–Implication for Remediation	Kwong	2001
R106	Mt Nansen Mine Reclamation Terrain Mapping and Materials Search	EBA Engineering	2009
R112	Bathymetric Analysis of Mt Nansen Tailings Pond	EDI	2005
R113	Brown McDade Waste Rock Pile Mount Nansen Mine Site, Yukon, Summary of 2009 Work Program, December 2009	Altura Environmental Consulting	2009

Table 11.1: Information Reviewed for Site Characterization Gap Analysis

Report ID	Title	Author	Year
R114	Brown McDade Waste Rock Pile, Ecological Restoration Strategy	Altura	2009
R130	Limited Phase 2 Environmental Site Assessment Draft Rev 2	Kearah Environmental	2008
R132	Mount Nansen Mine Closure: Mine to Mill Haul Road – Summary of Rock Characterization Studies, December 2009	Altura Environmental Consulting	2009
R133	Mount Nansen Closure Plan Options Evaluation, Oct 2010 Draft	LORAX Environmental	2010
R156	Ketza Shop Hydrocarbon Impacted Soil Delineation, Mount Nansen Site	EBA Engineering	2012
R159	Groundwater & Surface Water Sampling Field Report - Sept-Oct 2011	LORAX Environmental	2012
R160	Mount Nansen Closure Synopsis of Remediation Field Work; Sept 2011	Altura Environmental Consulting	2011
R161	Mount Nansen Mine Closure: Mill Area Geochemical Characterization, Summary of 2010 Field Investigation Summary of Rock Characterization Studies, December 2010	Altura Environmental Consulting	2010
R162	Mount Nansen Closure Synopsis of Remediation Field Work; Oct 2011	Altura Environmental Consulting	2011
R170	Load Rating of Mt Nansen Bridge at Diversion Channel	Associated Engineering	2012

Table 12.1: Information Reviewed for Drafting Gap Analysis

Title	Author	Year
Quickbird Satellite Orthoimagery		2008
IRS Imagery		1998
Landsat 7 – 15 m resolution Mosaic		
Natural Resources Canada Orthoimage		
Natural Resources Canada DEM, 30 m shaded relief, regional overview		
Base Planimetry Mapping		
1 m contours		1998 (?)
1 m DEM in Bare Earth ASCII files / ESRI GRID files		2012
0.5 m and 1.0 m contours in CAD and ESRI shapefiles		2012
10 cm Digital Orthomosaic		2012
YES site survey	YES	2012
R112, Bathymetric Analysis of Mt, Nansen Tailings Pond	EDI	2005

TABLES

GAP ANALYSES

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
General Design Approach						
G01	Identify what the requirements are for the placed tailings vs. the effort and cost of the relocation	Clear definition of project objectives and criteria. What is required for the tailings to meet these criteria (e.g., do the tailings need to be deposited to a specification that will allow limited settlement and placement of essentially unsaturated tailings or does the potential to place frozen and saturated material exist).	Various competing concepts: • Cover design (LORAX report R88 Appendix C3 and C4) requires relatively small settlement for geomembrane liner. • Transportation method (AECOM R70, memo) indicates excavation of partly frozen material and wet which may result in large settlements and/or porewater discharge. • Various statements that the tailings will be "maintained in a dry state".	n/a	Identify what is required for the pit backfill to meet water quality objectives (i.e., how dry and by when). Identify what is required for the pit backfill to meet stability objectives and avoid a dam structure. Reconcile project objectives with relocation methods assumed and costed to date and identifying potential impacts to Option 4 assumptions and costs.	No site investigation required. The proposed excavation method is not consistent with a controlled placement of material to a certain specification, nor is it consistent with the current water balance for Option 4 which assumes dry tailings. It is understood that the project partners have agreed to "dry" tailings, the methods to achieve this do not have to be those outlined in Option 4 of the LORAX report.
G02	Define and quantify material to be relocated	Detailed contours of existing ground surface and original ground. Characterization of materials including as acceptable or unacceptable from a geochemical perspective. Materials of concern include: tailings in main impoundment, tailings at mill site, underlying affected native material, potentially acid generating (PAG) waste rock, main dam and seepage dam material (this may be able to be reused). The possibility of relocating debris from the remediation activities to within or near the Open Pit will also be explored.	2012 digital elevation model. Original ground from NTS maps and hard copy in original design documentation (R13,17,18,47,48). Appendix F of R02 indicates there is (was) a digital version of the original ground based on survey information. LORAX R88 (2000 t of tailings at mill, 6500 m^3 of mineralized rock at mill, ~300,000 m^3 of tailings from impoundment, 300,000 m^3 of waste rock (not mill site)).	Current volumes are estimates and need to be confirmed. Waste rock volumes are particularly uncertain and it has not been shown if the dam materials are acceptable for reuse or if they need to be relocated to the Open Pit.	Design level volumes of all material requiring relocation. Detailed contours below the current water level in the pit. More detailed original ground contours (if available).	Site investigation required for geochemical characterization. See Section 11.0 and Table 11.2.
G03	Quantify storage volume available in Open Pit and possibly surrounding area	Detailed contours of existing Open Pit and surrounding area. Original ground in waste rock area.	2012 LiDAR data with 0.5 m contours above existing water level in pit and of existing waste rock area. Less detailed information of original ground in pit / waste rock area (R20 has some hard copy data).	Existing ground information is adequate except below existing water level in pit. Less detail available for original ground.	Existing pit contours below current water levels. More detailed original ground (if available).	Requires site investigation. Digital models will be produced in AutoCAD, see section 21 and Table 12.2.

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
Material Characterization						
G04	In-situ state of the tailings in the impoundment	Frozen / unfrozen state and areal extent of each. Water level within tailings deposit (is pond perched). Saturation / in-situ moisture content. Consistency / Density.	Inferential data available on frozen/thawed state from drilling observations (R24, R04, R66) and from monitoring well water levels (R102, R158, 159). Care and Maintenance records have water levels in several locations around the periphery of the tailings deposit.	Limited to poor	Accurate delineation of frozen vs. unfrozen and any seasonal variation. Water level within tailings, particularly under the pond to assess if pond is perched. Saturation / in-situ moisture content. In-situ density, especially of saturated material.	Requires site investigation to fully define. Consideration of investigation effort versus uncertainty will be required to define priority of this investigation. It seems that the majority of the tailings are unfrozen. However, the climate is such that tailings beaches could be frozen (MW 13 and 14). The extent and thickness of any frozen tailings needs confirmation (i.e., drilling with temperature measurements). Report R21 indicates difficulties have been encountered in other tailings relocation projects because the variability of the tailings was not sufficiently characterized and removal of frozen tailings was significantly more difficult than anticipated. The effect of tailings variability will depend on the relocation method selected.
G05	Geotechnical properties of tailings	To completely characterize the tailings would require: • Mineralogy • Particle size distribution (PSD) • Moisture content • Consolidation characteristics • Hydraulic conductivity • Plasticity (Atterberg limits) • Specific gravity • Moisture – density relationship • Moisture retention • Strength • Thermal properties • Trafficability	Various reports (R24, R04, R133). See Table A1 and Figure 1. Logs with visual descriptions are available. Specific geotechnical quantitative information includes: PSD, many from laser some from sieve/hydrometer, 2 moisture contents, 2 soil water characteristic curves, in-situ permeability, a few laboratory hydraulic conductivity. Appendix A of LORAX report refers to on-site trafficability studies.	Limited to poor	Confirmation of amount of data needed for design. Properties that need further assessment may include: moisture content, Atterberg limits, PSD, mineralogy, hydraulic conductivity, moisture retention, consolidation behaviour (type of assessment will depend on the placement method), specific heat, thermal conductivity, moisture-density relationship (depending on placement methods).Locate site trafficability study report.	
G06	Understanding of the depositional environment for the tailings	Did tailings deposition occur above or below water / year round or seasonally. Pond extent and tailings elevations during mining / tailings deposition operation.	General descriptions available in R07, R72, R61A, R12, provide the following: spot elevation of pond during operation, tailings discharge rate, general comments regarding large pond.	General, few specifics	Actual operating records (understood that these were not kept).	No site investigation required. A general understanding of the conditions under which the tailings were deposited has been developed. A more detailed review of historical reports may be completed to try and develop a better understanding if warranted.
G07	In-situ state and characteristics of the tailings at the mill site	Tailings in-situ state (frozen/unfrozen, saturated/unsaturated) Tailings characteristics (PSD, moisture content, consistency, plasticity).	R88 p. 5-8: Tailings identified in Pond #1 and possibly near Pond #2.	No specific qualitative data about the tailings characteristics available	Geotechnical tailings characteristics including: state, PSD, moisture content, consistency, plasticity.	Requires site investigation and will be coordinated with the geochemical sampling and characterization. These appear to be a minor volume and therefore detailed geotechnical testing is not considered necessary. With regards to relocation, they may require special consideration if they cannot be treated as a solid.

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
G08	Geotechnical Characteristics of Tailings Placed in Open Pit	Identification of placement method to allow selection of design parameters. Required design parameters will depend on placement method and may include: compaction characteristics (if applicable), consolidation characteristics, strength, PSD, moisture content, state (frozen vs. unfrozen), hydraulic conductivity, moisture retention, thermal properties. Assessment of long term thermal, seepage and consolidation behaviour of placed tailings.	Characteristics assumed in cover design (R117 and Appendix C of R88). Some soil water characteristic curve SWCC measurements but few details regarding test conditions.	Limited and may not be valid for relocation and placement method ultimately selected.	Placed tailings conditions with regards to: consolidation characteristics, hydraulic conductivity and moisture retention, moisture density relationship, strength, thermal conductivity, specific heat of tailings. Depending on placement method selected these may be measured from laboratory testing on reconstituted samples or estimated based on the in-situ characteristics.	Depending on placement method selected may require site investigation to obtain samples that can be reconstituted to representative conditions and tested. A significant issue to be determined is whether the tailings need to be dewatered and mechanically compacted or if they can be placed at their current in-situ moisture content and allowed to drain and consolidate over time (possibly delaying the cover construction and requiring pit water treatment). This will significantly affect the configuration of the tailings that can be achieved in the Open Pit and the backfilling requirements.
G09	Geotechnical Characteristics of Waste Rock	Key waste rock characteristics include: PSD, general assessment of strength of large particles, plasticity of fine particles, water levels, moisture content	Limited number (3) of PSD (R177, R88 Appendix C)	Limited	General geotechnical characterization index tests	Requires site investigation. Given nature of waste rock assessment of material behaviour and selection of design parameters will be based on basic characterization rather than detailed laboratory testing. Geochemistry of the waste rock is important to identify volumes of material requiring relocation to the Open Pit. This is addressed in Section 11.0 and Table 11.2.
G10	Define State and Geotechnical Characteristics of Main Tailings Dam Material	Key characteristics of concern include: frozen / unfrozen state, saturated / unsaturated state, water level, PSD, moisture content, Atterberg limits, in-situ density	Dam design report (R13, R17, R18, R47, and R48). Dam construction report (R46). Dam investigation and instrumentation review (R02, R03, R08, R33, and R166). Dam reviews / visual inspection reports (R61-62, R12, R83, and R165).	Reasonable	None, pending detailed review of the data.	Requires site investigation to confirm conditions only. The geochemical nature of the soils will determine if the dam material can be reused or has to be stored in the Open Pit (see G02 and Section 11.0 and Table 11.2). Typically freezing temperatures are encountered within the native materials beneath the dam. Water levels generally appear low in the dam. Near freezing temperatures have been recorded in the thermistors. However, general comments imply that the dam isn't frozen. More detailed review is required to assess the condition. A significant volume of frozen material may present challenges for relocation.

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
G11	Define State and Geotechnical Characteristics of Material at Seepage Collection Dam.	Key characteristics of concern include: frozen / unfrozen state, location of groundwater, in-situ density, particularly of saturated material, PSD, moisture content and Atterberg limits.	Construction report, including site investigation (R11 and R100). Inspection and instrumentation review reports (R08, R33, R83, R100, R165 and R166).	Reasonable	None, pending detailed review of the data.	Site investigations required to confirm conditions only. The geochemical nature of the soils will determine if the dam material can be reused or has to be stored in the Open Pit (see G02 and Section 11.0 and Table 11.2). A brief review of thermistor data suggests freezing temperatures are below the dam fill.
Cover Design						
G12	Long term cover infiltration less than or equal to that required to meet water quality criteria (current requirement per LORAX is 5% mean annual precipitation).	Climate data (precipitation, evaporation, temperature). Cover design requirements. Available cover material properties. Tailings properties and predictions regarding behaviour (see tailings characterization G05 and G08).	Current infiltration assumption included in R88.	Limited data with regards to tailings properties and behaviour, and characteristics of locally available cover material. Climate data available is adequate and will be updated in the hydrotechnical task (Section 7.0). Cover design in R88 is very conceptual.	Confirmation of design requirements for cover. Placed tailings characteristics (G08). Predicted tailings behaviour that must be accommodated. Characteristics of materially locally available for cover (see G31).	Requires site investigation as outlined in other design issues (G05, G08). Current tailings relocation plan is in conflict with proposed cover design philosophy. A detailed cover design will be developed based upon updated infiltration requirements determined form water quality modelling and predicted tailings behaviour. The cover design will address settlement/heaving, freeze/thaw cycling, wet/dry cycling, physical degradation, root/animal penetration, air intrusion, gas generation.
G13	Ability of cover to support vegetation	Climate data Cover material properties	Information in R88, R37 and Faro revegetation data.	Limited	Details of Mount Nansen trails (work plan in R37 but little reporting of results).	Any site work will be in conjunction with the landform and site revegetation task (see Section 10.0 and L17 and L18). Desk studies will be required to support design due to time constraints. Field work will be used to validate and uphold the design intent. Plant transpiration is currently excluded from cover design performance. Cover to address short term and long term plant survival (e.g., soil fertility, water holding capacity, potential uptake of contaminants).
G14	Maximum stress and strain on cover geosynthetics due to settlement	Expected long term settlement, differential settlement, and potential for movement due to freezing and/or thawing.	Included in R88.	Conceptual discussion only, very preliminary analyses which may not be applicable to placed conditions.	Predictions for short and long term movement (settlement or heave) of pit backfill.	No site investigation required (addressed in G08) Cover movement (settlement and possibly heave) will be significantly affected by placement conditions of the tailings which, in turn, will be determined by the relocation method selected.

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
G15	Final configuration of cover, extent required to cover affected area and slopes to provide adequate drainage	Extent of affected material to be covered. Water flows to be managed and desired drainage characteristics.	Conceptual cover design in R88.	Conceptual level only	Areal extent of cover required. Final drainage plan (flows and direction).	No site investigation required. This will be an interdisciplinary issue in conjunction with landform and hydrotechnical engineering.
G16	Confirmation that the only cover required is in the Open Pit / waste rock area.	Materials / locations that require an engineered cover.	LORAX R88, p. 5-9 assumption that “additional landfill or cover material not required”, p.5-10 “remaining waste (old refuse disposal area) can be landfilled in place” no mention of cover design needed.	Conceptual level assumption.	Identification of any areas other than the Open Pit that require an engineered cover.	No site investigation required. If additional areas require a cover this will be identified as part of the site characterization and water quality work.
Material Relocation						
G17	Identify requirements that must be met by relocation method.	Requirements for placed tailings (water quality and stability) and at what point there is flexibility with regards to requirements in consideration of effort and cost required to achieve the requirements.	Various competing objectives (see Item G01).	Conceptual description of objective (“dry tailings”) but no quantitative definition of dry or specific requirements.	Quantitative criteria for in-pit backfilled material. Integration of placement objectives, assumed relocation method for costing and desired timelines.	No site investigation is required. As requirements are better understood discussions with project partners will be needed to discuss the implications of possible relocation strategies.
G18	Define relocation method for main tailings impoundment.	Requirements that must be met by relocation operation with regards to tailings placement in Open Pit. Existing tailings characteristics.	LORAX R88 p 5-113 states that “mechanical removal provides a more viable option”. AECOM R70, Mem-091118 Consolidation of tailings indicates a truck and shovel operation of partly frozen material in the winter time is preferred based on a discussion with one contractor. Brodie R21 states tailings are too wet to be moved by truck and shovel. See tailings characterization (G05).	Conceptual	Identify requirements of placed tailings. Characteristics of in-situ tailings. Identify relocation options that will provide a material that meets the requirements.	No additional site investigation required (G05 will cover). As relocation options are developed, any insights that can be gained from planed field work will be identified and monitored (e.g., trafficability of equipment used, stability of test pits, seepage into test pits, etc.). Selected relocation method will be driven by the required in-pit tailings properties in (physical and water quality). Tailings trafficability is likely poor. This will influence the equipment that can be used and/or the removal methods used and/or the rate at which removal can occur. R21 identified that difficulties had been encountered on other projects because of unexpectedly large volumes of debris were encountered in the tailings – the possibility of this needs to be addressed.

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
G19	Timing and duration of relocation work.	Any considerations other than removal and placement practicalities that would require work to be done during a certain time of year or completed in a certain period (e.g., avoiding hunting season, animal migration etc.).	Issue not considered	No data	Definition of any restrictions on work period.	No site investigation required. It is understood from discussions with AAM that there are no restrictions on when work is carried out.
G20	Define relocation methods for tailings at mill site.	Volume and physical characteristics of material.	R88 LORAX pgs 5-10, approximately 2,000 t	None	Relocation method. Quantity (see G02). Properties (G07).	Requires site investigation. May not be able to handle as a solid. This may necessitate dewatering during construction or possibly post construction in pit which would require consideration in design.
G21	Tailings and waste rock placement method in pit	Conceptual plans for placement of tailings and waste rock in pit. Issues to consider include: what type of tailings deposit has to be delivered; how will the tailings be placed -are trucks planned to drive down into the pit and dump material, which would be pushed by a dozer; how and where would trucks be unloaded; will placed tailings be trafficable, etc.	No specific discussion of how material would be placed in pit found in R70 or R88.	Placement methods have not been developed.	Evaluation of different placement methods (conveying/stacking options, and mobile equipment in pit). Specifics of truck handling (currently identified as the preferred relocation option) not defined. Assessment of need to remove water from pit prior to any material placement.	No site investigation required. Key issue is trafficability and characteristics of the tailings in the pit; once a waste rock platform has been established, placement is expected to be relatively straight forward. This is a significant data gap and may affect the cost for this option.
G22	Mobilization, procurement	What is capital expenditure CAPEX has been budgeted for the project as it relates to truck and shovel, or alternate, solutions?	Have found several cost estimates (R88, R70), unsure if any are baseline estimates.	Unclear what has been assumed in cost estimate.	Identify if any mobile equipment exists already. Identify if there is local experience with regards to available equipment or expertise that needs to be considered.	No site investigation required. It is understood that equipment will be provided by the contractor selected for the remediation work.
G23	Assess on-site haul roads and effect on relocation methods.	Site road grades, weight restriction etc.	Site topography, 2012 LiDAR and YES 2012 site survey.	The conceptual assessment of relocation options has not specifically considered this to date. Topography available is sufficient for assessment.	Assessment of the hauling logistics (or other relocation options) and effects of site grades on relocation methods and costs.	No site investigation required.
General Geotechnical Considerations						
G24	Geotechnical Hazard Assessment	Air photos General information regarding geology and site conditions.	Reports on local and regional geology from the various geological survey associations.	No site geotechnical hazard assessment has been located in the documentation provided.	Air photos, site reconnaissance.	Requires site investigation.

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
G25	Stability of Tailings During Removal	State and characterization of tailings.	See G05	See G05	See G05	Requires site investigation per G05. As removal options are developed, consideration will be given to the possibility of observations or assessments during the field program to provide insight to tailings stability (e.g., stability of test pits, etc.).
G26	Stability and Integrity of Tailings Dam During Tailings Removal	Characterization of current state of dam (configuration, material strength, water levels).	See G10	See G10	See G10	Requires site investigation only to confirm conditions, see G10.
G27	Design of waste rock platform in Open Pit	Long term groundwater levels (input from hydrogeological discipline). Waste rock PSD (for filter compatibility with tailings). Pit volume.	Conceptual waste rock platform elevation in R88, based on maximum water level measured in the pit (Appendix E of R88): • Limited PSD (R88 Appendix C, R117) • Approximate pit volumes (R88)	Preliminary assessment. Does not appear to be based on a hydrogeologic model of long term groundwater levels with a backfilled pit.	Design long term water level. Representative PSD distribution. Detailed pit contours below current water levels (see Drafting section).	Requires site investigation. Depending on PSD of tailings and waste rock, may require processing of waste rock for filter compatibility. May need to provide for a system to monitor and potentially remove pit water for treatment.
G28	Design of Waste Rock Overlying Tailings including stability and assessment of response to earthquake loading	Characteristics and achievable profile of deposited tailings to identify stabilization needs that must be provided by waste rock. PSD of waste rock. Waste rock strength properties. Groundwater conditions in the Open Pit.	• Limited waste rock PSD (R88 Appendix C, R117) Conceptual configuration (R88, R70). Groundwater below upper waste rock unit (see discussion in G27 above).	There is no documented analyses of the backfilled Open Pit.	Waste rock PSD. Identification of placed tailings conditions (short term and long term). Analyses and assessment of backfilled Open Pit.	Requires site investigation to characterize the waste rock. The configuration of the tailings and waste rock will take into consideration the project objective of avoiding a dam structure.
G29	Assessment and considerations for “abutments”, particularly at the south end of the Open Pit	Condition of pit wall.	Pit assessment reports R177 and R119.	Pit condition with respect to stability and access has been investigated and well documented (see G32 and G34). The interaction of the pit walls and the pit backfill have not been considered.	Condition of pit walls with respect to interaction with pit backfill.	Requires site investigation.

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
G30	Stability of remaining waste rock area	Foundation conditions. Current slopes. Historical performance of waste rock area. Waste rock strength. Groundwater conditions.	Some logs from drilling in the general vicinity of the Open Pit (R24, R64). Existing stability R07, p.27 and R70 Appendix C. Brief summary of construction in R07 p. 27. No stripping below waste rock area (R72). Original design R19, R20, Appendix I-VII, and R59.	Limited: • General understanding of geology and conditions around Open Pit likely sufficient for foundation assessment. • Waste rock strength properties can be estimated from understanding of waste rock characteristics (composition and PSD).	Representative characterization of waste rock. Description of historic waste rock area performance. Confirmation of foundation conditions. Groundwater levels.	Requires site investigation.
G31	Characterize borrow sources	New borrow material needs to be characterized with regards to: location, areal extent and depth, PSD, moisture content, and Atterberg limits. Depending on the use of borrow material, characterization may also require: moisture density relationship, hydraulic conductivity and moisture retention. For reuse of existing fill dam and waste rock material need to assess geochemical acceptability.	EBA materials search report (R106). PSD for local sand near tailings facility (R46). PSD (1) for Victoria Creek gravel (R88 Appendix C) Various reports regarding waste rock and its reuse, some with conflicting conclusions.	Borrow search is preliminary and focused on fine grained material. Limited to poor data available to assess the reuse of on-site materials as borrow.	Field truthing and characterization of potential borrow locations identified in R106 and other potential borrow sources. Volume and location of waste rock suitable as borrow material. Confirmation that dam material can be reused as borrow. Characterization of on-site borrow (sand and “shale”)	Requires site investigation both geotechnical and geochemical. Given the project time constraints, potential borrow sources will be likely be characterized before the material requirements for the project have been identified. There is a lack of fine grained material within the OIC boundary and no clay material has been identified within close proximity to the site. This may require the use of a synthetic cover component.
Open Pit						
G32	Assessment of short-term pit wall stability during site remediation (safe access)	As-built pit slopes on bench and inter-ramp scale. Condition of rockmass.	Brown-McDade Pit Assessment at the Mount Nansen Site, EBA, Nov. 2012 (R177). R 29. Original pit design R14, 19, 20 and 59.	Systematic and comprehensive (21 sectors identified, risk matrix used).	Confirmation of reported conditions. Assessment of rock angularity. RocFall (Rocscience) or Colorado Rockfall Simulation Program (Colorado Geol. Survey) simulation. Updates to the recommendations.	Requires site investigation.

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
G33	Assessment of short-term stability of Pony Creek adit surroundings	As-built pit slopes. Assessment of how much rubble is present on the catch benches above the adits. Current adit conditions.	Limited information in pit assessment report (R177). Design for bulkhead in Pony Creek Adit (R50-51).	Limited, the design and specifications for the Pony Creek adit bulkhead are available but there is no record of what was actually constructed. No comprehensive evaluation of current adit conditions.	Actual bulkhead constructed. Current conditions in adit.	Requires site investigation. The Pony Creek adit is not considered to have any impact on pit slope stability. If work is required within the adit to reduce seepage flows (this is a hydrogeology issue see HG01), requirements for safe access will be developed. Report R177 indicates 5 portals, only the Pony Creek adit is discussed in detail in any other reporting. It is understood that with the exception of the Pony Creek Adit, the other portals reported are limited in depth to a few meters and are not likely significant with regards to pit stability.
G34	Assessment of long-term stability of any pit slope that remain exposed in final landscape	Identification of slopes that will remain in final landscape. Rockmass characterization. Assessment of potential instability mechanisms. Stability assessment.	Pit assessment report (R177) Pit geology assessment (R119)	Reasonable	Location and configuration of slopes remaining in final landscape. Confirmation of reported conditions. Long term stability assessment.	Requires site investigation.
Permafrost / Thermal						
G35	Assessment of time required to freeze tailings to support winter excavation (if chosen)	Thermal properties of tailings in the impoundment. Climate data.	Temperature data available around tailings facility (R166 provides summary). No data regarding tailings thermal properties.	Climate data is adequate. No site specific tailings data.	Thermal conductivity of tailings. Specific heat of tailings. Unfrozen moisture content.	Site investigation required to define site specific parameters. Assessments could be done on the basis of assumed thermal parameters.
G36	Assessment of thermal behaviour of placed tailings in Open Pit (short and long term)	Temperature in and around Open Pit. Thermal properties of materials in backfilled Open Pit.	Limited qualitative data regarding thermal regime at the Open Pit based on frozen vs. thawed monitoring wells (R102, R158, R159). No data regarding tailings thermal properties.	No quantitative data.	Temperatures of ground surrounding Open Pit. Thermal conductivity of tailings. Specific heat of tailings. Unfrozen moisture content.	May benefit from laboratory testing depending on relocation method. However, assessments could be done using assumed parameters. Design is not premised on frozen tailings. Frozen tailings would be considered a benefit as it would reduce seepage; however, there are potential complications that could result (such as heave, upward flow of tailings water, consolidation upon thaw). It is therefore recommended that thermal assessments be carried out to assess the likelihood of developing frozen tailings.

Table 6.2: Geotechnical Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
G37	Interaction of unfrozen and freezing soils (potential for erosion and thermo-erosion) within the tailings and dam impoundment and restored Dome Creek.	Climate data. Current permafrost conditions / ground temperatures. Thermal properties of soils.	Climate data (EDI monitoring reports, also see references in the hydrotechnical section HT05). Pre impoundment drilling of native materials (R13, R18, and R48). Thermistors in main dam and seepage areas (R02, R03, R08, R33, R100, and R166). Description of permafrost during drilling in tailings facility (R24).	Limited	Thermal characterization of native materials in Dome Creek. Depth of talik under tailings facility.	Requires site investigation. Assessments will be carried out to estimate the erosion/thermo-erosion rate and provide recommendations on mitigative measures if the erosion/thermo-erosion rate will be excessive.
G38	Potential effects of freezing of the talik under the tailings and/or dam.	Thickness of the talik and soil parameters of the soils within the talik are required. Climate data projected in the future during period of the talik freezing. Physical soil parameters.	Data from pre-impoundment drilling (R13, R18, and R48). Limited data for current conditions in native material under tailings based on comments in drill logs that penetrated through tailings (R24). R24 show cross section through tailings indicating top of permafrost is near tailings / native soil interface.	Limited	Characterization of native materials under tailings.	Requires site investigation. General site descriptions do not suggest that this is a significant risk of adverse effects due to ground freezing (e.g., pingos); however, the potential should be assessed on a screening level with further assessments carried out if warranted.
G39	Exposure of potentially ice rich permafrost following excavation of the waste material.	Data on ice content and temperature of the native soil under the waste material.	Thermistors in surrounding area (R02, R03, R08, R33, R100, and R166). Visual descriptions of permafrost encountered during drilling through native soils in tailings area R02, R11/12, R24, R100.	Very limited data beneath tailings impoundment.	Temperature measurement during drilling. Possibly installation of thermistors in native material under tailings.	Requires site investigation. Ground vegetation under the waste material was destroyed. Thus, exposure of ice rich permafrost may potentially result in deep thawing and development of thermokarst and thermoerosion. Geothermal analyses should be carried out to assess potential for development of thermokarst and thermoerosion.

Table 7.2: Hydrotechnical Gap Analysis

ID #	Issue/Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
HT01	Overall Site Drainage (flow paths)	Flow paths and characteristics – surface water/groundwater interaction.	R025 (GLL 2007). R093 (AECOM 2008).	Limited - catchment areas are defined and seepage data from flowmeters are available from 1999-2003 but there is no current data.	Sources and quantities of Springs/Groundwater discharge/surface water interaction.	Requires site investigation. Includes observations of freshet conditions to understand flow variability.
HT02	Restoration of Dome Creek (tailings and mill areas)	Bank-full flow rate.	Unavailable	No data	Estimated bankfull flow rate.	No site investigation required. Information from detailed survey will be used for estimating bank-full flow rate.
		Extreme flow data or design storms	R009 (GLL 2004) R089 (AECOM 2010)	Limited - insufficient rainfall records on-site (2000-2003).	Extreme flow data corresponding to appropriate return interval and watershed area.	No site investigation required. Detailed watershed modeling is required.
		Typical annual hydrograph, mean, minimum, maximum flows and any changes to flow rate	R078 (AECOM 2011)	Limited - there is enough spatial coverage (6 continuous gauge stations) but insufficient quantity of data records. (2011-2012).	Relating site hydrograph to regional long-term flow monitoring stations.	No site investigation required. Ongoing flow and weather station monitoring to continue. Further data analysis might be required, including correlating site data to regional records.
		Upstream watershed characteristics, detailed topography (0.5 m interval or less) and any major changes	LiDAR 2013	Good - enough spatial coverage and detail.	None	No site investigation required.
		Channel forming soils	Unavailable	No data	Soil characteristics in the channel.	Requires site investigation. Sampling of channel bottom sediments for gradation analysis.
		Sediments characteristics (aggradations and degradations)	Unavailable	No data	Segments of channel aggradation or degradation. Sediment characteristics	Requires site investigation. Walk channel alignment during site visit. Identifying sections of the creek where sediments are accumulating and where sediments are being lost.
		Upstream and downstream channel characteristics - slopes, x-sections and patterns	R040 BYG (1995) R011 EBA (2003)	Limited - Low level of detail of the existing data.	Detailed x-sections and channel alignment survey of upstream and downstream.	Requires site investigation. Information will also be used for estimating bank flow rate. Select upstream and downstream channel segment which will require detailed surveying and evaluation of channel characteristics.
HT03	Pit area drainage design (diversion channels cover drainage)	Upstream watershed characteristics with detailed topography (0.5 m interval or less)	LiDAR 2013	Good - Spatial coverage for all sites. 0.5 m interval resolution.	None	No site investigation required.
		Extreme flow data or design storms	R009 (GLL 2004) R089 (AECOM 2010)	Limited Original analysis is old and needs to be updated	Extreme flow data corresponding to appropriate return interval and watershed area.	No site investigation required. Ongoing flow and weather station monitoring to continue. Detailed watershed modeling is required

Table 7.2: Hydrotechnical Gap Analysis

ID #	Issue/Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
		Detailed cover layout design	Conceptual layout in R88	Conceptual	Detailed design configuration.	No site investigation required. Information will be available after the design.
		Availability and suitability of riprap for erosion control material	Unavailable	No data	Riprap borrow area and characteristics.	Site investigation required (see Tables 6.2 and 11.2). Need to confirm geochemical suitability of waste rock.
HT04	Construction water management plan and erosion control plan	Detailed construction areas characteristics	Topography site imagery and site survey	Good	None	No site investigation required Need to identify site (e.g., pit area, tailing area) water treatment needs during construction (i.e., sediment, metals, etc.)
		Average year flows and extreme flow or storm data	R088 (App F. LORAX 2011) R009 (GLL 2004) R089 (AECOM 2010)	Limited -Not sufficient record (2000-2003)	Flow data corresponding to appropriate return interval and watershed area.	No site investigation required. Ongoing flow monitoring to continue. Further data analysis may be required, including possibly correlating site data to regional records.
		Upstream watershed characteristics with detailed topography	LiDAR 2013	Good - Spatial coverage for all sites. 0.5 m interval resolution. Sufficient to describe watershed characteristics.	None	No site investigation required.
HT05	Water balance	Monthly precipitation, average year, dry year and wet year	R088 (App F. LORAX 2011)	Satisfactory - Climate record for the site for 1964-2006 using Carmacks station. There is enough quantity and quality of data for estimation.	Assessment / confirmation of data	No site investigation required. Ongoing weather station monitoring. Update the water balance model, starting with a detailed review of validity of the existing modeling assumptions. Estimation of any surface water recharge from the Pony Creek to the pit and vice versa. For water balance modeling around the Open Pit, an understanding of the interaction between surface water in Pony Creek and the pit is important. This is addressed in HG05
		Mean, minimum, maximum monthly annual flows	R088 (App F. LORAX 2011)	Satisfactory - Monthly flows were calculated for each precipitation condition in Dome Creek, Pony Creek and Victoria Creek. Enough spatial coverage.	Relating site hydrograph to regional long-term flow monitoring stations.	No site investigation required. Ongoing monitoring to continue. Further data analysis may be required, including correlating site data to regional records.
		Upstream watershed characteristics with detailed topography	LiDAR 2013	Good - Spatial coverage for all sites. 0.5 m interval resolution.		No site investigation required.

Table 8.2: Hydrogeology Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
HG01	Quantification of groundwater rate and quality leaving the Open Pit via pit floor. Determination whether major faults intersecting the in Open Pit act as groundwater conduits. Characterization of Open Pit adit(s).	Rock mass characterization of: Open Pit floor, plus lower walls with respect to major fault intersections, plus open adit(s) notably at or below El. 1190 m (TBC). Groundwater quality below Open Pit.	R009 (GLL 2004) R056 (GLL 2007) R064 (GLL 2008) R088 (App. E, AECOM 2010).	No rock mass or groundwater quality data below Open Pit floor. No pathway assessment of major faults intersecting Open Pit.	Connectivity of pit floor and major faults to deeper groundwater system. Influence of thermal regime on deeper groundwater movement. Connectivity of adit(s) intersecting the Open Pit and outside environment.	Requires site investigation. Possible water tracer use to assess groundwater movement out of the Open Pit.
HG02	Quantification of Pony Creek water contribution to Open Pit.	Pony Creek-Open Pit. Recharge assessment.	R009 (GLL 2004) R056 (GLL 2007) R064 (GLL 2008) R088 (App. E, AECOM 2010).	Open pit water balance models used to estimate Pony Creek recharge volumes.	No surface water-groundwater interaction assessment between Pony Creek and Open Pit.	Requires site investigation. Potential recharge reduction needed, involving Pony Creek watercourse modification.
HG03	Evaluate long-term pit water level(s) for Option 4 design use (preliminary El. 1190 m).	Water balance updates for Pony Creek recharge and new data collected since last model (GLL 2007).	R009 (GLL 2004) R056 (GLL 2007) R064 (GLL 2008) Previous Excel-based model (2007).	Data from 2004 to 2007.	Update model with 2010 to 2012 data. Revise water balance to simulate remediation design (Option 4), i.e., Pony Creek recharge reduction and evaporative loss change after low-infiltration Open Pit cover is constructed.	No site investigation required. Ongoing collection of data from pit and groundwater wells.
HG04	Quantification of groundwater moving hydraulically down gradient of Open Pit. Long-term groundwater quality.	Shallow and deeper groundwater system connectivity. Hydraulic gradients for flow directions, quantities and multi-level (shallow, intermediate and deeper) sampling for groundwater quality.	No data between Open Pit and tailings pond area. Some data available on Pony Creek side.	No rock mass or groundwater quality data between Open Pit and tailings pond area.	Groundwater pathways and groundwater quality. Influence of thermal regime on shallow, intermediate and deeper groundwater movement.	Requires site investigation.
HG05	Long-term general groundwater quality entering Dome and Pony/Back Creeks.	Groundwater baseflow contribution to Dome and Pony/Back Creeks. Discharge-recharge assessment of creeks, i.e., gaining or losing stages.	No data.	No data.	Creek baseflow and groundwater quality contributing to potential groundwater contaminants.	Requires site investigation.
HG06	Long-term point-source groundwater quality entering Dome Creek from adit drainage (lower Huestis and possibly Webber adit).	Point source location, groundwater flow and quality from adit source.	R142 (BYG 1997).	Limited information. One low-resolution drawing showing Huestis and Webber underground workings and associated veins mined out.	Location and environmental impact to upper Dome Creek watershed.	Requires site investigation. Historic mine records search (if existing). Historic aerial photo search.
HG07	Water supply well(s) at Victoria Creek.	Well(s) total depth and artesian flow rate to design decommissioning.	General depth only.	Limited information.	Total depth, artesian flow (or shut-in pressure) and decommissioning access.	Requires site measurements. Well depth and flow survey.

Table 9.2: Water Quality

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
W01	Pit Lake water treatment (water quality)	Detailed water quality profile. Stratified or mixed conditions prevalence.	Limited data available on water quality in pit lake information. (AECOM WQ Baseline report; EDI Monthly WQ reports).	Water quality on limit parameters at top, middle, bottom layers provided, no details by depth.	Detailed water quality profiles. Pit depth and volumes / stage-volume curve.	Requires site investigation. The scope of this SI requirement will be defined to address information requirements that are not captured by the existing EDI monitoring program.
W02	Pit Lake water treatment – (volumes of water)	Stage volume curve / information.	No data	No data	Existing water volume requiring treatment	Requires site investigation to survey depth profiles and provide volumes estimate (stage – volume curve).
W03	Tailings water treatment (water quality)	Surface water quality and porewater quality.	A recent sampling event available (by LORAX, 2012; Site specific report).	Surface and groundwater quality sampling data.	Porewater quality data are not available.	This will be addressed by sampling the tailings pond.
W04	Flow data in creeks at the sampling events	Site water quality mass balance calculations.	Field flow data.	Site data adequate, requires assessment and use in water quality model.	Assessment of site data.	Requires site investigation. Ongoing EDI monitoring program to be continued..
W05	Site water balance and quality model input and output data (Option 4)	Existing water quality model. Water quality data in creeks. Water quality data for surface runoff in mill area, tailings area, and waste rock area). Water quality from major seepages (e.g., Huestis adit).	Summary of current water quality model (GOMM engineering). EDI sampling data. Geochemical data (many Altura reports).	Model assumptions in water balance and water quality components are very generic and do not account to a variety of drainage and water quality loadings conditions.	Watershed characteristics and related mass loadings. Geochemical characteristics are not accounted for in model inputs. Surface runoff quality from site facilities, particularly during high/low flow conditions. Quality of seepage locations particularly during high / low flow condition. Quality of channel bottom sediments in potential erosion / deposition reaches.	Requires site investigation. Ongoing monitoring to continue. The existing model will be modified and updated to provide an integrated water balance/water quality model that will facilitate the evaluation of the relationship between key design parameters for remedial Option 4 and the resulting water quality parameters downstream. The model will help assess the existing conditions at the site and evaluate the long term performance of the remediation design. This model updating will be undertaken as part of TAR #6 activity.
W06	Identify water quality guidelines application	It is unclear how guidelines for metals were applied as they are pH or hardness dependent.	No guidelines application method available.	No guidelines application description provided.	Site specific water quality guidelines	No additional site investigation required. Due to potentially elevated concentrations in background (reference sites) water quality a development of site specific guidelines will be proposed (using CCME methodology and/or BC MoE approach) for further application in the assessment and regulatory application.

Table 10.2: Infrastructure, Landform, and Revegetation Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
L01	Site grading	Site Survey sufficient for design.	BCG Engineering (2012) LiDAR Survey	Site wide (25 ha); accuracy (15-30 cm)	Underground utilities; areas obscured by water; road/trail culverts or drainage structures; areas obscured by vegetation. Ground Truthing.	Requires site visit. Site visits will be required to become familiar with the site, surrounding area, project constraints, and provide the opportunity to compare the information reviewed through the desktop study with the actual field conditions. Additional survey requirements may be identified in consultation with other project disciplines.
L02	Closure of site roads	Inventory and characterization of road network.	LORAX Report 2011 Altura Reports	Full site LiDAR. Full Site Ortho photos	Contamination delineation. Characterization of road material. Confirmation of geochemistry.	Requires site visit and investigation in conjunction with site characterization (see Table 11.2). Will require site characterization (S05 and S11) input
L03	Closure of site trails	Inventory and characterization of trail network.	LORAX Report 2011 Altura Reports	Full site LiDAR Full Site Ortho photos	N/a	Requires site visit to verify desktop study information and observe actual conditions. Trails are minor and current documentation suggests that decompaction is not required but that trails will require revegetation.
L04	Remediation of exploration trenches	Inventory Characterization and quantity of material available adjacent to trenches for backfilling.	LORAX Report 2011 Altura Reports	Full site LiDAR Full Site Ortho photos	Field verification	Requires site visit to verify desktop study information and observe actual conditions. If material has visual indication of contamination or metal leaching, it will be characterized. Some areas of remediation should be compared to access requirements.
L05	Miscellaneous Infrastructure	Complete inventory of underground and surface features.	LORAX Report 2011 Stantec Electrical Assessment	General description but no detailed inventory.	Inventory of on-site infrastructure, including: • Power Infrastructure. • Pipelines. • Underground infrastructure. • Pump houses. • Storage area. • Misc. debris. • Confirm no hazardous products. • Confirm location and nature of sewage disposal system. Determine if on-site bridge needs upgrading for construction. Identify if remediation of landfill is required. Confirm critical infrastructure required to operate past closure. Preliminary assessment of power requirements during and post remediation.	Requires site visit to verify desktop study information and observe actual conditions. Assessment of landfill is covered by site characterization (S08). Unless an issue is identified, the landfill will be integrated into the final landscape with as little disturbance as possible.
L06	Miscellaneous Clearings	Inventory	Ortho Photos LORAX Report	Full site LiDAR Full Site Ortho photos	Adequate	Requires site visit for field confirmation.

Table 10.2: Infrastructure, Landform, and Revegetation Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
L07	Borrow Material Requirements with regards to desired characteristics (e.g., soil type or gradation) and volume.	Volume and type of borrow required.	LORAX 2011	Little work has been completed on required volumes of borrow material.	Volumes Required materials Source identification	No site investigation required. Characterization of available borrow is considered in geotechnical discipline (G31). During the 30% design stage, Infrastructure will quantify borrow requirements based on the borrow material available and the grading plan developed. This will include identifying the material types (this could be common fill, rip rap, granular, topsoil etc.) and preliminary volumes. Grading volumes and types will be directly related to the landform concepts prepared by the landform engineer.
L08	Remediating the landscape to its original form and traditional land use and natural appearance.	Characterization of the landscape type. Survey data, orthophotos, site photos, organic material characterizations and source, vegetation data.	R69 Bioengineering Works. R07 Historical Review, Site Assessment. R106 Mount Nansen Mine Reclamation Terrain Mapping and Materials Search. R114 Brown McDade Waste Rock Pile, Ecological Restoration Strategy. R148 Review of Several Yukon Revegetation Projects.	Site wide LiDAR	Target form for landform design. Material Source. Vegetation Analysis (see details below, L14, L18).	Requires site visit to observe site characteristics. The landform engineer's work relies on field conformation of topography to develop sketches of desired landform shape that characterizes the greater landscape. This will provide a target form for the final "aesthetic" of the site.
L09	Building demolition including development of a waste management plan and identifying feasible deconstruction method(s)	Building inventory Hazardous materials assessment Identify and obtain as built drawings for all buildings/structures, including: • description of construction type, with photos • quantified floor area and height per floor if multiple floors • inventory of materials, including known hazardous materials based on pre-deconstruction assessments.	Human Health Screening Level Risk Assessment - SENES Consultants (2003). Hazardous Materials Inventory and Site Assessment - Kearah & Weri (2006). Limited Phase 2 Environmental Site Assessment draft rev 2 - Kearah Environmental (2008). Mount Nansen Hazardous Materials Classification - EBA Engineering (2011). Hazardous Material Removal 2012 - KBL (2013).	Site Wide	As-built drawings	Requires site visit and possibly survey. Record drawings must be available before the field inspection. Where record drawings are insufficiently dimensioned additional field surveys will be completed to augment the available data. Hazardous materials will be quantified and delineated by site characterization discipline.

Table 10.2: Infrastructure, Landform, and Revegetation Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
L10	Define and quantify total volume of demolition material to be landfilled (on-site and/or off-site), recycled or otherwise disposed of.	• Type of waste generated during demolition. • Volume of waste generated during demolition. • Feasibility / cost of recycling materials. • Implications and cost of on-site vs. off-site landfilling.	See items L09 and L05	General descriptions are available but no specific volumes or other quantifications	See item L09 and L05 Trade off information between on-site disposal, off-site disposal and recycling.	Requires site investigation as outlined in L05 and L09.
L11	New landfill development	Quantity and type of material to be stored. Location and configuration of new landfill.	No data available.	No data available.	Quantity and type of material to be stored. Location and configuration of new landfill.	Requires site visit and possible investigation depending on design developed. Input may be required from geotechnical and site characterization disciplines depending on the materials to be stored and the location selected. If a new landfill is required, consideration will be given to locating the new landfill in an area of existing disturbance, with the currently favoured location in or near the Open Pit. This would allow the pit cover to be extended over the landfill if required and may allow the pit backfill and new landfill to create a single landform integrated with the existing landscape. This area will also be well investigated and characterized. If a different site is selected during the design phase, the landfill plan developed may include confirmatory investigation as an initial step in the implementation.
L12	Pre-disturbance and traditional land use	Landscape conditions prior to development. Traditional plant (e.g., berries, roots, herbs, medicinal) and wildlife harvesting.	R15 Norecol 1989 R114 Altura 2009	Good quality of overview information for the Mount Nansen area.	A more detailed review of local knowledge is required.	No site investigation required. The wildlife information is at a reconnaissance level, but provides relevant baseline conditions and sufficient descriptions of wildlife use to allow the landform and revegetation design to be carried out. Interaction with AAM's other subconsultants carrying out the baseline work will be undertaken.
L13	Pre-disturbance and adjacent ecology	Vegetation ecology for the site prior to disturbance. Vegetation ecology of the adjacent landscape in undisturbed or minimally disturbed areas.	R15 Norecol R07 Conor Pacific 2002 R114 Altura 2009 R69 EDI 2008 Other reports will be available by April 30 (e.g., ELR baseline reports, EDI reports)	Limited in spatial extent and level of detail.	Limited pre-disturbance species lists or ecological community classification	Requires site investigation. Dominant trees and shrub species is provided, but the number of species is limited to less than five. A more detailed species list is relevant to the end landscape and vegetation composition goals.

Table 10.2: Infrastructure, Landform, and Revegetation Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
L14	Baseline Mapping	Current vegetation cover and composition and substrate characterization.	R114 Altura 2009 R69 EDI 2008 Other reports will be available by April 30 (e.g., ELR baseline reports, EDI reports)	• Limited in spatial extent.	No delineation of substrate characterization or vegetation cover on the site or adjacent area.	Requires site investigation. This will provide the spatial extent of disturbance, different substrates within those disturbed units and vegetation cover. It will also provide a base map of adjacent vegetation types to be used in planning for plant material sources and natural colonization areas.
L15	Vegetation, soils and wildlife baseline	Vegetation communities and species present and the level of ground cover; soil quantity and quality; wildlife use within and adjacent to the site. Presence of toxins within vegetation on and adjacent to the site.	R69 EDI 2008 R07 Conor Pacific 2002 R106 EBA Engineering 2009 R114 Altura 2009 R148 EDI 2009	Limited level of detail and spatial extent.	Species lists and community composition adjacent to the disturbance units and within the disturbance. Wildlife presence/absence and level of use within and adjacent to the site. Soil depth, location and quality. Vegetation metal uptake.	Requires site investigation. Planning will be directed by vegetation species available and location for planting and natural colonization. Wildlife use will determine potential implications to planting and direct end land use objectives. Soil information will direct remediation planning and is intrinsic to revegetation success. A baseline of tissue metal uptake is important for future reference especially pertaining to traditional use.
L16	Topography and substrate drainage	The slopes and aspects of the sites to be revegetated, and site drainage.	BCG Engineering (2012) LiDAR Survey	Good as it is site wide (25 ha); accuracy (15-30 cm)	Detailed substrate drainage is not defined at post remediation or currently.	Requires site investigation in conjunction with other disciplines. This will be determined as part of other components and will be made available through information sharing. In some locations site drainage will be altered during the remediation process.
L17	Surficial materials characteristics	Surface material physical and chemical characterization.	R114 Altura 2009 R105 Kwong, CANMET 2003 R88 LORAX 2011	Limited in spatial extent and quantity of data.	Detailed material characterization including chemistry and physical characteristics.	Information on surficial material characteristics will be assembled by various disciplines during the SI program. This data gap will be addressed via interactions with other disciplines to ensure SI scope captures requirements for reclamation.
L18	Seed and plant source material	Species presence and abundance within and adjacent to the site for seed and plant propagule harvesting and propagation.	R36 Arctic Alpine Reclamation Group 2006 R69 EDI 2008 R148 EDI 2009 R114 Altura 2009 R160 Altura 2011 R162 Altura 2011 EDI habitat classification report and ELR baseline work will be available April 30 2013.	Moderate level of detail specific to Mount. Nansen site, but spatially restricted.	Spatial distribution of vegetation available for revegetation of the entire site.	Requires site investigation. Appropriate vegetation surveys will be undertaken during the SI program to provide an understanding of the species within and adjacent to the site that will be relevant for reclamation planning.

Table 10.2: Infrastructure, Landform, and Revegetation Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
L19	Revegetation techniques for the Yukon	Plant species and methods for revegetation of disturbed sites in the Yukon.	EDI (2009) Faro mine revegetation plan R148 EDI 2009 R36 Arctic Alpine Reclamation Group 2006 R114 Altura 2009 R160 Altura 2011 R162 Altura 2011	Very detailed and relevant based on ecology and type of disturbance revegetated.	The success of planting at the Mount Nansen site.	The need for longer term, site specific revegetation trails will be assessed as part of the reclamation planning that will be undertaken during the TAR #6 design development work.

Table 11.2: Site Characterization Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
S01	Mapping and Geochemical Characterization of Waste Rock Material at waste rock area	Geochemical characteristics of waste rock material and locations of waste rock.	From 1989 to 2010, 128 waste rock samples were collected from Brown McDade waste rock pile, McDade pit, and drill cores of deposits. These samples included 64 samples collected from the Brown McDade waste rock pile. Acid Base Accounting (ABA), and l metal data are available for these samples. Leachable metal data are available for selected samples. Kinetic field bin testing data on selected waste rock samples (R73, R 113 and R 80). Seepage samples from the waste rock pile were collected at two monitoring points on the east toe of the Northwest Pile and west of Southwest Lower pile (R 113 and R 80).	Data quality and coverage are not sufficient to characterize ARD/ML risk of waste rock. Waste rock samples were not collected in all sectors of McDade waste rock pile. Many samples were collected as surface and test pit (average 1 m depth) samples.	Geochemical characterization of waste rock materials at some sectors of McDade waste rock pile.	Requires site investigation. Need to test materials potentially to be used as borrow materials. See Figure 2 for sampling locations of waste rock samples.

Table 11.2: Site Characterization Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
S02	Mapping and Geochemical Characterization of low grade ore near Open Pit, pit wall, and mill area	Geochemical characteristics of ore at low grade ore pile, pit wall, and mill area.	Six samples were collected from the McDade pit in 1999 and fourteen samples collected from McDade pit wall in 2009. ABA and metal testing are available for these samples. Leachable meal data are available for selected samples. Kinetic field bin testing data are also available for one selected ore sample. In 2008, two samples were collected from ore stock pile at the waste rock area. In 2009, seven samples were collected from test pits located in the central of McDade waste rock area. ABA and metal data are available for these samples. In 2009, 9 ore material samples were collected from the south end of the Brown McDade pit. ABA and metal data are available for these samples. Samples were collected from Upper Mill platform. Only paste pH and metal data were available.	Data quality and coverage are sufficient to characterize ARD/ML potential of ore materials at the ore stock pile at McDade waste rock pile and the south end of the Brown McDade pit. Data quality and coverage are not sufficient to characterize ARD/ML potential of ore contaminated materials at the upper mill platform.	Geochemical characterization of ore contaminated material at the upper mill platform.	Requires site investigation. See Figure 2 for sampling locations of ore samples.

Table 11.2: Site Characterization Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
S03	Mapping and Geochemical Characterization of tailings at tailings storage facility area	Geochemical characteristics of tailings at tailings storage facility	In total, 88 tailings samples were collected from the tailings impoundment during multiple sampling programs that were performed from 1999 to 2009 (R04, R07, R66, R105, and R80). Data includes: • Acid Base Accounting and metal data are available for these samples. • Results of kinetic testing included columns, humidity cells and field bins for selected samples are available. • In July 2009, nine samples of native soil below the tailings impoundment were collected. Only sulphur speciation data are available. In 2009 a total of 14 groundwater wells and piezometers were installed in/around the tailings impoundment, and the seepage collection pond. Data of groundwater samples collected in July 2009, September 2009 and July 2010 are available (R66, R105, and R80). R 102 with data from 2012 will be available on April 30	Data quality and coverage sufficient to characterize ARD/ML potential of tailings material at the tailings impoundment. Data quality and coverage not sufficient to assess contamination of native soils underneath tailings at the tailings impoundment. Data quality and coverage not available for tailings dam material and seepage pond materials.	Geochemical characterization of native soils underneath tailings at the tailings impoundment, materials of tailings dam, seepage pond materials, and other potential borrow materials near the tailings storage facility area.	Requires site investigation. Need to test materials potentially to be used as cover and borrow materials See Figure 3 for sampling locations of tailings samples.

Table 11.2: Site Characterization Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
S04	Mapping and Geochemical Characterization of waste rock and tailings at mill area	Geochemical characterization of waste rock and tailings at mill area.	In 2010, 14 solid phase samples were collected as part of the mill area characterization program. These samples consisted of 12 rock drill samples from 8 trenches around the immediate mill site, 1. Sediment core sample from Pond #1, and 1 sediment sample from Pond #2. ABA and metals analyses data are available (R161 and R80). In 2009 four wells were installed and groundwater samples were collected in July 2009, September 2009 and July 2010. R102 with data from 2012 will be available on April 30	Data quality and coverage are not sufficient to identify if tailings are present in all settling ponds (ponds #1, #2, and #3) and to characterize the ARD/ML potential since the previous sampling was conducted on pond shoreline deposits only.	Geochemical characterization of historical ponds and riparian areas. Water quality from Huestis and Weber Adits.	Requires site investigation. See Figure 2 for sampling locations of samples from Mill Area.
S05	Mapping and Geochemical Characterization of waste rock at Pit to Mill Haul Road	Geochemical characterization of waste rock materials at Haul Road from Pit to Mill.	In 2009, 32 samples were collected from 22 test pits in the haul road. Two samples were collected from the berm area (R132 and R80). Data includes: • Paste pH and metals for samples, and leachable metals for selected samples. • ABA testing results for the limited number of samples.	The current data are limited to characterize the ARD potential of materials from the haul road due to lack of ABA data particularly for rock materials from the haul road near mill area.	Geochemical characterization of waste rock materials from haul road near mill area.	Requires site investigation. See Figure 2 for sampling locations of samples from Pit to Mill Haul Road.
S06	Complete and reliable hazardous materials inventory including contents of materials in tanks outside the mill.	Confirmation of Hazardous Material inventories.	Inventories of hazardous materials were completed in (R07, R57, R38, R104 and R130).	Inventories complete on-site provide good coverage but poor accuracy of hazardous materials stored at the site.	A reliable and complete hazardous materials inventory is lacking. Once that is complete, a hazardous materials sampling work plan will be completed.	Requires site investigation. One inventory (Kearah & Weri). 2008) is thought to be of questionable accuracy. For this reason, a complete hazardous materials inventory will be undertaken as part of the SI program and/or subsequent design development activity.

Table 11.2: Site Characterization Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
S07	Characterization and delineation of contamination from hazardous material releases	Location, characterization and delineation of hazardous material releases.	Reports of environmental releases of hazardous materials are contained in previous assessment reports including R07, R38, R57, R63, R104 and R130. Specific releases noted include: • Metals contamination in wood chips in the educor area (R130). • Metals contaminated sediment within mill complex (R130). Cyanide slurry release in mill area (R63). • Antifreeze release in front of mill powerhouse (R63). Metals contaminated soil in the mill, SAG and polish pond (R07).	The data quality and coverage for each of the hazardous material releases are poor.	Contamination extents in the areas of known releases have not been determined. Presence/absence characterization data is required for the cyanide slurry or antifreeze releases. Leachable metals results are needed for metals impacted soils in the mill, SAG and polish pond.	Requires site investigation.
S08	Identification off-site contaminant migration from the former landfill near the Mill Building	Hazardous material analytical results from material down gradient of the former landfill near the mill per regulatory requirements.	The former landfill next to the Mill building contains a fridge, a freezer, batteries and drums of waste oil (R104).	There are no analytical data for the potential off-site migration of hazardous materials from the former landfill area near the Mill Building.	Hazardous material analytical results adjacent to the former landfill near the Mill Building.	Requires site investigation. It is our understanding that the size and location of the landfill has been reliably identified in R104. The data gap is not designed to further delineate the extents of the landfill.
S09	Characterization and potential delineation of hydrocarbon contaminated material near the former Ketza Shop	Representative analytical results which characterize hydrocarbon concentrations in material per regulatory requirements.	Hydrocarbon impacted soil (250 m^3) has been identified and delineated within and adjacent to the Ketza Shop (R156). The data for the soil in the Ketza Shop meets the assessment standards for delineation.	The data and coverage is poor.	There is no characterization data or delineation data for staining in two locations outside of the Ketza Shop.	Requires site investigation.

Table 11.2: Site Characterization Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
S10	Systematic characterization and potential delineation of hydrocarbon contaminated materials across the site and at two reported historical spills	Identification, characterization, with potential delineation and confirmatory sampling across the site and at two reported hydrocarbon spill locations.	Staining has been documented in locations across the site (R38, R104 and R130). Two hydrocarbon spills were reported on-site (R07). The data includes partial characterization of hydrocarbon contamination but no delineation or confirmatory samples and very little detail on remedial efforts.	The systematic identification of hydrocarbon contamination data is poor in quality and in coverage. The two spill locations have data which is good in quality but outdated and the coverage is poor.	There is no systematic identification or characterization of hydrocarbon contamination across site. Re-characterization and potential delineation of hydrocarbon contaminated materials from two reported hydrocarbon spill locations is required.	Requires site investigation. A review of YG and Environment Canada spill reports should be completed prior to commencing this work.
S11	Characterization and potential delineation of hydrocarbon contaminated soil along site roads	Representative analytical results which confirm hydrocarbon concentrations per regulatory requirements.	Potential hydrocarbon impacted soil has not been characterized, delineated and remediated on the roads. Hydrocarbons may have been spread on roads for dust suppression. Soil hydrocarbon sampling has not been carried out on the roads.	There is currently no data on this.	Characterization and potential delineation of hydrocarbon contamination on the roads.	Requires site investigation.
S12	Characterization and delineation of hydrocarbon contaminated material adjacent to transformer storage	Representative analytical results which confirm hydrocarbon concentrations per regulatory requirements.	Transformer oil was found to have leaked onto soil in the scrap yard in front of the Mill (R38). Analytical results from the transformers are available and they indicate that liquid in the transformers contains hydrocarbons but no PCBs.	The data quality is good but the coverage is poor.	Characterization and delineation sample results are required for the stained soil beneath the transformer storage area in front of the Mill in the scrap yard.	Requires site investigation.
S13	Delineation of hydrocarbon contaminated material adjacent to drums in the Warehouse	Representative analytical results which confirm hydrocarbon concentrations per regulatory requirements.	Staining was observed beneath drums in Warehouse stockpile. Analytical results from the drum contents are available (R38). The data indicates that liquid in the drums is waste oil.	The data quality is good but the coverage is poor.	Characterization, delineation and confirmatory sample results are required for the stained soil beneath the waste oil drums in the Warehouse.	Requires site investigation.

Table 11.2: Site Characterization Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
S14	Characterization and potential delineation of hydrocarbon contaminated material from three sumps inside the Generator Building and stained soil in front of the Generator Building	Characterization and potential delineation of hydrocarbon contaminated material from three sumps inside the Generator Building and stained soil in front of the Generator Building.	Product observed in the Generator Building's three sumps (R104). Staining immediately in front of the Generator Building where waste oil barrels were located (R104).	The data quality and coverage is poor.	Characterization and quantification of the contents of the three sumps in the Generator building. Characterization, delineation and confirmatory sample results are required for the stained soil beneath the waste oil drums in the Generator Building.	Requires site investigation. The staining from the waste oil barrels in front of the Generator building may be the same as that in front of the diesel containment (S17). This potential overlap should be clarified prior to sampling. After this work is complete we will plan for emptying the sumps and dispose of the material as per regulatory standards and after the building's foundation has been removed, field screen samples to determine if the contents of the sumps and the staining in front of the waste oil barrels have contaminated the material beneath. If there are indications of that, the material will need to be characterized, delineated and its remediation confirmed through sampling and analyses. Characterization, delineation and confirmatory sample results are required for the stained soil beneath the waste oil drums in the in the Generator Building.
S15	Characterization and potential delineation of hydrocarbon contaminated material near the AST in the Warehouse Building	Representative analytical results which confirm hydrocarbon concentrations per regulatory requirements.	Staining within the warehouse on the concrete floor in the center of the building and under the raised AST (R104).	The data quality and coverage is poor.	Characterization, delineation and confirmatory sample results may be required beneath the Warehouse Building' foundation in association with the staining near the AST.	Requires site investigation. After the building's foundation has been removed, field screen samples to determine if the AST staining has contaminated the material beneath. If there are indications of that, the material will need to be characterized, delineated and its remediation confirmed through sampling and analyses. Characterization, delineation and confirmatory sample results are required for the stained soil beneath the AST in the Warehouse Building.
S16	Characterization and potential delineation of hydrocarbon contaminated material from the basin within the Upper Mill Building	Representative analytical results which confirm hydrocarbon concentrations beneath the basin per regulatory requirements.	Product has been observed in the basin of the Upper Mill Building (R104).	The data quality and coverage is poor.	Characterization and quantification of the contents of the basin in the Upper Mill Building.	Requires site investigation. Empty the sumps and dispose of the material as per regulatory standards. As hydrocarbons can seep through concrete and contaminate material below, after the buildings foundation has been removed, field screen samples to determine if the staining has contaminated the material beneath. If there are indications of that, the material will need to be characterized, delineated and its remediation confirmed through sampling and analyses. Characterization, delineation and confirmatory sample results are required for the stained soil beneath the Upper Mill Building.

Table 11.2: Site Characterization Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
S17	Characterization and potential delineation of hydrocarbon contaminated material near the waste oil barrel, adjacent to the Diesel Containment	Representative analytical results which confirm hydrocarbon concentrations near the waste oil barrel, adjacent to the Diesel Tank Containment per regulatory requirements.	Stained soil where a waste oil barrel was located next to the diesel tank containment to the south east of the mill (R104).	The data quality and coverage is poor.	Characterization, delineation and confirmatory sample results are required for area around the stained soil where a waste oil barrel was located next to the diesel containment.	Requires site investigation. The staining from the waste oil barrels in front of the Diesel Containment may be the same as that in front of the Generator Building (S14). This potential overlap should be clarified prior to sampling.
S18	Characterization and potential delineation of stained soil on the Upper	Representative analytical results which confirm hydrocarbon concentrations of the stained soil on the Upper Road to the SAG Building per regulatory requirements.	Stained soil and barrels with oil soaked rags were observed on the Upper Mill Road to the SAG Building. The area of estimated to cover approximately 303 m^2 (R104).	The data quality and coverage is poor.	Characterization, delineation and confirmatory sample results are required for the stained soil on the Upper Mill Road to the SAG Building.	Requires site investigation.
S19	Characterization and potential delineation of hydrocarbon contaminated material from oil sludge in the Mill Building	Representative analytical results which confirm hydrocarbon concentrations of the oil sludge observed within the mill building per regulatory requirements.	Oil sludge was observed on the concrete in the mill.	The data quality and coverage is poor.	Characterize and quantify the oil sludge in the mill building, then have that material removed from site.	Requires site investigation. Hydrocarbon contamination seeps through concrete to contaminate material below. A plan to allow characterization, delineation and confirmatory sample results of soils once the building foundation has been removed will be included in the remediation plan..
S20	Locate, identify, quantify fuel volumes and plan for the removal of all fuel storage equipment	Identify fuel storage equipment. Document quantity of fuel in each storage equipment.	20 fuel storage tanks remaining on-site have been located and partially identified, and their contents have been partially quantified (R104 and R130). The product has been identified through labelling on the tanks for all except one tank. Quantities in the tanks are mostly unknown.	The data quality is poor but the coverage is good.	The product in all the fuel storage tanks needs to be quantified.	Requires site investigation.

Table 11.2: Site Characterization Gap Analysis

ID #	Issue / Design Objective	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
S21	Assess and plan for the removal of the Rail Tanker.	Rail tanker contents need to be identified and quantified.	The outside of the rail tanker has been assessed for lead based paint and (R38 and R104). There is no reliable data on the rail tankers contents or their volume.	The data quality and coverage is poor.	The contents of the rail tanker need to be sampled and quantified by a trained professional. Refer to the Detailed Rail Tanker Assessment Work Plan for the proposed methods.	Requires site investigation.

Table 12.2: Drafting Gap Analysis

ID #	Information Required	Data Available	Data Quality and Coverage	Data Gaps	Comments
D01	Site Ortho Imagery	2012 10 cm Digital Orthomosaic	0.5 m resolution covering Mount Nansen site (OIC Boundary)	none	No site investigation required.
		Quickbird Satellite Orthoimagery – 2008	15 m resolution Mosaic Poor image quality		
		Natural Resources Canada Orthoimage	partial coverage (~ 50%) of OIC low resolution		
D02	Site Imagery	IRS Imagery – 1998	Regional Image, outside OIC extents	none	No site investigation required.
		Landsat 7 – 15 m resolution Mosaic	low resolution		
D03	Site Survey	Base Planimetry Mapping (YES site survey)	Covers Mount Nansen site OIC.	none	No site investigation required. File contains the following features: • Adit locations • Buildings • Catchments Boundary • Geological Faultlines • Old mine areas • New OIC boundary, Roads • Trails • Site Hydrology (Creeks and Water Bodies)
D04	Existing site elevation data	2012 1 m DEM in Bare Earth ASCII files / ESRI GRID files	Covers Mount Nansen site (OIC Boundary).	Elevation data below existing water levels (e.g., pit) n/a	Requires site investigation to obtain detailed survey below current water level in pit. 2004 Underhill pit survey data understood to be only above water elevation. Various cross sections have been drawn through the pit. It is unclear what data these cross sections are based on.
		Natural Resources Canada DEM	30 m Shaded Relief Hillshade, no elevation data. Useful for Regional Overview only.		
D05	Site contour data	2012 0.5 m and 1.0 m contours in CAD and ESRI shapefiles 1998 1 m contours	Covers Mount Nansen site (OIC Boundary).	Contour data below existing water levels (e.g., pit).	
D06	Original ground contours	NTS mapping data Hard copy plans from various tailings design reports (R13 1994, R17 1990, R18 1988, R47 and 48 1995) and the dam construction report R46 1996.	Not available digitally in material provided.	Electronic file of original ground in tailings area	No site investigation required. Digital version of original ground contours in tailings area may exist with Klohn-Crippen (1996 survey) or Yukon Engineering Services (YES)
D07	Tailings Bathymetry to assess tailings volume	Referred to in R12, Hard copy print from Laberge Environmental services 1999 survey was digitized. Water depth data provided in EDI report R112 but not tied to elevation data	No digital version available in material provided.	Electronic copy of tailings bathymetry survey or tailings water depth survey	No site investigation required.

Table A1: Geotechnical Tailings Characterization Data Located to Date

Geotechnical Property Reported	Reference	Specific Information Available	Comments
General.	R88 p. 5-115.	Mentioned laboratory testing and published information.	No specifics about the properties tested in the laboratory and those assumed based on published information.
PSD data available, measurements other than laser particle size distribution (LPSD). Visual description on fence plots.	R04 p. 10, Appendix C and Appendix G-B.	LPSD results are presented in Figure 4, p. 10 and Appendix C. Cursory investigation of the effect of freeze-thaw on LPSD for 5 tailings samples is presented in Appendix G-B.	No other PSD test results are available Typically PSD is evaluated using ASTM D422.
Tailings PSD in R88 and R133 vs. R04. Borehole logs with visual descriptions.	R88 and R133 p. 2-1 tailings samples and Table 2-2 p. 2-8. R88 and R133 2.4.1.4 p. 2-25 and Table 5-1 p. 5-2.	Summary of tailings samples collected in 2009. p. 2-25 PSD method (screen sizes) and results Table 5-1 p. 5-2.	Comparison between tailings samples collected and evaluated in 2009 R88 and those collected and evaluated in 2002 R04 would be useful given the different testing methods.
Hydraulic conductivity functions used for seepage analyses.	R88 Appendix C/ Appendix C-1 Seepage Analysis for Dam AECOM 2009, page 2 Soil water characteristic curve for coarse and fine tailings.	p. 2, Figure 1, p. 3 Figure 3.	Hydraulic conductivity functions were assumed based on measured values for similar materials.
Seepage characteristics and PSD used for cover design.	R88 Appendix C3/C4.	Measure PSD and soil water characteristic curve for tailings.	No context as to where data came from.

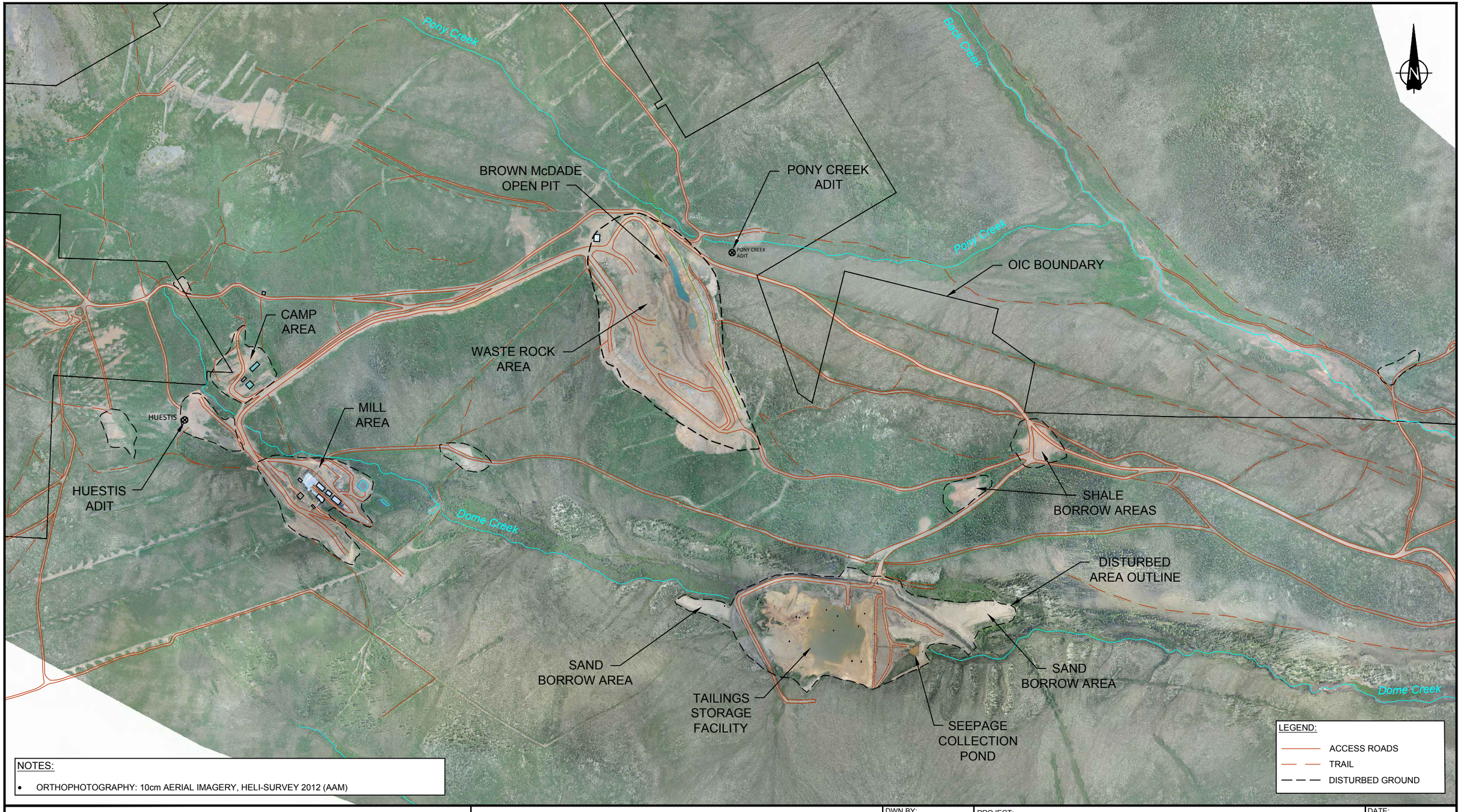
Table A1: Geotechnical Tailings Characterization Data Located to Date

Geotechnical Property Reported	Reference	Specific Information Available	Comments
Hydraulic Conductivity Moisture content. Atterberg limits. Specific gravity. Particle Size Distribution. Soil moisture characterization curve.	R88 Appendix E Hydrogeological characterization, AECOM 2009 & [8].	2.1.5 Hydraulic conductivity testing, p. 4; Table 3 Permeability testing (in situ (3) and in the laboratory(10) results. 2.1.7 physical characterization of tailings, p. 5, Table 4 Physical property characterization (listed: moisture content, Atterberg limits (2), specific gravity (SG) (2), grain size (3), soil moisture characterization curve); Appendix F MDH Engineering Solutions results hydrometer (3), SG (2), moisture content (2) moisture characteristics (2), Atterberg limits (2).	It is assumed that the results presented in R88 Appendix E supersede those in R88 Appendix C in terms of physical tailings characterization and hydraulic conductivity results.
Mineralogy / colour / texture. Particle size distribution.	R105 CANMET 2003, PSD.	p. 57-58: 4 main types of tailings identified based on mineralogy, color and texture; range of PSD for the main types of tailings identified. Reference to R04 CANMET study 2002.	Details of tailings relocation in terms of the source/type of tailings identified.

Table A1: Geotechnical Tailings Characterization Data Located to Date

Geotechnical Property Reported	Reference	Specific Information Available	Comments
Soil parameters for stability assessment for tailings, compacted dam fill, native foundation soil.	R10 table soil parameters.	3.2.2 Stability analyses, Assumptions, p. 14: table including soil parameters bulk unit weight, frictional strength, cohesion, foundation value, residual strength for tailings, compacted dam fill and native foundation soil.	It is not clear how the soil parameters were selected for the stability analyses.
Tailings sampling goal.	R158.	p. 1 tailings sampling and Table 1.	Selection of tailings samples, tests to be conducted.

FIGURES



NOTE:
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DWN BY:	TH
CHK'D BY:	RW / SM
DATUM:	NAD 83
PROJECTION:	UTM Zone 8
SCALE:	AS SHOWN

PROJECT: MOUNT NANSEN REMEDIATION PROJECT
GAP ANALYSIS

TITLE: GENERAL SITE PLAN

DATE:	JULY 2013
PROJECT NO:	VM00605
REV. NO:	A
FIGURE NO:	1

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ROAD TO MILL

ROAD TO OPEN PIT

Dome Creek

HISTORIC BORROW AREA

DIVERSION DITCH

HISTORIC BORROW AREA

DIVERSION DITCH

Dome Creek

SEEPAGE COLLECTION POND

TAILINGS STORAGE FACILITY

MP09-13
W14103083-BH03
MNBH1
MNBH2
MNBH9
MNBH10
MNBH17
MW09-11
MP09-14
T2
MW09-07
LRC-009
NW-11521
LRC-006
LRC-008
MP09-09,10
LRC-005
W14103083-BH01
W14103083-BH02
W14103083-BH04
MNBH11
MW09-05
MNBH3
MNBH8
LRC-007
T1
D C B A
MNBH16
LBH16
MW09-06
MW09-24
MP09-11
MNBH7
MNBH12
MNBH4
LBH4
MP09-12
MP09-05
MW09-20
LBH15
MNBH15
MW09-21
MNBH18
MNBH19
MW09-02
MW09-04
MW09-23
NW-11522
T4
MNBH6
LBH6
MW09-01
MW09-03
MW09-22
MNBH5
MNBH13
MNBH14
LBH14
MP09-06

NOTES:

- ILLUSTRATIVE FIGURE TO SHOW HISTORIC SITE INVESTIGATIONS. LOCATIONS ARE APPROXIMATE
- COMPLETE SAMPLING IN DAM, SEEPAGE DAM AND ABUTMENT AREAS NOT SHOWN
- ORTHOPHOTOGRAPHY: 10cm AERIAL IMAGERY, HELI-SURVEY 2012 (AAM)

LEGEND:

- ACCESS ROADS
- TRAIL
- DISTURBED GROUND
- MNBH1 — CANMET, 2002, Program Borehole [(7) Laser, PSD and Geochemistry]
- T2 — LORAX, 2009, Trenches, Shallow Samples [PSD (7) and Geochemistry]
- LRC-006 — LRC, 2005, Grab Samples [Minerology]
- LBH4 — LORAX, 2008, Large Split Spoon Sampling [Porewater Geochemistry]
- NW-1154 — NORWEST, 2011, Grab Samples
- MW09-01 — AECOM, 2009, Boreholes with Standpipe [Geotechnical Index Tests (2)]
- MP09-13 — LORAX, 2009, Mini Piezometers [Standpipe or Drivepoint]
- W14103083-BH03 — EBA, 2012, Boreholes with Standpipe, Thermistors and Pneumatic Piezometers [Moisture Content, 2 PSD]

PSD - Particle Size Distribution

NOTE:
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DATUM:	NAD 83
PROJECTION:	UTM Zone 8
SCALE:	AS SHOWN

PROJECT: MOUNT NANSEN REMEDIATION PROJECT GAP ANALYSIS

TITLE: HISTORIC INVESTIGATION LOCATIONS OF TAILINGS

DATE:	JULY 2013
PROJECT NO:	VM00605
REV. NO:	A
FIGURE NO:	2

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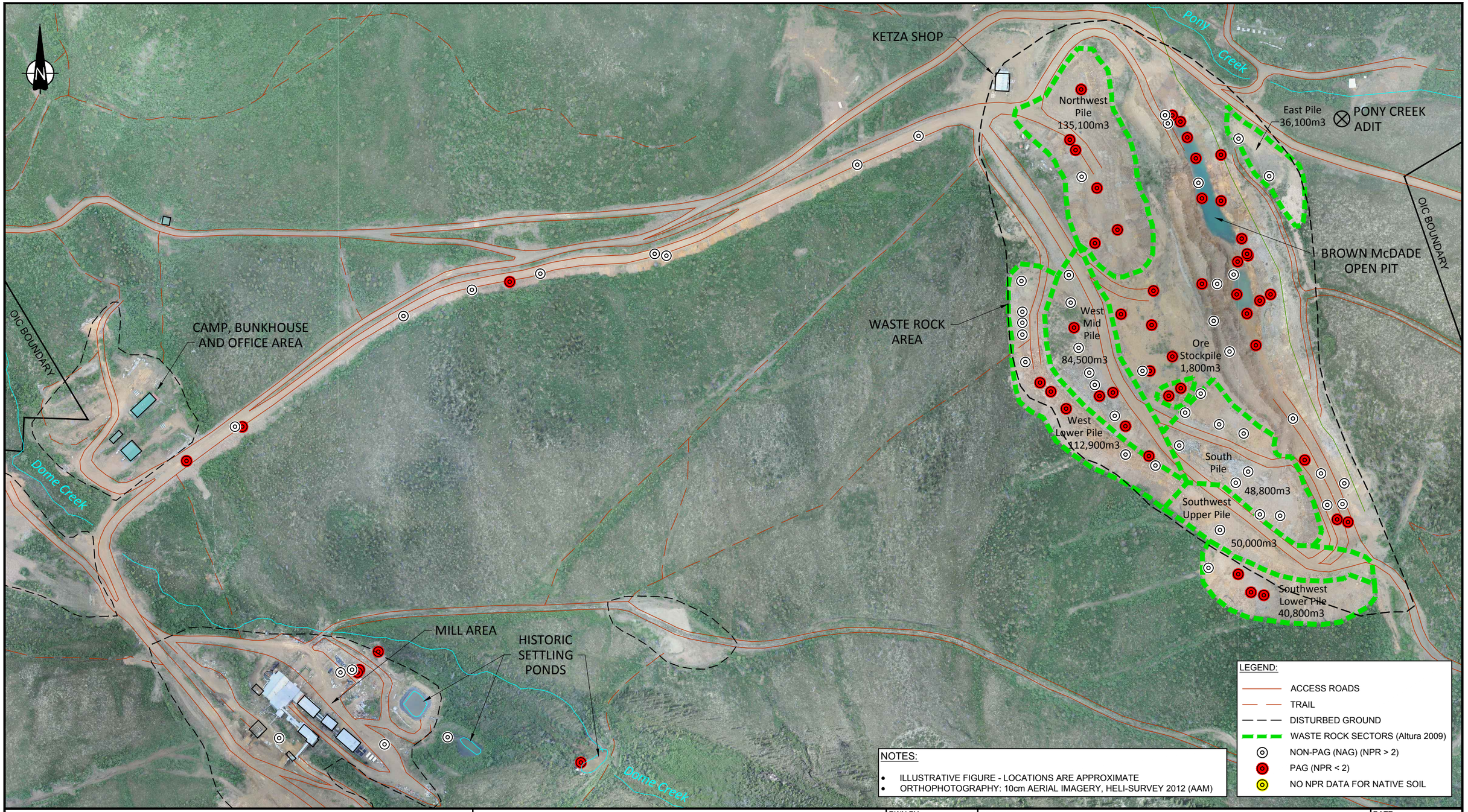

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SCALE:	AS SHOWN

PROJECT:
MOUNT NANSEN REMEDIATION PROJECT
GAP ANALYSIS

TITLE:
HISTORIC GEOCHEMICAL TESTING
AT WASTE ROCK DUMP, PIT AND MILL SITES

DATE:	JULY 2013
PROJECT NO:	VM00605
REV. NO:	A
FIGURE NO:	3

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ROAD TO MILL

ROAD TO OPEN PIT

Dome Creek

HISTORIC BORROW AREA

DIVERSION DITCH

HISTORIC BORROW AREA

DIVERSION DITCH

Dome Creek

SEEPAGE COLLECTION POND

TAILINGS STORAGE FACILITY

LEGEND:

- ACCESS ROADS
- TRAIL
- DISTURBED GROUND
- WASTE ROCK SECTORS (Altura 2009)
- NON-PAG (NAG) (NPR > 2)
- PAG (NPR < 2)
- NO NPR DATA FOR NATIVE SOIL

NOTES:

- ILLUSTRATIVE FIGURE - LOCATIONS ARE APPROXIMATE
- ORTHOPHOTOGRAPHY: 10cm AERIAL IMAGERY, HELI-SURVEY 2012 (AAM)

NOTE:
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DATUM:	NAD 83
PROJECTION:	UTM Zone 8
SCALE:	AS SHOWN

PROJECT: MOUNT NANSEN REMEDIATION PROJECT
GAP ANALYSIS

TITLE: HISTORIC GEOCHEMICAL TESTING AT TAILINGS AREA

DATE:	JULY 2013
PROJECT NO:	VM00605
REV. NO:	A
FIGURE NO:	4

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