**,**

****Mount Nansen Remediation Project****

Review of Phase 1 (30% Design Phase)

Cost Estimate Scope and Bases

Submitted to:

**Assessment and Abandoned Mines
Energy Mines and Resources**

**Whitehorse, YT**

Submitted by:

**AMEC Environment & Infrastructure,**

**a Division of AMEC Americas Limited**

**Burnaby, BC**

**December 18, 2014**

AMEC File: VM00605K.1.105

TABLE OF CONTENTS

**Page**

[1 Introduction 1](#_Toc404336626)

[1.1 Background 1](#_Toc404336627)

[1.2 Objective 1](#_Toc404336628)

[1.3 Scope of Work 1](#_Toc404336629)

[1.4 Methodology 2](#_Toc404336630)

[1.4.1 Cost Reconciliation 2](#_Toc404336631)

[1.4.2 Updating Estimating Assumptions 2](#_Toc404336632)

[1.4.3 Assessment of Estimating Uncertainties (Sensitivity Assessment) 2](#_Toc404336633)

[1.4.4 Meetings 3](#_Toc404336634)

[2 Estimate Reconciliation 4](#_Toc404336635)

[2.1 Overview 4](#_Toc404336636)

[2.2 Source Estimates 4](#_Toc404336637)

[2.3 Key Option 4 Tenets and Driving Project Criteria 4](#_Toc404336638)

[2.3.1 AECOM 5](#_Toc404336639)

[2.3.2 AMEC 5](#_Toc404336640)

[2.3.3 Reconciliation Implications 7](#_Toc404336641)

[2.4 Reconciliation Formats 7](#_Toc404336642)

[2.4.1 Detailed Estimate Reconciliation 7](#_Toc404336643)

[2.4.2 Detailed Quantity Reconciliation 9](#_Toc404336644)

[2.5 Reconciliation Findings 9](#_Toc404336645)

[2.5.1 Estimate Objectives 9](#_Toc404336646)

[2.5.2 Detailed Estimate Reconciliation 11](#_Toc404336647)

[2.5.3 Detailed Quantity Reconciliation 13](#_Toc404336648)

[2.5.4 Summary Comments 13](#_Toc404336649)

[3 Estimate Assumptions 15](#_Toc404336650)

[3.1 Review Scope and Objectives 15](#_Toc404336651)

[3.2 Key Scope Areas and Alternate Assumptions 15](#_Toc404336652)

[3.3 Review Limitations 15](#_Toc404336653)

[4 Sensitivity Assessment 21](#_Toc404336654)

[4.1 Format 21](#_Toc404336655)

[4.2 Assessment Outcomes 26](#_Toc404336656)

[4.2.1 Lower Bound Estimate 26](#_Toc404336657)

[4.2.2 Upper Bound Estimate 30](#_Toc404336658)

[4.3 Balancing Cost, Uncertainty and Risk 30](#_Toc404336659)

[5 Cost Reduction Opportunities 32](#_Toc404336660)

[5.1 Reducing Uncertainty 32](#_Toc404336661)

[5.1.1 Design Development 32](#_Toc404336662)

[5.1.2 Contractor Engagement 32](#_Toc404336663)

[5.2 Scope Revisions 35](#_Toc404336664)

[5.2.1 Within the Option 4 Concept 35](#_Toc404336665)

[5.2.2 Outside of the Option 4 Concept 35](#_Toc404336666)

[5.3 Value Engineering 35](#_Toc404336667)

[5.3.1 Overview 36](#_Toc404336668)

[5.3.2 VE Process 36](#_Toc404336669)

[5.3.3 VE Team 36](#_Toc404336670)

TABLE OF CONTENTS (cont'd)

**Page**

[6 Cost Review Workshop 38](#_Toc404336671)

[6.1 Purpose and Agenda 38](#_Toc404336672)

[6.2 Outcomes 38](#_Toc404336673)

[7 Summary and Conclusions 39](#_Toc404336674)

[7.1 Cost Reconciliation 39](#_Toc404336675)

[7.2 Cost Assumptions Review and Sensitivity Assessment 40](#_Toc404336676)

[7.3 Cost Reduction Opportunities 41](#_Toc404336677)

[8 Limitations and Closure 43](#_Toc404336678)

[9 References 44](#_Toc404336679)

List of tables

[Table 2.3.1-1: Pre-Phase 1 Option 4 Objectives and Scope Elements 5](#_Toc406511628)

[Table 2.4.1-1: Summary Level Cost Reconciliation Results 8](#_Toc406511629)

[Table 2.4.2-1: Summary Reconciliation of the Quantities 10](#_Toc406511630)

[Table 3.2-1: Summary of Key Estimating Assumptions 16](#_Toc406511631)

[Table 4.1-1: Lower Bound Estimate 22](#_Toc406511632)

[Table 4.1-2: Upper Bound Estimate 24](#_Toc406511633)

[Table 4.2-1: Summary of Lower and Upper Bound Estimates 27](#_Toc406511634)

[Table 4.3-1: Assessment of Key Scope, Cost and Risk Issues 31](#_Toc406511635)

[Table 5.1.2-1: Procurement Options Summary 33](#_Toc406511636)

List of APPENDICES

Appendix 2A: Detailed Cost Reconciliation Worksheets

Appendix 2B: Detailed Quantity Breakdowns/Reconciliation

Appendix 6A: Cost Review Workshop Agenda and Presentation Slides

# Introduction

## Background

The Phase 1 (30% Design Phase) Cost Estimate Report for the Mount Nansen Remediation Project (MNRP) (AMEC, 2014) provided an execution estimate considerably higher than the estimate available as Phase 1 was initiated ($90 M vs. $34 M). Following their review, Aboriginal Affairs and Northern Development Canada (AANDC), the federal funding partner for the MNRP, indicated that a review of opportunities for reducing execution cost estimates should be undertaken before initiating Phase 2 (60% Design Phase) design development activity. The scope of work outlined in this document was developed to respond to this request.

## Objective

Assessment and Abandoned Mines’ (AAM) specified objective for the work was to review the costs included in the Phase 1 estimate with the intent to identify potential reductions in the overall project cost. This was to be done by reviewing potential adjustments to the techniques and/or approaches proposed for implementing the selected remedial approach (i.e. Option 4 in the pre-Phase 1 alternative evaluations) by optimizing these techniques, or by adjusting the assumptions associated with the definition of Option 4.

## Scope of Work

The scope of work for the cost review was outlined in a document forwarded by AAM on
August 7, 2014. The work was to include the following steps:

* Teleconference with AAM, AANDC and Little Salmon Carmacks First Nation (LSCFN) to identify potential areas for further consideration.
* Reviewing costs included in the AACE (Association for Advancement of Cost Engineering) Class 3 cost estimate and the previous cost estimate for this project (LORAX/AECOM) to produce a report that identifies any potential reductions. Any incremental risks to the Partners associated with the cost reductions were to be identified as part of the process. The report was to be presented using a table(s) to compare AMEC’s cost estimate and assumptions to the LORAX/AECOM cost estimate, the reason for the cost difference (e.g. scope missed by either estimate, low or high unit rates, assumptions/conservatism, general difference), identification of potential reductions or efficiencies and any resulting risks.
* Workshop with AAM, AANDC and LSCFN in Whitehorse to present the findings of the cost refinement exercise.

The work was not to include a value engineering exercise, which may or may not be the next steps following the cost refinement above.

## Methodology

AMEC’s methodology for addressing the scope of work was comprised of the following three tasks:

* Cost reconciliation;
* Estimating assumptions review and update; and
* Estimating sensitivity assessment.

### Cost Reconciliation

AMEC completed a reconciliation of the pre-Phase 1 LORAX/AECOM estimate and the Phase 1 AMEC estimate. This reconciliation was intended to identify:

* Any previously unidentified scope elements that were added to the Phase 1 estimate;
* Key elements of the project scope and/or the associated execution methods that exhibit significant differences between the estimates; and
* The primary drivers for cost differences in those scope areas/execution methods (e.g. differences in quantity, pricing and/or execution methodology).

### Updating Estimating Assumptions

One of the dangers in any cost review exercise is the tendency to “cherry pick” estimating assumptions to reduce costs to thresholds that meet a pre-determined objective. To avoid this, it is important to apply a consistent and objective approach to setting assumptions that may be required in the context of considerable uncertainty, and that kind of effort was reflected in establishing the Phase 1 estimating assumptions. Nevertheless, it was known that there were some modifications to key assumptions that could be defended. AMEC reviewed these key assumptions in light of developments since the conclusion of Phase 1 to identify where modifications could be justified, or to identify those scope elements where equally valid estimating assumptions could produce a significant range in cost outcomes.

### Assessment of Estimating Uncertainties (Sensitivity Assessment)

There are a variety of methods that could be applied to characterize and quantify uncertainties in an estimate. A cost risk analysis could be undertaken to illustrate the impact of likely ranges in quantities and prices on the probabilities of various cost outcomes. These exercises can be labour intensive and may not add justifiable value at this stage. They are likely to identify those components of uncertainty that are already known to influence the estimate, and predict a fairly wide range of possible cost outcomes.

For this exercise, AMEC completed a relatively straightforward cost sensitivity analysis intended to quantify the influence of those inputs known to carry the greatest uncertainty (i.e. defining a consensus range for the most sensitive quantities and/or prices and determining the influence on final estimate ranges). This effort did not attach probabilities to specific cost outcomes, but provided a reasonable characterization of the relationship between estimate variability and key estimating inputs and assumptions.

AMEC also addressed some of those key variables where assumptions about contractor execution methods and capabilities have a strong influence on estimate outcomes. In some cases, conservative assumptions about likely contractor methods increased the estimate. As part of this assessment, AMEC attempted to quantify how more liberal assumptions about likely contractor responses to tender specifications could influence the estimate.

### Meetings

#### Kick-off Teleconference

The cost review was initiated with a teleconference on September 17, 2014 attended by representatives of AAM, AANDC, LSCFN and key members of the AMEC estimating team. The teleconference focused on:

* A review of the scope of work to ensure alignment on activity and deliverables;
* The formats anticipated for the cost reconciliation and the sensitivity assessment; and
* Discussion around key scope areas and potential adjustments to assumptions that strongly influence the estimate.

#### Cost Review Workshop

A cost review workshop was conducted on October 23, 2014 in Whitehorse (attended by AAM, AANDC, LSCFN, and AMEC) that focused on the draft outcomes of AMEC’s cost review and continued the discussions around scope adjustments and their estimated influence on project costs.

# Estimate Reconciliation

## Overview

The cost review began with a detailed reconciliation of the pre-Phase 1 AECOM estimate against the Phase 1 AMEC estimate. This section confirms the source estimates that were compared, explains the format that was used for the reconciliation of quantities and costs, and presents key findings made regarding the following reconciliation objectives:

* Identify any previously unidentified scope elements that were added to the Phase 1 estimate;
* Identify key elements of the project scope and/or the associated execution methods that exhibit significant differences between the estimates; and
* Identify the primary drivers for cost differences in those scope areas/execution methods (e.g. differences in quantity, pricing and/or execution methodology).

## Source Estimates

The source documents for the reconciliation were the estimate completed for AAM during the pre-Phase 1 option selection work and the Phase 1 estimate completed by AMEC. The specific documents were as follows:

* Pre-Phase 1 (the “AECOM Estimate”) - a consolidation of the pre-Phase 1 estimate was provided by AECOM (2011). This document, in turn, consolidated or referenced information from the following supporting estimates:
	+ AECOM (2010) provided costs for the core elements (largely materials handling scopes) for the various remedial options under consideration at the time;
	+ Altura (2010) provided costs for surface reclamation and scope elements that were common to all remedial options;
	+ Golder (2010) provided costs for the Open Pit cover;
	+ AECOM (2009) provided costs for project water treatment requirements;
	+ Altura (2011) provided costs for water quality mitigation actions that might be required in future (i.e. potential Adaptive Management costs);
* Phase 1 (the “AMEC Estimate”) - the final Phase 1 estimate is provided by AMEC (2014).

## Key Option 4 Tenets and Driving Project Criteria

In reconciling the AECOM and AMEC estimates, it is useful to consider how remedial Option 4 was defined and interpreted for each.

### AECOM

The AECOM estimate was based on the statement of Option 4 objectives and scope elements that are provided in Table 2.3.1-1 (LORAX, 2011).

Table 2.3.1-1: Pre-Phase 1 Option 4 Objectives and Scope Elements

|  |
| --- |
| **Option 4 Objectives** |
| 1) Remove the geotechnical liability associated with maintaining a tailings dam in the Dome Creek Valley; |
| 2) Restore the Dome Creek valley in the area of the TSF to a more natural condition compatible with the original land use; |
| 3) Minimize the potential for tailings oxidation and ML/ARD through the maintenance of dry conditions within the tailings deposits (minimize infiltration); and |
| 4) Restore area of open pit to a condition more compatible with the original land use via tailings and waste rock backfill. |
| **Option 4 Scope Elements** |
| **Closure Element** | **Description** |
| Tailings and Pit | Relocation of approximately 300,000 m3 of tailings and contaminated soil to the open pit. Tailings will be stored in a dry condition to the extent possible through storage of tailings above the water table and placement of a synthetic cover designed to minimize infiltration. The cover will also serve to physically stabilize the tailings to prevent water/wind erosion. |
| In-Pit Dam | Preliminary assessment indicates that an in-pit dam structure will not be required. |
| Waste Rock | Relocation of ~344,000 m3 of waste rock to open pit. Approximately 156,000 m3 of waste rock will be left in place and regraded and revegetated as necessary. |
| Tailings and Storage Facility | Relocation of tailings will allow restoration of the Dome Creek valley in the area of the TSF to a condition compatible with the original land use. |
| Pony Creek Adit | Additional measures may be required to provide a more effective seal of the adit to minimize the hydraulic connection between the pit and Pony Creek. |

### AMEC

For the AMEC estimate, the key tenets of Option 4 were summarized as follows:

* Tailings relocation and dam decommissioning followed by restoration of the Dome Creek valley;
* Placement of “low moisture” tailings;
* Maintenance of tailings above the water table;
* Provision of stable and useable backfilled pit surfaces over reasonable timeframes (i.e. without creating practically indefinite restrictions on land use); and
* Maintenance of downstream surface water quality within recognized regulatory standards.

These tenets are of necessity fairly broad and required interpretations by the AMEC design team for translation into a specific Design Base Case for which an execution schedule and cost estimate could be developed. To facilitate this translation, AMEC applied the following “Driving Project Criteria” which interpret the key project tenets in ways that can be connected to the anticipated performance of specific execution plans and methods:

* The “Stable Surfaces Criterion” - refers to the provision of stable and useable backfilled pit surfaces over reasonable timelines. The performance of the pit cover ultimately depends on complex and largely unpredictable interactions between and amongst a number of key design elements (e.g. the moisture content of tails (which, in turn, is influenced by the required/ desired removal method), the methods of placement, the degree of mixing with waste rock, pit groundwater conditions and the physical configuration of the pit). Meeting the stable surfaces criterion by attempting reliable, quantitative predictions of these interactions would be difficult, costly and probably counterproductive (e.g. it cannot be done without defining specific tailings removal methods which would then counterproductively constrain the procurement process; i.e. contractors could not bring forward potentially better approaches). The approach AMEC took to this criterion was to apply professional judgement to the definition of an integrated execution method that was considered likely to meet the need for a stable pit surface, without defining the specific quantitative performance outcomes for each of the relevant design media (e.g. tails moisture, tails compaction specification). In effect, the method has been defined and fixed, and the performance outcomes have not, except that those outcomes are expected to fall within acceptable limits.
* The “Water Quality Criterion” - refers to the maintenance of downstream surface water quality within recognized regulatory standards. This is a critical project outcome and some of the key Option 4 tenets (specifically the placement of low moisture tailings and the maintenance of tailings above the water table) are really intended as a means to this end, and are not, in and of themselves, independent performance requirements. Indeed, for a great many design decisions/ elements (e.g. the kinds of, and how much, waste rock must go into the pit), there are a variety of potential selections that are ultimately determined by their influence on downstream surface water quality. Again, reliably predicting how all of these design decisions interact to produce a particular water quality is extraordinarily complex and indeed may simply not be possible. This leads to the reliance on professional judgement to define approaches that are likely (but not certain) to be successful and the development of robust (and potentially costly) Adaptive Management measures to mitigate intolerable uncertainties.
* The “Proven Methods Criterion” - refers to the application of methods that are known, or are judged likely, to be feasible at Mount Nansen. In short, this means that we need to be confident that the combination of methods and equipment proposed in the Base Case will work. Again, this determination relies on professional judgement and is limited by the experience of the design team. It is entirely possible that a broader group of experienced and capable contractors, whose business relies on the development of ever more competitively cost effective methods, could propose more efficient processes during the procurement process.
* The “Pit Volume Criterion” - refers to the maintenance of materials directed to the pit containment structure within the physical constraints and/or boundaries that apply to the site. This criterion acknowledges that there are physical constraints to the lands available for pit containment that the project has no control over and that therefore become physical boundary conditions for the design (e.g. the public access road to the north which must not be disturbed by the works).
* The “Safety Criterion” - refers to the application of methods consistent with recognized standards of construction health and safety. This criterion acknowledges that it has to be possible to execute the proposed plan safely. This may be self-evident, but could have a significant influence on the detailed development of specific methods for key scope areas (it is part of the reason for proposing wellpoint dewatering prior to tailings excavation for example).

### Reconciliation Implications

There are differences in how the central objectives and features of Option 4 were described in the AECOM and AMEC estimates. However, the differences in cost between the AECOM and AMEC estimates are not grounded in any significant changes in the basic tenets of the selected remedial approach, but rather from evolutions in the thinking about execution methods and schedules that were, in turn, influenced by the additional site characterization data and design development activity brought to bear during Phase 1.

## Reconciliation Formats

Sections 2.4.1 and 2.4.2 present the formats used to compare the estimated costs and work quantities contained in the two reconciled estimates. The common thread between much of the information is the Activity ID coding assigned to the Primavera construction schedule that accompanied the 30% AMEC estimate submitted in Phase 1 (AMEC, 2014).

### Detailed Estimate Reconciliation

Based on the breakdown of the work and the levels of detail available, it was decided to use the AMEC estimate as the base case and compare the AECOM estimate to it. Two lump sum items from the AECOM estimate (Restoration of Dome Creek Valley and Common Elements) were also broken down into smaller components for easier comparison to the AMEC estimate.

For the reconciliation, the 30% AMEC estimate was first rearranged into significant work groupings. AECOM cost estimate items were then assigned as applicable to comparable work groupings. To add clarity, the AMEC scope items were left aligned and assigned a black font, while the AECOM scope items were right aligned in the same column and assigned a red font. Three columns were added on the right hand side of the detailed reconciliation to clarify the scope of the work if necessary and to characterize the variance into quantity driven and price driven components.

Refer to Table 2.4.1-1 for the summary level cost reconciliation results and to Appendix 2A for the detailed reconciliation, as well as summaries of the two source estimates used for the exercise. For the summary reconciliation in Table 2.4.1-1, the Q4 2010 AECOM estimate numbers were escalated by 9% (based on AMEC data for cost escalation between 2010 and 2014) to bring them in line with the Q1 2014 AMEC estimate (i.e. they do not match the numbers shown in the detailed reconciliation in Appendix 2A).

Table 2.4.1-1: Summary Level Cost Reconciliation Results

### Detailed Quantity Reconciliation

As noted previously, the common thread through much of the reconciliation exercise is the Activity ID coding used in the Primavera construction schedule developed in Phase 1. That schedule also included a column showing the quantities of work on which the individual schedule durations were based.

The first step in the reconciliation of estimate quantities was to provide as much detail as possible on the makeup of the quantities shown in the Primavera schedule. The details of that breakdown can be found in Appendix 2B. The broken down quantities were also colour coded and summarized into major quantity groupings at the bottom of the spreadsheet.

Appendix 2B also contains a second detailed quantities reconciliation that identifies the sources of rock and tailings used for the various components in the closed out facility, allowing a higher level understanding of material movements onsite during closure.

Finally, a summary reconciliation of the quantities is presented in Table 2.4.2-1. The quantities in the table are colour coded to correlate with the detailed reconciliation quantities in Appendix 2B.

## Reconciliation Findings

### Estimate Objectives

Before undertaking any detailed assessment of differences between the AECOM and AMEC estimates, it is useful to consider that they were provided for different purposes, at different points in the project development process. The AECOM estimate was developed from design concepts and intended primarily to support selection of a preferred remedial option. The AMEC estimate was the first to focus on a single remedial approach, and was prepared from a design that reflected the additional development resulting from Phase 1 activity. In short, the AECOM estimate focused on points of difference among alternatives, while the AMEC estimate was the first cost milestone on a prescribed development path for a specific design scope. It could be expected then that there would be significant variations between these two estimates. Differing objectives may not account for the full separation between the estimates, but it was likely a significant contributing factor.

Table 2.4.2-1: Summary Reconciliation of the Quantities

### Detailed Estimate Reconciliation

The total cost estimate variance between the Phase 1 AMEC estimate ($89.8 million) and the
pre-Phase 1 AECOM estimate ($33.7 million including 9% escalation) is $56.1 million. The following presents the major sources identified as contributing to this variance.

From the summary cost reconciliation in Table 2.4.1-1, it is clear that the following items were excluded from the 2010 AECOM estimate:

* Site maintenance between construction seasons ($2.1 million);
* Haul road and pit wall stabilization ($0.7 million);
* Wellpoint dewatering ($11.3 million);
* PAG rock/tails mixing ($4.7 million);
* Design contingencies ($1.4 million); and
* Adaptive management items ($3.8 million).

These missing scope items alone account for some $29 million (including the associated 20% contingency) of the difference between the AECOM and AMEC estimates. It is interesting to note that combining this missing scope with the applicable upper and lower variances of the AECOM and AMEC estimates covers much of the Table 2.4.1-1 variance, as follows:

* Upper bound variance on AECOM Class D estimate (i.e. +40%) $13.5 million
* Lower bound variance on AMEC Class 3 estimate (i.e. -15%) $13.5 million
* Missing scope elements $29.0 million

 Total: $56.0 million

In addition, major differences between the AECOM and AMEC estimates can also be attributed to the following items.

* **The general approach to the two estimates as introduced in Section 2.5.1.** Unlike the AMEC estimate, it is believed that the AECOM unit cost rates do not completely account for all contractor indirects that will be incurred to perform the direct work scope items, such as contractor site overhead staff, camp catering and housekeeping, haul road improvements, and major sediment and water management works required during construction. In addition, the AMEC estimate was based on, and integrated with, an execution schedule tied to judgements of individual activity durations.
* **The general methodology assumed for removing the tailings from the TSF.** Although the AECOM estimate has little detailed cost breakdown information related to their assumed tailings removal methodology, the unit rate used for tailings removal does not allow for much more than loading the tailings, hauling them to the open pit, and depositing them in their final location. AECOM assumed the execution method was based on winter relocation of frozen and partially frozen materials.

To reduce the risk of contractor non-performance and lower the moisture content of the materials stored under cover at the open pit, AMEC assumed a much more robust approach for removal of the tailings and deposition in the pit. Based on the 2013 Site Investigation (SI) findings, AMEC concluded that rock platforms should be built over the in situ tailing surfaces with potentially acid generating (PAG) rock from nearby waste dumps, with those platforms used for excavator and haul truck traffic and wellpoint operations, before being mixed with the tailings at the work face benches when loading into trucks. The handling characteristics of the in situ tailings are further improved by installing and operating a series of well points ahead of the excavation operations. Not including the cost of loading, hauling, and dumping the tailings (which are close between the two estimates according to Table 2.4.1-1, but based on different quantities as discussed in the next subsection), the cost variance between the two estimates resulting from different excavation methodologies is approximately $16 million.

In short, the AMEC methodology aligns with the project need to provide conditions in the backfilled pit consistent with the development, within reasonable timelines, of a stable pit cover and reclamation surface. AECOM’s concept involves relocating tailings largely at their in-place moisture content and does not explicitly define how the result can provide surfaces stable enough to sustain the specified pit cover.

* **Reclamation of the TSF footprint.** It is clear that there are large differences between the two estimates when it comes to reclamation of the TSF area once the tailings are removed. Those differences begin with the amount of subexcavation assumed below the TSF footprint about $1 million) and the treatment of the exposed ground surfaces. AMEC assumes that a 300 mm layer of sand will be placed first, and then overlaid with a 1,200 mm layer of non-acid generating (NAG) rock before final contouring and revegetation. Although the AMEC and AECOM estimates for Dome Creek reclamation are similar for the sand cover and revegetation components, the AMEC assumption for armouring the entire area with NAG rock adds over $2 million to the project costs.
* **Water treatment**. The two estimates vary by over $5 million, largely because AMEC concluded that a larger, fixed (vs. mobile) plant with additional process units would be needed.
* **Landforming**. The AMEC estimate may be slightly conservative regarding the amount of rough grading and revegetation required after removal of all NAG and hydrocarbon contaminated materials. This will be examined more closely in the 60% design phase, once clear consensus is reached on expectations for the site’s final appearance.
* **Removal of hazardous materials from site**. It’s likely the AMEC cost for this item will be lowered in the 60% design phase, potentially by more than $1 million, with agreement from the Project Partners on the final disposal location (onsite versus offsite).
* **Open pit cover**. The two estimates vary widely in scope and cost (over $5 million), with the AMEC estimate assuming an interim cover followed by a final engineered cover, and the AECOM estimate a final less complex cover only.
* **Contingency**. The AMEC estimate contains more than $7 million in additional contingency, but this is strictly the result of the overall increase in capital costs since the AMEC markup is 20% compared to AECOM’s 30%. AMEC used a lower rate to reflect the level of effort put into developing the contractor methodology and project costs and note that it is lower than what is typically used for a 30% level of design.

### Detailed Quantity Reconciliation

There are some relatively large quantity differences between the AMEC and AECOM estimates that will need to be investigated during the 60% design phase. The main differences are:

* **Tailings**. The AECOM estimate assumes about 25% more tailings than does the AMEC estimate (300,000 m3 versus 237,000 m3). This is offset by an AMEC unit cost that is about 40% higher than the AECOM unit rate, bringing the total tailings relocation costs within $0.5 million of one another.
* **Waste Rock**. The total volume of rock ultimately placed in the open pit varies from 344,000 m3 in the AECOM estimate to almost 525,000 m3 in the AMEC estimate. It is not possible to pinpoint where the differences originate since the AECOM volume is not broken down into source components.
* **TSF Subexcavation**. The volume difference of 40,000 m3 between the two estimates is based mostly on the depth of excavation assumed below the tailings, with another small component originating from differences in assumed footprint areas.
* **Dam Fills**. The AECOM estimate assumes a dam volume that is about 50% greater than the one used in the AMEC estimate. As with the tailings, the higher unit costs in the AMEC estimate to move that material offsets the lower volumes used and results in total removal costs that are similar between the two estimates (roughly $1.4 million).
* **Open Pit Cover**. As indicated in Section 2.4.2, the AECOM and AMEC cover designs are very different. It is, therefore, not surprising that the quantities for the individual schemes are also very different, with the AMEC cover requiring twice the volume of granular fill materials than the AECOM scheme. In addition, the AMEC cover section includes a clay/plastic composite section of geosynthetic materials. Part of the reason for the major differences may be the larger footprint occupied by the AMEC cover.

### Summary Comments

As a consequence of the above reconciliation findings, important action items during subsequent reviews or design development will include:

* **Scope of work**. It will be important to address more specifically the assumed contractor methodology to remove the tailings and relocate them to the pit (in particular the need for dewatering and waste rock mixing), clarify the expectations from the Project Partners with regards to final landforming and revegetation, confirm the need for rock armouring within the TSF footprint, look more closely at water treatment options (including adjustments to the project construction schedule to reduce treatment rates), and agree on an Open Pit cover section that “better” reflects the quality of backfilled rock and tailings placed beneath it.
* **Quantities**. Confirming quantities to the greatest accuracy possible will be very important because of the ripple effect those quantities have throughout the estimate and construction schedule. Unlike costs which are based on more subjective estimator assumptions, developing accurate quantities should be a more straightforward action that definitively removes uncertainty from the overall project estimate and schedule.
* **Unit Prices**. Pricing is a function of the assumed quantities, execution method and schedule, and so, as a largely dependent variable, may have less prominence in future estimate developments and reviews. However, pricing will nonetheless be an important consideration, particularly for those items subject to uncertainties relating to quantities and methods.
* **Project Schedule**. Schedule activities are driven by quantities of work and estimator productivity assumptions. Although few changes are expected in the project schedule at this time, assuming an earlier start in Season #1 and a relook at possible multi-shifting in earlier years may provide some opportunities for cost reductions.

# Estimate Assumptions

## Review Scope and Objectives

This component of the estimate review is intended to identify any changes to key estimate assumptions that might be defended based on design developments post Phase 1, or based on reconsideration of the Phase 1 estimate variables. The focus is on scope areas where uncertainties relating to project requirements and/or outcomes are thought to be significant and where, as a consequence, there is a comparatively wide range in possible estimate assumptions that strongly influence the final estimate.

## Key Scope Areas and Alternate Assumptions

Table 3.2-1 provides a summary of key project scope areas and the influence of assumptions applied in these areas on the cost estimate. This table focuses on those elements of the project that are known to carry significant uncertainty with respect to scope and/or execution method(s) and that, given their nature and/or scale, are likely to have significant influences on total project costs. The table also provides broad characterizations of the level of conservatism reflected in assumptions, and outlines alternate assumptions that will be considered in the cost sensitivity assessment (Section 4).

It should be noted that estimate changes resulting from the alternate assumptions in Table 3.2-1 are outside of the normal estimating tolerance that would be associated with an AACE (Association for Advancement of Cost Engineering) Class 3 estimate (typically -15 to +25%). These alternate assumptions are intended to focus on scope and/or execution method changes, rather than the normal estimating variance that would apply to a defined scope.

## Review Limitations

It is important to recognize some of the limitations to, and/or constraints on, any re-examination of estimate assumptions undertaken at this stage. Design development activity has not progressed materially post Phase 1 (other than the conduct of a supplementary Site Investigation Program in the summer of 2014 (AMEC, 2014a)), so that the outcomes of the more detailed considerations of key project variables that are contemplated for Phase 2 are not yet available. This will limit the range of assumption variations that can be supported technically.

In addition, it will be important to avoid any tendency to preferentially select optimistic estimating assumptions with a view towards reducing the resulting estimate. Reviews that consistently bias assumption selection so as to reduce the estimate in those key scope areas that carry significant uncertainty (and, therefore, have a relatively wide range of possible estimate assumptions) is arbitrary, unsupported technically and will produce a revision to the estimate with little real meaning.

Table 3.2-1: Summary of Key Estimating Assumptions

| **Key Scope Area** | **Basis of Phase 1 Estimate** | **Characterization of Phase 1 Assumptions** | **Potential Range of Assumption Adjustments** |
| --- | --- | --- | --- |
| **1. Civil Quantities** |
| Civil quantities refers to the large volume material categories that will require movement and/or handling to affect remediation, specifically:* Tailings;
* Dam fill;
* Waste rock; and
* Contaminated soils and rock

To a large degree, remediation for the Mount Nansen property means relocation of these key material categories (i.e. civil materials management and remediation are, to a large degree, the same thing), meaning that the quantity estimates for these material categories have a major influence on the estimate. | The Phase 1 civil quantity estimates were developed using contemporary civil software (AutoCAD and Eaglepoint) and the site topographic and LiDAR data available (Canada Digital Elevation Data (CDED) topo and AAM supplied LiDAR survey). Some key inputs to this process relied on interpretations and/or judgements about the physical extents of particular material categories, namely:* The base of the tailings;
* The limits of contaminated sand fill;
* The depth of contamination below the TSF footprint;
* The limits of contaminated soils and rocks in the mill area; and
* The extent of tailings movement and deposition within the Dome Creek valley outside the immediate limits of the TSF.
 | Generally speaking, AMEC’s assumptions about the physical extents of material categories that are poorly understood were in the middle of the range of possible assumptions. There is more than a small probability that the actual material limits could combine in ways that reduce the total materials handling liability. Of course, this observation goes both ways, and volumes could increase. In addition, the 2014 SI work (i.e. post Phase 1) suggests that contaminated sediment impacts in the Dome Creek valley beyond the TSF are greater than previously thought. | AMEC’s judgement would be that a range of ±20% on key quantities that are influenced by poorly defined material limits would be reasonable for the sensitivity analysis (again, this is beyond the normal variance in civil quantity estimating described in Section 3.2). This range has been incorporated into the lower and upper bound sensitivity assessments. Greater resolution or definition of this range cannot be supported without the more detailed examinations and calculations that will form part of Phase 2.In addition, assumed sediment volumes in the Dome Creek valley outside of the TSF will be increased by roughly 100% for the upper bound sensitivity assessment to evaluate the potential cost impact of the increased creek bed sediment removal scope that has been identified post Phase 1. |
| **2. Waste Rock Characterization** |
| This is related to the civil quantities issue in that it influences the volumes of waste rock that are ultimately directed to the Open Pit. The issue is the potential challenge related to distinguishing between PAG and non-PAG waste rock during project execution. Managing and/or mitigating this challenge might require extensions to the execution schedule and/or additional costs for onsite laboratory capabilities. | The Phase 1 estimate assumed that PAG/ non-PAG distinctions could be made without significantly influencing project execution schedules or support requirements (i.e. on the basis of pre-execution characterization data or readily applied field protocols). | This Phase 1 estimating assumption was comparatively liberal in that there is a good possibility that direct analytical measures will be required to make reliable PAG/non-PAG distinctions in practice. This will likely require the development and maintenance of a fairly robust onsite analytical capability with an associated sampling capability and infrastructure. In addition, the effectiveness and efficiency of these capabilities will have practical limits that could result in some proportion of the non-PAG inventory being directed to the Open Pit. | AMEC has assumed that the PAG/non-PAG field differentiation issue can be adequately managed during field execution via the development and maintenance of an onsite sampling and testing capability, and that applying this capability will not compromise the efficiency of the materials handling operation, or the proportion of the non-PAG rock inventory directed to the Open Pit. For the upper bound sensitivity assessment, AMEC has assumed upfront laboratory development costs of $100,000 and annual operating costs (including staffing) of $500,000 for this sampling and testing capability. |
| **3. Materials Handling Methods** |
| The specific techniques used to move the major civil material categories, particularly tailings, to the Open Pit has a fundamental influence on both the execution schedule and total project cost. The assumptions about methods reflect AMEC’s interpretations of how several key project uncertainties (e.g. tailings handling and placement characteristics) might be managed and/or mitigated (i.e. these assumptions are not only critical to the estimate, they must be made within a context of considerable uncertainty). | The Phase 1 Design Base Case and estimate assumed conventional truck and shovel movement of key material categories. Wet tailings were assumed to be managed via upfront wellpoint dewatering and mixing of tails with PAG rock (i.e. a significant portion of the PAG rock inventory destined for the Open Pit is double handled). The general PAG/tails mixing ratio was set at between 1:2 to 1:2.5 for the Phase 1 estimate. In addition, the Phase 1 concept assumed that a certain proportion of the PAG inventory would be used at the TSF (prior to disposition in the Open Pit) to provide trafficable surfaces on the TSF excavation benches and haul roads. | AMEC views the assumed dewatering/ mixing/truck and shovel methods as a robust approach for managing and mitigating the uncertainties related to tailings movement and placement. It is possible, indeed likely, that an experienced and well equipped contractor could propose an alternative combination of methods and equipment that could lower costs, particularly if contractors could mitigate their commercial risks by undertaking some form of trial prior to full scale execution.In addition to assumptions about the general execution methods, AMEC’s Phase 1 estimate relies on assumptions about the effectiveness of tailings dewatering (see subsequent table entry), the required PAG rock/tails mixing ratio and the interrelation between these variables. AMEC’s assumption for PAG/tails mixing is in the middle of a potentially fairly wide range for this variable, which is influenced not only by tailings handling requirements, but by the configuration and height of excavation benches within the TSF. | For the lower bound sensitivity analysis, a general materials handling scope and price reduction factor of 20% will be applied. Absent more detailed analysis, greater resolution of this figure is not possible; it simply reflects AMEC’s view that there is a good possibility that a successful engagement of the contracting community in an appropriately structured procurement strategy (see Section 5.1.2) could identify more cost effective materials handling methods.A variation of ±30% on the potential PAG/ tails mixing ratio will also be considered in the sensitivity assessment. |
| **4. Water Treatment** |
| Pit and pond waters will require treatment both to provide unencumbered access to key work areas and to meet water quality release standards. | The Phase 1 estimate includes the construction of a fixed (i.e. non mobile) water treatment plant dedicated to the project’s requirements.The Phase 1 estimate assumed that most of the onsite water inventory would need to be treated over a relatively short time frame to support the assumed execution schedule (i.e. onsite water storage was not used to attenuate the peak plant throughput capacity).Finally, the assumed Phase 1 treatment plant incorporated a comparatively broad inventory of process units to accommodate the full range of critical parameters that could report to the plant. | The assumed water treatment configuration and capacity is viewed as conservative. It was known at the outset that costs could likely be reduced by optimizing the provision of onsite water storage with plant throughput capacity, and via a more detailed examination of process unit and reagent consumption requirements. | Post Phase 1 treatability testing undertaken during the 2014 SI program suggests that a 15% reduction in the scope of the treatment capability can likely be defended (AMEC, 2014a). This reduction will be reflected in the lower bound sensitivity assessment.In addition, a general 20% reduction in treatment scope/cost will be applied to reflect AMEC’s judgement about the potential outcome of the storage vs. capacity optimization planned for Phase 2. |
| **5. Open Pit Cover** |
| The cover used to limit water and oxygen ingress into the backfilled Open Pit is a significant component of the project scope because of both its influence on project outcomes (i.e. surface water quality) and because of its nature, scale and hence, cost. In addition, the cover will be subject to substantial differential settlements and the methods assumed to mitigate these settlements have a significant influence on costs. | The Phase 1 estimate assumed that the problem of large and somewhat unpredictable differential cover sediments would be addressed by replacing an interim cover (constructed with locally available granular materials) by a permanent structure constructed after tailings consolidation has reduced differential settlements to more manageable levels (assumed to occur some 10 years after interim cover placement). The permanent cover was assumed to be a composite, geosynthetically based structure. | The Phase 1 interim/permanent cover concept is viewed to be a conservative approach to mitigating differential settlements. It may be possible to lower costs by relying more on cover maintenance and/or repair than complete replacement. | The lower bound sensitivity assessment will assume the interim cover is replaced by a thicker sand/bentonite mix that will be more amenable to regular regrading and maintenance. The assessment will assume that this alternate cover concept will avoid the need for replacement in year 10. Absent the Phase 2 design, performance modelling and estimating needed to support this alternative cover concept, the sensitivity assessment will simply assume parity between the Phase 1 interim and alternate cover concept costs, and delete the expense related to cover replacement in season 10 and the subsequent maintenance costs originally included in the estimate for this permanent cover. |
| **6. Dewatering** |
| A wellpoint dewatering system is used both to meet the Option 4 objective of “low moisture tails” and to provide conditions in the TSF compatible with a safe truck and shovel removal operation. The assumed dewatering system is of a significant scale, and is closely integrated with the execution schedule and, therefore, has a significant influence on project costs. | The Phase 1 estimate assumed a wellpoint dewatering system operated on a 25 m grid over the TSF, with production characteristics consistent with complete dewatering over two summer construction seasons. These assumptions were based on a consideration of the physical characteristics of the tailings, what is known about the variation of those characteristics, and typical wellpoint system efficiencies (i.e. at this stage of project development, site specific field trial or pilot data that are often used to refine system designs and efficiencies were not available). | The Phase 1 dewatering assumptions were of necessity made within a wide range of possibilities. The assumed wellpoint densities and production characteristics could be viewed as generally conservative. It should be noted that costs for these systems are fairly sensitive to relatively modest adjustments in assumed spacing and production. | For the lower bound sensitivity analysis, AMEC has made the following adjustments:* Increasing the required wellpoint spacing from a 25 m grid to a 30 m grid; and
* Increasing wellpoint production capacity by 30%.

Combining these elements reduces the required scope and cost of the dewatering effort by some 50%. |
| **7. Reclamation of the TSF Footprint** |
| The removal of the TSF will leave an excavation in the Dome Creek valley that must be stabilized thermally, geotechnically and hydraulically by the placement of appropriately graded fill. | The Phase 1 estimate assumed that the remediated TSF footprint would be stabilized by placing a 1.2 m layer of NAG waste rock over a bedding of imported sand. This stabilization is required to mitigate hydraulic erosion forces and thermal effects at disturbed/undisturbed land interfaces. | The thickness of the NAG waste rock cover was conservatively set at 1.2 m. There is a reasonable possibility that detailed design activities would support a reduction in this thickness. | For the lower bound sensitivity assessment, AMEC has reduced the NAG waste rock cover thickness by 25%. |
| **8. Reclamation Concept** |
| The costs of reclamation are influenced by the extent to which vegetated surfaces (as opposed to graded granular surfaces) are included in the Reclamation Plan. | The Phase 1 Reclamation Plan acknowledged the limited availability of organic substrates and the associated constraints on reclamation plans by limiting revegetation efforts to patches in specified areas and spacings. | Current regulations provide considerable latitude in the specific prescriptions proposed for restoring land capability and aesthetics. The extent to which revegetation features in the Reclamation Plan depends, therefore, in no small part on the subjective preferences of the Project Partners. It is possible that a non-vegetated reclamation concept relying on regraded granular surfaces could be defended, provided this was accepted by the Partners. | The lower bound sensitivity assessment assumes that all revegetation elements (including the associated trials and/or plots) are removed from the estimate. |
| **9. Special Waste Disposition** |
| A portion of the contaminated soil/rock inventory is anticipated to exhibit parameter levels above regulatory thresholds defining special or hazardous waste. This designation invokes additional handling and disposition requirements for the materials involved. | This Phase 1 estimate assumed that the relatively modest proportion of Mount Nansen soils/rocks likely to be categorized as special waste would be directed to an existing, appropriately permitted facility near Fort Nelson, BC. This assumption was made largely to avoid the permitting and public consultation liabilities that are often created by locating special waste disposition facilities (usually landfills) on a source site. | While the Mount Nansen volumes involved are likely to be comparatively small, the very high unit costs of transport and disposal make this line item a significant contributor to the total project estimate. The decision to mitigate potential permitting and consultation liabilities via offsite disposition can be viewed as a conservative one. Technically, there is little reason to believe that an appropriate disposal capability for these materials could not be incorporated at much lower unit cost into the broader Open Pit containment design. | The lower bound sensitivity assessment will assume that the special waste inventory will be directed to an appropriately engineered and dedicated location within the Open Pit containment structure. The incremental development costs for this dedicated containment structure will be assumed to be $100/m3. |
| **10. Design Contingencies**  |
| These are measures considered during Phase 1 to mitigate the risks that unacceptable degradations of downstream surface water quality could develop at some time following remediation. | The Phase 1 estimate included provisions for design contingencies focused on facilitating the collection of pit seepage (should they become necessary) to ensure compliant surface water quality. | The provision of these design contingencies was based on a conservative interpretation of pit containment and cover performance over the long term. There is a reasonable probability that acceptable water qualities could be realized without invoking these measures. | The lower bound sensitivity assessment will delete the provisions for design contingencies focused on mitigating surface water quality compliance risks. |
| **11. Adaptive Management** |
| These are measures considered during Phase 1 to mitigate the risks that unacceptable degradations of downstream surface water quality could develop at some time following remediation. | The Phase 1 estimate included provisions for Adaptive Management measures ranging up to the long term treatment of pit seepage to ensure compliant surface water quality. | The provision of these Adaptive Management measures was based on a conservative interpretation of pit containment and cover performance over the long term. There is a reasonable probability that acceptable water qualities could be realized without invoking these measures. | The lower bound sensitivity assessment will delete the provisions for Adaptive Management measures focused on mitigating surface water quality compliance risks. |

# Sensitivity Assessment

## Format

The cost sensitivity analysis was undertaken using the worksheets presented as Tables 4.1-1 and
4.1-2. These worksheets capture the range of input variations described in Table 3.2-1. The worksheets include both potential decreases and increases to scope and/or cost. Potential decreases are described in the lower bound estimate provided in Table 4.1-1, while potential increases are shown in the upper bound estimate provided in Table 4.1-2.

Tables 4.1-1 and 4.1-2 were developed using the following structure and format:

* The basic format borrows from the summary worksheet prepared for the Phase 1 estimate which presents costs for each construction season in the assumed execution schedule and then adds general project costs (e.g. design development, tendering, contingencies and Adaptive Management requirements) as individual line items.
* For the purposes of the sensitivity assessment, line items for each construction season were sorted from greatest to lowest cost. This was done to focus reviews on those higher cost elements having the greatest influence on the overall estimate.
* Columns have been added to the worksheet to facilitate the adjustment of costs for each line item by a single specified factor. Another column has been added to describe the rationale for selecting the factor noted. Those line items that have been adjusted in the sensitivity assessment from the base estimate are identified by shading.
* The worksheet also incorporates selectable factors to assess inputs that apply globally to the estimate. These selectable factors are grouped and described at the top of the worksheet. Colour coding has been used to identify those particular line items that have been influenced by an individual factor.
* Adjustments to civil quantities that a factor might produce were completed in ways that maintained the overall materials balance (i.e. the linkages that exist between and amongst the various material categories were maintained as a single key input quantity was varied).
* Indirect costs have not been re-estimated, but simply modified in proportion to the change in direct costs, and then redistributed amongst the line items, again in proportion to the revised distribution of direct costs.

Table 4.1-1: Lower Bound Estimate

Table 4.1-1 page 2

Table 4.1-2: Upper Bound Estimate

Table 4.1-2 page 2

## Assessment Outcomes

Tables 4.1-1 and 4.1-2 are developed from the potential adjustments to key estimating assumptions that were described and rationalized in Table 3.2-1. Table 4.2-1 summarizes both the lower and upper bound estimates against the base estimate and tabulates the variances from the base for each. These tables describe a lower bound estimate of about $60 M and an upper bound of $94 M, on a base estimate of some $90 M. The position of the base estimate within the limits of this range can be viewed as a rough indication of the degree of conservatism in the base estimate. However, this interpretation should be applied with caution, absent a more systematic, risk based quantification of the probabilities that might be attached to these figures.

The following sections summarize those parameters that have the greatest influence on the variances identified in Table 4.2-1.

### Lower Bound Estimate

Table 4.2-1 indicates that the following assumptions/issues are likely to have the greatest influence on potential reductions from the base estimate (in declining order of importance):

* The specific materials handling methods applied for the movement of tailings and PAG rock to the Open Pit;
* The configuration and efficiency of the wellpoint dewatering system used to facilitate the excavation of tailings;
* The capacity, configuration and reagent consumption for the water treatment capability developed to accommodate waters incompatible with direct release;
* The pit cover concepts and maintenance protocols applied to mitigate post remediation differential settlements in the backfilled pit;
* The extent to which design contingencies and Adaptive Management protocols must be applied to mitigate risks associated with post remediation downstream surface water quality excursions;
* The approach taken for the disposition of contaminated soils categorized as special waste (i.e. onsite vs. offsite); and
* The extent to which reclamation concepts rely on revegetated vs. granular finished landscapes.

Table 4.2-1: Summary of Lower and Upper Bound Estimates

Table 4.2-1 page 2

Table 4.2-1 page 3

### Upper Bound Estimate

Table 4.2-1 indicates that the following assumptions/issues are likely to have the greatest influence on potential increases to the base estimate (in declining order of importance):

* The materials handling methods applied for the movement of tailings and PAG rock to the Open Pit (the appearance of this issue on both the lower and upper bound lists reflects the conclusion that the specific materials management methods and plans executed (and likely developed) by the contractor will have a major influence on project costs); and
* The methods used to distinguish in the field between PAG and non-PAG waste rocks during project execution.

## Balancing Cost, Uncertainty and Risk

Ultimately, the objective of this review is to identify actions or opportunities for lowering the overall costs of the MNRP. It is useful then to consider what decisions might be required, and/or what outcomes are needed, to realize costs approaching the lower bound estimate for the MNRP that is outlined in Table 4.1-1. For some issues, realizing these lower costs may be a matter of taking on higher risks and accepting the negative consequences potentially associated with them. For others, it is not really a matter of taking discretionary risk management decisions, but rather, mitigating uncertainties in ways that produce positive cost outcomes through additional design development activity (e.g. the physical efficiency of dewatering, the required rock/tails mix ratio, water treatment process requirements and efficiency). Predicting the likelihood that any particular set of risk management decisions and/or design development outcomes will produce an estimate trending towards the lower bound is difficult, absent a more detailed cost risk analysis exercise. However, some qualitative judgements and comments relating to how these issues might play out can be offered. Table 4.3-1 provides an assessment along these lines for the key scope issues influencing the lower bound cost estimate for the MNRP.

Table 4.3-1: Assessment of Key Scope, Cost and Risk Issues

| **Issue** | **Desired Outcome** | **Probability of Desired Outcome** | **Partner Decisions/Actions Required** | **Associated Risks** | **Risk Consequences** |
| --- | --- | --- | --- | --- | --- |
| 1. Materials Handling Methods for Tailings and PAG Rock
 | Preferred contractor proposes field validated execution methods that improve efficiency of materials handling. | High; effective engagement of contracting community offers potential for identification of innovative materials handling proposals. | Adoption of procurement processes that include a large, or full scale field validation stepAdoption of more liberal pit backfill performance objectives (e.g. acceptance of wet material placement) | Procurement process extends schedule without providing the efficiency improvements sought.Extended pit consolidation/settlement timelines render pit landscape unusable over an indefinite period.Alternate materials handling methods could compromise performance outcomes. | Moderate; unsuccessful trial/procurement process could introduce significant new costs and/or delays.Degradation in water quality; compromised pit cover integrity/stability. |
| 1. Tailings dewatering system configuration and efficiency (in practice, this issue will be related to, and integrated with, Issue 1)
 | Per Issue 1 | High; per Issue 1. | Per Issue 1. | Per Issue 1. | Moderate; per Issue 1. |
| 1. Water Treatment System
 | A water treatment capacity with fewer process units, reduced reagent consumption and lower hydraulic throughput than the Phase 1 configuration. | High; it is likely that Phase 2 design development will identify savings in water treatment concepts. | Proceed with Phase 2 design development (i.e. issue requires uncertainty mitigation via design development; there are no discretionary risk management options currently available). | Phase 2 design does not lower cost estimate. | Low. |
| 1. Pit Cover Concept
 | Single cover constructed at remediation that facilitates mitigation of differential settlements via maintenance and avoids the need for a second permanent cover. | Moderate; there is a reasonable probability that a single, maintainable cover concept can be developed. | Acceptance of greater cover maintenance liability and potentially a more extended period of limitations on the utility of the pit landscape. | Cover maintenance cannot adequately mitigate settlements, requiring a second, potentially more costly, permanent cover. | Low; failure of the concept means reverting, in large part, to the two cover concept that is in the current base estimate. |
| 1. Maintenance of Compliant Surface Water Quality
 | Maintenance of water quality compliance without the need for design contingencies (i.e. pit drainage structures) or Adaptive Management protocols (principally, future water treatment). | Moderate; there is a reasonable probability that an effective pit containment concept could mitigate water quality concerns without additional supports. | Accepting a higher potential for water quality excursions and a reduced capacity for responding to those excursions. | Extended periods of non-compliant surface water quality that may not become evident for many years post remediation (i.e. when institutional memory of related issues and potential responses diminished). | High; water quality excursions would be difficult to address after the fact, and tolerating extended compliance excursions would undermine one of the central purposes for undertaking remediation at the Mount Nansen site. |
| 1. Disposition of Soils Classified as Special Wastes
 | Disposal onsite (i.e. dedicated cell incorporated within pit containment structure). | High; proposal is technically straightforward to develop and defend. | Accepting additional permitting and public consultation liability associated with onsite special waste facility development. | Proposal for onsite disposition is rejected at a later stage of project development. | Low; rejection of concept means reverting to the base estimate (with perhaps some incremental costs related to delays and proposal development). |
| 1. Use of Revegetation in Reclamation Concepts
 | Reclamation plans that do not rely on revegetated landscapes. | Moderate; proposal is technically straightforward to develop, but acceptance may be dependent on the subjective views of public stakeholders. | Accepting additional permitting and public consultation liability potentially associated with reclamation plans proposing granular landscapes. | Proposed reclamation plans rejected at a later stage of project development. | Low; rejection of the concept means reverting to the base estimate (with perhaps some incremental costs related to delays and proposal development). |

# Cost Reduction Opportunities

## Reducing Uncertainty

### Design Development

The sensitivity assessment in Section 4 attempts to characterize the influence of uncertainty on the Phase 1 cost estimate. The progression of any design beyond the 30% milestone (i.e. Phase 1) reduces uncertainties and increases the reliability of cost estimates, and AMEC expects that will apply to the MNRP. The sensitivity analysis illustrates the limits to providing more cost definition and certainty in advance of this additional design development activity. This section examines approaches for reducing, or at least managing uncertainty in ways that could lead to cost reductions, and discusses potential adjustments or changes to project scope elements that might also open opportunities for reduced costs.

### Contractor Engagement

It is clear that additional work is required to define detailed execution strategies that properly balance execution performance, risk and cost. The Phase 2 design development scope includes examining those execution and procurement strategies that are most likely to achieve this. AMEC believes that the most effective way to finalize methods, mitigate detailed execution uncertainties, incorporate proprietary or innovative expertise, achieve fair pricing, and minimize chances of contractor
non-performance, will be to engage the contracting community in the final development of detailed methods and prices. The most effective way to engage the contracting community will likely be to tender with facts and performance objectives/specifications only (no methods) and allow contractors to apply their expertise and equipment with as few boundary conditions as possible. For this to work, the design team must be confident that the objectives/specifications are achievable. The key project performance specifications will relate to placed fill characteristics (which could range anywhere from ‘placed within the pit’ to ‘placed to a specified Proctor density’).

To achieve fair pricing given the unmitigated uncertainties and risks that even capable contractors will need to manage after a comprehensive consideration of available data, AMEC believes that approaches in which the execution contract is staged in some fashion should be considered (see potential options outlined in Table 5.1.2-1). The point of the first stage would be to allow the contractor to refine methods and pricing, and for the Owner to re-tender subsequent phases if outcomes and/or pricing do not satisfy contracting objectives (i.e. a process that gives both contractor and Owner “off ramps” if the initial assessments of uncertainties, risks and costs are misjudged). The overriding point will be to achieve fair pricing (i.e. pricing not burdened with contingencies covering unmitigated risks) for the largest possible proportion of the materials inventory.

Table 5.1.2-1: Procurement Options Summary

| **Option** | **Pros/Cons** | **Comments** |
| --- | --- | --- |
| 1. Standalone field trial tendered during latter stages of design | Pros* Allows execution methods/pricing findings to be reflected in regulatory submissions and early project funding processes.

Cons* Not conducted at full scale; significantly limits utility of findings.
* No direct linkage to large scale scope; discourages contractors from being fully open with their expertise (i.e. they will be concerned about disclosing competitive advantages in the absence of a clear connection to a potential commercial upside).
 | Cons outweigh pros unless Partners place compelling weight on early information or if alternate procurement strategies are simply not possible. |
| 2. Stages full scale execution with procurement “off ramps”.* Initial tender is a data/performance spec only; process open to all qualified contractors (i.e. follows a pre-qualification process).
* Owner defines a first stage scope that is anticipated to be sufficient to allow contractor to establish fair pricing (cannot let contractor define because if initial tender price too high, will extend first stage).
* At conclusion of Stage 1:
* Owner has access to all data (other than proprietary pricing) acquired during stage and that could be used by any contractor to develop fair pricing.
* Contractor submits pricing for balance of scope based on learnings/outcomes of Stage 1.
* Owner then has option of:
* accepting contractor’s Stage 2 pricing; or
* re-tendering Stage 2 with the expanded database provided by Stage 1 learnings/outcomes.
 | Pros* Reduces contractor’s commercial risks and thereby increases chances for securing fair pricing.
* Reduces Owner’s cost risk in the event that Stage 1 pricing is burdened by contingencies.
* Reduces potential for contractor non-performance in the face of unanticipated conditions.
* Can provide fair pricing based on full scale execution experience and data.

Cons* Gives incumbent contractor what may be perceived as unfair advantage for the Stage 2 scope.
* Replacing incumbent contractor would incur two mobilization charges (i.e. incumbent contractor’s Stage 2 pricing would consider/reflect this advantage).
* Extends execution schedule by adding, at a minimum, an assessment/re-pricing effort between the stages and, at a maximum, the need to incorporate a second tender process.
* May not be compatible with AAM/AANDC procurement processes and constraints.
 | On balance, offers the best potential for engaging the contracting community and securing fair pricing for the largest component of project scope. |
| 3. Per Option 2 except that Stage 1 is scaled/executed as a trial (not a full scale mobilization). | Pros* Avoids potential for incurring two full mobilization charges.
* Potentially reduces the overall execution schedule impact.

Cons* Does not provide Stage 2 pricing based on full scale execution data (i.e. pricing would, therefore, still reflect the associated incremental uncertainties).
 | Better than Option 1, but not as effective as Option 2. Might be considered if judged to be more compatible with AAM/AANDC procurement policies and constraints. |
| 4. Per Option 3 except that at conclusion of Stage 1, the contractor provides target pricing (with rewards and penalties) for completion of Stage 2. The Owner and contractor would negotiate the basis for measuring performance against the target and the basis for quantifying rewards and penalties. If this negotiation was not successful, the Owner would retain the option of re-tendering Stage 2. | Pros* Reduced potential for incurring two full mobilization charges.
* Potentially reduces overall execution schedule impact.
* Provides both Owner and contractor with mechanism for mitigating cost risk of uncertainties and thereby increases the potential for achieving fair pricing.

Cons* Does not provide Stage 2 pricing based on full scale execution data.
* Difficulties of defining the basis of measuring performance against the target and of negotiating appropriate rewards and penalties.
* May be relatively difficult to align with procurement policies and constraints.
 | A variant of Option 3 that provides a mechanism for mitigating the uncertainties associated with a trial scale Stage 1. |

AMEC recognizes that while contractor engagement during the procurement process may provide opportunities for cost reduction, it offers limited benefit for the purposes of the current cost review. The immediate requirement is to achieve sufficient clarity and alignment on potential costs to facilitate Partner approval for advancing the design. Any cost benefits provided by contractor engagement are likely to come later in the project development and execution process.

## Scope Revisions

### Within the Option 4 Concept

The scope of this review was to identify and consider cost reduction opportunities within the constraints and objectives of Option 4 (i.e. without re-examining the basic option assessment or selection process). The assumptions review and sensitivity analysis were based on alternate assumptions that were intended to satisfy the key tenets of Option 4, specifically:

* Tailings relocation and dam decommissioning followed by restoration of the Dome Creek valley;
* Placement of “low moisture” tailings;
* Maintenance of tailings above the water table;
* Provision of stable and useable backfilled pit surfaces over reasonable timeframes (i.e. without creating practically indefinite restrictions on land use); and
* Maintenance of downstream surface water quality within recognized regulatory standards.

Arguably, some of the alternate assumptions proposed may test the limits of these constraints. That said, there may also be additional cost reduction opportunities provided by a re-examination of the need for, and/or value provided by, these basic characteristics of Option 4 (e.g. are indefinite tailings consolidation timelines tolerable? Would the downstream ecological impacts of the above criteria water quality parameters be acceptable?).

### Outside of the Option 4 Concept

As noted, this review was not intended to consider potential changes that would take the remedial plan outside of the basic definition of Option 4. In AMEC’s view, there would likely be additional cost reduction opportunities available if changes beyond the current definition of Option 4 were to be considered.

## Value Engineering

Value Engineering (VE) is a process that the Partners could consider for systematically considering the alternate assumptions described herein, others that might come from a re-examination of the basic Option 4 characteristics and boundary conditions, or changes that might go beyond the current definition of Option 4.

### Overview

VE is a systematic process used by a multidisciplinary team to improve the value of a project through the analysis of its functions. Value is defined as a fair return or equivalent in goods, services, or money for something exchanged. Value is commonly represented by the relationship:

**Value = Function/Resources**

where **function** is measured by the project’s performance requirements and **resources** are measured in materials, labour, price, and time required to accomplish that function. A VE methodology focuses on improving value by identifying alternate ways to reliably accomplish a function that meets the performance expectations of the project (SAVE International, 2007).

### VE Process

A VE process typically applies a plan that includes the following sequential phases (SAVE International, 2007):

1. **Information Phase**
The team reviews and defines the current conditions of the project and identifies the goals of the study.
2. **Function Analysis Phase**The team defines the project functions and reviews and analyzes these functions to determine which need improvement, elimination, or creation to meet the project’s goals.
3. **Creative Phase**The team employs creative techniques to identify other ways to perform the project’s function(s).
4. **Evaluation Phase**The team follows a structured evaluation process to select those ideas that offer the potential for value improvement while delivering the project’s function(s) and considering performance requirements and resource limits.
5. **Development Phase**The team develops the selected ideas into alternatives (or proposals) with a sufficient level of documentation to allow decision makers to determine if the alternative should be implemented.
6. **Presentation Phase**The team leader develops a report and/or presentation that documents and conveys the adequacy of the alternative(s) developed by the team and the associated value improvement opportunity.

### VE Team

VE processes are normally undertaken by a dedicated VE Team facilitated by a VE Team Leader (SAVE International, 2007).

1. **VE Team**
The Value Study Team is a **multidisciplinary group** of experienced professionals and project stakeholders. Team members are chosen based on their expertise and experience with the project. Sometimes individuals who have relevant expertise, but are not directly involved with the project are added to provide a different point of view.
2. **VE Team Lead**The **Value Team Leader** is experienced in value methodology techniques and is nominated to lead a study team using the VE Plan. VE Team leads often have specific VE training and credentials issued by recognized VE organizations or authorities.

# Cost Review Workshop

## Purpose and Agenda

The cost review scope of work included a workshop in Whitehorse with the Parties (i.e. AAM, AANDC and LSCFN) facilitated by AMEC. The purpose of the workshop was to:

* Outline the components of the cost review and present its findings;
* Continue discussions regarding cost reduction opportunities and strategies; and
* Review next steps.

The meeting agenda is included in the workshop materials provided in Appendix 6A. This agenda started with an introductory statement that provided some general context for the review. Much of the agenda was then given over to a presentation of the cost review document and its findings. The presentation slides are included in Appendix 6A. The final portion of the workshop was a discussion around design assumptions, potential alternatives to those assumptions and the Parties’ requirements for final review outcomes.

## Outcomes

The participants noted the challenges of making clear connections between key assumptions in the Design Base Case and the Option 4 performance requirements or criteria driving those assumptions. This lack of clarity is grounded in the fact that the general tenets of Option 4 are of necessity, fairly broad and required interpretation by the design team to identify specific plans and methods for addressing them (for example, what constitutes a stable pit surface does not easily or transparently translate into a specific compaction specification or relocation methodology). It was noted as well that this lack of clarify complicates the process of identifying potential changes to Base Case elements, performance and cost in ways that can be understood and assessed by the Parties. It was agreed that AMEC would consider summary approaches for clarifying these links between design elements and performance outcomes, and review the utility of those approaches in subsequent consultations with the Parties.

# Summary and Conclusions

## Cost Reconciliation

AMEC completed a reconciliation of the pre-Phase 1 LORAX/AECOM estimate and the Phase 1 AMEC estimate. This reconciliation was intended to identify:

* Any previously unidentified scope elements that were added to the Phase 1 estimate;
* Key elements of the project scope and/or the associated execution methods that exhibit significant differences between the estimates;
* The primary drivers for cost differences in those scope areas/execution methods (e.g. differences in quantity, pricing and/or execution methodology).

AMEC’s review identified a variance between the Phase 1 AMEC estimate ($89.8 million) and the pre-Phase 1 AECOM estimate ($33.7 million including a 9% escalation to present in 2014 dollars) of $56.1 million. The following incremental scope elements (i.e. included in the AMEC estimate, but not the AECOM estimate) contributed to this variance:

* Site maintenance between construction seasons $2.1 million
* Haul road and pit wall stabilization $0.7 million
* Wellpoint dewatering $11.3 million
* PAG rock/tails mixing $4.7 million
* Design contingencies $1.4 million
* Adaptive Management requirements $3.8 million
* Estimate contingency (on incremental scope items) $4.8 million

 Total: $29.0 million

In addition, the following primary differences between the AMEC and AECOM estimates contributed to the variance:

* **The general approach to the two estimates.** The AMEC estimate accounts for all contractor indirects (e.g. contractor site overhead staff, camp catering and housekeeping, haul road improvements, and major sediment and water management works required during construction) and is based on an execution schedule based on estimated activity durations.
* **The general methodology assumed for removing the tailings from the TSF.** In short, the AMEC methodology aligns with the project need to provide conditions in the backfilled pit consistent with the development, within reasonable timelines, of a stable pit cover and reclamation surface. AECOM’s concept involves relocating tailings largely at their in-place moisture content and does not explicitly define how the result can provide surfaces stable enough to sustain the specified pit cover.
* **Reclamation of the TSF footprint.** AMEC assumed that a more physically robust protection for exposed ground surfaces comprised of 300 mm of sand overlaid by a 1,200 mm layer of NAG rock would be needed to address permafrost conditions and to mitigate erosion potentials.
* **Water treatment**. AMEC assumed a fixed treatment capacity would be needed to address a larger hydraulic capacity than AECOM.
* **Landforming**. AMEC assumed a relatively comprehensive rough grading and revegetation plan would follow removal of all NAG and hydrocarbon contaminated materials.
* **Removal of hazardous materials from site**. AMEC assumed that all special waste soils would be directed to offsite, commercial disposition facilities.
* **Open pit cover**. The AMEC estimate applied a two cover concept incorporating an interim cover followed by a final engineered cover, while the AECOM estimate assumed a single, less complex cover.
* **Contingency**. The higher AMEC estimate attracted a higher absolute value for estimating contingency.

## Cost Assumptions Review and Sensitivity Assessment

The assumptions applied for the key scope areas in AMEC’s estimate were reviewed and potential alternates to these assumptions identified. Those alternate assumptions were then applied to the Phase 1 estimating format to assess the impact on costs. This exercise predicted a lower bound estimate of about $60 M and an upper bound of $94 M, on a base estimate of some $90 M. The position of the base estimate within the limits of this range can be viewed as a rough indication of the degree of conservatism in the base estimate. However, this interpretation should be applied with caution, absent a more systematic, risk based quantification of the probabilities that might be attached to these figures.

The lower bound estimate was of particular interest, given the objectives of this review. The following assumptions/issues were found to have the greatest influence on potential reductions from the base estimate (in declining order of importance):

* The specific materials handling methods applied for the movement of tailings and PAG rock to the Open Pit;
* The configuration and efficiency of the wellpoint dewatering system used to facilitate the excavation of tailings;
* The capacity, configuration and reagent consumption for the water treatment capability developed to accommodate waters incompatible with direct release onsite;
* The pit cover concepts and maintenance protocols applied to mitigate post remediation differential settlements in the backfilled pit;
* The extent to which design contingencies and Adaptive Management protocols must be applied to mitigate risks associated with post remediation downstream surface water quality excursions;
* The approach taken for the disposition of contaminated soils categorized as special waste (i.e. onsite vs. offsite); and
* The extent to which reclamation concepts rely on revegetated vs. granular finished landscapes.

## Cost Reduction Opportunities

The scope of this review was to identify and consider cost reduction opportunities within the constraints and objectives of Option 4 (i.e. without re-examining the basic option assessment or selection process). The assumptions review and sensitivity analysis were based on alternate assumptions that were intended to satisfy the key tenets of Option 4, specifically:

* Tailings relocation and dam decommissioning followed by restoration of the Dome Creek valley;
* Placement of “low moisture” tailings;
* Maintenance of tailings above the water table;
* Provision of stable and useable backfilled pit surfaces over reasonable timeframes (i.e. without creating practically indefinite restrictions on land use); and
* Maintenance of downstream surface water quality within recognized regulatory standards.

Arguably, some of the alternate assumptions proposed may test the limits of these constraints. That said, there may also be additional cost reduction opportunities provided by a re-examination of the need for, and/or value provided by, these basic characteristics of Option 4 (e.g. are indefinite tailings consolidation timelines tolerable? Would the downstream ecological impacts of the above criteria water quality parameters be acceptable?).

Identifying those alternate assumptions and/or revisions to the key tenets of Option 4 that will produce the desired cost reductions, while accommodating the needs and requirements of the Partners, will require additional review and consultation. Various approaches to this could be considered; for example, a Value Engineering (VE) process structured to systematically work through the issues involved with the Partners and their consultants could be undertaken.

A VE exercise would include a detailed consideration of the elements of the current Design Base (i.e. the basis of the current estimate), its derivation and bases. It might also be useful to posit a “Minimalist Base Case” that would be intended to bookend the lowest effort scope that could potentially satisfy the key tenets of Option 4 (adjusted as may be necessary). The Partners could then review the associated performance compromises, and incremental risks and uncertainties to determine if this Minimalist Base Case could be accepted, or where targeted supplements to this base might be required.

An example of a Minimalist Base Case for Option 4 would be as follows:

* No performance criteria applied to tailings and contaminated dam sands placed in the pit;
* No requirement for tailings dewatering prior to relocation;
* No relocation of waste rock (PAG or NAG) to the pit unless required to facilitate tails relocation and/or pit construction;
* No requirement to maintain pit groundwater levels below the tailings (i.e. elimination of the waste rock bench);
* No removal of tailings from creek beds outside the TSF footprint;
* No performance criteria for the pit cover beyond a broad objective to provide a trafficable surface at some point in the future;
* Surface reclamation limited to aesthetically driven recontouring of stockpiles and disturbed surfaces;
* no revegetation of finished surfaces; and
* Downstream surface water quality impacts assessed and managed via Adaptive Management.

In essence, this approach involves defining and applying a basic method specification, acknowledging the associated uncertainties with respect to performance outcomes, and committing to managing and/or mitigating those outcomes via maintenance and Adaptive Management. Physically, the method specification limits the scope to relocating the tailings as expeditiously as possible and with a minimum of treatment and/or conditioning, covering those tails with an end dumped waste rock cover, physical stabilization of the TSF footprint, dismantling and onsite disposition of structures and minimal recontouring and regrading of the remaining disturbed landscape.

Adopting a Base Case like this clearly means accepting some adjustments and compromises in the key tenets of Option 4, particularly related to downstream water quality and the stability and utility of final pit landscapes. Developing this Base Case would require some re-focusing of subsequent design development efforts to better understand the base performance outcomes that must be managed via maintenance and/or Adaptive Management. For example, given the compromises to downstream surface water quality that would likely be associated with this minimalist Base Case, it will be that much more important to understand if the worst case water quality outcomes are within the mitigative capabilities of the available Adaptive Management measures and technologies.

# Limitations and Closure

This report was prepared exclusively for Assessment and Abandoned Mines, Energy Mines and Resources by AMEC Environment & Infrastructure, a wholly owned subsidiary of AMEC Americas Limited. The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in AMEC services and based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by Assessment and Abandoned Mines, Energy Mines and Resources only, subject to the terms and conditions of its contract with AMEC. Any other use of, or reliance on, this report by any third party is at that party’s sole risk.

Yours truly,

**AMEC Environment & Infrastructure** Reviewed by:

R. Brian Geddes, P.Eng. Christine M. Peters, P.Eng.

Senior Design Lead Project Manager

Serge N. Chevrier

Estimating Lead

# References

AECOM (2009). *Mount Nansen Mine, Water Treatment Study*. Prepared for Government of Yukon - Energy, Mines and Resources.

AECOM (2010). *Geotechnical Assessment and Costing of the Mt. Nansen Mine Closure Alternatives.* Submitted to Yukon Government, Assessment and Abandoned Mines Branch.

AECOM (2011). *Correspondence to Assessment and Abandoned Mines Branch, Yukon Government, re: Summary of Estimated Closure Costs, Mt. Nansen Mine Site.* May 13, 2011. Project No.: 60159089 (402).

Altura Environmental Consulting (Altura) (2011). *Technical Memorandum to LORAX Environmental Services Ltd. re: Mount Nansen Mine Site - Provisional Cost Estimates for Water Quality Mitigation - Final Draft*. May 13, 2011.

Altura Environmental Consulting (Altura) (2010). *Mount Nansen Mine Site, Yukon, Common Element and Supplemental Cost Estimate for Conceptual Closure Planning*. Prepared for LORAX Environmental Services Ltd.

AMEC Environment & Infrastructure (AMEC) (2014). *Mount Nansen Remediation Project, 30% Design Phase Cost Estimate.* Submitted to Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon.

AMEC Environment & Infrastructure (AMEC) (2014a). *Mount Nansen Remediation Project, 2014 Site Investigation Report and Site Characterization Update.* Submitted to Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon.

Golder Associates (Golder) (2010). *Technical Memorandum to LORAX Environmental Services Ltd. re: Conceptual Assessment of Law Infiltration Cover Options for the Mt. Nansen Project, Yukon.*
October 1, 2010. Project No.: 10-1427-0018.

LORAX Environmental Services Ltd. (LORAX) (2011). *Mount Nansen Options for Closure*. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon.

SAVE International (2007). *Value Methodology Standard and Body of Knowledge*. SAVE International Value Standard, 2007 edition.

Appendix 2A – Detailed Cost Reconciliation Worksheets

Appendix 2B – Detailed Quantity Breakdowns/Reconciliation

Appendix 6A – Cost Review Workshop Agenda and Presentation Slides