Dry Stack Tailings Facility (DSTF) Expansion
Detailed Design

Pogo Mine, Alaska, USA

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1 Introduction

The Dry Stack Tailings Facility (DSTF) at the Pogo mine consists of an above-ground, valley fill waste storage facility in which filtered tailings and development waste rock from the Pogo mine are permanently deposited. The DSTF consists of an outer shell (which is constructed progressively in three phases – Shell 1, Shell 2, and Shell 3), and a General Placement Area (GPA) that is located adjacent to the upstream side of Shell 1 which is constructed of waste rock. The DSTF is located within the limits of the Liese Creek valley and is located upstream of the maximum water storage elevation of the Recycle Tailings Pond (RTP) dam.

2 Background

2.1 Background of the Project

In January 2011, Sumitomo Metal Mining Pogo LLC (SMMP) contracted SRK to complete a preliminary study to investigate expansion of the DSTF. Expansion of the DSTF to provide storage for 20 M tons was anticipated by the 2011 Life of Mine Plan and as such, stability analyses were required to confirm stability of the expanded structure. In addition, based on current waste deposition rates, it was anticipated that the DSTF would begin to encroach on the existing south diversion ditch by 2013 which would necessitate construction of a new diversion system to facilitate management of non-contact water.

The preliminary study was completed in March 2011 and concluded the following:

- The capacity of the current DSTF will be reached in 2013, and the new diversion ditch would need to be constructed by the end of 2013;
- New diversion ditches to direct non-contact water around the expanded DSTF would be required; and
- The factors of safety (FoS) for the expanded structure exceed the minimum FoS values specified by the design criteria even for scenarios in which an elevated phreatic surface and a range of failure modes were modelled.

Results of the preliminary study are documented in the Preliminary Expansion Study Report (SRK 2011a). The main findings of the study were also presented and discussed at a meeting with the Alaska state regulatory agencies held in Fairbanks in June 2011. The scope for the detailed design work program was developed following acceptance of the findings of the preliminary study during the June 2011 meeting.

3 Program Objectives and Work Program

3.1 Program Objectives

In July 2011 SMMP contracted with SRK to complete detailed design of the new clean water diversion system and haul road access for the proposed expansion of the DSTF. The primary objective was to obtain the construction drawings and engineer's cost estimate required to:

a) receive the required approval to proceed with construction of the new diversion ditches and haul truck access; and
b) ensure that the new diversion ditches were installed to provide continued diversion of non-contact water around the DSTF beyond 2013.

The plan view of the general work arrangement is shown on Figure 1.

### 3.2 Purpose of the Report

This report describes the work that was completed by SRK to design the water diversion system and haul truck access road necessitated by:

- Anticipated encroachment of the current diversion ditches by the DSTF by 2013; and
- Proposed expansion of the DSTF to provide storage capacity for 20 M tons of waste material.

The scope of this report has been limited to discussion of key design criteria impacting the engineering design of the new haul road and diversion ditches and considerations for the construction phase of this project. For detailed discussion about stability analysis and design criteria for expansion of the DSTF, the Pogo Mine Dry Stack tailings Facility Expansion Preliminary Study report (SRK 2011a) and the Recommendations for DSTF Construction and QA/QC Procedures (SRK 2011b) should be reviewed. The Geotechnical Investigation Summary, Technical Memo (SRK 2011c) provides additional discussion about the high level geotechnical site investigation that was completed to investigate near surface conditions along the proposed alignments of the new diversion ditches and haul road.

The Issued for Construction (IFC) Drawings, Technical Specifications and Engineer’s Cost Estimate for the design have been provided to SMMP under separate cover.

### 3.3 Work Program

The scope of work described in this report was initiated to provide engineering design detail for construction of a new water diversion system suitable to accommodate the expanded storage capacity requirements of the DSTF.

Since the preliminary study for expanding the DSTF confirmed the stability of the expanded configuration, SRK advanced detailed design by completing the following tasks:

- Verifying the footprint of the 20 M ton capacity DSTF using the lower limit of compaction density allowed for placement of materials in the GPA (90% Standard Proctor density, ~ 98.1 pcf in the GPA);
- Confirming the preliminary alignment of the new water diversion system (north and south diversion ditches), and haul road to facilitate survey of the alignments and completion of a high level geotechnical site investigation along the proposed alignments;
- Completing a high level geotechnical site investigation of the valley walls along the preliminary ditch and haul road alignments;
- Completing detailed design of the new haul truck access road;
- Reviewing existing site hydrologic data;
- Completing detailed design of hydraulic structures to be included in the new water diversion system; and
• Preparing of IFC drawings of all designed works, Technical Specifications, Engineer’s Cost Estimate, and Detailed Design report.

### 3.4 Project Team

Work for this project was completed by the following individuals:

- Mr. Alvin Tong completed the high level geotechnical site investigation of the valley side walls and was the primary geotechnical engineering designer of the new haul road access. Mr. Tong also developed the engineering cost estimate and technical specifications.

- Mr. Nelson Veloso served as the CAD designer for the project and rendered all engineering design drawings using AutoCAD Civil 3D.

- Mr. Sean Neuffer assisted with design of the hydraulic structures for the project.

- Mr. John Duncan provided supervision and technical oversight for design of all hydraulic structures for the project.

- Mr. Victor Munoz Saavedra provided technical review for all hydraulic structures designed.

- Ms. Lois Boxill served as senior geotechnical reviewer for design of all geotechnical aspects of the project. Ms. Boxill also provided technical review of all submittals issued to SMMP and served as Project Manager.

- Mr. Cameron Scott served as Project Principal and provided final review of all submittals issued to SMMP. Mr. Scott also served as the lead client liaison for the project.
4 Program Results

The following subsections describe the outcomes of the various tasks that were completed by SRK during completion of Detailed Design.

4.1 Confirmation of Limits of Expanded DSTF

To confirm disturbance limits associated with proposed expansion of the DSTF, SRK developed extents of the expanded DSTF using the lower limit compaction density (90% Standard Proctor Density, or 98.1 pcf) for materials placed in the GPA. The developed extents for the expanded DSTF are shown on Figure 1. Allowance has also been made for a minimum 50 foot offset to exist between the anticipated extents of the expanded DSTF and the centerline of the new diversion ditches.

4.2 Site Characterization

The DSTF is located within the limits of the Liese Creek Valley and as such, expansion of this facility would entail continued placement of waste materials adjacent to the valley walls consistent with current operations procedures. The increased height of the expanded facility would require construction of new diversion ditches along the south and north valley walls as indicated on Figure 1. Based on the anticipated construction work to be completed, SRK limited the scope of its site investigation which was completed between July 25 and July 27, 2011 to the following:

- Visual inspection along the proposed alignments of the new diversion ditches and haul road; and
- Use of simple probing methods (i.e. driving a piece of rebar into the soils) to assess the thickness and nature of overburden materials, and where possible, confirm the depth to bedrock.

While details of the completed site investigation program are described in the Geotechnical Investigation Summary (SRK 2011c) the key findings of the high level site investigation were as follows:

**North Diversion Ditch Alignment**

- Natural slope of valley wall is approximately 40% grade (22 degrees) and heavily forested.
- Observed overburden thickness (the term “overburden” used in this report to describe rippable material above competent rock) ranges between 3 and 5 feet with topsoil thickness (the term “topsoil” used to describe growth media that could be used for site reclamation activities) ranged between 6 and 12 inches. The overburden thickness was approximated by driving a 3-foot long piece of rebar to refusal and by inspection of existing material cuts in the valley walls. Depth measurements were also taken in holes where trees were uprooted and the soil profile exposed. Topsoil thickness was approximated using hand dug test pits.
- The proposed diversion alignment intercepts three streams designated: Stream 1 (@ Sta. 12+50), Stream 2 (@ Sta. 35+80) and Stream 3 (aka Liese Creek, @ Sta. 58+00) as seen on Figure 1. At the time of the site investigation, little to no flow was observed in the Stream 1 channel while a few springs, with dispersed flows of approximately 5 gpm were observed entering the existing north channel in the vicinity of Stream 1. Stream 2 was observed to be
flowing at approximately 150 to 200 gpm in a roughly defined rock channel that was 5 feet wide and 1 foot deep. Stream 3 (Liese Creek) was observed to have a flow of approximately 150 to 250 gpm that was conveyed in a roughly defined rock channel. In addition, flow from Liese Creek was observed flowing into an old rock slide/boulder train around Elevation 2,660’. Below this elevation, creek flow was dispersed among boulders and flowed in a few small and roughly defined channels before being intercepted by the existing north diversion ditch.

**South Diversion Ditch**

- Natural slope of the valley wall varies between 40% grade (22 degrees) and 70% grade (35 degrees).

- Steeper slopes are associated with three historic rock slides/boulder trains located along the south valley wall as indicated on Figure 1. Construction of the new south diversion ditch will require excavation into material located at two of these historic slide areas. Moss and algae growth on the surface of the rocks and boulders in both rock slide areas suggests that the slide debris has been in place for a long time, experiencing little movement. Water flows are observed within this slide debris but are difficult to quantify due to their dispersion within the rock slide boulders. The thickness of these slides is unconfirmed but is inferred to be between 6 feet and 15 feet with boulders up to 15 feet in diameter.

- Observed overburden thickness ranges between 1 and 4 feet and is thinner when compared to observed overburden depths along the proposed north diversion ditch. Topsoil depth ranges between 6 inches and 12 inches.

- The south valley wall where the proposed south diversion ditch is to be located is less densely forested than the north valley wall along the alignment of the new north diversion ditch. Thirteen springs/seeps were observed along the proposed south ditch alignment, with flows between 5 gpm and 10 gpm.

### 4.3 Haul Road Design

#### 4.3.1 Haul Road Design Criteria

The primary objectives of the haul road design were to:

- Provide dual lane haul truck access to the DSTF that was safe and allowed for optimal operation of mine equipment;

- Optimize the cut and fills required to construct the road; and

- Utilize design criteria consistent with the typical design sections presented in the Issued for Construction drawing set developed by AMEC in 2004.

Design criteria for the typical haul road section were provided by SMMP to SRK. The New Haul Road has a maximum slope of 12.1% along the road profile which facilitates use of the entire road alignment by mine haul trucks. The road alignment was also designed to eliminate pinch points that could potentially constrain or restrict haul truck operation – i.e. number of turning functions has been minimized and tight turns have been eliminated. The new haul road also ties in to the existing haul road.
The New Haul Road is 33 feet wide and will be surfaced with 1 foot of \( \frac{1}{2} \) inch crush material. The haul road will be adjoined by a 3 foot deep ditch along the inside cut edge (to provide collection and conveyance of contact water) and by a 3 foot tall safety berm that will be located along the external cut edge.

SRK has defined structural fill as material located within the traffic limit (33 feet width) of the haul road on which haul trucks will operate which must be compacted per the specifications included in the technical specifications prepared. The traffic limit is bounded by a vertical plane located along the outside edge of the road cut and it is expected that compactive effort used to construct the surface of the access road will extend into the upper reaches of the adjacent general fill that will be located on the slopes adjacent to cut areas along the haul road alignment. It should be noted that in instances where a thin veneer of general fill exists on the slope adjacent to haul road cuts compaction of this material is not required to maintain structural performance or geotechnical stability of the haul road within its traffic limits. Once the road surface on which haul trucks will transit has been compacted in accordance with the technical specifications provided, sloughing of general fill immediately adjacent to the safety berm will likely occur as a result of subsequent subsidence of this material under self-weight and from the effects of gravity and should be monitored for periodic repair.

4.4 Diversion Ditch Design

4.4.1 Hydrologic Design Criteria

The new North and South Diversion channels were designed to intercept non-contact runoff from undisturbed areas upgradient of the DTSF proposed expansion. The new diversion channels will convey the runoff to segments of the existing diversion channels that will not be impacted by expansion of the DSTF. The existing channels ultimately discharge into Liese Creek downstream of the RTP. The new diversion channels were sized to convey the 1 in 200-year, 24-hour precipitation event of 4.6 inches. This design storm is consistent with the one used to design the segments of the existing diversion system (portions of the north and south diversion ditches, and Flume 1 and Flume 2) that will receive flows from the new diversion ditches. This design storm was utilized for the original diversion channel design prepared by AMEC in 2004 (AMEC 2004).

4.4.2 Design of Hydraulic Structures

The hydrologic analysis for the new diversions was performed using HEC-HMS 3.5 (released August 2010). The SCS curve number and unit hydrograph methods were utilized to determine watershed runoff for the design event. Channel routing was performed in the model and peak flow rates were obtained at various locations along the new channel alignments. Design flow rates vary from 26 cfs to 69 cfs along the new North Diversion and 13 cfs to 24 cfs along the new South Diversion.

4.4.3 Description of Overall Diversion System

The new diversion channels will be V-shaped with a total depth of 3 feet to 3.5 feet. This channel geometry allows for conveyance of the design storm event with a minimum of one foot of freeboard. A ten foot wide access road with a 4 foot wide berm will be constructed adjacent to each diversion to allow access for channel maintenance.
As overburden thickness varies along the channel alignments shotcrete will be applied to areas where the channel is constructed in overburden to prevent channel erosion and reduce infiltration. Existing drainages will enter the new diversions through a basin (dimensions 10 feet by 10 feet) lined with rip-rap to reduce velocities and a geomembrane liner to limit infiltration.

Flows from the new South Diversion will be conveyed to the existing South Diversion via a drop intake structure and a flume. The piping and drop structure was designed to pass the 200-year, 24-hour design storm event. The flume intake consists of a concrete drop box with a 24-inch HDPE pipe outlet that will daylight to a 30-inch diameter open CMP. The open CMP pipe will run down the hillside before transitioning to a closed 30-inch diameter CMP. The closed CMP pipe will bend to allow for a parallel discharge into the existing South Diversion. Concrete thrust blocks will be placed at horizontal bends to prevent pipe movement. The open CMP will be secured to the hillside with rebar anchors.

The new North Diversion will intersect the existing North Diversion directly eliminating the need for any piping. This transition will be field fitted during construction.

Hydraulic structures including ditches should be periodically inspected and maintained. Sediments and debris that are deposited throughout the system should be removed to allow for uninhibited flow.

4.5 Construction Considerations

The technical specifications (submitted to SMMP under separate cover from this report) provide expanded discussion about the construction considerations to be accounted for during the construction phase of this project. However, the following key considerations should be noted:

- Construction activities, especially those associated with the new haul road and north diversion ditch should be scheduled in consultation with SMMP’s surface operations crew to minimize disruption of haul truck access to the DSTF along the current haul truck access routes;
- Installation of shotcrete lining along the segments of the diversion system should be done by a professional contractor to realize the design intent of providing effective containment and conveyance of non-contact water;
- Inlet and flume structures should be constructed by a qualified contractor using the design details provided to facilitate effective interception and conveyance of the major flows that were designed to be conveyed by the water diversion system; and
- While not considered by SRK to be a fatal flaw in the project design, excavation into material from historic rock slides to construct the new south diversion ditch represents a potential risk during construction. SRK recommends that an assessment of the slides be completed prior to construction with a view to defining suitable risk mitigation measures that can be implemented prior to or during construction. Furthermore, additional work is required to confirm the depth of materials contained in rock slide areas.
5 Conclusions and Recommendations

The General Arrangement of the construction components is shown in Figure 1. The haul road and non-contact water diversion system designs described in this report will facilitate the following key project objectives:

- Provision of dual-lane haul truck access to the expanded configuration of the DSTF. The New Haul Road would need to be tied in to the existing haul road and modifications will be required onto the expanded DSTF configuration. It is anticipated that the segment of the new haul road that will be constructed on the surface of the expanded DSTF will also facilitate dual-lane traffic access on to and off of the DSTF;

- Interception and conveyance of the three streams that will be intercepted by the alignment of the north diversion ditch; and

- Conveyance of flow from the new south diversion ditch to the segment of the existing south diversion ditch using a flume section similar to that currently used on the existing north diversion ditch (Flume 1).

In SRK’s estimation, construction of the new diversion system (excavation of ditches, construction of inlets, and installation of flumes) can be completed by a qualified large civil earthworks construction contractor. While SRK concurs with SMMP and does not believe that the intersection of two historic slide areas during construction of the new south diversion ditch or expansion of the DSTF represents a fatal design flaw, SRK believes that a more rigorous assessment and characterization of the potential risks associated with the two historic slides should be completed prior to the start of project construction activities. At a minimum, SRK suggests that potential contractors be allowed to inspect the slide areas and review existing data so that their bids can account for mitigation of potential associated risks.

SRK also believes that input from SMMP’s Surface Operations lead personnel is essential for successful completion of the construction phase of this project. While discussion of all aspects of the project with Surface Operations lead personnel is considered essential, feedback is most critical to successfully staging construction of the new haul road, new north diversion ditch, and awareness of the potential risks and mitigation measures associated with construction of the south diversion ditch and flume.
This report "Dry Stack Tailings Facility (DSTF) Expansion Detailed Design" has been prepared by SRK Consulting (Canada) Inc.:

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.
6 References


Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting Inc. (SRK) by Sumitomo Metal Mining Pogo LLC (SMMP). These opinions are provided in response to a specific request from SMMP to do so, and are subject to the contractual terms between SRK and SMMP. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK’s investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report.

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NOTES
1. Contour interval is 20ft.
2. Contour data shown based on LIDAR survey (May, 2010).
3. DSTF tailings storage and ongoing operation will be carried out by SMMP.
4. SMMP will be responsible to construct and extend the rock drains for the DSTF to the extents indicated during DSTF expansion.
5. The Contractor is responsible to construct the indicated structures below, associated components, support facilities and as directed by SMMP and their representatives.
   - New Haul Road
   - New North Diversion Ditch
   - New South Diversion Ditch and Pipeline

POGO MINE
DSTF Expansion Detailed Design
General Arrangement