APPENDIX E05

Sedimentation and Pollution Control Ponds Technical Memorandums

SRK Vancouver
Suite 2200 - 1066 West Hastings Street
Vancouver, BC V6E 3X2

T: +1.604.681.4196
F: +1.604.687.5532

vancouver@srk.com
www.srk.com

# Memo

| | | | |
|---|---|---|---|
| **To:** | Chris Hanks | **Date:** | August 17, 2011 |
| **Company:** | Hope Bay Mining Limited | **From:** | Maritz Rykaart |
| **Copy to:** | Melanie Smith, Angela Holzapfel, Kevin Mather, Calvin Goldschmidt | **Project #:** | 1CH008.033 |
| **Subject:** | Doris North Project Water Management – Remedial Measures for Leaking Pollution Control and Sedimentation Ponds | | |

## 1 Introduction

Water management at the Doris North Project is currently being carried out in accordance with the Interim Water Management Plan (IWPM). This plan includes a clean water diversion north of the camp/mill pads to minimize the amount of surface runoff that would have to be managed through event ponds. Water from the east side of the camp/mill area, downstream of the clean water diversion structures, that has come into contact with mine waste rock, drains towards the 3,820 $m^3$ capacity Pollution Control Pond (PCP). Water from the western side of the camp/mill area, that have not come into contact with waste rock drains towards the 2,049 $m^3$ capacity Sedimentation Pond (SEP). These capacities are based on the design Full Supply Level (FSL) of the ponds and exclude freeboard capacity.

Water collected in the PCP was to be treated via a water treatment plant (WTP) (reverse osmosis and filtration) located on Pad E, with the treated water discharged to the SEP, and if it met the water quality criteria it will then get discharged to the tundra. WTP reject water was to be pumped back to the PCP.

In May 2011, while freshet flows drained into the PCP, continuously dropping water levels suggested that the PCP was leaking, and since clean water diversion structures were not in place prior to the freshet, it became apparent that additional on site water storage was required. As a result a 5,500 $m^3$ capacity Temporary Pond (TEP) was constructed on Pad D, and a 500 $m^3$ spare water tank (Windy Camp Fire Water Tank) was prepared to add additional storage capacity. The TEP was commissioned on June 12 and from that point forward any water reporting to the PCP was immediately pumped into the TEP. In addition, the water tank was filled with water pumped from the PCP.

Between July 8 and July 22, a total of 3,871 $m^3$ of water collected in the TEP was inadvertently discharged to the tundra via the SEP and PCP. 1,151 $m^3$ of this water passed through the WTP, and the remaining 2,721 $m^3$ was untreated. This memo describes the chronology of events that led to these discharges and provides recommendations for remedial measures to prevent further uncontrolled discharges.

## 2 Chronology of Events

Detailed records of the chronology of events leading up to the uncontrolled discharge of water is not available, as a result SRK interviewed key staff, reviewed site records, produced as-built stage capacity curves for the ponds in question and applied engineering judgment to compile this chronology of events and to develop a water balance to estimate the total volume of water that was discharged.

About 2,691 $m^3$ of water was pumped from the TEP to the initially empty PCP between July 8 and July 13, in anticipation of commissioning of the WTP. Even though the PCP was suspected to be leaking, this was done because the WTP was designed with its inlet line from the PCP in accordance with the IWMP. By July 13 it was confirmed that the PCP was leaking and the remaining water in the pond was immediately pumped back to the TEP. At this time the WTP was modified to allow water to be drawn directly from the TEP rather than from the PCP.

Pre-commissioning of the WTP occurred between July 14 and July 17 and during this time about 613 $m^3$ of water was drawn from the TEP, treated and pumped into the PCP (both treated water and reject), before being cycled back to the TEP.

The WTP was formally commissioned on July 17, and operated until July 22 during which time a volume of 1,570 $m^3$ of water was drawn from the TEP. 1,151$m^3$ of treated water emerged which was pumped to the SEP, while 420 $m^3$ of reject water was pumped to the PCP, from where it cycled back to the TEP.

On July 22 a rapid drop in the SEP water level was observed and as a result the WTP was shut down halting all further pumping from the TEP. In less than five hours the SEP was completely drained.

On July 8, when this chronology of events started, there was 6,050 $m^3$ (exceeding the FSL) of water in the TEP and both the SEP and PCP was empty. On July 22 when the WTP was shut down, and both the SEP and PCP was once again empty, the volume in the TEP was 1,887 $m^3$, implying to a total loss of 4,163 $m^3$ to the tundra. During this time about 147 $m^3$ was used by the Mining Department for brine make-up water and about 145 $m^3$ was likely lost though evaporation. This means that the total actual loss to the tundra is about 3,871 $m^3$, with 1,151 $m^3$ of this having been treated (excluding the pre-treatment period) and 2,721 $m^3$ untreated.

# 3 Origin and Cause of Leaking Ponds

Several hypothesises were considered which could explain the origin of the leak from the ponds. The likelihood of each hypothesis to be the controlling mechanism of leakage was rated, using engineering judgement from 1 to 10, with 1 being the least likely and 10 being the most likely. The hypotheses are summarised in Table 1.

**Table 1: Summary of possible causes of the leak**

| Case | Hypothesis | Likelihood Rating |
|---|---|---|
| A | Flow under the liner through the granular material of the bedding layer (only applies to PCP) | 10 |
| B | Flow under the liner through the thawed interflow zone | 10 |
| C | Leaking through holes in the liner | 1 |
| D | Preferential flow paths through melted ice wedges | 1 |
| E | Overflow upstream of the liner on the north side of each pond | 8 |

The exact origin and cause of the leak in the two ponds cannot be determined with absolute certainty; however, as listed in Table 1, the most likely hypothesis, supported by field and anecdotal evidence, are A, B and E. The cause of A and B is due to the fact that the key trench had not had a chance to freeze in below the active layer and therefore there is an open flow path. On July 27 SRK probed the depth of the active layer in both ponds and confirmed that the current active layer is deeper than the base of the key trench in the lower sections of each pond (i.e. near the sumps).

The most likely reason for this condition is the late season construction of these ponds, exacerbated by continuous warm weather and a continuous inflow of water into the key trench during construction, further depressing the active layer locally. Furthermore, the ponds had to be put into commission immediately following the completion of construction, before the key trench had an opportunity to freeze in.

Field evidence suggests that water leaking from the SEP preferentially flows towards the PCP, and leakage from the PCP preferentially flows subsurface eastward along the upstream face of the Float Plane Access Road (FPAR) where it emerges as a surface seep downstream of the road about 100 m east of the PCP. Aerial reconnaissance and a review of pre-construction photos confirm that where the seepage is observed is in fact a historic drainage path for water from the camp/mill area.

Anecdotal evidence, supported by SRK observations, suggests there is a direct link between the volume of flow from this point and the elevation of water in the PCP. This suggests that water seeping under the liner in the currently thawed key trench is being retained by the elevated active layer created by the FPAR which has been in place since 2007. This observation is consistent with thermal modelling that suggest that with fill thicknesses exceeding 2 m, the active layer moves up into the fill.

It should be noted that water quality measurements have been taken (both by SRK and HBML) in an attempt to provide additional factual information with respect to determining the exact origin of any leakage from the ponds. Based on data available to SRK to date, the hypothesis presented appears to be supported by the water quality data.

# 4 Pond Remediation Measures

## 4.1 Approach

Since the ponds are not meeting their design intent, mitigation measures must be put in place to ensure no further uncontrolled release of water from the camp/mill area. Although there is a continuous pump-back system to the TEP in place for water that enters either pond, it is not sustainable. When the TEP reaches capacity, there will be no ability to further contain potentially contaminated water.

A series of brainstorming sessions was held (both on site and in Vancouver) to develop potential remedial measures to stop the ponds from leaking, and to ensure that potentially contaminated water from the camp/mill area is captured to prevent further uncontrolled releases. The potential options are summarized in the following sections.

## 4.2 Common Remedial Elements

### 4.2.1 Downstream Collection Sumps

Common to all of the remedial options is the need to install two permanent sumps downstream of the camp/mill area to capture any water that either seeps from, or bypasses the PCP and SEP. Sump #1 will be located at the point where seepage directly linked to the ponds have been observed and Sump #2 will be located at the junction between the FPAC and the Tail Lake Access Road (TLAR).

During freshet, significant flow was observed at the Sump #2 location and this water originated from the subsurface flow under Pads F and G, which is not captured by the PCP (note that surface runoff from these pads does drain to the PCP). While there is no waste rock loaded onto these pads, this is an acceptable situation (if supported by appropriate water quality data); however, future plans calls for these pads to be loaded with waste rock, at which time this water will likely be contaminated and will need to be captured.

### 4.2.2 Wing Walls

Currently the key trenches in both ponds do not extend up to the top of the freeboard elevation along their wing walls. This was intentional due to the presence of Pads I and E respectively for the PCP and SEP. This means that there is a possibility that water can seep out from the back of the ponds if the water level exceeds the maximum elevation of the liner in the key trench at the edge of the wing walls (i.e. hypothesis E in Table 1). This limitation was known when the ponds were designed but given the thickness of Pads E, F, G, the separator berm, and the FPAR, a conclusion was drawn that in all likelihood the ponds would be sealed due to the raised active layer surrounding each pond.

Although there is no evidence that the ponds have leaked via this route (although it would only be observed if the ponds are near capacity), remedial measures to prevent leakage via this potential pathway should be implemented to prevent this from possibly happening in the future.

### 4.2.3 Upstream Collection Sumps

A lined upstream diversion berm and collection sumps were designed to divert clean water from entering the PCP and SEP. These berms were not all in place at the start of the freshet; however, to a large extent these have now been constructed. SRK conducted subsurface investigations on July 27 and 28 and confirmed that a continuous base flow is passing underneath the diversion berm along a perched water table in the active zone. This is the origin of the continuous flow of water that is draining into the PCP at this time.

The design of the diversion berm, although effective during the freshet period, when the ground is frozen at surface will not intercept this summer base flow. In order to capture these flows, at least three permanent sumps excavated into the permafrost are required at designated spots along the upstream diversion berm. Aerial reconnaissance has confirmed that these spots correlate to historic drainage channels.

## 4.3 Remedial Options

### 4.3.1 Option 1: Do Nothing

This option is based on the assumption that freeze-back will seal the liner (and the granular under-liner fill material in the PCP). This was the original design intent, and is based on the concept that the active layer is typically about 0.5 m thick and thus keying in the liner at a depth greater than 1 m would ensure a good seal. SRK probed the depth of the active layer in the ponds on July 27 and confirmed that in fact the active layer close to the sumps was approaching depths greater than 1 m. At the same time, in wet marshy areas, including areas subject to permanent ponding immediately downstream of the ponds across the FPAR, the active layer was less than 0.5 m. This is good evidence for suggesting that the ponds would seal themselves once they have underwent at least one freezing cycle.

For this option to work, the ponds would have to be completely decommissioned for the remainder of the season. The likelihood of this being 100% successful at repairing the leak is moderate to high; however, given the significant thaw reached this year, there does remain a chance that further mitigation may still be required, especially for the PCP that has the gravel bedding layer under the liner.

Given the fact that this option would imply that both these ponds will be completely unavailable for the rest of the season, and the potential risk that a leak may still exist next year, this option is not recommended.

### 4.3.2 Option 2: Reseat Liner using Bentonite Mix Cut-off Wall

This concept entails removing the rip-rap and thermal cover of Run-of-Quarry (ROQ) covering the key trench to expose the upstream liner edge. A narrow trench would be excavated upstream of the liner to a depth of at least 1.2 m, or at least 0.5 m below the current active layer. The trench will be backfilled using a compacted low permeability crush fines/bentonite mixture. The exposed liner and engineered fill would be keyed into this cut-off wall and the thermal cover and rip-rap will be replaced.

To successfully implement this option a mix design would be required (laboratory testing), powdered bentonite would have to be flown to site, a mixing system will have to be put in place, and a rigorous quality control plan would have to be implemented. Finally it will be imperative that proper dewatering of the trench continuously be done during construction to avoid compromising the design. These complexities make this to not be a desirable option.

### 4.3.3 Option 3: Reseat Liner using Sheet Pile Cut-off Wall

This concept is similar to Option 2; however, rather than installing a cut-off wall, shallow steel sheet piles are driven into the permafrost. The liner is then attached to the top of the sheet piles to ensure a good seal.

There is pile driving equipment and metal sheet piles on site; however, mobilizing this equipment and a specialist contractor to site will be time consuming and expensive. The sheet piles cannot be driven into frozen ground, so in order to install them deeper than the current active layer they would have to be pre-drilled or alternatively heated up to allow a local thaw zone to be developed. The final challenge associated with this option is the specialized bond between the sheet pile and the liner. This will be a time consuming installation, and the longevity of the bond given repeated freeze-thaw cycles are uncertain. The challenges associated with this option make it undesirable.

### 4.3.4 Option 4: Reseat Liner using Grout Curtain

In this option, again similar to Options 2 and 3, a grout curtain will be installed onto which the liner can be attached via a pony-wall. Grouting will however not work unless the ground is thawed, which will be time consuming and expensive. This option was thus not considered further.

### 4.3.5 Option 5: Reseat Liner in Remediated Key Trench

This option entails exposing the key trench and liner as for Options 2 and 3, but rather than installing a new cut-off wall of some kind, exposing the base of the key trench (after lifting the liner), removing any gravel (in the PCP) and in the thawed ground, deepening the key trench by excavating at least 0.5 m into frozen ground and then reseating the liner into the cleaned out key trench base with a proper bentonite plug. Once the liner has been reseated it gets backfilled as before.

Implementation of this remedial measure does not require special equipment or material and is therefore reasonably simple. Once the liner has been reseated the ponds cannot be commissioned until the key trench has had time to properly freeze in. This implies that the ponds would have to remain out of commission for the remainder of the season. The relative simplicity of this remedial option suggests that it would be the preferred remedial option; however, not having both ponds available for the remainder of the season would be risky.

### 4.3.6 Option 6: Retrofit Ponds to Line their Base (Floor)

For this option the floor of each of the ponds will be lined, tying into the existing liner. The new upstream edge of the liner would be keyed into permafrost as per the original design. The liner floor would not be covered with gravel, leaving the liner exposed.

This option would still allow both ponds to operate in accordance with their original indented design, i.e. collecting subsurface flows from the upstream pads; however, the upstream key trench would have to undergo one freeze cycle before it would be expected to be fully sealed. This means that the pond would not be able to operate at full capacity for the remainder of the season. The exposed liner will act as a heat sink depressing the active layer over time, which may ultimately lead to failure of the upstream key trench. For this reason this option is not recommended.

### 4.3.7 Option 7: Retrofit Ponds to be Fully Lined

This concept calls for fully lining of the ponds. This would mean that the ponds would not have the ability to collect subsurface flows from the upstream pads, effectively negating their original design intent. Based on the summer base flow draining into the SEP and PCP respectively it is evident that only the PCP is receiving base flow, suggesting that fully lining the SEP may be a viable option; but that is not the case for the PCP.

Another advantage of fully lining the SEP would be that the integrity of the pond would in no way be linked to the state of the active layer.

# 5 Recommendation

In order to ensure proper diversion of clean water as well as containment and capture of potentially contaminated water from the camp/mill area, SRK recommends that the following remediation actions be implemented with immediate effect:

- Retrofit the SEP to a fully lined pond (remedial Option 7). This will provide immediate additional capacity to store about 2,050 $m^3$ of potentially contaminated water.
- Reseat the liner in the PCP in accordance with remedial Option 5, and extend the wing walls to the proper design elevation. This pond must however be kept out of commission for the remainder of the season to allow complete freeze back of the key trench.
- Construct two permanent downstream collection sumps to ensure capture of any potentially contaminated water that may in future seep from the SEP and PCP, as well as capture subsurface water that does not naturally drain towards the event ponds.
- Update and improve the protocols currently in place to monitor movement of water on site. This includes installing calibrated staff gauges in ponds, flow meters on all pumps, properly recoding pump logs, collecting spot water quality checks (e.g. pH, conductivity, etc.) and conducting frequent quality control checks by qualified people on the data collected.
- Complete and upgrade the upstream clean water diversion system including installation of proper upstream collection sumps.
- Keep the TEP in place as an alternate, until an emergency pond can be commissioned. This may be substituted by Tail Lake, provided the fish out is complete, the dam has been completed and systems are in place to convey water from the camp/mill site to Tail Lake.

Regards

**SRK Consulting (Canada) Inc.**

Maritz Rykaart, Ph.D., P.Eng.
Principal Geotechnical Engineer

SRK Vancouver
Suite 2200 - 1066 West Hastings Street
Vancouver, BC V6E 3X2

**T: +1.604.681.4196**
**F: +1.604.687.5532**

vancouver@srk.com
www.srk.com

# Memo

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| **To:** | Bob Princewright | **Date:** | June 8, 2011 |
| **Copy to:** | Greg Blaylock, Kevin Mather, Calvin Goldschmidt, Doug Fielding, Jerry Graham, Ishan Fechter | **From:** | Maritz Rykaart |
| **Subject:** | Pollution Control Pond Liner Extension | **Project #:** | 1CH008.033.213 |

As stipulated in an email from Maritz Rykaart (SRK) to Kevin Mather (JDS) on May 31, 2011, SRK identified a design error in the crest elevation of the Pollution Control Pond. The pond design Full Supply Level (FSL) elevation is 35.3m with a freeboard elevation of 0.3m. This translates to a minimum design liner elevation in the Pollution Control pond of 35.6m. A review of the as-built survey of the liner crest has confirmed that the liner has been installed in accordance with the IFC drawings, but that approximately between stake-out points S2-22 and S2-48 (Drawing DN-DMC-16, Rev. 0) the crest of the liner is lower than the required 35.6m elevation. The variance ranges between 0.1m to 0.5m over a distance of about 65m.

In order to remedy this situation the following is required, as illustrated in attached Figures 1 through 4:

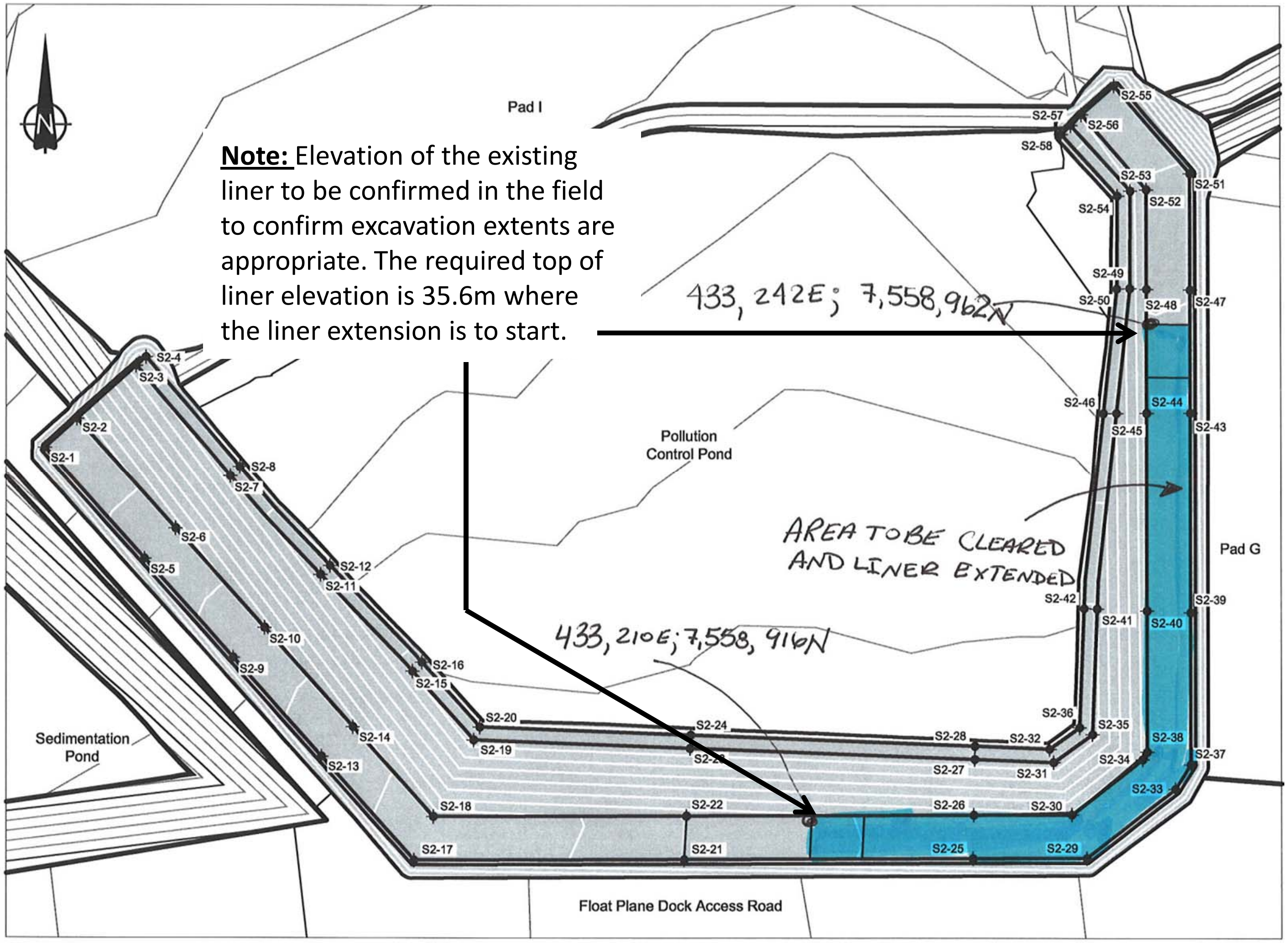
- STEP 1: For a distance of about 75m, as shown in Figure 1, the liner must be carefully exposed. The extent of the required excavation is schematically illustrated on Figure 2. The excavation should start about 1m from the crest of the RipRap and the cut slope should be approximately 1H:1V (or as steep as practical bearing in mind the slope needs to be safe for people top work below the cut). Mechanical excavation methods can be adopted up to the point where the ¾" inch protective crush layer has been placed over the liner. Note this point is marked with a geotextile and should thus be easily identified in the field. Hand excavation techniques, or partial careful mechanical removal with a cleaning bucket should be adopted from that point on to remove the ¾" crush and expose the liner system. The base of the excavation should be between 2m and 3m wide.

- STEP 2: A strip, at least 1m wide of the liner system, at the base of the excavation from Step 1 above must be thoroughly cleaned. The liner system must be cut along this horizontal surface to allow seaming of new strips of HDPE (sandwiched between geotextiles) to be extended as shown on Figure 3 (liner extension). A berm must be constructed immediately downstream of the liner extension using compacted crush material, to an elevation of 35.6m. The liner extension should be placed on this berm and extend horizontally by at least 1.5m at elevation 35.6 m. The liner extension will be composed of the same liner materials as the existing liner system. All seams must be completed, surveyed, and tested in accordance with standard liner QC protocols.

- STEP 3: The excavation of the liner must be backfilled using ¾" crush and/or select ROQ as appropriate based on the minimum dimensions shown on Figure 4.

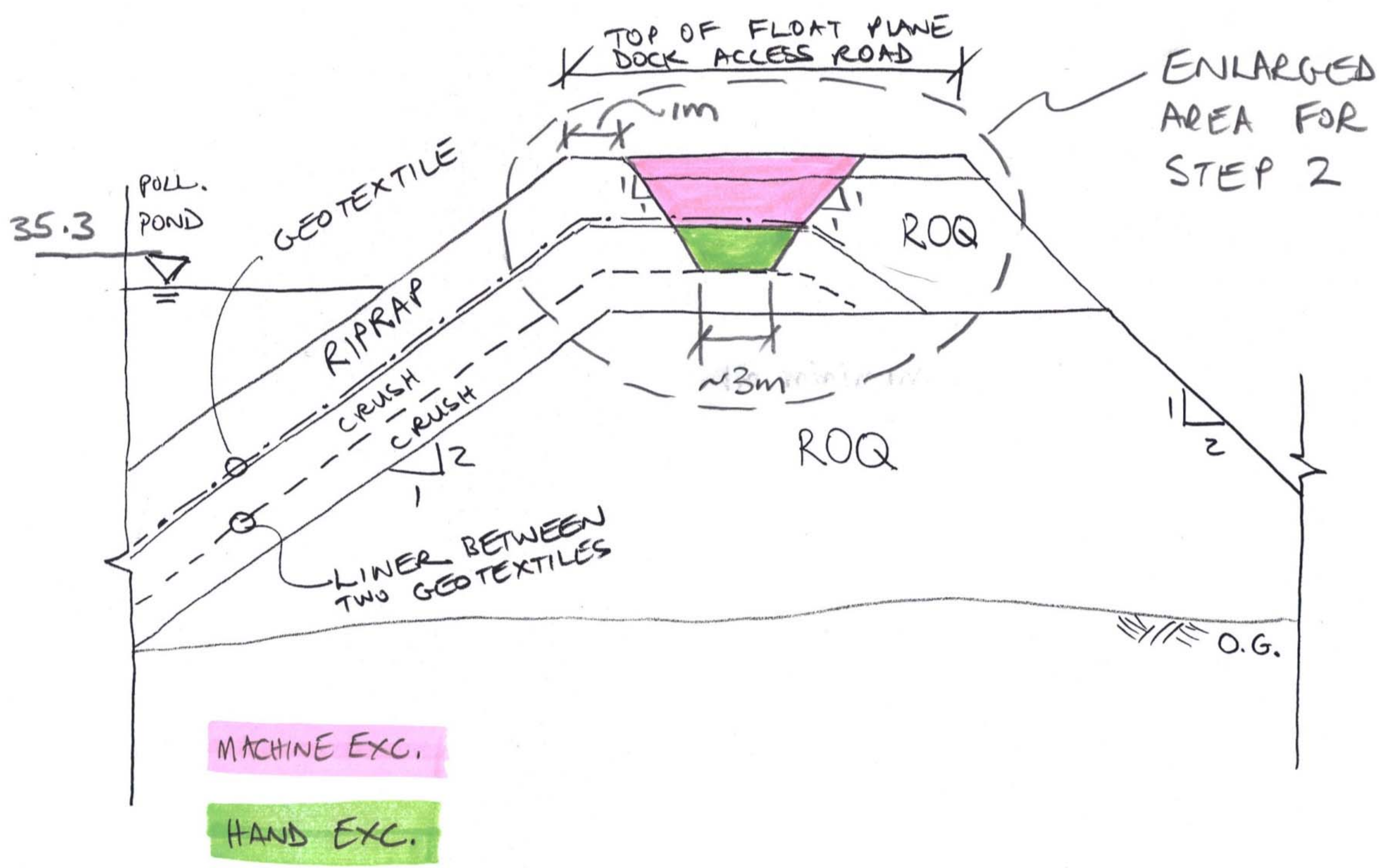
This remedial works must be carried out in strict accordance with these steps and Technical Specifications Revision G; however, it is recognized that some field fitting may be required. It is expected that the Contractor will work closely with the Owner and the SRK field engineer to ensure that where there are deviations that those be clearly discussed and documented.

# Figures



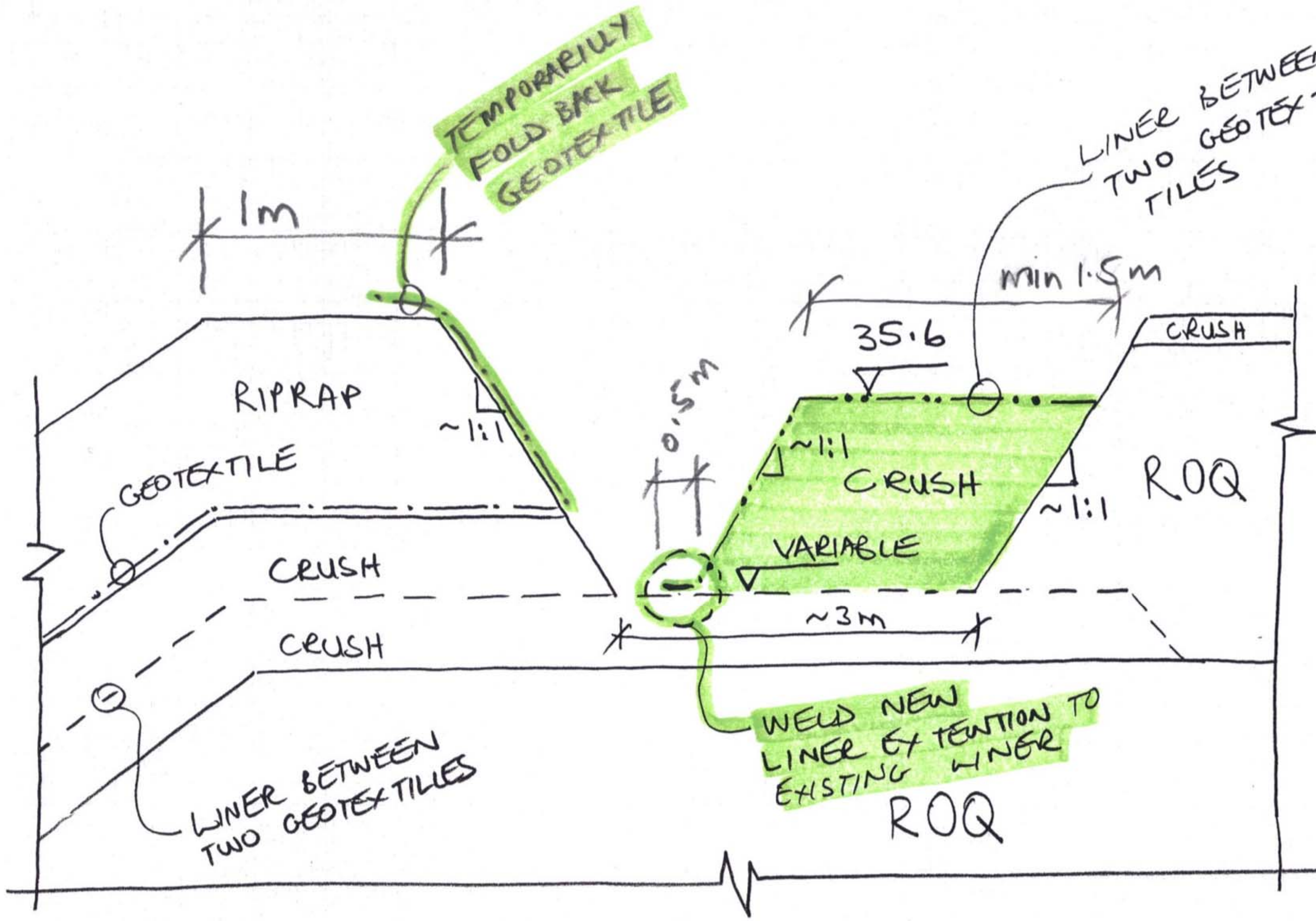

PLAN VIEW (NTS)

| srk consulting | HOPE BAY MINING LIMITED | Pollution Control Pond — Liner Extension Zone | | |
|---|---|---|---|---|
| Job No: 1CH008.033.0213<br>Filename: Poll Pond Repair Drawings.pptx | Doris North Project | Date: June 8, 2011 | Approved: EMR | Figure: 1 |




TYPICAL SECTION (NTS)

| | | | | |
|---|---|---|---|---|
| srk consulting | HOPE BAY MINING LIMITED | Pollution Control Pond | | |
| | | Step 1: Exposing Liner | | |
| Job No: 1CH008.033.0213<br>Filename: Poll Pond Repair Drawings.pptx | Doris North Project | Date: June 8, 2011 | Approved: EMR | Figure: 2 |




TYPICAL SECTION (NTS)

| srk consulting | HOPE BAY MINING LIMITED | Pollution Control Pond<br>**Step 2: Install Liner Extension** | | |
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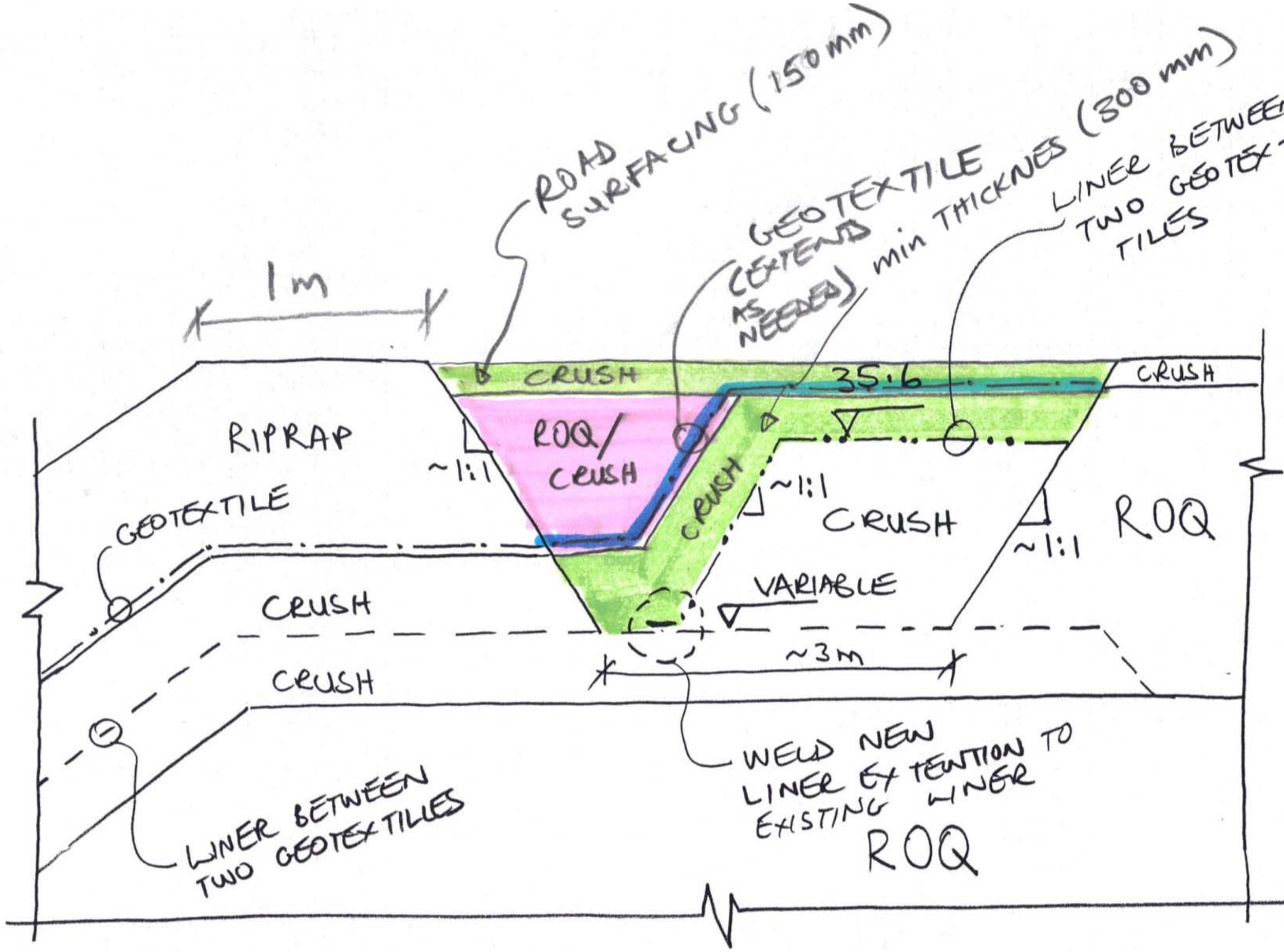
| Job No: 1CH008.033.0213<br>Filename: Poll Pond Repair Drawings.pptx | Doris North Project | Date: June 8, 2011 | Approved: EMR | Figure: 3 |




TYPICAL SECTION (NTS)

| srk consulting | HOPE BAY MINING LIMITED | Pollution Control Pond<br>**Step 3: Backfill Excavation** | | |
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| Job No: 1CH008.033.0213<br>Filename: Poll Pond Repair Drawings.pptx | Doris North Project | Date: June 8, 2011 | Approved: EMR | Figure: 4 |