ANVIL RANGE PROPERTY
2007 DAM SAFETY REVIEW
Cross Valley Dam, Intermediate Dam, and Little Creek Dam

Prepared for

Deloitte & Touche Inc.

On behalf of

Faro Mine Closure Planning Office

Klohn Crippen Berger

M09237A05.505

Klohn Crippen Berger

April 9, 2008

Deloitte & Touche Inc.
79 Wellington Street West, Suite 1900
PO Box 29 TD Centre
Toronto, Ontario
M5K 1B9

Mr. Doug Sedgwick

Dear Mr. Sedgwick:

Anvil Range Mining Complex
2007 Dam Safety Review for
Cross Valley, Intermediate and Little Creek Dams

Enclosed is the dam safety review report for the above dams. The fieldwork for this review was done in July 2007 and was conducted according to the new 2007 CDA guidelines issued in November 2007.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Bryan D Watts.

Bryan D. Watts, P. Eng.
Principal

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EXECUTIVE SUMMARY

This is the 2007 Dam Safety Review for the Intermediate Dam and the Cross Valley Dam which retain the Rose Creek tailings. This review also includes the Little Creek Dam which retains contaminated runoff from the Vangorda waste rock piles before it is pumped into the Vangorda pit. The last Dam Safety Review was done in 2002 by Klohn Crippen Consultants Ltd. (2002). That 2002 review included the Fresh Water Supply Dam which has now been breached so it no longer is a dam safety issue and thus not included in this review. The Canadian Dam Association published new guidelines in November 2007 which are used in this review and, therefore, new documentation requirements are identified in order to be compliant with these new guidelines.

The Cross Valley Dam retains the polishing pond downstream of the Intermediate Dam which retains tailings from the closed mine. If the Cross Valley Dam fails, it will release its pond which is a relatively small volume of contaminated water. However, in the present configuration, a failure of the Cross Valley Dam might destabilize the Intermediate Dam whose consequences of failure are much greater because of the potential loss of tailings downstream. The consequence of failure from the Intermediate Dam is considered to be high which means that the dams must be able to withstand the 1 in 2500 return period earthquake and 1/3 between 1 in 1000 and probable maximum flood (PMF). On-going studies show that the Intermediate Dam and Cross Valley Dam cannot pass the design flood. The present diversion, the Rose Creek Diversion Channel, can just pass the 1 in 500 flood so upgrades to flood routing are being evaluated. The Cross Valley Dam cannot withstand a 1 in 2500 seismic motion without failure; the Intermediate Dam can withstand this motion and the MCE motions.

Upgrade options to the seismic resistance and the flood routing capability of these two dams are underway. Both upgrades are being done to the maximum loadings of the Maximum Credible Earthquake (MCE) and the Probable Maximum Flood (PMF).

Although much greater loadings than strictly required by CDA (2007), this design approach is reasonable given that the entire mining facility must be closed and operate safely in perpetuity. Also, upgrades to higher design criteria than mandated by the CDA is reasonable given the small incremental cost relative to adherence to the minimum.

Presently, these two dams do not meet the above dam safety criteria but remediation option alternatives are currently being evaluated. Both dams meet the requirements of the Water Licence which requires stability for 1 in 500 year events. The current progress of evaluating remediation options is normal but substantial progress should be made before the next dam safety review or the remediation option review duration will start to lag perceived industry norms.

Given that the seismic and flood design options are proceeding and compliant with the 2007 CDA guidelines, our dam safety review deals primarily with static stability, operating procedures, and emergency response procedures. The static safety of existing dams is only assured by continuous inspection, appropriate operation and maintenance, and reading/interpretation of instrumentation. For sand and gravel dams with glacial till cores on granular foundations such as these, the most useful instruments are weirs and piezometers.

The Cross Valley Dam is instrumented with piezometers and weirs. The weir flows show that most of the flow comes from the right abutment where there is a relatively continuous pervious, granular terrace along the north side of Rose Creek valley. The preference for seepage through the north flank of the dam may be due to the pervious terrace but may also result from preferential sludge blanketing of the lower southern portion of the polishing pond.

Although mentioned in the BGC Operating Manual, record drawings do not show the seepage blanket at the toe of the Cross Valley Dam. The seepage blanket was built in the early 1990s after more than 10 years of operation of the Cross Valley Dam which was built in the early 1980s. This seepage blanket needs to be shown on the record drawings for the Cross Valley Dam.

The weir flows have been steadily decreasing at the toe of the Cross Valley Dam since the early 1990s and earlier according to others. This decrease is not associated with a drop in the polishing pond level. It may be due to sludge accumulation in the pond and/or a drop in the pressure head in the tailings due to lack of tailings transport water.

The static safety of the Cross Valley Dam is acceptable. In effect, the drop in the weir readings with time means that the static safety of the Cross Valley Dam is improving with time. Maintenance procedures, inspection procedures, and instrument reading type and frequency meet current standards.

The Intermediate Dam toe is inundated so there is no opportunity for seepage discharge monitoring with weirs. The dam has a sloping upstream core with filters and drains in a granular downstream shell. The main blanket drain is just above the polishing pond level. The pond inundates the granular downstream shell to the sloping upstream core. There is no phreatic surface above the polishing pond level. There should be no seepage from the drain above the 1031 m berm on the downstream slope except from precipitation.

The downstream foundation piezometers in the Intermediate Dam generally show downward seepage. This is likely because the polishing pond water discharges through the downstream shell of the Intermediate Dam because the upstream blanket of the Cross Valley Dam and sludge accumulation in the polishing pond may restrict seepage. This downward seepage at the toe of the dam makes the dam safer than it would otherwise be. The static safety of the Intermediate Dam is acceptable.

Although both dams are inspected, instrumented, maintained, and operated to acceptable standards as judged by performance only, the Operating, Maintenance, and Surveillance and Emergency Preparation Plans do not meet CDA November (2007) standards. Both reports were prepared by BGC and are embedded within the style of a consulting report. Instead the manuals should be stand-alone documents which are owned by the operator and/or owner of the dams or facility. As example, the February 2007 update of the OMS manual lists “critical” items that should have been in the update. Thus, the OMS cannot be said to be updated to that date. Both manuals need to be updated with current information and become the responsibility of the owner/operator, not the consultant. We understand that this update is in progress.

The Little Creek Dam is used to collect contaminated water from the Vangorda Waste dumps. It is operated at much less than full supply level and inspected annually by SRK. The downstream slope of the dam is slumping because of repeated freeze/thaw cycles. Also, some piezometers showed an increase in head in 2006 which is unrelated to pond level fluctuation. This could have resulted from slumping and covering of the finger drains at the downstream face of the dam.

The downstream slope of the Little Creek Dam needs repair if it is to continue in operation, even at these low water levels. The cause of the increased heads in the piezometers needs to be understood. Also, the OMS manual for the Little Creek Dam needs to be updated together with the seismic and flood requirements that emanate from the new 2007 CDA Guidelines

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1. INTRODUCTION

1.1 General

This report presents the 2007 dam safety review of the Intermediate and Cross Valley Dams at the closed Faro Mine and the Little Creek Dam at the closed Vangorda Mine. This is the second dam safety review since mining and processing ceased in 1998. The Little Creek and Cross Valley Dams are water retaining dams. The Intermediate Dam retains primarily tailings with a relatively small water pond.

The closed mines are part of the Anvil Range lead/zinc complex which is located approximately 200 km north-northeast of Whitehorse, Yukon, as shown on Figure 1.1 This report has been prepared in accordance with our proposal dated April 16, 2007, with cost update on June 8, 2007. Authorization to proceed was received on June 19, 2007.

The Canadian Dam Association published new guidelines in November 2007 which are used in this review and, therefore, new requirements are identified in order to be compliant with these new guidelines.

1.2 Scope of Report

Dam safety reviews normally include a review of all potential failure modes as was done in 2002. That 2002 report identified potential seismic and flood failure modes for the Intermediate and Cross Valley dams relative to very high consequences of failure as determined from the CDA (1999) criteria.

Since then much work has been done to determine the seismic and flood vulnerability of the Intermediate and Cross Valley Dams which is summarized herein. Conceptual designs to bring these two structures to current seismic and flood standards are on-going. These studies are reviewed and summarized in this report with a view to assessing whether the work itself meets current standards for dam safety assessments. Otherwise, the report is by necessity confined to issues of static safety, operation, maintenance and emergency preparedness.

The 2002 report also reviewed the safety of the Fresh Water Dam on the south fork of Rose Creek above the tailings area. In 2003 that dam was breached to release the pond so is no longer a hazard to the downstream environment.

Periodic dam safety reviews such as this are much different than annual dam safety inspections. The intent of a periodic dam safety review is to identify whether site procedures are adequate and whether site staff have sufficient training and experience to identify dam safety issues and can react in an emergency. As part of our review, we observed the condition of the dams and supporting information but this is primarily to confirm that the dam is in the condition claimed and that the instrumentation is being read and interpreted.

This report also includes an assessment of the safety of the Little Creek Dam (LCD) in the Vangorda Creek watershed. LCD is not a tailings retention dam but rather collects contaminated runoff from a waste dump which is pumped into Vangorda Pit. The LCD is described only in Section 7.

2. SITE CONDITIONS

2.1 Climate

A weather station (elevation 1158 m) was located at the Faro Mine site from 1967 to 1980. The mean annual temperature for that period was –3.4°C. The mean monthly maximum daily temperature was 17.5°C in July, and the mean monthly minimum daily temperature was –24.9°C in January. Months with no mean minimum temperatures below zero were June, July and August.

The mean annual precipitation as recorded at the Faro airport station is 304.7 mm for the period 1978 to 2001. This total comprises roughly equal proportions of rainfall and snowfall as water equivalent. The maximum monthly mean of 58.9 mm occurred in July. The minimum monthly mean of 7.2 mm occurred in April. The accumulation of snow at the tailings impoundment typically begins in October, and the snow generally melts by the end of April. The prevailing wind direction in the region is from the southeast.

2.2 Geology

The stratigraphy of the Anvil District consists of regionally metamorphosed sedimentary bedrock, ranging in age from late Precambrian to Permian (approximately 900 million to 250 million years ago). The degree of metamorphism ranges from moderate (schist) to low (phyllite). The landforms and surficial deposits of the area have been shaped and are attributable to the last ice age.

The surficial geology of the Faro site generally consists of colluvial, glaciofluvial, and morainal (glacial till) deposits forming a discontinuous cover over bedrock. On the valley sides, bedrock is discontinuously covered with a veneer of moraine and colluvial deposits which increases in thickness towards Rose Creek. A complex assemblage of fan and outwash sand and gravels, dissected by stream channel and lacustrine material fill Rose

Creek valley. Terraces and fans are prominent on the north side of the valley, where they, in part, underlie the existing Down Valley tailings area.

2.3 Extreme Flood Flows

The Faro Mine site facilities are within the Rose Creek watershed, which is a tributary of approximately 340 km^2 to the Anvil Creek watershed. Anvil Creek is a tributary of the Pelly River. Rose Creek has two principle tributaries, the North and South Fork, which join upstream of the tailings impoundment. Two local streamflow gauging stations at Stn. R7 on the North Fork and at Stn. X14 on Rose Creek downstream of the tailings have operated seasonally since 1994. The peak daily discharge during the recording periods since 1994 at Stn. X14 was over 14 m/sec in 2000 (*valid to 2002*).

Water Management Consultants (2006) updated the Probable Maximum Flood (PMF) Their PMF estimate used the Probable Maximum Precipitation (PMP) by Mr. George Taylor of the Oregon Climate Service. Their estimate and the earlier PMF estimate by Northwest Hydraulics (2001) are given in Table 2.1 together with estimated floods at lower return periods.

Table 2.1 Estimated Floods at Specific Locations at the Faro Mine Site

Mine Site Sub Basins	**Drainage Area Km^2**	**Flood Discharge (Instantaneous)**					**PMF - m^3/s**	
		2-yr m^3/s	**50-yr m^3/s**	**100-yr m^3/s**	**200-yr m^3/s**	**500-yr m^3/s**	**nhc 2001**	**WMC 2006**
North Fork Rose Creek at Flow-through Rock Drain	118	9.3	48	59	72	92	920	384
Rose Creek above Tailings Diversion Channel	203	15	71	88	105	135	1480	674
Rose Creek at Stn 14 Downstream of Tailings Area	230	17	78	96	115	145	1680	692

Table 2.1 shows that the PMF estimate has significantly decreased from the previous estimate but we understand that both nhc and WMC agree on the new estimates.

2.4 Seismicity

The 2002 Dam Safety Review summarized seismic hazard evaluations done for the tailings dams over the mine life and re-assessed the seismicity at the site using the Adams et al (1999) GSC open file report seismic hazard models. Subsequent to that work, the project commissioned Dr. Gail Atkinson, a noted Canadian seismologist, to assess the seismic hazard given the possibility, identified by Hyndman et al (2003), that the nearby Tintina fault could be active. That work was published in Atkinson (2003).

The starting point for any seismic hazard assessment in Canada is the Geologic Survey of Canada (GSC) per Adams and Halchuk (2003) which forms the basis of the National Building Code of Canada seismic hazard for design of buildings. The GSC work is directed towards annual exceedance probabilities of 1 in 2500. Klohn Crippen (2002) extrapolated the GSC work which gave a horizontal peak ground acceleration (PGA) of 0.19 g for firm ground NEHRP C site conditions.

Atkinson used Frisk 88 to estimate the seismic hazard at the site. Frisk 88 is a computer program based on the Cornell-McGuire method which also treats epistemic or model uncertainty. In short, Frisk 88 allows weighting of different seismic models to give, in effect, a blended result. Atkinson gave a 1/3 weight to the GSC model which does not include a separate Tintina Trench zone, 1/3 weight to a Tintina Trench treated as a zone, and 1/3 weight to the Tintina Trench treated as a fault source. All other parameters were as in the GSC model.

Atkinson presents the results as response spectra (spectral acceleration versus frequency) for the mean, median, 16th and 84th percentiles. At 50 Hz or peak ground acceleration, Atkinson obtained 0.3 g for the median motion which compares to 0.19 g for the unaltered, extrapolated GSC model. This means that incorporation of possible Tintina Trench activity increases the seismic hazard by 50% at the median.

Atkinson also chose acceleration records for seismic analysis which fit the target or calculated spectrum for M7 earthquakes at 10 to 20 km. Atkinson chose actual records that match the entire spectrum as well as possible, without scaling to any point on the target spectrum. This results in the use of acceleration records with PGAs ranging from 0.3 to 0.55 g.

The Atkinson seismic hazard work was subsequently used in all Klohn Crippen Consultants Ltd. (KCCL) seismic vulnerability assessments of the Cross Valley, Intermediate and Secondary Dams.

3. DAM CONSEQUENCE CLASSIFICATION

In the KCCL (2002) dam safety report, the Intermediate and Cross Valley Dams were assigned a Very High Consequence category. This classification was not based on a formal inundation study where the consequences of pond and tailings release on the population, infrastructure, and environment together with the cost of cleanup were assessed but rather on a November (2001) report titled Qualitative Risk Assessment of Down Valley Area by BGC Engineering Inc. (2001c). While no formal CDA rating was assigned to the dam failure modes, a ranking of Very High Consequence was assigned to a number of failure modes for the Intermediate Dam and Cross Valley Dam as these modes could cause major uncontrolled releases of fluids and tailings with resulting surface and groundwater contamination for long periods. The consequences were assessed to have repair, fines, and clean-up costs in the range of US$10 million to US$100 million. Although the cleanup costs may now be higher, this BGC study is still relevant so will be used herein for dam classification.

In late 2007, the new edition of the CDA guidelines were published which is given here as Table 3.1. This new consequence classification system adds one category, now five (5) classification categories instead of the previous four (4) classification categories. This new classification table is the new consensus and must be used to classify the consequences of failure for dams in Canada going forward. The new classification system separates “Infrastructure and economics” from “Environmental and cultural values” and added to “Loss of life” gives three categories.

Failure of the Cross Valley Dam, in its present configuration, should be treated in a similar manner to a failure of the Intermediate Dam simply because a rapid loss of the polishing pond could fail the Intermediate Dam.

Table 3.1 From Table 2-1: Dam Classification (CDA, 2007)

Dam class	Population at risk [note 1]	Incremental losses		
		Loss of life [note 2]	**Environmental and cultural values**	**Infrastructure and economics**
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of *critical* fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Note 1. Definitions for population at risk:

None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary – People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

Note 2. Implication for loss of life:
Unspecified – The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

In both cases, loss of life would be less than 100 and quite likely less than 10. Similarly, infrastructure and economic losses would be low. The crucial failure consequence would be environmental damage or loss of critical fish habitat in the downstream watersheds. To the writer's knowledge a dam breach and inundation study of the downstream consequences has not been done for the Intermediate and Cross Valley Dams. In absence of a formal study, available information suggests that the dam classification fits into the "high" consequence category on Table 2-1 from CDA.

Given that classification, the safety criteria emanate from Table 6-1 (our Table 3.2) in the 2007 edition of the CDA Dam Safety Guidelines. That table stipulates that the dams must be able to pass a flood 1/3 between the 1 in 1000 year and the PMF and withstand an earthquake with a return period of 1 in 2500. These criteria are lower than values used for evaluation of the flood and seismic safety of the dams to date.

In its current state, the Intermediate Dam (with the polishing pond in place) would survive a MCE earthquake but the Cross Valley would not because of extensive foundation liquefaction. However, breach of the Cross Valley Dam and rapid loss of the polishing pond may cause failure of the Intermediate Dam and release of tailings to the environment. The Cross Valley Dam would fail at the lower earthquake motions described above with the same deleterious effect on the Intermediate Dam. The Cross Valley Dam has a small pond which would not release much tailings into the downstream environment if failure occurred and certainly not warrant a high consequence classification by itself.

Table 3.2 From Table 6–1: Suggested Design Flood and Earthquake Levels (CDA, 2007)

Dam class [note 1]	**AEP**	
	IDF [note 2]	**EDGM** [note 3]
Low	1/100	1/500
Significant	Between 1/100 and 1/1000 [Note 4]	1/1000
High	1/3 between 1/1000 and PMF [note 5]	1/2500 [note 6]
Very high	2/3 between 1/1000 and PMF [note 5]	1/5000 [note 6]
Extreme	PMF [note 5]	1/10,000

Acronyms: AEP, annual exceedance probability; EDGM, earthquake design ground motion; IDF, inflow design flood; PMF, probable maximum flood.

Note 1. As defined in Table 2-1, Dam Classification

Note 2. Extrapolation of flood statistics beyond 1/1000 year flood (10^{-3} AEP) is discouraged.

Note 3. AEP levels for EDGM are to be used for mean rather than median estimates of the hazard.

Note 4. Selected on the basis of incremental flood analysis, exposure, and consequences of failure.

Note 5. PMF has no associated AEP. The flood defined as “1/3 between 1/1000 year and PMF” or “2/3 between 1/1000 year and PMF” has no defined AEP.

Note 6. The EDGM value must be justified to demonstrate conformance to societal norms of acceptable risk. Justification can be provided with the help of failure modes analysis focused on the particular modes that can contribute to failure initiated by seismic event. If the justification cannot be provided, the EDGM should be 1/10,000.

Much more damaging to the downstream environment would be overtopping of the Intermediate Dam by flooding which would erode and carry tailings into Rose Creek, the Pelly River and, likely, the Yukon River. Again this needs to be confirmed by inundation mapping of, not only flood waters, but of suspended tailings. According to recent work, the Diversion Channel which passes normal flows and flood waters around the tailings area would overtop and spill into the tailings impoundment for floods which exceed the 1 in 475 return period. The spillways on the Intermediate Dam and the Cross Valley Dam have limited capacity so these dams would fail by overtopping if the Diversion Channel failed during a flood.

As the measures needed to improve the dams to meet CDA standards are evaluated, we understand the project has an interim permit which requires only that the Cross Valley and Intermediate Dams survive the 1 in 500 return period for both the flooding and earthquake motions. Our review of past work indicates that the dams will survive such loadings.

The CDA Guidelines are meant to establish minimum guidelines for dam safety evaluations. Given that the both dams are deficient relative to both flooding and seismic loading, remedial measures need to be designed and constructed to meet the new CDA (2007) criteria. The writer understands that these remedial design initiatives are in progress within the context of the overall mine closure design by others. It is normal practice to consider higher standards for remedial design than the criteria used to decide whether the dam should be upgraded in the first place. This is because incremental construction costs to a higher standard may be small and reduce the possibility that the dam will have to be upgraded in future as the consequences of failure inevitably increase with time. This is especially valid in the case of mine closure where the structure must be safe in perpetuity. Accordingly, the writer considers that the design of remedial measures to PMF and MCE for the tailings retention dams is appropriate.

4. DESIGN AND CONSTRUCTION HISTORY

4.1 During Mining

The Faro Mine was first started by Anvil Range Corporation and began production in 1969 at 5000 tonnes of zinc-lead-silver ore per day. The production increased to 6000 tonnes per day in 1970. In 1974, a mill expansion allowed a further increase in ore production to 9300 tonnes per day. In 1979, Cyprus Anvil purchased the mineral deposits and claims including Grum and Vangorda and then embarked on a program of expansion to bring the Vangorda Plateau deposits (Vangorda and Grum) into production to supplement the Faro Mill feed. Cyprus Anvil ceased production in 1982. The property was shut down and remained idle until the operation was acquired by Curragh Resources in November 1985. The mine facilities were reactivated in December 1985 with a production rate of 13,500 tonnes per day. The deposit was depleted of economic ore reserves in 1992.

Mining of the Vangorda Deposit began in 1990 and 5.7 million tonnes of ore were mined from 1990 to 1993 by Curragh Resources. 52,000 tonnes of ore was mined from the Grum Pit by Curragh Resources prior to a temporary mine shut down in 1993.

Anvil Range Mining Corporation assumed ownership of the mine site in November 1994 and resumed pre-production stripping at the Grum open pit and mining in the Vangorda open pit. By early 1998, mining in the Vangorda open pit was completed, and mining in the Grum open pit was partially completed.

Anvil Range Mining Corporation entered into receivership in April 1998. The mine sites have been shut down and under the management of Deloitte & Touche Inc., acting as the court-appointed interim receiver, since that time.

From mill start-up to 1992, tailings were deposited in Rose Creek Valley south of the mill as shown in Figure 1. From 1992 to 1996, tailings were deposited in a spent open pit. Figure 1 shows the major tailings retention structures in Rose Creek Valley that are described below.

Tailings are retained in the Rose Creek Valley behind three retention dykes; the Original Dyke; the Secondary Dam, and the Intermediate Dam. Downstream of the Intermediate Dam is a polishing pond which is retained by Cross Valley Dam. Rose Creek is diverted around the tailings by a diversion canal (RCDC) on the south side of the valley.

The alignment of the original tailings dyke is shown on Figure 1. The original starter dyke was constructed on natural ground on the north side of the Rose Creek Valley starting near the old Faro Creek confluence with Rose Creek. It appears that diversion works for Rose Creek during that stage of development were minimal. The tailings retention dyke was constructed of uncompacted rockfill and raised using upstream construction. According to Golder (2004), the original dyke was 20 m high including the starter dyke. This original dyke operated until 1973 and was subsequently inundated with tailings deposited behind the Secondary Dam. The downstream slope of the original dyke is buried by tailings with only the crest alignment visible. The original tailings dyke failed in 1975 losing tailings into the Rose Creek Valley (Gartner Lee, 2001). The seismic stability of the original dam is not an issue as it is completely inundated by tailings without a pond.

The Secondary Dam was designed by Golder Associates and construction was started in 1974. The West Limb of the Secondary Dam is defined as that curved portion which crosses the valley roughly north to south. The East Limb is that portion of the Secondary Dam whose alignment is parallel to the south valley wall. The West Limb of the Secondary Dam was raised using centerline construction and compacted fill to a maximum height of 27 m. The East Limb is a low retention dyke which was constructed of compacted fill. Tailings were deposited behind this dam from 1975 to 1982 and then for approximately 5 months in 1986. Rose Creek was diverted to a channel which ran parallel to the south valley wall and emptied into its original channel downstream of the Secondary Dam.

The Intermediate Dam was constructed as part of the Down Valley Project in 1979 to 1981 to create additional tailings storage. The Down Valley Project was designed by Golder Associates and consists of the Intermediate Dam, the Rose Creek Diversion and outlet channels, and the Cross Valley Dam which retains the polishing pond. Rose Creek was diverted around the tailings area while tailings transport water and direct precipitation were conveyed to the polishing pond by a spillway on the north abutment. The polishing pond was designed for 60 day retention before release. Syphons are currently used to maintain pond levels for both the Intermediate and Cross Valley Dams.

4.2 After Mining

As far as the writer is aware, there have been no construction changes to the Cross Valley Dam and the Intermediate Dam since mining ceased in 1998. The dams are operated and maintained by Deloitte & Touche Inc. resident staff.

The previous Dam Safety Assessment (2002) identified that the Cross Valley and Intermediate Dams met static stability criteria but would not meet current standards for passing floods and resisting earthquakes. That conclusion was based on the consequence rating of "very high" for the dams which mandated that the design criteria be to Probable Maximum Flood (PMF) and Maximum Credible Earthquake (MCE) standards.

The Rose Creek Diversion Channel (RCDC) which diverts water around the tailings area has a capacity of 135 m^3/sec, which is approximately equal to the one in 500 year flood.

Any flood flows in excess of this capacity would spill into the tailings disposal area and quickly overtop the Intermediate Dam and Cross Valley Dams. Both dams have spillways sufficient to pass floods from the local catchment but not from a breach in the RCDC. Accordingly, various alternatives to pass the flood have been evaluated or are being evaluated.

Correspondingly, Klohn Crippen reports on the seismic stability of the Cross Valley Dam and the Intermediate Dam consider that the Cross Valley Dam could survive a 1 in 500 year earthquake but not the MCE motions and that the Intermediate Dam could survive both levels of earthquakes on its own. However, it is noted that failure of the Cross Valley dam with sudden release of the polishing pond may be sufficient to fail the Intermediate Dam. The Klohn Crippen reports present conceptual designs for these dams to resist MCE motions.

We understand that the Mine Closure project operates under a permit that requires these dams to withstand 1 in 500 floods and earthquakes. We also understand that the Mine Closure project intends to upgrade the dams to meet current flood and earthquake criteria if the dams are left in place.

Within this project basis, there is no need to comment further on the seismic and flood resistance of the dams. The rest of the report is devoted to the operation and static stability of the dams.

5. INTERMEDIATE DAM

5.1 Description

The Intermediate Dam was constructed across the Rose Creek valley to contain supernatant water and tailings solids in 1981, and raised in 1988, 1989 and 1991 to a final crest elevation of 1049.4 m amsl, a maximum height of 32 m above the old Rose Creek channel. A typical section through the dam is shown on Figure 2. There is an emergency spillway channel on the right abutment, constructed as a rock lined channel in natural overburden material

The Intermediate Dam is a zoned earthfill embankment with a sloping upstream low permeability core, and a downstream random fill shell. Granular filter zones were constructed on both sides of the core. The initial construction in 1981 made use of natural terrace material present across the valley. A drainage blanket was placed over this footprint downstream of the core and filter zone, extending to the toe of the ultimate height dam. Upstream and downstream slopes are at 2H:1V. Including the 20 m wide berm adjacent to the polishing pond, the overall downstream slope is at 2.1H: 1V.

There is a nominal cutoff for seepage reduction through the uppermost soils beneath the core of the dam. There is no deep foundation cutoff to reduce seepage through the permeable soils. Instead, the tailings on the upstream slope and foundation were relied on to reduce seepage to an acceptable level. The drains on the dam section are set to just above the design level of the polishing pond.

5.2 Site Observations

Mr. Bryan Watts, P.Eng and Dr. Thava Thavaraj, P.Eng inspected the Intermediate Dam on the morning of July 22, 2007. The weather was bright and sunny. Photographs are included in Appendix II.

We observed the condition of the Intermediate Dam from the Elev. 1031 m berm on the downstream slope and from the crest of the dam. The toe is inundated by the polishing pond which gives no opportunity to measure seepage discharge from the tailings and supernatant pond retained by the dam. Piezometer readings are the sole instrumental indication of dam behaviour.

Photo II-16 shows the intake pump barge in the supernatant pond on the right abutment of the Intermediate Dam. That pump discharges pond water into the HDPE pipe shown on Photo 11-16 in the spillway on the right abutment. This outlet pipe discharges into the polishing pond.

Photo II-17 shows a pipe outlet discharge at the toe of the dam. This outlet works well currently but the closure plan should consider moving the discharge point well away from the toe of the dam.

Photo II-17 shows erosion rills on the downstream slope of the dam. This contrasts with the Cross Valley Dam which shows no downstream slope erosion because the slope material is coarser. Photo II-20 shows the downstream slope from the left abutment looking north while Photo II-22 shows the blanket drain just above the 1031 m berm.

Photo II-17 shows the Elev. 1031m berm from north to south. The downstream blanket drain empties on to the 1031 m berm but there is no evidence of seepage along the berm. As further evidence of lack of seepage from the drain there is no ditch along the upstream side of the berm. Instead the seepage through the dam bypasses the drain and discharges into the polishing pond out of sight.

Photo II-18 shows the crest and the upstream slope riprap from the right abutment. Photo 11-19 shows riprap beaching[1] on the upstream slope. Photo II-21 shows the upstream slope with riprap from the left abutment looking north. In general, the riprap is in good condition but will require a periodic maintenance as was done in 2007

Photos II -23 and 24 show the 1031m berm from the left and right abutments respectively. Note that there is no riprap on the berm slope at the polishing pond but there is also no evidence of erosion. The 1031 m berm is in good shape with no evidence of cracks or slumps. Photos II-17 and II-18 show the crest of the dam which is also in good shape with no evidence of cracking or slumping.

5.3 Piezometric observations

Most of the piezometers in the Intermediate Dam that are operating and useful are in the 1031m berm on the downstream slope. The Intermediate Dam has an upstream sloping core with a downstream granular shell that is inundated by the polishing pond. Thus, the water level in the downstream shell below the abutments must be at the polishing pond elevation because all of the head will have been dissipated in the core. Any piezometer in the downstream shell below the pond level will or should show the pond level. This is why all of the piezometer readings should also be plotted against the polishing pond level. Even the piezometers installed from the crest should register polishing pond level because their tips are generally downstream of the core.

Two standpipe piezometers were installed in 2004 by KCCL from the crest of the dam towards the left abutment above the drain. As predicted by KCCL, both of these piezometers are dry because the tips are above the polishing pond level. Any water

[1] Riprap beaching is a small bench in an upstream slope formed at a stable water line by long term wave action.

emanating from the drain above the 1031 m berm should be temporary and due to infiltration of precipitation only.

The two piezometer nests at 91-ID6 and 91-ID4 both show slight downward gradients. Both also show a drop in the piezometric level with time which should be coincident with the polishing pond level. All other piezometers show some variant of this behaviour until malfunctioning.

The upstream impervious blanket of the Cross Valley Dam does not extend to the toe of the Intermediate Dam. It is possible that sludge in the deeper portion of the polishing pond has filled the gap between the impervious blanket and the downstream toe of the Intermediate Dam. If that is the case, then the south end, downstream shell of the Intermediate Dam is a preferential conduit for polishing pond discharge beneath the Cross Valley Dam. However, most of the seepage through the Cross Valley Dam is from the north end where the pond is most shallow. There should be less sludge accumulation in the north, shallow end of the pond.

6. CROSS VALLEY DAM

6.1 Description

The Cross Valley Dam was constructed as part of the Down Valley Project in the early 1980s to expand the tailings disposal capacity in the Rose Creek Valley. The Cross Valley Dam retains a polishing pond downstream of the Intermediate Dam. The embankment is a conventional water retaining dam with no retained tailings. Figure 3 shows the design section of the Cross Valley Dam without the seepage berm.

The crest of the dam is at El. 1034 m and the downstream toe is at El. 1016 m (nominal). The height of the dam is about 18 m above original grade. The dam is approximately 500 m long. The dam section is a central impervious core supported by upstream and downstream granular shells at slopes of 2H:1V. The core and downstream shell are separated by a chimney drain which connects to a blanket drain to the toe. There is also a chimney drain on the upstream side of the core.

The central impervious core connects to an impervious upstream blanket which extends beneath the upstream shell to 60 m upstream of the toe. The core was extended a few meters into existing ground below stripped grade. This nominal cut-off and upstream blanket were designed to reduce seepage through the foundation soils. There are no other cutoffs into the pervious Rose Creek sediments.

6.2 Site Observations

Mr. Bryan Watts, P.Eng. and Dr. Thava Thavaraj, P.Eng inspected the Cross Valley Dam on the morning of July 22, 2007. The weather was bright and sunny. Photographs are included in Appendix II. The dam was inspected in the following order:

- Right abutment syphon
- Right abutment spillway

- Crest together with upstream slope and downstream slope
- Intersection of left abutment with natural ground
- Downstream toe and berm
- Downstream weirs

The right abutment syphon is used to control the level of the polishing pond. The syphon has a floating intake as shown in Photo II-1 which conveys pond water to an HDPE pipe, Photo II-2, thence to Rose Creek, well downstream of the toe of the dam. The inlet and pipe are performing acceptably. If the syphon is overwhelmed, there is a rock lined spillway in alluvium on the right abutment as shown on Photo II-3. The rockfill lining is in good shape but there are no records to show that the spillway has ever seen flow. BGC notes in their 2006 report that the rockfill lining needs to be repaired in spots.

Photo II-4 shows the downstream contact of the right abutment of the dam with natural ground. Photo II-5 shows the adjacent downstream slope which is covered with sand and gravel with larger, scattered boulder sizes of 2 to 3 ft. Photos II-5 and II-13 also show low trees near the toe of the dam. Usually vegetation on the downstream slope is an indication of seepage discharge but there were no obvious seeps. This vegetation should be removed at regular intervals as was done in 2007 (BGC, personal communication).

Photo II-6 shows the upstream slope of the dam from the right abutment looking south. Generally there is a lack of riprap above the previous high water mark on the upstream slope which is again illustrated in Photo II-7. There are a few spots where the riprap is beached or washed out but these minor repairs are part of normal maintenance. BGC (2007) shows that, at times, the polishing pond level drops below the base of the upstream riprap. This should be avoided as upstream wave action could erode the face of the dam.

Photos II-8 and II-9 show the downstream slope from the crest near the left abutment. There is a lack of vegetation on the downstream slope. The slope itself is in good shape with few erosion gulleys. Photos II-8 and II-9 also show the crest of the dam which is good shape without any signs of cracking or other distress.

Also shown on Photos II-8 and II-9 is the "seepage" berm on the downstream toe. This berm is separated from the toe road by a ditch. Although not shown on any of the drawings available to the writer, this berm was apparently constructed to control seepage at the toe of the dam. Near the right abutment, geotextile beneath the toe berm is exposed in the toe ditch as shown on Photo II-12. There is no sign of seepage discharge from the top of the toe berm so the toe berm elevation is above any artesian pressure heads at the toe. The berm toe is lined with rockfill as shown in Photos II-11 and II-12.

Annual site inspection reports by BGC noted longitudinal cracking on the crest of the dam. The writer did not observe such cracking in July 2007 so it must have been repaired. Longitudinal cracking of dam crests because of freeze-thaw is common and not a safety issue.

6.3 Review of Instrumentation Readings

As the dam is supported on a pervious foundation, the major factor affecting static stability is the control of seepage flow through the foundation and the embankment itself. To monitor pore pressures and flows, there are weirs, foundation piezometers, thermistor strings, and embankment piezometers at the Cross Valley Dam. These instruments are read regularly by site staff and summarized annually by BGC.

There are four weirs; X13(combined), X11(north), X12(south), and W3(central); at the toe of the dam beyond the toe berm. In 2006, the northern weir was about twice the flow of the central weir, and ten times the flow of the southern weir. This is consistent with the presence of a pervious terrace on the northern side of the former Rose Creek Valley which is now buried beneath tailings or below the polishing pond level. It is also consistent with greater sludge accumulation in the polishing pond which should be deepest on the south.

Most relevant to stability is that the total flow at X13 has decreased by a factor of four since 1982. This reduction occurred with a relatively constant polishing pond elevation over that period and relatively constant piezometric pressure in the foundation piezometers. For seepage to reduce, the gradient must be reducing or permeability is reducing somewhere in the system. The most logical source of permeability reduction is the polishing pond where sludge could be accumulating with time. The writer is not aware whether this accumulation is monitored and cleaned with time. There is no geotechnical reason to remove sludge from the polishing pond. Alternatively, the reduction in seepage could be due in part to the cessation of tailings deposition. In that case, we would expect that the seepage discharge would asymtopically reach some steady state value. The reduction in seepage discharge over time is encouraging because incipient piping, a candidate failure mode for this dam, would likely result in an increase in seepage over time.

The foundation and embankment piezometers heads are relatively constant over time. The foundation piezometers below the crest are much below the elevation of the polishing pond which means that the upstream blanket plus sludge accumulation are effective in reducing head from the pond.

7. LITTLE CREEK DAM, VANGORDA MINE

7.1 Description and Operating Procedures

The Little Creek Dam was completed in 1991 to collect water pumped from the Vangorda open pit and from runoff and seepage at the Vangorda waste dump. The water from the dam was pumped directly to the treatment plant. Electrical power was supplied by a single line to a transformer located on the dam crest adjacent to the pump house. The pump house, no longer operational, had two 35 HP and one 125 HP pumps that were used to pump from the Little Creek pond to the treatment facilities.

Operations have changed at the site. Now only runoff from the Vangorda waste dump collects behind the dam, and this water is pumped in the summer months to the abandoned Vangorda pit. Water from the Vangorda pit is now routed directly to the treatment plant. A 30 hp Flyte pump conveys water from the LCD to the Vangorda pit.

The dam is a homogeneous embankment section of local glacial till, with a cutoff trench and granular drains under the downstream slope. The crest is about 10 m above natural ground, ranging in elevation from 1114.5 m to 1120 m. Side slopes are 2H:1V on the downstream side and 2.5H:1V on the upstream side. A zone of permafrost encountered at the south abutment was excavated prior to till placement.

The dam is inspected daily during the summer months. Instrumentation includes six pneumatic piezometers and three thermistors, which are read twice a year, typically in the spring and fall. The site is inspected once a week during the winter months.

We understand that SRK inspects the Little Creek Dam annually and summarizes the piezometer readings. We have the draft of the 2007 inspection report which is fit for purpose.

As described above, the pond level is not operated at full supply level (FSL). It varies between about Elev. 1108 and 1110 m. The crest slopes from north to south with the minimum level at Elev. 1114.5 m. The minimum freeboard (except for short duration exceedances) is 4.5 m on a 10 m high dam. For the purposes of assigning consequences of failure and dam classification for earthquake and static loading, this is a small volume of potential water release, hence the "Low" consequence failure classification given in the 2002 Dam Safety Review. If the pond level was operated consistently at a higher water level then the dam classification might have to be re-considered.

The BGC (2007) OMS manual includes a section on the Little Creek Dam. The BGC (2007) EPP report also includes the Little Creek Dam.

7.2 Site Observations

Photo II -26 shows the upstream slope of the Little Creek Dam. There is no evidence of slumping or erosion on the upstream slope. The crest is also in good shape. There is no riprap on the upstream slope as the fetch of the reservoir is too small to generate waves and hence wave erosion.

Photos 11-27, 28, and 29 show erosion and slumping on the downstream slope of the dam which requires repair. Because the downstream slope is glacial till, and not free draining sand and gravel like the Cross Valley Dam and the Intermediate Dam, it is subject to freeze/thaw softening. Rainfall then erodes gulleys into the loose surficial slope material. There is also shallow sloughing down the slope.

This freeze/thaw loosening is common in similar dams in northern Canada and can be reduced by placing material on the downstream slope whose thickness exceeds the average frost penetration depth. This improvement needs to be designed to find the optimum material and construction procedure. Sand and gravel, filter compatible with the glacial till, of thickness 2.5 m would be a suitable frost protection fill. This fill should be placed on the downstream slope from the bottom after stripping the slope of vegetation and loose material.

The condition of the downstream slope of the Little Creek Dam is not consistent with the stated objectives in Section 4.3.3.6, Maintenance Requirements, of the OMS manual.

7.3 Instrumentation

Instrumentation includes six pneumatic piezometers and three thermistors, which are read twice a year, typically in the spring and fall. The SRK inspection report includes a summary of the piezometer versus pond level readings for all six piezometers. The pond level readings are only available from the middle of December 2003. From then to 2007, the pond level varied from Elev. 1108 to 1110 m with some short term levels to 1111.0 m against a maximum pool level 1112.6 m.

From 1994 to the middle of 2006 the piezometer readings are remarkably uniform. Although the records are not available, we presume that the pond level was operated at a higher level during mine operation. This makes the rise in the LCD2 and LCD3 piezometer levels in the middle of 2006 somewhat surprising. The largest rise was in the LCD3 deep piezometer but the rise appears to be all in the foundation soils. This piezometer reading rose to the pond level which means that there is no head drop from the pond to this LCD3 deep piezometer.

The rise in these piezometers means that there is either foundation or embankment materials downstream of the piezometers where most of the head from the pond is dissipated. This normally is an indication of blockage of drains. It could be that the downstream slope erosion is blocking the drainage on the downstream slope of the dam and foundation slope beyond the toe of the dam. The reason for the piezometer rise needs to be understood.

7.4 Dam Safety Issues

Since 2002, the seismicity and the precipitation estimates for the site have been better defined. The stability of the Little Creek Dam needs to be checked against these new seismic and flood loading estimates. The culvert spillway is designed for 1 in 200 year flood according to SRK (1998) relative to the hydrologic estimates at that time.

The consequences of failure of the Little Creek Dam remain “Low” according to the new CDA (2007) guidelines. However, closure considerations have led to the adoption of a higher standard for the Rose Creek dams. This needs to be addressed formally with respect to the Little Creek Dam starting with a study of consequences of failure which would be higher for the flood mode where the full pond would be released. Whether the Little Creek Dam is temporary or not will determine ultimately the standards of safety adopted for this structure.

The static stability of the dam is acceptable. However, erosion of the downstream slope will eventually, without remediation, compromise the safety of the dam.

8. OMS FOR THE CROSS VALLEY AND INTERMEDIATE DAMS

8.1 General

BGC (2007) issued the second revision of the Operations, Maintenance, and Surveillance (OMS) manual for selected dams at the Faro site in February 2007. The first revision was issued in February 1, 2004. This OMS manual includes recommendations for improvement of the document itself. For instance, Section 5.2 lists critical information that should have been updated in the manual to February, 2007. The writer agrees with each of the recommendations by BGC.

OMS manuals which have been revised to a date should not contain recommendations for the material that should have been updated to that date. The update recommendation list should be the basis for the revision itself.

As we concur with the list of BGC (2007) recommendations which is a declaration that the manual is out of date at the time of issue, our recommendation must be that the manual be updated. When the OMS manual is revised, it should adopt the style of an OMS manual with removal of consulting report issues. Although consultants may prepare the manual, the owner of the manual should be the senior site representative responsible for on-going operation, maintenance, and surveillance of the dam in question.

8.2 Operations and Maintenance

The general content of the operations and maintenance section of the Manual itself (subject to above comments) is acceptable. However, the Manual itself is out-of-date making it difficult to use as a site document and difficult to review. There are dozens of dated references. We understand that an update is in progress (Deloitte & Touche Inc., personal communication).

An OMS manual should include reference to a filing system which contains all records of maintenance and incidents. The existence of such a filing system is not known to us. BGC presented a training seminar to site staff in September, 2006 that described the relationship between dam monitoring and dam integrity. BGC have also indicated other training sessions were given to site staff. These need to be documented in the site records.

8.3 Surveillance

Golder Associates was responsible for annual inspection and instrumentation review from 1981 to 1999 according to BGC (2007) who have been responsible for these duties since

2000. The instruments are read by site staff who transmit the data to BGC for their annual compilation and review. There is reading schedule published for each instrument in the BGC annual report for 2005.

Trigger levels have not yet been adopted for the Intermediate Dam and Cross Valley Dam. We suggest:

- The flows at the Cross Valley Dam weirs have been steadily dropping since the 1990's. Any reversal in this trend, independent of precipitation, should trigger a review of readings and action, if required.

- Piezometers in the Cross Valley Dam toe should always show heads less than the top of the seepage berm which should be surveyed and added to drawings.

- Piezometers in the Intermediate Dam should always show heads less than the polishing pond (for those piezometers within the footprint of the pond).

9. EMERGENCY RESPONSE PROCEDURES

BGC (2003) prepared an emergency preparation and response plan for "selected" dams and water diversion structures. This document is dated October 23, 2007 with a recommendation that "*Nevertheless, this EPP should be considered a "living document" that must be constantly reviewed and updated to reflect current site conditions and information*". We fully concur with this statement but this has not been done. Many of the references are out-of-date. We do not know if critical telephone numbers are out-of-date. We understand from Deloitte & Touche Inc. that an update is in progress at the time of writing.

The EPP, as with the OMS manual, has been written as a consulting report. That is, the emergency response procedures are embedded within the necessary qualifications of the report. Given that the document is signed by BGC (2003), clearly the ownership of the document resides with BGC who have no mandate to update or test the document. This is an unusual situation. The ownership of the document must reside with those who would use the Emergency Response procedures.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Bryan D. Watts, P.Eng.
Principal

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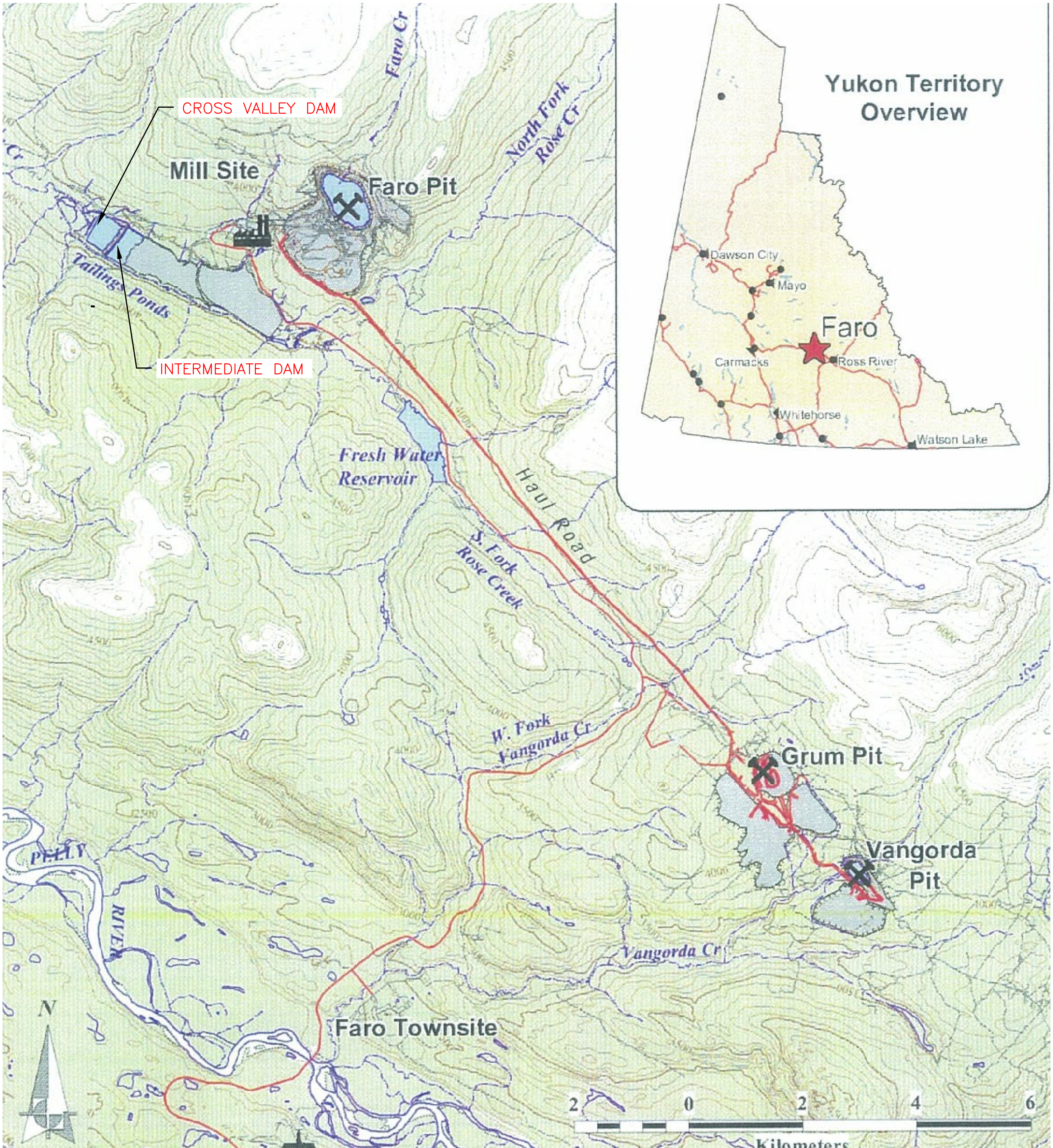
FIGURES



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TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 2008

CLIENT	PROJECT
DELOITTE & TOUCHE INC. ANVIL RANGE MINING COMPLEX	2007 DAM SAFETY REVIEW
Klohn Crippen Berger	TITLE LOCATION PLAN
	PROJECT No. M09237A05 / FIG. No. 1

Date: 1/28/2008
Scale: 1=1(PS)
Drawing File: M\M09237A04-A01-A06- Rose Creek YK Tailings Liquefaction\400 Site Work and Design Calculations\413-2007 Drawings\2007-DamSafety\Figure1-5.dwg (cwong)

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Date: 1/28/2008
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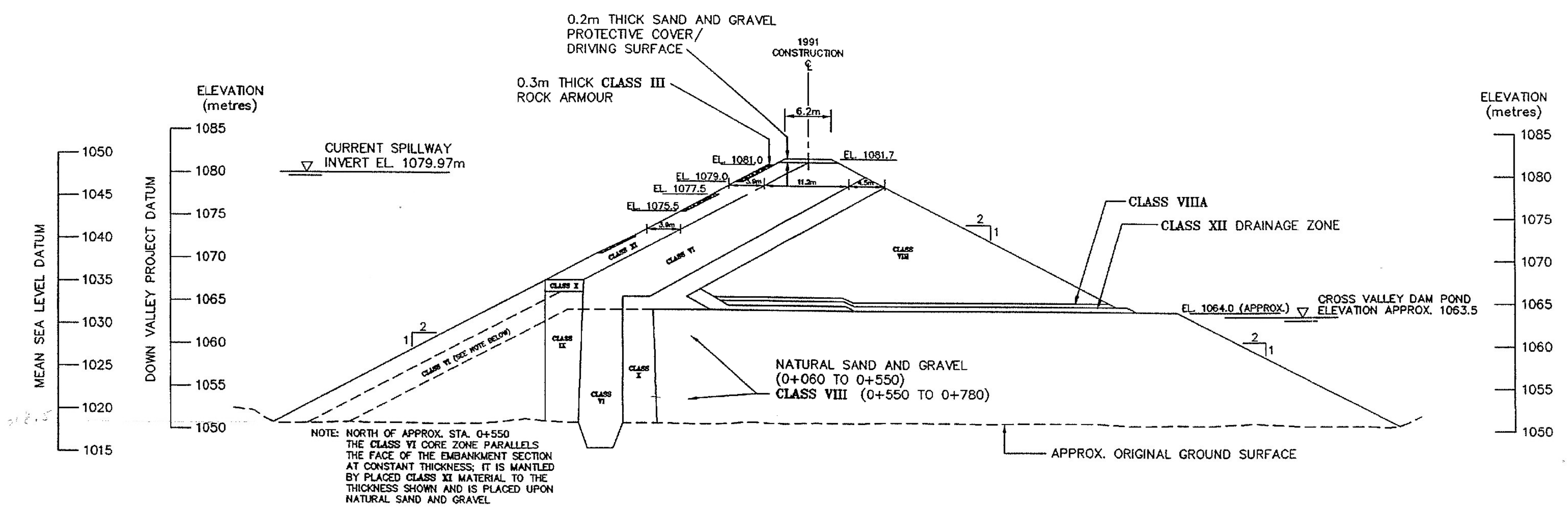

NOTES :

1. Embankment geometry and internal zoning as shown in Golder Associates Drawing 912-2402-3, Int. Dam Raising & C.V. Dam Toe Drain, Cross Section and Detailed Plan, Rev. 1, Aug. 8, 1991.

2. All elevations are referenced to Down Valley Project Datum. Subtract 32.3m from elevations shown to convert to mean sea level (NAD27) datum.

3. Refer to Golder Associates as built reports for detailed descriptions of material classes. General descriptions as follows :

CLASS VI	Dam Core (glacial till)
CLASS VII	Upstream Shell (silty sand and gravel)
CLASS VIII	Downstream Shell (sand and gravel)
CLASS VIIIA	Drainage Filter (sand and gravel)
CLASS IX	Upstream Filter (silty sand)
CLASS X	Downstream Filter (sand and gravel)
CLASS XI	Tailings Sand (fine to medium sand)
CLASS XII	Drainage Zone (gravel)

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0 5 10 15 20 25 metres

CLIENT: DELOITTE & TOUCHE INC.
ANVIL RANGE MINING COMPLEX

Klohn Crippen Berger

PROJECT: 2007 DAM SAFETY REVIEW

TITLE: TYPICAL SECTION
INTERMEDIATE DAM

PROJECT No. M09237A05

FIG. No. 2

KCR-R-MI A4

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Date: 1/28/2008
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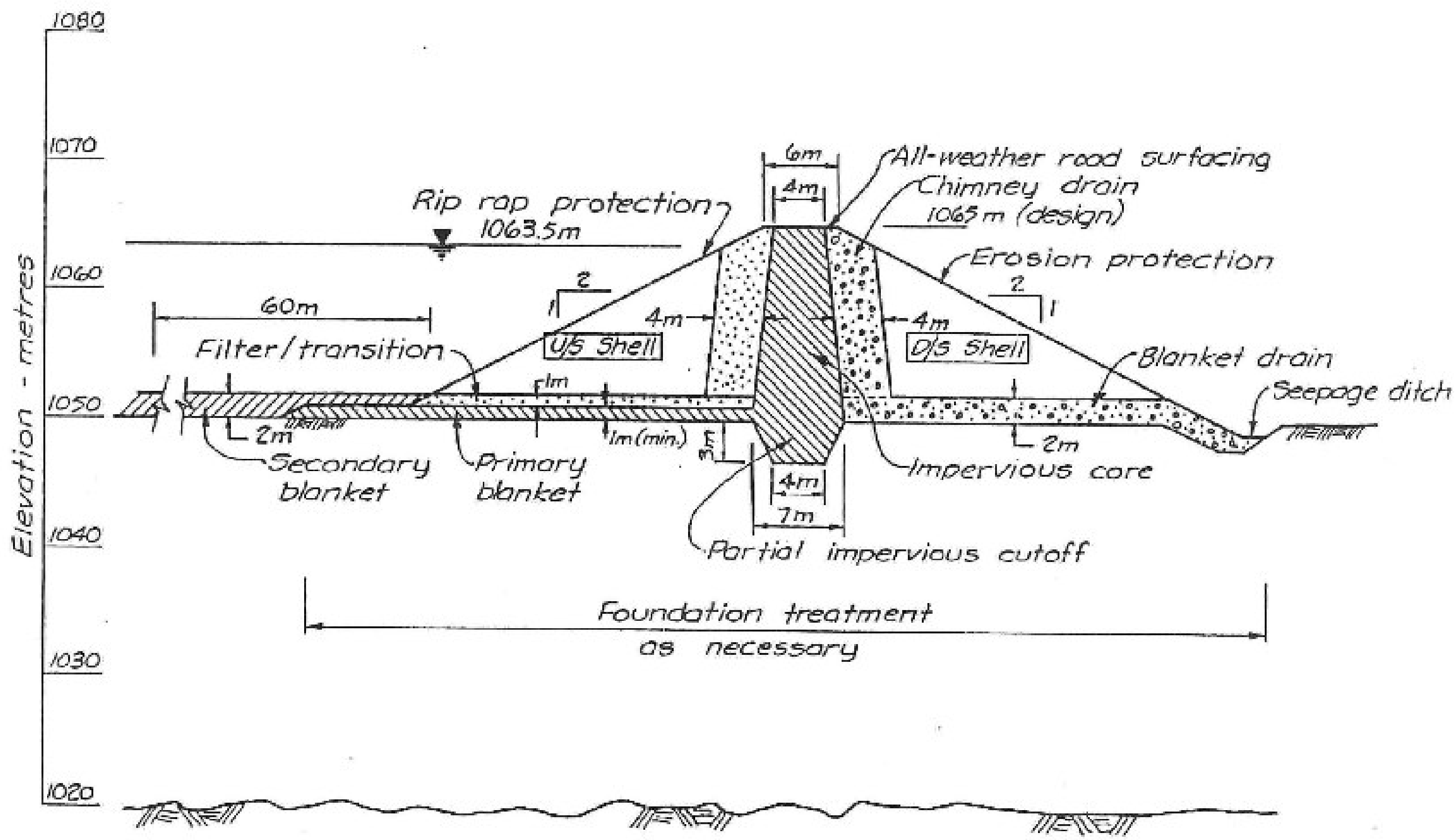
Drawing File: M\M09237A04-A01-A06- Rose Creek YK Tailings Liquefaction\400 Site Work and Design Calculations\413-2007 Drawings\2007-DamSafety\Figure1-5.dwg (cwong)



NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 2008

NOTES:
FIGURE SHOWING THE TYPICAL DESIGN SECTION OF THE CROSS VALLEY DAM TAKEN FROM GOLDER ASSOCIATES REPORT TO CYPRUS ANVIL MINING DATED JUNE 1980.

CLIENT: DELOITTE & TOUCHE INC. ANVIL RANGE MINING COMPLEX	PROJECT: 2007 DAM SAFETY REVIEW
Klohn Crippen Berger	TITLE: CROSS VALLEY DAM TYPICAL DESIGN SECTION
	PROJECT No. M09237A05 — FIG. No. 3

KCR-R-MI A4

Time: 9:38:57
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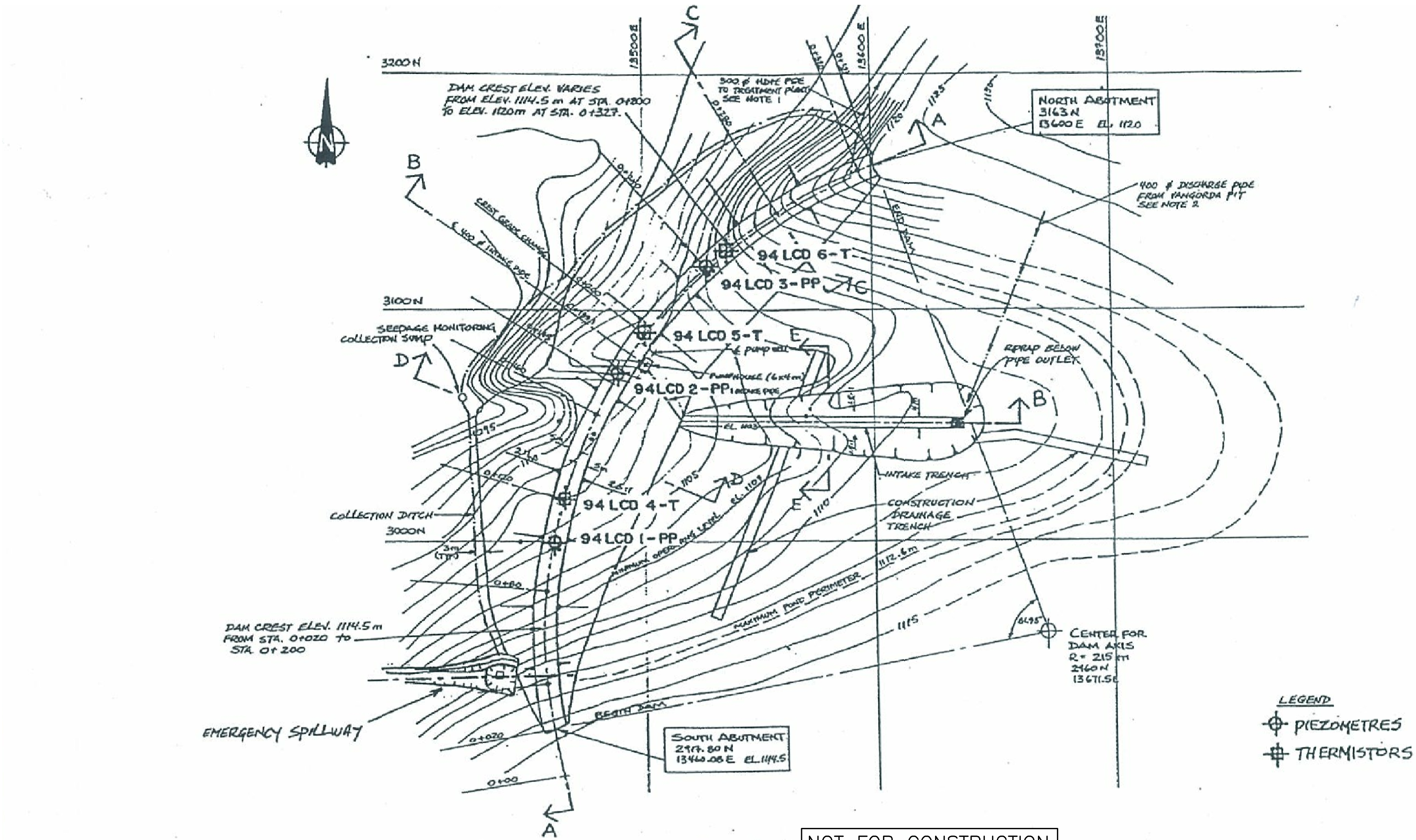

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 2008

SOURCE OF FIGURE
LITTLE CREEK DAM, PLAN, ANVIL RANGE MINE COMPLEX, 2002 BASELINE ENVIRONMENTAL INFORMATION, DeLOITTE & TOUCHE, FIGURE 3.5, DATED APRIL, 2002.

CLIENT: DELOITTE & TOUCHE INC. ANVIL RANGE MINING COMPLEX

Klohn Crippen Berger

PROJECT: 2007 DAM SAFETY REVIEW

TITLE: LITTLE CREEK DAM PLAN

PROJECT No. M09237A05

FIG. No. 4

KCR-R-MI A4

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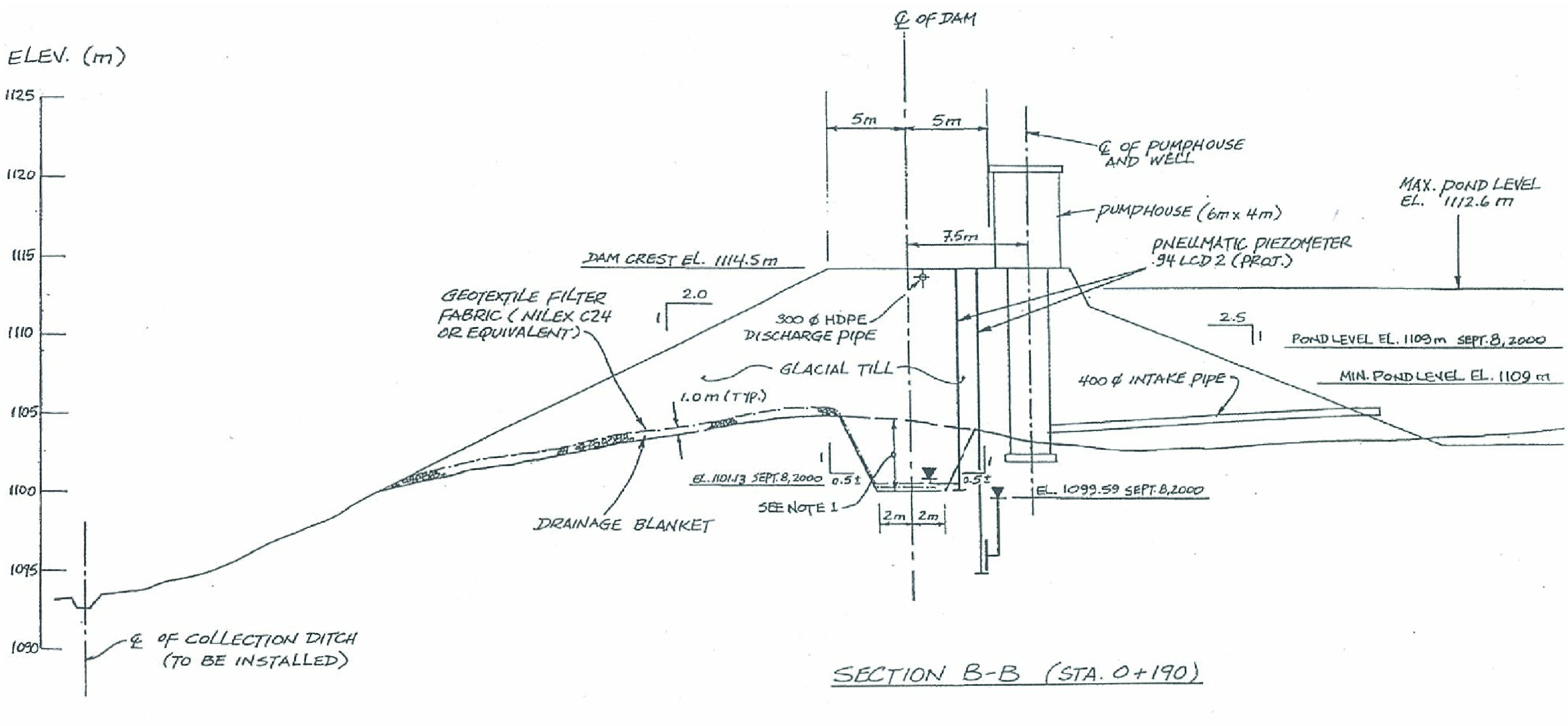
Drawing File: M\M09237A04-A01-A06- Rose Creek YK Tailings Liquefaction\400 Site Work and Design Calculations\413-2007 Drawings\2007-DamSafety\Figure1-5.dwg (cwong)



SECTION B-B (STA. 0+190)

SOURCE OF FIGURE
LITTLE CREEK DAM, SECTION, ANVIL RANGE MINE COMPLEX,
2002 BASELINE ENVIRONMENTAL INFORMATION, DeLOITTE & TOUCHE,
FIGURE 3.6, DATED APRIL, 2002.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JANUARY 2008

CLIENT	PROJECT
DELOITTE & TOUCHE INC. ANVIL RANGE MINING COMPLEX	2007 DAM SAFETY REVIEW
Klohn Crippen Berger	TITLE: LITTLE CREEK DAM SECTION
	PROJECT No. M09237A05 — FIG. No. 5

KCR-R-MI A4

APPENDIX I

CDA (2007) PRINCIPLES

CDA DAM SAFETY GUIDELINES 2007

The new CDA guidelines were issued in November 2007. These guidelines include a Principles volume plus supporting technical volumes. We have extracted the Principles themselves below and have added comments on the compliance of the Intermediate and Cross Valley Dams with the Principles.

Compliance or lack thereof is not always definitive. We have adopted the BC Hydro compliance language from their Access database of dam safety compliance with the previous guidelines as given in the following table.

Conformance Type	Description	Type
An	Actual Deficiency	Deficient under normal loads
Au	Actual Deficiency	Deficient under unlikely loads
Pn	Potential Deficiency	Expected to deficient under normal loads
Pu	Potential Deficiency	Expected to deficient under unlikely loads
Pq	Potential Deficiency	Expected not to be deficient, quickly demonstrated
Pd	Potential Deficiency	Expected not to be deficient, difficult to demonstrate
NC_i	Non-conformance	Information
NC_s	Non-conformance	Surveillance
NC_m	Non-conformance	Maintenance
NC_o	Non-conformance	Operations
NC_p	Non-conformance	Other Procedures
Cnf	Conformance	Conforms
N/A	Others	Not Applicable

PRINCIPLE la

The public and the environment shall be protected from the effects of dam failure, as well as release of any or all of the retained fluids behind a dam, such that the risk are kept as low as reasonably practicable.

The Cross Valley Dam and the Intermediate Dam are classified as “High” consequence of failure dams according to CDA (2007) because of their potential for contamination of Faro Creek and the Pelly River. There are no life safety issues. For this consequence rating, the Cross Valley Dam and the Intermediate Dam do not currently meet safety standards with respect to the influent design flow (IDF). The Cross Valley Dam does not meet safety standards with respect to the EDGM. The Intermediate Dam does meet safety standards with respect to MCE. Both dams meet safety standards for their current static loading.

Remedial designs of both dams are being prepared so that each meets all required safety standards. Both dams are well constructed and currently meet 1 in 500 return period influent design floods and earthquake motions as required by the Government of Yukon temporary operating permit.

During design closure period – Cnf.
Post Closure – Au

PRINCIPLE 1b

The standard of care to be exercised in the management of dam safety shall be commensurate with the consequences of dam failure.

The dam safety operating, maintenance, and surveillance procedures together with the qualifications of personnel who conduct such procedures are appropriate for the consequences of failure of the dams. However, the documentation of such procedures does not conform which is covered by a later principle.

Cnf.

PRINCIPLE 1c

Due diligence shall be exercised at all stages of a dam's life cycle.

The Faro mine site is not operating. It is in the process of abandonment. The Cross Valley Dam retains a contaminated polishing pond whose original purpose is no longer required.

The Intermediate Dam retains tailings and supernatant water whose current function will always be required. "Due diligence' during this "designing for closure" stage of the life cycle of these dams is appropriate.

During design closure period – Cnf.

PRINCIPLE 1d

A dam safety management system, incorporating policies, responsibilities, plans and procedures, documentation, training, and review and correction of deficiencies and non-conformances, shall be in place.

Although such dam safety management procedures are conducted, there is no identifiable, documented dam safety management system in effect. This manual needs to be prepared with the operator of the site as the "owner".

$NC_{i,s,m}$ – Acceptable documentation should be prepared within one year.

PRINCIPLE 2a

Requirements for the safe operation, maintenance, and surveillance of the dam shall be developed and documented with sufficient information in accordance with the impacts of operation and the consequences of dam failure.

The dams are operated, maintained, and surveyed safely but the documentation is not adequate.

$NC_{i,s,m}$ – Acceptable documentation should be prepared within one year.

PRINCIPLE 2b

Documented operating procedures for the dam and flow control equipment under normal, unusual, and emergency conditions shall be followed.

There are no documented operating procedures for the syphons at the Intermediate and Cross Valley Dams. There is no documented operating procedure for the pumps at the Little Creek Dam.

NC_o Non-conformance.

PRINCIPLE 2c

Documented maintenance procedures shall be followed to ensure that the dam remains in a safe and operational condition.

NC_m Maintenance documentation is out-of-date.

PRINCIPLE 2d

Documented surveillance procedures shall be followed to provide early identification and to allow for timely mitigation of conditions that might affect dam safety.

NC_s Surveillance procedures adequate but documentation is not.

PRINCIPLE 2e

Flow control equipment shall be tested and be capable of operating as required.

There are no records of tests on the syphons and pumps. However, these syphons and pumps are in constant use unlike gates which only have to be opened in emergencies. The OMS manual should state that the flow control equipment does not have to be tested as it is in constant use.

NC_o – not urgent

PRINCIPLE 3a

An effective emergency management process shall be in place for the dam.

Cnf. – Emergency management process in place.

PRINCIPLE 3b

The emergency management process shall include emergency response procedures to guide the dam operator and site staff through the process of responding to an emergency at a dam.

Cnf. – Emergency response procedure in place but documentation is out-of-date.

PRINCIPLE 3c

The emergency management process shall ensure that effective emergency preparedness procedures are in place for use by external response agencies with responsibilities for public safety within the floodplain.

Cnf.

PRINCIPLE 3d

The emergency management process shall ensure that adequate staff training, plan testing, and plan updating are carried out.

According to BGC (pers. Communication), annual training sessions are presented to site staff to better inform them of operations, maintenance, and surveillance issues required for tailings and water retention structures.

NC – Testing of emergency response not done or not documented.

PRINCIPLE 4a

A safety review of the dam ("Dam Safety Review") shall be carried out periodically.

A dam safety review was conducted in 2002 and now in 2007.

Cnf.

PRINCIPLE 4b

A qualified registered professional engineer shall be responsible for the technical content, findings, and recommendations of the Dam Safety Review and report.

The Dam Safety Reports in 2002 and 2007 were prepared by qualified, registered Professional Engineers in the Province of Alberta.

Cnf.

PRINCIPLE 5a

The dam system and components under analysis shall be defined.

The dam system and components comprise the embankments, the embankment foundations, the emergency spillways, and the syphon systems. Each is properly defined for the purpose of dam safety analysis.

Cnf.

PRINCIPLE 5b

Hazards external and internal to the dam shall be defined.

The dam safety hazards are earthquake loading, flooding, piping through the foundation and embankment, and static stability of the upstream and downstream slopes. Each is defined adequately for the purposes of dam safety management.

Cnf.

PRINCIPLE 5c

Failure modes, sequences, and combinations shall be identified for the dam.

The failure modes, sequences, and combinations for the hazards listed in Principle 5b are adequately identified for the purposes of dam safety management.

Cnf.

PRINCIPLE 5d

The dam shall safely retain the reservoir and any stored solids, and it shall pass flows as required for all applicable loading conditions.

The Cross Valley Dam cannot retain the polishing pond for the influent design flood nor the design earthquake motions appropriate to the consequences of failure. The Intermediate Dam cannot retain the tailings and supernatant for the influent design flood but can retain the tailings and supernatant for the design earthquake motions appropriate to the consequences of failure.

The safety of both dams is under review for the loading conditions just described. The safety review process and duration is appropriate to the consequences of failure.

NC – Under Active Review
Cnf – Conforms for "design for closure" period.

APPENDIX II

JULY 22, 2007 SITE VISIT PHOTOS

Photo II - 1 - Cross Valley Dam Floating Syphon Inlet.

Photo II - 2 – Cross Valley Dam Syphon HDPE.

Photo II - 3 – Cross Valley Dam – Rockfill-lined Spillway.

Photo II - 4 –Cross Valley Dam – Downstream slope intersection with right abutment.

Photo II - 5 – Cross Valley Dam – Vegetation on Downstream slope near toe.

Photo II - 6 – Cross Valley Dam – Upstream slope without riprap above high water mark – looking south from right abutment.

Photo II - 7 – Cross Valley Dam – Upstream slope from left abutment looking north.

Photo II - 8 – Cross Valley Dam – Downstream slope looking north.

Photo II - 9 – Cross Valley Dam – Downstream slope looking south to left abutment.

Photo II - 10 – Cross Valley Dam – Downstream slope and toe looking north.

Photo II - 11 – Cross Valley Dam – Rockfill lining at toe of berm.

Photo II - 12 – Cross Valley Dam – Rockfill lining at toe of berm on right abutment.

Photo II - 13 – Cross Valley Dam – Downstream slope from right abutment looking north. Note low trees on toe as shown on Photo II-5 from crest.

Photo II - 14 – Cross Valley Dam – Weir X-13.

Photo II - 15 – Intermediate Dam – Right Abutment Spillway.

Photo II - 16 – Intermediate Dam – Intake Pump Barge.

Photo II - 17 – Intermediate Dam – Outlet at toe at Intermediate Dam.

Photo II - 18 – Intermediate Dam – Upstream riprap looking south from right abutment.

Photo II - 19 – Intermediate Dam – Riprap beaching.

Photo II – 20 – Intermediate Dam – Downstream slope from left abutment looking north.

Photo II – 21 – Intermediate Dam – Upstream slope from left abutment looking north.

Photo II – 22 – Intermediate Dam – Downstream slope looking north along 1031m berm. Note drain exposure and minor erosion rills above drain.

Photo II – 23 – Intermediate Dam – 1031m berm looking north. No erosion of berm at waterline, no riprap.

Photo II – 24 – Intermediate Dam – 1031m berm looking south.

Photo II – 25 – Intermediate Dam – Right abutment.

Photo II – 26 – Little Creek Dam – Upstream slope from right abutment.

Photo II – 27 – Little Creek Dam – Downstream slope, note slumping.

Photo II – 28 – Little Creek Dam – Slumping and erosion of slope at downstream toe.

Photo II – 29 – Little Creek Dam – Slumping and erosion of downstream slope.