NORTHERN AFFAIRS PROGRAM

FARO AND VANGORDA PLATEAU MINES

REPORT
ON
1999 INSPECTION

Prepared by:

geo-engineering (M.S.T.) LTD.

April 2000

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Whitehorse, Yukon

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Calgary, Alberta

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1.0 INTRODUCTION

The Water Resources Division of the Northern Affairs Program commissioned Mr. M. Stepanek, P.Eng., of Geo-Engineering (M.S.T.) Ltd., to inspect geotechnical aspects of Anvil Range Mining Corporation's mining operations (in receivership) in the Faro and Vangorda Plateau areas. The site was visited between June 23 and 25, 1999 and on September 13 and 14, 1999 in the company of Mr. H.F. McAlpine, P.Eng. A previous inspection was undertaken between June 24 and 26, 1998.

Mining at the Faro open-pit and Faro underground mines was permanently discontinued in the winter of 1992/93. The ore was supplied to the Faro mill from the Vangorda open-pit mine until April 1993, when that operation was temporarily halted, and then indefinitely suspended in October 1993.

Anvil Range re-opened the mine in 1996, by mining the Grum pit, and shut it down again in January 1998. Mining of the Vangorda open-pit mine was discontinued late in 1996 and was not renewed during the 1997 and 1998 season when the Grum pit became the main source of ore. The east slope of Grum pit became unstable in 1996 and since that time the slide retrogressed further behind the original pit rim.

Deloitte & Touche was the appointed receiver in 1998 and retained a small crew to monitor and maintain the mine infrastructure. Useable parts of haul trucks were removed and removal of iron scrap was in progress.

The purpose of our site visits was to examine the surface appearance of stream diversions, retaining structures and waste dumps at the Faro (Figure 1), Vangorda and Grum mine sites (Figure 2) and, on that basis, evaluate their current performance. A selection of photographs, taken to document the main terrain or structural features, is contained in Appendix A. The 1997 Annual Report, prepared by Golder Associates Ltd. (Golder), dated June 1998, presenting performance evaluation and summarizing monitoring data, was also reviewed.

2.0 FARO OPEN PIT AND WASTE DUMPS

Little change has occurred in the Faro area (Figure 1) since the Faro pit was shut down in 1993. A detailed report on Faro Mine was prepared in 1993 and may be referenced for some background data.

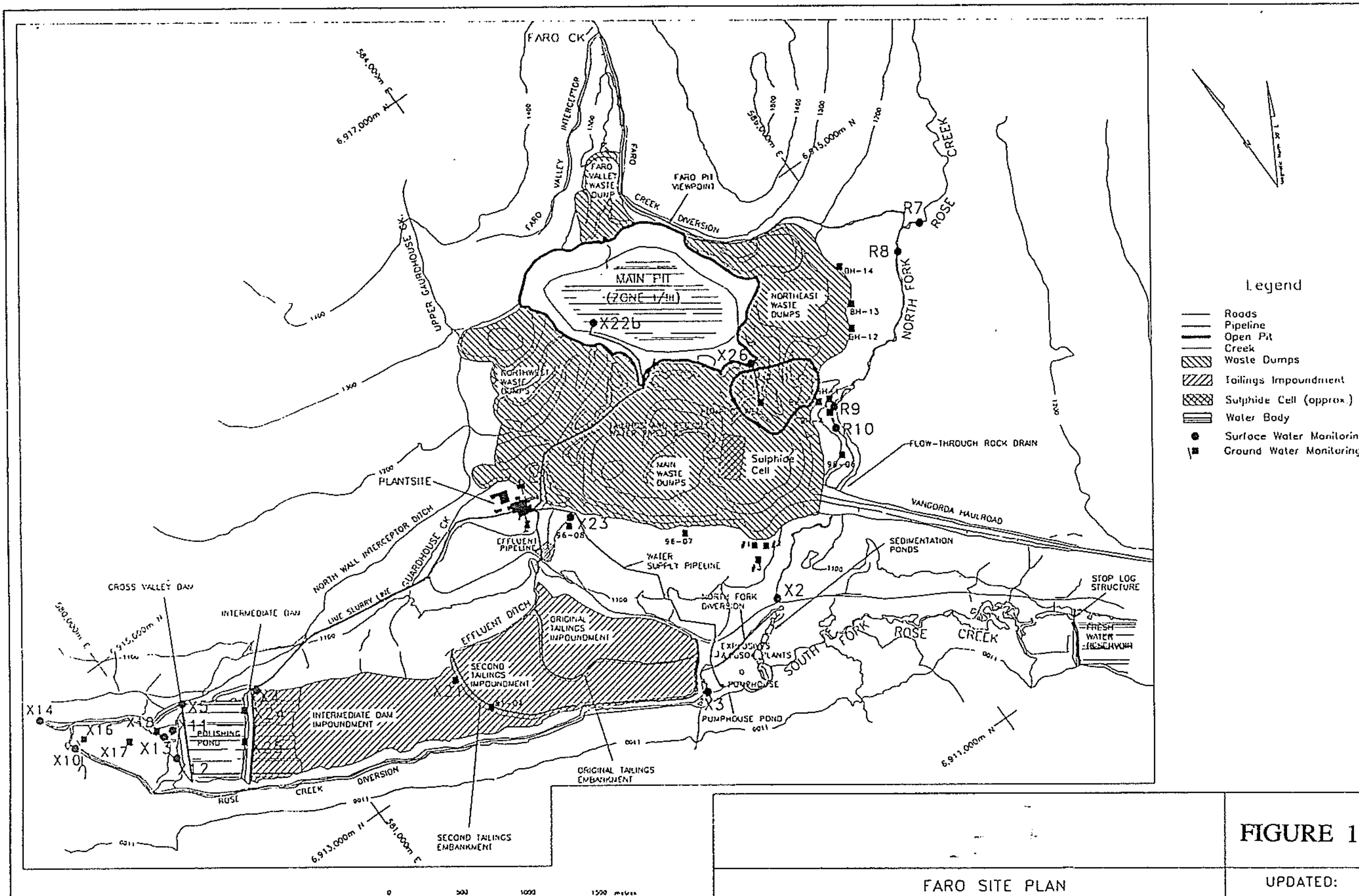

FIGURE 1

FARO SITE PLAN
SHOWING ROUTINE MONITORING LOCATIONS

UPDATED:
SEPTEMBER 1997

The water level in the open pit is controlled by pumping water to the Down Valley Tailings Pond. The water level in the pit was at elevation 1,143.75 m on August 6, 1997. On June 25, 1999 the level of water in the pit was at 1,142.61 m. The northeast pit walls continue to slide, while on the east side, the sloughing did not significantly retrogress towards the Faro Creek diversion channel since the 1998 inspection. The width of the ground remaining between the pit rim and the creek diversion channel, at the narrowest point, is estimated to be about 20 m. The Faro channel upslope cut started to slump at two locations in its upstream reach (Photo 1). Similar to the past, significant seepage from the creek is visible on the east pit wall.

The Faro waste dumps do not show signs of significant deformations, and where they occur, they are localized and superficial rather than deep-seated.

The waste dump on the west side of the North Fork Rose Creek at the Vangorda Haul Road, was showing very little movement. Several reference lines, painted in the past along the toe area, were found undisturbed.

3.0 DOWN VALLEY TAILINGS DISPOSAL SYSTEM

The Down Valley Tailings Disposal System includes the Rose Creek Diversion, the North Valley Wall Interceptor Ditch, the original Tailings Pond (5.3 x 10^6 m^3), a second Tailings Pond (10.4 x 10^6 m^3), the Main Pond (12.8 x 10^6 m^3) formed by the Intermediate Dam, and the so-called Polishing Pond, formed by the Cross Valley Dam.

The facility has been in operation since 1969. Major expansion was undertaken in 1980 and 1981 by constructing the Intermediate and Cross Valley Dams. The Main Pond capacity was reached in the summer of 1992 when the company started pumping of tailings into the Faro open-pit. Due to a frozen pipe some additional tailings were deposited into the Down Valley tailings pond during the winter of 1992-1993.

3.1 ROSE CREEK DIVERSION CANAL

This structure was required to accommodate placement of tailings into the Rose Creek valley bottom. At the same time, it represents the most significant hazard to the tailings stored behind the Intermediate dam. The diversion canal, constructed as cut-and-fill in the south valley wall, is located above the tailings dam crest. Should an overtopping of the canal dyke occur, the creek would flow into the pond. The long-term concern relates to the on-going degradation of permafrost pockets under some canal dyke and backwall segments.

While localized sloughing of the backwall and deposition of eroded material into the canal has a minor impact on its capacity, the stability of the dyke and the maintenance of adequate freeboard within the canal are critical to the integrity of the tailings disposal system.

Major dyke deformations were noted between Stations 2+100 and 2+250 (Photo 2). Another, somewhat smaller, crest deformation exists between Station 1+500 and 1+600 and at Station 1+800 and 1+870. Heavy seepage from the diversion canal, similar to that in previous years, was observed at Station 1+300.

Monitoring of thermistors between Stations 2+100 and 2+250 indicates that permafrost conditions persist below 5 m to 8 m depths. It appears that elsewhere warming thawed frozen ground to or below the bottom of installed thermistors. Old fissures and cracks were effaced by previous crest grading and no new cracks were observed during this year's inspection.

While the overall function of the canal drop section (system of rock weirs) is good, deterioration of some of the weirs continues. It is evident that the diversion canal requires periodic maintenance. The creek bank downstream from the weir section was rip-rapped (Photo 3).

3.2 INITIAL AND SECOND TAILINGS PONDS

Deposition of the tailings into the Initial and Second Tailing Ponds was discontinued in 1982. The so-called Original Tailings Pond has a surface area of about 42 ha at an elevation of 1,100 m. It was expanded by a new dyke surrounding the old structure (so-called Second Tailings Pond or 74 Pond) and has a surface area of about 62 ha at an average elevation of 1,093 m, i.e., about 7 m lower than the first pond and some 8 m above the level of tailings in the main pond located downstream.

The tailings in the second pond have very little freeboard. In the past, the runoff has overtopped the perimeter dyke during spring break-up. This condition is exacerbated by icing which forms along the original discharge of Faro Creek at the north end of the Second Tailings Dam. No signs of overtopping were noticed during the 1999 inspection.

3.3 MAIN TAILINGS POND AND INTERMEDIATE DAM

Seepage from the Rose Creek diversion, at its upstream end, continues to be heavy and contributes to ponding of water in the channel at the creek channel emergency spillway (Photo 4). Additional seepage from the diversion channel occurs at several locations further downstream. The water level in the pond (at the Intermediate Dam) was estimated to be about 0.75 to 1.0 m below the dam crest. In June 1999, the spillway was blocked by an about 0.5 m high earth dyke. This dyke was removed and the spillway rip-rap restored in September 1999.

Rip-rap, placed on the upstream face of the Intermediate Dam a couple of years ago, controls erosion despite its relatively small size (Photo 5). Cracks in the dam crest were first observed in 1996 and 1997. The cracks were more common in 1998, at some locations, up to 2 m back from the upstream edge of the crest. However, no new cracks were observed in 1999.

The downstream face of the dam is rilled but dry and appears to be stable. The south abutment drain at the downstream bench level functions well; however, there is also some seepage discharging from the dam toe (Photo 6).

The 1997 Annual Geotechnical Performance Evaluation (prepared by Golder in June 1998) concludes that piezometric elevations registered in October 1997 at the toe of the intermediate dam were the highest measured values since September 1992. This is supported by visual observations during the 1997 inspection. These indicated that the dam toe was wet to a height of about 2 m above the bench. Deep piezometers were not read in 1997 due to the limit of readout instrument capacity. Piezometers located in both abutments are believed to reflect drainage from upslope areas rather than pond water level fluctuation.

The tie-in of the emergency spillway dyke to the crest of the Intermediate Dam, was finally modified, during the September 1999 visit, to meet the dam crest elevation.

3.4 POLISHING POND AND CROSS VALLEY DAM

No significant deformations were evident on the Cross Valley dam slopes. The available thermistor data indicates that the permafrost in the valley bottom thawed to the instrumented depths. The water level in the polishing pond was lowered for a fourth year to some 3.5 m below the crest of the dam (Photo 7), prior to the onset of winter, while the full supply level is reached or exceeded (by placing a temporary dyke across the spillway during the warm season).

While fissures in the dam crest are evident, no fresh cracks were noticed since the 1997 site visit (Photo 8). It appears that the lowering of the water level has been beneficial since the core is not saturated to the depth of seasonal frost (determined to be about 3.5 m on the dam crest) thus minimizing the adverse affects of the freeze-thaw process.

No deformations were observed on the downstream slope of the dam. Fissures were observed on the toe berm along its interface with the dam slope probably caused by frost heave. The volume of seepage appeared to be in the same order of magnitude as during previous inspections. In 1998 the minimum and maximum measured seepage flows were 647 igpm and 1571 igpm, respectively.

4.0 FRESH WATER RESERVOIR

All stop-logs were removed from the spillway inlet in 1997 and since that time the water level in the reservoir was kept about 2 to 3 m below the crest of the dam. The thermistor string installed in the dam crest indicates the depth of seasonal frost to be 4 m.

Fissures and cracks in the dam crest were fresh and appeared to be larger and wider than in 1998 (Photo 9). The main crack, which is 35 to 150 mm wide and up to 200 mm deep, parallels the upstream side of the dam crest at a distance of some 1 to 2 m (Photo 10). Smaller cracks, about 5 to 30 mm wide, are discontinuous and occur locally on either side of the main crack. Some secondary cracks reach locally to the centreline of the dam crest.

Seepage zones and localized discharges continue to occur along the dam toe berm (about in the 5 to 10 l per min), from the south abutment and in the vicinity of the valve house. The total volume of seepage appears to be the same as that observed during previous visits.

5.0 VANGORDA CAUSEWAY

The causeway (haul road) between the Faro Mine mill and Vangorda open pit is approximately 16 km long and crosses six creeks. The road is mostly routed over embankment fill (up to about 70 m high), composed of material ranging from end-dumped mine waste rock to end-dumped till. There have been no failures or significant stability problems with the embankment. Because of road grades, surface runoff is locally directed into the streams, eroding embankment material.

North Fork Rose Creek is conveyed through the causeway by means of a rock drain, designed for a 1 in 100 year flow. Other stream crossings were designed to convey a 1 in 25 year flood. These minor crossings involve corrugated steel pipe culverts, except for Reservoir Creek which flows through another rock drain.

The upstream side of the North Fork Rose Creek rock drain shows signs of slow, but continuing deformations. The rocks at the surface are generally loose and the embankment slope, at and below the high water level mark, exceeds a 50 degree gradient. However, reference lines established in 1996 were found and they do not confirm any significant slope surface deformations. Despite the deposition of additional debris (Photo 11) on the upstream face, no significant changes were observed at the downstream discharge area. The flow in the creek, at the time of the site visit, appeared to be similar to that observed during previous site visits.

At the time of the site visit (June 25, 1999) the level of the pond upstream from the drain was about 4 m below the historical high level, indicated by deposited driftwood.

The Vangorda Creek crossing was also checked at this time. The embankment at this crossing is approximately 25 m high and the creek is conveyed through a culvert (possible capacity of 1 in 20 year flood) and the flow is discharged over a corrugated steel flume, composed of two sections. The last flume section continues retrogressive erosion in the plunge pool (Photo 12).

6.0 VANGORDA MINE

The Vangorda Mine infrastructure comprises an open-pit mine (gradually flooding - Photo 13), the Vangorda Creek Diversion (progressively deteriorating), and the Vangorda Waste Rock Dump with an acid drainage collection connected to Little Creek Pond (Figure 2 in Appendix B). Because of the lack of power, the water treatment plant was not operating in 1999.

6.1 VANGORDA CREEK DIVERSION

Vangorda Creek has been diverted around the western perimeter of the Vangorda open-pit mine. The creek is controlled upslope from the pit by means of a small dam (about 10 m high), with a culvert and trash rack but without an emergency spillway. The diversion itself consist of an 0.5 km long, 2,400 mm diameter half-culvert set on a pit bench carved into the north side of the open-pit wall. The culvert and channel have been designed to accommodate the 1 in 20 year flow, estimated to be in the range of 5.2 m^3/s. The culvert-lined channel does not have a constant gradient and locally rocks are deposited on its bottom. Consequently, the actual flow capacity may be less than the design one. Because of bends and occasional blockages (specifically icing), spills have been experienced and erosion problems have occurred along the downstream portion of the flume. At points of overtopping, the culvert bedding has been locally washed away, resulting in culvert misalignment. Removal of debris and ice from the channel often causes damage to the channel (Photo 14).

A failure (rock fall) of a section of the rock wall above the Vangorda Creek diversion flume occurred in June 1999 (Photo 15), which resulted in a blockage of the diversion channel. The rock debris filled approximately 25 metres of the length of the flume and several half culvert flume sections were crushed. The damaged sections were subsequently replaced and the flow was diverted into the pit during that time A total of seven sections of culvert were replaced, representing a 30 m section of the flume.

Another rock fall (smaller than the June one – Photo 16) involving an estimated 10 to 15 m^3 of rock, occurred on September 12, 1999 and partially blocked the flume. However, most of the rock fall was retained on a ledge between the channel and the rock wall toe. There are steep rock faces resting on the joints dipping towards the diversion channel.

The wall segments, downstream and upstream from the failed slope segment (Photos 17 and 18), may fall in the future. Possible mitigative measures would entail the following:

- Removal of potentially unstable rock blocks and scaling of the rock wall. This would require a bench cut along the crest of the rock wall and temporary protection of the diversion channel.

- Clean-up of the ledge between the channel rim and the toe of the rock wall and construction of a retention barrier along the channel. The barrier may be constructed using gabions or concrete New Jersey road barriers. This option may be combined with placement of an anchored wire mesh, intended to direct small rock blocks into the rock retention area.

Removal of potentially unstable rock blocks represents better protection of the diversion channel, resulting in less water discharge into the open pit.

6.2 VANGORDA WASTE ROCK DUMP

Overburden rock types mined from the Vangorda pit included sulphides and phyllites, both rock types having the potential to generate acid mine drainage (AMD). Contrary to the original plan, both rock types have been mixed in the dump.

In 1998 some of the sulphide-rich rock was hauled to the designated area. This did not result in any significant changes in the dump configuration.

The original design also considered encapsulation of the waste rock with glacial till to minimize infiltration of water. The capping was supposed to be implemented progressively. A starter cover dyke was constructed to approximate elevation of 1,135 m with one or two additional lifts locally extending above this level. However, major segments of the dump remain uncapped.

There is a depression behind the top of the second till berm on the northeast side of the dump, upslope from the Drain Nos. 5 and 6. Surface runoff was ponded in this depression, reportedly causing concern about the till berm stability. In an attempt to drain this area, a drainage ditch, up to 2.5 m deep and about 1.5 m wide (Photo 19), was excavated along the toe of the second till berm. The second berm face was steepened to about 40 degrees slope and excess material dumped over the face of the first berm, destabilizing this slope as well. This work, in the writer's opinion, substantially decreased the stability of both berms. It would be prudent to drain the depression straight down over both till berms via a sand-gravel-rock rip-rapped channel, backfill the ditch and re-grade the till berm slopes.

6.3 ACID DRAINAGE COLLECTION

The Vangorda rock dump acid drainage control measures comprise six drains extending into the south and west perimeter of the waste rock dump, a collector channel and the Little Creek pond. Water from the pond is supposed to be pumped to the water treatment plant at the Grum mine.

Seepage was discharged from Drain Nos. 3, 5 and 6 during the 1999 site visit. Iron oxide staining was observed at Drain No. 2, indicating discharge in the past. Vegetation kill was noticed at Drain Nos. 5 and 6.

The water level in Little Creek pond was about at elevation of 1,111.0 m, i.e., some 1.6 m below the "critical" level, on June 24, 1999.

No significant deformations were observed on the Little Creek dam. Relatively extensive erosion rills on the downstream dam slope continue to expand and cut deeper into the dam slope. The emergency spillway, comprised of a culvert with a rock apron at its discharge end, was finally constructed (Photo 20). The outlet channel requires placement of additional rip-rap.

7.0 GRUM MINE

The Grum mine area includes an open pit, overburden (till) waste dump, waste rock dump and water treatment plant with a sludge pond (Figure 2). A so-called Moose Pond was established downslope from the waste rock dump with the objective of controlling siltation.

7.1 GRUM OPEN PIT

Overburden stripping from this pit started again in 1996 and the pit was the main source of ore during the 1997/1998 operation. While most of the pit perimeter is composed of phyllitic rocks, its eastern segment consists of thick glacial till deposits.

A major failure occurred in the eastern segment of the pit in 1997 (Photo 20), possibly because pumping of perimeter wells was discontinued during a temporary halt of operations in the winter of 1996/1997. Anvil Range decided to construct a so-called Slot Cut access into the pit and excavate the slide debris, chiefly comprised of clay till. The excavated material was dumped into the rock waste dump.

It was noted, during this site visit, that the pit slide continues to be active, several mud flows were developed and the slide retrogressed behind the original pit rim and sideways into previously stable rock slopes.

7.2 GRUM OVERBURDEN DUMP

The Grum Overburden Dump has been used to store glacial till excavated from the Grum pit in 1992 and 1993. The original ground surface was very gently sloping (7 degrees) and covered with a shallow layer of organics overlying glacial till. Initial placement was undertaken in one lift, about 15 m high. Extensive sliding was experienced, forcing the stripping contractor to modify the dumping procedures. The height of individual lifts was reduced to 5 m and a second and third bench were developed.

Dump slope faces continued to slide for several years, resulting in flatter slopes. The reduced heights of individual lifts and wider benches resulted in the overall slope of the dump face being approximately 18 degrees (3H:1V). Except for surface erosion and localized shallow sloughing the slopes appeared to be stable at the time of the 1999 site inspection.

7.3 GRUM WASTE ROCK DUMP

Most of the excavated overburden rock, chiefly phyllite with some till from the slot cut, was deposited into the main waste dump, located on gently sloping ground towards the Vangorda Creek valley. The dump, to date, was developed in six benches (Photo 22). The conceptual design developed by SRK considered placement and encapsulation of sulphide rock in the centre portion of the lower bench. This concept has not been implemented since sulphide rocks are encountered at other locations as well.

Slides occurred in sectors, chiefly comprised of the till material in 1997. Wide and apparently deep cracks formed on the second and higher dump benches, some as far as 50 to 60 m back from the crest of the lift.

More widespread cracks and other signs of ongoing deformations were observed on all dump levels and slopes, except the top dump segment which is only 10 to 15 m high. Instabilities involve all types of waste materials (Photo 23 and 24).

7.4 SLUDGE POND

The sludge pond was practically empty at the time of the 1998 site visit. Slumps occurred on the east dyke and cracks were evident on the west and south dykes. Erosion steepened the inside surface of the north dyke.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The most serious concern, in the writer's view, is the stability of the north rock slope of the Vangorda Creek diversion canal. It would be prudent to control possible future rock falls. On the other hand, the creek diversion is deteriorating every year and sooner or later a more permanent arrangement would be required.

The Vangorda Waste Rock Dump drainage ditch represents a hazard to the stability of the till berms in this area. It is recommended that this drain be backfilled and a new drain constructed, if deemed necessary.

Since the mining operation appears to be discontinued for a significant time period (or indefinitely), a review of temporary or permanent closure plans should be considered. The main issues of concern, in the writer's opinion, are:

- stability and hydraulic capacity of Rose Creek diversion,
- stability of the fresh water reservoir,
- control of the water level in the Faro pit and maintenance of the Faro Creek diversion,
- control of water levels in the main tailings pond and polishing pond,
- long-term performance of the North Fork Rose Creek rock drain,
- Vangorda Creek diversion, flooding of Vangorda pit and water level control,
- flooding of Grum pit and overflow management.

Respectfully submitted,

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APPENDIX A

APPENDIX A

PHOTOGRAPHS

Photo 1: North Fork Rose Creek diversion channel. View of a slump developing in the upslope cut in the upstream section of this diversion

Photo 2: Depression and sloping crest of the Rose Creek diversion dyke between Station 2+100 and 2+250.

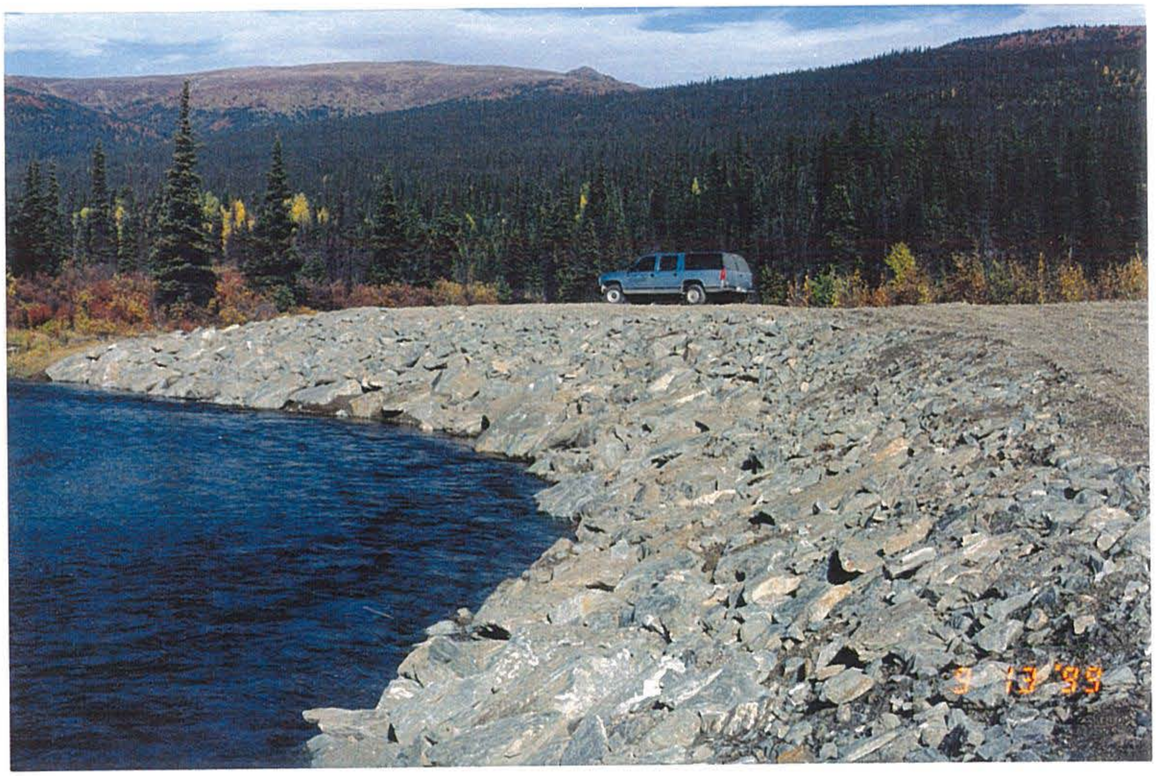

Photo 3: Rose Creek diversion. View of the recently constructed rip-rap bank downstream from the weir section.

Photo 4: Looking at the Second Tailings Pond dyke. Note ponded seepage from the Rose Creek diversion.

Photo 5: View of rip-rap protection of the upstream face of the Intermediate Dam.

Photo 6: Intermediate Dam, downstream face.

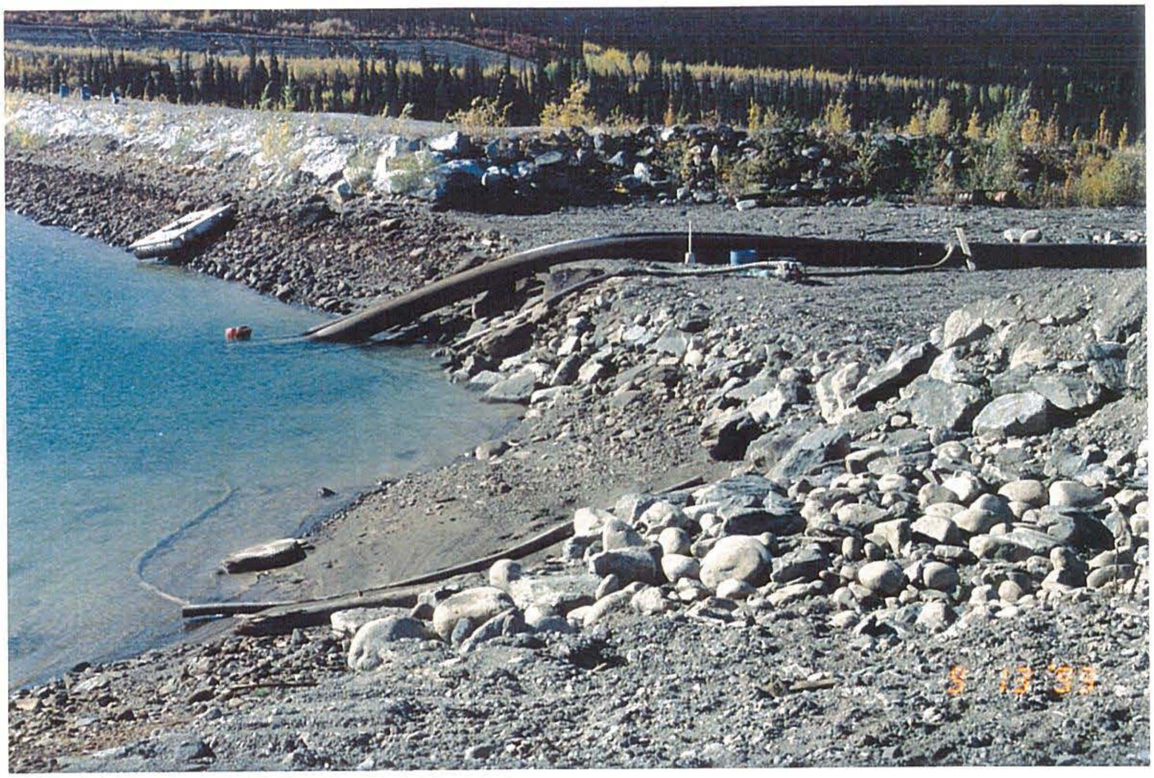

Photo 7: Lowering water level in the polishing pond by syphon.

Photo 8: Partially healed crack in the crest of the Cross Valley Dam.

Photo 9: Primary and secondary cracks in the crest of the Fresh Water Dam, near the north abutment.

Photo 10: Fresh Water Dam crest, main crack at the approach to the south abutment.

Photo 11: Vangorda causeway, view of the upstream slope of the rock fill and deposited driftwood.

Photo 12: Vangorda Creek diversion. View of the discharge flume downslope from causeway.

Photo 13: Vangorda open pit, looking southeast.

Photo 14: Vangorda Creek flume. Cleaning of the channel causes its misalignment and damages this structures.

Photo 15: View of the Vangorda Creek diversion cut wall in the segment which failed in June 1999.

Photo 16: View of a minor rock fall which occurred in the same area on September 12, 1999.

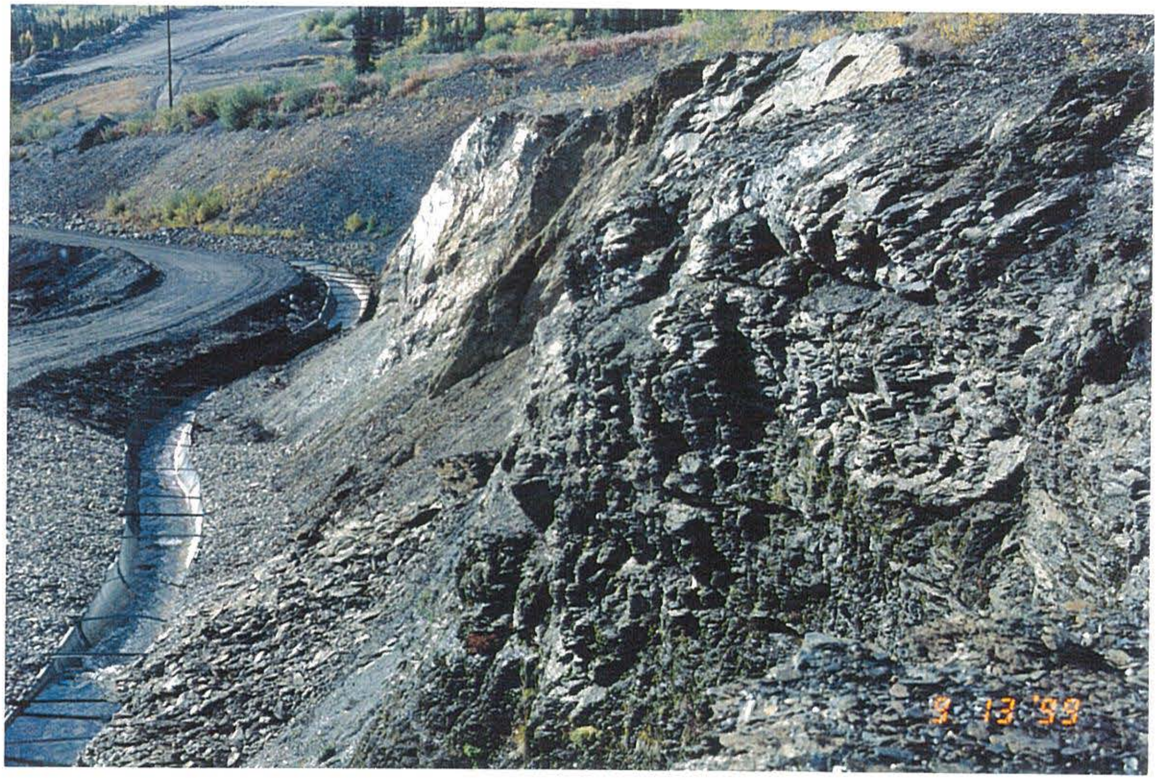

Photo 17: Looking downstream over the June-September 1999 rock fall area. Note step escarpment resting on adversely dipping joint.

Photo 18: View of the potentially unstable area upstream from the 1999 rock fall.

Photo 19: View of the drainage ditch, undercutting the toe of the second till berm on the Vangorda rock dump.

Photo 20: Little Creek Dam; view of the culvert spillway and discharge channel.

Photo 21: Grum pit, view of its eastern segment affected by a major slide. So-called slot cut pond surface runoff which, in turn, contributes to the instability of the adjacent pit wall.

Photo 22: Looking from Vangorda dump to Grum waste rock dump.

Photo 23: Second level of the Grum waste dump comprised, in this segment, chiefly of till.

Photo 24: Fourth level of the Grum waste dump, comprised predominantly of phyllite.

APPENDIX B

APPENDIX B

FIGURE 2 – VANGORDA PLATEAU SITE PLAN