Government of Yukon, Water Resources Branch

Former Whitehorse Copper Mine Geotechnical Assessment

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Project Number:

60160522 (402.19.2.2)

Date:

November, 2010

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November 10, 2010

Mr. Glenn Ford
Geotechnical Technologist
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Government of Yukon
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Y1A 2C6

Dear Mr. Ford:

Project No: **60160522 (402.19.2.2)**
Regarding: **Former Whitehorse Copper Mine – 2010 Geotechnical Inspection Report**

AECOM Canada Ltd. (AECOM) is pleased to submit our report for the above referenced project. If you require further information or clarification, please contact the undersigned directly.

Sincerely,

AECOM Canada Ltd.

Tom Wingrove, P.Eng.
Executive Vice-President
Deputy Operations Director,
North America, Environment

KT:dh
Encl.

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1. Introduction

1.1 Terms of Reference and Scope of Work

This report summarizes the results of our geotechnical inspection of the tailings impoundment facilities at the former Whitehorse Copper Mine near Whitehorse, YT. The terms of reference for the inspection were outlined in AECOM's letter to Mr. Glenn Ford of the Government of Yukon Water Resources Branch dated May 31, 2010. The purpose of the inspection was to i) determine the existing condition of the facilities comprising the main tailings impoundment(s), ii) determine if they are being operated according to acceptable engineering practice and iii) and identify any issues for follow-up. A qualitative risk assessment was also identified as part of the scope of services. In order to achieve these objectives, the program was broken into the following tasks:

1. Review background information provided by the GY Project Manager including: water license; design documents; past inspection reports; licensee annual and monthly reports, and incident reports; in order to become familiar with the structures and potential issues,
2. Visit the mine site and inspect the tailings impoundment facilities in the company of the GY Project Manager,
3. Prepare a site visit report detailing condition of the facilities, changes from the last inspection (based on the file review), required repairs and/or maintenance and other observed issues. If considered appropriate, assess the risks posed by the facilities and provide recommendations regarding the need for and frequency of follow-up site inspections.
4. Participate, as required, in teleconferences with the owners of the structures and/or their representatives and other government representatives to discuss observations and recommendations, and to assess any proposed mitigation measures.
5. Review the issues noted against proposed mitigation measures, taken or to be taken, and submit to the Project Manager a follow-up report reviewing the adequacy of mitigation measures proposed and recommendations regarding any oversight or follow-up work that should be done.

This inspection report is based on a cursory visual inspection and data provided in previous reports by others. Detailed investigations of the individual structures were not carried out and as such, this investigation was not intended to be detailed assessment of their condition. There has been no attempt made to corroborate or further analyze much of the information presented in past engineering reports (eg. stability analysis, water quality, piezometric conditions).

2. Review of Background Information

Background information provided by the Yukon Government Project Manager prior to the inspection included the following:

- Thompson Geotechnical Consultants Ltd. – Annual Report on Tailings Storage and Water Reclaim Facilities at the Whitehorse Copper Mine, Report, January 1982.
- Thompson Geotechnical Consultants Ltd. – Whitehorse Copper Mines Tailings Storage and Water Reclaim Systems – Final operations and Abandonment, Report, August 1982.
- Geo-Engineering (M.S.T.) Ltd. – Whitehorse Copper Mine Tailings Ponds, 1988
- Gadsby Consultants Ltd. – Whitehorse Copper Mine Conceptual Decommissioning Plan, Report, 1992
- Geo-Engineering (M.S.T.) Ltd. - Whitehorse Copper Minesite Decommissioning – Report, August, 1996
- Gadsby Consultants in Association With Steffen Robertson & Kirsten, Drawings – Whitehorse Copper Mine Site Decommissioning Plan, Drawings 1-11, September 1991.

3. Site Description and Background

The former Whitehorse Copper Mine is situated in the Yukon Territory about 10 km south of Whitehorse on the west side of the Alaska Highway (Figure 01). The mine was operated by Hudson Bay Mining and Smelting from 1967 until 1982. The mine site, including the tailings impoundment system occupies an area of about 320 ha. All buildings in the millsite area have been removed as part of decommissioning.

Figure 01 Location Plan

The tailings were deposited into the following facilities (Geo-Engineering, 1996) and as illustrated on Drawing 01:

- Old Pond Impoundment - containing 5 X 10^6 m^3 of tailings,
- A-Valley Impoundment - containing 2 X 10^6 m^3 of tailings, and
- B-Valley Impoundment - containing 0.75 X 10^6 m^3 of tailings.

Since 1982, several measures have been implemented for decommissioning as recommended in a 1982 Final Operations and Abandonment Plan (prepared by Thompson Geotechnical Consultants Ltd.) and a Conceptual Decommissioning Plan prepared by Gadsby Consultants Ltd. in 1992. The most recent account of the completed works is described in a report to the Northern Affairs Program by Geo-Engineering in 1996. According to the 1996 inspection, the following work (relative to AECOM's inspection) had been undertaken at the time of the inspection:

- Construction of rock lined Spillways 6 and 7;
- Breaching of small (internal) dykes to direct surface water drainage into Spillway 6 and 7;
- Construction of a rock lined discharge channel between the A-Valley Impoundment and the B-Valley Impoundment;
- Construction of a rock lined spillway channel through the right abutment of the B-Dam including an armoured discharge chute; and
- Construction of an inverted filter of selected rock fill downstream of the left abutment of the B-Dam to prevent seepage erosion.

4. Geotechnical Inspection

The geotechnical inspection was carried out on July 23rd 2010 by Mr. Ken Skaftfeld of AECOM in the company of the Government of Yukon's Project Manager, Mr. Glenn Ford.

The major components of the Tailings Storage Facility (TSF), including the perimeter dykes, dams, and associated spillways were included in the geotechnical inspections. The general mine site layout is illustrated on Drawing 01. Photographs and a video were taken during the inspection; these have been included on the DVD attached to this report in Appendix A. The photo locations and features of note are referenced to GPS waypoints which are shown on the aerial photographs on Drawings 02 and 03. Their locations are approximate based on the accuracy of the hand held GPS unit. The TSF consists of the following components:

- South Extension Dyke;
- Perimeter Dyke and Spillway 6 and 7;
- A-Dam; and
- B-Dam, Spillway and Discharge Chute.

4.1 South Extension Dyke

The South Extension Dyke is about 400 m long, extending west from Spillway 7 to natural high ground at the access road into the former mill site. The dyke crest is about 5 to 6.5 wide and comprised of rounded gravel and cobbles up to 100 mm diameter. The dyke height varies from 1.5 m at WP 111 to 4.4 m at WP 116 (Figure 02 and 03). Upstream and downstream sideslopes are typically about 1.5 horizontal to 1 vertical (1.5H:1V). Small clusters of vegetation including saplings have become established along sections of the upstream face (Figure 04). A 1 m wide bench has been constructed along the downstream toe from WP 117 to Spillway 7 (Figure 05). The tailings are typically about 1 to 2 m below the dyke crest. The dyke appears stable with no visible signs of cracking or deformations. Seepage was not observed along the toe.

Figure 02 D/S Face at WP 116 (View NW)

Figure 03 U/S Face at WP 116 (View NW)

Figure 04 View W Along Dyke from WP 117

Figure 05 Berm Along D/S Toe at WP 117

A section of the dyke has been removed at WP 113. It appears that gravel from the dyke fill at this location was used to construct a gravel pad about 30 m by 30 m by 0.3 m thick on the upstream side of the opening. The opening is about 5 m wide with 4H:1V transition slopes back onto the dyke on either side of the opening (Figure 06). The purpose of the opening is not clear although it could be for equipment access into the tailings area. It does not appear that the opening serves as a spillway. A gravel pile on the west side of the opening prevents vehicle access along the dyke, however, vehicle ramps have been constructed on the upstream sides of the dyke to gain access as seen on Figure 08.

Figure 06 Opening in Dyke at WP 113

4.2 Spillway 7

Spillway 7 is located at the east end of the South Extension Dyke where it transitions into the Perimeter Dyke. The spillway was constructed to drain water from the impoundment into the Crater Lake watershed following the 1982 Abandonment Plan described as Alternative 3 (Thompson Geotechnical Consultants, 1982). The spillway is about 2 m deep and 6 m wide with 5H:1V (approximately) sideslopes to the dyke crest on either side (Figure 07). The spillway is connected to the pond shown on Drawing 03 with a drainage swale although there was no water entering the spillway at the time of the inspection (Figure 08). The spillway has been constructed with a crushed coarse granular fill which is grey in colour compared with the brown dyke fill. The maximum size is estimated to be 300 mm although the majority of the visible granular material is smaller sized. A spillway discharge pad on the downstream side of the dyke grades into the high ground to the southeast. Drainage from the pad is to the low ground to the east. There are no signs of erosion of the spillway channel or pad.

Figure 07 Spillway 7

Figure 08 Entrance to Spillway from Tailings

4.3 Perimeter Dyke

The Perimeter Dyke is about 900 m long, beginning at Spillway 7 and ending at high ground at its north end (Drawing 03). The dyke height ranges from about 6 m to 14 m north of Spillway 7 immediately east of the pond (WP 121) to 18 m at the A-Valley Impoundment at WP 168. Within the high dyke section in the vicinity of WP 122 and 123, the downstream slope is supported by a toe berm built from what appears to be waste rock as illustrated on Figure 09. The berm is about 5 to 6 m wide with its top about 2.5 m below the dyke crest. The waste rock is up to 800 mm in diameter. The tailings on the upstream side are about 1.5 m below the dyke crest. Downstream slopes range from about 1.5 to 1.7H:1V. There is a noticeable tilt of the dyke crest of about 0.3 m towards the tailings at WPs 121 and 123. There is also a 5 m wide road along the downstream toe of the waste rock berm. It appears that the road was constructed with tailings.

Two vertical corrugated metal pipes (CMPs) are located within a raised gravel pad on the downstream side of the

Figure 09 Downstream Face at WP 126 (View N)

dyke at WP 155 (Figures 10 and 11). Both pipes appear to have been backfilled with concrete. There are also two PVC riser pipes behind the pad. Based on mine site drawings, the CMPs are the remnants of a decant structure abandoned as part of decommissioning (Gadsby, Drawing 10, 1991). There was no evidence of any seepage in the vicinity of the CMPs.

Figure 10 View of CMPs at Toe of Dyke from Crest

Figure 11 CMPs at Toe of Dyke

There is an area of ponded water at the edge of the road near the center of the valley at the location shown on Drawing 03 (WPs 157-159) and Figures 12 and 13. Although the water is clear, tailings extend some distance out into the water. There was no active seepage visible although it appears that the area is perpetually wet. Coincident with this ponded water are minor depressions in the tailings surface on the upstream side of the dyke (Figure 14). The depressions are about 300 to 500 mm in diameter and about 250 mm deep. Ponded water was previously reported at the downstream toe in 1987 but the area was dry at the time of development of the decommissioning plan by Gadsby in 1981 (Drawing 11 in Gadsby 1981). Geo-Engineering (1988) noted localized undrained depressions with seasonally ponded water that apparently recharged seepages occurring at several locations on the main dyke.

Figure 12 Ponded Water at Toe of Dyke

Figure 13 Tailings in Ponded Water

Figure 14 Depressions in Tailings Surface

At WP 160, the dyke height is in the order of 6 m with a downstream slope of about 1.7H:1V (Figure 15). The tilted dyke crest is still visible at this location and the freeboard above the tailings is only about 0.4 m (Figure 16). There is no berm at this location nor is there any evidence of seepage at the downstream toe. The dyke is in good condition from WP 160 to 161 at which point the height decreases towards Spillway 6. The dyke height increases to about 18 m at the narrow valley northwest of Spillway 6 at WP 168 (Figure 17). The freeboard is less than 0.5 m at this location and wind-blown tailings have flattened out the upper portion of the downstream slope face to about 3H:1V (Figure 18). The slope face below the wind-blown tailings is at about 1.7H:1V.

Figure 15 Downstream Face at WP 160

Figure 16 Dyke Crest and Upstream Tailings at WP 160

Figure 17 Dyke Crest and U/S Tailings at WP 168 (View NW)

Figure 18 D/S Dyke Face at WP 168 (View NW)

Tailings span a narrow valley for a distance of about 50 m along the downstream toe of the dyke at WP 166. The tailings extend to the north where they form the A-Valley Impoundment between a bedrock controlled valley constriction. Tailings and the remnants of a timber flume and wood stave pipe on the east flank suggest that tailings were likely deposited across the Perimeter Dyke at Spillway 6 where they flowed or were conveyed along the toe of the dyke to WP 166. Photos taken from WP 166 are shown on Figures 19 to 22.

Figure 19 View SW at Perimeter Dyke from WP 166

Figure 20 View SE at Tailings from Spillway 6 from WP 166

Figure 21 View NE at A-Valley Impoundment

Figure 22 View NW at Bedrock Outcrop

Seepage water accumulates along the toe of the dyke on the west side of the constriction. Flow from this area across the tailings and to the north was estimated to be at a rate of about 0.3 l/sec (Figure 23). The water appeared to be slightly turbid (cloudy) in the pond at the toe of the dyke. The toe of the dam above the A-Valley impoundment was reported as damp, suggesting seepage in previous inspection reports (Gadsby, 1992).

Figure 23 Seepage Water Downstream of Perimeter Dyke at WP 167, View N

4.4 A-Dam

The A-Dam is located at the downstream (west) end of the A-Valley Impoundment as shown on Drawing 02. The dam is about 150 m long and 34 m high (Figure 24). The dam crest is about 8 m wide and there is about 4 m of available freeboard between the tailings and the crest on the upstream side. There is no water impounded on the upstream side of the dam (Figure 25). The downslope side of the dam is about 2H:1V with coarse gravel, cobbles and boulders visible on the surface. For scale, a derelict vehicle can be seen on the downstream slope on Figure 24. There are a number of narrow benches on the downstream face for the full width of the dam which appears stable with no visible signs of cracking or deformations. There was no evidence of seepage at the downstream toe of the dam. The former decant culverts at the downstream toe of the right abutment were not visible, having been plugged and grouted as part of decommissioning (Geo-Engineering, 1996).

A saddle spillway is located on the access road to the west abutment as shown on Drawing 02. The spillway is about 8 m wide across the bottom with 2H:1V sideslopes (Figure 26). The entrance to the spillway and the spillway channel are well armoured with 100 mm down crushed rock and there is no evidence of erosion of this material. There was no water passing through the spillway at the time of the inspection.

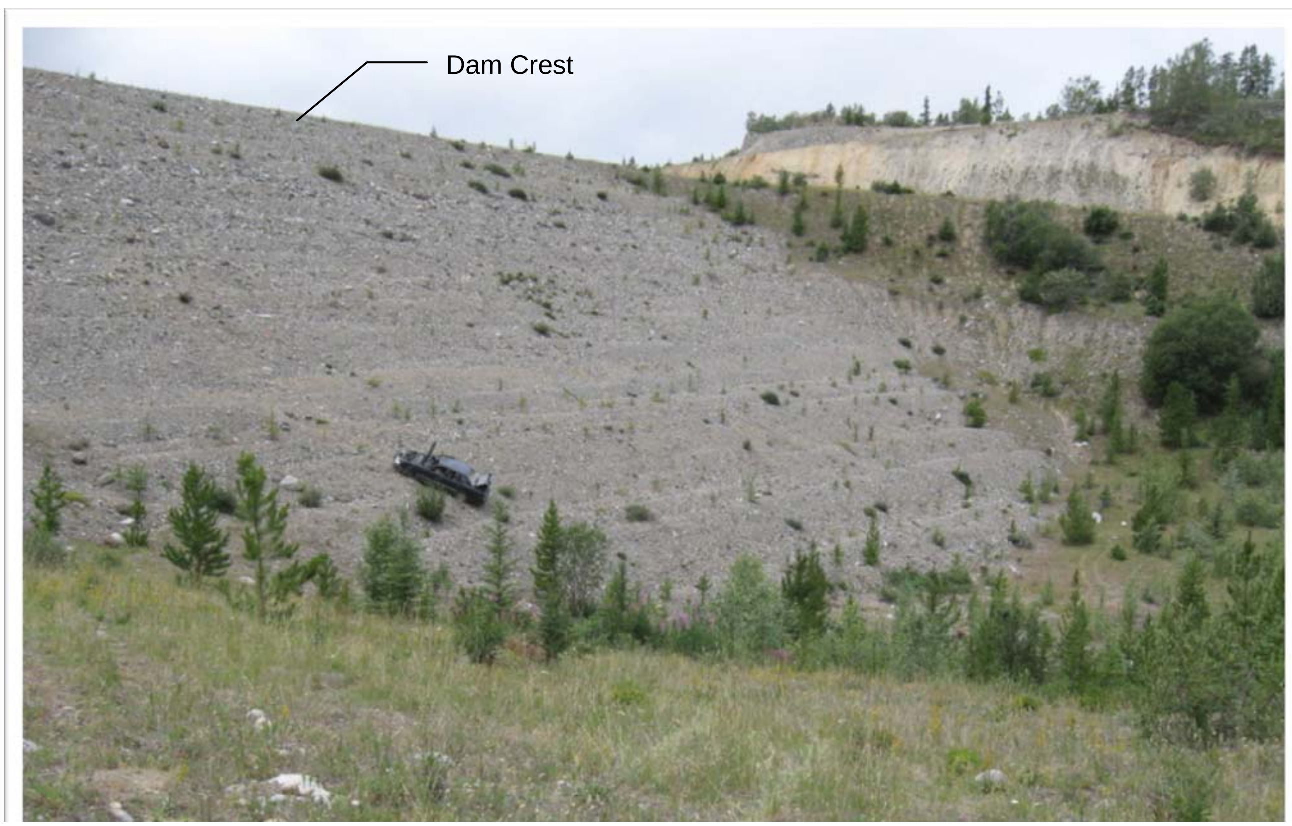


Figure 24 View at Downstream Slope from East Abutment at WP 170

Figure 25 A-Valley Impoundment Upstream of A-Dam from WP 169

Figure 26 Saddle Spillway from WP 169

Figures 27 and 28 show the road through the B-Valley Impoundment that leads from the A-Dam to the B-Dam. Figure 27 is looking south while Figure 28 was taken looking north. There is some ponded water in the impoundment on the east side of the road at this location although the road is sufficiently elevated and in good condition.

Figure 27 View S from WP 174

Figure 28 View N from WP 174

4.5 B-Dam

The B-Dam is located at the downstream end of the B-Valley Impoundment as shown on Drawing 03. The dam is about 150 m long and 22 m high (Figure 29). The downstream slope is made up of a series of benches with a two level rip rap buttress on the east half as shown on Figures 30 and 31. The rip rap benches are about 2 m high by 3.5 m wide (lower bench) and 4 m high by 8 m wide (upper bench). The main bench which extends the full length of the dam is about 15 m wide and about 18 m from the dam crest (measured vertically). The dam appears to have been constructed using locally available gravel with cobbles and boulders. Water is ponded on the south side of the dam although there is several metres of freeboard. The dam appears stable with no visible signs of cracking or deformations. There is no discernable difference in the appearance of the downstream slope of the dam from 1992 with the exception of the construction of an inverted filter on the left downstream abutment and saplings are now becoming established as seen on Figure 29. There is no evidence of seepage at the downstream toe of the dam.

Water was seeping from the left downstream abutment at the locations shown on Drawing 03. Seep A is immediately upslope of the inverted filter constructed in 1996 on the left downstream abutment. Water from Seep A flows overland where it infiltrates the filter. Seep B is located about 30 m farther west at the upstream end of a drainage ditch on the left abutment above the B-Dam (WP 179). Seepage water from Seep B is conveyed along the ditch where it discharges into the tailings pond at WP 183 as shown on Figure 32. Flow from Seep B was estimated to be in the order of 2-3 l/sec. Seep C is located along the edge of the pond where the ground is very soft with iron staining visible (Figure 33). Flow was estimated to be in the order of 0.25 l/sec. Flow into the pond from the drainage channel was estimated to be in the order of 4-5 l/sec indicating additional seepage water enters the drainage channel downstream of Seep B.

Figure 29 Downstream Side of B-Dam from WP 213, View SW

Figure 30 Water Ponded on Filter from Seep A at WP 177

Figure 31 Seep B at WP 179

Figure 32 Drainage Ditch Outlet into Tailings Pond from WP 183

Figure 33 Iron Staining at Seep C at WP 182

An inverted filter was constructed during mine decommissioning to guard against potential piping failures on the left downstream abutment. Previous inspection reports described gullies formed on the downstream slopes of the abutment above the pond elevation (Figure 34). The filter, seen on the left abutment in Figure 29 consists of 8 to 10 terraces, each 1-3 m wide consisting of cobbly gravel with 300mm diameter maximum size. Seepage at the abutment has been previously documented and is believed to be a consequence of seepage from a shallow lake about 800 ft west of the abutment (Gadsby, 1992). There was no visible seepage water at the toe of the filter. A spring is located in the densely vegetated area about 50 m north of the filter as shown on Drawing 03. The spring feeds a creek that meanders to the west edge of the spillway pad where it accumulates in a small pond. There is no surface water discharge from the pond suggesting that the flow from this point on is subterranean through the natural sands and gravels visible on ground surface. Two 100 mm diameter well casings were located about 50 m north of the spillway pad at the location shown on Drawing 03.

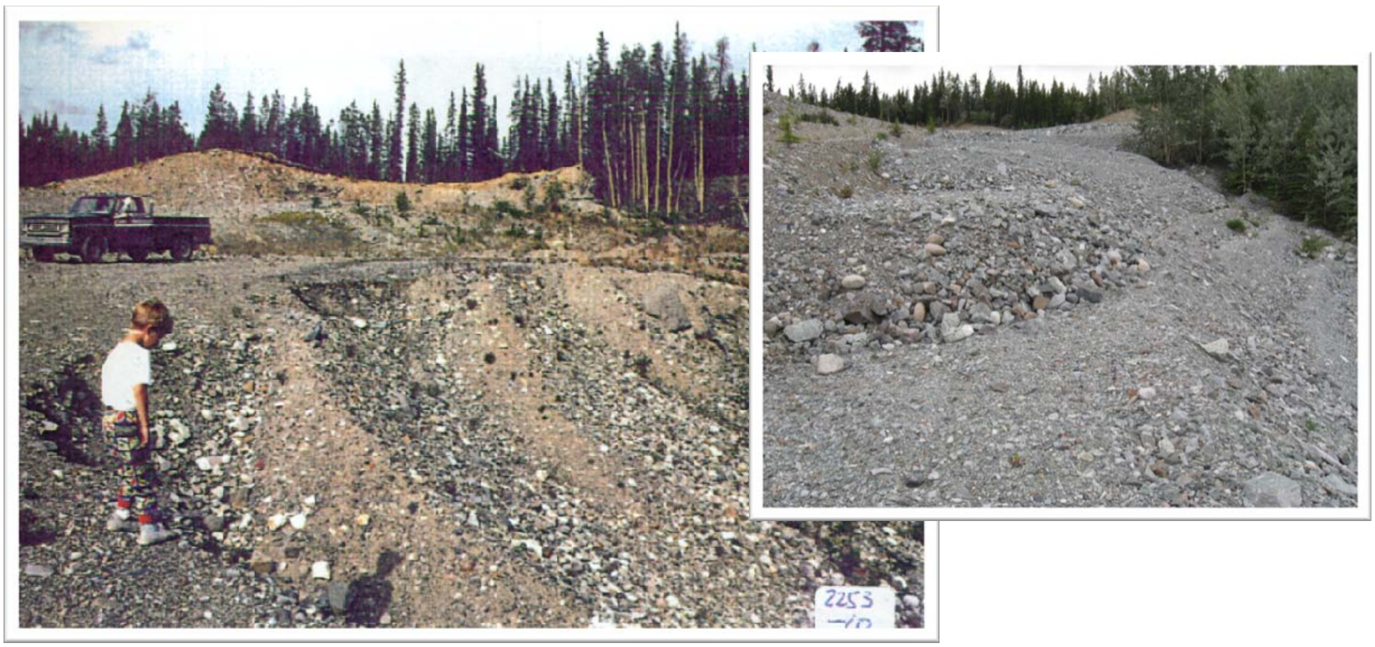


Figure 34 Erosion Gullies on Left Abutment in August 1991 (Gadsby, 1992) and Repaired Area in 2010 (right photo)

Water from the tailings pond during active mining and for some period after closure was discharged through 2-600 mm diameter decant pipes passing through the base of the embankment. In 1996, a rock-lined spillway was constructed at the right abutment including an armoured discharge chute. The decant pipes were plugged and grouted (Geo-Engineering, 1996). The entrance to the spillway is shown on Figure 35 and 36. The channel at this location is about 8 m wide, 2.5 m deep with 2H:1V sideslopes. The armouring material in this relatively flat section consists of 100 mm down crushed granular. There is no evidence of erosion at this location.

Discharge over the spillway was estimated to be in the order of 5 l/sec. Water discharges through the end of the chute over two benches and then onto a spillway apron about 50 m by 50 m and 11 m high. The first (upper) bench shown on Figure 37 and 38 is about 5 m below the end of the spillway chute. Water was flowing over the upper bench and had ponded on the second bench about 2.5 m lower. The water infiltrates into the bench at this location where flow become subterranean. There was no evidence of seepage at the toe of the spillway pad. Erosion gullies have formed on the sloped surfaces between the benches as seen on Figures 39 and 40. The material on the benches and spillway pad is a cobbly gravel with trace boulders up to a maximum size of about 400 mm. This material is smaller in size than originally specified (Geo-Engineering, 1996).

Figure 35 Entrance to Spillway from B Pond from WP 175

Figure 36 View D/S Along Spillway Chute from WP 175

Figure 37 D/S End of Spillway Chute at Drop Section from WP 212

Figure 38 View U/S at End of Spillway Chute from WP 210

Figure 39 Water Flowing Over First Bench at WP 210

Figure 40 Erosion Gully on Slope Between Upper and Lower Benches and Water on Second Bench from Top (from WP 210)

5. Structure Classifications

The tailings dams, dykes, and spillways are structures considered to be part of the overall tailings storage facility. These structures have been classified using the 2007 Canadian Dam Association (CDA) Guidelines in terms of the reasonably foreseeable consequences of failure. The CDA classifications are shown Figure 41. The results of the classification of the structures at the former Whitehorse Copper Mine are summarized in Table 1. The loss of life consequences were evaluated separately from infrastructure and economics consequences, and cultural values and environmental consequences. The structure classification in Table 1 is taken as the higher of the three consequence categories. Also shown in Table 1 are the associated time periods between Dam Safety reviews as recommended in the CDA (2007) Guidelines.

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. Implications 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.

Figure 41. Dam Classifications (CDA 2007)

Table 1. Structure Classifications

Structure	Consequence Category			Structure Classification	Max. Period Between Reviews
	Loss of Life	Environmental & Core Values	Infrastructure & Economics		
Perimeter and South Extension Dykes	Low	Low	Low	Low	NA[1]
A-Dam	Low	Significant	Low	Significant	10 Years
B-Dam and Spillway	Low	Significant	Low	Significant	10 Years
Note 1: A Dam Safety review is not required for low-consequence dams. However, the consequences of failure should be reviewed periodically, since they may change with downstream development. If the classification increases, a Dam Safety Review is required at that time					

Several assumptions were made when determining the appropriate structure classifications. These assumptions included:

- The tailings porewater and pondwater are suitable for discharge into the environment with little consequence to the quality of the downstream water bodies. This assumption is based on the assessment in Gadsby (1992) which concluded that both surface and groundwater met Canadian Council of Resource and Environment Ministers (CCREM) drinking water guidelines applicable at that time (with the exception of some aesthetic criteria). Gadsby also noted and that the trends in the water quality were showing improvement with time.
- The tailings themselves are chemically stable (Gadsby 1992).
- The TMF is generally unoccupied, with no regular visitors.
- The immediate area downslope of the structures is not used regularly for any recreation or commercial purposes.

6. Risk Assessment

6.1 Approach

A qualitative risk assessment was carried out for the tailings storage facility to assist in determining an appropriate risk management strategy. The approach considers a number of possible events (e.g. dam failure) for which a risk score can be determined. The risk score is the product of the likelihood, exposure and the possible consequences of the event. The risk scores are then used to determine the risk level for each structure. Recommendations for action (e.g. monitoring or repairs) are based on the risk level. The individual components used in determining the risk score are as follows:

Likelihood - Likelihood is the probability of the event occurring. The risk assessment approach for this study uses a ranking of likelihood that is directly related to a failure of a tailings dam or spillway. A summary of the risk likelihood categories and associated scores is given in Table 2.

Table 2. Likelihood Categories

Likelihood of Failure	Description	Score
Negligible **(N)**	Practically Impossible	**0.2**
Unlikely **(U)**	Conceivable But Very Unlikely	**0.5**
Low **(L)**	Remotely Possible	**1**
Moderate **(M)**	Unusual But Possible	**3**
Probable **(P)**	Quite Possibly Could Happen	**6**
Highly Probable **(HP)**	Might as Well Be Expected	**10**

Exposure - For each event in the risk assessment, there is a potential exposure to that risk. The exposure is the frequency that there is a likelihood of the event occurring. A summary of the exposure categories and associated scores is given in Table 3.

Table 3. Exposure Categories

Likelihood of Failure	Description	Score
Unlikely **(U)**	Very Rare (Yearly or Less)	**0.5**
Very Low **(VL)**	Rare (Few Times Per Year)	**1**
Low **(L)**	Unusual (Once Per Month)	**2**
Moderate **(M)**	Occasional (Once Per Week)	**3**
Probable **(P)**	Frequent (Daily)	**6**
Highly Probable **(HP)**	Continuous	**10**

Consequences - Each event may have a number of possible consequences as a result of the event in terms of an impact on operations of the TSF, for example, an injury or fatality or the cost of an environmental clean-up. The environmental impact has been combined with the overall economic consequence of a particular event. The possible consequences and associated scores are given in Table 4.

Table 4. Consequence Categories

Consequences	Category	Score
Minor incident or inefficiency of little or no consequence. **Operations:** No impact on operations. **Health & Safety:** Near miss or recordable first aid to multiple employees. **Environmental and Economic:** <$10k	VERY LOW **(VL)**	**3**
Minor incident or inefficiency that may require review and is easily remediated. **Operations:** Operations delay of up to two weeks **Health & Safety:** Recordable case, minor injuries to multiple employees. **Environmental and Economic:** $10,000 to $100,000	LOW **(L)**	**7**
Moderate event that may need some physical attention and certainly review. **Operations:** Operations delay of up to a few months. **Health & Safety:** Serious lost time injuries to multiple employees. **Environmental and Economic:** $100,000 to $1,000,000	MODERATE **(M)**	**15**
Significant event that can be addressed but with great effort. **Operations:** Significant delay of six months to one year. **Health & Safety:** Serious injuries to multiple employees, possible fatality to an employee. **Environmental and Economic:** $1,000,000 to $10,000,000	HIGH **(H)**	**40**
Major uncontrolled event with uncertain and perhaps prohibitively costly remediation. **Operations:** Operations delay more than one year. **Health & Safety:** Multiple fatalities. **Environmental and Economic:** > $10,000,000.	EXTREME **(E)**	**100**

Risk Level - The risk level can then be assessed based on the risk score as shown in Table 5. Three categories, **I**, **II** and **III** are used for low, moderate and high levels of risk respectively. For example, the risk level associated with a risk score of 100 would be **II** or moderate.

Table 5. Risk Levels

Risk Level	Description	Risk Score
I	Low Level of Risk	less than 70
II	Moderate Level of Risk	70 to 200
III	High Level of Risk	greater than 200

Confidence - Finally, it is necessary to identify the degree of confidence and variability for the Risk Levels as shown in Table 6.

Table 6. Confidence Levels

Confidence Level	Degree of Confidence	Degree of Variability
Low **(L)**	Low Confidence	Could Vary Significantly
Moderate **(M)**	Moderate Confidence	Moderate Variability
High **(H)**	Confident	Low Variability

6.2 Discussion

The Risk Assessment for the Whitehorse Copper TSF focuses on the potential failures of structures that result in the release of untreated water and tailings to the downstream environment. It must be recognized that this evaluation is based on the current condition and operation of the TMA and does not take into account any alterations to the method of operation or major modifications to structures. The consequences of such events include but may not be limited to environmental damage, property damage, injury or loss of life. The following paragraphs provide a brief description of the pertinent structures which form the TSF and some of the potential events (for example, slope instability, over topping, surface erosion, internal erosion, seismic events etc.) and resulting impacts.

Perimeter Dyke

The Perimeter Dyke, including the South Extension Dyke and North Extension Dyke is generally in good condition, and no evidence of historical or active instabilities was noted. There are several locations where seepage through or beneath the perimeter dyke is suspected (WP 158 and 166). Near WP 168 the seepage water was cloudy indicating that there was some erosion occurring. It has not been confirmed that the suspended solids originated within or beneath the dam (ie. resultant from piping or internal erosion). Based on the analysis presented by Gadsby (1992) the tailings in the Old Pond Impoundment are drained, and therefore may not be liquefiable. Gadsby also reported the calculated factor of safety of the perimeter dyke was greater than the minimum values that have since been established by the CDA Guidelines (2007)

Tailings released due to a failure of the North part of the Perimeter Dyke would naturally flow into the A-Valley tailings area where the flow of tailings and surface water would be contained (to a limited extent) by the A-Dam and subsequently the B-Dam. A breach along the south part of the Perimeter Dyke would generally release tailings and pond water towards Crater Lake, which has been used to collect and reclaim tailings pond water during the operation of the mine.

Spillway 6 and Spillway 7

Spillways 6 and 7 see little use, except during the spring thaw and heavy rain events. The spillways are currently in good condition. The spillways should be inspected at the same time as the main dam structures to assess the ongoing condition of the armouring and channel. Currently the armouring appears to be under-sized (based on the preliminary design) but it has provided adequate protection to this point.

A-Dam and B-Dam

A deep-seated slope instability on the A-Dam, B-Dam or the Perimeter Dyke could result in a breach of the structure and the release of tailings and surface water into the environment. This would result in a moderate to significant environmental impact in the run-out area. Gadsby (1992) reported that the tailings were not generally acid producing and that the surface water generally met drinking water standards (except with respect to aesthetics) and a release of tailings and pond water would not be expected to have a major environmental impact (using the consequence terminology in Table 4) on the ground or surface water. A run-out analysis or failure analysis has not been performed, and the extents of the impact have not been estimated. The results of the stability analysis by Gadsby (1992) indicate that the computed factors of safety for both the A and B-Dams are greater than the recommended minimum values that have since been established by the CDA Guidelines (2007). The stability analysis has not been checked or updated as part of the current assessment.

There is ongoing seepage at the left abutment of the B-Dam from at least 3 locations (Seep A, B, and C). These seeps are from natural groundwater sources. Currently the flows from these seeps are diverted by surface channels either to the B-Pond (Seep B and C) or through the inverted filter downslope of the dam crest (Seep A). The flows from these seeps do not appear to be impacting the structure of the B-Dam at this time, but monitoring should continue.

B-Spillway

The B-Spillway is generally in good condition although some erosion gullies have developed between the benches, indicating that the armouring material may not be adequate. The spillway and drop structure may require additional armouring in the future.

1.1 Risk Assessment Score

For each of the structures which form the TSF, a risk score has been calculated and is presented in Table 7. The Risk Assessment Score has been evaluated for failures that could result in the release of untreated water and/or tailings. The risk score is the matrix (product) of the likelihood of the event occurring, the exposure to the event occurring and consequences that may result from the event occurring.

Table 7. Risk Assessment Score

Structure	Likelihood	Exposure	Consequence	Risk Score	Risk Level	Confidence Level
Old Pond Impoundment						
Perimeter Dyke	1	2	7[1]	14	I	Moderate
Spillway 6	0.5	1	3	1.5	I	Confident
Spillway 7	0.5	1	3	1.5	I	Confident
A-Valley Impoundment						
A-Dam	1	0.5	40[1,2]	20	I	Moderate
Saddle Spillway	0.2	1	3	0.6	I	Confident
B-Valley Impoundment						
B-Dam	3	0.5	40[1,2]	60	I	Moderate
B-Spillway	3	1	7	21	I	Moderate

Note 1: It has been assumed that any tailings released as a result of a structure failure, could be placed back into containment, and that the run-out area could be restored to a condition similar to the present.

Note 2: Assuming that the run-out from a catastrophic breach of any of the structures would not reach the infrastructure and private property in the Yukon River Valley. The Alaska Highway is located approximately 1100 m downstream from the A and B-Dams, and there are some homes located on Canyon Crescent, as close as 750 m from the dams.

7. Discussion and Recommendations

All the structures at the Whitehorse Copper Mine fall under Risk Level I at this time. The following guidelines for follow-up work are provided for the three Risk levels:

Risk Level I

- Upgrade deficiencies.
- Conduct an annual condition assessment.

Risk Level II

- Implement a comprehensive monitoring program.
- Prepare an Emergency Preparedness Plan (EPP).
- Develop an action plan for remedial works.
- Consider Implementation of remedial works to reduce risk.

Risk Level III

- Immediate action should take place to reduce/control risk.

As the structures all fall into Risk Level I, the recommended works include upgrades to deficiencies, and annual condition assessments. The following remedial works should be considered, but are not expected to be critical to the general safe operation of the TSF at this time:

- improve wind erosion protection in the tailings in the Old Pond Impoundment by establishing vegetation or covering layer of gravel and cobbles (as originally recommended by Gadsby(1992))
- provide and maintain additional armouring along spillways including Spillway 6, 7 and the B-Spillway

There are several locations that should receive closer monitoring to identify changes in condition or behaviour:

- seepage along perimeter dyke, specifically near waypoints 157-159 and 168 (Drawing 03)
- depressions in tailings upslope of seepage points, specifically near waypoints 157-159
- Seeps A, B and C near the left abutment of the B-Dam

As Dam A, Dam B are classified as “Significant Consequence” structures, they should undergo *Dam Safety Reviews* at regular intervals as recommended in Table 1. The limited scope of the current assessment and report does not constitute a dam safety review. To our knowledge, a dam safety review has not been conducted since the decommissioning activities. An updated dam safety review should include an update of the stability analysis considering the most recent CDA Guidelines using contemporary analysis methods.

To our knowledge, there has not been an assessment of surface or ground water quality since Gadsby (1992). It is recommended that the water quality be investigated because it may have additional implications on future classifications, and monitoring and maintenance activities.

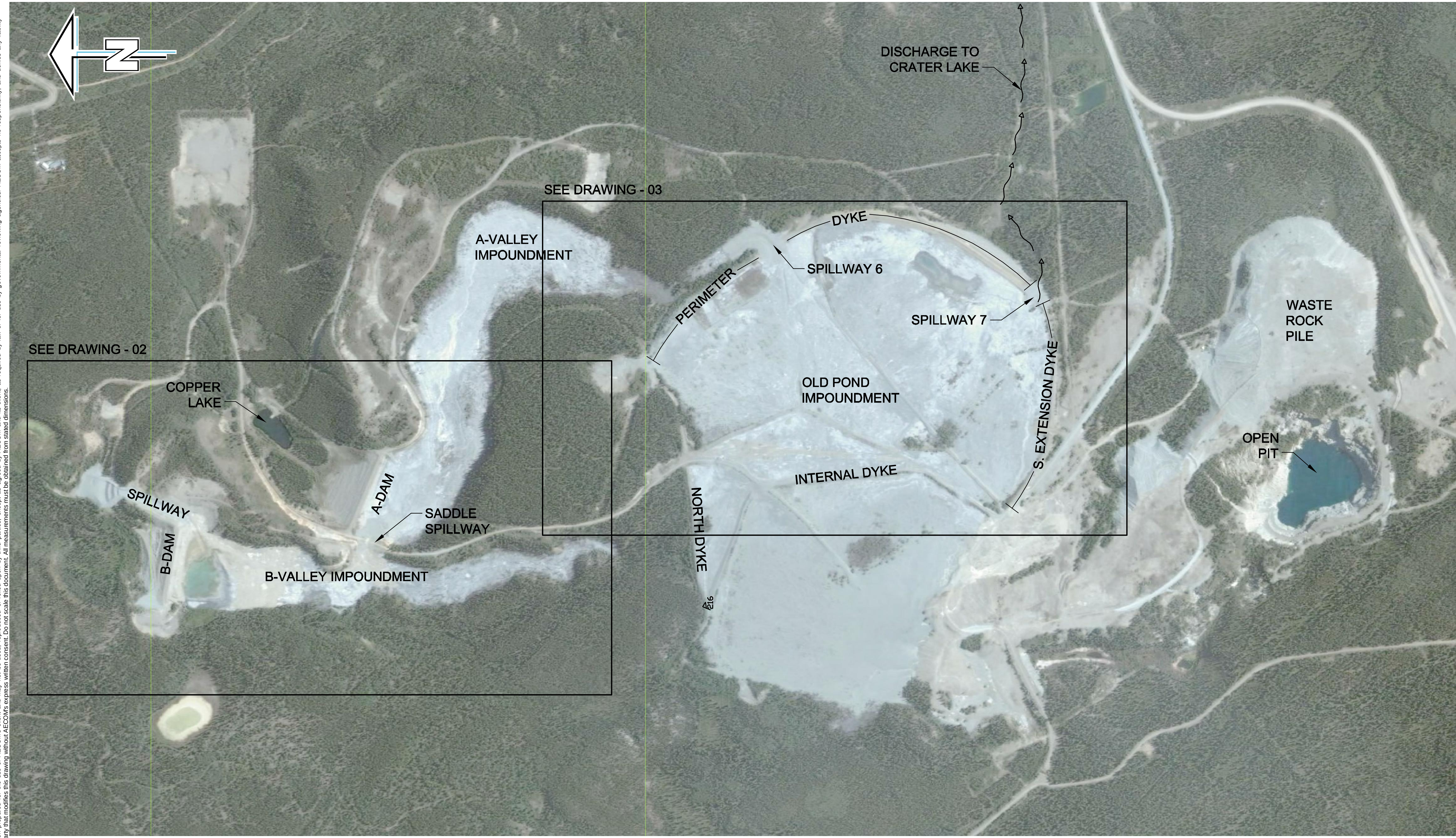
8. Closure

The findings, assessment and recommendations of this report are based on a review of the available information and the results of the 2010 inspections by AECOM. Interpretation of this information has been intended for the sole purpose of assessing the condition and performance of the various structures of the TSF in order to qualitatively assess the risk posed by these structures. This approach is an engineering reliability technique to systematically identify, characterize and screen risks that derive from the failure to operate as intended. This risk assessment does not reduce risk in itself.

This review has been based on the current operating conditions for the Whitehorse Copper Tailings Storage Facility. Should a revised operation plan for the TSF be considered, the risk assessment should be updated, beginning with any necessary reclassification of the structures.

AECOM trusts that this information has been of value to the Government of Yukon. Should you have any questions regarding this report, please contact the undersigned.

Drawings



SITE PLAN

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IMAGE SOURCE: GOOGLE IMAGE PRO AUGUST 8, 2004

B SIZE 11" x 17" (279.4mm x 431.8mm)

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AECOM

Yukon Government
Whitehorse Copper Dam

Overall Site Plan

Drawing - 01

B SIZE 11" x 17" (279.4mm x 431.8mm)

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IMAGE SOURCE: GOOGLE IMAGE PRO AUGUST 8, 2004

AECOM

Yukon Government
Whitehorse Copper Dam

Site Plan
A & B Dams
Drawing - 02

0 30 60 m SCALE 1:3000

IMAGE SOURCE: GOOGLE IMAGE PRO AUGUST 8, 2004

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AECOM

Yukon Government
Whitehorse Copper Dam

Site Plan
Perimeter & South Extension Dykes
Drawing - 03

Appendix A

Photos and Video