6 March 2018

REPORT ON

2017 Dam Safety Inspection Pine Point Tailings Impoundment Area Pine Point, NT

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REPORT

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Executive Summary

This report presents the results of the 2017 annual dam safety inspection (DSI) for the south, west, north, and east dykes of the Tailings Impoundment Area (TIA) at the closed Pine Point Mine in the Northwest Territories.

The report was prepared by Golder Associates Ltd. (Golder) at the request of Teck Metals Ltd. (Teck).

The DSI site visit was completed on 27 July 2017 by the Engineer of Record, Bjorn Weeks, of Golder. Routine inspections were conducted by Maskwa Engineering Ltd. (Maskwa) on 23 May and 16 October 2017 in accordance with the operation, maintenance, and surveillance (OMS) manual.

A new Water Licence was obtained for the Pine Point Mine (MV2017L2-007) from the Mackenzie Valley Land and Water Board. The new Water Licence is valid to 24 October 2027.

Summary of Facility Description

The site is located approximately 75 km east of the town of Hay River and south of Great Slave Lake in the Northwest Territories. The Pine Point TIA is currently closed and in an active care and maintenance phase. The TIA is formed by dykes located on the north, east, west and south sides and covers an area approximately 2.5 by 2.8 km in plan, or roughly 700 ha. Approximately 60 million tonnes of lead-zinc tailings are stored within the Pine Point TIA.

Summary of Key Hazards and Consequences

As part of annual DSI reporting, key potential hazards are identified. The key potential hazards identified for the south, west, north, and east dykes are consistent with facilities similar to the Pine Point TIA and include:

- Overtopping
  - Minimum water freeboards within the TIA have been established based on up-to-date guidelines (CDA 2013).
  - The water level was not observed to exceed the maximum operating water level of 201.8 m at any point during the monitoring period and, as such, the site fully complied with minimum freeboard guidelines indicated by the Canadian Dam Association (CDA 2013).
- Internal erosion (piping)
  - Observations during the 2017 DSI indicate that that there are not piping-related concerns with the dyke stability.

- Instability
  - The visual inspection during the 2017 site visits did not identify any sign of stress such as cracks, settling, or bulging of the dykes. The condition of the dykes has remained generally unchanged from previous site visits. The dyke slopes appear to be stable and, as a result, it is Golder's opinion that the overall stability of the perimeter dykes has continued to be satisfactory.
- Erosion
  - Wave cut erosion—During the 2014 and 2015 inspections, erosion was observed at the central section of the north dyke at or just above the water level. In 2016 repairs were made to a test section of the north dyke to evaluate if coarser fill is necessary for restoration. These repairs were in good condition at the time of the inspection. The erosion in areas that had not been repaired in 2016 did not increase significantly between 2016 and 2017.
  - Surface erosion rills (gullies)—Some relatively shallow rills were observed during the 2017 inspection. Areas of rilling which have been repaired were observed to be in good condition.
  - None of the observed erosion extended into the dyke crest, and the erosion is not believed to compromise dam safety.

Consequence Classification

The TIA is considered to be in the Closure – Active Care phase of mine life. The Canadian Dam Association *Dam Safety Guidelines* (CDA 2013) classify dams based on the consequences (i.e., potential damage that can be caused in the unlikely event that a dam fails). Per the *Dam Safety Guidelines*, the south and east dykes are classified as Low consequence structures, while the west and north dykes are classified as Significant consequence structures. There have been no changes in the guidelines or regulations or the nature of the structures over the past year, and as such these classifications remain unchanged from the 2016 DSI.

Summary of Key Observations

The south, west, north, and east dykes of the TIA were observed to be in good condition at the time of the 2017 annual inspection. No significant changes in dam stability were noted.

Water treatment at the Pine Point TIA is carried out in summer each year to reduce pond levels and prepare the facility for the winter and spring freshet. Water treatment typically commences in late June each year. To assist with managing pond levels, an alert level has been established (201.6 m) to provide a window of opportunity for the early commencement of water treatment prior to the pond reaching the maximum operating water level (201.8 m). A pond water elevation of 201.7 m was reported during the 23 May routine inspection. This level was above the alert water level of 201.6 m but below the maximum operating water level (201.8 m), and as such did not present an immediate dam safety concern. As a result of the water level being above the alert level, preparations were made to begin water treatment, and an additional visit was conducted by Maskwa on 6 June 2017 as a precautionary measure and in accordance with the OMS manual. During this follow-up visit, the pond water elevation was recorded to be approximately 201.62 m. During both the routine and follow-up inspection visits, there was no evidence of seepage at the spillway or on the downstream face/toe of the dykes.

Following the 23 May inspection, Golder also carried out daily checks of the weather data and forecast from Environment and Climate Change Canada, monitoring for possible high rainfall events to be reported to Teck. The annual water treatment campaign began on 4 July 2017, at which point the daily checks stopped. Treatment and discharge was conducted until 1 September 2017. A total of 440,218 m^3 of water was decanted from the main pond to the polishing pond, treated with lime to adjust pH, followed by release, via the polishing pond spillway, to Channel 35-1B and the wetlands south of Great Slave Lake.

Dam condition, maintenance and surveillance of the facility were reviewed through site observations. This 2017 annual DSI report and photographs were prepared based principally on observations during the July DSI visit and supplemented by those made as part of the May routine inspection and the supplementary inspection in June. The October inspection report was not available to Golder at the time of this report, though a pond level reading was provided. The only monitoring device at the TIA is a water level gauge at the culvert inlet to the polishing pond, which is read each time the site is visited, typically three times per year.

Overall, the dykes appear to be in good condition and are achieving their intended purpose of retaining the tailings and ponded water.

There is the potential for ongoing erosion of the upstream face of the north dyke. Historical erosion in this area has previously been repaired and may require additional maintenance in the future. The upstream slope is inspected annually to confirm that erosion does not compromise stability in the future.

Summary of Significant Changes

None of the information monitored indicated a concern with the integrity of the dykes. At the time of the 2017 DSI visit, no significant changes to site conditions were observed that could reasonably be expected to compromise the stability of the dykes or surface water control systems. Conditions therefore remain materially unchanged from the 2016 DSI.

Summary of Review of Operation, Maintenance, and Surveillance and Emergency Preparedness and Response Plan Manuals

The OMS manual for the Pine Point TIA was updated in February 2017 to align with the Canadian Dam Association *Dam Safety Guidelines* (CDA 2013), as well as the Teck *Guideline for Tailings and Water Retaining Structures* (Teck Resources Ltd. 2014).

A further update of the OMS manual was completed in February 2018 to reflect changes in the updated Water Licence (MV2017L2-007).

The emergency preparedness and response plan for the Pine Point TIA was updated in February 2017 (Golder 2017b) to align with the *Dam Safety Guidelines* (CDA 2013), the updated OMS manual (Golder 2018), and the Teck *Guideline for Tailings and Water Retaining Structures* (Teck Resources Ltd. 2014).

Summary Table of Deficiencies and Non-conformances

A summary of deficiency / non-conformances and recommended actions from the 2017 DSI are presented in Table E-1.

Table E-1: Summary of 2017 Dam Safety Inspection Recommended Actions

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline/Status
North dyke	2014-01	Erosion observed on the pond side of the north dyke with potential to cause dyke instability.	OMS manual Section 5.5.2	Continue observation and evaluation of replacement fill placed in 2016 throughout 2018 monitoring period. Should restored area indicate adequate performance, repair the remaining sections of observed erosion in 2019 with the same fill material used in the trial. Should significant erosion occur within the test section during 2018, complete a new test restoration using coarser fill in 2019, or evaluate alternative approaches such as periodic repair work on the fill.	3	end of Q2 2019

Priority[(a)]	Description
1	High probability or dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
2	If not corrected/implemented could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
3	Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

a) Source: After HSRC 2016.

ID = identification; OMS = operation, maintenance, and surveillance; DSR = dam safety review; CDA = Canadian Dam Association.

Dam Safety Review

A dam safety review of the south, west, and north dykes was conducted by SRK Consulting in 2014 (SRK 2016). The Canadian Dam Association *Dam Safety Guidelines* (CDA 2013) recommend that a dam safety review be conducted once every 10 years for embankments with a Significant dam classification, such as the west and north TIA dykes. The next dam safety review for these dykes should be undertaken no later than the end of 2024.

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1.0 INTRODUCTION

As requested by Teck Metals Ltd. (Teck), Golder Associates Ltd. (Golder) prepared this 2017 annual dam safety inspection (DSI) report for the south, west, north, and east dykes of the Tailings Impoundment Area (TIA) at the Pine Point Mine, Northwest Territories. This report should be read in conjunction with the Study Limitations, provided at the end of the report.

1.1 Purpose, Scope, and Methodology

The DSI report was prepared in accordance with CDA (2013), as well as the Teck *Guideline for Tailings and Water Retaining Structures* (Teck Resources Ltd. 2014), and is intended to meet the requirement of the Pine Point Water Licence (MV2017L2-007) for the production of an annual geotechnical inspection report.

This report consists of the following:

- a summary of the site conditions and background information
- a summary of the construction, operating, and/or repair activities (if any) for the reporting period
- dam consequence classification
- site photographs and records of dam inspection
- review of the following:
  - required operational documents
  - climate data
  - water balance
  - assessment of dam safety relative to potential failure modes
  - monitoring data
- findings and recommended actions

The report is based primarily on observations made by Golder during the DSI site visit carried out in July 2017 and supplemented by observations made by Maskwa Engineering Ltd. (Maskwa) during a routine inspection in May 2017 and a supplementary inspection in June 2017.

The previous annual DSI for the TIA was carried out in July 2016, and is reported in the 2016 DSI report (Golder 2017c).

1.2 Regulatory Requirements

Applicable codes, guidelines, and regulations governing the Pine Point TIA are listed in the following sections.

1.2.1 Mines Act

Mackenzie Valley Resources Management Act, S.C. 1998, c.25, last amended 1 September 2016.

1.2.2 Water Act

Mackenzie Valley Waters Act, S.N.W.T, 2014, c.18.

1.2.3 Permits and Licences

The Pine Point TIA has a current Water Licence, number MV2017L2-007 from the Mackenzie Valley Land and Water Board. This Water Licence is valid to 24 October 2027.

The Pine Point TIA is currently closed and does not have a permit to operate.

1.2.4 Guidelines

- Canadian Dam Association (CDA) *Dam Safety Guidelines* (CDA 2013)
- *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams* (CDA 2014)
- Mining Association of Canada Guidelines (MAC 2017)

1.3 Facility Description

The site is located approximately 75 km east of the town of Hay River and south of Great Slave Lake in the Northwest Territories (Figure 1). The Pine Point TIA is currently closed and in a state of active care and maintenance. The TIA covers an area approximately 2.5 by 2.8 km in plan, or roughly 700 ha, and contains approximately 60 million tonnes of lead-zinc tailings.

The TIA is formed by dykes located on the north, east, west, and south sides and retains lead-zinc tailings from historical mining operations and a surface water pond. A plan showing the layout of the TIA is presented in Figure 2.

The TIA is located to the north of the former Pine Point mill site on terrain that slopes gently towards the northwest. As a result of the topography, earthfill perimeter dykes, which retain the tailings and any ponded water, extend fully along the north and west sides of the disposal area and along a portion of the south and east sides.

The total length of the dyke system is approximately 8.5 km, with a maximum height of approximately 15 m at the northwest corner. The south dyke varies in height from flush with existing terrain at the southeast corner of the TIA to 4 m at the southwest corner. The west dyke connects to the south dyke and has a maximum height at the northwest corner of the TIA of 15 m. The north dyke extends from the west dyke to the east dyke, and includes the perimeter dyke enclosing the polishing pond. The north dyke varies from 15 m in height at the connection with the west dyke to 1.0 m in height at the northeast corner of the TIA. The 1.0 m dyke height continues on the east dyke until the natural ground surface rises above the dyke crest elevation. The east dyke is approximately 200 m long.

Ponded water is typically present on the north side of the TIA, with the pond in contact with the north dyke. A culvert, through an internal dyke, connects the main pond and the polishing pond, which is located on the north side of the impoundment. The culvert is fitted with a gate valve that can be used to control the flow from the main pond to the polishing pond.

Water within the pond is discharged annually to reduce pond levels prior to the winter. Lime is used to treat water prior to discharge. During treatment, a lime solution, prepared in a slurry tank, is fed with a peristaltic pump to the water flowing in the culvert connecting the main pond to the polishing pond. Historical consumption of lime indicates an average usage of 0.17 kg of lime for every 1 m^3 of released water.

Water treatment is usually begun in late June and runs for between four and six weeks until no water can be conveyed through the culvert between the main and polishing ponds by gravity flow. This occurs when the water in the pond reaches an approximate elevation of 200.0 m. An average annual volume of approximately 241,000 m^3 of water is discharged to Channel 35-1B and the wetlands south of Great Slave Lake as authorized by the current Water Licence (MV2017L2-007).

The Engineer of Record for the Pine Point TIA is Dr. Björn Weeks, P.Eng., an employee of Golder. During 2018, the Engineer of Record role will formally transition from Björn to Dr. Ben Wickland, P.Eng. As part of this transition, both Björn and Ben will be actively involved in the management of the Pine Point TIA.

The site manager for the Pine Point TIA is Ms. Michelle Unger, an employee of Teck.

Due to the isolated location of the site, Mr. Clell Crook acts as a local consultant and is responsible for carrying out routine inspections and event-driven/special inspections. Mr. Crook is an employee of Maskwa.

1.4 Background Information and History

Mine construction at Pine Point started in 1962, and mining began in 1964. High grade ore was shipped by rail starting in 1965. The mine operated at 5,000 tonnes per day initially, with an expansion to 10,000 tonnes per day in 1973.

The TIA is located approximately 6 km south of Great Slave Lake on the Taiga Plains (Great Slave Lake plain). The site is underlain by glacial till, gravel and sand, or clay deposits, which are underlain by sedimentary rocks of the Devonian period. The site is within the discontinuous permafrost zone. Historical information suggests that permafrost underlies approximately 50% of the TIA site.

The TIA dykes are founded on glacial deposits. The north dyke is the tallest dyke at some 11 to 15 m. The pond was operated with a minimum 1 m freeboard. The dykes consist of a silt or clay upstream zone, which acts as a low permeability element, and a downstream zone developed with sand and gravel from local eskers. The downstream slopes have been developed with 2 horizontal to 1 vertical slopes.

The tailings dykes were raised and extended in several stages during the life of the mine as required to contain the increasing volume of mill tailings. The last three crest level increases to the dykes were:

- **1976**—The crest of the north dyke was raised to elevation 203.5 m above mean sea level or some 2.1 m above the previous crest. Also, the dyke was extended eastward to the northeast corner of the pond. Construction of a segment of the east dyke was also carried out.
- **1981—**During the summer of 1981, the west and south dykes were raised and the south dyke extended eastwards.
- **1987—**The height of the perimeter dykes was again raised in July and August 1987, to a final elevation of 205.7 m, to provide additional tailings storage. Fill was added to the south, west, and a portion of the north dyke at this time. The increase in height of the dyke was generally 1 m or less.

A stability review of the west dyke, carried out as part of the 1987 raise (Golder 1987), indicated that the dyke achieved a factor of safety for static loading of 1.5 with the inclusion of a toe berm. This toe berm was developed in 1987, when the dyke crest was last raised, and is 1.5 m high.

The north and west dykes were designed to retain tailings pond water. The south dyke was not designed to retain water as the impoundment was operated such that water did not pond against it. The east dyke is 1 m high and is effectively a freeboard dyke, with no tailings or water ponded against it.

The mine ceased operations in 1988, and the mill buildings and tailings conveyor (trestle) were subsequently dismantled and removed. The only remaining mining installation at the site is the closed TIA.

2.0 CONSTRUCTION AND OPERATION

The Pine Point Mine has not been in operation since 1988. There were no operations in 2017, and no new tailings or other wastes were deposited within the TIA. The only activities at the TIA at present are annual water treatment and discharge of accumulated pond water, routine maintenance, and inspections.

There was no construction completed in 2017. Maintenance work consisted of the ongoing clearing of vegetation.

The dam is inspected three times a year (spring, summer, and fall). At the time of this report, the fall inspection report was not available, although a water level reading was provided and is reported.

Typical cross-sections of the west and north dykes are presented in Figures 3 and 4, respectively.

3.0 CLIMATE DATA AND WATER BALANCE

3.1 Review and Summary of Climate Data

The climate characteristics at the Pine Point Mine were reviewed with respect to precipitation, the main driver for the water balance at the site. Air temperatures were also reviewed to provide support for the assessment of precipitation. Long-term climate characteristics from 1953 to 2016 were established for a hydrological year (September to August) at the Pine Point Mine, and were compared to recent climate observations from September 2016 to August 2017. The recent climate at the Pine Point was estimated based on observations from Environment and Climate Change Canada Hay River station (Station ID: 2202402) (ECCC 2017). Data from this station were adjusted to account for regional and under-catch factors as well as sublimation, as recommended by Golder (2017a). The estimated annual rainfall, snowfall, total precipitation, and air temperature at the Pine Point Mine is presented in Table 3-1.

Table 3-1: Average Climate Characteristics: September 2016 to August 2017 and Long-Term at the Pine Point Mine (September to August period)

Climate	Average Air Temperature (ºC)	Annual Precipitation (mm)		
		Rainfall	Snowfall[a]	Total Precipitation
Long-term annual average (September 1953 to August 2016)	-2.9	231.8	229.9	461.7
Recent (September 2016 to August 2017)	-1.3	303.1	301.4	604.5

a) Water equivalent inclusive of snow loss.

The recent climate data suggest that total precipitation has been about 31% higher than the long-term average at the Pine Point Mine, and that it has also been warmer. Monthly rainfall, snowfall, total precipitation, and air temperature at the Pine Point Mine (i.e., long-term and recent climate) are presented in Illustration 3-1 and indicate the following:

- Recent air temperatures were higher than the long-term values throughout the year, with the exception of December 2016, March 2017, April 2017, and June 2017. The largest variation in temperature was in January 2017, when average daily air temperatures were 6.8°C higher than long-term values.
- Higher snowfall was recorded for the period September 2016 to August 2017 compared to the long-term data, although monthly snowfall amounts in September 2016, November 2016, April 2017, May 2017, and June 2017 were lower than the long-term values.
- Higher rainfall amounts were recorded during the period September 2016 to August 2017 than the long-term values. The largest increase occurred in September 2016 when an additional 55.8 mm of rainfall fell compared to the long-term values.

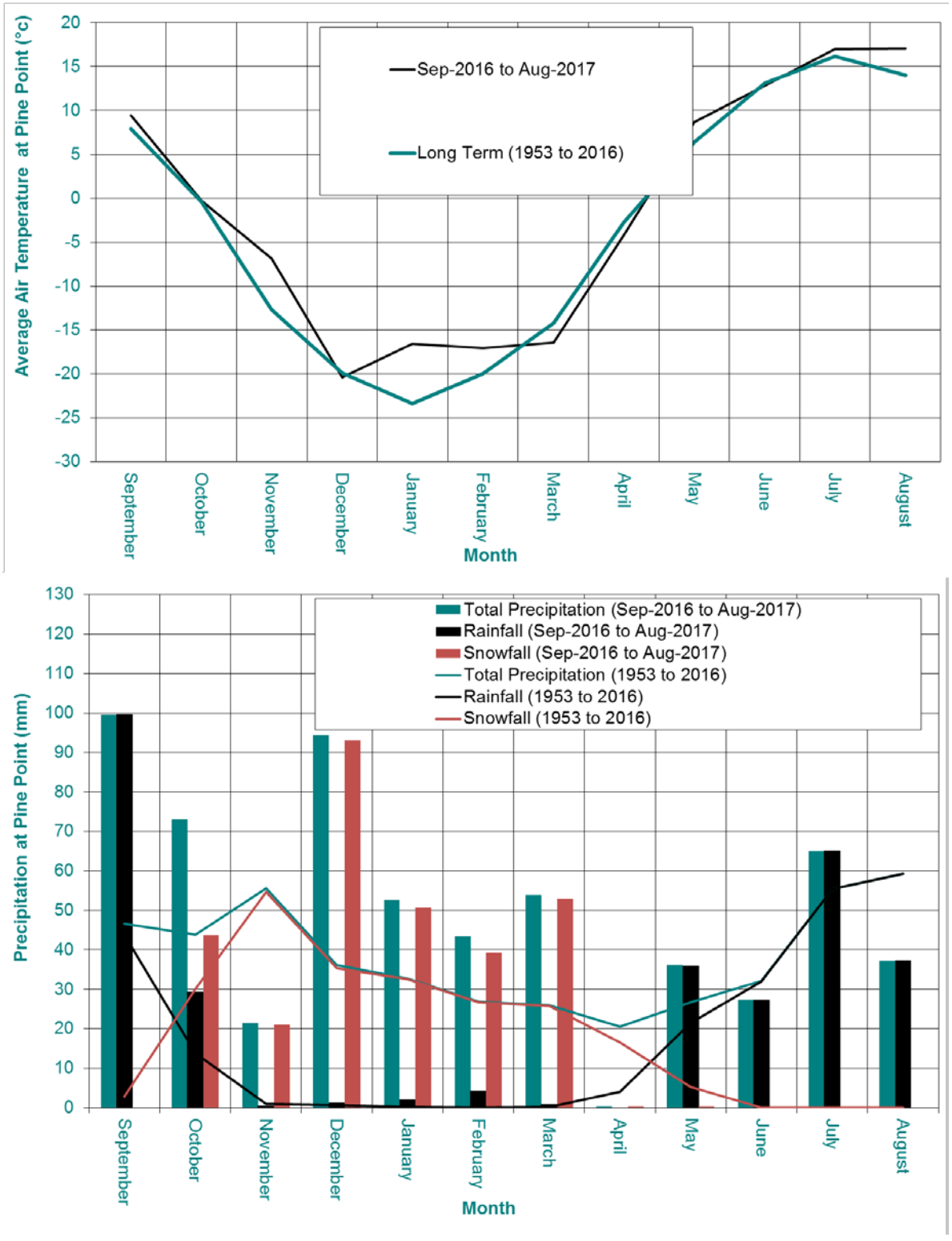

Illustration 3-1: Monthly Temperature and Precipitation at the Pine Point Mine

3.2 Review and Summary of Water Balance

The TIA has a limited catchment area (approximately 3 km^2), and direct precipitation from rainfall and snow on the pond (approximately 6 km^2) contributes the majority of the water collected in the pond. The water balance from Golder (2017a) indicated that the pond water level should vary by approximately 1 m on average throughout the year.

A simplified water balance for the Pine Point TIA is presented in Table 3-2, for both the average long-term data from 1993 to 2016 (Golder 2018), and the period September 2016 to August 2017, for comparison.

Inputs to the water balance were:

- annual precipitation (rainfall and snowfall) from September 2016 to August 2017 (Table 3-1)
- volume of water discharged during annual water treatment (440,218 m^3)

The volume of discharged water was converted into an equivalent water depth by dividing it by the watershed area of the TIA (approximately 9 km^2). The total losses (evaporation, evapotranspiration, and infiltration) were calculated as the difference between the sum of rainfall and snowfall (inflows) and the water released.

Table 3-2: Water Balance for Pine Point Main Pond

Year	Rainfall (m^3)	Snowfall[(a)] (m^3)	Water Released (m^3)	Total Losses[(b)] (m^3)
Long-term September-August average (1993 to 2016)	2,233,957	2,628,000	240,911	4,621,045
Recent (September 2016 to August 2017)	2,727,829	2,712,438	440,218	5,000,049

a) Snowfall amounts are adjusted to account for sublimation and snow redistribution.

b) Total losses include evaporation, evapotranspiration, seepage and infiltration.

3.3 Freeboard and Storage

As part of the 2017 operation, maintenance, and surveillance (OMS) manual and emergency preparedness and response plan (EPRP) updates (Golder 2017a, b), the alert and maximum operational water levels were updated for the TIA pond water level recorded at the gauge. These levels, freeboard and required actions, if observed, are presented in Table 3-3.

Table 3-3: Quantitative Performance Objectives – Pine Point Tailings Impoundment Area Pond Level

Objective	Pond Level (m)	Freeboard (m)	Actions if Observed
Alert pond level[a]	201.6	1.9	The site manager should be informed immediately, and water treatment should start as early as practicable. A site inspection should take place two weeks after the initial alert level is observed.
Maximum operational pond level	201.8	1.7	The site manager should be informed immediately and actions to reduce the water level within the pond should commence as a matter of urgency.

a) The trigger level was established based on historical records and is equivalent to the highest water level record for the site. The level is intended to provide a window for water treatment operations to be commenced.

Analyses indicated that with a freeboard of less than 1.7 m (pond level of 201.8), there is a possibility of the north dyke overtopping due to waves caused by the most critical wind with a return period of 1 in 1,000 years (further details are provided in Section 5.3.1). An overtop of the north dyke by waves has the potential to cause erosion of the dam fill which, if not repaired, could become progressive and damage the integrity of the dam.

It is necessary to specify an alert pond level that is lower than the maximum operating pond level, such that there is warning when the maximum level is being approached. The level should also be high enough that it is not passed regularly during normal operations. The 201.6 m alert level (1.9 m of freeboard) was adopted in the 2017 OMS manual and EPRP updates, as at the time of selection it was equivalent to the highest water level on record for the site. Applying this alert level to the historical data, three alerts would have occurred since May 2001, including the one in spring of 2017. The trigger level was established to provide a window for the commissioning of water treatment operations in time to maintain the water level below the maximum operational level (201.8 m).

Pond storage capacity calculations (presented in the updated OMS manual, Golder 2018) indicate a difference in pond volume of 132,316 m^3 between the alert (201.6 m) and maximum operational pond (201.8 m) levels. Based on an approximate watershed area of the TIA of 9 km^2, this is equivalent to 14.7 mm of precipitation.

3.4 Water Discharge Volumes

Annual water treatment in the settling pond area commenced on 4 July and ceased on 1 September 2017. A total of 440,218 m^3 of water was decanted from the main pond to the polishing pond, treated with lime to adjust pH, followed by release to the environment via the polishing pond spillway.

3.5 Water Discharge Quality

Water discharge quality results are submitted to the Mackenzie Valley Land and Water Board as part of the annual Water Licence report in March each year.

4.0 SITE OBSERVATIONS

4.1 Visual Observations

A DSI site visit was carried out on 27 July 2017 by the Engineer of Record, Dr. Björn Weeks, P.Eng., (Golder) and Mr. Clell Crook (Maskwa).

The temperature during the visit was approximately 25°C and the weather was sunny with some clouds and a light breeze. There was some intermittent light rain in the days prior to the inspection. The July inspection report is presented in Appendix A and includes site photographs and observations.

A routine inspection was carried out by Maskwa on 23 May 2017. The site visit report, including photographic record and inspection form, is presented in Appendix B.

A supplementary visit to read the pond water level was carried out on 6 June 2017 (per OMS manual requirements). Field notes from this visit are provided in Appendix C. In addition, Golder carried out daily checks of the weather data and forecast from Environment and Climate Change Canada to monitor for possible high rainfall events to be reported to Teck. The annual water treatment began on 4 July 2017, at which point the daily checks stopped.

Details of the site observations relative to the potential failure modes are discussed in Section 5.3.

Compiled general observations from the site inspections in 2017 include:

- Dykes are in overall good condition. Repairs made to a number of minor erosion features, by placing dam fill on the downstream side of the north dyke in 2016 were observed to be in place and intact. Minor erosion rills in other portions of the north dyke, including a 4 to 5 m section at the ramp remnant, do not appear to have grown significantly and do not impact dam integrity.
- Restoration trial works along the upstream face of the north dyke appear to have been successful in preventing ongoing erosion in this area, and should continue to be monitored in the coming years. Erosion in the non-trial areas does not appear to have increased significantly and does not impact dam integrity.
- Historically, the development of erosion features has been slow, allowing time for observation and repair before the erosion features run a risk of compromising dam integrity.
- Clearing of vegetation should continue in accordance with the OMS manual. Vegetation regrowth will be an ongoing issue. Priority should be given to the western portion of the south dyke, where some of the densest vegetation was observed. Teck has indicated that spraying and vegetation clearance was completed in summer 2017.
- Other than the ongoing clearing of vegetation, there is no other maintenance noted for 2017.
- The formation of erosion gullies on the downstream slopes of the south, west, and east dykes has been observed during previous site inspections. In the last seven years of inspections, including 2017, the degree of erosion has not been observed to increase significantly.

4.2 Instrumentation Review

The TIA is considered to be in the Closure – Active Care phase of the mine life. There is no geotechnical instrumentation in the dykes at the Pine Point TIA. The only monitoring device is a water level gauge, at the culvert inlet to the polishing pond, which is read each time the site is visited, typically three times per year (spring, summer, and fall).

The recorded readings from May 2009 to October 2017 are presented in Illustration 4-1, and individual values are presented in Appendix D.

Pond water levels in 2017 were, on average, higher than those observed between 2011 and 2016 but, with the exception of the May 2017 reading (201.67 m), are in keeping the overall trend at the TIA.

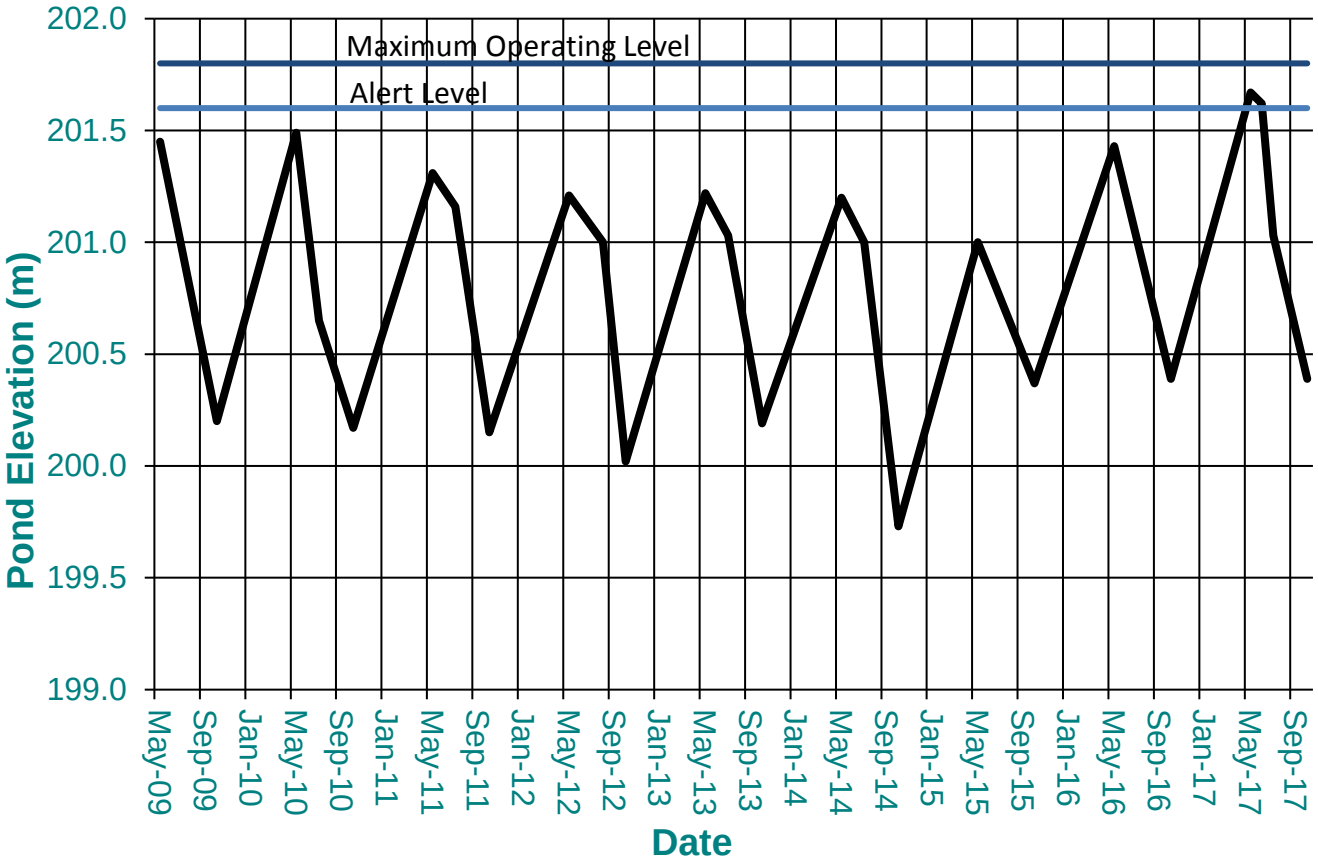

Illustration 4-1: Pond Water Levels

4.3 Pond and Discharge Water Quality

Water quality results are submitted to the Mackenzie Valley Land and Water Board as part of the annual Water Licence report in March each year.

4.4 Site Inspection Forms

Site inspection forms completed at the time of the 27 July 2017 site visit by Golder and the 23 May 2017 inspection by Maskwa are provided in Appendices A and B, respectively.

5.0 DAM SAFETY ASSESSMENT

5.1 Dam Classification Review

The CDA *Dam Safety Guidelines* (CDA 2013) present a dam classification system based on consequence of failure to define design requirements for water retaining structures and dams. The descriptions of the 2013 dam classes are provided in Table 5-1.

Table 5-1: Dam Failure Consequence Classification

Dam Failure Consequences Classification	Population at Risk	Consequences of Failure		
		Loss of Life	Environment and Cultural Values	Infrastructure and Economics
Low	None[a]	There is no possibility of loss of life other than through unforeseeable misadventure	Minimal short-term loss or deterioration and no long-term loss or deterioration of: ■ fisheries habitat or wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance	Minimal economic losses mostly limited to the dam owner's property, with virtually no pre-existing potential for development within the dam inundation zone
Significant	Temporary only[b]	Low potential for multiple loss of life	No significant loss or deterioration of: ■ important fisheries habitat or important wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance ■ restoration or compensation in kind is highly possible	Low economic losses affecting limited infrastructure and residential buildings, public transportation or services or commercial facilities, or some destruction of or damage to locations used occasionally and irregularly for temporary purposes
High	Permanent[c]	10 or fewer	Significant loss or deterioration of: ■ important fisheries habitat or important wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance ■ restoration or compensation in kind is highly possible	High economic losses affecting infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to scattered residential buildings
Very High	Permanent[c]	100 or fewer	Significant loss or deterioration of: ■ critical fisheries habitat or critical wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance ■ restoration or compensation in kind is possible but impractical	Very high economic losses affecting important infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas
Extreme	Permanent[c]	More than 100	Major loss or deterioration of: ■ critical fisheries habitat or critical wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance ■ restoration or compensation in kind is impossible	Extremely high economic losses affecting critical infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas

Source: CDA (2013).

a) There is no identifiable population at risk.

b) People are only occasionally and irregularly in the dam-breach inundation zone, for example stopping temporarily, passing through on transportation routes, or participating in recreational activities.

c) The population at risk is ordinarily or regularly located in the dam-breach inundation zone, whether to live, work, or recreate.

Note 1. Definitions for populations 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.

The dykes at the site are classified as Low to Significant, based on the CDA (2013). Only the north dyke retains water at any time; the south and west dykes only retain tailings, while the east dyke does not retain water or tailings but is required for freeboard. The criteria for classification are evaluated as follows:

- **Population at risk**—None. There is no known permanent population at risk downstream of the site.
- **Loss of life**—There is no possibility of loss of life other than through unforeseeable misadventure.
- **Environmental and cultural values**—A dyke failure would impact the local environment. There is a possibility of minimal short-term loss or deterioration of wildlife habitat as a result of a failure of the south and east dykes. Failure of the north or west dykes presents a higher risk, due to the impoundment of water; however, failure would not lead to a significant loss or deterioration of important wildlife habitat or areas of cultural significance; restoration or compensation for impacts is considered highly possible.
- **Infrastructure and economics**—None. There is no development or infrastructure downstream of the TIA.

Consequence classifications are summarized in Table 5-2.

Table 5-2: Dam Failure Consequence Classification for the North, East, South, and West Dykes

Dam	Dam Class	Population at Risk	Consequences of Failure		
			Loss of Life	Environment and Cultural Values	Infrastructure and Economics
North dyke	Significant	none	low to none	low to significant	none
East dyke	Low	none	low to none	low	none
West dyke	Significant	none	low to none	low to significant	none
South dyke	Low	none	low to none	low	none

Further to criteria in the *Dam Safety Guidelines* (CDA 2013), the CDA has published a *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams* (CDA 2014), which provides recommendations on criteria for different phases of mine life. The TIA is considered to be in the Closure – Active Care phase of mine life, based on regular monitoring of the dykes and regular treatment and release of water from the facility. The design criteria for the dam therefore follow the CDA (2013). Should the TIA move to the Closure – Passive Care phase, where the system is considered stable, with no water treatment or regulation of the pond, such that water may be passively released from the system, then the design criteria for the dam should be revisited based on recommendations of the CDA (2014).

5.2 Design Basis Review

The design criteria related to floods and seismic and static stability based on the CDA (2013) guidelines are summarized in Table 5-3.

Table 5-3: Minimum Design Criteria for Pine Point Dykes

Dykes	Dam Class	Annual Exceedance Probability – Floods	Annual Exceedance Probability – Earthquakes	Factors of Safety			
				Static		Pseudo-static	Post-earthquake
				Long-Term	Full or Partial Drawdown		
North and west	Significant	between 1/100 and 1/1,000	between 1/100 and 1/1,000	1.5	1.2 to 1.3	1.0	1.2 to 1.3
South and east	Low	1/100	1/100	1.5	1.2 to 1.3	1.0	1.2 to 1.3

Note: Design criteria based on CDA 2013.

In addition, the CDA (2013) provides two calculations for freeboard; the most critical of the two scenarios sets the minimum freeboard to be adopted (as presented in Golder 2018):

- **Scenario 1**–no overtopping by 95% of the waves caused by the most critical wind with a return period of 1,000 years with the pond at its maximum normal operating elevation.
- **Scenario 2**—no overtopping by 95% of the waves caused by the most critical wind with a return period of 10 years (for Significant consequence structures), with the pond at the maximum level during the passage of the inflow design flood.

Details of how the Pine Point TIA achieves the required design criteria are discussed relative to the potential failure modes in Section 5.3.

5.2.1 Annual Exceedance Probability – Floods

An assessment of flood capacity to meet the CDA (2013) guidelines is provided in the OMS manual (Golder 2018) and the net annual precipitation volumes for the 1-in-100-year and 1-in-1,000-year return events determined, as presented in Table 5-4.

Table 5-4: Flood Capacity Analysis for Extreme Annual Total Precipitation Events

Return Period (years)	Total Annual Precipitation (mm)	Total Annual Losses[(c)] (mm)	Net Annual Precipitation[(d)] (mm)	Net Annual Precipitation Volume[(e)] (m^3)
100[(a)]	742	709	33	301,178
1,000[(b)]	844	806	38	342,580

a) Design criteria for south and east dykes.

b) Design criteria for north and west dykes.

c) Total annual losses include evaporation, evapotranspiration, and infiltration. Total losses are calculated based on the relationship between total precipitation and total losses presented in Illustration 5-1

d) Net annual precipitation is total annual precipitation minus total annual losses.

e) Net annual precipitation volume is net annual precipitation multiplied by a watershed area of 9 km^2.

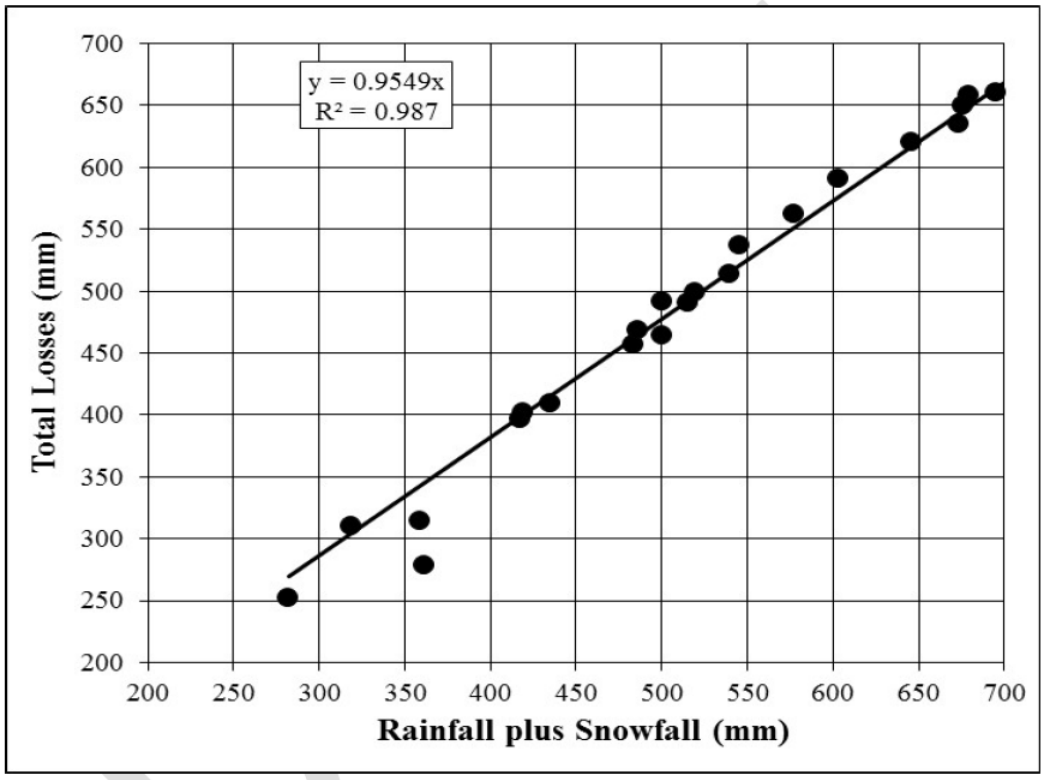

Illustration 5-1: Correlation between Losses and Total Precipitation (after OMS Manual Golder 2018)

5.2.2 Annual Exceedance Probability – Earthquakes

According to the 2010 National Building Code of Canada seismic hazard calculator (NRC 2011), peak ground acceleration for the Pine Point Mine site is:

- 0.003 g for the 1-in-100-year event (40% probability of exceedance in 50 years)
- 0.019 g for the 1-in-1,000-year event (5% probability of exceedance in 50 years)

5.3 Hazards and Failure Modes Review

The dykes at the Pine Point TIA were evaluated for four failure modes which could impact the dyke safety:

- **Overtopping**—occurs when the pond level rises above the dyke crest level, resulting in flow over the dyke that may cause progressive erosion of the dyke and loss of the pond and tailings.
- **Piping**—occurs when there is development of internal erosion. This erosion can lead to loss of material, formation of a hole in the dyke, and rapid loss of water and tailings from the storage pond.

- **Instability**—occurs due to imbalance of forces resulting in movement of a part of the dyke with possible loss of integrity of the dyke.
- **Erosion**—occurs from either wave action or surface run-off, resulting in a loss of the dyke cross-section.

5.3.1 Overtopping

Design Basis

The CDA (2013) provides two calculations for freeboard (vertical distance between the dyke crest and the pond water); the more critical of the two following scenarios sets the minimum freeboard (as presented in Section 5.2):

The minimum freeboard (1.7 m) was updated as part of the 2017 update to the OMS manual. Details are provided in Section 3.3.

Instrumentation – Water Level Gauge

The recorded readings from May 2009 to October 2017 are presented in Illustration 4-1, and individual values are presented in Appendix D.

The gauge is installed to a datum at 201.032 m (i.e., reads 0 m), which is the elevation of the top of the flange at the culvert between the main and polishing ponds, and does not read freeboard directly. The pond level is calculated with reference to the datum.

Observed Performance

The water level was not observed to exceed the maximum operating water level of 201.8 m at any point during the monitoring period, and as such, the site fully complied with minimum freeboard guidelines indicated by the CDA (2013).

A pond water elevation of 201.7 m was reported during the 23 May routine inspection. This level was above the alert water level of 201.6 m but below the maximum operating water level (201.8 m), and as such did not present an immediate dam safety concern. As a result of the water level being above the alert level, preparations were made to begin water treatment, and an additional visit was conducted by Maskwa on 6 June 2017 as a precautionary measure and in accordance with the OMS manual. During this follow-up visit, the pond water elevation was recorded to be approximately 201.62 m. During both the routine and follow-up inspection visits, there was no evidence of seepage at the spillway or on the downstream face/toe of the dykes.

Following the 23 May inspection, Golder also carried out daily checks of the weather data and forecast from Environment and Climate Change Canada, monitoring for possible high rainfall events to be reported to Teck. Water treatment began on 4 July 2017, at which point water was decanted from the main pond to the polishing pond (as part of the treatment process), and the daily checks on weather forecasts stopped.

The water level during the 27 July 2017 DSI was 201.03 m and had reduced further to 200.39 m at the time of the 16 October 2017 routine inspection.

5.3.2 Piping

Internal instability of a dyke can be caused by materials migrating out of the dyke when water or seepage flows pass through the dyke, leaving voids. This generally happens with dyke materials that do not have filter compatibility; that is, the fines fraction of one material can migrate into or through the voids of the adjacent material under a sufficient hydraulic gradient. Piping is induced by regressive erosion of particles towards an outside environment until a continuous pipe is formed. This can occur in some cases along pipes through a dyke structure, but also can occur through any soils subject to seepage pressures where soil layers fail to meet applicable filter (grain size compatibility) criteria.

Design Basis

Detailed records from the construction of the initial dykes at the Pine Point Mine are not available, and as such it is not possible to determine whether filter compatibility was designed for between the tailings and the dyke construction fills.

Observed Performance

At the time of the visits in May, June, and July, the only water in the tailings area was ponded against a portion of the north dyke (similar to the conditions shown in Figure 2). No surface water was present along the inside of the west, south, or east dykes.

There were no visible signs of seepage through the dykes, although the healthy growth of some bushes or small trees at the outside toe of portions of the north, west, and south dykes is considered indicative of soil moisture in these areas. Ponded water at the toe of the dykes may or may not be indicative of seepage through the dykes. Some of the wet areas beyond the perimeter of the disposal area are due to naturally ponded water, and are not indicative of seepage.

The ponded water is clear, and no cloudy seepage was observed. This suggests that there are not piping-related concerns with the dyke stability (cloudy seepage or seepage with a sediment load is indicative of the erosion of fine soils). Some seepage of clear water through properly designed earthen water retaining structures is considered normal.

5.3.3 Instability

Design Basis

A stability review was completed as part of the 2014 dam safety review (DSR) (SRK 2016). This analysis used a horizontal peak ground acceleration of 0.019 g, based on the 2010 National Building Code seismic hazard calculator (NRC 2011) for the 1-in-1,000-year event.

Complete stability analyses were carried out for the north and west dykes. The analyses indicated factors of safety of between 1.4 and 1.5 for the north dyke and 1.3 and 1.6 for the west dyke under seismic loading conditions (a factor of safety of 1.0 is recommend by the CDA [2013] for seismic loading conditions). This meets the requirements for a facility in the Closure – Active Care phase of mine life, as defined by the CDA (2014).

Should the TIA move to the Closure – Passive Care phase, the stability of the facility should be assessed for the 1-in-2,475-year event (2% probability of exceedance in 50 years; CDA 2014).

All static factors of safety were in excess of the 1.5 factor recommended by the CDA (2013).

All analyses were conducted based on sections and material properties determined as part of the 1981 geotechnical investigation stability report (Golder 1981), with some modification to the shear strength of the underlying peat material.

Observed Performance

The visual inspection during the 2017 site visits did not identify any sign of stress such as cracks, settling, or bulging of the dykes. The condition of the dykes has remained generally unchanged from previous site visits. The dyke slopes appear to be stable and, as a result, it is Golder's opinion that the overall stability of the perimeter dykes has continued to be satisfactory.

5.3.4 Erosion

There are two types of surface erosion occurring at the Pine Point TIA. These are:

1) **Wave cut erosion**—This is occurring on the inside (tailings side) of the north dyke and is caused by wind-driven waves against the interior north dyke slope or possibly ice plucking. The previous erosion was repaired in 2008 with a rebuilt slope developed at 2 horizontal to 1 vertical. During the 2014 and 2015 inspections, the erosion was observed again in the central section of the north dyke at or just above the water level. In 2016, repairs were made to a test section of the north dyke to evaluate if coarser fill is necessary for restoration. These repairs were in good condition at the time of the inspection. The erosion in areas that had not been repaired in 2016 did not increase significantly between 2016 and 2017.

2) **Surface erosion rills (gullies)**—This is occurring primarily down the outside (downstream) slopes of all the dykes. These rills are typically relatively shallow, normally less than 0.1 to 0.2 m in depth, although two deeper rills (0.3 and 0.5 m) were observed in 2015. These two deeper rills were repaired in the summer of 2016. None of the observed rills extended into the dyke crest.

   The cause of the erosion rills is likely surface water or snow melt from the dyke crest flowing down the slope. Most of the dyke crests appear to slope towards the inside or tailings side of the dyke, which will help minimize (but not eliminate) erosion on the outer slopes.

5.4 Operation, Maintenance, and Surveillance Manual Review

An OMS manual for the Pine Point Mine TIA was completed in 2009 (Golder 2009). The OMS manual was updated in February 2017 (Golder 2017a) to align with the CDA (2013), as well as the Teck *Guideline for Tailings and Water Retaining Structures* (Teck Resources Ltd. 2014).

A further update of the OMS manual was completed in February 2018 to reflect changes in the updated Water Licence (MV2017L2-007).

5.5 Emergency Preparedness and Response Plan Review

An EPRP for the Pine Point Mine TIA was completed as part of the OMS manual in 2009 (Golder 2009). The EPRP was updated in February 2017 (Golder 2017b) to align with CDA (2013), the updated OMS manual (Golder 2017a), and the Teck *Guideline for Tailings and Water Retaining Structures* (Teck Resources Ltd. 2014).

5.6 Dam Safety Review

The last DSR for the south, west, and north dykes of the Pine Point TIA was conducted by SRK Consulting in 2014 (SRK 2016). The next DSR for the facilities should be carried out by the end of 2024 to comply with CDA (2013) recommendations.

6.0 SUMMARY AND RECOMMENDATIONS

6.1 Summary of Activities

The following activities were completed at the Pine Point TIA in 2017:

- DSI on 27 July 2017
- routine inspections on 23 May and 16 October 2017
- additional water level check on 6 June 2017
- water treatment, which was conducted from 4 July 2017 to 1 September 2017
- routine vegetation clearance

6.2 Summary of Climate and Water Balance

During the 2017 monitoring period (September 2016 to August 2017), the total annual precipitation was 604.5 mm, which is approximately 142.8 mm higher than the long-term trend. The average air temperature was -1.3°C.

A total of 440,218 m^3 of water was treated and discharged from the TIA to Channel 35-1B and the wetlands south of Great Slave Lake.

6.3 Summary of Performance

Overall, the dykes appear to be in good condition and are achieving their intended purpose of retaining the tailings and ponded water in a satisfactory manner.

No significant changes to the dyke stability or surface water control were observed and conditions therefore remain generally unchanged from the 2016 DSI.

6.4 Consequence Classification

The following consequence classifications (per CDA 2013) for the Dykes at the Pine Point TIA were determined:

- north dyke: Significant
- west dyke: Significant
- east dyke: Low
- south dyke: Low

6.5 Table of Deficiencies and Non-conformances

Table 6-1 summarizes deficiencies / non-conformances, key findings and recommended actions for the Pine Point TIA.

Table 6-1: Summary of 2017 Dam Safety Inspection Recommended Actions

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline/Status
North dyke	2014-01	Erosion observed on the pond side of the north dyke with potential to cause dyke instability.	OMS manual Section 5.5.2	Continue observation and evaluation of replacement fill placed in 2016 throughout 2018 monitoring period. Should restored area indicate adequate performance, repair the remaining sections of observed erosion in 2019 with the same fill material used in the trial. Should significant erosion occur within the test section during 2018, complete a new test restoration using coarser fill in 2019, or evaluate alternative approaches such as periodic repair work on the fill.	3	end of Q2 2019

Priority[a]	Description
1	High probability or dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
2	If not corrected/implemented could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
3	Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

a) Source: after HSRC 2016.

ID = identification; OMS = operation, maintenance, and surveillance; DSR = dam safety review; CDA = Canadian Dam Association.

6.6 Opportunities for Improvement

The following areas represent opportunities for improvement in relation to the Pine Point TIA:

- Complete an updated stability review of the north, south, and west dykes. This review would aim to update past analyses with current seismic data for the area and to provide a critical re-evaluation of input data used in past evaluations (such as material strength parameters). This review should also aim to identify critical gaps in the data to be addressed.
- Commence studies with the aim of reclaiming the Pine Point TIA and moving the facility towards the Closure – Passive stage of mine life.

7.0 CLOSURE

The reader is referred to the Study Limitations, which follows the text and forms an integral part of this report.

We trust that the factual information provided in this report is sufficient for your present needs. Should you have any questions regarding the above information or require additional information please contact the undersigned.

GOLDER ASSOCIATES LTD.

REGISTERED PROF. ENGR. 03-06-2018 B. WEEKS LICENSEE NT/NU

Martyn Willan, M.Sc.
Geotechnical Specialist

Bjorn Weeks, Ph.D., P.Eng.
Principal, Senior Geo-Environmental Engineer

NC/MBW/BW/cr

https://golderassociates.sharepoint.com/sites/12802g/Deliverables/Issued/1776943-003-R-Rev1-1600/1776943-003-R-Rev1-1600-Pine Point 2017 Annual Insp 06MAR_18.docx

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD.
Signature
Date 6 march 2018
PERMIT NUMBER: P 049
NT/NU Association of Professional Engineers and Geoscientists

REFERENCES

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STUDY LIMITATIONS

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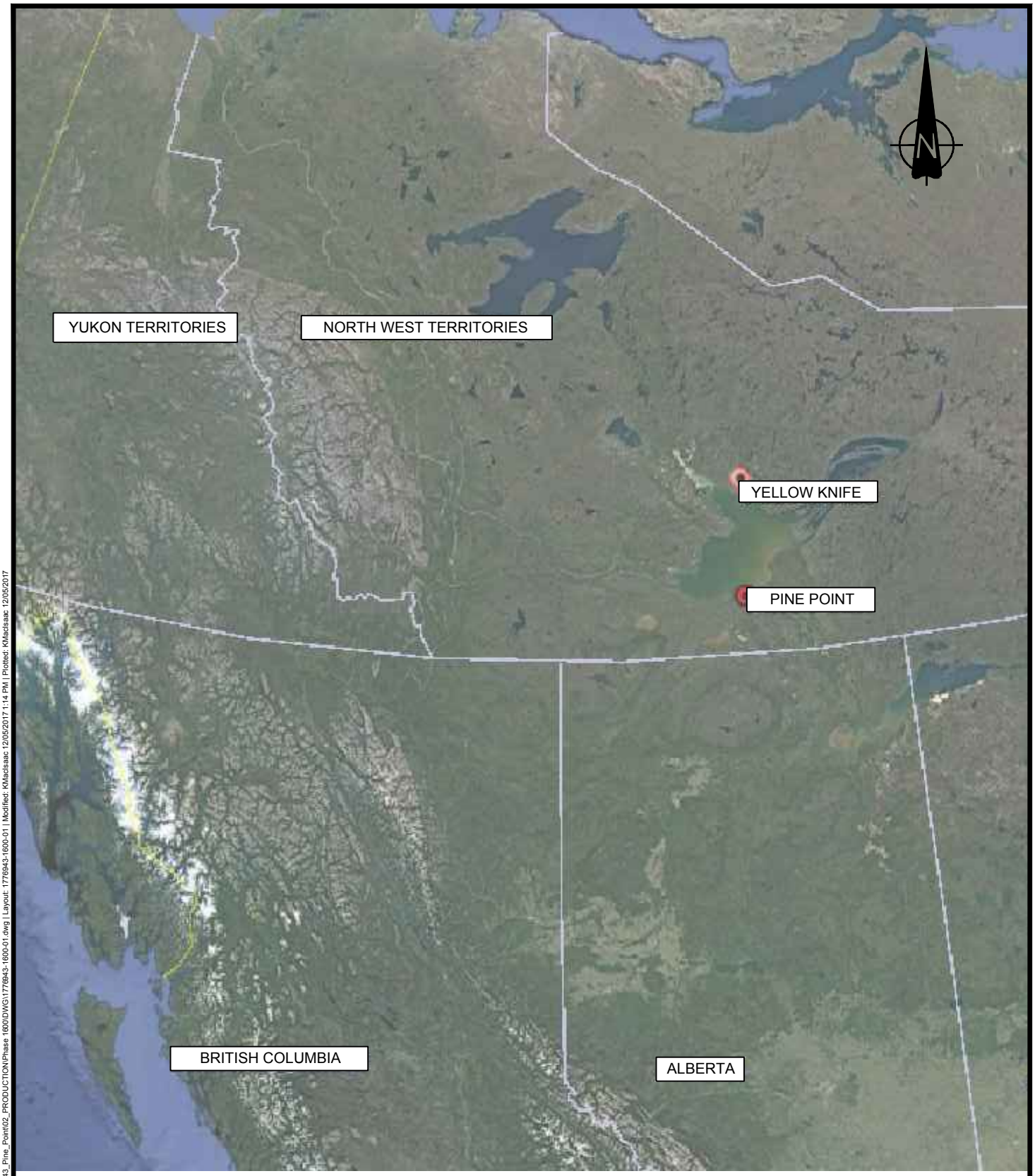


PROJECT

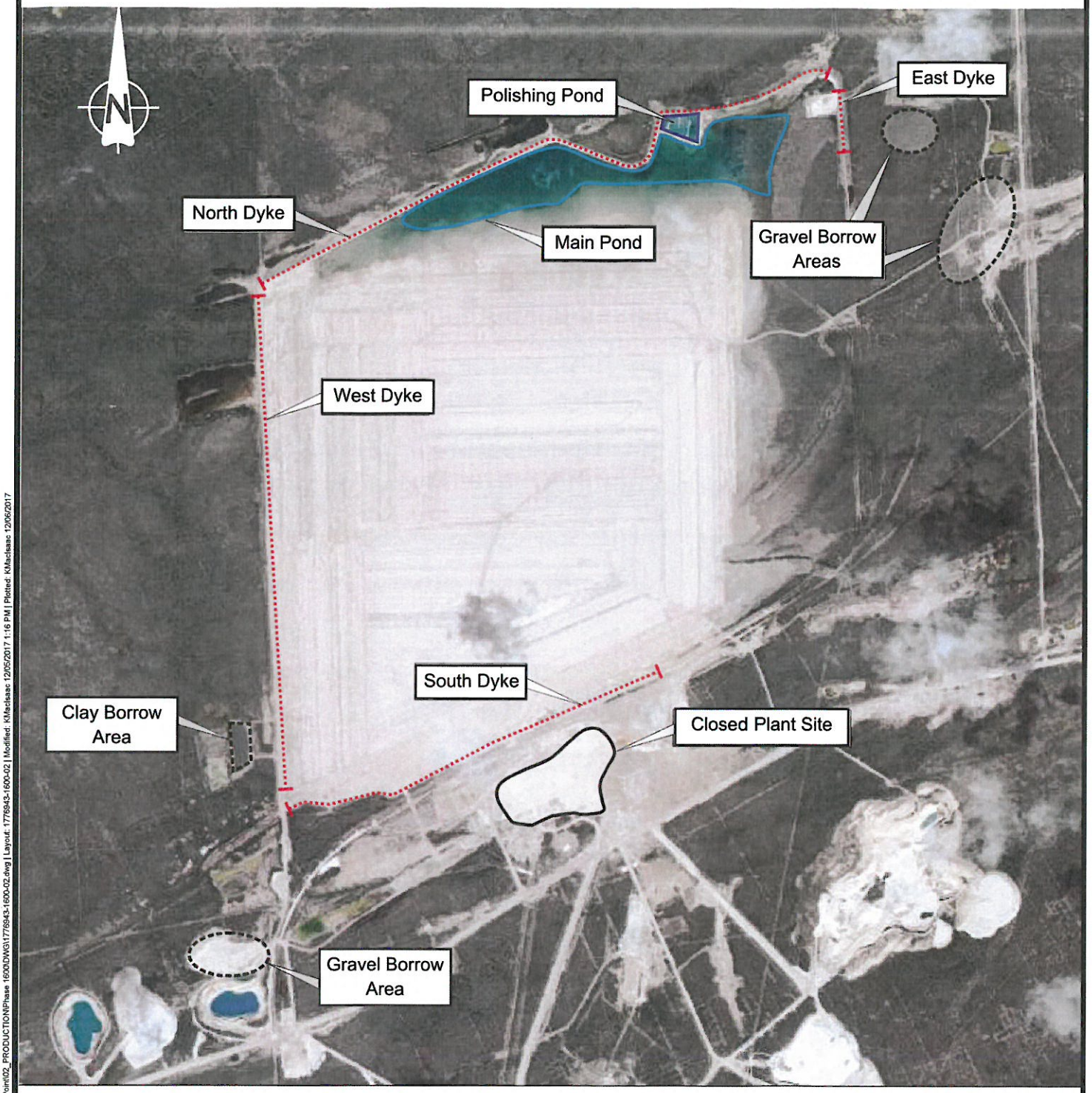
TECK
PINE POINT, NT

TITLE

GENERAL LOCATION OF PINE POINT MINE SITE

Golder Associates

PROJECT No.		1776943	FILE No.	1776943-1600-01	
DESIGN			SCALE	NTS	
CADD	KM	2017-12-05	**FIGURE 1**		
CHECK	NC	2017-12-05			
REVIEW					



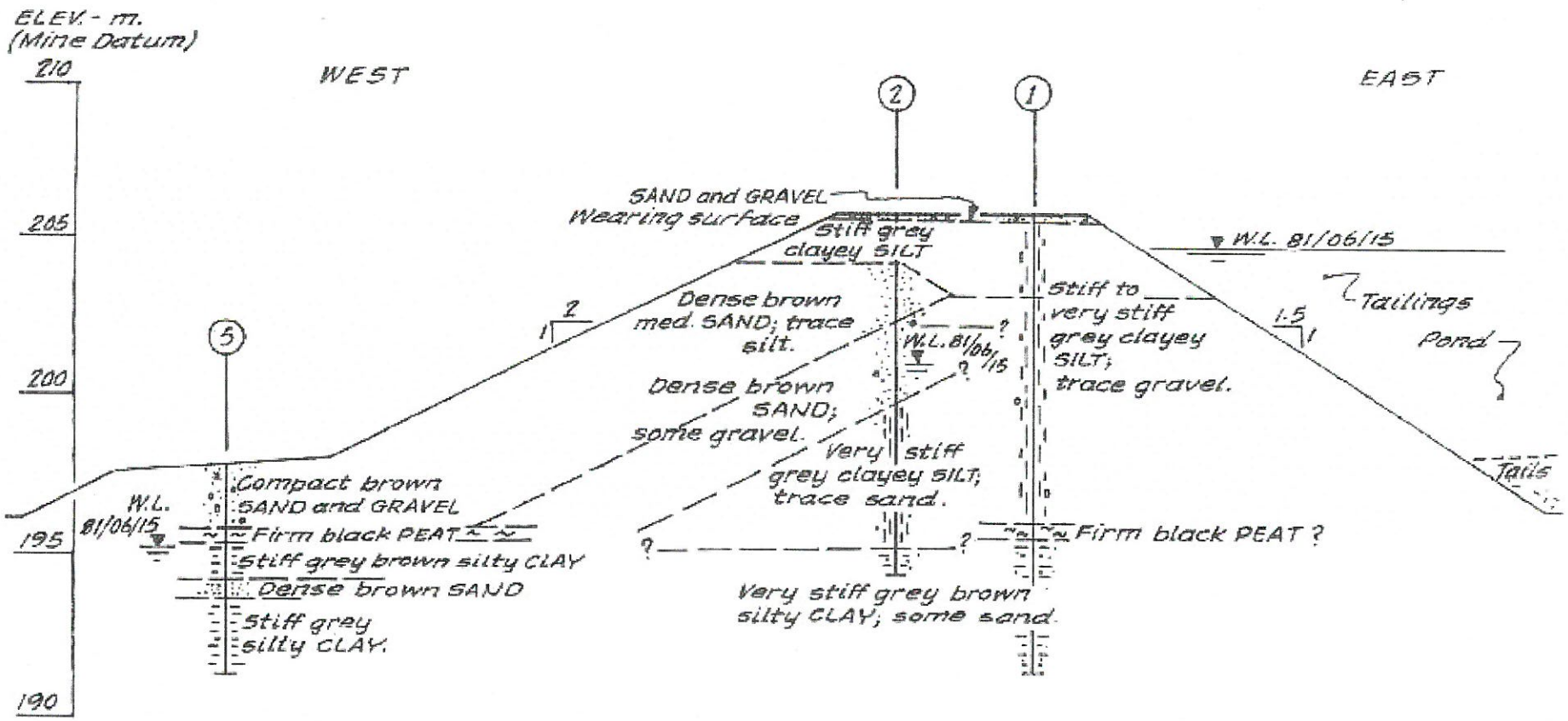
Meters
0 100 200 400 600 800 1000

PROJECT
TECK
PINE POINT, NT

TITLE
TAILINGS IMPOUNDMENT AREA

Golder Associates

PROJECT No.		1776943	FILE No.	1776943-1600-02
DESIGN			SCALE AS SHOWN	REV.
CADD	KM	2017-12-05		
CHECK	NC	2017-12-05	**FIGURE 2**	
REVIEW				



SCALE 1 : 200

LEGEND

(2) Location of Borehole

NOTE

1. Section partially inferred from construction records.
2. Black peat removed from under toe berm of west dyke south of Sta. 35+00.

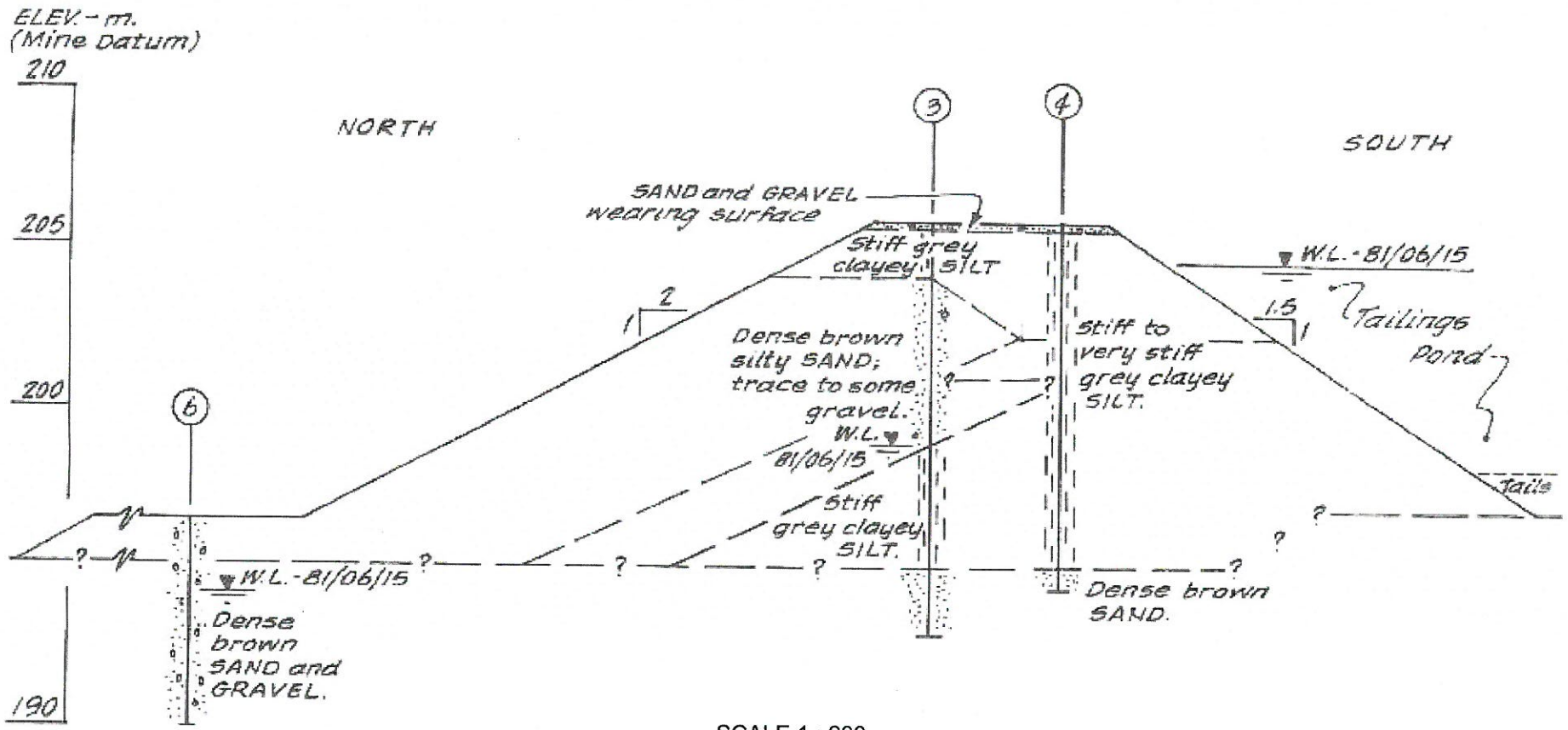
PROJECT
TECK
PINE POINT,NT

TITLE
TYPICAL SECTION
WEST DYKE

Golder Associates

PROJECT No.		1776943	FILE No.	1776943-1600-03	
DESIGN			SCALE	AS SHOWN	REV.
CADD	KM	2017-12-05			
CHECK	NC	2017-12-05			
REVIEW					

FIGURE 3



SCALE 1 : 200

LEGEND

(6) Location of Borehole

NOTE

1. Section partially inferred from construction records.

PROJECT	TECK PINE POINT, NT
TITLE	**TYPICAL SECTION NORTH DYKE**

Golder Associates

PROJECT No.		1776943	FILE No.	1776943-1600-04
DESIGN			SCALE AS SHOWN	REV.
CADD	KM	2017-12-05		
CHECK	NC	2017-12-05	**FIGURE 4**	
REVIEW				

APPENDIX A

Inspection 27 July 2017 Pine Point Mine, NT

TECHNICAL MEMORANDUM

DATE 8 August 2017 **REFERENCE No.** 1776943-001-TM-Rev0-1400

TO Dana Haggar
Teck Metals Limited

FROM Martyn Willan and Bjorn Weeks **EMAIL** Martyn_Willan@golder.com; Bjorn_Weeks@golder.com

INSPECTION 27 JULY 2017 PINE POINT MINE, NT

1.0 SITE INSPECTION NOTES

Golder Associates - Bjorn Weeks

Maskwa Engineering - Clell Crook

Weather - Sunny, some cloud, light breeze and 25 degrees Celsius. Light rain intermittently in the days prior to inspection.

Time - 9:00 am to 1:30 pm

1.1 South Dyke

East End

- Vegetation developing on upstream slope. No water observed on pond side (upstream of dyke). Clear standing water present in ditch on downstream side, consistent with observations in previous years. No indication that water presence is the result of seepage.

Central

- Dyke continues to be in good shape with minor rilling – no evidence that rilling has increased significantly from previous years.
- No standing water observed either upstream or downstream of the dyke. On the downstream side some quad tracks noted on the slopes perpendicular to the crest, but no signs of runoff concentration or erosion in the tracks.

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West End

- Dyke crest narrow compared with crest in all other areas of the facility, with vegetation encroaching from the downstream side. No change in dyke width.
- Crest slopes towards pond side and crest is in good condition, no erosion on crest.
- Need to continue to monitor vegetation on downstream slope and remove larger trees. The Operations, Maintenance, and Surveillance (OMS) manual for the facility indicates removal of trees over 10 cm in diameter on the south and west dykes is required.
- Downstream of the west end continues to be the area of the dyke with some of the densest vegetation. While there is dead vegetation, indicating the effectiveness of past herbicide application, this area will need continuing attention with ongoing application of herbicide and cutting of larger trees/shrubs, in accordance with the stipulations of the OMS manual.
- Permanent swamp area to the south of dam at the west end.

1.2 West Dyke

South End

- Dyke in good shape with no new or noticeable erosion of crest or downstream slopes. No change from last year.
- Crest and tailings side (upstream) slope in good condition.
- Ponded water below dike, outside impoundment. Water is clear. There is some sections with rust-colored staining near the pond that may be indicative of historic seepage, as per observations in past years. There is no evidence of new or ongoing seepage.
- Vegetation on the upstream and downstream faces.
- No water on impoundment side. Evidence of past ponding on tailings near dyke, comparable to previous years, but no surface channel which would indicate erosion. Water that had ponded may have infiltrated and evaporated.

Central

- Overall slopes and crest in good condition.
- Small swamp at toe appears to be natural ponding of water in zone with poor drainage.
- Vegetation encroaching on crest and in need of cutback or herbicide application.
- No new erosion of slope, crest on downstream side looks good.

North End

- Toe area generally dry, although there is some soft ground near the permanently ponded areas.
- No significant new erosion of slope noted. Old gullies on lower part of slope have not increased in size and appear stable, approximately 30 cm deep (maximum).
- Overall slopes and crest in good condition.
- Water to the west of the impoundment appears to be natural accumulation in low area. As noted in previous years, there is a runoff drainage course between the dyke toe and the pond, with some residual staining and salts. However, the drainage course was dry (no visible seepage from the tailings impoundment), and there was no free water in the tailings impoundment adjacent to this location, although the ground was soft relative to the areas further away from the pond.

1.3 North Dyke

West End

- Water north of downstream toe in old borrow area was clear with no visible movement or evidence of seepage.
- Some evidence of erosion rills on downstream slope near northwest corner; relatively shallow and not currently in need of attention.
- Minor rilling of upstream slope.
- No pond against dyke at west end.
- Crest and downstream slope otherwise in good condition.
- Several dead trees noted, presumable from herbicide application during the past years.

Central

- Lager erosion rills noted on downstream slope in 2016 have been repaired and are in good shape.
- Small ponds north of dyke in downstream toe area in old borrow pit. No visible seepage. Water in the ponds appears to be clear and still.
- Water in North Dyke pond is some 2.5 to 3.0 m below the crest, with a similar extent to previous years.
- As per observations noted in previous year, the upstream (tailings pond side) slope was flattened 9 years ago with a well graded sand with some gravel. Wave action or possibly ice action has started to erode the pond side slope, with erosion benches visible above the water line. The elevation of the erosion bench crest are relatively consistent, approximately 50 cm above the water line at the time of inspection. This erosion feature does not appear to have grown significantly from the previous two years.
- Dyke width is currently adequate. Should future erosion on upstream face steepen the overall slope then regrading of the overall pond side slope may be required. Erosion features should continue to be monitored.
- Crest and downstream slope in good condition.

East End

- Similar to the central section, the upstream face has been repaired and now has cobbles/coarse gravel sized material at the water line.
- Repairs extend along the dogleg to the east around the polishing pond area, with original slope on upstream face restored east of the dogleg. Restoration in generally good shape, although there is one zone where some sloughing of the repair material may have occurred (Photograph 10c) and should continue to be monitored. West of the dogleg, coarse material appears to have been placed at the toe, without reconstructing the slope. This material was photographed for future monitoring.
- On the downstream side near the dogleg, there is a zone where a former ramp has been removed. The remnants of this ramp extend north. Several erosion features are now present on the remnants of this ramp (5 or 6 features, typically 2 to 3 m long, and up to 30 cm wide and 20 cm deep at their maximum extent). These erosion features do not impinge on dam structural material, nor are they likely to even if they grow significantly. They should be monitored, and may be patched/repaired in the future as a part of housekeeping activities, but do not need to be addressed as a structural concern.
- Ponding in the dogleg area downstream of the dyke showed no visible seepage at two locations where seepage had been previously noted. The water in the pond was clear and showed no visible movement or accumulation of sediments.
- At the far east end of the dyke the natural ground is higher than the pond. Erosion gullies observed in 2015 have been repaired, and have not reappeared.

1.4 Polishing Pond Area

- Slopes in good shape on land side.
- Water treatment started 4 July 2017 and is expected to continue until end of August, due to efforts to attain a lower discharge pH.
- Spillway 1 – from main pond - seepage previously noted under spillway at the downstream end was not visible. Permanent concrete closure wall in spillway. Soil placed in inlet area with vegetation in outlet area. Small pond downstream of weir. Water upstream below spillway level. Concrete in spillway generally in good shape although some minor spalling was visible on the downstream side (not known if this is new spalling or damage at the time of construction. Noted and photographed for future monitoring).
- Spillway 2 – from polishing pond - syphons were in place with treated water being discharged through four of the five siphons. No seepage from soils around the spillway discharge side, including the embankment to the immediate north of the siphon discharge point, where slight seepage had been noted in the past. Permanent concrete closure wall is in place.
- Slopes in good shape at spillway with no evidence of seepage, outlet is clear.
- Culvert – Water level registered at culvert during inspection was 201.03 m (see photo 14). Water treatment was in progress at time of inspection.

1.5 East Dyke

- Dyke in good shape, minor rills on land side.
- More heavily vegetated on both sides and crest along section south of access road. The road is accessible, however vegetation continues to grow back after last clearing, and will eventually need to be cleared again if access is to be maintained.

2.0 OVERALL

- Dykes are in overall good condition, with repairs completed in 2016 in place and intact. Minor erosion rills in other portions of the dyke do not appear to have grown significantly.
- Restoration works along upstream face of North Dyke appear to have been generally successful, and should continue to be monitored in the coming years.
- Clearing of vegetation should continue in accordance with the OMS manual. Vegetation regrowth will be an ongoing issue. Priority should be given to the western portion of the South Dyke, where some of the densest vegetation was observed.
- Other than the ongoing clearing of vegetation, there is no other maintenance noted for 2017. Erosion of the ramp remnant, north of the North Dyke, does not carry any structural implication for the dam, and should be monitored to ensure that the erosion features does not extend to the dam.

Spillways

- Spillway 1 from Main Pond – pond present, no apparent movement in seep - appears to be stable, should continue to be monitored.
- Spillway 2 from Polishing Pond – in good shape no apparent issues.

3.0 CONCLUSION

No geotechnical maintenance work required in 2017.

Photos- attached.

4.0 CLOSURE

The reader is referred to the Study Limitations, which follows the text and forms an integral part of this technical memorandum.

We trust the above meets your present requirements. If you have any questions or requirements, please contact the undersigned.

GOLDER ASSOCIATES LTD.

REGISTERED PROFESSIONAL ENGINEER
8 - August 2017
B. WEEKS
LICENSEE
NT/NU

Martyn Willan, M.Sc., P.Eng.
Geotechnical Engineer

Bjorn Weeks, Ph.D., P.Eng.
Principal, Geo-Environmental Engineer

MBW/BW/cr

Attachments: Study Limitations
Attachment 1: Inspection Photographs

https://golderassociates.sharepoint.com/sites/12802g/deliverables/issued/1776943-001-tm-rev0-1400/1776943-001-tm-rev0-1400-july 2017 inspection pine point 08aug_17.docx

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD.
Signature
Date 8 August 2017
PERMIT NUMBER: P 049
NT/NU Association of Professional Engineers and Geoscientists

STUDY LIMITATIONS

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ATTACHMENT 1
Inspection Photographs

Photograph 1: South Dyke – Downstream Face at East End, Looking West. 27 July 2017

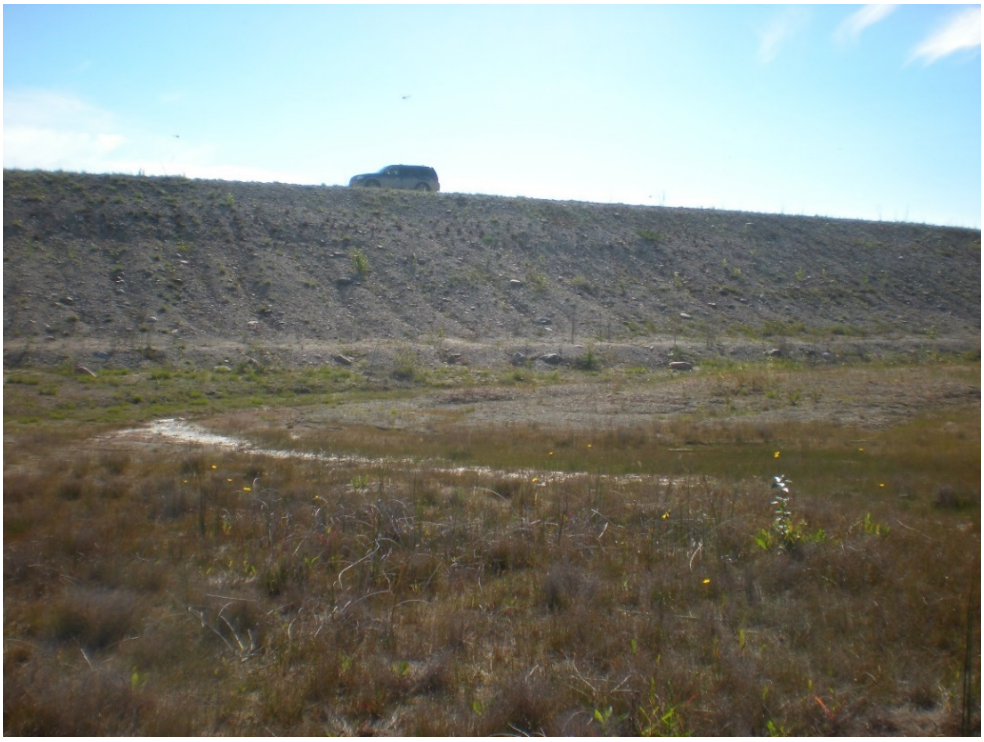
Photograph 2: South Dyke – Upstream Face of Central Portion, Looking West. 27 July 2017

Photograph 3: South Dyke – Downstream Face of West End with Vegetation, Looking West. 27 July 2017

Photograph 4: West Dyke – Downstream Face, Looking North. 27 July 2017

Photograph 5: West Dyke, South End. Ponded Water Downstream Of Toe, Looking North. 27 July 2017

Photograph 6: West Dyke – Downstream Drainage Course near North End - Dry. 27 July 2017



Photograph 7: West Dyke, Downstream Side – Looking East, Stable Erosion Features. 27 July 2017

Photograph 8: North Dyke – Downstream Slope (left side of photo) with 2016 Patch on Erosion Feature in Place, Looking East. 27 July 2017

Photograph 9: North Dyke – Erosion Feature on Downstream Slope (former ramp, non-structural), Near Center (dogleg), Looking South. 27 July 2017

Photograph 10a: North Dyke Upstream Face, Gravel and Cobbles at Pond Waterline. 27 July 2017

Photograph 10b: North Dyke Upstream Face, Gravel and Cobbles at Pond Waterline, at Dogleg Looking East. 27 July 2017

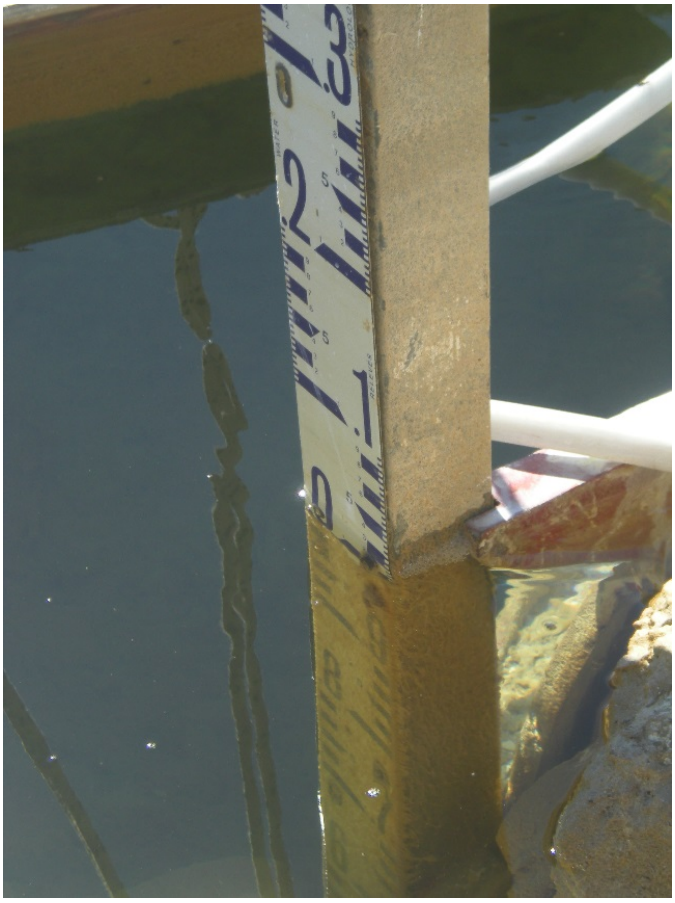
Photograph 10c: North Dyke Upstream Face, Gravel and Cobbles at Pond Waterline, at Dogleg Looking East. Detail Showing Possible Sloughing of Previous Repair. 27 July 2017

Photograph 11a: Main Pond Spillway (Spillway No. 1). 27 July 2017

Photograph 11b: Main Pond Spillway (Spillway No. 1). Detail of Limited Spalling 27 July 2017

Photograph 12: Settlement Pond Spillway (Spillway No.2) – Syphon Piping Discharge at Outlet. 27 July 2017

Photograph 13: Settlement Pond Spillway (Spillway No.2) – Settling Pond Side. 27 July 2017



Photograph 14: Main Pond Water Level at Culvert Intake to Settling Pond (201.03 m). 27 July 2017

https://golderassociates.sharepoint.com/sites/12802g/deliverables/issued/1776943-001-tm-rev0-1400/attachment 1/attachment 1 - inspection photographs.docx

APPENDIX B

Pine Point Inspection 23 May 2017

Pine Point Mine
Field Notes 2017

To: Golder Associates Ltd. **From:** Clell Crook, C.E.T.

Attention: Ben Wickland, P.Eng. **Date:** May 26, 2017

RE: May 23, 2017 Pine Point Inspection
Pine Point Tailings Facility
Teck Cominco Metals Ltd.

Maskwa Engineering Representatives: Clell Crook, C.E.T., Mitch Heron, C.E.T.
Weather: Clear, calm, +8 Celsius
Time: 08:00hrs to 13:00hrs

SOUTH DYKE

East End

- No standing water on mine waste side of dyke
- Standing water on land side (downstream) of dyke appears to be permanent swampy area with vegetation consistent with previous May Inspection.
- Seasonal vegetation change consistent with observations from Hay River to site.
- Minor vegetation starting to advance along crests

Central

- Crests and slopes of dyke in good condition, no erosion.
- Standing seasonal water on downstream side of dyke near access ramp appears to be consistent with previous May Inspection.
- Minor seasonal standing water on upstream side
- Minor vehicle rutting on top of dyke near access ramp

West End

- Crests and slopes of dyke in good condition, no erosion.
- Standing water on downstream side of dyke appears to be permanent swampy area with vegetation consistent with previous May Inspection.

WEST DYKE

South End

- Crests and slopes of downstream side of dyke in good condition, no erosion.
- Downstream toe area at approximately 17+00, no stains observed, no seep observed.
- Downstream toe area at approximately 19+00, minor stains observed, no seep observed.
- Mine waste side – No erosion observed on crest or slope.
- No water observed against dyke on mine waste side.

WEST DYKE CONTINUED

Central

- Crests and slopes of downstream side of dyke in good shape.
- Observed swampy area at toe due to seasonal run off and natural standing water, consistent with last May's observation.
- Downstream slope: Old gullies on lower part of slope consistent with previous inspections, they have not increased in size.
- Mine waste side crest and slopes in fair to good condition.

North End

- Crests and slopes of mine waste side of dyke in good condition.
- No water observed against dyke on mine waste side.
- Downstream slope: Old gullies on lower part of slope consistent with previous inspections, they have not increased in size.
- At pond before the corner observed staining at toe of slope on the downstream side consistent in size with previous inspections. Vegetation change consistent with observed seasonal changes.
- Observed staining at toe of slope on downstream side near pond at corner, staining consistent with previous inspections.

NORTH DYKE

West End

- Crests and slopes of mine waste and downstream sides of dyke in good condition.
- No water observed against dyke on mine waste side at corner of West dyke and North dyke.
- Downstream side – water in an old borrow area, away from toe, no apparent evidence of seepage.

Central

- Crest and top of dyke in good condition.
- Mine waste side of slope showing erosion due to wave action consistent with previous inspection.
- Downstream side – water in an old borrow areas/ponds, away from toe, no apparent evidence of seepage.

East

- Mine waste side of dyke – 2016 summer repair areas of top of dyke remain in good condition.
- Downstream side, dog leg section, Reference location taken at center line of dyke: Northing: 6753692 Easting: 639889:
    - Water in low swampy area consistent in size with previous inspections.
    - Observed staining at toe of slope along edge of pond.
    - No apparent seep observed on the downstream side.
    - Vegetation change consistent with observed seasonal change.

Main Pond Spillway

- Concrete cut off wall in place stopping approximately 1.6 metres below crest.
- The clay plug on the mine waste side was in place.
- Downstream of spillway - Vegetation change consistent with observed seasonal vegetation change.
- Main Pond Water Elevation: 201.67 metres – Elevation taken on mine waste side near culvert inlet to polishing pond.

Polishing Pond Area:

Treatment Spillway

- Concrete cut off wall in place stopping approximately 1.63 metres below crest.
- The clay plug on the polishing pond side was in place, no evidence of seeps on the downstream side.
- Downstream of spillway - Vegetation change consistent with observed seasonal vegetation change.

EAST DYKE

North

- Overall dyke in good condition.
- Vegetation growth on top of dyke south access road - vegetation colour change consistent with observed seasonal vegetation colour change.

OVERALL

Along the West Dyke in the south section, near Borrow Pit 600, approximately 17+00 to 19+00, no apparent seep observed on the downstream side, no staining observed along toe of slope. Area will continue to be monitored and inspected in detail during the scheduled 2017 inspections.

Along the West Dyke at pond before the corner observed staining at toe of slope on the downstream side. No flow observed from previously identified boil. Area will continue to be monitored and inspected in detail during the scheduled 2017 inspections.

Along the North Dyke in the dog leg section, no apparent seep observed on the downstream side, observed staining at toe of slope along edge of pond. Area will continue to be monitored and inspected in detail during the scheduled 2017 inspections.

Main pond spillway and Polishing pond Spillway areas will continue to be monitored and inspected in detail during 2017 scheduled inspections.

The remainders of the dykes are generally in the same condition as previous inspections.

Clell Crook

Clell Crook, C.E.T.
May 26, 2017

South Dyke East End, facing west

South Dyke East End, facing east

South Dyke, approaching central area facing west.

South Dyke, facing east towards central area.

South Dyke, Central Area, minor seasonal water upstream side

South Dyke, Central area facing east, minor vehicle rutting

South Dyke, West End corner, facing West.

West Dyke, South end, facing North

West Dyke, minor staining near toe, Approximate Station 19+00

West Dyke, Central Area, Facing South

West Dyke, Central Area, Facing North

West Dyke, staining near toe.

West Dyke, Previously Observed Boil Area, Staining near toe, facing East.

West Dyke, Pond at Northern corner facing West.

West end of North Dyke, facing South, mine waste side.

North Dyke, facing East.

North dyke central area facing west

North Dyke, 2008 Construction area, facing East

North Dyke, 2008 Construction area, mine waste side, facing East

North Dyke, 2008 Construction area, facing West.

North Dyke, dog leg section, facing north, staining at toe.

Main Pond Spillway, Mine Waste Side

Downstream side of main pond spillway

Downstream Main Pond Spillway.

Treatment Pond Spillway, Upstream Side.

Downstream side of treatment pond spillway.

Treatment Pond Spillway, Down Stream Side.

Main Pond Culvert to polishing pond.

Main pond to polishing pond culvert, polishing pond side

North Dyke, Polishing Pond

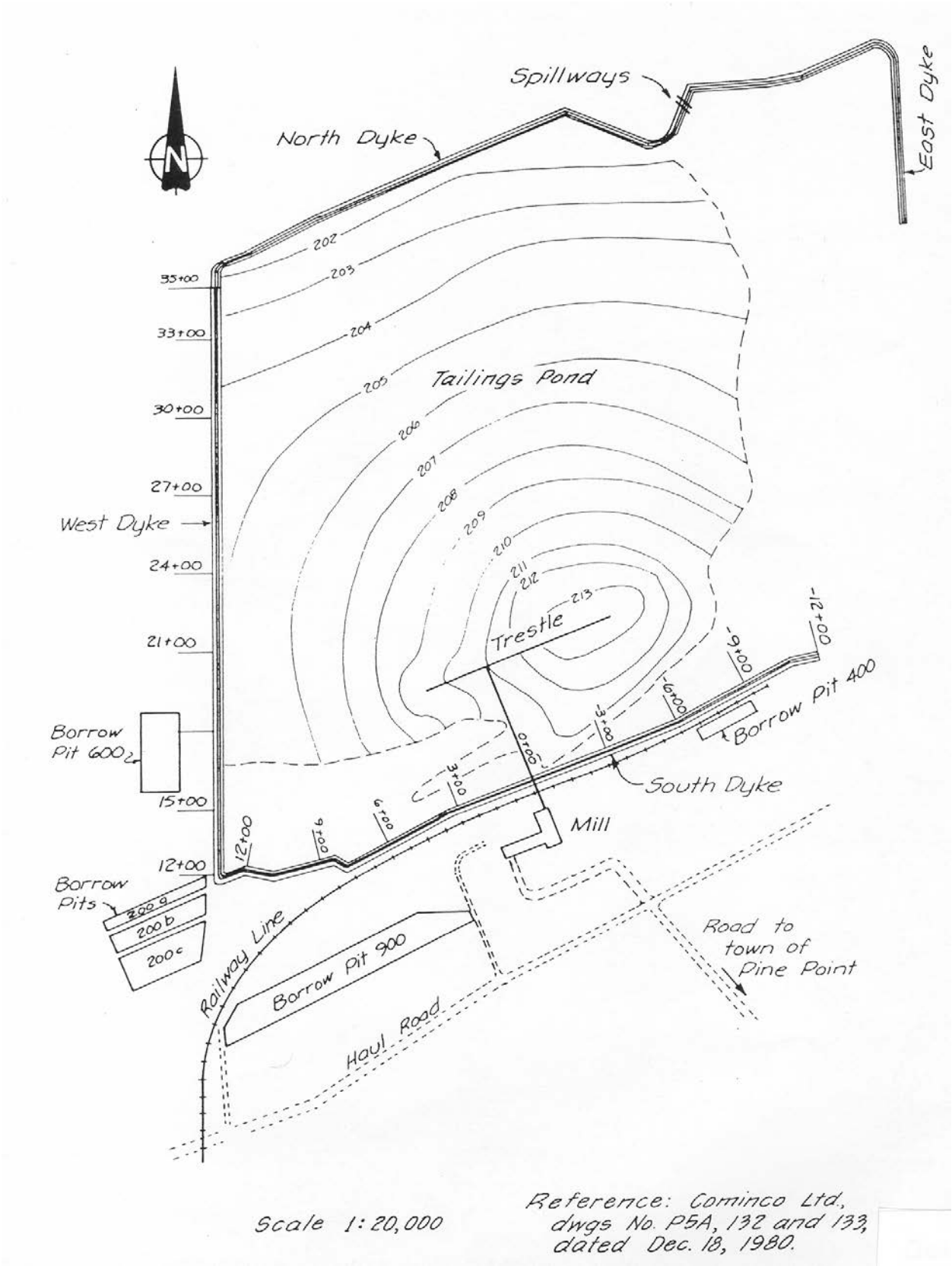
North Dyke, East of Polishing Pond

East Dyke, Facing South.

Teck Metals Ltd
Tailings Impoundment Inspection Form
Pine Point Tailings Impoundment

Date: May 23, 2017		Inspected By: Clell Crook, Mitch Heron
Weather: Partly Cloudy, Slight Breeze, +8 Celsius		
Tailings Pond Information:		
Pond Elevation: 201.67m		Operating Limits:
Crest Elevation:		Freeboard: (Minimum 1m) Approx. 2.4 metres
Dyke Inspection Check List (✓ = checked and no problems; x = not checked)		
Check: Upstream Slope of Dyke, Crest and Downstream Slope of Dyke		
South Dyke	**Checked**	**Comment**
Ponded Water	✓	Standing water on downstream side of dyke consistent in size with previous May Inspections.
Erosion	✓	Erosion Rill near upstream crest at station 8+00 consistent in size with previous inspections -
Settlement/Depressions	✓	None observed
Cracks/Movement	✓	None observed
Debris: on upstream side.	✓	None observed
Vegetation	✓	Minor vegetation along crests at East and West Ends
Other – (photos)		
Notes:		
West Dyke		
Ponded Water	✓	Ponded water remains consistent in size with previous May Inspections.
Erosion	✓	Downstream slope, old gullies on lower slope, Central and North end of Dyke consistent in size with previous inspections.
Settlement/Depressions (on dam crest)	✓	None observed
Sinkholes	✓	None observed
Cracks/Movement	✓	None observed
Debris	✓	None observed
Vegetation	✓	None observed
Other – (photos)		
Notes:	✓	No flow from previously identified boil.

North Dyke	**Checked**	**Comment**
Ponded Water	✓	Ponded water remains consistent in size with previous May Inspections.
Erosion	✓	Erosion along 2008 reconstruction on the upstream slope due to wave action, terminating at dogleg section. No Clay core exposed.
Settlement/Depressions	✓	None observed
Sinkholes	✓	None observed
Cracks/Movement	✓	None observed
Debris	✓	None observed
Vegetation	✓	None observed
Main Pond Spillway	✓	Clay plug and concrete cut off wall in place.
Treatment Spillway	✓	Clay plug and concrete cut off wall in place.
Other – (photos)	✓	Observed staining on downstream side at dogleg section, consistent with previous inspections.
Notes:		
East Dyke		
Ponded Water	✓	Ponded water remains consistent in size with previous May Inspections.
Erosion	✓	None observed
Settlement/Depressions	✓	None observed
Sinkholes	✓	None observed
Cracks/Movement	✓	None observed
Debris	✓	None observed
Vegetation	✓	Vegetation developing on top of East Dyke in low traffic area.
Other – (photos)		
Notes:		


Spillways
East Dyke
North Dyke
N
202
203
204
205
Tailings Pond
206
207
208
209
210
211
212
213
Trestle
35+00
33+00
30+00
27+00
West Dyke
24+00
21+00
15+00
12+00
-12+00
-9+00
-6+00
-3+00
0+00
3+00
6+00
9+00
12+00
Borrow Pit 600
Borrow Pit 400
South Dyke
Mill
Borrow Pits
200a
200b
200c
Railway Line
Borrow Pit 900
Haul Road
Road to town of Pine Point
Scale 1:20,000
Reference: Cominco Ltd., dwgs No. P5A, 132 and 133, dated Dec. 18, 1980.

Tailings Impoundment Inspection
Explanation of Details

Ponded Water:

Look for pools of water against the inside or outside slopes of the Dyke structure. The pooled water is a potential source of water to erode the dyke and therefore the presence of any water must be recorded. Ideally the GPS location should be noted in the comments area.

Another aspect of pooled water is that it may be a source of seepage water at the outside toe of the dyke therefore where pooled water is observed look for increased seepage at the toe. The presence of water at the dyke face can be an indication of increased water levels within the dyke which can decrease Dyke stability.

Erosion:

The presence of small rills, up to 0.3m deep, on the downstream face of the dyke are normal and of no concern. If the rills start eroding into channels greater than 0.3 m and are cutting into the crest more than 0.5 m then the rills must be filled to prevent further progress.

Erosion can also be caused by wave action on the pooled water. Erosion has been occurring on the inside slope of the North Dyke and will soon require placement of material to armor the dyke face. Erosion into the till core must be prevented therefore any excessive erosion must be reported. Ideally record the GPS location so the area can be found on future inspections.

Settlement/Depressions:

Settlement or depressions in the crest or slopes indicate groundwater erosion of the interior of the dyke. Look for any visible seepage at the toe of the dyke. This is a very serious problem and it must be investigated by a professional.

Ideally record the GPS location so the depression can be easily found.

Sinkholes:

Sinkholes are localized deep depressions and are another indication of interior erosion of the dyke. This is a very serious problem and it must be investigated by a professional.

Ideally record the GPS location so the depression can be easily found.

Cracks/Movement:

Cracks accompanied by movement are an indication of a dyke failure and material would probably be seen flowing from the toe of the dyke. This is a very serious situation which must be reported immediately and be investigated by a professional. Ideally record the GPS location so the area can be easily found.

Debris:

Accumulation of debris on the dyke can prevent inspection of the dyke and should be removed.

Vegetation:

Small vegetation on the slopes of the dykes is good to minimize surface erosion. Larger vegetation hinders inspections of the dyke and can damage the dyke if root systems penetrate the till core or large root systems are ripped out by the wind. Therefore any trees on the dyke slopes over 1” diameter should be removed.

Photos:

A log of photos should be maintained.

Locations of key photos should be noted so future photos are taken from the same spot of area looking at the same feature.

APPENDIX C

Pine Point Water Level Check 6 June 2017

Pine Point Mine
Field Notes 2017

To: Golder Associates Ltd. **From:** Clell Crook, C.E.T.

Attention: Ben Wickland, P.Eng. **Date:** June 6, 2017

RE: June 6, 2017 Pine Point Water Level Check
Pine Point Tailings Facility
Teck Cominco Metals Ltd.

Maskwa Engineering Representatives: Clell Crook, C.E.T., Mitch Heron, C.E.T.
Weather: Clear, calm, +18 Celsius
Time: 13:00hrs to 16:00hrs

Main Pond Spillway

- Main Pond Water Elevation: 201.62 metres – Elevation taken on mine waste side near culvert inlet to polishing pond.

Main Pond to Polishing Pond Water Level Check

The was no evidence of seepage observed at spillways or from previously observed seeps.

Clell Crook

Clell Crook, C.E.T.
June 6, 2017

APPENDIX D

Pond Elevations May 2009 to October 2017

Date	Water Elevation (metres)
May 2009	201.5
October 2009	200.2
May 2010	201.5
July 2010	200.7
October 2010	200.2
May 2011	201.3
July 2011	201.2
October 2011	200.2
May 2012	201.2
August 2012	201.0
October 2012	200.0
May 2013	201.2
July 2013	201.0
October 2013	200.2
May 2014	201.2
July 2014	201.0
October 2014	199.7
May 2015	201.0
October 2015	200.4
May 2016	201.4
October 2016	200.4
May 2017	201.7
June 2017	201.6
July 2017	201.0
October 2017	200.4

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