Klohn Crippen Berger

# Teck Metals Ltd.

## Pinchi Lake Mine Tailings Storage Facility

## *2019 Dam Safety Inspection*



M07728A34.730

September 2019

Klohn Crippen Berger

September 10, 2019

Teck Metals Ltd.
Kimberley Operations
Bag 2000
Kimberley, British Columbia
V1A 3E1

**Ms. Michelle Unger**
**Mine Manager**

Dear Ms. Unger:

**Pinchi Lake Mine Tailings Storage Facility**
**2019 Dam Safety Inspection**

We are pleased to submit the 2019 Dam Safety Inspection Report on the Pinchi Lake Mine Tailings Storage Facility.

Please contact us if you have any questions regarding this report.

Yours truly,

**KLOHN CRIPPEN BERGER LTD.**

Daniel Klassen

Daniel Klassen, P.Eng.
Project Manager

DK:jc

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# Teck Metals Ltd.

## Pinchi Lake Mine Tailings Storage Facility

## *2019 Dam Safety Inspection*

# EXECUTIVE SUMMARY

This report presents the 2019 Dam Safety Inspection (DSI) of Teck Metals Ltd.'s (Teck) Pinchi Lake Mine Tailings Storage Facility (TSF) by Klohn Crippen Berger Ltd. (KCB). The dam safety inspection of the TSF facilities was conducted in June 2019 by the Engineer of Record, Bob Chambers, of KCB. Routine inspections were carried out in October 2018 and April 2019 by the Site Surveillance Officer, Mark Pokorski, of EcoFor.

This summary section is provided in accordance with the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (MEM 2016, 2017), and Teck's "Guideline for Tailings and Water Retaining Structures" (Teck 2019). The summary is provided solely for purposes of overview. Any party who relies on this report must read the full report. The summary omits a number of details, any one of which could be crucial to the proper application of this report.

## Summary of Facility Description

Pinchi Lake Mine has been closed since 1975. Teck completed the reclamation/closure works for the TSF in 2011. The TSF and associated water management infrastructure include the following:

- An earthfill tailings dam: 3 m to 15 m high, approximately 1300 m long.
- A tailings impoundment containing approximately one million cubic metres of tailings. The impoundment is a dry facility with glacial till cover and vegetation on the tailings surface. There is no storage of water in the impoundment.
- A free-flowing, riprap lined open channel Closure Spillway.
- The Ed Creek Diversion Channel, which diverts Ed Creek away from the TSF.

## Summary of Key Hazards

As a required component of the annual dam safety inspection, key observations related to the potential hazards associated with the TSF are summarized as follows:

**Earthquakes:** There is lacustrine clay in the foundation of the dam that may be susceptible to cyclic softening under earthquake loading. However, the dam is located in a region of low seismicity, with a peak ground acceleration of less than 0.05 g for the 1/2475 annual exceedance probability earthquake. Simplified deformation and post-earthquake stability analyses were performed and show that the dam meets CDA guidelines for seismic stability (CDA 2014) and that the predicted seismic deformation is 10 cm, which indicates that the dam is expected to perform well under seismic loading (KCB 2017b). **Summary – no present concern and no long-term concern indicated.**

**Surface Erosion:** A portion of the Ed Creek Diversion Channel is approximately 10 m from the dam toe, and failure of the channel during a flood could potentially erode the dam toe. The riprap in the channel is weathering and breaking down, and Teck is looking at options for remediating the channel, including replacing the riprap and possibly realigning the channel away from the dam. **Summary – no present concern but some long-term concern is possible and further evaluation recommended.**

### Consequence Classification

Consequence classification is not related to the likelihood of a failure, but rather the potential impact resulting from a failure if it did occur. The downstream consequence classification of the TSF was reviewed in 2012 after the completion of the reclamation/closure works, and the Tailings Dam was classified as **Significant** based on the 2007 Dam Safety Guidelines published by the Canadian Dam Association (CDA 2007). The consequence classification was based on a simplified dam breach assessment, did not provide inundation maps showing the areas affected, and did not specifically address the presence of the on-site residence. The dam breach assessment should be updated to meet current state of practice, including inundation maps for sunny-day and rainy-day failures.

### Summary of Key Observations and Significant Changes

There has been no construction or any other significant changes to the TSF or associated water management infrastructure since the 2018 DSI.

There are six vibrating wire piezometers at three locations around the dam and fourteen survey monuments. Piezometers are read twice per year, and survey monuments are measured every ten years. There were no significant changes in the measurements made from these instruments in 2019, and the quantifiable performance objectives (QPOs) were met. Piezometer readings show seasonal fluctuations between spring and summer/fall. Survey monitoring stations were last read in December 2016, and the readings were below the alert criteria and did not give any cause for concern. There is normally no storage of water in the TSF and no instrumentation for water level or flow monitoring.

Overall, there were no significant changes to the stability of the dam in 2019, which means the dam is in a good state of repair. A stability assessment of the Tailings Dam was performed in 2017, which concluded that the dam meets industry standard static and seismic stability design criteria (KCB 2017b).

### OMS Manual and EPRP

The Operation, Maintenance and Surveillance (OMS) Manual and the Emergency Preparedness and Response Plan (EPRP) for the Pinchi Lake Mine TSF were updated in 2019 (KCB 2019) and are considered up to date.

### Dam Safety Review

A Dam Safety Review (DSR) of the Pinchi Lake Mine TSF and associated water infrastructure was performed by SRK in 2018 and the report has not yet been finalized as of September 2019. The draft DSR report includes a number of recommendations that are due to missing information and will likely be revised in the final document. The remainder of the recommendations are either addressed in this 2019 DSI report or they relate to minor deficiencies and areas of potential improvement to the site tailings management systems and do not require immediate attention. Subject to potential revisions during further review of the site documentation, these items will be discussed more fully in the final DSR report. The HSRC (MEM 2016, 2017) requires that all tailings storage facilities undergo a DSR every 5 years at minimum. To comply with the HSRC, the next DSR should be carried out in 2023.

## Summary of Recommendations

The deficiencies and recommendations related to dam safety are summarized in the following table. Aligned with the noted good state of repair of the facility and no observed or computed stability concerns, none of the issues are high priorities. The levels of priority assigned to each item in the table are based on priority ratings developed by Teck (and consistent with HSRC) as follows:

Priority 1 A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
Priority 2 If not corrected 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.
Priority 3 Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
Priority 4 Best Management Practice as a suggestion for continuous improvement towards industry best practices that could further reduce potential risks.

As shown in the table, none of the issues are expected to result in a dam safety issue upon occurrence and are therefore considered “best practice” issues rather than urgent, dam safety items.

| Structure | ID No. | Deficiency or Non-Conformance | Applicable Regulation or OMS Reference | Recommended Action | Priority | Recommended Deadline/Status |
|---|---|---|---|---|---|---|
| Ed Creek Diversion Channel | 2014-02 | The riprap along the Ed Creek Diversion Channel is undersized and is deteriorating due to weathering. | HSRC | Measures to re-establish the required erosion protection along the channel should be undertaken. This may include the replacement of the riprap or other suitable alternative(s).<br>As this work may take some time to undertake, in the interim, the channel should be inspected twice per year and the riprap along selected sections of the channel should be replaced when deemed necessary. | 3 | CLOSED - replaced by 2019-02 |
| TSF | 2018-01 | N/A | OMS Manual | Remove the West Ditch from regular surveillance in the 2019 DSI and in the next update of the OMS Manual. | 4 | CLOSED – Removed from surveillance in 2019 OMS Manual update |
| Borrow Area A | 2018-02 | N/A | OMS Manual | Discontinue Borrow Area A monitoring rod measurements and remove from the 2019 DSI and the next update of the OMS Manual. | 4 | CLOSED – Removed from surveillance in 2019 OMS Manual update |
| TSF | 2019-01 | The dam breach assessment performed in 2012 did not specifically assess potential consequences related to the on-site residence. | HSRC | The dam breach assessment should be updated to meet current state of practice. | 3 | End of 2020 |
| Ed Creek Diversion Channel | 2019-02 | The riprap along the Ed Creek Diversion Channel is undersized and is deteriorating due to weathering (2014-02). | OMS Manual | An options assessment and conceptual design should be completed for upgrading the channel to meet erosion protection requirements. Since failure of the riprap would not immediately affect the dam, the risk to the dam in the interim is effectively managed through inspections and maintenance as per the OMS Manual, and there is no immediate concern for dam safety. | 3 | End of 2020 |

Notwithstanding the deteriorating riprap in the Ed Creek Diversion Channel, which has both an interim and longer term remedial plan, the Pinchi Lake Mine TSF appears to be in good condition and there are no major concerns related to dam safety.

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# 1 INTRODUCTION

## 1.1 Purpose, Scope of Work and Methodology

This report presents the 2019 Dam Safety Inspection (DSI) of Teck Metals Ltd.'s Pinchi Lake Mine Tailings Storage Facility (TSF) by Klohn Crippen Berger Ltd. (KCB). The following activities were undertaken by KCB as part of the DSI:

- Site inspections by Mr. Bob Chambers, P.Eng. (the Engineer of Record) and Mr. Daniel Klassen, P.Eng. on June 11 and 12, 2019.
- Review and update of the list of outstanding recommendations from the previous dam safety inspections.
- Review instrumentation and confirm that readings are within acceptable limits.

KCB was accompanied by Ms. Michelle Unger (Teck), Ms. Morgan Lykpa, EIT (Teck), and Mr. Mark Pokorski, R.P.Bio. (Ecofor Consulting Ltd.). Mr. Pokorski conducted the spring freshet inspection of the TSF and associated facilities.

The 2019 DSI was conducted and this report prepared in accordance with the Teck Guideline for Tailings and Water Retaining Structures (Teck 2019).

The DSI report is issued before the end of the calendar year, so the period considered for climate data and instrumentation is from September 2018 to August 2019.

## 1.2 Regulatory Requirements

This DSI addresses the performance of the TSF and associated water management infrastructure in accordance with the Health, Safety and Reclamation Code for Mines in British Columbia (HSRC) (MEM 2016, 2017) and the Permit Amendment Approving Closure Plan (Permit No. M-5) dated July 12, 2010.

## 1.3 Engineer of Record and TSF Qualified Person

The Engineer of Record for the TSF is Mr. Bob Chambers, P.Eng., of KCB. The responsibilities of the TSF Qualified Person, as defined in the HSRC (MEM 2016), are performed by the Mine Manager, Ms. Michelle Unger of Teck.

## 1.4 Facility Description

The Pinchi Lake Mine is located in central British Columbia on the northern shore of Pinchi Lake approximately 25 km northwest of Fort St. James and 75 km northwest of Vanderhoof. Pinchi Lake is long (23 km) and narrow (ranging from approximately 1000 m to 3250 m wide) and lies at an elevation of approximately 720 metres above sea level (masl). At the mine site, Pinchi Lake is only 1250 m wide. The terrain near the mine site is heavily wooded with rolling hills and generally less than 300 m of relief, although some hills rise to over 1000 masl.

The mine was originally commissioned in the 1940s and operated from 1940 to 1944 during the Second World War. The mine was closed until 1968, when it re-opened and operated from 1968 to 1975. The property was placed on care and maintenance in 1975. Teck substantially completed the mine reclamation and closure works from 2010 to 2012.

A mine site plan and the general arrangement of the TSF are presented in Figures 1.1 and 1.2, respectively. Cross-sections of the Tailings Dam, based on 2012 topography, are shown in Figure 1.3.

The Pinchi Lake Mine TSF is a side hill impoundment covering approximately 24 ha and contained on three sides by an embankment dam. Approximately one million cubic metres of tailings are stored in the TSF. The Tailings Dam is approximately 1300 m long, and 3 m to 15 m high. The original dam was designed and constructed in the late 1960s, and it was raised in 1975 as shown in the historical drawing presented in Appendix IV. The dam was originally a homogeneous dam constructed with local glacial till and upstream slopes of 2.0H:1V near the crest and 2.5H:1V elsewhere, and downstream slopes of 2.0H:1V near the crest and 3.0H:1V elsewhere. When the dam was raised in 1975, a zone of rockfill was placed on the downstream slope with a transition zone between the glacial till and the rockfill.

Ed Creek originally flowed through the impoundment area as shown in the drawing in Appendix IV (labelled as “Main Creek” and “Ed Main Creek” in the drawing). The creek was diverted to Pinchi Lake via the Ed Creek Diversion Channel, which was constructed on the east side of the TSF (see Figure 1.2).

Water management for the TSF, prior to the implementation of the reclamation/closure works in 2010, comprised a low level decant system supplemented by an open channel Emergency Spillway. The decant box and spillway were located near the west abutment of the Tailings Dam as shown in the drawing in Appendix IV. The decant box and the spillway are labelled in the drawing as “new water collection box” and “overflow ditch”, respectively. The decant system and the Emergency Spillway were decommissioned, and a Closure Spillway was constructed, as part of the closure works completed by Teck in 2010 and 2011.

A facility data sheet for the TSF is presented in Appendix I.

## 1.5 Background Information and History

### 1.5.1 General

The design and construction history, from start-up to closure, is summarized below.

### 1.5.2 Pre-2010 Construction

The Pinchi Lake Mine TSF was constructed in 1967 and utilized between 1967 and 1975. The design/construction chronology was as follows:

- 1967 engineering of the facility (Stage 1) by Ripley, Klohn and Leonoff;

- 1967 construction under Kootenay Engineering inspection with Tara Engineering Laboratories carrying out fill placement quality control;
- 1971 inspection letter from Cominco Civil Designer noting settlement (approximately 2 ft) and resulting loss of freeboard - remedial measures were suggested;
- 1974 engineering report by Golder Associates for a 10 ft dam raise (Stage 2);
- 1975 letter by Golder Associates approving design drawings for a reduced dam raise of 5 ft;
- 1975 construction of the 5 ft raise;
- 2000 stabilization and rehabilitation of the Ed Creek Diversion Channel;
- 2001 rehabilitation of the Ed Creek Diversion Channel as the riprap and fish habitat were eroded by a large flood wave that resulted from a series of beaver dam failures; and
- 2001 Emergency Spillway excavation to increase flow capacity.

### 1.5.3 2010 and 2011 Reclamation/Closure Works

The following reclamation/closure works for the TSF were completed by Teck in 2010 and 2011:

- drained the water from the Tailings Impoundment;
- abandoned the Emergency Spillway;
- abandoned the decant system and backfilled the concrete decant inlet box with soil;
- placed and seeded soil cover over the tailings in the TSF;
- trimmed the crest of the western leg of the Tailings Dam for use as cover material for the tailings; and
- constructed the TSF Closure Spillway.

In addition to trimming the TSF dam crest for the 2010/2011 closure works, Teck developed three borrow areas adjacent to the TSF as a source of cover material for the tailings (see Figure 1.2): Borrow Areas B and C are located upstream of the TSF and Borrow Area A is located downstream of the south leg of the Tailings Dam.

The Closure Spillway is located in the area of the former supernatant pond. The spillway invert is set such that water would not be stored in the Tailings Impoundment under normal conditions. Draining of the water from the impoundment and constructing the spillway has converted the TSF into a “dry” facility.

# 2 SITE ACTIVITIES – FALL 2018 TO SUMMER 2019

The TSF is a closed facility and does not require operational intervention, except for scheduled and event driven inspections and maintenance work carried out on an as-required basis. Requirements for routine inspection and monitoring, and trigger levels for inspection following an extreme event are presented in the Operation, Maintenance and Surveillance (OMS) Manual and Emergency Preparedness and Response Plan (KCB 2019).

The Site Surveillance Officer, Mr. Mark Pokorski, carries out inspections of the facility twice per year: one in the spring after freshet, and one in the fall. The 2018 fall inspection was carried out on October 12, 2018, and the 2019 spring inspection was carried out on April 25, 2019. These inspections did not identify any dam safety issues. The 2019 fall inspection had not yet been performed at the time of issuing this DSI report.

An annual inspection of the TSF is conducted by the Engineer of Record in late spring. As noted previously, in 2019 this inspection occurred on June 11 and 12.

Two holes (60 cm diameter by 75 m deep) previously identified at the upstream and downstream edges of the dam crest were filled with gravel during the 2018 fall inspection. These holes were located next to stakes marked 1018 and 1025, and were likely former survey monument locations.

Apart from these routine inspections and site maintenance, there were no other site activities during 2019.

# 3 CLIMATE DATA AND WATER BALANCE DURING 2019

## 3.1 Climate Data

There is no climate station at the mine site; however, temperature and precipitation data for Fort St. James (Environment Canada climate station no. 1092975, located approximately 25 km southeast of the mine) were reviewed. Table 3.1 presents a comparison of the recorded monthly temperatures and precipitation from Sep. 1, 2018 to Aug. 31, 2019 with the station's temperature and precipitation normals for 1981 to 2010. The records of temperature and total precipitation (rainfall + snowfall) from this station are fairly complete, but separate measurements of rain and snow are only available from another climate station at essentially the same location (Environment Canada climate station no. 1092970, located about 1.5 m from the other station based on the provided latitude and longitude). However, these rain and snow measurements were recorded only 3 or 4 days per week in 2018 and 2019, so they are too incomplete for calculating monthly totals.

The climate data shows that temperatures during the period examined were close to average conditions, apart from an unusually cold February (daily average -15.3°C compared to -6.8°C climate normal). The precipitation data shows some unusually wet months (November and December, with 67 mm and 61 mm compared to 29 mm and 38 mm normal) and some unusually dry months (October, March, April, and June, with 22 mm, 6 mm, 6 mm and 16 mm compared to 45 mm, 26 mm, 24 mm and 51 mm normal), but overall the precipitation was similar to average conditions (401 mm compared to 487 mm normal annual precipitation).

## 3.2 Water Balance

The HSRC (MEM 2016, 2017) calls for a water balance review. Since the Pinchi Lake Mine TSF is a dry facility, there is no storage of water in the Tailings Impoundment and stormwater inflows are passively released from the impoundment via the Closure Spillway. Based on observations, there has been no indication of ponding of water behind the spillway, except in small local depressions in the tailings cover. Because inflow to the impoundment is limited to direct precipitation and stormwater runoff from small catchments upslope of the TSF, an annual water balance review is deemed to be unnecessary. However, a water balance was prepared in 2019 based on average precipitation from 1998 to 2017 at Fort St. James (Environment Canada climate station no. 1092970). The water balance is included in Appendix V. The average discharge through the spillway was estimated to be 0.5 L/s.

## 3.3 Water Quality

Water quality was not assessed by KCB. The surface water quality discharging from the TSF is currently monitored annually under effluent permit PE-224. The groundwater quality at Pinchi Lake Mine is currently monitored under the Contaminated Sites Regulation (B.C. Reg. 375/96). Both surface and groundwater quality are reported by Teck to B.C. Ministry of Environment and B.C. Ministry of Energy, Mines & Petroleum Resources.

**Table 3.1 Fort St. James (No. 1092975) Temperatures and Precipitation – September 2018 to August 2019 vs. Normal Values**

| | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1981-2010 Normals** | | | | | | | | | | | | | |
| **Temperature** | | | | | | | | | | | | | |
| Daily Average (°C) | 10.2 | 4.3 | -3.0 | -7.8 | -9.5 | -6.8 | -1.8 | 3.9 | 9.2 | 13.4 | 15.4 | 14.8 | 3.5 |
| Daily Maximum (°C) | 16.4 | 9.0 | 0.6 | -3.8 | -5.3 | -1.7 | 4.0 | 9.9 | 15.6 | 19.6 | 21.8 | 21.7 | 9.0 |
| Daily Minimum (°C) | 3.9 | -0.5 | -6.5 | -11.7 | -13.7 | -11.8 | -7.7 | -2.2 | 2.8 | 7.2 | 8.9 | 7.9 | -2.0 |
| **Precipitation** | | | | | | | | | | | | | |
| Rainfall (mm) | 39.1 | 38.7 | 15.7 | 4.2 | 4.9 | 3.6 | 5.9 | 18.0 | 38.2 | 50.6 | 50.6 | 45.0 | 314.5 |
| Snowfall (cm) | 0.2 | 9.5 | 28.8 | 38.4 | 43.3 | 26.4 | 19.8 | 5.7 | 0.7 | 0.0 | 0.0 | 0.0 | 172.7 |
| Precipitation (mm) | 39.3 | 48.1 | 44.5 | 42.6 | 48.1 | 30.0 | 25.7 | 23.7 | 38.9 | 50.6 | 50.6 | 45.0 | 487.2 |
| | | | | | | | | | | | | | |
| **September 2018 – August 2019** | | | | | | | | | | | | | |
| **Temperature** | | | | | | | | | | | | | |
| Daily Average (°C) | 8.2 | 5.0 | 0.2 | -3.8 | -4.2 | -15.3 | -3.6 | 4.7 | 12.5 | 13.8 | 15.6 | 15.4 | 4.2 |
| Daily Maximum (°C) | 13.2 | 10.4 | 3.0 | -0.7 | -0.5 | -8.7 | 3.8 | 10.8 | 19.3 | 19.6 | 20.8 | 21.3 | 9.5 |
| Daily Minimum (°C) | 3.3 | -0.4 | -2.6 | -7.0 | -8.0 | -21.9 | -11.0 | -1.5 | 5.7 | 8.0 | 10.4 | 9.6 | -1.2 |
| **Precipitation** | | | | | | | | | | | | | |
| Rainfall (mm) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Snowfall (cm) | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Precipitation (mm) | 40.4 | 21.9 | 66.8 | 61.2 | 37.7 | 17.5 | 6.1 | 6.4 | 34.3 | 15.8 | 58.0 | 34.6 | 400.7 |
| **No. of days of missing data** | 4 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |

# 4 SITE OBSERVATIONS – JUNE 2019

## 4.1 Visual Inspection

The following areas were inspected during the June 11 to 12, 2019 site visit:

- Tailings Storage Facility:
  - Tailings Impoundment (drained and covered with soil);
  - Tailings Dam; and
  - Closure Spillway.
- Borrow Area A Slope;
- Ed Creek:
  - Ed Creek Diversion Channel; and
  - Ed Creek culverts under Pinchi Lake Road.

Site observations and recommendations are presented in the following sub-sections. Observation locations referred to in the following sub-sections are identified in Figure 4.1. Selected photographs taken during the inspection are presented in Appendix II, and inspection forms are presented in Appendix III.

### 4.1.1 Tailings Storage Facility

#### Tailings Impoundment

- There was no flowing or standing water in the Tailings Impoundment at the time of inspection, apart from a small pond on the south side of the Closure Spillway as described below.
- The soil cover on the tailings is covered in grass (Photos II-6 and II-8 in Appendix II). A detailed inspection of the cover was not conducted as it was not a part of the scope of this DSI.
- As noted during previous inspections, a channel has formed in the soil cover parallel to the southwest leg of the Tailings Dam adjacent to the dam (Location 3 in Figure 4.1; Photos II-15). There is good growth of grass and some cattails along most of the channel, with no signs of erosion.
- In 2014, Teck placed riprap at the downstream end of the above-mentioned channel where it discharges into the Closure Spillway (Location 2 in Figure 4.1; Photos II-20 and II-21). The riprap appears to be performing well. A small pond (about 1 m wide) was observed south of the riprap (Photo II-21).

#### Tailings Dam

- The dam crest, and upstream and downstream slopes of the Tailings Dam appeared to be in good condition.

- One longitudinal crack (3 m long, 10 mm wide, and 70 mm deep) was observed on the dam crest along the southwest leg of the Tailings Dam (Location 4 in Figure 4.1; Photo II-14), similar to those observed in 2015, 2017 and 2018. The cracks appear to be aligned with tire tracks. These cracks are believed to have been formed by loosening and drying of the soil as part of the reclamation and seeding. The cracks are not a dam safety issue.
- There is vegetation on the slope of the east leg of the dam, especially on the north section, including trees up to about 3 m tall (Location 9 in Figure 4.1; Photos II-1, II-2, II-4, and II-5). This vegetation is not currently considered to be a dam safety concern, although it may be prudent to clear it before the trees become more difficult to remove. The vegetation management plan recommends vegetation clearing prior to vegetation exceeding 1.5 m in height (Spectrum 2017).
- A pond was observed in the trees near the toe of the east leg of the Tailings Dam (see Figure 1.2 for location; Photo II-3) as in previous inspections. This pond is located near a drainage channel that was shown on historical drawings of the TSF (see Appendix IV) and labelled “runoff channel.” The channel ran parallel to the main Ed Creek channel, and apparently once joined up with Ed Creek just inside the TSF. The pond appears to collect local runoff, and it drains through a channel to the south and through a culvert into Ed Creek Diversion Channel.
- Apart from the pond noted above, the ground at the downstream toe of the dam was dry and no ponded water or seepage were observed.

### Closure Spillway

- There was no flow or standing water in the Closure Spillway channel at the time of inspection; there was a 40 cm deep pond at the downstream end of the riprap (Photo II-29).
- The riprap along the entire Closure Spillway channel appeared to be in good condition (Photos II-20, II-23 to II-26, II-28 and II-29). The spillway has likely not experienced any high flood discharges since it was constructed. Vegetation growth in the channel was minimal at the time of inspection, only a few small shrubs (Photo II-28).
- A small slump in the slope above the riprap on the right (north) side of the spillway channel has been noted in inspections since 2014 (Location 1 in Figure 4.1). The slump area was covered in grass and the head scarp was only visible at close range (Photo II-27). The upstream side of the slump is located about 90 m downstream of the dam centreline. The condition of the slump has not noticeably changed in the last five years, and it is not expected to impact the Tailings Dam or the performance of the spillway.
- The spillway downstream channel was observed at the culvert crossing on the road to the on-site residence (Photos II-30 to II-34). The middle reach immediately upstream of the culvert appeared to be in good condition with minor vegetation growth (Photo II-32). There was grass growing in front of the culvert inlet, partially blocking it (Photos II-30 and II-31). There was no flow into the culvert at the time of the inspection. The outlet of the culvert was clear of vegetation, but there was water ponding locally at the outlet to 11 cm above the invert

(Photo II-33). The culvert is not related to dam safety but clearing of the inlet may be prudent to restore its normal flow capacity. The lower reach of the spillway downstream channel appeared to be in good condition with minor vegetation growth (Photo II-34).

### 4.1.2 Borrow Area A Slope

- The slope of Borrow Area A is located near the south leg of the Tailings Dam, about 10 m downstream of the toe. The slope appeared to be in good condition (Photos II-35, II-37, II-39).
- Cracks were observed on the slope from 2013 to 2017 (Location 5 in Figure 4.1). These cracks are no longer visible due to vegetation growth, and no new cracks were observed during the inspection. Measurements of crack movements were taken from 2015 to 2018 using metal rods installed on either side of the cracks (Photo II-36), and these measurements showed no sign of ongoing movements. These measurements were discontinued and removed from routine surveillance in the OMS Manual in 2019 (KCB 2019).
- A few small areas of wet ground were observed starting in the northeast corner of the borrow area and moving slightly downhill to the west along the toe of the slope for 60 m (Location 7 in Figure 4.1; Photo II-38), where a small pond was observed (Location 6 in Figure 4.1). There was no flowing water observed. Similar wet areas have been observed since 2011, and they are believed to be associated with groundwater unrelated to the TSF. Outside of these wet areas, the ground on the slope and along the toe was dry.

### 4.1.3 Ed Creek

#### Ed Creek Diversion Channel

- The 460 mm diameter HDPE culvert on the north bank of the Ed Creek Diversion Channel had some vegetation growing in front of the inlet (see Figure 1.2 for culvert location, and Photos II-52 and II-53). This is not a dam safety concern.
- Vegetation growth at the base of Ed Creek Diversion Channel has reached up to 2 m height (Photos II-42, II-43 and II-45 to II-51). This is not currently considered to be a dam safety concern. However, the vegetation management plan recommends vegetation clearing prior to vegetation exceeding 1.5 m in height (Spectrum 2017).
- Previous annual inspection reports have noted that the riprap along some areas of the Ed Creek Diversion Channel is weathering and breaking up (Photo II-44). The condition of the riprap appeared similar to previous inspections.

  The riprap along a small section of the channel (Location 8 in Figure 4.1; Photo II-47), where a depression had formed in the riprap surface, was replaced in 2014. This riprap appeared to be in good condition.

  A complete failure of the Ed Creek Diversion Channel could potentially affect the Tailings Dam by eroding the west bank of the channel towards the dam and undermining the dam foundation. That level of event could not occur within a one-year period given the current

level of inspection occurring. However, a long-term solution remains the recommendation, first made in 2014, for Teck to re-establish erosion protection. Teck is actively investigating erosion protection options for the channel given the lack of immediately available riprap material at site of appropriate size. The existing recommendation has been updated as below to clarify how the interim risk to the dam is managed.

*Recommendation/Action:*

*An options assessment and conceptual design should be completed for upgrading the channel to meet erosion protection requirements. Since failure of the riprap would not immediately affect the dam, the risk to the dam in the interim is effectively managed through inspections and maintenance as per the OMS Manual, and there is no immediate concern for dam safety.*

#### Ed Creek Culverts Under Pinchi Lake Road

- There are two culverts on Ed Creek under Pinchi Lake Road east of the mine gate (see Figure 1.2 for location). Flow was observed in the east culvert only, with a depth of 80 mm at the inlet.
- There was overhanging vegetation in front of the culvert inlets (Photos II-55 and I-56). A blockage of the culverts could potentially cause a washout of the road, and a sudden failure of the road embankment may subject the Ed Creek Diversion Channel to large flood flows. Monitoring of these culverts is included in the inspection checklists in the OMS Manual, and they will continue to be monitored in future inspections.

## 4.2 Instrumentation Review

### 4.2.1 Tailings Dam Instrumentation

There are six vibrating wire piezometers at three locations around the dam (four piezometers at the toe, two at the crest) as shown in Figure 1.2, and these are read twice per year at minimum. These are currently the only functional instruments in the dam. Quantifiable performance objectives (QPOs) for the piezometers are defined as threshold piezometric elevations, and these are given in Appendix VI.

Piezometer readings taken in fall 2018 and spring 2019 are included in Table 4.1, and threshold values are shown for comparison. The readings are all below the threshold values. The readings show that the phreatic surface is 1 m to 3 m below ground at the toe of the dam, and 10 m below the crest at the highest dam section. Piezometer readings are shown as elevations versus time in Figure 4.2. The readings in the piezometers at the dam toe (DH16-01-VWP1,2 and DH16-03-VWP1,2) show seasonal fluctuations up to 2 m, with higher readings in the spring and lower readings in the fall. The piezometers installed below the dam crest (DH16-02-VWP1,2) have shown less variation in the readings apart from an initial drop from October 2016 to April 2017. The drop in readings is likely due to the piezometers having not yet reached equilibrium with the ground around the grout column after the September 2016 installation.

Prior to the installation of the 2016 piezometers there had been no functioning instruments in the Tailings Dam for several years. One piezometer (BH3) was installed on the dam at the highest dam section in 1998 (located 10 m from 2016 piezometers DH16-02-VWP1,2). Teck indicated that the piezometer was destroyed sometime after 2008. Piezometer readings from May 2000 to October 2008, presented in the 2008 Annual Review Report (KCB 2009a), indicate that the phreatic surface at the piezometer was typically around El. 733.5 m, which is 1.4 m higher than the June 11, 2019 reading in DH16-02-VWP1. This suggests the piezometric levels in the dam have gone down compared to the condition before the pond was drained.

**Table 4.1 Fall 2018 to Spring 2019 Piezometer Readings**

| Piezometer ID | Piezometric Elevation (m) | | | | Depth Below Ground (m) | | |
|---|---|---|---|---|---|---|---|
| | Threshold Value | Oct. 12, 2018 | Apr. 25, 2019 | Jun. 11, 2019 | Oct. 12, 2018 | Apr. 25, 2019 | Jun. 11, 2019 |
| DH16-01-VWP1 | 736.1 | 733.2 | 735.2 | 734.8 | 2.9 | 0.9 | 1.3 |
| DH16-01-VWP2 | 736.1 | 733.3 | 734.2 | 734.1 | 2.8 | 1.9 | 2.0 |
| DH16-02-VWP1 | 738.5 | 732.1 | 732.1 | 732.1 | 9.9 | 9.9 | 9.9 |
| DH16-02-VWP2 | 738.5 | 732.2 | 732.2 | 732.3 | 9.8 | 9.8 | 9.7 |
| DH16-03-VWP1 | 737.0 | 734.2 | 735.4 | 735.3 | 3.7 | 2.5 | 2.6 |
| DH16-03-VWP2 | 737.0 | 734.1 | 735.3 | 735.1 | 3.8 | 2.6 | 2.8 |

### 4.2.2 Flow and Water Level Measurements

Since there is no pond, there is no flow measurement or water level instrumentation at the TSF. Prior to decommissioning, flow out of the decant system was measured. Water is now released through the Closure Spillway but, given that the spillway channel is lined with large riprap, most of the low flows pass through the riprap, making it difficult to measure flow.

### 4.2.3 Survey Monitoring Monuments

Survey monitoring stations were installed on the Tailings Dam crest in 1998; however, some stations were destroyed over the years. New survey monitoring stations were installed in June 2014. The locations of the 2014 monuments and the surviving 1998 monuments are shown in Figure 1.2. QPOs for the survey monuments are provided in Appendix VI.

Readings were last taken in December 2016, and the readings met the QPOs and did not give any cause for concern (KCB 2017a). The monitoring stations are to be read every ten years, so the next readings will be in 2026.

# 5 DAM SAFETY ASSESSMENT

## 5.1 Design Basis Review

The relevant design criteria from CDA (2014) and HSRC (MEM 2016, 2017) are compared in Table 5.1. The site conditions are being evaluated to confirm that the TSF meets design criteria for the Closure – Passive Care phase, as described by CDA (2014). The criteria in HSRC are similar to the CDA criteria for Closure – Passive Care.

**Table 5.1 Comparison of CDA and HSRC Design Criteria for Tailings Dams Classified as Significant**

| Parameter | CDA (2014) | | HSRC (MEM 2016, 2017) |
|---|---|---|---|
| | Construction, Operation, and Transition Phases | Closure – Passive Care Phase | |
| Annual Exceedance Probability (AEP) – Floods | Between 1/100 and 1/1000 | 1/3 between 1/1000 and PMF | 1/3 between 1/975 and PMF |
| AEP – Earthquakes | Between 1/100 and 1/1000 | 1/2475 | 1/2475 |
| Factor of safety for slope stability:<br>Static, Long Term<br>Pseudostatic<br>Post-Earthquake | <br>1.5<br>1.0<br>1.2 | <br>1.5<br>1.0<br>1.2 | <br>1.5<br>Not specified<br>Not specified |
| Steepest Allowable Downstream Slope | Not specified | Not specified | 2H:1V |

## 5.2 Dam Safety Review

A Dam Safety Review (DSR) of the Pinchi Lake Mine TSF and associated water infrastructure was performed by SRK in 2018 and the report has not yet been finalized as of September 2019. The draft DSR report includes a number of recommendations that are due to missing information and will likely be revised in the final document. The remainder of the recommendations are either addressed in this 2019 DSI report or they relate to minor deficiencies and areas of potential improvement to the site tailings management systems and do not require immediate attention. Subject to potential revisions during further review of the site documentation, these items will be discussed more fully in the final DSR report. The HSRC (MEM 2016, 2017) requires that all tailings storage facilities undergo a DSR every 5 years at minimum. To comply with the HSRC, the next DSR should be carried out in 2023.

## 5.3 Failure Modes Review

The potential failure modes included in the CDA Dam Safety Guidelines (2013) were reviewed based on the inspection and review of available documents:

- **Overtopping:** There is no permanent pond in the TSF, and the Closure Spillway is designed to convey flood flows passively without developing a large pond in the TSF. A hydrotechnical review of the Closure Spillway is in progress, but based on previous assessments the freeboard during the design flood is expected to be several metres (KCB 2009b). Based on

these factors, the likelihood of an overtopping failure is considered to be "Close to Non-Credible"[1].

- **Internal Erosion and Piping:** The dam includes three fill zones: local silt-clay and glacial till borrow material, a rockfill zone on the downstream slope, and a transition material between the silt-clay/glacial till and the rockfill. The filter adequacy was reviewed previously, and it was found that the as-built information is insufficient to assess the filter compatibility of these materials (KCB 2015). However, the observed performance of the dam, combined with the fact that the TSF is now a dry facility, provide evidence that the filter is functioning adequately to prevent piping. Seepage water or evidence of piping at the dam toe have not been observed during annual inspections. Since the pond was drained during the 2010 to 2011 closure works the seepage gradients through the dam have reduced, and this is reflected in lower piezometer readings in the dam compared to the pre-2010 readings, as discussed in Section 4.2.1. Checking the dam toe for seepage is included in the scheduled surveillance in the OMS Manual (KCB 2019). The likelihood of failure due to piping is considered to be "Very Rare"[2].
- **Slope Instability:** A stability assessment of the TSF was completed in 2017 (KCB 2017b) and found that the stability criteria described in Section 5.1 are met. The assessment included analyses using undrained strengths in the foundation clay. The condition of the dam is generally more favourable for stability now than it was during operations due to the draining of the pond, and trimming of the dam crest in some areas. Based on the stability assessment and the long performance history with no visible or documented displacements, the likelihood of failure due to slope instability is considered to be "Very Rare".
- **Foundation Irregularities:** A drilling and laboratory testing program was carried out in 2016 to confirm whether silt or clay soils are present beneath the dam and to characterize their geotechnical properties (KCB 2017c). The investigation identified lacustrine clay below the west leg and the east leg of the dam, but the drill hole at the southwest leg of the dam, where the dam is highest, did not encounter lacustrine clay. The Borrow Area A slope has exposed foundation soils near the south leg of the dam and no lacustrine clay was visible, and earlier drill holes in this area confirm glacial till-like soils. The foundation investigation is believed to be sufficiently detailed for this facility.

  The stability assessment described above examined slip surfaces through the lacustrine clay and found that design criteria were met. Based on this analysis and the long performance history with no visible or documented displacements, the likelihood of failure due to a foundation irregularity is considered to be "Very Rare".

[1] "Close to Non-Credible" Likelihood Rating is defined as: for a natural hazard (earthquake, flood, windstorm, etc.), the predicted return period for an event of this strength/magnitude is greater than 1 in 10,000 years; this rating is also applicable for failure modes such as instability and internal erosion that are close to non-credible. Factor of Safety (FoS) against slope instability of 2.0 or greater.

[2] "Very Rare" Likelihood Rating is defined similar to "Close to Non-Credible" rating, except with a natural hazard return period of between 1 in 1,000 years and 1 in 10,000 years; this rating is also applicable for failure modes that are very rare. FoS against slope instability of 1.5 to 2.0.

- **Surface Erosion:** There are no significant erosion features on the crest or slopes of the dam. Surface runoff from the impoundment drains towards the closure spillway and will not erode the dam surface. The dam surface is vegetated and well protected against surface erosion. The downstream slope of the dam includes coarse rockfill, so any erosion channels that form would be self-armouring and unlikely to rapidly erode through the dam.

  A portion of the Ed Creek Diversion Channel is approximately 10 m from the dam toe, and failure of the channel during a flood could potentially erode the dam toe. The riprap in the channel is weathering and breaking down, and Teck is looking at options for remediating the channel, including replacing the riprap and possibly realigning the channel away from the dam. Until this is completed, the interim risk is managed through surveillance and maintenance. A failure of the riprap in the channel would not immediately affect the dam, and there would be time to halt the erosion of the natural glacial till soils in the right bank before it could impact the dam. Therefore, the likelihood of failure due to surface erosion is considered to be “Very Rare”.

- **Earthquakes:** A simplified deformation analysis was performed as part of the stability assessment (KCB 2017b) using the Hynes-Griffin and Franklin (1984) method. A peak ground acceleration (PGA) of 0.044 g was used, corresponding to the 1/2475 AEP earthquake event. The results showed that the predicted deformation is 10 cm, which indicates that the dam is expected to perform well under seismic loading. A post-earthquake stability analysis was also performed assuming full liquefaction of the tailings. Note that a liquefaction triggering analysis has never been performed for these tailings, but given the low PGA, full liquefaction of the tailings is likely a conservative assumption. The post-earthquake analysis met the minimum FOS of 1.2 recommended by CDA (2014), indicating that a flow-slide failure due to liquefaction of the tailings is unlikely. Note that both the deformation and post-earthquake analyses used 80% of the peak undrained strength in the lacustrine clay to account for cyclic softening, which is likely conservative given the low PGA. Based on this analysis, the likelihood of failure due to earthquake loading is considered to be “Very Rare”.

## 5.4 Dam Classification Review

Consequence classification is not related to the likelihood of a failure, but rather the potential impact resulting from a failure if it did occur. As a follow-up on the completion of the reclamation/closure works, KCB reviewed the dam classification for the TSF in 2012 with respect to the criteria presented in the 2007 CDA Dam Safety Guidelines (CDA 2007), and the HSRC. Details of the classification review are presented in Pinchi Lake Mine Post-Reclamation Monitoring Requirements (KCB 2012), and the results are summarized below.

### CDA Dam Classification

KCB (2012) stated that the area downstream of the dam is undeveloped, with no settlements, public roads or any other infrastructure. There is no permanent population at risk. In the event of a breach at the Tailings Dam, releases from the impoundment could enter Pinchi Lake. The TSF was classified

as Low for economic and cultural losses, and Significant for loss of life and environmental losses. Therefore, the overall classification of the Tailings Dam is Significant.

The 2012 classification review included a simplified dam breach assessment to estimate the peak discharge, tailings outflow volume and tailings runout distance for hypothetical sunny-day and rainy-day failure scenarios. The study did not provide information on the lateral extent of tailings and water flow or inundation maps showing the areas effected. The study did not specifically address the presence of the on-site residence, which is still occupied by the former mine caretaker and his wife at the time of writing, and may be considered a permanent population at risk if the residence is within the inundation area. There have also been improvements to the state of practice for tailings dam breach analyses since that time.

*Recommendation/Action:*

> *The dam breach assessment should be updated to meet current state of practice.*

### HSRC Classification

The Tailings Dam and the impoundment were classified as a “major dam” and a “major impoundment” under the 2008 version of the HSRC (MEMPR 2008). The current edition of the HSRC (MEM 2017) does not include the terms “major dam” or “major impoundment”. All tailings storage facilities are required to have the consequence classification determined by the Engineer of Record in accordance with the CDA Dam Safety Guidelines (CDA 2013), and design criteria are given in the Code based on the consequence classification. Design criteria that are relevant to the Pinchi TSF are described in Section 5.1.

## 5.5 Physical Performance

### Geotechnical

The dam has performed adequately for over 40 years, and there is no record of slumping or instability since operations ceased in 1975. The closure works in 2010 and 2011 included changes that improved the stability of the dam, including:

- draining the pond, resulting in a decrease in phreatic levels within the dam (as discussed in Section 4.2.1); and
- trimming the crest of the west leg of the Tailings Dam, resulting in a reduction in driving forces for potential failure surfaces in that area.

Borrow Area A was excavated about 10 m from the toe of the south leg of the Tailings Dam during the closure works, and is therefore relevant to performance of the dam. Longitudinal cracks were identified on the north slope of Borrow Area A in August 2013. The stability of the overall slope (which includes the Tailings Dam) was reviewed in 2017 under static and seismic loadings, and was found to meet the design criteria summarized in Table 5.1 (KCB 2017b).

However, localized slumping of the borrow area slope could occur and may impact the Tailings Dam if allowed to progress. Therefore, monitoring of the Borrow Area A slope for development of cracks, seeps and movement is part of regular surveillance as described in the OMS Manual (KCB 2019).

A foundation investigation was performed in 2016 to confirm whether silt or clay soils are present beneath the dam and to characterize their geotechnical properties (KCB 2017c). The investigation concluded that lacustrine clay is present below portions of the dam. The strength of the clay was characterized through laboratory testing of sonic core samples. The data obtained during the investigation was used to perform a stability assessment of the Tailings Dam, which concluded that the dam meets the static and seismic stability design criteria described in Section 5.1 (KCB 2017b).

### Hydrotechnical

The Closure Spillway is a free-flowing riprap lined open channel, which passively releases water from the TSF. There is no storage of water in the TSF. The spillway is lined with large riprap and non-flood flows pass through the riprap with very little, if any, flow over the riprap surface. To the best of our knowledge, the Closure Spillway has not been subjected to any large flood flows since it was constructed in 2010.

The Closure Spillway was designed to route the 24-hour 1000-year rainfall plus 100-year snowmelt event (KCB 2009b). This design was adequate to meet CDA (2007) criteria, which specified the 1000-year flood event as the criteria for a Significant dam. CDA (2014) increased the criteria for Significant tailings dams in the Passive Care phase of closure to 1/3 between the 1000-year event and the Probable Maximum Flood (PMF), and HSRC (MEM 2016) set the criteria in all phases of the mine life to 1/3 between the 975-year event and the PMF (see Table 5.1 for a summary of the revised criteria). However, the HSRC states that the revised criteria do not apply when the chief inspector has received a permit application before the date when the criteria came into force, which is the case for the spillway. Nevertheless, an evaluation of the spillway capacity with respect to Passive Care criteria is in progress.

Vegetation should be cleared periodically from the water conveyance structures including the Closure Spillway, Ed Creek Diversion Channel, and ditches or they will not operate to design capacity. This is covered under the vegetation management plan (Spectrum 2017).

## 5.6 Operational Performance

The Pinchi Lake Mine TSF has been closed for about 40 years and, as indicated in Section 2, there are no operational requirements.

## 5.7 OMS Manual and EPRP Review

The Operation, Maintenance and Surveillance (OMS) Manual and the Emergency Preparedness and Response Plan (EPRP) for the Pinchi Lake Mine TSF were revised in 2019 (KCB 2019) and are considered up to date.

# 6 CONCLUSIONS AND RECOMMENDATIONS

The deficiencies and recommendations from previous years and from the 2019 inspection are summarized in Table 6.1. The priorities assigned to each item in Table 6.1 are based on priority ratings developed by Teck (and consistent with HSRC) as follows:

Priority 1 A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.

Priority 2 If not corrected 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.

Priority 3 Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.

Priority 4 Best Management Practice as a suggestion for continuous improvement towards industry best practices that could further reduce potential risks.

Notwithstanding the deteriorating riprap in the Ed Creek Diversion Channel, which has both an interim and longer term remedial plan, the Pinchi Lake Mine TSF appears to be in good condition and there are no major concerns related to dam safety.

Inspections were carried out in October 2018 and April 2019 by the Site Surveillance Officer, and in June 2019 by the Engineer of Record.

There were no threshold exceedances in the piezometers in 2019.

The riprap along the Ed Creek Diversion Channel is undersized and is deteriorating due to weathering. A failure of the Diversion Channel could potentially affect the Tailings Dam. Measures to re-establish the required erosion protection along the channel, such as replacement of the riprap or other suitable alternatives, should be undertaken. Teck is actively investigating options to remediate the channel, and may require additional studies to assess the long-term implications of each option in terms of risk, cost, and maintenance requirements. A failure of the riprap in the channel would not immediately affect the Tailings Dam, and there would be time to halt the erosion of the natural glacial till soils in the right bank before it could impact the dam. Therefore, the interim risk to the dam is effectively managed through the surveillance and maintenance activities that are carried out as per the OMS Manual.

Climate data from the nearest climate station for the period from Sep. 1, 2018 to Aug. 31, 2019 showed temperatures and precipitation were close to average conditions (based on 1981 to 2010 climate normals). Since the water balance is based on annual average climate data, there is no storage of water in the TSF, and inflows are limited to direct precipitation and stormwater runoff from upslope, updating the water balance on an annual basis is deemed to be unnecessary.

The downstream consequence classification of the TSF was reviewed in 2012 after the completion of the reclamation/closure works, and the dam was classified as Significant. That study was based on a

simplified dam breach assessment, did not provide inundation maps showing the areas affected, and did not specifically address the presence of the on-site residence. The dam breach assessment should be updated to meet current state of practice, including inundation maps for sunny-day and rainy-day failures.

The OMS Manual and the EPRP were updated in 2019 and are considered up to date.

**Table 6.1 Summary of Deficiencies and Recommendations**

| Structure | ID No. | Deficiency or Non-Conformance | Applicable Regulation or OMS Reference | Recommended Action | Priority | Recommended Deadline/Status |
|---|---|---|---|---|---|---|
| Ed Creek Diversion Channel | 2014-02 | The riprap along the Ed Creek Diversion Channel is undersized and is deteriorating due to weathering. | HSRC | Measures to re-establish the required erosion protection along the channel should be undertaken. This may include the replacement of the riprap or other suitable alternative(s).<br>As this work may take some time to undertake, in the interim, the channel should be inspected twice per year and the riprap along selected sections of the channel should be replaced when deemed necessary. | 3 | CLOSED - replaced by 2019-02 |
| TSF | 2018-01 | N/A | OMS Manual | Remove the West Ditch from regular surveillance in the 2019 DSI and in the next update of the OMS Manual. | 4 | CLOSED – Removed from surveillance in 2019 OMS Manual update |
| Borrow Area A | 2018-02 | N/A | OMS Manual | Discontinue Borrow Area A monitoring rod measurements and remove from the 2019 DSI and the next update of the OMS Manual. | 4 | CLOSED – Removed from surveillance in 2019 OMS Manual update |
| TSF | 2019-01 | The dam breach assessment performed in 2012 did not specifically assess potential consequences related to the on-site residence. | HSRC | The dam breach assessment should be updated to meet current state of practice. | 3 | End of 2020 |
| Ed Creek Diversion Channel | 2019-02 | The riprap along the Ed Creek Diversion Channel is undersized and is deteriorating due to weathering (2014-02). | OMS Manual | An options assessment and conceptual design should be completed for upgrading the channel to meet erosion protection requirements. Since failure of the riprap would not immediately affect the dam, the risk to the dam in the interim is effectively managed through inspections and maintenance as per the OMS Manual, and there is no immediate concern for dam safety. | 3 | End of 2020 |

# 7 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Teck Metals Ltd. (Client) for the specific application to the Pinchi Lake Mine project. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

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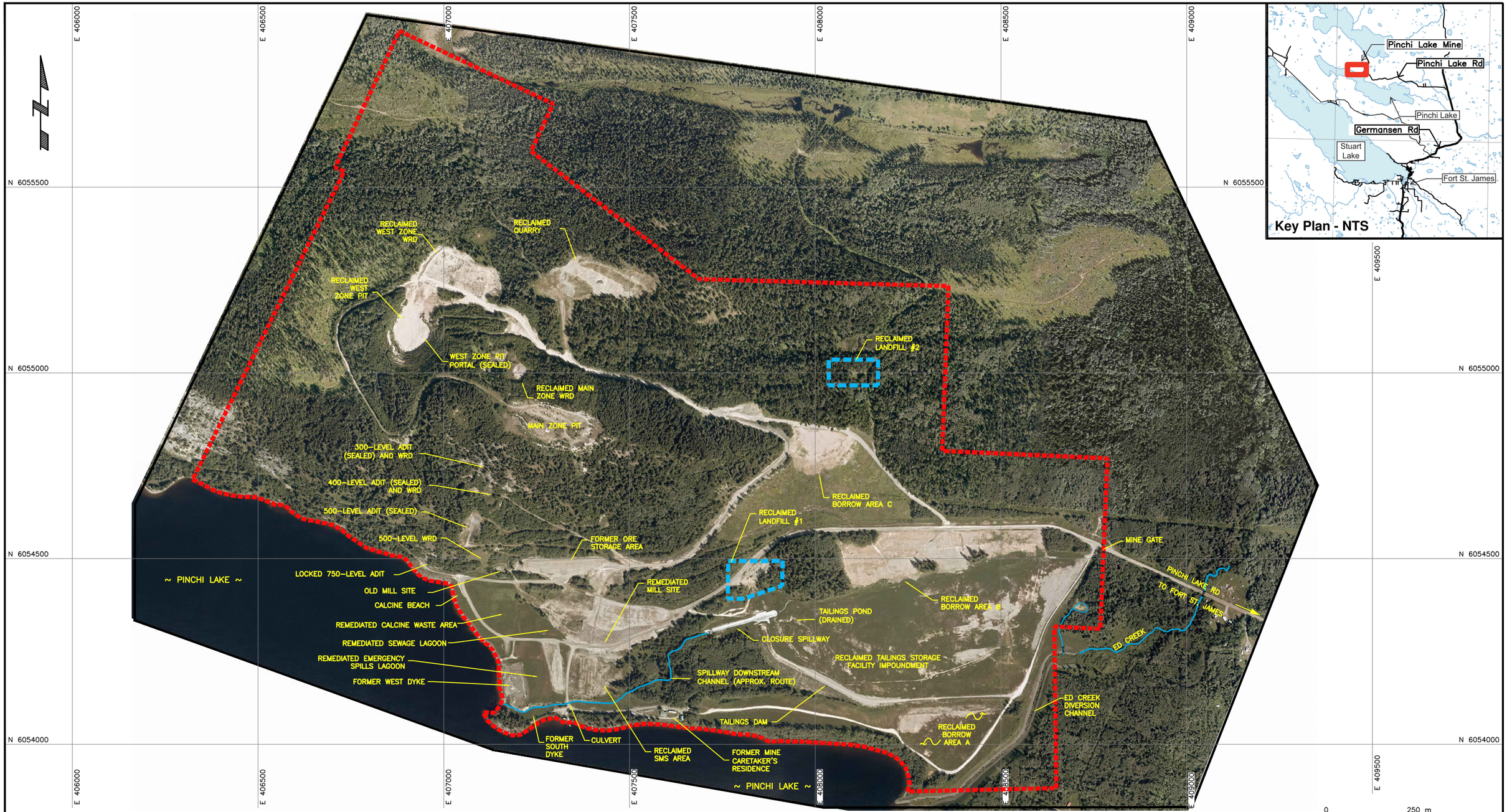
# FIGURES




TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED SEPTEMBER 2019

SCALE 0 250 m

## LEGEND

PROPERTY BOUNDARY

WRD WASTE ROCK DUMP

## NOTES

1. ORTHOPHOTO IMAGE TAKEN IN 2013 (PROVIDED BY TECK).
2. NAD83, UTM ZONE 10.

NOT FOR CONSTRUCTION



CLIENT: Teck

Klohn Crippen Berger

PROJECT: PINCHI LAKE MINE TSF
2019 DAM SAFETY INSPECTION

TITLE: MINE SITE PLAN

PROJECT No. M07728 A34

FIG. No. 1.1

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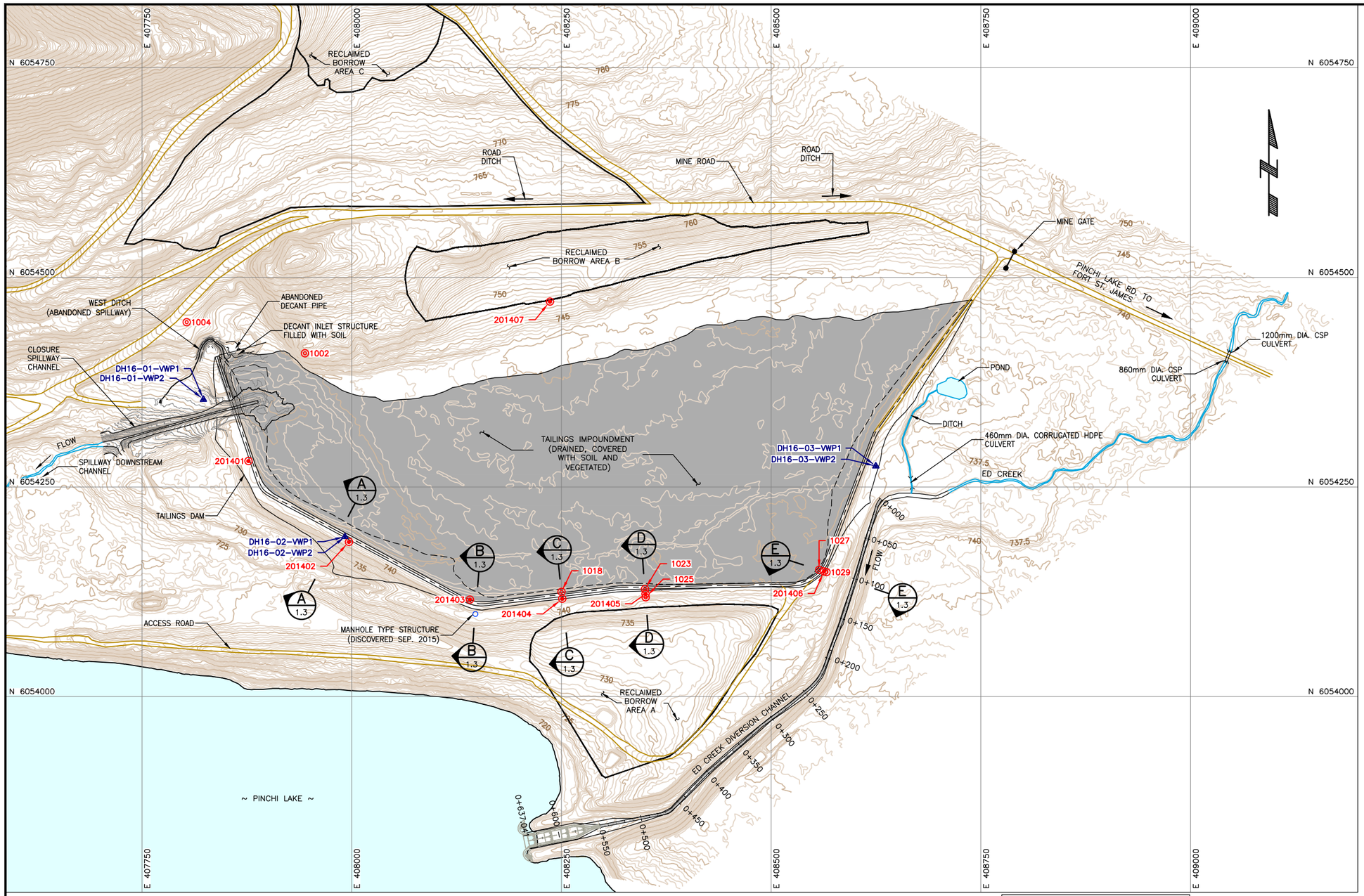


## LEGEND

- 1998 SURVEY MONUMENT
- 2014 SURVEY MONUMENT
- 2016 VIBRATING WIRE PIEZOMETER

## NOTES

1. GENERAL SITE TOPOGRAPHY IS BASED ON SEPTEMBER 2012 LIDAR SURVEY BY McELHANNEY ENGINEERING. TOPOGRAPHY FOR SPILLWAY CHANNEL IS BASED ON JUNE 2011 GROUND SURVEY.
2. COORDINATES ARE NAD83, UTM ZONE 10.

REFERENCE DRAWINGS:
CHAINAGE FOR ED CREEK DIVERSION CHANNEL IS FROM KLOHN CRIPPEN DWG No. D-6101.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED SEPTEMBER 2019

SCALE 0 100 m



CLIENT: Teck

Klohn Crippen Berger

PROJECT: PINCHI LAKE MINE TSF
2019 DAM SAFETY INSPECTION

TITLE: TAILINGS STORAGE FACILITY PLAN

PROJECT No. M07728 A34

FIG. No. 1.2

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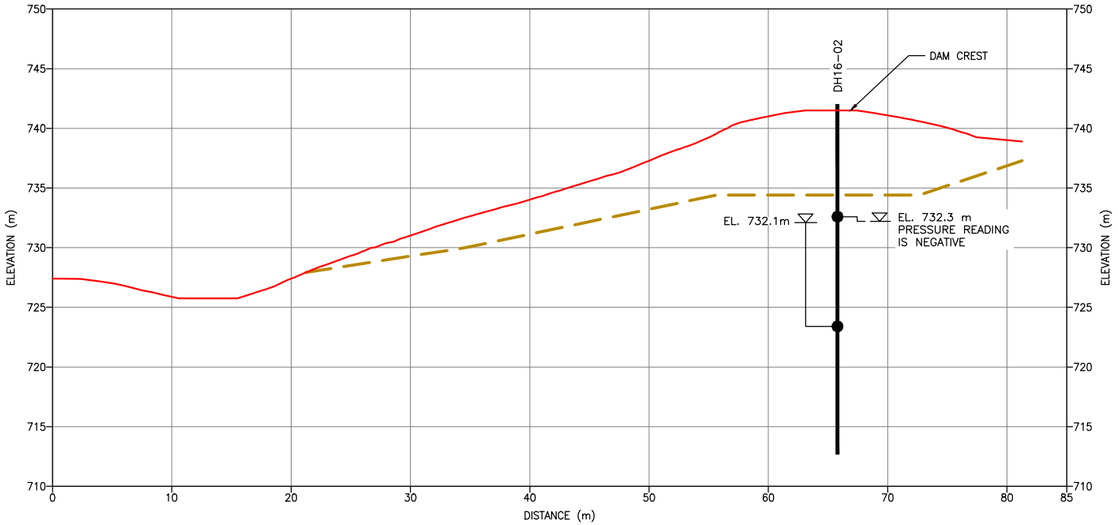
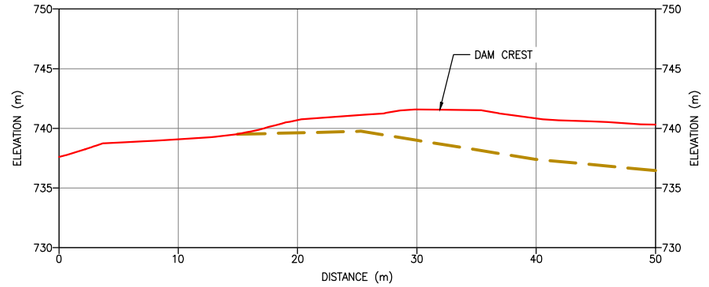



SECTION A 1.2

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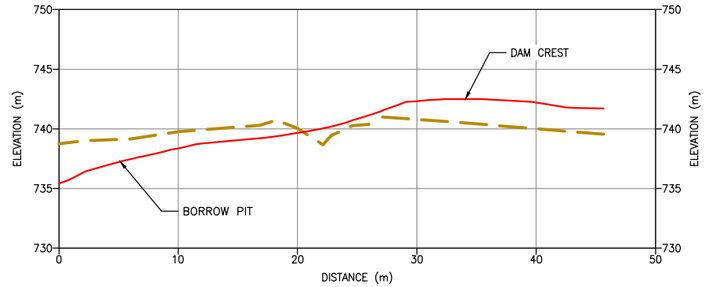
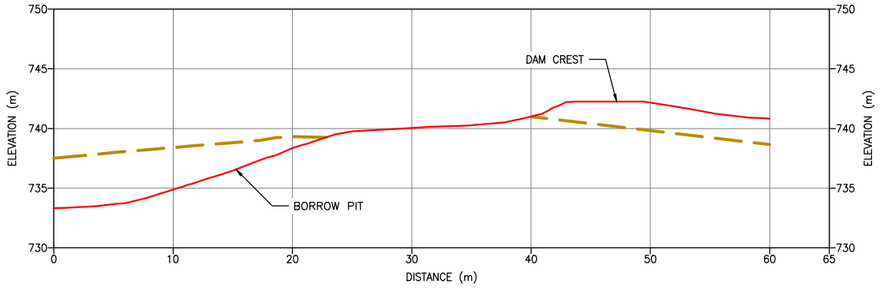
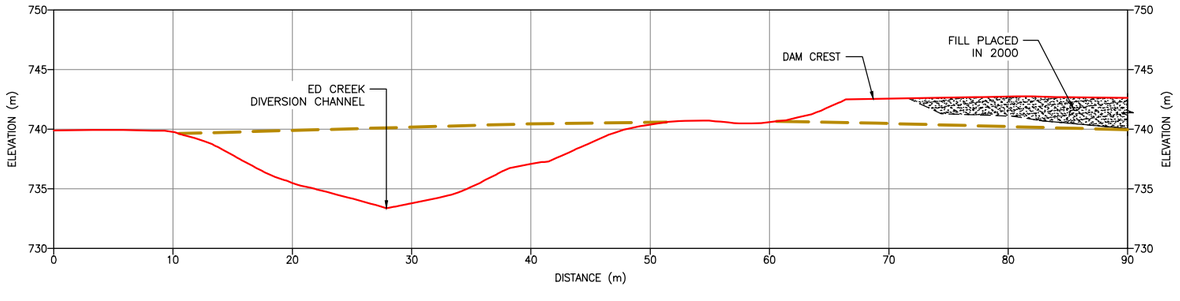



SECTION D 1.2




SECTION C 1.2




SECTION E 1.2

| DAM HEIGHT AND SLOPE | | | OVERALL SLOPE (NOTE 2) |
|---|---|---|---|
| SECTION | DAM HEIGHT (m) | SLOPE OF D/S FACE | |
| A | 14.0 | 2.7H:1V | 2.7H:1V |
| B | 2.5 | 2.7H:1V | 2.4H:1V |
| C | 1.8 | 2.3H:1V | 4.5H:1V |
| D | 1.5 | 2.0H:1V | 4.3H:1V |
| E | 1.8 | 4.3H:1V | 4.3H:1V |

## LEGEND:

- PIEZOMETER TIP/SCREEN
- 732.1 m — JUNE 11, 2019 READING (m)
- ORIGINAL GROUND SURFACE PRE-1967
- GROUND SURFACE AFTER 2010/11 RECLAMATION/CLOSURE WORKS (SEP. 2012 LIDAR SURVEY)

## NOTES:

1. ORIGINAL GROUND SURFACE HAS BEEN EXTRACTED FROM DWG. PLM-D-3, REV.1 AND IS APPROXIMATE.
2. OVERALL SLOPE IS MEASURED FROM DOWNSTREAM EDGE OF DAM CREST TO TOE OF NATURAL GROUND SLOPE (SECTIONS A AND B), TOE OF BORROW PIT SLOPE (SECTIONS C AND D) OR BASE OF ED CREEK DIVERSION CHANNEL (SECTION E).

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED SEPTEMBER 2019

SCALE 0 10 m



CLIENT: Teck

Klohn Crippen Berger

PROJECT: PINCHI LAKE MINE TSF
2019 DAM SAFETY INSPECTION

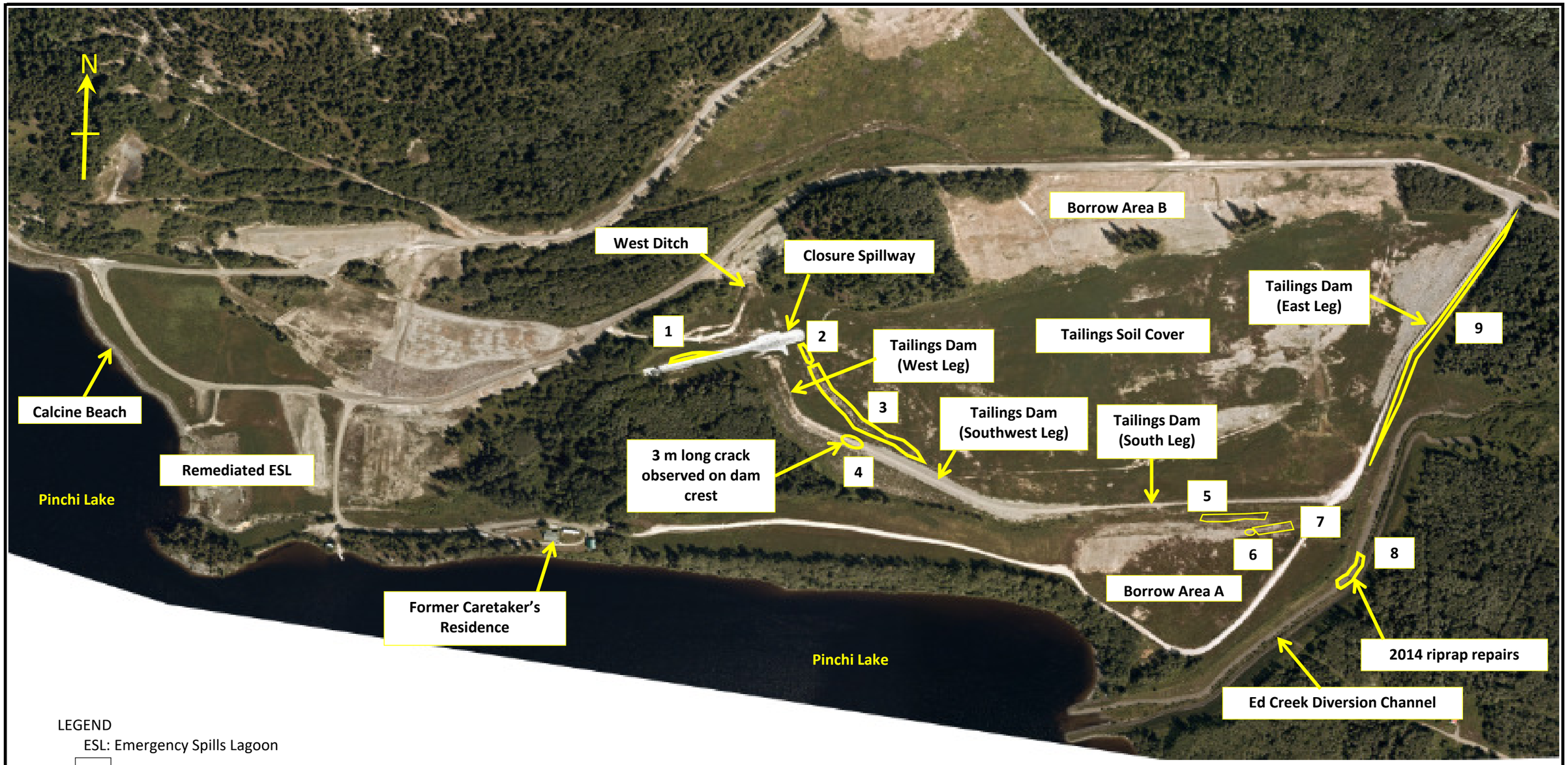
TITLE: TAILINGS STORAGE FACILITY
DAM CROSS SECTIONS

PROJECT No. M07728 A34

FIG. No. 1.3

KCB-R-MLB

Time: 09:34:04
Date: 9/11/2019
Scale: 1:2.5849(PS)
Drawing File: Z:\M\VCR\M07728A34-TML-Pinchi Lake 2019 Services\400 Drawings\CAD\05-FIGURES\DSI\Fig1.3 - Sections.dwg (thawker)
Xref File(s):
Image File(s): Teckcominco-color-logo




LEGEND

ESL: Emergency Spills Lagoon

**7** Observation Location

**Not to Scale**

NOTES:

1. All Locations shown are approximate.



CLIENT: Teck

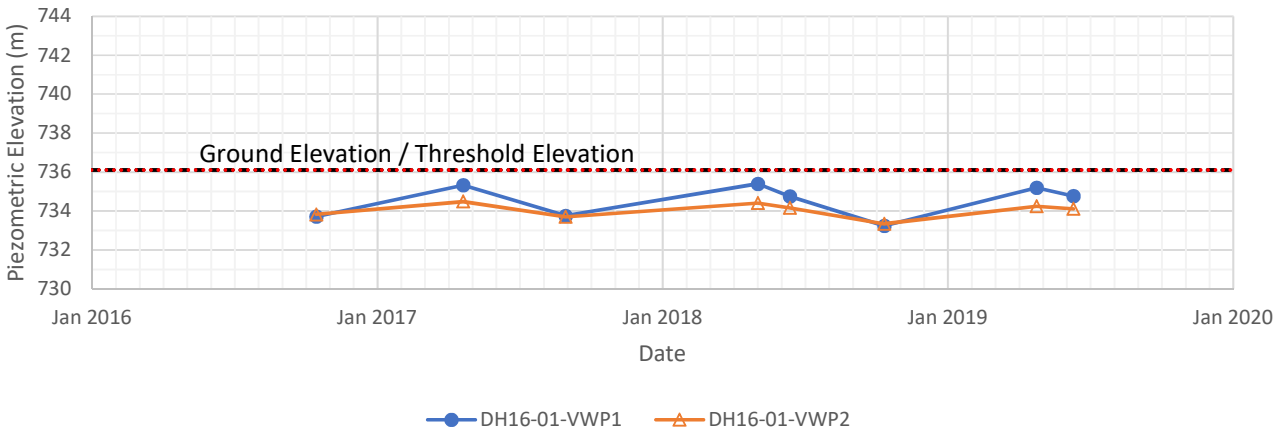
Klohn Crippen Berger

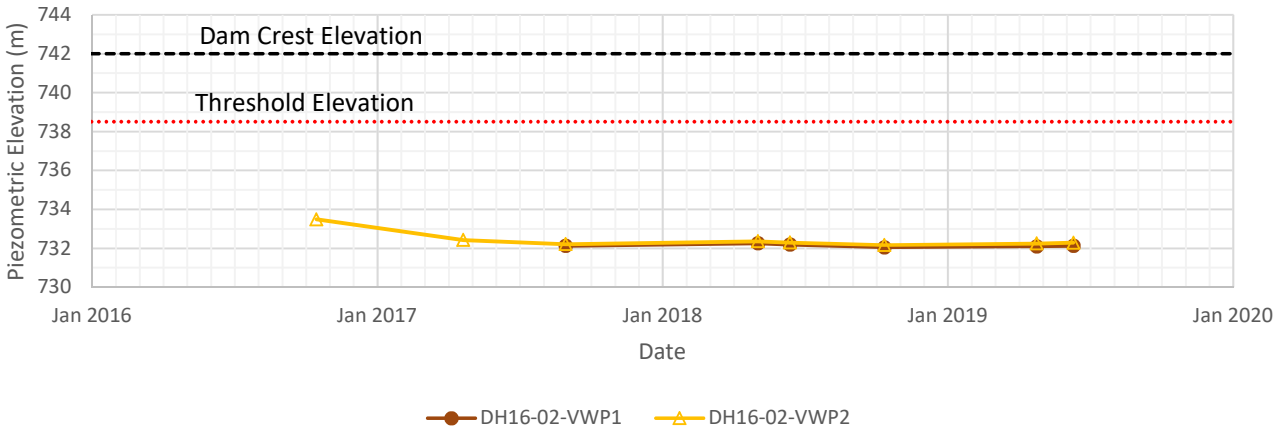
PROJECT: PINCHI LAKE MINE TSF
2019 DAM SAFETY INSPECTION

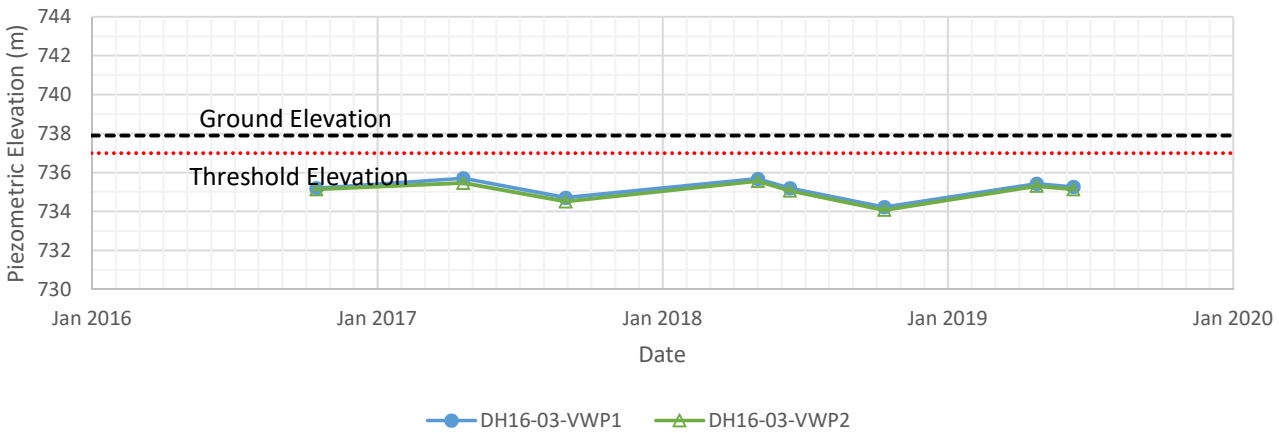
TITLE: JUNE 2019 OBSERVATION LOCATIONS

PROJECT No. M07728A34

FIG No. 4.1






CLIENT: Teck

Klohn Crippen Berger

PROJECT: PINCHI LAKE MINE TSF
2019 DAM SAFETY INSPECTION

TITLE: PIEZOMETER READINGS

PROJECT No.: M07728A34

FIG No.: 4.2

# APPENDIX I

## Facility Data Sheet

# Appendix I
# Facility Data Sheet

## PINCHI LAKE MINE TSF DAM
## PHYSICAL DESCRIPTION

| | |
|---|---|
| Dam Type | Earthfill |
| Maximum Dam Height | 15 m |
| Dam Length | 1300 m |
| Dam Crest Width | 6 m to 8 m<br>May be wider in some areas. |
| Impoundment Area | 21 ha (surface area of covered tailings) |
| Volume of Tailings | 1 million $m^3$ approximate |
| Reservoir Capacity | This is a “dry” tailings impoundment. There is no storage of water and the impoundment is normally dry. |
| Consequence Classification | Significant |
| Inflow Design Flood (IDF) | 1/3 between 1/1000 and PMF<br>(based on consequence classification of Significant) |
| Design Earthquake | 1/2475 annual exceedance probability<br>(based on consequence classification of Significant) |
| Spillway Capacity | Spillway has capacity to route IDF with > 4 m freeboard in the impoundment, and 0.5 m in the spillway channel. However, riprap from the dam toe to the downstream end of the channel is undersized for the IDF and may be damaged.<br>Estimated peak spillway discharge = 7 $m^3/s$ |
| Catchment Area | 55 ha |
| Access to Dam | Vehicle access to the mine from Fort St. James is 25 km north along Germansen Road, and then 20 km west along Pinchi Lake Road. Both roads are gravel surfaced. The access road into the mine site is gated.<br>The mine site can also be reached by water over Pinchi Lake. The lake usually has ice cover from November to mid-April. |

# APPENDIX II

## June 2019 Photographs

# Appendix II
# June 2019 Photographs

**Photo II-1 Tailings Dam – east leg, looking south. Note vegetation on dam slope.**

**Photo II-2 Tailings Dam – east leg, looking north. Note vegetation on dam slope.**

**Photo II-3 Tailings Dam – pond near toe of east leg.**

**Photo II-4 Tailings Dam – east leg, looking upstream from toe.**

**Photo II-5 Tailings Dam – east leg, looking north. Note vegetation on dam slope.**

**Photo II-6 Tailings Dam – east leg, looking west at the covered tailings surface.**

**Photo II-7 Tailings Dam – south leg, looking east towards Ed Creek.**

**Photo II-8 Tailings Dam – south leg, looking north at the covered tailings surface.**

**Photo II-9 Tailings Dam – south leg, looking west along downstream slope.**

**Photo II-10 Tailings Dam – southwest leg, looking northwest along the crest.**

**Photo II-11 Tailings Dam – southwest leg, looking southeast along the downstream slope.**

**Photo II-12 Tailings Dam – southwest leg, looking downstream from the crest.**

**Photo II-13 Tailings Dam – southwest leg, looking northwest along the downstream slope.**

**Photo II-14 Tailings Dam – southwest leg, crack on dam crest in tire track.**

**Photo II-15** **Tailings Dam – southwest leg, surface runoff channel in tailings cover upstream of dam (no water observed in channel).**

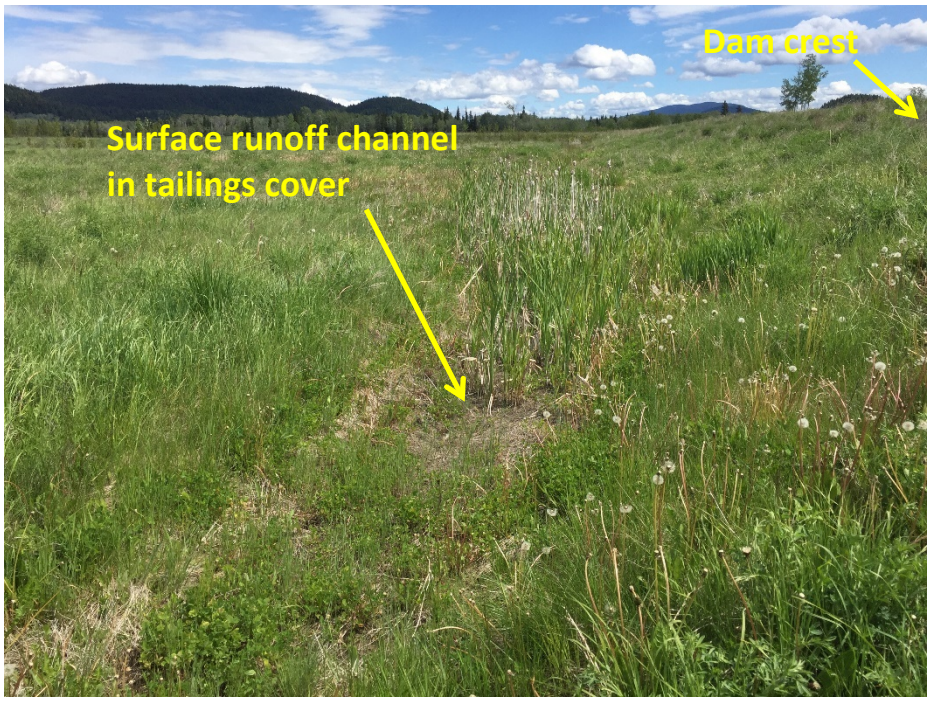



**Photo II-16** **Tailings Dam – west leg, looking south along downstream slope.**

**Photo II-17 Tailings Dam – west leg, looking south along upstream slope. Covered tailings surface is on the left.**

**Photo II-18 Tailings Dam – west leg, looking north along dam slope towards Closure Spillway.**

**Photo II-19 Tailings Dam – west leg, looking south along dam slope.**

**Photo II-20 Closure Spillway – inlet apron.**

**Photo II-21** **Downstream end of surface runoff channel where it discharges to the Closure Spillway, showing riprap which was placed in 2014.**

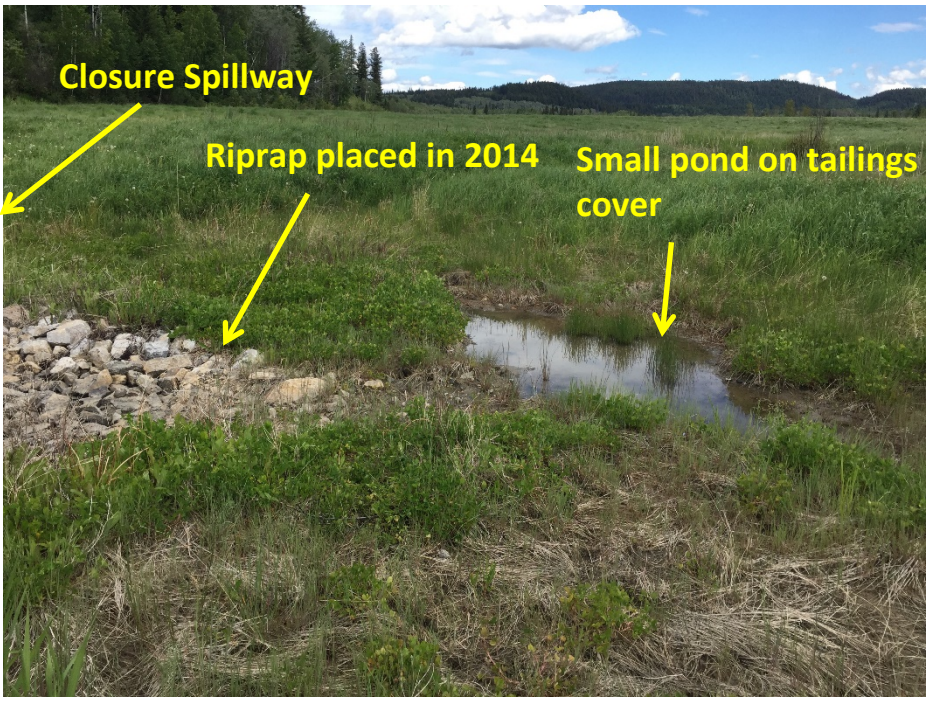



**Photo II-22** **Downstream end of surface runoff channel in tailings cover, looking southeast from Closure Spillway.**

**Photo II-23 Closure Spillway – looking downstream from dam crest.**

**Photo II-24 Closure Spillway – looking southwest from upstream of dam crest.**

**Photo II-25 Closure Spillway – looking upstream from dam toe area.**

**Photo II-26 Closure Spillway – looking downstream.**

**Photo II-27 Closure Spillway – head scarp of slump above right bank, 90 m downstream of centreline**


**Photo II-28 Closure Spillway – looking upstream from downstream end of riprap.**

**Photo II-29 Closure Spillway – pond at downstream end of riprap.**

**Photo II-30 Spillway Downstream Channel – inlet to culvert beneath road to on-site residence. Note vegetation growth.**

**Photo II-31 Spillway Downstream Channel – close up of inlet to culvert beneath road to on-site residence. Note vegetation growth.**

**Photo II-32 Spillway Downstream Channel – Middle Reach, looking upstream from near culvert beneath road to former caretaker's house.**

**Photo II-33 Spillway Downstream Channel – outlet of culvert beneath road to former caretaker's house.**

**Photo II-34 Spillway Downstream Channel – Lower Reach, looking downstream.**

**Photo II-35 Borrow Area A – looking west from access road.**

**Photo II-36 Borrow Area A – crack monitoring rod location 103 (crack not visible).**

**Photo II-37 Borrow Area A – looking east along the slope.**

**Photo II-38 Borrow Area A – wet ground in northeast corner.**

**Photo II-39 Borrow Area A – looking north from south end.**

**Photo II-40 Road ditch above tailings impoundment, looking east.**

**Photo II-41 Road ditch above tailings impoundment, looking west.**

**Photo II-42 Ed Creek Diversion Channel – outlet at Pinchi Lake.**

**Photo II-43 Ed Creek Diversion Channel – looking upstream from near outlet.**

**Photo II-44 Ed Creek Diversion Channel – Riprap on right bank, showing weathering and breakage.**

**Photo II-45 Ed Creek Diversion Channel – looking upstream from between third bend and outlet.**

**Photo II-46 Ed Creek Diversion Channel – looking upstream from between second and third bends.**

**Photo II-47 Ed Creek Diversion Channel – looking downstream from near second bend. Light-coloured area of riprap was replaced in 2014, and is in good condition.**

**Photo II-48 Ed Creek Diversion Channel – looking downstream from between first and second bends.**

**Photo II-49 Ed Creek Diversion Channel – looking upstream from between first and second bends.**

**Photo II-50 Ed Creek Diversion Channel – looking downstream from near first bend.**

**Photo II-51 Ed Creek Diversion Channel – looking upstream towards first bend.**

**Photo II-52 Outlet of 460 mm culvert on north bank of Ed Creek Diversion Channel.**

**Photo II-53** **Inlet of 460 mm culvert on north bank of Ed Creek Diversion Channel. There is vegetation upstream of the inlet that could block the channel during flood conditions.**

**Photo II-54** **Drainage ditch between pond area at the toe of the east leg of the Tailings Dam and Ed Creek Diversion Channel. Looking upstream from culvert shown in Photo II-53.**

**Photo II-55 Inlets of Ed Creek culverts under Pinchi Lake Road.**

**Photo II-56 Inlet of east culvert under Pinchi Lake Road.**

**Photo II-57 Outlets of Ed Creek culverts under Pinchi Lake Road. Note only one culvert is flowing.**

# APPENDIX III

## June 2019 Inspection Forms

1. Tailings Dam and Tailings Impoundment
2. Closure Spillway
3. Spillway Downstream Channel
4. Road Ditch Above Tailings Impoundment
5. Borrow Area A
6. Ed Creek Diversion Channel
7. Ed Creek Culverts at Pinchi Lake Road

**Pinchi Lake Mine Tailings Storage Facility**
**Inspection Checklist**

**TAILINGS DAM AND TAILINGS IMPOUNDMENT**

Date: _June 11, 2019_____ Inspected By: _D. Klassen, B. Chambers_____

Time: _1 pm to 4 pm_____ Pond Water Level: _No standing water_____

Weather: _Cloudy, 20°_____

| Is there any apparent ….. | Yes | No | Comments |
|---|---|---|---|
| Cracks | | | |
| • Embankment cracks on the dam crest? | X | | See comment 1 below |
| o Enlargement of cracks or new cracks in SW leg and S leg of dam (first observed in 2015)? | | X | |
| • Embankment cracks on the u/s slope? | | X | |
| • Embankment cracks on the d/s slope? | | X | |
| Vegetation Growth and Debris | | | |
| • Excessive tree or shrub growth on embankment? | | X | See comment 2 below |
| • Debris in tailings impoundment? | | X | |
| Other Structural Problem | | | |
| • Settlement or erosion on the dam crest? | | X | |
| • Slough, slides, bulges or erosion on u/s slope of dam? | | X | |
| • Slough, slides, bulges or erosion on d/s slope of dam? | | X | |
| • Sinkhole on dam crest? | | X | |
| • Sinkhole on u/s slope of dam? | | X | See comment 3 below |
| • Sinkhole on d/s slope of dam? | | X | |
| • Sinkhole in tailings pond till cover? | | X | |
| • Erosion of flow channels in tailings pond till cover? | | X | See comment 4 below |
| Ponding / Seepage | | | |
| • Evidence of water ponding on dam crest? | | X | |
| • Wet areas or seepage on d/s slope or toe of dam? | | X | |
| • Evidence of water ponding at d/s toe of dam? | X | | See comment 5 below |
| • Wet areas or seepage along d/s abutments? | | X | |
| Animal Activity | | | |
| • Rodent burrows in dam embankment? | | X | |
| • Beaver dam in Tailings Pond? | | X | |

Additional comments:

1. Observed one longitudinal crack on the southwest leg, smaller than cracks observed in previous years: 3 m long, 5 to 10 mm wide, grass could be pushed 70 mm deep into the crack. Cracks have been observed in this area for several years and are believed to been formed by loosening and drying of the soil as part of the reclamation and seeding, and are not considered to be a dam safety issue.
2. Vegetation growth on parts of the east leg is greater than the 1.5 m height stated in the vegetation management plan. This is not currently a dam safety concern, but it will eventually become a concern if allowed to keep growing.

| | |
|---|---|
| 3. | In 2018 a 50 cm diameter by 60 cm deep hole was observed near a stake marked 1018 (possibly a former survey monument). This hole has now been filled in. |
| 4. | No evidence of recently eroded flow channels. Existing channels are vegetated and unlikely to erode under normal weather conditions. |
| 5. | A pond is located near the toe of the east leg of the dam, which drains to the south through a culvert into Ed Creek Diversion Channel. This pond has been observed in previous inspections and appears to be related to local runoff. No other ponds were observed near the dam toe. |

**Pinchi Lake Mine Tailings Storage Facility**
**Inspection Checklist**

**CLOSURE SPILLWAY**

Date: _June 11, 2019_____ Inspected By: _D. Klassen, B. Chambers_____

Time: _3 pm_____

Weather: _Cloudy, 20°C_____

Is the spillway flowing? ____No_____(yes / no) If yes, give approx. flow depth: _____ mm

Is the flow above the riprap? ___No_____(yes / no) If yes, give approx. flow depth above riprap: _____ mm

| **Is there any apparent …..** | **Yes** | **No** | **Comments** |
|---|---|---|---|
| Vegetation Growth and Debris | | | |
| • Excessive tree or shrub growth along the channel? | | X | A few small shrubs |
| • Debris in the channel? | | X | |
| Riprap | | | |
| • Displaced or broken down riprap in channel bottom? | | X | |
| • Displaced or broken down riprap along the right bank? | | X | |
| • Displaced or broken down riprap along the left bank? | | X | |
| Erosion, cracks, slough, slides or bulges | | | |
| • Along the bottom of channel? | | X | |
| • Along the right bank of channel? | | X | |
| o Any signs of recent movement of slump on right bank? | | X | Appears unchanged from previous inspections |
| • Along the left bank of channel? | | X | |
| Seepage | | | |
| • Seepage into the channel from right side slope? | | X | |
| • Seepage into the channel from left side slope? | | X | |
| Animal Activity | | | |
| • Beaver dam in spillway channel? | | X | |
| • Any other animal activity? | | X | |

NOTE: left and right banks are looking downstream along the channel.

Additional comments:

Small pond on south side of riprap apron at intake. No flow.

40 cm deep pond at the downstream end of the spillway. No flow.

**Pinchi Lake Mine Tailings Storage Facility**
**Inspection Checklist**

**SPILLWAY DOWNSTREAM CHANNEL**

Date: _June 12, 2019_____ Inspected By: _D. Klassen, B. Chambers____

Time: _11 am_____

Weather: _Partly cloudy, 20°C_____

Is there flow in the channel? _No_____ (yes / no)

Give location of flow: _____ Give approx. flow depth: _____ mm

| Is there any apparent ….. | Yes | No | Comments |
|---|---|---|---|
| | | | |
| **Middle Reach*** | | | |
| • Debris in the channel? | | X | |
| • Erosion in the channel? | | X | |
| • Beaver activity in channel? | | X | |
| | | | |
| **Culvert under Road to Caretaker's Residence** | | | |
| • Blockage of culvert inlet or outlet? | X | | Grass is growing in front of inlet, partially blocking it. |
| • Structural damage or deformation of culvert pipe? | | X | |
| • Displaced or broken-down riprap? | | X | |
| | | | |
| **Lower Reach (along former Emergency Spills Lagoon)** | | | |
| • Excessive tree or shrub growth in the channel? | | X | |
| • Debris in the channel? | | X | |
| • Erosion in the channel? | | X | |
| • Displaced or broken-down riprap in channel? | | X | |
| • Beaver activity in channel? | | X | |

*NOTE: Middle reach of Spillway Downstream Channel is the flow route from the end of the riprap lined Closure Spillway channel to the culvert under the road to the Caretaker's residence.

Additional comments:

1. Only the upper and lower ends of the middle reach of the Spillway Downstream Channel were inspected. This reach follows natural channels, and has dense tree and bush growth and debris such as windfalls.
2. Water ponding locally at the outlet, 11 cm above the invert of the culvert. The channel downstream of this is dry until it reaches the lake.

**Pinchi Lake Mine Tailings Storage Facility**
**Inspection Checklist**

**ROAD DITCH ABOVE TAILINGS IMPOUNDMENT**

Date: _June 12, 2019_____ Inspected By: _D. Klassen, B. Chambers_____

Time: _10:30 am_____

Weather: _Partly cloudy, 20°C_____

Is there flow in the channel? _No_____ (yes / no)

Give location of flow: _____ Give approx. flow depth: _____ mm

| Is there any apparent ….. | Yes | No | Comments |
|---|---|---|---|
| **Road Ditch** | | | |
| • Excessive tree or shrub growth in the channel? | | X | Primarily grass with some localized cattails |
| • Debris in the channel? | | X | |
| • Erosion in the channel? | | X | |
| • Beaver activity in the channel? | | X | |
| | | | |

Additional comments:

**Pinchi Lake Mine Tailings Storage Facility**
**Inspection Checklist**

**BORROW AREA A**

Date: _June 11, 2019_____ Inspected By: _D. Klassen, B. Chambers_____

Time: _3:30 pm_____

Weather: _Cloudy, 20°C_____

| **Is there any apparent …..** | **Yes** | **No** | **Comments** |
|---|---|---|---|
| Cracks | | | |
| • Cracks on ground between borrow pit and toe of dam? | | X | |
| • Cracks on borrow pit slope? | | X | See comment 1 below |
| Other Structural Problems | | | |
| • Sloughs, slides, bulges or erosion on borrow pit slope? | | X | |
| Ponding / Seepage | | | |
| • Wet areas or seepage on borrow pit slope? | | X | |
| • Wet areas or seepage at toe of borrow pit slope? | X | | See comment 2 below |
| • Evidence of water ponding within borrow area? | | X | |
| Animal Activity | | | |
| • Rodent burrows in borrow pit slope? | | X | |

Additional comments:

1. Cracks have been observed on the borrow pit slope since 2013. The cracks have filled in with vegetation and were not clearly visible during the inspections in 2018 or 2019.
2. A few small areas of wet ground were observed between the northeast corner of the borrow area and 60 m to the west, where a small pond was observed close to the toe of the slope.

**Pinchi Lake Mine Tailings Storage Facility**
**Inspection Checklist**

**ED CREEK DIVERSION CHANNEL**

Date: _June 11, 2019_____ Inspected By: _D. Klassen, B. Chambers_____

Time: _4 pm_____

Weather: _Cloudy, 20°C_____

Is there flow in the channel? _Yes_____ (yes / no)

Give location of flow: _Base of channel_____ Give approx. flow depth: _130__ mm

| **Is there any apparent …..** | **Yes** | **No** | **Comments** |
|---|---|---|---|
| Vegetation Growth and Debris | | | |
| • Excessive tree or shrub growth along the channel? | | X | See comment 1 below |
| • Debris in the channel? | | X | |
| Riprap | | | |
| • Displaced or broken down riprap in channel bottom? | X | | See comment 2 below |
| • Displaced or broken down riprap along the right bank? | X | | See comment 2 below |
| • Displaced or broken down riprap along the left bank? | X | | See comment 2 below |
| Erosion, cracks, slough, slides or bulges | | | |
| • Along the bottom of channel? | | X | |
| • Along the right bank of channel? | | X | |
| • Along the left bank of channel? | | X | |
| Seepage | | | |
| • Seepage into the channel from right side slope? | | X | |
| • Seepage into the channel from left side slope? | | X | |
| Animal Activity | | | |
| • Beaver dam in spillway channel? | | X | |
| • Any other animal activity? | | X | |

NOTE: left and right banks are looking downstream along the channel.

Additional comments:

1. Vegetation was observed throughout the base of the channel and had reached up to 2 m height in places. Not excessive but may require removal based on vegetation management plan.
2. As noted during previous inspections, riprap along entire diversion channel is deteriorating. Visual inspection suggested there were no significant changes from the condition in recent years.

**Pinchi Lake Mine Tailings Storage Facility**
**Inspection Checklist**

**ED CREEK CULVERTS AT PINCHI LAKE ROAD**

Date: _June 12, 2019_____ Inspected By: _D. Klassen, B. Chambers_____

Time: _10 am_____

Weather: _Partly cloudy, 20°C_____

Is there flow in the culverts? _Yes_____ (yes / no)

Give approx. water depth in channel at culvert inlet: _80___ mm

| Is there any apparent ….. | Yes | No | Comments |
|---|---|---|---|
| **Culverts Under Pinchi Lake Road** | | | |
| • Excessive tree or shrub growth at inlet or outlet? | | X | Some vegetation overhanging at the inlet of the culverts |
| • Blockage of culvert inlets or outlets? | | X | |
| • Structural damage or deformation of culvert pipe? | | X | |
| • Erosion in channel u/s or d/s of culvert? | | X | |
| • Beaver activity in Ed Creek u/s or d/s of culvert? | | X | |

Additional comments:

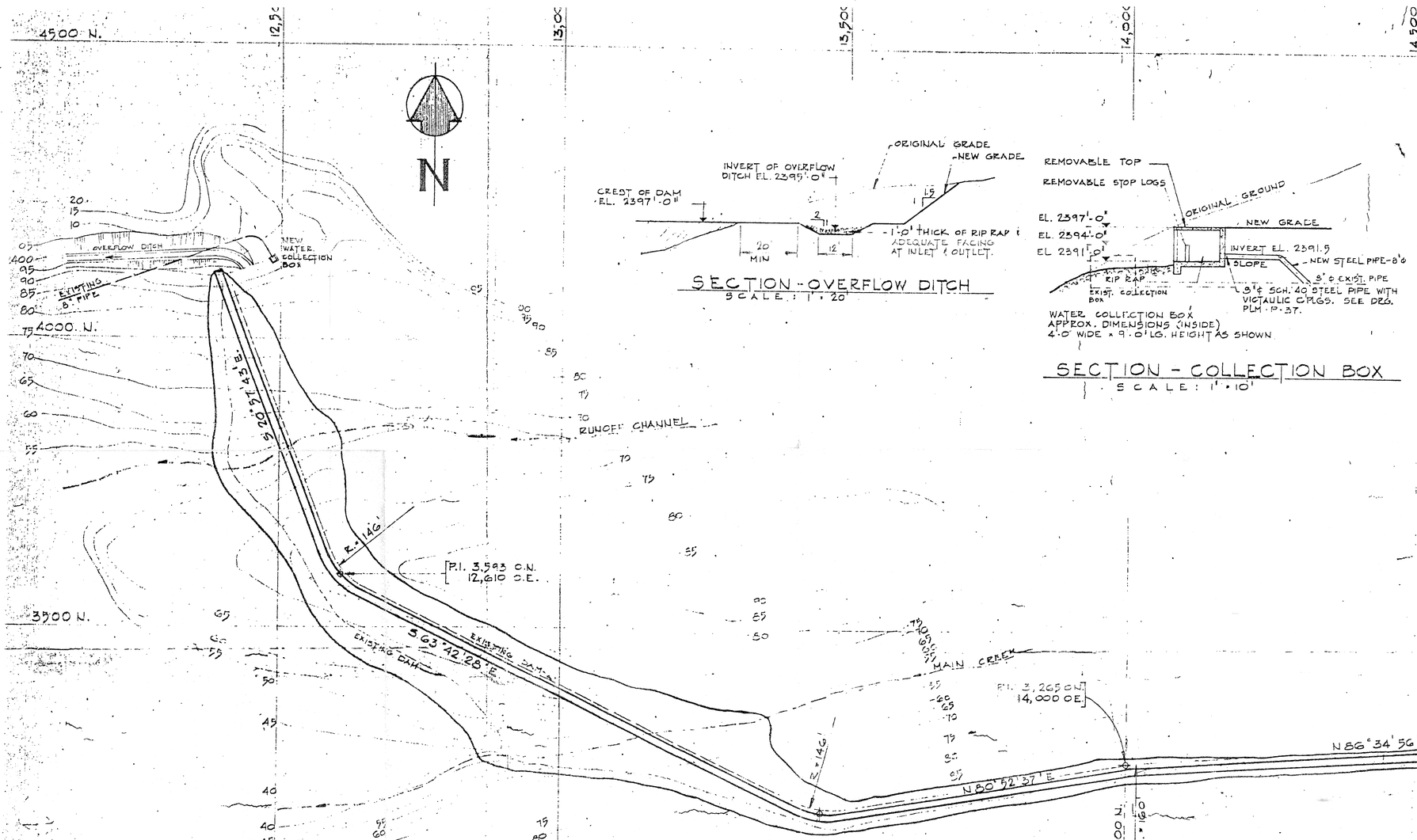
Only east culvert is flowing

# APPENDIX IV

## 1975 Tailings Dam Drawing

Dwg. PLM-D-514, Rev. 0 - Tailings Dam Extension 1975 – Plan & Sections

| No. | Req'd | Description | Supplied or Made by | Date Ordered | Requisition No. |
|---|---|---|---|---|---|




PLAN - TAILINGS DAM

SCALE: 1" = 100'



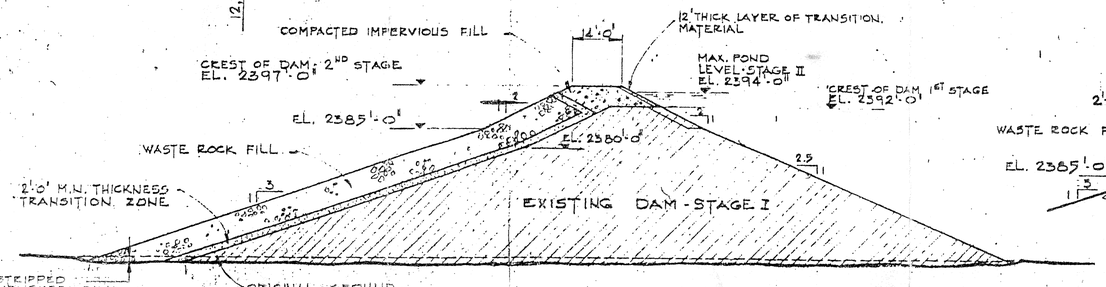

SECTION - OVERFLOW DITCH

SCALE: 1" = 20'



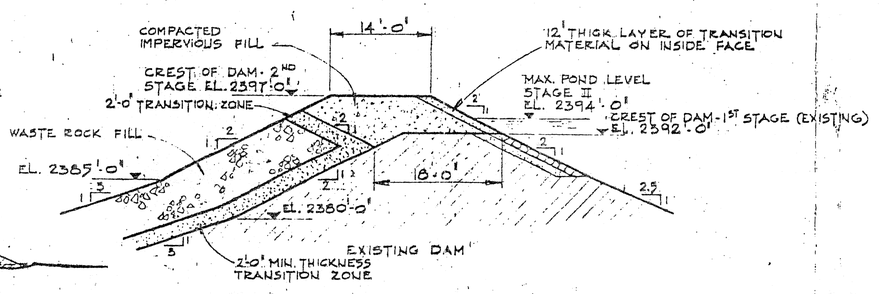

SECTION - COLLECTION BOX

SCALE: 1" = 10'




TYPICAL SECTION THRU DAM

SCALE: 1" = 20'




DETAIL - TOP OF DAM TYPICAL

SCALE: 1" = 10'

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Job No. J-7710.003 | | PLM-P-37, TAILINGS DISPOSAL | | Drawn by K. FRICKE | JAN. 14/75 | Function MINES | Scale AS NOTED |
| Drawing No. PLM D 514 | Revision 0 | | | Checked by J.E. PRIME | FEB/7/75 | Activity PINCHI LAKE MERCURY | Drawing No. PLM D 514 |
| Issued to | | Reference | | Design Eng. | | Section TAILINGS DAM EXTENSION - 1975 | Revision 0 |
| Issued to | | | | Proj. Eng. | Approved | Job PLAN & SECTIONS | |
| | | | Revisions: No. Made by Date Approved Description | | | Engineering TRAIL, B.C. | Commoo |

210-0650

# APPENDIX V

## Water Balance

Klohn Crippen Berger

September 10, 2019

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**Ms. Michelle Unger**
**Mine Manager**

Dear Ms. Unger:

**Pinchi Lake Mine Tailings Storage Facility**
**Water Balance**

## 1 INTRODUCTION

This letter summarizes an update to the water balance completed by Klohn Crippen Berger Ltd. (KCB) in 2009 for the Pinchi Lake Mine Tailings Storage Facility (TSF).

The Pinchi Lake Mine TSF is located in central British Columbia, on the north side of Pinchi Lake, at an elevation of approximately 750 m. No tailings have been deposited in the facility since 1975 and closure reclamation works were completed in 2011.

## 2 METHODOLOGY

The previous Pinchi Lake Mine TSF water balance (KCB 2009) included a small (0.4 ha) pond near the outlet of the TSF where water levels and discharge (through a decant structure) had been measured since 1997. The last year of measurement at the TSF outlet occurred in 2008, just prior to reclamation and closure of the TSF that saw: the pond drained; the decant structure and emergency spillway replaced with the current riprap closure spillway; and the tailings covered with glacial till and vegetated.

The water balance was modelled in GoldSim® as a single catchment area reporting to the spillway. Snow accumulation and snowmelt were estimated using daily precipitation and temperature data. Snow accumulation was validated using regional snow course data. Runoff, seepage loss and evaporation loss in the catchment were estimated using a soil moisture accounting (SMA) model[1].

[1] A model that uses daily precipitation, temperature, soil moisture, and soil permeability of a catchment to estimate the amount of water that enters, is stored in, and leaves the catchment.



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The surface soil storage and seepage rate were calibrated to water level and flow measurements taken in 2007 and 2008 (assuming the small pond present in 2008), or the “pre-cover scenario”.

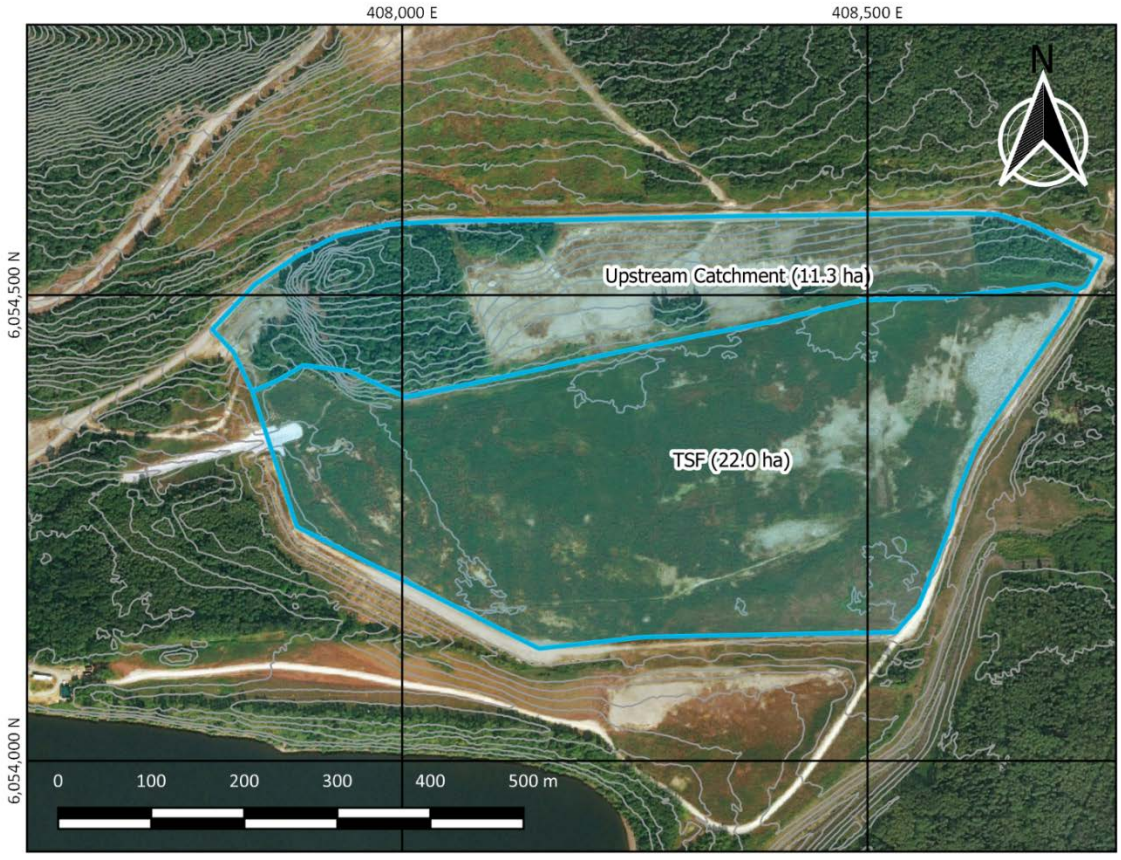
For this 2019 assessment, the GoldSim model was updated to reflect current closure conditions, or the “post-cover scenario”, by removing the free water pond and increasing soil storage to account for the vegetated glacial till closure cover. The updated model was then run using the past 20 years of climate data (1998 to 2017) to estimate monthly average flows. Modelled runoff volumes in April and May were compared to estimated runoff volumes from flow measurements in 2011 and 2012 to provide a level of confidence in the results. However, there is not enough data to calibrate the post-cover scenario.

## 2.1 Input Data

### 2.1.1 Catchment Areas

Approximately 22.0 ha of past tailings deposition area and 11.3 ha of upstream catchment report to the closure spillway (Figure 2.1). The upstream catchment assumes the ditch beside the access road operates during normal conditions. Note that this upstream catchment area is less than what was used in the assessment of the TSF spillway capacity because that assessment assumed the road upstream of the TSF is breached during the Inflow Design Flood (IDF).

**Figure 2.1 TSF Water Balance Catchment Areas**



### 2.1.2 Climate

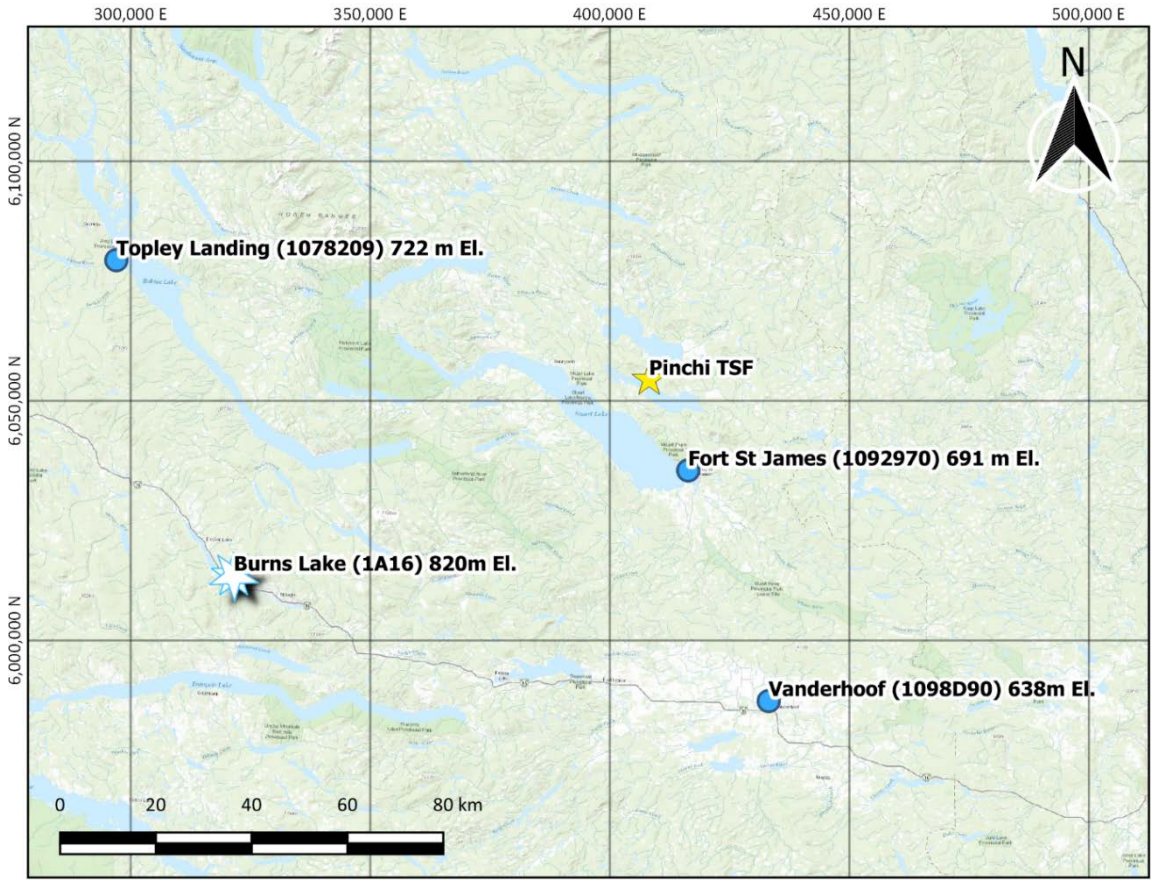
Regional Environment Canada climate stations with parameters of interest, along with period of record and elevation, are listed in Table 2.1 and shown in Figure 2.2.

Snowpack and snowmelt are estimated based on precipitation and temperature data; however, measurements of snowpack are needed to validate these estimates. Snow course is measured in the spring at Burns Lake, 100 km southwest of site, at an elevation 820 m, similar to Pinchi TSF (750 m).

**Table 2.1 Regional Climate Stations**

| Station Name | Station ID | Period of Record | Elevation (m) | Distance from Site | Parameters of Interest |
|---|---|---|---|---|---|
| Fort St James | 1092970 | 1895 to 2018 | 691 | 20 km southeast | Precipitation, Temperature |
| Fort St James Auto | 1092975 | 2013 to 2018 | 688 | 20 km southeast | Precipitation, Temperature |
| Vanderhoof | 1098D90 | 1980 to 2018 | 638 | 70 km southeast | Precipitation, Temperature |
| Topley Landing | 1078209 | 1962 to 2017 | 722 | 110 km northwest | Lake Evaporation |
| Burns Lake | 1A16 | 1970 to 2018 | 820 | 100 km southwest | Snow Course |

**Figure 2.2 Regional Climate Station Locations**




Note: Fort St. James and Fort St James Auto stations are in the same location on this map.

Precipitation and temperature are inputs to the Pinchi Lake TSF water balance. These parameters were taken first from the Fort St James station due its proximity to site, with gaps filled in with data from Vanderhoof. To account for Pinchi Lake TSF being at a higher elevation, precipitation data from these stations was increased by 3%[2] and temperature data was decreased by 0.3°C[3].

Lake evaporation, or potential evapotranspiration (PET), is measured at Topley Landing from May to September and was used to estimate actual evapotranspiration (AET) losses from the pond and catchment.

Monthly averages of the 1998 to 2017 climate data inputs used in the GoldSim model are presented in Table 2.2.

**Table 2.2 1998 to 2017 Monthly Climate Averages**

| Period | Precipitation (mm) | Rain[1] (mm) | Snow[1] (mm) | PET[2] (mm) |
|---|---|---|---|---|
| January | 45 | 2 | 43 | 3 |
| February | 28 | 2 | 27 | 6 |
| March | 27 | 7 | 19 | 23 |
| April | 26 | 21 | 5 | 48 |
| May | 40 | 40 | 1 | 80 |
| June | 47 | 47 | 0 | 92 |
| July | 49 | 49 | 0 | 98 |
| August | 43 | 43 | 0 | 84 |
| September | 40 | 40 | 1 | 48 |
| October | 52 | 37 | 15 | 20 |
| November | 42 | 7 | 34 | 6 |
| December | 41 | 1 | 40 | 2 |
| **Annual Totals** | **480** | **295** | **185** | **509** |
| **Percent of Precipitation** | **100%** | **62%** | **38%** | |

Notes:
1. Estimated from precipitation data based on temperature.
2. PET is estimated from October to April, when data from Topley Landing is not available.

### 2.1.3 Surface Storage

Based on the recorded data, discharge from the TSF spillway normally occurs only during freshet indicating that there is enough surface depression, vegetation and upper soil moisture storage to contain most rain events. An initial estimate of these storages for the pre-cover model calibration (i.e., 2007/2008 condition) is 80 mm, broken down as follows:

- 65 mm of soil moisture storage in a dry antecedent moisture condition (AMC) based on:
  - 0.221 water content at wilting point (i.e. dry antecedent condition);
  - 0.430 water content at saturation point; and

[2] Based on an increase of 5% per 100 m elevation gain suggested by Quick (2005).
[3] Based on a decrease of 0.65°C per 100 m elevation gain, which is the average lapse rate defined for the International Standard Atmosphere.

  - 300 mm thick surface soil layer involved in evapotranspiration processes (i.e., 300 mm capillary rise for a silty/clay soil type).
- 10 mm of surface depression storage, assumed on a permeable surface and mild grade; and
- 5 mm of vegetation storage (before the closure cover was installed).

Using the measured data from spring freshet events to calibrate the pre-cover Goldsim model, the total moisture storage for the TSF was estimated to be 90 mm (Section 2.2), compared to the initial estimate of 80 mm. A 90 mm storage is equivalent to a curve number of 74 under the Soil Conservation Service (SCS) TR-55 hydrology model, which is reasonable for a flat and permeable area.

For the post-cover water balance, surface storage was increased to 100 mm to account for the vegetated glacial till cover. This is approximately consistent with an SCS curve number of 72.

### 2.1.4 Seepage Rate

Seepage is estimated as the amount of precipitation and/or snowmelt percolating into the tailings and reporting somewhere downstream of the spillway. In the 2009 water balance, a saturated hydraulic conductivity of $1x10^{-8}$ m/s, or approximately 1 mm/day, was used for the tailings. This value was not revised during pre-cover model calibration. The glacial till closure cover is assumed to have a hydraulic conductivity similar to the tailings, so no change to this value was made for the post-cover scenario.

## 2.2 Pre-Cover Scenario Calibration

Selection of the period for model calibration[4] was based on periods where there were concurrent data sets for pond level, discharge measurements in the TSF, and snow course measurements (at Burns Lake). This level of information was only available for the pre-cover scenario in 2007 and 2008. Results of the model calibration are presented in Figure 2.3.

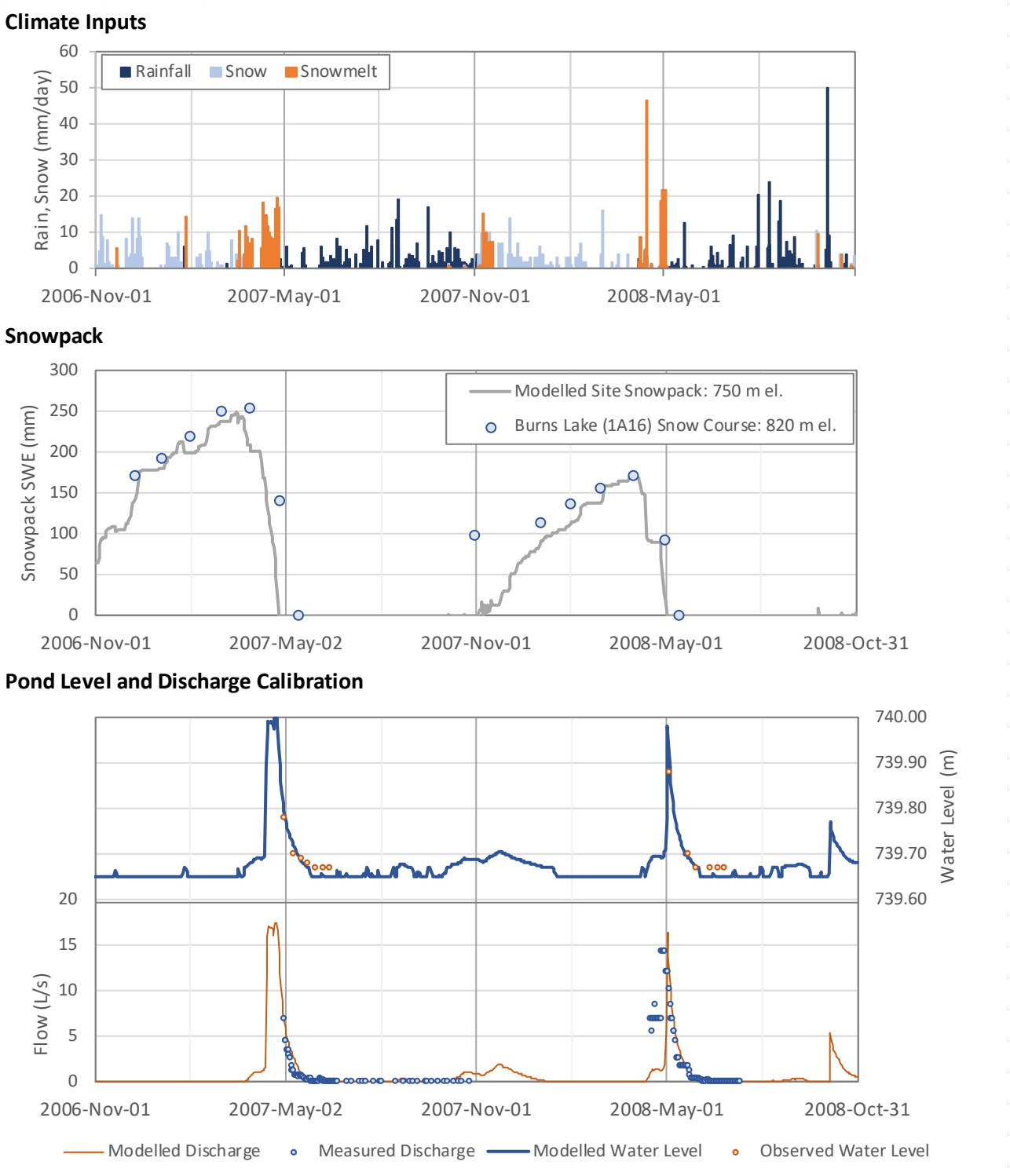
The estimated snow accumulation snow water equivalent (SWE) from the calibrated water balance model is comparable to the snow course SWE measurements at Burns Lake in 2007 and 2008. Burns Lake is at a similar elevation to the Pinchi TSF, so no elevation correction was required.

The estimated water level and TSF discharges from the calibrated water balance model closely correlate to the measured data in 2007 and 2008. The model predicted some discharge in late fall in both years when measurements were not taken; however, these volumes were small compared to the freshet discharge volumes.

The results described above and shown in Figure 2.3 indicate that the calibrated water balance model provides a reasonable representation of the hydrologic performance of the Pinchi TSF.

[4] Calibration included adjusting watershed storage, seepage and evaporation input parameters to fit measured pond level and flow data. Modelled snow accumulation was compared to measured values at Burns Lake, but no snowmelt parameters were adjusted.

**Figure 2.3 Pre-Cover Model Calibration using 2007 and 2008 Data**



## 2.3 Post-Cover Scenario Validation

The post-cover scenario was validated[5] using flow rates measured[6] approximately 450 m downstream of the TSF spillway. In 2011 and 2012, flows were measured five and four times, respectively; however, in 2013 to 2019, flows were measured either once or twice a year. Due to the higher number of measurements in 2011 and 2012, this period was selected for validation of the post-cover scenario model. Flow measurements and the associated runoff volume estimated for April-May in 2011 and 2012 are compared with modelled April-May runoff volumes in Table 2.3.

**Table 2.3 Post-Cover Model Validation using 2011 and 2012 Data**

| Parameter | 2011 | 2012 |
|---|---|---|
| Flow Measurement 1 | 3.2 L/s on April 19 | 11.8 L/s on April 23 |
| Flow Measurement 2 | 9.4 L/s on April 26 | 9.2 L/s on April 30 |
| Flow Measurement 3 | 7.3 L/s on May 3 | 3.6 L/s on May 7 |
| Flow Measurement 4 | 3.2 L/s on May 10 | 0.9 L/s on May 14 |
| Flow Measurement 5 | 0 L/s on May 17 | n/a |
| Measured April-May Runoff Total[1] | 10,500 $m^3$ | 11,000 $m^3$ |
| Modelled April-May Runoff Total | 8,300 $m^3$ | 9,400 $m^3$ |

Note:
1. Total April-May runoff volumes were estimated based on the measured flow rates and estimated flow durations.

The estimated measured runoff volume is between 15% and 25% higher than the modelled April-May runoff volumes in 2011 and 2012. This difference is likely due to the increase in catchment area between the TSF outlet and the location of the measurements. This comparison indicates that the post-closure scenario model is a reasonable representation of the conditions and that no further calibration of the model is needed.

# 3 RESULTS

The estimated average monthly TSF water balance[7] results reflecting the current (2018) post-cover closure conditions, with no free water pond and a vegetated glacial till cover, are summarized in Table 3.1. The table also includes annual totals for 2017[(8)] for comparison purposes.

An estimated 10% of direct precipitation on the TSF is lost to seepage, while 80% is lost to AET on an average annual basis. Average spillway discharge is the remaining 10% of direct precipitation on the TSF plus runoff from the upstream catchment.

[5] Validation included to comparing modelled April and May runoff volumes for the post-cover scenario to measured data in 2011 and 2012, without the adjustment of any input parameters.
[6] Collected by Ecofor in April and May between 2011 and 2019.
[7] The post-closure water balance used climate data from 1998 to 2017.
[8] 2017 totals reflect the period January 1, 2017 to December 31, 2017. This is different from the 2017 water year, which runs from October 1, 2016 to September 30, 2017.

## Table 3.1 Average and 2017 TSF Water Balance Results

| Period | TSF Inflows | | TSF Outflows and Storage | | | |
|---|---|---|---|---|---|---|
| | Upstream Catchment Runoff ($m^3$) | Rainfall and Snowmelt ($m^3$) | AET ($m^3$) | Seepage ($m^3$) | Spillway Discharge ($m^3$) | Change in Storage[1] ($m^3$) |
| January | 100 | 3,600 | 700 | 1,400 | 400 | 1,200 |
| February | 200 | 1,800 | 1,500 | 1,200 | 600 | -1,300 |
| March | 1,000 | 13,900 | 6,000 | 1,900 | 3,000 | 4,000 |
| April | 3,300 | 19,800 | 12,600 | 3,100 | 9,800 | -2,400 |
| May | 200 | 9,200 | 16,500 | 1,200 | 700 | -9,000 |
| June | 0 | 10,400 | 11,900 | 0 | 0 | -1,500 |
| July | 0 | 10,700 | 9,800 | 100 | 0 | 800 |
| August | 0 | 9,500 | 9,500 | 0 | 0 | 0 |
| September | 0 | 8,800 | 8,700 | 0 | 0 | 100 |
| October | 100 | 10,400 | 4,700 | 300 | 200 | 5,300 |
| November | 100 | 6,100 | 1,500 | 1,200 | 300 | 3,200 |
| December | 100 | 1,700 | 400 | 1,300 | 300 | -200 |
| **Average Annual Totals** | **5,100 (0.2 L/s)** | **105,900 (3.4 L/s)** | **83,800 (2.7 L/s)** | **11,700 (0.4 L/s)** | **15,300 (0.5 L/s)** | **200 (0.0 L/s)** |
| **2017 Totals** | **1,900 (0.1 L/s)** | **82,200 (2.6 L/s)** | **61,000 (1.9 L/s)** | **17,600 (0.6 L/s)** | **5,300 (0.2 L/s)** | **200 (0.0 L/s)** |

Note:

1. Reflects water stored as pore water in the closure cover over the tailings or in depressions on the surface.

## 4 CLOSING

This letter is an instrument of service of Klohn Crippen Berger Ltd. The letter has been prepared for the exclusive use of Teck Metals Ltd. (Client) for the specific application to the Pinchi Lake Mine Tailings Storage Facility. The letter's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

Yours truly,

**KLOHN CRIPPEN BERGER LTD.**

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9 Sep. 2019

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Sep 10, 2019

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SC:jc

## REFERENCES

Klohn Crippen Berger. 2009. “Pinchi Lake Tailings Facility: 2008 Annual Review”. Prepared for Teck Cominco Metals Ltd., May 6.

Quick, M.C. 2005. “UBC Watershed Model: User’s Manual”. University of British Columbia.

# APPENDIX VI

## Quantifiable Performance Objectives

# Appendix VI
# Quantifiable Performance Objectives

Quantifiable Performance Objectives for the Pinchi Lake Mine Tailings Storage Facility are as follows.

## VI-1. PIEZOMETERS

The threshold levels established for piezometers are based on stability analysis and are summarized in Table VI-1. Threshold level exceedances will be reviewed by the Engineer of Record, and further action will be advised based on subsequent engineering analysis.

**Table VI-1 Threshold Levels for Piezometers**

| Piezometer ID | Serial # | Threshold Value (Piezometric Elevation in metres) |
|---|---|---|
| DH16-01-VWP1 | VW38610 | 736.1 |
| DH16-01-VWP2 | VW38611 | 736.1 |
| DH16-02-VWP1 | VW38608 | 738.5 |
| DH16-02-VWP2 | VW38609 | 738.5 |
| DH16-03-VWP1 | VW38606 | 737.0 |
| DH16-03-VWP2 | VW38607 | 737.0 |

## SURVEY MONUMENTS

Alert criteria for displacement of survey monuments on the dam are as follows:

- Vertical displacements over one year greater than 50 mm.
- Horizontal displacements over one year, perpendicular to the dam alignment, greater than 50 mm.
- An engineering assessment is required for a continuing trend of movement if cumulative displacements of the dam in a credible (i.e., plausible) direction exceed 100 mm, relative to the baseline readings.