REPORT

Beaverdell Tailings Storage Facilities 2018 Annual Dam Safety Inspection

Teck Resources Limited - Beaverdell Mine

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Executive Summary

This report presents the 2018 annual dam safety inspection (DSI) for the embankments of the tailings storage facilities (TSFs) at the closed Beaverdell Mine. The facilities consist of the South TSF and North TSF.

This report was prepared by Golder Associates Ltd. (Golder) at the request of Teck Resources Limited (Teck), in consideration of the guidelines for annual DSI reports provided in the Health, Safety, and Reclamation Code (HSRC) for Mines in British Columbia Guidance Document (Ministry of Energy and Mines 2016) and the Teck Guidelines for Tailings and Water Retaining Structures (Teck 2014).

The DSI is based on a site visit carried out on 14 June 2018 by the Engineer of Record, John Cunning, and Martyn Willan, both of Golder, and a review of data provided by Teck. The reporting period for the data review was from October 2017 through November 2018 unless otherwise noted. Over this reporting period, Teck inspected the facility ten times:

- spring routine inspection on 8 May 2018
- seven additional inspections due to high water levels in the West Kettle River (WKR) in May 2018
  - daily to twice daily between 7 and 11 May 2018
  - 16 May 2018, accompanied by the Engineer of Record
  - 18 May 2018
- inspection on 11 June 2018 with the Teck Legacy Independent Tailings Review Board, accompanied by the Engineer of Record
- fall routine inspection on 26 November 2018

Construction, maintenance, and investigation works in 2018 included:

- construction at the South TSF Cell 3 spillway, between 14 and 16 August 2018
- removal of debris from the WKR bank adjacent to Cells 3, 4, and 5
- completion of cone penetration testing (CPT) at 38 locations within the South and North TSFs for geotechnical characterization of tailings between 30 July and 4 August 2018 (Golder 2019)
- installation of nine groundwater monitoring wells outside of the North and South TSFs between 17 and 21 July 2018
- removal of a large uprooted tree in the WKR on 10 October 2018, after high water flows in the spring

Four water quality sampling visits along with resultant analyses were completed in 2018.

A LiDAR survey of the facilities including portions of the WKR floodplain was completed by flight mission on 19 July 2018. This survey was referenced to the new Canadian Geodetic Vertical Datum (CGVD2013). Elevations in this report are referenced to this datum, unless otherwise noted.

Summary of Facility Description

The TSFs are located within the valley of the WKR, at elevations between 777 and 800 m. The east side of Cranberry Ridge, including the area of the TSFs, is part of the drainage area of the WKR. The TSFs are divided into the South TSF and the North TSF. Both the South and North TSFs have been inactive for 27 years since the mine was permanently closed in 1991.

The South TSF includes five tailings deposition cells (Cells 1 to 5) and the North TSF includes two cells (Cells 6 and 7). The South TSF Cell 5 dam and the North TSF Cell 6 and 7 dam were designed to be constructed of earthfill using the downstream construction method (Binnie 1973, 1980a,b,1988). No construction record reports are available for Cells 5, 6, and 7. Site investigations are planned for 2019 to assist with the determination of dam construction materials and methods.

The South TSF Cell 3 and 4 dam is assumed to have been constructed in a similar manner to Cells 5 to 7 using earthfill and the downstream construction method. Cells 3 to 5 were constructed downstream of Cells 1 and 2; however, a portion of Cell 1 is retained by an external dam. Design and construction record reports for Cells 1 to 4 are not available. Site investigations are planned for 2019 to assist with the determination of dam construction materials and methods.

Summary of Key Hazards and Consequences

A required component of the annual DSI is a review of the key hazards and consequences. The facility dam safety assessment for the Beaverdell TSFs was completed based on site observations and data review for each of the hazards that are most relevant to the types of dams present at Beaverdell. The key potential hazards for the South and North TSFs are described in the following sections.

Internal Erosion

The Beaverdell TSFs have been inactive for 27 years. Small, shallow ponds are occasionally present in Cells 4 and 6. Only minor ponding was observed in these areas during the 16 May 2018 inspection (Golder 2018d) following an unusually high rainfall / runoff period. A CPT program completed in July and August 2018 indicated generally unsaturated conditions with some limited zones of saturation. Data interpreted from CPT testing indicated low pore-water pressure conditions within the inferred foundations below the tailings, which may be indicative of vertical drainage occurring from the tailings into the foundation materials. Observed saturated zones corresponded with observed surface ponding areas. Zones of non-saturated tailings were observed in CPT data collected adjacent to the dams.

Conditions indicative of a potential piping failure, such as high hydraulic gradients or saturation within the tailings, have not been observed. There is typically insufficient saturation or hydraulic gradient to drive a potential piping failure. Internal erosion is considered to be a rare[1] to very rare[2] likelihood.

Overtopping

The small, shallow, temporary ponding that occurs at the Beaverdell TSFs, under typical conditions, is not an overtopping risk. Large non-typical storm events could generate surface ponding which would be managed by spillways. The North TSF Cell 7 has a spillway, and Cell 7 can contain the inflow design flood (IDF), therefore the likelihood of overtopping for this facility is considered to be very rare[2]. The South TSF routes surface water to Cell 3 where it can exit the facility through a spillway. The likelihood of overtopping for the South TSF is considered to be very rare[2].

Instability

The visual inspection during the June 2018 site visit did not identify any signs of stress such as cracks, settling, or bulges on the South and North TSF dams. This is consistent with previous reviews by Golder. No significant erosion was noted on either the upstream or downstream slopes of either facility. The conditions of the dams have remained unchanged from previous site visits. No seepage or signs of uncontrolled past seepage were identified during the site visit. The dam slopes appear to be stable.

A stability analysis was completed in 2017 (Golder 2018a) to check against the seismic design criteria provided in the HSRC and the HSRC Guidance Document (Ministry of Energy and Mines 2016, 2017). This assessment was carried out based on a dam consequence classification for the TSFs of “Significant”. The stability analysis indicated factors of safety for the Beaverdell TSFs meet or exceed design requirements under the HSRC and the Canadian Dam Association (CDA 2013) *Dam Safety Guidelines*, which is consistent with visual observations.

A number of trees within the Cell 3 dam crest were observed. These could present a potential risk to dam stability in that they could reduce the height of the Cell 3 dam should they fall (e.g., from high winds). Felling of these trees was completed by Teck in Q1 2019 as per Golder’s preliminary recommendation following the DSI site visit in June 2018.

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[1] Rare likelihood: For a natural hazard (earthquake, flood, windstorm, etc.), the predicted return period for an event of this strength / magnitude is between 1-in-100 and 1-in-1,000 years. Also for failure modes such as instability and internal erosion that are rare.

[2] Very rare likelihood: For a natural hazard (earthquake, flood, windstorm, etc.), the predicted return period for an event of this strength / magnitude is between 1-in-1,000 and 1-in-10,000 years. Also for failure modes such as instability and internal erosion that are very rare.

Erosion of Toe from West Kettle River

Erosion protection was constructed along a portion of the right bank of the WKR adjacent to the South TSF in late 2015 and early 2016 (Golder 2016c). This erosion protection was designed by Golder for a peak flow resulting from a WKR flood event 1/3 between the 1-in-975-year flood and the probable maximum flood (Golder 2015b). Between 9 and 10 May 2018, a high water level event occurred in the WKR adjacent to the South TSF. Some riprap protection which was installed along the WKR bank downstream of Cell 4 prior to 2015 and riverbank material was eroded during this 2018 event. An approximately 8 m high tree was also uprooted, along with the associated root bulb, and came to rest adjacent to Cell 5 in the WKR channel. The tree was observed to cause the river to flow at greater velocities adjacent to the erosion protection located below the Cell 5 dam toe. No erosion of the downstream slopes of the dams was observed during a 16 May 2018 inspection (Golder 2018d). This tree was removed on 10 October 2018.

Following the 2018 WKR high water event, the river geomorphology was observed to have significantly altered. As such, the assumptions and parameters adopted in the design of the riprap in 2015 / 2016 may no longer be valid. Erosion of the downstream toe of Cell 4 and 5 dams represents an ongoing hazard to dam safety, should additional protection measures not be implemented. A new hydraulic model for the WKR and riprap design is currently in preparation, by Golder, to address this hazard.

Dam Consequence Classification

Dam consequence classification is based on the potential consequences of a dam failure irrespective of the potential for such an event to occur. At the time of this report, the consequence classifications for both the North and South TSFs remain “Significant” following the dam consequence classification guidelines from the HSRC Guidance Document Section 3.4 (Ministry of Energy and Mines 2016), which references the CDA (2013) *Dam Safety Guidelines*. This is the second lowest classification for a dam under these guidelines.

A report by Fisheries and Oceans Canada (DFO 2018) identified the area of the WKR immediately to the east of the South TSF as critical habitat for Speckled Dace. The classification of this habitat as critical has the potential to increase the consequence classification of the South TSF based on the consequence classification guidelines (CDA 2013). A review of the consequence classification of the South TSF is required.

Summary of Key Observations and Significant Changes

The Beaverdell TSFs were in good condition at the time of the 2018 site inspection.

Dam condition, maintenance, and surveillance of the facility were reviewed through site observation and discussion with Teck personnel. The 2018 annual DSI report and photographs were prepared for the South and North TSF dams based on observations during the 14 June 2018 site inspection.

No significant changes in visual monitoring records or dam stability were noted during the 2018 DSI for the South and North TSFs at the Beaverdell site. There is no functional geotechnical instrumentation installed at the Beaverdell TSFs. Quantitative performance objectives have been established and are presented in this DSI.

Review of Operation, Maintenance and Surveillance Manual

The operation, maintenance, and surveillance (OMS) manual for the TSF was updated in February 2018 (SP&P BEA-OMS-001.V002; Teck 2018a). The OMS manual meets the guidelines provided by the HSRC (Ministry of Energy and Mines 2016), the CDA (2013), the Mining Association of Canada (MAC 2011), and Teck (2014).

Review of Emergency Preparedness and Response Plan

The emergency preparedness and response plan (EPRP) was updated in February 2018 (Teck 2018b) (SP&P BEA-EPRP-001.V002). This document meets the guidelines provided by the HSRC (Ministry of Energy and Mines 2016), the CDA (2013), the Mining Association of Canada (MAC 2011), and Teck (2014).

Dam Safety Review

The last dam safety review for the Beaverdell TSFs was conducted in 2012 (Golder 2013). The next dam safety review for the facilities based on the requirement of the HSRC (Ministry of Energy and Mines 2017) is to be completed by the end of 2021.

Status of 2017 Dam Safety Inspection Recommended Actions

There was one high priority deficiency / non-conformance noted in the 2017 DSI report (Golder 2018c), with a recommendation to design and construct a Cell 3 spillway. The design for the Cell 3 spillway was completed in March 2018 (Golder 2018b) and construction works were undertaking in August 2018. This deficiency / non-conformance is considered “Closed” as part of this DSI.

Table E-1 provides the current status of the 2017 DSI recommendations for the TSFs.

Table E-1: Current Status of 2017 Recommended Actions for the Beaverdell Tailings Storage Facility Dams

ID Number	Deficiency or Non-conformance	Recommended Action	Priority in 2017 DSI	Current Status at March 2019
2016-01	The South TSF would discharge through the Cell 3 spillway during a 24-hour IDF event. The consequence of potential tailings migration due to flood transport is not quantified.	Complete sampling and testing of tailings for geochemical properties.	**3**	**In progress** Surface samples of tailings collected and tested for chemistry for Preliminary Quantitative Risk Assessment. Geotechnical site investigation and geochemical sample collection and testing program has been scoped by Golder and is scheduled for execution by Teck in 2019.
2016-02b	Cell 3 cannot contain IDF; flood water will leave the South TSF via spillway in Cell 3.	Detailed design for the South TSF spillway and construction scheduled to be completed by 31 May 2018, subject to weather conditions or approval of extension to order from EMPR.	**1**	**Closed**
2016-03	Existing facility phreatic conditions not confirmed.	Complete drilling program to gather subsurface information and install piezometers.	**3**	**In progress** CPT program was carried out in 2018 (Golder 2019). Site investigation with piezometer installation has been scoped by Golder and is scheduled for execution by Teck in 2019.
2016-05	Closure plan not updated.	Initiate investigation of existing physical and geochemical properties.	**4**	**In progress** Surface samples of tailings collected and tested for chemistry for Preliminary Quantitative Risk Assessment. Geotechnical site investigation and geochemical sample collection and testing program has been scoped by Golder and is scheduled for execution by Teck in 2019. Teck is planning to hold a closure workshop in 2019.
2017-01	Annual risk assessment for facilities.	Update a risk assessment for the facilities.	**4**	**Closed**
2017-02	No dam breach and inundation study completed.	Complete dam breach and inundation assessment. Reassess consequence classification if necessary.	**3**	**In progress** Geotechnical site investigation program has been scoped by Golder and is scheduled for execution by Teck in 2019.

CPT = cone penetration testing; DSI = dam safety inspection; IDF = inflow design flood; EMPR; Ministry of Energy, Mines and Petroleum Resources TSF = tailings storage facility.

2018 Dam Safety Inspection Recommended Actions

The Beaverdell TSF dams were observed to be in good condition at the time of the 2018 DSI site visit. This conclusion is based on a review of visual monitoring records and on observations of dam stability and surface water control.

Table E-2 provides recommendations from this 2018 DSI for the TSFs.

Table E-2: Summary of 2018 Dam Safety Inspection Recommended Actions

<table>
<tr><th>Structure</th><th>ID Number</th><th>Deficiency or
Non-conformance</th><th>Applicable Regulation or OMS Manual Reference</th><th>Recommended Action</th><th>Priority</th><th>Recommended Deadline</th></tr>
<tr><td rowspan="5">South TSF</td><td>2016-01</td><td>The South TSF would discharge through the Cell 3 spillway during a 24-hour IDF event. The consequence of potential tailings migration due to flood transport is not quantified.</td><td>HSRC 10.1.12</td><td>Execute the planned geochemical site investigation and testing program. Teck should schedule this program to start in Q2 2019.</td><td>3</td><td>Q4-2019</td></tr>
<tr><td>2018-01</td><td>Cell 3 spillway riprap is too thick at invert and requires removal to achieve required freeboard.</td><td>CDA (2014)</td><td>Complete recommended additional construction works to address freeboard requirements.</td><td>2</td><td>Q2-2019</td></tr>
<tr><td>2018-02</td><td>Dam consequence classification requires review due to changes in downstream conditions.</td><td>HSRC §10.1.7</td><td>Review dam consequence classification as recommended in Golder (2018g).</td><td>2</td><td>Q4-2019</td></tr>
<tr><td rowspan="2">2018-03 a, b</td><td rowspan="2">Existing riprap along the toe of Cell 4 and 5 may not be sufficient to prevent erosion of dam fill during a large river freshet flood event, based on observed changes in river alignment and adjacent river bank conditions.</td><td rowspan="2">HSRC §10.1.8</td><td>Design and implement interim measures to mitigate risk of flood damage during 2019 freshet, including stockpiling of riprap material and a freshet flood management plan (in progress).</td><td>2</td><td>April 2019</td></tr>
<tr><td>Assess long-term requirements for riprap based on changes in river hydrology and flood statistics (in progress).</td><td>3</td><td>Q3-2019</td></tr>
<tr><td rowspan="5">South and North TSFs</td><td>2016-03</td><td>Facility phreatic conditions not confirmed.</td><td>CDA 2013 §6.6</td><td>Execute the planned drilling program to gather subsurface information and install piezometers. Teck should schedule this program to start Q2 2019.</td><td>3</td><td>Q4-2019</td></tr>
<tr><td rowspan="2">2016-05 a, b</td><td rowspan="2">Closure plan not updated.</td><td rowspan="2">HSRC §10.4.1</td><td>Complete investigation of existing physical and geochemical properties to inform the development of an updated closure plan. Teck should schedule this program to start in Q2 2019.</td><td>4</td><td>Q4-2019</td></tr>
<tr><td>Update Closure Plan.</td><td>4</td><td>2020</td></tr>
<tr><td>2017-02</td><td>No dam breach and inundation study completed.</td><td>HSRC §10.1.11</td><td>Complete investigation of existing physical and geochemical properties to inform the completion of a dam breach and inundation assessment in 2019. Teck should schedule this program to start Q2 2019.
Complete a dam breach and inundation study.</td><td>3</td><td>Q4-2019</td></tr>
<tr><td>2018-04</td><td>Water management plan is out of date.</td><td>HSRC §10.1.12</td><td>Update existing water management plan.</td><td>4</td><td>2020</td></tr>
</table>

CDA = Canadian Dam Association; HSRC = Health, Safety and Reclamation Code; ID = identification; IDF = inflow design flood; OMS = operation, maintenance, and surveillance; TSF = tailings storage facility.

Priority	Description
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.
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.
3	Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

Source: HSRC Guidance Document, Section 4.2 (Ministry of Energy and Mines 2016).

ABBREVIATIONS

Abbreviation	Definition
BC	British Columbia
CDA	Canadian Dam Association
CGVD	Canadian Geodetic Vertical Datum
DSI	dam safety inspection
DSR	dam safety review
EoR	Engineer of Record
EPRP	emergency preparedness and response plan
Golder	Golder Associates Ltd.
HSRC	Health, Safety and Reclamation Code for Mines in British Columbia (Ministry of Energy and Mines 2017)
EMPR	British Columbia Ministry of Energy, Mines and Petroleum Resources (formerly Ministry of Energy and Mines). Also referred to as MEMPR
n/a	not applicable
NRC	Natural Resources Canada
OMS manual	operation, maintenance, and surveillance manual
QPO	quantitative performance objective
Teck	Teck Resources Limited
TSF	tailings storage facility
WKR	West Kettle River
Wood	John Wood Group PLC

UNITS OF MEASURE

Unit	Definition
%	percent
cm	centimetre
km	kilometre
km^2	square kilometre
m	metre
m^3	cubic metre
mm	millimetre

GLOSSARY

Term	Definition
Dam Safety Inspection (DSI)	An annual dam safety inspection report as required by Section 10.5.3 of the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (Ministry of Energy and Mines 2017) in consideration of the HSRC Guidance Document (Ministry of Energy and Mines 2016), both available at http://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/health-safety/health-safety-and-reclamation-code-for-mines-in-british-columbia.
Dam Safety Review (DSR)	A systematic review and evaluation of all aspects of design, construction, maintenance, operation, process, and system affecting a dam's safety, including the dam safety management system (Ministry of Energy and Mines 2017).
Downstream	The side of the embankment farthest away from the reservoir or cell.
Downstream Construction	A dam raised by adding additional fill to the downstream side of the dam.
Earthfill Dam	An engineered barrier constructed of naturally occurring materials, including blasted or crushed rockfill and/or mineral soil fill, for the retention of water, water containing any other substance, fluid waste, or tailings.
Freeboard	The vertical distance between the still water surface elevation in the reservoir and the lowest elevation at the top of the containment structure (CDA 2013).
Inflow Design Flood (IDF)	The most severe inflow flood (peak volume, shape, duration, timing) for which a dam and its associated facilities are designed (CDA 2013).
Left Bank	Left bank of the West Kettle River while looking downstream from a fixed point.
Right Bank	Right bank of the West Kettle River while looking downstream from a fixed point.
Tailings	Fine-grained residual material remaining after the valuable resources have been separated.
Upstream	The side of the embankment nearest to the reservoir or cell.

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1.0 INTRODUCTION

1.1 Purpose, Scope of Work, Methodology

As requested by Teck Resources Limited (Teck), Golder Associates Ltd. (Golder) prepared this 2018 annual dam safety inspection (DSI) report for the tailings storage facilities (TSFs) at the closed Beaverdell Mine in British Columbia (BC). The facilities consist of the North TSF and South TSF.

The DSI report has been prepared with consideration of the guidelines for annual DSI reports provided in the Health, Safety, and Reclamation Code (HSRC) for Mines in British Columbia Guidance Document (Ministry of Energy and Mines 2016) and the Teck Guidelines for Tailings and Water Retaining Structures (Teck 2014). It is understood that this report will be submitted by Teck to the Chief Inspector of Mines.

The report is based on a site visit carried out by the Engineer of Record (EoR) on 14 June 2018, which included a walkover of the TSF areas with Teck staff involved in the maintenance and surveillance of the dams. The report consists of the following key components:

- a summary of the site conditions and background information
- a summary of the activities for the 2017 / 2018 reporting period
- dam consequence classification and required operational documents review
- site photographs and records of dam inspection
- review of
  - climate data
  - water balance
  - dam safety relative to potential failure modes
- findings and recommended actions

A LiDAR survey of the facilities and surrounding area including portions of the West Kettle River (WKR) floodplain was completed by flight mission on 19 July 2018. This survey was referenced to the new Canadian Geodetic Vertical Datum (CGVD2013). Elevations in this report are referenced to this datum, unless otherwise noted.

Photographs of the TSF areas from the site inspection are presented in Appendix A. A summary of the observations for each TSF is included in the inspection reports presented in Appendix B.

The previous annual DSI site visit for these facilities was carried out in August 2017 and is reported in the 2017 annual DSI report (Golder 2018c).

This report should be read in conjunction with the Study Limitations, which follows the report text.

1.2 Regulatory Requirements

1.2.1 Health, Safety and Reclamation Code

The Beaverdell TSFs are regulated under the HSRC (Ministry of Energy and Mines 2017). Both the North TSF and South TSF dams meet the definition of a “dam” as defined in the HSRC.

As required by the HSRC, the following personnel have been designated for the Beaverdell TSFs:

- Engineer of Record: John Cunning, P.Eng., Golder Associates Ltd.
- Tailings Storage Facility Qualified Person: Gerry Murdoch, Teck Resources Limited.

1.2.2 Permits and Licences

The Beaverdell Mine is regulated under the following permits:

- *Waste Management Act* Permit No. PE-444, dated July 1990
- *Mines Act* Permit M-71, dated January 1981

1.3 Facilities Description

The Beaverdell Mine was an underground mine development adjacent to the community of Beaverdell, BC, which is located 87 km from Kelowna via BC Highway 33 (Figure 1). Silver was the main ore extracted from the mine, with appreciable quantities of lead, zinc, gold, and cadmium. The Beaverdell Mine was closed in 1991 and is now under active care and maintenance, with no current or planned mining activities. Teck is evaluating options for long-term management of the mine site and TSFs with an end goal of minimizing the risks associated with these facilities.

A general view of the topography and region surrounding the Beaverdell TSFs, which sit at the toe of the east side of Cranberry Ridge, is provided in Figure 2. The TSFs are located within the valley of the WKR, at elevations between 777 and 800 m. The TSFs have been inactive for 27 years since the mine was permanently closed in 1991.

The east side of Cranberry Ridge, including the area of the TSFs, is part of the drainage area of the WKR. Figure 2 illustrates the general view of the TSFs, which are divided into the South TSF and the North TSF. The South TSF includes five tailings deposition cells (Cells 1 to 5) and the North TSF includes two cells (Cells 6 and 7). Figure 3 shows the various infrastructure, and locations of representative cross-sections of the cells. The cross-sections are presented in Figures 4 and 5.

The dams were classified as “Low” consequence structures by the BC Ministry of Energy and Mines in 2003 (Ministry of Energy and Mines 2003) and updated to “Significant” consequence structures as reported by Golder (2013). A review of the dam consequence classifications is provided in Section 5.1.

The Beaverdell Mine is an inactive facility under the closure – active phase of mine life. A caretaker is present in the town of Beaverdell year-round. No operation activities are required at the TSFs and they do not include any structures or mechanical components (e.g., pipes, pumps, spigots, gates, or valves) that require an operator. Drainage at the TSFs is solely by gravity (infiltration and spillways).

Golder’s first involvement with the TSFs was the dam safety review (DSR), completed in 2012 (Golder 2013). Golder has been the EoR for the Beaverdell TSFs since 2013.

1.3.1 South Tailings Storage Facility Description

The South TSF includes five tailings deposition cells (Cells 1 to 5). The South TSF area intersects the natural upslope of the WKR valley, and as a result, no dam was required on the north and west sides of Cell 3, the west side of Cell 2, and parts of the west side of Cell 1. The main perimeter dam of the South TSF is to the south of Cells 1 and 5 and east of Cells 3, 4, and 5 (Figure 3).

The South TSF Cell 5 dam was designed to be constructed of earthfill using the downstream construction method (Binnie 1973, 1980c). No construction record reports are available for Cell 5.

The South TSF Cell 3 and 4 dam is assumed to have been constructed in a similar manner to Cell 5 using earthfill and the downstream construction method. Cells 3 to 5 were constructed downstream of Cells 1 and 2; however, a portion of Cell 1 is retained by an external dam. Design and construction record reports for Cells 1 to 4 are not available.

The downstream slopes of the South TSF dam are covered with trees. The trees are generally straight with diameters of 10 to 15 cm, suggesting that there is no apparent movement or creep of the dam slopes.

A ditch along the road to the west of the South TSF area (Beaverdell Station Road, Figure 3) directs water runoff from Cranberry Ridge away from the facility. As a result, the watershed zone of the South TSF consists of the surface area of the facility plus the area between the facility and the road. Surface water is observed to seasonally pool in a depression in Cell 4. During flood events, surface water can migrate through internal spillways to Cell 3, which has an external spillway. During normal precipitation events water will collect in localized low spots in the topography.

The South TSF contains a decant tower in Cell 5 which was understood to be used during operations. No decant tower has been observed in any of the other South TSF cells. The decant tower in Cell 5 is shown in Photograph 15, Appendix A, and its approximate location is shown in Figure 3. This decant tower was sealed with foam in 2016.

A supernatant pond existed in the southwest corner of Cell 5, where it is understood the decant tower outlet exited the cell during operations (Figure 3) (Binnie 1980c). The decant pipe outlet is not currently visible in the downstream area of Cell 5. During previous inspections, tailings were observed in this area downstream of Cell 5. The tailings could be related to the decant outlet. The area is a known low spot in the topography, and there has been ponding in this area during spring freshet.

1.3.1.1 Dimensions of South Tailings Storage Facility Dam

Based on observations made during annual site inspections and information from the latest topographic survey of the site, the South TSF dam has a maximum height of about 10 m and an approximate length of 1,010 m. The configuration of Cells 1, 2, and 3 is unknown on the upstream side of the embankments, but the downstream slopes can be determined from survey data. A portion of Cell 1 and all of Cell 2 tailings appear to be from deposition of slurry with runoff of water from the deposited tailings (i.e., tailings water was not contained). This contrasts with Cells 3, 4, and 5, where tailings water was contained behind the South TSF dam. The dimensions of each cell are shown in Table 1 and are approximate. The existing crest length excludes the dividers between cells; it is only the dam length. Cross-sections are provided in Figures 4 and 5.

Table 1: Embankment Geometry and Storage for the South Tailings Storage Facility

Cell	Downstream Slopes	Upstream Slopes	Exterior Crest Length (m)	Crest Width (m)	Embankment Height (m)	Approximate Minimum Crest Elevation[(a)] (m)
1	2.0 to 4.0H:1V	unknown	110	1 to 3	3 to 10	785.5
2	n/a[(b)]	unknown	n/a[(b)]	n/a[(b)]	n/a[(b)]	n/a[(b)]
3	1.5 to 2.4H:1V	1.5 to 3H:1V	360	2.5 to 3.5	2 to 3	780.5
4	1.2 to 1.4H:1V	1.5H:1V (assumed from original design)	240	3 to 3.5	7 to 8	785.0
5	1.3 to 2.5H:1V	1.5H:1V (assumed from original design)	300	3 to 6	7 to 8	785.0

(a) Elevation in CGVD2013.

(b) Tailings in Cell 2 appear to be from deposition of slurry with runoff of water from the deposited tailings (i.e., tailings water was not contained).

n/a = not applicable.

1.3.1.2 Dimensions of South Tailings Storage Facility Spillways

Dimensions of the various spillways through the cells have been determined based on the 2018 LiDAR survey data and observations made during site inspections. The spillway through the Cell 3/4 divider dyke has a bottom width of 3 m, a minimum depth of 1 m, lateral slopes of 2H:1V, and an invert elevation of approximately 784.0 m. It is trapezoidal in shape, partially riprap-armoured, and allows the conveyance of surface water from Cell 4 to Cell 3 (Photograph 19, Appendix A). The small, partially riprap-armoured spillway through the Cell 4/5 divider dyke has a bottom width of 1 m and lateral slopes of about 1.5H:1V and allows conveyance of surface water from Cell 5 to Cell 4. The invert elevation of this spillway is approximately 784.5 m. Construction on the upgraded spillway exiting Cell 3 was undertaken in August 2018. See Section 2.4 for additional details.

1.3.1.3 Storage Capacity of South Tailings Storage Facility

The storage capacity of each of the TSF cells was calculated in AutoCAD® Civil3D® using topography from the July 2018 LiDAR survey. Storage was assumed to be available from the tailings surface elevation to the lowest spillway elevation of each cell. From the 2018 cone penetration testing (CPT) investigation, it was estimated that the South TSF currently stores approximately 544,000 m^3 of tailings (Golder 2019).

The cells in the South TSF area are connected by a system of spillways, resulting in overflow from upstream cells discharging to downstream cells, with excess runoff ultimately reporting to Cell 3 and discharging via the Cell 3 spillway. Cell 1 has no capacity and its berms were raised in August 2016 to facilitate the movement of water from Cell 1 to Cell 5. Cell 2 has no capacity and runoff overflow reports to Cell 4. Cells 4 and 5 are estimated to be able to store approximately 7,500 and 14,500 m^3 of water, respectively. Excess runoff from Cell 5 reports to Cell 4, which in turn reports to Cell 3. With the construction of the spillway, Cell 3 has almost no storage capacity (other than in localized low spots) and excess runoff from Cell 3 would discharge via the spillway to the area downstream of the Cell 3 dam. The calculated storage and tailings volumes, and the locations of overflow discharge, are presented in Table 2.

Table 2: South Tailings Storage Facility Cell Storage Capacities Based on 2018 LiDAR Survey

Cell	Storage Volume (m^3)	Storage to Elevation[(a)]	Overflow Discharged To	Volume of Stored Tailings (m^3)
1	0	n/a	Cell 5	27,000
2	0	n/a	Cell 4	18,000
3	0	n/a	downstream of Cell 3 (via spillway)	192,000
4	7,400	784.0	Cell 3	165,000
5	14,500	785.0	Cell 4	142,000
Total	**21,900**	n/a	n/a	**544,000**

(a) Elevation in CGVD2013. Freeboard not considered.

n/a = not applicable.

1.3.2 North Tailings Storage Facility Description

The North TSF consists of two cells (Cells 6 and 7) contained by the North TSF dam and separated by a divider dyke (Figure 3). The North TSF area intersects the natural upslope of the WKR valley, and consequently, no dam was required on parts of the west side of Cell 7. The main perimeter dam for the North TSF surrounds Cells 6 and 7, except for a portion to the west of Cell 7 where the topography has sufficient elevation to contain the facility.

The North TSF Cell 6 and 7 dam were designed to be constructed of earthfill using the downstream construction method (Binnie 1980a, 1988). No construction record reports are available for Cells 6, and 7.

The downstream slopes of the dam are covered with trees. These trees have diameters of 12 cm or less and are generally straight, suggesting that there is no apparent movement or creep of the dam slopes.

The dam and the Cell 7 diversion and spillway channel to the west of Cell 7 prevent water runoff from Cranberry Ridge from entering the North TSF area (Photographs 44 and 49, Appendix A). The watershed of the North TSF area therefore consists of the surface area of this facility. Water collected in Cell 6 would report to Cell 7 and discharge via the Cell 7 spillway south of the TSF.

The decant towers in the North TSF, which originally managed pond water, have been sealed (Golder 2014b). The diameter of each of the decant tunnel pipes was estimated at 0.2 m (i.e., 8 inches). The locations of the two decant towers in Cells 6 and 7 are shown in Figure 3.

1.3.2.1 Dimensions of North Tailings Storage Facility Dam

Based on observations made during annual site inspections and data from the 2018 LiDAR survey, the North TSF consists of an earthfill dam with a maximum height of about 12 m and an approximate length of 840 m. The approximate dimensions of each cell are shown in Table 3. The existing crest length excludes the dividers between cells; it is only the dam length. Sections are provided in Figure 5.

Table 3: Embankment Geometry and Storage for the North Tailings Storage Facility

Cell	Downstream Slopes	Upstream Slopes	Exterior Crest Length (m)	Crest Width (m)	Embankment Height (m)	Approximate Minimum Crest Elevation[(a)] (m)
Cell 6	1.4 to 1.9H:1V	1.5H:1V (assumed from original design)	510	3 to 4	10 to 12	797.5
Cell 7	1.6 to 2.6H:1V	1.5H:1V	330	3 to 4	8 to 10	798.0

(a) Elevation in CGVD2013 vertical datum.

Tailings within Cell 6 have settled to an elevation typically 1.5 m below the dam crest, while the tailings are between 6 and 7 m below the dam crest in Cell 7.

1.3.2.2 Dimensions of North Tailings Storage Facility Spillways

Dimensions of the spillway from Cell 7 have been determined based on the 2018 LiDAR data and observations made during site inspections. The spillway built on the west side of Cell 7 is a trapezoidal outlet armoured with riprap, with a bottom width of approximately 3 m, a bank height of approximately 1.5 m below the dam crest, slopes of 1.5H:1V, and an invert elevation of approximately 797.4 m. There are no construction records for this spillway. There is no constructed channel in the divider dyke between Cells 6 and 7; there is a low point that will allow conveyance of surface water between Cells 6 and 7.

1.3.2.3 Storage Capacity of North Tailings Storage Facility Dam

The storage capacity of each of the TSF cells was calculated in AutoCAD Civil3D as part of this DSI using topography from the July 2018 LiDAR survey. Storage was assumed to be available from the tailings surface elevation to the lowest spillway / low spot elevation of each cell. From the 2018 CPT investigation, it was estimated that the North TSF currently stores approximately 384,000 m^3 of tailings.

Calculated storage and tailings volumes, and the locations of overflow discharge, are presented in Table 4.

Table 4: North Tailings Storage Facility Cell Storage Capacities Based on 2018 LiDAR Survey

Cell	Storage Volume (m^3)	Storage to Elevation[(a)]	Overflow Discharged To	Volume of Tailings Stored (m^3)
6	22,500	797.0	Cell 7	271,000
7	162,100	797.0	see row below	113,000
6&7[(b)]	28,500	797.4	area downstream (south) of Cell 7 dam (via spillway)	n/a
Total	**213,100**	n/a	n/a	**384,000**

(a) Elevation in CGVD2013 vertical datum.

(b) Storage volume from elevation 797 to 797.4 m which is above the berm between Cells 6 and 7.

n/a = not applicable.

1.3.3 Subsurface Conditions

The foundation conditions for Cells 4, 5, 6, and 7 are reported to be sandy gravel alluvial deposits typical of river valleys in central BC (Binnie 1971, 1973, 1980a, 1988). Interpretations of data from the 2018 CPT investigation indicated sand materials in the foundation. No samples are recovered from CPTs. Further site investigations are planned in 2019, including sample collection to confirm these interpretations. Pore pressure readings from the CPT investigation indicated low pore-water pressure within the inferred foundations, which may be indicative of vertical drainage occurring from the tailings to the foundation materials.

Laboratory testing was completed on a sample obtained from original ground at the northwest toe of Cell 5 to confirm the strength of the material (Golder 2016b).

Soil units under the sand and gravel were not described in the design documents, and CPT soundings in 2018 were terminated prior to reaching these strata. Bedrock outcrops are present west of Cell 7.

Well records from the Beaverdell area, available from the Government of BC website (Government of BC 2016), were reviewed in October 2016. The well records were completed by drillers conducting groundwater well installations and contain limited information. Based on review of the logs within the area of Beaverdell and those closest to the TSFs, the majority of the deposits in the valley are interpreted to be alluvial deposits of sand and gravel. The alluvial deposits range from 8 to 23 m in thickness based on drillhole termination and bedrock depth. Discrete layers of clay (0.3 to 8.5 m) are reported in various logs. These layers do not appear to be continuous along a wide area and are considered to be alluvial in origin. It is interpreted that the identified fine-grained deposits are most likely related to historical abandoned meanders of the WKR. Further site investigations are planned for 2019.

Additional groundwater monitoring wells were installed in July 2018 by John Wood Group PLC (Wood), which are shown in Figure 3. Geotechnical logs for these wells were not available for review at the time of this report; however, recovered core left at site was reviewed by Golder on 30 July 2018. Data provided by Wood indicate groundwater levels in these wells ranged from 774.5 to 781.8 m (CGVD2013), with the lowest elevations being recorded adjacent to the WKR at the south end of the site. The minimum and maximum water depths below ground surface were 1.9 and 11.3 m, respectively.

1.3.4 Embankment Fill Materials

Based on the design documents, construction of Cells 5, 6, and 7 consisted of excavation of the centre of the cell area to source material for construction of the dams. Therefore, the embankment fills are generally sandy gravel alluvial materials. The material placed for the embankment may be slightly more compacted than the original alluvial material based on construction methods, but no testing records are available to confirm this.

Based on observations of the facility during several site visits, the embankment construction materials for Cells 3 and 4 appear to also be alluvial material.

Cells 4 and 5 have a waste rock or alluvial cobble protective layer on the downstream face (Binnie 1971, 1973). Based on the design drawings, this layer is approximately 1.8 m (6 ft) at the crest and 3.0 m (10 ft) at the base of the embankment (Binnie 1971, 1973).

Cells 1 and 2 appear to have been originally constructed without embankments. At some unknown time, a waste rock spoil was constructed to the south of Cell 1, and tailings appear to have been subsequently deposited using the waste rock spoil as an embankment.

1.4 Background Information and History

The Beaverdell Mine was an underground mine development. The main ore extracted was silver, with appreciable quantities of lead, zinc, gold, and cadmium. Records (BCGS 2018) indicate that mining commenced in the Beaverdell area in the late 1800s and milling ceased in 1991. Ore production records are available from 1913 to 1991 and indicate approximately 1.2 million tonnes of ore were mined and milled. Based on an estimated volume of tailings of 930,000 m^3, calculated using data from the 2018 CPT investigation (Golder 2019), the average dry density of deposited tailings is approximately 1.3 t/m^3.

A summary of the early history of the facilities, paraphrased from Verzosa and Goetting (1972), is provided in the paragraph below.

Available records indicated ongoing exploration activities in the Beaverdell area as early as 1898 by various companies, each exploring individual veins or vein systems. The first shipment of ore from the development was directed to the Hall Mines smelter at Nelson, BC, in 1900. In 1936, the Bell and the Highland Lass mines merged to form Highland Bell Limited, which soon added the Beaverdell mines to its holdings. Leith Gold Mines Limited acquired a controlling interest in Highland Bell Limited and the Sally mine property in 1946. This company continued shipping ore to the smelter at Trail, BC, and undertook an exploration and development program that led to new ore discoveries and the decision to build a mill at Beaverdell. The mill was inaugurated in the 1950s, with an initial capacity of 50 tons per day that was later increased to 85 tons per day in 1964 and 110 tons per day in 1967. The mill was located to the west of the community of Beaverdell, across the West Kettle River.

The Beaverdell Mine was acquired by Teck Corporation Limited in 1969 or 1970, and continued production until 1991, when the mining development was permanently closed (Teck 2012). The Beaverdell Mine is now a closed facility under active care and maintenance, with no current or planned mining activities. The primary remaining facilities include the TSFs west of Beaverdell and waste rock dumps and mine openings on Mount Wallace to the east of Beaverdell. Teck is evaluating options for long-term management of the mine site and TSFs with an end goal of minimizing the risks associated with these facilities.

1.4.1 Site Investigations

Known site investigations for each cell include the following:

- Cell 1: five CPTs completed in tailings in 2018 (Golder 2019)
- Cell 2: three CPTs completed in tailings in 2018 (Golder 2019)
- Cell 3: four CPTs completed in tailings in 2018 (Golder 2019)
- Cell 4
  - samples taken from existing dam for gradation testing (Binnie 1971)
  - eight CPTs completed in tailings in 2018 (Golder 2019)
- Cell 5
  - surface and subsurface soil samples for gradation testing (Binnie 1973)
  - six CPTs completed in tailings in 2018 (Golder 2019)
- Cell 6
  - surface soil samples for gradation testing (Binnie 1980a)
  - six CPTs completed in tailings in 2018 (Golder 2019)
- Cell 7
  - three test pits, samples taken for gradation testing (Binnie 1988)
  - five CPTs completed in tailings in 2018 (Golder 2019)

In addition, nine groundwater monitoring wells, outside of the North and South TSFs, were completed by Wood in 2018.

Additional details on investigations carried out in 2018 are presented in Section 2.0.

1.4.2 Original Design Dimensions

1.4.2.1 South Tailings Storage Facility Dam

A summary of the original design and references for the South TSF dam are shown in Table 5. Original design / assumed cross-sections are provided in Appendix C. There are no design reports for Cells 1 to 4 hence, the original design dimensions of these cells are unknown.

Table 5: Original Design Dam Geometry for Cells in the South Tailings Storage Facility

Cell	Downstream Slopes	Upstream Slopes	Crest Width (m)	Embankment Height (m)	References	Figure
Cell 1	no known design					
Cell 2						
Cell 3						
Cell 4[(a)]	2H:1V	1.5H:1V (if drawn to scale)	3.2 to 5.1	3.8 to 4.6	Binnie 1971, 1973	Figure C-1
Cell 5	2H:1V	1.5H:1V	5.1	7	Binnie 1973, 1980c	Figure C-2

(a) Geometry based on observations and discussions with mine management (Binnie 1971, 1973).

1.4.2.2 North Tailings Storage Facility Dam

A summary of the original design and references for the North TSF dam are shown in Table 6. Original design cross-sections are provided in Appendix C.

Table 6: Original Design Dam Geometry for Cells in the North Tailings Storage Facility

Cell	Downstream Slopes	Upstream Slopes	Crest Width (m)	Embankment Height (m)	References	Figure
Cell 6	2H:1V	1.5H:1V	4	9.5	Binnie 1980a	Figure C-3
Cell 7	2H:1V	1.5H:1V	4	8	Binnie 1988	Figure C-4

1.4.3 Construction Summary

Initial construction of the South TSF was, presumably, concurrent with the opening of the Beaverdell mill in the 1950s. At the time, the site was owned by Highland Bell Limited and Leith Gold Mines Limited.

The South and North TSFs are understood to have been constructed as earthfill dams using a downstream construction technique.

1.4.3.1 South Tailings Storage Facility

No construction records are available for Cells 1 to 5.

Binnie (1971) indicates that Cell 4 experienced tailings migration through the dam section during the winter of 1970 / 1971. In response to this event, coarse rock was placed on the downstream slope of a section of the Cell 4 dam and operations were changed to spigotted deposition to deposit coarse tailings against the upstream slope and push the slimes toward the centre of the facility (Binnie 1971). The tailings against the upstream face were found to contain less fines than the unsegregated tailings, which confirmed a wedge of coarse tailings was being successfully developed to act as a filter. The remedial measures directed in Binnie (1971) were determined to have been successful (Binnie 1973).

Cell 5 was constructed after Teck Corporation Limited obtained the property and was designed by Binnie (1973). Construction of Cell 5 consisted of excavation of the centre of the cell area to source material for construction of the dam.

Available records indicate that design reports for Cell 5 required that operations create a wedge of coarse tailings against the upstream slope of the TSF dams to act as a filter for the slimes. Samples of the tailings were taken once deposited to confirm the coarse tailings wedge (beach) was being created and spigotting methods were observed (Binnie 1980a). Results of the 2018 CPT investigation (Golder 2019) also indicate that material is coarser near the upstream face of the Cell 4 and 5 dam.

1.4.3.2 North Tailings Storage Facility

Cells 6 and 7 of the North TSF were constructed after Teck Corporation Limited obtained the property and were designed by Binnie (1980a,b, 1988). Construction of Cells 6 and 7 consisted of excavation of the centre of the cell area to source material for construction of the dam.

Design reports for Cells 6 and 7 specified that operations create a wedge of coarse tailings against the upstream slope of the TSF dam to act as a filter for the slimes. Samples of the tailings were taken to confirm the coarse tailings wedge (beach) was being created and spigotting methods were observed (Binnie 1983, 1988). Results of the 2018 CPT investigation (Golder 2019) also indicate that material is coarser near the upstream face of the North TSF dam.

Cell 7 of the North TSF is only partially filled with tailings.

1.4.3.3 Historical Piezometers

There are 13 documented standpipe piezometers around Cells 5, 6, and 7 (Binnie 1973, 1983, 1988) that are assumed to have been monitored during operations. Of the 13 piezometers, 9 were located in 2016 by Teck (Golder 2017b). The piezometers that were located and measured were all dry. Piezometer 7-2 exceeded the length of the water level reader; therefore, it is unknown whether the piezometer is dry below this depth.

The installation details of the piezometers are unknown, and the condition and usefulness of the piezometers are uncertain. As a result, these piezometers are considered non-functional. Installation of vibrating wire piezometers and standpipes is proposed as part of site investigations in 2019.

2.0 ACTIVITIES DURING 2018

2.1 Tailings Deposition

The Beaverdell Mine was not operating in 2018 and no new tailings were sent to either the North TSF or South TSF.

2.2 Inspections

The inspection by the EoR, as part of the DSI, was conducted 14 June 2018.

The dams are inspected biannually (during spring freshet and in the fall) by Teck personnel. The inspection forms were reviewed by the EoR.

Between 9 and 10 May 2018, a high water level event occurred in the WKR near the Beaverdell TSFs. The site caretaker, Tex Hewitt, and TSF Qualified Person, Gerry Murdoch, completed seven inspections between 7 and 18 May. Teck reported that the river level reached a maximum level at approximately the elevation of the top of the 2015 / 2016 riprap (Golder 2018d). There was erosion of the historical riprap (installed prior to 2015 and adjacent to Cell 4) and riverbank material at the toe of Cells 4 and 5. Though water ponded at the toe of the dam, there was no observed erosion of the dam fill (Golder 2018d).

An inspection of the facility was also completed by Teck with the Teck Legacy Independent Tailings Review Board, accompanied by the EoR, John Cunning, on 11 June 2018.

2.3 Water Quality Testing

Water quality sampling and analyses in the WKR (upstream and downstream of the TSF) were completed quarterly during the reporting period in 2017 / 2018.

2.4 Construction for Cell 3 Spillway

The detailed design of a Cell 3 spillway was completed in March 2018 (Golder 2018b) with the aim of conveying the required inflow design flood (IDF) to meet or exceed the requirements of the HSRC (Ministry of Energy and Mines 2017) with allowance for freeboard. Following review of the spillway design with the Teck Legacy Independent Tailings Review Board, Teck requested Golder prepare a revised design and construction drawing for the Cell 3 spillway to pass the flood volume from a 24-hour probable maximum flood (PMF) event as the IDF, which exceeds the requirements of HSRC (Golder 2018e). Spillway construction took place in August 2018 with the as-built survey completed in October 2018.

The riprap installed was Class 50 kg standard (MOT 2013) with an average D_{50} of 330 mm. This riprap sizing was selected to prevent erosion from flow rates associated with a 24-hour PMF, which exceeds the required IDF for the South TSF, based on consequence classification.

The condition of the Cell 3 spillway at the time of the DSI visit (before upgrade) is shown in Photographs 23 and 24 (Appendix A). The condition of the spillway in August 2018 is shown in Photographs 25 and 26 (Appendix A).

As-built conditions of the constructed Cell 3 spillway were reviewed by the EoR. Based on the as-constructed conditions, additional thickness of riprap has been placed at the spillway invert compared to design. The Cell 3 spillway can convey the IDF associated with a "Significant" consequence classification as required by the HSRC. Freeboard during an IDF would be 0.1 m, which is less than required by the Canadian Dam Association (CDA 2013), and additional works are required in 2019 to lower the invert.

2.5 Cone Penetration Testing Investigation

Golder completed a CPT program between 30 July and 4 August 2018 for the deposited tailings in both the North and South TSF. The purpose of this investigation was to collect in situ geotechnical data.

Initial findings were reported in Golder (2019) and have been incorporated into this DSI report.

2.6 Monitoring Well Installation

Nine groundwater monitoring wells were installed in July 2018 by Wood. These locations are shown in Figure 3. Geotechnical logs of these wells were not available for review at the time of this document, but recovered core left at site was viewed by Golder on 30 July 2018.

3.0 CLIMATE DATA AND WATER BALANCE

3.1 Review and Summary of Climate Data

The review of climate characteristics at the Beaverdell Mine is focused on total precipitation, since this variable constitutes the main driver for the Beaverdell annual water balance. The water year is based on October to September the following year, which is October 2017 through September 2018 for this reporting period.

The most representative climate station for the Beaverdell Mine was the Beaverdell North climate station, which operated from 1975 to 2006. The stations that are currently active in the region and were selected as representative of the Beaverdell site include Billings (Station ID 1140876) and Penticton (Station ID 1126150 / 1126146) (data from ECCC 2018). Data from three regional stations representing Kelowna airport were previously compiled and included in the Beaverdell climate data analyses. However, data from Kelowna airport stations were excluded from this analysis due to there being no continuous data for the reporting period.

The Billings and Penticton stations are in a region that encompasses Beaverdell Mine. The Billings station provides a baseline to the southeast of the site with greater annual total precipitation than Beaverdell. Penticton is located to the west of site and has less annual total precipitation than Beaverdell. Table 7 shows the long-term statistics for total precipitation obtained from monthly records at the active stations, as well available records from the Beaverdell North climate station (ECCC 2018). Long-term statistics of total precipitation at Beaverdell North are within the range of those at the active stations in the region (i.e., Billings and Penticton).

Table 7: Total Precipitation Long-Term Statistics

Location	Period of Record	Station Number	Latitude; Longitude	Elevation[d] (m)	Distance to TSF (km)	Minimum (mm)	Average (mm)	Maximum (mm)
Beaverdell North[a]	1975 to 2006	1130771	49°28'; 119°02'	838	11	346.0	475.1	614.9
Billings[b]	1984 to 2018	1140876	49°01'; 118°13'	519	90	393.0	524.0	631.9
Penticton A[c]	1944 to 2018	1126150 / 1126146	49°27'; 119°36'	344	37	197.3	320.6	470.5

(a) Beaverdell data are from Beaverdell North climate station. Years excluded from statistics due to incomplete data are 1975, 1981, 1983, 1984, 1987, 2002, and 2004 to 2006.

(b) Years excluded from the Billings statistics due to incomplete data are 1984, 1989, 1996, 1997, and 2007 to 2018.

(c) Data are from two Penticton A climate stations. Once operating and one historical. Years excluded from the Penticton statistics include 1941, 2007, 2012, 2013, and 2018.

(d) Elevation in CGVD1928 to nearest 1 m.

TSF = tailings storage facility.

Table 8 shows the total precipitation for the period from October 2017 through September 2018 at the active regional stations. The operating Penticton A station has a nearly complete record of observation for total precipitation during this period (three days of data missing). However, gaps were seen in the data at Billings (73 days of missing data). For analysis, the Billings months with more than five days missing or more than three consecutive days missing were excluded. The monthly total precipitation for the remaining months at Billings were then compared to the average monthly total precipitation for those months (i.e., February, March, May, June, August, and November).

Table 8: Total Recorded Precipitation from October 2017 through September 2018 at Active Stations

Location	Days with Observations	Total Recorded (mm)
Billings	292	475[(a)]
Penticton A	362	411

(a) Data Reported Only for February, March, May, June, August, and November.

The recorded total precipitation at Billings for the assessed months was 13% above the long-term average (316.1 mm compared to 279.4 mm). The recorded total precipitation at Penticton A for the period of October 2017 through September 2018 was 28% above the long-term annual average (410.9 mm compared to 320.6 mm). For both stations the time period associated with higher than average precipitation was November 2017 to March 2018 (Table 9). The summer months (June, July and August) were below long-term average total precipitation for the two stations analyzed.

Table 9: Difference Between the October 2017 to September 2018 Recorded Monthly Total Precipitation (mm) and the Average Long-Term Monthly Total Precipitation (mm) at Regional Stations

Station		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Billings	2017 / 2018	NA[(a)]	60.4	NA[(a)]	NA[(a)]	56.2	70.3	NA[(a)]	67.6	56.6	NA[(a)]	5	NA[(a)]
	average	39.8	56.0	58.7	48.3	34.8	42.7	44.8	62.0	61.7	34.3	22.1	31.6
	difference	NA[(a)]	8%	NA[(a)]	NA[(a)]	61%	65%	NA[(a)]	+9%	-8%	NA[(a)]	-77%	NA[(a)]
Penticton A	2017 / 2018	14.2	46.1	57.6	43.1	31.9	70.4	47.2	30.4	34.8	6	2.4	26.8
	average[(b)]	23.4	27.3	30.6	29.6	21.6	21.4	25.3	34.0	39.1	24.7	25.0	21.6
	difference	-39%	69%	88%	46%	47%	229%	86%	-11%	-11%	-76%	-90%	24%
Average Monthly Difference		**-39%**	**38%**	**88%**	**46%**	**55%**	**149%**	**86%**	**-1%**	**-10%**	**-76%**	**-84%**	**24%**

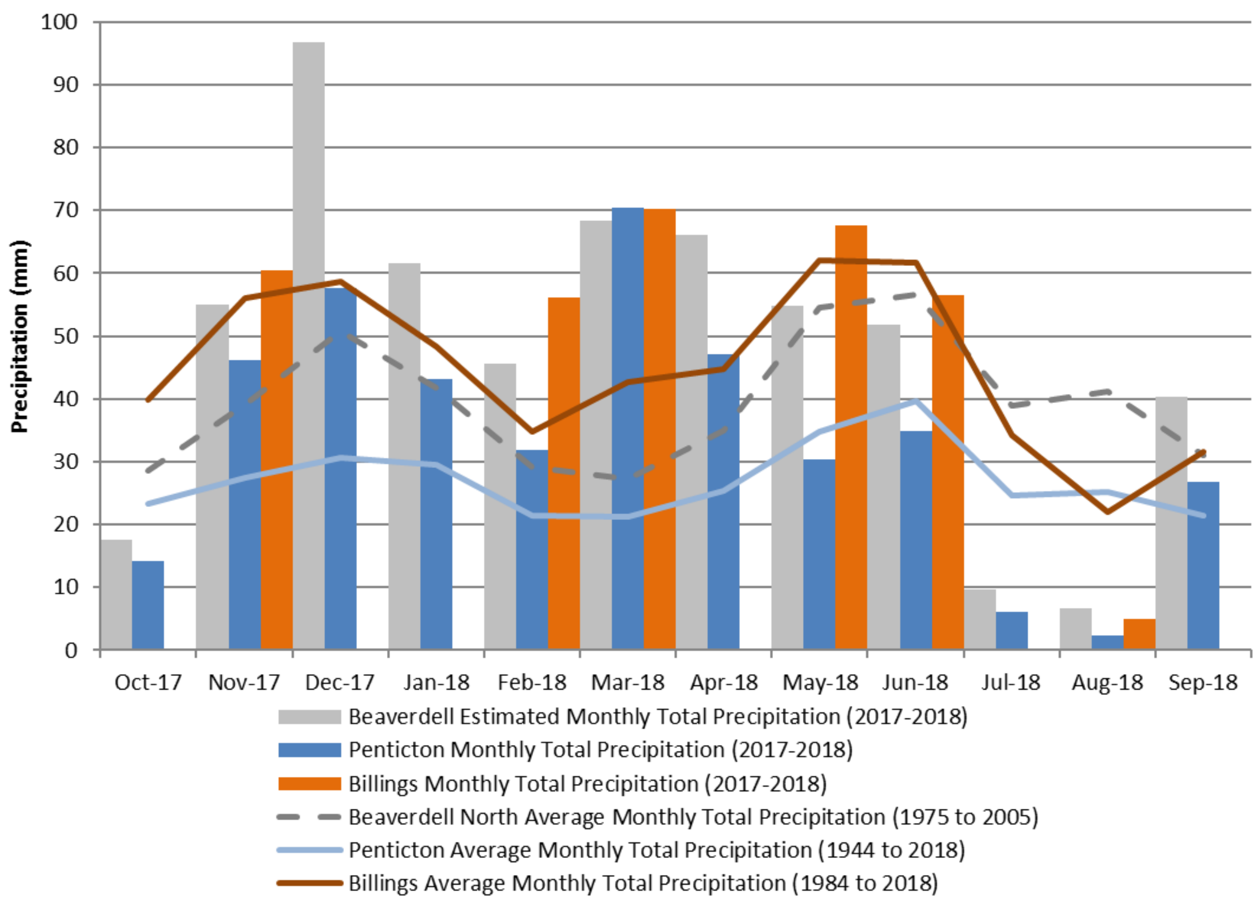
(a) Not available (NA) - Month with incomplete data.

(b) Average data from two Penticton A climate stations. Years excluded from the Penticton statistics include 1941, 2007, 2012, 2013.

The long-term monthly total precipitation at Beaverdell has been estimated by scaling the long-term monthly precipitation at Beaverdell North with the average monthly differences from the regional stations presented in Table 9. This equates to an estimated total precipitation of 574 mm at Beaverdell over the 12-month period, or 21% over average annual precipitation. This value was used for the North and South TSF water balances in Section 3.2.

Monthly total precipitation from October 2017 through September 2018, at Beaverdell (estimated) Billings, and Penticton are presented in Illustration 1. Trendlines of long-term monthly total precipitation for these stations are also presented in Illustration 1. Conclusions regarding precipitation at Beaverdell are summarized as follows:

- Total precipitation at Beaverdell from November 2017 to May 2018 would likely have been above average. The precipitation during this period would be predominantly snow, leading to a larger snowpack than in average years. The total precipitation that fell in April would likely have been a mix of snow and rain. Based on the historical Beaverdell snowfall, half of the total precipitation that falls in April is rain, leading to combined rain and snowmelt events.
- Total precipitation at Beaverdell over October 2017 and the period of June, July, and August of 2018 would likely have been below average.



Note: Billings data are only shown for the months of November, February, March, May, June, and August due to data gaps.

Illustration 1: Monthly Total Precipitation Long-Term Statistics and Recorded October 2017 to September 2018

3.2 Review and Summary of Water Balance

The water balances for the South and North TSFs were based on the watershed areas of each facility, summarized in Table 10. The total watershed of the South TSF area is limited by the South TSF dam and Beaverdell Station Road (ditches divert runoff from Cranberry Ridge away from the TSF). The total watershed of the North TSF is limited to the areas of Cells 6 and 7 (ditches to the west of the North TSF, including the emergency spillway, divert runoff from Cranberry Ridge away from the TSF).

Table 10: North and South Tailings Storage Facility Watershed Areas

TSF	Cell	Cell Drainage Area (km^2)	TSF Drainage Area (km^2)
South TSF	1	0.017	0.158
	2	0.015	
	3	0.079	
	4	0.023	
	5	0.024	
North TSF	6	0.027	0.062
	7	0.035	

Source: Golder 2017a.

TSF = tailings storage facility.

The water balance inflow is limited to the surface water contribution from precipitation. It is assumed that all inflows to the TSF exit the TSF and there is no long-term accumulation of water in the cells. The inflow volumes were calculated by multiplying the total precipitation by the watershed areas, without accounting for losses (e.g., evaporation). Using the estimated precipitation at Beaverdell for the water year as discussed in Section 3.1, the inflow volumes equate to the following:

- a total inflow volume of 108,000 m^3 for the South TSF area
- a total inflow volume of 46,600 m^3 for the North TSF area

No surface discharge or seepage from the TSFs through the dam has been observed. The outflows from the TSFs are therefore assumed to be from the following processes:

- **Evaporation**—Loss of water to the atmosphere occurs from temporary water ponding and from near-surface soil.
- **Transpiration**—A vegetation cover is partially present on the tailings surface and on the slopes of the dams. This cover traps water that is then released to the atmosphere in the form of transpiration.

- **Infiltration to ground**—Surface water drains through the tailings deposits and infiltrates the underlying ground.
- **Sublimation**—A fraction of the snow cover on the TSFs during the winter is lost to the atmosphere through sublimation (the transition from solid to water vapour).

There is no surface water accumulation at the TSFs (i.e., no storage of surface water). All precipitation inflows are conveyed out of the TSFs through the outflow processes, as discussed above. The distribution of inflows to outflows was not assessed. It is assumed that sublimation is negligible, and therefore all outflows are in the form of evaporation, transpiration, and infiltration to ground.

3.3 Freeboard and Storage

Freeboard is not measured directly at the Beaverdell TSFs as the tailings surface is generally dry. Surface water conditions are recorded during regular inspections through estimating the distance from the upstream crest of the dam to any ponding, if observed.

A trigger action response plan and related quantitative performance objectives (QPOs) for surface water conditions at the Beaverdell TSFs were developed and are summarized in Table 11.

Table 11: Trigger Action Response Plan for Surface Water Conditions for Beaverdell Tailings Storage Facilities

Item	Threshold Criteria		
	Acceptable	Warning	Alarm
QPO of ponding within the cell	Small central pond, edge of pond is located more than 10 m from upstream crest	Edge of pond is less than 10 m but greater than 2 m from upstream crest	Edge of pond is within 2 m of upstream crest OR discharging through Cell 3 or Cell 7 spillways
Action required	▪ Document during biannual (twice per year) inspections. ▪ This is normal operations.	▪ Increase frequency of inspections to weekly until conditions meet acceptable. ▪ Document weekly inspections.	▪ Increase frequency of inspections to daily. ▪ Sample downstream water quality. ▪ Document daily inspections.
Personnel notified	▪ Record and file with inspection reports. ▪ EoR receives a copy of the inspections annually.	▪ Gerry Murdoch (TSF Qualified Person) ▪ Kathleen Willman (Mine Manager) ▪ EoR	▪ EMPR ▪ Gerry Murdoch (TSF Qualified Person) ▪ Kathleen Willman (Mine Manager) ▪ Teck's Tailings Working Group ▪ EoR ▪ Communities of Interest

Notes:

The upstream crest is defined as location where the tailings beach intersects the cell crest.

Distances can be measured with tape measure or distance wheel.

EMPR = British Columbia Ministry of Energy, Mines and Petroleum Resources; EoR = Engineer of Record; QPO = quantitative performance objective.

Ponding conditions as noted from inspections and observations in 2018 are summarized in Table 12.

Table 12: Summary of Ponding Observations in Tailings Storage Facilities

Facility	Cell	16 May 2018	14 June 2018	30 July 2018[(a)]	27 November 2018
South TSF	1	no pond	no pond	no pond	no pond
	2	no pond	no pond	no pond	no pond
	3	no pond	no pond	no pond	no pond
	4	pond, estimate >10 m from dam crest	pond, estimate >10 m from dam crest	no pond	no pond
	5	pond, estimate >10 m from dam crest	no pond	no pond	no pond
North TSF	6	pond, estimate >10 m from dam crest	pond, estimate >10 m from dam crest	no pond	no pond
	7	no pond	no pond	no pond	no pond

(a) Observations during Golder CPT investigation.

CPT = cone penetration test; n/a = not applicable; TSF = tailings storage facility.

3.4 Water Discharge Volumes

There are no records of water discharge volumes for the facilities. No water was observed discharging from the North TSF or South TSF spillways at the time of the site inspections. Losses in the water balance are assumed to occur through evaporation, evapotranspiration, and infiltration.

3.5 Water Discharge Quality

Water quality testing results are submitted to the British Columbia Ministry of Environment in accordance with Water Licence No. PE-444 (MOE 1990).

4.0 SITE OBSERVATIONS

4.1 Visual Observations

A site inspection was carried out on 14 June 2018 by John Cunning, P.Eng., and Martyn Willan, P.Eng., of Golder, accompanied by Gerry Murdoch of Teck.

The temperature during the visit was between approximately 10°C, and the weather was overcast.

Appendix A presents a summary of photographs from the site inspection.

4.2 High Water Levels in West Kettle River

As part of the response to forecasted high flows in the WKR, Teck initiated daily inspections of the TSFs starting 6 May 2018. The highest 2018 flow occurred between 9 and 10 May and was estimated to be 204 m^3/s, based on a catchment area transfer method calculation using data recorded at hydrotechnical stations at Carmi (8 km upstream of Beaverdell) and Westbridge (40 km downstream of Beaverdell). This flow was estimated by Golder to represent a flood with a return period of between 1-in-200 years and 1-in-500-years. Riverbank material and sections of the historical riprap were eroded during the event; however, no erosion of the downstream slopes of the dams was observed. Teck reported that the river reached a maximum level equal to the approximate top elevation of the riprap protection below the Cell 4 and 5 dams. A large tree along with its root mat was observed in the river adjacent to the downstream toe of Cell 5. This tree was removed on 10 October 2018. Riverbank material has been almost fully eroded adjacent to Cell 5, and riprap installed in 2015 and 2016 is exposed in this location.

During the May inspections, it was observed that riprap armouring had been placed on the south riverbank of the WKR in the area upstream of Cell 4 and 5, as shown in Figure 3. The WKR was flowing near the height of this riprap and, on 16 May 2018, the WKR was observed to be flowing over an area of the south riverbank just downstream of the length of riprap and some flow from the river was reporting to the floodplain area east of the main WKR channel opposite to Cell 5. This resulted in a slight reduction of the WKR flows acting against the downstream toe area of the South TSF.

Work to assess WKR flows and consider options for erosion protection measures along the downstream toe of the South TSF was ongoing at the time this report was prepared.

4.3 Instrument Review

There is currently no functional geotechnical instrumentation installed at the Beaverdell TSFs. QPOs have been established for ponding in the cells, as described in Section 3.3. Ponded water was observed in Cells 4, 5, and 6 during the May 2018 Teck inspection, and in Cells 4 and 6 during the June 2018 DSI site inspection. These ponds were within the acceptable range of the site QPOs. Ponds were observed to be dry at the start of the CPT investigation program on 30 July 2018 and during the fall routine inspection on 27 November 2018.

New piezometers are planned to be installed in 2019 to confirm the phreatic conditions, support closure planning, and provide information relevant to the inundation assessment.

4.4 Pond and Discharge Water Quality

There was no observed surface pond discharge from the Beaverdell TSFs in 2018 based on site inspections and observations. Water quality is discussed in Section 3.5.

4.5 Site Inspection Forms

A summary of the observations is included in the Golder inspection report for each TSF in Appendix B.

5.0 DAM SAFETY ASSESSMENT

5.1 Dam Classification Review

The North and South TSF dams are considered dams, and prevent the uncontrolled release of tailings, based on the definition in the HSRC (Ministry of Energy and Mines 2017), as follows:

- "Dam" means a barrier on the surface preventing uncontrolled release of either water, slurry or solids or a barrier underground to prevent the uncontrolled flow of water, slurry or solids.

Guidelines for the classification of dams are presented in the HSRC Guidance Document, Section 3.4 (Ministry of Energy and Mines 2016), which references the CDA (2013) *Dam Safety Guidelines*. Table 13 presents the dam classification criteria. Dam consequence classification is based on incremental losses that a failure of the dam may inflict on downstream or upstream areas, or at the dam location itself irrespective of the potential for such an event to occur. Incremental losses are those over and above losses that might have occurred in the same natural event or condition had the dam not failed. The consequences of a dam failure are ranked as Low, Significant, High, Very High, or Extreme for each of four loss categories. The classification assigned to a dam is the highest rank determined among the four loss categories.

Table 13: Dam Classification in Terms of Consequences of Failure

Dam Class	Population at Risk	Incremental Losses		
		Loss of Life	Environmental and Cultural Values	Infrastructure and Economics
Low	None.	0	Minimal short term loss. No long term loss.	Low economic losses; area contains limited infrastructure or service.
Significant	Temporary only (e.g., seasonal cottage use, passing through on transportation routes, participating in recreation activities).	The appropriate level of safety required depends on the number of people, the exposure time, the nature of their activities, and other considerations.	No significant loss or deterioration of fish or wildlife habitat. Loss of marginal habitat only. Restoration or compensation in kind highly possible.	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes.
High	Permanent– ordinarily located in the dam-breach inundation zone (e.g., as permanent residents).	10 or fewer	Significant loss or deterioration of important fish or wildlife habitat. Restoration or compensation in kind highly possible.	High economic losses affecting infrastructure, public transport, and commercial facilities.
Very High	Permanent– ordinarily located in the dam-breach inundation zone (e.g., as permanent residents).	100 or fewer	Significant loss or deterioration of critical fish or wildlife habitat. Restoration or compensation in kind possible but impractical.	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances).
Extreme	Permanent – ordinarily located in the dam-breach inundation zone (e.g., as permanent residents).	More than 100	Major loss of critical fish or wildlife habitat. Restoration or compensation in kind impossible.	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances).

Source: HSRC Guidance Document (Ministry of Energy and Mines 2016).

The HSRC Guidance Document and the CDA guidelines were used to assign a dam class to the Beaverdell TSF dams based on conditions during the 2017 / 2018 monitoring period (Table 14).

Table 14: Dam Failure Consequence Classification for the South and North Tailings Storage Facilities

Dam	Dam Class	Population at Risk	Consequences of Failure		
			Loss of Life	Environment and Cultural Values	Infrastructure and Economics
South TSF dam	**Significant**	Significant	Low	Low to Significant	Low
North TSF dam	**Significant**	Significant	Low	Low	Low

Note: The class assigned to a dam is the highest rank determined among the four attributes (i.e., population at risk, loss of life, environmental and cultural values, and infrastructure and economics).
TSF = tailings storage facility.

The rationale for assigning the consequence level for each attribute of the South TSF is as follows:

- **Population at risk (Significant consequence)**—No permanent dwellings have been observed near the dam structures. However, recreational facilities (i.e., trails and a baseball field) are located near these structures and may be sporadically used by the residents of Beaverdell. A sporadic human presence qualifies as a temporary population.
- **Loss of life (Low consequence)**—The extent of the area impacted by a dam failure is expected to be very small. Loss of life, if any, would be the result of unforeseen misadventures.
- **Environmental and cultural values (Low to Significant consequence)**—A report by Fisheries and Oceans Canada has designated a 2.4 km section of the WKR, including a section of river adjacent to the South TSF as critical habitat for the Speckled Dace (DFO 2018), which has the potential to change the consequence classification for incremental environmental and cultural losses. However, the extent of the area impacted and the impacts on Speckled Dace populations by a dam failure are unknown, and further studies are required to determine these factors.
- **Infrastructure and economics (Low consequence)**—Economic losses are expected to be limited to the owner of the South TSF (i.e., Teck).

The rationale for assigning the consequence level for each attribute for the North TSF area is as follows:

- **Population at risk (Significant consequence)**—One permanent dwelling is located approximately 150 m south of a portion of the Cell 7 dam. The limited volume of tailings in the cell is, however, not considered a risk to the dwelling or the residents. A temporary population should be considered as present near the North TSF.
- **Loss of life (Low consequence)**—The extent of the area impacted by a dam failure is expected to be small. Loss of life, if any, would be the result of unforeseen misadventures.

- **Environmental and cultural values (Low consequence)**—Tailings from the North TSF are not expected to reach the WKR in the event of a failure. As such, no long-term loss or deterioration of valued components is expected. Short-term loss or deterioration of valued components is expected to be negligible.
- **Infrastructure and economics (Low consequence)**—Economic losses are expected to be limited to the owner of the North TSF (i.e., Teck).

Golder recommends a review of the dam consequence classification of the South TSF based on the changes in downstream conditions noted in this DSI as per Golder (2018g).

The CDA (2014) *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams* describes the following phases of a mining dam:

- site selection
- operation
- transition
- closure – active care
- closure – passive care

The closure – active care phase is often referred to as "care and maintenance." It involves the active care of a mining dam including monitoring, inspection, water management, operation of a water treatment system, etc. The mine owner will typically have staff monitoring the site regularly, and the dam should achieve a steady state condition during this phase.

Beaverdell is currently considered to be in closure – active care.

5.2 Review of Downstream and Upstream Conditions

Erosion protection has been installed in two areas along the WKR as shown in Figure 3. Riprap was installed within the right bank of the WKR adjacent to the South TSF in late 2015 and early 2016 (Golder 2016c). This armouring was placed to limit erosion of the right bank and downstream toe of the Cell 4 and 5 dams during high river flows. The left bank of the WKR, adjacent to Cells 4 and 5, was observed to have been armoured with riprap by a private land owner, as shown in Figure 3.

Following WKR flood events in both 2017 and 2018, the alignment and hydrological conditions of the WKR were observed to have changed significantly from those used to prepare the design for erosion protection measures. The revised river hydrology was assessed, and a new design for river armouring is in progress by Golder.

As noted in Section 5.1, a 2.4 km section of the WKR has been designated as critical habitat for Speckled Dace (Figure 3).

A detailed inundation study has not yet been completed for the Beaverdell TSFs; however, the 2018 CPT program provided initial details on the location of the phreatic surface at the time of CPT work. Data were also used to estimate the volume of tailings within each cell (Golder 2019).

As a result of these changes in downstream conditions, it is recommended that a study be carried out to detail the potential dam break and tailings inundation followed by a review of the environmental consequence classification of the South TSF.

Earthmoving equipment was observed in the land south of Cell 1 and south of the Teck property boundary and is assumed to be associated with residential development.

No changes to conditions upstream were observed.

5.3 Review of Potential Hazards and Failure Modes, Design Basis, and Dam Performance

A required component of the annual DSI is a review of the key potential hazards and the associated failure modes, design basis, and observed dam performance. The assessment of the Beaverdell TSFs was completed based on the site observations and data review for each of the hazards that are most relevant to the types of dams present at Beaverdell. The key potential hazards for the South and North TSFs are described in the following sections.

5.3.1 Internal Erosion (Suffusion and Piping)

Internal instability of a dam can be caused by materials migrating out of the dam, leaving voids. This happens with materials that do not have filter compatibility; that is, the fine-grained fraction of one material can migrate into or through the voids of the adjacent material under a sufficient hydraulic gradient. Piping is induced by regressive erosion of particles towards an outside environment until a continuous pipe is formed. Suffusion is the migration of soil particles through the soil matrix.

Design Basis and Design Assessment

Based on review of the available reports, as discussed in this report, it is understood that the dams were constructed of locally borrowed free-draining sand and gravel materials.

There are no known design or construction records for Cells 1, 2, 3, or 4. As described in Section 1.4.3.1, remedial measures were implemented under the direction of Binnie (1971) in response to observed tailings migration through a section of the Cell 4 dam during the winter of 1970 / 1971. Coarse rock was placed on the downstream slope of a section of the Cell 4 dam, and operations were changed to spigotted deposition to place coarse tailings against the upstream slope and push the slimes toward the centre of the facility, creating a wedge of coarse tailings to act as a filter. The design reports for Cells 5, 6, and 7 included a coarse tailings beach adjacent to the sand and gravel dams to act as a filter for the slimes. Filter compatibility between the coarse tailings and the sand and gravel dam section was defined graphically by multiplying the gradation of the coarse tailings by a factor of five (Binnie 1973).

The filter compatibility between the coarse tailings and the sand and gravel material of the dam was reassessed as part of the response to the Ministry of Energy and Mines order dated 3 February 2015 (Golder 2015a).

The reassessment found that the available gradations of sand and gravel understood to be used for the dams are generally filter compatible with the coarse tailings based on Sherard et al. (1984) and Sherard and Dunningan (1989); however, some gradations were found to not meet the criteria.

The internal stability of the filter was assessed based on the Li-Fannin criteria, an update to the original Kenney-Lau criteria (Kenney and Lau 1985; Li et al. 2009). The available gradations of sand and gravel understood to be used for the embankments of Cells 4, 5, and 6 generally met the updated Li-Fannin criteria, although two samples from Cell 6 were assessed as being marginal. Three of four samples from Cell 7 did not meet the criteria.

Observed Performance

The Beaverdell TSFs have been inactive for 27 years. Small, shallow ponds are occasionally present in Cell 4 and Cell 6. Only minor ponding was observed in these areas during the 16 May 2018 inspection (Golder 2018d) following an unusually high rainfall / runoff period.

Sites visits from 2012 through to 2018, including those used for this DSI, included a visual inspection of the toe of the North and South TSF dams. The inspection did not identify any seepage at the time of site visits, or any signs such as dampness, wetlands, or eroded zones that would be indicative of uncontrolled past seepage areas. Vegetation, including trees, is apparent on the downstream face and toe of the North and South TSF dams. However, water demand from that vegetation may assist in keeping the water table at a level that minimizes seepages (if any).

The decant pipes in the North TSF were sealed under the supervision of Teck, as noted in the 2013 DSI (Golder 2014b). The decant pipe in Cell 5 was sealed in 2016. It is unknown whether the pipes have seepage collars or similar structures to limit water flow adjacent to the pipe. It is possible that seepage flows may occur and thus piping could develop around the decant pipes. However, a sufficient hydraulic gradient is not expected to develop, as evidenced by the limited or non-existent ponds in the TSFs. No seepage at the Cell 6 or Cell 7 pipe outlets was noted during the June 2018 inspection.

No zones of subsidence or sinkholes were observed that would indicate voids due to either suffusion or piping.

The 2018 CPT investigation generally indicated unsaturated conditions with some limited zones of saturation in the tailings deposit. Data interpreted from CPT testing indicated low pore-water pressures within the inferred foundations which may be indicative of vertical drainage occurring from the tailings to the foundation materials. Observed saturated zones corresponded with observed ponding areas. Inferred conditions indicate typically insufficient hydraulic gradient to drive a potential piping failure.

Internal erosion is considered to be a rare[1] to very rare[2] likelihood event.

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[1] Rare likelihood: For a natural hazard (earthquake, flood, windstorm, etc.), the predicted return period for an event of this strength / magnitude is between 1 in 100 and 1,000 years. Also for failure modes such as instability and internal erosion that are rare.

[2] Very rare likelihood: For a natural hazard (earthquake, flood, windstorm, etc.), the predicted return period for an event of this strength / magnitude is between 1 in 1,000 and 10,000 years. Also for failure modes such as instability and internal erosion that are very rare.

5.3.2 Overtopping

Design Basis and Design Confirmation

Golder (2017a) presents a water management plan for the Beaverdell TSFs, which includes a summary of the site climate, a description of the water management for the TSFs, and a water balance. The HSRC Guidance Document (Ministry of Energy and Mines 2016) requires the facility to store:

- an IDF 1/3 between the 1-in-975-year flood event and the PMF with a duration of 72-hours for "Significant" consequence structures (North and South TSFs) in the passive-care phase of mine life

The available storage volume of the Beaverdell North TSF was compared to the 72-hour IDF of 1/3 between the 1-in-975-year event and the PMF (Golder 2017a). The estimated inflow design storm is defined as 142 mm of rain and snowmelt, which comprises a 72-hour event as required by the HSRC (Ministry of Energy and Mines 2017) for a facility that stores, rather than passes, the IDF. The North TSF can store the IDF without discharging through the Cell 7 spillway; therefore, the likelihood of overtopping for this facility is very rare[2].

The South TSF volume capacity was found to be insufficient to store the 72-hour IDF of 1/3 between the 1-in-975-year event and the PMF (Golder 2017a). The detailed design of an upgraded spillway was completed in March 2018 (Golder 2018b) with the aim of conveying the required IDF to meet or exceed the requirements of the HSRC (2017) with allowance for freeboard. Spillway construction took place in August 2018, with the as-built survey completed in October 2018. The likelihood of overtopping of the dams for this facility is very rare[2].

The minimum freeboard can be defined as the minimum vertical distance between the tailings pond level and the crest of the containing structure (CDA 2013). This distance needs to be maintained at all times (including during the IDF) to prevent overtopping of the containing structure by large waves resulting from the sum of wind, wave set-up, and wave run-up.

The North and South TSFs are dry with occasional, temporary ponding away from the dam crests. In the South TSF, the tailings are often beached to the same elevation as the crest. The North TSF generally has a vertical difference of at least 0.5 m between the top of tailings at the upstream dam crest. The North TSF can store 72-hour IDF (Golder 2017c) and has a spillway. As such, a minimum freeboard is not defined. The minimum freeboard for South TSF, based on Cell 3, is 0.3 m (Golder 2017c), although there is typically no water in the South TSF. Due to dry conditions, the freeboard is not measured directly; instead, the distance from the pond to the upstream edge of the dam is measured, as described in Section 3.3.

Observed Performance

Ponding was observed in Cells 4, 5, and 6, during the May 2018 inspection by the EoR (Golder 2018d). At the time of the DSI inspection in June 2018, ponding remained in Cells 4 and 6. There is no indication that surface water accumulation has reached the upstream face or crest of the dam. No ponding was observed at the start of the CPT investigation on 30 June 2018 or during the fall routine inspection on 27 November 2018.

5.3.3 Instability

Design Basis and Design Confirmation

The HSRC Guidance Document (Ministry of Energy and Mines 2016) recommends a minimum factor of safety of 1.5 under normal (static) operating conditions, and the CDA (2013) recommends a minimum factor of safety of 1.0 under pseudo-static seismic loading conditions. The HSRC Guidance Document recommends a return period for seismic events of:

- 1-in-2,475-year probability of annual exceedance for "Significant" consequence structures

Seismic information from the seismic hazard maps developed by Natural Resources Canada (NRC) was used to determine the peak horizontal ground acceleration for use in the stability reassessment. Earthquake ground motions calculated for the Beaverdell site (49.4423 north latitude and 119.0968 west longitude) from NRC (2015) are presented in Table 15. The 2015 seismic information is the most recent available from NRC.

Table 15: Peak Ground Acceleration by Return Period for the Beaverdell Site

Exceedance Probability	Return Period	Peak Ground Acceleration
40% in 50 years	100 years	0.0085 g
10% in 50 years	475 years	0.026 g
5% in 50 years	1,000 years	0.040 g
2% in 50 years	2,475 years	0.065 g

Note: Spectral and peak hazard values are determined for soil site Class C.

Return periods are not exact representations of annual exceedance probabilities; rounding per CDA is shown.

The HSRC (Ministry of Energy and Mines 2017) requires a return period 1-in-2,475-year for a seismic event for "Significant" consequence structures.

CDA = Canadian Dam Association; HSRC = Health, Safety and Reclamation Code.

A dam stability reassessment for the North and South TSFs was completed by Golder (2018a) in accordance with the HSRC Guidance Document (Ministry of Energy and Mines 2016), based on both facilities being "Significant" consequence structures. The 1-in-2,475-year earthquake event was selected (2% probability of exceedance in 50 years) for long-term stability analyses under pseudo-static seismic loading conditions as recommended by the HSRC Guidance Document. The reassessment found that the facilities are stable under static and pseudo-static conditions, and no analyses were required for post-earthquake conditions. Data made available by Wood, from the installation of groundwater wells in 2018 (Section 1.3.3) indicated groundwater levels at similar levels or below those adopted in the 2018 dam stability reassessment (Golder 2018a). As such, factors of safety are expected to be similar.

The 2018 CPT investigation indicates that the material within the TSFs is generally unsaturated, with low pore-water pressures within the inferred foundations. New piezometers are planned to be installed in 2019 to confirm the phreatic conditions, support closure planning, and provide information relevant to the inundation assessment. Piezometric levels in the tailings were similar to those adopted in the 2018 dam stability reassessment (Golder 2018a). As such, factors of safety are expected to be similar.

The HSRC requires justification for overall downstream dam slopes that are steeper than 2H:1V (Ministry of Energy and Mines 2017). The dam slopes range from 1.2H:1V to 4.0H:1V. Based on the current stability results, the dams are stable under static and pseudo-static conditions (Golder 2018a). Inspections from 2012 through 2018 have indicated that the slopes are performing adequately at a steeper slope angle than 2H:1V.

Observed Performance

The visual inspection during the June 2018 site visit did not identify any sign of stresses such as cracks, settling, or bulges on the North and South TSF dams. The trees on the downstream slopes are straight and do not indicate there has been any long-term or recent slope movement.

Minor erosion on the downstream slope of Cell 6 was noted (Photograph 36, Appendix A), but is limited by the armouring of the downstream slope face and is not considered to put the facility at risk of instability.

Some mature trees were observed on the crest of the Cell 3 dam (Photograph 30, Appendix A). These trees could cause a reduction in freeboard if felled by high winds. Golder recommended that these be removed as part of preliminary recommendations following the DSI visit, and this was reported by Teck to have been completed in Q1 2019.

No significant erosion was noted on the upstream or downstream slopes of either facility. The conditions of the dams have remained unchanged from previous site visits (Golder 2013, 2014b,c, 2016a, 2017b, 2018c). No seepage was observed during the site visit. The dam slopes appear to be stable.

5.3.4 River Erosion Protection

Erosion of the dam fill due to flooding / high velocities of the WKR could cause dam instability.

Design Basis and Design Confirmation

Erosion protection was designed for the right bank of the WKR, adjacent the South TSF, and installed between 2015 and 2016. The erosion protection comprises a trench of buried riprap that will “self-launch” to protect the South TSF in the event that the natural ground between the riprap and river is eroded.

The erosion protection was designed for a peak flow resulting from an event 1/3 between the 1-in-975-year flood and the PMF (Golder 2015b). This meets the design criteria in the HSRC Guidance Document (Ministry of Energy and Mines 2016) for a minimum IDF 1/3 between the 1-in-975-year and PMF.

Observed Performance

Erosion protection was constructed within the right bank of the WKR, adjacent the South TSF, in late 2015 and early 2016 (Golder 2016c). Between 9 and 10 May 2018, a high-water level event occurred in the WKR near the Beaverdell TSFs. This event is described in Section 4.2.

Following this event, the river geomorphology was observed to have significantly varied, and the assumptions and parameters adopted in the 2015 / 2016 riprap design may no longer be valid. Erosion of the downstream toe of Cell 4 and 5 dams represents an ongoing risk to dam safety.

Work is in progress at the time of this report to design new erosion protection measures along the toe of the South TSF based on changes in river geomorphology that occurred as a result of high flows in the WKR in 2018. Short-term mitigation measures include the placement of riprap stockpiles in Q1 2019 to protect against possible high river flows in the 2019 freshet, and the development of a flood management plan.

5.4 Review of Operational Documents

5.4.1 Operation, Maintenance, and Surveillance Manual Review

An operation, maintenance, and surveillance (OMS) manual for the TSF was originally developed in 2014 (Golder 2014a) and most recently updated in February 2018 (SP&P BEA-OMS-001.V002; Teck 2018a). The OMS manual meets the guidelines provided by the HSRC (Ministry of Energy and Mines 2016), the CDA (2013), the Mining Association of Canada (MAC 2011), and Teck (2014).

5.4.2 Emergency Preparedness and Response Review

The Emergency Preparedness and Response Plan (EPRP) was originally contained in the same document as the OMS manual (Golder 2014a). The EPRP was subsequently developed into its own document with the most recent update completed in February 2018 (SP&P BEA-EPRP-001.V002; Teck 2018b). This document was updated to meet the guidelines provided by the HSRC (Ministry of Energy and Mines 2016), the CDA (2013), the Mining Association of Canada (MAC 2011), and Teck (2014).

5.4.3 Dam Safety Review

The last DSR for the Beaverdell TSF dams was conducted in 2012 (Golder 2013). The next DSR for the facilities, based on the CDA *Dam Safety Guidelines* (CDA 2013), was recommended for 2022. In 2016, the HSRC was updated with revised requirements for DSR frequency; therefore, the next DSR is required in 2021 (i.e., five years after the revised regulations came into effect).

6.0 SUMMARY AND RECOMMENDATIONS

6.1 Summary of Activities

Activities completed during the reporting period were:

- spring routine inspection on 8 May 2018
- seven additional inspections as a result of high water levels in the WKR in May 2018
  - daily / twice daily between 7 and 11 May 2018
  - 16 May 2018, accompanied by the EoR, John Cunning
  - 18 May 2018
- inspection on 11 June 2018 with the Teck Legacy Independent Tailings Review Board, accompanied by the EoR
- fall routine inspection on 27 November 2018
- four water quality sampling visits and resultant analyses
- construction at the South TSF spillway at Cell 3, between 14 and 16 August 2018
- removal of debris from the WKR bank adjacent to Cell 3, 4 and 5
- completion of CPT at 38 locations between 30 July and 4 August 2018 (Golder 2019)
- installation of nine groundwater monitoring wells outside of the North and South TSFs between 17 and 21 July 2018
- removal of a large uprooted tree in the WKR on 10 October 2018
- LiDAR survey of the facility including the WKR completed by flight mission on 19 July 2018

6.2 Summary of Climate and Water Balance

The water year for this reporting period is October 2017 through September 2018. Based on comparisons between historical and active regional stations (Beaverdell North, Billings, and Penticton), the total annual precipitation at the Beaverdell site between during the water year is estimated to be 574 mm, or 21% greater than the average annual precipitation.

The water balance assumes all inflows to the TSF exit the TSF and there is no long-term accumulation of water in the cells. The inflow volumes were calculated by multiplying the total annual precipitation by the watershed areas, without including losses. Using the estimated precipitation at Beaverdell for the water year, the inflow volumes are estimated to be 108,000 m^3 for the South TSF area and 46,600 m^3 for the North TSF area. Losses are assumed to equate to inflows and include evaporation, transpiration, sublimation, and infiltration to ground. Seepage has not been observed and is assumed to be negligible.

6.3 Summary of Performance and Changes

The Beaverdell TSF dams were observed to be in good condition at the time of the 2018 DSI site visit. No significant changes in condition were noted, based on visual monitoring records, dam stability, and surface water control.

6.4 Consequence Classification

Following the consequence classification in Section 3.4 of the HSRC Guidance Document (Ministry of Energy and Mines 2016):

- The North and South TSF dams are “Significant” consequence class structures, which is unchanged from the 2017 DSI.

As a result of changes in downstream conditions, it is recommended that an inundation study and dam class review for the South TSF be completed.

6.5 Previous Deficiencies and Non-conformances

There was one high priority deficiency and non-conformance noted in the 2017 DSI report (Golder 2018c) relating to the South TSF IDF storage and Cell 3 spillway. The design for the Cell 3 spillway was completed in March 2018 (Golder 2018b) and construction works were undertaking in August 2018. This deficiency / non-conformance is considered “Closed” as part of this DSI.

Table 16 provides the current status of the 2017 DSI recommendations for the TSFs.

Table 16: Current Status of 2017 Recommended Actions for the Beaverdell Tailings Storage Facilities

ID Number	Deficiency or Non-conformance	Recommended Action	Priority in 2017 DSI	Current Status at March 2019
2016-01	The South TSF would discharge through the Cell 3 spillway during a 24-hour IDF event. The consequence of potential tailings migration due to flood transport is not quantified.	Complete sampling and testing of tailings for geochemical properties.	**3**	**In progress** Surface samples of tailings collected and tested for chemistry for Preliminary Quantitative Risk Assessment. Geotechnical site investigation and geochemical sample collection and testing program has been scoped by Golder and is scheduled for execution by Teck in 2019.
2016-02b	Cell 3 cannot contain IDF; flood water will leave the South TSF via spillway in Cell 3.	Detailed design for the South TSF spillway and construction scheduled to be completed by 31 May 2018, subject to weather conditions or approval of extension to order from EMPR.	**1**	**Closed**
2016-03	Existing facility phreatic conditions not confirmed.	Complete drilling program to gather subsurface information and install piezometers.	**3**	**In progress** CPT program was carried out in 2018 (Golder 2019). Site investigation with piezometer installation has been scoped by Golder and is scheduled for execution by Teck in 2019.
2016-05	Closure plan not updated.	Initiate investigation of existing physical and geochemical properties.	**4**	**In progress** Surface samples of tailings collected and tested for chemistry for Preliminary Quantitative Risk Assessment. Geotechnical site investigation and geochemical sample collection and testing program has been scoped by Golder and is scheduled for execution by Teck in 2019. Teck is planning to hold a closure workshop in 2019.
2017-01	Annual risk assessment for facilities.	Update a risk assessment for the facilities.	**4**	**Closed**
2017-02	No dam breach and inundation study completed.	Complete dam breach and inundation assessment. Reassess consequence classification if necessary.	**3**	**In progress** Geotechnical site investigation program has been scoped by Golder and is scheduled for execution by Teck in 2019.

CPT = cone penetration testing; DSI = dam safety inspection; IDF = inflow design flood; EMPR; Ministry of Energy, Mines and Petroleum Resources TSF = tailings storage facility.

6.6 Current Deficiencies and Non-conformances

Table 17 summarizes the recommended actions for the Beaverdell TSF dams.

Table 17: Summary of 2018 Dam Safety Inspection Recommended Actions

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline
South TSF	2016-01	The South TSF would discharge through the Cell 3 spillway during a 24-hour IDF event. The consequence of potential tailings migration due to flood transport is not quantified.	HSRC 10.1.12	Execute the planned geochemical site investigation and testing program. Teck should schedule this program to start in Q2 2019.	3	Q4-2019
	2018-01	Cell 3 spillway riprap is too thick at invert and requires removal to achieve required freeboard.	CDA (2014)	Complete recommended additional construction works to address freeboard requirements.	2	Q2-2019
	2018-02	Dam consequence classification requires review due to changes in downstream conditions.	HSRC §10.1.7	Review dam consequence classification as recommended in Golder (2018g).	2	Q4-2019
	2018-03 a, b	Existing riprap along the toe of Cell 4 and 5 may not be sufficient to prevent erosion of dam fill during a large river freshet flood event, based on observed changes in river alignment and adjacent river bank conditions.	HSRC §10.1.8	Design and implement interim measures to mitigate risk of flood damage during 2019 freshet, including stockpiling of riprap material and a freshet flood management plan (in progress).	2	April 2019
				Assess long-term requirements for riprap based on changes in river hydrology and flood statistics (in progress).	3	Q3-2019
South and North TSFs	2016-03	Facility phreatic conditions not confirmed.	CDA 2013 §6.6	Execute the planned drilling program to gather subsurface information and install piezometers. Teck should schedule this program to start Q2 2019.	3	Q4-2019
	2016-05 a, b	Closure plan not updated.	HSRC §10.4.1	Complete investigation of existing physical and geochemical properties to inform the development of an updated closure plan. Teck should schedule this program to start in Q2 2019.	4	Q4-2019
				Update Closure Plan.	4	2020
	2017-02	No dam breach and inundation study completed.	HSRC §10.1.11	Complete investigation of existing physical and geochemical properties to inform the completion of a dam breach and inundation assessment in 2019. Teck should schedule this program to start Q2 2019. Complete a dam breach and inundation study.	3	Q4-2019
	2018-04	Water management plan is out of date.	HSRC §10.1.12	Update existing water management plan.	4	2020

CDA = Canadian Dam Association; HSRC = Health, Safety and Reclamation Code; ID = identification; IDF = inflow design flood; OMS = operation, maintenance, and surveillance; TSF = tailings storage facility.

Priority	Description
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.
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.
3	Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

Source: HSRC Guidance Document, Section 4.2 (Ministry of Energy and Mines 2016).

7.0 CLOSURE

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

We trust that this report meets your present requirements. If you have any questions or further requirements, please contact the undersigned.

Signature Page

Golder Associates Ltd.

PROFESSIONAL
PROVINCE OF
J. C. CUNNING
BRITISH COLUMBIA
ENGINEER

29 March 2019

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Principal, Senior Geotechnical Engineer

MBW/JCC/TM/cf/it/no

https://golderassociates.sharepoint.com/sites/26376g/deliverables/issued/122-r-rev0-4000-tsf 2018 annual dsi beav/18100805-122-r-rev0-4000-tsf 2018 annual dsi 29mar_19.docx

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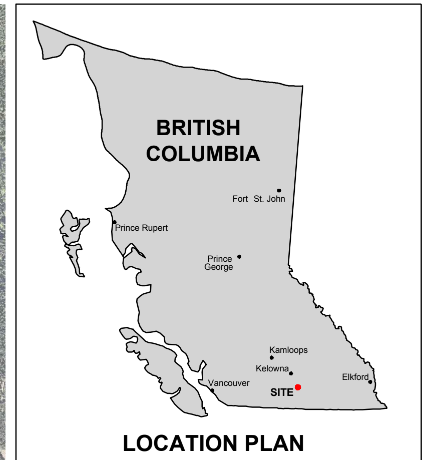

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LIMITS OF 2018 ORTHO PHOTO

NOTE

1. COORDINATES ARE IN UTM ZONE 11 NAD83.

REFERENCES

1. 2013 ORTHOPHOTO RECEIVED FROM TECK RESOURCES LIMITED.
2. 2018 ORTHOPHOTO BY MCELHANNEY, RECEIVED 24 AUGUST 2018.

CLIENT
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BEAVERDELL, B.C.

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YYYY-MM-DD	2019-03-26
DESIGNED	ZS
PREPARED	BM
REVIEWED	MBW
APPROVED	JCC

PROJECT
2018 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

TITLE
BEAVERDELL SITE PLAN

PROJECT NO.	PHASE/TASK/DOC#	REV.	FIGURE
18100805	4000/4100/122	0	1

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LEGEND

- 2018 TOPOGRAPHIC CONTOURS
- EXTENT OF RIPRAP ARMOURING
- CELL BOUNDARY
- # 2018 SITE VISIT PHOTOGRAPH LOCATION

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN UTM ZONE 11 NAD83.
3. 2018 TOPOGRAPHIC CONTOURS SHOWN AT 1.0 m MINOR AND 5.0 m MAJOR INTERVAL.
4. VERTICAL DATUM IS CGVD2013 DATUM.

REFERENCES

1. 2018 EXISTING GROUND LIDAR SURVEY AND ORTHO PHOTO BY MCELHANNEY 19 JULY 2018, PROVIDED BY TECK RESOURCES LIMITED, RECEIVED: 24 AUGUST 2018, FILE NAME: 358400VLIDARCONTOURS.DWG.

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PROJECT
2018 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

TITLE
2018 INSPECTION PHOTOGRAPH LOCATIONS

PROJECT NO.	PHASE/TASK/DOC#	REV.	FIGURE
18100805	4000/4100/122	0	2

LEGEND

- 2018 TOPOGRAPHIC CONTOURS
- EXTENT OF RIPRAP ARMOURING
- CELL BOUNDARY
- APPROXIMATE DECANT TOWER LOCATION
- APPROXIMATE OUTLET LOCATION
- APPROXIMATE SPILLWAY LOCATION AND FLOW DIRECTION
- CRITICAL HABITAT OF SPECKLED DACE (SEE REFERENCE 2)
- APPROXIMATE LEASE BOUNDARY
- GROUNDWATER MONITORING WELLS (BY WOOD PLC, COMPLETED SUMMER 2018)

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN UTM ZONE 11 NAD83.
3. 2018 TOPOGRAPHIC CONTOURS SHOWN AT 1.0 m MINOR AND 5.0 m MAJOR INTERVAL.
4. VERTICAL DATUM IS CGVD2013 DATUM.

REFERENCES

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2. FISHERIES AND OCEANS CANADA. 2018. RECOVERY STRATEGY FOR THE SPECKLED DACE (*RHINICHTHYS OSCULUS*) IN CANADA. SPECIES AT RISK ACT RECOVERY STRATEGY SERIES. FISHERIES AND OCEANS CANADA, OTTAWA. v + 31 pp.

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PROJECT
2018 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

TITLE
DETAIL PLAN

PROJECT NO.	PHASE/TASK/DOC#	REV.	FIGURE
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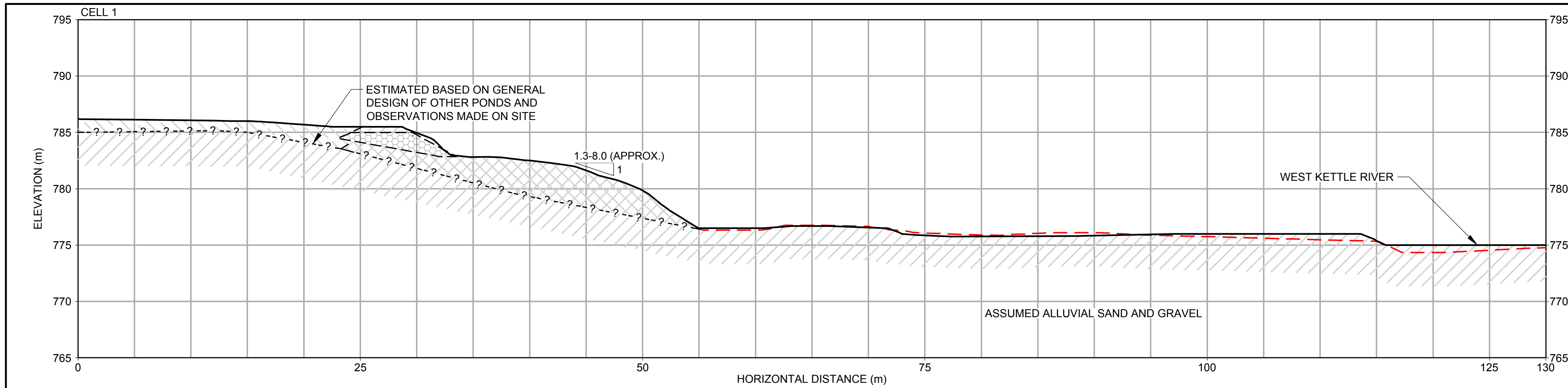

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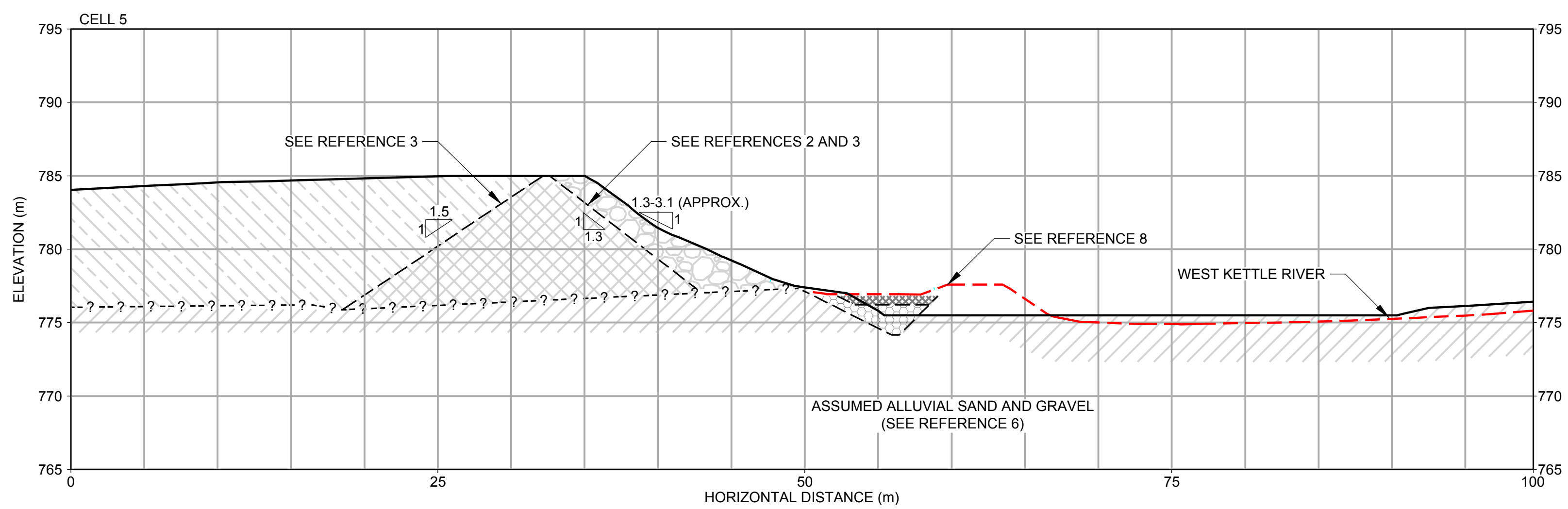

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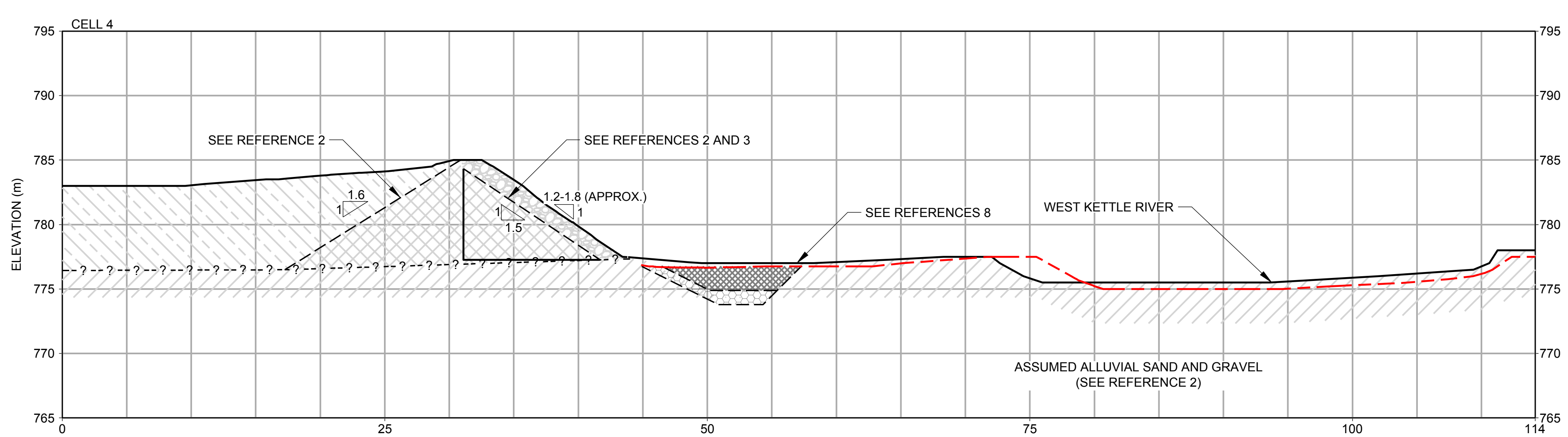

SCALE 1:500 m (C/3) SECTION

LEGEND

- EXISTING GROUND SURFACE (JULY 2018)
- ESTIMATED ORIGINAL GROUND SURFACE
- 2013 TOPOGRAPHIC SURFACE (SHOWN FROM TOE OF DAMS TO WEST KETTLE RIVER)
- INFERRED MATERIAL BOUNDARY
- TAILINGS
- EMBANKMENT FILL
- ALLUVIAL SAND AND GRAVEL
- ALLUVIAL COBBLE COVER
- WASTE ROCK/ALLUVIAL COBBLES
- RIPRAP MIXED WITH GRANULAR FILL
- BACKFILLED EXCAVATED MATERIAL

NOTES

1. ALL UNITS ARE SHOWN IN METERS UNLESS OTHERWISE NOTED.
2. STRATIGRAPHY BENEATH ALLUVIAL SAND AND GRAVEL IS UNKNOWN. GROUND SURFACE UNDER TAILINGS BASED ON 2018 CPT INVESTIGATION.
3. VERTICAL DATUM IS CGVD2013 DATUM.

REFERENCES

1. 2018 EXISTING GROUND LIDAR SURVEY AND ORTHO PHOTO BY MCELHANNEY 19 JULY 2018, PROVIDED BY TECK RESOURCES LIMITED, RECEIVED: 24 AUGUST 2018, FILE NAME: 358400VLidarContours.dwg.
2. BINNIE (ROBERT F. BINNIE LTD.). 1971. *REPORT ON STABILITY OF TAILINGS DAM.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 8 JUNE 1971.
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BEAVERDELL MINE
BEAVERDELL, B.C.

CONSULTANT

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DESIGNED	ZS
PREPARED	BM
REVIEWED	MBW
APPROVED	JCC

PROJECT
2018 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

TITLE
CROSS SECTIONS (1 OF 2)

PROJECT NO.	PHASE/TASK/DOC#	REV.	FIGURE
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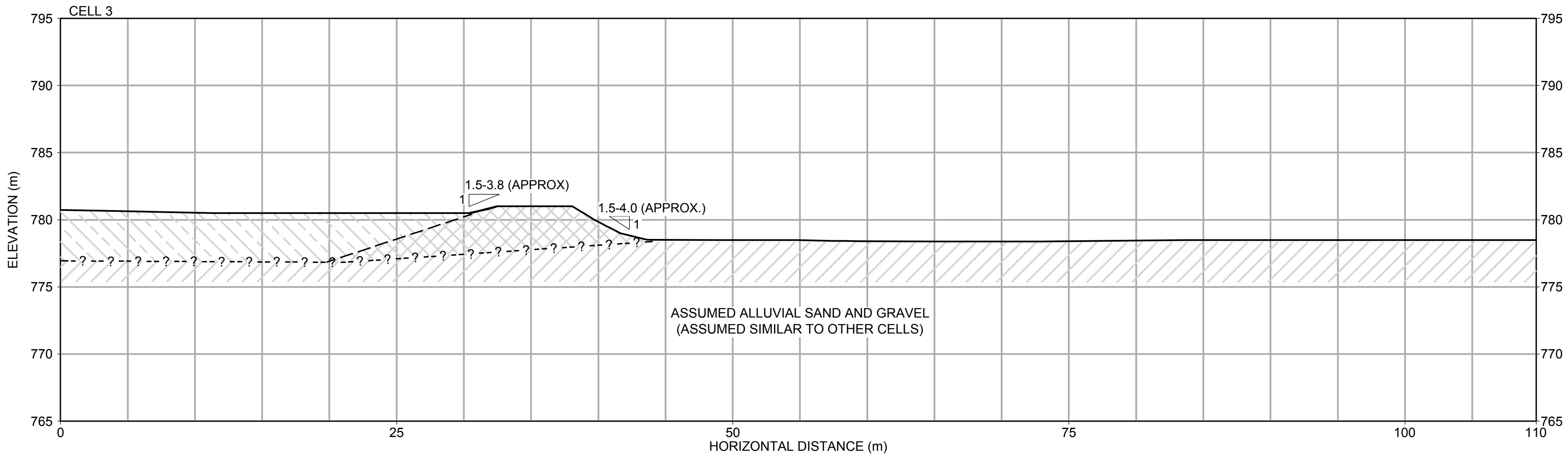

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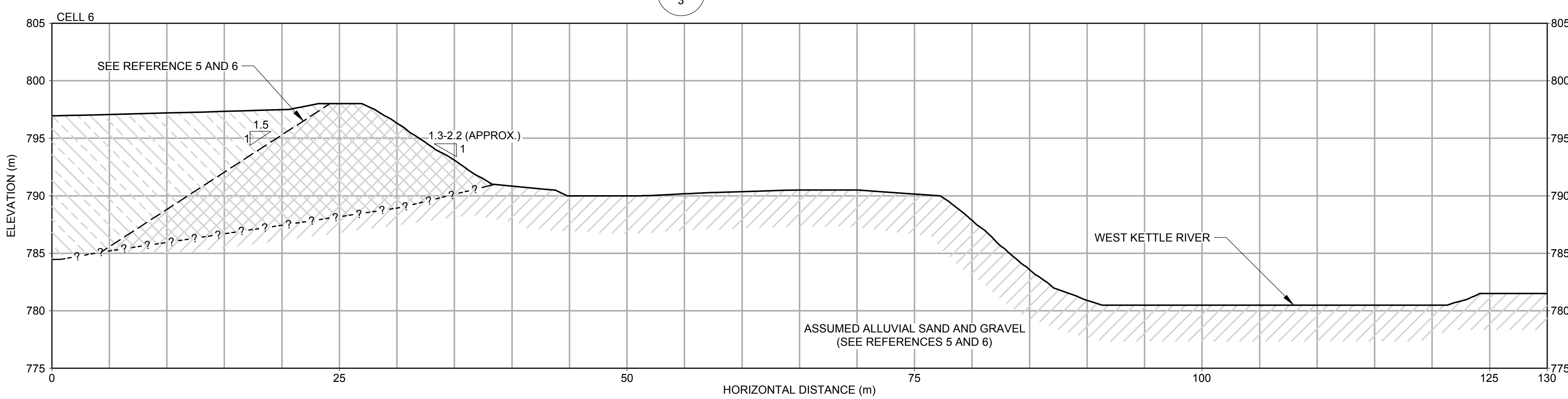
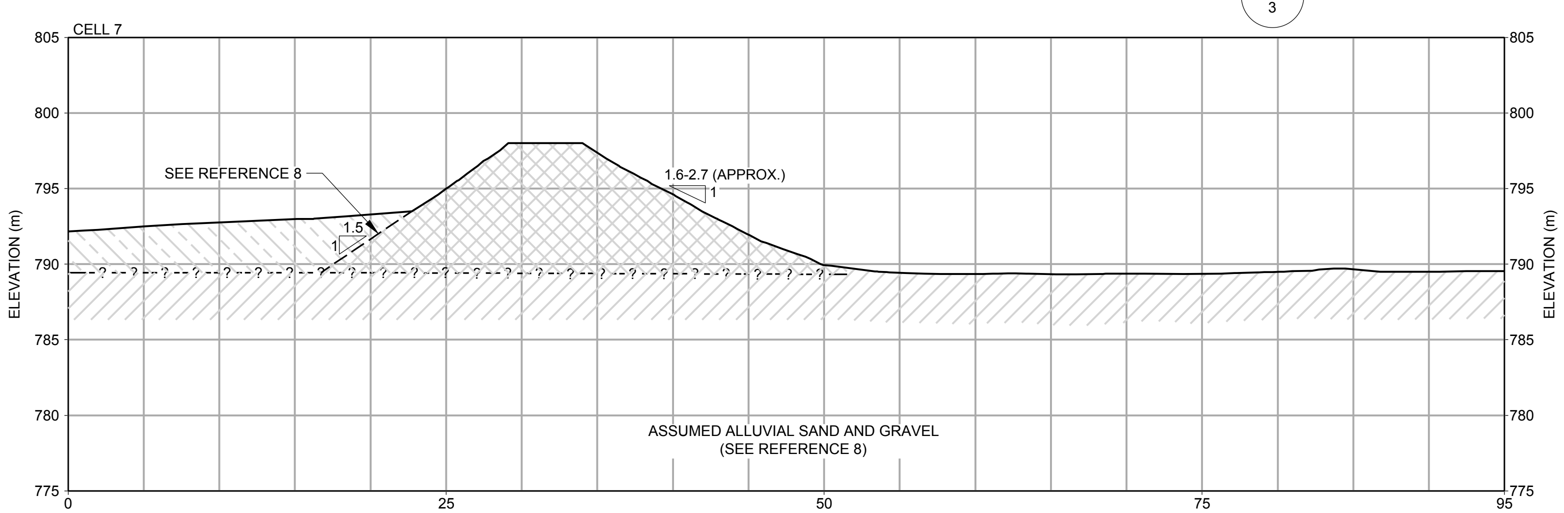


SCALE 1:500 m E/3 SECTION



SCALE 1:500 m F/3 SECTION

LEGEND

- EXISTING GROUND SURFACE (JULY 2018)
- ESTIMATED ORIGINAL GROUND SURFACE
- INFERRED MATERIAL BOUNDARY
- TAILINGS
- EMBANKMENT FILL
- ALLUVIAL SAND AND GRAVEL

NOTES

1. ALL UNITS ARE SHOWN IN METERS UNLESS OTHERWISE NOTED.
2. STRATIGRAPHY BENEATH ALLUVIAL SAND AND GRAVEL IS UNKNOWN.
3. GROUND SURFACE UNDER TAILINGS BASED ON 2018 CPT INVESTIGATION.
4. VERTICAL DATUM IS CGVD2013 DATUM.

REFERENCES

1. 2018 EXISTING GROUND LIDAR SURVEY AND ORTHO PHOTO BY MCELHANNEY 19 JULY 2018, PROVIDED BY TECK RESOURCES LIMITED, RECEIVED: 24 AUGUST 2018, FILE NAME: 358400VLidarContours.dwg
2. 2016 TOPOGRAPHIC CONTOURS FOR CELL 1, 3, AND 5 SURVEYED: 10 AUGUST 2016 BY ALLTERRA LAND SURVEYING LTD. AND PROVIDED ON 30 AUGUST 2016.
3. BINNIE (ROBERT F. BINNIE LTD.). 1971. *REPORT ON STABILITY OF TAILINGS DAM.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 8 JUNE 1971.
4. BINNIE. 1973. *REPORT ON PROPOSED NEW TAILINGS POND.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 27 AUGUST 1973.
5. BINNIE. 1980A. *REPORT ON TAILINGS DISPOSAL POND NO. 5 AND PROPOSED POND NO. 6.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 20 FEBRUARY 1980.
6. BINNIE. 1980B. *SUPPLEMENTARY REPORT ON PROPOSED POND NO. 6.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 31 MARCH 1980.
7. BINNIE. 1980C. *REPORT ON STABILITY OF ABANDONED POND NO. 5.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 9 DECEMBER 1980.
8. BINNIE (R.F. BINNIE & ASSOCIATES LTD.). 1988. *REPORT ON PROPOSED POND NO. 7.* REPORT PREPARED FOR TECK CORPORATION, BEAVERDELL, BC. SUBMITTED APRIL 1988.

NOT FOR CONSTRUCTION

0 10 20
1:500 METRES

CLIENT
TECK RESOURCES LTD.
BEAVERDELL MINE
BEAVERDELL, B.C.

PROJECT
2018 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-26
DESIGNED	ZS
PREPARED	BM
REVIEWED	MBW
APPROVED	JCC

TITLE
CROSS SECTIONS (2 OF 2)

PROJECT NO.	PHASE/TASK/DOC#	REV.	FIGURE
18100805	4000/4100/122	0	5

APPENDIX A

2018 Site Inspection Photographs

Photograph 1: South Tailings Storage Facility (TSF) Cell 1, overview of tailings surface, looking northwest. 14 June 2018.

Photograph 2: South TSF, Cell 1, west embankment (access road) looking northeast. 14 June 2018.

Photograph 3: South TSF, Cell 1, crest of dam, looking southeast. 14 June 2018.

Photograph 4: South TSF, Cell 1 crest and upstream ditch at southeast embankment, looking northeast. 14 June 2018.

CLIENT
TECK RESOURCES LIMITED

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-26
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

PROJECT
BEAVERDELL MINE
2018 DAM SAFETY INSPECTION

TITLE
PHOTOGRAPHS 1 to 4

PROJECT No.	PHASE No.	Rev.	SHEET
18100805	4000	0	1

Photograph 5: South TSF, Cell 1, crest and upstream ditch at southeast embankment, looking southwest. 14 June 2018.

Photograph 6: South TSF, Cell 1/5, downstream dam face waste rock, looking west. 14 June 2018.

Photograph 7: South TSF, Cell 5, overview of tailings surface, looking northeast. 14 June 2018.

Photograph 8: South TSF, Cell 5, crest on southwest side of cell, looking southeast. 14 June 2018.

CLIENT
TECK RESOURCES LIMITED

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-26
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

PROJECT
BEAVERDELL MINE
2018 DAM SAFETY INSPECTION

TITLE
PHOTOGRAPHS 5 to 8

PROJECT No.	PHASE No.	Rev.	SHEET
18100805	4000	0	2

Photograph 9: South TSF, Cell 5, east dam and West Kettle River, looking southeast. 14 June 2018.

Photograph 10: South TSF, Cell 5, downstream dam face and buried riprap at toe of slope, looking southwest. 14 June 2018.

Photograph 11: South TSF, Cell 5, buried riprap at toe of TSF downstream slope, looking northeast. Low river flow. 8 August 2017.

Photograph 12: South TSF, Cell 5, buried riprap at toe of TSF downstream slope, looking northeast. 14 June 2018.

CLIENT
TECK RESOURCES LIMITED

PROJECT
BEAVERDELL MINE
2018 DAM SAFETY INSPECTION

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-26
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

TITLE
PHOTOGRAPHS 9 to 12

PROJECT No.	PHASE No.	Rev.	SHEET
18100805	4000	0	3

Photograph 13: South TSF, Cell 5, uprooted tree in the West Kettle River downstream of TSF toe, looking southeast. 14 June 2018.

Photograph 14: South TSF, Cell 5, downstream face of southwest dam, looking northeast. 14 June 2018.

Photograph 15: South TSF, Cell 5, backfilled decant tower, looking northeast. 14 June 2018.

Photograph 16: South TSF, Cell 4, ponded water on tailings surface, looking northwest. 14 June 2018.

CLIENT
TECK RESOURCES LIMITED

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-26
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

PROJECT
BEAVERDELL MINE
2018 DAM SAFETY INSPECTION

TITLE
PHOTOGRAPHS 13 to 16

PROJECT No.	PHASE No.	Rev.	SHEET
18100805	4000	0	4


Photograph 17: South TSF, Cell 4, downstream face of eastern dam, looking southwest. 14 June 2018.


Photograph 18: South TSF, Cell 4, downstream slope and northern extent of buried riprap, looking northeast. 14 June 2018.


Photograph 19: South TSF, spillway between Cell 4 and Cell 3, looking northwest. 14 June 2018.


Photograph 20: South TSF, Cell 3, overview of tailings surface and embankment crest, looking northwest. 14 June 2018.

CLIENT **TECK RESOURCES LIMITED**		PROJECT **BEAVERDELL MINE 2018 DAM SAFETY INSPECTION**	
CONSULTANT GOLDER	YYYY-MM-DD: 2019-03-26 PREPARED: ZS DESIGN: ZS REVIEW: MBW APPROVED: JCC	TITLE **PHOTOGRAPHS 17 to 20**	
		PROJECT No. **18100805** · PHASE No. **4000**	Rev. **0** · SHEET **5**

Photograph 21: South TSF, Cell 3, upstream face of western embankment, looking southeast. 14 June 2018.

Photograph 22: South TSF, Cell 3, crest of dam on east side of cell, looking northeast. 14 June 2018.

Photograph 23: South TSF, Cell 3, spillway from crest, looking east. 14 June 2018.

Photograph 24: South TSF, Cell 3, spillway from crest, looking west from downstream toe. 14 June 2018.

CLIENT **TECK RESOURCES LIMITED**	PROJECT **BEAVERDELL MINE** **2018 DAM SAFETY INSPECTION**
CONSULTANT GOLDER YYYY-MM-DD: 2019-03-26 PREPARED: ZS DESIGN: ZS REVIEW: MBW APPROVED: JCC	TITLE **PHOTOGRAPHS 21 to 24** PROJECT No. **18100805** PHASE No. **4000** Rev. **0** SHEET **6**

Photograph 25: South TSF, Cell 3, As-Built Spillway Crest., looking south 16 August 2018.

Photograph 26: South TSF, Cell 3, As-Built Spillway Downstream., looking southeast 16 August 2018.

Photograph 27: South TSF, Cell 3, eastern dam crest, looking south. 14 June 2018.

Photograph 28: South TSF, Cell 3, overview of tailings surface, looking northwest. 14 June 2018.

CLIENT **TECK RESOURCES LIMITED**	PROJECT **BEAVERDELL MINE 2018 DAM SAFETY INSPECTION**
CONSULTANT GOLDER	YYYY-MM-DD: 2019-03-26 PREPARED: ZS DESIGN: ZS REVIEW: MBW APPROVED: JCC
TITLE **PHOTOGRAPHS 25 to 28**	
PROJECT No. **18100805**	PHASE No. **4000**
Rev. **0**	SHEET **7**

Photograph 29: South TSF, Cell 3, upstream face of western embankment, looking southeast. 14 June 2018.

Photograph 30: South TSF, Cell 3, mature trees on dam crest, looking southeast. 14 June 2018.

Photograph 31: South TSF, downstream of Cell 3, groundwater extraction well. Looking west. 14 June 2018.

Photograph 32: North TSF, Cell 6, tailings surface overview, looking north. 14 June 2018.

CLIENT **TECK RESOURCES LIMITED**	PROJECT **BEAVERDELL MINE** **2018 DAM SAFETY INSPECTION**
CONSULTANT GOLDER YYYY-MM-DD: 2019-03-26 PREPARED: ZS DESIGN: ZS REVIEW: MBW APPROVED: JCC	TITLE **PHOTOGRAPHS 29 to 32** PROJECT No. **18100805** · PHASE No. **4000** · Rev. **0** · SHEET **8**

Photograph 33: North TSF, Cell 6, ponding water on tailings surface, looking north. 14 June 2018.

Photograph 34: North TSF, Cell 6, crest on east side of cell, looking southwest. 14 June 2018.

Photograph 35: North TSF, Cell 6, tailings surface overview, looking west. 14 June 2018.

Photograph 36: North TSF, Cell 6, minor erosion in north embankment, looking northeast. 14 June 2018.

CLIENT **TECK RESOURCES LIMITED**	PROJECT **BEAVERDELL MINE 2018 DAM SAFETY INSPECTION**
CONSULTANT GOLDER YYYY-MM-DD: 2019-03-26 PREPARED: ZS DESIGN: ZS REVIEW: MBW APPROVED: JCC	TITLE **PHOTOGRAPHS 33 to 36**

PROJECT No.	PHASE No.	Rev.	SHEET
18100805	4000	0	9

Photograph 37: North TSF, Cell 6, division between cells 6 (left) and 7, looking south. 14 June 2018.

Photograph 38: North TSF, Cell 7, tailings surface overview, looking north. 14 June 2018.

Photograph 39: North TSF, Cell 7, north embankment downstream face, looking south. 14 June 2018.

Photograph 40: North TSF, Cell 6, decant outlet at toe of dam, looking north. 14 June 2018.

CLIENT **TECK RESOURCES LIMITED**		PROJECT **BEAVERDELL MINE** **2018 DAM SAFETY INSPECTION**	
CONSULTANT GOLDER	YYYY-MM-DD: 2019-03-26 PREPARED: ZS DESIGN: ZS REVIEW: MBW APPROVED: JCC	TITLE **PHOTOGRAPHS 37 to 40**	
		PROJECT No. **18100805** / PHASE No. **4000**	Rev. **0** / SHEET **10**

Photograph 41: North TSF, Cell 7, crest of dam on south side of cell, looking southeast. 14 June 2018.

Photograph 42: North TSF, Cell 6, overview of tailings surface, looking east. 14 June 2018.

Photograph 43: North TSF, Cell 7, upstream slope of dam, looking southeast. 14 June 2018.

Photograph 44: North TSF, Cell 7, spillway at southwest corner, looking north. 14 June 2018.

CLIENT
TECK RESOURCES LIMITED

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-26
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

PROJECT
BEAVERDELL MINE
2018 DAM SAFETY INSPECTION

TITLE
PHOTOGRAPHS 41 to 44

PROJECT No.	PHASE No.	Rev.	SHEET
18100805	4000	0	11

Photograph 45: North TSF, Cell 6, tailings surface overview, looking northwest. 14 June 2018.

Photograph 46: North TSF, Cell 7, tailings surface overview, looking south.14 June 2018.

Photograph 47: North TSF, Cell 6, animal burrow in tailings surface, looking east. 14 June 2018.

Photograph 48: North TSF, Cell 7, decant outlet at toe of dam, looking northwest. 14 June 2018.

CLIENT
TECK RESOURCES LIMITED

PROJECT
BEAVERDELL MINE
2018 DAM SAFETY INSPECTION

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-26
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

TITLE
PHOTOGRAPHS 45 to 48

PROJECT No.	PHASE No.	Rev.	SHEET
18100805	4000	0	12

Photograph 49: North TSF, Cell 7, diversion channel west of the TSF, looking northeast. 14 June 2018.

CLIENT	TECK RESOURCES LIMITED	PROJECT	BEAVERDELL MINE 2018 DAM SAFETY INSPECTION
CONSULTANT: GOLDER	YYYY-MM-DD: 2019-03-26	TITLE	PHOTOGRAPH 49
	PREPARED: ZS		
	DESIGN: ZS		
	REVIEW: MBW		
	APPROVED: JCC	PROJECT No. 18100805 · PHASE No. 4000 · Rev. 0	SHEET 13

APPENDIX B

Inspection Reports

CLIENT:	Teck Resources Limited	**BY:**	John Cunning, P.Eng., and Martyn Willan, P.Eng.
PROJECT:	Beaverdell Mine	**DATE:**	14 June 2018
LOCATION:	North TSF (Cells 6 and 7)	**REVIEWED:**	John Cunning, P.Eng.

GENERAL INFORMATION **Dam Type: Zoned Earthfill**			
WEATHER CONDITIONS:	Overcast	**TEMP:**	5 to 10°C

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST		32,34,35	
1.1 Crest Elevation	Cell 6: El. 797 m Cell 7: El. 797 m		McElhanney Survey (July 2018)
1.2 Reservoir Level/ Freeboard	Dry	30,31,32,33,35, 36,40,43,44,45	No ponding observed against dams during site inspection.
1.3 Distance to Tailings Pond (if applicable)	>10 m	31,43	Pond observed in Cell 6
1.4 Surface Cracking	None		
1.5 Unexpected Settlement	None		
1.6 Lateral Movement	None		
1.7 Other Unusual Conditions	Variable dam crest width: Cell 6: 3 to 4 m Cell 7: 3 to 4 m		
2. UPSTREAM SLOPE		32,34	
2.1 Slope Angle	Cells 6 and 7: 1.5H : 1V		McElhanney Survey (July 2018)
2.2 Signs of Erosion	Minor	34	Minor surficial erosion noted
2.3 Signs of Movement (Deformation)	None		
2.4 Cracks	None		
2.5 Face Liner Condition (if applicable)	N/A		
2.6 Other Unusual Conditions	None		

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
3. DOWNSTREAM SLOPE		37,41,47	
3.1 Slope Angle	Cell 6: 1.4 to 1.9H :1V Cell 7: 1.6 to 2.6H : 1V		McElhanney Survey (July 2018)
3.2 Signs of Erosion	Minor	None	Minor surficial erosion noted
3.3 Signs of Movement (Deformation)	None		
3.4 Cracks	None		
3.5 Seepage or Wet Areas	Dry		
3.6 Vegetation Growth	Mature trees	32,35,37,47	
3.7 Other Unusual Conditions	None		
4. DOWNSTREAM TOE AREA		38,47	
4.1 Seepage from Dam	None		
4.2 Signs of Erosion	None		
4.3 Signs of Turbidity in Seepage Water	N/A		
4.4 Discoloration / Staining	N/A		
4.5 Outlet Operating Problem (if applicable)	N/A		
4.6 Other Unusual Conditions	Decant outlets	38,46	
5. ABUTMENTS			
5.1 Seepage at Contact Zone (Abutment/Embankment)	None		
5.2 Signs of Erosion	None		
5.3 Vegetation	Immature Trees		
5.4 Presence of Rodent Burrows	None		
5.5 Other Unusual Conditions	None		
6. RESERVOIR		30,31,32,33,35, 36,40	Ponding in Cell 6
6.1 Stability of Slopes	N/A		
6.2 Distance to Nearest Slide (if applicable)	N/A		
6.3 Estimate of Slide Volume (if applicable)	N/A		
6.4 Floating Debris	N/A		
6.5 Other Unusual Conditions	Decant tower inlets	40	Tower inlet filled

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
7. EMERGENCY SPILLWAY / OUTLET STRUCTURE	From Cell 7 to environment	42	Requires significant ponding within Cell 7 to receive flow, use unlikely.
7.1 Surface Condition	Alluvial cobbles, original ground		
7.2 Signs of Erosion	None		
7.3 Signs of Movement (Deformation)	None		
7.4 Cracks	None		
7.5 Settlement	None		
7.6 Presence of Debris or Blockage	Small trees		
7.7 Closure Mechanism Operational	N/A		
7.8 Slope Protection	N/A		
7.9 Instability of Side Slopes	None		
7.10 Other Unusual Conditions	N/A		
8. INSTRUMENTATION			
8.1 Piezometers	none functioning		
8.2 Settlement Cells	None		
8.3 Thermistors	None		
8.4 Settlement Monuments	None		
8.5 Accelerograph	None		
8.6 Inclinometer	None		
8.7 Weirs and Flow Monitors	None		
8.8 Data Logger(s)	None		
8.9 Other	None		
9. DOCUMENTATION			
9.1 Operation, Maintenance and Surveillance (OMS) Manual 9.1.1 OMS Manual Exists	Yes		SP&P BEA-OMS-001.V002
9.1.2 OMS Manual Reflects Current Dam Conditions	Yes		
9.1.3 Date of Last Revision	16 February 2018		
9.2 Emergency Preparedness Plan (EPP) 9.2.1 EPP Exists	Yes		SP&P BEA-EPRP-001.V0002
9.2.2 EPP Reflects Current Conditions	Yes		
9.2.3 Date of Last Revision	22 February 2018		

10. NOTES

No significant changes since 2017 DSI.

https://golderassociates.sharepoint.com/sites/26376g/deliverables/issued/122-r-rev0-4000-tsf 2018 annual dsi beav/appendices/appendix b - inspection reports/appendix b1 - north tsf inspection report.docx

CLIENT:	Teck Resources Limited	**BY:**	John Cunning, P.Eng., and Martyn Willan, P.Eng.
PROJECT:	Beaverdell Mine	**DATE:**	14 June 2018
LOCATION:	South TSF (Cells 1 through 5)	**REVIEWED:**	John Cunning, P.Eng.

GENERAL INFORMATION **Dam Type: Zoned Earthfill**			
WEATHER CONDITIONS:	Overcast	**TEMP:**	5 to 10°C

INSPECTION ITEM	OBSERVATIONS/ DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST		2,3,4,5,20,22	
1.1 Crest Elevation	<u>Low Point in Embankment:</u> Cell 1: El. 785 m Cell 5: El. 785 m Cell 4: El. 784 m Cell 3: El. 780 m		McElhanney Survey (July 2018)
1.2 Reservoir Level / Freeboard	Dry	1,7,8,16,19,20,22,25,26,27	No ponding observed against dams during site inspection.
1.3 Distance to Tailings Pond (if applicable)	>10 m	16	Pond observed in Cell 4
1.4 Surface Cracking	None		
1.5 Unexpected Settlement	None		
1.6 Lateral Movement	None		
1.7 Other Unusual Conditions	Variable crest width: Cell 1: 1 to 3 m Cell 5: 3 to 6 m Cell 4: 3 to 3.5 m Cell 3: 2.5 to 3.5 m Mature trees on Cell 3 crest	25,28	

INSPECTION ITEM	OBSERVATIONS/ DATA	PHOTO	COMMENTS & OTHER DATA
2. UPSTREAM SLOPE		5,22,27	
2.1 Slope Angle	Cells 1 and 2: unknown Cell 3: 1.5 to 3H : 1V Cells 4 and 5: 1.5H : 1V		McElhanney Survey (July 2018)
2.2 Signs of Erosion	None		
2.3 Signs of Movement (Deformation)	None		
2.4 Cracks	None		
2.5 Face Liner Condition (if applicable)	N/A		
2.6 Other Unusual Conditions	Dead trees on upstream slope on west side of Cell 3.	27	Dead trees should be removed.
3. DOWNSTREAM SLOPE		6,10,11,12,14,17,18,24	
3.1 Slope Angle	Cell 1: 2.0 to 4.0H : 1V Cell 5: 1.3 to 2.5H : 1V Cell 4: 1.2 to 1.4H : 1V Cell 3: 1.5 to 2.4H : 1V		McElhanney Survey (July 2018)
3.2 Signs of Erosion	Minor erosion gulley's on downstream slopes	None	Minor surficial erosion noted
3.3 Signs of Movement (Deformation)	None		
3.4 Cracks	None		
3.5 Seepage or Wet Areas	Dry		
3.6 Vegetation Growth	Mature trees	2,3,5,9,10,11,12,14,17,18,20,22, 23,24,25	
3.7 Other Unusual Conditions	None		
4. DOWNSTREAM TOE AREA		9,10,11,1218	
4.1 Seepage from Dam	None		
4.2 Signs of Erosion	Erosion of river bank along toe of Cell 4 and 5	10,11,12	
4.3 Signs of Turbidity in Seepage Water	N/A		
4.4 Discoloration / Staining	N/A		
4.5 Outlet Operating Problem (if applicable)	N/A		

INSPECTION ITEM	OBSERVATIONS/ DATA	PHOTO	COMMENTS & OTHER DATA
4.6 Other Unusual Conditions	Large mature tree in river against bank downstream of Cell 5 Historic tailings downstream of Cell 5 Earthmoving equipment observed south of Cell 1 outside Teck property boundary.	12,13 None	Tailings noted downstream near abandoned supernatant pond location, area dry at time of inspection
5. ABUTMENTS			
5.1 Seepage at Contact Zone (Abutment / Embankment)	None		
5.2 Signs of Erosion	None		
5.3 Vegetation	Mature Trees		
5.4 Presence of Rodent Burrows	None		
5.5 Other Unusual Conditions	None		
6. RESERVOIR		1,5,7,9,16,19,20,21,22,27	Small pond in Cell 4 at time of inspection
6.1 Stability of Slopes	N/A		
6.2 Distance to Nearest Slide (if applicable)	N/A		
6.3 Estimate of Slide Volume (if applicable)	N/A		
6.4 Floating Debris	N/A		
6.5 Other Unusual Conditions	Plugged decant tower inlet in Cell 5	15	Tower inlet filled in 2016
7. EMERGENCY SPILLWAY / OUTLET STRUCTURE	Outlet to environment at Cell 3	23,24	
7.1 Surface Condition	Alluvial cobbles, original ground		
7.2 Signs of Erosion	N/A		
7.3 Signs of Movement (Deformation)	N/A		
7.4 Cracks	N/A		
7.5 Settlement	N/A		
7.6 Presence of Debris or Blockage	None		
7.7 Closure Mechanism Operational	N/A		

INSPECTION ITEM	OBSERVATIONS/ DATA	PHOTO	COMMENTS & OTHER DATA
7.8 Slope Protection	None		
7.9 Instability of Side Slopes	None		
7.10 Other Unusual Conditions	Interior spillways: From Cell 5 to 4 From Cell 4 to 3	19	
8. INSTRUMENTATION			
8.1 Piezometers	none functioning		
8.2 Settlement Cells	None		
8.3 Thermistors	None		
8.4 Settlement Monuments	None		
8.5 Accelerograph	None		
8.6 Inclinometer	None		
8.7 Weirs and Flow Monitors	None		
8.8 Data Logger(s)	None		
8.9 Other	None		
9. DOCUMENTATION			
9.1 Operation, Maintenance and Surveillance (OMS) Manual 9.1.1 OMS Manual Exists	Yes		SP&P BEA-OMS-001.V002
9.1.2 OMS Manual Reflects Current Dam Conditions	Yes		
9.1.3 Date of Last Revision	16 February 2018		
9.2 Emergency Preparedness Plan (EPP) 9.2.1 EPP Exists	Yes		SP&P BEA-EPRP-001.V0002
9.2.2 EPP Reflects Current Conditions	Yes		
9.2.3 Date of Last Revision	22 February 2018		

10. NOTES

No significant changes since 2017 DSI.

Required work based on inspection:

- Removal of tree in West Kettle River at downstream of Cell 5.
- Remove mature trees on Cell 3 crest.
- Tailings on site to be characterized to quantify risk of migration out of facility.

APPENDIX C

Available Cross-Sections

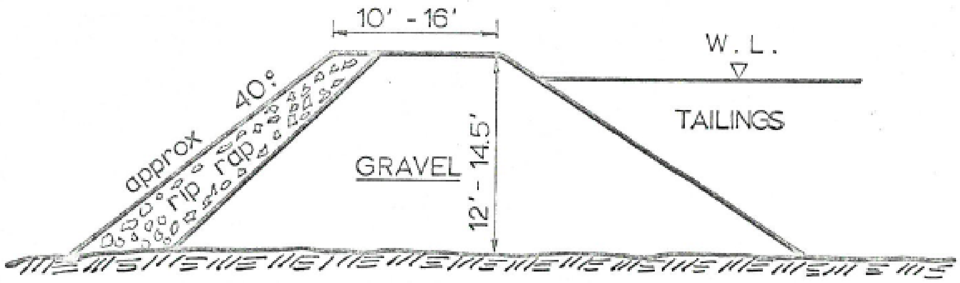


FIG. A

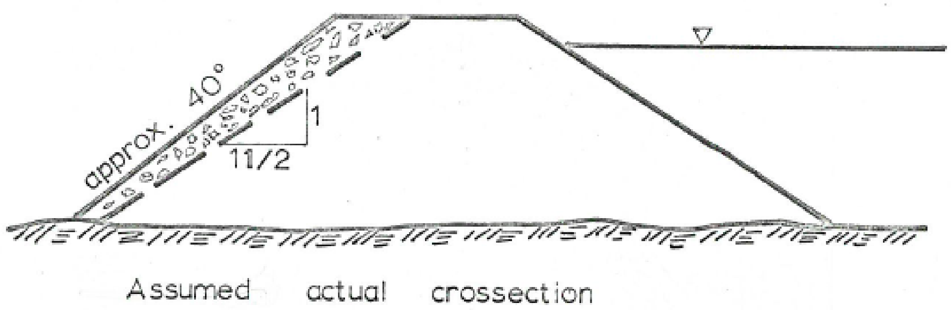
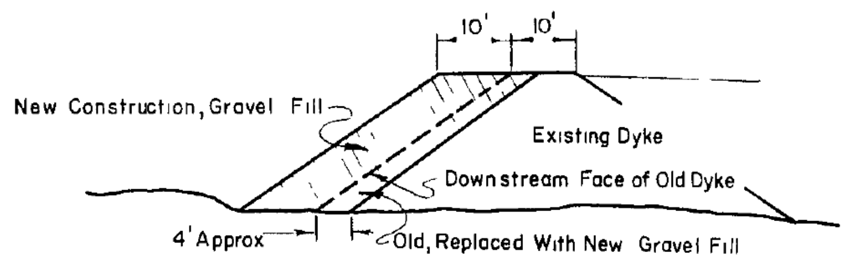


FIG. B

REFERENCE: BINNIE (ROBERT F. BINNIE LTD.). 1971. REPORT ON STABILITY OF TAILINGS DAM. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 8 JUNE 1971.

TYPICAL SECTION Y-Y

SCALE 1" = 20' Approx



REFERENCE: BINNIE (ROBERT F. BINNIE LTD.). 1973. REPORT ON PROPOSED NEW TAILINGS CELL. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL

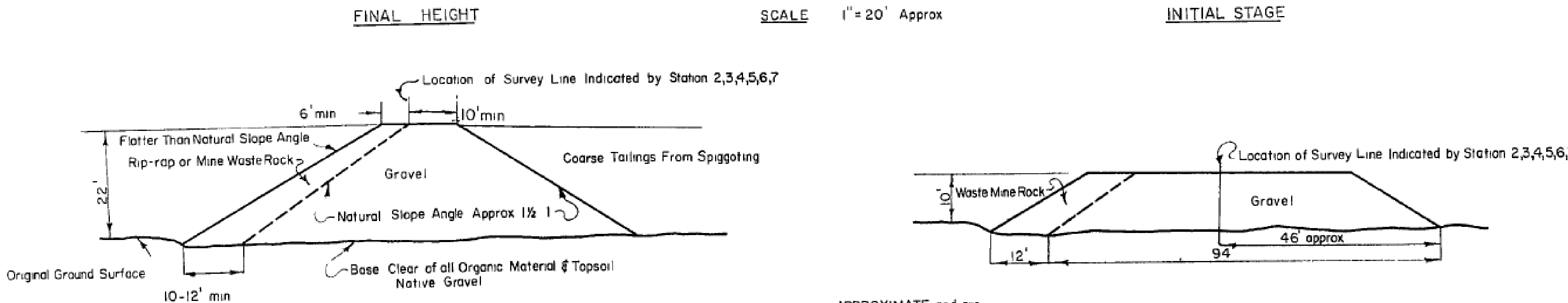
CLIENT **TECK RESOURCES LIMITED BEAVERDELL MINE BEAVERDELL, B.C.**	PROJECT **BEAVERDELL MINE 2018 DAM SAFETY INSPECTION**

CONSULTANT		
GOLDER	YYYY-MM-DD	2019-MAR-26
	PREPARED	ZS
	DESIGN	ZS
	REVIEW	MBW
	APPROVED	JCC

TITLE
CELL 4 CROSS SECTIONS

PROJECT No.	PHASE No.	Rev.	FIGURE
18100805	**4000**	**0**	**C-1**

TYPICAL SECTION X-X AT FINAL HEIGHT & INITIAL CONSTRUCTION STAGE



NOTE Dimensions are APPROXIMATE and are only for the highest section. Dimensions should be decreased accordingly where the ultimate height will be less. Slopes remain constant

REFERENCE: BINNIE (ROBERT F. BINNIE LTD.). 1973. REPORT ON PROPOSED NEW TAILINGS CELL. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL

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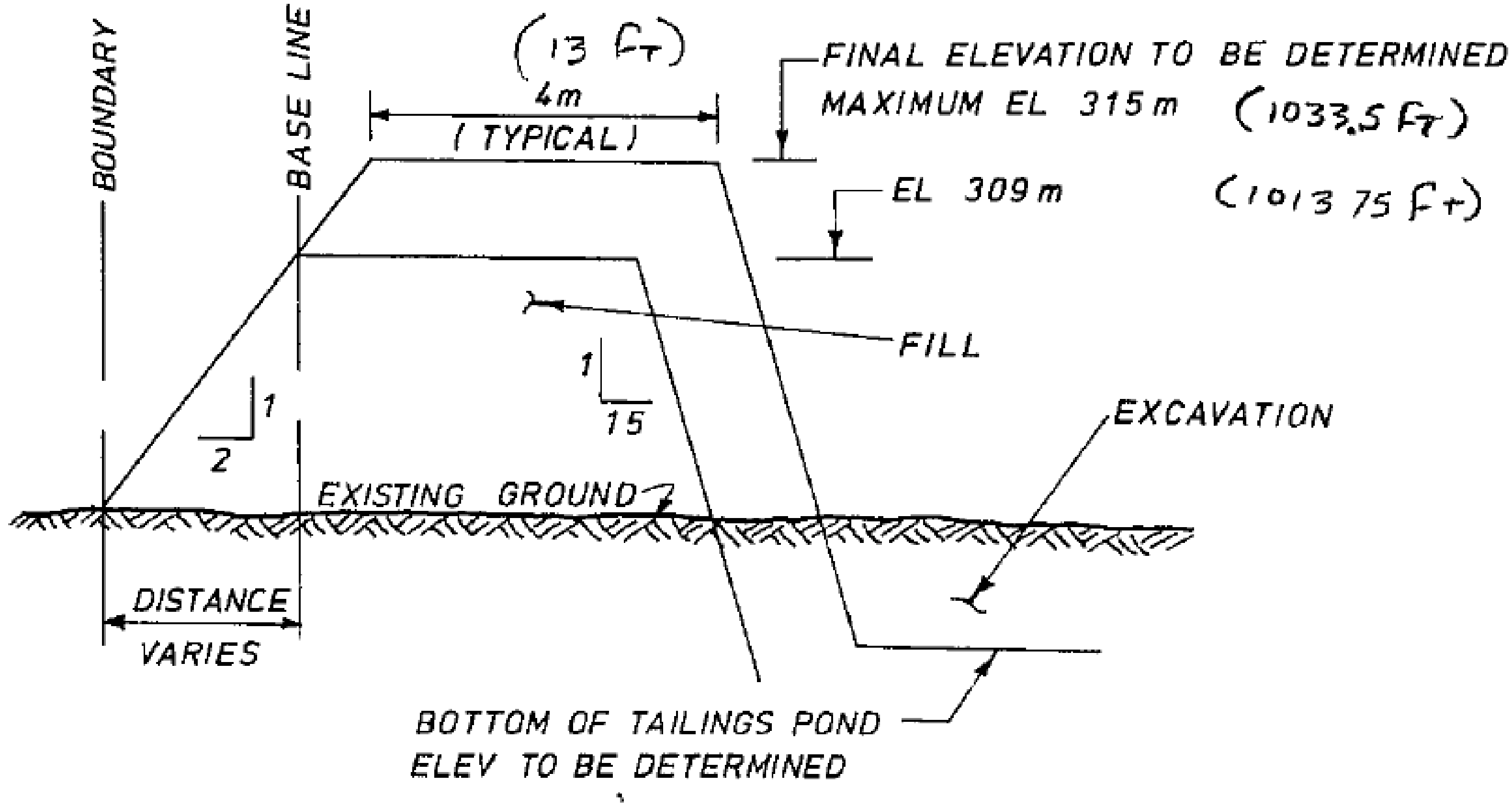
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

PROJECT
BEAVERDELL MINE
2018 DAM SAFETY INSPECTION

TITLE
DAM DESIGN FOR CELL 5
CROSS SECTIONS

PROJECT No.	PHASE No.	Rev.	FIGURE
18100805	4000	0	C-2



TYPICAL DAM CROSS-SECTION

NOT TO SCALE

REFERENCE: BINNIE (ROBERT F. BINNIE LTD.). 1980A. REPORT ON TAILINGS DISPOSAL POND NO. 5 AND PROPOSED POND NO. 6. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 20 FEBRUARY 1980.

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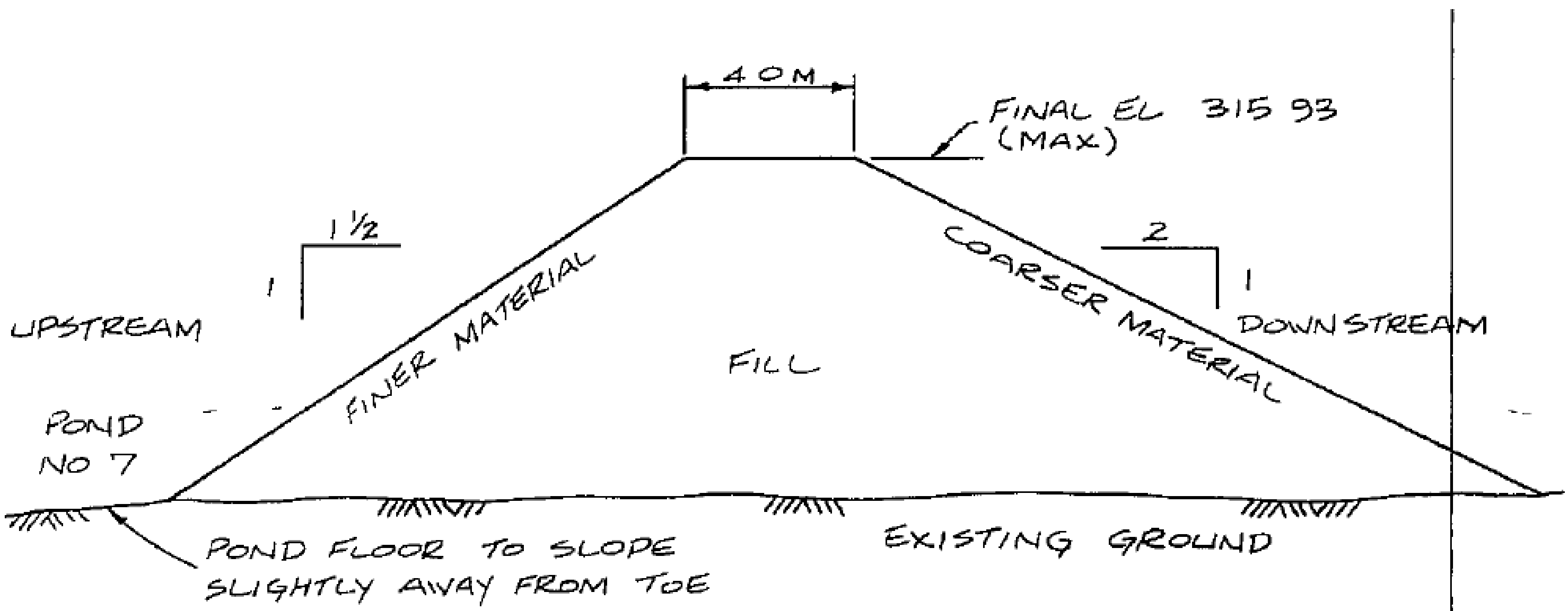
TITLE
DAM DESIGN FOR CELL 6
CROSS SECTIONS

PROJECT No.	PHASE No.	Rev.	FIGURE
18100805	4000	0	C-3



SECTION A-A

REFERENCE: BINNIE (R.F. BINNIE & ASSOCIATES LTD). 1988. REPORT ON PROPOSED POND NO. 7. REPORT PREPARED FOR TECK CORPORATION, BEAVERDELL, BC. SUBMITTED APRIL 1988.

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PROJECT
BEAVERDELL MINE
2018 DAM SAFETY INSPECTION

TITLE
DAM DESIGN FOR CELL 7
CROSS SECTIONS

PROJECT No.	PHASE No.	Rev.	FIGURE
18100805	4000	0	C-4

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