REPORT

Beaverdell Tailings Storage Facilities

2019 Annual Dam Safety Inspection

Submitted to:

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Executive Summary

This report presents the 2019 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 requirements of the most recent version of Teck's Guideline for Tailings and Water Retaining Structures (Teck 2019a).

The DSI is based on a site visit carried out on 10 July 2019 by the Engineer of Record (EoR) team from Golder, and a review of data provided by Teck. The reporting period for the data review was 1 September 2018 through 31 August 2019 unless otherwise noted. Over this reporting period, Teck inspected the facility three times:

- fall routine inspection on 22 November 2018
- spring routine inspection on 11 June 2019
- DSI inspection on 10 July 2019, accompanied by Golder

Construction and maintenance during the 2018/2019 reporting period included:

- removal of a large uprooted tree in the West Kettle River (WKR) on 10 October 2018 and flood debris from right bank of the WKR adjacent to Cells 3, 4, and 5
  - tree was originally observed following high water flows in the WKR in spring 2018
- felling of trees on the Cell 3 dam crest and downstream slope on 25 and 26 January 2019
- stockpiling of emergency riprap at the toe of Cells 4 and 5 and adjacent to the baseball field in April 2019
  - stockpiled riprap was used for the armouring of the Cell 4 and 5 riverbank in December 2019
  - stockpiling of additional riprap material was commenced in early January 2020
- remediation and as-built survey of the South TSF Cell 3 spillway on 3 and 4 July 2019, following initial construction works in August 2018

Water quality sampling visits are generally completed 4 times per year. Four water quality sampling visits along, with resultant analyses, have been completed in the 2018/2019 reporting period.

The latest topographic plan for the facilities was developed using LiDAR survey data collected 19 July 2018 with elevations referenced to the 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. There are two TSFs at the site, the South TSF and the North TSF. Both TSFs have been inactive for 28 years since the mine was permanently closed in 1991.

The South TSF includes five tailings storage cells (Cells 1 to 5) and the North TSF includes two cells (Cells 6 and 7). The South TSF Cell 5 embankment and the North TSF Cell 6 and 7 embankments 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, however visual observations of the facilities appear to indicate that the construction of the Cell 5, 6 and 7 embankments are consistent with available design reports.

The South TSF Cell 4 embankment is assumed to have been constructed in a similar manner to Cells 5 to 7 using earthfill and the downstream construction method. External embankments forming Cells 3 to 5 were constructed downstream of Cells 1 and 2; however, a portion of Cell 1 is retained by an external embankment. Design and construction record reports for Cells 1 to 4 are not available. Site investigations are planned for 2020 to assist with the determination of dam construction materials and methods (Recommendation 2017-02).

Summary of Key Hazards and Consequences

A required component of the annual DSI is a review of the credible failure modes and consequences. The facility dam safety assessment for the Beaverdell TSFs was completed based on site observations and data review for each of the credible dam failure modes.

An annual review of the Beaverdell risk register was completed by Teck on 8 January 2019 with input from the EoR.

Internal Erosion

The Beaverdell TSFs have been inactive without the deposition of waste materials or water for 28 years. Small, shallow ponds are occasionally present in Cells 4 and 6. Minor ponding, 40 m from the upstream crest, was observed in Cell 4 during the spring routine inspection, by Teck, on 11 June 2019. No ponding was observed during the fall routine inspection, by Teck, on 22 November 2018 or the DSI inspection, by Golder and Teck, on 10 July 2019. A cone penetration testing program completed in July and August 2018 (Golder 2019a) indicated generally unsaturated conditions with some limited zones of saturation. Data interpreted from cone penetration 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 cone penetration testing data collected adjacent to the dams.

A supernatant pond historically existed downstream of the southwest corner of Cell 5, where it is understood the decant tower outlet exited the cell during operations (Binnie 1980c). The decant pipe outlet is not currently visible in the downstream area of Cell 5. During previous inspections, tailings were observed in the area downstream of Cell 5 which could be related to the decant outlet. The vertical portion of the Cell 5 decant pipe has been plugged. The location and alignment of the horizontal portion of the Cell 5 decant pipe should be determined (Recommendation 2019-01).

No seepage at the Cell 6 or Cell 7 decant pipe outlets was noted during the July 2019 inspection, although a small accumulation of water was observed at the outlet structure of the Cell 6 decant. Concentration of water in this structure may lead to water chemistry readings exceeding permit requirements. It is recommended that this outlet structure be decommissioned (Recommendation 2019-04).

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. The likelihood of a dam failure of the North TSF through internal erosion is considered to be close to non-credible[1]. Due to the lack of tailings beach between areas of potential ponding within Cells 3 and 4 and the embankment the likelihood of a dam failure of the South TSF through internal erosion is considered to be rare[2].

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). The South TSF routes surface water to Cell 3 where it can exit the facility through a spillway, sized to convey the 24-hour peak maximum flood. The likelihood of overtopping for the North TSF and South TSF is considered to be close to non-credible[1] to very rare[3].

Instability

Visual inspection during the July 2019 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 condition of the dams has remained generally unchanged from previous site visits. No seepage or signs of uncontrolled past seepage were identified during the site visit. The dam slopes were observed 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 2017, 2016, respectively). 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 met or exceed design requirements under the HSRC Guidance Document (Ministry of Energy and Mines 2016) and the Canadian Dam Association (CDA 2013) Dam Safety Guidelines, which is consistent with visual observations.

Mature trees, observed on the crest and downstream slope of the Cell 3 dam during the 2018 DSI site visit (Golder 2019b), had the potential to reduce the facility freeboard in the event of uncontrolled felling, such as by high winds or disease. These trees were removed by Teck on 25 and 26 January 2019.

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1 Close to non-credible likelihood: For a natural hazard (earthquake, flood, windstorm, etc.): the predicted return period for an event of this strength / magnitude is greater than 1 in 10,000 years. Also, for failure modes such as instability and internal erosion that are close to non-credible.

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

3 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.

A number of dead trees were identified at the toe of the Cell 5 dam at the South TSF during the July DSI site inspection. Uncontrolled felling of these trees could lead to damage of the dam and should be removed (Recommendation 2019-02).

During the July 2019 site visit, soft ground was observed at the downstream toe of the Cell 3 dam, north of the Cell 3 spillway, with felled trees, from the 25 and 26 January 2019 work, placed in this area. Discussions with Teck staff indicated that these trees were placed to provide platforms for equipment during the tree felling work, as a result of soft ground. In addition, a review of the draft borehole log for monitoring well MW18-03 (Wood 2019), indicated an approximately 0.8 m thick layer of dark brown, low plasticity, damp silt approximately 0.15 m below ground surface. Topographic contours also indicate that the tailings surface slopes towards the dam with deposition from the west, i.e., prior to the use of spigot deposition of tailings from the dam. These conditions may be indicative of tailings deposition in Cell 3 prior to the construction of the Cell 3 embankment (i.e., tailings and water were not contained), similar to conditions observed for Cells 1 and 2. Tailings may therefore be present in the foundation of the Cell 3 embankment which could pose a risk to the stability of the dam in this section of the South TSF, and should be investigated (Recommendation 2019-03). Similar conditions were not observed at the remainder of the South TSF and at the North TSF. The likelihood of instability for the North TSF and South TSF is considered to be close to non-credible (drained condition) to unlikely[4] (seismic loading condition).

Erosion of Facility Toe from West Kettle River

Based on a review of data from the hydrometric stations at McCulloch (upstream of Beaverdell TSFs) and Westbridge (downstream of Beaverdell TSFs), there was no flooding of the WKR in the area of the Beaverdell TSF in the reporting period. No new significant erosion of the riverbank or historically installed riprap material was noted during the routine inspections by Teck in fall 2018 and spring 2019 or by Golder during the 2019 DSI site visit.

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. Following the 2018 WKR high water event, the river geomorphology was observed to have significantly altered, as a result the assumptions and parameters adopted in the design of the riprap in 2015/2016 were considered to be no longer valid.

A revised design for armouring of the Cell 4 and 5 riverbank for up to a 1:200-year flood event was completed in 2019 (Golder 2019f and 2019g), permitting for construction in Q4 2019 was also undertaken (Recommendation 2018-03b). Construction commenced in November 2019 and continued up to a shutdown on 21 December 2019 due to winter conditions. Additional permitting is required in 2020, in progress at the time of this report, to allow for construction to complete armouring works in 2020.

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4 Unlikely: For a natural hazard (earthquake, flood, windstorm, etc.): the predicted return period for an event of this strength / magnitude is between 1 in 10 and 100 years.

A flood response protocol including trigger action response plan (TARP) was in draft format (Teck 2019b) and in the process of being finalized at the time of this report. This document provides guidance on preparing for and response to flooding of the WKR. Stockpiling of emergency riprap at the toe of Cells 4 and 5 and adjacent to the baseball field was completed in April 2019 as part of flood preparation works for freshets in 2019. Stockpiled riprap was used for the armouring of the Cell 4 riverbank in December 2019, the importation and stockpiling of additional riprap material was commenced in early January 2020. The likelihood of external erosion for the North TSF is considered to be very rare. The likelihood of external erosion for the South TSF during the reporting period, prior to the design and initial construction of riprap, was considered to be possible[5] based on previous observed flooding of the WKR. Following the completion of the ongoing construction of riprap, for an event up to and including the 1:200-year flood, along the toe of the South TSF the likelihood is expected to reduce to rare.

Dam Consequence Classifications

Dam consequence classification is based on the potential consequences of a hypothetical 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 (*Rhinichthys osculus*). The classification of this habitat as critical by others has the potential to increase the consequence classification of the North and South TSFs based on the consequence classification guidelines (CDA 2013) and a review of the consequence classifications is recommended (Golder 2019d), (Recommendation 2018-02).

Summary of Key Observations and Significant Changes

The Beaverdell TSFs were in good condition at the time of the 2019 site inspection.

Dam condition, maintenance, and surveillance of the facility were reviewed through site observation and discussion with Teck personnel. The 2019 annual DSI report and photographs were prepared for the South and North TSF dams based on observations during the 10 July 2019 site inspection.

No significant changes in visual monitoring records or dam stability were noted during the 2019 DSI for the South and North TSFs at the Beaverdell site. There is no functional geotechnical instrumentation installed at the Beaverdell TSFs. Quantifiable performance objectives have been established for surface water conditions (temporary ponding) and are presented in this DSI.

[5] Possible: For a natural hazard (earthquake, flood, windstorm, etc.): the predicted return period for an event of this strength / magnitude is between 1 in 5 and 10 years.

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). This OMS manual was prepared to meet guidelines provided by the HSRC Guidance Document (Ministry of Energy and Mines 2016), the CDA (2013), the Mining Association of Canada (MAC 2011, 2017), and Teck (2014).

An update of the OMS manual is planned for Q1 2020 to reflect staff changes at the TSF and to meet revised guidelines provided by MAC (2019a,b) and Teck (2019a). A flood response protocol including TARP is currently in development for the TSFs (Teck 2019b). The flood response protocol and TARP should be finalized and added to the OMS, as per the amended Mines Act Permit M-71, 4 October 2019 (Recommendation 2018-03b).

The water management plan for the facility is out of date and should be updated (Recommendation 2018-04).

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 was prepared to meet guidelines provided by the HSRC and HSRC Guidance Document (Ministry of Energy and Mines 2016, 2017, respectively), CDA (2013), MAC (2011, 2017), and Teck (2014).

An update of the EPRP was in progress at the time of this report, including incorporation of the TSF EPRP into a mine emergency response plan for the Beaverdell Mine (Teck 2019c). Updates will reflect staff changes at the TSF and revised guidelines provided by MAC (2019a,b) and Teck (2019a). A tabletop exercise to test the EPRP was conducted on 17 December 2018.

The hypothetical failure of the Beaverdell TSF’s are not considered to present a potential for loss of life, 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.

Dam Safety Review

The last dam safety review for the Beaverdell TSFs was conducted in 2012 (Golder 2013). At that time it was recommended that the next DSR be completed within ten years. However, based on the post-2016 requirement of the HSRC (Ministry of Energy and Mines 2017) the next dam safety review should be undertaken by 2021.

Summary Table of Deficiencies and Non-conformances

Deficiencies / non-conformances and recommended actions are presented in Table E-1, which includes an update of the status, as of March 2020, of Recommended Actions from the 2018 DSI.

Table E-1: Table of Deficiencies and Non-conformances and Status Update of Previous DSI Recommendations

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Status, as of March 2020, and 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.	Permit PE-444	Collect tailings samples for geochemical testing and initiate the geochemical laboratory testing program in 2020. Develop a contingency protocol (with Trigger Action Response Plan) to be implemented in the event that discharge through the spillway occurs.	3	**In Progress** Site geochemical investigation program is in development. Tailings samples will be collected in 2020 for geochemical analysis. A contingency plan will be developed as part of the OMS Manual updates in 2020. End Q4 2020
South TSF	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	**Closed** Completed 4 July 2019
South TSF	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 riverbank 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. *Updated to:* *Finalize flood response protocol for the West Kettle River including the trigger action response plan prior to 2020 freshet.*	2	**In Progress** Riprap stockpiled on 12 April 2019 (used for riprap construction works in December 2019). Additional riprap stockpiled in January 2020 as part of riprap construction preparations for 2020. Finalization of flood response protocol in progress End Q2 2020
				Assess short-term and long-term requirements for riprap based on changes in river hydrology and flood statistics.	3	**In Progress** Design for riprap up to a 1-in-200-year event complete, permitting for 2019 construction complete. 2019 riprap construction works carried out. Permitting is in progress and required in 2020 to allow for construction to complete armouring works in 2020. Document long-term plan to mitigate risk of erosion along the toe of Cell 4 and 5 End Q3 2020
South TSF	2019-01	The location and alignment of the Cell 5 decant pipe are unknown.	OMS §5.5	Determine the location and alignment of the outlet of the Cell 5 decant	3	**New** End Q2 2023
South TSF	2019-02	Dead trees along the toe of the Cell 5 dam.	OMS §5.5	Remove dead trees along the toe of the Cell 5 dam as part of clearance works for the installation of riprap in 2020 (see 2018-03b).	3	**New** End Q3 2020
South TSF	2019-03	Reviewed data, including observed conditions during the removal of trees in 2019, could indicate the possibility of tailings in the foundation of the Cell 3 embankment. Foundations may be prone to liquefaction in a seismic event potentially leading to failure.	HSRC §10.1.4	Investigate the toe area and foundation of the Cell 3 dam for the presence of tailings or other soft, loose soils.	2	**New** Test pits excavated during March 2020 Phase 1 geotechnical site investigation, report is in preparation. End Q2 2020
North TSF	2019-04	The outlet structure of the Cell 6 decant accumulates a small quantity of water behind a metal weir, which may affect water chemistry when sampled.	OMS §5.5	Review collected water quality data to determine source of the accumulated water. Assess opportunity for maintaining the collection point to inform ongoing geochemistry studies. Consider upgrading to remove steel as a potential source of water contamination. Decommission the outlet structure if deemed of no value.	3	**New** End Q2 2023

Table E-1: Table of Deficiencies and Non-conformances and Status Update of Previous DSI Recommendations

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Status, as of March 2020, and Recommended Deadline
South and North TSF	2016-03	Facility phreatic conditions not confirmed.	CDA 2013 §6.6 HSRC §10.1.4 (3)	Execute the planned drilling program to gather subsurface information and install piezometers.	3	**In Progress** Phase 1 Site investigation executed in March 2020, piezometers were installed and connected to remote monitoring system, which needs to be programmed with installation details. End Q2 2020
	2016-05 a, b	Closure plan not updated.	HSRC §10.4.1	Complete the planned Phase 1 geotechnical investigation of to inform the development of an updated closure plan. Execute the planned geochemical site investigation and testing program. Teck should collect tailings samples for geochemical testing and initiate the geochemical laboratory testing program in 2020 (See 2016-01).	4	**In Progress** Site investigation programs in development. Phase 1 geotechnical site investigation commenced in March 2020. Geochemical characterization in progress. End Q2 2023
				Update the closure plan.	4	**Not Started** End Q2 2023
	2017-02	No dam breach and inundation study completed.	HSRC §10.1.11	Complete the planned Phase 1 geotechnical investigation of to inform the development of a dam breach and inundation study. Complete a dam breach and inundation study.	3	**In Progress** Phase 1 geotechnical site investigation executed in March 2020. Dam breach and inundation study scope in preparation. End Q4 2020
	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 (2019d).	3	**Not Started** End Q4 2020
	2018-04	Water management plan is out of date.	HSRC §10.4.1 (3)	Update the existing water management plan.	4	**Not Started** End Q4 2020

CDA = Canadian Dam Association; HSRC = Health, Safety and Reclamation Code; ID = identification; IDF = inflow design flood; 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)
IDF	inflow design flood
n/a	not applicable
OMS manual	operation, maintenance, and surveillance manual
QPO	quantifiable performance objective
PMF	probable maximum flood
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
t	tonne

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, and Methodology

As requested by Teck Resources Limited (Teck), Golder Associates Ltd. (Golder) prepared this 2019 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. This revision (Rev.) 1 version of this report supersedes the previously issued Rev 0. version.

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 requirements of the most recent version of Teck's Guideline for Tailings and Water Retaining Structures (Teck 2019a). It is understood that this report will be submitted by Teck to the Chief Inspector of Mines for British Columbia.

This report is based on a site visit carried out by the Engineer of Record (EoR) on 10 July 2019, which included a walkover of the TSF areas with Teck staff involved in the maintenance and surveillance of the dams. This report consists of the following key components:

- a summary of the site conditions and background information
- a summary of the activities for the 2018/2019 reporting period
- dam consequence classification and required operational documents review
- site photographs and records of TSF inspection
- review of
  - climate data
  - water balance
  - dam safety relative to potential failure modes
- findings and recommended actions

A TSF data sheet for each facility is presented in Appendix A. Photographs of the TSF areas are presented in Appendix B. A summary of observations for each TSF during the 10 July 2019 DSI site visit are included in the inspection reports presented in Appendix C.

The previous annual DSI site visit for these facilities was carried out in June 2018 and is reported in the 2018 annual DSI report (Golder 2019b).

This report is to 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: Jason McBain, P.Eng., 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, Amended 12 December 2019
- *Mines Act* – Permit No. M-71, amended 4 October 2019

Additional permits are required for specific projects at Beaverdell, such as West Kettle River (WKR) erosion protection installation downstream of Cell 4 and Cell 5 of the South TSF.

1.3 Facility Description

The Beaverdell Mine was an underground mine development adjacent to the community of Beaverdell, BC, which is located 87 km south of 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 28 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 North and South TSFs. 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 infrastructure related to the TSFs, along with locations of representative cross-sections. 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. 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 personnel have undertaken the EoR role 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 slope of the WKR valley, and as a result, no dam was required on the north and west sides of Cell 3, and the west side of Cell 2. The main perimeter dam of the South TSF is along the west side of Cell 1, south of Cell 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,, however visual observations of the facilities appear to indicate that the construction of the Cell 5 embankment is consistent with the available design report.

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

The downstream slopes of the Cell 4 and 5 dams are covered with trees.

A ditch along the road to the west of the South TSF area (Beaverdell Station Road, Figure 3) directs surface water runoff from Cranberry Ridge away from the facility (Golder 2019c). As a result, the catchment area 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 on the tailings surface.

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 11, Appendix B, and its approximate location is shown in Figure 3. This decant tower was sealed with foam in 2016.

A supernatant pond historically existed downstream of 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 the area downstream of Cell 5. These 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 dams is unknown on the upstream side of the embankments, but the downstream slopes can be determined from survey data. A portion of the tailings deposited in Cell 1, and all the tailings deposited in Cell 2 appear to be from deposition with limited control of runoff of solids and water (i.e., tailings solids and water was not contained behind a dam). This contrasts with Cells 4, and 5, where tailings and water were contained behind the South TSF dams. Observations during the 2019 inspection and a review of available data (Section 5.3.3) indicate that tailings may have been deposited in Cell 3 prior to the construction of the embankment (i.e., the dam may be constructed on tailings).

The dimensions of each cell are shown in Table 1 and are approximate. The existing crest length excludes the divider dykes between cells; it is only the exterior 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	1 to 5(c)	2 to 3	781.1
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 and water were not contained).

(c) An earthfill berm, approximately 1 m wide, was constructed upstream of the Cell 3 dam as part of spillway remediation in 2019 to provide freeboard. This berm forms a portion of the Cell 3 dam.

n/a = not applicable.

1.3.1.2 Dimensions of South Tailings Storage Facility Spillways

Dimensions of the internal 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 base width of 3 m, a minimum depth of 1 m, lateral slopes of 2H:1V, and an invert elevation of approximately 784.5 m. It is trapezoidal in shape, partially riprap-armoured, and allows the conveyance of surface water from Cell 4 to Cell 3 (Photograph 15, Appendix B).

The small, partially riprap-armoured spillway through the Cell 4/5 divider dyke has a base 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 785.0 m.

The Cell 3 external spillway, which conveys surface water from the South TSF, was upgraded in August 2018 and remediation works (Section 2.7) completed on 4 July 2019 (Photographs 17 and 18, Appendix B). Based on the construction record (Golder 2019e) the Cell 3 spillway has a minimum base width of 13.6 m at the invert, a longitudinal slope of 5H:1V, and an invert elevation of 780.4 m. It is trapezoidal in shape and armoured with Class 50 riprap, minimum 0.66 m thick. The spillway is capable of conveying the 24-hour probable maximum flood (PMF).

1.3.1.3 Storage Capacity of South Tailings Storage Facility

The storage capacity of Cells 1, 2, 4, and 5 was calculated in AutoCAD Civil3D as part of the 2018 DSI (Golder 2019b) using topography from the July 2018 LiDAR survey. The storage capacity of Cell 3 was calculated in AutoCAD Civil3D using topography from the July 2018 LiDAR survey and 4 July 2019 spillway construction record survey. Storage was assumed to be available from the tailings surface elevation to the lowest spillway invert 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 2019a).

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 7,400 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 and remediation 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 consequence of potential tailings migration due to flood transport is not quantified and should be investigated (Recommendation 2016-01).

The calculated storage and tailings volumes, and the destinations of overflow discharge, are presented in Table 2.

Table 2: South Tailings Storage Facility Cell Storage Capacities

Cell	Storage Volume (m^3)	Storage to Elevation[(c)]	Overflow Discharged To	Estimated Volume of Stored Tailings (m^3)[(d)]
1[(a)]	0	n/a	Cell 5	27,000
2[(a)]	0	n/a	Cell 4	18,000
3[(b)]	0	n/a	downstream of Cell 3 (via spillway)	192,000
4[(a)]	7,400	784.5	Cell 3	165,000
5[(a)]	14,500	785.0	Cell 4	142,000
Total	**21,900**	n/a	n/a	**544,000**

(a) Based on 2018 LiDAR Survey.

(b) Based on 2018 LiDAR Survey and 2019 Cell 3 Spillway Construction record.

(c) Elevation in CGVD2013. Freeboard not considered.

(d) Golder (2019a).

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 slope of the WKR valley. 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 without a dam.

The North TSF Cell 6 and 7 dam was 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, however visual observations of the facilities appear to indicate that the construction of the Cell 6 and 7 embankments are consistent with available design reports.

The downstream slopes of the dam are covered with trees.

Cell 6 is contained by a dam on the north, east, and south side and by an internal divider dyke (with Cell 7) on the west side. As a result, the catchment area of Cell 6 is limited to the surface area of the facility. Cell 6 has the capacity to store the inflow design flood (IDF) event (1/3 between the 1-in-975-year flood event and the PMF). In the event of flood flows larger than the IDF, water in Cell 6 is assumed to overflow the divider dyke between Cell 6 and 7 (which has a crest elevation approximately 0.5 m lower than the Cell 6 dam) and report to Cell 7.

A ditch along Cranberry ridge to the west of the North TSF area (Figure 3, Photographs 39 and 40, Appendix B) directs surface water runoff to the north and away from the facility (Golder 2019c). This ditch is divided in two reaches, as described in (Golder 2019c):

- Reach 1 – Southern most section of the diversion (approximately 115 m long)
  - cannot convey the IDF and flows would enter Cell 7 during an IDF flood event
- Reach 2 – Northern most section of the diversion (approximately 110 m long)
  - capable of conveying the 24-hour PMF event, which exceeds the IDF

As a result, the catchment area of the North TSF, in an IDF event, consists of the surface area of the facility plus a 90,000 m^2 area of external catchment. Cell 7 has the storage capacity to store the IDF event. Water can also discharge via the Cell 7 spillway south of the TSF (Photograph 34, Appendix B).

The decant towers in the North TSF, which originally managed pond water, have been sealed (Golder 2014b). The diameter of each of the decant tower pipes was estimated at 0.2 m (i.e., 8 inches). The locations of the 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 divider dyke between the cells; it is only the dam length. Cross-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)
6	1.4 to 1.9H:1V	1.5H:1V (assumed from original design)	510	3 to 4	10 to 12	797.5
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. Tailings in Cell 7 are between 6 and 7 m below the dam crest.

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 base width of approximately 2 m, a depth of approximately 2 m below the dam crest, side slopes of 4H:1V, and an invert elevation of approximately 797.0 m. There are no construction records for this spillway. There is no constructed channel in the divider dyke between Cells 6 and 7; however, survey data indicates the maximum elevation of the divider dyke (797.0 m) is 0.5 m lower than the minimum elevation of Cell 6 (797.5 m).

1.3.2.3 Storage Capacity of North Tailings Storage Facility Dam

The storage capacity of Cells 6 and 7 was calculated in AutoCAD Civil3D as part of the 2018 DSI (Golder 2019b) using topography from the July 2018 LiDAR survey. Storage was assumed to be available from the tailings surface elevation to the minimum elevation of the divider dyke and the Cell 7 spillway invert elevation (both at 797.0 m).

From the 2018 CPT investigation (Golder 2019a), it was estimated that the North TSF currently stores approximately 384,000 m^3 of tailings.

Calculated storage and tailings volumes, and the destination 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	Estimated Volume of Tailings Stored (m^3)[(b)]
6	22,500	797.0	Cell 7	271,000
7	162,100	797.0	area downstream (south) of Cell 7 (via spillway)	113,000
Total	**184,600**	n/a	n/a	**384,000**

(a) Elevation in CGVD2013 vertical datum.

(b) Golder (2019a).

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 (Golder 2019a) indicated sand materials in the foundation. No samples are recovered from CPT. 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. Further site investigations are planned in 2020, including sample collection to confirm these interpretations (Recommendations 2016-03 and 2017-02).

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 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.

Additional groundwater monitoring wells were installed in July 2018 by John Wood Group PLC (Wood), and locations shown in Figure 3. Draft borehole records (Wood 2019) for these wells were reviewed by Golder in July 2019 as part of planning for geotechnical investigations. Drilling records indicate that the subsurface is predominantly sands, gravels, and cobbles. An approximately 1.2 m thick layer of clay was also encountered 0.3 m below ground surface in borehole MW18-05, located to the south of Cell 5 in a former oxbow of the WKR. This material is likely indicative of overwash materials in the former river course(s) of the WKR as well as in the WKR flood plain. In borehole MW18-03, downstream of Cell 3, and adjacent to the baseball field, an approximately 0.8 m layer of dark brown silt was encountered less than 0.2 m below the ground surface.

Topographic contours indicate that the Cell 3 tailings surface slopes towards the Cell 3 dam, which suggests deposition was from the west side and prior to the commencement of spigot discharge (as described in Section 1.4.3.1). As a result, the Cell 3 dam may have been built following the start of tailings deposition and tailings may be present in the dam foundation, this should be investigated (Recommendation 2019-03).

Data provided by Wood indicate groundwater levels in these wells ranged from 774.5 to 781.8 m (Wood 2019), 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 1.1 m and 10.4 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, however 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, waste rock spoil was placed 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, based on data from the 2018 CPT investigation (Golder 2019a), the estimated average dry density of deposited tailings is 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 [45.4 tonnes] per day that was later increased to 85 tons [77.1 tonnes] per day in 1964 and 110 tons [99.8 tonnes] per day in 1967. The mill was located to the west of the community of Beaverdell, across the WKR.

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 and Data

Known site investigations for each cell include:

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

Nine groundwater monitoring wells, outside of the North and South TSFs, were completed by Wood in 2018 (Wood 2019) (Section 1.3.3) along with a testpit in the area downstream, south, of Cell 5. Records for this testpit were not available for review by Golder as part of this DSI.

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 D. There are no design reports for Cells 1 to 3, so the original design dimensions of these cells are unknown. Dimensions of Cell 4 are based on observations and discussions with mine staff, as presented in Binnie (1971, 1973).

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 D-1
Cell 5	2H:1V	1.5H:1V	5.1	7	Binnie 1973, 1980c	Figure D-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 D.

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 D-3
Cell 7	2H:1V	1.5H:1V	4	8	Binnie 1988	Figure D-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 TSF (Cells 4 and 5) and North TSF (Cell 6 and 7) dams 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 spigot 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 design reports indicate that the design 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 to confirm the coarse tailings wedge (beach) was being created and spigot methods were observed (Binnie 1980a). Results of the 2018 CPT investigation (Golder 2019a) also indicated coarser material 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 spigot methods were observed (Binnie 1983, 1988). Results of the 2018 CPT investigation (Golder 2019a) also indicated coarser material 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

The installation details of existing piezometers are unknown, and the condition and usefulness of the piezometers are uncertain. As a result, historical piezometers at Beaverdell are considered non-functional. Installation of vibrating wire piezometers and standpipes are proposed as part of site investigations in 2020 (Recommendation 2016-03).

2.0 ACTIVITIES DURING 2019

2.1 Tailings Deposition and Storage

The Beaverdell Mine was not operational in 2019 and no new tailings or waste were deposited in either the North TSF or South TSF.

The approximate volume of tailings stored in the South TSF is presented in Table 2. The approximate volume of tailings stored in the North TSF is presented in Table 4.

2.2 Inspections

The inspection by the EoR, as part of the DSI, was conducted 10 July 2019.

The dams are inspected twice per year (during spring freshet and in the fall) by Teck personnel. The fall 2018 (22 November 2018) and spring 2019 (11 June 2019) routine inspections were completed by the TSF Qualified Person at the time, Gerry Murdoch. Inspection forms were reviewed by the EoR.

The TSF Qualified Person role was transferred to Jason McBain, P.Eng., in Q3 2019. Both Gerry Murdoch and Jason McBain participated in the 10 July 2019 inspection.

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 2018/2019 with four sampling and analysis visits completed.

2.4 Removal of Tree and Flood Debris

Following high flows in the WKR in spring 2018, a large tree along with its root mat was observed in the river adjacent to the downstream toe of Cell 5 (Golder 2019b). This tree was removed by Teck on 10 October 2018.

Flood debris from the right bank of the WKR adjacent to Cells 3, 4, and 5 was also removed.

2.5 Cell 3 Dam Crest Tree Removal

Mature trees on the crest of the Cell 3 dam, with the potential to reduce freeboard if they were felled by high winds or disease, were removed by Teck on 25 and 26 January 2019. The Cell 3 dam at the time of the 2019 inspection, following tree removal, is shown in Photograph 23, Appendix B. Trees were cut as close to the ground as safely possible, and roots left in place to avoid disturbance of the dam.

2.6 Stockpiling of Emergency Riprap

Emergency riprap was stockpiled at two locations in April 2019 (indicative locations shown in Figures 2 and 3) to provide material in case mitigation against flood risk was required during the 2019 freshet. Approximately 1,400 m^3 of Class 50 riprap was stockpiled at the toe of Cells 4 and 5 (Photograph 42) and adjacent to the baseball field east of Cell 3 (Photograph 43).

Riprap placement was not required during the 2019 freshet and stockpiled materials were used for planned construction of riverbank protection measures in December 2019 (as described in Section 5.3.4). Stockpiling of additional riprap material was commenced in early January 2020.

2.7 Remediation of Cell 3 Spillway

An upgrade to the Cell 3 spillway was designed and constructed in 2018 to pass the water volume resulting from a 24-hour PMF event as the IDF, which exceeds the requirements of HSRC (Golder 2018d). Spillway construction took place in August 2018 with the construction record survey completed in October 2018. Based on the as-constructed conditions, reviewed by the EoR, the thickness of riprap at the spillway invert exceeded design thickness. This meant freeboard during an IDF would be 0.1 m, which is less than required by the Canadian Dam Association guidelines (CDA 2013).

Spillway remediation was completed between 3 and 4 July 2019 to correct deficiencies identified by the October 2018 construction record survey and provide a spillway with the capacity to pass the 24-hour PMF event including adequate freeboard to meet CDA (2013) guidelines. A construction record survey for the remediated spillway was completed in July 2019 and confirmed the remediated spillway meets design criteria (Golder 2019e). The completion of the spillway remediation closes recommendation 2018-01.

The condition of the spillway in July 2019 (after remediation) is shown in Photographs 17 and 18 (Appendix B).

3.0 CLIMATE DATA AND WATER BALANCE

3.1 Review and Summary of Climate Data

The climate characteristics at the Beaverdell TSFs were reviewed for the reporting period (1 September 2018 to 31 August 2019, inclusive) with respect to total precipitation, the main driver of the site water balance. There were no climate data available for the Beaverdell local area for the reporting period. As such, data from nearby active regional climate stations were used. Historical data were obtained from the Beaverdell and Beaverdell North climate stations (most representative of climate at the TSFs); historical and recent data were obtained from three nearby active climate stations (Table 7). All climate stations are managed by Environment and Climate Change Canada (ECCC).

Table 7: Historical and Active Climate Station Data

Location	Period of Record	ECCC Station Number	Latitude; Longitude	Elevation[c] (m)	Distance to TSFs (km)
Beaverdell North	1975 to 2006	1130771	49°28'; 119°02’	838	11
Beaverdell	1962 to 2004	1130770	49°25'; 119°06	780	5
Billings	1984 to 2019	1140876	49°01'; 118°13’	519	90
Penticton A[a]	1944 to 2019	1126146	49°27'; 119°36'	344	37
Kelowna[b]	1968 to 2019	1123939	49°57'; 119°22'	430	62

(a) Penticton A station changed the World Meteorological Organization climate identifier from 1126150 to 1126146 on 10 May 2012.

(b) Kelowna data includes Kelowna A from 1968 to 20 January 2005 (inclusive), Kelowna AWOS from 2005 to 2 September 2009 and Kelowna 2009 to 2019. All three stations refer to the same climate station at Kelowna International Airport (YWL). Missing data is infilled with Kelowna UBCO from 16 December 2013 to 31 August 2019.

(c) CGVD2013 vertical datum to nearest 1 m.

TSFs = tailings storage facilities.

To create a more complete local data set, the Beaverdell and Beaverdell North daily total precipitation data were merged. The data set was created using the Beaverdell station, where data were available, and infilling with Beaverdell North where required. The resulting data set spans a period from 1962 to 2004. The long-term average, maximum, and minimum total precipitation for the merged Beaverdell and Beaverdell North data set are shown in Table 8. A hydrologic year (1 September to 31 August) was used for annual statistics.

Table 8: Long-Term Annual Average, Minimum, and Maximum Total Precipitation for the Merged Beaverdell and Beaverdell North Data Set (1962 to 2004)

Minimum Annual Total Precipitation (mm)	Average Annual Total Precipitation (mm)	Maximum Annual Total Precipitation (mm)
209	480	600

(a) Years excluded from the analysis due to incomplete data are 1962, 1981, 1984,1987 to 1988 and 2002.

The merged Beaverdell and Beaverdell North data set was compared to the nearby regional station data during concurrent years. This provides an assessment of the appropriateness of using the nearby stations to estimate total precipitation at Beaverdell during the reporting period. Table 9 shows the concurrent period of records between the selected active and historical stations, from 1984 to 2004, excluding years where one or more stations had an incomplete data set (i.e., 10 years of concurrent data). A hydrologic year (1 September to 31 August) was used for annual statistics.

Table 9: Concurrent Annual Average, Minimum and Maximum Total Precipitation from 1984 to 2004 (a)

Location	Minimum (mm)	Average (mm)	Maximum (mm)
Merged Beaverdell and Beaverdell North	340	490	584
Billings	453	533	622
Penticton A	215	325	412
Kelowna	218	367	504

(a) Years excluded due to incomplete data at one or more station include 1984 to 1985 (inclusive), 1987 to1989 (inclusive), 1993 to 1997 (inclusive), and 2002.

The development of a relationship between station data and elevation was considered for estimating the total precipitation at Beaverdell for the reporting period. The long-term precipitation averages for the selected regional stations (Billings, Penticton A, Beaverdell, Beaverdell North, and Kelowna) were analyzed against their respective station elevations to assess whether a regional orographic trend could be established for Beaverdell. The derived statistical relationship was deemed unacceptable and was not applied to the climate review presented in this report. An improved statistical relationship could be determined by assessment of additional regional stations, snow surveys, and extracted data sets. An update of the site water management plan, including baseline hydrology report is recommended (Recommendation 2018-04).

The data in Table 9 indicate that there is a similar ratio between minimum/maximum and average recorded annual total precipitation between Beaverdell, Billings, Penticton A and Kelowna. This suggests similar annual total precipitation trends between these locations. As such, the use of nearby active station data to estimate total precipitation at Beaverdell during the DSI reporting period provides a reasonable approach considering the availability of local climate data.

A summary of available total precipitation data at the active stations during the reporting period include:

- Billings
  - 52 days missing from the data set.
  - Notable gaps from January to February (inclusive).
    - Due to the incomplete data set, Billings was not included in the estimation of total precipitation at Beaverdell for the 2018/2019 reporting period.
- Penticton A
  - Complete record of observations for reporting period (i.e., no days of missing data).

- Kelowna
  - 16 days of missing data.
  - Notable gaps in September (8 days missing) and October (6 days missing) 2018.
  - Infilling of missing Kelowna station data with daily total precipitation from the Kelowna UBCO (ID 1123996) station, approximately 1.5 km away, was adopted to create a more complete data set. An adjustment factor was derived based on the elevation difference between the two stations and was applied to the Kelowna station on days where data were missing.

The total precipitation at the Penticton A and Kelowna stations during the reporting period was compared to the respective long-term average total precipitation. Table 10 shows the results of this comparison. The relative difference measured at each station was compiled and an average percentage difference in total precipitation was determined.

Table 10: Comparison of Long-Term Average Total Annual Precipitation to 2018/2019 DSI Reporting Period at nearby Active Climate Stations

Location	Long-Term Average Total Annual Precipitation (mm)	Total Annual Precipitation in DSI Reporting Period (mm)	Percent Difference (%)
Penticton A	322	287	-11
Kelowna[(a)]	343	222	-35
		Average Percent Difference	**-23**

(a) Kelowna station total precipitation data was infilled with Kelowna UBCO station data from December 2013 to 31 August 2019.

DSI = dam safety inspection.

The average annual percent difference (-23%) was applied to the merged Beaverdell and Beaverdell North long-term data set to estimate a total precipitation for the reporting period at the TSFs. Applying the correction factor to the long-term average total precipitation at Beaverdell results in an estimated total annual precipitation of 369 mm for the period 1 September 2018 to 31 August 2019.

The monthly total precipitation at Beaverdell during the reporting period was estimated using the same approach as that used for the annual total precipitation. The estimated monthly and annual total precipitation at Beaverdell during the reporting period are shown in Table 11 and a comparison with the long-term average precipitation presented in Illustration 1.

Table 11: Estimated Beaverdell Annual and Monthly Total Precipitation (September 2018 to August 2019)

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
2018/2019 scaled monthly total precipitation (mm)	33	20	18	18	25	34	41	27	39	41	45	27	**369**

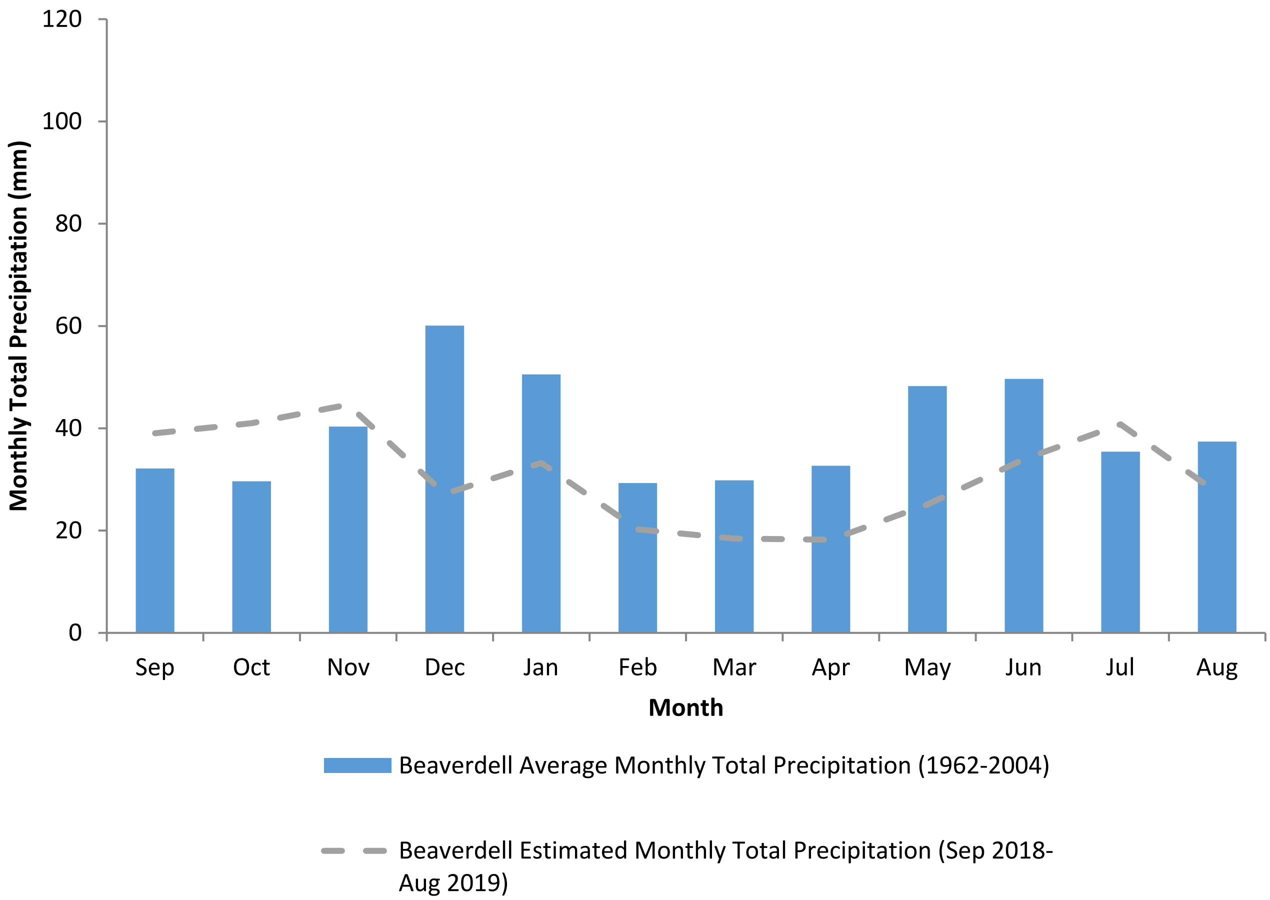

Illustration 1: Estimated and Historical Average Monthly Precipitation at Beaverdell

Conclusions regarding precipitation at Beaverdell are summarized as follows:

- 2018/2019 was a dry year compared to historical average, with a total annual precipitation just above the minimum annual precipitation recorded at the Beaverdell stations.
- Total precipitation at Beaverdell from November 2018 to August 2019 (inclusive), has been estimated to be 43% lower than the historical average for the same time period.
- Total precipitation at Beaverdell in the fall season, from September to October 2018 (inclusive), has been estimated to be 23% greater than the historical average for the same period.

3.2 Review and Summary of Water Balance

The water balances for the South TSF and North TSF were based on the catchment areas of each facility, summarized in Table 12. The total watershed of the South TSF area is limited by the South TSF dam and a diversion channel along Beaverdell Station Road which diverts 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. A diversion ditch to the west of the North TSF, including the spillway, diverts runoff from Cranberry Ridge away from the North TSF during normal climate conditions (as described in Section 1.3.2). For the purpose of the annual water balance, it is assumed that the facility did not experience an extreme flood event capable of overtopping Reach 1 of the North TSF diversion and runoff from the Cranberry Ridge catchment area did not enter the North TSF.

Table 12: North and South Tailings Storage Facility Catchment Areas

TSF	Cell	Cell Drainage Area[(a)] (km^2)	TSF Drainage Area (km^2)
South TSF	1	0.029	0.188
	2	0.020	
	3	0.086	
	4	0.027	
	5	0.026	
North TSF	6	0.031	0.081
	7	0.050	

Source: Golder 2017a.

TSF = tailings storage facility.

(a) Areas downstream of diversion channels, assumes no runoff from Cranberry Ridge enters TSFs.

The water balance inflows are limited to surface water contribution from total precipitation, as determined in Section 3.1. The annual evaporation at the site is estimated to be 600 mm/year (Golder 2017a), which is higher than the long-term average total precipitation (480 mm); hence the site has an overall water deficit. It is assumed that all inflows to the TSF are removed from the TSF and that there is no long-term accumulation of water in the cells (only seasonal, temporary ponding is observed at the Beaverdell TSFs). Inflow volumes were calculated by multiplying the total annual precipitation for the reporting period (369 mm as detailed in Section 3.1) by the catchment areas, without accounting for losses (i.e., evaporation, transpiration, infiltration, sublimation, and seepage through dam). Predicted inflows were:

- 68,200 m^3 for the South TSF area
- 29,700 m^3 for the North TSF area

No surface discharge of water from the TSFs 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 surficial soil (wetting and drying sequence).
- **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).
- **Seepage**—Seepage occurs through the dam or dam foundation.

The distribution of inflows to outflows was not assessed. An update of the site water management plan, including a baseline hydrology report, is recommended (Recommendation 2018-04), and this will improve the understanding of losses occurring at the TSFs.

3.3 Freeboard and Storage

Freeboard is not measured directly at the Beaverdell TSFs as the tailings surface is generally dry. Temporary water ponding locations 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 (TARP) and related quantifiable performance objectives (QPOs) for surface water conditions at the Beaverdell TSFs were developed and are summarized in Table 13.

Table 13: Trigger Action Response Plan for Surface Water Conditions for Beaverdell Tailings Storage Facilities (Adapted from Teck 2018a)

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 criterion. ■ Document weekly inspections.	■ Increase frequency of inspections to daily until conditions meet warning criterion. ■ Sample downstream water quality. ■ Document daily inspections.
Personnel notified	■ Record and file with inspection reports. ■ EoR receives a copy of the inspections annually.	■ Jason McBain (TSF Qualified Person) ■ Kathleen Willman (Mine Manager) ■ EoR	■ British Columbia Ministry of Energy, Mines and Petroleum Resources ■ Jason McBain (TSF Qualified Person) ■ Kathleen Willman (Mine Manager) ■ Teck's Tailings Working Group ■ EoR ■ Communities of Interest

Notes:

The upstream crest is defined as the location where the tailings beach intersects the upstream face/toe of the dam or crest.

Distances can be measured with tape measure or distance wheel.

EoR = Engineer of Record; QPO = quantifiable performance objective; TSF = tailings storage facility.

Ponding conditions as noted from inspections and observations during the 2018/2019 reporting period are summarized in Table 14.

Table 14: Summary of Ponding Observations in Tailings Storage Facilities

Facility	Cell	22 November 2018	11 June 2019	10 July 2019
South TSF	1	no pond	no pond	no pond
	2	no pond	no pond	no pond
	3	no pond	no pond	no pond
	4	no pond	pond, estimated 40 m from dam crest	no pond
	5	no pond	no pond	no pond
North TSF	6	no pond	no pond	no pond
	7	no pond	no pond	no pond

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 process listed in Section 3.2.

3.5 Water Discharge Quality

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

4.0 SITE OBSERVATIONS

4.1 Visual Observations and Photographs

A site inspection was carried out on 10 July 2019 by John Cunning, P.Eng., and Martyn Willan, P.Eng., of Golder, accompanied by Gerry Murdoch and Jason McBain, P.Eng., of Teck.

The air temperature during the visit was approximately 15°C, and the weather cloudy.

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

4.2 Water Levels in West Kettle River

As a response to high water flows in the WKR in spring 2017 and 2018, flood monitoring of the WKR began in March 2019 based on the Beaverdell TSF flood response protocol and TARP, which was in draft at the time of the 2019 freshet (Teck 2019b).

Flows are measured at hydrometric stations at Westbridge (downstream of Beaverdell) and McCulloch (upstream of Beaverdell), both operated by Environment and Climate Change Canada. There were no observed flooding events in the 2019 freshet period (1 April and 30 June 2019), and maximum daily flows at both stations peaked below a 1-in-2-year return period.

Snowpack is measured by the BC Ministry of Forestry, Lands and Natural Resources Operations River Forecast Centre at Grano Creek, 40 km northeast of Beaverdell, and Mission Creek, 55 km north of Beaverdell. Data from the River Forecast Centre indicates that snowpack at both stations remained below the historical average at the time of the 2019 freshet period.

4.3 Instrument Review

There was no functional geotechnical instrumentation installed at the Beaverdell TSFs during the reporting period. QPOs have been established for ponding in the cells, as described in Section 3.3.

- No ponded water was observed in any cells during the November 2018 routine inspection.
- Limited ponded water was observed in Cell 4 during the June 2019 routine inspection.
    - Cell 4 ponds were within the acceptable range of the site QPOs.
- No ponded water was observed in any cells during the July 2019 dam safety inspection.

New piezometers are planned to be installed in 2020 to confirm the phreatic conditions, support closure planning, and provide information relevant to the completion of an inundation assessment for the TSFs (Recommendations 2016-05a, 2016-03, and 2017-02).

4.4 Pond and Discharge Water Quality

There was no observed surface water discharge from the Beaverdell TSFs in 2019 based on site inspections and observations. Water quality is discussed in Section 3.5.

4.5 Site Inspection Forms

A summary of observations from the 10 July 2019 inspection is presented for each TSF in Appendix C.

4.6 Facility Data Sheet

A TSF data sheet for the North and South TSFs is presented in Appendix A.

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):

> *"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 15 presents the dam classification criteria. Dam consequence classification is based on incremental losses that a hypothetical 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 hypothetical 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. A detailed inundation study has not yet been completed for the Beaverdell TSFs (Recommendation 2017-02).

Table 15: 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 (2016) and the CDA guidelines (2013) were used to assign a dam class to the Beaverdell TSF dams based on conditions during the 2018/2019 reporting period (Table 16).

Table 16: 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 small. Loss of life, if any, would be the result of unforeseeable misadventure.
- **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, by others, for the Speckled Dace (*Rhinichthys osculus*; 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 recommended to determine impact (Recommendation 2018-02).
- **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 unforeseeable misadventure.
- **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 both the North and South TSFs based on the changes in downstream conditions noted in this DSI as per Golder (2019d), (Recommendation 2018-02).

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

The land south of Cell 1 and the Teck property boundary is understood to currently be undergoing residential development. During the 2018 site inspection earthmoving equipment was observed to have cleared an area of land south of Cell 1. No changes in the extent of clearance, no equipment or additional development were observed during the 2019 DSI visit.

Riprap armouring on the left bank of the WKR adjacent to Cells 4 and 5, which was first observed in May 2018, was observed to be in place during the 2019 DSI site visit, as shown in Figure 3 and Photograph 41 (Appendix B). No changes in the extent or condition of the armouring was observed.

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 credible 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 credible hazards for the dams present at Beaverdell. Credible hazards for the South and North TSFs are described in the following sections.

An annual review of the Beaverdell risk register was completed by Teck on 8 January 2019 with input from the EoR team.

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 spigot deposition to place coarse tailings against the upstream slope and push the finer 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 (Li et al. 2009), an update to the original Kenney-Lau criteria (Kenney and Lau 1985). 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 without the deposition of waste materials or water for 28 years. Small, shallow ponds are occasionally present in Cell 4 and Cell 6. Minor ponding was observed in Cell 4 and no ponding at Cell 6 during the 11 June 2019 routine inspection. No ponding was observed at either Cell 4 or 6 during the 22 November 2018 routine inspection or the 10 July 2019 DSI inspection.

Site visits from 2012 through to 2019, 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 seepage (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 that piping could develop around the decant pipes.

A supernatant pond historically existed downstream of 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 the area downstream of Cell 5. These tailings could be related to the decant outlet. A sufficient hydraulic gradient is not expected to develop, as evidenced by the limited or non-existent ponds in the TSFs, to pose a dam safety concern. However, the location and alignment of the Cell 5 decant should be determined (Recommendation 2019-01).

No seepage at the Cell 6 or Cell 7 pipe outlets was noted during the July 2019 inspection although a small quantity of water was observed behind a metal weir at the outlet structure of the Cell 6 decant. Concentration of water in this structure may lead to water chemistry readings exceeding permit requirements. It is recommended that this outlet structure be decommissioned (Recommendation 2019-04).

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 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.

The likelihood of a dam failure of the North TSF through internal erosion is considered to be close to non-credible[1]. Due to the lack of tailings beach between areas of potential ponding within Cells 3 and 4 and the embankment the likelihood of a dam failure of the South TSF through internal erosion is considered to be rare[2].

The likelihood of internal erosion was updated as part of the January 2019 risk register review based on the findings of the 2018 CPT investigation (Golder 2019a).

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 and the HSRC Guidance Document (Ministry of Energy and Mines 2016) requires the following for a that Significant consequence class dam:

- An IDF 1/3 between the 1-in-975-year flood event and the PMF.
- A facility that stores the IDF, i.e., cannot pass the required IDF, shall use a storm duration of 72-hours.

[1] Close to non-credible likelihood: For a natural hazard (earthquake, flood, windstorm, etc.): the predicted return period for an event of this strength / magnitude is greater than 1 in 10,000 years. Also, for failure modes such as instability and internal erosion that are close to non-credible.
[2] Rare likelihood: For a natural hazard (earthquake, flood, windstorm, etc.): the predicted return period for an event of this strength / magnitude is 1 in 100 and 1,000 years. Also for failure modes such as instability and internal erosion that are rare.

The detailed design of an upgraded spillway for the South TSF was completed in March 2018 (Golder 2018b) with the aim of conveying the 24-hour PMF (which exceeds the requirements of the HSRC 2017) with allowance for freeboard. Spillway construction took place in August 2018 and remediation in July 2019 (Golder 2019e). As a result, the South TSF spillway exceeds the IDF requirements of the HSRC (2017).

A ditch along Cranberry ridge to the west of the North TSF directs water runoff from the external catchment (Golder 2019c). A section of the diversion cannot convey the IDF and water from a 90,000 m^2 area of external catchment could enter the North TSF (Section 1.3.2). Cell 7 has the storage capacity to store the IDF event. In the event of flood flows larger than the IDF, water could discharge via the Cell 7 spillway south of the TSF.

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. As such, a minimum freeboard is not defined. 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

Minor ponding was observed in Cell 4 and no ponding at Cell 6 during the June 2019 routine inspection by the TSF Qualified Person at the time of the inspection. No ponding was observed in any cells at the time of the November 2018 routine inspection or the July 2019 DSI inspection. There is no indication that surface water accumulation has reached the upstream face or crest of the dam.

The likelihood of overtopping for the North TSF and South TSF is considered to be close to non-credible to very rare[3]. The likelihood of overtopping for the South TSF was updated as part of the January 2019 risk register review based on the construction of the upgraded spillway.

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 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 Natural Resources Canada (NRC 2015) are presented in Table 17. The 2015 seismic information is the most recent available from Natural Resources Canada.

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3 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.

Table 17: 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 (2019) 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). The 2018 CPT investigation indicated that the material within the TSFs is generally unsaturated, with low pore-water pressures within the inferred foundations (Golder 2019a). Piezometric levels in the foundations and tailings during the CPT investigation were similar to those adopted in the 2018 dam stability reassessment (Golder 2018a). As such, factors of safety are expected to be similar, based on observed piezometric levels. New piezometers are planned to be installed in 2020 to confirm the phreatic conditions (Recommendation 2016-03).

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 2019 have indicated that the slopes are performing adequately at a steeper slope angle than 2H:1V.

Observed Performance

The visual inspection during the July 2019 site visit did not identify any sign of stresses such as cracks, settling, or bulges on the North and South TSF dams.

The downstream slopes of the South TSF Cell 4 and 5 dams are covered with trees. The trees are generally straight with diameters of 10 to 15 cm and conditions generally suggest that there is no apparent movement or creep of the dam slopes. Some exposed non-mature trees at the toe of dams were observed to be leaning as a result of the removal of mature trees during previous flooding of the WKR, and do not indicate any concern in relation to dam safety. A number of dead trees were identified at the toe of the Cell 5 dam at the South TSF. Uncontrolled felling of these trees could lead to damage to the dams and should be removed (Recommendation 2019-02).

Minor erosion on the downstream slope of Cell 6 was noted (Photograph 27, Appendix B), but is limited by the armouring of the downstream slope face and is not considered to put the facility at risk of instability.

Mature trees on the crest of the Cell 3 dam, which had the potential to reduce the freeboard in the event of them being felled by winds or disease, had been removed.

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, 2019b). No seepage was observed during the site visit. The dam slopes were observed to be stable.

During the July 2019 site visit, soft ground was observed at the downstream toe of the Cell 3 dam, north of the Cell 3 spillway, with felled trees from the 25 and 26 January 2019 work placed in this area. Discussions with Teck staff indicated that these trees were placed to provide platforms for equipment during the tree felling work, as a result of soft ground. In addition, a review of the draft borehole records for monitoring well MW18-03 (Wood 2019), indicated an approximately 0.8 m thick layer of dark brown, low plasticity, damp silt approximately 0.15 m below ground surface. Topographic contours also indicate that the tailings surface slopes towards the dam with deposition from the west, i.e., prior to the use of spigot deposition of tailings from the dam. These conditions may be indicative of tailings deposition in Cell 3 prior to the construction of the Cell 3 embankment (i.e., tailings and water were not contained), similar to conditions observed for Cells 1 and 2. Tailings may therefore be present in the foundation of the Cell 3 embankment which could pose a risk to the stability of the dam in this section of the South TSF, and should be investigated (Recommendation 2019-03) Similar conditions were not observed at the remainder of the South TSF and at the North TSF. The likelihood of instability for the North TSF and South is considered to be close to non-credible (drained condition) to unlikely[4] (seismic loading condition).

5.3.4 Erosion of Facility Toe from West Kettle River

The South TSF is constructed adjacent to the WRK and erosion of the South TSF toe due to flooding / high velocities of the WKR could cause dam instability to the South TSF.

The toe of the North TSF dam is located approximately 9 m above the normal flow elevation of the. WKR and approximately 100 m (horizontally) from the centerline of the WKR. Erosion of the North TSF toe is not considered to represent a risk to dam safety based on a very rare likelihood of occurrence.

Design Basis and Design Confirmation

Erosion protection was designed for the right bank of the WKR, adjacent to the South TSF, and installed between 2015 and 2016. The erosion protection comprised a trench of buried riprap that would “self-launch” to protect the South TSF in the event that the natural ground between the riprap and river was eroded. This occurred in 2018 over portions of the riprap downstream of Cell 5 as a result of high-water levels in the WKR near the Beaverdell TSFs. Further, including as a result of additional riprap placed upstream and on left bank by others, 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.

4 Unlikely: For a natural hazard (earthquake, flood, windstorm, etc.): the predicted return period for an event of this strength / magnitude is between 1 in 10 and 100 years.

Observed Performance

River levels in 2019 peaked below a 1-in-2-year return period maximum daily flow (Section 4.2).

Short-term mitigation measures included the placement of riprap stockpiles in April 2019 for use in case of high river flows in the 2019, and the development of a flood management plan, currently in draft, which was in the process of being finalized at the time of this report (Recommendation 2018-03a).

A revised design for armouring of the Cell 4 and 5 riverbank for up to a 1:200-year flood event was completed in 2019 (Golder 2019f and 2019g), permitting for construction in Q4 2019 was also undertaken (Recommendation 2018-03b). Construction commenced in November 2019 and continued up to a shutdown on 21 December 2019 due to winter conditions. Stockpiled riprap materials were used for armouring in 2019 and additional materials were stockpiled in January 2020.

Additional permitting is required in 2020, in progress at the time of this report, to allow for construction to complete armouring works in 2020. The likelihood of external erosion for the South TSF during the reporting period, prior to the design and initial construction of riprap, was considered to be possible[5] based on previous observed flooding of the WKR. Following the completion of the ongoing construction of riprap, for an event up to and including the 1:200-year flood, along the toe of the South TSF the likelihood is expected to reduce to rare.

5.4 Review of Operational Documents

5.4.1 Operation, Maintenance, and Surveillance Manual Review

The operation, maintenance, and surveillance (OMS) manual for the TSF was updated in February 2018 (SP&P BEA-OMS-001.V002; Teck 2018a). This OMS manual was prepared to meet guidelines provided by the HSRC Guidance Document (Ministry of Energy and Mines 2016), the CDA (2013), the Mining Association of Canada (MAC 2011, 2017), and Teck (2014).

An update of the OMS manual is planned for Q1 2020 to reflect staff changes at the TSF and to meet revised guidelines provided by MAC (2019a,b) and Teck (2019a).

A flood response protocol including TARP is currently in development for the TSFs (Teck 2019b). The flood response protocol and TARP was in the process of being finalized at the time of this report and is to be added to the OMS, as per the amended Mines Act Permit M-71, 4 October 2019 (Recommendation 2018-03b), on completion.

The water management plan for the facility is out of date and requires update (Recommendation 2018-04).

5.4.2 Emergency Preparedness and Response Review

The emergency preparedness and response plan (EPRP) was updated in February 2018 (Teck 2018b) (SP&P BEA-EPRP-001.V002). This document was prepared to meet guidelines provided by the HSRC and HSRC Guidance Document (Ministry of Energy and Mines 2016, 2017, respectively), CDA (2013), MAC (2011, 2017), and Teck (2014).

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[5] Possible: For a natural hazard (earthquake, flood, windstorm, etc.): the predicted return period for an event of this strength / magnitude is between 1 in 5 and 10 years.

An update of the EPRP was in progress at the time of this report, including incorporation of the TSF EPRP into a mine emergency response plan for the Beaverdell Mine (Teck 2019c). Updates will reflect staff changes at the TSF and revised guidelines provided by MAC (2019a,b) and Teck (2019a).

A tabletop exercise to test the EPRP was conducted on 17 December 2019.

The hypothetical failure of the Beaverdell TSF's are not considered to present a potential for loss of life, 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.

5.4.3 Dam Safety Review

The last dam safety review for the Beaverdell TSFs was conducted in 2012 (Golder 2013). At that time it was recommended that the next DSR be completed within ten years. However, based on the post-2016 requirement of the HSRC (Ministry of Energy and Mines 2017) the next dam safety review should be undertaken by 2021.

6.0 SUMMARY AND RECOMMENDATIONS

6.1 Summary of Activities

Activities completed during the reporting period were:

- removal of a large uprooted tree in the WKR on 10 October 2018 and flood debris from the right bank of the WKR adjacent to Cells 3, 4, and 5
- fall routine inspection on 22 November 2018, spring routine inspection on 11 June 2019, both by Teck, and DSI inspection on 10 July 2019 by Teck and Golder
- felling of trees on the Cell 3 dam crest and downstream slope on 25 and 26 January 2019
- stockpiling of emergency riprap at the toe of Cells 4 and 5 and adjacent to the baseball field in April 2019
  - stockpiled riprap was used for the armouring of the Cell 4 and 5 riverbank in December 2019
  - stockpiling of additional riprap material was commenced in early January 2020 and approximately 300 m^3 of 250 kg class material had been placed at the time of this report
- remediation and as-built survey of the South TSF Cell 3 spillway on 3 and 4 July 2019, following initial construction works in August 2018
- four water quality sampling visits and resultant analyses

6.2 Summary of Climate and Water Balance

A comparison between historical and active regional stations (Beaverdell, Beaverdell North, Kelowna, and Penticton A) was completed for the total annual precipitation at the Beaverdell site during the reporting period (1 September 2018 through 31 August 2019). Results indicate:

- 2018/2019 was a dry year compared to historical average, with a total annual precipitation just above the minimum annual precipitation recorded at the Beaverdell stations.
- Total precipitation at Beaverdell from November 2018 to August 2019 (inclusive), has been estimated to be 43% lower than the historical average for the same time period.
- Total precipitation at Beaverdell in the fall season, from September to October 2018 (inclusive), has been estimated to be 23% greater than the historical average for the same period.

A review of the facility water balance was completed using the estimated precipitation at Beaverdell for the reporting period. The total inflow volumes are estimated to be:

- 68,200 m^3 for the South TSF area
- 29,400 m^3 for the North TSF area

Losses are assumed to equate to inflows and include evaporation, transpiration, sublimation, and infiltration to ground.

6.3 Summary of Performance and Changes

The Beaverdell TSF dams were observed to be in good condition at the time of the 2019 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 2018 DSI (Golder 2019b).

As a result of changes in downstream conditions, it is recommended that an inundation study and dam consequence review for the TSFs be completed as per Golder (2019d), (Recommendation 2018-02).

6.5 Table of Deficiencies and Non-Conformances

Deficiencies/non-conformances and recommended actions are presented in Table 18, which includes an update of the status, as of March 2020, of Recommended Actions from the 2018 DSI.

Table 18: Table of Deficiencies and Non-conformances and Status Update of Previous DSI Recommendations

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Status, as of March 2020, and 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.	Permit PE-444	Collect tailings samples for geochemical testing and initiate the geochemical laboratory testing program in 2020. Develop a contingency protocol (with Trigger Action Response Plan) to be implemented in the event that discharge through the spillway occurs.	3	**In Progress** Site geochemical investigation program is in development. Tailings samples will be collected in 2020 for geochemical analysis. A contingency plan will be developed as part of the OMS Manual updates in 2020. End Q4 2020
	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	**Closed** Completed 4 July 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 riverbank 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. *Updated to:* *Finalize flood response protocol for the West Kettle River including the trigger action response plan prior to 2020 freshet.*	2	**In Progress** Riprap stockpiled on 12 April 2019 (used for riprap construction works in December 2019). Additional riprap stockpiled in January 2020 as part of riprap construction preparations for 2020. Finalization of flood response protocol in progress End Q2 2020
				Assess short-term and long-term requirements for riprap based on changes in river hydrology and flood statistics.	3	**In Progress** Design for riprap up to a 1-in-200-year event complete, permitting for 2019 construction complete. 2019 riprap construction works carried out. Permitting is in progress and required in 2020 to allow for construction to complete armouring works in 2020. Document long-term plan to mitigate risk of erosion along the toe of Cell 4 and 5 End Q3 2020
	2019-01	The location and alignment of the Cell 5 decant pipe are unknown.	OMS §5.5	Determine the location and alignment of the outlet of the Cell 5 decant	3	**New** End Q2 2023
	2019-02	Dead trees along the toe of the Cell 5 dam.	OMS §5.5	Remove dead trees along the toe of the Cell 5 dam as part of clearance works for the installation of riprap in 2020 (see 2018-03b).	3	**New** End Q3 2020
	2019-03	Reviewed data, including observed conditions during the removal of trees in 2019, could indicate the possibility of tailings in the foundation of the Cell 3 embankment. Foundations may be prone to liquefaction in a seismic event potentially leading to failure.	HSRC §10.1.4	Investigate the toe area and foundation of the Cell 3 dam for the presence of tailings or other soft, loose soils.	2	**New** Test pits excavated during March 2020 Phase 1 geotechnical site investigation, report is in preparation. End Q2 2020
North TSF	2019-04	The outlet structure of the Cell 6 decant accumulates a small quantity of water behind a metal weir, which may affect water chemistry when sampled.	OMS §5.5	Review collected water quality data to determine source of the accumulated water. Assess opportunity for maintaining the collection point to inform ongoing geochemistry studies. Consider upgrading to remove steel as a potential source of water contamination. Decommission the outlet structure if deemed of no value.	3	**New** End Q2 2023

Table 18: Table of Deficiencies and Non-conformances and Status Update of Previous DSI Recommendations

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Status, as of March 2020, and Recommended Deadline
South and North TSF	2016-03	Facility phreatic conditions not confirmed.	CDA 2013 §6.6 HSRC §10.1.4 (3)	Execute the planned drilling program to gather subsurface information and install piezometers.	3	**In Progress** Phase 1 Site investigation executed in March 2020, piezometers were installed and connected to remote monitoring system, which needs to be programmed with installation details. End Q2 2020
	2016-05 a, b	Closure plan not updated.	HSRC §10.4.1	Complete the planned Phase 1 geotechnical investigation of to inform the development of an updated closure plan. Execute the planned geochemical site investigation and testing program. Teck should collect tailings samples for geochemical testing and initiate the geochemical laboratory testing program in 2020 (See 2016-01).	4	**In Progress** Site investigation programs in development. Phase 1 geotechnical site investigation commenced in March 2020. Geochemical characterization in progress. End Q2 2023
				Update the closure plan.	4	**Not Started** End Q2 2023
	2017-02	No dam breach and inundation study completed.	HSRC §10.1.11	Complete the planned Phase 1 geotechnical investigation of to inform the development of a dam breach and inundation study. Complete a dam breach and inundation study.	3	**In Progress** Phase 1 geotechnical site investigation executed in March 2020. Dam breach and inundation study scope in preparation. End Q4 2020
	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 (2019d).	3	**Not Started** End Q4 2020
	2018-04	Water management plan is out of date.	HSRC §10.4.1 (3)	Update the existing water management plan.	4	**Not Started** End Q4 2020

CDA = Canadian Dam Association; HSRC = Health, Safety and Reclamation Code; ID = identification; IDF = inflow design flood; 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 WORK IN PROGRESS

At the time of this report work the following work was in progress:

- Data collection from the Phase 1 geotechnical site investigation of the Beaverdell TSFs completed in March 2020.
  - aims to assist with addressing a number of dam safety inspection recommendations, including recommendations made in this DSI:
    - 2016-03: Install piezometers to determine phreatic surfaces within the dams and foundations
    - 2016-05a: Determine existing geotechnical properties of tailings and foundation materials to inform the development of an updated closure plan.
    - 2017-02: Determine existing geotechnical properties of tailings and foundation materials to inform the completion of a dam breach and inundation study.
    - 2019-03: Investigate the toe area and foundation of the Cell 3 dam for the presence of tailings or other soft, loose soils.
- Installation of armouring for up to a 1:200-year flood event of the Cell 4 and 5 riverbank of the WKR.
  - a revised design was completed in 2019 (Golder 2019f and 2019g)
  - permitting of design for construction in Q4 2019
  - construction commenced in November 2019 and continued up to a shutdown on 21 December 2019 due to winter conditions
  - Additional construction permitting is required in 2020, in progress
  - construction is scheduled to recommence in 2020, pending permitting approvals

8.0 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.

Golder Associates Ltd.

16 April 2020

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https://golderassociates.sharepoint.com/sites/104499/project files/6 deliverables/issued/197-r-rev1-tsf-2019 annual dsi/19117544-197-r-rev1-1000-bes tsf 2019 annual dsi 16apr_20.docx

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STUDY LIMITATIONS

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Path: \\golder.gds\gal\burnaby\CAD-GIS\Client\Teck_Resources_Ltd\Beaverdell Mine\99_PROJECTS\19117544\1000\1400\197\02_PRODUCTION\DWG\ | File Name: 19117544-1000-1400-01.dwg

LOCATION PLAN

0 500 1,000

1:20,000 METRES

LEGEND

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
TECK RESOURCES LIMITED
BEAVERDELL MINE
BEAVERDELL, B.C.

CONSULTANT
GOLDER

YYYY-MM-DD	2020-02-21
DESIGNED	M. WILLAN
PREPARED	A. KIM / A. FARLOW
REVIEWED	M. WILLAN
APPROVED	J. CUNNING

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
BEAVERDELL SITE LOCATION PLAN

PROJECT NO.	PHASE/TASK/DOC#	REV.	FIGURE
19117544	1000/1400/197	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

25 mm

0

LEGEND

- 2018 TOPOGRAPHIC CONTOURS (SEE REFERENCE 1)
- EXTENT OF RIPRAP ARMOURING INSTALLED IN 2015 / 2016
- APPROXIMATE EXTENT OF ARMOURING (OBSERVED SINCE MAY 2018)
- 2019 SITE VISIT PHOTOGRAPH LOCATION
- INDICATIVE LOCATION OF EMERGENCY RIPRAP STOCKPILE

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN UTM ZONE 11 NAD83.
3. VERTICAL DATUM IS CGVD2013.
4. CONTOURS SHOWN AT 0.5 m MINOR AND 2.5 m MAJOR INTERVAL.

REFERENCES

1. 2018 EXISTING GROUND LIDAR SURVEY AND ORTHOPHOTO BY MCELHANNEY 19 JULY 2018, PROVIDED BY MCELHANNEY, RECEIVED: 24 AUGUST 2018, FILE NAME: 358400VLIDARCONTOURS.DWG.
2. 2019 CONSTRUCTION: CELL 3 SPILLWAY AND BERM REPAIR WORKS SURVEY COMPLETED BY GOLDER; SURVEYED 3 JULY 2019, FILE: 1788497-1000-BEAVERDELL CELL 3 SPILLWAY 2019 CONSTRUCTION ASBUILT 2019-07-04.xml.
3. CELL 3 DAM SURVEY PROVIDED BY WSP. CAD FILE: 181-08185-00-000-00-SRWCA001-R0.dwg. DATE: 23 TO 28 JULY 2018

0 100 200
1:4,000 METRES

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

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GOLDER

YYYY-MM-DD	2020-02-21
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REVIEWED	M. WILLAN
APPROVED	J. CUNNING

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
2019 INSPECTION PHOTOGRAPH LOCATIONS

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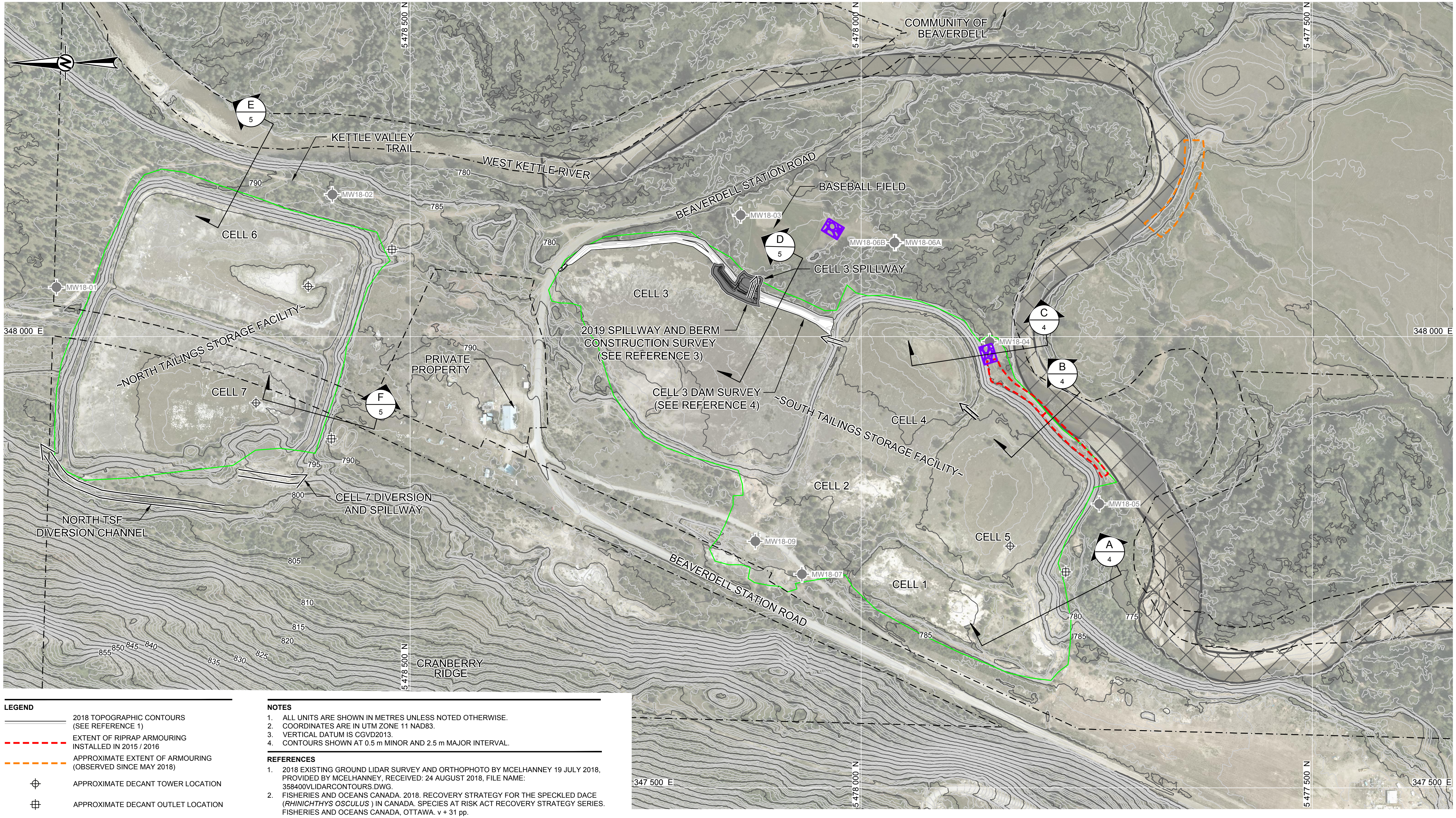

LEGEND

- 2018 TOPOGRAPHIC CONTOURS (SEE REFERENCE 1)
- EXTENT OF RIPRAP ARMOURING INSTALLED IN 2015 / 2016
- APPROXIMATE EXTENT OF ARMOURING (OBSERVED SINCE MAY 2018)
- APPROXIMATE DECANT TOWER LOCATION
- APPROXIMATE DECANT OUTLET LOCATION
- FLOW DIRECTION
- APPROXIMATE M-71 PERMIT BOUNDARY
- APPROXIMATE PROPERTY BOUNDARY
- CRITICAL HABITAT OF SPECKLED DACE (SEE REFERENCE 2)
- GROUNDWATER MONITORING WELLS (BY WOOD PLC, COMPLETED JULY 2018)
- INDICATIVE LOCATION OF EMERGENCY RIPRAP STOCKPILE

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN UTM ZONE 11 NAD83.
3. VERTICAL DATUM IS CGVD2013.
4. CONTOURS SHOWN AT 0.5 m MINOR AND 2.5 m MAJOR INTERVAL.

REFERENCES

1. 2018 EXISTING GROUND LIDAR SURVEY AND ORTHOPHOTO BY MCELHANNEY 19 JULY 2018, PROVIDED BY MCELHANNEY, RECEIVED: 24 AUGUST 2018, FILE NAME: 358400VLIDARCONTOURS.DWG.
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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4. CELL 3 EAST DAM SURVEY PROVIDED BY WSP. CAD FILE: 181-08185-00-000-00-SRWCA001-R0.dwg. DATE: 23 TO 28 JULY 2018.

0 100 200
1:4,000 METRES

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

CONSULTANT
GOLDER

YYYY-MM-DD	2020-02-21
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REVIEWED	M. WILLAN
APPROVED	J. CUNNING

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
DETAIL PLAN

PROJECT NO.	PHASE/TASK/DOC#	REV.	FIGURE
19117544	1000/1400/197	0	3

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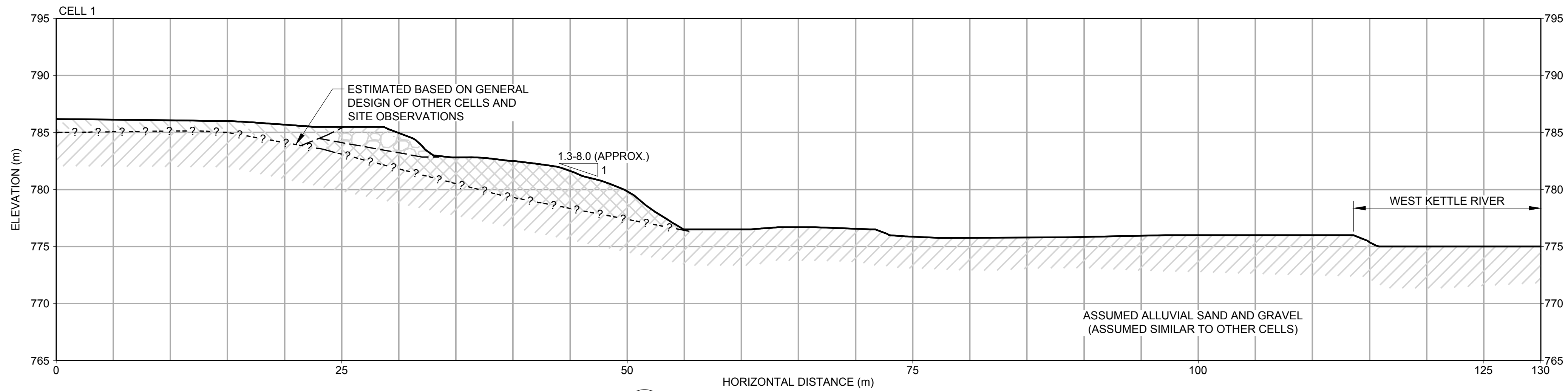
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



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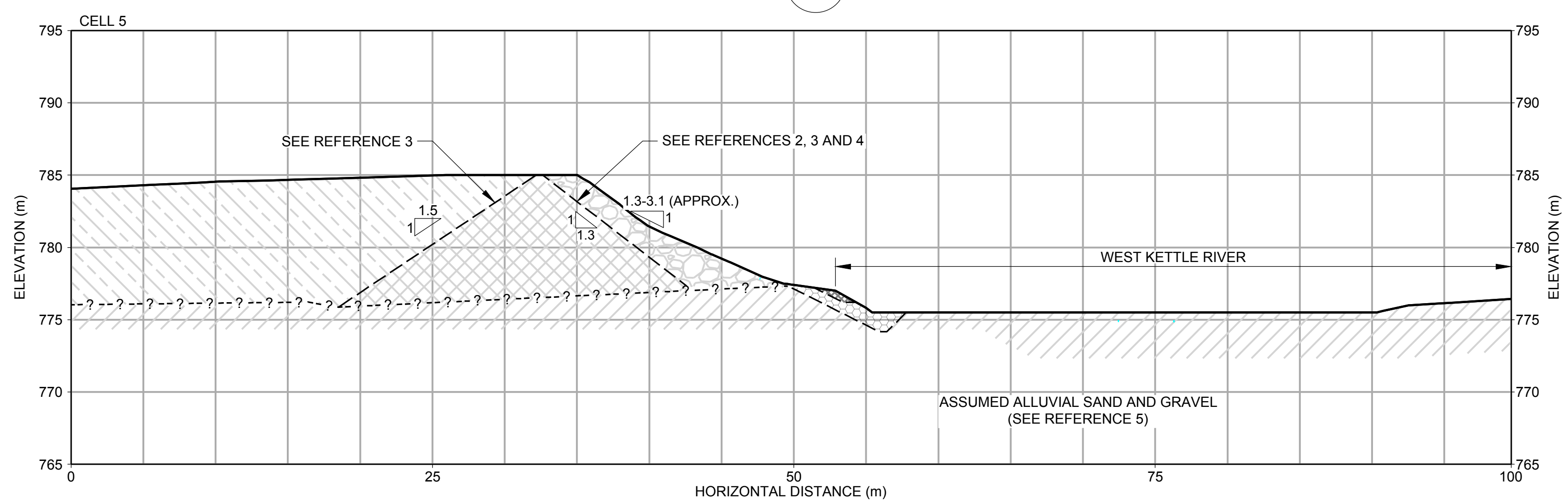

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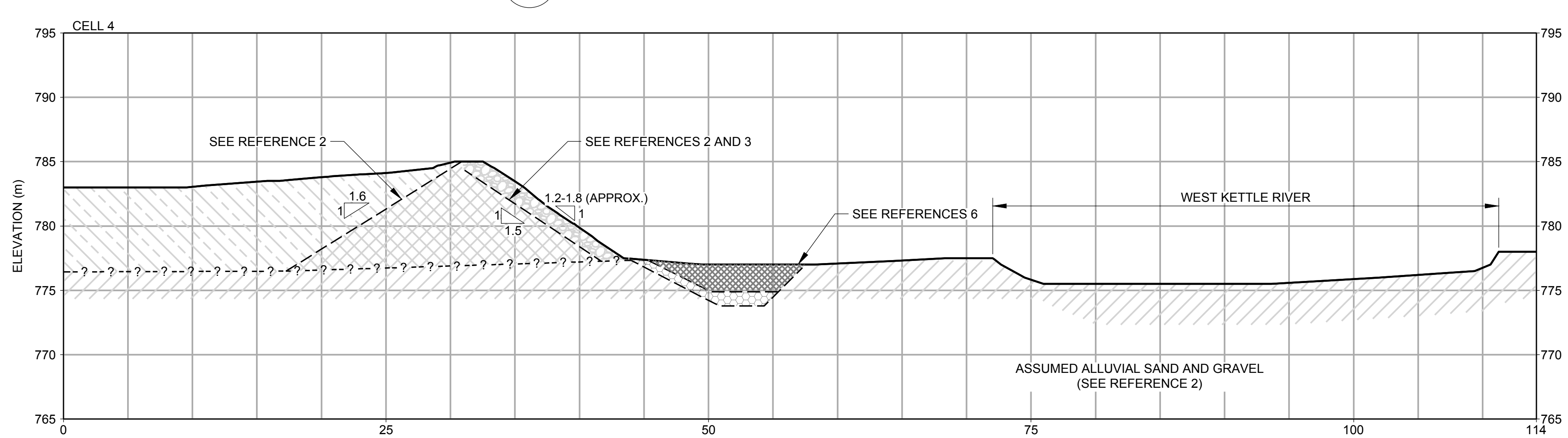

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LEGEND

- EXISTING GROUND SURFACE (SEE REFERENCE 1)
- ESTIMATED ORIGINAL GROUND SURFACE
- 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 METRES UNLESS OTHERWISE NOTED.
2. STRATIGRAPHY BENEATH ALLUVIAL SAND AND GRAVEL IS UNKNOWN.
3. GROUND SURFACE UNDER TAILINGS BASED ON 2018 CPT INVESTIGATION. (SEE REFERENCE 7)
4. VERTICAL DATUM IS CGVD2013.

REFERENCES

1. 2018 EXISTING GROUND LIDAR SURVEY AND ORTHOPHOTO BY MCELHANNEY 19 JULY 2018, PROVIDED BY MCELHANNEY, RECEIVED: 24 AUGUST 2018, FILE NAME: 358400VLidarContours.dwg.
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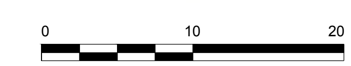

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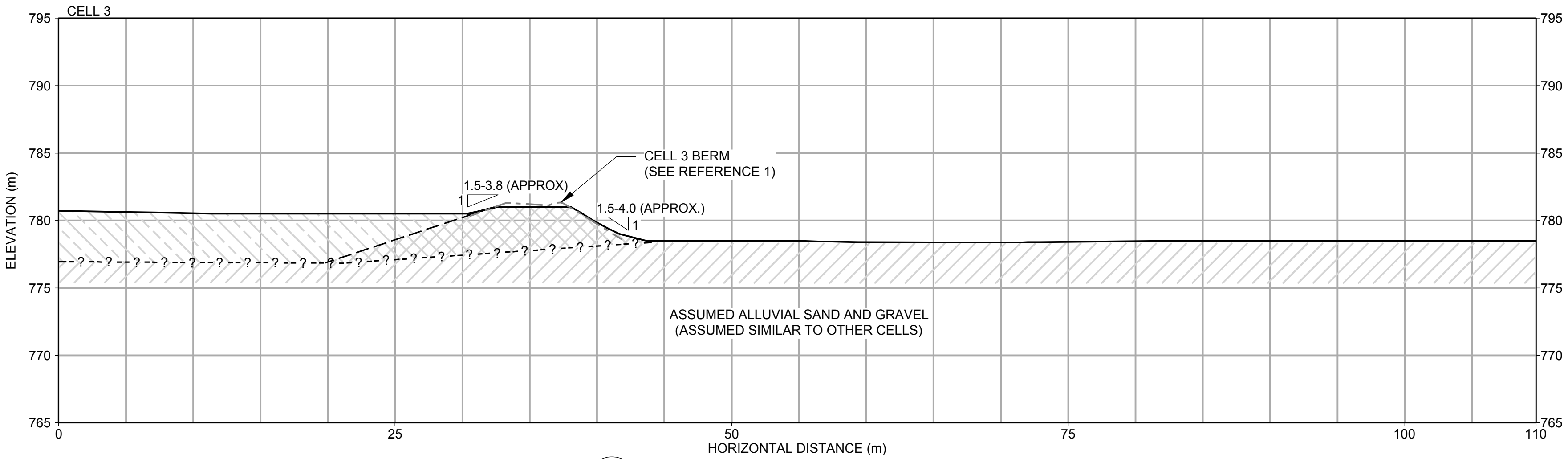
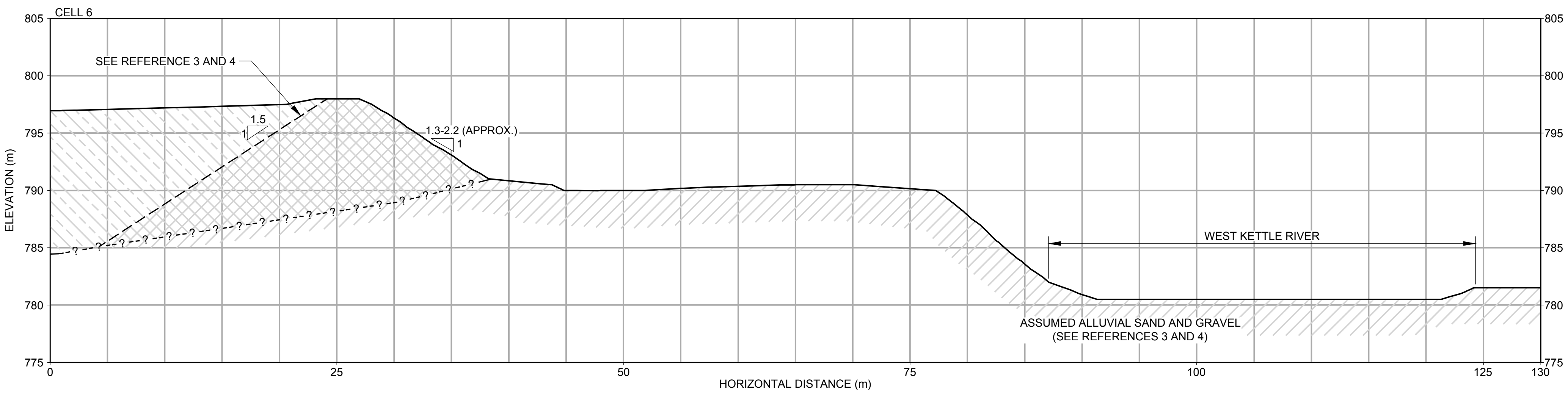
PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
CROSS SECTIONS (1 OF 2)

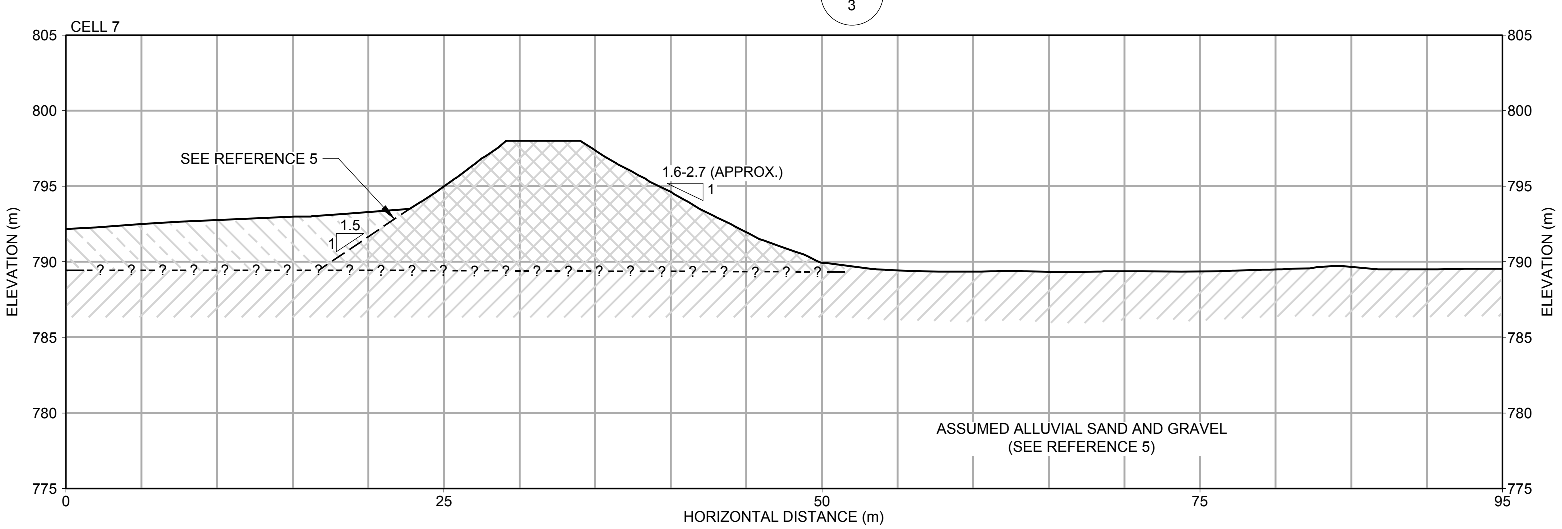
PROJECT NO.	PHASE/TASK/DOC#	REV.	FIGURE
19117544	1000/1400/197	0	4



SCALE 1:500 m D 3 SECTION THROUGH CELL 3 EMBANKMENT



SCALE 1:500 m E 3 SECTION TROUGH CELL 6 EMBANKMENT



SCALE 1:500 m F 3 SECTION THROUGH CELL 7 EMBANKMENT

LEGEND

- EXISTING GROUND SURFACE (SEE REFERENCE 2)
- --?--?--?--?- ESTIMATED ORIGINAL GROUND SURFACE
- INFERRED MATERIAL BOUNDARY
- CELL 3 BERM (SEE REFERENCE 1)
- TAILINGS
- EMBANKMENT FILL
- ALLUVIAL SAND AND GRAVEL

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS OTHERWISE NOTED.
2. STRATIGRAPHY BENEATH ALLUVIAL SAND AND GRAVEL IS UNKNOWN.
3. GROUND SURFACE UNDER TAILINGS BASED ON 2018 CPT INVESTIGATION. (SEE REFERENCE 6)
4. VERTICAL DATUM IS CGVD2013.

REFERENCES

1. CELL 3 EAST DAM SURVEY PROVIDED BY WSP. CAD FILE: 181-08185-00-000-00-SRWCA001-R0.dwg. DATE: 23 TO 28 JULY 2018
2. 2018 EXISTING GROUND LIDAR SURVEY AND ORTHOPHOTO BY MCELHANNEY 19 JULY 2018, PROVIDED BY MCELHANNEY, RECEIVED: 24 AUGUST 2018, FILE NAME: 358400VLIDARCONTOURS.DWG.
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4. BINNIE. 1980B. *SUPPLEMENTARY REPORT ON PROPOSED POND NO. 6.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 31 MARCH 1980.
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0 10 20
1:500 METRES

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

CONSULTANT

GOLDER

YYYY-MM-DD	2020-02-21
DESIGNED	M. WILLAN
PREPARED	A. KIM / A. FARLOW
REVIEWED	M. WILLAN
APPROVED	J. CUNNING

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
CROSS SECTIONS (2 OF 2)

PROJECT NO.	PHASE/TASK/DOC#	REV.	FIGURE
19117544	1000/1400/197	0	5

APPENDIX A

2019 TSF Data Sheets

CLIENT:	Teck Resources Limited	**PROJECT:**	Beaverdell Tailings Storage Facilities
LOCATION:	Beaverdell Mine	**REVIEWED:**	M. Willan

SOUTH TSF – FACILITY DATA SHEET

Impoundment Area (tailings and dam footprint area)	150,000 m^2	Measured from 2018 LiDAR Survey Data
Volume of Stored Tailings	544,000 m^3	Estimated Golder (2019a)
Reservoir Capacity	21,900 m^3 (in Cell 4 and 5 to internal spillway invert levels)	Calculated 2018 LiDAR Survey Data and 2019 Cell 3 spillway as-built survey
Consequence Classification	Significant	Ministry of Energy and Mines (2016) and CDA (2013)
Inflow Design Flood (IDF)	1/3 between the 1-in-975-year flood event and the PMF.	Ministry of Energy and Mines (2016)
Design Earthquake	1/2,475-year event	Ministry of Energy and Mines (2016)
Spillway Capacity	4.8 m^3/s considering a design storm calculated based on 24-hour probable maximum precipitation plus snow melt plus 10% climate change factor. Includes 0.3 m of freeboard.	Calculated Golder (2019c)
Catchment Area	188,000 m^2	Calculated Golder (2017a)
Dam Type	Earthfill Dam	Assumed from Binnie (1980a, 1988). No construction record reports available.
Maximum Dam Height	2 to 10 m	Estimated from 2018 LiDAR Survey Data
Dam Crest Width	1 to 5 m	Estimated from 2018 LiDAR Survey Data and 2019 spillway as-built survey
Access to Facility	Permanent wire fence installed around South TSF. Access via gate located on access road from west side of Cell 3, adjacent to Cell 2. Vehicle access to dam crest not generally available.	-

NORTH TSF – FACILITY DATA SHEET

Impoundment Area (tailings and dam footprint area)	90,000 m^2	Measured from 2018 LiDAR Survey Data
Volume of Stored Tailings	384,000 m^3	Estimated Golder (2019a)
Reservoir Capacity	184,600 m^3 (to Cell 7 spillway invert elevation of 797.0 m)	Calculated 2018 LiDAR Survey Data
Consequence Classification	Significant	Ministry of Energy and Mines (2016) and CDA (2013)
Inflow Design Flood (IDF)	1/3 between the 1-in-975-year flood event and the PMF. Available capacity to store the IDF with a duration of 72-hours.	Ministry of Energy and Mines (2016)
Design Earthquake	1 in 2,475-year event.	Ministry of Energy and Mines (2016)
Spillway Capacity	2 m^3/s considering a design storm calculated based on 24-hour probable maximum precipitation plus snow melt plus 10% climate change factor.	Calculated Golder (2019c)
Catchment Area	81,000 m^2	Calculated Golder (2017a)
Dam Type	Earthfill Dam	Assumed from Binnie (1980a, 1988). No construction record reports available.
Maximum Dam Height	8 to 12 m	Measured from 2018 LiDAR Survey Data
Dam Crest Width	3 to 4 m	Measured from 2018 LiDAR Survey Data
Access to Facility	Permanent wire fence installed around North TSF. Access via gate located on access road from downstream toe area at southeast corner of facility to crest of Cell 6 dam. Continuous road around crest of North TSF perimeter.	-

APPENDIX B

2019 Site Inspection Photographs

Photograph 1: South TSF Cell 1, tailings surface, looking southwest. 10 July 2019.

Photograph 2: South TSF, Cell 1, crest of west embankment looking northeast. 10 July 2019.

Photograph 3: South TSF, Cell 1, crest and upstream ditch at southeast embankment, looking northeast. 10 July 2019.

Photograph 4: South TSF, Cell 1, southeast embankment, looking northeast. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT	TECK RESOURCES LIMITED
PROJECT	BEAVERDELL TAILINGS STORAGE FACILITIES 2019 ANNUAL DAM SAFETY INSPECTION
CONSULTANT	GOLDER
YYYY-MM-DD	2020-04-16
PREPARED	AVE
DESIGN	AVE
REVIEW	MBW
APPROVED	JCC
TITLE	PHOTOGRAPHS 1 to 4
PROJECT No.	19117544
PHASE No.	1400
REV.	1
SHEET	B-1

Photograph 5: South TSF, Cell 1/5, downstream slope waste rock, looking west. 10 July 2019.

Photograph 6: South TSF, Cell 5, tailings surface, looking northeast. 10 July 2019.

Photograph 7: South TSF, Cell 5, downstream slope and West Kettle River, looking east. 10 July 2019.

Photograph 8: South TSF, Cell 5, downstream dam slope riprap at toe, looking southwest. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT
TECK RESOURCES LIMITED

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

CONSULTANT

GOLDER

YYYY-MM-DD	2020-04-16
PREPARED	AVE
DESIGN	AVE
REVIEW	MBW
APPROVED	JCC

TITLE
PHOTOGRAPHS 5 to 8

PROJECT No.	PHASE No.	REV.	SHEET
19117544	1400	1	B-2

Photograph 9: South TSF, Cell 5, toe and downstream slope, looking northeast. 10 July 2019.

Photograph 10: South TSF, Cell 4, downstream slope, looking northeast. 10 July 2019.

Photograph 11: South TSF, Cell 5, backfilled decant tower, 10 July 2019.

Photograph 12: South TSF, Cell 4, tailings surface, looking northwest. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT
TECK RESOURCES LIMITED

CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-16
PREPARED	AVE
DESIGN	AVE
REVIEW	MBW
APPROVED	JCC

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
PHOTOGRAPHS 9 to 12

PROJECT No.	PHASE No.	REV.	SHEET
19117544	1400	1	B-3

Photograph 13: South TSF, Cell 4, downstream slope, looking northwest. 10 July 2019.

Photograph 14: South TSF, Cell 4, downstream slope, looking northeast. 10 July 2019.

Photograph 15: South TSF, spillway between Cell 4 and Cell 3, looking northwest. 10 July 2019.

Photograph 16: South TSF, Cell 3, tailings surface and embankment crest, looking northwest. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT **TECK RESOURCES LIMITED**	PROJECT **BEAVERDELL TAILINGS STORAGE FACILITIES 2019 ANNUAL DAM SAFETY INSPECTION**
CONSULTANT GOLDER	TITLE **PHOTOGRAPHS 13 to 16**

YYYY-MM-DD	2020-04-16
PREPARED	AVE
DESIGN	AVE
REVIEW	MBW
APPROVED	JCC

PROJECT No.	PHASE No.	REV.	SHEET
19117544	1400	1	B-4

Photograph 17: South TSF, Cell 3, remediated spillway crest, looking southwest. 10 July 2019.

Photograph 18: South TSF, Cell 3, remediated spillway downstream, looking southeast. 10 July 2019.

Photograph 19: South TSF, Cell 3, crest and berm, looking northeast. 10 July 2019.

Photograph 20: South TSF, Cell 3, downstream slope and toe with felled trees, looking south. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT
TECK RESOURCES LIMITED

CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-16
PREPARED	AVE
DESIGN	AVE
REVIEW	MBW
APPROVED	JCC

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
PHOTOGRAPHS 17 to 20

PROJECT No.	PHASE No.	REV.	SHEET
19117544	1400	1	B-5

Photograph 21: South TSF, Cell 3, crest and downstream slope with felled trees, looking northeast. 10 July 2019.

Photograph 22: South TSF, Cell 3, tailings surface, looking south. 10 July 2019.

Photograph 23: South TSF, Cell 3, felled trees on crest and downstream slope, looking south. 10 July 2019.

Photograph 24: North TSF, Cell 6, tailings surface, looking northwest. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT
TECK RESOURCES LIMITED

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-16
PREPARED	AVE
DESIGN	AVE
REVIEW	MBW
APPROVED	JCC

TITLE
PHOTOGRAPHS 21 to 24

PROJECT No.	PHASE No.	REV.	SHEET
19117544	1400	1	B-6

Photograph 25: North TSF, Cell 6, tailings surface, looking west. 10 July 2019.

Photograph 26: North TSF, Cell 6, east embankment crest, looking southwest. 10 July 2019.

Photograph 27: North TSF, Cell 6, erosion on north embankment downstream slope, looking northeast. 10 July 2019.

Photograph 28: North TSF, Cell 6, east embankment downstream slope, looking south. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT		PROJECT			
TECK RESOURCES LIMITED		BEAVERDELL TAILINGS STORAGE FACILITIES 2019 ANNUAL DAM SAFETY INSPECTION			
CONSULTANT GOLDER	YYYY-MM-DD 2020-04-16	TITLE			
	PREPARED AVE	PHOTOGRAPHS 25 to 28			
	DESIGN AVE				
	REVIEW MBW	PROJECT No.	PHASE No.	REV.	SHEET
	APPROVED JCC	19117544	1400	1	B-7

Photograph 29: North TSF, Cell 6, decant outlet at toe of south embankment, looking north. 10 July 2019.

Photograph 30: North TSF, Cell 6, tailings surface from division between Cell 6 (left) and Cell 7 (right), looking southeast. 10 July 2019.

Photograph 31: North TSF, Cell 7, crest of south embankment, looking east. 10 July 2019.

Photograph 32: North TSF, Cell 7, downstream slope of south embankment, looking southwest. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT	TECK RESOURCES LIMITED
PROJECT	BEAVERDELL TAILINGS STORAGE FACILITIES 2019 ANNUAL DAM SAFETY INSPECTION
CONSULTANT	GOLDER
YYYY-MM-DD	2020-04-16
PREPARED	AVE
DESIGN	AVE
REVIEW	MBW
APPROVED	JCC
TITLE	PHOTOGRAPHS 29 to 32
PROJECT No.	19117544
PHASE No.	1400
REV.	1
SHEET	B-8

Photograph 33: North TSF, Cell 7, animal burrow in downstream slope of south embankment, looking north. 10 July 2019.

Photograph 34: North TSF, Cell 7, spillway at southwest corner, looking north. 10 July 2019.

Photograph 35: North TSF, Cell 7, tailings surface, looking east. 10 July 2019.

Photograph 36: North TSF, Cell 7, tailings surface, looking north. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT	TECK RESOURCES LIMITED
PROJECT	BEAVERDELL TAILINGS STORAGE FACILITIES 2019 ANNUAL DAM SAFETY INSPECTION
CONSULTANT	GOLDER
YYYY-MM-DD	2020-04-16
PREPARED	AVE
DESIGN	AVE
REVIEW	MBW
APPROVED	JCC
TITLE	PHOTOGRAPHS 33 to 36
PROJECT No.	19117544
PHASE No.	1400
REV.	1
SHEET	B-9

Photograph 37: North TSF, Cell 7, tailings surface and decant tower, looking east. 10 July 2019.

Photograph 38: North TSF, Cell 7, animal burrow in tailings surface, looking east. 10 July 2019.

Photograph 39: North TSF, Cell 7, diversion channel reach 1, west of TSF, looking north. 10 July 2019.

Photograph 40: North TSF, Cell 7, diversion channel reach 2, west of TSF, looking north. 10 July 2019.

TSF = Tailings Storage Facility

CLIENT	TECK RESOURCES LIMITED
PROJECT	BEAVERDELL TAILINGS STORAGE FACILITIES 2019 ANNUAL DAM SAFETY INSPECTION
CONSULTANT	GOLDER
YYYY-MM-DD	2020-04-16
PREPARED	AVE
DESIGN	AVE
REVIEW	MBW
APPROVED	JCC
TITLE	PHOTOGRAPHS 37 to 40
PROJECT No.	19117544
PHASE No.	1400
REV.	1
SHEET	B-10

1 in

Photograph 41: Armouring of neighbouring land on left bank of West Kettle River, looking southeast. 10 July 2019.

Photograph 42: Riprap stockpile at the toe of Cells 4 and 5, looking southwest. 12 April 2019.

Photograph 43: Riprap stockpile adjacent to the baseball field east of Cell 3, looking west. 12 April 2019.

TSF = Tailings Storage Facility

CLIENT **TECK RESOURCES LIMITED**		PROJECT **BEAVERDELL TAILINGS STORAGE FACILITIES 2019 ANNUAL DAM SAFETY INSPECTION**	
CONSULTANT GOLDER	YYYY-MM-DD	2020-04-16	TITLE **PHOTOGRAPHS 41 to 43**
	PREPARED	AVE	
	DESIGN	AVE	
	REVIEW	MBW	PROJECT No. **19117544** · PHASE No. **1400** · REV. **1** · SHEET **B-11**
	APPROVED	JCC	

APPENDIX C

2019 Site Inspection Reports

CLIENT:	Teck Resources Limited	**BY:**	Martyn Willan, P.Eng.
PROJECT:	Beaverdell Mine	**DATE:**	10 July 2019
LOCATION:	South TSF (Cells 1 through 5)	**REVIEWED:**	John Cunning, P.Eng.

GENERAL INFORMATION

Dam Type: Earthfill

WEATHER CONDITIONS:	Cloudy	**AIR TEMPERATURE:**	15°C

INSPECTION ITEM	OBSERVATIONS / DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST		2,3,4,16,17,19, 21	
1.1 Crest Elevation	Low Point of Embankment: Cell 1: El. 785.5 m Cell 5: El. 785.0 m Cell 4: El. 785.0 m Cell 3: El. 781.1 m		2018 LiDAR Survey and 2019 Spillway as-built survey
1.2 Reservoir Level / Freeboard	Dry	6,12,15,16,17,22	No ponding observed during site inspection
1.3 Distance to Tailings Pond (if applicable)	N/A		
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: 1 to 5 m		2018 LiDAR Survey and 2019 Spillway as-built survey
2. UPSTREAM SLOPE		3,19	
2.1 Slope Angle	Cells 1 & 2: unknown Cell 5: 1.5H:1V Cell 4: 1.5H:1V Cell 3: 1.5 to 3H:1V		Assumed from original design (Cell 4 and 5) Estimated for Cell 3
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	None		

INSPECTION ITEM	OBSERVATIONS / DATA	PHOTO	COMMENTS & OTHER DATA
3. DOWNSTREAM SLOPE		4,5,7,8,9,10,13,14, 20,21,23	
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		2018 LiDAR Survey
3.2 Signs of Erosion	Minor erosion gullies		Minor surficial erosion noted at north end of cell 4 dam
3.3 Signs of Movement (Deformation)	None		
3.4 Cracks	None		
3.5 Seepage or Wet Areas	Dry		
3.6 Vegetation Growth	Mature trees	2,3,4,7,8,9,10,13	Mature trees removed from Cell 3 embankment in 2019.
3.7 Other Unusual Conditions	None		
4. DOWNSTREAM TOE AREA		5,7,8,9,14,18, 20,21,23	
4.1 Seepage from Dam	None		
4.2 Signs of Erosion	Erosion of WKR bank along toe of Cell 4 & 5	9	
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	Soft ground encountered during tree removal from Cell 3 embankment. Dead trees observed along toe of Cell 5.	20,23 8,9	Felled trees used as work platform on soft ground.
5. ABUTMENTS			
5.1 Seepage at Contact Zone (Abutment / Embankment)	None		
5.2 Signs of Erosion	None		
5.3 Vegetation	Mature Trees	4	
5.4 Presence of Rodent Burrows	None		
5.5 Other Unusual Conditions	None		
6. RESERVOIR		1,3,6,12,15, 16,19,22	No ponding observed 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		

INSPECTION ITEM	OBSERVATIONS / DATA	PHOTO	COMMENTS & OTHER DATA
6.4 Floating Debris	N/A		
6.5 Other Unusual Conditions	Plugged decant tower inlet in Cell 5	11	Tower inlet filled in 2016, downstream outlet not found
7. EMERGENCY SPILLWAY / OUTLET STRUCTURE	From Cell 3 to environment	17,18	Can pass 24-hour PMF
7.1 Surface Condition	Class 50 riprap		
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		
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	None 15	
8. INSTRUMENTATION			
8.1 Piezometers	None		
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	No		Update planned for Q4 2019 / Q1 2020
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	No		Update planned for Q4 2019 / Q1 2020
9.2.3 Date of Last Revision	22 February 2018		

10. NOTES
Cell 3 spillway constructed. Trees removed along Cell 3 crest and downstream slope. Required work based on inspection: ■ Remove dead trees along downstream toe of Cell 5 dam. ■ Locate outlet from Cell 5 decant pipe to confirm location and alignment. ■ Investigate downstream toe area of Cell 3 dam for cause of soft ground.

https://golderassociates.sharepoint.com/sites/104499/project files/6 deliverables/issued/197-r-rev1-tsf-2019 annual dsi/appendices/appendix c - inspection reports/appendix c1 - south tsf inspection report.docx

CLIENT:	Teck Resources Limited	**BY:**	Martyn Willan, P.Eng.
PROJECT:	Beaverdell Mine	**DATE:**	10 July 2019
LOCATION:	North TSF (Cells 6 and 7)	**REVIEWED:**	John Cunning, P.Eng.

GENERAL INFORMATION

Dam Type: Earthfill

WEATHER CONDITIONS:	Cloudy	**AIR TEMPERATURE:**	15°C

INSPECTION ITEM	OBSERVATIONS / DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST		26,30,31	
1.1 Crest Elevation	Low Point in Embankment: Cell 6: El. 797.5 m Cell 7: El. 798.0 m		2018 LiDAR Survey
1.2 Reservoir Level / Freeboard	Dry	24,25,26,30,35,36,37	No ponding observed during site inspection.
1.3 Distance to Tailings Pond (if applicable)	N/A		
1.4 Surface Cracking	None		
1.5 Unexpected Settlement	None		
1.6 Lateral Movement	None		
1.7 Other Unusual Conditions	Variable crest width: 3 to 4 m		2018 LiDAR Survey
2. UPSTREAM SLOPE		26,30	
2.1 Slope Angle	1.5H:1V		2018 LiDAR Survey
2.2 Signs of Erosion	Minor	-	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		
3. DOWNSTREAM SLOPE		27,28,32	
3.1 Slope Angle	Cell 6: 1.4 to 1.9H:1V Cell 7: 1.6 to 2.6H:1V		2018 LiDAR Survey

INSPECTION ITEM	OBSERVATIONS / DATA	PHOTO	COMMENTS & OTHER DATA
3.2 Signs of Erosion	Minor	27	Minor surficial erosion noted at north section of Cell 6
3.3 Signs of Movement (Deformation)	None		
3.4 Cracks	None		
3.5 Seepage or Wet Areas	Dry		
3.6 Vegetation Growth	Mature trees	26,27,28,30, 31,32,33	
3.7 Other Unusual Conditions	Animal burrow in Cell 7 south embankment	33	
4. DOWNSTREAM TOE AREA		27,28,29,33	
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 Animal burrows	29 33	
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		24,25,30,35,36,37	
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 Animal burrows	37 38	Tower inlet filled

INSPECTION ITEM	OBSERVATIONS / DATA	PHOTO	COMMENTS & OTHER DATA
7. EMERGENCY SPILLWAY / OUTLET STRUCTURE	From Cell 7 to environment	34	
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 within diversion and spillway channels	34	
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		
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	No		Update planned for Q4 2019 / Q1 2020
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	No		Update planned for Q4 2019 / Q1 2020
9.2.3 Date of Last Revision	22 February 2018		

10. NOTES
No significant changes since 2018 DSI. Required work based on inspection: ■ Decommission Cell 6 decant outlet structure at downstream toe by removing steel structure and removing / sealing pipe outlet.

https://golderassociates.sharepoint.com/sites/104499/project files/6 deliverables/issued/197-r-rev1-tsf-2019 annual dsi/appendices/appendix c - inspection reports/appendix c2 - north tsf inspection report.docx

APPENDIX D

Available Design and As-Built Cross-Sections

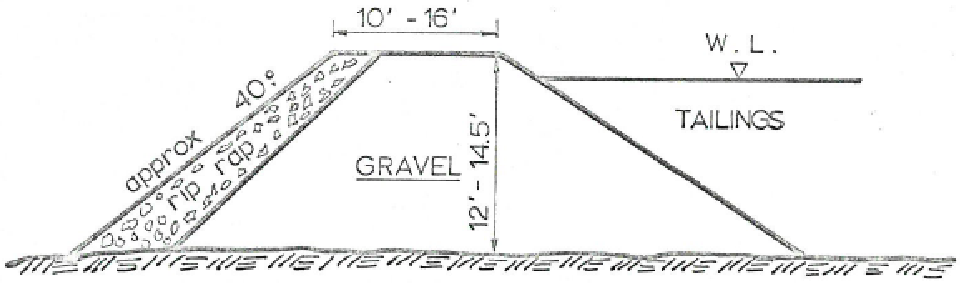
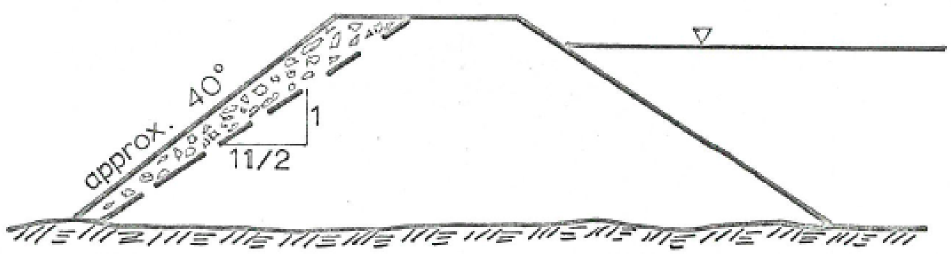


FIG. A



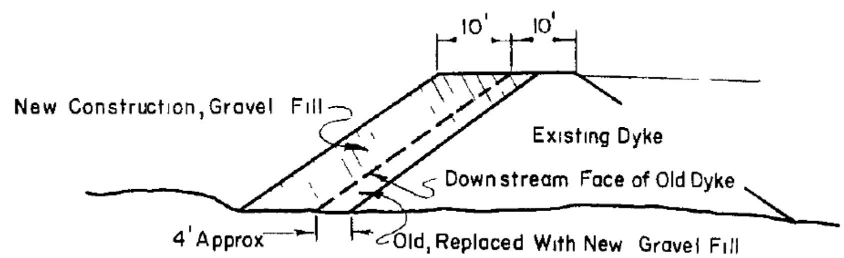
Assumed actual crossection

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

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

CONSULTANT
GOLDER

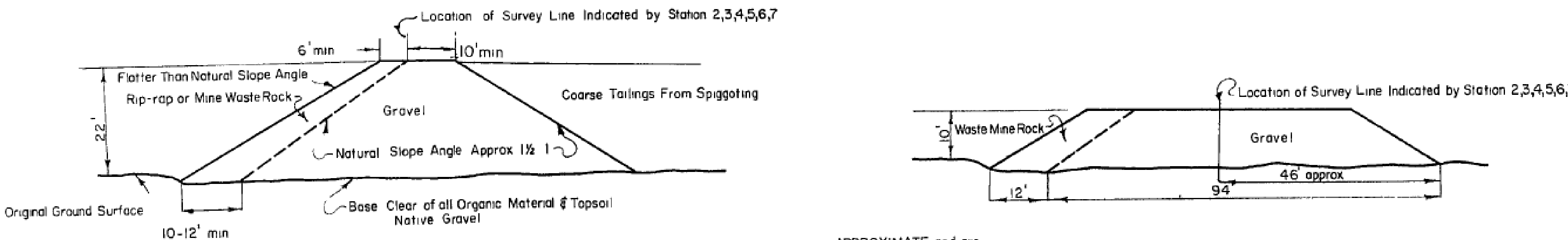
YYYY-MM-DD	2020-04-16
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

TITLE
CELL 4 CROSS SECTIONS

PROJECT No.	PHASE No.	Rev.	FIGURE
19117544	1400	1	D-1

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

FINAL HEIGHT | SCALE 1" = 20' Approx | INITIAL 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

CLIENT
TECK RESOURCES LIMITED

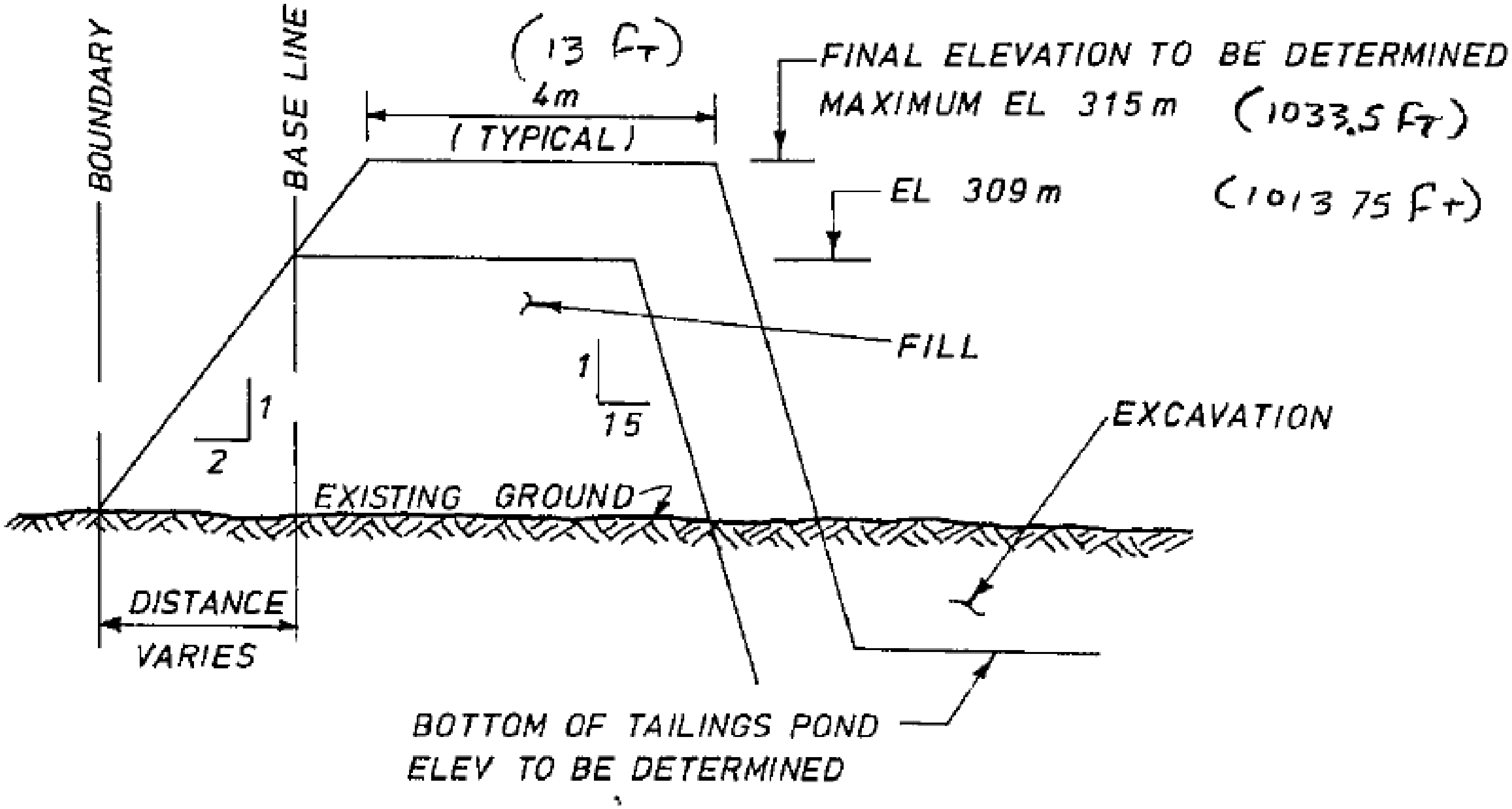
PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-16
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

TITLE
DAM DESIGN FOR CELL 5
CROSS SECTIONS

PROJECT No.	PHASE No.	Rev.	FIGURE
19117544	1400	1	D-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.

CLIENT
TECK RESOURCES LIMITED

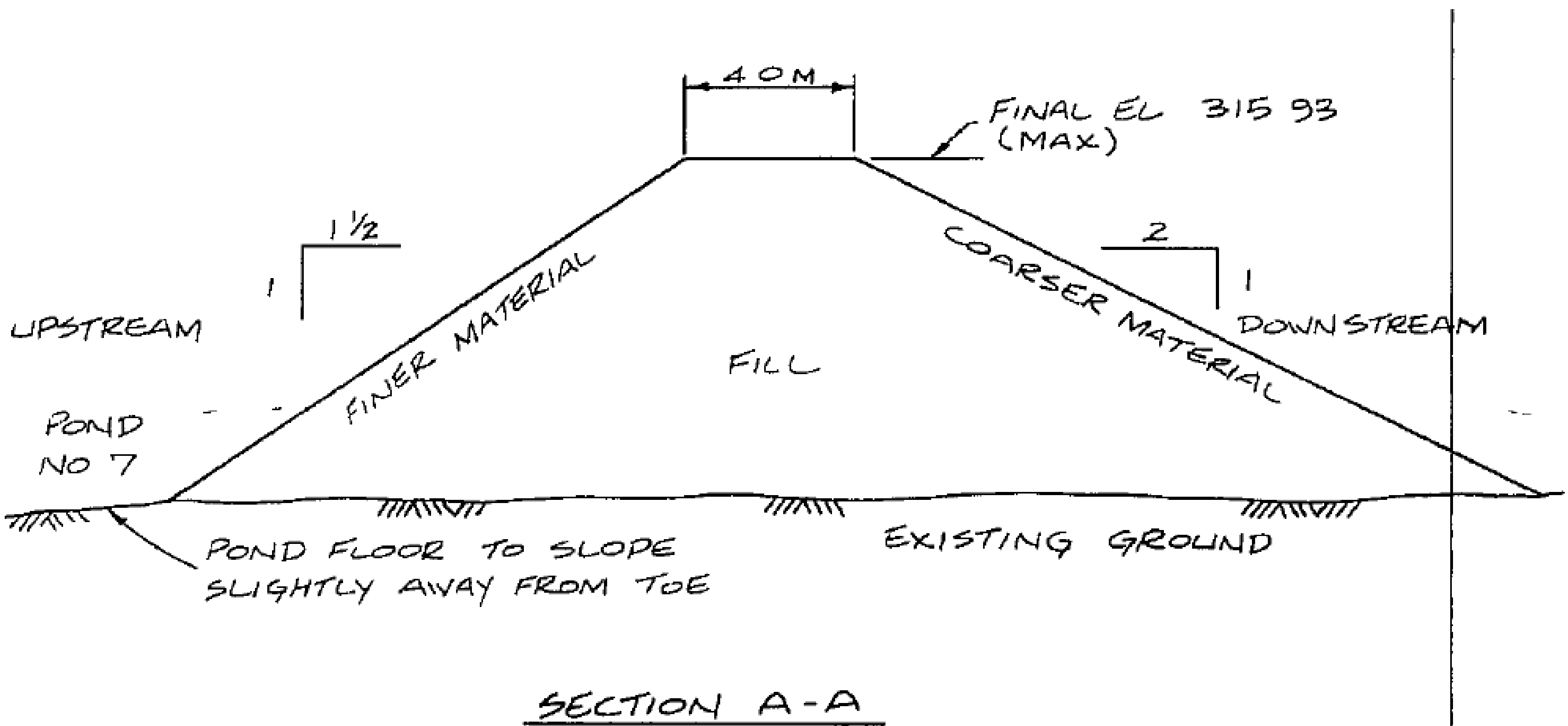
PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-16
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

TITLE
DAM DESIGN FOR CELL 6
CROSS SECTIONS

PROJECT No.	PHASE No.	Rev.	FIGURE
19117544	1400	1	D-3



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

CLIENT
TECK RESOURCES LIMITED

PROJECT
BEAVERDELL TAILINGS STORAGE FACILITIES
2019 ANNUAL DAM SAFETY INSPECTION

CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-16
PREPARED	ZS
DESIGN	ZS
REVIEW	MBW
APPROVED	JCC

TITLE
DAM DESIGN FOR CELL 7
CROSS SECTIONS

PROJECT No.	PHASE No.	Rev.	FIGURE
19117544	1400	1	D-4

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