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TECK RESOURCES LIMITED
BEAVERDELL MINE

Beaverdell Tailings Storage Facilities 2017 Annual Dam Safety Inspection

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REPORT

Golder Associates

Executive Summary

This report presents the 2017 annual dam safety inspection (DSI) for the embankments of the tailings storage facilities (TSF) 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 accordance with the Teck Guideline for Tailings and Water Retaining Structures (Teck 2014).

The DSI is based on a site visit carried out on 8 August 2017 by the Engineer of Record, John Cunning, of Golder and a review of data provided by Teck. The reporting period for the data review was from September 2016 through September 2017 unless otherwise noted. Over this reporting period Teck inspected the dams three times: two regular inspections and a special inspection for a high level water event that occurred on 5 May 2017. Maintenance activities included removing debris from the spillway in Cell 3, infilling animal burrows, and removing dead vegetation from the dam embankments.

Summary of Facility Description

The TSFs are located within the valley of the West Kettle River, at elevations between 770 and 800 m. The east side of Cranberry Ridge, including the area of the TSFs, is part of the drainage area of the West Kettle River. The TSFs are divided into the South TSF and the North TSF. The South TSF includes five tailings deposition cells (Cells 1 to 5) and the North TSF includes two cells (Cells 6 and 7). The South and North TSF dams are most likely (as-built reports not available) to have been constructed as earthfill dams using a downstream construction technique.

Summary of Key Hazards and Consequences

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

Internal erosion:

- The Beaverdell TSFs are no longer active. Small, shallow ponds are occasionally present in Cell 4 and Cell 6. No ponding was observed during the 2017 site inspection. Due to the expected drained, non-saturated condition of the tailings within the TSFs and the sand and gravel dams, it is believed there is typically insufficient hydraulic gradient to drive a potential piping failure. Internal erosion is considered to be a rare[1] to very rare[2] likelihood.

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

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

Overtopping:

- The small, shallow, temporary ponding that occurs at the Beaverdell TSFs under typical conditions is not an overtopping risk, however large non-typical storm events could generate more significant quantities of ponded water. The North TSF has a spillway in Cell 7, and Cell 7 can contain the inflow design flood (IDF), therefore the likelihood of overtopping for this facility is very rare. The South TSF routes surface water to Cell 3 where it can exit the facility through a spillway. The spillway is currently undersized with respect to the IDF. A detailed design to upgrade the spillway has been completed and Teck plans for spillway upgrade construction in 2018. Irrespective of the spillway, the dam height at Cell 3 is low (2 to 3 m), and an overtopping failure at this location is expected to have relatively minor consequences.

Instability:

- The visual inspection during the August 2017 site visit did not identify any sign of stresses 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 upstream or downstream slopes of either facility. The conditions of the dams have remained unchanged from previous site visits. No seepage or signs of uncontrolled past seepages were identified during the site visit. The dam slopes appear to be stable. An updated stability analyses was completed in 2017 to check against the new seismic design criteria provided in the Health, Safety, and Reclamation Code for Mines in British Columbia (HSRC) Guidance Document (MEMPR 2016). The reassessment found that the facilities are stable under static and pseudo-static (i.e. seismic) conditions (Golder 2018a).

Erosion of toe from West Kettle River:

- Erosion protection was constructed within the north bank of the West Kettle River adjacent the South TSF in late 2015 and early 2016 (Golder 2016c). The erosion protection was designed for a peak flow resulting from a flow event 1/3 between the 1,000-year flood and the probable maximum flood (PMF) (Golder 2015b). On 5 May 2017 a high water level event occurred in the West Kettle River near the Beaverdell TSFs. The newly constructed riprap was not disturbed and ponded water at the toe of the dam flowed to the south away from the TSF (special inspection, Appendix D).

Dam Consequence Classification

Dam consequence classification is based on the potential consequences of a dam failure irrespective of the potential for such an event to occur. The South and North TSF dams at the Beaverdell Mine are Significant dam class structures, following the consequence classification in Section 3.4 from the HSRC Guidance Document (MEMPR 2016). This is the second lowest classification for a dam under these guidelines. There have been no changes to the conditions of the structures or regulations in the past year that would necessitate a change to this classification.

Summary of Key Observations and Significant Changes

The Beaverdell TSFs were in good condition at the time of the 2017 site inspection.

Dam condition, maintenance, and surveillance of the facility were reviewed through site observation and discussion with Teck personnel. The 2017 annual DSI report and photographs were prepared for the South and North TSF dams based on observations during the time of August 2017 site inspection.

No significant changes in visual monitoring records or dam stability were noted during the 2017 DSI for the South and North TSFs at the Beaverdell site. There is no functional geotechnical instrumentation installed at the Beaverdell TSFs. Quantitative performance objectives have been established and are presented in this DSI.

Review of Operation, Maintenance and Surveillance Manual

The operation, maintenance, and surveillance (OMS) manual for the TSF was updated in February 2018 (SP&P BEA-OMS-001.V002; Teck 2018a). The OMS manual meets the guidelines provided by the HSRC (MEMPR 2016, 2017a), the Canadian Dam Association (CDA 2013), the Mining Association of Canada (MAC 2011), and Teck (2014).

Review of Emergency Preparedness and Response Plan

The emergency preparedness and response plan (EPRP) plan was updated in February 2018 (Teck 2018b) (SP&P BEA-EPRP-001.V002). This document was updated to meet the guidelines provided by the HSRC (MEMPR 2016, 2017a), CDA (2013), the Mining Association of Canada (MAC 2011), and Teck (2014).

The EPRP was tabletop tested in September 2017. The exercise was summarized in a memorandum (Appendix G).

Dam Safety Review

The last dam safety review (DSR) for the Beaverdell TSFs was conducted in 2012 (Golder 2013). The next DSR for the facilities based on the CDA (2013) *Dam Safety Guidelines* was recommended for 2022. Based on the revised requirement in the HSRC (MEMPR 2017a), a DSR is required by 2021.

Status of 2016 Dam Safety Inspection Recommended Actions

There were no high priority deficiencies and non-conformances noted in the 2016 DSI report (Golder 2017b). Table E-1 provides the current status of the 2016 DSI recommendations for the TSFs.

Table E-1: Current Status of 2016 Recommended Actions for the Beaverdell Tailings Storage Facility Dams

ID Number	Deficiency or Non-conformance	Recommended Action	Current Status
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.	Conduct geochemical testing of the tailings to quantify the hazard if tailings are mobilized out of the TSF during a flood event.	**In Progress**—Moisture content, metals, and cyanide testing on tailings and soil surface samples has been completed. Teck is planning to issue a Request for Proposal for collection of samples for geochemical characterization of tailings.
2016-02a	Cell 3 cannot contain IDF; flood water will leave the South TSF via spillway in Cell 3. Spillway's ability to pass IDF uncertain.	Review existing Cell 3 spillway dimensions and riprap armouring; make recommendations to allow for safe passage of the IDF.	**Closed**
2016-02b		Raise the Cell 3 embankment to contain the IDF, **or** incorporate water management plan into closure plan *(updated recommended action: spillway to pass the IDF).*	**In Progress**—Detailed design for the spillway works in the South TSF is complete. Teck is developing a construction plan and schedule.
2016-03	Existing standpipe piezometers not suitable for future monitoring. (Updated to: Existing facility phreatic conditions not confirmed.)	Replace piezometers, either for closure purposes or dam monitoring, to be determined based on development of closure plan.	**In Progress**—Teck is planning to issue a Request for Proposal for installation of piezometers.
2016-04	Seismic stability assessment out of date.	Assess stability under seismic loading in accordance with HSRC Guidance Document (MEMPR 2016) for appropriate consequence classification.	**Closed**
2016-05	Closure plan not updated.	Start development of closure plan update. This could include: ■ piezometer installation ■ vegetation plans ■ surface water routing plan	**In Progress**—Teck is planning to issue a Request for Proposal for collection of data for development of updated closure plan.

ID = identification; TSF = tailings storage facility; IDF = inflow design flood; HSRC = Health, Safety and Reclamation Code.

2017 Dam Safety Inspection Recommended Actions

The Beaverdell TSF dams were observed to be in good condition at the time of the 2017 DSI site visit. No significant change in condition was noted from the good condition in 2016. This conclusion of good condition was based on visual monitoring records, dam stability, and surface water control.

Table E-2 summarizes the recommended actions for the Beaverdell TSF dams.

Table E-2: Summary of 2017 Dam Safety Inspection Recommended Actions

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline
South TSF	2016-01	The South TSF would discharge through the Cell 3 spillway during a 24-hour IDF event. The consequence of potential tailings migration due to flood transport is not quantified.	HSRC §10.1.3 & 10.1.12	Complete subsurface sampling and testing of tailings for geochemical properties.	3	2019
	2016-02b	Cell 3 cannot contain IDF; flood water will leave the South TSF via spillway in Cell 3.	HSRC §10.1.8	Detailed design for the South TSF spillways and construction scheduled to be completed by 31 May 2018, subject to weather conditions or approval of extension to order from MEMPR.	1	Q2-2018 to meet current MEMPR order
South and North TSFs	2016-03	Existing facility phreatic conditions not confirmed.	CDA 2013 §6.6	Complete drilling program to gather subsurface information and install piezometers.	3	2019
	2016-05	Closure plan not updated.	HSRC §10.4.1	Initiate investigation of existing physical and geochemical properties.	4	2019
	2017-01	Annual risk assessment for facilities.	HSRC Guidance Document §3.2	Update a risk assessment for the facilities.	4	2019
	2017-02	No dam breach and inundation study completed.	HSRC §10.1.11	Complete dam breach and inundation assessment. Reassess consequence classification if necessary.	3	2019

ID = identification; CDA = Canadian Dam Association; MEMPR = British Columbia Ministry of Energy, Mines and Petroleum Resources; HSRC = Health, Safety and Reclamation Code; IDF = inflow design flood; TSF = tailings storage facility; OMS = operation, maintenance, and surveillance.

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 (MEMPR2016).

ABBREVIATIONS

Abbreviation	Definition
MEMPR	British Columbia Ministry of Energy, Mines and Petroleum Resources (formerly Ministry of Energy and Mines). Also referred to as EMPR
CDA	Canadian Dam Association
DSI	dam safety inspection
DSR	dam safety review
EPRP	emergency preparedness and response plan
Golder	Golder Associates Ltd.
HSRC	Health, Safety and Reclamation Code for Mines in British Columbia (MEMPR 2017a)
MEM	British Columbia Ministry of Energy and Mines (now MEMPR)
n/a	not applicable
OMS manual	operation, maintenance, and surveillance manual
Teck	Teck Resources Limited

UNITS OF MEASURE

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

GLOSSARY

Term	Definition
Dam Safety Inspection (DSI)	An annual dam safety inspection report as required by Section 10.5.3 of the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (MEMPR 2017a) in consideration of the HSRC Guidance Document (MEMPR 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 (MEMPR 2017a).
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).
Tailings	Fine-grained residual material remaining after the valuable resources have been separated.
Upstream	The side of the embankment nearest to the reservoir or cell.

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1.0 INTRODUCTION

1.1 Purpose, Scope of Work, Methodology

As requested by Teck Resources Limited (Teck), Golder Associates Ltd. (Golder) prepared this 2017 annual dam safety inspection (DSI) report for the tailings storage facilities (TSFs) at the closed Beaverdell Mine in British Columbia. The facilities consist of the North TSF and South TSF.

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

The report is based on a site visit carried out by the Engineer of Record on 8 August 2017, which included a walkover of the TSF areas with Teck staff involved in the maintenance and surveillance of the dams. The report consists of the following key components:

- a summary of the site conditions and background information
- a summary of the activities for the 2016/2017 reporting period
- dam consequence classification and required operational documents review
- site photographs and records of dam inspection
- a review of the following:
  - climate data
  - water balance
  - assessment of dam safety relative to potential failure modes
- findings and recommended actions

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

The previous annual DSI site visit for these facilities was carried out in August 2016 and is reported in the 2016 annual DSI report (Golder 2017b).

This report should be read in conjunction with the Study Limitations, provided at the end of the report.

1.2 Regulatory Requirements

1.2.1 BC *Mines Act* and Health, Safety and Reclamation Code

The Beaverdell TSFs are regulated under the HSRC (MEMPR 2017a). Both the North TSF dam and South TSF dam are considered to be dams as determined by the HSRC.

As required by the HSRC, the following personnel have been designated Engineer of Record and Qualified Person for the TSFs:

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

The HSRC governs the design criteria of the facilities (Section 5.3) and includes documentation (Section 5.4) and reporting requirements, including the requirement for this DSI.

1.2.2 Permits and Licences

The Beaverdell Mine is regulated under the following permits:

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

1.3 Facilities Description

The Beaverdell Mine was an underground mine development adjacent to the community of Beaverdell, BC, which is located 87 km from Kelowna via BC Highway 33 (Figure 1). Silver was the main ore extracted from the mine, with appreciable quantities of lead, zinc, gold, and cadmium. The Beaverdell Mine was closed in 1991 and is now under active care and maintenance, with no current or planned mining activities.

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 West Kettle River, at elevations between 770 and 800 m. The east side of Cranberry Ridge, including the area of the TSFs, is part of the drainage area of the West Kettle River. Figure 2 illustrates the general view of the TSFs, which are divided into the South TSF and the North TSF. The South TSF includes five tailings deposition cells (Cells 1 to 5) and the North TSF includes two cells (Cells 6 and 7). Figure 3 shows the approximate locations of historical (not functional) instrumentation on the TSFs, various infrastructure, and the locations of representative cross-sections of the cells. The cross-sections are presented in Figures 4 and 5.

The dams were classified as Low consequence structures by the British Columbia Ministry of Energy and Mines in 2003 (MEM 2003) and updated to Significant 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 Closure – Active Phase. A caretaker is present in Beaverdell year round. No operation activities are required at the TSFs; the TSFs 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 gravity driven (infiltration and spillways).

Golder's first involvement with the TSFs was the dam safety review (DSR) inspection, completed in 2012 (Golder 2013). Golder has been the Engineer of Record for the Beaverdell TSFs since 2013.

1.3.1 South Tailings Storage Facility Description

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

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

A ditch along the road to the west of the South TSF area (Beaverdell Station Road, Figure 3) collects water runoff from Cranberry Ridge. As a result, the watershed zone of the South TSF consists only 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. Overall, surface water can migrate through internal spillways to Cell 3, which has an external spillway.

The South TSF contains a decant towers/tunnels in Cell 5 which originally managed pond water. No decant tower has been observed in any of the other South TSF cells. The decant tower in Cell 5 is shown in Photograph 10, Appendix A, and its approximate location is shown in Figure 3. This decant tower was sealed with foam in 2016.

A supernatant pond existed in the southwest corner of Cell 5 where the decant tower outlet exited the cell during operations (Figure 3) (Binnie 1980c). During previous inspections, tailings were observed in this area downstream of Cell 5. The tailings could be related to the decant outlet. The area is a known local low spot in the topography, and there is often ponding in this area during spring freshet (South TSF May 2017 inspection, Appendix D).

1.3.1.1 Dimensions of South Tailings Storage Facility Dam

Based on observations made during annual site inspections and current survey data of the site, the South TSF dam has a maximum height of about 10 m and an approximate length of 1,010 m. The configuration of Cells 1, 2, and 3 is unknown on the upstream side of the embankments, but the downstream slopes can be determined from survey data. A portion of Cell 1 and all of Cell 2 appears to be stacked tailings, based on observations. The dimensions of each cell are shown in Table 1 and are approximate. The existing crest length excludes the dividers between cells; it is only the dam length. Typical 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 (m)
Cell 1	2.0 to 4.0H:1V	unknown	110	1 to 3	3 to 10	785
Cell 2	n/a - stacked tailings	unknown	n/a – stacked tailings	n/a – stacked tailings	n/a – stacked tailings	n/a – stacked tailings
Cell 3	1.5 to 2.4H:1V	1.5 to 3H:1V	360	2.5 to 3.5	2 to 3	780

Cell	Downstream Slopes	Upstream Slopes	Exterior Crest Length (m)	Crest Width (m)	Embankment Height (m)	Approximate Minimum Crest Elevation (m)
Cell 4	1.2 to 1.4H:1V	1.5H:1V (assumed from original design)	240	3 to 3.5	7 to 8	784
Cell 5	1.3 to 2.5H:1V	1.5H:1V (assumed from original design)	300	3 to 6	7 to 8	785

n/a = not applicable.

1.3.1.2 Dimensions of South Tailings Storage Facility Spillways

Dimensions of the various spillways through the cells have been determined based on observations made during site inspections. The spillway through the Cell 3/4 divider dike has a bottom width of 3 m, a height of 1 m above the tailings at Cell 4, and lateral slopes of 2H:1V. It is trapezoidal in shape, partially riprap-armoured, and allows the conveyance of surface water from Cell 4 to Cell 3 (Photographs 22 and 23, Appendix A). The small, partially riprap-armoured spillway through the Cell 4/5 divider dike has a bottom width of 1 m and lateral slopes of about 1.5H:1V and allows conveyance of surface water form Cell 5 to Cell 4 (Photographs 16 and 17, Appendix A). There is a spillway exiting Cell 3 (Teck Cominco 2004), but the dimensions for this outlet are unknown. The current status of the Cell 3 spillway is shown in Photographs 27 and 28, Appendix A. There are no construction as-builts for these spillways. Plans are in place to upgrade the capacity of the Cell 3 spillway in 2018.

1.3.1.3 Storage Capacity of South Tailings Storage Facility

The storage capacity of each of the TSF cells was calculated in AutoCAD® Civil3D® using topography from a LiDAR survey taken in July 2013 and a survey of the east side of Cell 3 and the south side of Cell 1 conducted on 10 August 2016 (Golder 2017a). Storage for runoff was assumed to be available from the tailings surface elevation to the lowest spillway elevation of each cell.

The cells in the South TSF area are connected by a system of spillways, meaning that overflow from upstream cells is discharged to downstream cells. 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. Excess runoff from Cell 3 would discharge via the spillway to the area downstream of the Cell 3 dam.

The calculated storage volumes and locations of overflow discharge are presented in Table 2.

Table 2: South Tailings Storage Facility Cell Storage Capacities

Cell	Storage Volume (m^3)	Overflow Discharged To
1	0	Cell 5
2	0	Cell 4
3	2,380	spillway to area downstream of Cell 3 dam
4	8,500	Cell 3
5	18,300	Cell 4

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 dike (Figure 3). The North TSF area intersects the natural upslope of the West Kettle River valley, and consequently, no dam was required on parts of the west side of Cell 7. The main perimeter dam for the North TSF surrounds Cells 6 and 7, except for a portion to the west of Cell 7 where the topography has sufficient elevation to contain the facility (Figure 3).

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

The dam and the Cell 7 spillway channel to the west of Cell 7 prevents water runoff from Cranberry Ridge from entering the North TSF area. The watershed of the North TSF area therefore consists only of the surface area of this facility. Water collected in Cell 6 would report to Cell 7 and discharge via the Cell 7 spillway south of the TSF.

The decant towers/tunnels in the North TSF that originally managed pond water have been sealed (Golder 2014b). The diameter of each of the decant tunnel pipes was estimated at 0.2 m (i.e., 8 inches). The location of the two decant towers/tunnels in each cell of the North TSF is shown in Figure 3.

1.3.2.1 Dimensions of North Tailings Storage Facility Dam

Based on observations made during annual site inspections and current survey data of the site, the North TSF consists of an earthfill dam with a maximum height of about 12 m and an approximate length of 840 m. The dimensions of each cell are shown in Table 3 and are approximate. The existing crest length excludes the dividers between cells; it is only the dam length. Typical 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 (m)
Cell 6	1.4 to 1.9H:1V	1.5H:1V (assumed from original design)	510	3 to 4	10 to 12	797
Cell 7	1.6 to 2.6H:1V	1.5H:1V	330	3 to 4	8 to 10	797

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

1.3.2.2 Dimensions of North Tailings Storage Facility Spillways

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

1.3.2.3 Storage Capacity of North Tailings Storage Facility Dam

The storage capacity of each of the TSF cells was calculated in AutoCAD Civil3D using topography from a LiDAR survey taken in July 2013 (Golder 2017a).

The calculated storage volumes and locations of overflow discharge are presented in Table 4.

Table 4: North Tailings Storage Facility Cell Storage Capacities

Cell	Storage Volume (m^3)	Overflow Discharged To
6	20,100	Cell 7
7	151,200	spillway to area downstream of Cell 7 dam

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). 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). The foundation conditions for Cells 1, 2, and 3 are unconfirmed, but are assumed to be similar to the rest of the site (sand and gravel alluvial deposits). Soil units under the sand and gravel were not described in the design documents. Bedrock outcrops are present west of Cell 7.

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

1.3.4 Embankment Fill Materials

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

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

Cells 4 and 5 have a waste rock or alluvial cobbles 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 as stacked tailings. At some unknown time, a waste rock spoil was constructed to the south of Cell 1 and tailings appear to have been subsequently deposited using the waste rock spoil as an embankment.

1.4 Background Information and History

The Beaverdell Mine was an underground mine development. The main ore extracted was silver, with appreciable quantities of lead, zinc, gold, and cadmium. A summary of its early history, 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 Beaver 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 ore shipping to the smelter at Trail, BC, and undertook an exploration and development program that led to new ore discoveries and the decision to build a mill at Beaverdell. The mill was inaugurated in the 1950s, with an initial capacity of 50 tons per day that was later increased to 85 tons per day in 1964 and 110 tons per day in 1967. The mill was located to the west of the community of Beaverdell, across the West Kettle River (Verzosa and Goetting 1972).

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.

1.4.1 Historical Site Investigations

Known site investigations for each cell include the following:

- Cell 1: no known site investigations, conditions inferred
- Cell 2: no known site investigations, conditions inferred
- Cell 3: no known site investigations, conditions inferred
- Cell 4: samples taken from existing dam, conditions as described by site personnel (Binnie 1971)
- Cell 5: surface and subsurface soil samples for gradation testing (Binnie 1973)
- Cell 6: surface soil samples for gradation testing (Binnie 1980a)
- Cell 7: three test pits, samples taken for gradation testing (Binnie 1988)

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 is shown in Table 5, and original design cross-sections are in Appendix C. There are no original design or construction as-builts of Cells 1 to 3 in the South TSF. The original design dimensions of these cells are unknown. There are no construction as-builts for Cells 4 and 5.

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	2H:1V	1.5H:1V (if drawn to scale)	3.2 to 5.1	3.8 to 4.6	Binnie 1971, 1973	Figure C-1
Cell 5	2H:1V	1.5H:1V	5.1	7	Binnie 1973, 1980c	Figure C-2

1.4.2.2 North Tailings Storage Facility Dam

A summary of the original design and references for the North TSF dam is shown in Table 6, and original design cross-sections are in Appendix C. There are no construction as-builts for Cells 6 and 7.

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

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

1.4.3 Construction Summary

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

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

1.4.3.1 South Tailings Storage Facility

No construction records are available for Cells 1 to 4.

For Cell 4, Robert F. Binnie Ltd. (Binnie) provided site observations and recommendations for remedial actions in 1971.

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

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

Available records indicate that design reports for Cell 5 required that operations create a wedge of coarse tailings against the upstream slope of the TSF dams to act as a filter for the slimes. Samples of the tailings were taken once deposited to confirm the coarse tailings wedge (beach) was being created and spigotting methods were observed (Binnie 1980a).

1.4.3.2 North Tailings Storage Facility

Cells 6 and 7 of the North TSF was 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.

Available records indicate that design reports for Cells 6 and 7 required that operations create a wedge of coarse tailings against the upstream slope of the TSF dam to act as a filter for the slimes, and samples of the tailings were taken to confirm the coarse tailings wedge (beach) was being created and spigotting methods were observed (Binnie 1983, 1988).

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

1.4.3.3 Historical Piezometers

There are 13 documented standpipe piezometers around Cells 5, 6, and 7 (Binnie 1973, 1983, 1988) that are assumed to have been monitored during operations. Their locations are shown in Figure 3. Of the 13 piezometers, 9 were located in 2016 by Teck (Golder 2017b). The piezometers that were located and measured were all dry. Piezometer 7-2 exceeded the length of the water level reader; therefore, it is unknown whether the piezometer is dry below this depth.

The installation details of the piezometers are unknown, and the condition and usefulness of the piezometers are uncertain. Teck indicates that a Request for Proposal will be issued to install piezometers by end of 2018.

2.0 ACTIVITIES DURING 2017

2.1 Tailings Deposition

The Beaverdell Mine was not operating in 2017 and no new tailings were sent to either the North TSF or South TSF.

2.2 Teck Inspections

The dams are inspected biannually (during spring freshet and fall). Dam inspection forms for the May and September 2017 inspections, and a special inspection for a high level water event that occurred on 5 May 2017, are provided in Appendix D.

On 5 May 2017, a high water level event occurred in the West Kettle River near the Beaverdell TSFs. The site caretaker, Tex Hewitt, checked the South TSF riprap along Cells 4 and 5. The newly constructed riprap was not disturbed and ponded water at the toe of the dam flowed to the south away from the TSF (special inspection, Appendix D).

2.3 Water Quality Testing

Water quality sampling and analyses in the West Kettle River (upstream and downstream of the TSF) were completed twice during the reporting period in 2017.

2.4 Teck Maintenance Record

Teck completed a maintenance record for the reporting year and it is included in Appendix E. Key maintenance activities comprised the following:

- removed debris from the spillway in Cell 3
- infilled animal burrow in Cell 3 embankment
- removed vegetation on Cell 5 embankment

2.5 Ministry of Energy, Mines and Petroleum Resources Inspection

A geotechnical inspection of the Beaverdell Mine was conducted on 8 September 2017 by Paul Hughes, contracted Geotechnical Mines Inspector for MEMPR. An order resulted from the inspection related to the Beaverdell TSFs. The order is as follows:

> *Per Section 10.6.10 of the Code, the Mine is to address the spillway in Cell 3 per the recommendations* [of the Engineer of Record] *or provide a suitable alternative to spillway construction in Cell 3 to manage the IDF* [inflow design flood]*. This order is to be in compliance by May 31, 2018.* (MEMPR 2017b)

The full inspection report is included in Appendix F. The detailed design of the spillway is complete (Golder 2018b), and plans are in place to upgrade the spillway in 2018 (Teck will be submitting a request to MEMPR for an extension of the installation date).

2.6 Emergency Preparedness and Response Plan Tabletop Exercise

The emergency preparedness and response plan (EPRP) was tabletop tested on 12 September 2017. A memorandum outlining the exercise is provided in Appendix G.

2.7 Conceptual and Detailed Design and Construction for Cell 3 Spillway

Golder completed a conceptual spillway and ditch design for the North and South TSFs in August 2017 (Golder 2017c). Two options were assessed:

- Option 1: Provide conceptual designs for the South TSF Cell 3 spillway and divider dike spillways to safely convey the IDF.
- Option 2: Provide ditch conceptual designs for the North and South TSF, conveying runoff from the most upstream cells to the downstream cell with discharge to the environment to reduce the overall ponding of water.

Based on the order given by the MEMPR, Teck decided to go ahead with Option 1 and the detailed design was completed (Golder 2018b). It is anticipated that construction will be completed in 2018, with the completion date pending the result of Teck's discussions with MEMPR.

2.8 Stability Reassessment of Tailings Storage Facilities

The stability of the TSFs was reassessed due to updated seismic design criteria in the HSRC (Golder 2018a). This is discussed in more detail in Section 5.3.3.

3.0 CLIMATE DATA AND WATER BALANCE

3.1 Review and Summary of Climate Data

The review of climate characteristics at the Beaverdell Mine is focused on total precipitation, since this variable constitutes the main driver for the Beaverdell annual water balance. The most representative climate station for the Beaverdell Mine was the Beaverdell North climate station, which operated from 1975 to 2006. Since the Beaverdell North station ceased recording data in 2006, there has been no active climate station within the vicinity of Beaverdell Mine (i.e., a 25 km radius). Therefore, active stations in the region were considered. The active stations selected included Penticton, Kelowna, and Billings (ECCC 2017), which are in a region that encompasses Beaverdell Mine. Table 7 shows the long-term statistics for total precipitation obtained from monthly records at the active stations, as well as those at the Beaverdell North climate station (ECCC 2017). Table 8 shows the total precipitation for the period from October 2016 through September 2017.

Table 7: Total Precipitation Long-Term Statistics

Location	Period of Record	Station Number	Latitude; Longitude	Elevation (m)	Distance to TSF (km)	Minimum (mm)	Average (mm)	Maximum (mm)
Beaverdell North[(a)]	1975 to 2006	1130771	49°28'; 119°02'	838	11	346.0	474.3	614.9
Billings[(b)]	1984 to 2017	1140876	49°01'; 118°13'	519	90	393.0	524.0	631.9
Kelowna [(c)]	1968 to 2017	1123970	49°57'; 119°22'	430	62	230.7	355.5	504.6
Penticton A[(d)]	1944 to 2017	1126150	49°29'; 119°35'	348	37	197.3	318.2	470.5

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

b) Years excluded from the Billings statistics due to incomplete data are 1984, 1989, 1996, 1997, and 2007 to 2017.

c) Years excluded from the Kelowna statistics due to incomplete data are 1968, 1977, 1995, 2002, 2005, 2010 to 2015, and 2017. Station data set merges Kelowna A (1968-2004), Kelowna AWOS (2005 to 2009) and Kelowna from 2010 to 2017d) Years excluded from the Penticton A statistics are 1944, 2010, 2012, 2013, 2016, and 2017.

TSF = tailings storage facility.

Table 8: Observed Precipitation from October 2016 through September 2017

Location	Days with Observations	Total Observed (mm)
Billings	314	558.8
Kelowna	323	228.4
Penticton	363	377.3

Long-term statistics of total precipitation at Beaverdell North are within the range of those at the active stations in the region (i.e., Billings, Kelowna, and Penticton). From October 2016 to September 2017, a nearly complete record of observation of total precipitation was available for Penticton (i.e., 2 missing days), and moderate gaps were seen in the data at Billings and Kelowna (i.e., 51 days and 42 days, respectively).

The recorded precipitation at Penticton for the period of October 2016 through September 2017 was 19% above the long-term annual average (377.3 mm compared to 318.2 mm). The recorded precipitation at Billings was approximately 7% above average (558.8 mm compared to 524.0 mm). The time periods associated with greater average precipitation were October 2016 and spring 2017, whereas the summer in both Penticton and Billings was significantly drier than average.

The observed precipitation at Kelowna for the period of October 2016 to September 2017 is moderately below (36%) the average annual precipitation at that station. The difference is partially due to the lack of recorded precipitation for February, April, May, and September, in addition to a dry summer. From July to September 2017, the total precipitation was 13 mm, compared to the average of approximately 129 mm. Due to the data gaps, scattered throughout the year, the station was excluded from the analysis.

Precipitation at Beaverdell is estimated to have exceeded its long-term average over the 12-month period because both Penticton and Billings exceeded their long-term averages (by 19% and 7%, respectively). The average percentage that Penticton and Billings exceeded their average annual precipitations by was 13%. Therefore, the precipitation at Beaverdell is expected to have been 13% above average, which leads to an estimated precipitation of 536 mm at Beaverdell over the 12-month period. This estimated precipitation value was used for the North and South TSF water balance in Section 3.2.

Observations of monthly precipitation, snowfall, and rainfall from October 2016 through September 2017 at Penticton and Billings are presented in Chart 1 (below), along with the long-term monthly statistics of precipitation at Beaverdell North (i.e., climate normal from 1975 to 2005). . Conclusions from Chart 1 are summarized as follows:

- Precipitation at Beaverdell during October 2016 and over the period of March through May 2017 would likely have been above average.
- Precipitation at Beaverdell over the period of June through September 2017 would likely have been well below average.

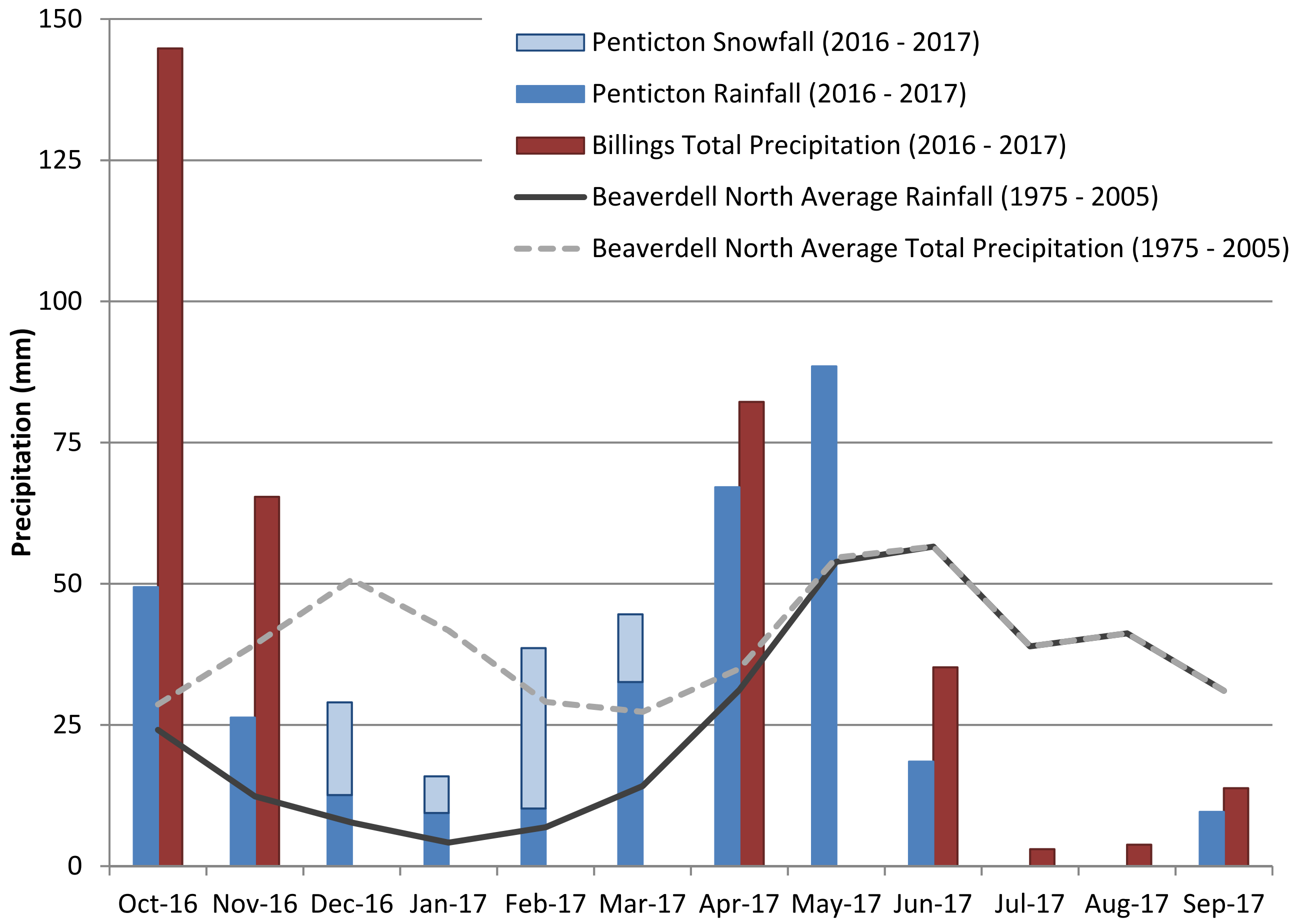

Chart 1: Monthly Precipitation Long-Term Statistics and Observed in 2016/2017

Notes: The Billings data for the months of December, January, February, March, and May have been excluded due to data gaps.

3.2 Review and Summary of Water Balance

The water balance for the South and North TSF were based on the watershed areas of each facility, summarized in Table 9. The total watershed of the South TSF area is limited by the South TSF dam and the Beaverdell Station Road (the road ditching 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 (ditching to the west of the North TSF, including the emergency spillway, diverts runoff from Cranberry Ridge away from the TSF).

Table 9: North and South Tailings Storage Facility Watershed Areas

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

TSF = tailings storage facility.

The water balance inflow is limited to the surface water contribution from precipitation. It is assumed that all groundwater inflows to the TSF (if any) exit the TSF. The inflow volume is therefore the total annual precipitation multiplied by the watershed areas, which, using the average long-term precipitation at Beaverdell plus 13% as discussed in Section 3.1, yield:

- a total inflow volume of 84,700 m^3 for the South TSF area
- a total inflow volume of 33,300 m^3 for the North TSF area

There is no surface water accumulation at the TSF (i.e., no surface water storage). No surface discharge to the downstream areas has been observed. The outflows from the TSF are therefore equal to the inflows. The distribution of the outflows cannot be assessed and are assumed to occur through the following processes:

- **Evaporation**—Loss of water to the atmosphere occurs with the TSF from temporary water ponding and from the soil near the surface.
- **Transpiration**—A vegetation cover is partially present at the TSF on the tailings surface and on the dam's slopes, and this cover captures water that will be released to the atmosphere in the form of transpiration.
- **Infiltration to ground**—Surface water percolates through the tailings deposits and infiltrates the underlying ground.
- **Sublimation**—A fraction of the snow cover on the TSF during the winter is lost to the atmosphere through sublimation (the transition from solid to water vapour).

3.3 Freeboard and Storage

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

A trigger-action-response plan (TARP) and related quantitative performance objectives (QPO) for surface water conditions at the Beaverdell TSFs were developed and are summarized in Table 10.

Table 10: Trigger Action Response Plan for Surface Water Conditions for Beaverdell Tailings Storage Facilities

Item	Threshold Criteria		
	Acceptable	Warning	Alarm
QPO of ponding within the cell	**Small central pond, edge of pond is located more than (>) 10 m from upstream crest**	**Edge of pond is less than 10 m but greater than 2 m from upstream crest**	**Edge of pond is within 2 m from upstream crest OR discharging is occurring through either the Cell 3 or Cell 7 spillways**
Action required	■ Document during biannual inspections, this is normal operations	■ Increase frequency of inspections to weekly until conditions meet acceptable ■ Document weekly inspections	■ Increase frequency of inspections to daily ■ Downstream water quality sampling ■ Document daily inspections
Personnel notified	■ Record and file with inspection reports ■ Engineering of Record receives a copy of the inspections annually	■ Gerry Murdoch ■ Kathleen Willman ■ Engineer of Record	■ MEMPR ■ Gerry Murdoch ■ Kathleen Willman ■ Teck's Tailings Working Group ■ Engineer of Record

Notes:

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

Distances can be measured with tape measure, distance wheel, or calibrated paces.

QPO = quantitative performance objective; MEMPR = British Columbia Ministry of Energy, Mines and Petroleum Resources

Surface water measurements were not taken in during the 2017 inspections as the QPOs were developed subsequent to the inspections. Ponding was noted as summarized in Table 11.

Table 11: Summary of Ponding in Tailings Storage Facilities

Facility	Cell	Inspections		
		23 May 2017	8 August 2017	7 September 2017
South TSF	Cell 1	no pond	no pond	no pond
	Cell 2	no pond	no pond	no pond
	Cell 3	no pond	no pond	no pond
	Cell 4	pond, estimate >10 m from dam crest	no pond	no pond
	Cell 5	no pond	no pond	no pond
North TSF	Cell 6	pond, estimate >10 m from dam crest	no pond	no pond
	Cell 7	no pond	no pond	no pond

TSF = tailings storage facility; n/a = not applicable.

3.4 Water Discharge Volumes

There was no observed discharge from the Beaverdell TSF spillways based on the site inspections. Losses occur through evaporation, evapotranspiration, and infiltration.

3.5 Water Discharge Quality

There are no measurements of water discharge quality from the TSFs due to the lack of surface discharge.

Water quality testing in the West Kettle River, upstream and downstream of the TSF was completed twice in 2017 during the reporting period (testing was completed a third time in 2017 outside of the reporting period). Teck retained Golder to complete the collection of water samples and testing starting in June 2017. Water quality testing results are submitted to the British Columbia Ministry of Environment in accordance with Water Licence No. PE-444 (MOE 1990). All parameters remained below relevant water quality guidelines.

4.0 SITE OBSERVATIONS

4.1 Visual Observations

A site inspection was carried out on 8 August 2016 by Mr. John Cunning, P.Eng., Mr. Mike Paget, P.Eng., and Ms. Alannah Gray Hubbard, E.I.T., of Golder, accompanied by Gerry Murdoch of Teck and Tex Hewitt, the site caretaker.

The temperature during the visit was between approximately 30°C and 35°C, and the weather was smoky/hazy and sunny.

4.2 Photographs

Appendix A presents a summary of photographs of the cells from the site inspection. The location, direction, and number for each photograph are noted in Figure 2.

4.3 Instrument Review

There is currently no functional geotechnical instrumentation installed at the Beaverdell TSFs. Quantitative performance objectives have been established for ponding in the cells, as described in Section 3.3. Ponded water in cell 4 and cell 6 was observed during the May 2017 Teck inspection. No ponding was observed during the August 2017 DSI site inspection.

4.4 Pond and Discharge Water Quality

There was no observed surface pond discharge from the Beaverdell TSFs in 2017 based on the site inspections. Water quality is discussed in Section 3.5.

4.5 Site Inspection Forms

A summary of the observations is included in the DSI report for each TSF in Appendix B. Details of Teck's site inspections are discussed in Section 2.2.

5.0 DAM SAFETY ASSESSMENT

5.1 Dam Classification Review

The TSF dams were checked against the definition of a dam in the HSRC (MEMPR 2017a). More specifically:

> ***"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.*

The North and South TSF dams are considered dams, since both facilities prevent uncontrolled flow of tailings and water.

Guidelines for the classification of dams are presented in the HSRC Guidance Document, Section 3.4 (MEMPR 2016), which references the Canadian Dam Association (CDA) *Dam Safety Guidelines* (CDA 2013). Table 12 presents the dam classification criteria. Consequence categories are based on the incremental losses that a failure of the dam may inflict on downstream or upstream areas, or at the dam location itself. Incremental losses are those over and above losses that might have occurred in the same natural event or condition had the dam not failed. The consequences of a dam failure are ranked as Low, Significant, High, Very High, or Extreme for each of four loss categories. The classification assigned to a dam is the highest rank determined among the four loss categories.

Table 12: 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.

Dam Class	Population at Risk	Incremental Losses		
		Loss of Life	Environmental and Cultural Values	Infrastructure and Economics
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 (MEMPR 2016), Table 3-3 based on CDA (2013), Table 2-1.

The HSRC Guidance Document and the CDA guidelines were used to assign a dam class to the Beaverdell TSF dams (Table 13).

Table 13: 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.

A screening level assessment of the classification of the TSF dams was previously completed for the DSR (Golder 2013). The rationale applied in the DSR for assigning the consequence level for each attribute for the South TSF area is as follows (Golder 2013):

- **Population at Risk (Significant)**—No permanent dwellings have been observed near the dam structures. However, recreational facilities (i.e., trails and a baseball field) would be 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)**—The extent of the area impacted by a dam failure is expected to be very small. Loss of life, if any, would be the result of unforeseen misadventures.

- **Environmental and Cultural Values (Low to Significant)**—The extent of the area impacted by a dam failure may possibly reach the banks of the West Kettle River. However, short-term loss or deterioration of valued components (i.e., fisheries and wildlife habitats, endangered species if any, and landscapes) is expected to be minimal. Long-term loss or deterioration of valued components is not expected.
- **Infrastructure and Economics (Low)**—Economic losses are expected to be limited and 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)**—One permanent dwelling is located approximately 150 m from the south 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 residence. A temporary population should be considered as present near the North TSF.
- **Loss of Life (Low)**—The extent of the area impacted by a dam failure is expected to be very small. Loss of life, if any, would be the result of unforeseen misadventures.
- **Environmental and Cultural Values (Low)**—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)**—Economic losses are expected to be limited only to the owner of the North TSF (i.e., Teck).

The consequence classification of the Beaverdell TSF remains at Significant as there is no new information available and the site conditions remain unchanged. However, an inundation assessment should be completed to better evaluate the consequence classification.

The CDA *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams* (2014) 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

No changes to the downstream and upstream conditions at the Beaverdell TSFs were observed during the August 2017 DIS inspection.

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

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 fines fraction of one material can migrate into or through the voids of the adjacent material under a sufficient hydraulic gradient. Piping is induced by regressive erosion of particles towards an outside environment until a continuous pipe is formed. Suffusion is the migration of soil particles through the soil matrix.

Design Basis and Design Assessment

Based on review of the available reports, it is understood that the dams were constructed of locally borrowed free-draining sand and gravel materials. The design reports for Cells 5, 6, and 7 considered a coarse tailings beach adjacent to the sand and gravel dams which were required to act as a filter for the slimes (fine fraction of tailings). 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).

There are no known design or construction records for Cells 1, 2, or 3. 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 embankment and operations were change to spigotted deposition to deposit coarse tailings against the upstream slope and push the slimes toward the centre of the facility (Binnie 1971). Samples of the gravels used for construction of Cell 4 were taken (Binnie 1971). Binnie (1973) followed up on the tailings deposition recommendations from 1971 and tailings samples were taken from Cell 4 to compare the gradation of tailings deposited near the dam faces against the unsegregated tailings. 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).

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 MEMPR order dated 3 February 2015 (Golder 2015a).

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

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

The Beaverdell TSFs are no longer active, and there is very little free water contained within them. Small, shallow ponds are occasionally present in Cell 4 and Cell 6, but no ponding was present during the 2017 DSI site inspection. Due to the expected drained, non-saturated condition of the tailings within the TSFs and the sand and gravel dams, it is believed there is typically insufficient hydraulic gradient to drive a potential piping failure. Internal erosion is considered to be a rare[3] to very rare[4] likelihood.

Observed Performance

Sites visits from 2012 through to 2016, as well as that conducted 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 the site visit, or any signs such as dampness, wetlands, or eroded zones that would be indicative of uncontrolled past seepage areas. Vegetation, including trees, is apparent on the downstream face and toe of the North and South TSF dams. However, water demand from that vegetation may assist in keeping the water table at a level that minimizes seepages (if any).

The decant pipes in the North TSF were sealed under the supervision of Teck, as noted in the 2013 DSI (Golder 2014b). The decant pipe could not be located in Cell 4. The decant pipe in Cell 5 was sealed in 2016. It is unknown whether the pipes have seepage collars or similar structures to limit water flow adjacent to the pipe. It is possible that seepage flows may occur and thus piping could develop around the decant pipes. However, a sufficient hydraulic gradient is not expected to develop, as evidenced by the limited or non-existent ponds in the TSFs. No seepage at the Cell 6 or Cell 7 pipe outlets was noted during the August 2017 inspection.

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

5.3.2 Overtopping

Design Basis and Design Confirmation

Golder (2017a) presents a water management plan for the Beaverdell TSFs, which includes a summary of the site climate, a description of the water management for the TSFs, and a water balance.

The HSRC Guidance Document (MEMPR 2016) requires an IDF 1/3 between the 1-in-1,000-year flood event and the probable maximum flood (PMF) for a Significant consequence structure. The storage of the Beaverdell South and North TSFs was checked against the 72-hour IDF of 1/3 between the 1,000-year event and the PMF (Golder 2017a). The estimated inflow design storm is defined as 142 mm of rain and snowmelt considering a 72-hour duration event as required by the HSRC (MEMPR 2017a) for a facility that stores the IDF.

The South TSF cannot store the IDF, and excess flood water is expected to exit via the Cell 3 spillway.

The North TSF can store the IDF without discharging through the Cell 7 spillway, therefore the likelihood of overtopping for this facility is very rare.

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

[4] 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.

The minimum freeboard can be defined as the minimum vertical distance between the still pool reservoir 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.

An initial evaluation of freeboard conditions was completed for the DSR in 2012 (Golder 2013), and a freeboard of 0.5 m was recommended based on typical design criterion for small mining dams (MELP 2001). This is not consistent with the CDA recommendations.

The current condition of the TSFs is dry with occasional, temporary ponding away from the dam crest. In the South TSF, the tailings are often beached to the same elevation as the crest. The North TSF generally has a vertical difference of at least 0.5 m between the crest and the top of tailings at the dam upstream. 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.

The North TSF does not require a freeboard assessment as capacity and freeboard of the facility are considered adequate based on observed water levels and the maximum estimated water level during a 72-hour IDF (Golder 2017c).

Minimum freeboard requirements for Cell 3 (South TSF) in relation to the spillway were assessed. Normal freeboard was not applicable as there is typically no water within the facility. The minimum freeboard for the South TSF based on Cell 3 is 0.3 m (Golder 2017c).

Observed Performance

Teck observed ponding in Cell 6 and Cell 4, along the east toe of Cells 3, 4, and 5, and along the south toe of Cell 5 during the May 2017 inspection (see inspection reports in Appendix D). The excess water had dried up at the time of the inspection in August 2017. There is no indication this surface water accumulation would have reached the dam upstream side slope or dam face. The use of the spillways has not been required.

5.3.3 Instability

Design Basis and Design Confirmation

The HSRC Guidance Document (MEMPR 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 seismic conditions. The HSRC Guidance Document (MEMPR 2016) recommends a return period 2,475-year seismic event be used for Significant consequence structures.

Seismic information from the seismic hazard maps developed by Natural Resources Canada (NRC) was used to determine the peak horizontal ground acceleration for use in the stability reassessment. Earthquake ground motions calculated for the Beaverdell site (49.4423 north latitude and 119.0968 west longitude) from NRC (2015) are presented in Table 14. The 2015 seismic information is the most recent available from NRC.

Table 14: 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.

CDA = Canadian Dam Association.

The HSRC (MEMPR 2017a) requires a return period 2,475-year seismic event be used for Significant consequence structures.

A dam stability reassessment for the North and South TSFs was completed by Golder (2018a) in accordance with the HSRC Guidance Document (MEMPR 2016). For Significant dam structures, the 2,475-year earthquake event was selected (2% probability of exceedance in 50 years) for long-term stability analyses under pseudo-static loading conditions as recommended by the HSRC Guidance Document (MEMPR 2016). The reassessment found that the facilities are stable under static and pseudo-static conditions, and no analyses were required for post-earthquake conditions (Golder 2017d).

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

The installation details of the piezometers are unknown, and the condition and usefulness of the piezometers is uncertain. Golder recommends that new piezometers be installed to confirm the phreatic conditions, support closure planning, and provide information relevant to the inundation assessment. Long term piezometric monitoring of the facility in its current configuration is not required.

The HSRC requires justification for overall downstream dam slopes that are steeper than 2H:1V (MEMPR 2017a). 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 2017d). Inspections from 2012 through 2017 have indicated that the slopes are performing adequately at a steeper slope angle than 2H:1V.

Observed Performance

The visual inspection during the August 2017 site visit did not identify any sign of stresses such as cracks, settling, or bulges on the North and South TSF dams. The trees on the downstream slopes are straight and do not indicate there has been any long-term or recent slope movement.

Minor erosion on the downstream slope of Cell 6 was noted (Photograph 37, Appendix A), but it is limited by the armouring of the downstream slope face and is not considered to put the facility at risk of instability.

A large animal burrow was observed on the downstream slope of Cell 3. This burrow is not considered to be a significant risk to the stability of the facilities, but should be infilled. Teck infilled the burrow in September 2017 (September inspection, Appendix D).

Some dead trees were observed on the west side of Cell 3’s upstream slope (Photograph 31, Appendix A). The dead trees are not considered to be a significant risk to the stability of the facility, but should be removed.

No significant erosion was noted on 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). No seepage was observed during the site visit. The dam slopes appear to be stable.

5.3.4 River Erosion Protection

Erosion of the dam toe due to flooding of the West Kettle River could cause dam instability.

Design Basis and Design Confirmation

Erosion protection was designed for the north bank of the West Kettle River adjacent the South TSF. The erosion protection comprises a trench of buried riprap that will self-launch to protect the South TSF in the event that the natural ground between the riprap and river is eroded.

The erosion protection was designed for a peak flow resulting from a flow event 1/3 between the 1,000-year flood and the PMF (Golder 2015b). This design criteria is equivalent to the HSRC Guidance Document (MEMPR 2016) required criteria for a structure classified as Significant.

Observed Performance

Erosion protection was constructed within the north bank of the West Kettle River adjacent the South TSF in late 2015 and early 2016 (Golder 2016c). On 5 May 2017, a high water level event occurred in the West Kettle River near the Beaverdell TSFs. The newly constructed riprap was not disturbed and ponded water at the toe of the dam flowed to the south away from the TSF (special inspection, Appendix D).

5.4 Review of Operational Documents

5.4.1 Operation, Maintenance, and Surveillance Manual Review

An operation, maintenance, and surveillance (OMS) manual for the TSF was originally developed in 2014 (Golder 2014a) and most recently updated in February 2018 (SP&P BEA-OMS-001.V002; Teck 2018a). The OMS manual meets the guidelines provided by the HSRC (MEMPR 2016, 2017a), CDA (2013), the Mining Association of Canada (MAC 2011), and Teck (2014).

Maintenance activities for the reporting year were documented by Teck and are presented in Appendix F. The document notes the date of the maintenance events, the person recording the event, a description of maintenance accomplished, and additional comments (i.e., supporting documentation and follow-up when needed).

5.4.2 Emergency Preparedness and Response Review

The EPRP was originally contained in the same document as the OMS manual (Golder 2014a). The EPRP was subsequently developed into its own document with the most recent update completed in February 2018 (SP&P BEA-EPRP-001.V002; Teck 2018b). This document was updated to meet the guidelines provided by the HSRC (MEMPR 2016, 2017a), CDA (2013), MAC (2011), and Teck (2014).

The EPRP was tabletop tested in September 2017. The exercise was summarized in a memorandum (Appendix G). Golder was informed of the tabletop test and was available as needed during the exercise.

5.4.3 Dam Safety Review

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

Table 15 summarizes the date of the last DSR, regulatory frequency requirements, and schedule for next DSR for the Beaverdell TSF dams.

Table 15: Schedule for Next Dam Safety Review

Structure	Date of Last Dam Safety Review	Dam Safety Review Frequency per CDA (2013)	Dam Safety Review Frequency per HSRC (MEMPR 2017a)	Schedule for Next Dam Safety Review
South TSF	2012	2022	5 years	2021
North TSF	2012	2022	5 years	2021

Note: HSRC DSR frequency requirements have changed since the last DSR.

CDA = Canadian Dam Association; TSF = tailings storage facility; HSRC = Health, Safety and Reclamation Code; DSR = dam safety review.

6.0 SUMMARY AND RECOMMENDATIONS

6.1 Summary of Activities

Activities completed during the reporting period were:

- five inspections: one DSI site inspection; two regular Teck inspections; one event-triggered inspection; one EMPR inspection
- two water quality sampling and resultant analyses
- routine maintenance by Teck
- a tabletop test of the EPRP
- conceptual and detailed design of the Cell 3 spillway
- reassessment of the dam stability

6.2 Summary of Climate and Water Balance

The precipitation at the Beaverdell site was likely:

- above average during October 2016 and over the period of March through May 2017
- well below average over the period of June through September 2017

The surfaces of the TSFs are typically dry, resulting in a neutral to negative water balance annually (i.e., dry condition remains unchanged).

6.3 Summary of Performance and Changes

The Beaverdell TSF dams were observed to be in good condition at the time of the 2017 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

The South and North TSF dams at the Beaverdell Mine remain as Significant dam class structures, following the consequence classification in Section 3.4 from the HSRC Guidance Document (MEMPR 2016).

6.5 Previous Deficiencies and Non-conformances

There were no high priority deficiencies and non-conformances noted in the 2016 DSI report (Golder 2017b). Table 16 provides the current status of the 2016 DSI recommendations for the TSFs.

Table 16: Current Status of 2016 Recommended Actions for the Beaverdell Tailings Storage Facilities

ID Number	Deficiency or Non-conformance	Recommended Action	Current Status
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.	Conduct geochemical testing of the tailings to quantify the hazard if tailings are mobilized out of the TSF during a flood event.	**In Progress**—moisture content, metals, and cyanide testing on tailings and soil surface samples has been completed. Teck is planning to issue a Request for Proposal for collection of samples for geochemical characterization of tailings
2016-02a	Cell 3 cannot contain IDF; flood water will leave the South TSF via spillway in Cell 3. Spillway's ability to pass IDF uncertain.	Review existing Cell 3 spillway dimensions and riprap armouring; make recommendations to allow for safe passage of the IDF.	**Closed**
2016-02b		Raise the Cell 3 embankment to contain the IDF, **or** incorporate water management plan into closure plan *(updated recommended action: spillway to pass the IDF).*	**In Progress**—detailed design for the spillway works in the South TSF is complete. Teck is developing a construction plan and schedule.
2016-03	Existing standpipe piezometers not suitable for future monitoring. (Updated to: Existing facility phreatic conditions not confirmed.)	Replace piezometers, either for closure purposes or dam monitoring, to be determined based on development of closure plan.	**In Progress**—Teck is planning to issue a Request for Proposal for installation of piezometers
2016-04	Seismic stability assessment out of date.	Assess stability under seismic loading in accordance with HSRC Guidance Document (MEMPR 2016) for appropriate consequence classification.	**Closed**
2016-05	Closure plan not updated.	Start development of closure plan update. This could include: ■ piezometer installation ■ vegetation plans ■ surface water routing plan	**In Progress**—Teck is planning to issue a Request for Proposal for collection of data for development of updated closure plan

ID = identification; TSF = tailings storage facility; IDF = inflow design flood; HSRC = Health, Safety and Reclamation Code.

6.6 Current Deficiencies and Non-conformances

Table 19 summarizes the recommended actions for the Beaverdell TSF dams.

Table 17: Summary of 2017 Dam Safety Inspection Recommended Actions

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline
South TSF	2016-01	The South TSF would discharge through the Cell 3 spillway during a 24-hour IDF event. The consequence of potential tailings migration due to flood transport is not quantified.	HSRC §10.1.3 & 10.1.12	Complete subsurface sampling and testing of tailings for geochemical properties.	3	2019
	2016-02b	Cell 3 cannot contain IDF; flood water will leave the South TSF via spillway in Cell 3.	HSRC §10.1.8	Detailed design for the South TSF spillways and construction scheduled to be completed by 31 May 2018, subject to weather conditions or approval of extension to order from MEMPR.	1	Q2-2018 to meet current MEMPR order
South and North TSFs	2016-03	Existing facility phreatic conditions not confirmed.	CDA 2013 §6.6	Complete drilling program to gather subsurface information and install piezometers.	3	2019
	2016-05	Closure plan not updated	HSRC §10.4.1	Initiate investigation of existing physical and geochemical properties.	4	2019
	2017-01	Annual risk assessment for facilities	HSRC Guidance Document §3.2	Update a risk assessment for the facilities	4	2019
	2017-02	No dam breach and inundation study completed	HSRC §10.1.11	Complete dam breach and inundation assessment. Reassess consequence classification if necessary	3	2019

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

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 (MEMPR 2016)

7.0 CLOSURE

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

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

GOLDER ASSOCIATES LTD.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
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28 March 2018

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https://golderassociates.sharepoint.com/sites/15578g/deliverables/3. issued/052-r-rev0-1000_beaverdell dsi/1778313-052-r-rev0-1000-beaverdell 2017 dsi 28mar_18.docx

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STUDY LIMITATIONS

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LOCATION PLAN

0 500 1,000

1:20,000 METRES

NOTE

1. COORDINATES ARE IN UTM ZONE 11 NAD83.

REFERENCE

1. 2013 ORTHOPHOTO RECEIVED FROM TECK RESOURCES LIMITED.

CLIENT

TECK RESOURCES LIMITED
BEAVERDELL MINE
BEAVERDELL, B.C.

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-11-15
DESIGNED	AGH
PREPARED	JY
REVIEWED	JMS
APPROVED	JCC

PROJECT

2017 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

TITLE

BEAVERDELL SITE PLAN

PROJECT NO.	PHASE/DOC.	REV.	FIGURE
1778313	1000/052	0	1

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LEGEND

- 2013 TOPOGRAPHIC CONTOURS
- 2016 TOPOGRAPHIC CONTOURS
- RIP-RAP ARMOURING A
- RIP-RAP ARMOURING B
- (#) 2017 SITE VISIT PHOTOGRAPH LOCATION

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN UTM ZONE 11 NAD83.
3. 2013 TOPOGRAPHIC CONTOURS SHOWN AT 1.0 m MINOR AND 5.0 m MAJOR INTERVAL.
3. 2016 TOPOGRAPHIC CONTOURS SHOWN AT 0.1 m MINOR AND 0.5 m MAJOR INTERVAL.

REFERENCES

1. 2013 ORTHOPHOTO PROVIDED BY TECK RESOURCES LIMITED.
2. GROUND SURVEY BY MCELHANNEY (JULY 2013) PROVIDED BY TECK RESOURCES LIMITED.
3. 2016 TOPOGRAPHIC CONTOURS FOR CELL 1 AND 3 SURVEYED 10 AUGUST 2016 BY ALLTERRA LAND SURVEYING LTD. AND PROVIDED ON 30 AUGUST 2016.

0 50 100
1:3,000 METRES

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

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-11-15
DESIGNED	AGH
PREPARED	JY
REVIEWED	JMS
APPROVED	JCC

PROJECT
2017 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

TITLE
2017 INSPECTION PHOTOGRAPH LOCATIONS

PROJECT NO.	PHASE/DOC.	REV.	FIGURE
1778313	1000/052	0	2

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

LEGEND

- 2013 TOPOGRAPHIC CONTOURS
- 2016 TOPOGRAPHIC CONTOURS
- RIP-RAP ARMOURING A
- RIP-RAP ARMOURING B
- APPROXIMATE STANDPIPE PIEZOMETER LOCATION
- APPROXIMATE DECANT TOWER LOCATION
- APPROXIMATE OUTLET LOCATION
- APPROXIMATE SPILLWAY LOCATION AND FLOW DIRECTION

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN UTM ZONE 11 NAD83.
3. 2013 TOPOGRAPHIC CONTOURS SHOWN AT 1.0 m MINOR AND 5.0 m MAJOR INTERVAL.
4. 2016 TOPOGRAPHIC CONTOURS SHOWN AT 0.1 m MINOR AND 0.5 m MAJOR INTERVAL.

REFERENCES

1. 2013 ORTHOPHOTO PROVIDED BY TECK RESOURCES LIMITED.
2. GROUND SURVEY BY MCELHANNEY (JULY 2013) PROVIDED BY TECK RESOURCES LIMITED.
3. 2016 TOPOGRAPHIC CONTOURS FOR CELL 1 AND 3 SURVEYED 10 AUGUST 2016 BY ALLTERRA LAND SURVEYING LTD. AND PROVIDED ON 30 AUGUST 2016.
4. CELL 5 STANDPIPE PIEZOMETER APPROXIMATE LOCATIONS FROM BINNIE (ROBERT F. BINNIE LTD.). 1973. *REPORT ON PROPOSED NEW TAILINGS POND*. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 27 AUGUST 1973.
5. CELL 6 STANDPIPE PIEZOMETER APPROXIMATE LOCATIONS FROM BINNIE (R.F. BINNIE & ASSOCIATES LTD.). 1983. *1982 REPORT ON TAILINGS DISPOSAL, PONDS NO. 5 AND 4*. REPORT PREPARED FOR TECK CORPORATION LTD. SUBMITTED 11 FEBRUARY 1983.
6. CELL 7 STANDPIPE PIEZOMETER APPROXIMATE LOCATIONS FROM BINNIE. 1988. *REPORT ON PROPOSED POND NO. 7*. REPORT PREPARED FOR TECK CORPORATION LTD. SUBMITTED APRIL 1988.

0 50 100

1:3,000 METRES

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

CONSULTANT

Golder Associates

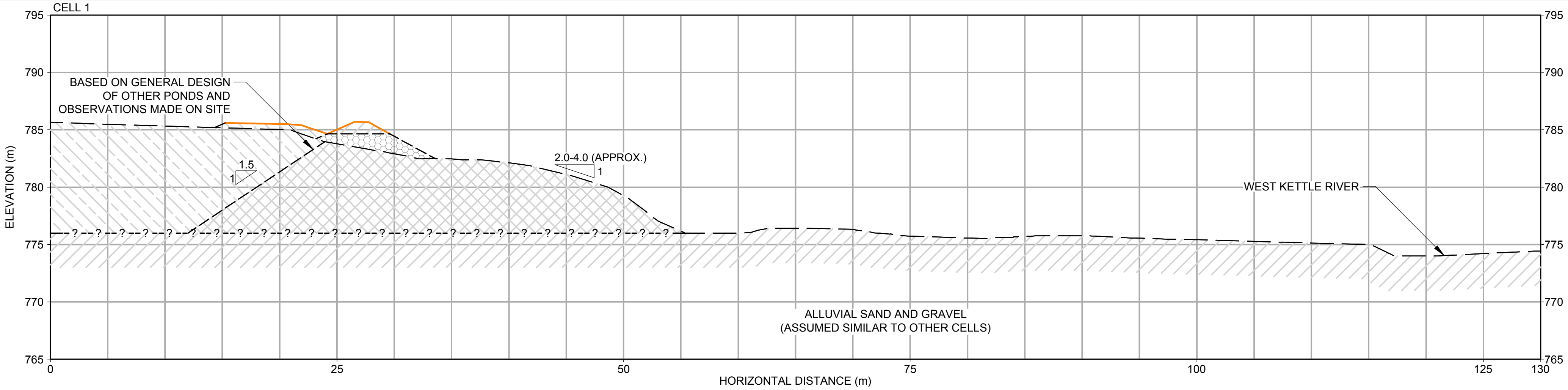
YYYY-MM-DD	2017-11-15
DESIGNED	AGH
PREPARED	JY
REVIEWED	JMS
APPROVED	JCC

PROJECT
2017 BEAVERDELL TAILINGS STORAGE FACILITIES ANNUAL DAM SAFETY INSPECTION

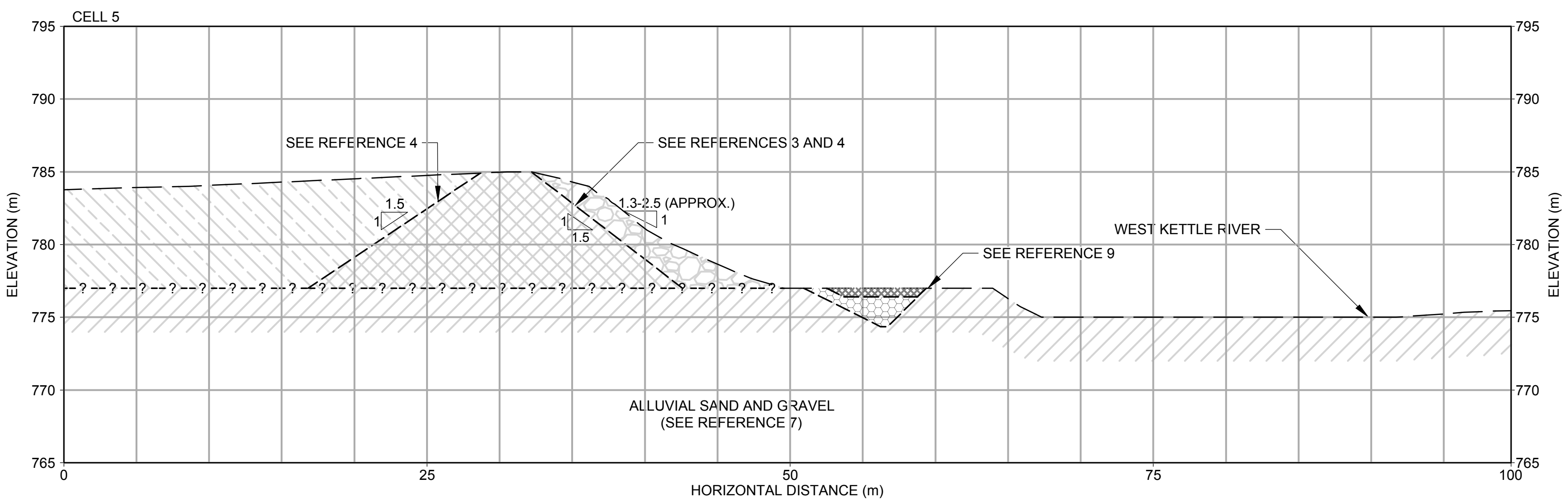
TITLE
DETAIL PLAN

PROJECT NO.	PHASE/DOC.	REV.	FIGURE
1778313	1000/052	0	3

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



SCALE 1:500 m A SECTION 3



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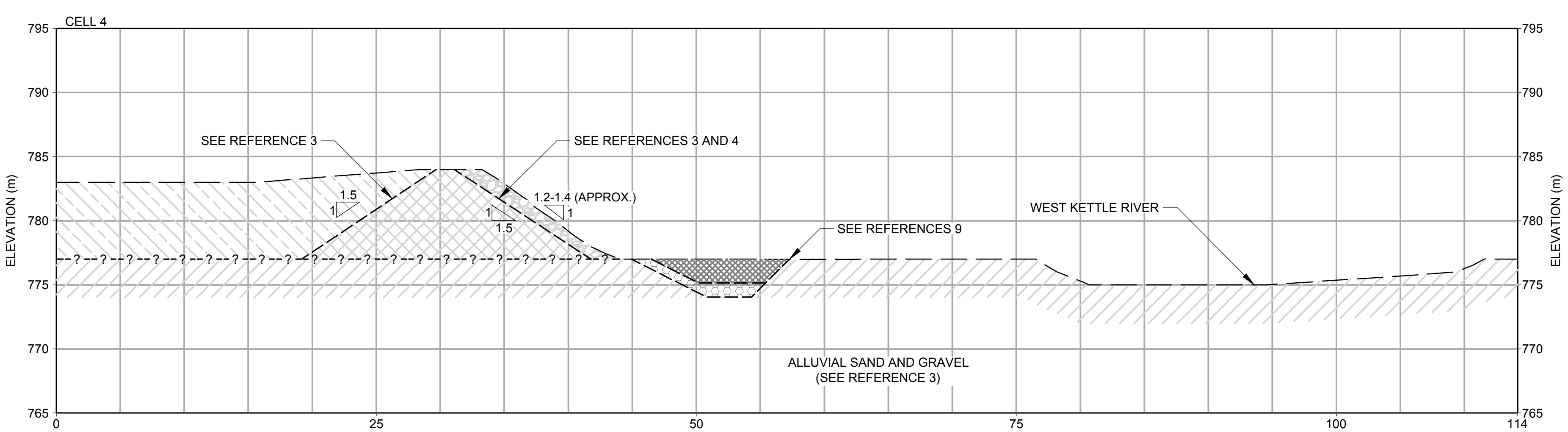


SCALE 1:500 m C SECTION 3

LEGEND

- EXISTING GROUND SURFACE (JULY 2013)
- ESTIMATED ORIGINAL GROUND SURFACE
- 2016 TOPOGRAPHIC SURFACE (AUGUST 2016)
- INFERRED MATERIAL BOUNDARY
- TAILINGS
- EMBANKMENT FILL
- ALLUVIAL SAND AND GRAVEL
- ALLUVIAL COBBLE COVER
- WASTE ROCK/ALLUVIAL COBBLES
- RIPRAP MIXED WITH GRANULAR FILL
- BACKFILLED EXCAVATED MATERIAL

NOTES

1. ALL UNITS ARE SHOWN IN METERS UNLESS OTHERWISE NOTED.
2. STRATIGRAPHY BENEATH ALLUVIAL SAND AND GRAVEL IS UNKNOWN.

REFERENCES

1. GROUND SURVEY BY MCELHANNEY (JULY 2013) PROVIDED BY TECK RESOURCES LIMITED.
2. 2016 TOPOGRAPHIC CONTOURS FOR CELL 1, 3 AND 5 SURVEYED: 10 AUGUST 2016 BY ALLTERRA LAND SURVEYING LTD. AND PROVIDED ON 30 AUGUST 2016.
3. BINNIE (ROBERT F. BINNIE LTD.). 1971. *REPORT ON STABILITY OF TAILINGS DAM*. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 8 JUNE 1971.
4. BINNIE. 1973. *REPORT ON PROPOSED NEW TAILINGS POND*. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED AUGUST 27, 1973.
5. BINNIE. 1980A. *REPORT ON TAILINGS DISPOSAL POND NO. 5 AND PROPOSED POND NO. 6*. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 20 FEBRUARY 1980.
6. BINNIE. 1980B. *SUPPLEMENTARY REPORT ON PROPOSED POND NO. 6*. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 31 MARCH 1980.
7. BINNIE. 1980C. *REPORT ON STABILITY OF ABANDONED POND NO. 5*. REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 9 DECEMBER 1980.
8. BINNIE (R.F. BINNIE & ASSOCIATES LTD.). 1988. *REPORT ON PROPOSED POND NO. 7*. REPORT PREPARED FOR TECK CORPORATION, BEAVERDELL, BC. SUBMITTED APRIL 1988.
9. GOLDER. 2016. *2016 CONSTRUCTION COMPLETION REPORT BEAVERDELL MINE RIPRAP EROSION PROTECTION*. REPORT PREPARED FOR TECK RESOURCES LIMITED. REFERENCE NO. 1214280022-036-R-REV0-14000. SUBMITTED 9 DECEMBER 2016.

0 10 20
1:500 METRES

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

CONSULTANT

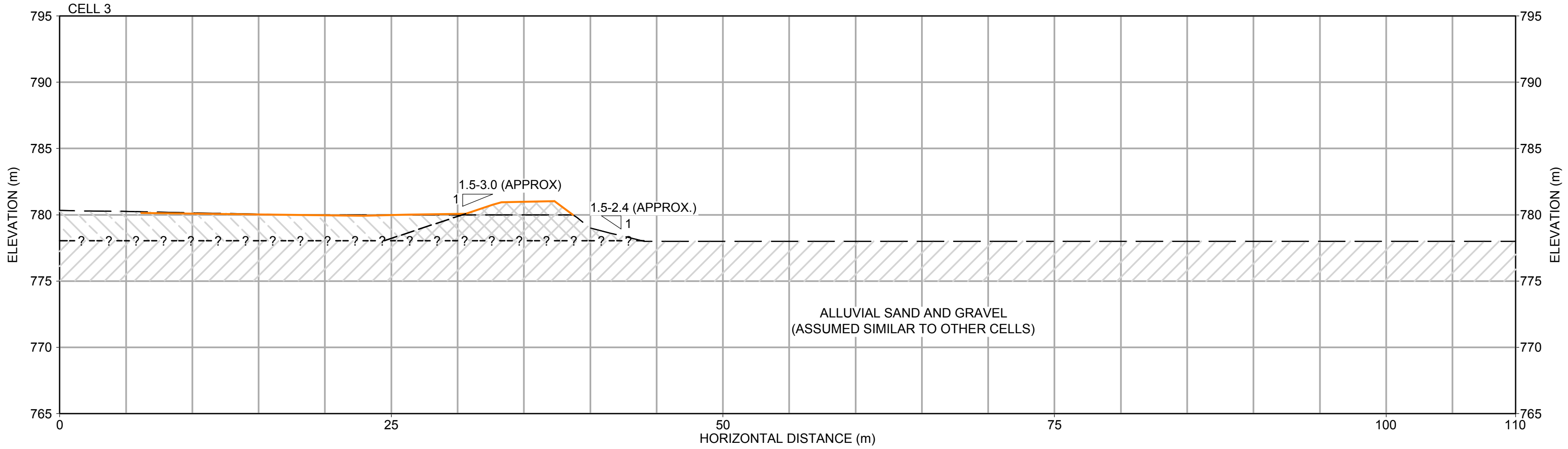
Golder Associates

YYYY-MM-DD	2017-11-15
DESIGNED	AGH
PREPARED	JY
REVIEWED	JMS
APPROVED	JCC

PROJECT
2017 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

TITLE
CROSS SECTIONS (1 OF 2)

PROJECT NO.	PHASE/DOC.	REV.	FIGURE
1778313	1000/052	0	4



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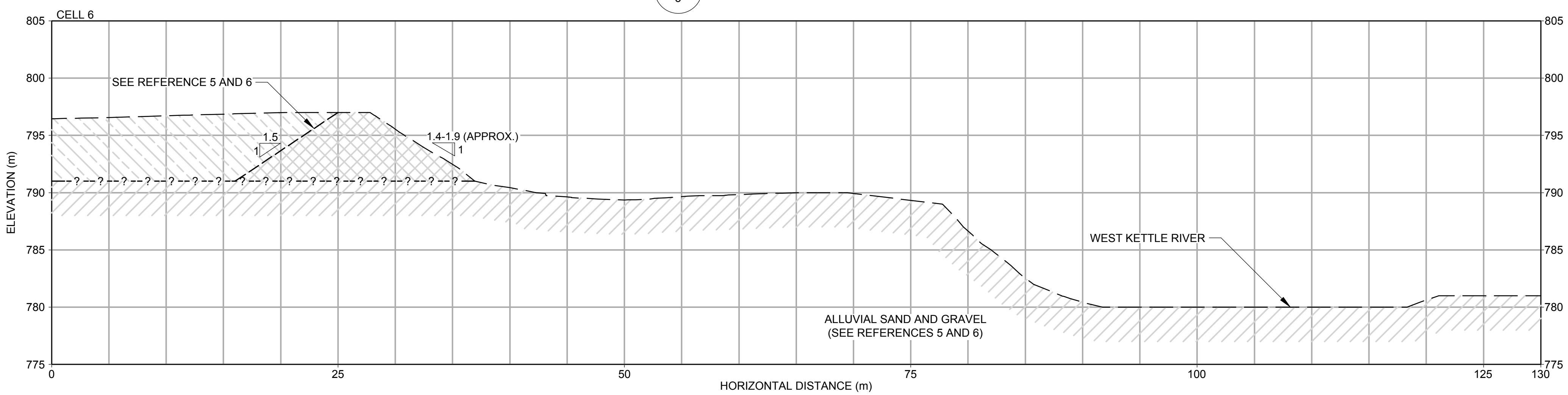

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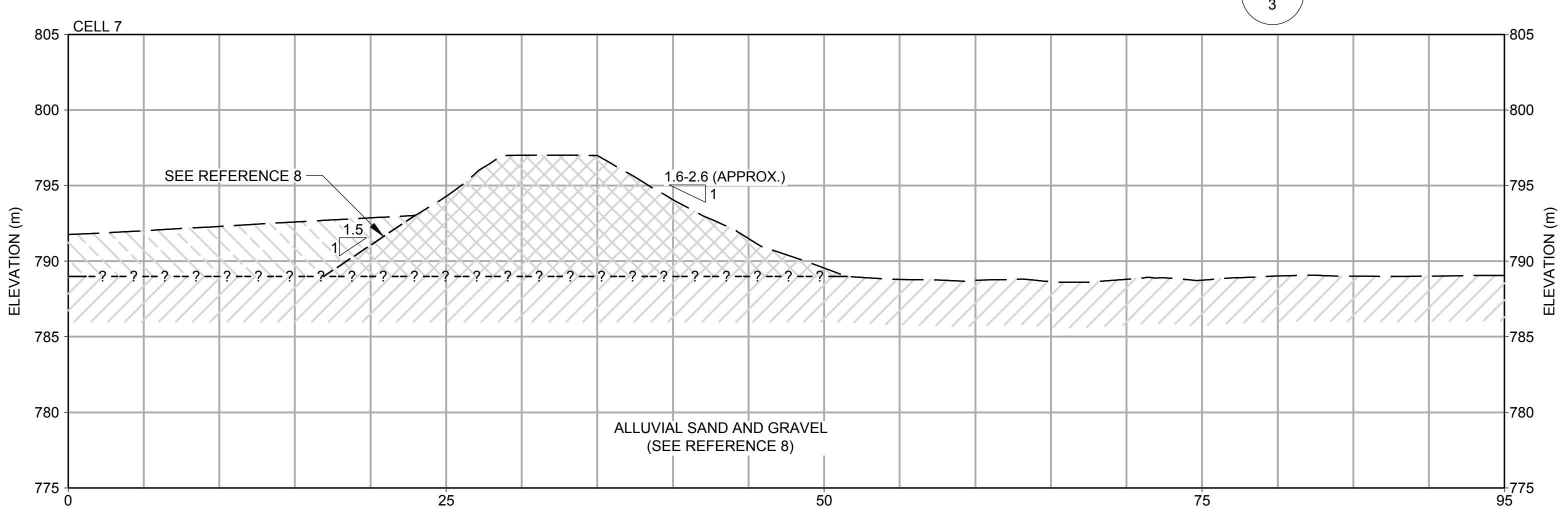

SCALE 1:500 m F/3 SECTION

LEGEND

- EXISTING GROUND SURFACE (JULY 2013)
- ESTIMATED ORIGINAL GROUND SURFACE
- 2016 TOPOGRAPHIC SURFACE (AUGUST 2016)
- INFERRED MATERIAL BOUNDARY
- TAILINGS
- EMBANKMENT FILL
- ALLUVIAL SAND AND GRAVEL

NOTES

1. ALL UNITS ARE SHOWN IN METERS UNLESS OTHERWISE NOTED.
2. STRATIGRAPHY BENEATH ALLUVIAL SAND AND GRAVEL IS UNKNOWN.

REFERENCES

1. GROUND SURVEY BY MCELHANNEY (JULY 2013) PROVIDED BY TECK RESOURCES LIMITED.
2. 2016 TOPOGRAPHIC CONTOURS FOR CELL 1, 3, AND 5 SURVEYED: 10 AUGUST 2016 BY ALLTERRA LAND SURVEYING LTD. AND PROVIDED ON 30 AUGUST 2016.
3. BINNIE (ROBERT F. BINNIE LTD.). 1971. *REPORT ON STABILITY OF TAILINGS DAM.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 8 JUNE 1971.
4. BINNIE. 1973. *REPORT ON PROPOSED NEW TAILINGS POND.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 27 AUGUST 1973.
5. BINNIE. 1980A. *REPORT ON TAILINGS DISPOSAL POND NO. 5 AND PROPOSED POND NO. 6.* REPORT PREPARED FOR TECK CORPORATION LTD., BEAVERDELL, BC. SUBMITTED 20 FEBRUARY 1980.
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0 10 20
1:500 METRES

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

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-11-15
DESIGNED	AGH
PREPARED	JY
REVIEWED	JMS
APPROVED	JCC

PROJECT
2017 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

TITLE
CROSS SECTIONS (2 OF 2)

PROJECT NO.	PHASE/DOC.	REV.	FIGURE
1778313	1000/052	0	5

APPENDIX A

Site Photographs

Photograph 1: South Tailings Storage Facility (TSF), Cell 1, overview of tailings surface, looking northwest. 8 August 2017.

Photograph 2: South TSF, Cell 1, west embankment (access road) with tailings on the right, looking northeast. 8 August 2017.

Photograph 3: South TSF, Cell 1, crest of west embankment (access road), looking southwest. 8 August 2017.

Photograph 4: South TSF, Cell 1, crest and upstream ditch at southeast embankment, looking northeast. 8 August 2017.

Photograph 5: South TSF, Cell 1, embankment at southeast corner of cell, looking west. 8 August 2017.

Photograph 6: South TSF, Cell 1, embankment at southeast corner of cell, looking north. 8 August 2017.

Photograph 7: South TSF, Cell 5, overview of tailings surface, looking northeast. 8 August 2017.

Photograph 8: South TSF, Cell 5, crest on southwest side of dam, looking southeast. 8 August 2017.

Photograph 9: South TSF, Cell 5, downstream dam slope, looking south. 8 August 2017.

Photograph 10: South TSF, Cell 5, backfilled decant tower, looking east. 8 August 2017.

Photograph 11: South TSF, Cell 5, overview of tailings surface, looking southwest. 8 August 2017.

Photograph 12: South TSF, Cell 5, buried riprap at toe of downstream slope, looking northwest. 8 August 2017.

Photograph 13: South TSF, Cell 5, buried riprap at toe of TSF downstream slope during May 2017 high water event, looking northeast. 23 May 2017. Photograph provided by Teck.

Photograph 14: South TSF, Cell 5, buried riprap at toe of TSF downstream slope, looking northeast. Same location as Photograph 13, low river flow. 8 August 2017.

Photograph 15: South TSF, Cell 5, downstream slope consisting of waste rock, looking northeast. 8 August 2017.

Photograph 16: South TSF, internal spillway between Cell 5 and Cell 4, looking northeast. 8 August 2017.

Photograph 17: South TSF, internal spillway between Cell 5 and Cell 4, looking southwest. 8 August 2017.

Photograph 18: South TSF, Cell 4, overview of tailings surface and dry ponding area, looking west. 8 August 2017.

Photograph 19: South TSF, Cell 4, crest of dam, looking south. 8 August 2017.

Photograph 20: South TSF, Cell 4, tailings on crest of dam, looking east. 8 August 2017.

Photograph 21: South TSF, Cell 4, downstream slope and northern extent of buried riprap, looking northwest. 8 August 2017.

Photograph 22: South TSF, spillway between Cell 4 and Cell 3, looking north. 8 August 2017.

Photograph 23: South TSF, spillway between Cell 4 and Cell 3, looking south. 8 August 2017.

Photograph 24: South TSF, Cell 3, overview of tailings surface, looking north. 8 August 2017.

Photograph 25: South TSF, Cell 3, internal divider between Cell 3 and Cell 4, looking west. 8 August 2017.

Photograph 26: South TSF, Cell 3, crest of dam on east side of cell, looking northeast. 8 August 2017.

Photograph 27: South TSF, Cell 3, spillway from Cell 3 crest, looking east from crest. 8 August 2017.

Photograph 28: South TSF, Cell 3, spillway from Cell 3, looking west from downstream toe area. 8 August 2017.

Photograph 29: South TSF, Cell 3, crest of dam on east side of cell, looking south. 8 August 2017.

Photograph 30: South TSF, Cell 3, overview of tailings surface, looking south. 8 August 2017.

Photograph 31: South TSF, Cell 3, west side of facility upstream slope, looking southwest. 8 August 2017.

Photograph 32: South TSF, Cell 3, overview of tailings surface, looking southwest. 8 August 2017.

Photograph 33: South TSF, Cell 3, animal burrow in dam on northeast side of cell, looking west. 8 August 2017.

Photograph 34: North TSF, Cell 6, overview of tailings surface, looking northwest. 8 August 2017.

Photograph 35: North TSF, Cell 6, crest and upstream slope of dam, looking south. 8 August 2017.

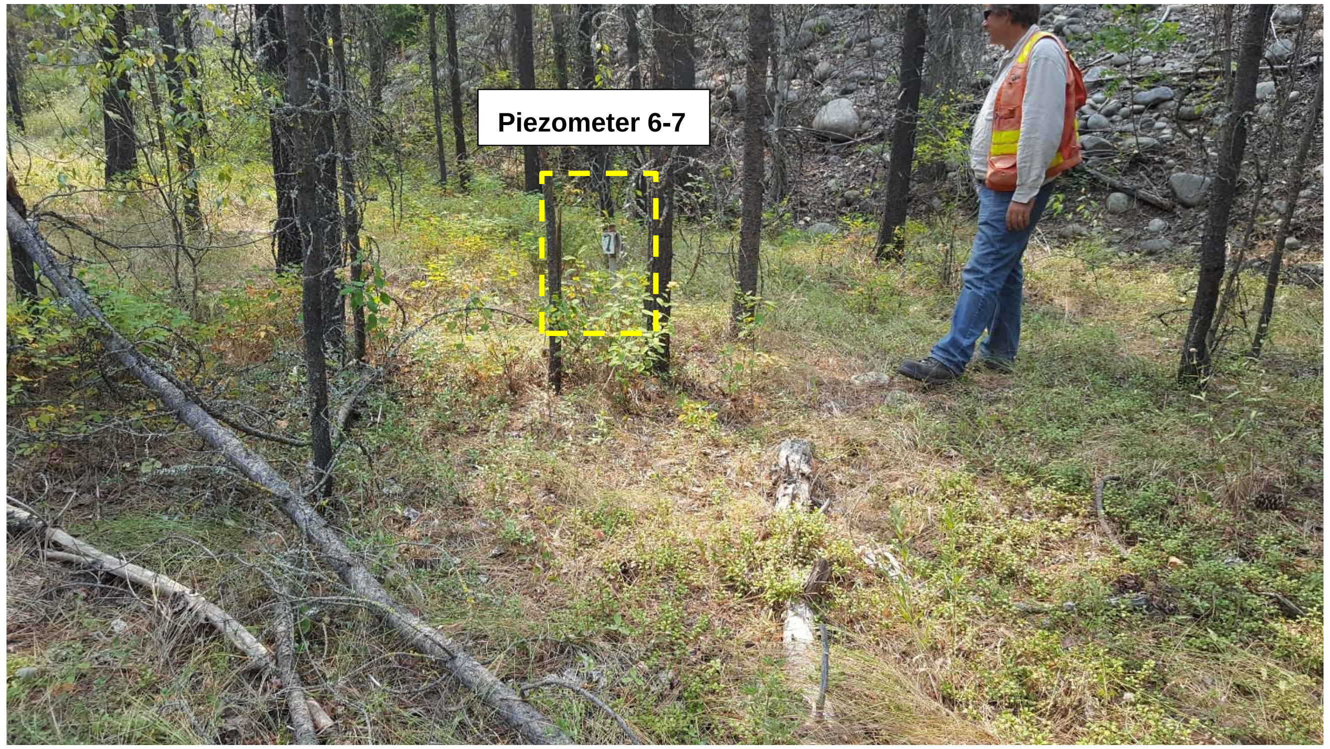
Photograph 36: North TSF, Cell 6, tailings surface and standpipe piezometer 6-3 (not functional), looking west. 8 August 2017.

Photograph 37: North TSF, Cell 6, minor erosion on downstream dam slope, looking north. 8 August 2017.

Photograph 38: North TSF, internal divider between Cell 6 and Cell 7, looking southwest. 8 August 2017.

Photograph 39: North TSF, Cell 6, plugged decant tower, looking east. 8 August 2017.

Photograph 40: North TSF, Cell 6, downstream slope and toe, looking south. 8 August 2017.



Photograph 41: North TSF, Cell 6, piezometer 6-7 (not functional) at toe of dam, looking southwest. 8 August 2017.

Photograph 42: North TSF, Cell 6, decant outlet at toe of dam, looking northwest. 8 August 2017.

Photograph 43: North TSF, Cell 6, crest of dam on south side of cell, looking east. 8 August 2017.

Photograph 44: North TSF, Cell 7, overview of tailings surface, looking southeast. 8 August 2017.

Photograph 45: North TSF, Cell 7, crest of dam on north side of cell, looking east. 8 August 2017.

Photograph 46: North TSF, Cell 7, upstream slope on dam on north side of cell, looking east. 8 August 2017.

Photograph 47: North TSF, Cell 7, spillway at southwest corner, looking north. 8 August 2017.

Photograph 48: North TSF, Cranberry Ridge above Cell 7, looking west. 8 August 2017.

Photograph 49: North TSF, Cell 7, tailings and original ground in southwest corner of Cell 7, looking northwest. 8 August 2017.

Photograph 50: North TSF, Cell 7, decant tower structure and animal den, looking south. 8 August 2017.

Photograph 51: North TSF, Cell 7, decant outlet at toe of dam, looking north. 8 August 2017.

Photograph 52: North TSF, Cell 7, downstream slope and toe, looking west. 8 August 2017.

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APPENDIX B

Inspection Reports

Client:	**Teck Resources Limited**	**By:**	**John Cunning, P.Eng., Mike Paget, P.Eng., Alannah Gray Hubbard, E.I.T.**
Project:	**Beaverdell DSI**	**Date:**	**8 August 2017**
Location:	**South TSF (Cells 1 through 5)**	**Reviewed:**	**John Cunning, P.Eng.**

GENERAL INFORMATION			
Dam Type:	Zoned Earth Fill		
Weather Conditions:	Smoke/haze and sun	**Temp:**	30 to 35°C

Inspection Item	Observations/Data	Photo	Comments & Other Data
1. DAM CREST		4, 5, 8, 19, 20, 26, 29	
1.1 Crest Elevation	Low Point in Embankment: Cell 1: El. 785 m Cell 5: El. 785 m Cell 4: El. 784 m Cell 3: El. 780 m		■ AllTerra Land Surveying Ltd. (2016) ■ McElhanney Survey (July 2013)
1.2 Reservoir Level/ Freeboard	Dry	1, 7, 11, 18, 24, 25, 30	No ponding observed during site inspection.
1.3 Distance To Tailings Pond (if applicable)	N/A	18	No ponding observed during site inspection.
1.4 Surface Cracking	None		
1.5 Unexpected Settlement	None		
1.6 Lateral Movement	None		
1.7 Other Unusual Conditions	Variable crest width: Cell 1: 1 to 3 m Cell 5: 3 to 6 m Cell 4: 3 to 3.5 m Cell 3: 2.5 to 3.5 m		

Inspection Item	Observations/Data	Photo	Comments & Other Data
2. UPSTREAM SLOPE		4, 8, 25, 29, 31, 32	
2.1 Slope Angle	Cells 1 and 2: unknown Cell 3: 1.5 to 3 H:1 V Cells 4 and 5: 1.5 H : 1 V		■ AllTerra Land Surveying Ltd. (2016) ■ Assumed from original design
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	Tailings on narrow crest of dam and downstream slope of Cell 4. Dead trees on upstream slope on west side of Cell 3.	20 31	■ Tailings on site to be characterized to quantify risk of migration out of facility. ■ Dead trees should be removed.
3. DOWNSTREAM SLOPE		5, 6, 9, 12, 14, 15, 21, 28	
3.1 Slope Angle	Cell 1: 2.0 to 4.0H :1V Cell 5: 1.3 to 2.5H :1V Cell 4: 1.2 to 1.4H :1V Cell 3: 1.5 to 2.4H :1V		■ McElhanney Survey (July 2013)
3.2 Signs of Erosion	None		Minor surficial erosion noted
3.3 Signs of Movement (Deformation)	None		
3.4 Cracks	None		
3.5 Seepage or Wet Areas	Dry		
3.6 Vegetation Growth	Mature trees	4, 8, 9, 12, 14, 21, 26	

Inspection Item	Observations/Data	Photo	Comments & Other Data
3.7 Other Unusual Conditions	Yes	33	■ Animal burrow on downstream slope of northeast portion of dam (Cell 3). Animal burrow should be filled.
4. DOWNSTREAM TOE AREA		12, 14, 15, 21, 28	
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	West Kettle River Historic tailings downstream of Cell 5	13, 14 None	■ High level water event in May 2017, river erosion protection constructed in trench downstream of Cell 5 dam intact and undamaged based on inspection ■ Tailings noted downstream near abandoned supernatant pond location, area dry at time of inspection
5. ABUTMENTS			
5.1 Seepage at Contact Zone (Abutment/Embankment)	None		
5.2 Signs of Erosion	None		
5.3 Vegetation	Mature trees		
5.4 Presence of Rodent Burrows	None		
5.5 Other Unusual Conditions	None		
6. RESERVOIR		1, 7, 11, 18, 24, 30	No reservoir
6.1 Stability of Slopes	N/A		

Inspection Item	Observations/Data	Photo	Comments & Other Data
6.2 Distance to Nearest Slide (if applicable)	N/A		
6.3 Estimate of Slide Volume (if applicable)	N/A		
6.4 Floating Debris	N/A		
6.5 Other Unusual Conditions	Plugged decant tower inlet in Cell 5	10	■ Tower inlet filled in 2016
7. EMERGENCY SPILLWAY/ OUTLET STRUCTURE	Outlet to environment at Cell 3	27, 28	■ Spillway upgrade required
7.1 Surface Condition	Lined with river rock		
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	16, 17 22, 23	
8. INSTRUMENTATION			
8.1 Piezometers	2 standpipes in Cell 5 area		Readings from 2016: ■ 5-1: Dry, depth unknown (>10 m) ■ 5-2: Not found
8.2 Settlement Cells	None		
8.3 Thermistors	None		
8.4 Settlement Monuments	None		
8.5 Accelerograph	None		

Inspection Item	Observations/Data	Photo	Comments & Other Data
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.V001.1 (draft)
9.1.2 OMS Manual Reflects Current Dam Conditions	Yes		
9.1.3 Date of Last Revision	October 2017		
9.2 Emergency Preparedness Plan (EPP) 9.2.1 EPP Exists	Yes		SP&P BEA-EPRP-001.V001.1 (draft)
9.2.2 EPP Reflects Current Conditions	Yes		
9.2.3 Date of Last Revision	October 2017		

10. NOTES

No significant changes since 2016 DSI

Required work based on inspection:

- Fill animal burrow on Cell 3
- Vegetation should be cut along Cell 5 crest
- Construct a riprap lined spillway on the Cell 3 dam to allow for safe passage of excess flows during the South TSF's inflow design flood event.
- Tailings on site to be characterized to quantify risk of migration out of facility.

Inspectors	A. Gray Hubbard, E.I.T.	**Date:**	8 August 2017

https://golderassociates.sharepoint.com/sites/15578g/deliverables/3. issued/052-r-rev0-1000_beaverdell dsi/appendices/appendix b - inspection reports/appendix b1 - south tsf insp rep.docx

Client:	**Teck Resources Limited**	**By:**	**John Cunning, P.Eng., Mike Paget, P.Eng., Alannah Gray Hubbard, E.I.T.**
Project:	**Beaverdell DSI**	**Date:**	**8 August 2017**
Location:	**North TSF (Cells 6 and 7)**	**Reviewed:**	**John Cunning, P.Eng.**

GENERAL INFORMATION			
Dam Type:	Zoned Earth Fill		
Weather Conditions:	Smoke/haze and sun	**Temp:**	30 to 35°C

Inspection Item	Observations/Data	Photo	Comments & Other Data
1. DAM CREST		35, 38, 43, 45	
1.1 Crest Elevation	Cell 6: El. 797 m Cell 7: El. 797 m		■ McElhanney Survey (July 2013)
1.2 Reservoir Level/ Freeboard	Dry	34, 44	■ 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 dam crest width: Cell 6: 3 to 4 m Cell 7: 3 to 4 m		
2. UPSTREAM SLOPE		35, 46	
2.1 Slope Angle	Cells 6 and 7: 1.5 H : 1 V		
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		37, 40, 52	
3.1 Slope Angle	Cell 6: 1.4 to 1.9H :1V Cell 7: 1.6 to 2.6H :1V		■ McElhanney Survey (July 2013)
3.2 Signs of Erosion	Minor	37	■ minor erosion, limited by rock facing on dams; not stability risk
3.3 Signs of Movement (Deformation)	None		
3.4 Cracks	None		
3.5 Seepage or Wet Areas	Dry		
3.6 Vegetation Growth	Mature trees	40, 43, 45, 52	
3.7 Other Unusual Conditions	None		
4. DOWNSTREAM TOE AREA		40, 52	
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	42, 51	
5. ABUTMENTS		49	
5.1 Seepage at Contact Zone (Abutment/Embankment)	None		
5.2 Signs of Erosion	None		
5.3 Vegetation	Immature trees	47	
5.4 Presence of Rodent Burrows	None		
5.5 Other Unusual Conditions	None		

Inspection Item	Observations/Data	Photo	Comments & Other Data
6. RESERVOIR		34, 44	■ Dry reservoir
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	39, 50	■ Tower inlets filled
7. EMERGENCY SPILLWAY/ OUTLET STRUCTURE	From Cell 7 to environment	47	■ Requires significant ponding within Cell 7 to receive flow, use unlikely.
7.1 Surface Condition	Alluvial cobbles, original ground		
7.2 Signs of Erosion	None		
7.3 Signs of Movement (Deformation)	None		
7.4 Cracks	None		
7.5 Settlement	None		
7.6 Presence of Debris or Blockage	Small trees		
7.7 Closure Mechanism Operational	N/A		
7.8 Slope Protection	N/A		
7.9 Instability of Side Slopes	No		
7.10 Other Unusual Conditions	N/A		

Inspection Item	Observations/Data	Photo	Comments & Other Data
8. INSTRUMENTATION			
8.1 Piezometers	7 standpipes at Cell 6 area 4 standpipes at Cell 7 area	36, 41	Readings from 2016: ■ 6-1: Not Found ■ 6-2: Pipe Bent ■ 6-3: Dry, 5.50 m to bottom ■ 6-4: Dry, 6.35 m to bottom ■ 6-5: Dry, 7.00 m to bottom ■ 6-6: Dry, 1.75 m to bottom ■ 6-7: Dry, 3.20 m to bottom ■ 7-1: Dry, 9.40 m to bottom ■ 7-2: Dry, 10.00 m to bottom ■ 7-3: Dry, 7.75 m to bottom ■ 7-4: Dry, 9.75 m to bottom
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.V001.1 (draft)
9.1.2 OMS Manual Reflects Current Dam Conditions	Yes		
9.1.3 Date of Last Revision	October 2017		

Inspection Item	Observations/Data	Photo	Comments & Other Data
9.2 Emergency Preparedness Plan (EPP) 9.2.1 EPP Exists	Yes		SP&P BEA-EPRP-001.V001.1 (draft)
9.2.2 EPP Reflects Current Conditions	Yes		
9.2.3 Date of Last Revision	October 2017		

10. NOTES

No significant changes from 2016 DSI.

Inspectors	A. Gray Hubbard, E.I.T.	**Date:**	8 August 2017

https://golderassociates.sharepoint.com/sites/15578g/deliverables/3. issued/052-r-rev0-1000_beaverdell dsi/appendices/appendix b - inspection reports/appendix b2 - north tsf insp rep.docx

APPENDIX C

Original Design Cross-Sections

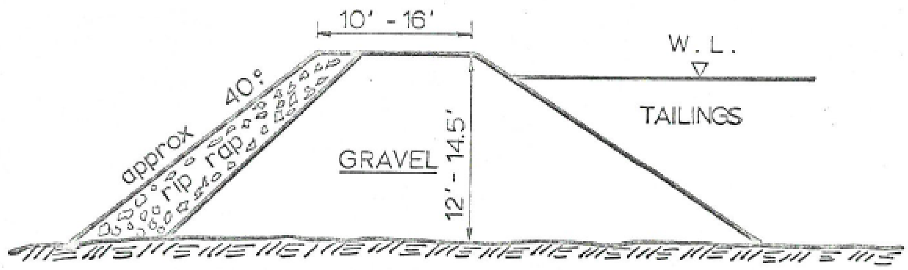
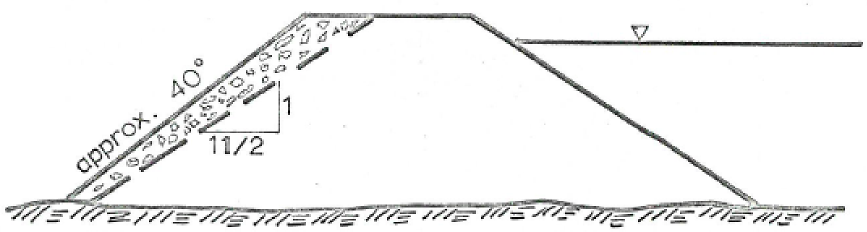


FIG. A



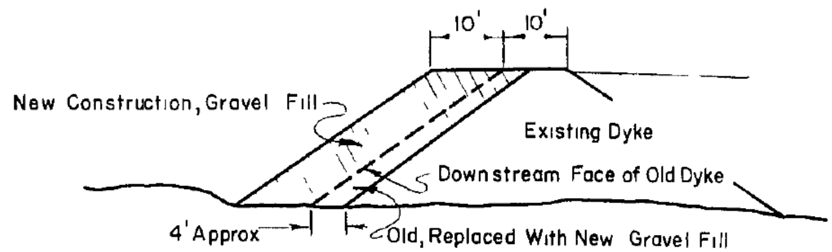
Assumed actual crossection

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

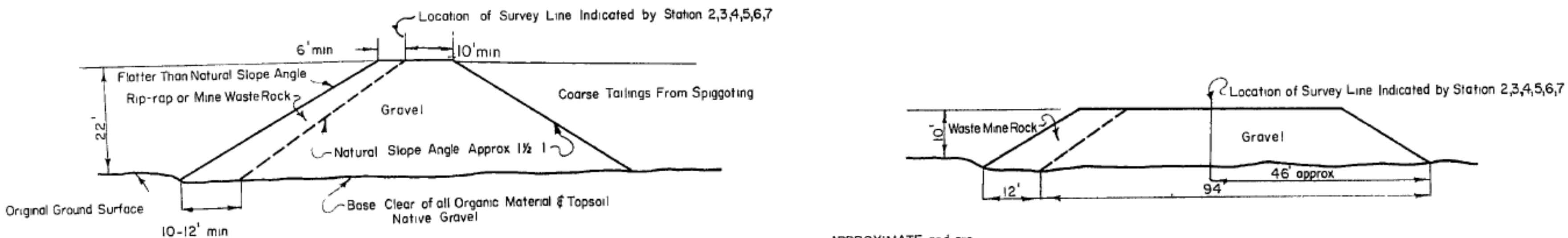
CLIENT TECK RESOURCES LIMITED BEAVERDELL MINE BEAVERDELL, B.C.		PROJECT 2017 BEAVERDELL TAILINGS STORAGE FACILITIES ANNUAL DAM SAFETY INSPECTION	
CONSULTANT Golder Associates	YYYY-MM-DD 2016-11-02 PREPARED AGH DESIGN AGH REVIEW JMS APPROVED JCC	TITLE **DAM DESIGN FOR CELL 4** **CROSS SECTIONS**	
		PROJECT No. **1778313** · PHASE **1000** · Rev. **0**	FIGURE **C-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
BEAVERDELL MINE
BEAVERDELL, B.C.

PROJECT
2017 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

CONSULTANT

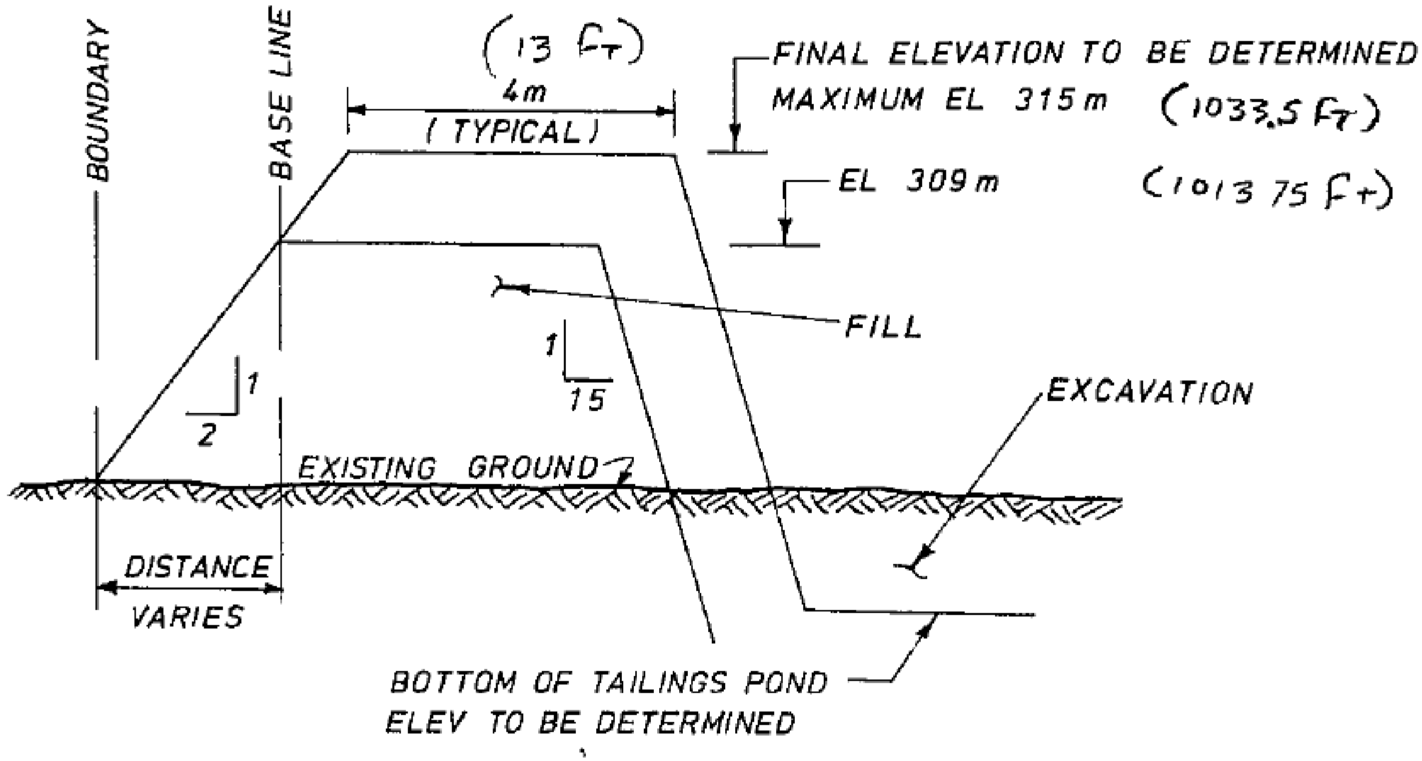
Golder Associates

YYYY-MM-DD	2016-11-02
PREPARED	AGH
DESIGN	AGH
REVIEW	JMS
APPROVED	JCC

TITLE
DAM DESIGN FOR CELL 5
CROSS SECTIONS

PROJECT No.	PHASE	Rev.	FIGURE
1778313	**1000**	**0**	**C-2**

1 in
0



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
BEAVERDELL MINE
BEAVERDELL, B.C.

PROJECT
2017 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

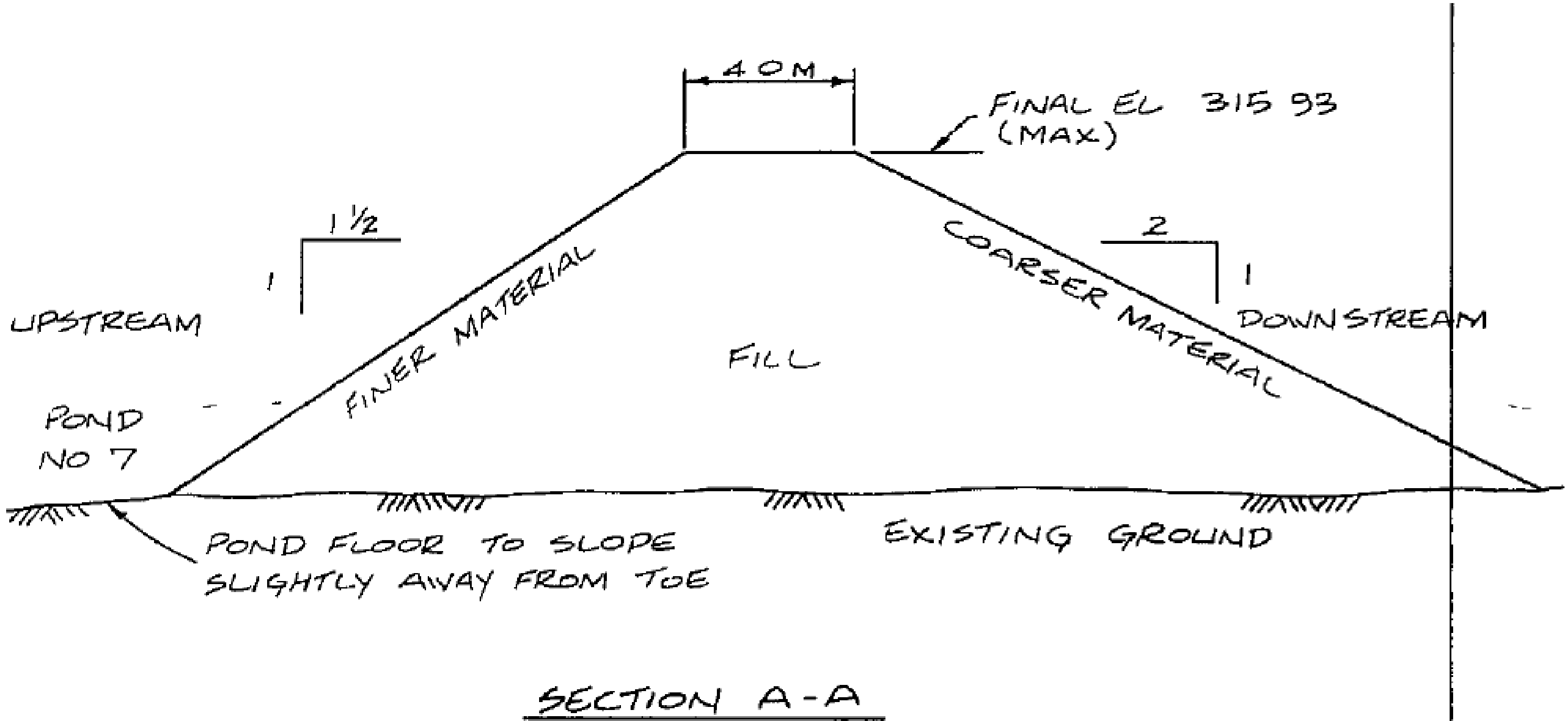
CONSULTANT
Golder Associates

YYYY-MM-DD	2016-11-02
PREPARED	AGH
DESIGN	AGH
REVIEW	JMS
APPROVED	JCC

TITLE
DAM DESIGN FOR CELL 6
CROSS SECTION

PROJECT No.	PHASE	Rev.	FIGURE
1778313	1000	0	C-3

0 1 in



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
BEAVERDELL MINE
BEAVERDELL, B.C.

PROJECT
2017 BEAVERDELL TAILINGS STORAGE FACILITIES
ANNUAL DAM SAFETY INSPECTION

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-11-02
PREPARED	AGH
DESIGN	AGH
REVIEW	JMS
APPROVED	JCC

TITLE
DAM DESIGN FOR CELL 7
CROSS SECTION

PROJECT No.	PHASE	Rev.	FIGURE
1778313	1000	0	C-4

APPENDIX D

Teck Inspection Summaries

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Project Manager
gerry.murdoch@teck.com

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MEMO

Teck

2017-05-09

Beaverdell TSF Cell 5 Riprap Event Inspection

On May 5 the West Kettle River (WKR) rose to its five year flood level and spilled its banks near our tailings storage facility (TSF) at our Beaverdell Mine in Beaverdell BC. The water receded on May 6, 2017. Our site caretaker Tex Hewitt, check the South TSF of the evening of May 5 and again on May 6th and report that the riprap along cell 4/5 was not disturbed. This triggered an event inspection on May 8, 2017 by Gerry Murdoch, assisted by Tex Hewitt.

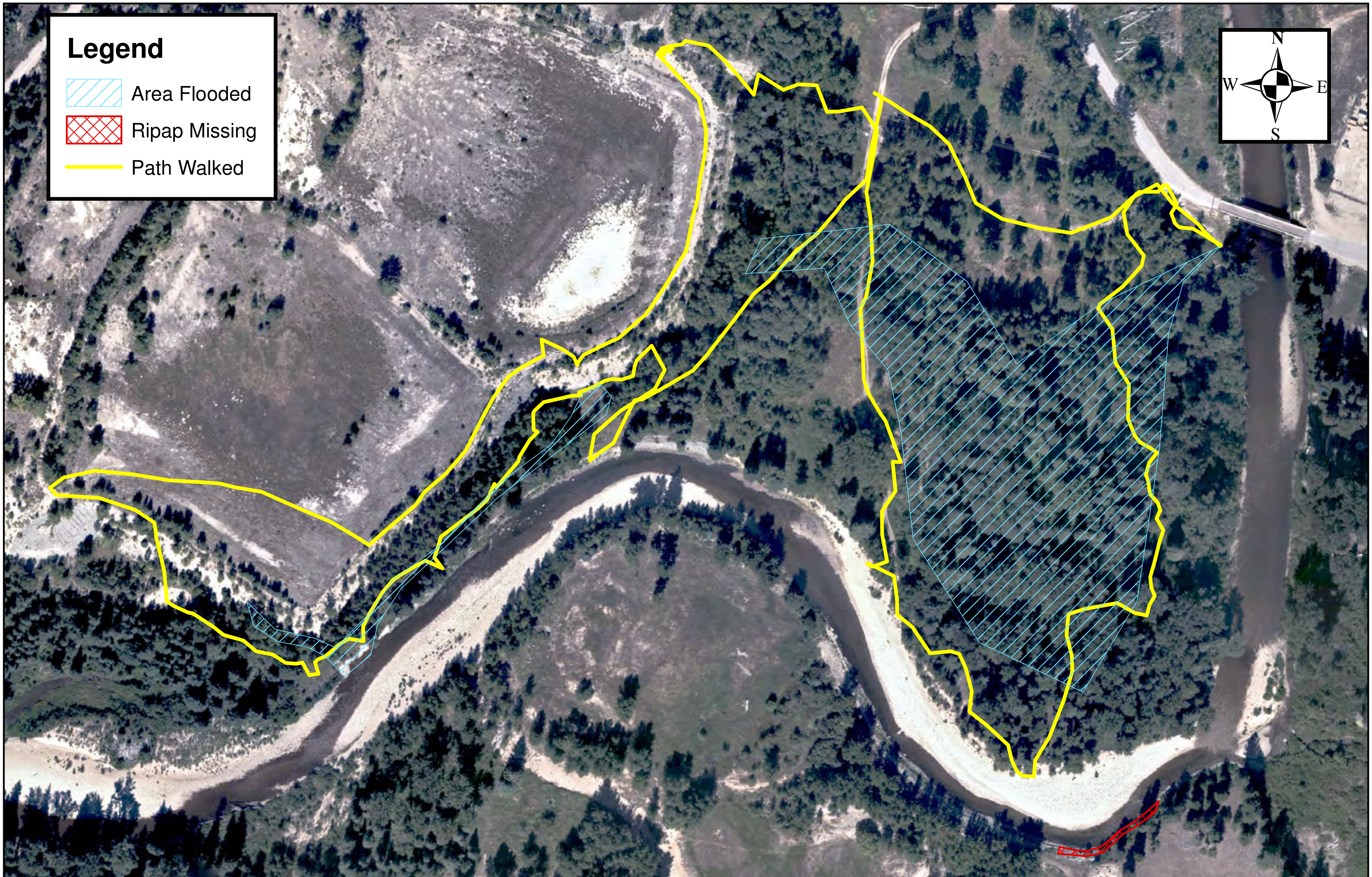
The main area that was flooded is to the east of cell 4 and to the west of the WKR. Figure BEA 2017-001 shows the location of this flooding. This area has standing water throughout it but is not in contact with any of the TSF cells.

The ponded water just to the east of cell 5 migrated through the sand and gravel material in the berm between the WKR and Cell 5 (photo 4). This area was riprapped in the distant past and in some sections the riprap is deteriorated or missing. There is evidence of deterioration of the riverbank in two locations on west side of the WKR near cell 5 (photos 1 & 2). Once this water reached the top of this low area it flowed south through the area we used to construct the new riprap system in 2016. The flow did not disturb the newly planted trees or old wooden debris we add to this area. There was no indication of an outflow to this water; it's believed to have drained into the sand gravel layer. During the excavation for the riprap installation in 2016 we encountered water in the sand and gravel layers at the same elevation as the WKR.

The water pond to the south of cell 5 (photo 3) is all that remained after the flood water receded. Water in this area appeared to flow south away from the toe of cell 5.

The south side of the WKR is armoured along the riverbank where the river turns to the west. The riprap in this area has been washed away causing a considerable section of the dike berm to also be removed (Photo 6). There is very little of the retaining berm left and the berm may fail. The breakthrough will cause the WKR to flood to the east, away from our TSF.

Figures



PROJECT:			DWN BY:	DATE:
RIPRAP INSPECTION WEST KETTLE RIVER FLOOD	TRACK WALKED	Teck	GM	2017-05-09
	DATUM: Nad 1983 UTM Zone 11 N		CHK'D BY: XX	REV. NO:
TITLE: BEAVERDELL MINE	PROJECTION: Projected Coordinate System		SCALE: 1:2500	FIGURE NO: BEA 2017-001
	PROJECT NO: XX			

Path: U:\Dormant Properties\Beaverdell\GIS\2017\2017-05 Riprap Inspection\BEA 2017-001.mxd

Photos

Photo 1
Deterioration in berm between WKR and Cell 4/5

Photo 2
Deterioration in river back, by south corner of Cell 5

Photo 3
Standing water to the south of Cell 5

Photo 4
Standing water between WKR and cell 4/5

Photo 5
Exposed riprap along cell 5

Photo 6
Missing armor and berm section south side of WKR
(red hatched section on figure BEA 2017-001)

Teck Beaverdell South TMF Dam INSPECTION CHECKLIST (Page 1 of 2)

Inspected by: G. Murdoch / T. Hewitt
Inspection Date: May 23, 2017
Inspection Time: 9:00 AM
Reviewed by: ____________
Review Date ____________

Inspection Type:
☒ Routine ☐ Event Driven
Weather/Visibility:
Sunny

Are any of the following conditions apparent?	YES	NO	N/A
Cracking on the crest?	☐	☒	☐
Cracking on the upstream slope?	☐	☒	☐
Cracking on the downstream slope?	☐	☒	☐

VEGETATION AND WILDLIFE	YES	NO	N/A
Vegetation or debris blocking spillway?	☒	☐	☐
Significant vegetation damaging the dam (crest and/or faces)?	☐	☒	☐
Animal presence (burrows or disturbance on the dam)?	☐	☒	☐

STRUCTURAL PROBLEMS	YES	NO	N/A
Settlement on crest?	☐	☒	☐
Slough, slides or bulges on upstream slope?	☐	☒	☐
Slough, slides or bulges on downstream slope?	☐	☒	☐
Slough, slide or erosion of spillway channel?	☐	☒	☐
Sinkhole on crest?	☐	☒	☐
Sinkhole on upstream slope?	☐	☒	☐
Sinkhole on downstream slope?	☐	☒	☐

SEEPAGE	YES	NO	N/A
Wet areas or seepage on downstream slope/toe?	☐	☒	☐
Ponded water at the downstream toe?	☒	☐	☐
If seepage is observed - estimated or measured quantity? ____________			
If seepage is observed - Quality / appearance, sampled? ____________			

Estimate of height between water surface and dam crest at Cell 5 (in metres) N/A
Estimate of height between water surface and dam crest at Cell 4 (in metres) 3 m
Estimate of height between water surface and dam crest at Cell 3 (in metres) N/A
Height estimate to be made if water is present in the cell, otherwise indicate no water.

	YES	NO	N/A
Crest and slopes SNOW COVERED?	☐	☒	☐

Teck Beaverdell South TMF Dam INSPECTION CHECKLIST (Page 2 of 2)

INSPECTION ITINERARY

Draw below the path followed during the inspection

Comments on Deficiencies Found:

① PONDING WATER ALONG EAST TOE OF CELLS 3, 4 & 5 AND PONDING WATER ALONG SOUTH TOE OF CELL 5

② TREE ACCROSS CELL 3 SPILLWAY.
TREE WAS REMOVED.

③ RIVER BANK - SE CORNER CELL 5 IS ERODING.

Spillway Debris Cell 3

Spillway Debris Removed Cell 3

Ponded Water to the South of Cell 5

Ponded water in Cell 4

Eroded River bank SE corner of cell 5

River Bank August 2016

Teck Beaverdell North TMF Dam INSPECTION CHECKLIST (Page 1 of 2)

Inspected by: G. Murdoch / T. Hewitt
Inspection Date: May 23, 2017
Inspection Time: 4:00 PM
Reviewed by: ____
Review Date ____

Inspection Type: [X] Routine [ ] Event Driven
Weather/Visibility: Sunny

Are any of the following conditions apparent?	YES	NO	N/A
Cracking on the crest?	[ ]	[X]	[ ]
Cracking on the upstream slope?	[ ]	[X]	[ ]
Cracking on the downstream slope?	[ ]	[X]	[ ]

VEGETATION AND WILDLIFE	YES	NO	N/A
Vegetation or debris blocking spillway?	[ ]	[X]	[ ]
Significant vegetation damaging the dam (crest and/or faces)?	[ ]	[X]	[ ]
Animal presence (burrows or disturbance on the dam)? ON POND	[X]	[ ]	[ ]

STRUCTURAL PROBLEMS	YES	NO	N/A
Water flowing from decant pipes ~~(broken seal)~~? SEE NOTES	[X] Cell 6	[X] Cell 7	[ ]
Settlement on crest?	[ ]	[X]	[ ]
Slough, slides or bulges on upstream slope?	[ ]	[X]	[ ]
Slough, slides or bulges on downstream slope?	[ ]	[X]	[ ]
Slough, slide or erosion of spillway channel?	[ ]	[X]	[ ]
Sinkhole on crest?	[ ]	[X]	[ ]
Sinkhole on upstream slope?	[ ]	[X]	[ ]
Sinkhole on downstream slope?	[ ]	[X]	[ ]

SEEPAGE	YES	NO	N/A
Wet areas or seepage on downstream slope/toe?	[scribbled out]	[X]	[ ]
Ponded water at the downstream toe?	[ ]	[X]	[ ]
If seepage is observed - estimated or measured quantity? ____			
If seepage is observed - Quality / appearance, sampled? ____			

Estimate of height between water surface and dam crest at Cell 6 (in metres) 2M
Estimate of height between water surface and dam crest at Cell 7 (in metres) N/A
Height estimate to be made if water is present in the cell, otherwise indicate no water.

	YES	NO	N/A
Crest and slopes SNOW COVERED?	[ ]	[X]	[ ]

INSPECTION ITINERARY

Draw below the path followed during the inspection

Comments on Deficiencies Found:

① ANIMAL BURROW IN POND OF CELL 7.

② DECANT PIPE ON CELL 6 – VERY SMALL TRICKLE OF WATER

Burrow in Floor of Cell 7

Weir at Decant Outlet Cell 6

Decant Outlet Cell 7

Ponded Water in Cell 6

Teck Beaverdell South TMF Dam INSPECTION CHECKLIST (Page 1 of 2)

Inspected by: G. MURDOCH
Inspection Date: 8:00AM
Inspection Time: 2017-09-07
Reviewed by:
Review Date

Inspection Type: [X] Routine [ ] Event Driven
Weather/Visibility: SMOKEY

Are any of the following conditions apparent?	YES	NO	N/A
Cracking on the crest?	[ ]	[X]	[ ]
Cracking on the upstream slope?	[ ]	[X]	[ ]
Cracking on the downstream slope?	[ ]	[X]	[ ]

VEGETATION AND WILDLIFE	YES	NO	N/A
Vegetation or debris blocking spillway?	[ ]	[X]	[ ]
Significant vegetation damaging the dam (crest and/or faces)?	[ ]	[X]	[ ]
Animal presence (burrows or disturbance on the dam)?	[X]	[ ]	[ ]

STRUCTURAL PROBLEMS	YES	NO	N/A
Settlement on crest?	[ ]	[X]	[ ]
Slough, slides or bulges on upstream slope?	[ ]	[X]	[ ]
Slough, slides or bulges on downstream slope?	[ ]	[X]	[ ]
Slough, slide or erosion of spillway channel?	[ ]	[X]	[ ]
Sinkhole on crest?	[ ]	[X]	[ ]
Sinkhole on upstream slope?	[ ]	[X]	[ ]
Sinkhole on downstream slope?	[ ]	[X]	[ ]

SEEPAGE	YES	NO	N/A
Wet areas or seepage on downstream slope/toe?	[ ]	[X]	[ ]
Ponded water at the downstream toe?	[ ]	[X]	[ ]
If seepage is observed - estimated or measured quantity? ______			
If seepage is observed - Quality / appearance, sampled? ______			

Estimate of height between water surface and dam crest at Cell 5 (in metres) DRY
Estimate of height between water surface and dam crest at Cell 4 (in metres) DRY
Estimate of height between water surface and dam crest at Cell 3 (in metres) DRY
Height estimate to be made if water is present in the cell, otherwise indicate no water.

	YES	NO	N/A
Crest and slopes SNOW COVERED?	[ ]	[X]	[ ]

Teck Beaverdell South TMF Dam INSPECTION CHECKLIST (Page 2 of 2)

INSPECTION ITINERARY

Draw below the path followed during the inspection

Comments on Deficiencies Found:

ANIMAL BURROW IN POND 3, DOWNSTREAM SIDE. REPAIRED

VEGETION ON DAM CREST HAS BEEN REMOVED


Riprap Cell 5


SE Corner of Cell 5


Cell 1 Berm & Channel


Cell 5 Dry


Cell 4 Dry


Cell 3 Dry


Cell 3 Spillway


Animal Burrow in Cell 3 Dike

Animal Burrow in Cell 3 Dike Filled In

Downstream Side of Cell 3 Dike

Vegetation on Cell 5 Dike

Vegetation on Cell 5 Dike Removed

Teck Beaverdell North TMF Dam INSPECTION CHECKLIST (Page 1 of 2)

Inspected by: G. Murdoch
Inspection Date: 2017-09-07
Inspection Time: 10:00 AM
Reviewed by:
Review Date

Inspection Type: [X] Routine [ ] Event Driven
Weather/Visibility: Smokey

Are any of the following conditions apparent?	YES	NO	N/A
Cracking on the crest?	☐	☒	☐
Cracking on the upstream slope?	☐	☒	☐
Cracking on the downstream slope?	☐	☒	☐

VEGETATION AND WILDLIFE	YES	NO	N/A
Vegetation or debris blocking spillway?	☐	☒	☐
Significant vegetation damaging the dam (crest and/or faces)?	☐	☒	☐
Animal presence (burrows or disturbance on the dam)?	☐	☒	☐

See note

STRUCTURAL PROBLEMS	YES	NO	N/A
Water flowing from decant pipes (broken seal)?	☐	☒	☐
Settlement on crest?	☐	☒	☐
Slough, slides or bulges on upstream slope?	☐	☒	☐
Slough, slides or bulges on downstream slope?	☐	☒	☐
Slough, slide or erosion of spillway channel?	☐	☒	☐
Sinkhole on crest?	☐	☒	☐
Sinkhole on upstream slope?	☐	☒	☐
Sinkhole on downstream slope?	☐	☒	☐

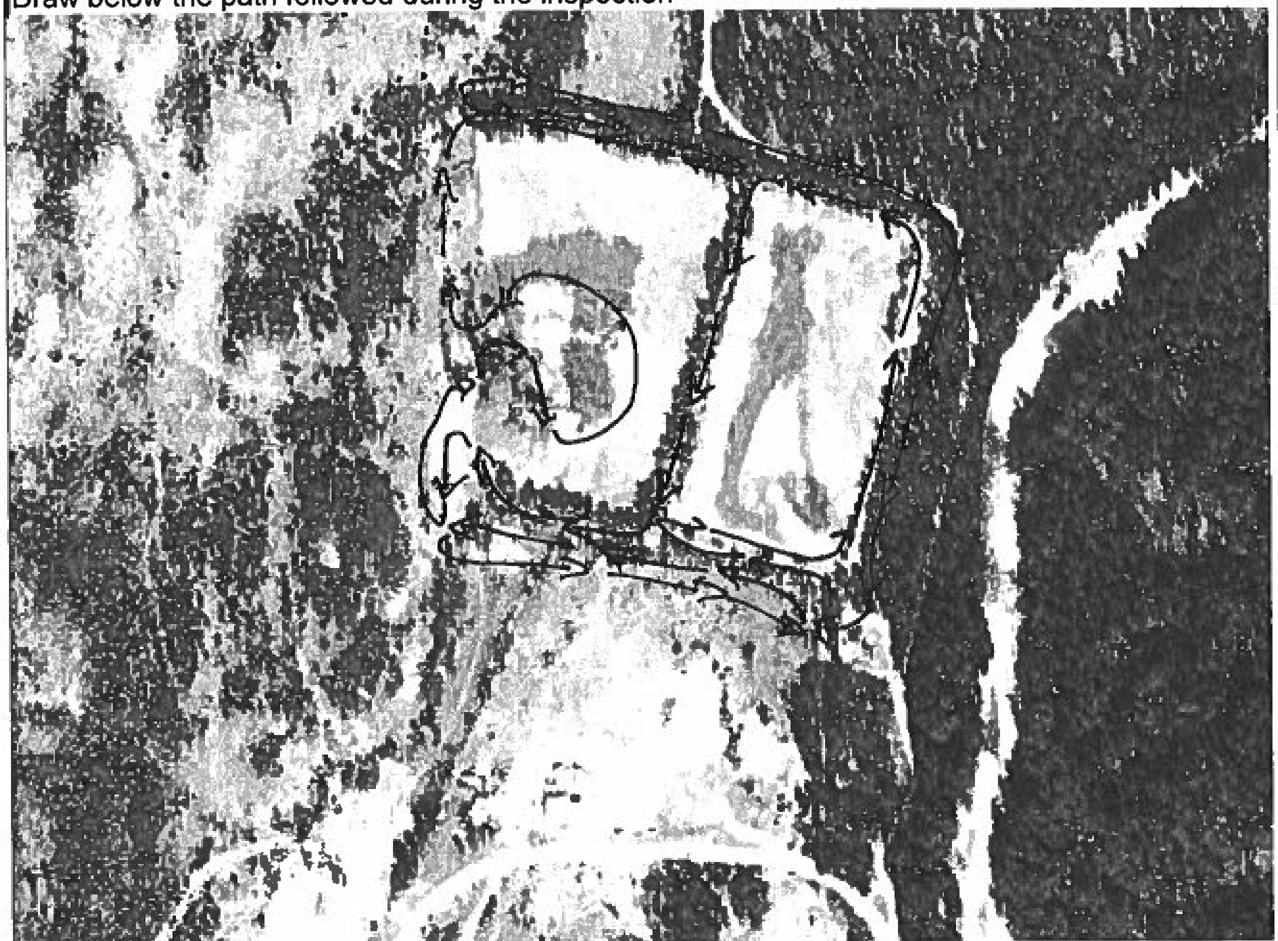
SEEPAGE	YES	NO	N/A
Wet areas or seepage on downstream slope/toe?	☐	☒	☐
Ponded water at the downstream toe?	☐	☒	☐
If seepage is observed - estimated or measured quantity? ________			
If seepage is observed - Quality / appearance, sampled? ________			

Estimate of height between water surface and dam crest at Cell 6 (in metres) Dry
Estimate of height between water surface and dam crest at Cell 7 (in metres) Dry
Height estimate to be made if water is present in the cell, otherwise indicate no water.

	YES	NO	N/A
Crest and slopes SNOW COVERED?	☐	☒	☐

INSPECTION ITINERARY

Draw below the path followed during the inspection



Comments on Deficiencies Found:

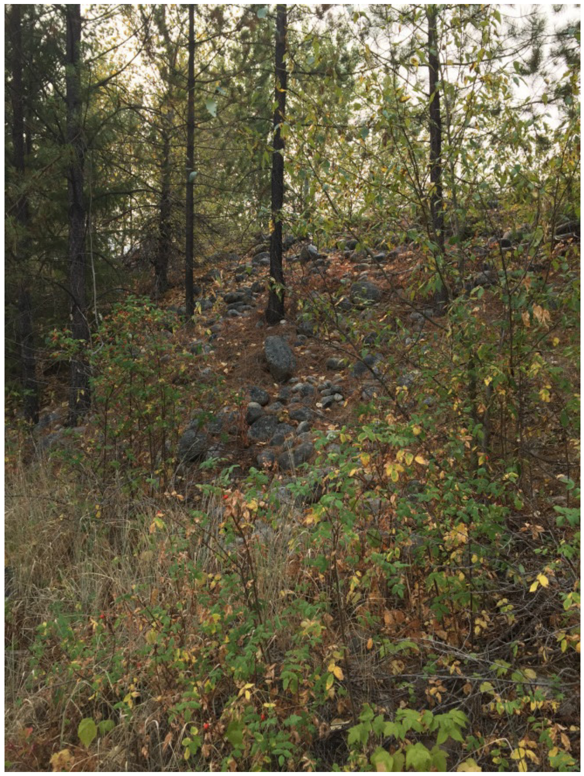
NOTE, ANIMAL DEN BESIDE DECANT INTAKE IN POND 7

Weir at Decant Outlet Cell 6

Animal Den in Cell 7

Cell 6 Dry

Cell 7 Dry


North Downstream Face Cell 7


East Downstream Face Cell 6

Decant Outlet Cell 7

APPENDIX E

Teck Maintenance Record

Beaverdell Mine

Inspection, Maintenance and Training Data Records

2015-10-27 to 30
Dave started clearing trees between Cell 4 & 5 and the West Kettle river for the Riprap Project.

2015-11-04
Training: Gerry Murdoch, Mine Manager
Completed the review of the document: Inspection & Maintenance of Dams, Dam Safety Guidelines. Province of British Columbia, Water Management Branch.

2015-11-16
Rip Rap pre-mobilization (on-site) meeting was conducted today.
Participants:

- Shawn Mcliver Lime Creek Logging (LCL) Contractor
- Geoffrey Cahill Golder
- Steve Turner Golder
- Gerry Murdoch Teck
- Harold (Tex) Hewitt Site Maintenance Contractor

2015-11-23
Started the rip rap project, see Project Daily Notes for details.

2015-11-26
Project shut down today due to lack of Rip Rap.

2016-02-13
Golder updated the site inspection check lists for both the North and South TMF. New check list are in the OMS Manual. Electronic copies are in DP.Beaverdell>Site Care & Mtce>Site Inspections>Check Lists

2016-02-25

2016-04-14

- Dave Ryder and I performed the routine spring dam inspection. No issues found. See the Routine Dam Safety Inspection Report. Note: There is possibly a badger or coyote den in the tailings in pond 7 beside the decant structure.
- We located all of the galvanized pipe and checked them for water. Some pipes on the plan were not found. We needed to cut some of the pipes as we could not remove the caps. There is no water in any of the pipes.
- Foamed the decant inlet pipe in Pond 5 as per DSI request 2015-06
- On the mountain side we located the four adits that are scheduled for closure this year. We will need to build a route into their locations prior to starting the project.

2016-05-16 & 17
Install new fence (4 strands Barbed Wire) on East side of the West Kettle River adjacent to Gary Pomrenke's property. (250.484.5654)

2016-05-17 & 18
Repair Fence in NW corner of Pond 7. (JRJ Fencing)

2016-08-02
Re start Riprap Project.

2016-08-06
Riprap project complete. Soil samples taken for dam analysis.

2016-08-08
Site Clean-up, De-limbed Trees removed for riprap project and dropped to ground. Cleaned up rock storage area, dozer all remaining rock into a storage pile.

2016-08-09
Tour mountainside, located two new openings. 350285E 5477828N and 350321E 5477382N

2016-08-10
Allterra Land Surveying on site to shoot Pond 3.

Golder Julia Steele and John Cunning performed the 2016 DSI

2016-08-11
MEM site inspection by Paul Hughes and Blythe Golobic. Also on site, Tex Hewitt, Julia Steele, John Cunning & Gerry Murdoch.

2016-09-10
M4.2 Earthquake ± 32km south of Beaverdell (49.170N 119.252W). Contacted site caretaker (TEX) to do an inspection of the dikes. Inspection completed on Sunday 2016-09-11, no noticeable changes in the dikes, everything looks good.

2016-09-17&18
Rocky Mountain Forestry on site doing invasive weed control.

2016-09-26
Fall routine TMF inspection completed. No issues. Seeded the disturbed area in pond 1, beside the ball diamond and the access road into the riprap project.

2016-09-27&28
Annual mountainside routine inspection. Checked all existing seals and looked for new openings. See Beaverdell Mountain Routine Inspection in Tec Docks.

2016-10-27
Golder and Interior Land Reclamation were on site to complete the riparian repair planting program associated with the riprap project.

2017-05-08
Event site inspection, WKR rose to 5 year flood levels (?), TSF cell 4 and 5 amour (riprap) inspected and in good shape see BEA Event Inspection (WKR flood) Report in Teck Doc's.

2017-05-23

Spring routine inspection conducted. See BEA N-TSF R Inspection & BEA S-TSF R Inspection in Teck Doc's. Cleared fallen tree & brush out of spillway on Pond 3 South TSF. Brushed out pathway along toe of ponds 3, 4 & 5.

2017-05-24
Removed approximately 20 plus wind fell trees off the mine roads and trails. Located the off-site openings that were featured in a You Tube video. Locations were GPS and in GIS file.

2017-06-19
Install safety fencing around 10-01 and 16-02. Note numbering error 15-13, 15-14 and 16-02 are all the same opening.

2017-06-20
Tour Tim Coleman and Olga Druecker, SRK, around the lower half of the site re: Site management RFP
New Openings 17-02, 17-06 & 17-07

2017-06-21
Tour Tim Coleman and Olga Druecker, SRK, around the upper half of the site re: Site management RFP. Installed safety fencing around failed seal 14-17. Closed road to the lower section of 14-20, 16-04 & 16-06 with safety fence. (unstable rock on slope above road)

2017-06-27
Tour Jenna Simzer, Golder, around the lower half of the site, re: Site management RFP
New openings 17-09 & 17-10
2017-06-28
Tour Jenna Simzer, Golder, around the upper half of the site, re: Site management RFP

2017-08-09
2017 DSI site visit with John, Mike, Alannah from Golder.

2017-09-06
Re sealed 10-01, 14-15 14-17 & 3550 Portal. Sealed new openings 15-13, 16-01, 16-03, and 16-05. Completed with Lime Creek Loggings Volvo 340 excavator.

2017-09-07
Cleared the brush off the crest of the South Tailings Facility (TSF). Fill in animal burrows in the downstream face of Cell 3.

2017-09-08
MEMRP site inspection by John Hughes. See inspection report “2017September08_Beaverdell_inspector Report” in Teckdoc’s

2017-10-16 (Jeff Rees)
Invasive plant management, meet with contractor and direct specific areas of treatment.
Sample water for the 2900 Portal, 4 Level Portal and 16-05 Seal.

APPENDIX F

Ministry of Energy, Mines and Petroleum Resources Inspection

MINISTRY OF ENERGY, MINES & PETROLEUM RESOURCES

Mines and Mineral Resources Division

REPORT OF GEOTECHNICAL INSPECTOR

(Issued pursuant to Section 15 of the Mines Act)

Name of Property: Beaverdell Mine **Permit No.: M-71**

Mine Manager: Gerry Murdoch

Company: Teck Ltd.

Address: 601 Knighton Road
Kimberley, BC
Canada V1A 1C7

Persons Contacted: Gerry Murdoch, Project Manager, Legacy Properties, Teck
Tex Hewitt, Teck

Copies To: Al Hoffman, Chief Inspector of Mines, MEMPR
Diane Howe, Deputy Chief Inspector of Mines, MEMPR
Lowell Constable, A/ Geotechnical Manager, MEMPR
Tania Demchuk, Mining Compliance and Enforcement Deputy Ministers Board, MEMPR
Kathie Wagar, Regional Director, Cranbrook Region, MEMPR

Date of Inspection: September 8, 2017

In this report "Code" means the Health Safety and Reclamation Code for Mines in British Columbia

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Introduction

A geotechnical inspection of Teck's Beaverdell Mine (the Mine) was conducted on September 8, 2017. The site inspection was performed by Paul Hughes, contracted Geotechnical Mines Inspector. Accompanying the Inspector were Teck representatives Gerry Murdoch, and Tex Hewitt. This report summarizes observations made during the inspection, and actions required based on the inspection.

The purpose of this inspection was:

- To assess if the Mine is meeting the intent of the geotechnical requirements of the Code.
- To assess if the Mine is meeting the intent of the geotechnical conditions in its M-71 Mine Permit.
- To assess if geotechnical engineering practices at the Mine are consistent with generally accepted practices at mines in British Columbia.
- To provide general comment on geotechnical conditions at the mine.

This report is governed by the conditions and limitations set forth in the Mines Act and Code and has been prepared in a manner consistent with the level of care and skill ordinarily exercised for such work at BC

Mines subject to the time limits and physical constraints applicable to the work. This report is based on an inspection audit of select work areas at the Mine, and cannot practically cover the entire site. A "high level" review of engineering reports was completed with a focus on assessing if the intent of geotechnical requirements of the Code and permit are being met, and if the investigations, analysis, results and recommendations are reasonable and generally consistent with accepted engineering practices at mines in BC. Detailed/critical review of investigation findings, assumptions, calculations, and recommendations was not completed. Professional reliance has been used throughout.

The review of the Beaverdell Mine included an inspection tour of select site infrastructure, a review of technical reports, and technical discussions with Mine representatives. This inspection report summarizes observations made during the inspection, and actions required for follow-up. Where applicable, inspection orders have been included in italics. For ease of reference, the Mine Manager is asked to respond in red text in the space provided below each inspection order. Unless otherwise noted, all geotechnical inspection orders are made under Section 18(a) of the Mines Act and/or under Part 1.1.2 of the Code.

As part of this inspection, the following technical reports were reviewed:

- "Beaverdell Mine – 2016 Dam Safety Inspection" prepared by Golder Associates, dated March 28, 2018
- "Beaverdell 2016 Geotechnical Annual Report" prepared by Teck, dated March 31, 2017.

OBSERVATIONS COMMENTS AND INSPECTION ORDERS

The Beaverdell Mine is considered a closed site by Teck and no mining has occurred at the site since cessation of mine development in 1991. At time of inspection, construction activity for the year consisted of sealing openings to the underground mine. There are no permanent staff on site, and Teck performs three inspections per year as part of monitoring the site. Weather at time of inspection was 21°C and smoky skies. The tailings storage facilities was inspected and a reconnaissance of old mine workings were performed.

<u>Location</u>: Tailings Storage Facilities

Observations and Comments:

The Tailings Storage at Beaverdell consists of two separate facilities: the south facility containing ponds 1 through 5, and the north facility containing ponds 6 and 7. The facilities are earthen embankment facilities constructed of local materials with spigot tailings deposited within each pond. The Tailings Storage Facility was accessed by foot; an overview of the facilities and an approximate path of the inspection of the TSF is shown in Photo 1.

No major construction has taken place at the TSF since Q3 2016. The work in 2016 consisted of armoring the toe of Cell 5 to prevent erosion from the West Kettle River and raising a low spot in Cell 1 such that there is a consistent embankment elevation. Photo 2 shows the armoring at the base of Cell 5 at time of inspection.

The TSFs have a CDA Guideline Rating of "Significant." A facility breach would pose a risk to the adjacent West Kettle River and a sports field adjacent to Pond 3 that is used seasonally. Elevation surveys were conducted in Cell 3 to confirm the storage capacity of the facility. The results of the survey are discussed in the 2016 DSI and indicate that Cell 3 cannot contain the design IDF. Further, the spillway for Pond 3 is not adequate to convey the IDF as discussed in the 2016 DSI. Teck are to construct an adequate spillway per recommendations of the EOR or provide a suitable alternative to spillway construction in Cell 3 to manage the IDF. Photo 3 is of the current spillway.

The northern facility (Pond 6 and 7) embankments were walked as part of the inspection. There are no noticeable changes to Pond 6 and 7 since the previous inspection. Animal burrows were noted in Pond 6 (minor) and Pond 3 (large). When burrows are observed, the Mine excavates all loose material and replaces the void with suitable material. The results of this process were noted in the eastern embankment of Pond 3.

A recommendation from the 2016 DSI is to determine the stability of the dam in a seismic event per the Code's standards. It is understood that this work is ongoing and work may be required based on the results of the analysis. The results of the stability analyses are to be forwarded to the Geotechnical Inspector when complete.

All recommendations of the EOR from the 2015 DSI have been completed by the mine. It is understood that the 2017 DSI has been performed by the EOR.

Teck are currently studying a proposal to alter the configuration of the tailings impoundments such that the facility sheds water and is no longer are able to contain ponded water. This study would result in all water flows being directed over recontoured and covered tailings into a water management feature that would direct water to the receiving environment outside of the facility. The Mine are asked to keep MEMPR posted on the status of the study.

Inspection Orders:

Order #1 *Per Section 10.6.10 of the Code, the Mine is to address the spillway in Cell 3 per the recommendations or provide a suitable alternative to spillway construction in Cell 3 to manage the IDF. This order is to be in compliance by May 31, 2018*
Mine Manager's Response
Inspector's Follow-up

<u>Location</u>: Mine Workings

Observations and Comments:

The Mine Workings of the Beaverdell Mine are located East of Highway 33 on Wallace Mountain (mine workings). During operations, the Teck owned mine was accessed through four main portals with various small adits around the property that followed surface showings underground. The workings are considered closed with no plans on re-entry. The inspection of the mine workings was to gain a general understanding of the area and geotechnical risk.

In general, the mine workings consist of main portals (2900 Level, 3550 Level, 3700 Level, and 4 Level) with waste rock dumps associated with each portal. In addition to the main portals, numerous smaller adits with associated waste rock piles exist. On the mine property, there is a vent raise access near the upper levels of the workings that has been backfilled and a water intake for the underground workings that is yet to be reclaimed. Where possible, the Mine has backfilled the openings that appear and performed necessary maintenance to ensure that the portals remain backfilled.

Photo 4 is of the 2900 Level Portal that has been backfilled. It was noted that water was draining out of the portal by way of two pipes. This water ponded above the waste rock pile that could pose a geotechnical risk. It was discussed on site that Teck are to provide positive drainage from the portal outlet, where the water is ponding, away from the waste rock pile and into the nearby access road drainage ditch to the south of the portal.

In comparison to the major dumps, Photo 5 shows a typical waste rock dump that is associated with an adit that 'chased' a surface exposure. The height was approximately 20 m high and was end dumped from an old mine entrance. The waste rock dumps pose a risk as the construction methods of the dump and volume of the dump is unknown. In addition, waste rock dumps at the main portal sites are within a mountain drainage and erosion of the waste rock dumps were noted (shown in Photo 6).

Numerous entries into the underground working exist. Discovery of old portals is through site reconnaissance by mine personnel. Where feasible, the portals are backfilled and the surface is recontoured. Photo 7 shows a recently completed backfilling of the portal. Mine personnel monitor the performance of portal closures and make necessary repairs (placing additional material on portal) to ensure portals are not accessible.

The Mine has engaged SRK Consulting to map the area and provide a complete plan of all portals and waste rock dumps within the mine property. As part of this study, the Mine is ordered to determine the risk rating of all waste rock dumps on site and provide a mitigation strategy to reduce any high-risk dumps.

Inspection Orders:

Order #2 *Per 10.5.4 of the Code, the Mine is to divert the water seeping out of the Lower Portal (2900 Level) into the access road side ditch located to the South of the portal. This order is to be completed prior to May 31, 2018.*
Mine Manager's Response
Inspector's Follow-up

Order #3 *Per 10.5.4 of the Code, the Mine is to develop a risk rating for ALL waste rock dumps located within the claim boundary. The Mine is to develop a mitigation strategy on reducing the risk on the dumps dependent on the determined risk. This is an ongoing order and the compliance with the order will be determined on subsequent inspections.*
Mine Manager's Response
Inspector's Follow-up

<u>Location</u>: Neighboring Mine Properties

Observations and Comments:

During the inspection, Teck representatives showed the Inspector two portals that are open to the public and no closure has been performed by the Mine Permit holder. Photo 8 and 9 show the entrance to both the portals. Human activity was noted around the opening and it is understood that videos of trespassers in the underground workings have been posted to the internet. It is recommended that these portals are sealed to prevent further trespassers gaining access. It is understood that as Teck are not the owners of the property on which the open portals exists, no action can be directed towards them to close the portal. Follow-up discussion with the Permit holders of the mineral tenure is required to address the possibility of sealing off the portals.

CLOSURE

Under Section 15 (6) of the Mines Act, a written response is required from the Mine Manager within 15 days of the receipt of this Inspection Report. In addition, Section 30 (1) of the Mines Act requires this Inspection Report to be posted in a conspicuous location at the mine site for 30 days.

Please feel free to contact the undersigned with any questions or comments.

ORIGINAL SIGNED AND SEALED

Paul Hughes, P. Eng., Ph.D.
Geotechnical Inspector (Contractor)
Ministry of Energy & Mines

____
Signature

Dated: September 16, 2017

Photo 1: Overview of TSF and Site Inspection Path (map courtesy of 2016 DSI Report)

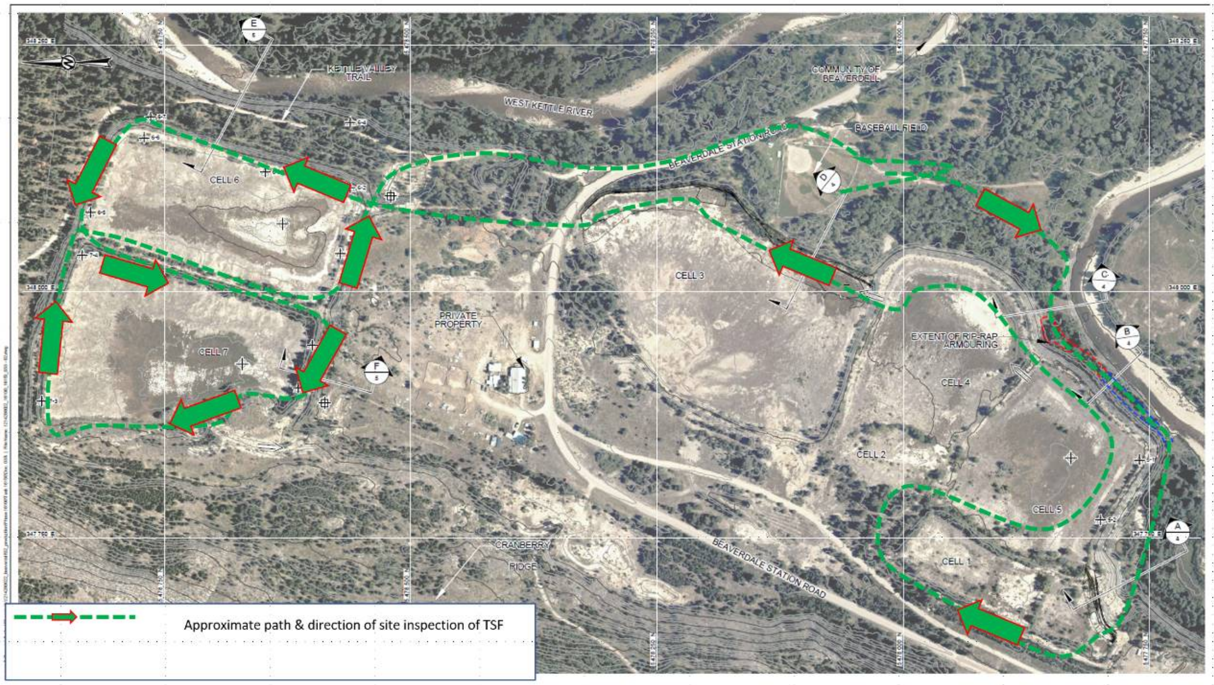

Photo 2: Completion of armoring of toe of Pond 5

Photo 3: Current spillway of Pond 3

Photo 4: 2900 Lower Portal (backfilled) with ponded water above waste rock dump

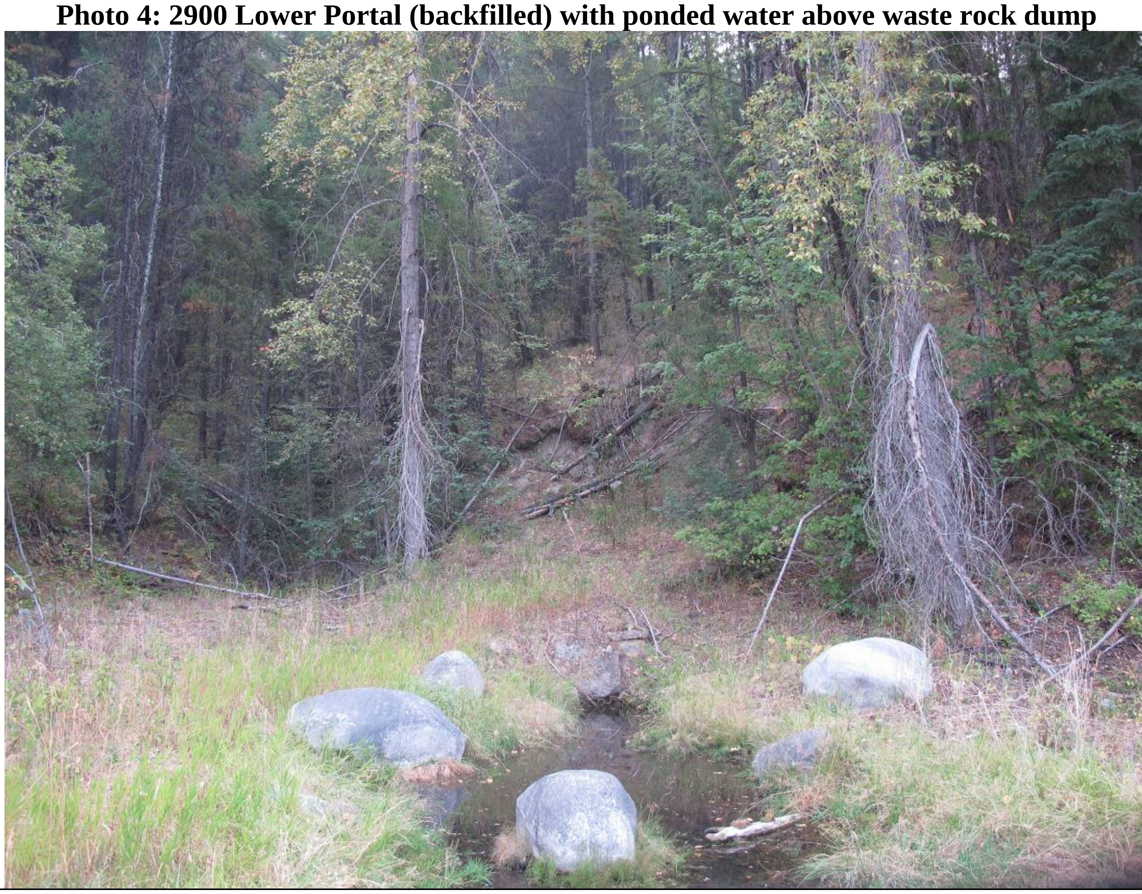

Photo 5: Typical waste rock dump on property

Photo 6: Erosional feature in waste rock dump above 3550 Portal

Photo 7: Completed backfill of mine adit

Photo 8: Abandoned portal outside of Beaverdell Mine Property

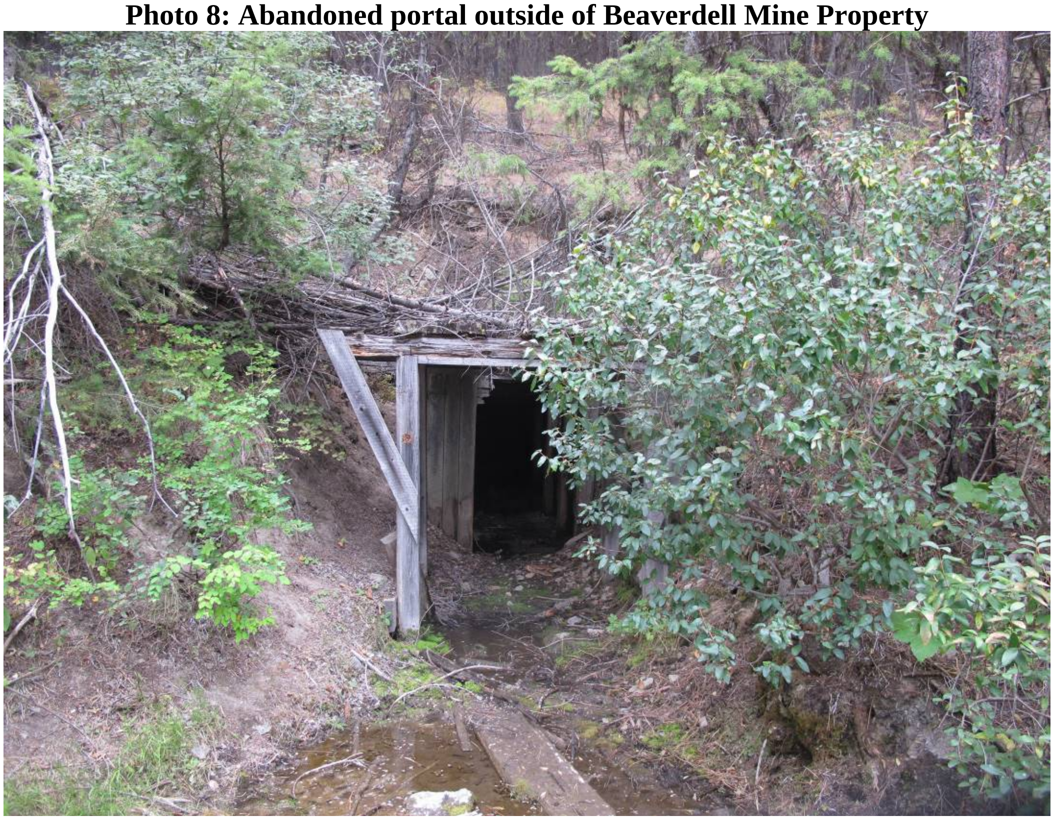

Photo 9: Abandoned adit providing access to underground workings outside of Beaverdell Mine Property

APPENDIX G

Emergency Preparedness and Response Plan Tabletop Exercise

Teck Resources Ltd. Beaverdell Mine
Tailings Storage Facilities
Emergency Preparedness and Response Plan
Tabletop Exercise
12 September 2017

Summary Report

Prepared by: Murray Bertram,

MJ Bertram Consulting

MJ Bertram Consulting
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Fostering Excellence in Emergency Management

Table of Contents

Introduction

Teck Resources Limited Kimberley Legacy Properties Office manages legacy mine properties across Canada. There is a requirement to review each property's tailing storage facility Emergency Preparedness and Response Plan (EPRP) on a regular basis. Accordingly, the Beaverdell Mine Tailings Storage Facilities EPRP was the subject of a tabletop exercise on 12 September 2017.

A record of participants is at Appendix 1 and a record of the exercise design is at Appendix 2.

Purpose

This Summary Report is a record of the discussion and actions generated by the tabletop exercise.

Discussion

Pre-exercise

The Tailings Storage Facility EPRPs are not in a standard format. A project is underway to standardize all EPRPs.

Integrating the Corporate Risk Management team into the incident management system is an issue that needs to be addressed.

Notification Procedures

Reporting of an incident may not always be available or timely. Remote monitoring is being considered but there is the issue of equipment vandalism to solve.

Establishing "triggers" such as rain and high stream flow advisories that would result in a physical inspection of the facility is being considered. Ideally, having that information pushed to Teck Legacy rather than having to search for it would enhance monitoring and notification procedures. This avenue is to be explored.

Notifications made to corporate depend on the level of concern caused by the event. Currently the system of describing levels of concern is not consistent as some are relayed by a numbering system while others by a word descriptor. The plan is to standardize on a Level 1, 2, 3 reporting system.

Identifying stakeholder notifications by level of concern and building a flowchart with contact information is a preferred method of displaying this information.

Command and Management

The Incident Command System (ICS) is used to establishing command and management at the site and site and site support levels (Teck Legacy Office). The participants are comfortable in the use ICS.

Methods to ensure personnel accountability at the site were evaluated. The Incident Commander will establish the accountability system appropriate to the situation.

Mapping all logistics resources, including accommodation and meals, for each site was discussed as a method to visually display information.

A project is under way to provide “go kits” with ICS forms and templates both in hard copy and digital format for those who will deploy to the site. A green vest and, possibly other safety equipment will be included.

Action Planning

Because of the Teck Legacy senior management knowledge of the tailings storage facilities and resources available, ICS action planning is a simple and effective process.

Contingency Planning

The in-depth knowledge of the Teck Legacy team supports contingency planning activities.

Appendix 1: Participant Sign-in Sheet

TECK RESOURCES LTD. BEAVERDELL TAILINGS STORAGE FACILITIES TTX SIGN-IN SHEET

DATE: 12 SEPT 2017

TIME: 0830

LOCATION: KIMB CONFERENCE ROOM #1

NAME	POSITION & AGENCY	PHONE, FAX, EMAIL	SIGNATURE
Michelle Unger	Manager, Envi Compliance	250-427-8422 michelle.unger@teck.com	MUnger.
Shari Loman	Supervisor, Health Safety	250-427-1061 Shari.loman@teck.com	[signature]
GERRY MURDOCH	PROJECT MANAGER	250.432.9943 gerry.murdoch@teck.com	[signature]
KATHLEEN WILLMAN	Manager, Eng? Remed.	250-432-9563 Kathleen.Willman@teck.com	K.Willman

Appendix 2: Exercise Design

The purpose of this exercise was to validate the Beaverdell Mine Tailings Storage Facilities EPRP by involving Kimberley Legacy Properties senior management in a simulated Beaverdell Mine Tailings Storage Facilities incident tabletop exercise.

There were four exercise objectives:

1. Review notifications procedures
2. Establish a command and management organization
3. Develop action plans
4. Conduct contingency planning

The exercise was held on 12 September 2017 in the Kimberley Legacy Properties Office. It was conducted in a tabletop format defined as a *discussion-based exercise in which players discuss and explore the response to a theoretical emergency scenario in an informal, stress-free environment*.

Exercise play was structured around standardized incident site and site support processes and procedures.

Initial Scenario:

News Bulletin: 5:00 PM 11 September 2017

Two earthquakes were recorded in southern B.C. this afternoon.

The first happened around 2:20, when a magnitude 2.2 earthquake was recorded three kilometres south of Princeton by the U.S. Geological Survey.

The second was a 2.5 magnitude earthquake, recorded by Earthquakes Canada, which happened six kilometres east of Penticton at 4:45 p.m.

Telecon 8:30 AM 12 September 2017

Gerry, this is Tex Hewitt calling from Beaverdell. I just had a call from one of the locals about what looks like sludge just down from the Beaverdell Mine facility. It has been raining hard for a number of days saturating the ground and there was that news release about a small earthquake in the area. I am going to do a quick site survey and will get back to you.

Telecon 10:30 AM 12 September 2017

Gerry, this is Tex again. A quick assessment indicates a slump failure reaching the river.

Objective #1: Review notifications procedures	
Expected actions	• Review situation assessment and notification procedures. • Identify who needs to be notified.
Questions	• What questions will you want to ask the site caretaker about the situation? • What is the level of concern for this incident? • Are there any worker safety concerns that need to be discussed with the site caretaker?
Tasks	• Create a list of all the agencies to be informed. • Review contact lists for accuracy.

Objective #2: Establish a command and management organization	
Expected actions	• Develop a site support organization. • Develop a site response organization.
Tasks	• Create and staff organization charts as appropriate. • Identify deployment requirements and means of travel.

Objective #3: Develop action plan(s)	
Expected actions	• Gather information and develop situational awareness. • Identify governing policies. • Set objectives. • Develop strategies. • Assign tasks. • Assign resources
Questions	• What method will you use to record information and develop situational awareness?
Tasks	• Create a site support action plan. • Create a site level action plan. • Identify resource requirements and procurement options.
Problem statement(s)	A contractor operated backhoe, bolstering the earthworks, has rolled over. The operator is seriously injured. WorkSafe BC has directed a temporary shutdown of activity until a safety plan is put in place.

Objective #4: Conduct contingency planning	
Expected actions	• Review current situation • Develop a 6, 12, 24 hour advance plan
Tasks	• Identify events that could change the course of the incident. • Create an advance plan for the site and site support levels
Problem statements(s)	The forecast is for a significant thunderstorm event in the area with strong winds and heavy precipitation. The earthworks remediation has been halted due to the heavy equipment accident. An increase in the level of the pond will put the structure at risk.

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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