REPORT

2018 Dam Safety Inspection for Greenhills Operations, Tailings Storage Facility

Teck Coal Limited, Greenhills Operations

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Reference No. 1894290-2018-133-R-Rev0-2000

26 March 2019

Distribution List

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Executive Summary

This report presents the 2018 annual dam safety inspection (DSI) for the tailings storage facility (TSF) at the Greenhills Operations (GHO) mine site, located near Elkford, British Columbia. This report was prepared based on site visits carried out on 21 June and 15 August 2018, and a review of data provided by GHO. The reporting period for the data review was from August 2017 through August 2018.

Summary of Facility Description

The tailings pond is retained on the southeast by the Main Tailings Dam and on the west by the West Tailings Dam.

The Main Tailings Dam is an approximately 50-m high zoned earth fill embankment structure. The dam shell is constructed from compacted coarse coal refuse material with a 6-m wide zone of compacted clay till (clay blanket) on the inclined upstream face. The dam has a design upstream slope of 2 horizontal to 1 vertical (2H:1V) and a design downstream slope of 2.5H:1V and has been raised in stages since 1983. Coarse coal refuse dumps Site C and D are located immediately downstream of the Main Tailings Dam. These dumps result in a wider dam section than required in the design and hence act as a buttress to the dam.

The West Tailings Dam is a zoned earth-fill dam similar in design to the Main Tailings Dam. The West Dam was initially constructed in 1993 and subsequently raised in stages, and as of early 2019 has a maximum height of around 25 m.

Summary of Key Hazards

The key hazards for the GHO TSF are as follows:

- Potential for overtopping of the Main and West Dams due to surface water inflows during storm events larger than the design flood or inappropriate water management.
- Internal instability of the Main and West Dams due to piping (internal erosion).
- Instability of the Main and West Dams, either under static conditions or due to seismic shaking.

Dam Consequence Classification

The Main and West Tailings dams are classified as High consequence dams, as per the criteria in the Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2013). The consequence classification for the dams has not changed based on this DSI.

Summary of Significant Changes

The Main Dam was raised to a crest elevation of 1,731.16 m, and West Dam crest was raised to a crest elevation of 1,731.14 m during 2018.

Significant Changes in Instrumentation or Visual Monitoring Records

No significant changes were noted in visual inspections.

Some of the monitoring instruments reported values that exceeded Quantitative Performance Objectives (QPO) warning and alarm levels during 2018. These exceedances are not of concern as most have been evaluated as erroneous and do not align with other instrumentation readings and visual observations. The functionality, calibration and suitability of the monitoring instruments reporting erroneous and suspect data must be reviewed and if necessary, adjusted or replaced.

It should be noted that the Engineer of Record (EoR) was not informed of these exceedances when they occurred, as required by the Trigger Action Response Plan (TARP). Golder recommends that GHO review the TARP to ensure that the actions following an exceedance are fully understood and followed in the future.

Significant Changes to Stability and/or Surface Water Control

There were no significant changes to stability or surface water control during 2018.

Operation, Maintenance, and Surveillance Manual and Emergency Preparedness Plan

The Operation, Maintenance, and Surveillance (OMS) Manual for the tailings facility was last updated in 2017 (GHO 2017). Review of the OMS Manual indicates that it meets the guidelines provided by the CDA (2013, 2014) and the Mining Association of Canada (MAC 2011, 2017). The OMS Manual is in the process of being updated by Teck. The updated document will be completed in 2019.

Emergency Preparedness Plan

The Emergency Preparedness Plan (EPP) for the tailings facility was last updated in 2018 (GHO 2019; Standard Practices and Procedures No. 1543).

The dam breach inundation study is currently being updated with additional modelling of the downstream area, up to Lake Koocanusa. The EPP will be updated by Teck once the additional modelling is complete. The revised document will include the Emergency Response Plan and the results from the updated inundation study.

Dam Safety Review

A Dam Safety Review (DSR) was completed in 2017 (KCB 2017). The DSR concluded that the tailings dams meet current safety standards.

The July 2016 revision of the Health, Safety and Reclamation Code (HSRC) (BC MEMPR 2016a) requires a DSR be completed at least every 5 years. The next DSR is scheduled for 2022.

Recommendations

The status of 2017 DSI deficiencies and non-conformances are summarized in Table E-1 (Golder 2018). The incomplete or partially complete issues were brought forward and are included with the 2018 DSI recommendations, provided in Table E-2.

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

ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Reference	Risk to Structure	Priority	Recommended Actions	Target Date	Status as of January 2019
2017-01	■ VW11-MD-1B is reporting erroneous data. ■ VW11-MD-1B, VW11-WD-1A and 1B, VW11-WD-2B, VW11-WD-3A did not report data (VW11-MD-3B, VW11-WD-2A and VW11-WD-3B also reported erroneous and/or no data for the reporting period, but are functioning correctly as of January 2018). VW11-MD-5A and 5B cables have been damaged. ■ SD-16-01 has no new readings since August 2017 when casing cover was partially buried during dam construction.	n/a	Potentially unstable condition not measured.	2	Confirm that dataloggers are functioning correctly and communication is restored as needed. Repair or replace damaged piezometer cables as necessary. Gain access to SD-16-01 and connect to datalogger.	Q3 2018	In progress. No repair or replacement of VW11-MD-2B is necessary, since sufficient monitoring coverage is provided by SD-16-03 and VW11-MD-2A. Repaired: MD-3A and 3B, MD-5A and 5B, WD-2A and 2B, WD-3A and 3B. Repairs required: ■ MD-1A, MD-1B and MD-4B ■ WD-1A, WD-1B ■ SD-16-01 Teck has committed to completing these repairs by end of Q2 2019.
2017-02	QPOs for the inclinometers have not been developed since data is still being collected to establish the baseline.	n/a	Potentially unstable condition not identified promptly.	2	Develop QPOs for the inclinometers once the baseline has been established.	Q3 2018	In progress. Readings started in 2018. Baseline will be established in 2019 (after 12 months of readings). Until a baseline is established, each inclinometer survey collected will be assessed and compared against the interim QPOs (Table 16, Section 5.3.3), and previous surveys to monitor the magnitude, direction, and rate of deformations.
2017-03	The weirs at the toe of Site C and West Dam were damaged in 2017.	n/a	Potentially unstable condition not measured.	2	Reinstate the weir at the toe of Site C. Establish baseline monitoring for weirs and consider automating to ensure continual data collection.	Q3 2018	Complete: Site C weir has been reinstated. Incomplete: Automation and baseline monitoring is planned for 2019. The weir at the toe of the West Dam has been moved downstream to the other side of the road and is now functioning again.
2017-04	Pond against upstream slope of Main Dam. The pond against the upstream slope of the Main Dam is consistent with design basis and not a dam safety concern, but there is an opportunity to improve towards best applicable practice by moving it away from the upstream slope of the Main Dam.	n/a	Increased potential for piping, and potential increased zone of influence if dam integrity is compromised.	4	Review options to move pond away from upstream slope of Main Dam.	Q3 2018	In progress. Deposition options to be reviewed in 2019.
2017-05	Closure plan does not meet HSRC requirements.	HSRC, OMS	n/a	4	Develop the current concept level closure plan into a more detailed plan aligned with the current LOM strategy and HSRC requirements.	Q1 2019	Update to start in 2019.
2017-06	In 2014, flood protection berms were constructed along the river near Elkford. The 2016 inundation study update (Golder 2017c) used the 2011 LiDAR, which did not include the flood protection berms. The inundation study needs to be updated with the 2017 LiDAR data to include the recently 2014 flood protection constructed berms.	n/a	n/a	4	Update inundation study with 2017 LiDAR for West Dam breach.	Q4 2018	Completed Q1 2019. Additional modelling is being completed further downstream, to Lake Koocanusa.

EPP = Emergency Preparedness Plan; OMS = operation, maintenance, and surveillance; DSI = dam safety inspection; DSR = Dam Safety Review; QPO = quantitative performance objective.

Table E-2: 2018 Dam Safety Inspection Recommended Actions for the Greenhills Tailings Facility

ID Number	Deficiency or Non-conformance	Photo	Applicable Regulation or OMS Reference	Potential Dam Safety Risk	Recommended Action	Priority Level	Recommended Deadline
2018-01 (2017-01)	Piezometers: ▪ VW11-MD-1A and 1B are missing data from September 2017 onwards, except for a few days of erroneous data in March to August 2018. ▪ VW11-MD 2A was missing data from August to October 2017 and in November 2017. ▪ VW11-MD-3A and 3B were missing data from October to December 2017. ▪ VW11-MD-5A and 5B were missing data from December 2017 to May 2018. ▪ SD-16-04 stopped recording in August 2018. ▪ SD-16-01 has no new readings since October 2017 when casing cover was partially buried during dam construction. ▪ WD-2A and 2B and WD-3A and 3B were missing data for part of September 2017. ▪ WD-1A and 1B stopped reading data in April 2018, with a few exceptions. Prisms and GPS units: ▪ Prism A is not within line of sight of total station. ▪ Non-functioning GPS units on Main Dam (MD-1_ROVER, MD-2_ROVER, MD-5_ROVER) ▪ Non-functioning GPS units on West Dam (WD-1_ROVER, WD-2_ROVER, WD-3_ROVER) Seepage Weirs: ▪ Suspect data reported by the weir at the toe of Site C by the Main Dam, and at the weir by the West Dam.	-	n/a	Potentially unstable condition not measured.	Piezometers: ▪ Repair or replace damaged piezometers/dataloggers as necessary. ▪ Review the reliability of instruments that have gaps within reporting period. ▪ Re-calibrate/repair/replace piezometers that have been reporting negative readings. ▪ Gain access to SD-16-01 and connect to datalogger. Prisms and GPS units: ▪ Relocate Prism A so that it is within the line of sight of the total station. ▪ Review functionality, calibration and suitability of GPS units. Repair or replace GPS units as necessary. Seepage Weirs: ▪ Take manual readings with tape measure ▪ Perform bucket calibration ▪ Automate weirs to ensure continual data collection. ▪ Install additional seepage weir at toe of Site D spoils.	2	Q2 2019
2018-02	The Trigger Action Response Plan (TARP) was not implemented as required when warning and alarm levels were exceeded during the 2017/2018 reporting period.	-	OMS	Potential delayed response of corrective actions and notification of responsible persons and emergency response team.	Review the TARP, update if appropriate, and retrain key GHO personnel so that the TARP procedures and requirements are enforced as intended.	2	Q1 2019
2018-03 (2017-02)	QPOs for the inclinometers still required.	-	n/a	Potentially unstable condition not identified promptly.	Develop QPOs for the inclinometers based on the baseline readings, once established. Until a baseline is established, each inclinometer survey collected must be assessed and compared against the interim QPOs (Table 16, Section 5.3.3), and previous surveys to monitor the magnitude, direction, and rate of deformations.	2	Q3 2019
2018-04 (2017-04)	Pond against upstream slope of Main Dam. The pond against the upstream slope of the Main Dam is consistent with design basis and not a dam safety concern, but there is an opportunity to improve towards best applicable practice by moving the pond away from the upstream slope of the Main Dam.	1 to 8	n/a	Increased potential for piping, and potential increased zone of influence if dam integrity is compromised.	Review options to move pond away from upstream slope of Main Dam.	4	Q4 2019
2018-05 (2017-05)	Closure plan does not meet HSRC requirements.	-	HSRC, OMS	n/a	Develop the current concept level closure plan to align with the current LOM strategy and HSRC requirements.	4	Q4 2019

Table E-2: 2018 Dam Safety Inspection Recommended Actions for the Greenhills Tailings Facility

ID Number	Deficiency or Non-conformance	Photo	Applicable Regulation or OMS Reference	Potential Dam Safety Risk	Recommended Action	Priority Level	Recommended Deadline
2018-06	Golder has recommended additional inundation study modelling of the downstream area, up to Lake Koocanusa.	-	n/a	n/a	Update inundation study with additional modelling downstream, up to Lake Koocanusa.	4	Q2 2019
2018-07	A portion of the seepage at the Site C toe is flowing under the SmartDitch, which may be causing a small bypass of seepage past the seepage monitoring weir. The flow entering the HDPE pipe and the flow from the HDPE pipe into the SmartDitch are not measured separately from the dam toe seepage. It is impossible to distinguish whether flow at the weirs is due to increased seepage or rainfall.	12b	n/a	Potentially unstable condition not measured.	Modify seepage collection to direct seepage into the SmartDitch, and add this to the list of inspection and maintenance tasks in OMS manual. Measure the flow entering the HDPE pipe (or flowing from the HDPE pipe into the SmartDitch) such that it can be tracked separately from the seepage from the dam toe during periods of rainfall. Add this to the list of monitoring tasks in the OMS manual.	4	Q3 2019

Priority Level	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.

OMS = operation, maintenance, and surveillance; EPP = Emergency Preparedness Plan; EoR = Engineer of Record; CDA = Canadian Dam Association; QPO = quantitative performance objective; Q1 = first quarter of the year; IDF = inflow design flood; n/a = not applicable.

Abbreviations

Abbreviation	Definition
CDA	Canadian Dam Association
DSI	Dam Safety Inspection
DSR	Dam Safety Review
EoR	Engineer of Record
EPP	Emergency Preparedness Plan
FoS	factor of safety
GHO	Greenhills Operations
Golder	Golder Associates Ltd.
HSRC	Health, Safety and Reclamation Code
IDF	inflow design flood
LCO	Line Creek Operations
MEMPR	British Columbia Ministry of Energy, Mines and Petroleum Resources
OMS	operation, maintenance, and surveillance
QPO	quantitative performance objective
PGA	peak ground acceleration
TDS	total dissolved solids
TSS	total suspended solids

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1.0 INTRODUCTION

At the request of Teck Coal Limited (Teck), Golder Associates (Golder) has completed this annual dam safety inspection (DSI) for the Greenhills tailings storage facility (TSF) at Teck's Greenhills Operations (GHO) near Elkford, BC. The reporting period for the data review was from August 2017 through to the end of August 2018. This inspection included the following structures:

- Main Tailings Dam
- West Tailings Dam

The DSI report has been prepared in accordance with Part 10 of the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (BC MEMPR 2016a) which sets out the frequency for inspection of the dams and appurtenant works. It is understood that this report will be submitted by Teck to the Chief Mines Inspector.

The guidelines for annual dam safety inspection reports by the BC Ministry of Energy and Mines (BC MEM 2013) and BC MEMPR 2016a were followed during the preparation of this report.

The report is based on site visits carried out on 21 June and 15 August 2018, discussions with GHO staff, and review of data provided by GHO. The report consists of the following:

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

The previous annual dam safety inspection for the tailings facility dams was carried out in September 2017, and is reported in the 2017 DSI report (Golder 2017d).

2.0 BACKGROUND

2.1 Site History

The GHO site is an active open pit coal mine located near Elkford, BC. The mine was started by Westar Mining Ltd. and initiated production in 1982 but shut down in 1992. Starting in December 1993, the mine was owned as a joint venture between Fording Coal Limited (Fording) and Pohang Steel Canada Ltd., and operated by Fording. The operating company was changed from Fording to Elk Valley Coal Corporation in 2003 and then to Teck Coal Limited in 2008.

Figure 1 shows a location and plan view of the GHO site and the location of the Greenhills Tailings facility.

2.2 Overview of Operations

Raw coal from the pit is processed at the wash plant to produce marketable coal with by-product streams of coarse refuse material and fine refuse tailings. The coarse refuse material, consisting of 50 mm minus sand and gravel sized particles of rock and coal, is placed into dumps located near the wash plant (Sites A to E in Figure 2). A tailings slurry of fine particles of rock and coal is discharged at a solids content of around 30 percent (%) by mass into the tailings facility, located on the west side of the wash plant (Figure 2).

Typically, about 500,000 m^3 of tailings is deposited annually. The slurry density was assumed to be about 1.13 tonnes per cubic metre (t/m^3). After the solids have settled from suspension, the clarified tailings water is recovered and re-circulated by barge pumps to the wash plant for reuse.

The tailings are silt sized with a D_{50} of around 0.2 mm.

The 2018 survey indicates that the highest point of the tailings surface is near the tailings discharge at the north side of the pond and is at approximately El. 1,729.4 m. The deepest point is approximately 25 m northwest of the barge at an elevation of about 1,722.6 m, which corresponds to a pond depth of about 4 m. This is an operational consideration and does not impact dam safety.

2.3 Site Characteristics

Climate

The typical range of climatic conditions for the GHO site are summarized in Table 1.

Table 1: Typical Range of GHO Climatic Conditions

Parameter	Monthly Minimum	Monthly Maximum	Annual Mean
Temperature	– 21.3°C	18.9°C	– 0.5°C
Precipitation	3 mm	229 mm	645 mm
Lake (1 m-depth) Potential Evaporation	0 mm	160 mm	814 mm
Actual Lake (1 m-depth) Evaporation	0 mm	117 mm	586 mm

Source: Golder (2015b).

°C = degrees Celsius.

Seismicity

The site is located in an area of relatively low seismicity. Golder developed a site-specific seismic hazard model for the GHO site based on historical seismicity and a review of geologic and paleoseismological features (Golder 2016b). Golder's model includes four area sources from the 5th Generation Seismic Hazard Model and nine faults and fault segments mapped in northwest Montana. The 5th Generation Seismic Hazard Model was developed by Natural Resources Canada for use in the 2015 National Building Code of Canada (NRCC 2015).

The site-specific peak ground acceleration was evaluated for a Class C soil site as described in the 2010 National Building Code of Canada as this represents Golder's understanding of the foundation conditions at the dam locations. The probabilistic analysis results from the site-specific hazard model are listed in Table 2.

Table 2: Seismic Hazard Values

Exceedance Probability	Return Period (Years)	Peak Ground Acceleration (PGA) (g)
40% in 50 years	100	0.020
10% in 50 years	475	0.063
5% in 50 years	1,000	0.097
2% in 50 years	**2,475**	**0.158**
1% in 50 years	5,000	0.222
½% in 50 years	10,000	0.300

Notes: For firm ground site class "C," very dense soil and soft rock foundation, as defined by 2010 National Building Code of Canada (NRCC 2010). Return periods are not exact representations of annual exceedance probabilities, rounding as per CDA (2013, 2014) is shown. GHO/FRO site coordinates for Golder (2016b) *Site Specific Probabilistic Seismic Hazard Assessment*: 50.202°N, -114.876°W.

The Canadian Dam Association (CDA) Dam Safety Guidelines (2013) recommends a 2,475-year seismic event for High consequence structures such as the GHO TSF Dams.

2.4 Subsurface Conditions

Main Tailings Dam

A geotechnical investigation was carried out by Hardy Associates in 1980 to determine the subsurface conditions underlying the Main Dam. It was inferred that a 1.5 to 2.0 m thick layer of colluvial clay (varying proportions of clay, sand and gravel) was present. Where the colluvium was predominantly clay, it is generally soft to stiff, whereas colluvium that is predominantly gravel or sand is generally very dense (Hardy 1980a). The foundation preparation involved the removal of soft or unsuitable materials (Hardy 1980b). Hard glacial till underlies the colluvial clay. Shale bedrock was encountered in boreholes 80-RA1 and 80-RA2 at depths of 12.5 and 12.2 m, respectively. All of the other fourteen boreholes were terminated within the till. Inferred stratigraphy based on Hardy 1978 can be seen in Sections A and B of Figure 4.

The design report indicated that unsuitable or soft materials with undrained shear strengths (Cu) less than 35 kilopascals (kPa) were to be removed during foundation preparation (Hardy 1980a, b). A geotechnical drilling program to determine the extent of removal of the unsuitable or soft materials in the Main Dam and Site C coarse refuse dump foundations was undertaken from October to December 2016. The investigation did not encounter soft colluvial clays. The investigation indicated that foundation conditions of the Main Dam typically comprise very stiff to hard glacial till; with a shear strength of about 32º and 50 kPa cohesion. The stiff to hard state of the till is supported by the Standard Penetrometer Test (SPT) results by Hardy (1980), where 92% of the tests had an "N" value greater than 30; which indicates that the till is typically dense to very dense. The water content of the till samples were all below the Liquid Limit (LL), and about 80% of the samples had a Liquidity Index (LI) less than or equal to zero (Golder 2017e). The thickness of the till ranged from 3.10 m to 56.75 m and is underlain by fine-grained sedimentary rock. The glacial till is anticipated to be over-consolidated relative to the stresses applied by the range of dam raises.

West Tailings Dam

Geotechnical investigations were completed in the West Dam area in 1992 and 2013. On the upstream side of the West Dam and underneath the tailings pond itself, the West Dam is underlain by a varying thickness of glacial till, with colluvial clays occurring on the downstream side of the dam. Thicknesses of glacial till were found to vary from 0.8 m to 2.8 m based on the 2013 field investigation. Inferred stratigraphy based on Golder (2014b) is shown on Sections C and D in Figure 5.

Removal of superficial loose, soft, organic or other deleterious materials from the West Dam foundation footprint was carried out for foundation preparation in the dam footprint area on the west side of the mine road (i.e., within the downstream portion of the foundation for the subsequently-constructed West Dam) and replaced with select free-draining material (Golder 1999).

No foundation preparation beneath the original mine road foundation was reported during initial construction, but pockets of clay fill or colluvial clay in the original mine road foundation would have been restricted to the upstream portion of the dam, and therefore not affect downstream stability.

Fill and colluvial clay were removed from the downstream toe of the West Dam footprint during 2016, as part of ongoing preparation for the dam raise. The resulting in situ foundation conditions beneath the new construction footprint (for El. 1,735 m dam design) are glacial till or bedrock.

2.5 Overview of Dam Design and Construction

The tailings pond is retained on the southeast by the Main Tailings Dam (Figure 4), and on the west by the West Tailings Dam (Figure 5). The original design of the Main Tailings Dam to crest elevation 1,706 m was carried out by Hardy Associates Ltd. for the former owner Westar Mining Ltd. Information concerning the geology, stratigraphy, and ground water conditions is presented in the Hardy Associates Ltd. reports (Hardy 1980a, 1980b, 1981). A design for the West Tailings Dam was completed by Golder in 1993 (Golder 1993). To increase the storage capacity of the tailings facility a design for a raise to crest elevation of 1,725 m (with a dam height of between 10 and 50 m) was completed by Golder in January 1994. Designs to raise the Main and West Dams to a crest elevation of 1,735 m were completed by Golder in 2005 and 2014 (Golder 2005, 2014b).

The tailings facility is being actively raised during the development of the mine. As of early 2019, the crest elevation is 1731.14 m to 1731.16 m.

A stage-storage curve of the facility is shown below in Chart 1. The current tailings storage capacity of the facility is approximately 17 million m^3.

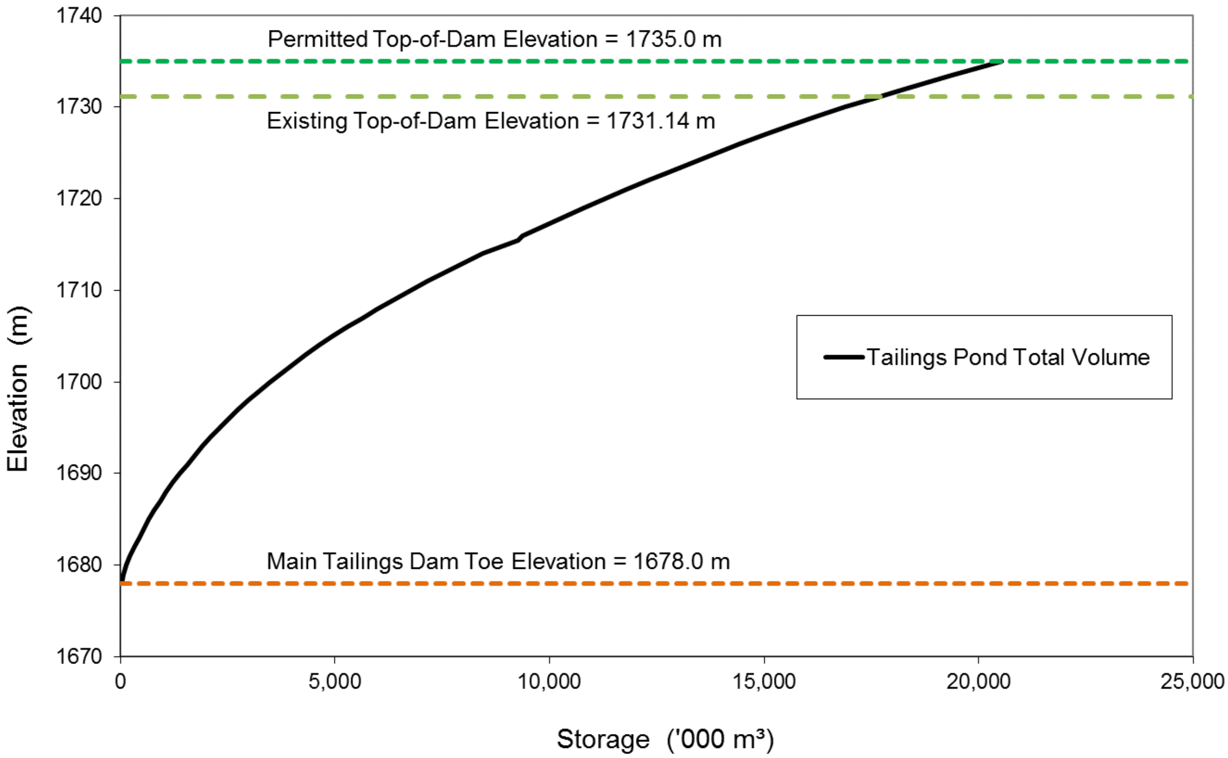


Chart 1: Elevation-Storage Curve

The following is a list of the owner, operator, and companies involved in design and construction reporting for this facility:

- Owner: Teck Coal Limited, Greenhills Operations
- Operator: Teck Coal Limited, Greenhills Operations
- Design Report: prepared by Hardy Associates (1978) Ltd. (1981)
- Engineer of Record: Andy Haynes, P.Eng. (Golder Associates Ltd.)
- GHO TSF Qualified Person: Mark Slater, P.Eng.

GHO operates the tailings facility following Operations, Maintenance and Surveillance Manual, Standard Practices and Procedures (SP&P) No. 1543 (GHO 2017). This requires that a daily visual inspection of the pond is carried out by the plant staff, weekly review of monitoring data is carried out by a site geotechnical engineer, and monthly engineering inspections are carried out by a GHO geotechnical engineer.

Main Tailings Dam

The Main Tailings Dam is an approximately 50-m high zoned earth fill embankment structure. The dam consists of a bulk fill of compacted coarse refuse material with a 6-m wide zone of compacted clay till (clay blanket) on the inclined upstream face. The design geometry of the Main Dam is outlined in the 2005 Design report (Golder 2005). The dam was designed with an upstream slope of 2H:1V and downstream slope of 2.5H:1V, with 6-m wide berms at approximately 15 m intervals as shown in Figure 4. The ultimate crest width at an elevation of 1,735 m is 12 m. GHO develops coarse refuse dumps Site A to E around the tailings facility (Figure 2). Coarse refuse dumps Site C and D are located immediately downstream of the Main Tailings Dam. They result in a wider dam section than required in the design and hence act as a buttress to the dam.

The Main Dam has been raised in stages since 1983 as summarized in Table 3.

Table 3: Main Dam Construction Summary

Year	Construction	Dam Crest Elevation (m)	References
1982–1983	Starter Dam, piezometers installed	1,687	Hardy 1980a, 1980b, 1984
1984–1985	Raise	1,695	No documentation
1986	Raise, piezometers damage, 10 pneumatic piezometers installed	1,699	Hardy 1987
1987	Coarse refuse shell raised, French drains installed beneath shell	1,700	Hardy 1988
1988	Rock drains (French drain) below coarse refuse spoil	No change	Westar 1988
1989	Raise	1,702	Golder 1989
1990	Raise	1,704	Golder 1990
1991	Raise	1,707	Golder 1992
1994	Coarse refuse shell raised	1,710	Golder 1995
1995	Raise, 3 standpipe piezometers installed	1,712	Golder 1996
1996	Coarse refuse shell raised	1,718	Golder 1997
1997	Blanket to El. 1,718 m, coarse refuse shell raise, rock drains extended beneath Site C and Site D refuse spoils	1,720	Golder 1998
2003	Raise	1,720.1	Golder 2004
2009	Raise	1,723.0	Golder 2010b
2010	Raise	1,724.6	Golder 2010c
2011	5 vibrating wire piezometers locations (2 sensors each location)	No change	Golder 2012a
2014	Raise	1,727.45	Golder 2015a
2015	Raise	1,727.58	Golder 2016a
2016	No construction raises. Additional instrumentation installed.	1,727.90[1]	Golder 2017b
2017	Raise	1,728.85	Golder 2017f
2018	Raise. Additional instrumentation installed.	1,731.16	Golder 2018d

Notes: No dam raise was completed from 2015 to 2016. The increase in crest elevation indicated from 2015 to 2016 is due to a change in the Main Dam alignment used. The alignment was changed from the upstream crest of the dam to the Till-CCR interface.
El. = elevation.

The active instrumentation in the Main Dam is summarized in Table 4.

Table 4: Summary of Active Main Dam Instrumentation

Instrumentation Type	Number	Comments
Vibrating Wire Piezometers	23	Each location, except SD-16-04, has two piezometers; one piezometer in the foundation and another piezometer above the subgrade transition in the coarse reject material. SD-16-01 was not active for the duration of this reporting period. The locations of the piezometers are shown in Figure 3.
Surface GPS Monitoring Stations	8	Two monitoring stations (#319 and #320) are located on the downstream slope of Site C, five along the downstream slope of the Main Dam (MD_ROVER series), and one monitoring station (#313) is on the pond reclaim barge.
Surface Monitoring Prisms	7	The prisms are situated on the upstream crest of the Main Dam.
Seepage Weir	1	At toe of Site C. The Site C weir was damaged during the 2017 upgrade of the seepage collection channel. The weir was reinstated in 2018.
Inclinometers	2	In downstream shell of Main Dam.

Following observed ground movement at Site C in 2011 and 2012, including the development of a scarp in the dumps and a bulge downslope from the dumps, Global Positioning System (GPS) monitors #319 and #320 were installed on the benches of the Site C coarse refuse dump to monitor the displacement, and the potential impact to the Main Tailings Dam was reviewed by GHO (2012). The locations of the GPS monitors and 2012 scarp and toe bulge areas are shown in Figure 3. Golder recommended that ground movement monitoring on the Site C dump should continue.

In 2018 Teck installed five new GPS units on the Main Dam (MD_ROVER series) to monitor for movements of the Main Dam. As a result of the new GPS units that have been installed, Teck plans to read the prisms on a reduced frequency of once per quarter. Golder recommends that the prisms still be used as the primary monitoring instrument until such time that the GPS units on the Main Dam can be demonstrated to be effective.

Seepage from the Main Tailings Dam is collected by rock drains installed in 1996 through the Site C and D dump footprints. These rock drains consist of geotextile-wrapped crushed limestone. The seepage exits at the toe of the dumps and is collected in a seepage collection channel, which was upgraded in 2017.

West Tailings Dam

The West Tailings Dam is a zoned earth-fill dam similar in design to the Main Tailings Dam, consisting of compacted coarse refuse bulk fill with a 6 m wide zone of compacted clay till (clay blanket) on the upstream face. The West Dam has a maximum height of around 25 m. The dam crosses a depression located at the northwest end of the tailings basin. The mine road is located to the west of the West Tailings Dam.

The West Dam has an upstream slope of 2H:1V and a downstream slope of 2.5H:1V, with 6 m wide berms at approximately 15 m intervals on the downstream face. The design includes a relatively wide 40 m crest width to provide access for haul trucks to the adjacent refuse spoils. Cross-sections of the West Tailings Dam are shown in Figure 5.

Design drawings to raise the Main and West Dams to El. 1,728 m (Golder 2014c,d) were submitted to GHO in May and June of 2014. The design included an enlarged West Dam footprint to support a future raise of the dam to El. 1,735 m.

The West Tailings Dam construction started in 1993 with a clay blanket on the upstream side of the mine road. The construction history of the West Dam is summarized in Table 5.

Table 5: West Dam Construction Summary

Year	Construction	Elevation (m)	References
1993	Raise as blanket on mine road	1,711	Golder 1993
1996	Raise as blanket on mine road	1,714.3	Golder 1997
1998	Foundation preparation to till and bedrock of El. 1,725 design footprint	No change	Golder 1999
1999	Raise, mine road relocated to west	1,719.1	Golder 2000
2004	Raise	1,721.6	No documentation
2010	Raise	1,724.8	Golder 2010b
2011	3 vibrating wire piezometers (2 sensors each)	No change	Golder 2012a
2014	Raise, mine road relocated to west	1,726.6	Golder 2015a
2015	Raise	1,728.07	Golder 2016a
2016	Extension of the downstream portion of the West Dam and construction of the temporary emergency spillway.	No change	Golder 2017b
2017	Raise, extension of the downstream portion of the West Dam and removal of the temporary emergency spillway.	1,728.73	Golder 2017f
2018	Raise. Additional instrumentation installed.	1,731.14	Golder 2018d

The active instrumentation in the West Dam is summarized in Table 6.

Table 6: Summary of Active West Dam Instrumentation

Instrumentation Type	Number	Comments
Vibrating Wire Piezometers	6	Each location has two piezometers, one piezometer in the foundation and another piezometer above the subgrade transition in the reject material. The locations of the piezometers are shown in Figure 3.
Surface GPS Monitoring Stations	3	Three monitoring stations along the downstream slope of the West Dam (WD_ROVER series).
Prisms	5	The prisms are situated on the upstream crest of the West Dam.
Seepage Weir	1	At toe of West Dam. The weir was damaged by a boulder during August 2017 West Dam construction. The weir was reinstated in 2017 further downstream.

In 2018 Teck installed three new GPS units on the West Dam (WD_ROVER series) to monitor for movements of the West Dam. As a result of the new GPS units that have been installed, Teck plans to read the prisms on a reduced frequency of once per quarter. Golder recommends that the prisms still be used as the primary monitoring instrument until such time that the GPS units on the West Dam can be demonstrated to be effective.

2.6 Material Properties

Material properties of the embankment fill materials and subsurface materials are provided in Table 7. The properties are based on the 2016 geotechnical investigation of the Main Dam (Golder 2017a), and the 2013 geotechnical report for the West Dam (Golder 2014c).

Table 7: Design Material Properties

Material	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (Φ)
Glacial Till	19.0	50	32°
Clay Blanket	21.5	50	n/a
Compacted Coarse Refuse	18.0	0	40°
Uncompacted Coarse Refuse	17.0	0	37°
Weathered Bedrock	25.0	300	n/a

kN/m^3 = kilonewtons per cubic metre; kPa = kilopascal; ° = degree; n/a = not applicable.

2.7 Dam Consequence Classification

The Health, Safety and Reclamation Code (BC MEMPR 2016a) references the CDA Dam Safety Guidelines (CDA 2013) with respect to consequence classification of tailings dams. Table 8 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. 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 loss categories (CDA 2013). The classification assigned to a dam is the highest rank determined among the four loss categories.

The CDA (2013) guidelines were used to assign a dam failure consequence classification to the GHO dams. The tailings facility Main and West Dams continue to be classified as High Consequence because the population at risk is expected to be permanent residents in houses in the floodway and for a hypothetical dam failure, the potential loss of life is expected to be less than 10, infrastructure and economic damages downstream are expected to be significant, and environmental damages are expected to be significant loss of fish and wildlife habitat, but for which compensation in kind is possible.

An inundation study for a potential breach of the TSF was completed by Golder in 2012 (Golder 2012) and updated in 2016 (Golder 2017c). The 2016 study was conducted to reassess an overtopping or piping failure of the Main Dam and assess an overtopping failure of the West Dam.

In 2014, flood protection berms were constructed along the Elk River near Elkford. The 2016 inundation study update (Golder 2017c) used the 2011 LiDAR, which did not include the flood protection berms. The inundation study is in the process of being updated with the 2017 LiDAR data to include the flood protection constructed berms. The updated inundation study will be completed in 2019.

Table 8: Dam Classification in Terms of Consequences of Failure

Dam Class	Population at Risk[(a)]	Incremental Losses		
		Loss of Life [(b)]	Environmental and Cultural Values	Infrastructure and Economics
Low	None	0	Minimal short term loss or no long term loss.	Low economic losses; area contains limited infrastructure or service.
Significant	Temporary Only	The appropriate level of safety required depends on the number of people, the exposure time, the nature of their activity, and other considerations.	No significant loss or deterioration of fish or wildlife habitat, or 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**	**10 or fewer**	**Significant loss or deterioration of important fish or wildlife habitat. Restoration or compensation in kind highly possible.**	**High economic losses affecting infrastructure, public transport, and commercial facilities.**
Very High	Permanent	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	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: CDA (2013), Table 2-1.

(a) Definition for Population at Risk:

None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary – People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

(b) Implications for loss of life:

Unspecified – The appropriate level of safety required a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

2.8 Quantitative Performance Objectives

Quantitative performance objectives (QPOs) form part of the operating framework for a tailings dam, and provide an early warning indication of anomalous conditions which may be detrimental to a dam's integrity. QPOs are a best practice measure for tailings dam management.

Golder developed QPOs for the piezometers, pond freeboard, and survey prisms for the GHO Tailings Pond dams in 2016 (Golder 2016d). QPOs for the GPS units were developed in 2017 (Golder 2017g) and seepage weirs in 2018 (Golder 2018a). The seepage weir QPOs will be reviewed once monitoring of the weirs has been automated and sufficient data is gathered to determine annual trends. QPOs for the inclinometers have not been developed since data is still being collected to establish the baseline. Readings were started in July 2018 for SD 16-04 and September 2018 for SD-16-05. QPOs for the inclinometers will be developed once the baseline has been established. Until a baseline is established, each inclinometer survey collected must be assessed and compared against the previous surveys to monitor the magnitude, direction, and rate of deformations. The initial inclinometer data for SD_16-04 is plotted and presented in Appendix C. No data for SD_16-05 was collected during the reporting period.

In 2017 the QPOs for the piezometers were updated (Golder 2017g) to reflect the findings of the 2016 Main Dam foundation investigation (Golder 2017e) and to align the piezometer QPOs with the Trigger Action Response Plan (TARP).

The QPOs are presented in later sections of this report as follows:

- seepage weirs are presented in Section 5.3.1 (Assessment of Dam Safety: Internal Erosion)
- freeboard is presented in Section 5.3.2 (Assessment of Dam Safety: Overtopping)
- prisms, GPS units, inclinometers and piezometers are presented in Section 5.3.3 (Assessment of Dam Safety: Instability)

3.0 OPERATION AND CONSTRUCTION DURING 2018

Construction and changes in the monitoring plans for the inspected structures and facilities since the 2017 inspection are discussed in the following sections.

Inspections of the Greenhills Tailings Facility were completed monthly from August 2017 to August 2018.

3.1 Tailings Facility Storage and Operation

GHO tracks in-place tailings volume through bathymetric surveys. The tailings volume accumulated in the pond between August 2017 and October 2018 is reported by GHO to be about 582,964 cubic metres (m^3). The annual deposition volume is estimated by GHO to be about 501,844 m^3.

3.2 2018 Construction

The Main Dam crest was raised to 1,731.16 m, and the West Dam crest was raised 1,731.14 m during 2018. The raise included placement of till and CCR on the crests of the Main Dam and West Dam. The 2018 construction records are documented in Golder (2018b).

Erosion of the downstream face of the GHO TSF West Dam occurred in April 2018, following some rainfall on melting snow. The water flowed through a cut-out in the roadside safety berm along the downstream side of the dam crest and then down the downstream face. The concentrated flow caused local erosion of the Coarse Coal Refuse (CCR), to a few metres depth, adjacent to piezometer VW11-WD-1. The crest width at the time was significantly greater than the design, since the downstream shell had been constructed to the footprint of the 1,735 m raise. As such, the erosion had no impact on the integrity of the dam. To remediate the area, the erosion features were excavated to undisturbed material during the 2018 raise construction, and CCR was compacted in layers to reinstate the downstream slope.

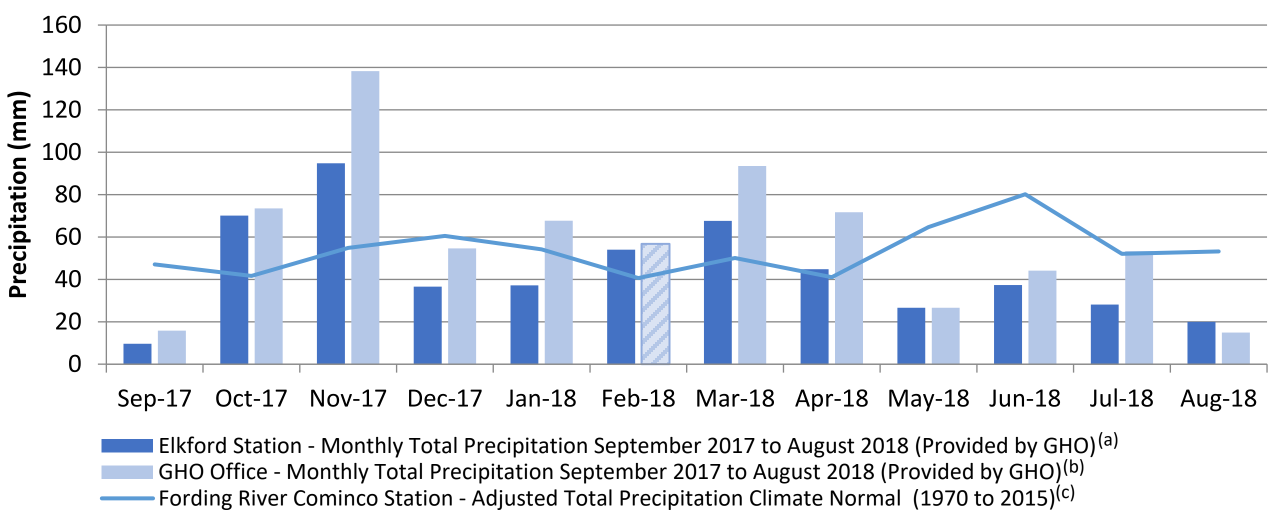
To reduce the potential for future erosion of the CCR during freshet, it was recommended by Golder (2018c) that the CCR materials on the dam crest be graded at a minimum of 1% downward towards the upstream crest to promote overland flow into the TSF impoundment. This grading was incorporated into the 2018 raise construction. Review of the survey of the 2018 dam raise construction indicates that the CCR materials have been graded downward towards the upstream crest as recommended for most of the dam, however, the grade is flat to slightly less than the 1% in some areas. Consequently, there are a few areas where ponding between the CCR and till will occur. Some ongoing monitoring will therefore be needed, and some maintenance may be required during the next construction season. A potential reoccurrence of similar erosion is not a risk for dam integrity, and it is appropriate to manage this via future inspection and as-required maintenance.

4.0 REVIEW OF CLIMATE DATA, WATER BALANCE, AND WATER QUALITY

4.1 Review of Climatic Information

Chart 2 summarizes the GHO site monthly total precipitation from August 2017 to July 2018 along with the 1970 to 2014 adjusted total precipitation climate normal, and the monthly total precipitation recorded at the Elkford climate station for comparison purposes. Historical climate normals were calculated in the Greenhills Operations Cougar Pit Extension Project Hydrology Baseline Report (Golder 2015) using regional and available local temperature and precipitation data from 1970 to 2014 (Government of Canada 2016) and infilled with 2014 to 2015 climate data from the Fording River Cominco (Station ID #1152899) Environment Canada weather station, located at the Fording River Operations site.

The total precipitation from the GHO weather station was about 710 mm for the reporting period, including the estimated February data. The total precipitation for the reporting period is more than the historical climate normal of 640 mm, and therefore the year was wetter than normal. The data indicate that precipitation was wetter than the climate normal from October to November 2017 and January to March 2018, and dryer than the climate normal in the remaining months. Precipitation data received from the GHO Office for February 2018 were deemed erroneous (623 mm total precipitation was reported for February, which was considered implausible based on field observations and in comparison to concurrent data from nearby weather stations) and omitted from the review. February precipitation data from Elkford were used to estimate the February precipitation at GHO assuming a scaling factor of 1.051 Elkford to GHO (Golder 2015b). The precipitation data collected from the Elkford weather station indicate February 2018 precipitation was slightly higher than the climate normal.



Notes:

(a) Elkford total precipitation received from GHO.

(b) GHO total precipitation received from GHO. Data for February 2018 were erroneous and monthly value was estimated from Elkford precipitation data.

(c) Fording River Cominco data obtained from Environment Canada website, Climate ID: 1152899. Snowfall measured in centimetres and converted to water equivalent precipitation in mm based on a 10:1 snowfall to rainfall conversion.

Chart 2: 2017/2018 Total Precipitation Data

4.2 Water Balance

The 2018 water balance for the Tailings Pond was completed by Golder based on inflow and outflow data provided by GHO personnel and using the GHO site water balance model (Golder 2013b). The model characterizes the conveyance and storage of water at the mine site and is intended to be used as a tool to support decision making on water management practices at the site. This model was developed based on available monitoring data supplemented by a site visit, regional data, assumptions, and guidance from Teck. The model was updated with 2017/2018 inflow and outflow data and was calibrated using the measured tailings pond water elevations provided by GHO.

Table 9 summarizes the tailings storage facility water balance for the period August 2017 to August 2018.

Table 9: August 2017 to August 2018 Greenhills Tailings Storage Facility Water Balance

IN	Volume (m^3)	OUT	Volume (m^3)	Total Inventory Change (m^3)
Direct Precipitation	79,600	Seepage to Greenhills Settling Pond	25,200	
Surface Runoff	301,100	Evaporation	124,300	
Water Discharge with Tailings[(a)]	2,692,700	Reclaim water to Plant	2,943,800	
Transfers from Phase 3 and Phase 6	281,000	Water retained in tailings[(b)]	138,300	
Sum	3,354,400		3,231,600	122,800

(a) Includes plant system loss to pond.

(b) The pore water volume is estimated by multiplying the annual tailings dry tonnage by a water content of 36% (Golder 2019).

m^3 = cubic metre

4.3 Water Quality

The Tailings Storage Facility (TSF) water is monitored as required by Environmental Management Act (EMA) Permits 6248 and 107517. The required monitoring includes semi-annual sampling for extractable petroleum hydrocarbons (EPH), conventional parameters, major ions, nutrients, total metals and dissolved metals.

GHO is required to submit quarterly and annual compliance reports for both EMA Permits 6248 and 107517.

5.0 TAILINGS FACILITY DAM SAFETY ASSESSMENT

This section presents the dam safety analysis for the tailings facility dams based on the observations and data review for each of the failure modes that are most relevant to these types of dams.

5.1 Method

5.1.1 Site Visit

A site inspection was carried out on 15 August 2018 by Mr. Andy Haynes, P.Eng., and Mr. Malcolm Shang, of Golder, accompanied by Mr. Mark Slater, P.Eng. of GHO. Andy Haynes also inspected the TSF area with Kristin Snider on 21 June 2018.

The weather on 15 August 2018 was overcast and hazy (due to the regional forest fires). The temperature during the visit was approximately 15 degrees Celsius (°C).

Appendix A presents a summary of photographs of the pond from the site inspection. The location and direction for each photograph are indicated in Figure 2.

A summary of the observations is included in the inspection reports in Appendix B. The Greenhills Main and West Tailings Dams were observed to be in good condition at the time of the 2018 annual inspection.

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

5.1.2 Review of Background Information and Instrumentation

GHO provided the following information for this dam safety inspection:

- 2018 GHO Site LiDAR Survey Data (July 2018)
- 2018 Tailings Dam Area Survey Data (October 2018)
- 2018 GHO Site Air Photo (July 2018)
- 2018 Tailings Pond Bathymetric Survey Data (October 2018)
- 2018 GHO Site Climate Data
- Piezometer Data
- Pond Water Level GPS data
- Site C Ground Movement GPS Monitoring Data
- Dam Survey Prism Data
- Plant Production Records up to August 2018
- Records of Visual Inspections
- Inspection Reports
- Operation, Maintenance, and Surveillance (OMS) Manual and Emergency Preparedness Plan (EPP)

5.2 Review of Operational Documents

5.2.1 Operation, Maintenance, and Surveillance Manual

The Operation, Maintenance, and Surveillance (OMS) Manual for the tailings facility was last updated in 2017 (GHO 2017). It is currently being updated by Teck. The updated document will be completed in 2019. The existing OMS Manual meets the guidelines provided by the CDA (2013, 2014) and the Mining Association of Canada (MAC 2011, 2017).

5.2.2 Emergency Preparedness Plan

An inundation study for a hypothetical breach of the TSF was completed by Golder in 2012 (Golder 2012) and updated in 2016 (Golder 2017c). The 2016 study was conducted to reassess an overtopping or piping failure of the Main Dam and assess an overtopping failure of the West Dam. Based on recent developments in the engineering practice of estimating tailings inundation flows, Golder has revised its approach to estimate the volume of tailings that could be potentially mobilized during a dam breach event. The 2016 study has been updated with new topographic data for the town of Elkford, new initial flow conditions in the Elk and Fording Rivers, and a reassessment of the dam breach parameters with the most up to date methods. Golder has recommended that additional modelling of the downstream area is completed up to Lake Koocanusa. This additional modelling is currently in progress.

The Emergency Preparedness Plan (EPP) for the tailings facility was last updated in 2018 (GHO 2019; Standard Practices and Procedures No. 1543). The EPP will be updated by Teck once the additional inundation study modelling of the downstream area, up to Lake Koocanusa, is complete. The revised document will include the Emergency Response Plan and the results from the updated inundation study.

5.2.3 Dam Safety Review

A DSR was commenced in June 2017 and issued in December 2017 (KCB 2017). The DSR concluded that the tailings dams meet current safety standards.

The July 2016 revision of the Health, Safety and Reclamation Code (HSRC) (BC MEMPR 2016a) requires a DSR be completed at least every 5 years. The next DSR is scheduled for 2022.

5.3 Assessment of Dam Safety Relative to Potential Failure Modes

This section reviews the dam safety implications of the instrumentation data and the site observations relative to potential failure modes that typically apply to similar dams. The design basis relevant to each of the typical potential failure modes is also presented.

5.3.1 Internal Erosion

Internal instability of a dam can be caused by materials migrating out of the dam via seepage and leaving voids within the dam. This generally 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. Under such conditions internal erosion (piping) can occur by regressive erosion of particles from within the dam forming a continuous pipe or void within the dam. Suffusion is the migration of soil particles through the soil matrix.

Design Basis

As part of the 2016 inundation study (Golder 2017c) Golder received samples of coal tailings from Teck, collected at the exit of the tailings spigot, on 10 May 2016. The particle size distribution (PSD) of the tailings was determined using mechanical sieving and a Fritsch laser particle size analyzer (ASTM D4464). The results are documented in Golder (2017c) Table 10. The filter compatibility of the tailings and the clay blanket (till) samples was reviewed, and the piping criteria were met; confirming that the materials are filter compatible and not prone to internal erosion.

Table 10: Particle Size Distribution

Sample	D_{10} (mm)	D_{30} (mm)	D_{50} (mm)	D_{60} (mm)	D_{80} (mm)
1528359 Tailings	0.011	0.079	0.220	0.297	0.506

D_{10} = 10 percent passing by mass.

The CCR has been tested throughout the construction of the dam and with occasional exceptions meets filter criteria. Overall, the samples are acceptable and the as-built condition meets the design requirements.

Grain size distribution tests were performed on ten CCR and five clay blanket (till) samples as part of the 2018 dam raises (Golder 2018d).Chart 3 shows the Grain size distributions and specification envelopes. Most of the samples had gradations within the specified envelope, three samples were slightly finer that the specified envelope. The ten CCR samples were assessed for filter compatibility, with all samples passing based on the Li et al. internal stability criterion (Li et al. 2009). The Canadian Dam Association (CDA 2007) recommends a filter specification based on Sherard et al (1984) and Sherard and Dunnigan (1989), which recommend a filter D_{15} for typical glacial tills of less than or equal to 0.7 mm. Nine samples met this criterion, one was coarser (D_{15}=1.3 mm).

The review indicates that the piping criteria are generally met between the clay blanket (till) and the CCR, and between the tailings and clay blanket (till). Overall, the as-built conditions are considered to be acceptable. On-site performance monitoring will continue to be implemented to confirm the acceptable performance of the dam.

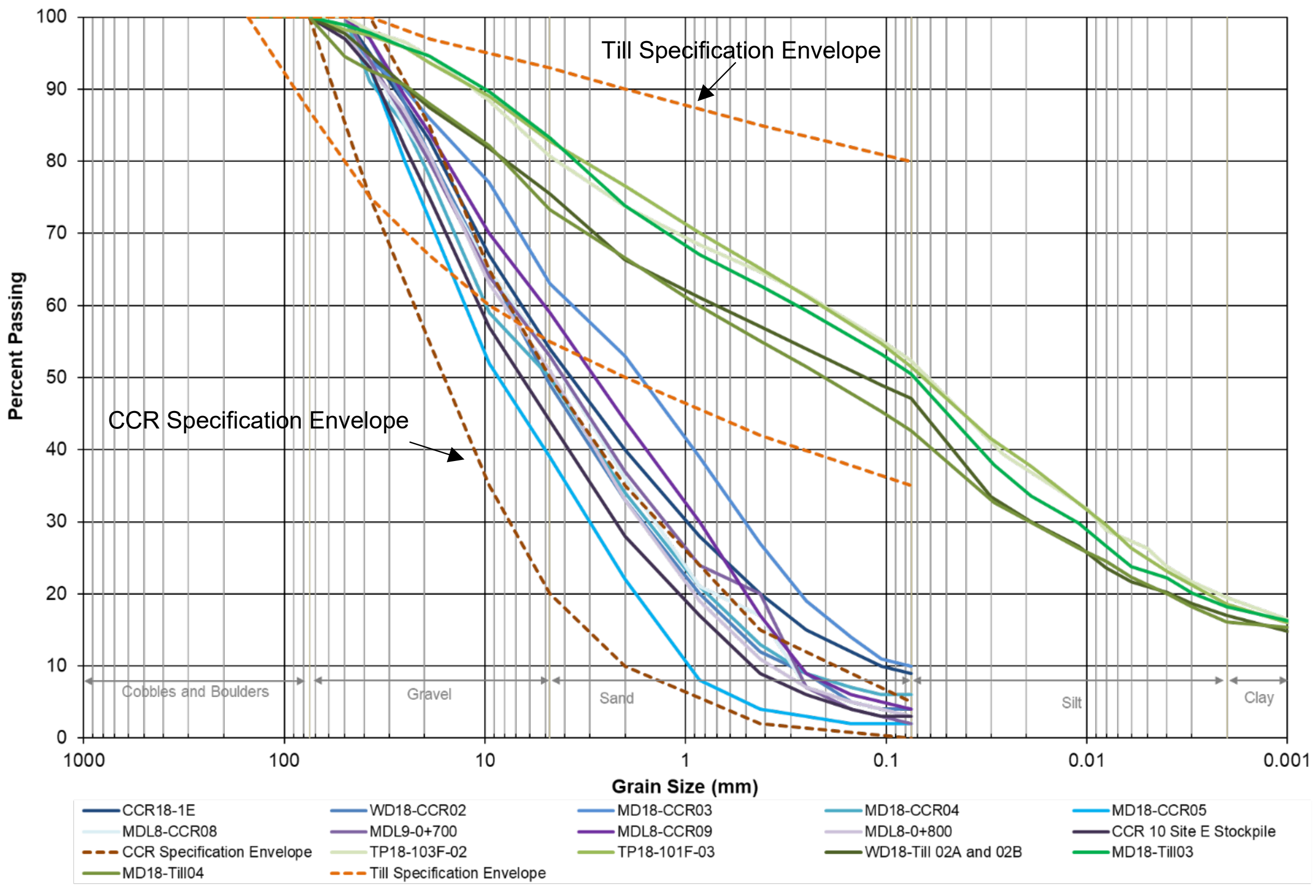


Chart 3: Grain Size Distribution and Specification Envelopes

Instrumentation Data and Quantitative Performance Objectives

V-notch weirs are located below the Main Dam (at the toe of Site C), and in the ditch downstream of the West Dam in order to measure the seepage flows from the tailings facility. The weir below the Main Dam, at the toe of Site C, was damaged during the 2017 upgrade of the seepage collection channel. The weir was reinstated in January 2018. The weir by the toe of the West Dam was damaged by a boulder in 2017. This weir was reinstated further downstream in October 2017.

Flow measurements were taken manually at the Main Dam (10 times) and at the West Dam (14 times) weirs between 1 August 2017 and 31 August 2018. The QPOs are summarized in Table 11, and the measurements of flow rates at the Main Dam and West Dam weirs are shown in Chart 4. The QPOs will be reviewed once monitoring of the weirs has been automated and sufficient data is gathered to determine annual trends. Automation of the monitoring of the flows through the weirs is planned for 2019. Comments on the instrumentation data are summarized in the Observed Performance section that follows.

Table 11: Seepage Weirs Quantitative Performance Objectives

Instrument	Range of 2017/2018 [(b)]		Yellow Warning (L/s)	Orange Alarm (L/s)	Red Alarm
	Minimum (L/s)	Maximum (L/s)			
Main Dam Weir	0.29	Refer to Note[(b)]	2	4	Refer to Note[(a)]
West Dam Weir	0.16	Refer to Note[(b)]	1	2	

(a) An Alarm (red) decision is to be made by the Engineer of Record and GHO's TSF Qualified Person.

(b) Higher than typical flows were reported from 1 August 2017 to 31 August 2018 (refer to Chart 4). The flows reported were about four times higher than typical for the Main Dam and twice as high for the West Dam. Some of these flows exceeded QPO warning and alarm levels, however, these flow rates are suspected to be erroneous when observations from the 2018 DSI are compared to previous years (Photograph 1 and 2 in Section 5.3.1).

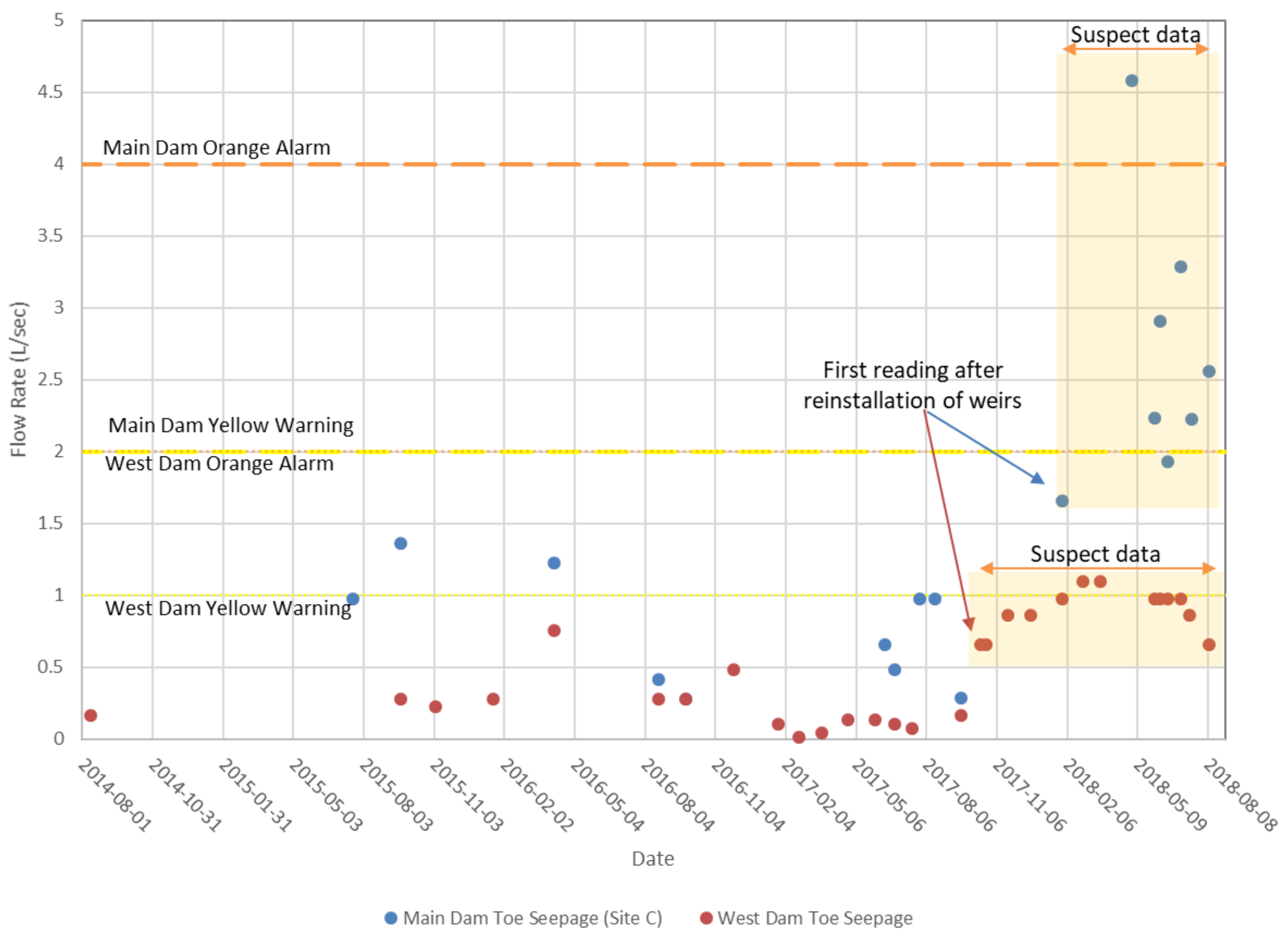


Chart 4: Flow Rates at Main Dam and West Dam Seepage Weirs

Observed Performance

During the site visits, it was observed that the water flowing from the Main Dam rock drains was clear and did not contain visible suspended particles. The water was noted to be causing red-brown staining (Photograph 12a and 12b, Appendix A); which is expected based on the water chemistry. Seepage flow through the V-notch weir installed in the ditch downstream of the West Dam was observed to be clear during the site visits (Photograph 25, Appendix A).

The seepage rates from the Main Dam and West Dam appear to be similar to those observed in previous inspections. No evidence of internal erosion was observed. No zones of subsidence or any sink holes were observed which would indicate voids due to either suffusion or piping.

It is noted that higher than usual flows, which exceeded QPO warning and alarm levels, were recorded by Teck since the weirs were reinstalled (in October 2017 for the West Dam weir, and January 2018 for the Main Dam weir). These readings are suspected to be erroneous based on comparison with readings from previous years (Photograph 1 and 2 in this section). It is therefore recommended that the flow rates from the weirs be checked and calibrated in 2019.

Although these higher than expected flows are suspected to be erroneous and not of concern, it should be noted that the EoR was not informed of the QPO exceedances (as required by the TARP) when they occurred. Golder recommends that GHO review the TARP to ensure that the actions following an exceedance are fully understood and followed in the future.

Photograph 1: Main Dam Seepage Comparison

Photograph 2: West Dam Seepage Comparison

The seepage at the most north-eastern location along the toe of Site C, which has historically been the dominant point at which seepage from the Main Dam has been observed, is mostly flowing under the SmartDitch to the seepage weir. Golder recommended (Golder 2018b) that the SmartDitch design at this location be altered so that more of the seepage is captured in the ditch. Golder (2018b) includes a sketch of the proposed modification.

Currently the flow entering the HDPE pipe and the flow from the HDPE pipe into the SmartDitch at the toe of Site C are not measured separately from the dam toe seepage. It is impossible to distinguish whether flow at the weirs is due to increased seepage or rainfall. Golder (2018b) recommends that the flow entering the HDPE pipe (or flowing from the HDPE pipe into the SmartDitch) be measured such that it can be tracked separately from the seepage from the dam toe during periods of rainfall.

Seepage from Site D reports to the same creek and as seepage from Site C (and measured by the Site C seepage weir) and has been visually monitored. The seepage rates have historically been low. The installation of an additional seepage monitoring weir near the toe of Site D is recommended.

5.3.2 Overtopping

Design Basis

The CDA (2013) provides the following two calculations for freeboard; the more critical of the two cases sets the minimum freeboard:

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

The maximum allowable pond levels for the Main and West Dams are presented in Table 12, which are consistent with 2016 amendment to Part 10 of the HSRC for Mines in British Columbia (BC MEMPR 2016a).

The updated PMF event (72-hour duration event inclusive of snowmelt) is documented in Golder (2017a), and the updated inflow design flood allowance is presented in Table 12. The 1 in 1000-year flood is estimated to be 445,120 m^3 and the PMF is estimated to be 621,670 m^3.

Table 12: Maximum Allowable Pond Levels

Item	Value (Current Condition) (m)
Lowest elevation on Main Tailings Dam or West Tailings Dam crests	1,731.14
Allowance for inflow design flood ($^1/_3$ between 1:1000-year flood and the probable maximum flood [(a)])	0.93
Allowance for wave run-up due to 1:2-year wind [(a)]	0.25 to 0.35
Minimum required freeboard (as per CDA 2013)[(b)]	1.3
Minimum required freeboard (as designated in OMS)	1.3
Standard operating maximum pond level (distance below dam crest)[(c)]	2.0
Maximum pond elevation to maintain minimum freeboard (1.3 m)	1,729.84
Standard pond operating elevation (2.0 m below minimum dam crest)	1,729.14

(a) Flood and wave run-up values reported in OMS Manual (GHO 2017).

(b) Freeboard calculated per CDA 2013 is reported as 1.3 m in OMS Manual (GHO 2017).

(c) When pond level exceeds standard pond operating level GHO implements increased monitoring and pond level controls.

OMS = Operation, Maintenance, and Surveillance.

GHO uses a standard maximum operating pond level of 2.0 m below the minimum dam crest elevation. The pond is therefore generally operated with a greater freeboard than the required 1.3 m minimum freeboard as calculated using the CDA guidelines (2013) and provides additional safety.

The technical bulletin Application of Dam Safety Guidelines to Mining Dams (CDA 2014) recommends examination of the condition where the high-water level (inflow design flood) occurs at a similar time as the high wind event for calculation of the minimum freeboard. Recommendations for the return period of the high wind event are not provided. A 1-in-1000-year wind combined with the inflow design flood would result in a freeboard of 1.5 m, and therefore, the standard pond operating level of 2.0 m below the minimum dam elevation used by GHO is conservative and no modifications to the operating practices are needed based on CDA (2014).

Instrumentation Data and Quantitative Performance Objectives

The water level in the pond is controlled by pumping at the reclaim barge. The tailings pond elevation is measured by a GPS monitor (#313) mounted on the reclaim barge, and the data are corrected for the elevation difference between the GPS and the pond level.

Installation of a staff gauge or other visual indicator was recommended in the 2014 DSI (Golder 2014f) to complement the electronic measurement by providing a quick way to confirm freeboard. A visual indicator was installed in 2017 on the dam crest. During the 2018 dam raise construction, the staff gauge was removed and was reinstalled once the dam raise construction was complete.

The freeboard QPOs are summarized in Table 13, and the pond levels measured from 1 August 2017 to 31 August 2018 are presented in Chart 5 (along with the minimum crest elevation, minimum freeboard, and standard pond operating level). Comments on the instrumentation data are summarized in the Observations section that follows.

Table 13: Freeboard Quantitative Performance Objectives

Pond Freeboard	Range of 2017/2018 Values		Warning (Yellow) (m)	Alert (Orange) (m)	Alarm (Red) (m)
	Minimum (m)	Maximum (m)			
	1.72 Refer to Note[a]	6.03	2.0	1.3	0.5

(a) Yellow warning level was exceeded between the end of April and the middle of July 2018. The facility still had capacity to contain the Inflow Design Flood (IDF) and the Probable Maximum Flood (PMF) during this time.

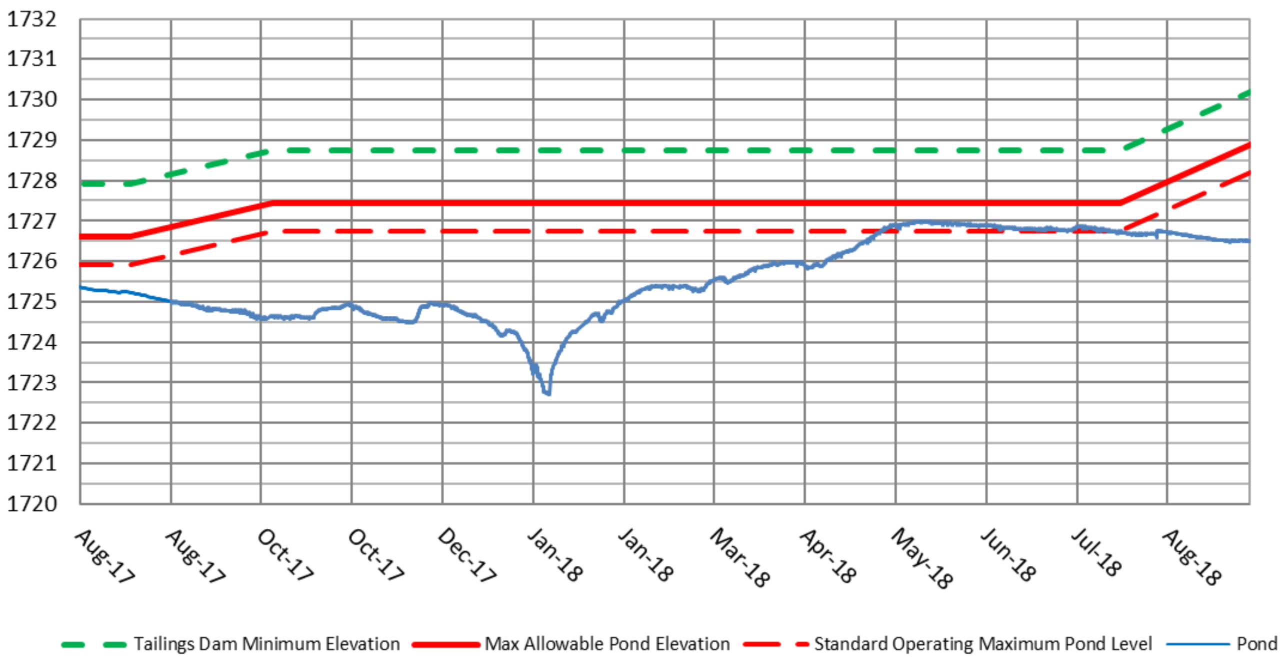


Chart 5: Tailings Pond Elevation Relative to Minimum Freeboard and Standard Pond Operating Level

Observed Performance

At the time of the site inspection (15 August 2018) the pond was at approximately El. 1,726.6 m (based on the GPS #313), which indicates that the freeboard was greater than 2 m. The pond water elevations measured during the reporting period (between 1 August 2017 and 31 August 2018) indicated that the pond water fluctuated between El. 1,722.7 and 1,727.0 m, resulting in freeboard of between 1.7 m and 6.0 m.

Review of the data indicates that the minimum CDA (2013) required freeboard was achieved during the entire reporting period, and that the facility had capacity to also contain the PMF throughout the reporting period.

Regarding QPO performance, no orange alert or red alarm levels were exceeded during the DSI reporting period, however, the yellow warning level was exceeded (standard pond operating level freeboard) between the end of April and the middle of July 2018. The EoR was not informed of the warning level exceedances when they occurred (as per the requirements of the TARP) and therefore Golder recommends that GHO review the TARP to ensure that the actions following an exceedance are fully understood and followed in the future.

Potential liquefaction of tailings during earthquake may trigger re-distribution of tailings into the pond and increase the pond level. The maximum potential pond increase that could occur from such a scenario (conservatively assuming that all tailings above the pond migrated into the pond) is estimated to be around 1.2 m, which would not overtop the dam under standard operating conditions.

The visual indicator was observed during the June site visit to have tilted due to the unbalanced loading applied by the cantilevered arm (Photograph 7, Appendix A) which resulting in the visual indicator plates having moved to a lower position. While this would have resulted in conservative indication of the available freeboard, such inaccuracies detract from the value of the indicator. To avoid the potential for such inaccuracies, a second concrete block was added to stabilize the cantilever arm of the visual indicator (Photograph 7, Appendix A). This remedial fix is sufficient for now, however, Golder recommends that the visual indicator's horizontal level be monitored monthly and adjusted if needed.

5.3.3 Instability

Design Basis

The dams are designed to provide factors of safety that meet or exceed the requirements of the CDA (2013) (minimum factor of safety of 1.5 under normal operating conditions and a minimum factor of safety of 1.0 under seismic conditions). The CDA recommends that an earthquake design ground motion based on an annual exceedance probability of 1 in 2,475 years be used for the design of High consequence dams (CDA 2013). As shown in Section 2.3 the predicted peak ground acceleration (PGA) for this return period is 0.158 g.

Following the 2016 geotechnical investigation, Golder reassessed the stability of the Main Dam (Golder 2017g). The results indicated that:

- The development of excess pore pressures is considered unlikely to occur in the foundation materials given the absence of soft colluvium or clay material found in the foundation during the 2016 geotechnical investigation (2017a), and the dense to very dense state and low liquidity index values of the glacial till in the foundation.
- The stability of the Main Dam meets the minimum requirements for static and pseudostatic stability under drained conditions.

Instrumentation Data and Quantitative Performance Objectives

The Dam Safety Guidelines (CDA 2013) Section 3.6.3, recommends the use of dam instrumentation to augment ongoing visual assessment of dam performance relative to potential failure modes.

Monitoring of the dam using survey prisms began in September 2015.

Survey prism readings were not taken during most of the 2018 DSI reporting period, partially because the prisms were removed during the dam raise construction period (July to September 2018). Therefore, there was insufficient data available to determine annual and monthly displacement values for the prisms. QPOs for the survey prisms remain unchanged and are shown below in Table 14.

Table 14: Survey Prism Quantitative Performance Objectives

Dam	Instrument	Range of 2017/2018 Annual Displacement Values (a)		Range of 2017/2018 Monthly Displacement Values (a)		Yellow Warning	Orange Alarm	Red Alarm
		Minimum (m)	Maximum (m)	Minimum (m)	Maximum (m)			
Main(d)	PR-A to PR-H	Refer to Note (a).	Refer to Note (a).	Refer to Note (a).	Refer to Note (a).	3D Displacement = 0.025 m/week or 0.1 m cumulative(b)	3D Displacement = 0.050 m/week or 0.2 m cumulative	Refer to Note (c).
West(d)	PR-I to PR-M	Refer to Note (a).	Refer to Note (a).	Refer to Note (a).	Refer to Note (a).			

(a) Insufficient data available since survey prism readings were not taken during most of the reporting period, partially because the prisms were removed during the dam raise construction period from July to September 2018. The last reading for all of the prisms, except Prism L, was on 15 August 2017. The last reading for Prism L was the 18 July 2017.

(b) Cumulative displacement is calculated based off the initial reading after installation or any relocation.

(c) No red alarm level was defined since the Engineer of Record and GHO's TSF Qualified Person will be contacted when the orange alarm level is triggered. The situation can be then evaluated prior to any evacuation orders being given.

Monitoring using GPS units on Site C started in October 2012, and QPOs for the GPS units were determined in September 2017 (Golder 2017g). Additional GPS units were installed in August 2018 on the Main and West Dams. The QPOs that determined in September 2017 (Golder 2017g) were adopted for these new GPS units. The QPOs for the GPS units are summarized in Table 15.

Table 15: GPS Units Quantitative Performance Objectives

Dam	Instrument	Range of 2017/2018 Cumulative Displacement Values		Range of 2017/2018 Weekly Displacement Values		Yellow Warning	Orange Alarm	Red Alarm
		Minimum (m)	Maximum (m)	Minimum (m)	Maximum (m)			
Main	GPS #320[a]	0.001	0.074	0.001	0.021	3D Displacement = 0.025 m/week or 0.1 m cumulative	3D Displacement = 0.050 m/week or 0.2 m cumulative	n/a
	GPS #319[a]	0.004	0.039	0.001	0.011			
	MD-1_ROVER	Non-functional (no data)						
	MD-2_ROVER[b]	0.000	0.091	0.002	Refer to Note[b]			
	MD-3_ROVER[c]	0.000	0.088	0.001	0.043			
	MD-4_ROVER[d]	0.000	0.072	0.001	0.028			
	MD-5_ROVER[b]	0.001	0.052	0.001	Refer to Note[b]			
West	WD-1_ROVER	Non-functional (no data)						
	WD-2_ROVER[b]	0	Refer to Note[b]	0.004	Refer to Note[b]			
	WD-3_ROVER[b]	0.001	Refer to Note[b]	0.000	Refer to Note[b]			

(a) The minimum and maximum annual cumulative displacement values are relative to 23 October 2012.

(b) Numerous values exceeded QPO levels, however, the data is considered erroneous since the values reported are erratic in direction and magnitude, and no signs of instability were observed in the 2018 DSI or Teck monthly inspections. Refer to Figure C-22 in Appendix C.

(c) The minimum and maximum annual cumulative displacement values are relative to 9 August 2018.

(d) The minimum and maximum annual cumulative displacement values are relative to 20 September 2018.

QPOs for the inclinometers have not been developed since data is still being collected to establish the baseline. Readings were started in July 2018 for SD 16-04 and September 2018 for SD-16-05. QPOs for the inclinometers will be developed once the baseline has been established. Until the baseline is established:

- Each inclinometer survey collected will be assessed and compared against the previous surveys to monitor the magnitude, direction, and rate of deformations.
- Interim QPOs for the inclinometers have been determined and are presented in Table 16.

Table 16: Interim Inclinometer Quantitative Performance Objectives

Dam	Instrument	Range of 2017/2018 Annual Displacement Values (a)		Range of 2017/2018 Monthly Displacement Values (a)		Yellow Warning	Orange Alarm	Red Alarm
		Minimum (m)	Maximum (m)	Minimum (m)	Maximum (m)			
Main	SD_16-04 and SD_16-05	Refer to Note(a).	Refer to Note(a)	Refer to Note(a).	Refer to Note(a).	Downstream localized shearing/ displacement between 5 and 10 mm	Downstream localized shearing/ displacement between 10 and 20 mm	Refer to Note(b)

(a) Insufficient data available since inclinometer readings were taken only twice during the reporting period for SD-16-04 and not at all during the reporting period for SD_16-05. Normal operating range is expected to be < 5 mm downstream localized shearing/displacement.

(b) No red alarm level was defined since the Engineer of Record and GHO's TSF Qualified Person will be contacted when the orange alarm level is triggered. The situation can be then evaluated prior to any evacuation orders being given.

The monitoring data for the prisms, GPS units and the initial data inclinometers are presented in Appendix C.

The piezometer ranges for the reporting period and the QPOs for the piezometers (installed in 2011 and 2016) are shown in Table 17. The piezometer ranges are also shown in Charts 6 and 7. Any erroneous data observed in Table 17 is not plotted in Charts 6 and 7. The orange alarm level alerts for the piezometers were determined based on the phreatic levels at which the factor of safety was equal to or below the factor of safety acceptance criteria of 1.5 for static stability and 1.0 for seismic stability, based on the CDA Dam Safety Guidelines for long term conditions. The analyses were completed for the dams' current configuration assuming drained conditions and conservatively not considering the buttressing effect from the Site C and Site D/E coarse refuse dumps.

Comments on the instrumentation data are summarized in the Observations section that follows.

Table 17: Piezometer Quantitative Performance Objectives

Dam	Instrument	Range of 2017 to 2018 Values		Yellow Warning		Orange Alarm	Red Alarm
		Minimum (m)	Maximum (m)	Water Elevation (m)		Water Elevation (m)	
Main	VW11-MD-1A[(a)]	El. 1,707.51	El. 1,707.58	±2	1,718.5	1,724	n/a
	VW11-MD-1B[(a)]	El. 1,710.58	El. 1,710.80				
	VW11-MD-2A[(b)]	El. 1,692.41	El. 1,693.74				
	VW11-MD-2B[(c)]	VWP stopped working Sept 2015 (removed from service)					
	VW11-MD-3A[(d)]	El. 1,687.68	El. 1,688.43				
	VW11-MD-3B[(d)]	El. 1,688.92	El. 1,689.76				
	VW11-MD-4A	El. 1,685.95	El. 1,686.86				
	VW11-MD-4B[(e)]	El. 1,684.68	El. 1,685.47				
	VW11-MD-5A[(f)]	El. 1,683.48	El. 1,684.33				
	VW11-MD-5B[(f)]	El. 1,683.99	El. 1,684.80				
	SD-16-01A (VW26133)[(g)]	VWP stopped working in Aug 2017		±2	1705.5	1713.5	
	SD-16-01B (VW29871)[(g)]	VWP stopped working in Aug 2017			n/a – bedrock groundwater flow		
	SD-16-02A (VW5439)	El. 1,685.10	El. 1,685.45		1692.5	1708	
	SD-16-02B (VW29869)	El. 1,692.34	El. 1,693.33		n/a – bedrock groundwater flow		
	SD-16-03A (VW5330) [(h)]	El. 1,690.71	El. 1,692.05		1705.5	1713.5	
	SD-16-03B (1504178) [(h)]	El. 1,707.38	El. 1,708.66		n/a – bedrock groundwater flow		
	SD-16-04 (VW29873) [(h)]	El. 1,674.67	El. 1,677.10		1697	1710	
	SD-16-05A (VW5441)	El. 1,683.30	El. 1,684.22		1699.5	1710.5	
	SD-16-05B (1504179)	El. 1,691.99	El. 1,695.34		n/a – bedrock groundwater flow		
	SD-16-06A (VW28871)	El. 1,685.14	El. 1,685.48		1697	1710	
	SD-16-06B (VW26204)	El. 1,704.96	El. 1,706.92		n/a – bedrock groundwater flow		
	SD-16-07A (1402102)	El. 1,651.11	El. 1,651.77		1682	1686.5	
	SD-16-07B (VW5438)	El. 1,650.48	El. 1,651.04		n/a – bedrock groundwater flow		
	SD-16-08A (VW28872)	El. 1,668.12	El. 1,668.69		1682	1686.5	
	SD-16-08B (VW5440)	El. 1,687.28	El. 1,688.19		n/a – bedrock groundwater flow		

Table 17: Piezometer Quantitative Performance Objectives

Dam	Instrument	Range of 2017 to 2018 Values		Yellow Warning		Orange Alarm	Red Alarm
		Minimum (m)	Maximum (m)	Water Elevation (m)		Water Elevation (m)	
West	VW11-WD-1A[i]	El. 1,712.51	El. 1,712.87	±2	1,733	1,733	n/a
	VW11-WD-1B[i]	El. 1,713.63	El. 1,714.03				
	VW11-WD-2A[j]	El. 1,712.83	El. 1,713.30				
	VW11-WD-2B[j]	El. 1,711.92	El. 1,713.89				
	VW11-WD-3A[j]	El. 1,713.47	El. 1,714.60				
	VW11-WD-3B[j]	El. 1,714.07	El. 1,714.46				

Notes:

Main and West Dam piezometers (VW11-MD-1 to VW11-MD-5, SD-16-01 to SD-16-08, and VW11-WD-1 to VW11-WD-3) minimum and maximum values were taken from between 1 August 2017 and 31 August 2018, excluding anomalous readings. The yellow warning range (±2 m) is based on the typical range of piezometer values recorded between 2017 and 2018. Orange alarm levels for VW11-WD-1, VW11-WD-2, VW11-MD-1, VW11-MD-2, VW11-MD-4, VW11-MD-5, SD-16-03A, SD-16-04, and SD-16-07A inferred from adjacent stability sections.

As agreed with Teck, no red alarm levels were defined since the Engineer of Record will be contacted when the orange alarm level is triggered. The situation can be then evaluated prior to any evacuation orders being given.

The readings of the 2016 piezometers (SD-16-01B to SD-16-08B) that were installed at the till/bedrock interface are on average higher than the shallow piezometers in the same holes because of isolated groundwater flow within the bedrock, which is separate from the upper groundwater system. A sensitivity analysis of the stability of the Main Dam to the presence of a confined groundwater unit was completed by Golder (Golder 2017g). The results of the sensitivity analysis indicated that the stability was not sensitive to the presence of a confined groundwater unit.

(a) Data missing from 3 September 2017 to 25 March 2018. Data after 25 March 2018 likely erroneous (ranging from EL. 1,481.53 m to 1,867.92 m for VW11-MD-1A, and El. 1,518.99 m to 1,870.27 m for VW11-MD-1B).

(b) Data missing from 1 August to 29 September 2017 and 27 October to 26 November 2017. VW11-MD-2B is not functioning and has been removed from service. No repair or replacement is necessary since sufficient monitoring coverage is provided by SD-16-03 and VW11-MD-2A.

(c) Data stopped recording after 29 September 2017.

(d) Data missing from 20 October to 12 December 2017.

(e) Data from 19 May 2018 to 8 August 2018 ranging from El. 1,681.9 m to 1,682.0 m likely erroneous. Data after 23 August 2018 likely erroneous (ranging from El. 1,678.27 m to 1,843.90 m).

(f) Data missing from 12 December 2017 to 3 March 2018 (VW11-MD-5A) and from 08 December 2017 to 3 March 2018 (VW11-MD-5B). Data from 3 March to 10 March 2018 likely erroneous (ranging from El. 1,687.4 m to 1,687.5 m from VW11-MD-5A and El. 1,681.4 m to 1,681.6 m for VW11-MD-5B).

(g) VWP not reporting data.

(h) Data stopped recording after 16 August 2018.

(i) Data stopped recording after 20 April 2018, with three exceptions.

(j) Data missing from 4 September to 21 September 2017.

n/a = not applicable; VWP = vibrating wire piezometer; El. = Elevation; QPO = Quantitative Performance Objective; ≤ = less than or equal; ≥ greater than or equal.

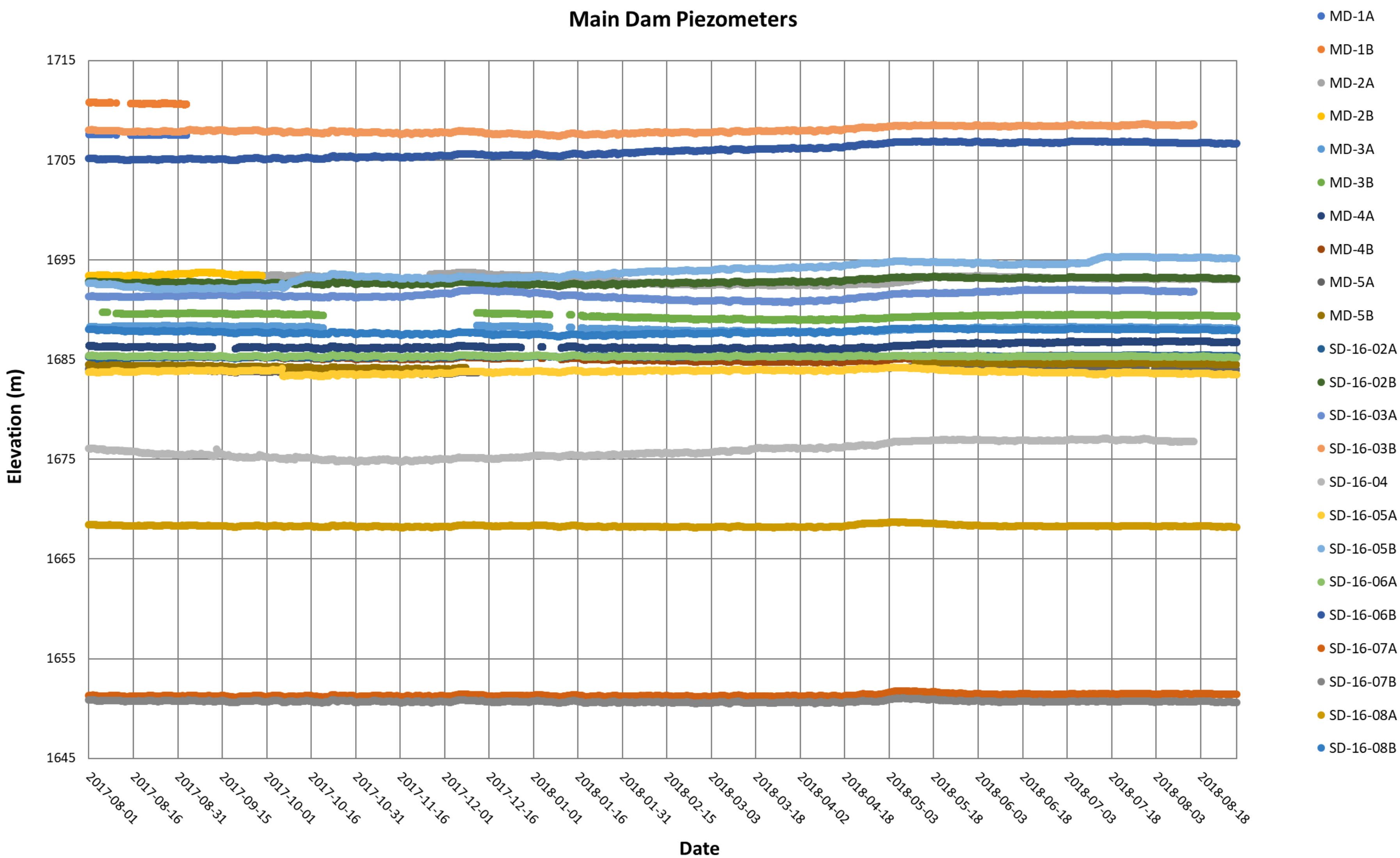


Chart 6: Main Tailings Dam Piezometer Data

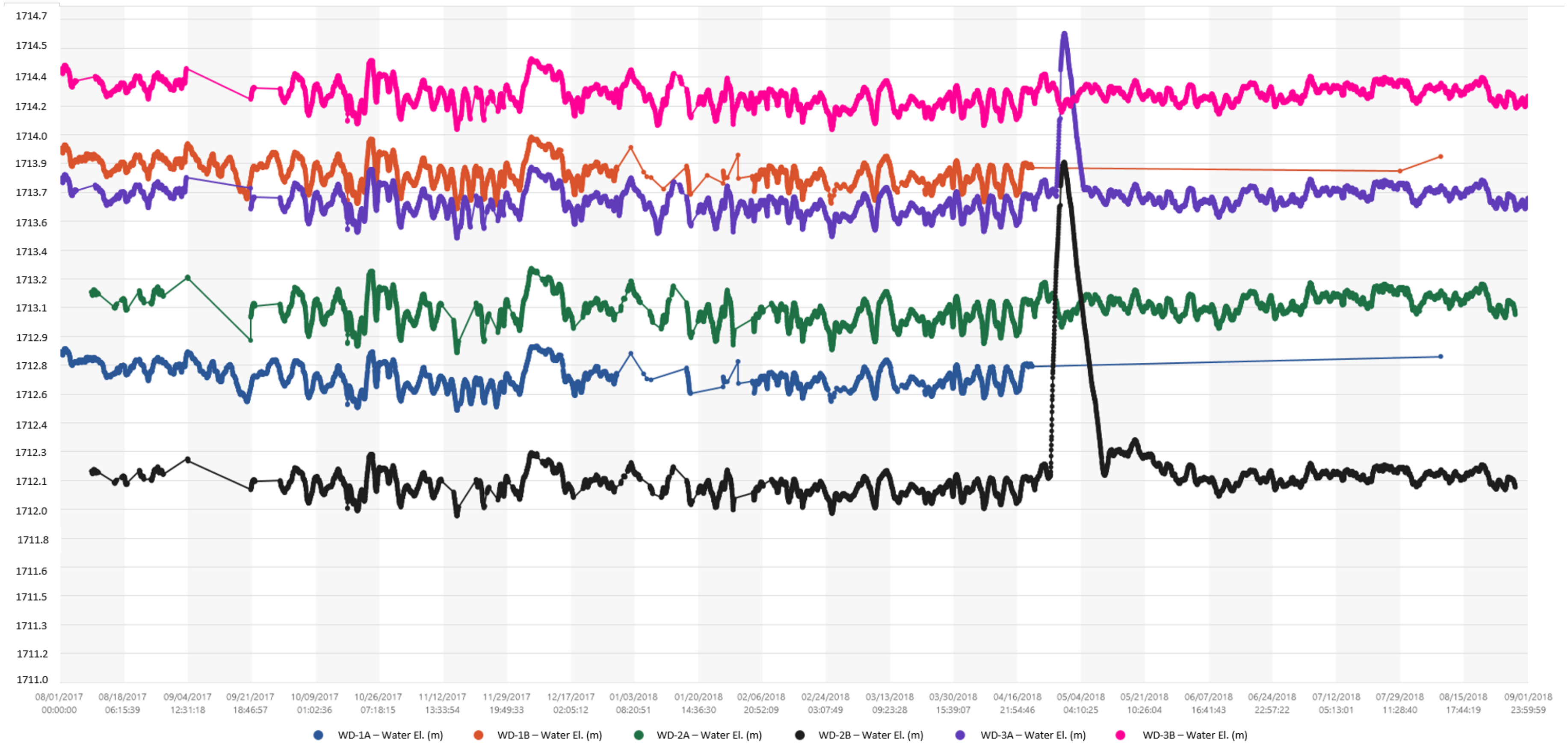


Chart 7: West Tailings Dam Piezometer Data

Observed Performance

No signs of instability (tension cracks, bulges, etc.) were observed on the Main Dam or West Dam during the site inspections.

The majority of the upstream slopes of the Main and West Dams were observed to be at 2H:1V as per the design and riprap has been placed to protect the steeper slopes from erosion (Photographs 4, 5, 6, 16, and 22 in Appendix A). The downstream face of the Main Dam is buttressed by the Site C and Site D coarse refuse spoils. The Site C coarse refuse spoil (located downstream of the Main Tailings Dam) provides additional support to the Main Dam. The instability observed on the lowest bench of Site C in 2012 (Golder 2013a) appears to have been arrested by the combination of improving surface drainage and not placing additional coarse refuse (Photograph 15 in Appendix A).

Review of the GPS monitoring data indicates that some warning and alarm levels were exceeded by the MD_ROVER and WD_ROVER GPS units during the reporting period, however, these exceedances are not considered an immediate concern because most of the exceedances are considered erroneous (MD-2_ROVER and MD-5_ROVER, and WD-2_ROVER and WD-3_ROVER), and no signs of instability were observed during the monthly visual inspections and DSI.

The data from MD-2_ROVER and MD-5_ROVER showed considerable scatter without any defined trend and the indicated movements were not corroborated by the values from the other MD_ROVER units (MD-3_ROVER and MD-4_ROVER) or the GPS units on Site C (#319 and #320). It is recommended that the functionality of MD-2_ROVER and MD-5_ROVER be checked, and repairs/alterations be made if needed.

The exceedances from the WD-Rover GPS units are also considered erroneous because the values reported are erratic in direction and magnitude, and no signs of instability were observed in the Teck monthly inspections.

In addition to reviewing the general functionality of the GPS units, Golder recommends that the level of accuracy of the units be reviewed as they may not be suitable to monitor the magnitude of displacements required by the QPOs. Evidence of this are the numerous, multi-directional and non-credible QPO warning and alarm level exceedances of the MD_ROVER and WD_ROVER GPS units during the DSI reporting period. If the level of accuracy is found to be unsuitable, the GPS units should be adjusted or replaced. It is recommended that the prisms are used as the primary monitoring instrument until such time that the GPS units on the Main Dam and West Dam can be demonstrated to be effective. The GPS data is presented in Appendix C (Figure C-14 to C-22).

The readings of the piezometers were reviewed and compared to the QPO levels. Overall, there appears to be little change in the measured phreatic surface in 2018 compared to previous measurements and the phreatic surface in the compacted coarse refuse material was relatively low and stable.

Based on the readings reported from September 2017 to August 2018, the phreatic surface in the Main Dam was generally about 10 to 13 m above the original ground surface, and the phreatic surface in the West Dam was generally within the dam foundation. These piezometer readings are relatively stable, and typically show seasonal increases in the range of 1 to 3 m during annual freshets. No warning or alarm levels were triggered in 2018. Three piezometers (MD-1A, MD-1B and MD-4B) did, however, report erroneous readings which exceeded the alarm levels during the reporting period. A spike in the piezometric pressure in two West Dam piezometers (VW11-WD-2B and 3A) was reported in April 2018. The spikes in piezometric pressure are not a concern as they were below the QPOs. These spikes in piezometric pressure are thought to be erroneous because the other piezometers in the area (VW11-WD-1A and 1B) and same holes (VW11-WD-2A and 3B) did not report similar readings, and the readings normalized soon after. In addition the spikes were not correlated with the pond location, pond level, nor precipitation. It is noted that the spike occurred at the same time as a result of the combination of snowmelt and rainfall that created the erosion on the downstream shell. It is possible that the spike in the upper piezometer (VW11-WD-3A) may be due to a combination of snow and rain, but this does not explain the spike in the lower piezometer (VW11-WD-2B). It is also noted that spikes have not observed to be seasonal occurrences based on the review of the data from previous years. This trend will be monitored during the 2019 freshet.

Data gaps were also reported by the following piezometers:

- VW11-MD-1A and 1B, no data from 3 September 2017 to 25 March 2018, and missing data between erroneous readings.
- VW11-MD-2A, no data from 1 August to 29 September 2017 and 27 October to 26 November 2017.
- VW11-MD-2B, no data after 29 September 2017 (removed from service).
- VW11-MD-3A and 3B, no data from 20 October to 12 December 2017.
- VW11-MD-5A, no data from 12 December 2017 to 3 March 2018.
- VW11-MD-5B, no data from 8 December 2017 to 3 March 2018.
- SD-16-01A and 01B, VWP not reporting data during the reporting period.
- SD-16-03A and 03B and SD-16-04, no data after 16 August 2018.
- VW11-WD-1A and 1B, no data after 20 April 2018, with three exceptions in July and August 2018.
- VW11-WD-2A and 2B, VW11-WD-3A and 3B, no data from 4 September to 21 September 2017.

It is recommended that the dataloggers be checked for the piezometers which reported erroneous data or reported no data during the reporting period. It is noted that Teck have already commenced assessing the West Dam piezometers. If the dataloggers are functioning correctly and the piezometers are found to be faulty, a plan should be developed to repair or replace the faulty piezometers in any areas identified as critical and not covered already covered by existing instruments. No repair or replacement of VW11-MD-2B is necessary at this time, since sufficient monitoring coverage is provided by SD-16-03 and VW11-MD-2A.

Some of the VWPs on the Main Dam (VW11- MD-1 to MD-5) and West Dam (VW11-WD-2B, WD-3A, and WD-3B) have been reporting negative values. Golder recommends that these piezometers be re-calibrated in 2019, and if needed they should be replaced or repaired.

Survey prism readings were not taken during most of the 2018 DSI reporting period and therefore, there was insufficient data available to determine annual and monthly displacement values for the prisms. This was partially due to the construction that took place from July to September 2018, during which time the prisms were removed from the dams as it was not practical to have them in place during construction. The prisms should be surveyed prior to construction and after construction.

Data for all the prisms, except Prism A, were collected after the completion of the dam raises. Data for Prism A was not collected because the prism is out of the line of sight of the total station. It is recommended that Prism A is relocated so that it is in the line of sight of the total station.

5.4 Review of Previous Deficiencies and Non-conformances

The following deficiencies and non-conformances, presented in Table 18, were noted in the 2017 DSI (Golder 2017d). The incomplete or partially complete issues were brought forward and included in the 2018 DSI recommendations presented in Section 6.0.

Table 18: Status of Previous (2017) Recommended Actions

ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Reference	Risk to Structure	Priority	Recommended Actions	Target Date	Status as of January 2019
2017-01	■ VW11-MD-1B is reporting erroneous data. ■ VW11-MD-1B, VW11-WD-1A and 1B, VW11-WD-2B, VW11-WD-3A did not report data (VW11-MD-3B, VW11-WD-2A and VW11-WD-3B also reported erroneous and/or no data for the reporting period, but are functioning correctly as of January 2018). VW11-MD-5A and 5B cables have been damaged. ■ SD-16-01 has no new readings since August 2017 when casing cover was partially buried during dam construction.	n/a	Potentially unstable condition not measured.	2	Confirm that dataloggers are functioning correctly and communication is restored as needed. Repair or replace damaged piezometer cables as necessary. Gain access to SD-16-01 and connect to datalogger.	Q3 2018	In progress. No repair or replacement of VW11-MD-2B is necessary, since sufficient monitoring coverage is provided by SD-16-03 and VW11-MD-2A. Repaired: MD-3A and 3B, MD-5A and 5B, WD-2A and 2B, WD-3A and 3B. Repairs required: ■ MD-1A, MD-1B and MD-4B ■ WD-1A, WD-1B ■ SD-16-01 ■ Teck has committed to completing these repairs by end of Q2 2019.
2017-02	QPOs for the inclinometers have not been developed since data is still being collected to establish the baseline.	n/a	Potentially unstable condition not identified promptly.	2	Develop QPOs for the inclinometers once the baseline has been established.	Q3 2018	In progress. Readings started in 2018. Baseline will be established in 2019 (after 12 months of readings). Until a baseline is established, each inclinometer survey collected will be assessed and compared against the interim QPOs (Table 16, Section 5.3.3), and previous surveys to monitor the magnitude, direction, and rate of deformations.
2017-03	The weirs at the toe of Site C and West Dam were damaged in 2017.	n/a	Potentially unstable condition not measured.	2	Reinstate the weir at the toe of Site C. Establish baseline monitoring for weirs and consider automating to ensure continual data collection.	Q3 2018	Complete: Site C weir has been reinstated. Incomplete: Automation and baseline monitoring is planned for 2019. The weir at the toe of the West Dam has been moved downstream to the other side of the road and is now functioning again.
2017-04	Pond against upstream slope of Main Dam. The pond against the upstream slope of the Main Dam is consistent with design basis and not a dam safety concern, but there is an opportunity to improve towards best applicable practice by moving it away from the upstream slope of the Main Dam.	n/a	Increased potential for piping, and potential increased zone of influence if dam integrity is compromised.	4	Review options to move pond away from upstream slope of Main Dam.	Q3 2018	In progress. Deposition options to be reviewed in 2019.
2017-05	Closure plan does not meet HSRC requirements.	HSRC, OMS	n/a	4	Develop the current concept level closure plan into a more detailed plan aligned with the current LOM strategy and HSRC requirements.	Q1 2019	Update to start in 2019.
2017-06	In 2014, flood protection berms were constructed along the river near Elkford. The 2016 inundation study update (Golder 2017c) used the 2011 LiDAR, which did not include the flood protection berms. The inundation study needs to be updated with the 2017 LiDAR data to include the recently 2014 flood protection constructed berms.	n/a	n/a	4	Update inundation study with 2017 LiDAR for West Dam breach.	Q4 2018	Completed Q1 2019. Additional modelling is being completed further downstream, to Lake Koocanusa.

El. = elevation; EoR = Engineer of Record.

6.0 FINDINGS AND RECOMMENDED ACTIONS

The Main Tailings Dam and West Tailings Dam were observed to be in good condition at the time of the 2018 site visit. No significant changes in the condition of the dams since the 2017 DSI were noted.

Although there are no visible signs of instability during the inspection, some of the monitoring instruments reported values that exceeded warning and alarm levels during the reporting period. Although these exceedances are not considered an immediate concern, it should be noted that the EoR was not informed of these exceedances when they occurred (as per the requirements of the TARP). Golder recommends that GHO review the TARP to ensure that the actions following an exceedance are fully understood and followed in the future. The functionality, calibration and suitability of the monitoring instruments reporting erroneous and suspect data should also be reviewed and if necessary, adjusted or replaced.

Table 19 summarizes the recommended actions for the Greenhills Tailings Facility.

Table 19: 2018 Dam Safety Inspection Recommended Actions for the Greenhills Tailings Facility

ID Number	Deficiency or Non-conformance	Photo	Applicable Regulation or OMS Reference	Potential Dam Safety Risk	Recommended Action	Priority Level	Recommended Deadline
2018-01 (2017-01)	Piezometers: ■ VW11-MD-1A and 1B are missing data from September 2017 onwards, except for a few days of erroneous data in March to August 2018. ■ VW11-MD 2A was missing data from August to October 2017 and in November 2017. ■ VW11-MD-3A and 3B were missing data from October to December 2017. ■ VW11-MD-5A and 5B were missing data from December 2017 to May 2018. ■ SD-16-04 stopped recording in August 2018. ■ SD-16-01 has no new readings since October 2017 when casing cover was partially buried during dam construction. ■ WD-2A and 2B and WD-3A and 3B were missing data for part of September 2017. ■ WD-1A and 1B stopped reading data in April 2018, with a few exceptions. Prisms and GPS units: ■ Prism A is not within line of sight of total station. ■ Non-functioning GPS units on Main Dam (MD-1_ROVER, MD-2_ROVER, MD-5_ROVER) ■ Non-functioning GPS units on West Dam (WD-1_ROVER, WD-2_ROVER, WD-3_ROVER) Seepage Weirs: ■ Suspect data reported by the weir at the toe of Site C by the Main Dam, and at the weir by the West Dam.	-	n/a	Potentially unstable condition not measured.	Piezometers: ■ Repair or replace damaged piezometers/dataloggers as necessary. ■ Review the reliability of instruments that have gaps within reporting period. ■ Re-calibrate/repair/replace piezometers that have been reporting negative readings. ■ Gain access to SD-16-01 and connect to datalogger. Prisms and GPS units: ■ Relocate Prism A so that it is within the line of sight of the total station. ■ Review functionality, calibration and suitability of GPS units. Repair or replace GPS units as necessary. Seepage Weirs: ■ Take manual readings with tape measure ■ Perform bucket calibration ■ Automate weirs to ensure continual data collection. ■ Install additional seepage weir at toe of Site D spoils.	2	Q2 2019
2018-02	The Trigger Action Response Plan (TARP) was not implemented as required when warning and alarm levels were exceeded during the 2017/2018 reporting period.	-	OMS	Potential delayed response of corrective actions and notification of responsible persons and emergency response team.	Review the TARP, update if appropriate, and retrain key GHO personnel so that the TARP procedures and requirements are enforced as intended.	2	Q1 2019
2018-03 (2017-02)	QPOs for the inclinometers still required.	-	n/a	Potentially unstable condition not identified promptly.	Develop QPOs for the inclinometers based on the baseline readings, once established. Until a baseline is established, each inclinometer survey collected must be assessed and compared against the interim QPOs (Table 16, Section 5.3.3), and previous surveys to monitor the magnitude, direction, and rate of deformations.	2	Q3 2019
2018-04 (2017-04)	Pond against upstream slope of Main Dam. The pond against the upstream slope of the Main Dam is consistent with design basis and not a dam safety concern, but there is an opportunity to improve towards best applicable practice by moving the pond away from the upstream slope of the Main Dam.	1 to 8	n/a	Increased potential for piping, and potential increased zone of influence if dam integrity is compromised.	Review options to move pond away from upstream slope of Main Dam.	4	Q4 2019
2018-05 (2017-05)	Closure plan does not meet HSRC requirements.	-	HSRC, OMS	n/a	Develop the current concept level closure plan to align with the current LOM strategy and HSRC requirements.	4	Q4 2019

Table 19: 2018 Dam Safety Inspection Recommended Actions for the Greenhills Tailings Facility

ID Number	Deficiency or Non-conformance	Photo	Applicable Regulation or OMS Reference	Potential Dam Safety Risk	Recommended Action	Priority Level	Recommended Deadline
2018-06	Golder has recommended additional inundation study modelling of the downstream area, up to Lake Koocanusa.	-	n/a	n/a	Update inundation study with additional modelling downstream, up to Lake Koocanusa.	4	Q2 2019
2018-07	A portion of the seepage at the Site C toe is flowing under the SmartDitch, which may be causing a small bypass of seepage past the seepage monitoring weir. The flow entering the HDPE pipe and the flow from the HDPE pipe into the SmartDitch are not measured separately from the dam toe seepage. It is impossible to distinguish whether flow at the weirs is due to increased seepage or rainfall.	12b	n/a	Potentially unstable condition not measured.	Modify seepage collection to direct seepage into the SmartDitch, and add this to the list of inspection and maintenance tasks in OMS manual. Measure the flow entering the HDPE pipe (or flowing from the HDPE pipe into the SmartDitch) such that it can be tracked separately from the seepage from the dam toe during periods of rainfall. Add this to the list of monitoring tasks in the OMS manual.	4	Q3 2019

Priority Level	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.

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 requirements, please contact the undersigned.

Golder Associates Ltd.

Malcolm Shang, P.Eng.
Geotechnical Engineer

Andy Haynes, P.Eng.
Principal, Senior Geotechnical Engineer

MS/AH/it/hg

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REFERENCES

BC MEM (British Columbia Ministry of Energy and Mines). 2013. Guidelines for Annual Dam Safety Inspection Reports. August 2013.

BC MEMPR (British Columbia Ministry of Energy, Mines and Petroleum Resources). 2016a. Health, Safety and Reclamation Code for Mines in British Columbia. Revisions to Part 10. Mining and Minerals Division, Victoria, British Columbia. Effective 20 July 2016.

BC MEMPR. 2016b. Guidance Document for Revisions to Part 10 of the Health, Safety and Reclamation Code for Mines in British Columbia. Mining and Minerals Division, Victoria, British Columbia. Effective 20 July 2016.

CDA (Canadian Dam Association). 2007. Technical Bulletin: Geotechnical Considerations for Dam Safety.

CDA. 2013. Dam Safety Guidelines. Original dated 2007, Revised 2013.

CDA. 2014. Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams. Published October 2014.

Environment Canada (Environment Canada National Climate Data and Information Archive). 2014. Climate Data Station 1152899. Available at: http://www.climate.weather.gc.ca/climateData/dailydata_e.html. Accessed: 23 September 2014.

GHO (Greenhills Operations). 2012. “Site C” Coarse Coal Rejects Area Ground Movement Initial Mitigation and Monitoring/Assessment Plan. Memorandum prepared for Teck Coal Limited. Dated 7 November 2012.

GHO. 2013. Tailings Pond Dam Breach Emergency Preparedness Plan (Dam Breach EPP). SP&P No. 1583. Ver. 0. Date of Issue: 31 January 2013. Date of Revision: 6 October 2014.

GHO. 2017. Operation, Maintenance, and Surveillance Manual for Greenhills Tailings Pond and Dams. SP&P No. 1543. Ver. 3. Date of Revision: 27 March 2017.

GHO. 2019. Tailings Pond Dam Breach Emergency Preparedness Plan (Dam Breach EPP). SP&P No. 1583. Ver. 1. Date of Issue: 31 January 2019. Date of Revision: 18 December 2018.

Golder (Golder Associates Ltd.). 1989. Report on Raising of Upstream Impervious Blanket to El. 1702. Report Prepared for Fording Coal Limited, Greenhills Operations. Project Number 882-1406C. Submitted October 1989.

Golder. 1990. Report on Raising of Upstream Impervious Blanket to El. 1704. Report Prepared for Fording Coal Limited, Greenhills Operations. Project Number 902-1406B. Submitted December 1990.

Golder. 1992. Report on Raising of Upstream Impervious Blanket to El. 1707. Report Prepared for Fording Coal Limited, Greenhills Operations. Project Number 912-1406B. Submitted January 1992.

Golder. 1993. Fine Tailings Lagoon West Dam Construction to 1711 m Elevation. Report prepared for Fording Coal Limited, Greenhills Operations. Project Number 932-2403. Submitted August 1993.

Golder. 1995. 1994 Annual Report on Tailings Dams and Settling Ponds. Report Prepared for Fording Coal Limited, Greenhills Operations. Project No. 942-2426. Submitted May 1995.

Golder. 1996. 1995 Annual Report on Tailing Dams, Coarse Rejects Stockpiles and Settling Ponds. Reported Prepared for Fording Coal Limited, Greenhills Operations. Project No. 962-2416. Submitted February 1996.

Golder. 1997. 1996 Annual Report on Tailing Dams, Coarse Rejects Stockpiles and Settling Ponds. Reported Prepared for Fording Coal Limited, Greenhills Operations. Project No. 962-2416. Submitted May 1997.

Golder. 1998. 1997 Annual Report on Tailing Dams, Coarse Rejects Stockpiles and Settling Ponds. Reported Prepared for Fording Coal Limited, Greenhills Operations. Project No. 972-2420. Submitted March 1998.

Golder. 1999. 1998 Annual Report on Tailings Dams, Coarse Rejects Stockpiles, Settling Ponds. Report prepared for Fording Coal Limited, Greenhills Operations. Project Number 982-2420. Submitted February 1999.

Golder. 2000. 1999 Annual Report on Tailings Dams, Coarse Rejects Stockpiles, Settling Ponds. Report prepared for Fording Coal Limited, Greenhills Operations. Project Number 992-2420. Submitted March 2000.

Golder. 2004. Geotechnical Construction Monitoring, Main Tailings Dam. Report Prepared for Elk Valley Coal Limited, Greenhills Operations. Project No. 03-1321-036. Submitted 12 April 2004.

Golder. 2005. Raising Main Tailings Dam to Elevation 1735 m, Greenhills Operations. Report prepared for Elk Valley Coal Corporation, Greenhills Operations. Document No. 04-1321-021. Submitted July 2005.

Golder. 2010a. Teck Coal Limited Final Report: Greenhills Operations Open Pit Mine 2010 Dam Safety Review. Report Prepared for Teck Coal Limited, Greenhills Operations. Project No. File No. 09-1321-0009.2300. Submitted August 2010.

Golder. 2010b. 2009 Geotechnical Construction Monitoring, Main Tailings Dam, Greenhills Operations, Elkford, British Columbia. Report Prepared for Teck Coal Limited, Greenhills Operations. Project No. 09-1321-0009.2000. Submitted 22 April 2010.

Golder. 2010c. As-Built Report on 2010 Geotechnical Construction Monitoring, Main and West Tailings Dam, Greenhills Operations, Elkford, British Columbia. Report Prepared for Teck Coal Limited, Greenhills Operations. Project No. 10-1321-0009.2000. Submitted 22 December 2010.

Golder. 2012a. 2011 Annual Report Greenhills Operations: Tailings Dams, Coarse Reject Stockpiles and Settling Ponds. Report prepared for Teck Coal Limited, Greenhills Operations. Report Number 11-1321-0001.1000. Submitted March 2012.

Golder. 2012b. Teck Tailings Pond Dams and Settling Pond Dam: Dam Breach Flood Inundation Study. Report Prepared for Teck Coal Limited, Greenhills Operations. File No. 11-1321-0001. Submitted August 2012.

Golder. 2013a. 2012 Annual Report Greenhills Operations: Tailings Dams, coarse refuse Stockpiles and Settling Ponds. Report Prepared for Teck Coal Limited, Greenhills Operations. File No. 12-1321-0056.1000. Submitted March 2013.

Golder. 2013b. Site Water Balance Model. Draft Report Prepared for Teck Coal Limited – Greenhills Operations. Reference No. 1314280015-2013-455-R-RevB-4000. Submitted 1 November 2013.

Golder. 2014a. 2013 Annual Dam Safety Inspection for Tailings Dams and Greenhills Settling Pond. Report Prepared for Teck Coal Limited- Greenhills Operations. Reference No. 1314270070-2014-506-R-Rev0-2000. Submitted 28 March 2014.

Golder. 2014b. Geotechnical Report, Greenhills Operations West Tailings Dam Raise to Elevation 1735 m. Report Prepared for Teck Coal Limited- Greenhills Operations. Report No. 13-1321-0018. Submitted 11 February 2014.

Golder. 2014c. Greenhills Operations Main and West Tailings Dams Embankment Raise. Revision 0. Issued for Construction Drawing Package prepared for Teck Coal Limited, Greenhills Operations. Project No. 13-1396-0014. Revision 0. Submitted 28 May 2014.

Golder. 2014d. Main and West Tailings Dams Embankment Raise Technical Specifications and Construction Quality Assurance/Quality Control Plan. Specifications prepared for Teck Coal Limited, Greenhills Operations. Project No. 13-1396-0014. Revision 0. Submitted 5 June 2014.

Golder. 2014e. Greenhills Operations Main Dam and Site C Stability Assessment. Technical Memorandum Prepared for Teck Coal Limited- Greenhills Operations. Reference No. 1314270070-2014-528-TM-Rev0-2000. Submitted 16 April 2014.

Golder. 2014f. 2014 Annual Tailings Dam Safety Inspection. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1414270070-2014-608-R-Rev0-5000. Submitted 26 November 2014.

Golder. 2015a. 2014 Interim Construction Summary Report. Greenhills Operations Main and West Tailings Dam. Report Prepared for Teck Coal Limited, Greenhills Operations. Report No. 13-1396-0014. Submitted 30 January 2015.

Golder. 2015b. Greenhills Operations Cougar Pit Extension Project Hydrology Baseline Report. Report Prepared for Teck Coal Limited – Greenhills Operations. Reference No. 1406455-2015-069-R-Rev2-4000. Submitted 14 October 2015.

Golder. 2016a. 2015 Construction Report. Greenhills Operations Main and West Tailings Dams. Report prepared for Teck Coal Limited, Greenhills Operations Report Number 1313960014.3000. Submitted 26 January 2016.

Golder. 2016b. Site Specific Probabilistic Seismic Hazard Assessment. Draft Report prepared for Teck Coal Limited, Fording River Operations, Greenhills Operations, and Coal Mountain Operations. Reference Number 1522835-2015-149-R-RevC-4000. Submitted 25 January 2016.

Golder. 2016c. 2015 Dam Safety Inspection for Greenhills Tailings Facility. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1528359-2016-008-R-Rev0 2000. Submitted 30 March 2016.

Golder. 2016d. Quantitative Performance Objectives for Tailings Ponds. Technical Memorandum Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1528359-2016-048-R-Rev0-2000. Submitted 19 July 2016.

Golder. 2017a. Update of the Design Hydrology for the Greenhills Operations Site. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1658561-2017-002-TM-Rev0-2000. Submitted 20 January 2017.

Golder. 2017b. 2016 Construction Report Greenhill Tailings Facility West Dam. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1658561-2016-085-R-Rev0-2000. Submitted 21 February 2017.

Golder. 2017c. Tailings Storage Facility Dam Breach Flood Inundation Study. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1528359-2016-081-R-Rev0-4000. Submitted 17 April 2017.

Golder. 2017d. 2016 Dam Safety Inspection for Greenhills Tailings Facility. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1658561-2016-085-R-Rev0-2000. Submitted 27 March 2017.

Golder. 2017e. 2016 Main Tailings Dam Drilling Investigation. Report prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1658561-2017-021-R-Rev0-3000. Submitted 8 May 2017.

Golder. 2017f. 2017 Construction Report. Greenhills Operations Main and West Tailings Dams. Report prepared for Teck Coal Limited, Greenhills Operations Report Number 1782871_RP0001. Submitted 4 December 2017.

Golder. 2017g. Stability Review and Update of the Quantitative Performance Objectives for Greenhills Tailings Pond Dams. Technical Memorandum Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1780315-2017-097-R-Rev0-1000. Submitted 21 December 2017.

Golder. 2018a. 2017 Dam Safety Inspection for Greenhills Tailings Facility. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1778487-2017-130-R-Rev0-2000. Submitted 27 March 2018.

Golder. 2018b. Greenhills Tailings Facility Main Dam – Site C Seepage Collection Observations and Recommendation. Technical Memo Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1894290-2018-079-TM-Rev0-2000. Submitted 6 July 2018.

Golder. 2018c. Greenhills Tailings Facility West Dam – Erosion Mitigation. Technical Memo Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1894290-2018-104-TM-Rev0-2000. Submitted 28 August 2018.

Golder. 2018d. 2018 Construction Report. Greenhills Operations Main and West Dams. Report prepared for Teck Coal Limited, Greenhills Operations Report Number 18103265-2018-001-R-RevA. Submitted 21 December 2018.

Golder. 2019. Greenhills site water balance model update – clarification of input data. Technical Memo Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1791043-2019-003-TM-RevA-2000. Submitted 19 January 2019.

Hardy (Hardy Associates [1978] Ltd.). 1980a. Greenhills Sedimentation Control Pond Sizing, Location and Proposed Geotechnical Investigation. Report Prepared for Kaiser Resources Ltd. File No. K5244-200. July 1980.

Hardy. 1980b. Tailings Dam Greenhills Surface Coal Mining Project. Report Prepared for Kaiser Resources Ltd. Project No. K5131-013. September 1980.

Hardy. 1984. Report on the Construction of the Starter Dam. Report Prepared for Westar Mining Ltd. Project No. VG-03259. 5 April 1984.

Hardy. 1987. 1986 Annual Report on Geotechnical Conditions Tailings Disposal Facility Greenhills Colliery. Report Prepared for Westar Mining Ltd. Project No. VG-03499. January 1987.

Hardy. 1988. Year End Report for Greenhills Tailings Dam. Report Prepared for Westar Mining Ltd. Project No. VG-03499. 8 June 1988.

KCB (Klohn Crippen Berger). 2017. Teck Coal Limited Final Report: Greenhills Operations Dam Safety Review of Main and West Tailings Dams and Greenhills Settling Pond Dam. File No. M10126A01.730. Submitted December 2017.

KWL (Kerr Wood Leidal Limited). 2012. GHO Water Audit 2012 Water Balance. Draft Technical Memorandum Prepared for Teck Coal Ltd. File No. 505.036-300. Dated 23 October 2013.

MAC (Mining Association of Canada). 2011. Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities.

MAC (Mining Association of Canada). 2017. A Guide to the Management of Tailings Facilities. October 2017.

NRCC (National Research Council Canada). 2010. National Building Code of Canada 2010. 1 April 2010.

NRCC. 2015. National Building Code of Canada 2015. 1 January 2015.

NRC (Natural Resources Canada). 2010. Seismic Hazard Calculator. Calculator based on Seismic Hazard Epicentre File used in fourth generation seismic hazard maps of Canada, Open File 6208. Available at www.earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index_2010-eng.php.

NRC. 2015. Seismic Hazard Calculator. Calculator based on Seismic Hazard Epicentre File used in fifth generation seismic hazard maps of Canada, Open File 6208. Available at http://www.earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index_2015-en.php.

Westar (Weststar Mining Ltd.). 1988. Greenhills Tailings Dam: Estimate of Work Required to be Completed in 1988. Plan of sitework. Dated May 1988.

STUDY LIMITATIONS

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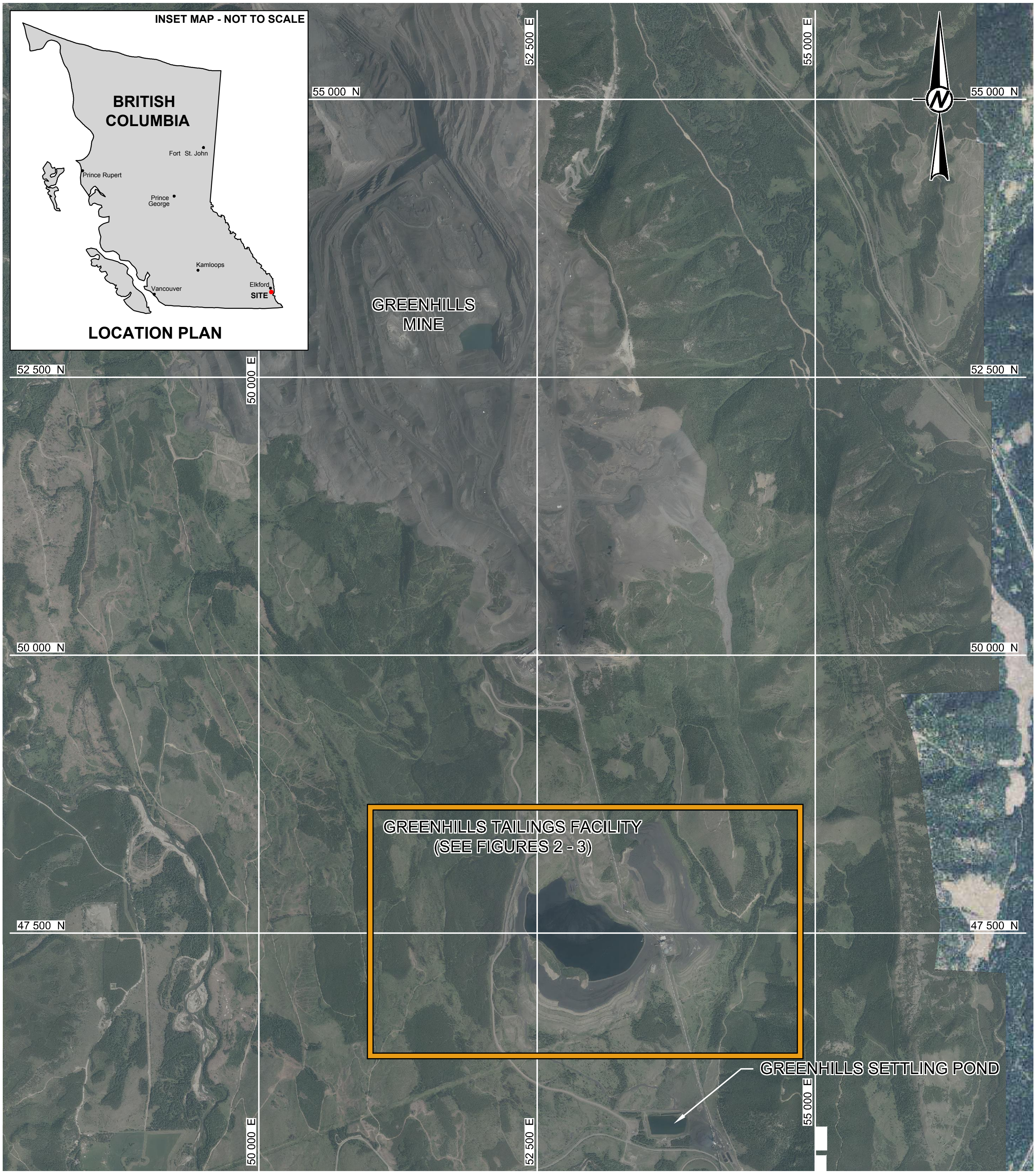


REFERENCE

1. 2013 AERIAL PHOTO PROVIDED BY TECK COAL LIMITED GREENHILLS OPERATIONS.
2. 2018 AERIAL PHOTO PROVIDED BY TECK COAL LIMITED FORDING RIVER OPERATIONS. FLOWN JULY 15 TO 16, 2018.

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN GHO MINE GRID.

0 1,000 2,000
1:50,000 METRES

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, B.C.

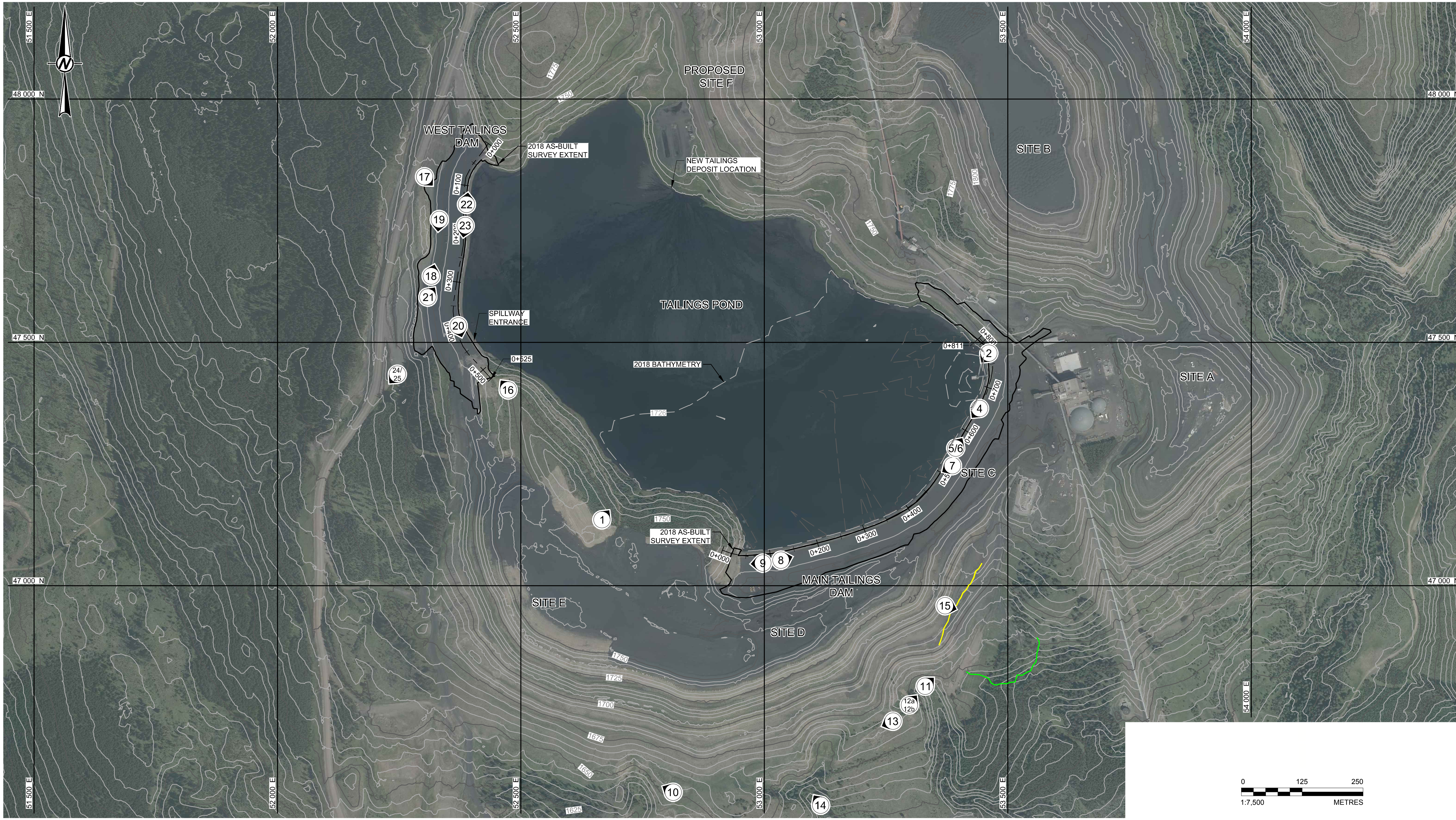
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-22
DESIGNED	NC
PREPARED	JY
REVIEWED	MS
APPROVED	AJH

TITLE
GREENHILLS SITE PLAN

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
1894290	2000/2060/2018-133	0	01



LEGEND

- 2018 TOPOGRAPHY (SEE REFERENCE 2)
- 2018 BATHYMETRY (SEE REFERENCE 3)
- (#) 2018 SITE VISIT PHOTO LOCATION
- 2012 TOE BULGE (SITE C)
- 2012 SCARP (SITE C)

REFERENCES

1. 2018 AERIAL PHOTO AND TOPOGRAPHY PROVIDED BY TECK COAL LIMITED. FLOWN 15 TO 16 JULY 2018.
2. 2018 AS-BUILT INFORMATION PROVIDED BY TECK COAL LIMITED, DATED: 2 OCTOBER 2018 FILE NAME: 2018-10-02 GHO DAM - VOLUME CALC.dxf
3. 2018 BATHYMETRY INFORMATION PROVIDED BY TECK COAL LIMITED, DATED 24 OCTOBER 2018 FILE NAME: 181024 Tailings Sounding.dxf
4. 2012 SCARP AND TOE BULGE LOCATIONS PROVIDED BY TECK COAL LIMITED GREENHILLS OPERATIONS ON 13 MARCH 2014.

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN GHO MINE GRID.
3. TOPOGRAPHIC CONTOURS SHOWN AT 5.0 m MINOR AND 25.0 m MAJOR INTERVAL.

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, B.C.

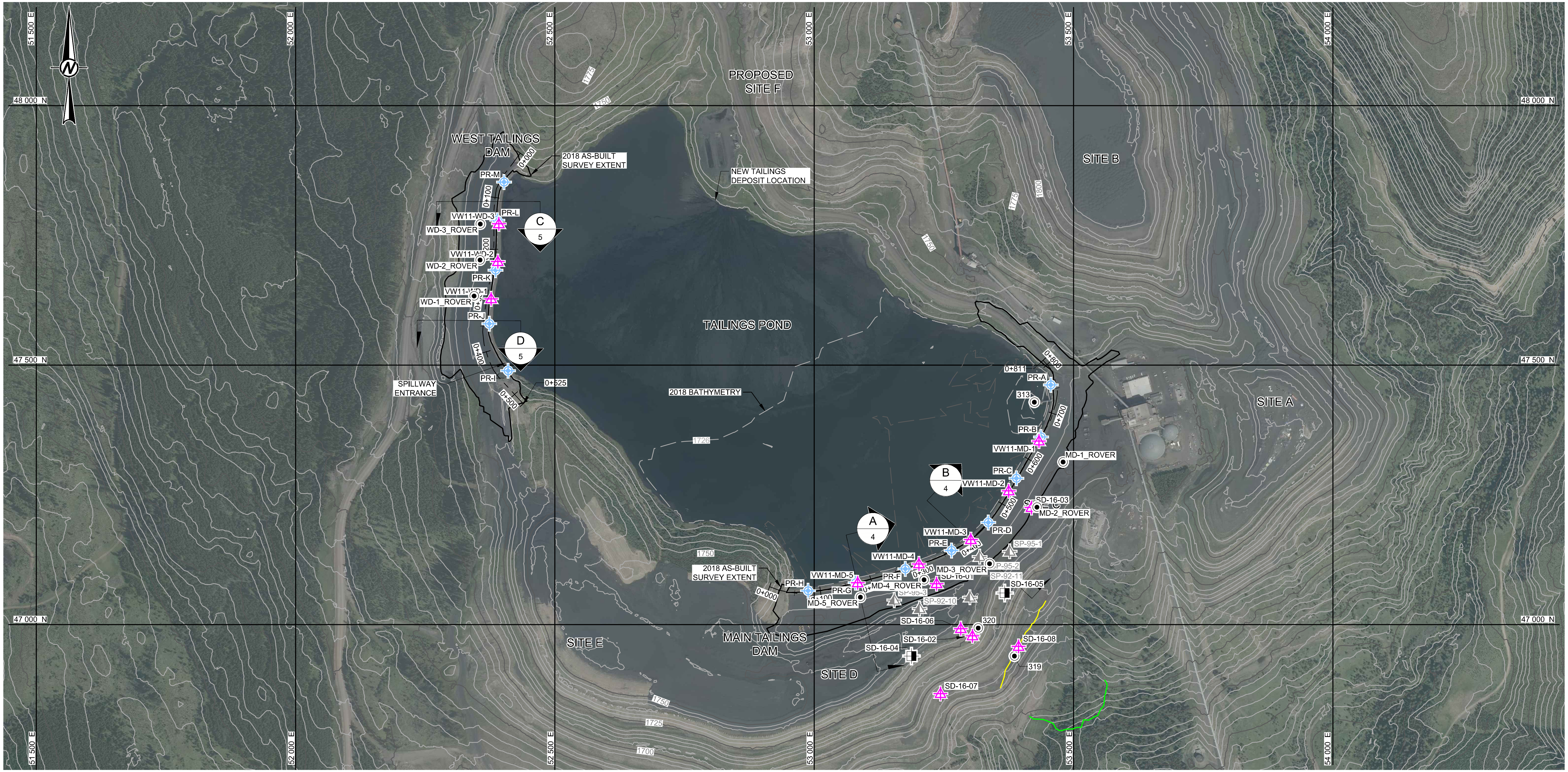
CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-22
DESIGNED	NC
PREPARED	JY
REVIEWED	MS
APPROVED	AJH

PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTIONS

TITLE
GREENHILLS SITE PLAN
PHOTO LOCATIONS

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
1894290	2000/2060/2018-133	0	02



LEGEND

- 2018 TOPOGRAPHY (SEE REFERENCE 2)
- 2018 BATHYMETRY (SEE REFERENCE 3)
- PNEUMATIC PIEZOMETER LOCATION (INACTIVE)
- STANDPIPE PIEZOMETER LOCATION (INACTIVE)
- VIBRATING WIRE PIEZOMETER LOCATION
- GPS MONITORING LOCATION
- PRISM LOCATION
- INCLINOMETER AND VIBRATING WIRE PIEZOMETER LOCATION
- 2012 TOE BULGE (SITE C)
- 2012 SCARP (SITE C)

REFERENCES

1. 2018 AERIAL PHOTO PROVIDED BY TECK COAL LIMITED. FLOWN 15 TO 16 JULY 2018.
2. 2018 LIDAR DATA PROVIDED BY TECK COAL LIMITED, FLOWN: 15 TO 16 JULY 2018.
3. 2018 AS-BUILT INFORMATION PROVIDED BY TECK COAL LIMITED, DATED: 2 OCTOBER 2018 FILE NAME: 2018-10-02 GHO DAM - VOLUME CALC.dxf
4. INACTIVE STANDPIPE LOCATIONS BASED ON DATA PROVIDED BY TECK COAL LIMITED GREENHILLS OPERATIONS, FILE NAME: "Exported Sensor Locations.csv", RECEIVED: 3 NOVEMBER 2016.
5. GPS UNITS 313, 319 AND 320 AND VIBRATING WIRE PIEZOMETER LOCATIONS PROVIDED BY TECK COAL LIMITED GREENHILLS OPERATIONS, FILE NAME: "Exported Sensor Locations.csv", RECEIVED: 9 SEPTEMBER 2014.
6. GPS 313 LOCATION PROVIDED BY TECK COAL LIMITED GREENHILLS OPERATIONS, FILENAME: "TSF_313_Barge.csv", RECEIVED: 5 NOVEMBER 2015.
7. PRISM LOCATIONS PROVIDED BY TECK COAL LIMITED GREENHILLS OPERATIONS, FILE NAME: "Dam Prism Data.xlsx", RECEIVED: 5 NOVEMBER 2015.
8. 2017 BATHYMETRY INFORMATION PROVIDED BY TECK COAL LIMITED, DATED 25 AUGUST 2017, FILE NAME: pond_170825_final.dxf.
9. 2012 SCARP AND TOE BULGE LOCATIONS PROVIDED BY TECK COAL LIMITED GREENHILLS OPERATIONS ON 13 MARCH 2014.
10. MD_ROVER AND WD_ROVER GPS SERIES COORDINATES DOWNLOADED FROM GEOEXPLORER ON 1 NOVEMBER 2018.

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN GHO MINE GRID.
3. TOPOGRAPHIC CONTOURS SHOWN AT 5.0 m MINOR AND 25.0 m MAJOR INTERVAL.
4. LOCATIONS OF SP-92-10 AND 92-SP-11 HAVE BEEN APPROXIMATED.

0 125 250

1:7,500 METRES

CLIENT
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GREENHILLS OPERATIONS
ELKFORD, B.C.

CONSULTANT

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YYYY-MM-DD	2019-03-22
DESIGNED	NC
PREPARED	JY
REVIEWED	MS
APPROVED	AJH

PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

TITLE
GREENHILLS SITE PLAN
MONITORING AND PRISM LOCATIONS

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
1894290	2000/2060/2018-133	0	03

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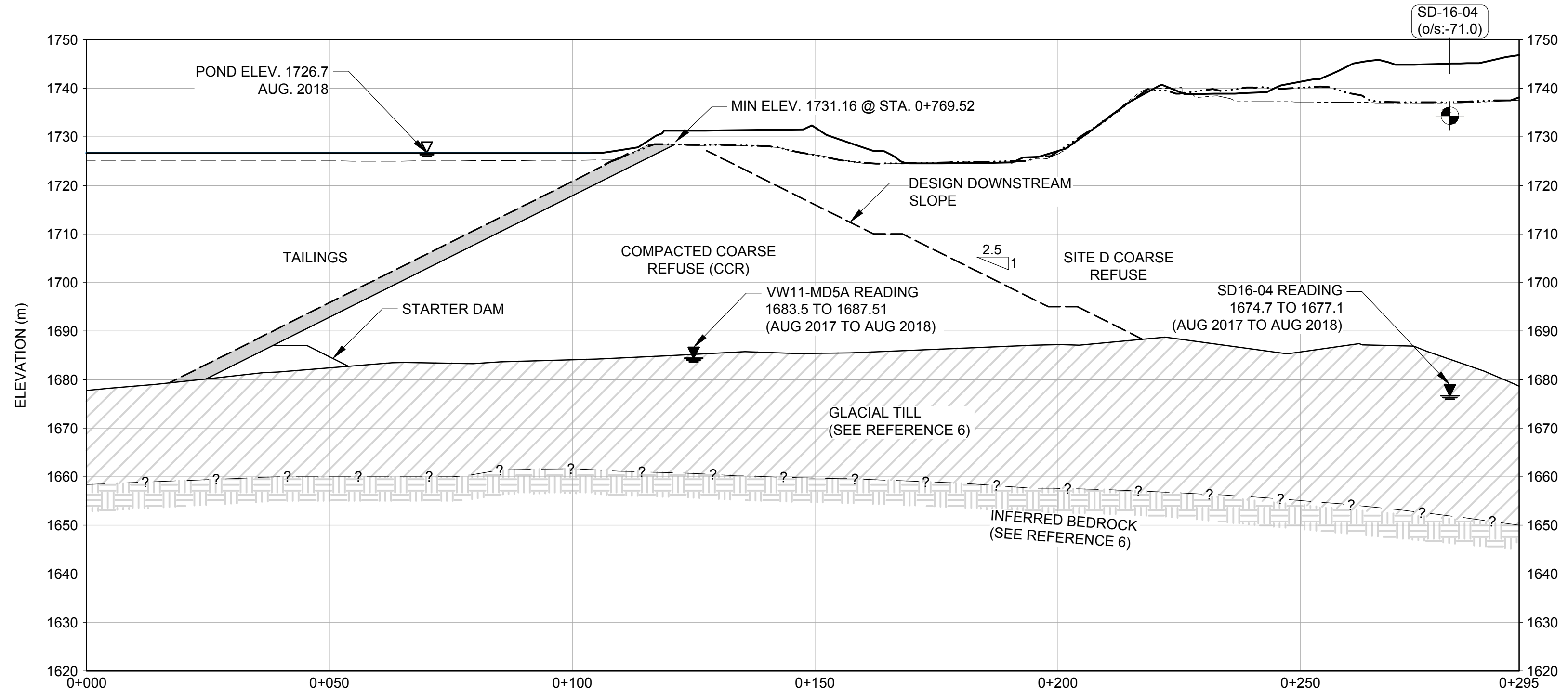

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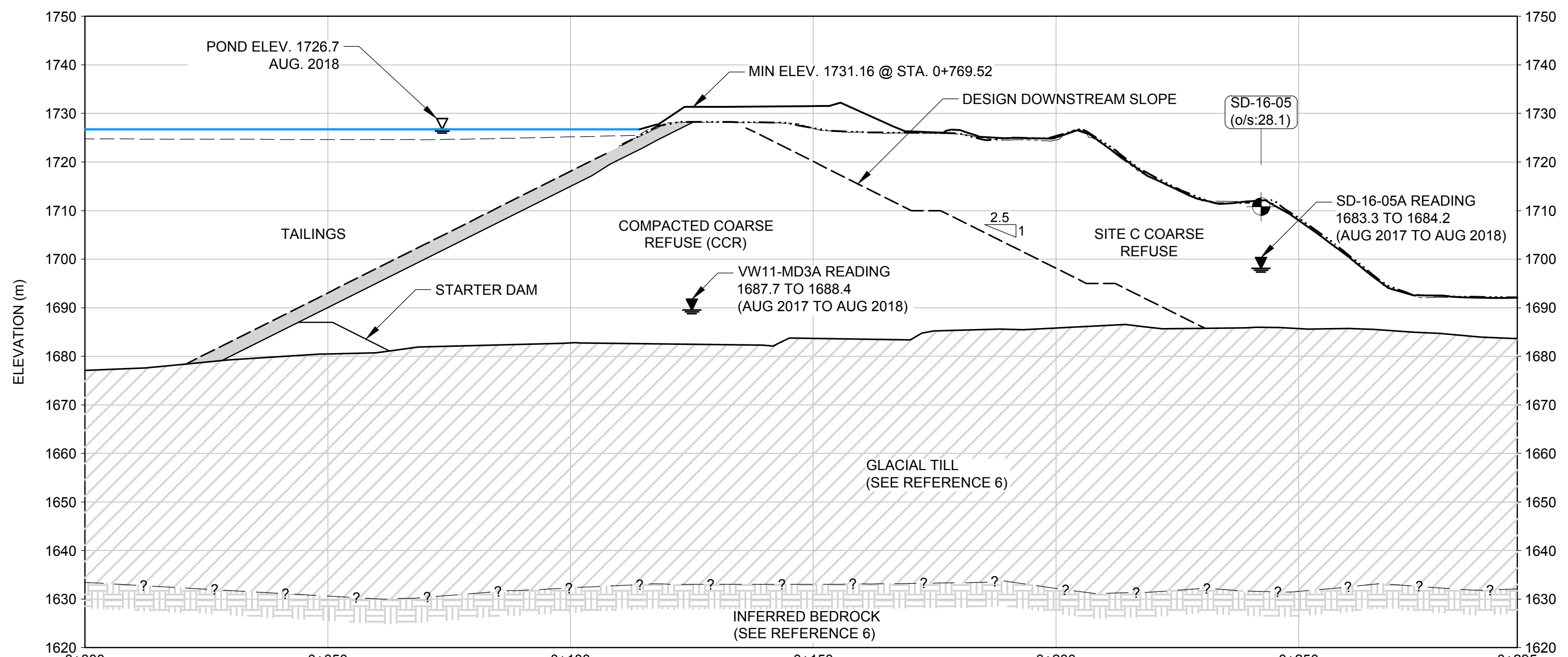


SCALE 1:1,500 m B 3 MAIN TAILINGS DAM CROSS-SECTION (0+405.36)

LEGEND

- OCTOBER 2018 SURVEY (SEE REFERENCE 1)
- AUGUST 2016 GROUND SURFACE
- OCTOBER 2018 BATHYMETRY
- CLAY TILL BLANKET
- GLACIAL TILL
- BEDROCK

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. DAM ZONINGS ARE APPROXIMATE.

0 25 50
1:1,500 METRES

REFERENCES

1. 2018 LIDAR DATA PROVIDED BY TECK COAL LIMITED, FLOWN: 15 TO 16 JULY 2018.
2. 2018 AS-BUILT INFORMATION PROVIDED BY TECK COAL LIMITED, DATED: 2 OCTOBER 2018 FILE NAME: 2018-10-02 GHO DAM - VOLUME CALC.dxf
3. NOVEMBER 2015 GROUND SURFACE PROVIDED BY TECK GHO, FILE NAMES: "MAIN DAM FINAL 2015.dxf" AND "WEST DAM FINAL 2015.dxf", RECEIVED: 26 NOVEMBER 2015.
4. 2018 BATHYMETRY INFORMATION PROVIDED BY TECK COAL LIMITED, DATED 24 OCTOBER 2018 FILE NAME: 181024 Tailings Sounding.dxf
5. APPROXIMATE ORIGINAL GROUND SURFACE PROVIDED BY TECK GHO.
6. MAIN DAM SECTION INFERRED GLACIAL TILL AND INFERRED BEDROCK BASED ON HARDY 1980 REPORT ON TAILINGS DAM GREENHILLS SURFACE COAL MINING PROJECT AND GOLDER 2016 MAIN TAILINGS DAM INVESTIGATION. GOLDER REFERENCE NUMBER: 1658561-2017-021-R-REV0-3000

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, B.C.

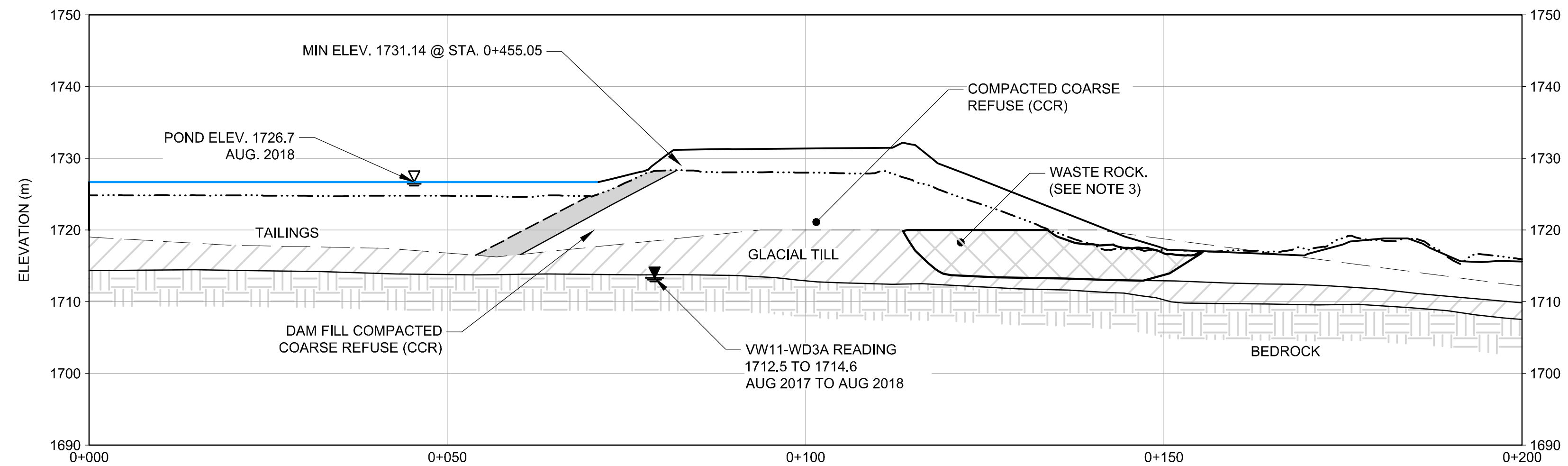
CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-22
DESIGNED	NC
PREPARED	JY
REVIEWED	MS
APPROVED	AJH

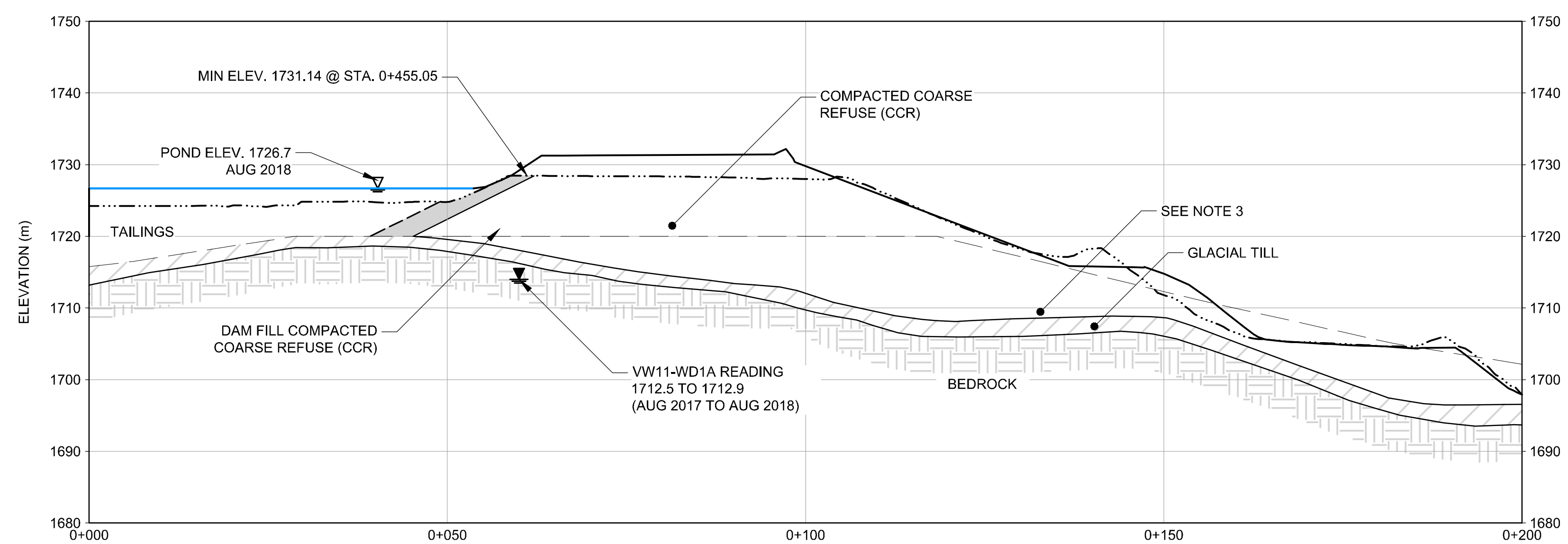
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTIONS

TITLE
GREENHILLS SITE PLAN
MAIN TAILINGS DAM CROSS-SECTIONS

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
1894290	2000/2060/2018-133	0	04



SCALE 1:1,000 m C 3 WEST TAILINGS DAM CROSS-SECTION (0+107.70)



SCALE 1:1,000 m D 3 WEST TAILINGS DAM CROSS-SECTION (0+338.96)

LEGEND

- OCTOBER 2018 SURVEY (SEE REFERENCE 1)
- NOVEMBER 2016 SURVEY
- APPROXIMATE ORIGINAL GROUND SURFACE (SEE REFERENCE 3)
- CLAY TILL BLANKET
- GLACIAL TILL
- BEDROCK

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. DAM ZONINGS ARE APPROXIMATE.
3. LOOSE MATERIAL STRIPPED FROM FOUNDATION AND BACKFILLED WITH WASTE ROCK BASED ON GOLDER 2016 *GREENHILLS OPERATIONS MAIN AND WEST TAILINGS DAMS*. REPORT PREPARED FOR TECK COAL LIMITED, GHO. REPORT NO. 1313960014.3000. SUBMITTED 26 JANUARY 2016.

REFERENCES

1. 2018 LIDAR DATA PROVIDED BY TECK COAL LIMITED, FLOWN: 15 TO 16 JULY 2018.
2. 2018 AS-BUILT INFORMATION PROVIDED BY TECK COAL LIMITED, DATED: 2 OCTOBER 2018 FILE NAME: 2018-10-02 DHO DAM - VOLUME CALC.dxf
3. SEPTEMBER 2014 GROUND SURFACE PROVIDED BY TECK GHO, RECEIVED: 23 SEPTEMBER 2014.
4. APPROXIMATE ORIGINAL GROUND SURFACE PROVIDED BY TECK GHO.
5. WEST DAM SECTION TYPICAL STRATIGRAPHY OBTAINED FROM GOLDER. 2014. *GREENHILLS OPERATIONS WEST TAILING DAM RAISE TO ELEVATION 1,735 m*. REPORT PREPARED FOR TECK GHO. REPORT NO. 13-1321-0018. SUBMITTED 11 FEBRUARY 2014.

0 25 50
1:1,000 METRES

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, B.C.

CONSULTANT GOLDER

YYYY-MM-DD	2019-03-22
DESIGNED	MS
PREPARED	JY
REVIEWED	MS
APPROVED	AJH

PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTIONS

TITLE
GREENHILLS SITE PLAN
WEST TAILINGS DAM CROSS-SECTIONS

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
1894290	2000/2060/2018-133	0	05

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

APPENDIX A

Site Inspection Photographs

Photograph 1: Overview from rise of natural ground to the south, looking northeast. 15 August 2018.

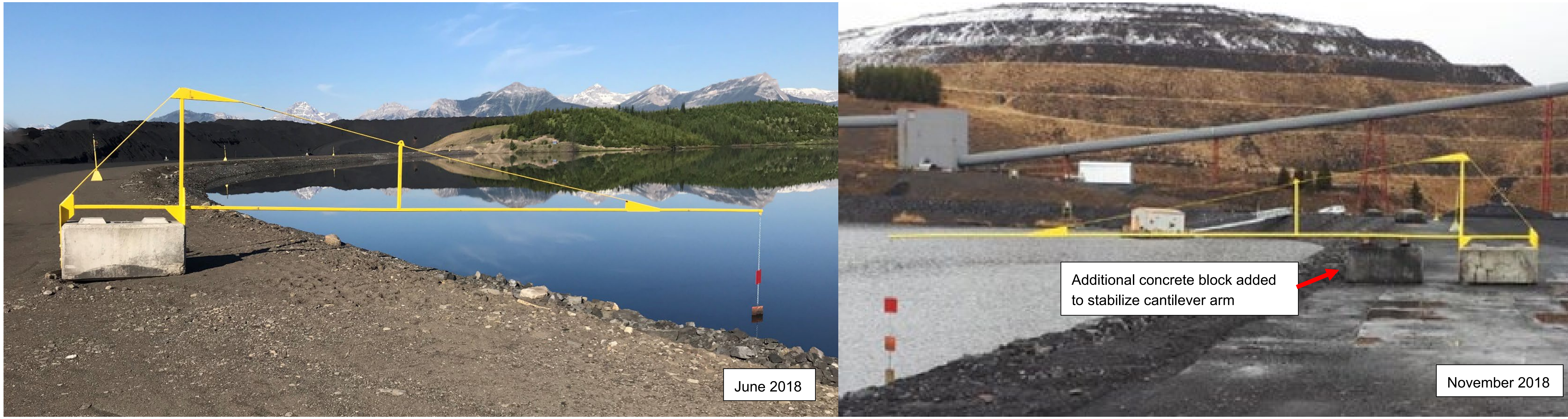
Photograph 2: Main Dam – overview of barge, looking southwest. 18 June 2018.

Photograph 3: Main Dam – crest, note clay till upstream blanket and coarse coal refuse fill, looking southwest. 15 August 2018.

Photograph 4: Main Dam – upstream slope and crest, looking southwest. 15 August 2018.

Photograph 5: Main Dam – overview of barge, east abutment, and natural ground north of GHO Tailings Pond, looking northeast. 15 August 2018.

Photograph 6: Main Dam – upstream slope, looking northeast. 15 August 2018



Photograph 7: Visual water level indicator showing rotation. June and November 2018.

Photograph 8: Main Dam – overview from natural ground above west abutment, looking northeast. 15 August 2018.

Photograph 9: Main Dam – west abutment, looking west. 15 August 2018.

Photograph 10: Site D and E – overview of Site D and Site E coarse coal refuse spoils, looking northwest. 15 August 2018.

Photograph 11: Site C – view of seepage collection channel. Looking northeast. 15 August 2018.

Photograph 12a: Site C – view of seepage collection channel. Looking northeast. 18 June 2018.

Photograph 12b: Site C –seepage under collection channel (red arrow), looking northeast. 15 August 2018.

Photograph 13: Site C – weir at toe of Site C refuse spoil after trench upgrade, looking west. 15 August 2018.

Photograph 14: Creek below Site C, D and E Looking north. 18 June 2018

Photograph 15: Historic 2012 Site C failure scarp and toe bulge, looking east. No significant change since 2012. 18 June 2018.

Photograph 16: West Dam – overview of upstream slope, looking northwest. 15 August 2018.

Photograph 17: West Dam – overview of downstream slope, looking south. 15 August 2018.

Photograph 18: West Dam – downstream slope, looking north. 15 August 2018.

Photograph 19: West Dam – downstream slope, looking south. 15 August 2018.

Photograph 20: West Dam – southern abutment, looking south. 15 August 2018.

Photograph 21: West Dam – Crest and downstream slope, looking north. 15 August 2018.

Photograph 22: West Dam – upstream slope and north abutment, looking north. 15 August 2018.

Photograph 213: West Dam – upstream slope and south abutment, looking south. 15 August 2018

Photograph 224: West Dam – seepage weir downstream of West Dam. 15 August 2018

Photograph 235: West Dam – seepage weir downstream of West Dam. 15 August 2018

APPENDIX B

Golder Inspection Reports

Client:	**Teck Coal Limited**	**By:**	**Andy Haynes, P.Eng. and Malcolm Shang**
Project:	**GHO Annual Dam Safety Inspection**	**Date:**	**15 August 2018**
Location:	**Main Tailings Dam**		

GENERAL INFORMATION

Dam Type: Zoned Earth Fill

Weather Conditions:	Overcast, smoke from regional fires	**Temp:**	15°C (average)

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST		2 - 9	
1.1 Crest Elevation (Till)	El. 1,731.16		■ ~ 3 m dam raise in 2018. ■ Crest El. from Oct. 2018 GHO survey.
1.2 Reservoir Level / Freeboard	El. 1,726.6 Freeboard > 2 m	2 - 8	■ Pond level from GHO GPS reading in 15 Aug. 2018 ■ Minimum crest on West Dam El. 1,731.14 m limits freeboard. ■ TARP visual warning levels installed (Photograph 7).
1.3 Distance to Tailings Pond (if applicable)	0 m (at dam)	2 - 8	
1.4 Surface Cracking	None		
1.5 Unexpected Settlement	None		
1.6 Lateral Movement	None		
1.7 Other Unusual Conditions	None		■ Under construction at time of inspection.
2. UPSTREAM SLOPE		3 - 6, 8	
2.1 Slope Angle	2H:1V	3 - 6, 8	■ Resloped above pond level, using riprap, since 2016 inspection.
2.2 Signs of Erosion	None		■ Riprap was being placed to protect against future erosion of the till layer.

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
2.3 Signs of Movement (Deformation)	None		
2.4 Cracks	None		
2.5 Face Liner Condition (if applicable)	N/A		
2.5 Other Unusual Conditions	None		■ At the time of inspection, riprap was being placed to protect against future erosion of the till layer.
3. DOWNSTREAM SLOPE		10 - 15	■ Site C and Site D spoils buttress downstream slope.
3.1 Slope Angle	~ 4 H:1 V (overall)		
3.2 Signs of Erosion	None		
3.3 Signs of Movement (Deformation)	None		
3.4 Cracks	None		
3.5 Seepage or Wet Areas	None		■ Site C downstream slope was regraded since 2016 inspection to minimize ponding.
3.6 Vegetation Growth	No concern		
3.7 Other Unusual Conditions	Yes	10, 14, 15	■ Site C and Site D spoils buttress downstream slope.
4. DOWNSTREAM TOE AREA		10 - 15	
4.1 Seepage from Dam	Yes	11 – 13	■ Seepage from rock drains below Site C and Site D ■ Seepage pipe fixed, and seepage collection channel has been upgraded since 2016 inspection. ■ Some seepage is flowing under the seepage collection channel (Photograph 12b). Golder has recommended measures to address this in Golder (2018b).
4.2 Signs of Erosion	None		
4.3 Signs of Turbidity in Seepage Water	None	11 - 13	
4.4 Discoloration/Staining	Yes (red-brown)	11 - 13	■ Red-brown staining along seepage discharge path; which is expected based on the water chemistry.
4.5 Outlet Operating Problem (if applicable)	N/A		

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
4.6 Other Unusual Conditions	Yes	15	■ Failure in surficial soils beneath and downslope of toe. No change since 2012.
5. ABUTMENTS		2, 9	
5.1 Seepage at Contact Zone (abutment/embankment)	None		
5.2 Signs of Erosion	None		
5.3 Excessive Vegetation	None		
5.4 Presence of Rodent Burrows	None		
5.5 Other Unusual Conditions	None		
6. RESERVOIR		1, 2 - 8	■ Tailings discharge point at north side of impoundment ■ Tailings discharge point has been moved about 250 m northwest of the 2016 location.
6.1 Stability of Slopes	No concern		■ Resloped above pond level, using riprap, since 2016 inspection.
6.2 Floating Debris	None		
6.3 Other Unusual Conditions	None		
7. EMERGENCY SPILLWAY/ OUTLET STRUCTURE	N/A.		■ No spillway required since the facility has the capacity to store the Probable Maximum Flood (PMF). ■ Temporary emergency spillway removed near the south abutment of the West Dam in 2017 (prior to site visit).
8. INSTRUMENTATION			
8.1 Piezometers	Yes		■ 10 VW piezometers installed in 2011 (in standpipes) on dam crest. ■ 12 VW piezometers installed on dam crest and Site C downstream slope during Oct-Dec 2016 field investigation.
8.2 Settlement Cells	Yes		■ Survey Prisms A to H on dam crest.
8.3 Thermistors	None		

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
8.4 Survey Monuments / GPS Units	Yes		▪ Survey Prisms A to H on dam crest. ▪ GPS MD-1_ROVER to MD-5_ROVER were installed on the Main Dam in 2018.
8.5 Accelerograph	None		
8.6 Inclinometer	None		▪ 3 slope indicators and 2 inclinometer casings installed during Oct-Nov 2016 field investigation.
8.7 Weirs and Flow Monitors	Yes	12a, 13	▪ Flow weir damaged at toe of Site C refuse stockpile during the upgrade to the seepage collection channel in 2017. ▪ New flow weir installed on the downstream slope of the Site C refuse stockpile in 2018.
8.8 Data Logger(s)	Yes		▪ VW piezometers included in GHO Geo-Explorer monitoring system.
8.9 Other	Yes		▪ GPS #313 on barge to monitor pond level. ▪ GPS #319 and 320 on Site C coarse refuse stockpile.
9. DOCUMENTATION			
9.1 Operation, Maintenance and Surveillance (OMS) Manual 9.1.1 OMS Manual exists	Yes		▪ GHO (2017) ▪ GHO SP&P No. 1543 v3.
9.1.2 OMS Plan reflects current dam conditions	In the process of being updated.		
9.1.3 Date of last revision	March 2017		
9.2 Emergency Preparedness Plan (EPP) 9.2.1 EPP Exists	Yes		▪ GHO (2013a) ▪ GHO SP&P No. 1583 v0.
9.2.2 EPP Reflects Current Conditions	In the process of being updated.		
9.2.3 Date of Last Revision	31 January 2013		

10. NOTES

Dam construction underway during dam safety inspection.

Inspector's Signature	[signature]	**Date:**	27 March 2018

Client:	**Teck Coal Limited**	**By:**	**Andy Haynes, P.Eng. and Malcolm Shang**
Project:	**GHO Annual Dam Safety Inspection**	**Date:**	**15 August 2018**
Location:	**Main Tailings Dam**		

GENERAL INFORMATION

Dam Type: Zoned Earth Fill

Weather Conditions:	Overcast, smoke from regional fires	**Temp:**	15°C (average)

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST		1, 16, 21, 23	
1.1 Crest Elevation (Till)	El. 1,731.14		■ ~ 3 m dam raise in 2018. ■ Crest El. from Oct. 2018 GHO survey.
1.2 Reservoir Level / Freeboard	El. 1,726.6 Freeboard > 2 m		■ Pond level from GHO GPS reading in 15 Aug. 2018. ■ Minimum crest on West Dam El. 1,731.14 m limits freeboard.
1.3 Distance to Tailings Pond (if applicable)	0 m	1	■ Minor ponding visible near the southern portion of the West Dam.
1.4 Surface Cracking	None		
1.5 Unexpected Settlement	None		
1.6 Lateral Movement	None		
1.7 Other Unusual Conditions	None		
2. UPSTREAM SLOPE		16, 22, 23	
2.1 Slope Angle	2H : 1V	16, 22, 23	
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		

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
2.5 Other Unusual Conditions	None		
3. DOWNSTREAM SLOPE		17 - 19	
3.1 Slope Angle	~ 2 to 2.5 H:1 V		
3.2 Signs of Erosion	None		
3.3 Signs of Movement (Deformation)	None		
3.4 Cracks	None		
3.5 Seepage or Wet Areas	None		
3.6 Vegetation Growth	None		
3.7 Other Unusual Conditions	Yes		
4. DOWNSTREAM TOE AREA		24, 25	
4.1 Seepage from Dam	Yes	24, 25	
4.2 Signs of Erosion	None		
4.3 Signs of Turbidity in Seepage Water	None	24, 25	
4.4 Discoloration/Staining	None	24, 25	
4.5 Outlet Operating Problem (if applicable)	N/A		
4.6 Other Unusual Conditions	None		
5. ABUTMENTS		20, 22	
5.1 Seepage at Contact Zone (abutment/embankment)	None		
5.2 Signs of Erosion	None		
5.3 Excessive Vegetation	No	20, 22	
5.4 Presence of Rodent Burrows	None		
5.5 Other Unusual Conditions	None		
6. RESERVOIR		1, 16	▪ Tailings discharge point at north side of impoundment.
6.1 Stability of Slopes	Stable		▪ Natural slopes located south of pond.
6.2 Floating Debris	None		
6.3 Other Unusual Conditions	None		
7. EMERGENCY SPILLWAY/ OUTLET STRUCTURE	N/A.		▪ No spillway required since the facility has the capacity to store the Probable Maximum Flood (PMF). ▪ Temporary emergency spillway removed near the south abutment of the West Dam in 2017 (prior to site visit).

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
8. INSTRUMENTATION			
8.1 Piezometers	Yes		■ 3 VW piezometers (in standpipe) (each has two depths) on dam crest.
8.2 Settlement Cells	Yes		■ Survey Prisms I to M on dam crest.
8.3 Thermistors	None		
8.4 Survey Monuments / GPS Units	None		■ Survey Prisms A to H on dam crest. ■ GPS WD-1_ROVER to WD-3_ROVER were installed on the West Dam in 2018.
8.5 Accelerograph	None		
8.6 Inclinometer	None		
8.7 Weirs and Flow Monitors	Yes	24, 25	
8.8 Data Logger(s)	Yes		■ VW piezometers included in GHO Geo-Explorer monitoring system.
8.9 Other	Yes		■ GPS #313 on barge to monitor pond level.
9. DOCUMENTATION			
9.1 Operation, Maintenance, and Surveillance (OMS) Manual 9.1.1 OMS Manual Exists	Yes		■ GHO (2017) ■ GHO SP&P No. 1543 v3.
9.1.2 OMS Plan reflects current conditions	In the process of being updated.		
9.1.3 Date of Last Revision	March 2017		
9.2 Emergency Preparedness Plan (EPP) 9.2.1 EPP exists	Yes		■ GHO (2013a) ■ GHO SP&P No. 1583 v0.
9.2.2 EPP reflects current conditions	In the process of being updated.		
9.2.3 Date of Last Revision	31 January 2013		

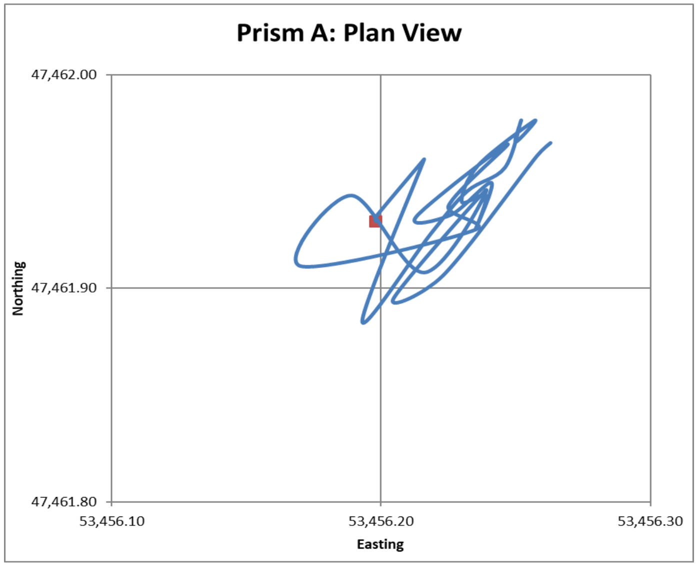
10. NOTES

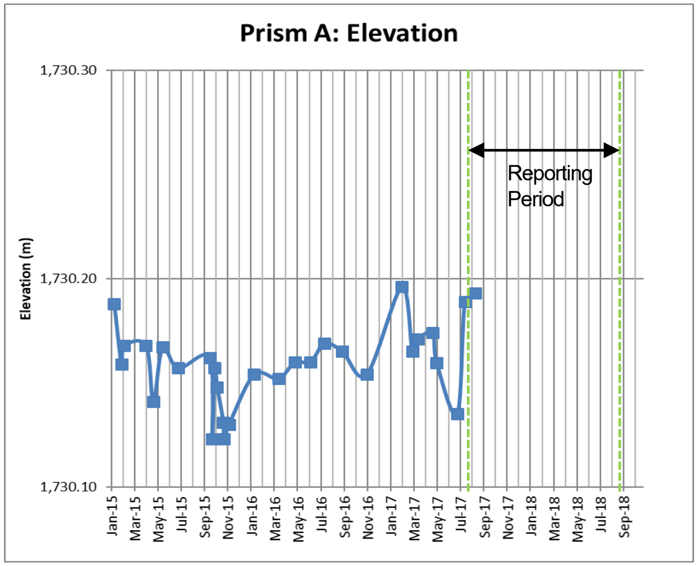
Inspector's Signature	[signature]	**Date:**	27 March 2018

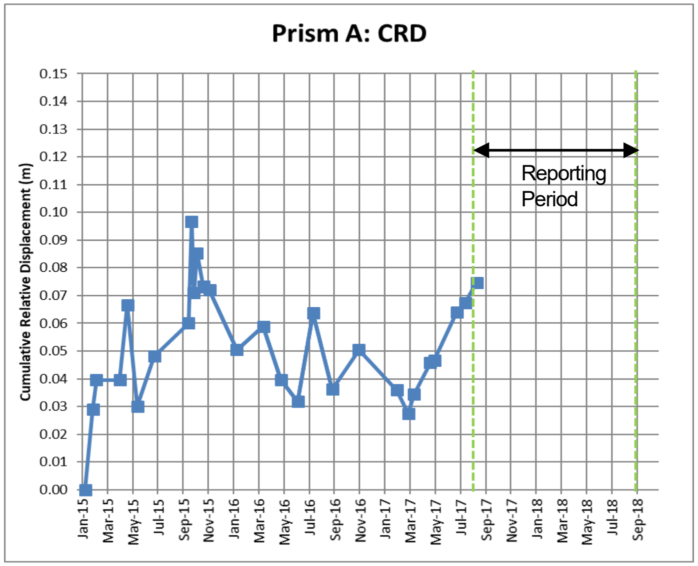
APPENDIX C

Site C, GPS & SI Monitoring

https://golderassociates.sharepoint.com/sites/13539g/Technical%20Work/Forms/AllItems.aspx?e=5%3Ac942849aac8946d6950a8e1862e830dd&FolderCTID=0x0120006B8675F76F83B446A8F064A43556ECB3&id=%2Fsites%2F13539g%2FTechnical%20Work%2FAnalysis%2FSite%20GPS%20and%20Prisms





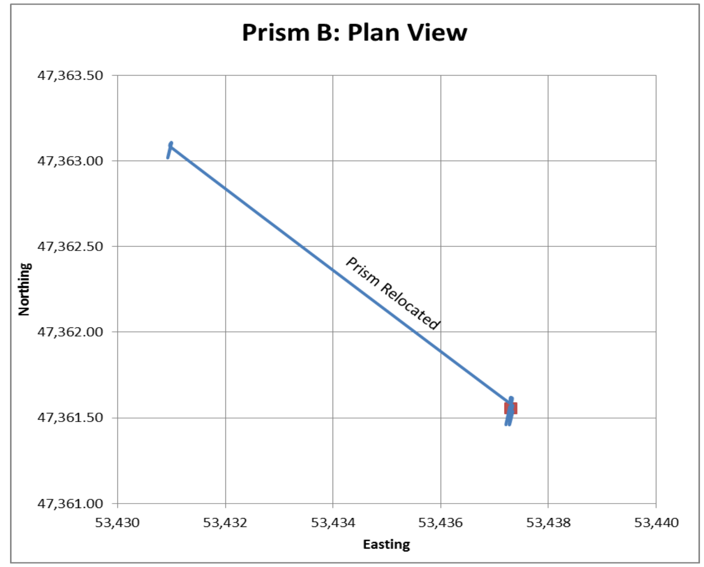


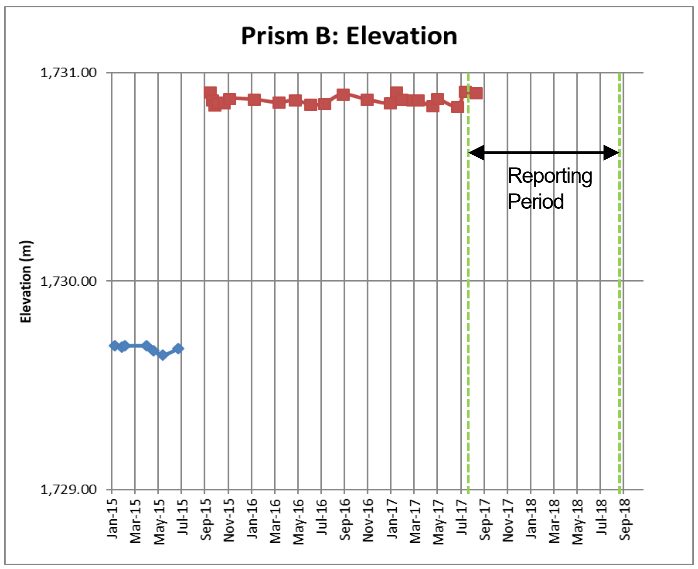
■ Initial Reading (Jan 2015)

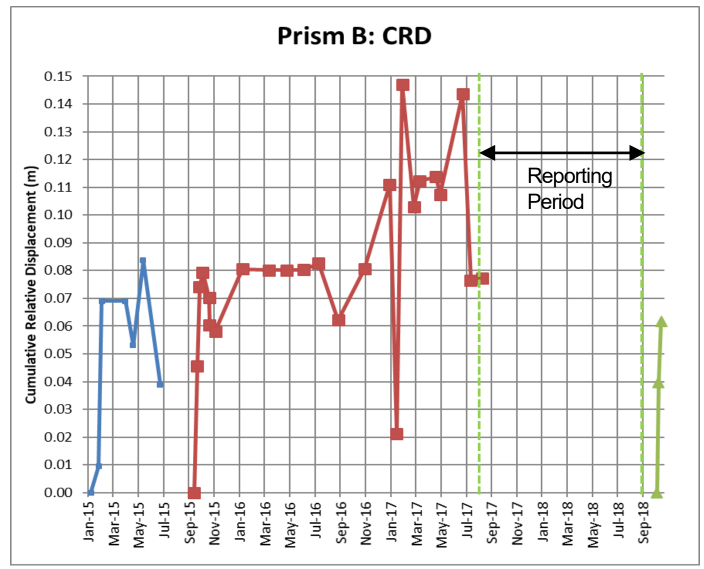
◆ Readings (2015 to 2017)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018.

CLIENT TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC		PROJECT 2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION	
CONSULTANT GOLDER	YYYY-MM-DD: 2019-03-04 PREPARED: NEC DESIGN: NEC REVIEW: MS APPROVED: —	TITLE **GREENHILLS TAILINGS FACILITY** **PRISM A**	
		PROJECT No. **1894290**	Phase/Task/DOC. **2000/2050/2018-133**
		Rev. **0**	FIGURE **C-1**





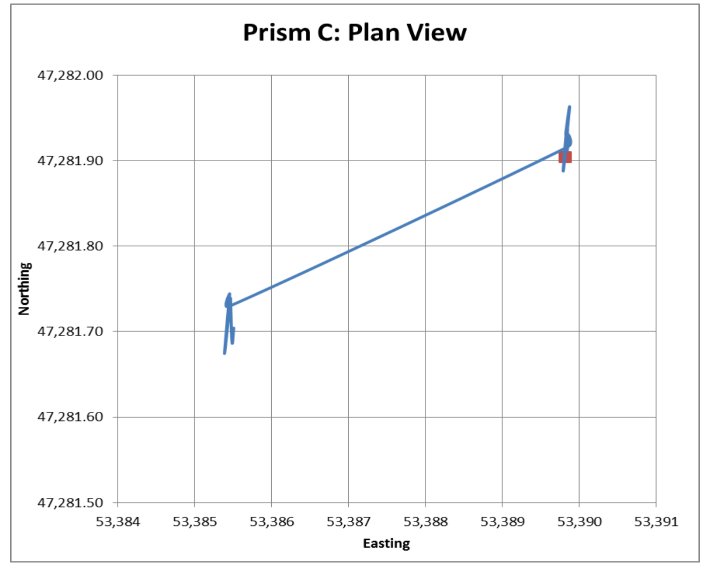


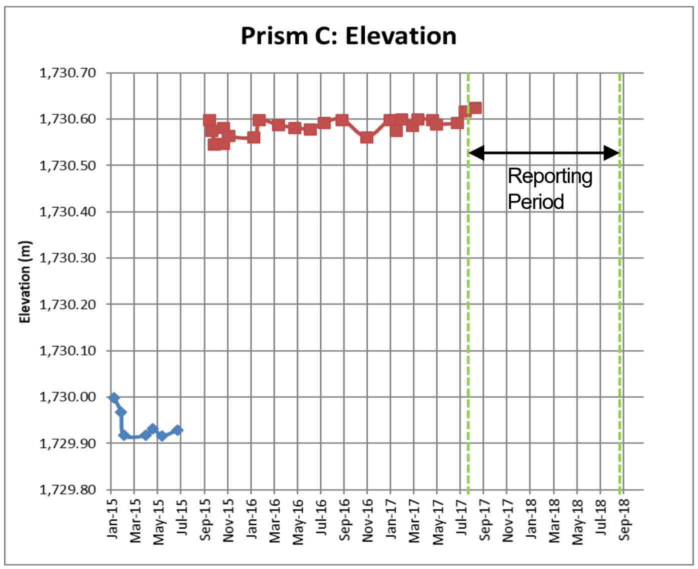
- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

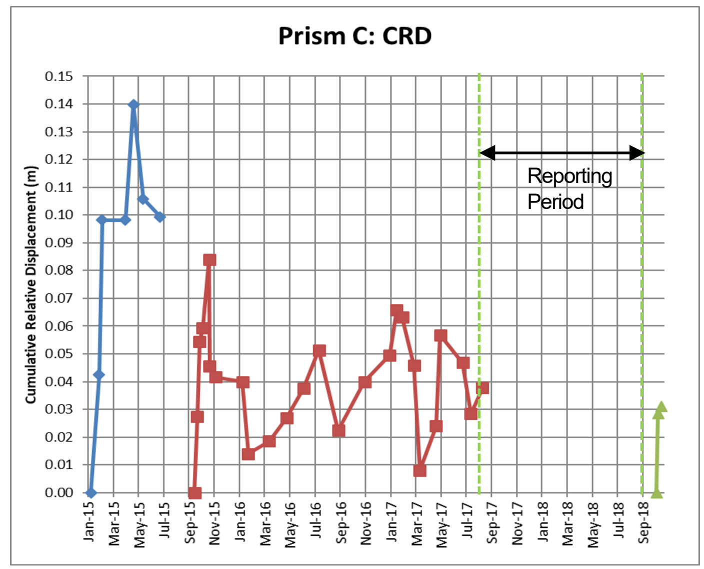
CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC		PROJECT 2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION	
CONSULTANT GOLDER	YYYY-MM-DD	2019-03-04	TITLE **GREENHILLS TAILINGS FACILITY** **PRISM B**
	PREPARED	NEC	
	DESIGN	NEC	
	REVIEW	MS	
	APPROVED	—	

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-2







- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

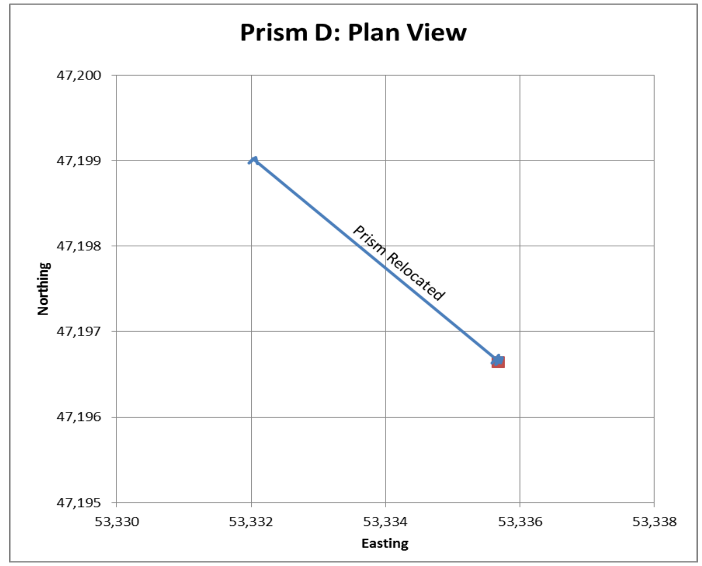
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

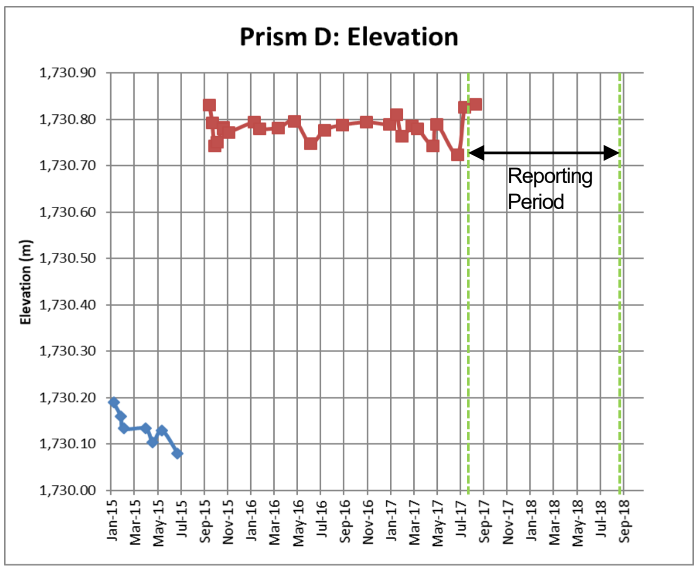
CONSULTANT
GOLDER

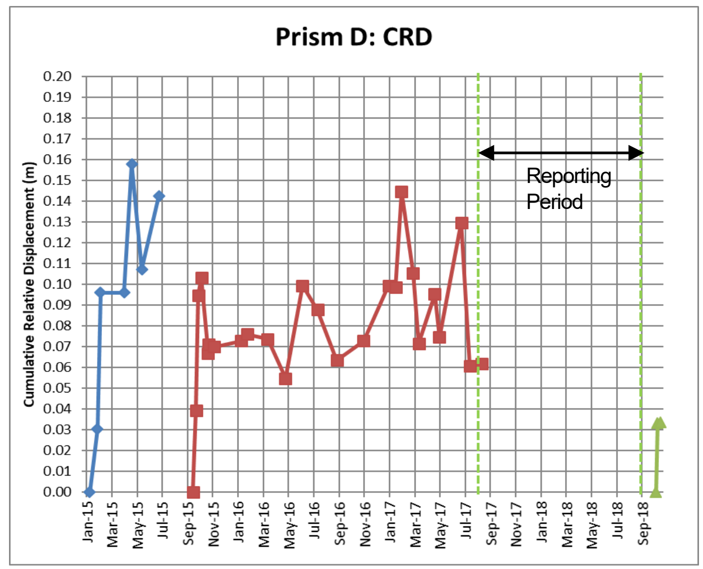
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

TITLE
GREENHILLS TAILINGS FACILITY
PRISM C

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-3







- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

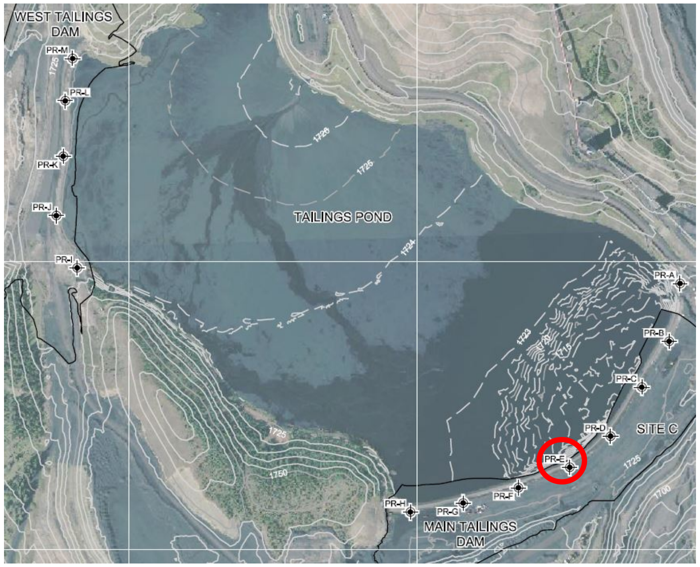
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

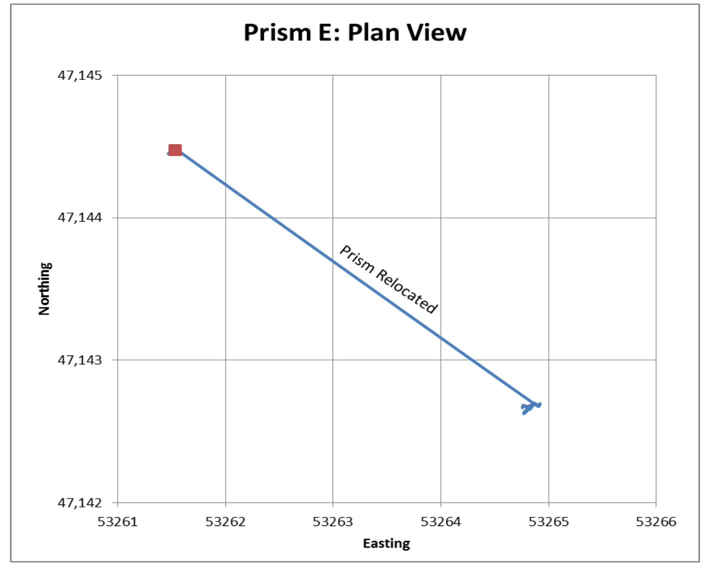
CONSULTANT
GOLDER

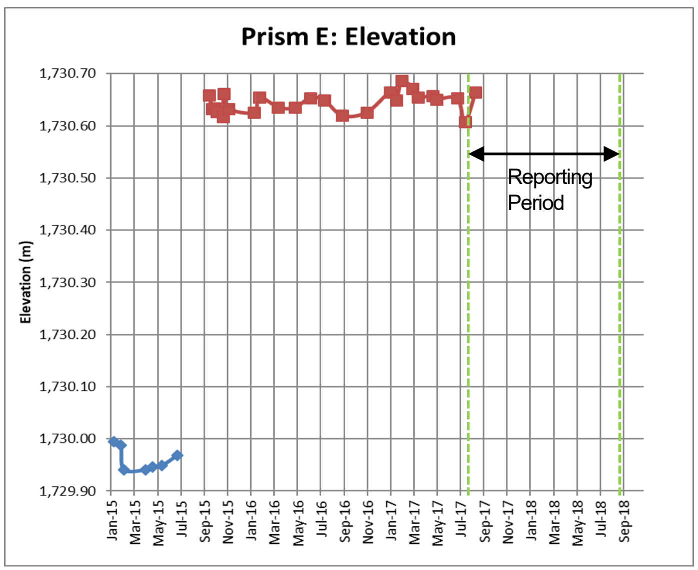
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

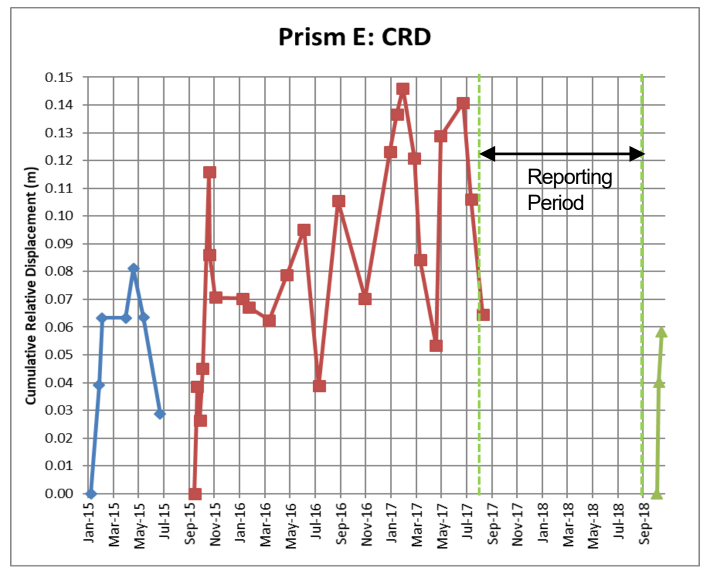
TITLE
GREENHILLS TAILINGS FACILITY
PRISM D

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-4









Initial Reading (Jan 2015)
Readings Before Relocation (2015)
Readings After Relocation (2015 to 2017)
Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

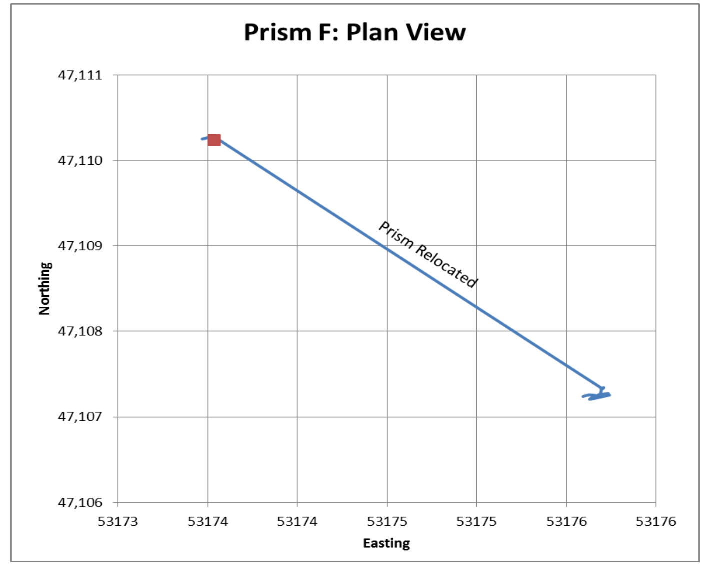
CONSULTANT
GOLDER

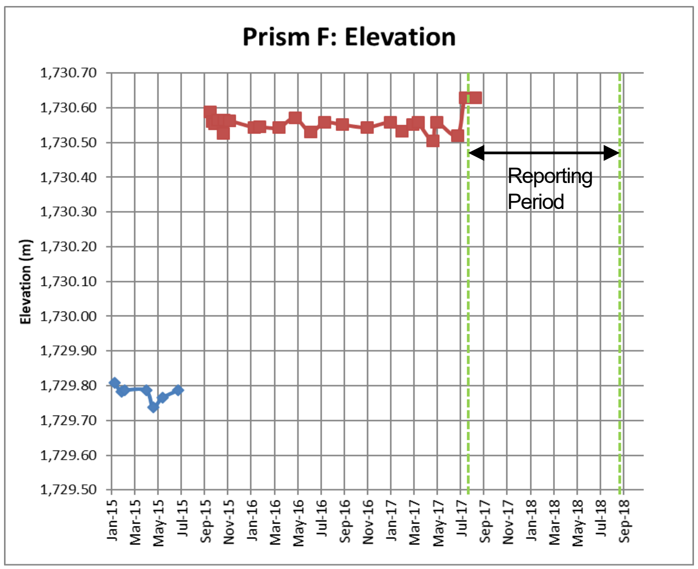
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

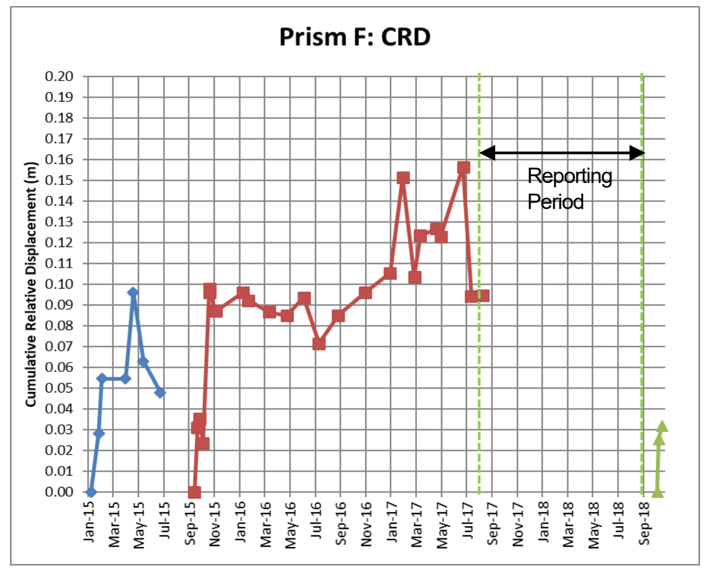
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

TITLE
GREENHILLS TAILINGS FACILITY
PRISM E

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-5



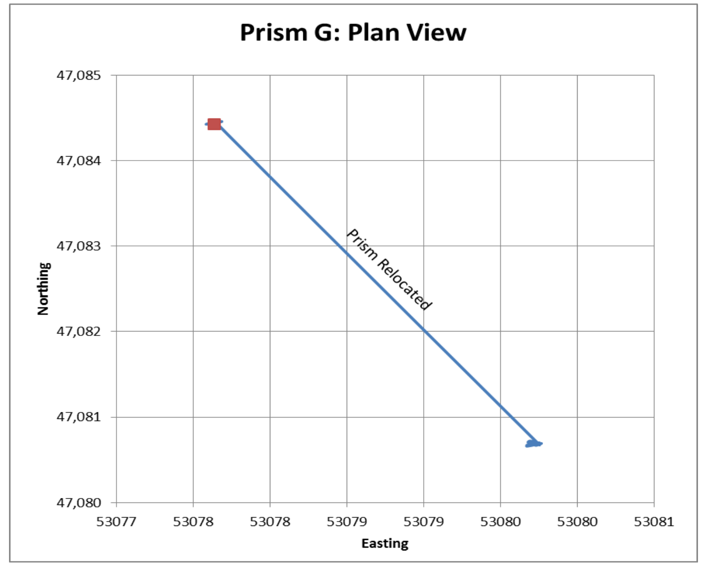


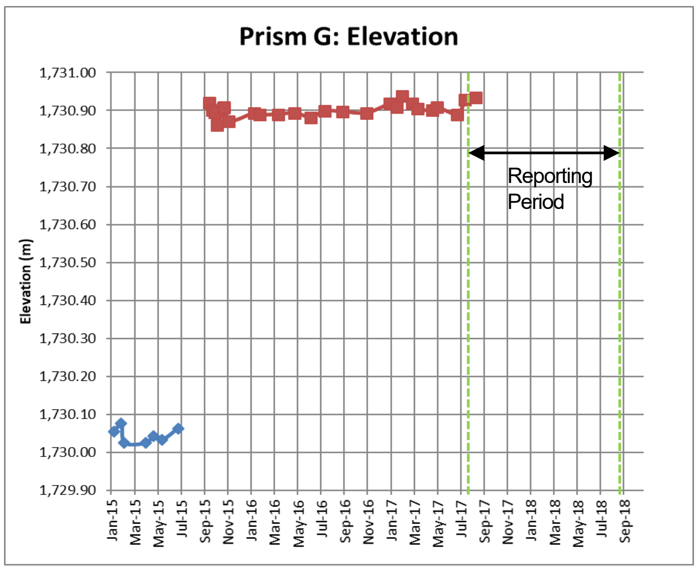


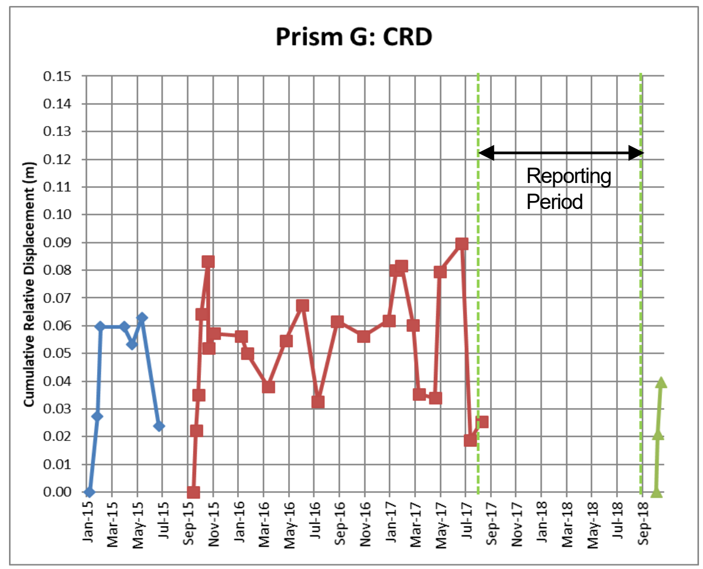
- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC		PROJECT 2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION	
CONSULTANT GOLDER	YYYY-MM-DD	2019-03-04	TITLE **GREENHILLS TAILINGS FACILITY** **PRISM F**
	PREPARED	NEC	
	DESIGN	NEC	
	REVIEW	MS	PROJECT No. **1894290** · Phase/Task/DOC. **2000/2050/2018-133** · Rev. **0** · FIGURE **C-6**
	APPROVED	—	



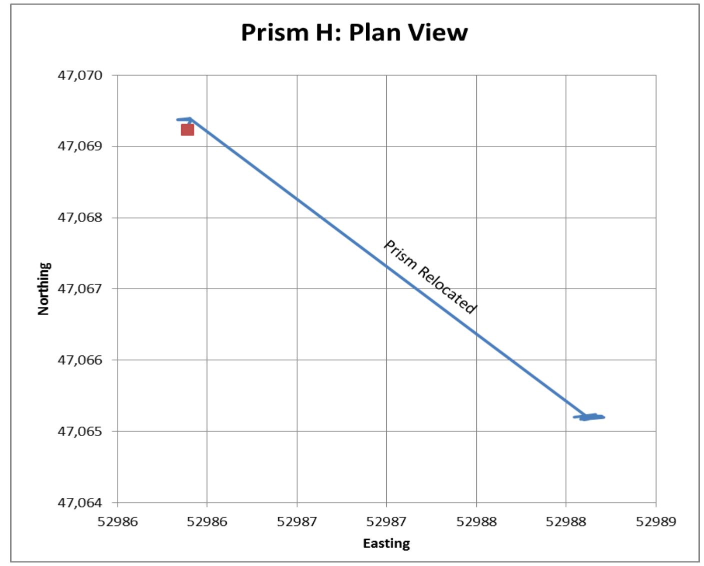


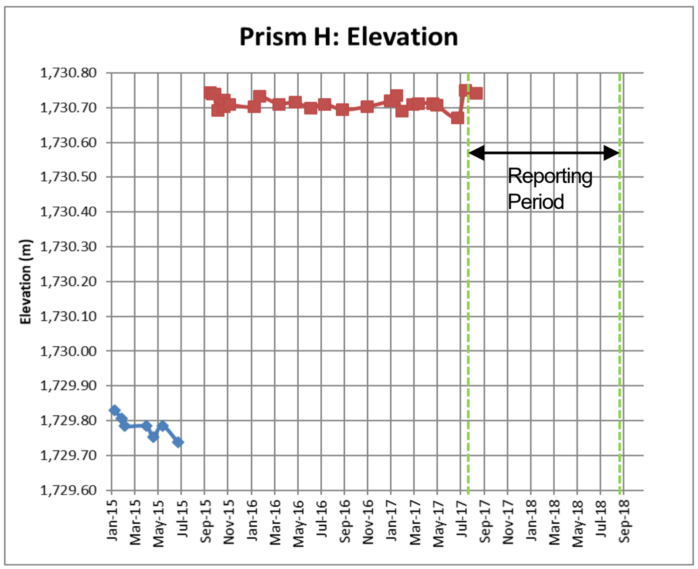


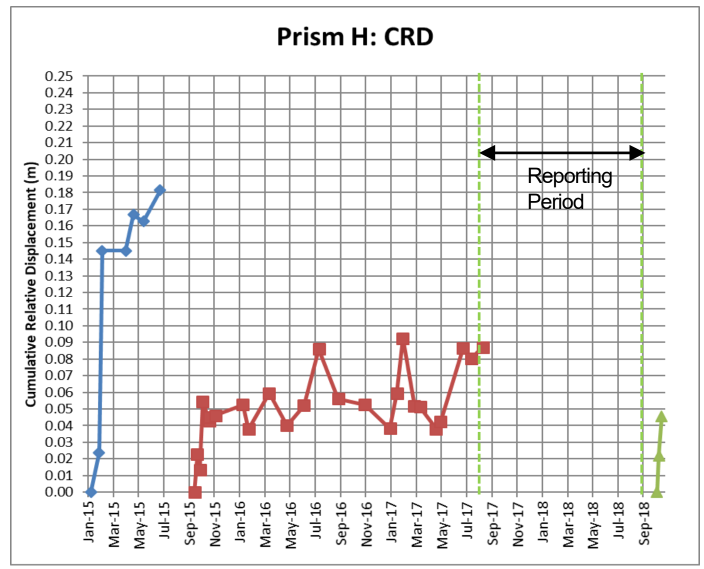
- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT	TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC
CONSULTANT	GOLDER
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—
PROJECT	2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION
TITLE	**GREENHILLS TAILINGS FACILITY** **PRISM G**
PROJECT No.	1894290
Phase/Task/DOC.	2000/2050/2018-133
Rev.	0
FIGURE	C-7







- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

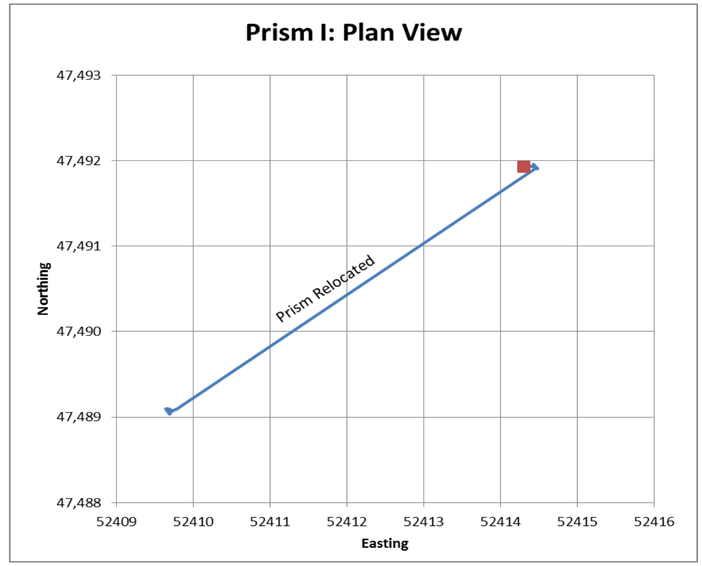
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

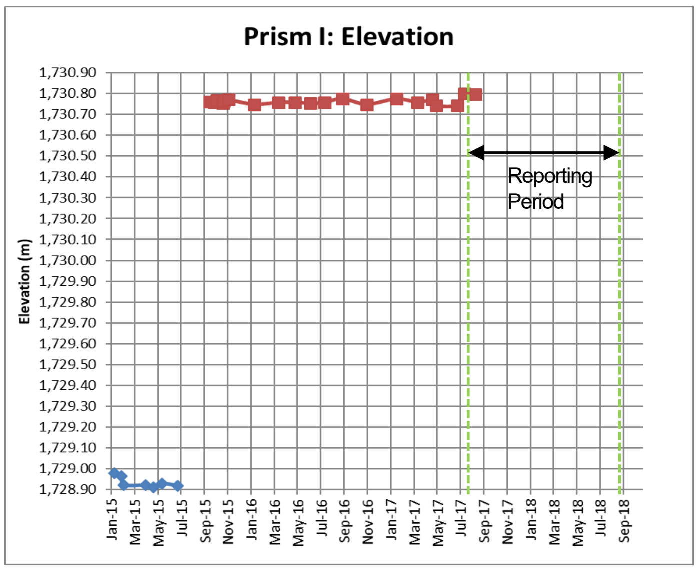
CONSULTANT
GOLDER

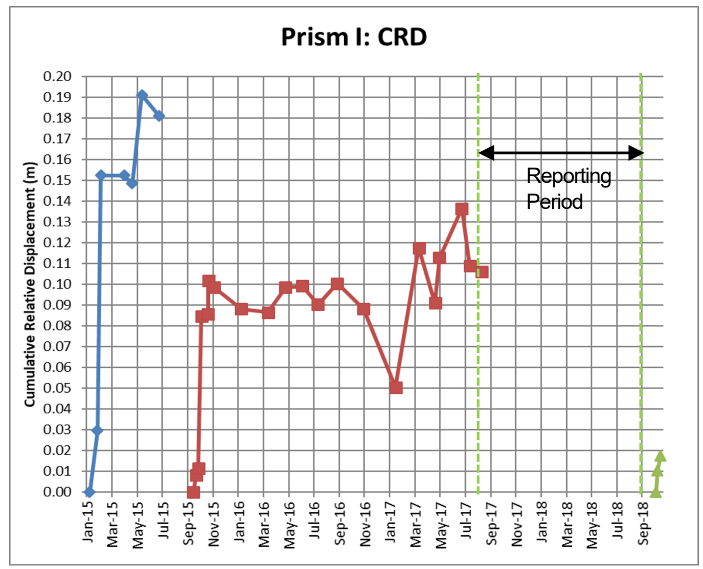
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

TITLE
GREENHILLS TAILINGS FACILITY
PRISM H

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-8







- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC		PROJECT 2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION	
CONSULTANT GOLDER	YYYY-MM-DD: 2019-03-04 PREPARED: NEC DESIGN: NEC REVIEW: MS APPROVED: —	TITLE **GREENHILLS TAILINGS FACILITY** **PRISM I**	
		PROJECT No.: 1894290	Phase/Task/DOC.: 2000/2050/2018-133
		Rev.: 0	FIGURE: C-9

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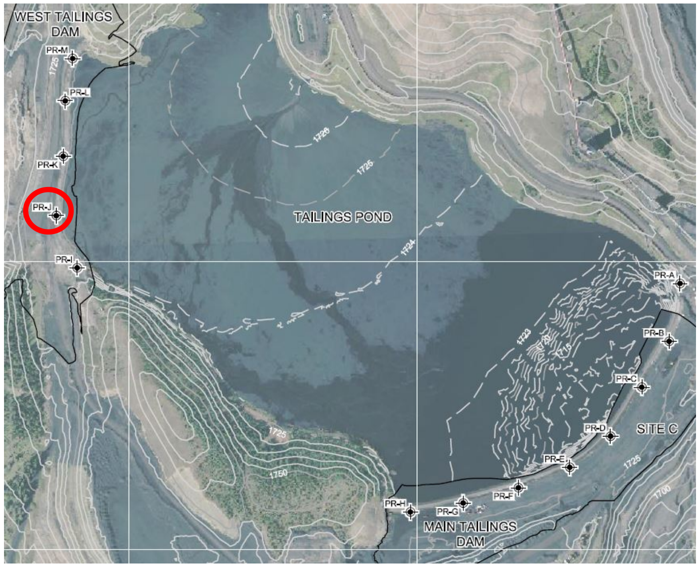
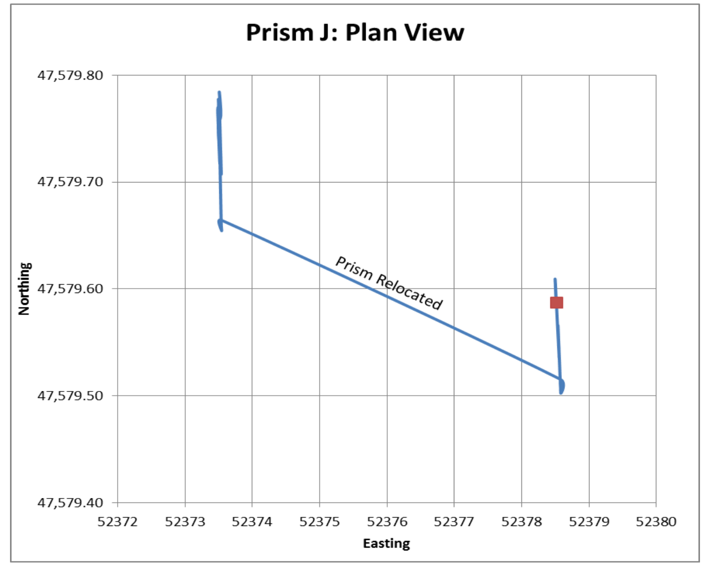
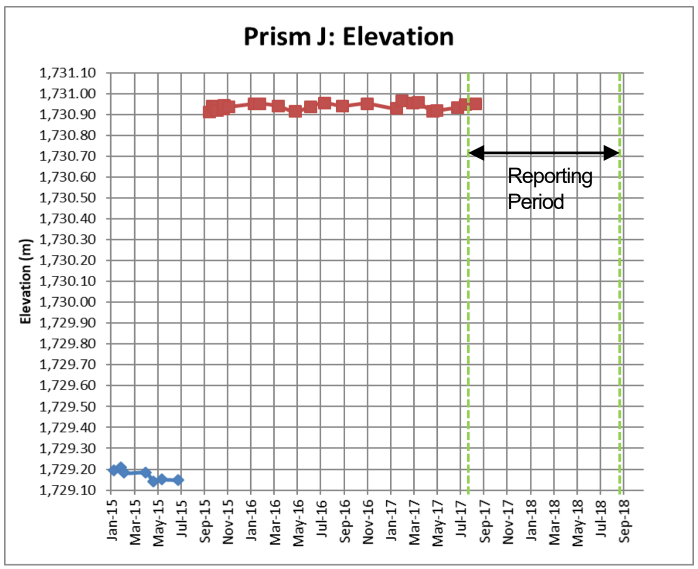
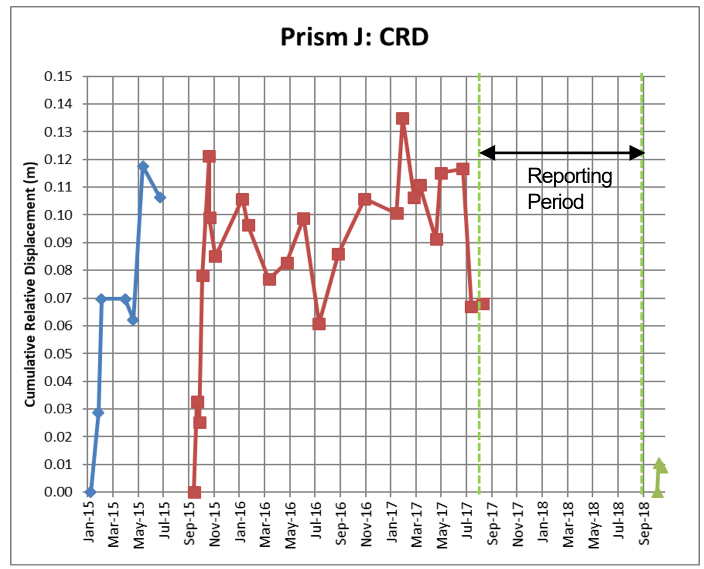








- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

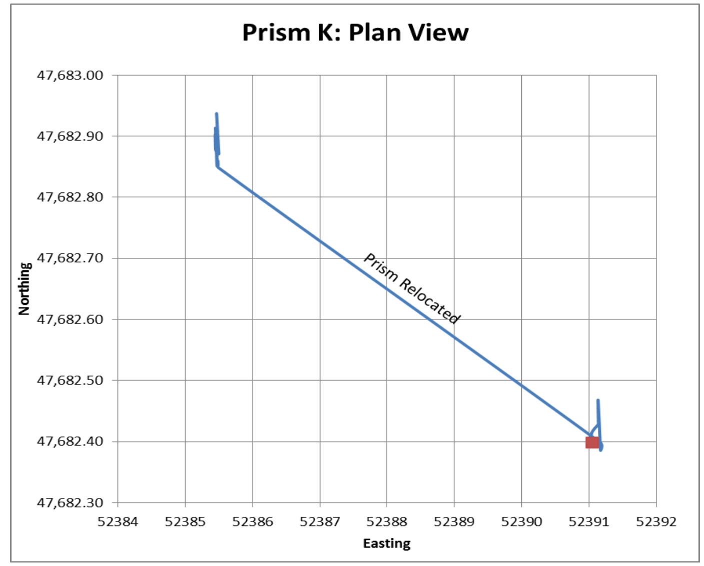
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

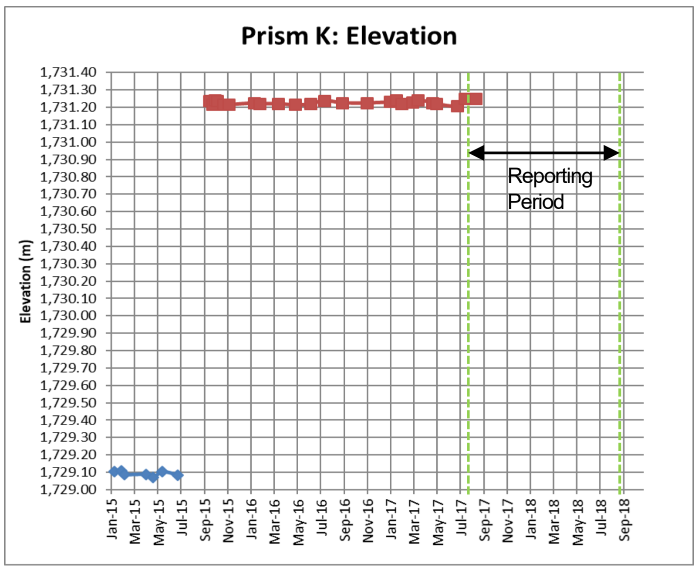
CONSULTANT: GOLDER

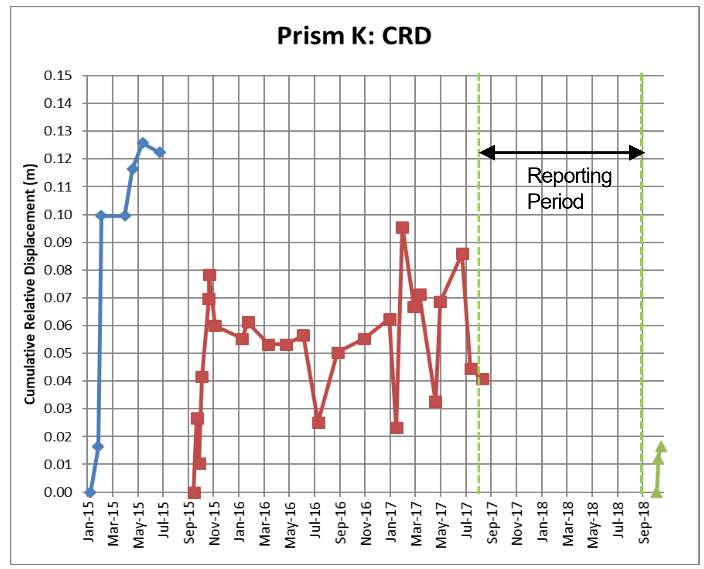
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

TITLE
GREENHILLS TAILINGS FACILITY
PRISM J

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-10







- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT	TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC
CONSULTANT	GOLDER
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—
PROJECT	2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION
TITLE	**GREENHILLS TAILINGS FACILITY** **PRISM K**
PROJECT No.	1894290
Phase/Task/DOC.	2000/2050/2018-133
Rev.	0
FIGURE	C-11

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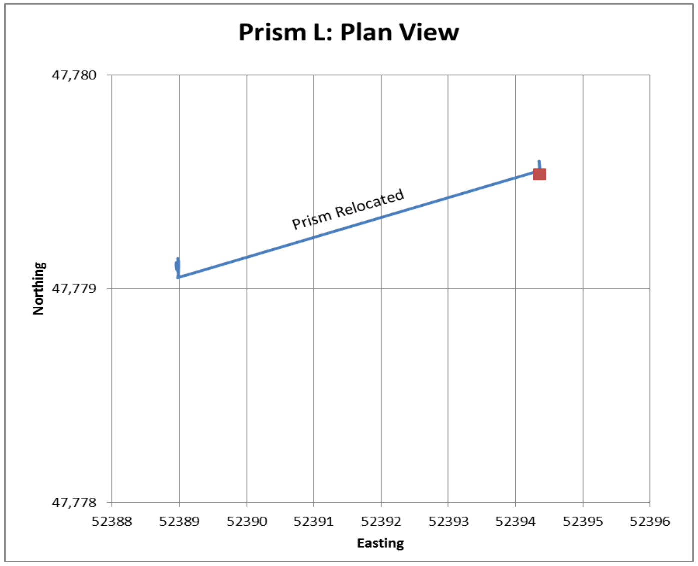
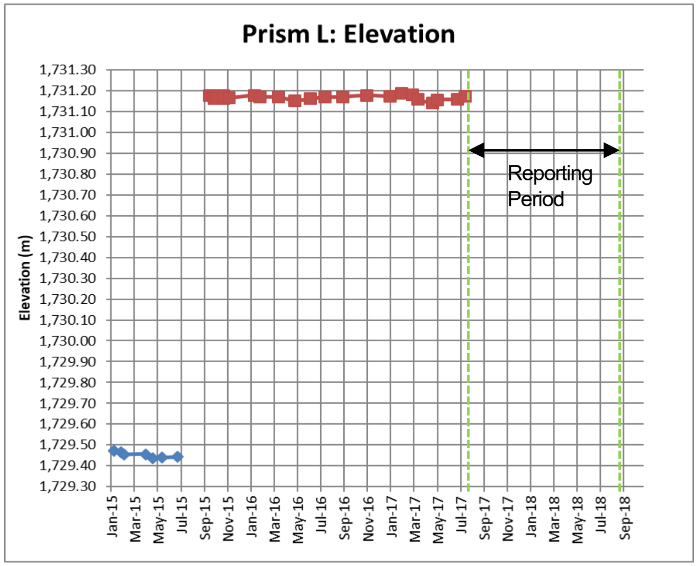
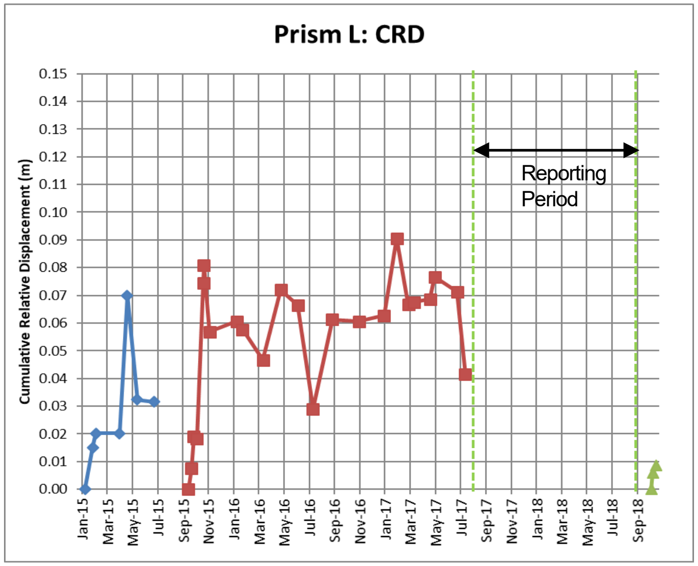


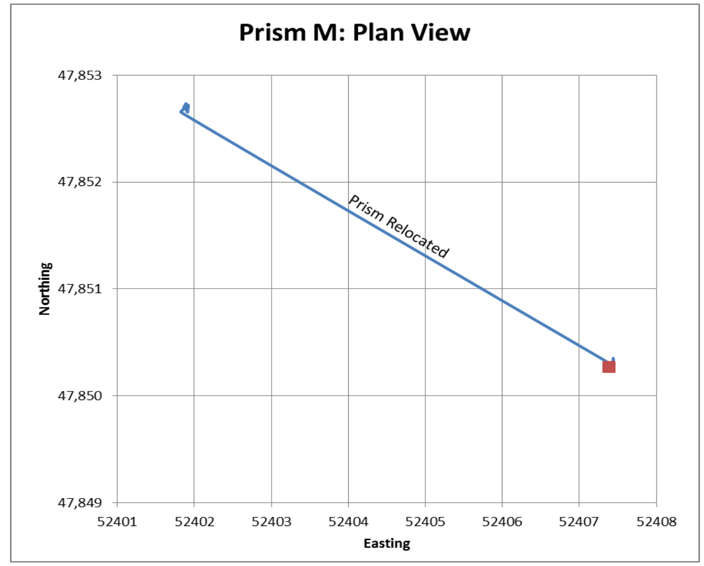


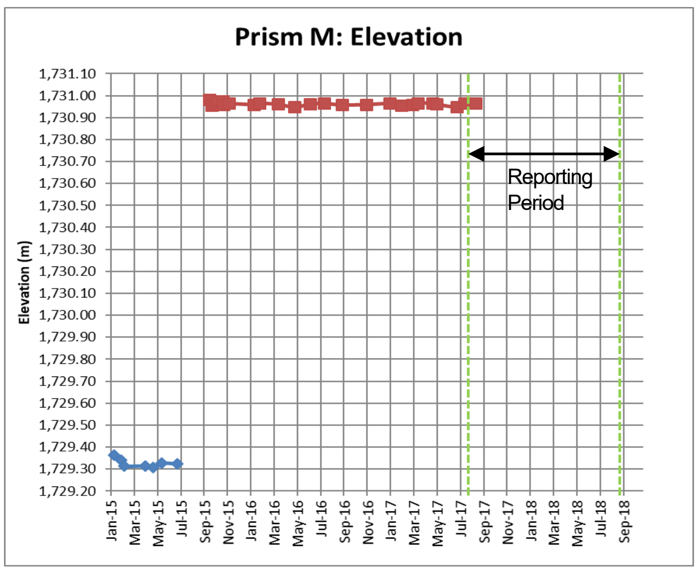


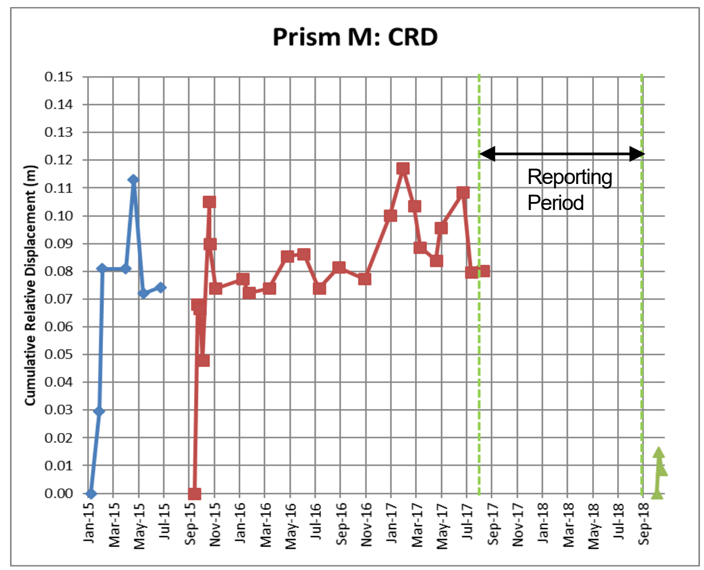
- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT	TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC
PROJECT	2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION
CONSULTANT	GOLDER
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—
TITLE	GREENHILLS TAILINGS FACILITY PRISM L
PROJECT No.	1894290
Phase/Task/DOC.	2000/2050/2018-133
Rev.	0
FIGURE	C-12







- Initial Reading (Jan 2015)
- Readings Before Relocation (2015)
- Readings After Relocation (2015 to 2017)
- Readings After Relocation (2018)

CRD = Cumulative Relative Displacement
Note: No readings taken during 2018 reporting period.

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

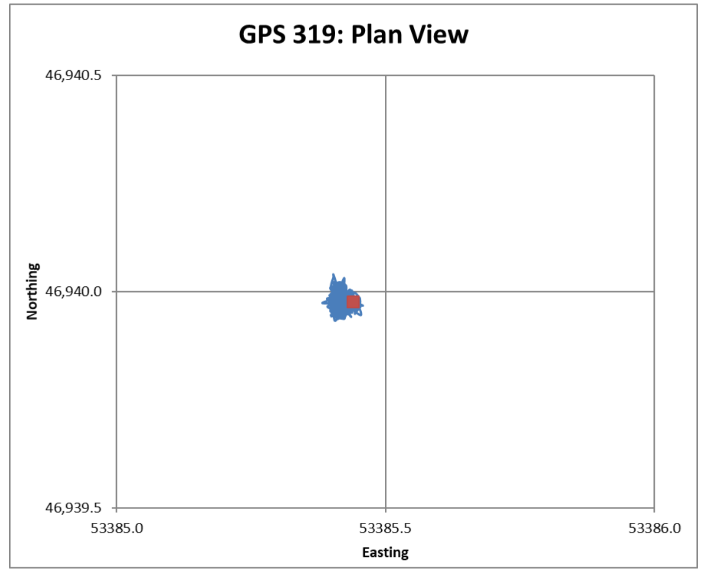
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

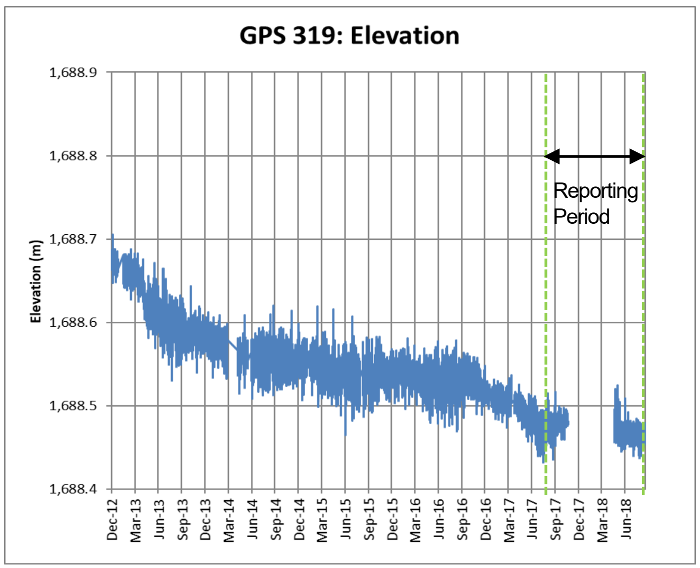
CONSULTANT
GOLDER

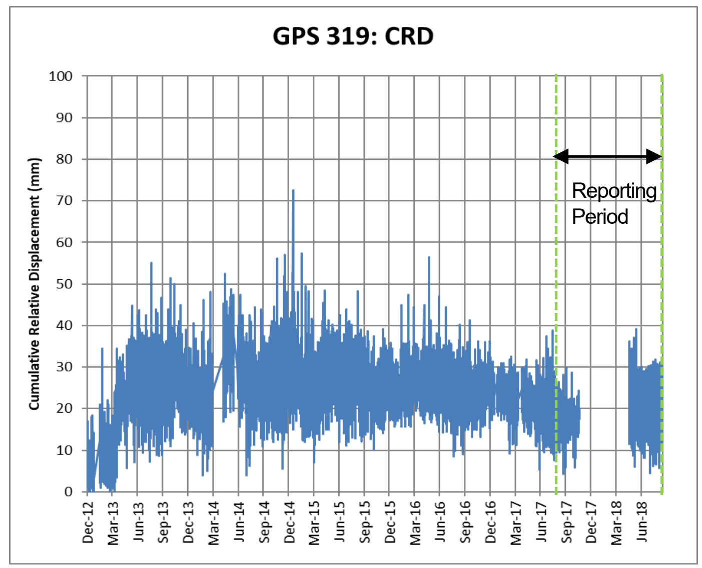
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

TITLE
GREENHILLS TAILINGS FACILITY
PRISM M

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-13







Initial Reading (December 2012)

Readings (2012-2018)

CRD = Cumulative Relative Displacement

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

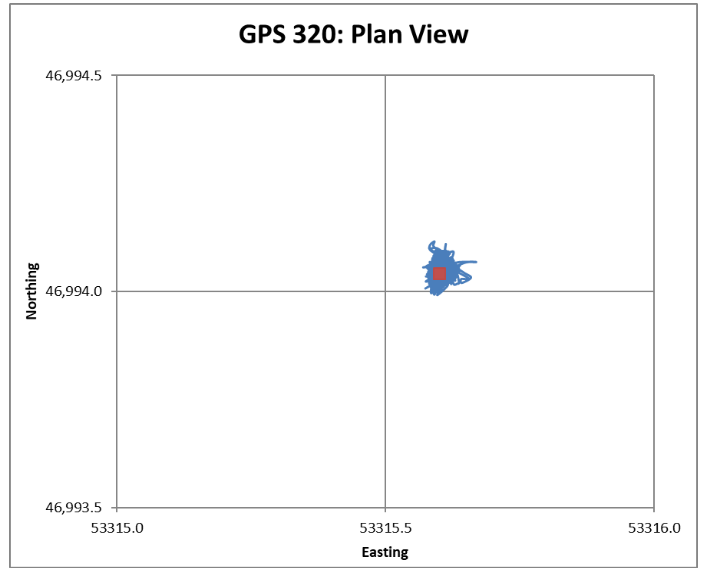
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

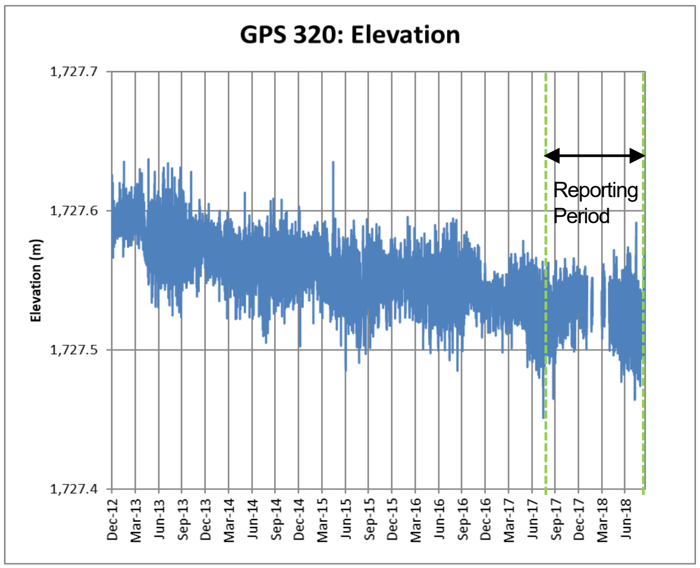
CONSULTANT
GOLDER

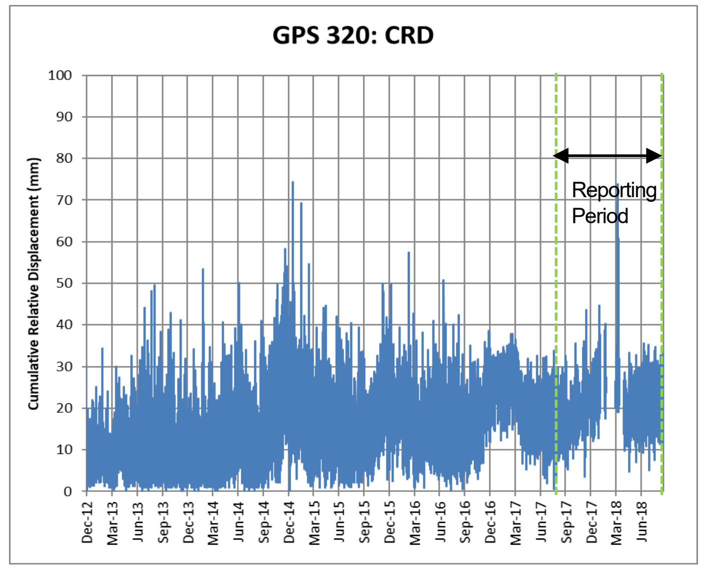
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

TITLE
GREENHILLS TAILINGS FACILITY
GPS 319

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-14







Initial Reading (October 2012)
Readings (2012-2018)

CRD = Cumulative Relative Displacement

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

CONSULTANT

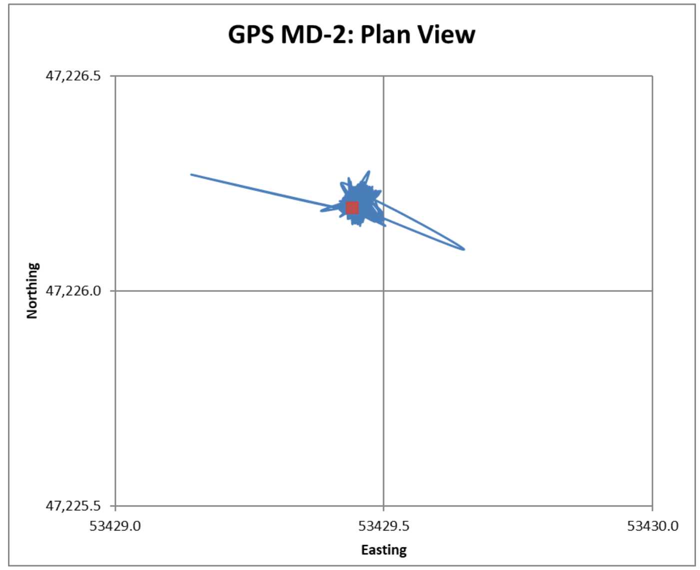
GOLDER

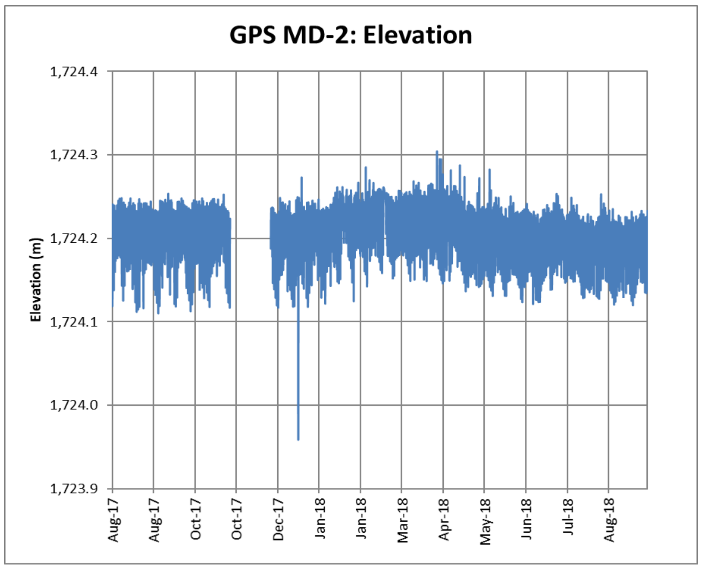
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

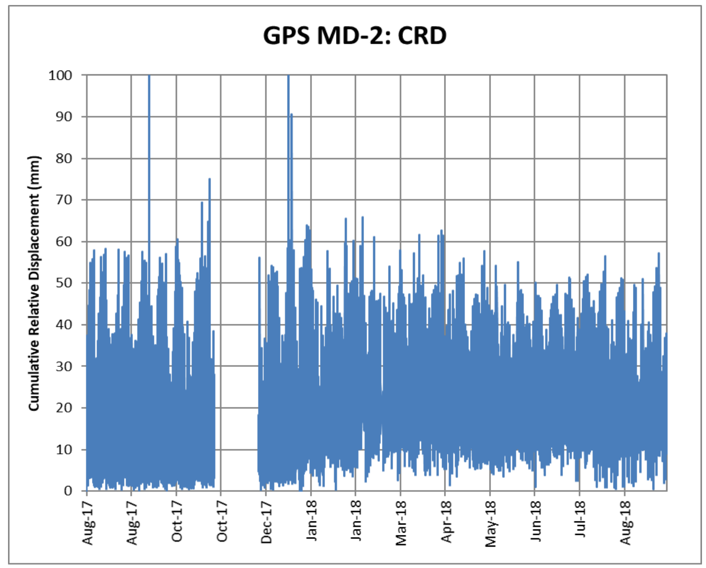
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

TITLE
GREENHILLS TAILINGS FACILITY
GPS 320

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-15





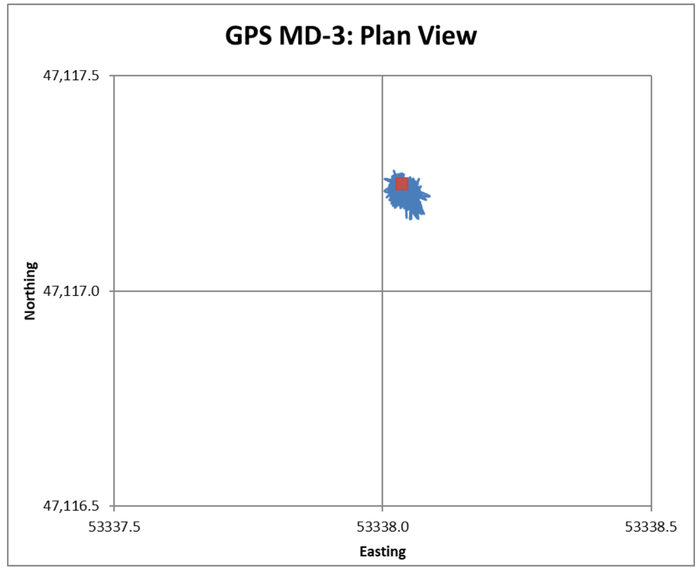


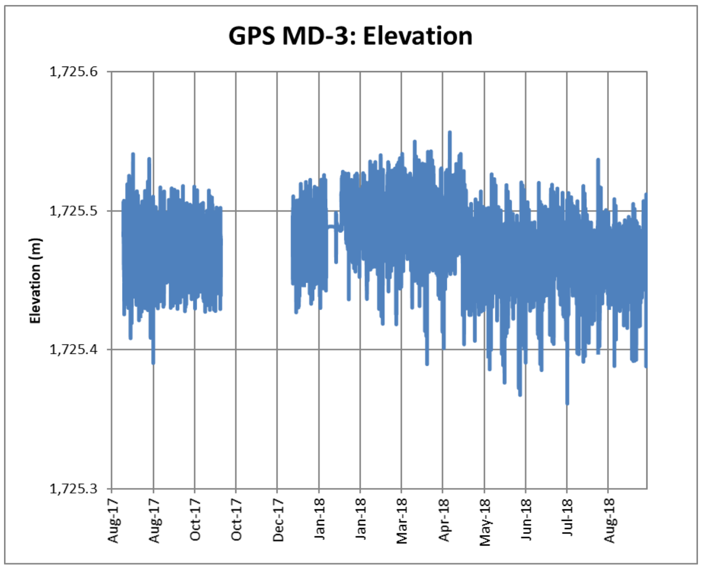
Initial Reading (August 2018)

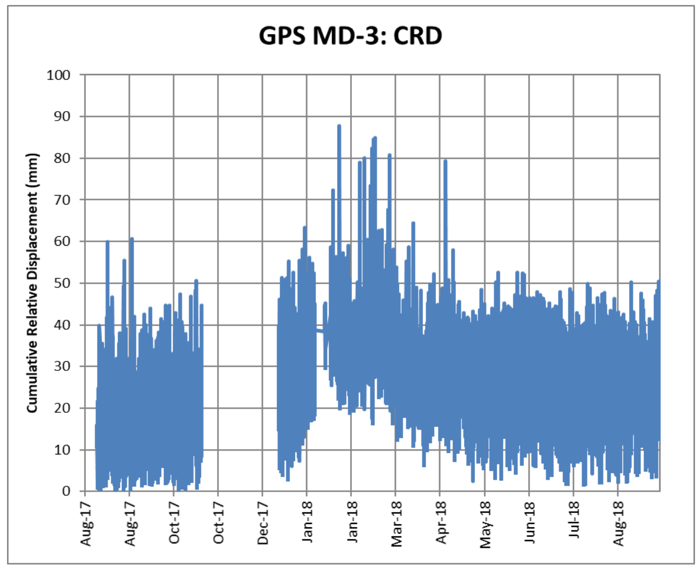
Readings (2018)

CRD = Cumulative Relative Displacement

CLIENT	TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC
CONSULTANT	GOLDER
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—
PROJECT	2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION
TITLE	**GREENHILLS TAILINGS FACILITY** **GPS MD-2_ROVER**
PROJECT No.	1894290
Phase/Task/DOC.	2000/2050/2018-133
Rev.	0
FIGURE	C-16





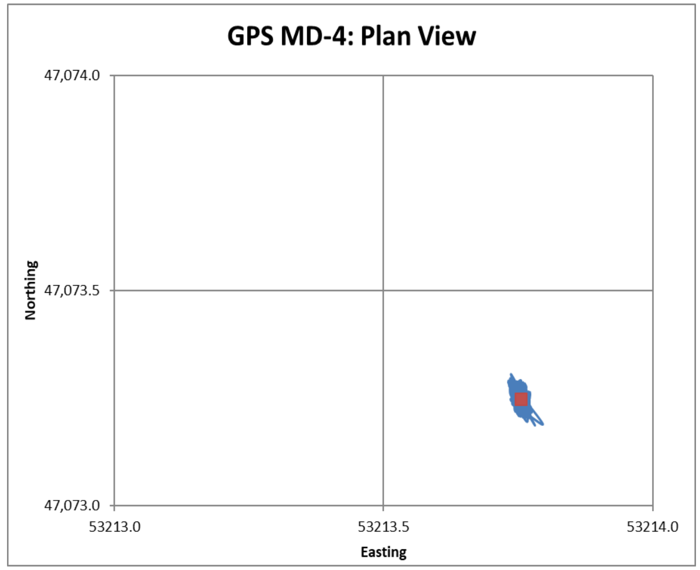


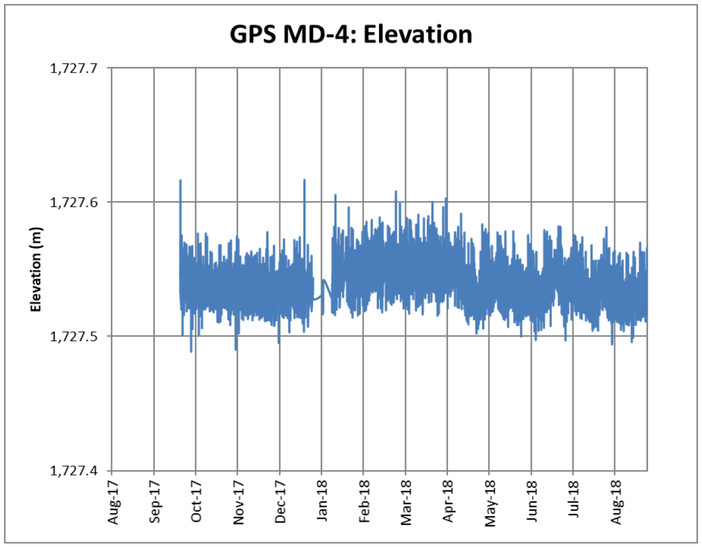
■ Initial Reading (August 2018)

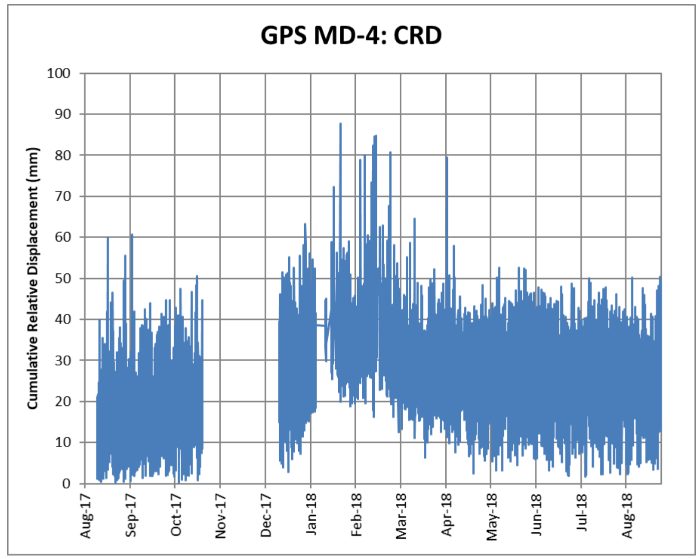
— Readings (2018)

CRD = Cumulative Relative Displacement

CLIENT TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC		PROJECT 2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION	
CONSULTANT GOLDER	YYYY-MM-DD	2019-03-04	TITLE **GREENHILLS TAILINGS FACILITY** **GPS MD-3_ROVER**
	PREPARED	NEC	
	DESIGN	NEC	
	REVIEW	MS	
	APPROVED	—	PROJECT No. 1894290 / Phase/Task/DOC. 2000/2050/2018-133 / Rev. 0 / FIGURE C-17







Initial Reading (September 2018)
Readings (2018)

CRD = Cumulative Relative Displacement

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

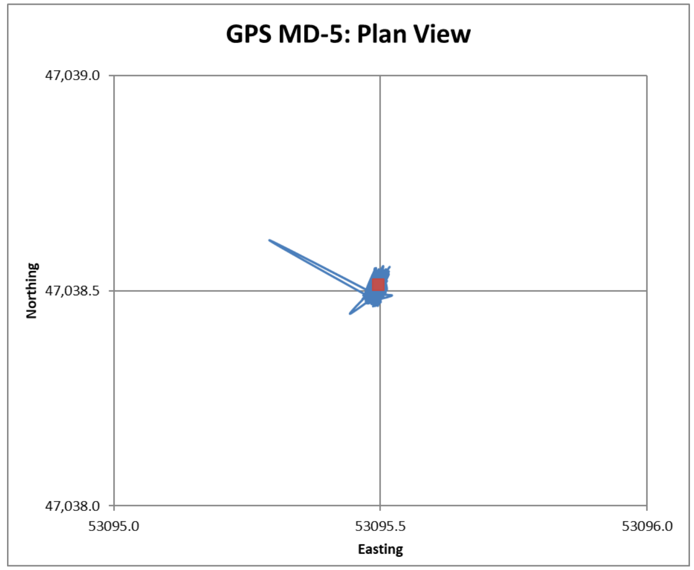
CONSULTANT
GOLDER

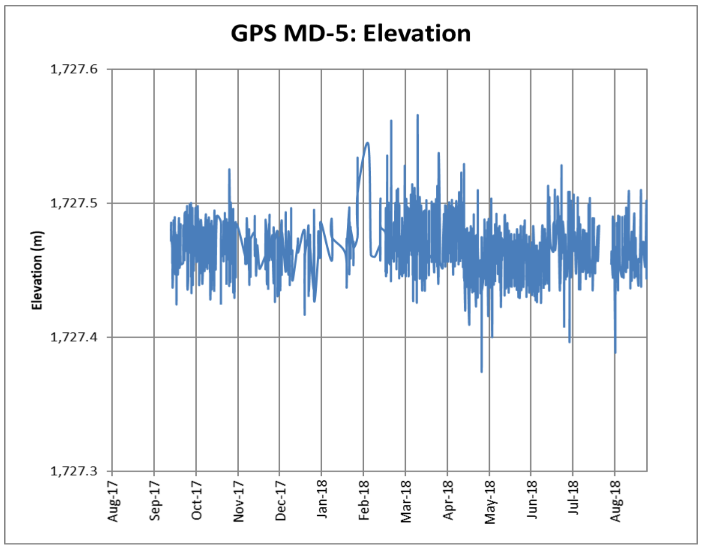
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

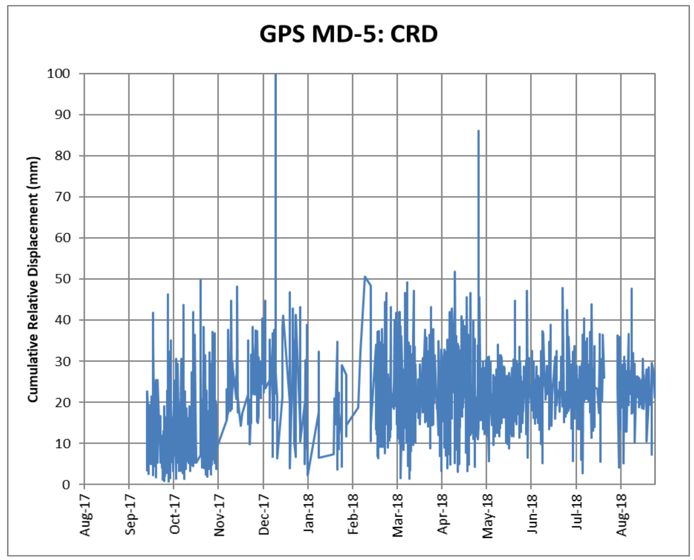
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

TITLE
GREENHILLS TAILINGS FACILITY
GPS MD-4_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-18







Initial Reading (September 2018)

Readings (2018)

CRD = Cumulative Relative Displacement

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

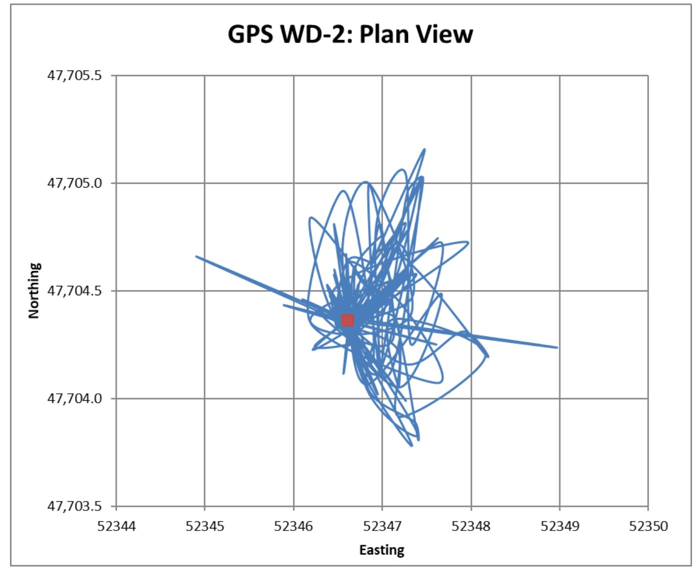
PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

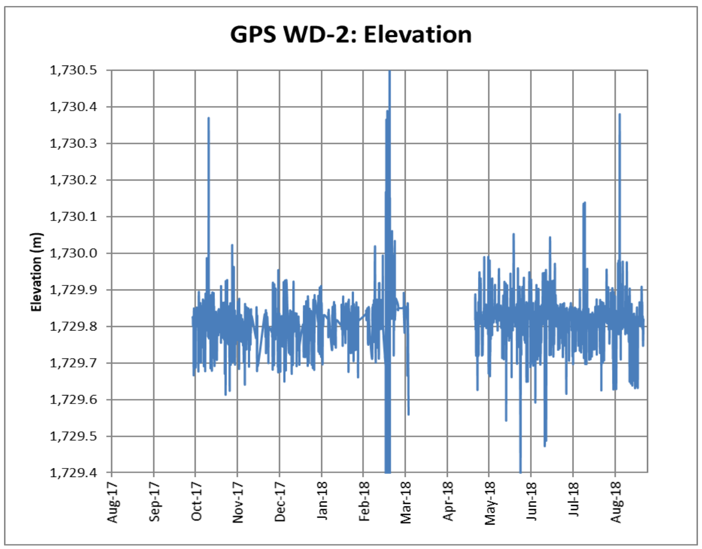
CONSULTANT
GOLDER

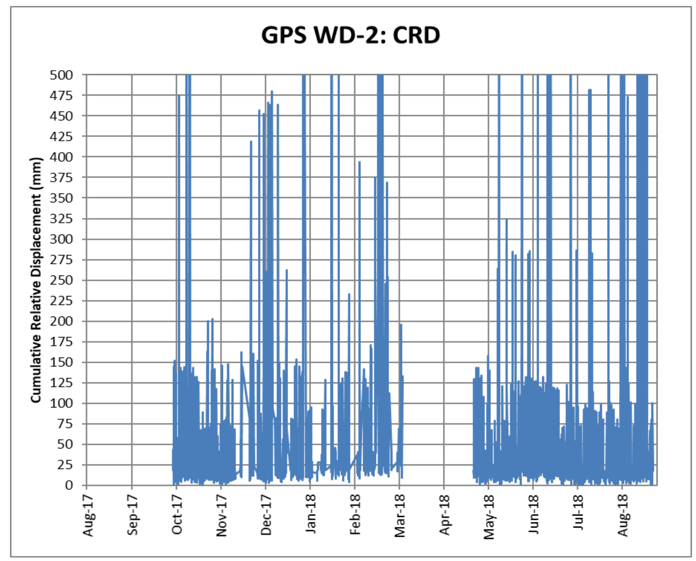
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

TITLE
GREENHILLS TAILINGS FACILITY
GPS MD-5_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-19







Initial Reading (September 2018)
Readings (2018)

CRD = Cumulative Relative Displacement

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

CONSULTANT

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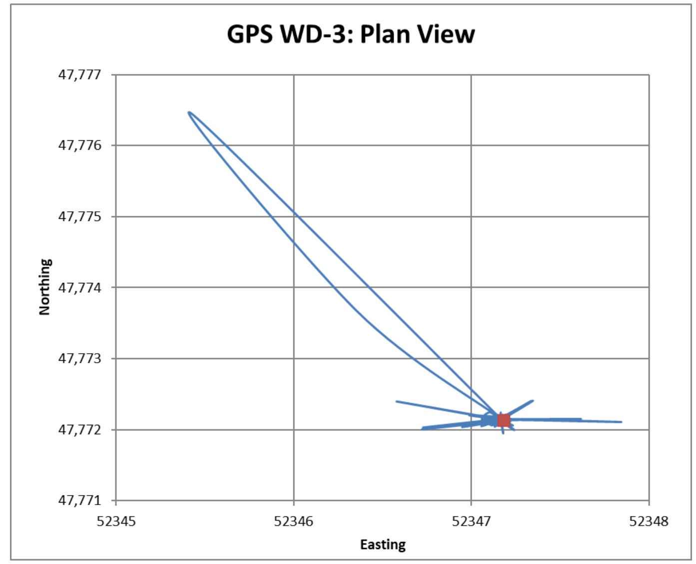
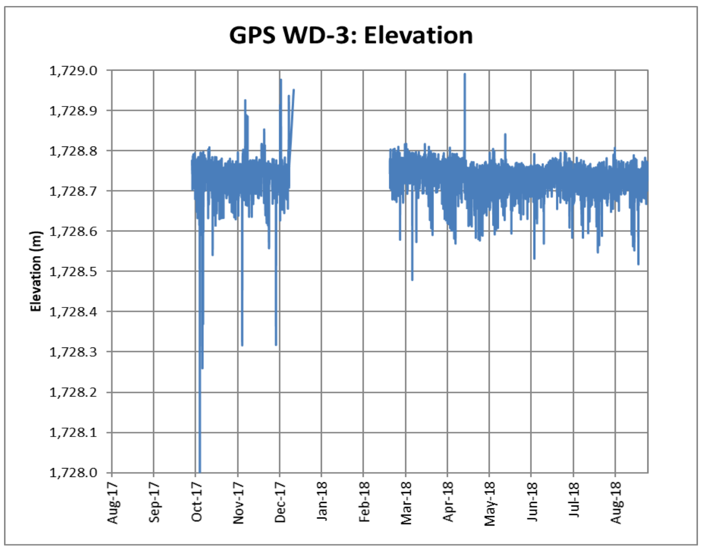
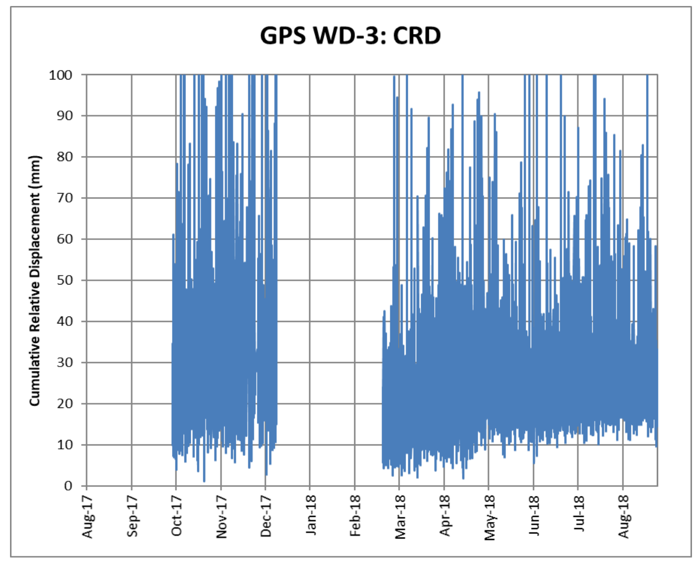
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

TITLE
GREENHILLS TAILINGS FACILITY
GPS WD-2_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-20







■ Initial Reading (September 2018)

— Readings (2018)

CRD = Cumulative Relative Displacement

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

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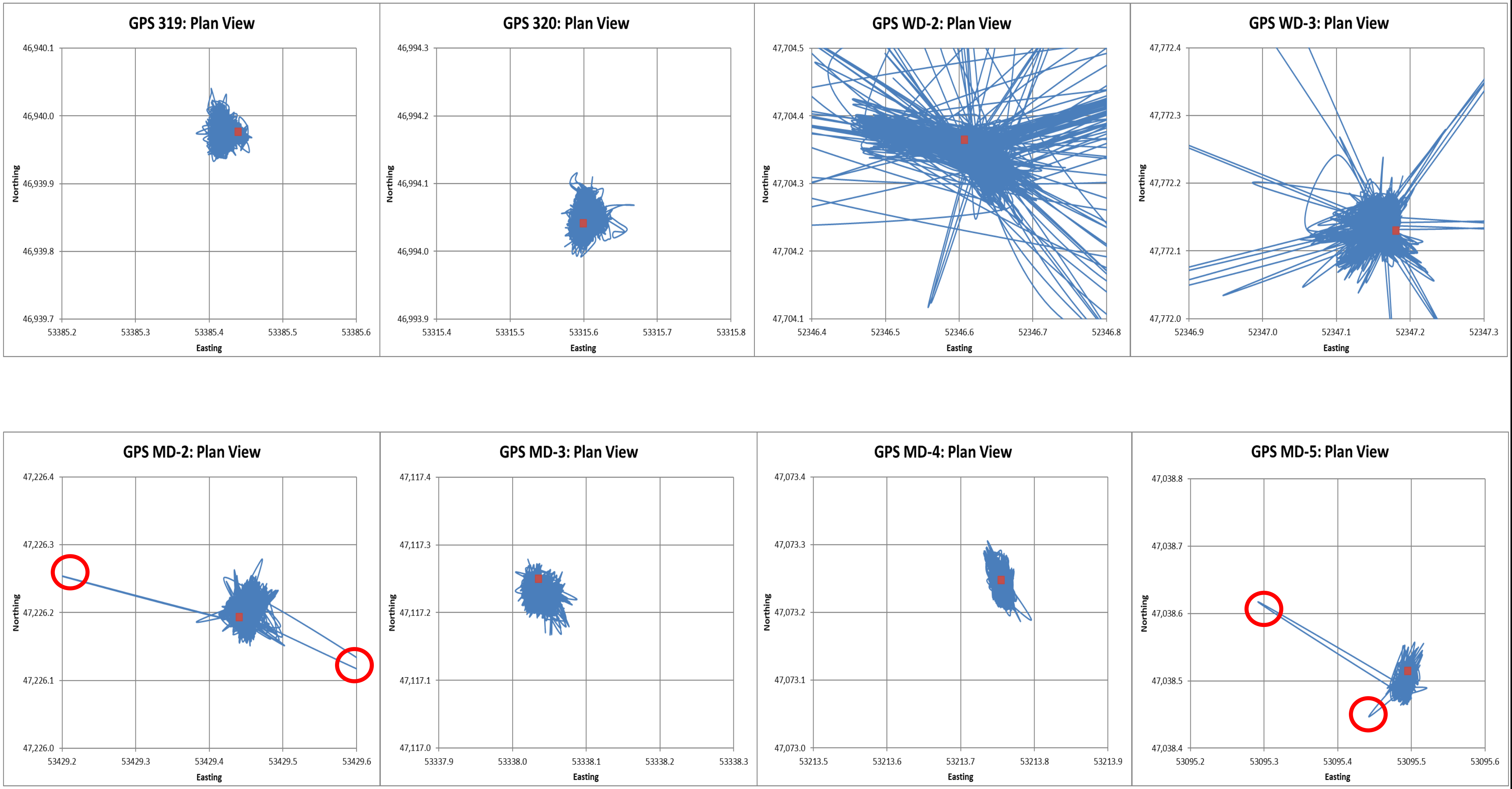
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

PROJECT
2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

TITLE
GREENHILLS TAILINGS FACILITY
GPS WD-3_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-21



■ Initial Reading (September 2018)

— Readings (2018)

○ Erroneous Data

CLIENT

TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

PROJECT

2018 GREENHILLS TAILINGS FACILITY
ANNUAL DAM SAFETY INSPECTION

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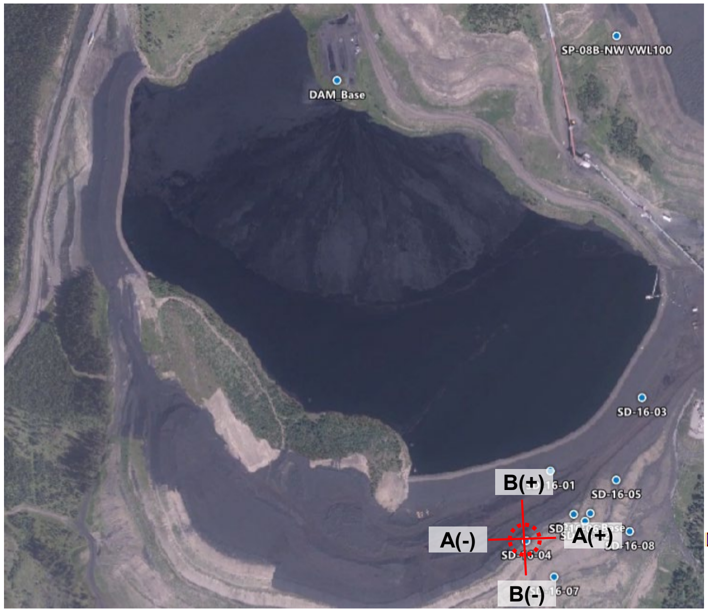
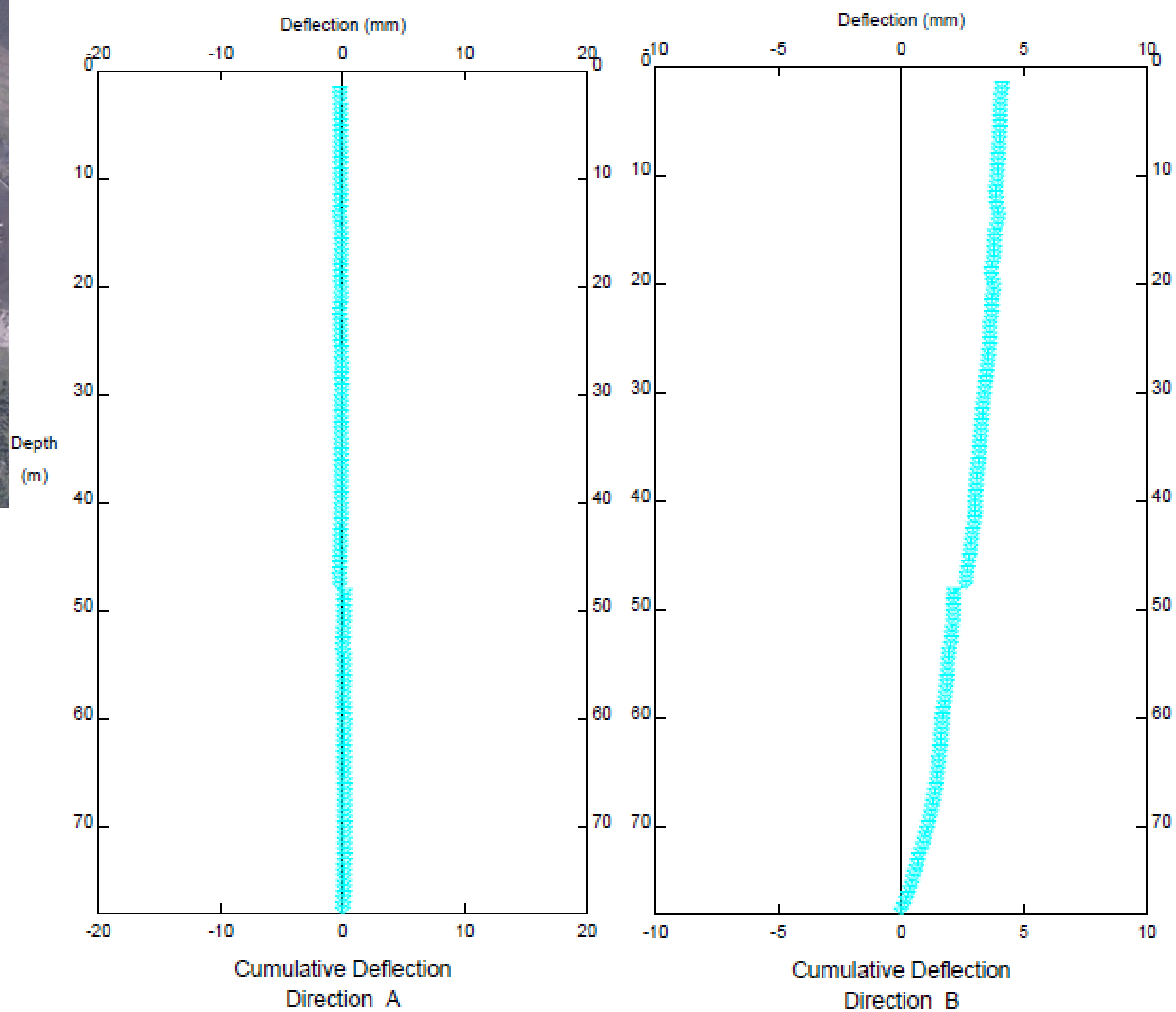
YYYY-MM-DD	2019-03-04
PREPARED	NEC
DESIGN	NEC
REVIEW	MS
APPROVED	—

TITLE

GREENHILLS TAILINGS FACILITY
GPS PLAN VIEW DISPLACEMENTS

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
1894290	2000/2050/2018-133	0	C-22





Initial 25 July 2018

25 July 2018

CLIENT TECK COAL LIMITED GREENHILLS OPERATIONS ELKFORD, BC		PROJECT 2018 GREENHILLS TAILINGS FACILITY ANNUAL DAM SAFETY INSPECTION	
CONSULTANT GOLDER	YYYY-MM-DD: 2019-03-04 PREPARED: NEC DESIGN: NEC REVIEW: MS APPROVED: —	TITLE **GREENHILLS TAILINGS FACILITY** **INCLINOMETER SD_16-04**	
		PROJECT No. **1894290**	Phase/Task/DOC. **2000/2050/2018-133**
		Rev. **0**	FIGURE **C-23**

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