GOLDER

REPORT

2019 Dam Safety Inspection

Greenhills Operations Tailings Storage Facility

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Reference No. 18110798-2019-148-R-Rev0-3000

19 March 2020

Distribution List

Electronic Copy – Teck Coal Limited

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Executive Summary

This report presents the 2019 annual dam safety inspection (DSI) for the tailings storage facility (TSF) at the Teck Coal Limited, Greenhills Operations (GHO) mine site.

The DSI site visit was carried out on 17 July 2019. Available instrumentation data were reviewed for a period between 1 September 2018 through 31 July 2019 (the reporting period).

Summary of Facility Description

The GHO site is an active open pit metallurgical coal mine located 14 km from Elkford, British Columbia.

Tailings and process water in the GHO TSF are impounded on the southeast side by the Main Tailings Dam and on the west side by the West Tailings Dam. The construction of the Main Tailings Dam began in 1982, and deposition of slurry tailings into the TSF began in 1983. West Tailings Dam construction began in 1993. Both dam foundations comprise dense till and sedimentary bedrock. Both the main and west tailings dams are currently at an elevation of approximately 1,731 m and are designed and permitted to be raised to an ultimate crest elevation of 1,735 m.

The Main Tailings Dam is a zoned earthfill embankment, approximately 50 m high. The downstream shell is constructed from compacted coarse coal refuse (CCR) material and supports a 6 m wide zone of compacted clay till (clay blanket) on the 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. CCR Site C and D spoils are located immediately downstream of the Main Tailings Dam. These spoils provide a buttressing effect that is favourable to dam stability but is not required by design. The Main Tailings Dam was designed to meet stability criteria without the buttress.

The West Tailings Dam is a zoned earthfill dam, approximately 25 m high. The West Tailings Dam acts as a saddle dam in a topographic low spot at the northwest end of the TSF and has a similar design and construction to the Main Tailings Dam. The main mine access road is located at the toe of the embankment on the west side.

Summary of Key Hazards

Three potential credible failure modes have been identified for the GHO TSF. These are presented as follows, together with comments on the mitigating controls that exist, and the observations from this DSI:

- **Instability**—Instability of the Main and West Tailings Dams could occur under static conditions or due to cyclic loading during an earthquake.
  - Investigations have confirmed the foundation materials. Analysis and design based on investigated materials indicate factors of safety that exceed the design criteria.
  - Instrumentation data were not indicative of conditions likely to present a stability concern such as elevated piezometric levels, increase in settlement rates, or signs of movement.
  - No conditions, such as cracks, settling, or bulging of the dams, were observed during the 2019 site visit or monthly inspections that would indicate instability. The dams therefore appear to be stable.

- **Overtopping**—There is potential for water to spill over the dam crest of the Main and West Tailings Dams due to surface water inflows during storm events or due to inappropriate operational water management.
  - The GHO TSF can store storm events up to and including the 72-hour probable maximum flood.
  - Minimum freeboard requirements, from dam crest to the main pond, were established based on Canadian Dam Association Guidelines (CDA 2013).
  - The water level in the pond was within operating limits and the facility met freeboard criteria for the reporting period.
- **Internal erosion** — Erosion of the Main or West Tailings Dam can lead to loss of material, formation of a void in the dam(s), and loss of water and tailings from the TSF.
  - No conditions were observed during the 2019 site visit or monthly inspections that would indicate piping, such as change in seepage rates, presence of fines in seepage, changes in piezometric readings within dam fill or foundations or depressions/sinkholes that would be indicative of internal erosion.

Dam Consequence Classification

The Main and West Tailings Dams are classified as High consequence dams, in accordance with CDA (2013). The consequence classifications for the dams have not changed based on this DSI.

Summary of Significant Changes

There were no significant changes in the operation of the TSF during the reporting period.

The performance of the dams during the reporting period were as expected for normal operating conditions. The GHO TSF was observed to be in good condition at the time of the 2019 site inspection. Records indicate that the discharge of tailings into the GHO TSF was observed to be consistent with the design intent.

Significant Changes in Instrumentation or Visual Monitoring Records

No significant changes were noted during the 2019 site inspection or monthly visual inspections. Some minor erosion of the upstream slope and crest of the Main and West Tailings Dams were observed which require routine maintenance. This minor erosion does not present a dam safety concern.

Some monitoring instruments reported values which exceeded the warning and alarm levels during the reporting period. These exceedances were assessed by Teck and the EOR promptly following their occurrence and are considered erroneous as they do not align with readings from other instrumentation and visual observations. Table E-1 provides a status update in relation to instrumentation.

Significant Changes to Stability and/or Surface Water Control

There were no significant changes to dam stability, integrity, or surface water control during the reporting period.

Water from pit dewatering was directed to the TSF to ensure sufficient water for plant operation.

Operation, Maintenance, and Surveillance Manual and Emergency Preparedness Plan

The operation, maintenance, and surveillance (OMS) manual for the TSF was updated in June 2019 (GHO 2019b) to meet the guidelines provided by CDA (2013, 2014), the Mining Association of Canada (MAC 2011, 2017), and Teck Resources Limited's Tailings and Water Retaining Structures Guidelines (Teck 2014).

An update of the OMS manual is required to:

- reflect updated guidance from MAC (MAC 2019) and Teck (Teck 2019)
- reference non-functioning instrumentation and revise outdated quantifiable performance objectives (QPOs)
- reference a single coordinate system for the GHO TSF

The emergency preparedness and response plan for the TSF was last updated in 2018 (GHO 2019a).

The dam breach inundation study was being updated at the time of this report with additional modelling of the downstream area, to Lake Koocanusa. An update of the emergency preparedness and response plan is planned once the dam breach and inundation study is complete.

Dam Safety Review

A dam safety review (DSR) was completed by Klohn Crippen Berger Ltd. in 2017 (KCB 2017). The DSR concluded that the condition and integrity of the dams met current safety standards. The Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (Ministry of Energy and Mines 2017) specifies that a DSR is to be completed once every five years; the next DSR is therefore required by the end of 2022.

Recommendations

An update on the status of deficiencies, non-conformances, and recommendations from the 2018 DSI (Golder 2019c) is presented in Table E-1.

Current deficiencies, non-conformances, and recommendations from the 2019 DSI are presented in Table E-2.

Table E-1: Status of 2018 Dam Safety Inspection Recommended Actions

ID Number	Deficiency or Non-conformance	Potential Dam Safety Risk	Priority Level	Recommended Action	Target Date	Status as of October 2019
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 Tailings Dam (MD-1_ROVER, MD-2_ROVER, MD-5_ROVER). ■ Non-functioning GPS units on West Tailings 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 Tailings Dam, and at the weir by the West Tailings Dam.	Potentially unstable condition not measured.	3	**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. **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.	Q3 2019	**Piezometers:** ■ VW11-MD-1A and 1B are not operational, but are not required at present given the coverage provided by adjacent instruments. ■ VW11-MD-4B is not operational, but are not required at present given the coverage provided by adjacent instruments. ■ SD-16-01A and 01B were repaired and were operational at the time of this report – Closed. ■ All other instruments are operational. **Prism and GPS:** ■ All instruments are operational. ■ All prisms are in line of site of total station – Closed. ■ GPS units removed from alert and warning system. Data to be used to establish long term trends. – Closed. **Seepage Weirs:** ■ Weir automation equipment on site and pending installation. ■ Bucket calibration completed 14 May 2019.- Closed. ■ Additional seepage weir at toe of Site D spoils not considered necessary – Closed.
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.	Potential delayed response of corrective actions and notification of responsible persons and emergency response team.	2	Review the TARP, update if appropriate, and retrain key GHO personnel so that the TARP procedures and requirements are enforced as intended.	n/a	Closed: ■ Engineer of Record (and other Golder representatives) currently receives GeoExplorer automated instrument notifications. Teck staff are following notification protocols.
2018-03 (2017-02)	QPOs for the inclinometers still required.	Potentially unstable condition not identified promptly.	n/a	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.	n/a	Closed: ■ QPOs for the inclinometers will not be established. ■ Data will continue to be used to assess conditions on a frequent basis. ■ Inclinometers will also be used to investigate conditions in the event of an orange alarm on prisms.
2018-04 (2017-04)	■ Pond against upstream slope of Main Tailings Dam. ■ The pond against the upstream slope of the Main Tailings 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 Tailings Dam.	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 Tailings Dam.	Q2 2019	In progress: ■ Depositional modelling to assess different spigot layouts currently in progress.
2018-05 (2017-05)	Closure plan does not meet HSRC requirements.	n/a	2	Develop the current concept level closure plan to align with the current life of mine strategy and HSRC requirements.	Q4 2019	In progress: ■ Update of closure plan in progress.

Table E-1: Status of 2018 Dam Safety Inspection Recommended Actions

ID Number	Deficiency or Non-conformance	Potential Dam Safety Risk	Priority Level	Recommended Action	Target Date	Status as of October 2019
2018-06	Golder has recommended additional inundation study modelling of the downstream area, up to Lake Koocanusa.	n/a	3	Update inundation study with additional modelling at the confluence of the Elk River and Fording River, and at Lake Koocanusa.	Q4 2019	In progress: ■ Update of dam breach inundation study currently in progress.
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.	Potentially unstable condition not measured.	3	■ 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.	Q3 2019	Complete: ■ Inspection and maintenance tasks for the SmartDitch have been added to the TSF OMS ■ Repair of SmartDitch was completed in October 2019 (construction record report in progress).

VW = vibrating wire; HSRC = Health, Safety and Reclamation Code; n/a = not applicable; OMS = operation, maintenance, and surveillance; QPO = quantifiable performance objective; TSF = tailings storage facility; n/a = not applicable; TARP = Trigger Action Response Plan.

Priority Level	Description
1	A high probability or actual 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 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 safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

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

Table E-2: 2019 Recommended Actions for Greenhills Tailings Storage Facility

ID Number	Deficiency or Non-conformance	Potential Dam Safety Risk	Priority Level	Recommended Action	Target Date
2019-01	Volume of water in TSF is greater than that needed for plant operation	Increased zone of inundation if failure were to occur	3	Reduce pond volume to less than 350,000 m^3.	End Q4 2020
2019-02 (2018-01)	Seepage weirs: ■ Weir automation equipment is on site and pending installation.	Potentially unstable condition not measured.	3	Install weir automation equipment.	End Q3 2020
2019-03 (2018-04)	Pond against upstream slope of Main Tailings Dam. ■ The pond against the upstream slope of the Main Tailings 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 Tailings Dam.	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 the Main Dam after results from depositional modelling are issued.	End Q2 2020
2019-04	Ponded water on downstream crest of Site C spoils at east abutment of Main Tailings Dam (See Photograph 9, Appendix A)	Erosion of downstream shell of CCR spoils leading to instability	3	Revise drainage to prevent long term ponding of surface water.	End Q3 2020
2019-05 (2018-05)	Closure plan does not meet HSRC requirements.	Operational procedures do not align with closure design; long-term environmental hazards become difficult and costly to mitigate.	3	Develop the current concept level closure plan to align with the current life of mine strategy and HSRC requirements.	In progress End Q1 2020
2019-06 (2018-06)	Inundation study modelling of the downstream area does not reflect recent changes in topography	Potential for sub-optimal emergency response	3	Update inundation study	In progress End Q1 2020
2019-07	■ OMS manual does not reflect: ▪ Current geotechnical instrumentation details including revised QPOs. ▪ Revised MAC and Teck guidance documents. ■ Multiple coordinate grid systems appear to be used in the OMS manual.	Potential to ineffectively respond to alerts and warnings from geotechnical instrumentation.	3	Update OMS manual to: ■ Remove non-functioning geotechnical instrumentation and update QPOs. ■ Update based on MAC (2019) and Teck (2019). ■ Use a single coordinate grid system.	End April 2020

HSRC = Health, Safety and Reclamation Code; n/a = not applicable; OMS = operation, maintenance, and surveillance; QPO = quantifiable performance objective; TSF = tailings storage facility; MAC = Mining Association of Canada; Teck = Teck Resources Limited.

Priority Level	Description
1	A high probability or actual 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 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 safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

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

Abbreviations

Abbreviation	Definition
CDA	Canadian Dam Association
CRD	cumulative relative displacement
DSI	dam safety inspection
DSR	dam safety review
EoR	Engineer of Record
GHO	Greenhills Operations
Golder	Golder Associates Ltd.
HSRC	Health, Safety and Reclamation Code
IDF	inflow design flood
Ministry of Energy and Mines	British Columbia Ministry of Energy and Mines. Now known as the British Columbia Ministry of Energy, Mines and Petroleum Resources (BC MEMPR)
n/a	not applicable
OMS	operation, maintenance, and surveillance
QPO	quantifiable performance objective
PMF	Probable Maximum Flood
Teck	Teck Coal Limited
TSF	Tailings Storage Facility

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1.0 INTRODUCTION

1.1 Purpose, Scope of Work, Method

At the request of Teck Coal Limited, Greenhills Operations (GHO), Golder Associates Ltd. (Golder) has completed the 2019 annual dam safety inspection (DSI) for the tailings storage facility (TSF) at the GHO mine site, which includes the Main Tailings Dam and West Tailings Dam. The site is located 14 km from Elkford, British Columbia.

This report is based on a site visit carried out by the Engineer of Record (EoR) on 17 July 2019, which included a walkover of the TSF area with GHO staff involved in the maintenance, operation, and surveillance of the facility, as well as a review of site data, including available instrumentation data between 1 September 2018 through 31 July 2019 (the reporting period).

This report consists of the following:

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

Photographs of the TSF are presented in Appendix A. A summary of observations during the 17 July 2019 DSI site visit are included in the inspection reports presented in Appendix B.

The previous annual DSI site visit for these facilities was carried out on 15 August 2018 and is reported in the 2018 annual DSI report (Golder 2019c).

All coordinates presented in this report are in GHO Mine Grid with elevations referenced to the Elk Valley Elevation Datum (Airborne 2017).

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

1.2 Regulatory Requirements

1.2.1 BC Health, Safety and Reclamation Code

The GHO TSF is regulated under the Health, Safety, and Reclamation Code (HSRC) for Mines in British Columbia (Ministry of Energy and Mines 2017).

This DSI report has been prepared in accordance with the requirements of the HSRC (Ministry of Energy and Mines 2017) and in consideration of the guidelines for annual DSI reports provided in the HSRC Guidance Document (Ministry of Energy and Mines 2016) and the Teck Resources Limited's *Guideline for Tailings and Water Retaining Structures* (Teck 2019). It is understood that this report will be submitted by Teck to the Chief Inspector of Mines for British Columbia.

1.2.2 Permits and Licences

Specific permits, including amendments, and licences that apply to the TSF, include:

- C-137 Permit (issued by Ministry of Energy and Mines 1993 and 2010)
- C-137 Permit Amendment of 7 April 2014, Approving Main and West Tailings Dam Raises and Boundary Amendment
- Environmental Management Permit PE6248, 16 October 2017 (BC Ministry of Environment)

2.0 BACKGROUND

The GHO site is an active open pit coal mine located near Elkford, BC. The GHO site plan including the location of the TSF is shown in Figure 1.

The mine was started by Westar Mining Ltd. with production between 1982 and 1992, after which the site was temporarily inactive. In December 1993, mine ownership changed to a joint venture between Fording Coal Limited (Fording) and Pohang Steel Canada Ltd., and was operated by Fording. The operating company changed from Fording to Elk Valley Coal Corporation in 2003 and then to Teck Coal Limited in 2008.

2.1 Overview of Operations

Raw coal from the open pit is processed at the wash plant to produce marketable metallurgical coal with by-product streams of coarse coal refuse (CCR) and fine refuse tailings. The CCR is unsaturated and comprises 50 mm minus gravel- to sand-sized rock and coal particles. CCR is transported, dumped, and stored near the wash plant in stockpiles (Sites A to E, Figure 2). The fine refuse stream consists of a slurry of coal and rock particles (tailings). The tailings are silt sized with a D_{50} (diameter of the particle that 50% of a material by mass is smaller than) of around 0.2 mm. Tailings are discharged from the wash plant on the west side from where they are transported, by gravity, to the TSF discharge point, located on the north side of the TSF (Figure 2). Tailings are discharged at an approximate solids content of between 10 and 20% by mass, an approximate density of 1.13 t/m^3 (GHO 2019b), into the impoundment area.

Approximately 500,000 m^3 of tailings are deposited annually (Golder 2018d). Slurry water is collected in a pond and, following a period of time to allow solid particle settlement, the clarified water is re-circulated by barge pumps to the wash plant for reuse.

2.2 Greenhills Tailings Storage Facility

Tailings and process water in the GHO TSF are impounded on the southeast side by the Main Tailings Dam and on the west side by the West Tailings Dam as shown in Figure 2. Both the main and west tailings dams are currently at an elevation of approximately 1,731 m and are designed and permitted to be raised to an ultimate crest elevation of 1,735 m.

The 2019 bathymetric survey indicates that the highest point of the tailings surface (approximate elevation of 1,731 m) is near the tailings discharge at the north side of the pond. The deepest point of the impoundment area is approximately 15 m northwest of the barge at an elevation of approximately 1,722.6 m, which corresponded to a pond depth of about 6.2 m at the time of the survey. This is an operational consideration and does not impact dam safety.

2.3 Subsurface Conditions

Details of subsurface conditions prior to the construction of the Main and West Tailings Dams are provided in the following sections.

Main Tailings Dam

A geotechnical investigation was conducted by Hardy Associates (1978) Ltd. (Hardy) during 1980 (Hardy 1980) to assess the subsurface conditions within the footprint of the Main Tailings Dam foundation. Dam foundation materials generally comprise a surficial layer of colluvium overlying glacial till which overlies shale bedrock. The colluvium layer beneath the starter dam was approximately 1.5 m thick, although it was assumed that up to 8 m of colluvium may be encountered on steep slopes. The colluvium comprises a mixture of clay, sand, and gravel. The consistency of colluvium comprising primarily clay materials was described as soft to stiff. The consistency of colluvium comprising primarily gravel or sand was described as very dense.

At the west end of the dam footprint, muskeg was found overlying the colluvium. The muskeg was observed to be soft, highly compressible and up to 3 m thick.

Hard subsoil (glacial till) was found to underlie the colluvium, and shale bedrock was encountered in two boreholes at depths of 12.5 and 12.2 m. The remaining 14 boreholes were terminated within the glacial till. Stability analyses indicated that soft colluvial clay with an undrained shear strength (s_u) less than 35 kPa were to be stripped from the foundation during preparation (Hardy 1980).

A geotechnical drilling program was conducted by Golder from October to December 2016 (Golder 2017e) to assess foundation conditions at the Main Tailings Dam and Site C with the objective of estimating the extent of any remaining unsuitable or soft materials. This investigation did not encounter soft colluvial clays, and anecdotal discussions confirm that weak materials were removed during construction.

Subsurface conditions generally consisted of a 3.1 to 56.8 m thick layer of cohesive glacial till underlain by fine grained sedimentary rock. The fines content, by mass, of recovered glacial till samples ranged from 31% to 74%, with an average of 54%. The gravimetric water content of recovered glacial till samples ranged from 5.3% to 29.9%, with an average of 14%. Large capacity direct shear tests were performed on combined samples of glacial till. Results indicated a drained peak friction angle of 22° and a drained peak apparent cohesion intercept of 142 kPa. One multistage triaxial test, conducted on a Shelby tube sample of glacial till, resulted in an approximate drained peak friction angle of 32° and apparent peak cohesion intercept of 50 kPa.

West Tailings Dam

Initial foundation investigations were carried out by Golder in March 1992 and July 1993 (Golder 1993). Prior to construction, a mine access road was present within what would become the West Tailings Dam footprint. The road embankment fill material was up to 8.8 m thick and comprised dense sand and gravel, with zones of loose to compact clayey silt. It was assumed that the embankment was initially constructed with locally excavated colluvium and till, and later raised with sand and gravel. During investigations, boreholes were drilled to the east of the access road and encountered moist to wet, soft to firm clayey silt with zones of rootlets and wooded debris up to 1.8 and 4.9 m below surface. Dense to very dense glacial till consisting of a clayey silt with gravel and cobbles was found underlying the colluvium. Three of the investigation locations terminated in siltstone bedrock at depths of between 0.6 m (at the south abutment) and 11.3 m (at the road embankment).

Additional site investigations were carried out in 2013 (Golder 2014b) as part of designs for raising the West Tailings Dam to an elevation of 1,735 m. Topsoil, 0.2 to 0.5 m thick, was encountered in some locations and consisted of organic root materials, and organic silt or fine sand. Colluvial deposits were of variable thickness and described as both non-cohesive and cohesive silty clays and gravelly sands, and sandy silty clays with gravimetric water content ranging from 1% to 26%. Glacial till was also encountered in varying thicknesses between 0.8 and 2.8 m below ground surface. The glacial till was highly variable, ranging from silty clay to gravelly sand and sandy silty clay; the consistency was described as hard with gravimetric water content ranging from 9% to 21%. Weathered claystone and siltstone were encountered below the glacial till.

The West Tailings Dam is located in a topographic low area, and peat and buried wood debris was excavated as part of initial dam construction to expose the stiff clay till and bedrock. These excavation areas were backfilled with 1.0 to 1.5 m of selected reject rock to promote drainage, as shown in cross-section in Figure 5 (Golder 1999).

Foundation preparation beneath the original mine access road was not reported during initial construction. Pockets of soft clay in the original mine access road foundation would likely be restricted to the upstream portion of the existing West Tailings Dam and are not considered to impact global dam stability.

2.4 Overview of Design and Construction

The construction of the Main Tailings Dam began in 1982, and deposition of slurry tailings into the TSF began in 1983. The original design of the Main Tailings Dam, to crest elevation 1,706 m, was provided by Hardy for the former mine owner Westar Mining Ltd. (Hardy 1980).

A design for the West Tailings Dam was completed by Golder in 1993 (Golder 1993) and construction of the dam began the same year.

A design to raise the crest of the Main and West Tailings Dams to an elevation of 1,725 m was completed in January 1994 (Golder 1994). A further design to raise the Main and West Tailings Dams to an elevation of 1,735 m (current permitted elevation) were completed by Golder in 2005 and 2014, respectively (Golder 2005, 2014b).

The TSF embankments are routinely raised during the development of the mine. As of early 2020, the minimum crest elevation is approximately 1,731 m. The facility is currently permitted to a maximum crest elevation of 1,735 m. Based on the 2019 bathymetric survey, it is estimated that a total struck level storage volume, without allowance for freeboard or beach angles, of approximately 4.6 million m^3 is available to elevation of 1,735 m (as shown in Illustration 1).

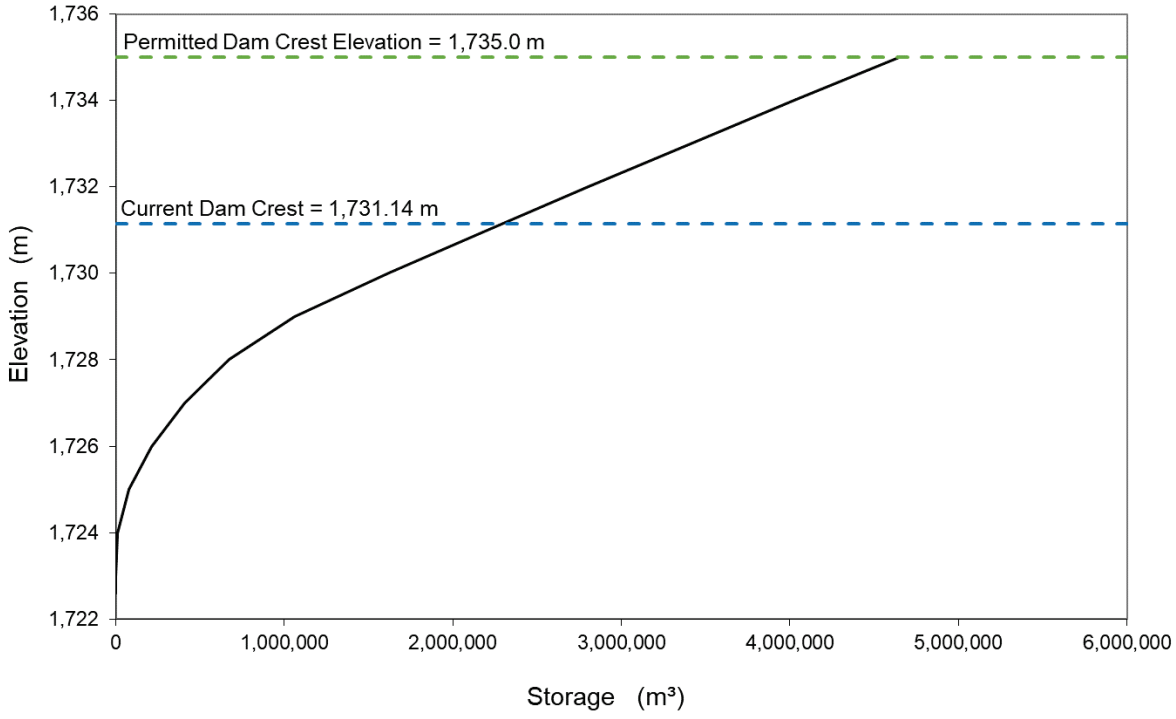


Illustration 1: Greenhills Operations Tailings Storage Facility Storage Capacity Curve for Elevations Above Surface Surveyed in 2019 Bathymetry Survey

Main Tailings Dam

The Main Tailings Dam is a zoned earthfill embankment with an approximate height of 50 m above original ground surface. The dam shell is composed of compacted CCR material, with a 6 m wide zone of compacted clay till (clay blanket) on the upstream face. The CCR acts as a filter material for the clay blanket. The design geometry of the Main Tailings 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; cross-sections are provided in Figure 4. The ultimate crest width, at an elevation of 1,735 m, is 12 m. CCR spoils Site C and D are located adjacent to the Main Tailings Dam. These spoils provide a buttressing effect that is favourable to dam stability but is not required by design. The Main Tailings Dam was designed to meet stability criteria without the buttress. The Main Tailings Dam has been raised in stages since 1983, as summarized in Table 1.

Table 1: Main Tailings Dam Construction Summary

Year	Construction	Dam Crest Elevation (m)	References
1982–1983	Starter dam, piezometers installed	1,687	Hardy 1980, 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	1,700.00	Hardy 1988
1988	Rock drains (French drain) below CCR	No change	Westar 1988
1989	Raise	1,702.00	Golder 1989
1990	Raise	1,704.00	Golder 1990
1991	Raise	1,707.00	Golder 1992
1994	Coarse refuse shell raised	1,710.00	Golder 1995
1995	Raise, 3 standpipe piezometers installed	1,712.00	Golder 1996
1996	Coarse refuse shell raised	1,718.00	Golder 1997
1997	Blanket to elevation 1,718 m, CCR shell raise, rock drains extended beneath Site C and Site D CCR spoils	1,720.00	Golder 1998
2003	Raise	1,720.10	Golder 2004
2009	Raise	1,723.00	Golder 2010b
2010	Raise	1,724.60	Golder 2010c
2011	5 vibrating wire piezometer locations (2 sensors in 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	Golder 2017b
2017	Raise	1,728.85	Golder 2017f
2018	Raise; additional instrumentation installed	1,731.14	Golder 2019b

Notes: No dam raise was constructed from 2015 to 2016. The increased crest elevation indicated from 2015 to 2016 is due to a change in the reference alignment for survey setout. The reference alignment was changed from the upstream crest of the dam to the till/CCR interface.

CCR = coarse coal refuse.

Geotechnical instrumentation, installed to monitor the Main Tailings Dam and operational at the time of this report, is summarized in Table 2. Locations are shown in Figure 3.

Table 2: Summary of Main Tailings Dam Instrumentation

Instrumentation Type	Number	Comments
Vibrating wire (VW) piezometers	22	■ Each VW piezometer location (Figure 3), has two VW piezometers, except for SD-16-04 which has one. ■ Instruments VW11-MD-1A, 1B, 4B are non-operational.
GPS units[a]	7	Two GPS units (319 and 320) are located along the downstream slope of Site C. Five units are positioned along the crest of Main Tailings Dam (MD_ROVER series).
Survey prisms	8	Prisms A to H are located on the centreline of Main Tailings Dam crest.
V-notch weir	1	One V-notch weir is located at the toe of Site C.
Inclinometer casing	2	Two boreholes were established during 2016 and inclinometer casing is installed at two locations downstream of the Main Tailings Dam on Sites C and D. The bottom of each casing is anchored in bedrock.

a) An additional GPS (313) is located on the pond reclaim barge to record tailings pond elevation.

VW = vibrating wire.

West Tailings Dam

The West Tailings Dam is a zoned earthfill embankment similar in design to the Main Tailings Dam. The downstream shell is constructed from CCR and has a 6 m wide clay blanket on the upstream slope. The West Tailings Dam has a maximum height of approximately 25 m above original ground. The main mine access road is located at the toe and immediately to the west of the West Tailings Dam.

The West Tailings Dam has an upstream slope of 2H:1V and a downstream slope of 2.5H:1V; cross-sections are provided in Figure 5. The design includes a relatively wide 40 m crest width, to provide access for haul trucks to the adjacent CCR spoils.

Design drawings to raise the Main and West Tailings Dams to a crest elevation of 1,728 m were completed in May and June of 2014. The design included an enlarged West Tailings Dam footprint to support a future raise of the dam to an ultimate crest elevation of 1,735 m (Golder 2014c,d). The construction history of the West Tailings Dam is summarized in Table 3.

Table 3: West Tailings Dam Construction Summary

Year	Construction	Elevation (m)	References
1993	Raise as blanket on mine road	1,711.00	Golder 1993
1996	Raise as blanket on mine road	1,714.30	Golder 1997
1998	Foundation preparation of till and bedrock for dam footprint to elev. 1,725 m	No change	Golder 1999
1999	Raise, mine road relocated to west	1,719.10	Golder 2000
2004	Raise	1,721.60	No documentation
2010	Raise	1,724.80	Golder 2010b
2011	5 vibrating wire piezometers (2 sensors in each of 3 locations) installed	No change	Golder 2012a
2014	Raise, mine road relocated to west	1,726.60	Golder 2015a

Table 3: West Tailings Dam Construction Summary

Year	Construction	Elevation (m)	References
2015	Raise	1,728.07	Golder 2016a
2016	Extension of the downstream portion of the West Tailings Dam and construction of the temporary emergency spillway.	No change	Golder 2017b
2017	Raise, extension of the downstream portion of the West Tailings Dam and removal of the temporary emergency spillway.	1,728.73	Golder 2017f
2018	Raise; additional instrumentation installed.	1,731.14	Golder 2019b

Geotechnical instrumentation, installed to monitor the West Tailings Dam and operational at the time of this report, is summarized in Table 4. Locations are shown in Figure 3.

Table 4: Summary of West Tailings Dam Instrumentation

Instrumentation Type	Number	Comments
Vibrating wire (VW) piezometers	6	Each location has two VW piezometers; plan locations of the piezometers are shown in Figure 3.
GPS units	3	Three GPS monitoring units are located on the crest of the West Tailings Dam (WD_ROVER series).
Survey prisms	5	Prisms I to M are located on the centreline of the West Tailings Dam crest
V-Notch Weir	1	One V-notch weir is located at the toe of West Tailings Dam.

VW = vibrating wire.

2.5 Material Properties

The material properties adopted for Golder's review of the stability of the Main Tailings Dam (Golder 2017g) and West Tailings Dam (Golder 2014d) are provided in Table 5. These properties are based on geotechnical investigations of the Main Tailings Dam (Golder 2017e) and West Tailings Dam (Golder 2014b).

Table 5: Design Material Properties

Material	Unit Weight (kN/m^3)	Peak Drained Apparent Cohesion Intercept (kPa)	Peak Drained Friction Angle (degrees)
Colluvial Silty Clay (West Tailings Dam)	17.3	0	26
Glacial till (West Tailings Dam)	21.2	0	32.5
Glacial till (Main Tailings Dam)	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; n/a = not applicable.

2.6 Site Seismicity

GHO is located in an area of low seismic risk. Golder has developed a seismic hazard model for GHO based on historical seismicity and a review of geologic and paleoseismological features (Golder 2016b). The model incorporates data from the 5th Generation Seismic Hazard Model including 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).

Based on Golder's understanding of foundation conditions and using the 2015 National Building Code of Canada seismic hazard calculator (NRC 2015) a peak ground acceleration for GHO was estimated for various event return periods assuming Class C soil in the dam foundations. The results of seismic probabilistic analysis from the site hazard model are presented in Table 6.

Table 6: Seismic Hazard Values

Exceedance Probability	Return Period (Years)	Peak Ground Acceleration (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 2015 National Building Code of Canada (NRCC 2015).

Return periods are not exact representations of annual exceedance probabilities, rounding as per CDA (2013, 2014) is shown.

The Canadian Dam Association (CDA 2013) recommends a seismic event with a return period of 1 in 2,475 years be adopted for High consequence structures such as the GHO TSF dams. Therefore, a peak ground acceleration equal to 0.158 g was adopted for pseudo-static stability analysis (Golder 2017g).

2.7 Key Operational Components

Key operational components of the GHO TSF are:

- visual inspections
- geotechnical instrumentation, including NavStar GeoExplorer software program
- process water reclaim and circulation
- dam raise construction

Geotechnical instrumentation is routinely monitored and assessed using the NavStar GeoExplorer software. Instruments are either read manually and uploaded to the software, or data are transmitted remotely to the software in real time. GHO and EoR staff receive email alerts when warning or alarm thresholds are triggered. Visual inspections are carried out monthly by GHO, and observations are recorded and communicated to the EoR team. The EoR and GHO teams review the observations and instrumentation data monthly and collaboratively identify deficiencies and determine action plans.

The process plant monitors the pond water elevation using a GPS unit located on the process water reclaim pump. The elevation of the tailings pond is recorded remotely and monitored in real time using GeoExplorer.

Dam raises are carried out following the development of construction drawings and specifications. Full-time quality control and assurance is maintained throughout the construction works.

2.8 Key Personnel

Key personnel associated with the GHO TSF are:

- the EoR: Andy Haynes, P.Eng., an employee of Golder
  - Mr. Haynes has been the EoR since 2013
- the TSF Qualified Person: Mark Slater, P.Eng., an employee of GHO, up to November 2019
  - from November 2019 to the date of this report the TSF Qualified Person was Andrew Knight, P.Eng., an employee of GHO
- the GHO Tailings Engineer in training: David Walker, E.I.T., an employee of GHO

2.9 Facility Consequence Classification

Guidelines for the classification of dams are presented in the HSRC Guidance Document, Section 3.4 (Ministry of Energy and Mines 2016), which references the CDA (2013) *Dam Safety Guidelines*.

Dam consequence classification is based on incremental losses that a hypothetical failure of the dam may inflict on downstream or upstream areas, or at the dam location itself irrespective of the potential for such an event to occur. Incremental losses are those over and above losses that might have occurred in the same natural event or condition had the dam not failed. The consequences of a hypothetical dam failure are ranked as Low, Significant, High, Very High, or Extreme for each of four loss categories. The classification assigned to a dam is the highest rank determined among the four loss categories, as shown in Table 7 (GHO TSF classification is shaded grey).

Table 7: Dam Consequence Classification Criteria Summary

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.

Based on the current facility risk assessment (Wood 2018), the GHO TSF is classified as a High consequence structure based on the following rationale:

- **Population at risk (High consequence)**—There is a permanent population in the towns of the Elk River valley, which are within the inundation zone.
- **Loss of life (High consequence)**—The loss of life is expected to be less than 10 if failure of the dams were to occur.

- **Environmental and cultural values (High consequence)**—Significant impact to the environment is possible should the containment fail, resulting in a release of tailings from the facility. This has the potential to impact important fish or wildlife habitat. Restoration or compensation in species is considered possible.
- **Infrastructure and economics (High consequence)**—High infrastructure and economic losses considering the impact to third parties including communities beyond the limit of the mine. Economics losses could be high for the mine due to loss of infrastructure including access road.

An inundation study for a hypothetical breach of the TSF was completed by Golder in 2012 (Golder 2012b) and updated in 2016 (Golder 2017c). The 2016 study included the assessment of overtopping or internal erosion of the Main Tailings Dam and assessed overtopping of the West Tailings Dam.

The inundation study is in the process of being updated to reflect updated survey data.

2.10 Quantifiable Performance Objectives

A geotechnical instrumentation and monitoring program is in place to monitor the stability of the TSF, including survey prisms, GPS units, and inclinometer surveys to monitor for displacement and VW piezometers to monitor piezometric levels within the dams and groundwater elevations in the foundations.

Quantifiable performance objectives (QPOs) have been developed and form part of Teck Resources Limited's risk management policy for tailings and water retaining structures (Teck 2019). The intention of the QPOs is to provide early warning indications of changing conditions that may affect the safe and effective management of the TSF.

QPOs for the VW piezometers are set based on specified phreatic surface elevations assessed during stability analyses. QPOs for the survey prisms are set based on cumulative relative displacement (CRD), i.e., the total three-dimensional displacement from the initial location when the prism or GPS was first surveyed. The QPOs are provided in the following subsections. A comparison between observed conditions during the reporting period and the QPOs are presented in the following sections:

- Section 5.5.1: instability—prisms and VW piezometers
- Section 5.5.2: overtopping—freeboard
- Section 5.5.3: internal erosion—V-notch weirs

2.10.1 Instability Monitoring

Surface Displacement Monitoring

Surface displacement monitoring of the dams at the GHO TSF consists of GPS units and survey prisms. The locations of surface displacement instrumentation are presented in Figure 3.

GPS units on the Site C CCR spoil were installed in October 2012. During August 2017 additional GPS units were installed on the Main and West Tailings Dams. Data from the GPS units are recorded hourly and remotely uploaded to GeoExplorer software.

Survey prisms were installed during September 2015 to monitor for deformation and establish displacement trends. Prisms are spaced at approximately 100 m intervals along the centreline of the Main and West Tailings Dam crests. The location and elevation of each prism is surveyed monthly by GHO. Prisms are relocated during each dam raise. Survey prism readings were not taken during most of the 2017/2018 DSI reporting period, due to having been removed as part of construction to raise the dams (Golder 2019b).

QPOs were established for all instruments in 2017 (Golder 2017g). Based on the level of variation observed in the data recorded by GPS units since installation and frequent exceedances of the established QPOs (see Section 5.5.1), a decision was made by GHO, following consultation with the EoR, that data from the GPS units are not suitable for measuring short-term movements of the GHO dams and QPOs for the GPS units removed. GPS units will continue to be monitored for the purpose of establishing and comparing long-term trends in data for use in determining potential indicators of instability. QPOs for survey prisms are incorporated in the TSF OMS manual (GHO 2019b) as summarized in Table 8.

Table 8: Survey Prisms – Quantifiable Performance Objectives

Warning/Alarm Level	Threshold Criteria
Yellow Warning	CRD >0.025 m/week or 0.1 m total
Orange Alarm	CRD >0.050 m/week or 0.2 m total
Red Alarm	No red alarm level is defined; the EoR and GHO's TSF Qualified Person will be notified when the orange alarm level is triggered. The situation would be then evaluated prior to any evacuation or subsequent actions.

Source: GHO 2019b.

Note: See OMS manual (GHO 2019b) for response actions for each warning/alarm.

CRD = cumulative relative displacement; EoR = Engineer of Record; GHO = Greenhills Operations; TSF = tailings storage facility.

Data in this DSI report are focused on the comparison of long-term trends in data.

Inclinometers

Inclinometer casings (SD-16-04 and SD-16-05) were installed in the Main Tailings Dam during the 2016 geotechnical investigation (Golder 2017e). Inclinometer surveys were carried out monthly and data reported to the EoR. Locations of inclinometer casings are presented in Figure 3.

Following discussions between GHO, the EoR, and the Independent Tailings Review Board in September 2019, it was agreed that it is not practical or valuable to set QPOs for the inclinometers. If an orange alarm is triggered in survey monuments, or deformation is visually observed, an inclinometer survey will be completed and the data used as part of an assessment of potential conditions in the Main Tailings Dam.

Vibrating Wire Piezometers

VW piezometers were installed during 2011 in the Main and West Tailings Dams (MD and WD series, respectively). Additional VW piezometers were installed in the Main Tailings Dam and Site C and D CCR spoils in 2016 (SD series). The locations of VW piezometers are presented in Figure 3.

SD series piezometers are connected to data loggers which record and store measurements. Data from the SD series piezometers are collected manually from the data loggers during routine monthly inspections and uploaded to GeoExplorer. Data from the MD series and WD series piezometers are automated and uploaded directly into GeoExplorer.

QPOs were established for all the VW piezometers in 2017 (Golder 2017g) and remained unchanged during the 2018/2019 reporting period. QPOs are incorporated in the TSF OMS manual (GHO 2019b) as summarized in Table 9. The yellow warning QPOs will be updated after the DSI to reflect the current pond level.

Table 9: Vibrating Wire Piezometers – Quantifiable Performance Objectives

Dam	Vibrating Wire Piezometer	Yellow Warning[b] Water Elevation (m)		Orange Alarm[b] Water Elevation (m)	Red Alarm[b][c]
Main	VW11-MD-1A[a]	±2	1,718.5	1,724.0	n/a
	VW11-MD-1B[a]				
	VW11-MD-2A				
	VW11-MD-2B				
	VW11-MD-3A				
	VW11-MD-3B				
	VW11-MD-4A				
	VW11-MD-4B[a]				
	VW11-MD-5A				
	VW11-MD-5B				
	SD-16-01A	±2	1,705.5	1,713.5	
	SD-16-01B		n/a – till/bedrock groundwater flow[d]		
	SD-16-02A		1,692.5	1,708	
	SD-16-02B		n/a – till/bedrock groundwater flow[d]		
	SD-16-03A		1,705.5	1,713.5	
	SD-16-03B		n/a – till/bedrock groundwater flow[d]		
	SD-16-04		1,697.0	1,710.0	
	SD-16-05A		1,699.5	1,710.5	
	SD-16-05B		n/a – till/bedrock groundwater flow[d]		
	SD-16-06A		1,697.0	1,710.0	
	SD-16-06B		n/a – till/bedrock groundwater flow[d]		
	SD-16-07A		1,682.0	1,686.5	
	SD-16-07B		n/a – bedrock groundwater flow[d]		
	SD-16-08A		1,682.0	1,686.5	
	SD-16-08B		n/a – till/bedrock groundwater flow[d]		
West	VW11-WD-1A	±2	1,733.0	n/a	n/a
	VW11-WD-1B				
	VW11-WD-2A				
	VW11-WD-2B				
	VW11-WD-3A				
	VW11-WD-3B				

Source: GHO 2019b.

a) Not operational, data infrequent, sporadic and/or erroneous.

b) See OMS manual (GHO 2019b) for further details about thresholds and response actions for each warning/alarm.

c) No red alarm levels were defined since the EoR will be contacted when the orange level is triggered. The situation can then be evaluated.

d) The readings of the 2016 piezometers (SD-16-01B to SD-16-08B) that were installed in bedrock or deep till are on average higher than the shallow piezometers due to artesian conditions within an isolated groundwater flow which is not hydraulically linked to the upper groundwater system.

n/a = not applicable; OMS = operation, maintenance, and surveillance; EoR = Engineer of Record.

2.10.2 Tailings Pond Level

The elevation of the tailings pond is controlled by the reclaim barge which recirculates water from the facility to the wash plant for use in processing. The tailings pond elevation is monitored by GPS Unit 313, which is mounted on the reclaim barge. QPOs for pond freeboard are presented in Table 10.

Table 10: Pond Freeboard – Quantifiable Performance Objectives

Warning/ Alarm Threshold	Yellow Warning	Orange Alarm	Red Alarm
Minimum Freeboard (m)	2.0	1.3	0.5

Source: GHO 2019b.

QPOs were developed on the following basis:

- Yellow Warning – Adopted as the maximum standard operating freeboard.
  - Allows for storage of the 72-hour Peak Maximum Flood (PMF) which exceeds the requirements of the HSRC (Ministry of Energy and Mines 2017).
  - Orange Alarm – Maximum water level at which the TSF can contain the 72-hour inflow design flood (IDF) (1/3 between the 1-in-1,000-year event and the PMF). This meets the requirements of the HSRC (Ministry of Energy and Mines 2017) for a High consequence classification facility including allowance for freeboard as per CDA (2013).
- Red Alarm – Maximum water level used to inform emergency decision making as per the EPRP (GHO 2019a).

A visual indicator was installed in 2017 on the crest of the Main Tailings Dam to complement electronic monitoring and provide a basis for visual confirmation of facility freeboard (Photo 5 in Appendix A).

2.10.3 Seepage

V-notch weirs are located downstream of the Main Tailings Dam at the toe of Site C (Site C Weir), and downstream of the West Tailings Dam (West Dam Weir). Weir locations are shown in Figure 3. Manual measurements are taken monthly, when accessible, and data uploaded to GeoExplorer for notification and tracking.

Seepage from the Main Tailings Dam is collected by rock drains that were installed through the Site C and D CCR stockpile footprints in 1996. These rock drains consist of geotextile-wrapped crushed limestone (Golder 2019b). Seepage at the toe of the Site C is collected in a seepage collection channel, at the end of which the Site C Weir monitors discharge. The Site C Weir was damaged during the 2017 upgrade of the seepage collection channel and was repaired and reinstalled in January 2018.

The West Dam Weir monitors discharge through a seepage ditch downstream from the dam toe. The West Dam Weir was damaged by a boulder in 2017 and was repaired and reinstalled further downstream during October 2017.

QPOs for the weirs were established in 2017 and are summarized in Table 11.

Table 11: Seepage Weirs – Quantifiable Performance Objectives

Instrument	Warning/Alarm Level		
	Yellow Warning (L/s)	Orange Alarm (L/s)	Red Alarm
Site C Weir	2	4	See Note (a)
West Dam Weir	1	2	

Source: GHO 2019b.

a) An alarm (red) threshold is to be determined by the Engineer of Record and GHOs TSF Qualified Person.

Since weir reinstallation in 2017/2018, records indicate flows are near or above the yellow warning threshold. Automation of the weirs was planned at the time of this report. The QPOs are outdated and will be reviewed and updated after the DSI to reflect the current pond level and the historic seepage trends.

3.0 OPERATIONS, MAINTENANCE, AND CONSTRUCTION DURING 2018/2019

During the reporting period GHO staff carried out visual inspections of the TSF on a monthly basis. Observations during the inspection were recorded and reviewed by GHO and the EoR team.

3.1 Tailings Storage Facility and Operations

GHO tracks in-place tailings volume through annual bathymetric surveys. Based on a comparison between the 2019 (17 October 2019) and 2018 (24 October 2018) bathymetric surveys approximately 531,000 m^3 of tailings were deposited between 24 October 2018 and 17 October 2019.

In September 2019 the tailings deposition point was moved to a higher elevation to prevent burying of the discharge pipe (as shown in Figure 2).

3.2 Maintenance

Maintenance and repair of instrumentation during the reporting period was routine and consisted of rectifying minor deficiencies, which are typical for the normal operation of tailings dams. The following maintenance and repairs were carried out during the reporting period:

- The batteries in the data loggers at SD-16-01A and 01B were replaced on 18 June 2019.
- The visual freeboard indicator, located on the Main Tailings Dam, was levelled in September 2019 following observations during the 2019 DSI site visit.
- GPS unit WD-1_Rover was repaired and began recording data on 16 January 2019. This GPS unit was operational throughout the remainder of the reporting period.
- The tailings deposition point was moved in September 2019.

3.3 Construction

No construction works were carried out in the 2018/2019 reporting period. The GHO TSF dams were last raised in 2018 to an elevation of approximately 1,731 m as reported in the 2018 DSI (Golder 2019c) and the construction record (Golder 2019b).

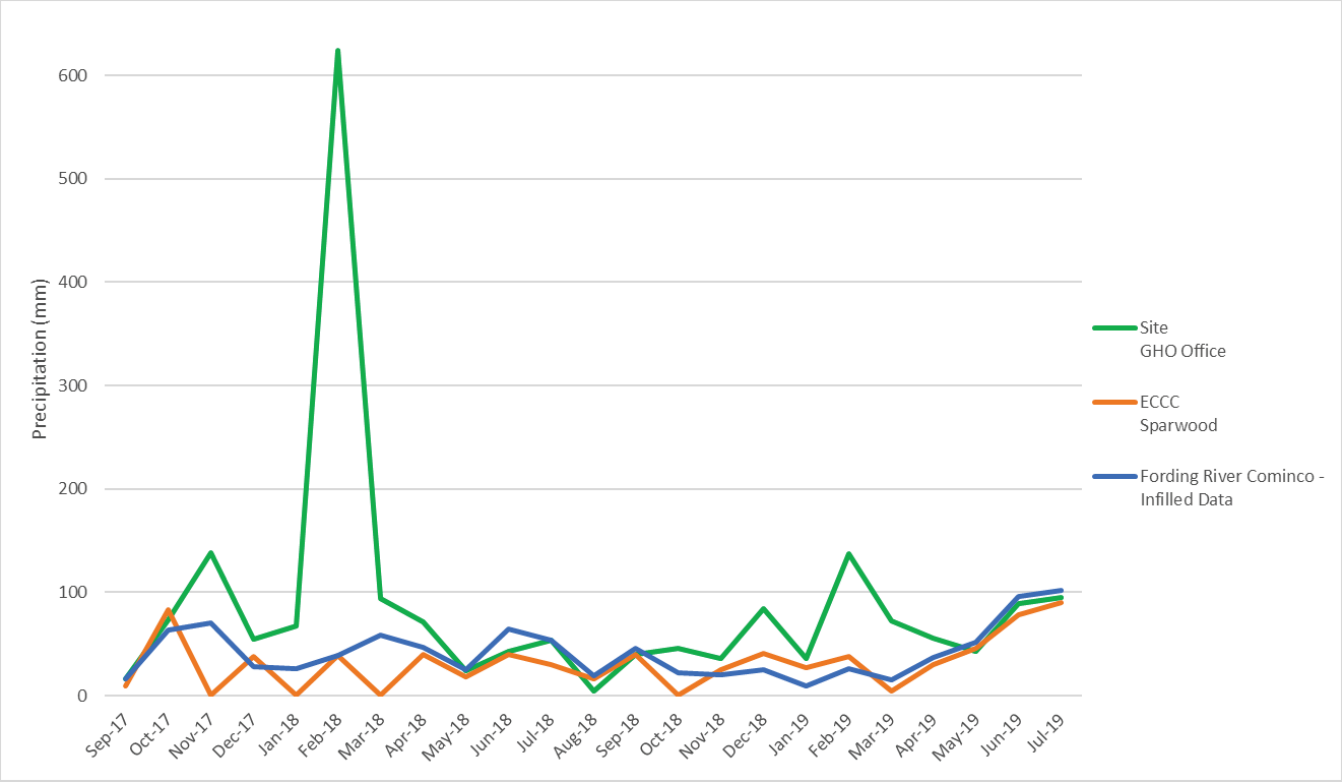
The next raise of the TSF dams is planned for Q2 2020.

4.0 REVIEW OF CLIMATE DATA, WATER BALANCE, AND TAILINGS STORAGE FACILITY REGISTRY

4.1 Climatic Review

Precipitation data collected at the GHO Office climate station were provided by GHO. The data provided were reviewed and found to be unreliable when compared to nearby climate data (Teck Fording River synergetic dataset, known as Fording River Cominco, and Environment and Climate Change Canada [ECCC] station at Sparwood). Precipitation data from September 2017 to July 2019 are compared in Illustration 2, and identified anomalies include:

- Monthly total precipitation at the GHO Office station shows a significantly different trend to nearby climate data for the same period.
- Total recorded precipitation at the GHO Office station for December 2018 and February 2019 was significantly higher than the values obtained from nearby climate data.



ECCC = Environment and Climate Change Canada; GHO = Greenhills Operations.

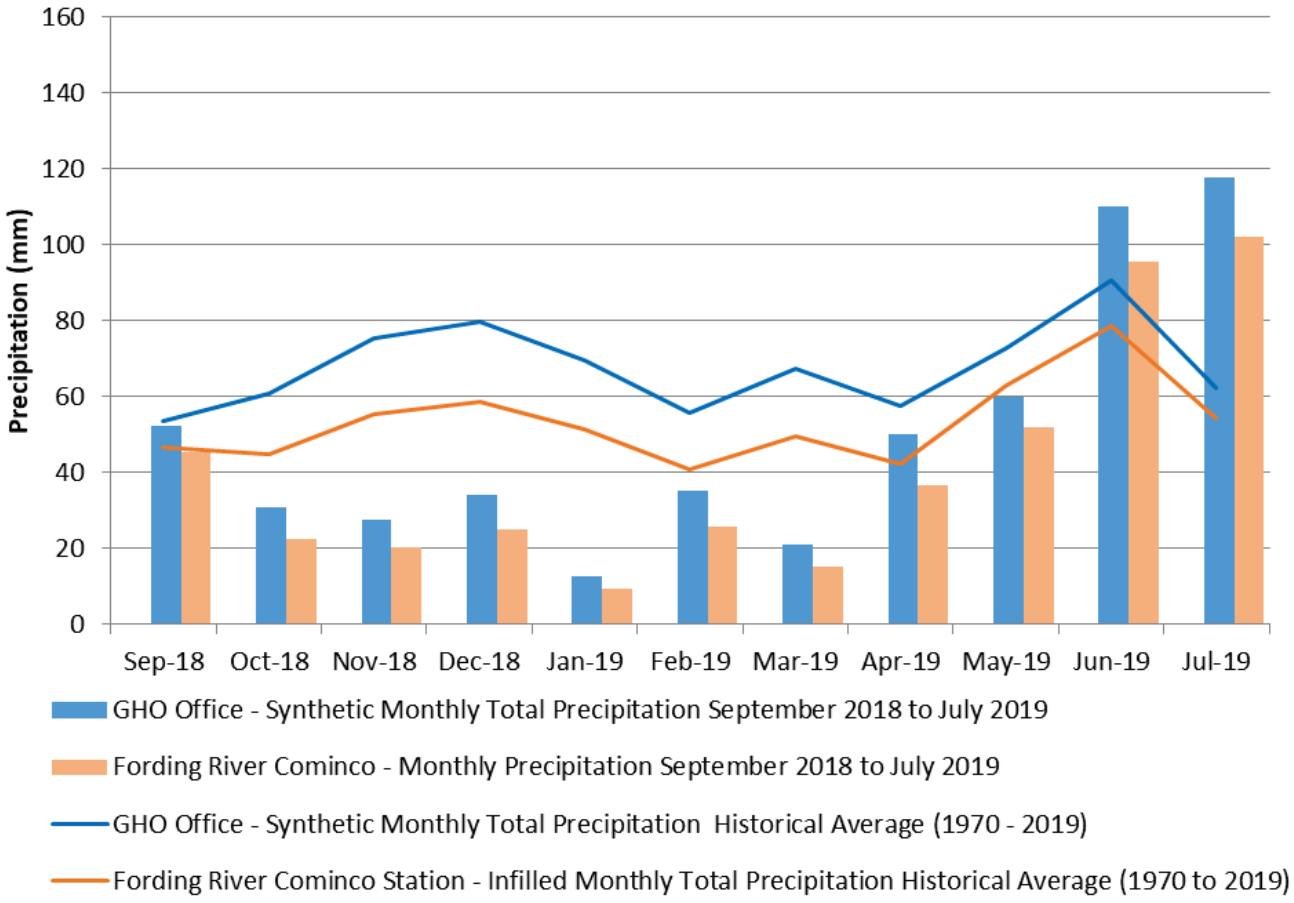
Illustration 2: Greenhills Operations Office Precipitation Data Compared to Nearby Climate Datasets from September 2018 to July 2019

Due to the identified anomalies, precipitation data from the GHO Office weather station for the period September 2018 to July 2019 were disregarded and replaced with precipitation data from the Fording River Cominco synthetic dataset, which for the 2018/2019 reporting period consisted of data solely from the Fording River Operations (FRO) waste water treatment (WWT) weather station. The FRO WWT weather station is approximately 7 km northeast of the GHO Office station, and 390 m lower in elevation.

The FRO WWT data were adjusted to the GHO Office station location based on summer and winter elevation precipitation adjustment factors previously determined for the region (Teck 2017). The summer and winter elevation adjustment factors were incorporated from May to September and from October to April, respectively.

A long-term synthetic precipitation dataset was created for the GHO Office station to allow for comparison of the precipitation data during the 2018/2019 monitoring period with the established historical precipitation data. The synthetic precipitation dataset was created using precipitation data from the Fording River Cominco dataset from 1970 to 2019 (Golder 2018a). The synthetic precipitation dataset was then adjusted to the elevation of the GHO Office station using the same summer and winter adjustment factors applied to the 2018/2019 monitoring period data.

A summary of the monthly total precipitation for the period 1 September 2018 to 31 July 2019 and the historical monthly averages at the GHO Office station location are presented in Illustration 3.



Notes:
Derived by elevation adjustment of Fording River Cominco station infilled dataset.
Missing data infilled with FRO WWT weather station dataset received from GHO.
Missing data infilled with unadjusted data from the weather stations nearby.
GHO = Greenhills Operations; FRO = Fording River Operations; WWT = waste water treatment.

Illustration 3: Comparison Between 2018/2019 Total Precipitation and Historical Average for Greenhills Operations

Precipitation records from the Fording River Cominco climate station are presented for comparison purposes. The data indicate that:

- Total monthly precipitation in the reporting period was approximately 26% lower than the historical average for the same period (1 September to 31 July).
- Total monthly precipitation in the reporting period was lower, in comparison with the historical monthly average, in every month except June and July 2019.
  - Total monthly precipitation between 1 September 2018 and 31 May 2019 was approximately 44% lower than the historical average for the same period.
  - Monthly precipitation between 1 June 2019 and 31 July 2019 was approximately 55% higher than the historical average for the same period.

4.2 Water Balance and Reclaim Water

The 2019 water balance for the Tailings Pond was completed by Golder based on inflow and outflow data provided by GHO and using the GHO site water balance model (Golder 2013b). The GHO site 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 2018/2019 inflow and outflow data and was calibrated using the measured tailings pond water elevations provided by GHO. Table 12 summarizes the tailings storage facility water balance for the period 1 September 2018 to 31 July 2019.

Table 12: 1 September 2018 to 31 July 2019 Greenhills Tailings Storage Facility Water Balance[a]

IN	Volume (m^3)	OUT	Volume (m^3)	Total Inventory Change (m^3)
Direct Precipitation	182,900	Seepage	190,300	
Surface Runoff	546,100	Evaporation	173,800	
Water Discharge with Tailings[b]	2,626,600	Reclaim water to Plant	3,408,700	
Transfers from Phase 3 and Phase 6	1,204,600	Water retained in tailings[c]	192,800	
Sum	**4,560,200**		**3,965,600**	**594,600**

a) Values presented above represent an eleven-month period.

b) Includes plant system loss to pond.

c) Water retained in the pore space of the tailings is estimated by multiplying the annual tailings dry tonnage by an estimated gravimetric water content of the consolidated tailings of 39% (Golder 2019).

d) Includes seepage to Greenhills Settling Pond.

The water balance model was calibrated to match the total inventory change calculated from volume estimates on 1 September 2018 and 31 July 2019. The estimated volumes were determined from pond level measurements and interpolated stage storage curves. Interpolated stage storage curves were derived from bathymetry measurements on 24 October 2018 and 17 October 2019.

The water balance results indicate there was approximately 1.2 million cubic metres of water transferred into the facility from Phase 3 and Phase 6 during the eleven-month reporting period. This volume is greater than the estimated 281,000 cubic metres transferred into the facility from Phase 3 and Phase 6 during the 2017/2018 reporting period (Golder 2019c). No water transfers from Phase 3 and/or Phase 6 to the TSF were reported in DSI reports from 2013 to 2017 (Golder 2014e, Golder 2014f, Golder 2016c, Golder 2017h, Golder 2018b). The additional 1.2 million cubic metres of water transferred into the facility during the 2018/2019 reporting period has contributed to the accumulation of approximately 600,000 cubic metres of water in the TSF.

The water balance results suggest the 2018/2019 reporting period was atypical from a water management perspective. The reporting period was drier than the historical average (Section 4.1), however there was a positive total inventory change due to the increased transfers from Phase 3 and Phase 6. The Phase 3 and Phase 6 transfers should not exceed the volume required to meet the reclaim demand while keeping the total inventory change close to zero, for long term pond management.

4.3 Water Discharge

Water from the tailings pond is pumped from the TSF to the wash plant for use in processing. No other water was discharged from the GHO TSF in the 2018/2019 reporting period.

4.4 Tailings Storage Facility Registry

A TSF registry for the Main and West Tailings Dams are presented in Appendix C.

5.0 GREENHILLS OPERATIONS TAILINGS STORAGE FACILITY SAFETY ASSESSMENT

This section presents an assessment of the safety of the dams based on a review of the instrumentation data and an assessment of the field observations and background information.

5.1 Site Visit

An inspection of the TSF was carried out on 17 July 2019 by the EoR, Mr. Andy Haynes, P.Eng., and Mr. Martyn Willan, P.Eng., of Golder. The visit was accompanied by Mr. David Walker, E.I.T, of GHO. A close-out meeting was also held and attended by the TSF Qualified Person, at the time of the inspection, Mr. Mark Slater, P.Eng., of GHO. The dams were also inspected by Andy Haynes, Martyn Willan and David Walker on 11 September 2019.

Appendix A presents a summary of photographs taken during the 17 July 2019 inspection. Photograph locations and directions are presented in Figure 2. A summary of observations made during the 17 July 2019 visit are included in Appendix B. The GHO Main and West Tailings Dams were observed to be in satisfactory condition at the time of the 2019 DSI site visit.

5.2 Review of Background Information

GHO provided the following information for this dam safety inspection:

- survey data
  - GHO air photograph and site LiDAR survey data (flown 15 to 16 July 2018)
    - A revised air photograph and site LiDAR survey data was completed between 21 and 29 July 2019 and data received from Teck in November 2019. The revised data will be presented in future DSI reports.
  - tailings dam area survey data, completed following dam raise (2 October 2018)
  - tailings pond bathymetric survey data (17 October 2019)
- site climate data recorded at the GHO Office station for the reporting period (Section 4.1)
- instrumentation data for the reporting period (downloaded from GeoExplorer software)
  - VW piezometer data
  - GPS unit data
  - survey prism data
  - inclinometer survey data
- monthly TSF inspection records, including photographs, visual observations and instrument data

5.3 Facility Consequence Classification Review

A review of the consequence classification of the GHO TSF is provided in Section 2.9.

5.4 Review Documentation

5.4.1 Operation, Maintenance, and Surveillance Manual

The operation, maintenance, and surveillance (OMS) manual for the TSF was updated June 2019 (GHO 2019b). Review of the OMS manual indicates that it meets the guidelines provided by the CDA (2013, 2014), the Mining Association of Canada (MAC 2011, 2017), and Teck' Resources Limited's *Tailings and Water Retaining Structures Guidelines* (Teck 2014).

A review of the OMS manual indicates that coordinates appear to be presented to different grid systems (UTM and Mine grid).

The revised OMS manual should be checked for compliance with the revised *Tailings and Water Retaining Structures Guidelines* (Teck 2019) and MAC OMS manual guide (MAC 2019). The OMS manual should also be updated to reflect changes in instrumentation QPOs and to update the status of non-functioning instruments.

5.4.2 Emergency Preparedness and Response Plan

The emergency preparedness and response plan for the TSF was last updated in 2018 (Standard Practices and Procedures No. 1583, GHO 2019a).

An inundation study for a hypothetical breach of the TSF was completed by Golder in 2012 (Golder 2012b) and updated in 2016 (Golder 2017c). The inundation study is in the process of being updated based on LiDAR data from 2017.

An update of the emergency preparedness and response plan is proposed following completion of the revised inundation study.

5.4.3 Dam Safety Review

A dam safety review (DSR) was completed by Klohn Crippen Berger Ltd. in 2017 (KCB 2017). The DSR concluded that the condition and integrity of the dams met current safety standards. The HSRC (Ministry of Energy and Mines 2017) specifies that a DSR is to be completed once every five years; the next DSR is therefore required by the end of 2022.

5.5 Assessment of Facility Safety Relative to Credible Failure Modes

The Main and West Tailings Dams at the GHO TSF were evaluated against credible failure modes:

- **Instability**—occurs due to imbalance of forces resulting in movement of a part of the dam with possible loss of integrity of the dam.
- **Overtopping**—occurs when the pond level rises above the dam crest level, resulting in flow over the dam that may cause progressive erosion of the dam and loss of the pond and tailings.
- **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.

5.5.1 Instability

Design Basis

The Main and West Tailings Dams were designed to provide factors of safety in accordance with CDA (2013) guidelines for High consequence dams, as shown in Table 13.

Table 13: CDA Recommended Minimum Factors of Safety for High Consequence Dams (CDA 2013)

Operating Status	Stability Analysis	Minimum Factor of Safety
Normal operating conditions	Limit equilibrium	1.5
1-2,475-year design earthquake	Pseudo-static[a]	1.0

a) Based on peak ground acceleration of 0.158g (See Table 6).

Following the 2016 geotechnical investigation, Golder assessed the stability of the Main Tailings Dam for a crest elevation of 1,735 m (Golder 2017g). Results indicated:

- The development of excess pore pressures in the foundation materials is considered unlikely as soft clay colluvium was not encountered during the 2016 geotechnical investigation.
- Glacial till, present in the foundation, was dense to very dense with low liquidity index values.
- The stability of the Main Tailings Dam satisfies both CDA (2013) and the HSRC (Ministry of Energy and Mines 2016) guidance for static and pseudo-static stability.

Following the 2013 geotechnical investigation, Golder assessed the stability of the West Tailings Dam for a crest elevation of 1,735 m (Golder 2014b). Results indicated:

- The upstream clay blanket is performing well in reducing seepage through the dam.
- The stability of West Tailings Dam satisfies both CDA (2013) and the HSRC (Ministry of Energy and Mines 2016) guidance for static and pseudo-static stability.

Observed Performance

A review of the performance of the GHO TSF, relative to the risk of instability, is summarized below. Performance was within that expected of normal operating conditions.

Measured deformations (as recorded by GPS and prism surveys) were low and consistent with the expected performance.

Slope deformation was observed at Site C during 2011 and 2012 when visual inspections noted the development of a head scarp and a toe bulge. GPS units 319 and 320 were installed on the benches of Site C. Scarp and toe bulge locations are shown in Figure 3. Conditions in 2019 did not indicate any signs of further movement or instability.

A small slough of CCR material on the downstream face of Site C (as shown in Figure 2) was identified by GHO personnel on 18 April 2019 (Photo 17, Appendix A). During the 2019 DSI site visit, small rills up to 50 mm deep were observed at the slough location. This slough is believed to be a result of surface water erosion from melting snow and does not present a dam safety risk.

General observations at the time of the 2019 DSI site visit, in relation to instability, include:

- minor cracking and erosion along the upstream slope and crest of the Main and West Tailings Dams
- some localized depressions on the upstream crest of the Main Tailings Dam
- minor erosion of riprap at the toe of the upstream face of the Main Tailings Dam

These features do not present a risk to dam safety, and routine maintenance should be scheduled to occur at the same time as the 2020 dam raise construction.

Survey Prisms

Survey prism data for the 2018/2019 reporting period are presented in Appendix D (Figures D-1 to D-13). Data analysis focuses on long-term data trends based on the average annual rate of the Cumulative Relative Displacement (CRD).

Prism D was the only prism to exceed the yellow warning QPO threshold during the reporting period; data indicates that the average CRD of Prism D was 0.11 m/year in the reporting period.

Measured deformations were low (less than 200 mm) in the reporting period, consistent with the expected performance and are not indicative of instability of the Main or West Tailings Dams. Movements, relative to maximum dam height were small (less than 0.36%) and within the expected range for earthfill embankments.

GPS Units

GPS data for the 2018/2019 reporting period are summarized in Table 14 and presented in Appendix D (Figures D-14 to D-23). Data in this DSI report are focused on the comparison of long-term data trends.

Table 14: Summary of GPS Unit Data 1 September 2019 to 31 July 2019

Dam	Instrument	Cumulative Relative Displacement (CRD) Observations	Figure
Main	GPS 319 (Site C)	■ Unit was relocated on 24 October 2018. ■ Data since 24 October 2018 indicate a general flat trend in CRD.	D-14
	GPS 320 (Site C)	Historical data show CRD trending towards the yellow warning, followed by a general flat trend during the 2018/2019 reporting period.	D-15
	MD-1_ROVER	Unit was not functional until 2 November 2018. Data since 2 November 2018 show a general flat trend in CRD.	D-16
	MD-2_ROVER	Historically a generally flat trend in CRD which continued during 2018/2019 reporting period.	D-17
	MD-3_ROVER	Historically a generally flat trend in CRD which continued during 2018/2019 reporting period.	D-18
	MD-4_ROVER	Historically a generally flat trend in CRD which continued during 2018/2019 reporting period.	D-19
	MD-5_ROVER	Historically a generally flat trend in CRD which continued during 2018/2019 reporting period.	D-20
West	WD-1_ROVER	Unit was not functional until 24 December 2018. Data since 24 December 2018 show a general flat trend in CRD.	D-21
	WD-2_ROVER	Historically a generally flat trend in CRD which continued during 2018/2019 reporting period up to 3 July 2019, after which data were not available.	D-22
	WD-3_ROVER	Historically a generally flat trend in CRD which continued during 2018/2019 reporting period.	D-23

CRD = Cumulative relative displacement

The inherent error in the GPS units make them unsuitable for the measurement of short-term deformations and therefore data are not assessed against QPOs. The GPS units continue to be used to complement prism data in the assessment of long-term trends.

No signs of instability which correlate to the observed variations in GPS data were observed during the 2019 DSI site visit or monthly inspections completed by GHO.

GPS unit data for the 2018/2019 reporting period are not indicative of instability of the Main and West Tailings Dams.

Inclinometer Surveys

Inclinometer survey data for the 2018/2019 reporting period are presented in Appendix D (Figures D-24 to D-25).

Results of the inclinometer surveys in the 2018/2019 reporting period indicate:

- Displacements were generally less than 10 mm in instrument SD-16-04, with some localized larger displacements observed at a depth of approximately 12.5 m:
  - Displacements of up to approximately 40 mm in the negative A-axis (to the north, upstream, direction), and up to approximately 65 mm in the positive B-axis (to the east, perpendicular to the downstream slope) were observed.
  - This movement appears to have occurred shortly after installation and has not continued since the 9 October 2018 reading.
  - Based on the direction, shallow depth relative to the total casing depth, and timing of this displacement, it may have occurred due to movement resulting from the installation of the casing. It is not believed to be an indicator of slope instability.
- Displacements were generally less than 2 mm in instrument SD 16-05 since the 9 October 2018 reading.

Inclinometer survey data for the 2018/2019 reporting period are not indicative of instability of the Main Tailings Dam.

Vibrating Wire Piezometers

Maximum and minimum water elevations in the 2018/2019 reporting period for installed piezometers are presented in Table 15 and in Appendix E (Figures E-1 to E-3).

Negative pressure readings were recorded consistently in nine piezometers during the reporting period. Negative pressure readings indicate that the tip is dry. Piezometric levels cannot be determined from VW piezometer recording negative pressures. Negative pressure readings are not presented in the figures in Appendix E.

Table 15: Summary of Maximum and Minimum Vibrating Wire Piezometer Readings During 2018/2019 Dam Safety Inspection Reporting Period

Tailings Dam	Instrument	Range of Water Elevations in 2018/2019 Reporting Period		Exceeds QPO
		Minimum (m)	Maximum (m)	
Main	VW11-MD-1A[a]	Not Operational		
	VW11-MD-1B[a]	Not Operational		
	VW11-MD-2A	1,692.53	1,693.42	None
	VW11-MD-2B	1,681.18	1,681.25	None
	VW11-MD-3A	1,687.75	1,688.18	None
	VW11-MD-3B	1,689.00	1,689.48	None
	VW11-MD-4A	1,686.54	1,687.86	None
	VW11-MD-4B[a]	Not Operational		
	VW11-MD-5A	1,683.57	1,684.21	None
	VW11-MD-5B	1,684.12	1,684.68	None
	SD-16-01A[b]	Dry at piezometer tip		None
	SD-16-01B	1,710.80	1,711.19	n/a[a]
	SD-16-02A[b]	Dry at piezometer tip		None
	SD-16-02B	1,693.06	1,694.07	n/a[a]
	SD-16-03A[b]	Dry at piezometer tip		None
	SD-16-03B	1,708.46	1,709.63	n/a[a]
	SD-16-04	1,675.68	1,676.69	None
	SD-16-05A[b]	Dry at piezometer tip		None
	SD-16-05B	1,693.99	1,698.14	n/a[a]
	SD-16-06A[b]	Dry at piezometer tip		None
	SD-16-06B	1,706.47	1,707.11	n/a[a]
	SD-16-07A[b]	Dry at piezometer tip		None
	SD-16-07B[b]	Dry at piezometer tip		n/a[a]
	SD-16-08A[b]	Dry at piezometer tip		None
	SD-16-08B	1,687.87	1,688.77	n/a[a]
West	VW11-WD-1A	1,712.61	1,712.90	None
	VW11-WD-1B[b]	Dry at piezometer tip		None
	VW11-WD-2A	1,712.86	1,713.24	None
	VW11-WD-2B	1,715.76	1,716.05	None
	VW11-WD-3A	1,715.48	1,715.82	None
	VW11-WD-3B	1,716.18	1,716.53	None

a) The readings of the 2016 piezometers (SD-16-01B to SD-16-08B) that were installed in bedrock or deep till are on average higher than the shallow piezometers due to artesian conditions within an isolated groundwater flow which is not hydraulically linked to the upper groundwater system.

b) Negative pressure readings indicate that the tip is dry and piezometric levels cannot be determined from recorded negative pressures. Negative pressure readings not shown

QPO = quantifiable performance objective; VW = vibrating wire; n/a = not applicable.

Overall, the elevation of the phreatic surfaces recorded in operational piezometers during the reporting period were within normal operating conditions and did not exceed the QPOs. The phreatic surface within the Main Tailings Dam was generally between 10 and 15 m above the glacial till foundation. The phreatic surface within the West Tailings Dam was generally within the glacial till foundation.

Erroneous readings which exceeded the QPOs during the reporting period occurred in instruments:

- VW11-MD-1A
- VW11-MD-1B
- VW11-MD-4B

These readings are considered erroneous due to large fluctuations in the data which are inconsistent with measurements in the other piezometers, other instruments, and visual observations. These instruments have been determined as being non-operational.

5.5.2 Overtopping

Design Basis

The TSF does not have an operational or emergency overflow structure (i.e., spillway) and is therefore required to contain the 72-hour inflow design flood (IDF) for a 1/3 between the 1-in-1,000-year event and the PMF, including allowance for freeboard, per the HSRC (Ministry of Energy and Mines 2017) for a High consequence classification facility.

The CDA (2013) provides two calculations for freeboard; the most critical of the two scenarios sets the minimum freeboard to be adopted:

- **Scenario 1**—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.
- **Scenario 2**—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 IDF.

The GHO TSF minimum freeboard (1.3 m) is calculated in accordance with the CDA (2013); however, GHO currently adopts a minimum 2 m operational freeboard. Maximum allowable pond levels and freeboard details are presented in Table 16.

Table 16: Greenhills Operations Tailings Storage Facility Pond Level and Freeboard Details

Item	Value (Current Condition) (m)
Lowest elevation on Main Tailings Dam or West Tailings Dam crests	1,731.14
Allowance for IDF ($^1/_3$ between 1:1,000-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 (per CDA 2013)	1.3
Minimum required freeboard (as designated in OMS manual)	1.3
Standard operating maximum pond level (distance below dam crest)	2.0
Standard pond operating elevation (2.0 m below minimum dam crest)	1,729.14
Maximum pond elevation to maintain minimum freeboard (1.3 m)	1,729.84

a) Flood and wave run-up values reported in OMS manual (GHO 2019b).

IDF = inflow design flood; CDA = Canadian Dam Association; OMS = operation, maintenance, and surveillance.

CDA (2014) guidance on the application of the Dam Safety Guidelines to mining dams recommends that a third scenario (in addition to Scenarios 1 and 2, as recommend by CDA 2013) be evaluated where the high water level (IDF) occurs at the same time as the high wind event, recommendations for the return period of the high wind event are not provided. A 1-in-1,000-year wind event combined with the IDF was assessed and resulted in a freeboard of 1.5 m, which is less than the 2.0 m operational freeboard adopted by GHO. As such, no modifications to the operating practices are required based on CDA (2014) guidelines.

Observed Performance

The pond elevation recorded from 1 September 2018 to 31 July 2019 is presented in Illustration 4.

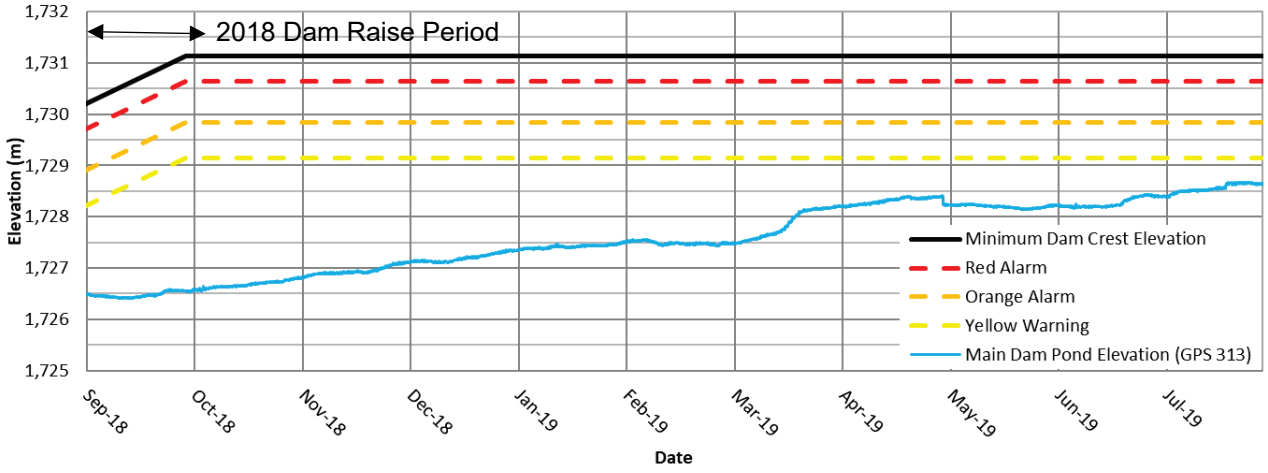


Illustration 4: Tailings Pond Elevation Relative to Minimum Freeboard and Standard Pond Operating Level

Data indicate that the pond elevation varied between 1,726.41 and 1,728.67 m during the 2018/2019 reporting period. Freeboard measurements, calculated relative to the minimum dam crest elevation (1,731.14 m), indicate the minimum freeboard during the reporting period was 2.5 m and therefore the TSF had the capacity to contain the 72-hour PMF throughout the reporting period.

During the 17 July 2019 inspection, the visual freeboard indicator was observed to not be level such that the freeboard could be underestimated. An additional block was added on the upstream side of the arm in September 2019 to provide more accurate visual readings of the freeboard.

It is noted that the pond volume has increased since the last DSI. This is understood to be a result of the addition of water from the Phase 3 and Phase 6 pit dewatering to ensure sufficient volume for plant operation. Based on the 2019 bathymetry survey the current pond volume is around 900,000 m^3, which is greater than the minimum needed for plant operation. The pond volume should be reduced to between 200,000 m^3 and 350,000 m^3.

5.5.3 Internal Erosion

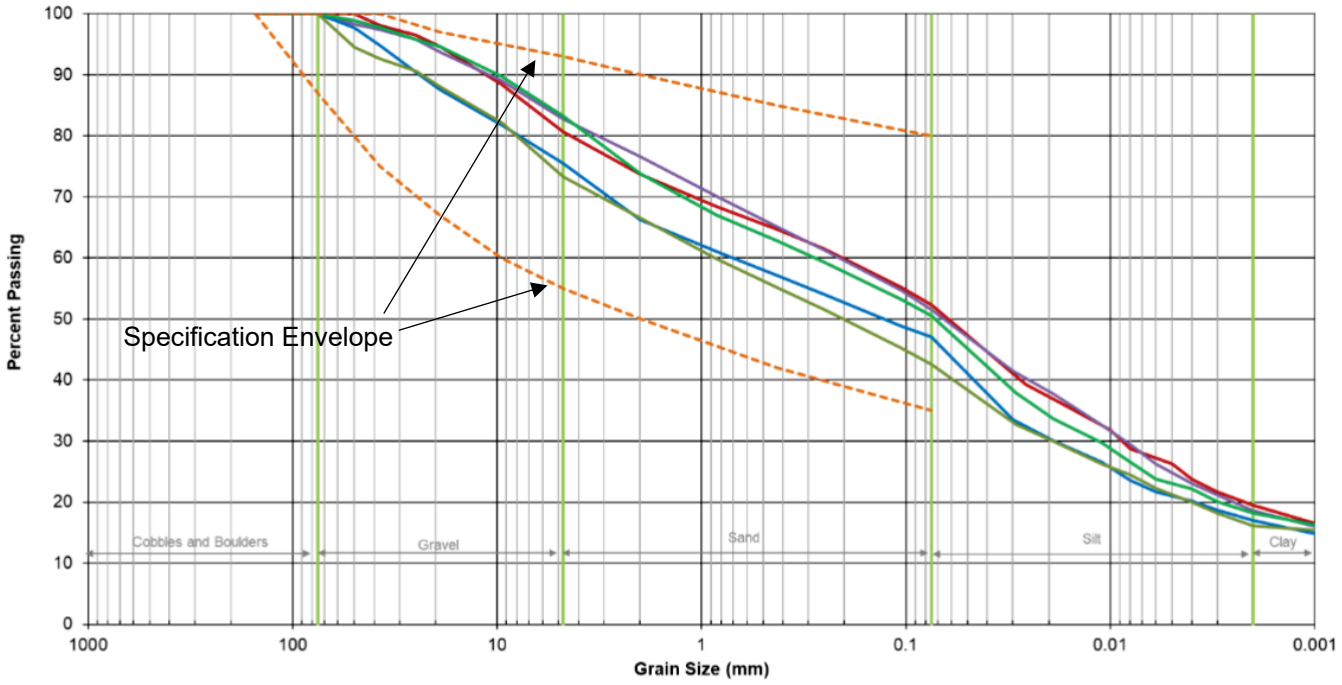
Design Basis

The till blanket on the upstream face of the dams and CCR material specification have been designed to meet internal stability criteria (Li et al. 2009) and filter compatibility (Sherard et al. 1984; Sherard and Dunnigan 1989), as recommend by the CDA (2007).

As part of the 2016 inundation study (Golder 2017c) Golder tested samples of coal tailings collected on 10 May 2016 at the exit of the tailings discharge. The particle size distribution of the tailings was determined using mechanical sieving (ASTM D6913) and a Fritsch laser particle size analyzer (ASTM D4464). The results are documented in Golder (2017c) and indicate that filter compatibility exists between the tested tailings and the clay blanket (till) samples.

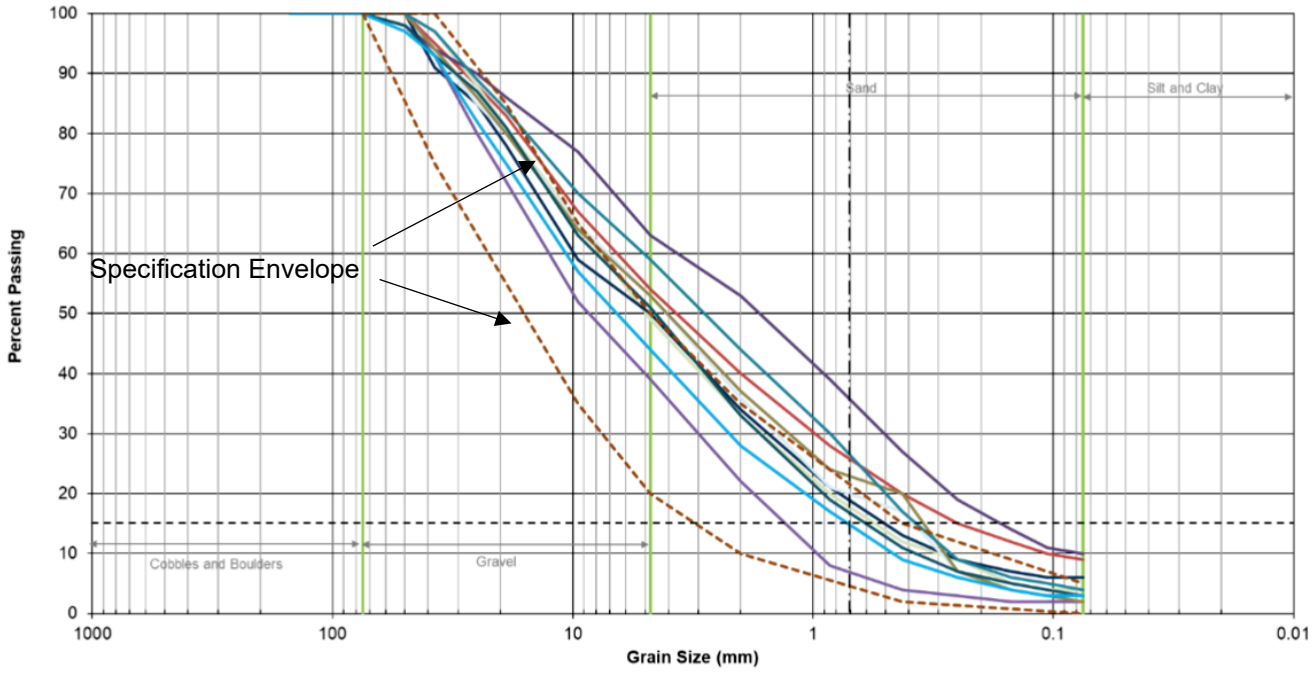
The CCR has been tested throughout construction of the dams and, with occasional exception, was found to meet filter criteria.

Grain size distribution tests were performed on 5 clay blanket (till) and 10 CCR samples as part of the 2018 dam raise (Golder 2019b). Results are presented in Illustration 5 (till sample) and Illustration 6 (CCR samples) along with the design specification envelopes.



Source: Golder 2019b.

Illustration 5: Grain Size Distribution and Specification Envelopes for Till



Source: Golder 2019b.

Illustration 6: Grain Size Distribution and Specification Envelopes for Coarse Coal Refuse

Tested till samples tested were within the specified envelope.

Four of the 10 CCR samples were finer than the specification. CCR material was assessed for filter compatibility, and all samples were found to meet the Li et al. (2009) internal stability criteria. Samples were also assessed against the Sherard et al. (1984) and Sherard and Dunnigan (1989) criteria, which recommend a filter D_{15} for glacial tills of less than or equal to 0.7 mm. Nine CCR samples met this criterion. One sample was coarser (D_{15}=1.3 mm).

In summary, results indicate that 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, and the GHO dams are unlikely to be prone to internal erosion.

Observed Performance

Recorded flow rates at the Site C Weir and West Dam Weir in the 2018/2019 reporting period are presented in Illustration 7 and Illustration 8, respectively. Data were not recorded from 1 September 2018 to 3 March 2019 due to difficulties accessing the weirs.

The flows in both weirs were low and within the expected range for normal operation. There were some exceedances of the Yellow Warning QPO, but this reflects a need to update the warning QPO to reflect the small increase in seepage that occurs with the normal increases in pond level as the TSF is raised.

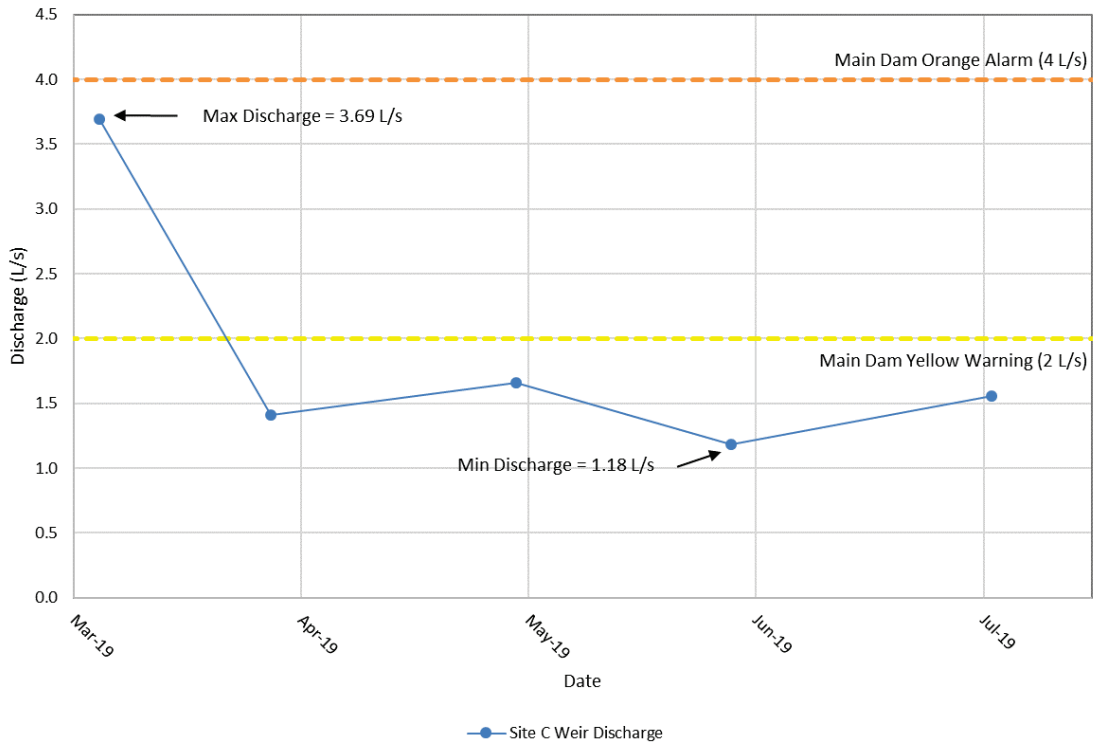


Illustration 7: Site C Weir Discharge

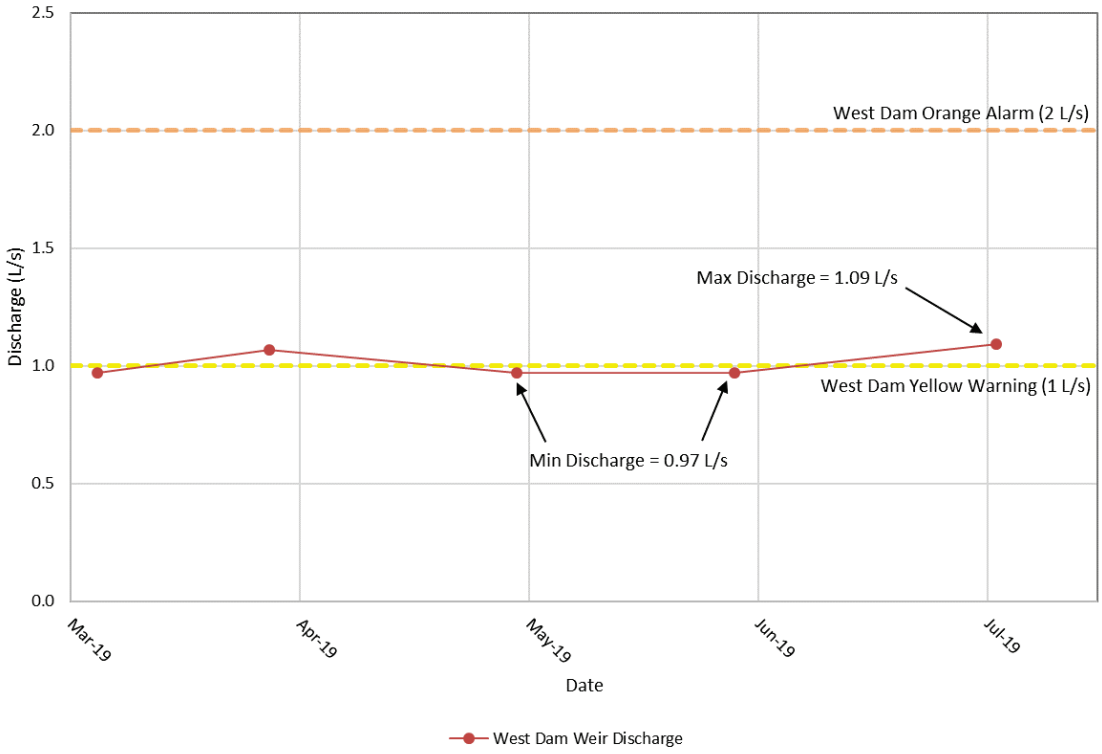


Illustration 8: West Dam Weir Discharge

During the 2019 DSI site visit, it was observed that flow in the Site C and West Tailings Dam seepage collection channels was clear and free of visible suspended solids. Overall, seepage rates during the reporting period were within normal operating conditions, and visual observations are not indicative of conditions which would be attributed to internal erosion of earthfill dams.

Observations during the 2018 DSI site visit indicated that seepage at the most northeastern location along the toe of Site C, which has historically been the dominant point at which seepage from the Main Tailings Dam has been observed, is mostly flowing beneath the seepage collection channel. Golder (2018c) recommended that the channel be altered to improve surface water collection and conveyance. Similar conditions were observed during the 2019 DSI site visit. Modifications were made in October 2019, outside of the 2018/2019 reporting period, and will be reported in the 2020 DSI report.

An HDPE pipe, installed at the southwest corner of the wash plant, collects surface water from the wash plant and conveys this flow into the seepage collection channel at the toe of the Site C CCR stockpile. This flow reports to the Site C Weir and is not measured separately. It is therefore not possible to distinguish whether flow at the weir is due to increased seepage or surface water runoff from the wash plant area. The flow from the HDPE pipe into the seepage collection channel should be monitored separately.

5.6 Review of Previous Deficiencies and Non-conformances

An update on the status of deficiencies, non-conformances, and recommendations from the 2018 DSI (Golder 2019c) is presented in Table 17. Incomplete items have been brought forward to the 2019 DSI recommendations, presented in Section 6.5.

Table 17: Status of 2018 Dam Safety Inspection Recommended Actions

ID Number	Deficiency or Non-conformance	Potential Dam Safety Risk	Priority Level	Recommended Action	Target Date	Status as of October 2019
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 Tailings Dam (MD-1_ROVER, MD-2_ROVER, MD-5_ROVER). ■ Non-functioning GPS units on West Tailings 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 Tailings Dam, and at the weir by the West Tailings Dam.	Potentially unstable condition not measured.	3	**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. **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.	Q3 2019	**Piezometers:** ■ VW11-MD-1A and 1B are not operational, but are not required at present given the coverage provided by adjacent instruments. ■ VW11-MD-4B is not operational, but are not required at present given the coverage provided by adjacent instruments. ■ SD-16-01A and 01B were repaired and were operational at the time of this report – Closed. ■ All other instruments are operational. **Prism and GPS:** ■ All instruments are operational. ■ All prisms are in line of site of total station – Closed. ■ GPS units removed from alert and warning system. Data to be used to establish long term trends. – Closed. **Seepage Weirs:** ■ Weir automation equipment on site and pending installation. ■ Bucket calibration completed 14 May 2019.- Closed. ■ Additional seepage weir at toe of Site D spoils not considered necessary – Closed.
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.	Potential delayed response of corrective actions and notification of responsible persons and emergency response team.	2	Review the TARP, update if appropriate, and retrain key GHO personnel so that the TARP procedures and requirements are enforced as intended.	n/a	Closed: ■ Engineer of Record (and other Golder representatives) currently receives GeoExplorer automated instrument notifications. Teck staff are following notification protocols.
2018-03 (2017-02)	QPOs for the inclinometers still required.	Potentially unstable condition not identified promptly.	n/a	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.	n/a	Closed: ■ QPOs for the inclinometers will not be established. ■ Data will continue to be used to assess conditions on a frequent basis. ■ Inclinometers will also be used to investigate conditions in the event of an orange alarm on prisms
2018-04 (2017-04)	■ Pond against upstream slope of Main Tailings Dam. ■ The pond against the upstream slope of the Main Tailings 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 Tailings Dam.	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 Tailings Dam.	Q2 2019	In progress: ■ Depositional modelling to assess different spigot layouts currently in progress.
2018-05 (2017-05)	Closure plan does not meet HSRC requirements.	n/a	2	Develop the current concept level closure plan to align with the current life of mine strategy and HSRC requirements.	Q4 2019	In progress: ■ Update of closure plan in progress.

Table 17: Status of 2018 Dam Safety Inspection Recommended Actions

ID Number	Deficiency or Non-conformance	Potential Dam Safety Risk	Priority Level	Recommended Action	Target Date	Status as of October 2019
2018-06	Golder has recommended additional inundation study modelling of the downstream area, up to Lake Koocanusa.	n/a	3	Update inundation study with additional modelling at the confluence of the Elk River and Fording River, and at Lake Koocanusa.	Q4 2019	In progress: ■ Update of dam breach inundation study currently in progress.
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.	Potentially unstable condition not measured.	3	■ 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.	Q3 2019	Complete: ■ Inspection and maintenance tasks for the SmartDitch have been added to the TSF OMS. ■ Repair of SmartDitch was completed in October 2019 (construction record report in progress).

VW = vibrating wire; HSRC = Health, Safety and Reclamation Code; n/a = not applicable; OMS = operation, maintenance, and surveillance; QPO = quantifiable performance objective; TSF = tailings storage facility; n/a = not applicable; TARP = Trigger Action Response Plan.

Priority Level	Description
1	A high probability or actual 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 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 safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

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

6.0 SUMMARY AND RECOMMENDATIONS

6.1 Summary of Activities

Activities completed during the reporting period were:

- The batteries in the data loggers at SD-16-01A and 01B were replaced on 18 June 2019.
- The visual freeboard indicator, located on the Main Tailings Dam, was levelled in September 2019 following observations during the 2019 DSI site visit.
- GPS unit WD-1_Rover was repaired on 24 December 2018 and began recording data on 16 January 2019. This GPS unit was operational throughout the remainder of the reporting period.
- The tailings deposition point was moved in September 2019.

No construction works were carried out in the 2018/2019 reporting period. The GHO TSF dams were last raised in 2018 to an elevation of approximately 1,731 m as reported in the 2018 DSI (Golder 2019c) and the construction record (Golder 2019b). The next raise of the TSF dams is planned for 2020.

6.2 Summary of Climate and Water Balance

Precipitation records from the Fording River Cominco climate station indicate that:

- Total monthly precipitation in the reporting period was approximately 26% lower than the historical average for the same period (1 September to 31 July).
- Total monthly precipitation in the reporting period was lower, in comparison with the historical monthly average, in every month except June and July 2019.
  - Total monthly precipitation between 1 September 2018 and 31 May 2019 was approximately 44% lower than the historical average for the same period.
  - Monthly precipitation between 1 June 2019 and 31 July 2019 was approximately 55% higher than the historical average for the same period.

The water balance results suggest the 2018/2019 reporting period was atypical from a water management perspective. The reporting period was drier than the historical average, however there was a positive total inventory change due to the increased transfers from Phase 3 and Phase 6. The Phase 3 and Phase 6 transfers should not exceed the volume required to meet the reclaim demand while keeping the total inventory change close to zero, for long term pond management.

6.3 Summary of Performance and Changes

There were no significant changes in the operation and performance of the TSF during the reporting period. The performance of the dams during the reporting period was as expected for normal operating conditions.

The GHO TSF was observed to be in good condition at the time of the 2019 site inspection. Records indicate that the discharge of tailings into the GHO TSF was consistent with the normal operating conditions.

No significant changes were noted during the 2019 site visit or monthly visual inspections by GHO. Some minor erosion of the upstream slope and crest of the Main and West Tailings Dams were observed which require routine maintenance.

6.4 Consequence Classification

The TSF remains a High consequence classified structure, following Section 3.4 from the HSRC Guidance Document (Ministry of Energy and Mines 2016).

6.5 Current Deficiencies and Non-conformances

Table 18 summarizes the 2019 recommended actions the GHO TSF.

Table 18: 2019 Recommended Actions for Greenhills Tailings Storage Facility

ID Number	Deficiency or Non-conformance	Potential Dam Safety Risk	Priority Level	Recommended Action	Target Date
2019-01	Volume of water in TSF is greater than that needed for plant operation	Increased zone of inundation if failure were to occur	3	Reduce pond volume to less than 350,000 m^3	End Q4 2020
2019-02 (2018-01)	Seepage weirs: ■ Weir automation equipment is on site and pending installation.	Potentially unstable condition not measured.	3	Install weir automation equipment.	End Q3 2020
2019-03 (2018-04)	Pond against upstream slope of Main Tailings Dam. ■ The pond against the upstream slope of the Main Tailings 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 Tailings Dam.	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 the Main Dam after results from depositional modelling are issued.	End Q2 2020
2019-04	Ponded water on downstream crest of Site C spoils at east abutment of Main Tailings Dam (See Photograph 9, Appendix A)	Erosion of downstream shell of CCR spoils leading to instability	3	Revise drainage to prevent long term ponding of surface water.	End Q3 2020
2019-05 (2018-05)	Closure plan does not meet HSRC requirements.	Operational procedures do not align with closure design; long-term environmental hazards become difficult and costly to mitigate.	3	Develop the current concept level closure plan to align with the current life of mine strategy and HSRC requirements.	In progress End Q1 2020
2019-06 (2018-06)	Inundation study modelling of the downstream area does not reflect recent changes in topography	Potential for sub-optimal emergency response	3	Update inundation study	In progress End Q1 2020
2019-07	■ OMS manual does not reflect: ▪ Current geotechnical instrumentation details including revised QPOs. ▪ Revised MAC and Teck guidance documents. ■ Multiple coordinate grid systems appear to be used in the OMS manual.	Potential to ineffectively respond to alerts and warnings from geotechnical instrumentation.	3	Update OMS manual to: ■ remove non-functioning geotechnical instrumentation and update QPOs. ■ update based on MAC (2019) and Teck (2019) ■ use a single coordinate grid system	End April 2020

HSRC = Health, Safety and Reclamation Code; n/a = not applicable; OMS = operation, maintenance, and surveillance; QPO = quantifiable performance objective; TSF = tailings storage facility; MAC = Mining Association of Canada; Teck = Teck Resources Limited.

Priority Level	Description
1	A high probability or actual 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 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 safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

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

7.0 CLOSING

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.

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Geotechnical Engineer

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MK/MBW/AH/hp

https://golderassociates.sharepoint.com/sites/100721/deliverables/issued/2019-148-r-rev0-3000-dsi gho tsf/18110798-2019-148-r-rev0-3000-dsi gho tsf 18mar_20.docx

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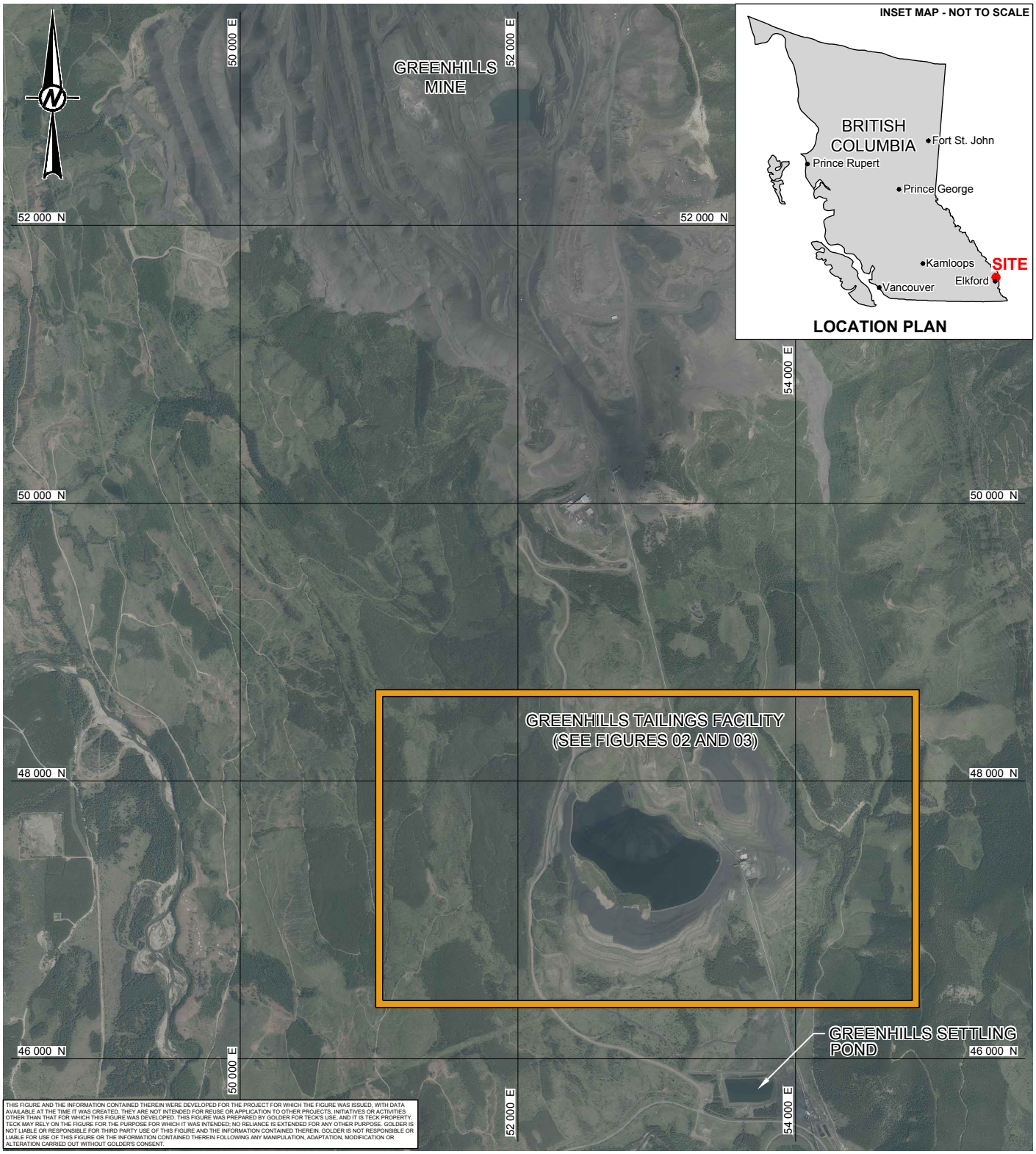


NOTES

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

REFERENCE

1. 2018 AERIAL PHOTO PROVIDED BY TECK COAL LIMITED, FLOWN 15 TO 16 JULY 2018.

0 1,000 2,000
1:40,000 METRES

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

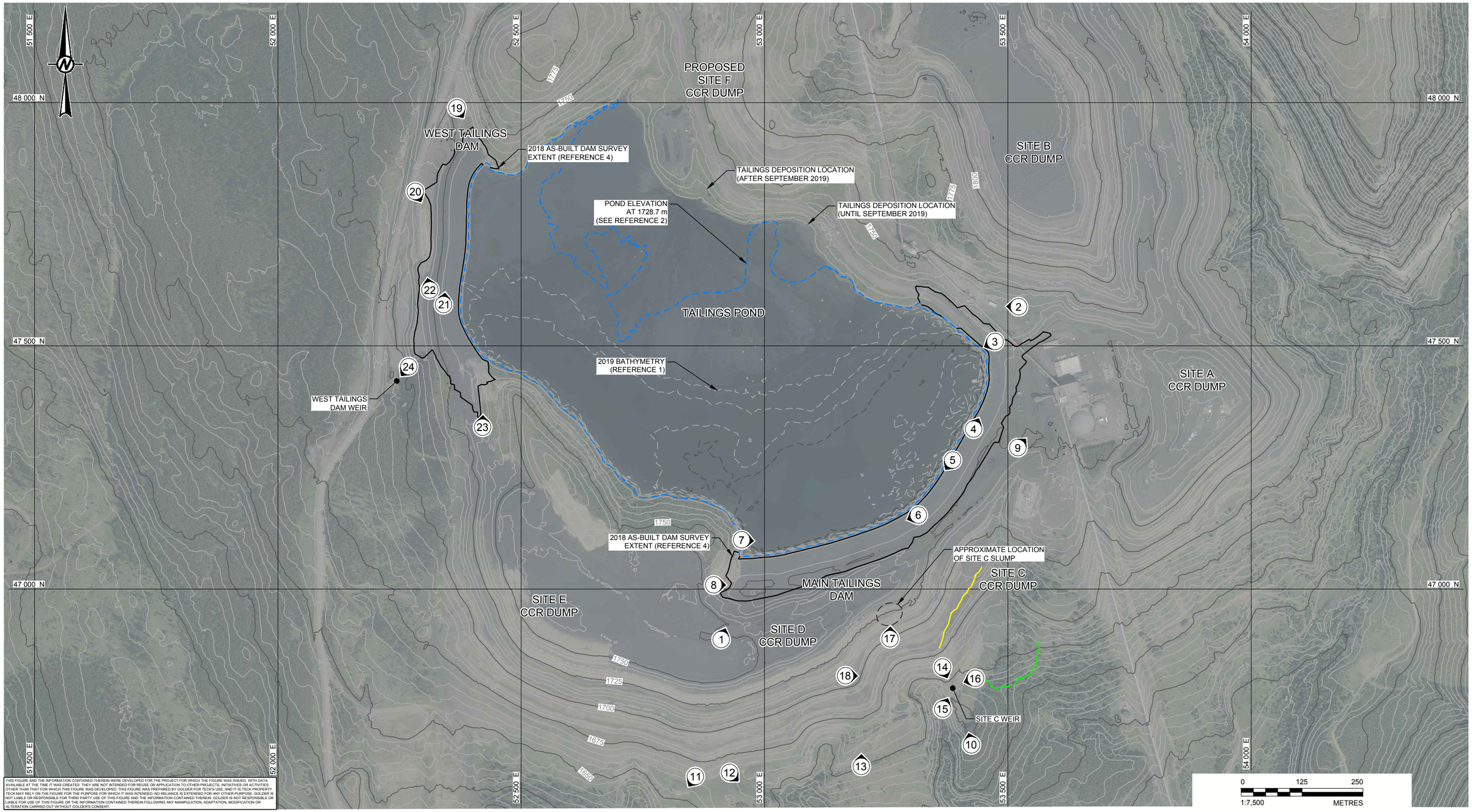
CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-18
DESIGNED	MK
PREPARED	TAK
REVIEWED	MBW
APPROVED	AJH

PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
SITE LOCATION PLAN

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
18110798	3000/3200/148	0	01



LEGEND

- 2019 BATHYMETRY (SEE REFERENCE 1)
- 2018 TOPOGRAPHY (SEE REFERENCE 3)
- (#) 2019 SITE VISIT PHOTO LOCATION
- 2012 TOE BULGE SITE C (SEE REFERENCE 5)
- 2012 SCARP SITE C (SEE REFERENCE 5)
- CCR COARSE COAL REFUSE

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN GHO MINE GRID, ELEVATIONS ARE REFERENCED TO THE ELK VALLEY ELEVATION DATUM.
3. BATHYMETRY CONTOURS (SEE REFERENCE 1) SHOWN AT 5.0 m MAJOR AND 1.0 m MINOR INTERVAL.
4. TOPOGRAPHIC CONTOURS (SEE REFERENCE 3) SHOWN AT 25.0 m MAJOR AND 5.0 m MINOR INTERVAL.

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3. 2018 AERIAL PHOTO AND TOPOGRAPHY PROVIDED BY TECK COAL LIMITED, FLOWN 15 TO 16 JULY 2018.
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CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, B.C.

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-18
DESIGNED	MK
PREPARED	TAK
REVIEWED	MBW
APPROVED	AJH

PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
SITE PLAN AND 2019 INSPECTION PHOTO LOCATIONS

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
18110798	3000/3200/148	0	02

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

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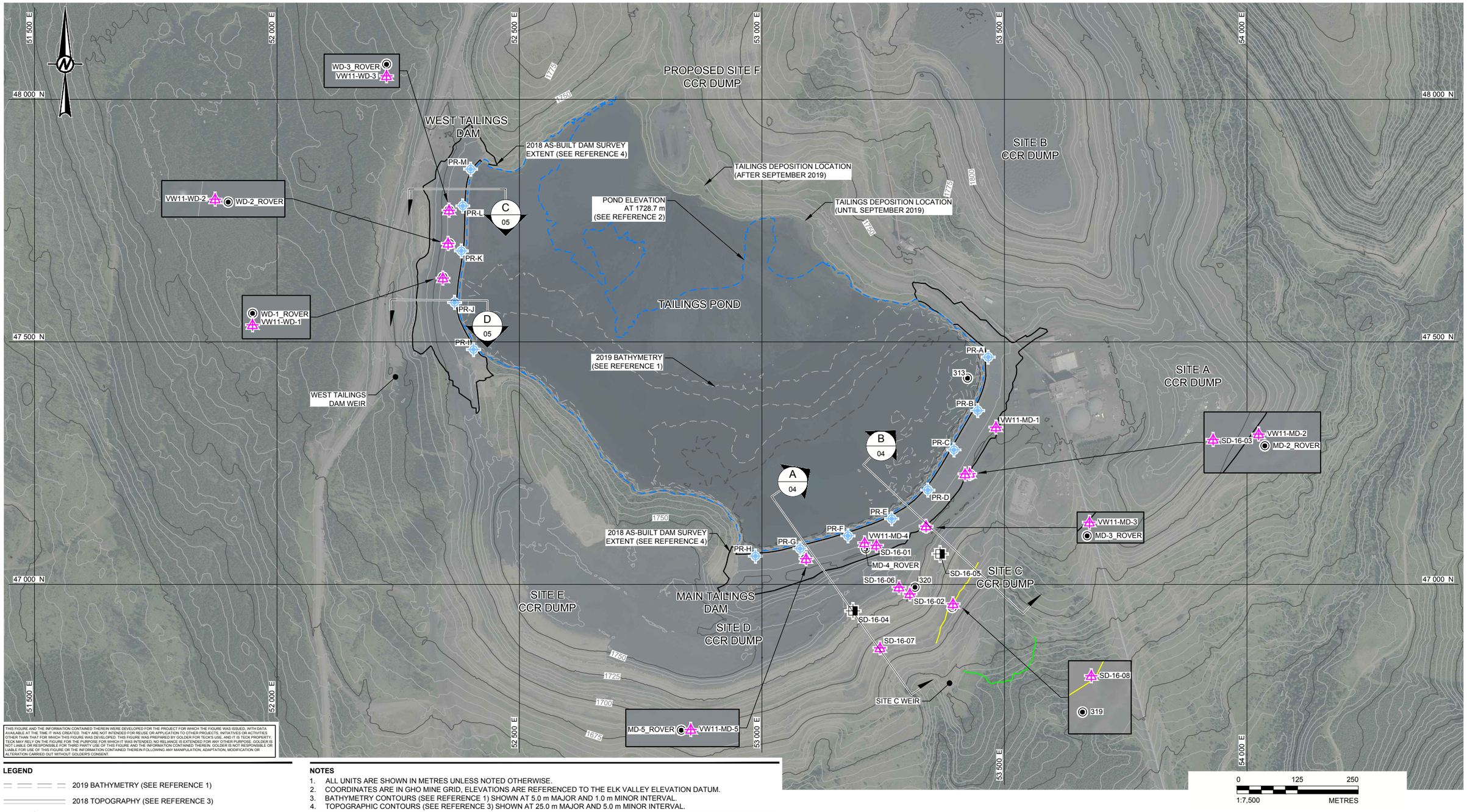

LEGEND

- 2019 BATHYMETRY (SEE REFERENCE 1)
- 2018 TOPOGRAPHY (SEE REFERENCE 3)
- VIBRATING WIRE PIEZOMETER LOCATION (SEE REFERENCE 5)
- INCLINOMETER AND VIBRATING WIRE PIEZOMETER LOCATION (SEE REFERENCE 5)
- GPS UNIT LOCATION (SEE REFERENCE 6)
- SURVEY PRISM LOCATION (REFERENCE 6)
- 2012 TOE BULGE SITE C (SEE REFERENCE 7)
- 2012 SCARP SITE C (SEE REFERENCE 7)
- CCR — COARSE COAL REFUSE

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES ARE IN GHO MINE GRID, ELEVATIONS ARE REFERENCED TO THE ELK VALLEY ELEVATION DATUM.
3. BATHYMETRY CONTOURS (SEE REFERENCE 1) SHOWN AT 5.0 m MAJOR AND 1.0 m MINOR INTERVAL.
4. TOPOGRAPHIC CONTOURS (SEE REFERENCE 3) SHOWN AT 25.0 m MAJOR AND 5.0 m MINOR INTERVAL.

REFERENCES

1. 2019 BATHYMETRY INFORMATION PROVIDED BY TECK COAL LIMITED, FILE NAME: "191017 tailings pond sounding surface_MG.dxf", DATED: 17 OCTOBER 2019, RECEIVED: 04 DECEMBER 2019.
2. POND ELEVATION DOWNLOADED FROM TECK COAL'S INSTRUMENT MONITORING SOFTWARE, GEOEXPLORER, FOR GREENHILLS OPERATIONS; FILE NAME: "SENSOR LOCATIONS.csv", RECEIVED: 17 OCTOBER 2019.
3. 2018 AERIAL PHOTO AND TOPOGRAPHY PROVIDED BY TECK COAL LIMITED, FLOWN 15 TO 16 JULY 2018.
4. 2018 AS-BUILT INFORMATION PROVIDED BY TECK COAL LIMITED, FILE NAME: "2018-10-02 GHO DAM - VOLUME CALC.dxf", DATED: 02 OCTOBER 2018.
5. VIBRATING WIRE PIEZOMETER AND INCLINOMETER LOCATIONS DOWNLOADED FROM TECK COAL'S INSTRUMENT MONITORING SOFTWARE, GEOEXPLORER, FOR GREENHILLS OPERATIONS; FILENAME: "Sensor Locations.csv", RECEIVED: 3 OCTOBER 2019.
6. PRISM AND GPS LOCATIONS DOWNLOADED FROM TECK COAL'S INSTRUMENT MONITORING SOFTWARE, GEOEXPLORER, FOR GREENHILLS OPERATIONS; FILENAME: "Geoexplorer Data.csv", RECEIVED: 18 SEPTEMBER 2019.
7. 2012 SCARP AND TOE BULGE LOCATIONS PROVIDED BY TECK COAL LIMITED GREENHILLS OPERATIONS ON 13 MARCH 2014.

CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
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PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
GEOTECHNICAL INSTRUMENTATION AND CROSS-SECTION LOCATIONS

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
18110798	3000/3200/148	0	03

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

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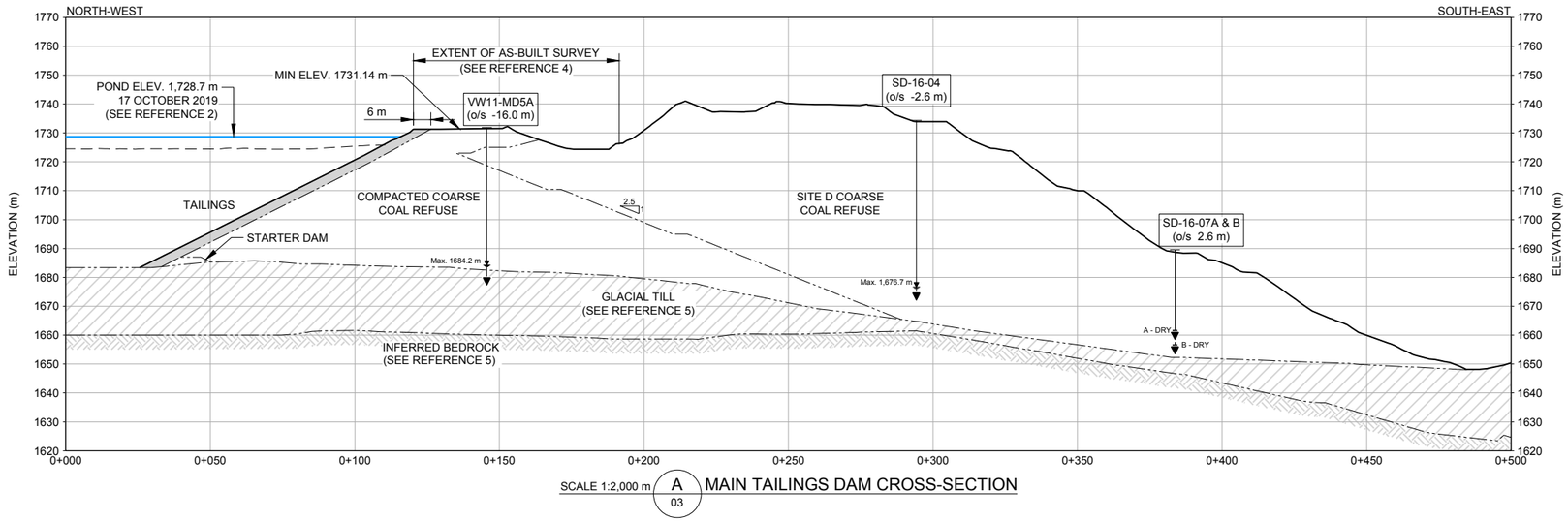
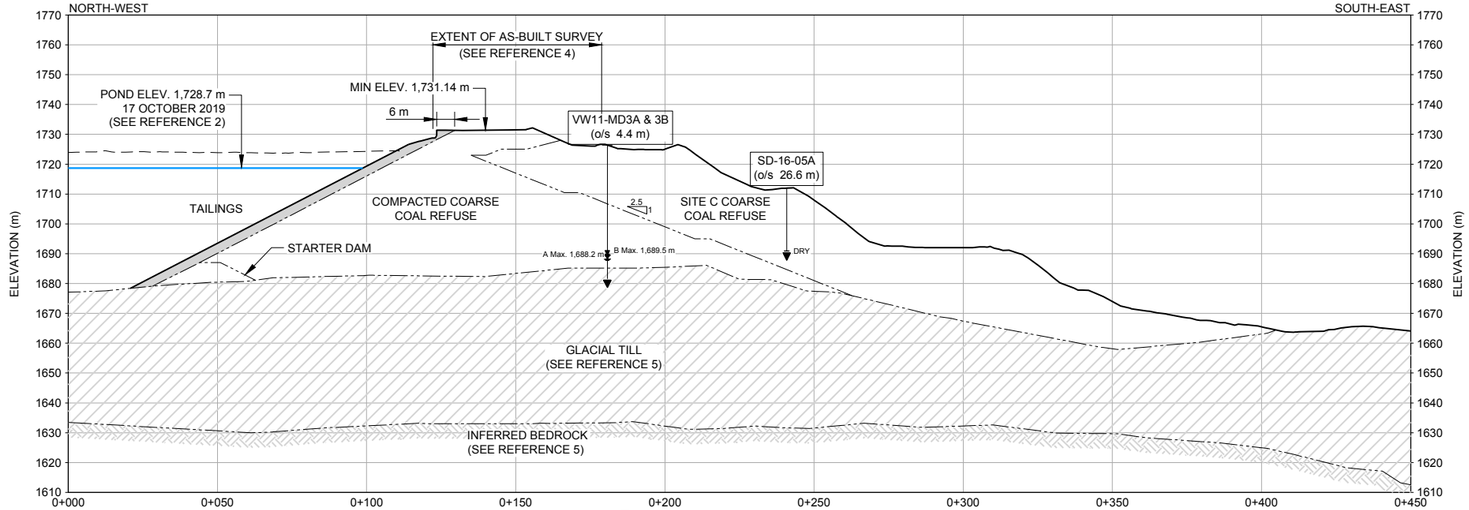


SCALE 1:2,000 m

A 03

MAIN TAILINGS DAM CROSS-SECTION



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B 03

MAIN TAILINGS DAM CROSS-SECTION

LEGEND

- OCTOBER 2019 BATHYMETRY (SEE REFERENCE 1)
- JULY 2018 SURVEY (SEE REFERENCE 3)
- INFERRED CONTACT
- CLAY BLANKET
- GLACIAL TILL
- BEDROCK
- ▼ VIBRATING WIRE PIEZOMETER TIP ELEVATION (SEE NOTE 3)

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. MATERIAL BOUNDARIES ARE APPROXIMATE.
3. VIBRATING WIRE PIEZOMETER MAXIMUM OBSERVATIONS FROM DATA BETWEEN 01 SEPTEMBER 2018 AND 31 JULY 2019.
4. ELEVATIONS ARE REFERENCED TO THE ELK VALLEY ELEVATION DATUM.

REFERENCES

1. 2019 BATHYMETRY INFORMATION PROVIDED BY TECK COAL LIMITED, FILE NAME: "191017 tailings pond sounding surface_MG.dxf", DATED: 17 OCTOBER 2019, RECEIVED: 04 DECEMBER 2019.
2. POND ELEVATION DOWNLOADED FROM TECK COAL'S INSTRUMENT MONITORING SOFTWARE, GEOEXPLORER, FOR GREENHILLS OPERATIONS; FILE NAME: "SENSOR LOCATIONS.csv", RECEIVED: 17 OCTOBER 2019.
3. 2018 TOPOGRAPHY PROVIDED BY TECK COAL LIMITED, FLOWN 15 TO 16 JULY 2018.
4. 2018 AS-BUILT INFORMATION PROVIDED BY TECK COAL LIMITED, FILE NAME: "2018-10-02 GHO DAM - VOLUME CALC.dxf", DATED: 02 OCTOBER 2018.
5. 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

0 50 100

1:2,000 METRES

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PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - CROSS-SECTIONS A AND B

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
18110798	3000/3200/148	0	04

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

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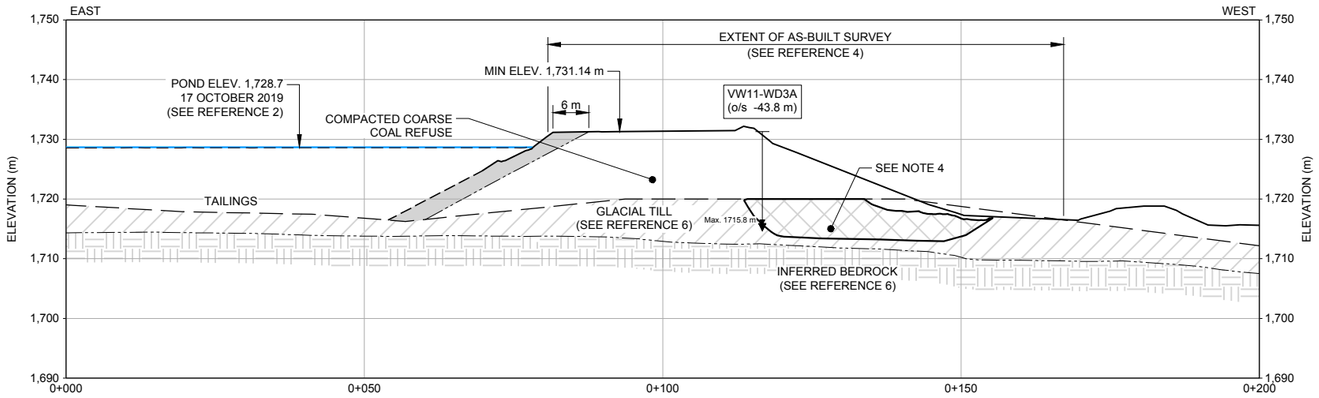

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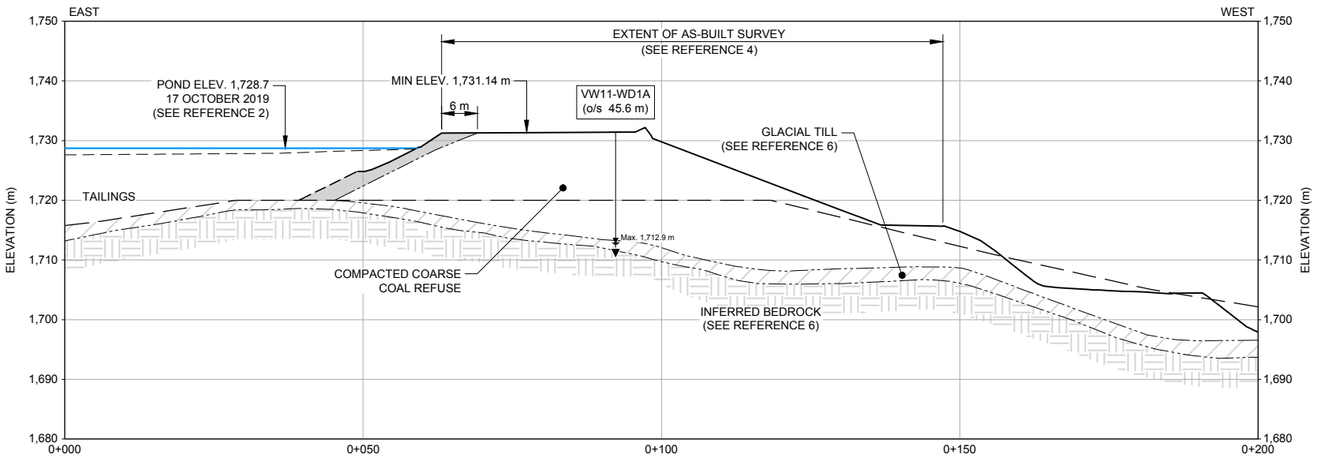

SCALE 1:1,000 m — D / 03 — WEST TAILINGS DAM CROSS-SECTION

LEGEND

- OCTOBER 2019 BATHYMETRY (SEE REFERENCE 1)
- JULY 2018 SURVEY (SEE REFERENCE 3)
- APPROXIMATE ORIGINAL GROUND SURFACE (SEE REFERENCE 5)
- INFERRED CONTACT
- CLAY BLANKET
- WASTE ROCK
- GLACIAL TILL
- BEDROCK
- ▼ VIBRATING WIRE PIEZOMETER TIP ELEVATION (SEE NOTE 3)

NOTES

1. ALL UNITS ARE SHOWN IN METRES UNLESS NOTED OTHERWISE.
2. MATERIAL BOUNDARIES ARE APPROXIMATE.
3. VIBRATING WIRE PIEZOMETER MAXIMUM OBSERVATIONS FROM 01 SEPTEMBER 2018 AND 31 JULY 2019.
4. 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.
5. ELEVATIONS ARE REFERENCED TO THE ELK VALLEY ELEVATION DATUM.

REFERENCES

1. 2019 BATHYMETRY INFORMATION PROVIDED BY TECK COAL LIMITED, FILE NAME: "191017 tailings pond sounding surface_MG.dxf", DATED: 17 OCTOBER 2019, RECEIVED: 04 DECEMBER 2019.
2. POND ELEVATION DOWNLOADED FROM TECK COAL'S INSTRUMENT MONITORING SOFTWARE, GEOEXPLORER, FOR GREENHILLS OPERATIONS; FILE NAME: "SENSOR LOCATIONS.csv", RECEIVED: 17 OCTOBER 2019.
3. 2018 TOPOGRAPHY PROVIDED BY TECK COAL LIMITED, FLOWN 15 TO 16 JULY 2018.
4. 2018 AS-BUILT INFORMATION PROVIDED BY TECK COAL LIMITED, FILE NAME: "2018-10-02 GHO DAM - VOLUME CALC.dxf", DATED: 02 OCTOBER 2018.
5. SEPTEMBER 2014 GROUND SURFACE PROVIDED BY TECK COAL LIMITED, RECEIVED: 23 SEPTEMBER 2014.
6. 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
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GREENHILLS OPERATIONS
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YYYY-MM-DD	2020-03-18
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PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
WEST TAILINGS DAM - CROSS-SECTIONS C AND D

PROJECT NO.	PHASE/TASK/DOC.	REV.	FIGURE
18110798	3000/3200/148	0	05

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

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APPENDIX A

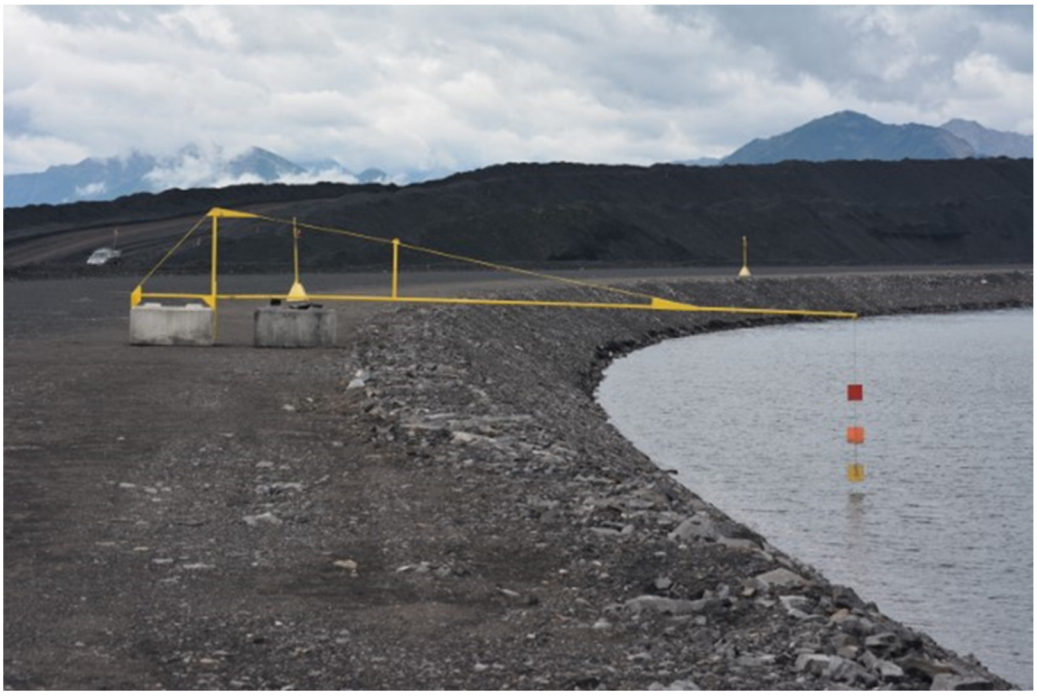
2019 Site Photographs

Photograph 1: Main Tailings Dam – looking Northeast, 26 September 2019

Photograph 2: Main Tailings Dam – looking West, 26 September 2019

Photograph 3: Main Tailings Dam – Reclaim Barge; looking Southwest, 17 July 2019

Photograph 4: Main Tailings Dam – Upstream Slope, Crest and East Abutment; looking Northeast, 17 July 2019



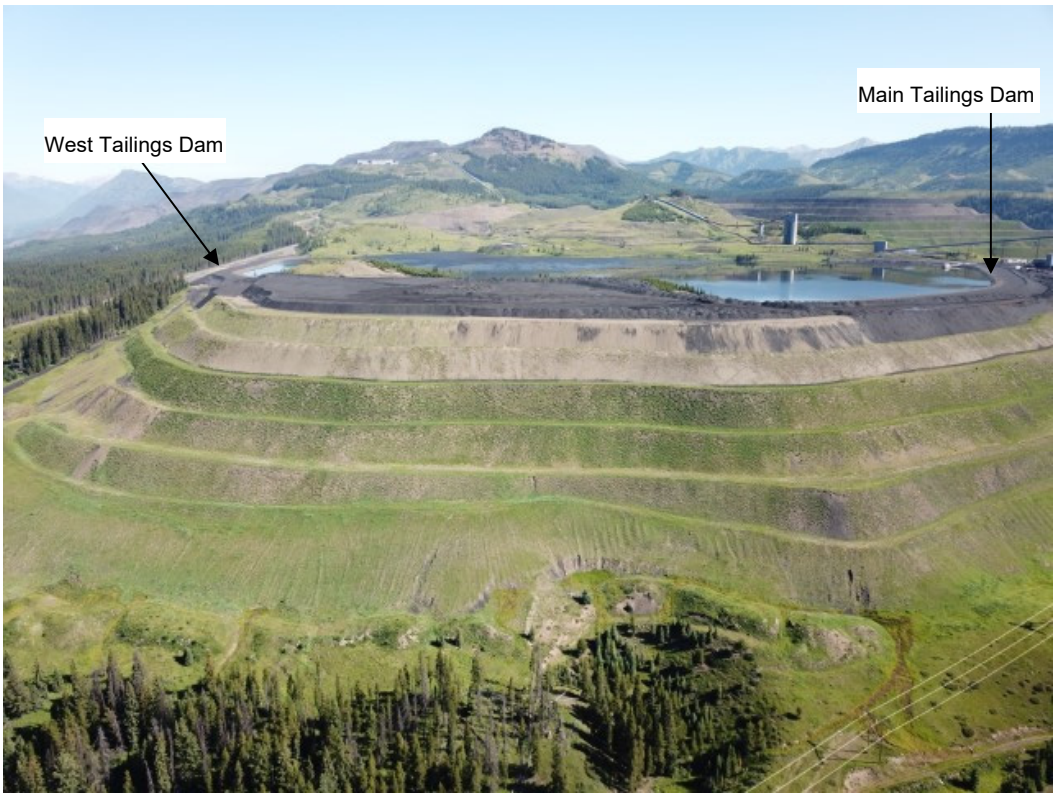
Photograph 5: Main Tailings Dam –Freeboard Indicator; looking Southwest, 17 July 2019

Photograph 6a (left) and 6b (right): Main Tailings Dam – Minor Longitudinal Cracks on Crest Adjacent to Riprap on Upstream Slope; looking Southwest, 17 July 2019

Photograph 7: Main Tailings Dam – Upstream Slope and Crest; looking Southeast, 17 July 2019

Photograph 8: Main Tailings Dam – Crest and West Abutment; looking East, 17 July 2019

Photograph 9: Main Tailings Dam – East Abutment, Ponded Surface Water; looking Northeast, 17 July 2019



Photograph 10: Site D and E Coarse Coal Refuse Spoils – Overview; looking North, 26 September 2019

Photograph 11: Site D Coarse Coal Refuse Spoil – Downstream Toe Area; looking Southwest, 17 July 2019

Photograph 12: Site D Coarse Coal Refuse Spoil– Downstream Toe Area; looking Southeast, 17 July 2019

Photograph 13: Site C Coarse Coal Refuse Spoil and Main Dam – looking North, 26 September 2019

Photograph 14: Site C Weir and Downstream Creek; looking South, 17 July 2019

Photograph 15: Site C Seepage Weir - looking Northeast, 17 July 2019

Photograph 16: Site C Seepage Weir – Measurement Gauge; looking West, 17 July 2019

Photograph 17: Site C Coarse Coal Refuse Spoil – Slump First Observed 18 April 2019; 17 July 2019

Photograph 18: Site C Coarse Coal Refuse Spoil – looking East, 17 July 2019

Photograph 19: West Tailings Dam – looking Southeast, 26 September 2019

Photograph 20: West Tailings Dam – Downstream Slope and Toe Area; looking Southeast, 17 July 2019

Photograph 21: West Tailings Dam – crest and Upstream Slope, Minor Erosion Rill on Upstream Slope; looking North, 17 July 2019

Photograph 22: West Tailings Dam – Downstream Slope and Toe Area; looking North, 17 July 2019

Photograph 23: West Tailings Dam – Crest and South and North Abutments; looking North, 17 July 2019

Photograph 24: West Tailings Seepage Weir - Measurement Gauge; 17 July 2019

APPENDIX B

2019 Site Inspection Records

Client:	**Teck Coal Limited**	**By:**	**Andy Haynes, P.Eng. and Martyn Willan, P.Eng.**
Project:	**GHO 2019 Dam Safety Inspection**	**Date:**	**17 July 2019**
Location:	**Main Tailings Dam**		

GENERAL INFORMATION

Dam Type: Compacted CCR with till blanket

Weather Conditions:	Clear and sunny	**Temp:**	15°C

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST			
1.1 Crest Elevation (Till)	1,731.1	1,2,4,5,6,7,8	Crest elevation from as-constructed report (Golder 2019b)
1.2 Reservoir Level / Freeboard	1,728.5 Approximately 2.6 m freeboard	1,2,3,4,5,7,8	Pond level from GHO GPS 313 reading on 17 July 2019
1.3 Distance to Tailings Pond (if applicable)	Water against upstream slope of dam. Approximately 2.6 m freeboard	1,2,3,4,5,7,8	
1.4 Surface Cracking	Minor cracks in till at crest on upstream side near interface with riprap.	6	Regrade during 2020 dam raise
1.5 Unexpected Settlement	None observed		
1.6 Lateral Movement	None observed		
1.7 Other Unusual Conditions	Visual indication for freeboard not level	5	Continue to level as required
2. UPSTREAM SLOPE		4,5,6,7,8	
2.1 Slope Angle	2:1		
2.2 Signs of Erosion	Some localized depressions at crest on upstream side		Repair during 2020 dam raise
2.3 Signs of Movement (Deformation)	None observed		
2.4 Cracks	None observed		
2.5 Face Liner Condition (if applicable)	n/a		
2.5 Other Unusual Conditions	Some erosion from wave action at water line	4,5,7	

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
3. DOWNSTREAM SLOPE		1,10,13,18	
3.1 Slope Angle	2.5:1		
3.2 Signs of Erosion	Site C slump first observed in April 2019. No further erosion observed. Some rills <50 mm deep	17	
3.3 Signs of Movement (Deformation)	None observed		
3.4 Cracks	None observed		
3.5 Seepage or Wet Areas	None observed		
3.6 Vegetation Growth	Not of concern		
3.7 Other Unusual Conditions	None observed		
4. DOWNSTREAM TOE AREA		10,11,12,13,14	
4.1 Seepage from Dam	Seepage/surface water runoff observed in collection channel	15,16	
4.2 Signs of Erosion	Some localized erosion on Site C		No action required at this time
4.3 Signs of Turbidity in Seepage Water	None observed		
4.4 Discoloration/Staining	Some red staining at weir	15	
4.5 Outlet Operating Problem (if applicable)	None observed		
4.6 Other Unusual Conditions	Animal burrows at toe		No action required at this time
5. ABUTMENTS			
5.1 Seepage at Contact Zone (abutment/embankment)	None observed		
5.2 Signs of Erosion	None observed		
5.3 Excessive Vegetation	None observed		
5.4 Presence of Rodent Burrows	None observed		
5.5 Other Unusual Conditions	Ponded water at east abutment	9	Remove water and fill with CCR
6. RESERVOIR			
6.1 Stability of Slopes	Satisfactory		
6.2 Floating Debris	None observed		
6.3 Other Unusual Conditions	Additional water storage from Phases 3 and 6 reported		
7. EMERGENCY SPILLWAY/ OUTLET STRUCTURE	n/a		

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
8. INSTRUMENTATION			
8.1 Piezometers	Yes		22 installed
8.2 Settlement Cells	None		
8.3 Thermistors	None		
8.4 Survey Monuments / GPS Units	Yes	3,4,5,67,8	7 GPS and 8 Survey Prisms installed
8.5 Accelerograph	None		
8.6 Inclinometer	Yes		2 installed
8.7 Weirs and Flow Monitors	Site C weir (0.3 L/s)	16	Site C weir gauge corroded
8.8 Data Logger(s)	Yes		Installed for various instruments
8.9 Other		3	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 SP&P No. 1543
9.1.2 OMS Plan reflects current dam conditions	No		Update required
9.1.3 Date of last revision	24 June 2019		Version 04
9.2 Emergency Preparedness Plan (EPP) 9.2.1 EPP Exists	Yes		GHO SP&P No. 1583
9.2.2 EPP Reflects Current Conditions	No		Update planned following completion of inundation study
9.2.3 Date of Last Revision	18 December 2018		Version 01
10. NOTES None			
Inspector's Signature		**Date:**	17 July 2019

Client:	**Teck Coal Limited**	**By:**	**Andy Haynes, P.Eng. and Martyn Willan, P.Eng.**
Project:	**GHO 2019 Dam Safety Inspection**	**Date:**	**17 July 2019**
Location:	**West Tailings Dam**		

GENERAL INFORMATION

Dam Type: Compacted CCR with till blanket

Weather Conditions:	Clear and sunny	**Temp:**	15°C

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
1. DAM CREST		19,21,23	
1.1 Crest Elevation (Till)	1,731		Crest elevation from as-constructed report (Golder 2019b)
1.2 Reservoir Level / Freeboard	1,728.5 Approximately 2.5 m freeboard	21	Pond level from GHO GPS reading on 17 July 2019
1.3 Distance to Tailings Pond (if applicable)	Water at upstream slope of dam. Approximately 2.5 m freeboard	21	
1.4 Surface Cracking	Crack and erosion rill at upstream edge of crest first observed in April 2018, no sign of increase in extent of width. Minor cracking along upstream edge of crest.	21	Regrade during 2020 dam raise
1.5 Unexpected Settlement	None observed		
1.6 Lateral Movement	None observed		
1.7 Other Unusual Conditions	Crest sloughing observed in April 2018 from surface water run-off, no sign of increase in extent of width		Regrade during 2020 dam raise
2. UPSTREAM SLOPE		21	
2.1 Slope Angle	2:1		
2.2 Signs of Erosion	Erosion on upstream face with channels cut to allow drainage in April 2018.	21	Trim upstream face and install riprap during 2020 dam raise

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
2.3 Signs of Movement (Deformation)	None observed		
2.4 Cracks	None observed		
2.5 Face Liner Condition (if applicable)	n/a		
2.5 Other Unusual Conditions	None		
3. DOWNSTREAM SLOPE		19,20,22	
3.1 Slope Angle	2.5:1		
3.2 Signs of Erosion	None observed		
3.3 Signs of Movement (Deformation)	None observed		
3.4 Cracks	None observed		
3.5 Seepage or Wet Areas	None observed		
3.6 Vegetation Growth	Not of concern		
3.7 Other Unusual Conditions	None		
4. DOWNSTREAM TOE AREA		19,20,22	
4.1 Seepage from Dam	Seepage observed in Site D culvert and at West Dam Weir		
4.2 Signs of Erosion	None observed		
4.3 Signs of Turbidity in Seepage Water	None observed		
4.4 Discoloration/Staining	None observed		
4.5 Outlet Operating Problem (if applicable)	n/a		
4.6 Other Unusual Conditions	Small pond at toe		
5. ABUTMENTS		923	
5.1 Seepage at Contact Zone (abutment/embankment)	None observed		
5.2 Signs of Erosion	None observed		
5.3 Excessive Vegetation	None observed		
5.4 Presence of Rodent Burrows	None observed		
5.5 Other Unusual Conditions	None observed		
6. RESERVOIR		2,17	
6.1 Stability of Slopes	Satisfactory		
6.2 Floating Debris	None observed		
6.3 Other Unusual Conditions	None observed		

INSPECTION ITEM	OBSERVATIONS/DATA	PHOTO	COMMENTS & OTHER DATA
7. EMERGENCY SPILLWAY/ OUTLET STRUCTURE	n/a		
8. INSTRUMENTATION			
8.1 Piezometers	Yes		6 installed
8.2 Settlement Cells	None		
8.3 Thermistors	None		
8.4 Survey Monuments / GPS Units	Yes	21,22	3 GPS units and 5 survey prisms installed
8.5 Accelerograph	None		
8.6 Inclinometer	None		
8.7 Weirs and Flow Monitors	Site D culvert weir depth measured as 0.5 mm. No change from previous years. V-notch weir at West Dam	24	
8.8 Data Logger(s)	Yes		Installed for various instruments
8.9 Other	None		
9. DOCUMENTATION			
9. DOCUMENTATION			
9.1 Operation, Maintenance and Surveillance (OMS) Manual 9.1.1 OMS Manual exists	Yes		GHO SP&P No. 1543
9.1.2 OMS Plan reflects current dam conditions	No		Update required
9.1.3 Date of last revision	24 June 2019		Version 04
9.2 Emergency Preparedness Plan (EPP) 9.2.1 EPP Exists	Yes		GHO SP&P No. 1583
9.2.2 EPP Reflects Current Conditions	No		Update planned following completion of inundation study
9.2.3 Date of Last Revision	18 December 2018		Version 01
10. NOTES None			
Inspector's Signature		**Date:**	17 July 2019

APPENDIX C

Tailings Storage Facility Registry

Appendix C:
Tailings Storage Facility Registry

Mine Name: Greenhills Operations
Permit No: No. C-137 (and amendments)

General Mine Information	
Owner/company	Teck Coal Limited
Nearest community	Elkford
Region	Elk Valley / East Kootenay
Ore(s) mined	Coal
Mine operational status	Operational
Number of tailings impoundments	1

TSF Documentation	
Date of last DSI	July 2019 (site visit)
Date of last DSR	December 2017
Date of next DSR	2022
Date of OMS update	24 June 2019
Date of EPRP update	18 December 2018
Date of EPRP test	27 August 2019
Date of dam breach and inundation study	17 April 2017
Tailings Management system (name)	GHO Tailings Management System (Draft)
Tailings management system (last audit)	None
TSF risk assessment last reviewed	12-May-18
Water balance and water management plan (last update)	18-Jul-19
Date of last as-built	22 March 2019

TSF Information	
TSF name	Greenhills Tailings Storage Facility
TSF operating status	Active
Year facility was last used (if closed)	N/A
Number of dams	2
Engineer of record	Andy Haynes (Golder Associates Ltd.)
TSF qualified person	Mark Slater up to November 2019. Andrew Knight from November 2019
Spillway present	No
Spillway date of last maintenance	N/A
Quantitative Performance Objectives (QPOs)	Yes
Volume of impoundment	19.5 million m^3 (to permitted elevation 1,735 m)

Dam Information	
Dam name	**Main Tailings Dam**
Height of dam	50 m
Consequence classification	High
Slope	Downstream: 2.5H:1V; Upstream: 2H:1V
Minimum factor of safety (long term steady state)	2.0
Minimum factor of safety (pseudo-static)	1.2
Permitted elevation	1,735 m
Current elevation	1,731.14 m
Seismic design (AEP)	1 in 2,475 years
Flood design (AEP)	1/3 between 1/1,000 year return period and PMF
Type of dam construction (upstream, downstream, centre)	Downstream
Type of dam core (till core, rock fill, cyclone sand, etc.)	Till blanket

Dam Information	
Dam names	**West Tailings Dam**
Height of dam	25 m
Consequence classification	High
Slope	Downstream: 2.5H:1V; Upstream: 2H:1V
Minimum factor of safety (long term steady state)	1.8
Minimum factor of safety (pseudo-static)	1.1
Permitted elevation	1,735 m
Current elevation	1,731.14 m
Seismic design (AEP)	1 in 2,475 years
Flood design (AEP)	1/3 between 1/1000 year return period and PMF
Type of dam construction (upstream, downstream, centre)	Downstream
Type of dam core (till core, rock fill, cyclone sand, etc.)	Till blanket

Sources:

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. December 2017.

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

GHO. 2019b. Operation, Maintenance, and Surveillance Manual for Greenhills Tailings Storage Facility. Standard Practices and Procedures No. 1543. Ver. 4. Date of Revision: 24 June 2019

Golder. 2014. 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. 11 February 2014.

Golder. 2017a. Tailings storage facility dam breach flood inundation study. Report prepared for Teck Coal Limited, Greenhills Operations. Golder Doc. No. 1528359-2016-081-R-Rev0-4000. 17 April 2017.

Golder. 2017b. Stability review and update of the quantitative performance objectives for Greenhills tailings pond dams. Technical memorandum prepared for Teck Coal Limited, Greenhills Operations. Golder Doc. No. 1780315-2017-097-R-Rev0-1000. 21 Decembe

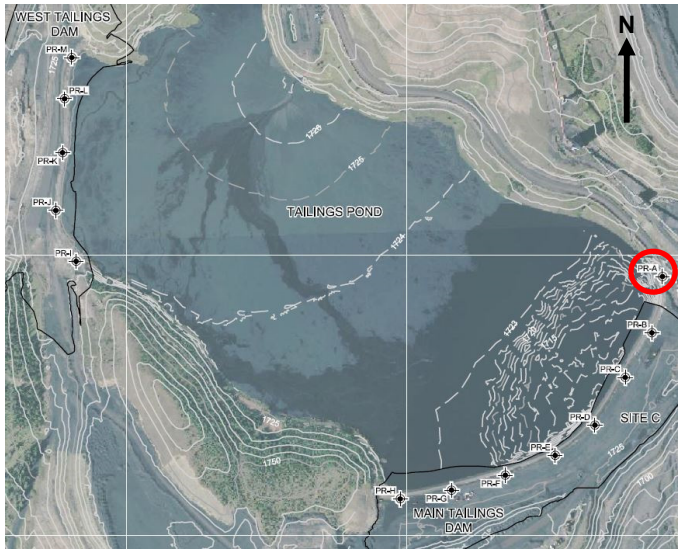
Golder. 2019a. 2018 Construction Report. Greenhills Operations Main and West Dams. Report prepared forTeck Coal Limited, Greenhills Operations. Golder Doc. No. 18103265-FINAL-Rev0. 22 March 2019.

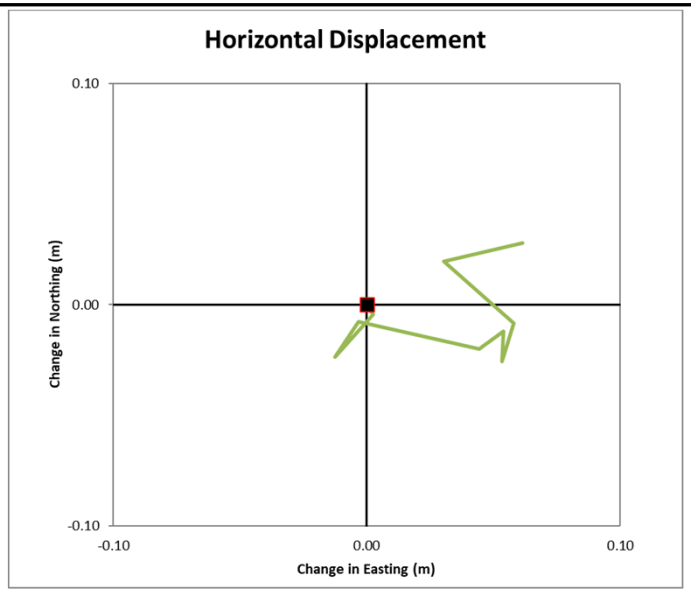
Golder. 2019b. 2018 Dam Safety Inspection for Greenhills Tailings Facility. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1894290-2018-133-R-Rev0-2000. Submitted 26 March 2019.

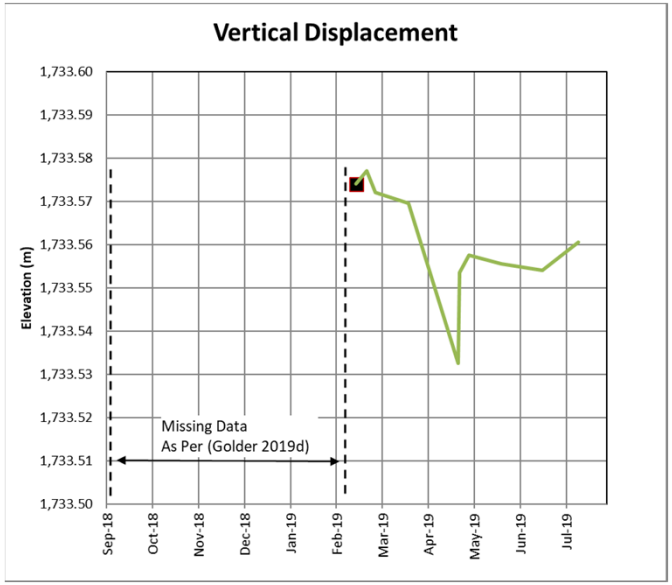
Wood . 2018. 2017 risk assessment of tailings dams classified as High or Higher: Greenhills Operations – Main and West Dams. TE173054. 12 May 2018.

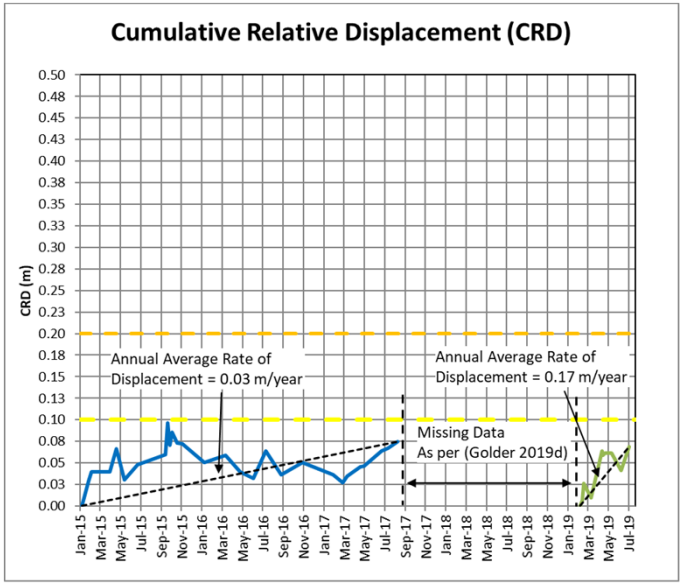
APPENDIX D

Prism and GPS Instrumentation Monitoring Data









- Initial Location After 2018 Dam Raise Construction
- 2018/2019 DSI Monitoring Data (1 September 2018 to 31 July 2019)
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- Yellow Warning (100 mm)
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References:
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Notes:
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CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

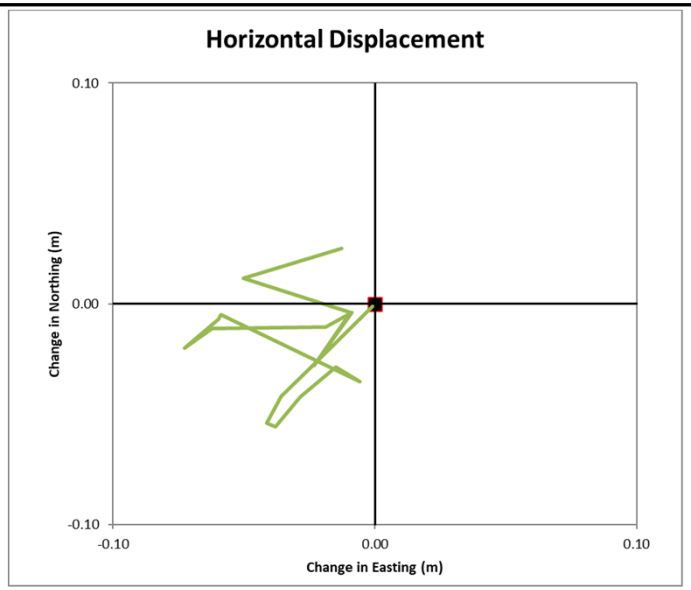
CONSULTANT
GOLDER

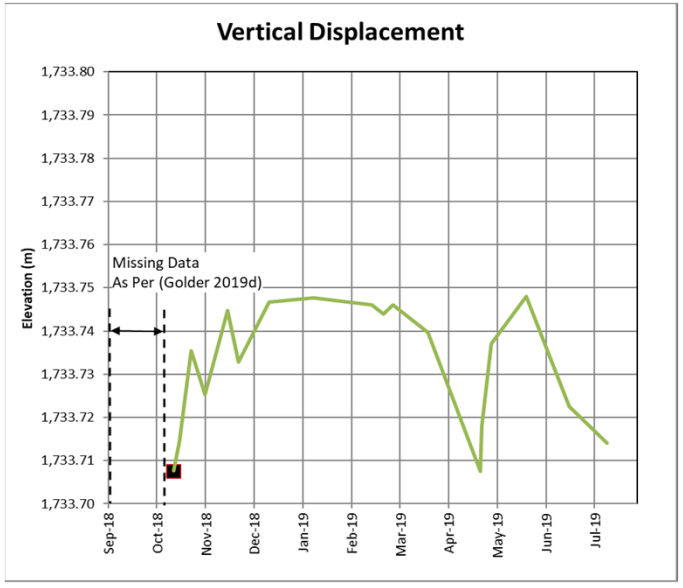
YYYY-MM-DD	2020-03-16
PREPARED	M.Klassen
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

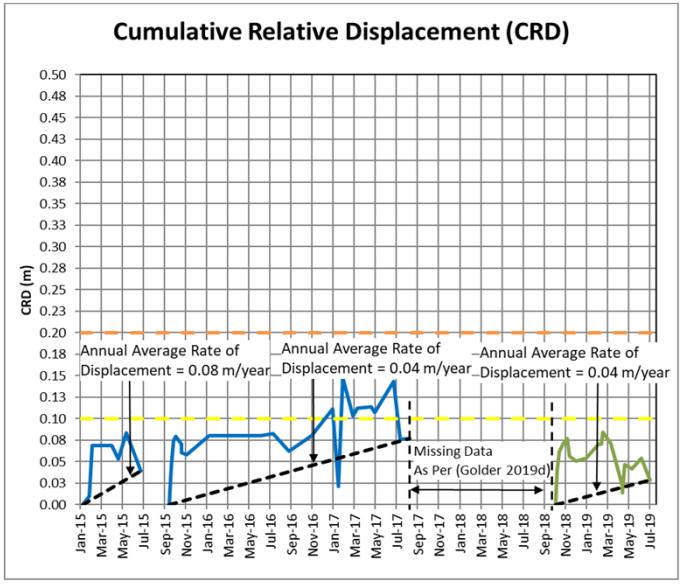
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - PRISM A

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-1**







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YYYY-MM-DD	2020-03-16
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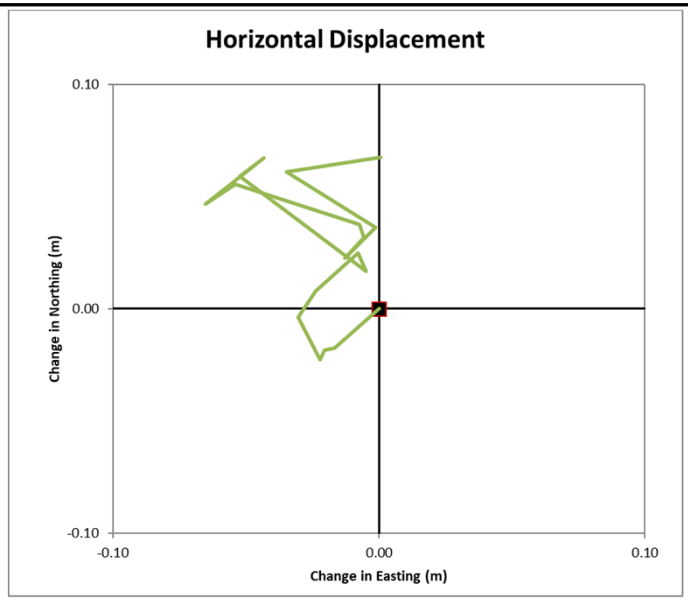
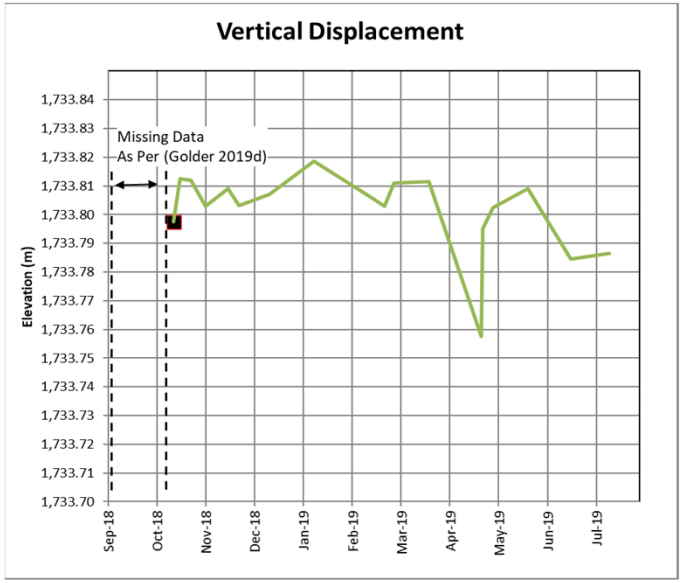
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

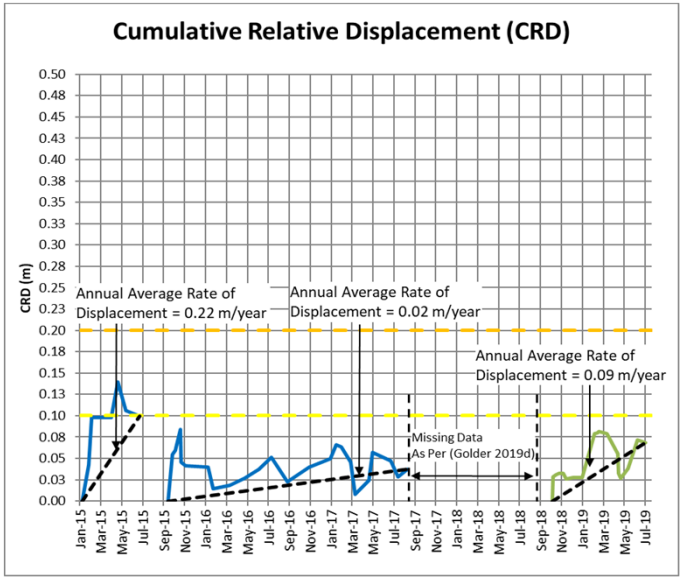
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - PRISM B

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-2**







Initial Location After 2018 Dam Raise Construction

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Historical Data Prior to 2018/2019 DSI Reporting Period

Yellow Warning (100 mm)

Orange Alarm (200 mm)

Instrument Location

References:
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DESIGN	M.Klassen
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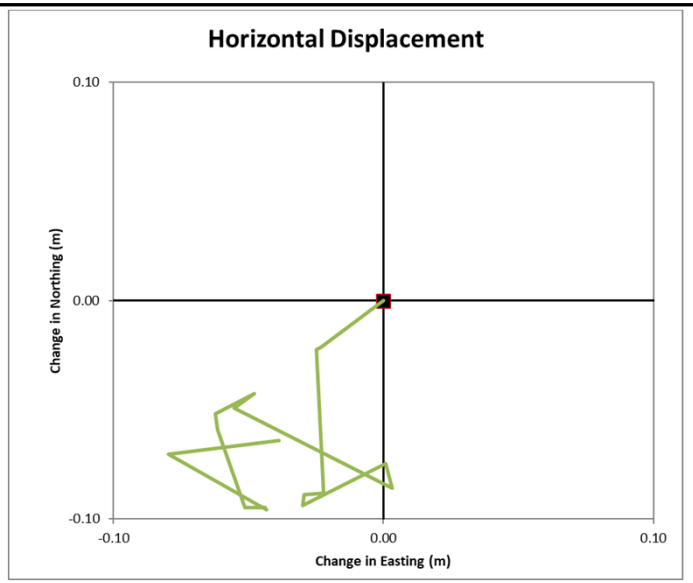
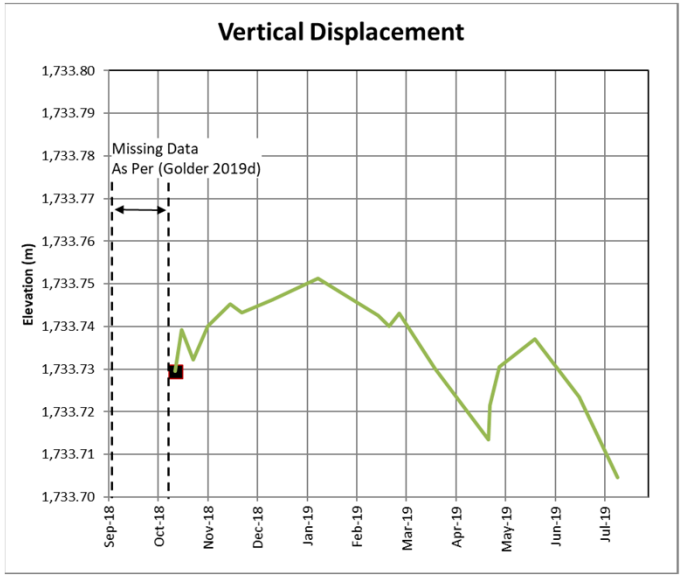
APPROVED	A.Haynes

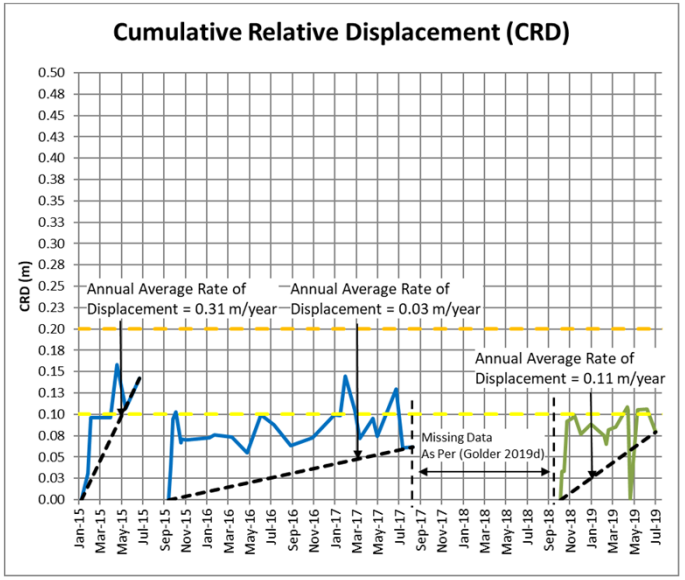
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - PRISM C

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-3**







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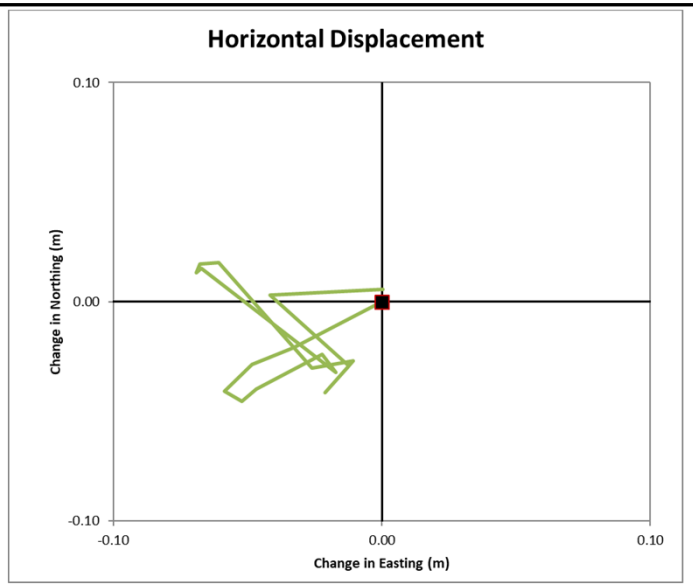
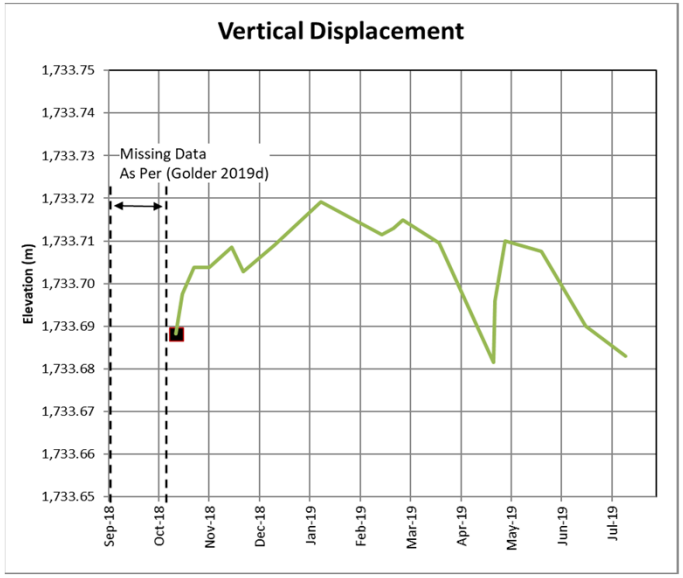
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

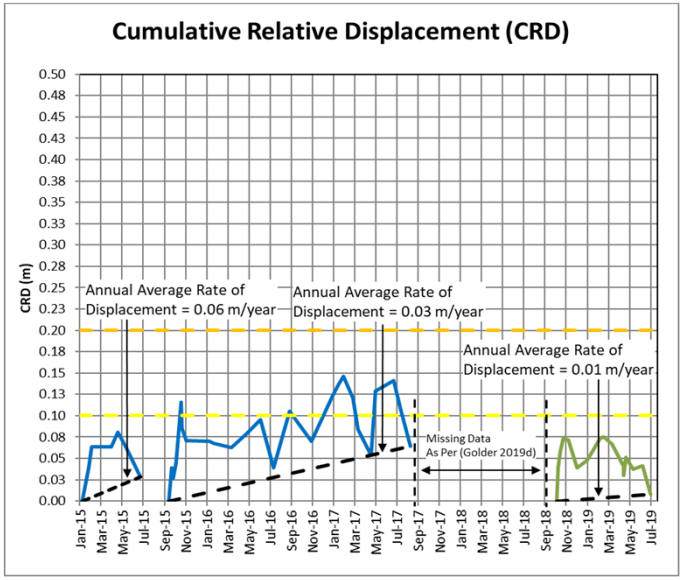
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - PRISM D

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-4**







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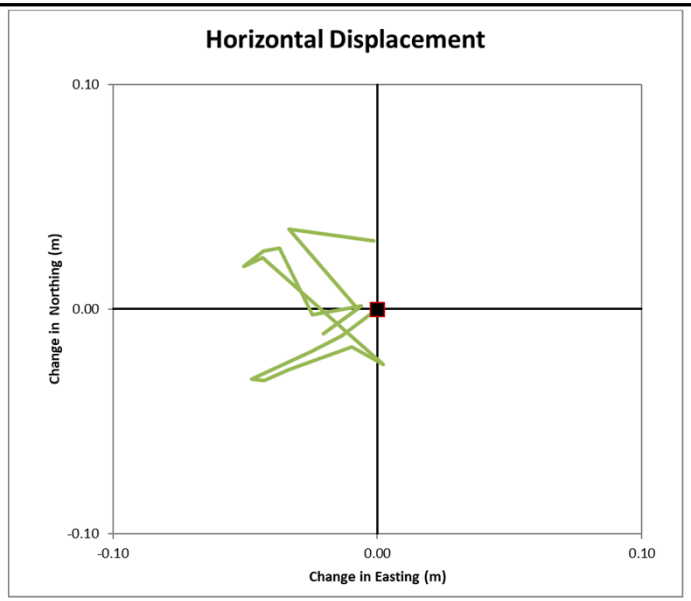
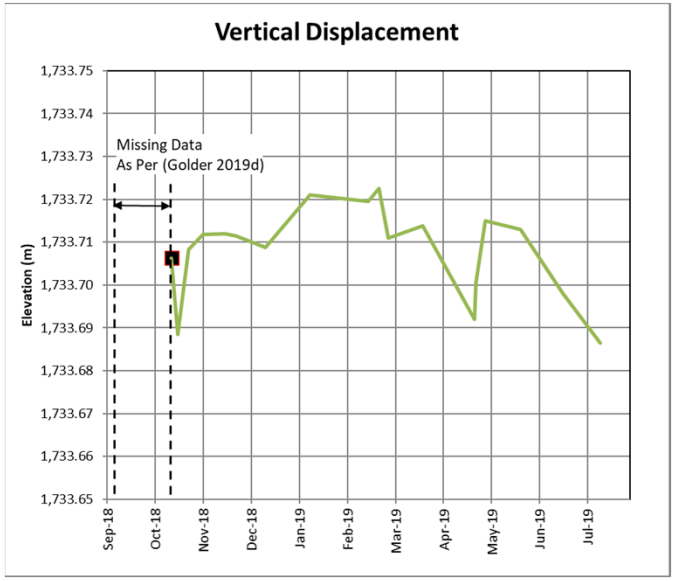
REVIEW	M.Willan
APPROVED	A.Haynes

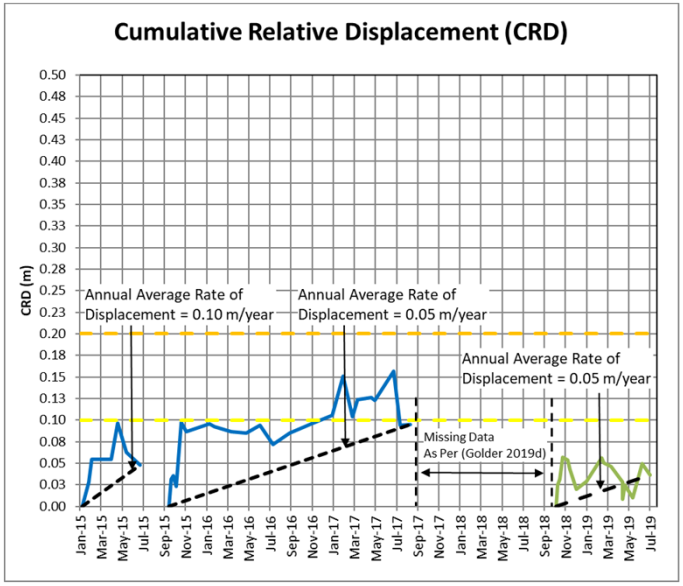
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - PRISM E

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-5**







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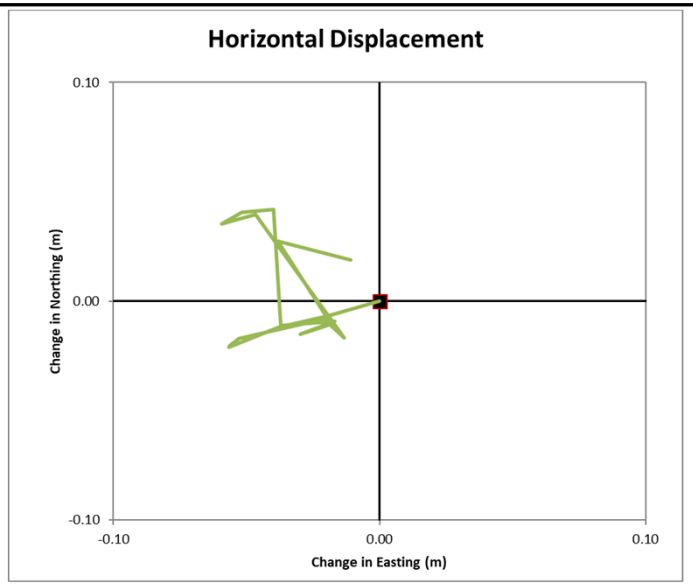
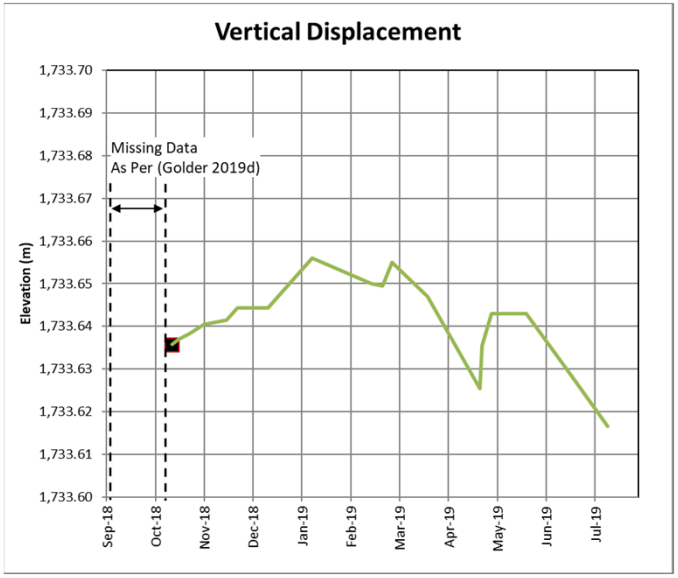
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

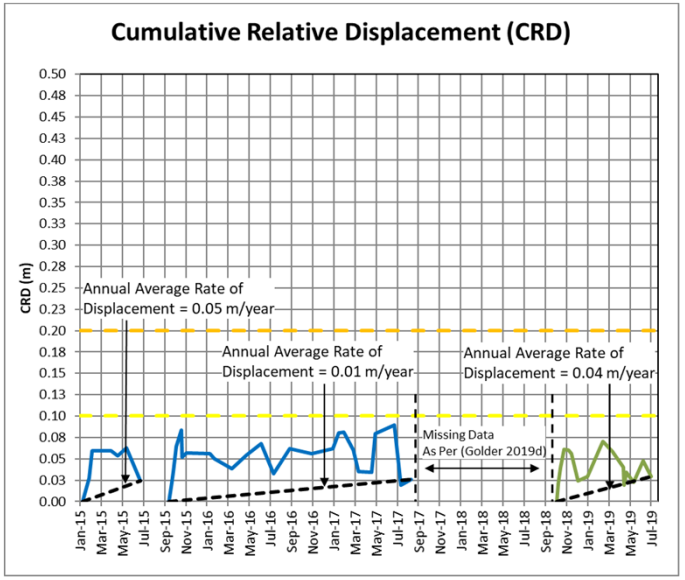
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - PRISM F

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-6**







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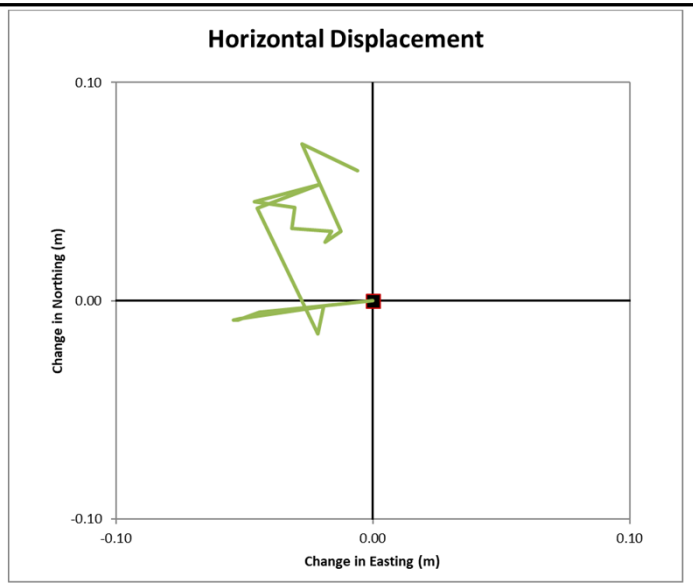
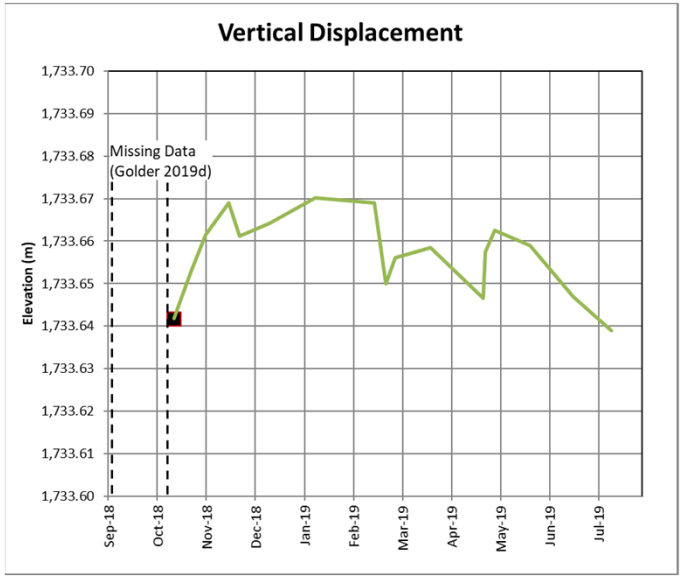
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

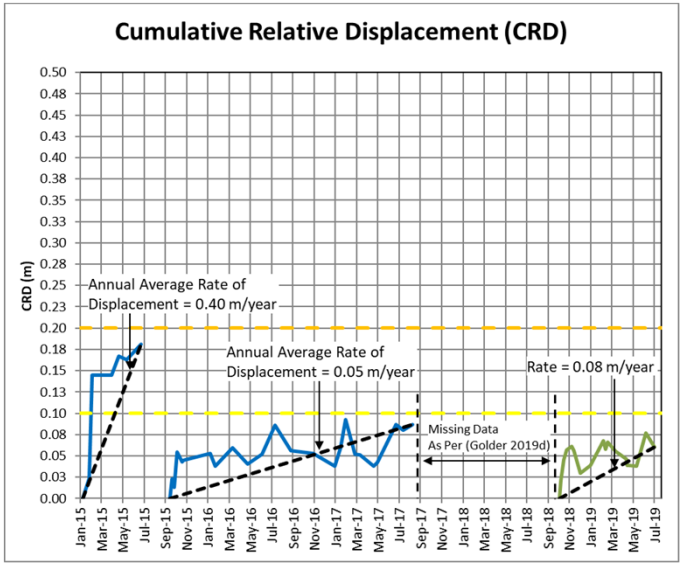
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - PRISM G

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-7**







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GOLDER

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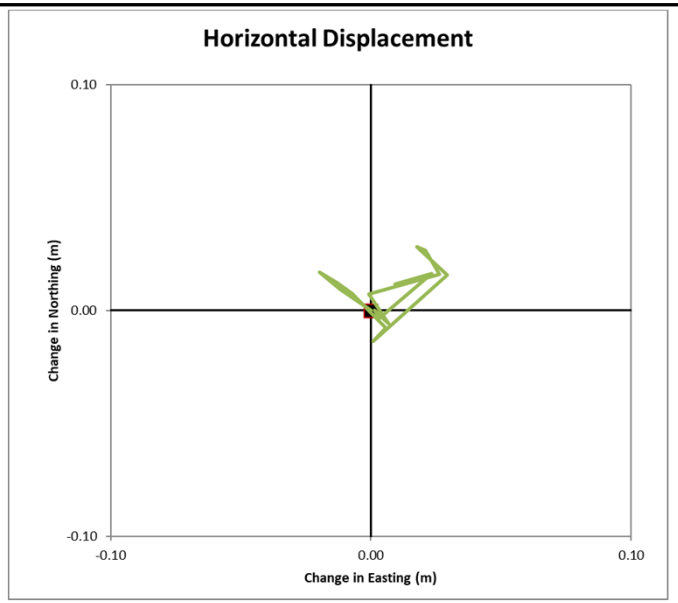
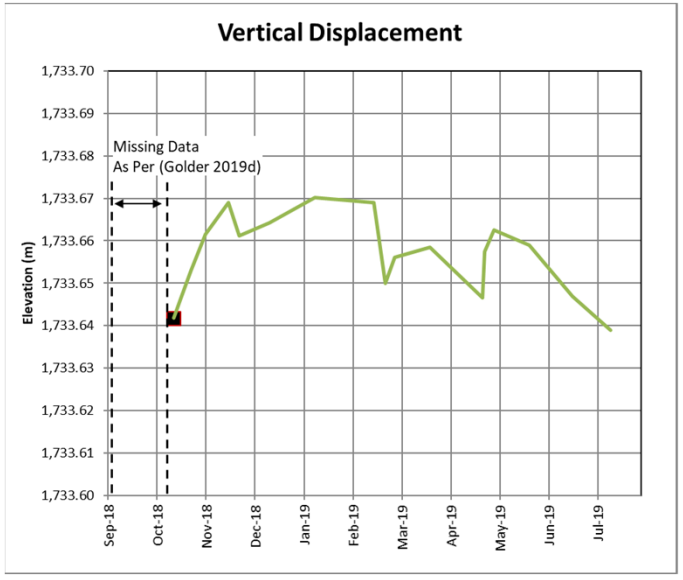
PREPARED	M.Klassen
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

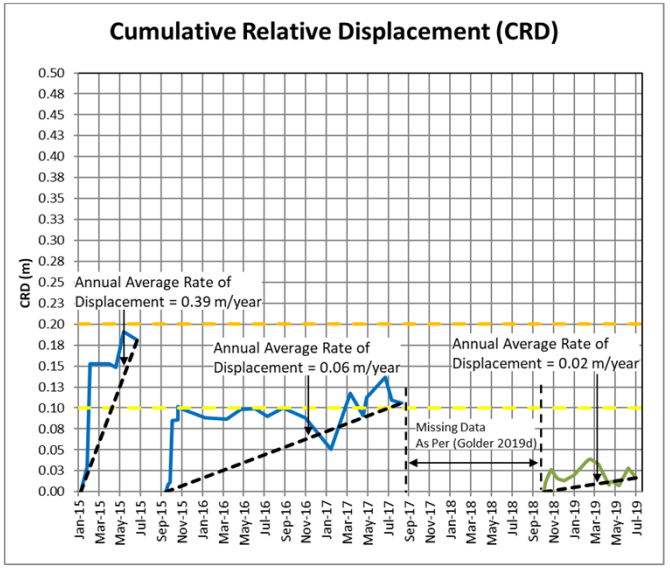
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - PRISM H

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-8**







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ELKFORD, BC

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GOLDER

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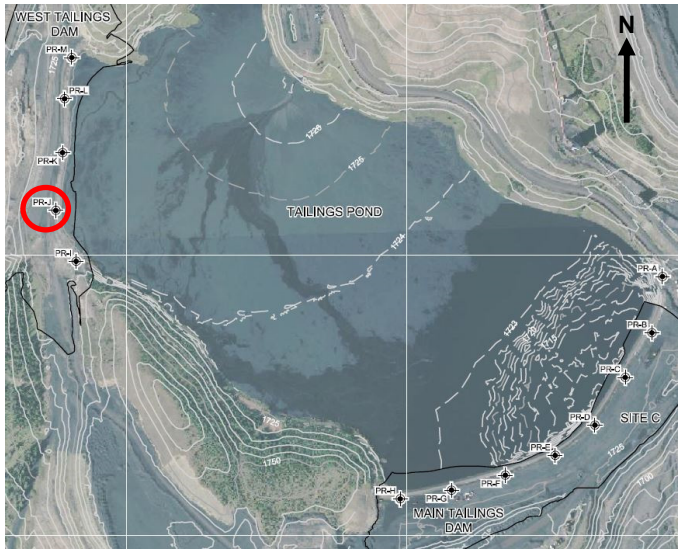
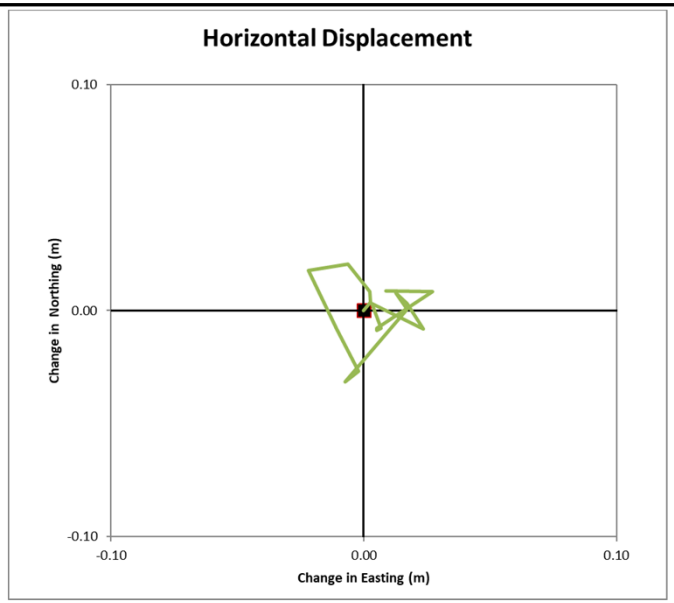
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

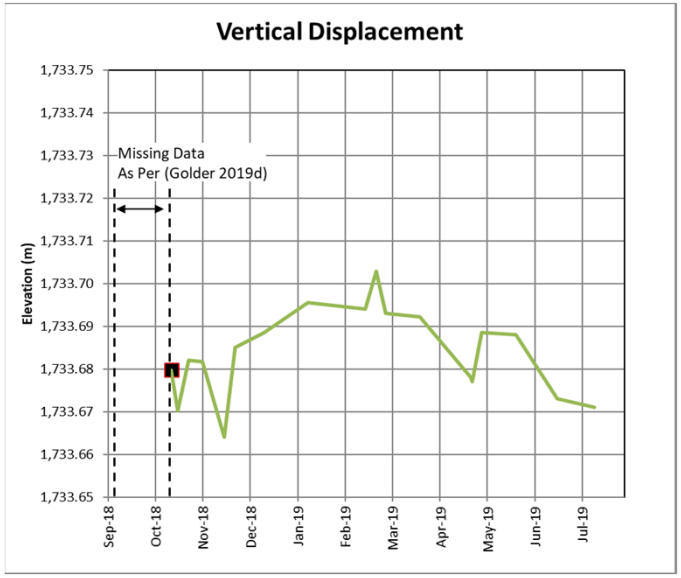
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

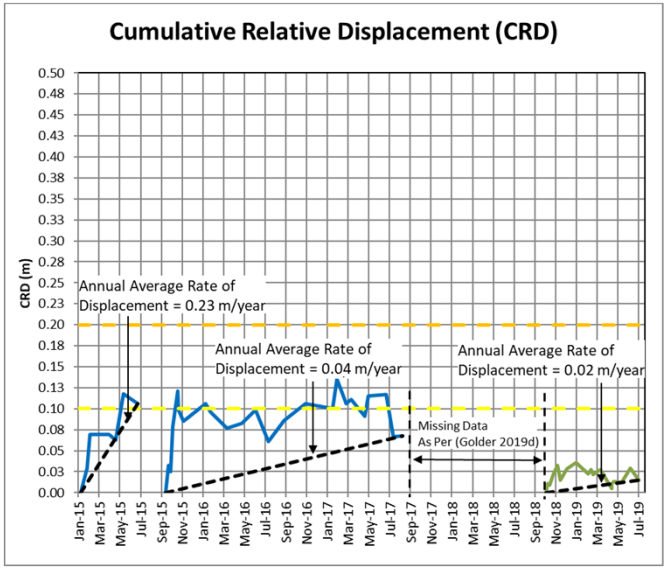
TITLE
WEST TAILINGS DAM - PRISM I

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-9**









- Initial Location After 2018 Dam Raise Construction
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References:
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Notes:
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CLIENT
TECK COAL LIMITED
GREENHILLS OPERATIONS
ELKFORD, BC

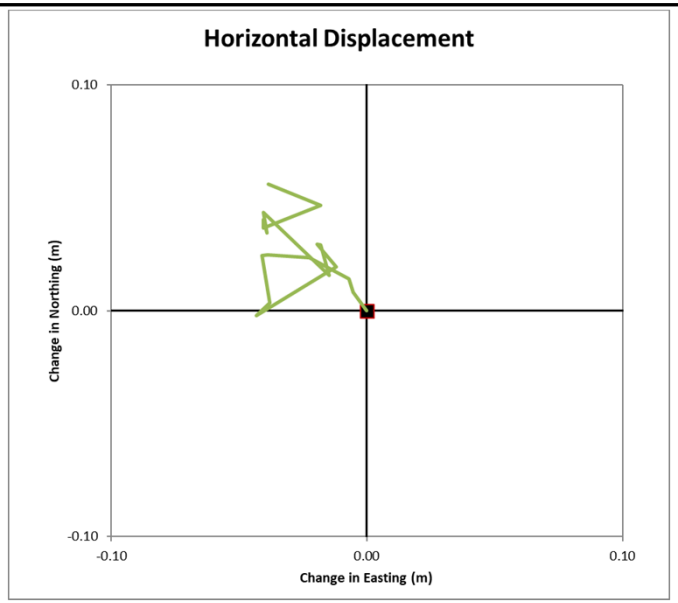
CONSULTANT
GOLDER

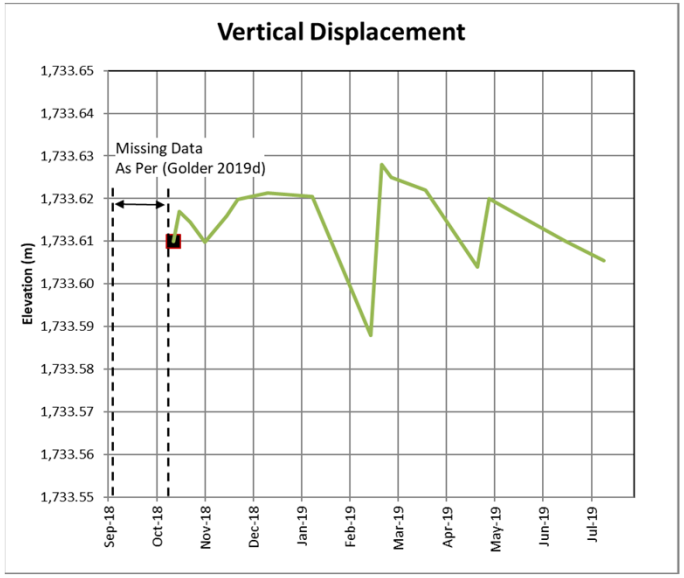
YYYY-MM-DD	2020-03-16
PREPARED	M.Klassen
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

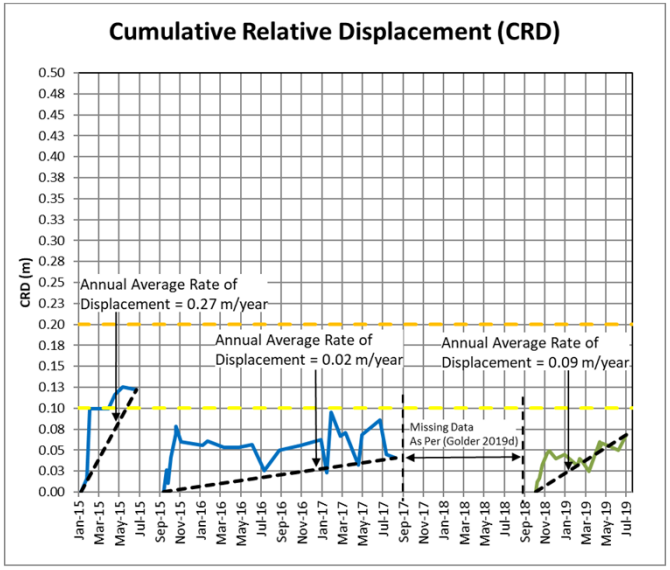
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
WEST TAILINGS DAM - PRISM J

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-10**







- Initial Location After 2018 Dam Raise Construction
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ELKFORD, BC

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-16
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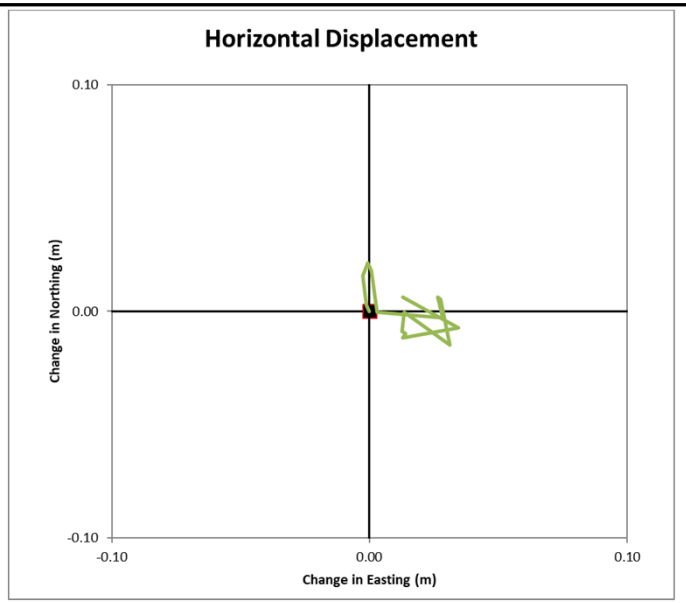
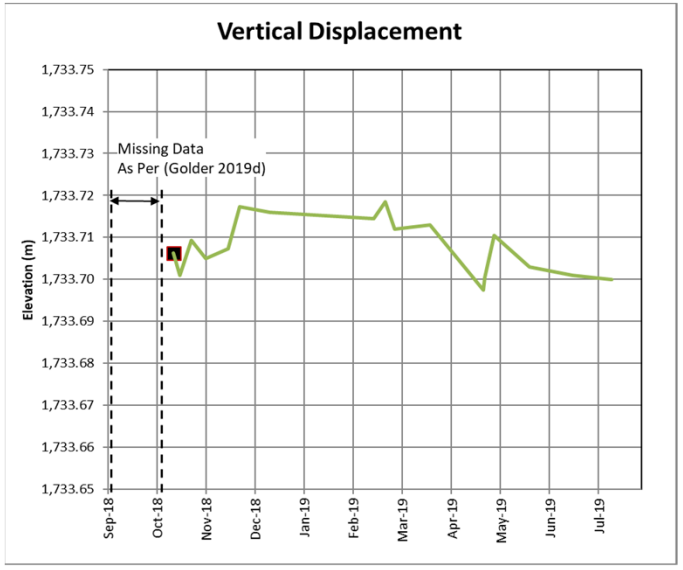
REVIEW	M.Willan
APPROVED	A.Haynes

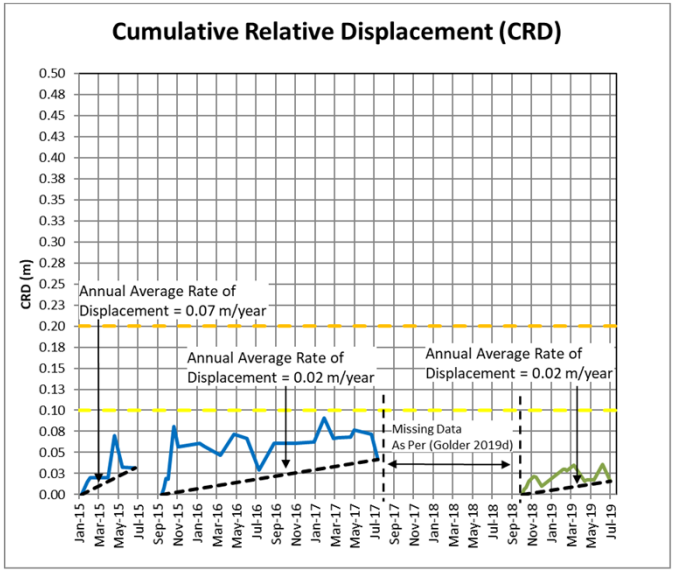
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
WEST TAILINGS DAM - PRISM K

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-11**







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GOLDER

YYYY-MM-DD	2020-03-16
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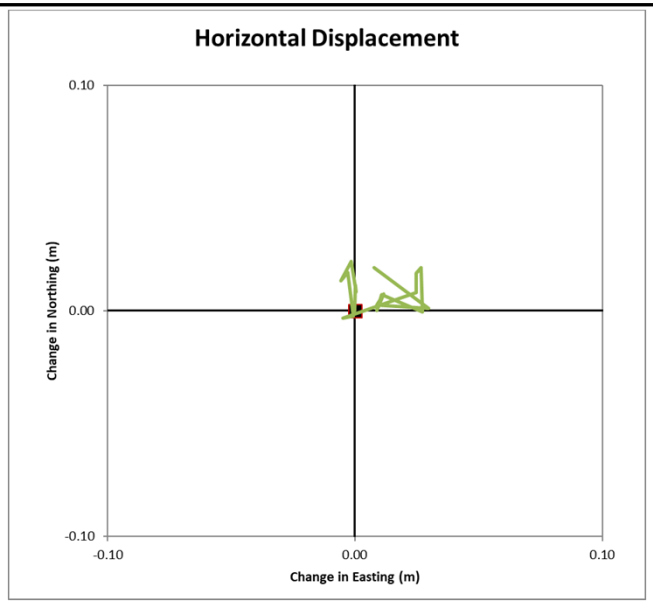
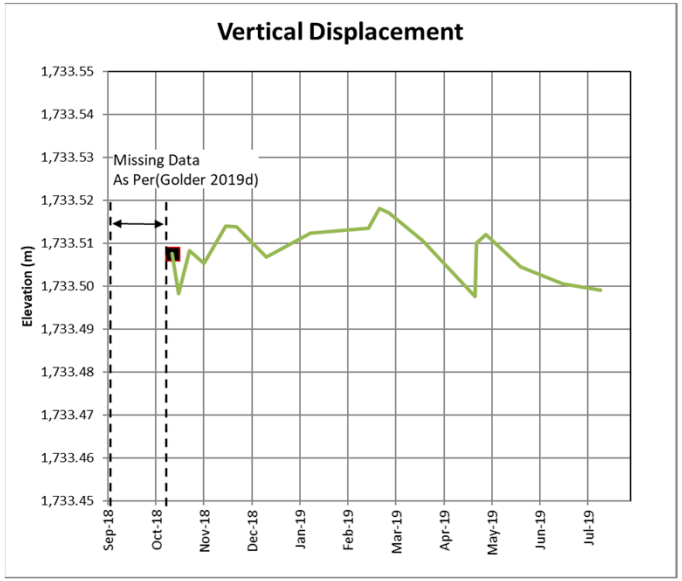
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

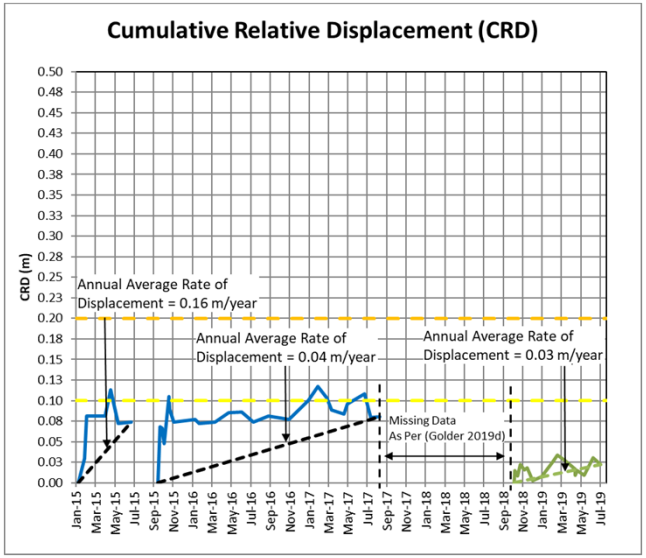
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
WEST TAILINGS DAM - PRISM L

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-12**







- Initial Location After 2018 Dam Raise Construction
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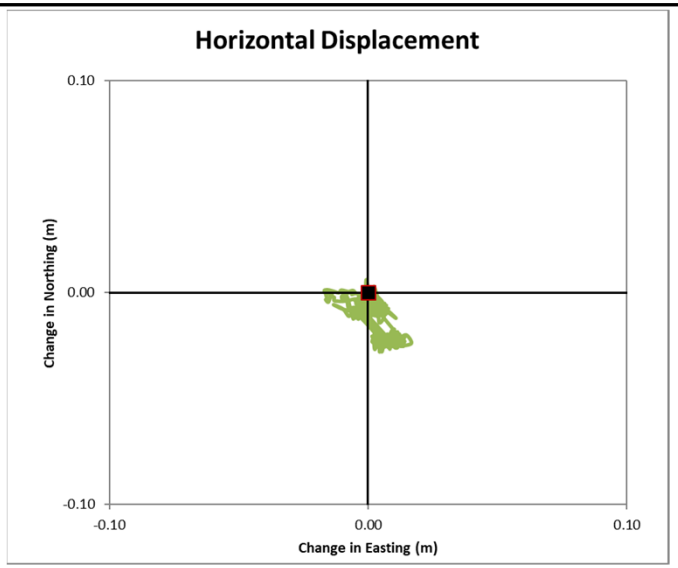
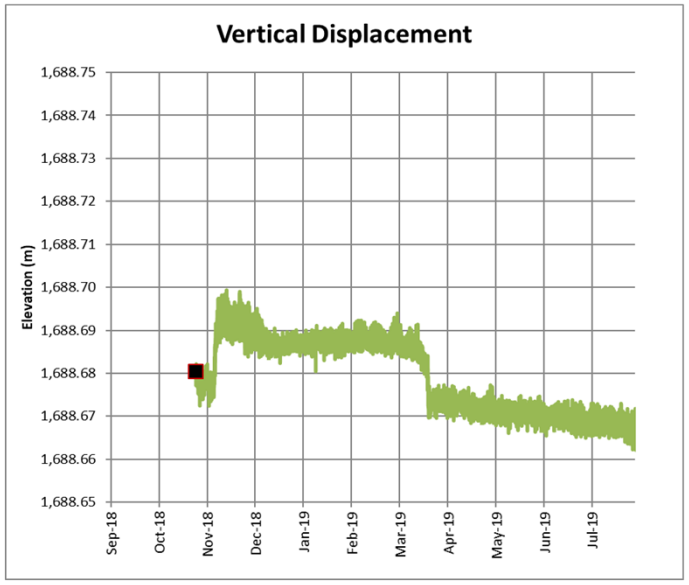
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

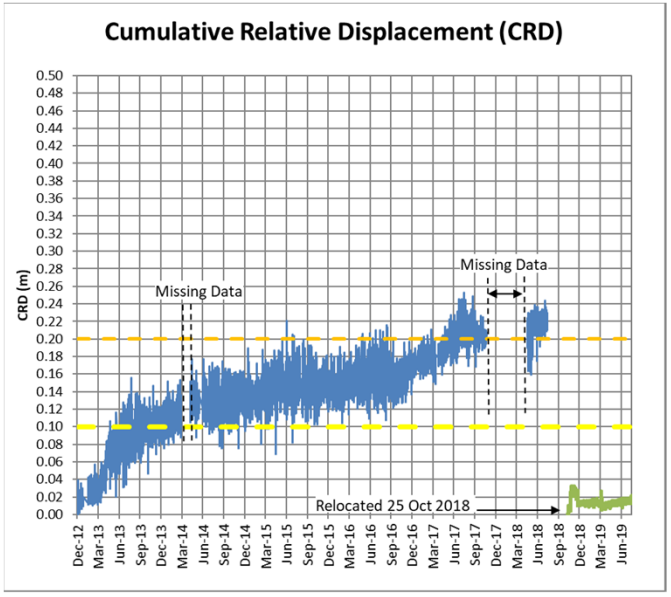
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
WEST TAILINGS DAM - PRISM M

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-13**







- Initial Location After 2018 Dam Raise Construction
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YYYY-MM-DD	2020-03-16
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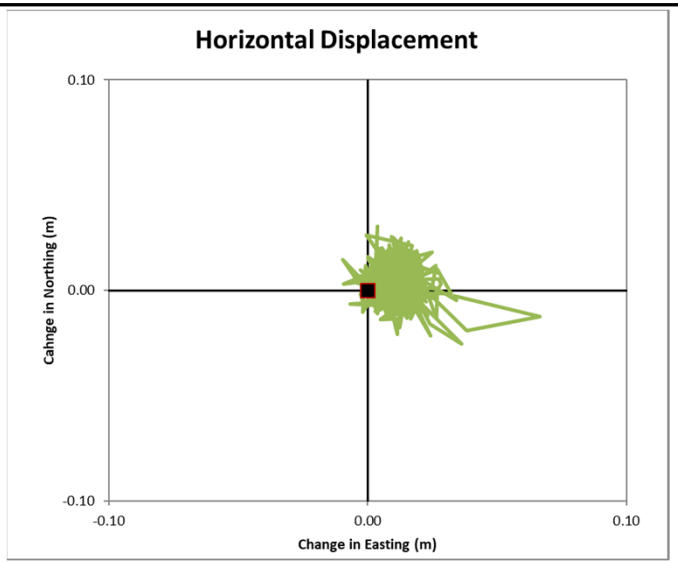
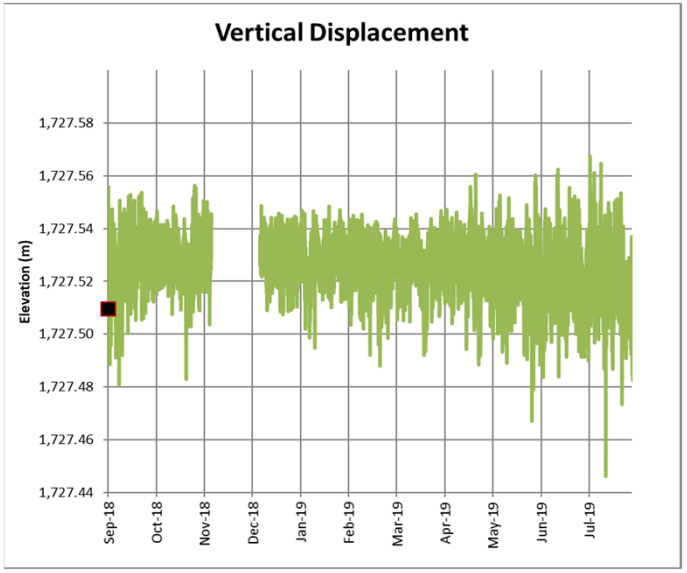
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

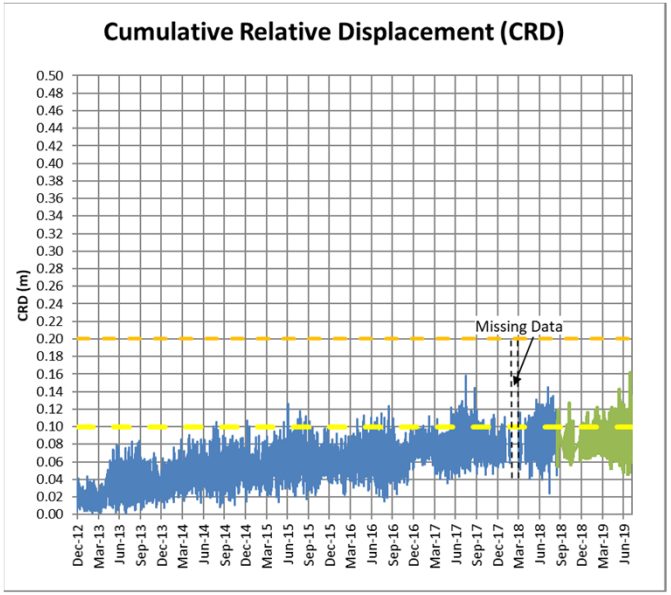
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM – GPS UNIT 319

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-14**







- Initial Location After 2018 Dam Raise Construction
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YYYY-MM-DD	2020-03-16
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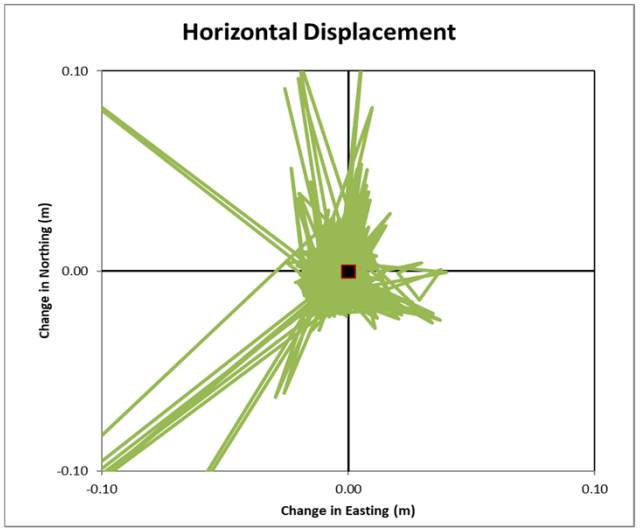
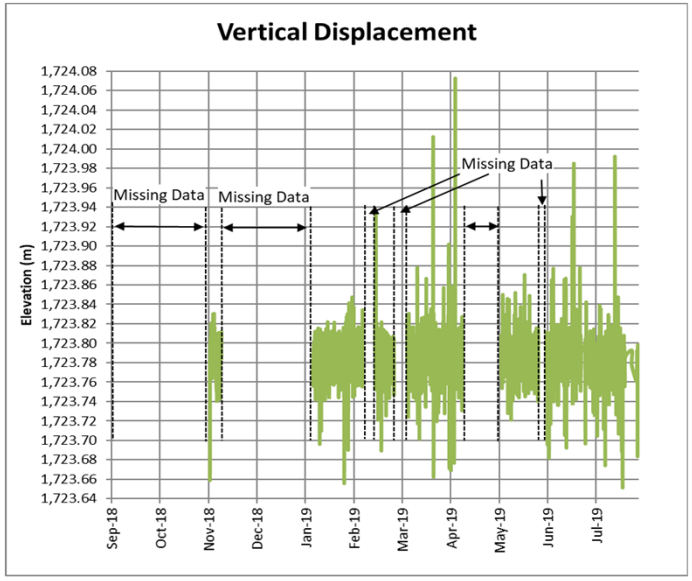
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

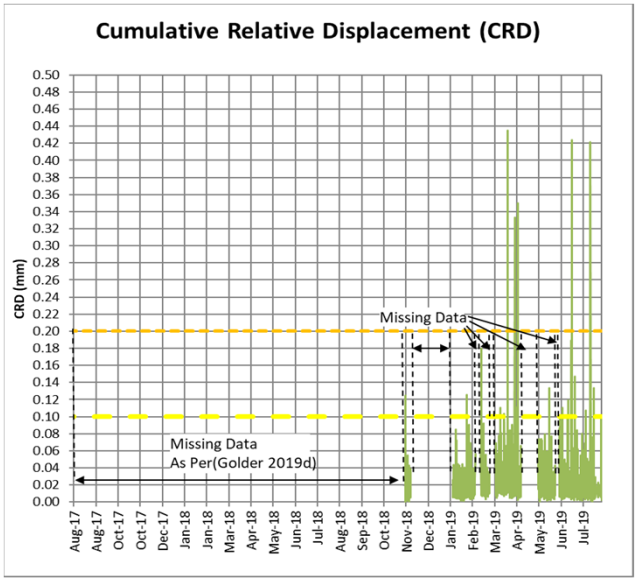
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - GPS UNIT 320

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-15**







- Initial Location After 2018 Dam Raise Construction
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ELKFORD, BC

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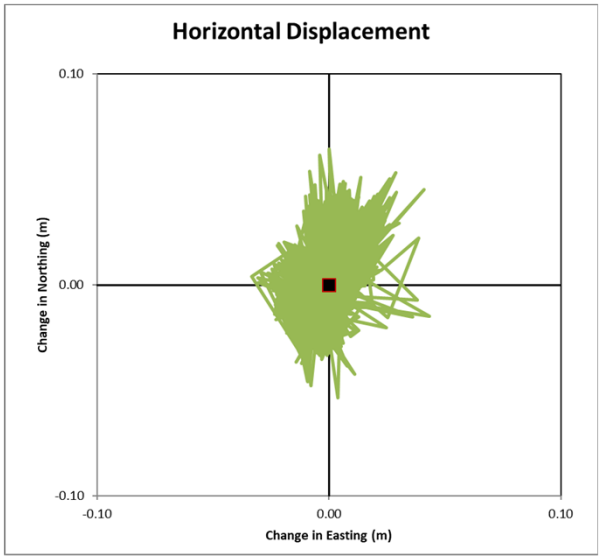
GOLDER

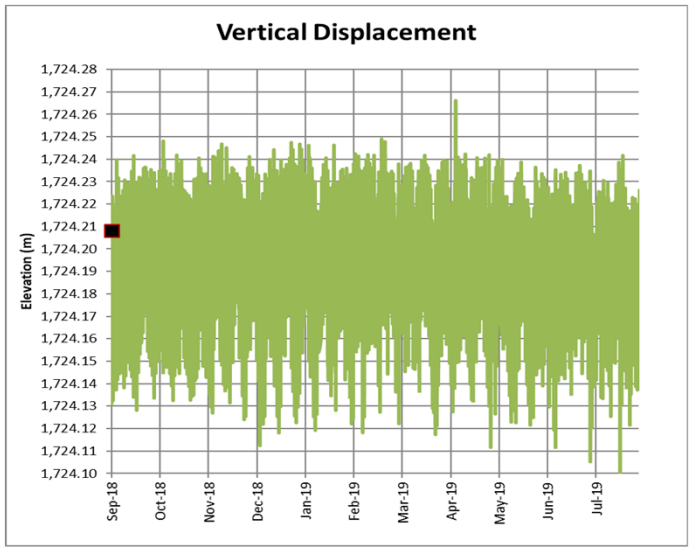
YYYY-MM-DD	2020-03-16
PREPARED	M.Klassen
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

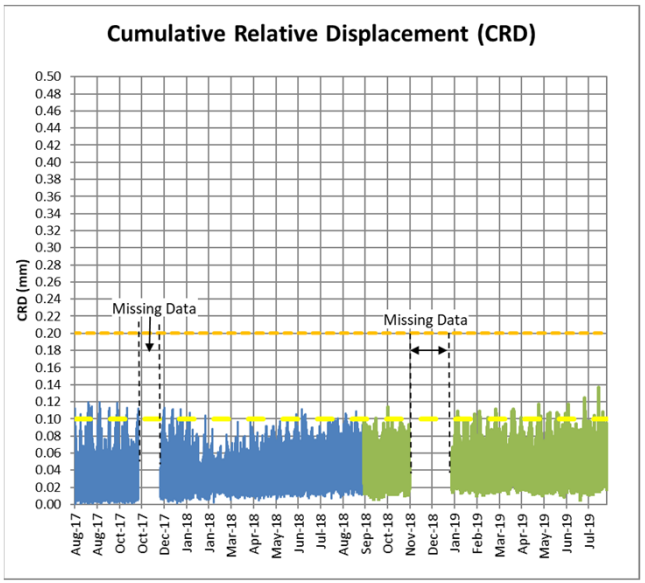
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - GPS UNIT MD-1_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-16**







- Initial Location After 2018 Dam Raise Construction
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YYYY-MM-DD	2020-03-16
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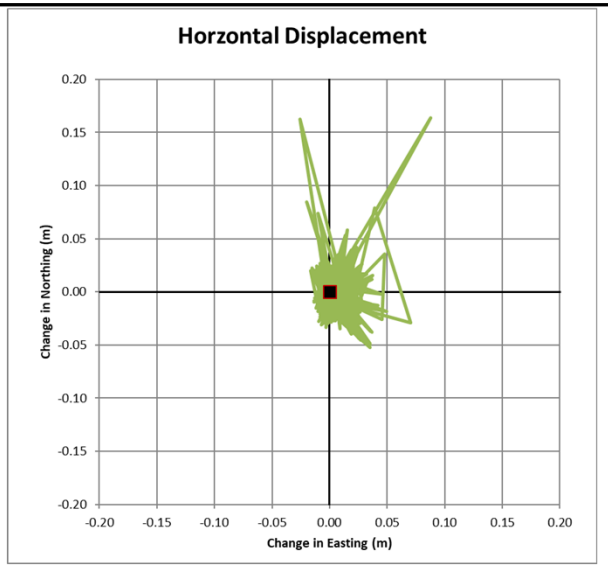
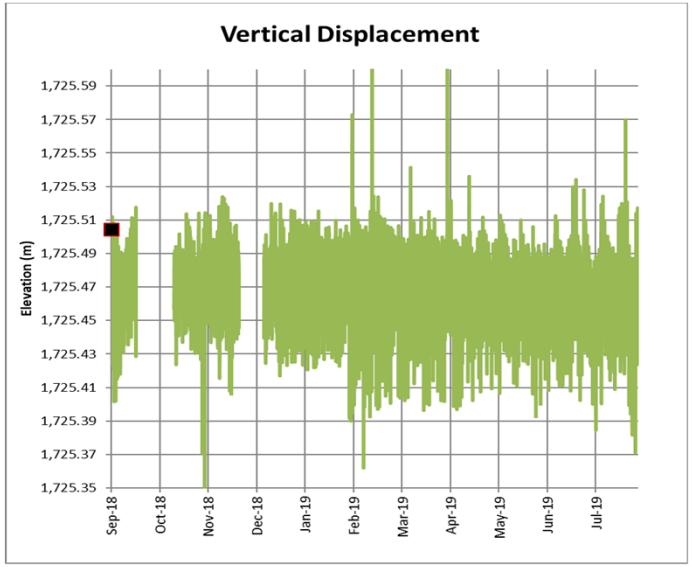
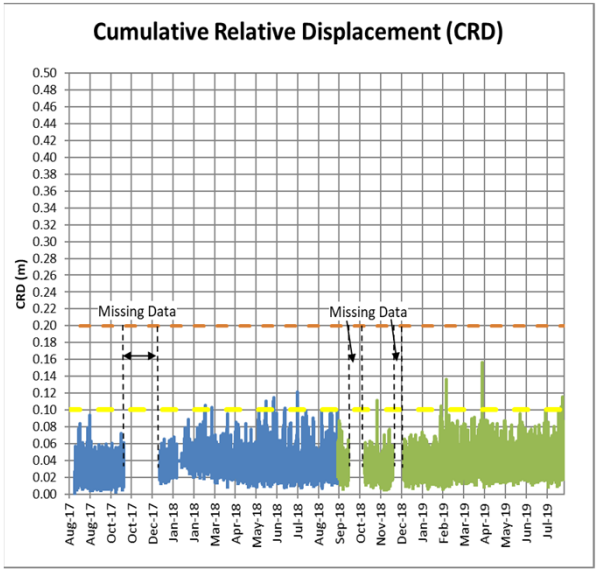
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - GPS UNIT MD-2_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-17**







- Initial Location After 2018 Dam Raise Construction
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- Instrument Location

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YYYY-MM-DD	2020-03-16
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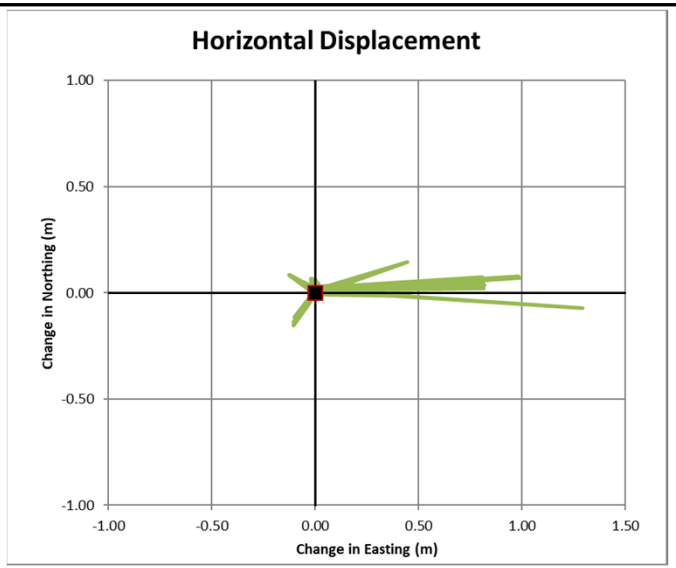
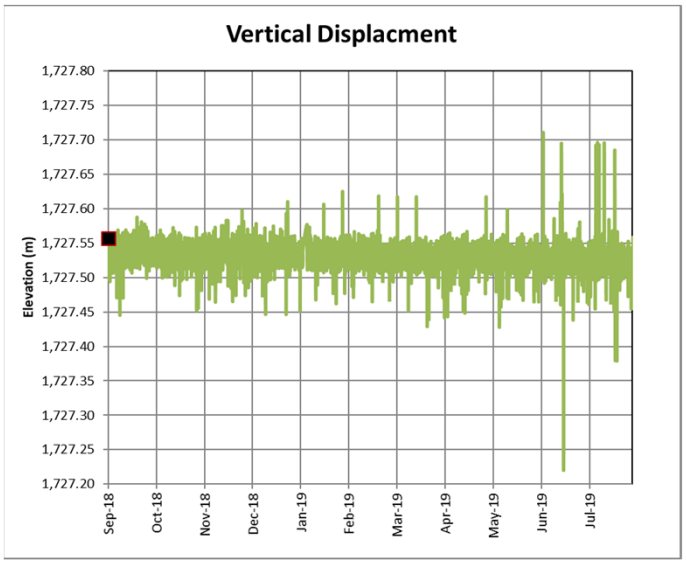
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

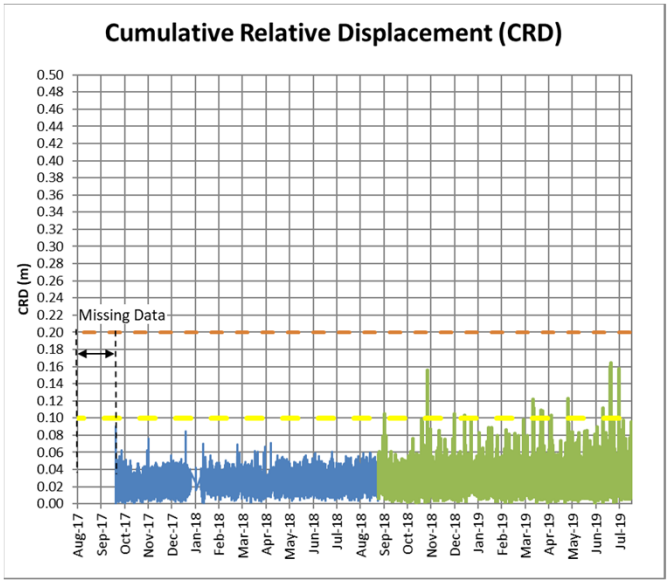
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - GPS UNIT MD-3_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-18**







Initial Location After 2018 Dam Raise Construction

2018/2019 DSI Monitoring Data (1 September 2018 to 31 July 2019)

Historical Data Prior to 2018/2019 DSI Reporting Period

Yellow Warning (100 mm)

Orange Alarm (200 mm)

Instrument Location

References:
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GOLDER

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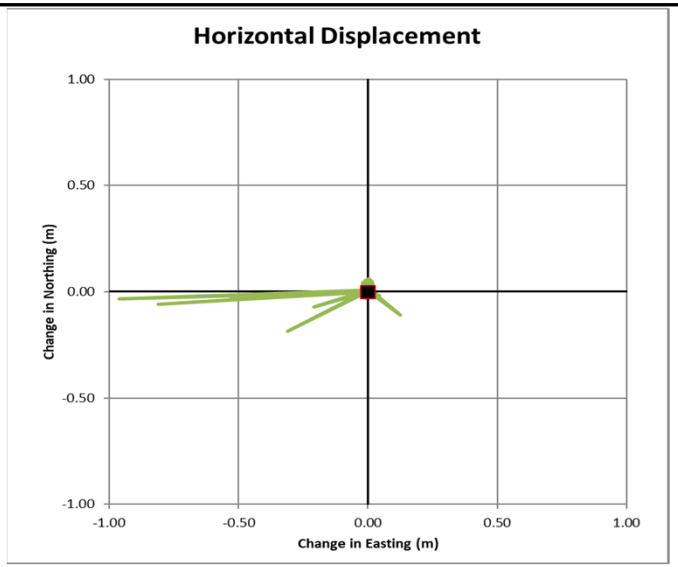
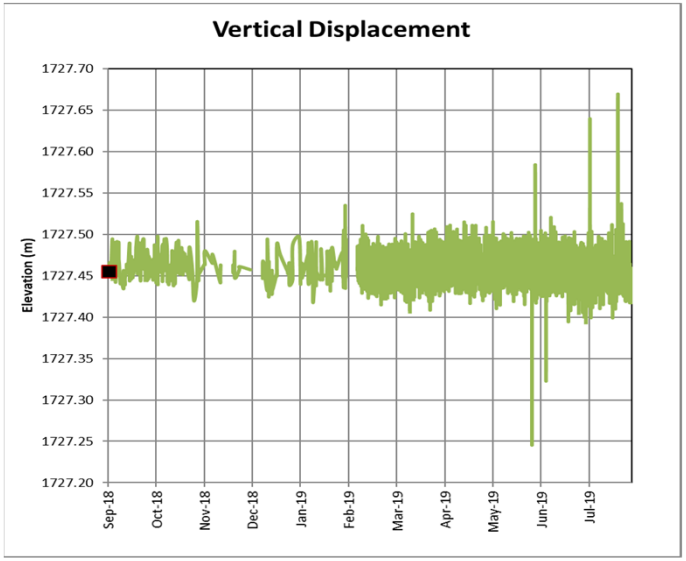
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

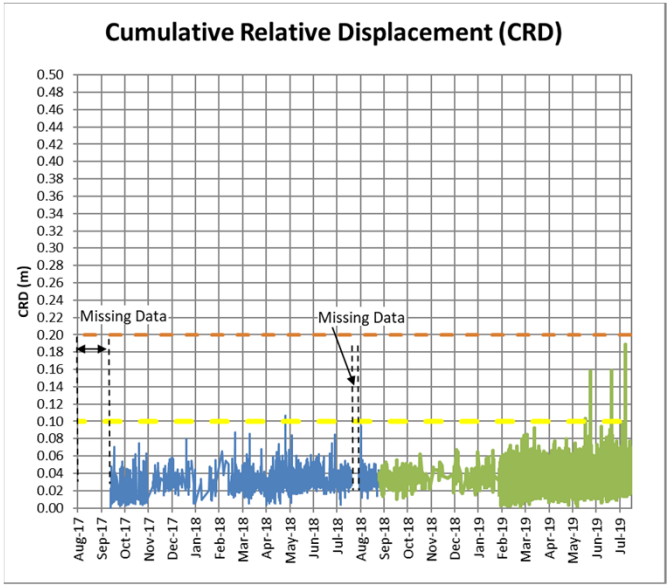
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - GPS UNIT MD-4_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-19**







- Initial Location After 2018 Dam Raise Construction
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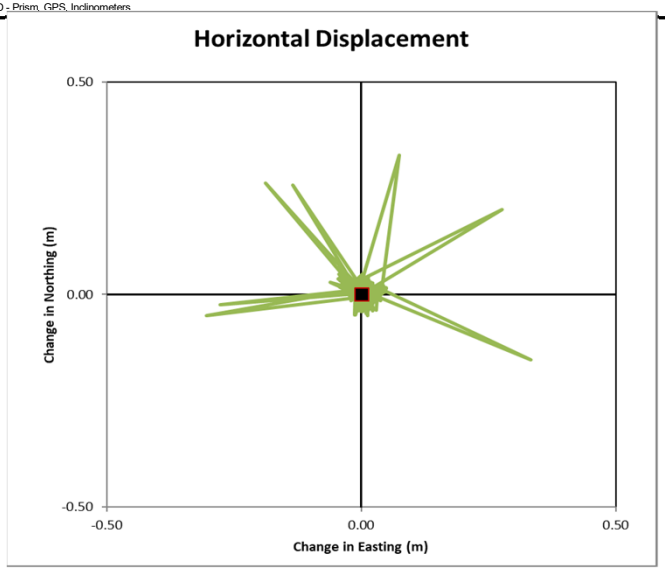
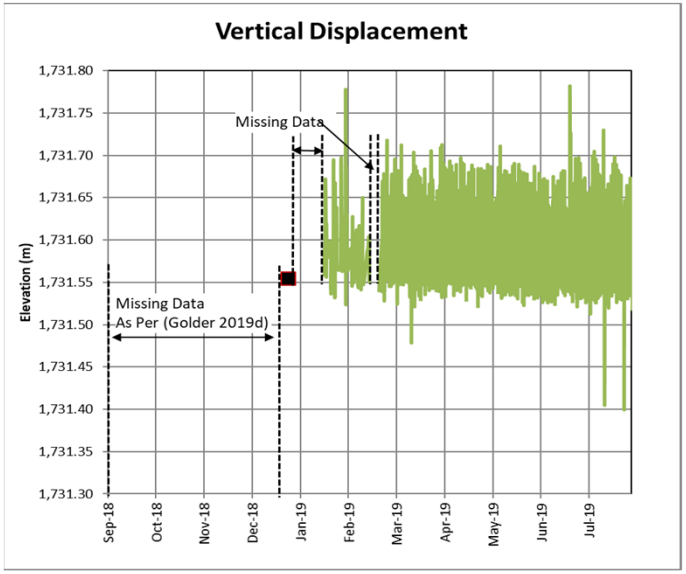
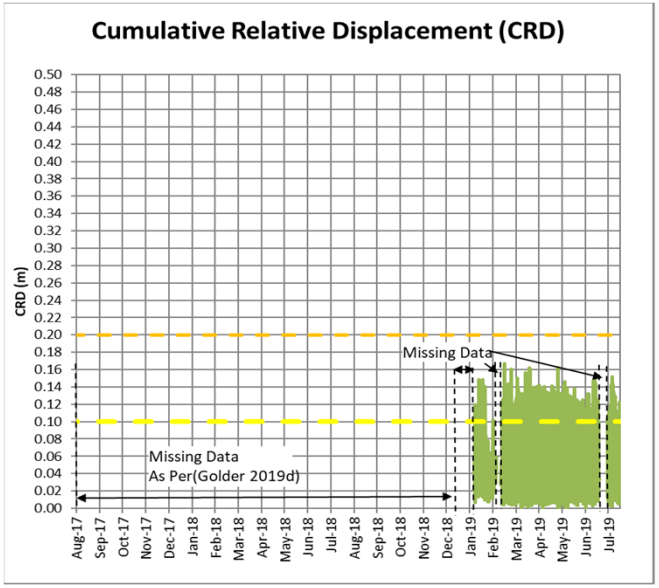
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - GPS UNIT MD-5_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-20**







Initial Location After 2018 Dam Raise Construction
2018/2019 DSI Monitoring Data (1 September 2018 to 31 July 2019)
Historical Data Prior to 2018/2019 DSI Reporting Period
Yellow Warning (100 mm)
Orange Alarm (200 mm)
Instrument Location

References:
-Golder. 2019d. 2018 Dam Safety Inspection for Greenhills Tailings Facility. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1894290-2018-133-R-Rev0-2000. Submitted 26 March 2019.
-2018 Aerial photo and topography provided by Teck Coal Limited. Flown 16 to 16 July 2018.
Notes:

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GREENHILLS OPERATIONS
ELKFORD, BC

CONSULTANT
GOLDER

YYYY-MM-DD	2020-03-16
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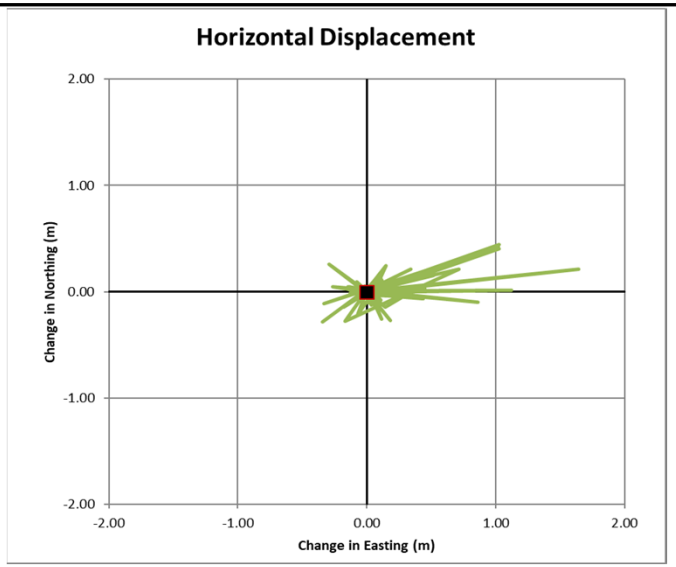
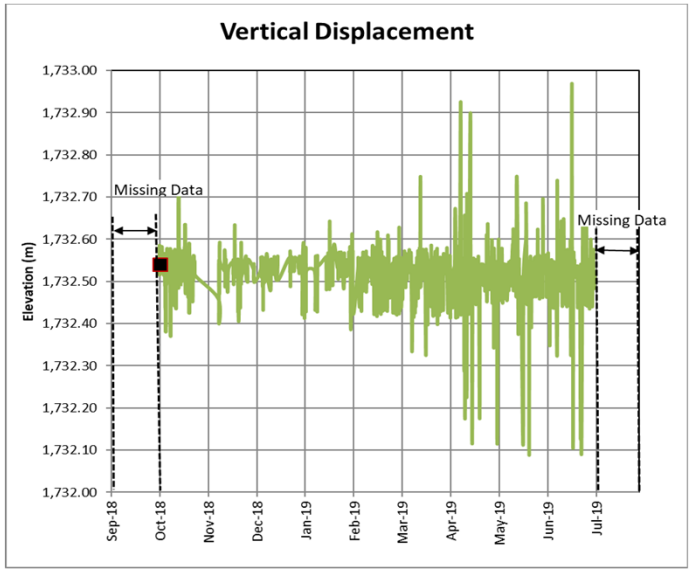
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

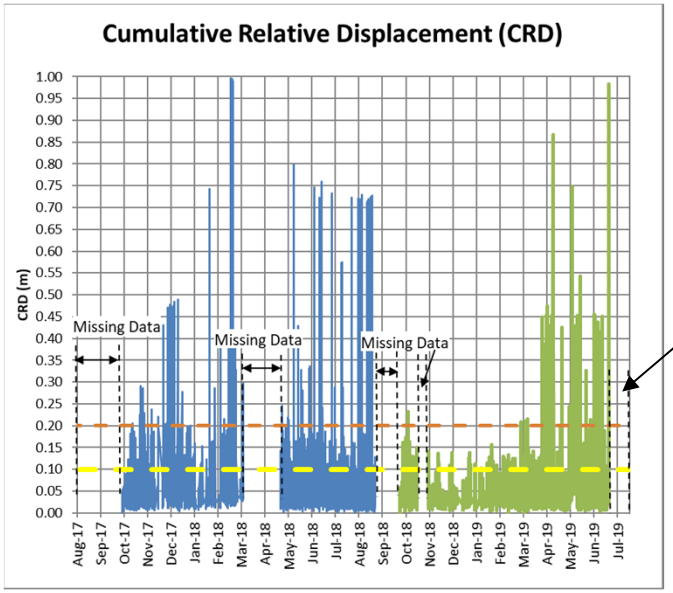
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
WEST TAILINGS DAM - GPS UNIT WD-1_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-21**







- Initial Location After 2018 Dam Raise Construction
- 2018/2019 DSI Monitoring Data (1 September 2018 to 31 July 2019)
- Historical Data Prior to 2018/2019 DSI Reporting Period
- Yellow Warning (100 mm)
- Orange Alarm (200 mm)
- Instrument Location

References:
-Golder. 2019d. 2018 Dam Safety Inspection for Greenhills Tailings Facility. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1894290-2018-133-R-Rev0-2000. Submitted 26 March 2019.
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Notes:

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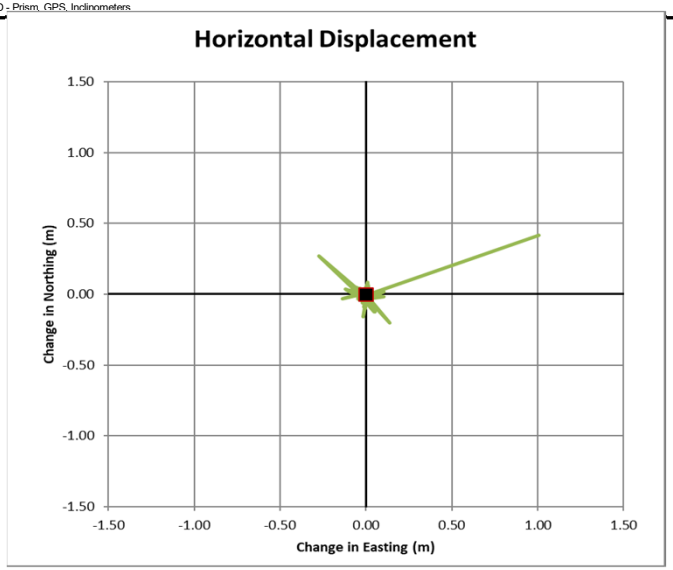
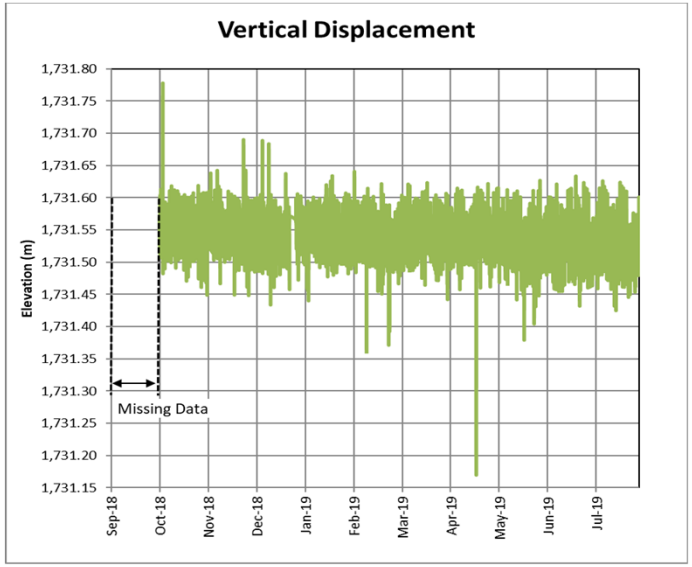
DESIGN	M.Klassen
REVIEW	M.Willan
APPROVED	A.Haynes

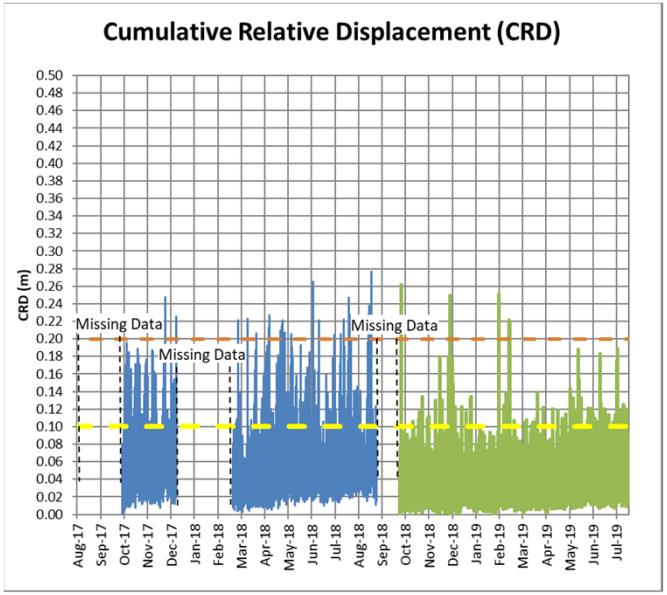
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
WEST TAILINGS DAM – GPS UNIT WD-2_ROVER

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-22**







- Initial Location After 2018 Dam Raise Construction
- 2018/2019 DSI Monitoring Data (1 September 2018 to 31 July 2019)
- Historical Data Prior to 2018/2019 DSI Reporting Period
- Yellow Warning (100 mm)
- Orange Alarm (200 mm)
- Instrument Location

References:
-Golder. 2019d. 2018 Dam Safety Inspection for Greenhills Tailings Facility. Report Prepared for Teck Coal Limited, Greenhills Operations. Reference No. 1894290-2018-133-R-Rev0-2000. Submitted 26 March 2019.
-2018 Aerial photo and topography provided by Teck Coal Limited. Flown 16 to 16 July 2018.
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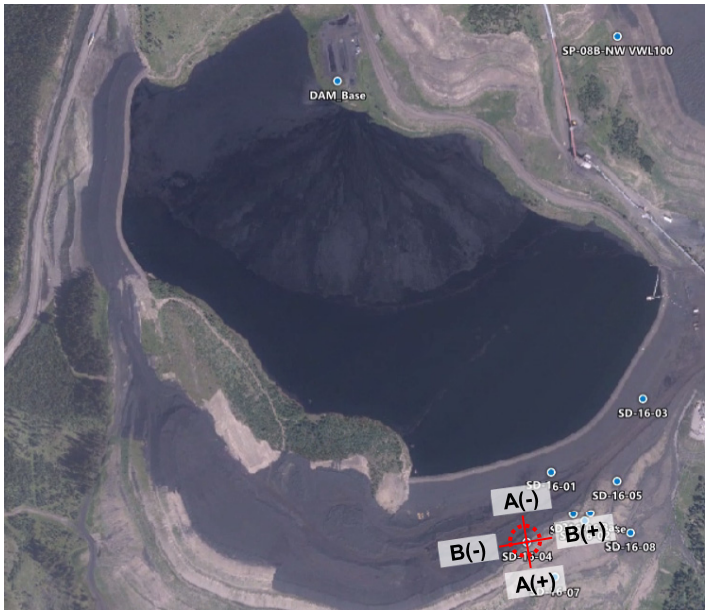
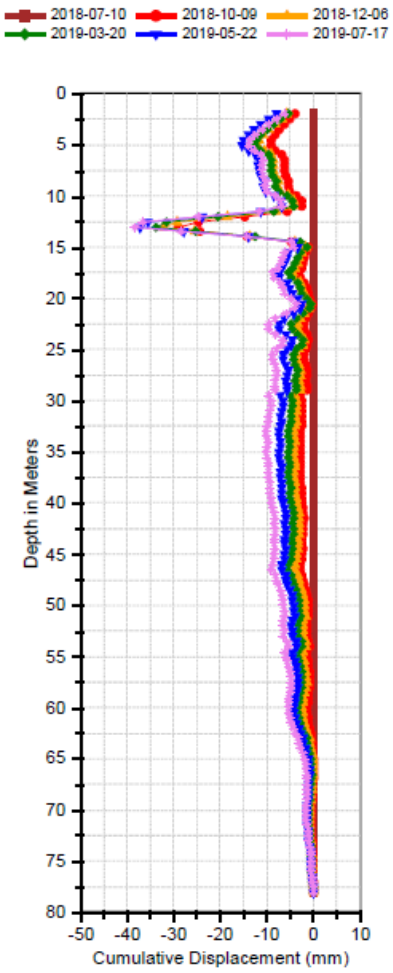
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
WEST TAILINGS DAM - GPS UNIT WD-3_ROVER

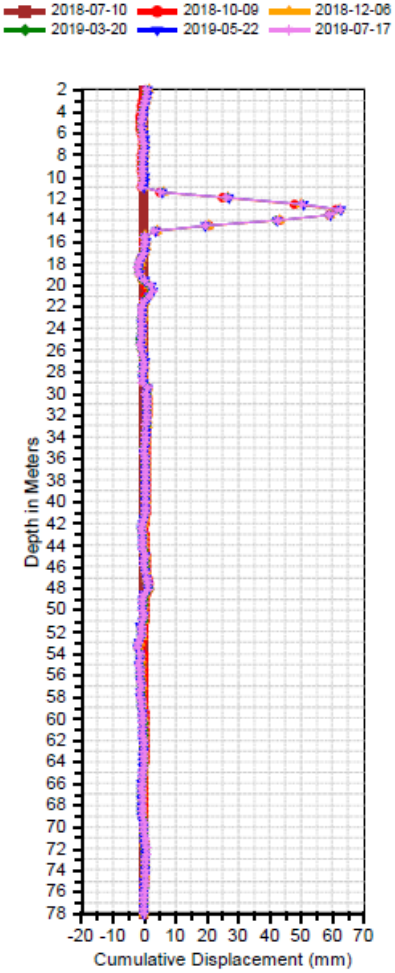
PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-23**



A-Axis



B-Axis



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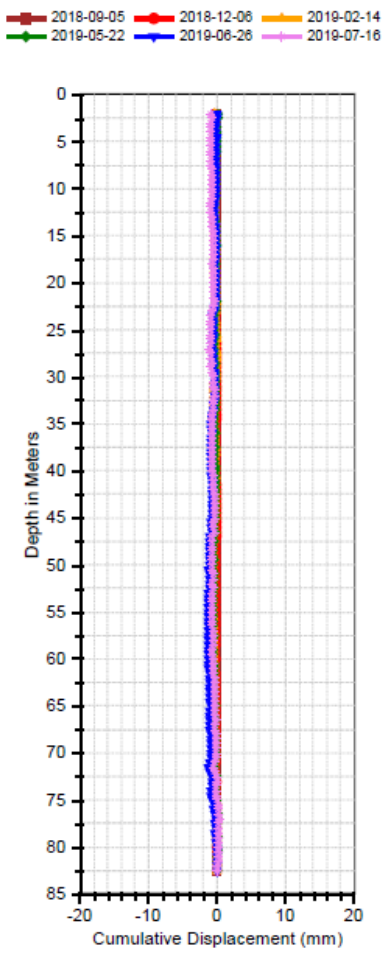
REVIEW	M.Willan
APPROVED	A.Haynes

PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

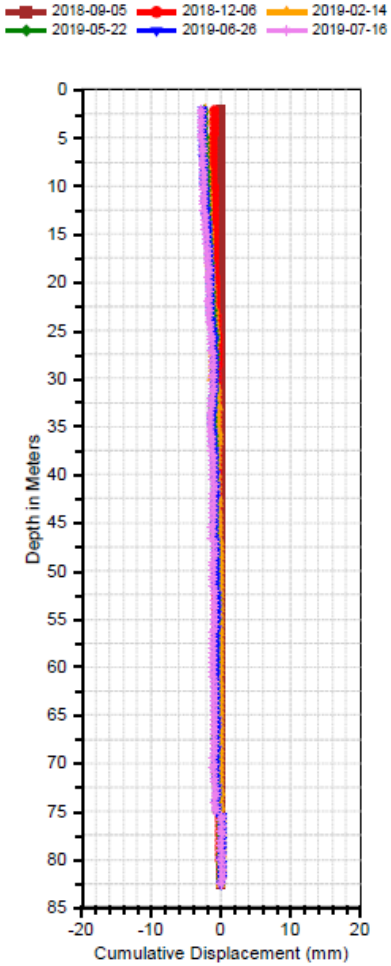
TITLE
MAIN TAILINGS DAM - INCLINOMETER SD 16-04

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-24**

A-Axis



B-Axis



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REVIEW	M.Willan
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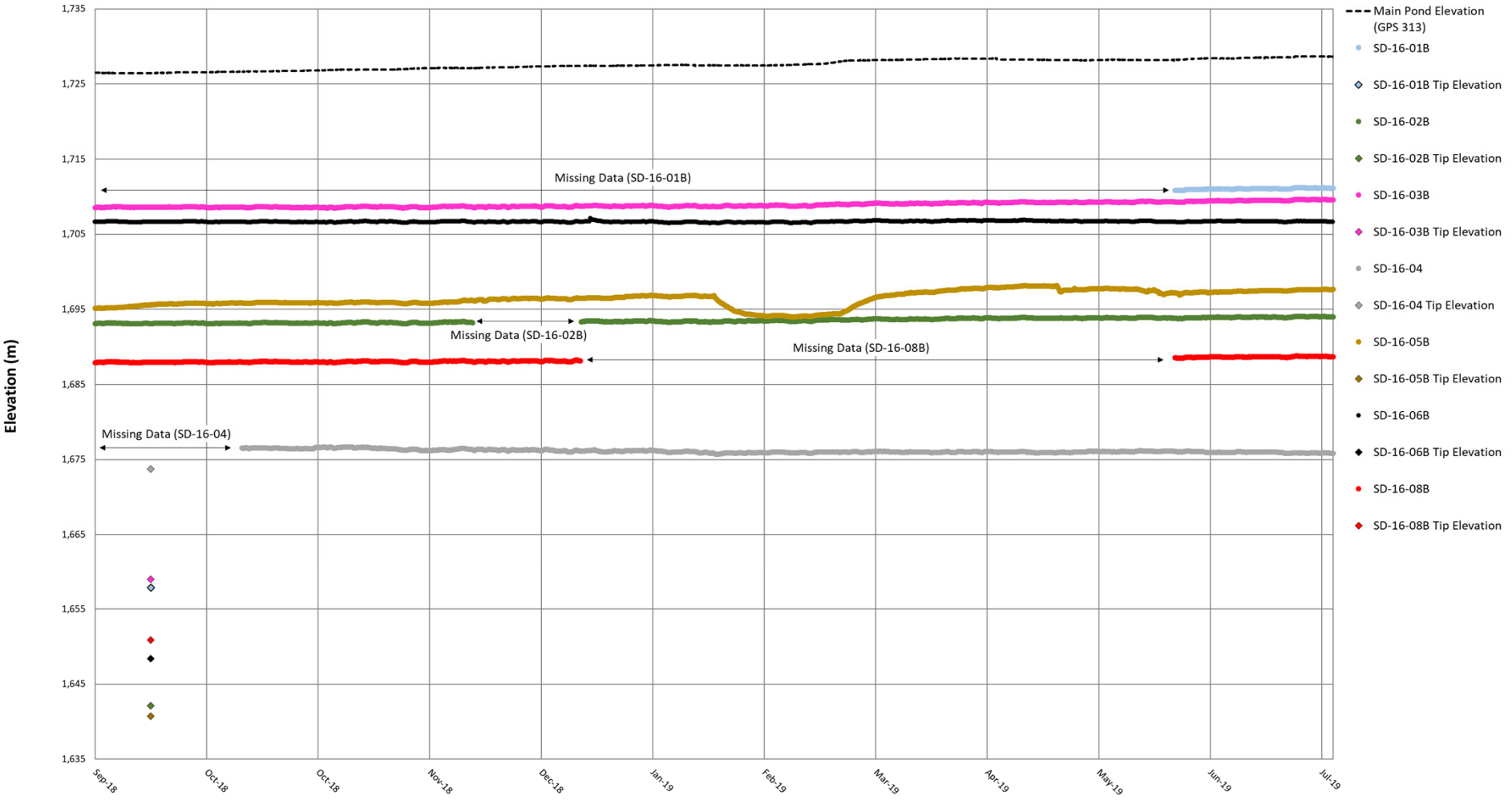
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM - INCLINOMETER SD 16-05

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**D-25**

APPENDIX E

Piezometer Monitoring Data



Date

Notes:
Data considered erroneous not shown

Negative pressure readings indicate that the tip is dry and piezometric levels cannot be determined from recorded negative pressures. Negative pressure readings not shown

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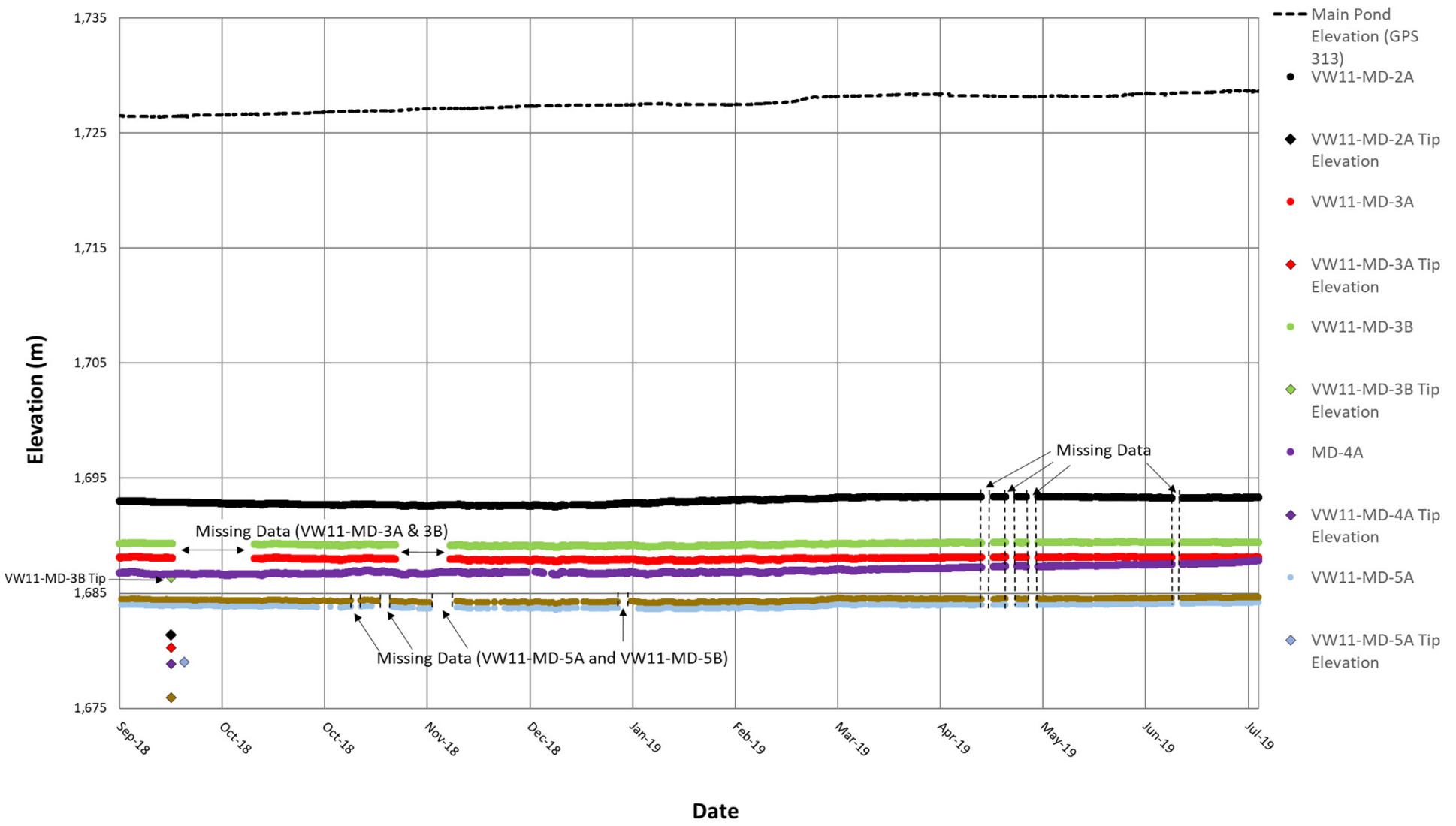
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM – SD SERIES PIEZOMETERS

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**E-1**



Notes:
Data considered erroneous not shown

Negative pressure readings indicate that the tip is dry and piezometric levels cannot be determined from recorded negative pressures. Negative pressure readings not shown

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GOLDER

YYYY-MM-DD	2020-02-14
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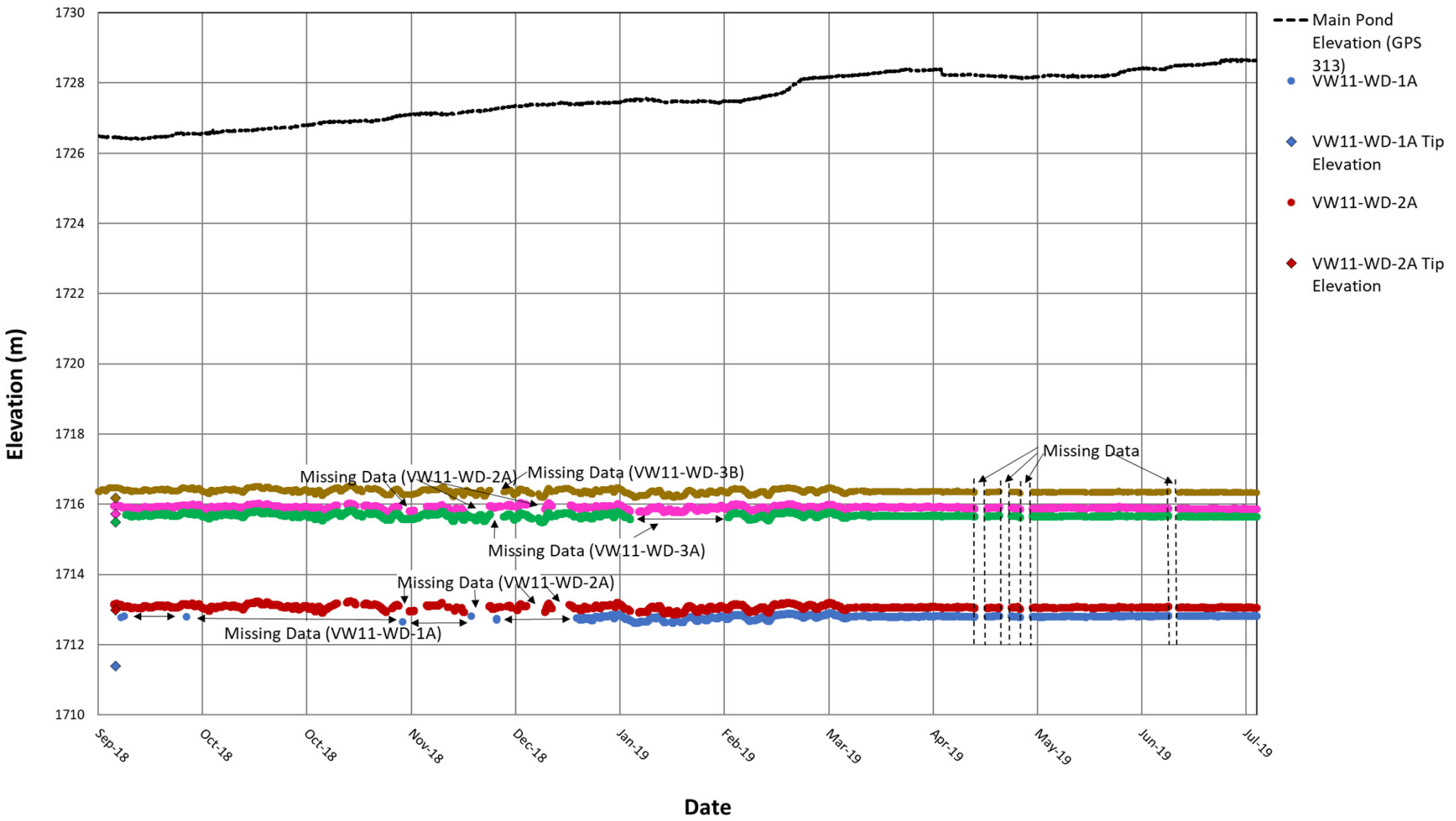
PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
MAIN TAILINGS DAM – MD SERIES PIEZOMETERS

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**E-2**



Notes:
Data considered erroneous not shown

Negative pressure readings indicate that the tip is dry and piezometric levels cannot be determined from recorded negative pressures. Negative pressure readings not shown

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YYYY-MM-DD	2020-02-14
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DESIGN	M.Klassen
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APPROVED	A.Haynes

PROJECT
GREENHILLS TAILINGS FACILITY
2019 ANNUAL DAM SAFETY INSPECTION

TITLE
WEST TAILINGS DAM – WD SERIES PIEZOMETERS

PROJECT No.	Phase/Task/DOC.	Rev.	FIGURE
18110798	**3000/3200/2019-148**	**0**	**E-3**

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