Klohn Crippen Berger

Teck Coal Ltd.

Greenhills Operations

Dam Safety Inspection Report

Independent Third Party Review

November 2014
M09963A01.730

Klohn Crippen Berger

November 28, 2014

Teck Coal Ltd.
Greenhills Operations
P.O. Box 5000
Elkford, British Columbia
V0B 1H0

Mr. Mark Slater
Senior Geotechnical Engineer

Dear Mr. Slater:

Greenhills Operations – Dam Safety Inspection Report
Independent Third Party Review

Please find attached the Third Party Review of the Dam Safety Inspection (DSI) Report for the Greenhills Operations Tailings Facility. The review concludes that the DSI meets the Ministry of Mines Guidelines for Annual Dam Safety Inspection Reports and that the consequence classifications for the tailing dams are appropriate. This report documents the KCB review and, where appropriate, identifies suggestions for improvement.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Harvey McLeod, P.Eng., P.Geo.
Principal

HM:dl

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1 INTRODUCTION

This report presents the Klohn Crippen Berger's (KCB) independent Third Party Review of the Dam Safety Inspection Report that was prepared by Golder Associates (2014) for the Greenhills Operations (GHO) tailings storage facility (TSF). The review included a site visit by the Review Engineer, Mr. Harvey McLeod, P.Eng., P.Geo., on October 26, 2014.

The Greenhills Mine is located in southeastern British Columbia, near the town of Elkford. The open pit mine produces approximately 5 Mt per year of clean coal. Fine coal refuse is stored in the tailings storage facility, which is formed with two dams.

Tailings impoundments are regulated under the Mines Act of British Columbia and must comply with the requirements of the Health Safety and Reclamation Code for Mines (HSRC) in BC (BC MEMPR 2008). The requirements related to tailing impoundments in the code include the following:

- Dams must be designed in accordance with the criteria provided in the Canadian Dam Association, Dam Safety Guidelines (HSRC 10.1.5).
- The Operation, Maintenance and Surveillance (OMS) manual must be revised regularly during operations (HSRC 10.5.2).
- Annual Dam Safety Inspection Report (HSRC 10.5.3) must be carried out and submitted to the Ministry of Mines. The MEM website provides the document "Guidelines for Annual Dam Safety Inspection Reports".
- There must be an Emergency Preparedness Plan for any dam with a consequence classification of "High" or "Very High." (HSRC 10.6.8).

The current dam classifications for both the Main and West Tailings Dams under the CDA Guidelines are "High". The MEM classifications for both dams under the HSRC are major dams and major impoundments.

KCB have been informed that the Engineer of Record (EOR) for the GHO Tailings Storage Facility (TSF) is Golder Associates (Golder), responsible for the design and performance of the dam including: 1) dam safety inspections; 2) construction monitoring and QA/QC; 3) instrumentation planning, design and review; and, 4) design modifications.

On August 18, 2014, the Chief Inspector's office of the MEM issued orders mandating that the 2014 Dam Safety Inspection (DSI) of tailing dams be completed, and that the report be reviewed by an independent third party Professional Engineer, and submitted by December 1, 2014. The order required that an independent party review:

- to assess if the DSI report meets the MEM Guidelines for Annual Dam Safety Inspections; and
- the consequence classification of the dam(s).

2 BACKGROUND INFORMATION AND PROJECT DESCRIPTION

2.1 Site Visit and Document Review

Site Visit

A site visit was made on October 16, 2014 and included: Mr. Harvey McLeod of KCB; Mr. Mark Slater (Engineering) of GHO; and, Mr. Andrew Bidwell of Teck Coal Ltd. The site tour included a walk-around inspection of the Main Tailings Dam (MTD) and the West Tailings Dam (WTD) and the overall TSF. The main observations from the site visit include the following:

- Construction works had recently been carried out and KCB were able to observe the compacted surfaces. The glacial till core and the coarse refuse dam fill were well compacted at both dams.
- The coarse refuse stockpile downstream of the Main Dam provides a large geotechnical buttress that significantly improves the stability.
- KCB did not observe any indication of deformations or significant erosion.
- Seepage observed at the West Dam was at a low rate and was being directed towards seepage collection ditches that could be used for ongoing monitoring of water flows. Seepage at the Main Dam is obscured by the coarse refuse piles and GHO reported that the seepage rate was low.
- Foundation preparation for the West Dam included removal of all loose, soft material and competent foundation material was exposed during the site visit.

Document Review

The documents listed in Table 2.1 were provided to KCB. The review was carried out at a “high” level to obtain an understanding of the design and site conditions. Items of interest, relevant to dam safety, are noted.

Table 2.1 Summary of Documents

Date	Prepared By	Title	Inspection (I), Design (D) or Construction (C)	Key Items of Interest
March 1980	Kaiser Resources Coal Division	Comments on Golder Associates' Report on Greenhills Creek Sedimentation Pond	I	
May 1981	Province of BC, Ministry of Environment	Meeting with B.C. Coal Ltd. To discuss the Sedimentation Pond Proposed for the Greenhills Coal Project	I	
July 2005	Golder Associates	Raising Main Tailings Dam to Elevation 1735 M	C	Main tailings dam instrumentation piezometer and standpipe readings, borehole records, Greenhills tailings system operating manual, typical slope stability analyses
July 2009	Summit Environmental Consultants Ltd.	Greenhills Creek Settling Pond Project – Evaluation of Proposed Settling Structures Scenarios - Draft	I	Discusses which scenario provides best settling pond retention time
March 2010	Golder Associates	Post-Construction Inspection Memo	C	
April 2010	Golder Associates	Geotechnical Construction Monitoring, Main Tailings Dam, Greenhills Operation	C	Lab test results, field density results
August 2010	Golder Associates	Greenhills Operation Open Pit Mine 2010 Dam Safety Review	I	Detailed results of dam safety review, dam inspection report, piezometer data for main tailings dam
August 2012	Golder Associates	Dam Breach Flood Inundation Study	I	Dam breach assessment of Main and West Dam indicated breach effects towards Fernie.
January 2013	Teck	Tailings Pond Dam Breach Emergency Preparedness Plan (Dam Breach EPP)	C	
March 2013	Kerr Wood Leidal	Teck Tailings Pond Dams and Settling Pond Dam, Dam Breach Flood Inundation Study – Peer Review	I	Review of assumptions, interpretation of results, recommendations
March 2013	Teck	Operation, maintenance and Surveillance manual for Greenhills Tailings Pond and Dams	C	
May 2013	Teck	Q1 2013 Geotechnical Inspection Report	I	Recommendations for structures
May 2013	GHO	Dam Safety Inspection Checklist – Greenhills Settling Pond Dam	I	
July 2013	GHO	Dam Safety Inspection Checklist – Tailings Pond Dams – GHO Settling Pond	I	
August 2013	Teck	Q2 2013 Geotechnical Inspection Report	I	Recommendations for structures

Date	Prepared By	Title	Inspection (I), Design (D) or Construction (C)	Key Items of Interest
October 2013	Kerr Wood Leidal	Teck Coal – GHO Water Audit, 2012 Water Balance	I	Design criteria, existing wells, coal balance, tailings pond balance, water conservation, overall water balance
December 2013		Dam Safety inspection Checklist – Tailings Pond Dams – GHO Sediment Pond	I	
December 2013		Dam Safety inspection Checklist – Tailings Pond Dams – West Dam	I	
February 2014	Golder Associates	Greenhills Operations West Tailings Dam Raise to Elevation 1735 m	C	Borehole and test pit records, lab test results, stability analyses results
March 2014	GHO	Dam Safety Inspection Checklist – Tailings Pond Dams – West Dam	I	
March 2014	Golder Associates	2013 Annual Dam Safety Inspection for Tailings Dams and Greenhills Settling Pond	I	Records of dam inspections, GHO 2013 west dam repair record, GPS monitoring data
June 2014	Golder Associates	Main and West Tailings Dams Embankment Raise Technical Specifications and Construction Quality Assurance/Quality Control Plan	C	Issued for Construction
August 2014	GHO	Dam Safety Inspection Checklist – Tailings Pond Dams – Main Dam	I	
November 2014	Teck	Tailings Pond Operation	C	
November 2014	Golder Associates	2014 Annual Tailings Dam Safety Inspection	I	Records of dam inspections, GHO geotechnical quarterly inspections, GHO plant summary data

2.2 Facility Description

The GHO Tailings Storage Facility consists of two dams, the Main Tailings Dam (MTD) to the southeast and the West Tailings Dam (WTD) to the west as shown in plan on Figure 2.1. The MTD, a zoned earthfill dam, has been raised several times and is approximately 45 m high. The WTD is also a zoned earthfill dam that has been raised various times, and is approximately 16 m high. Both dams are composed of a 6 m wide zone of compacted clay till on the upstream face with compacted coarse refuse bulk fill making up the rest of the structure.

Several consecutively joined large coarse refuse dumps (Refuse Dump Sites A to E) are downstream of the MTD). Sites C and D are located immediately downstream of the MTD. Although the stability of the dam does not depend on the dumps, they give significant additional support.

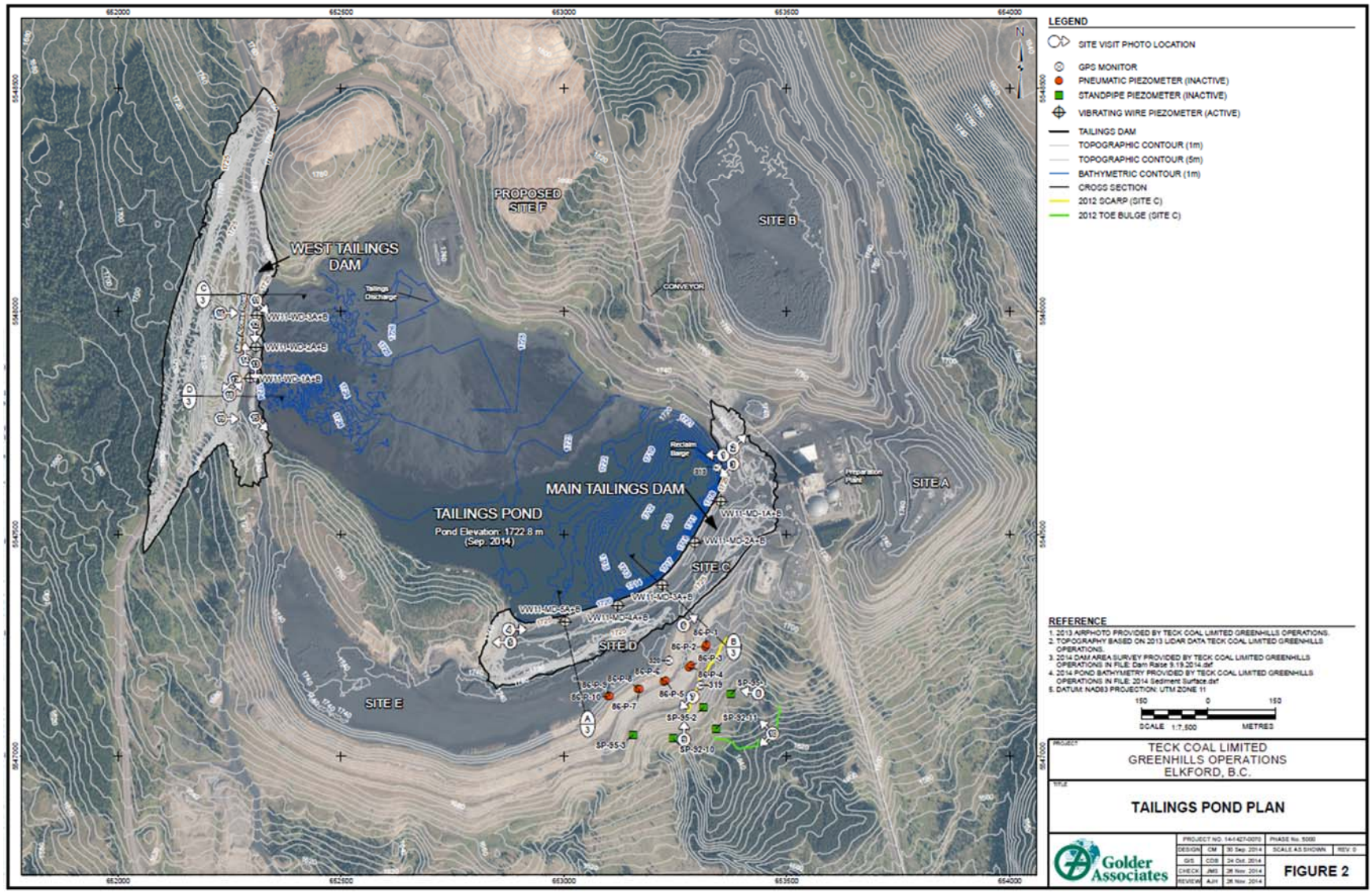

Figure 2.1 Plan of TSF

2.3 Site Conditions

Greenhills Operations is located in southeastern British Columbia. The average annual precipitation is on the order of 830 mm. GHO received 797 mm between September 2013 and August 2014 (Golder 2014).

At the time of original construction of the MTD, Hardy Associates described, as reported in the OMS Manual, a surficial layer of colluvium, with underlying glacial till and shale bedrock. At the west end of the MTD location, a 3 m thick layer of muskeg was found. KCB expect that the muskeg layer would have been removed for dam construction.

Site investigations (Golder 2014) for the West Dam adequately quantify the strength and distribution of soils in the dam foundation.

The area is moderately seismic with a peak ground acceleration of 0.12 g for the 1 in 2475 year return period.

3 REVIEW OF DAM SAFETY INSPECTION REPORT

3.1 General

The contents of the DSI Report have been compared against the MEM Guidelines for Annual DSI Reports and the results are summarized in Table 3.1.

Table 3.1 Dam Safety Inspection Conformance Table

Requirement			Included	KCB Observations
Executive Summary	Classification of the dam(s) in terms of Consequence of Failure in accordance with Table 2-1 of the CDA Dam Safety Guidelines (2007).		Yes	
	Significant changes in instrumentation and/or visual monitoring records.		Yes	Noted that measurements are consistent with previous trends.
	Significant changes to dam stability and/or surface water control		Yes	Did not identify any significant changes.
	For major impoundments, as defined in Part 10 of the Code, a current Operation, Maintenance and Surveillance (OMS) Manual is required. The annual report shall indicate the latest revision date of the OMS Manual.		Yes	Last updated October 2014
	For tailings dams classified as High, Very High or Extreme Consequence, an Emergency Preparedness Plan (EPP) is required. The annual report shall indicate the latest revision date of the EPP document.		Yes	Last updated October 2014
	Scheduled date for the next formal Dame Safety Review in accordance with Table 5-1 of the CDA Dam Safety Guidelines (2007). Formal Dam Safety Reviews are required every 5 to 10 years (depending on consequence classification) and differ from annual dam safety inspections. The requirements for Dam Safety Reviews may be conducted by the Engineer of Record with third party review, or by an independent third party with involvement of the Engineer of Record.		Yes	Last DSR was 2010. Next DSR scheduled for 2017 or earlier
Summary of past years' construction (if any) with a description of any problems and stabilization			Yes	
Plan and representative cross sections			Yes	
Site Photographs			Yes	
Review of climate data			Yes	
Water balance review			Yes	
Freeboard and storage availability (in excess of the design flood)			Yes	
Water discharge system, volumes, and quality			Yes	Water quality monitored but not discussed in report
Seepage occurrence and water quality			Yes	
Surface water control and surface erosion			Yes	Surface water control discussed in Site C Dump and tailings pond
Instrumentation Review		Phreatic surfaces	Yes	Piezometer data plots given
		Settlement	Yes	Observations and total displacement graph given
		Lateral movement	Yes	Observations and total displacement graph given

3.2 Consequence Classification Review

The Canadian Dam Association Dam Safety Guidelines (2007, revised in 2013) provide a classification of dams based on the consequences of failure, as shown in Table 3.2. The dam consequence classification should be selected based on the criteria shown in each category of incremental losses, and supported by relevant quantitative or qualitative evidence.

Table 3.2 Dam Classification Guideline (CDA 2007)

Dam class	Population at Risk	Incremental Losses		
		Loss of Life	Environmental and Cultural Values	Infrastructure and Economics
Low	None	0	Minimal short-term No long term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind is highly possible	High economic losses affecting infrastructure, public transportation, 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

See Table 2-1 in the CDA 2007 Guidelines for notes related to population at risk and implications of loss of life.

A dam breach inundation study (Golder 2012) was carried out that showed that the dam breach flood wave could extend past Fernie, British Columbia. Based on the dam breach inundation study the dam consequence classification was assessed (Golder 2014) and is summarized in Table 3.3.

Table 3.3 Dam Classifications (Golder, 2014)

Structure	Dam class	Population at Risk	Incremental Losses		
			Loss of Life	Environmental and Cultural Values	Infrastructure and Economics
Main Tailings Dam	High	Permanent	10 or fewer	Significant loss of fish and wildlife habitat, but for which compensation in kind is possible.	Significant
West Tailings Dam	High	Permanent	10 or fewer	Significant loss of fish and wildlife habitat, but for which compensation in kind is possible.	Significant

KCB are in agreement with the dam classifications, however, for record purposes, GHO should explicitly quantify and document the supporting information that provides the basis for dam classification for each of the consequence categories.

3.3 Instrumentation Review

The instrumentation program is appropriately summarized and presented in the DSI. KCB observations on the piezometer instrumentation include the following.

The piezometer data was consistent with previous trends with very little change seen in the elevation of the phreatic surface. Within the MTD, the elevation of the phreatic surface ranged from 1684.5 m to 1709.7 m while staying around 10 m to 13 m above the original ground surface. Likewise, the phreatic surface in the WTD ranged from 1711.1 m to 1714.0 m and mostly stayed within the dam foundation. The seasonal increases seen are typically on the range of 1 m to 3 m. The piezometers in the MTD show a damped response to the changes in the pond level while the piezometers in the WTD do not show any response to the pond level.

The low phreatic levels indicate that the seepage cutoff controls are effective and that the dam is well drained, which is good for stability.

V-Notch weirs were recommended in the DSI to obtain data regarding seepage flows in the rock drains beneath the MTD and the ditch next to the WTD. The weirs were onsite at the time of the inspection, but had yet to be installed. The weirs can be used to supplement regular visual estimates during each season.

The deformation monitoring program is appropriately summarized in the DSI. Deformation monitoring is carried out with GPS prisms, which require relocation after each major dam raise. The deformations observed to date are not significant.

3.4 Stability Review

The DSI reports that the dams are stable and in good condition, and KCB concurs based on no evidence of cracking, bulging, or deformations were observed during the KCB site visit or reported in the DSI. The stability of the MTD is significantly enhanced with the buttress effect of the large coarse refuse stockpiles. The design slope for the WTD is 2.5H:1V, which is appropriate. The dam shells are well drained and the dams are stable.

The coarse coal refuse used in the dam is filter compatible with the glacial till core. Seepage observed at the WTD was clear with no indication of internal erosion.

During the period between mid-April and mid-July 2014, the observed pond levels were higher than what the standard operating procedure defines. As a result, control measures were implemented and proved to be effective. The pond elevation has risen again since July 2014, but remains below the threshold (1724.6 m) at 1722.7 m. GHO have appropriate flood management response plans to react to pond level/freeboard thresholds.

4 REVIEW OF TAILINGS FACILITY STEWARDSHIP

GHO has a good team in place for managing and constructing the TSF and for providing oversight on the technical, environmental and social aspects. GHO manage and maintain the facility adequately and procedures are well documented The OMS Manual is complete and procedures are in place to manage and respond to emergencies.

As part of the KCB preliminary overview of the OMS, we have the following suggestions for improvement:

- Prepare a separate organization chart that clearly defines the GHO "person responsible for the tailings facility", e.g. Tailings Engineer, who is responsible for the tailing facilities. Identify who the person reports to and what other persons report to the person for matters pertaining to the tailing facilities.
- Document the 4 components of the dam consequence classification, with reference to the Inundation Study.

5 SUMMARY

The assessment of the physical conditions of the dams and associated works is thorough and comprehensive and no significant concerns have been identified. Management systems are in place, including OMS Manual and EPPs. The DSI Report is compliant with the MEM Guidelines. For reference purposes the recommendations from the DSI Report are summarized in Table 5.1.

Table 5.1 Summary of 2014 DSI Recommendation (Golder)

ID	Deficiency or Non-conformance	Applicable Regulation or OMS Reference	Potential Dam Safety Risk	Recommended Action	Priority[1]	Recommended Deadline	KCB Comment
2014-01 (2013-03)	Upstream slope steeper than design	HSRC 10.5.1	Potential instability	Confirm upstream slopes and reassess upstream stability	2	Q2 2015	Not considered critical for dam safety
2014-02	Not maintaining standard operating pond levels	HSRC 1.7.3(2)/OMS Manual Sections 5.6.4.2 and 6.3.1.3	Potential for overtopping and reduced stability	Develop dam raise schedule to maintain freeboard. Install staff guage on pond as back up to GPS.	2	Q1 2015	Freeboard basis should be reviewed with 2013 flood event
2014-03	Lack of seepage quantity measurement	HSRC 10.1.5/ CDA Section 3.6.3	Unknown of potential changes of seepage	Install V-Notch weir at downstream toe of both dams	3	Q3 2015 (in progress as of Oct 2014)	Important to get visual estimates if measurements are not practical
2014-04	Lack of dam crest displacement monitoring	HSRC 10.1.5/CDA Section 3.6.3	Delay in identifying crest displacement	Install prisms or GPS monitors on tailings dam crests. Dam crest should be monitored between 2014 and 2015 construction.	3	Q1 2015 (in progress as of November 2014)	Not considered critical but should be done

Note 1. Priorities defined in Golder 2014 as follows:
Priority 1 – A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
Priority 2 – If not corrected could result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or a repetitive deficiency that demonstrates a systematic breakdown of procedures.
Priority 3 – Single occurrences of deficiencies or non-conformances that alone would not be expected to result in Dam safety issues.
Priority 4 – Best Management Practices – Further improvements are necessary to meet industry best practices or reduce potential risks.

6 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Teck Coal Limited (Client) for the specific application to the Greenhills Operations Tailings Facility.

This Independent Third Party Review has been prepared for Teck Coal Limited in response to the Minister's Order dated August 18, 2014. KCB has not been involved in the design, construction, operation or surveillance of this facility. KCB is not the Engineer of Record for this facility. The conclusions and recommendations contained in this report are KCB's opinion formed from review of limited information provided by the client as described in this report and a site visit.

In the preparation of this Third Party Review Report, KCB has endeavored to observe the degree of care and skill generally exercised by other consultants undertaking similar reviews at the same time, under similar circumstances and conditions, and in the same geographical area. KCB makes no other warranty, expressed or implied.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

- The report is intended for the sole and exclusive use of the Client and it may not be used or relied upon in any manner or for any purpose whatsoever by any other party, without the express written permission of KCB.
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KLOHN CRIPPEN BERGER LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA J. L. CONSTABLE # 38020 2014-11-28

Lowell Constable, P.Eng.
Project Engineer

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA M. N. McLEOD 28 Nov. 2014

Harvey McLeod, P.Eng., P.Geo.
Review Engineer

REFERENCES

Note that additional references are included in Table 2.1.

Canadian Dam Association (CDA). 2007. Technical Bulletin. “Dam Safety Guidelines (update 2013).

Golder Associates (Golder, 2014). 2014 Annual Tailings Dam Safety Inspection. November 10, 2014.

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