

June 29, 2015

Teck Resources Limited
P.O. Box 1500
23097 Murray Forest Service Rd.
Tumbler Ridge, British Columbia
V0C 2W0

Mr. Kevin Sharman, P. Geo
Senior Geologist Supervisor

Dear Mr. Sharman:

Quintette Coal Operations
Shikano North Tailings Dam
Response to February 3, 2015 MEM Memorandum

1 INTRODUCTION

The Independent Expert Panel¹ (Panel) appointed by Ministry of Energy and Mines, British Columbia (MEM) released their report on the Mount Polley tailings dam failure on January 30, 2015. Subsequent to the release of the Panel report MEM issued a memorandum on February 3, 2015 (MEM memo), to all tailings dam owners in British Columbia to undertake a specific assessment of their tailing dams and report the results to MEM by June 30, 2015. A copy of the MEM memo is attached (Appendix I).

This report outlines Klohn Crippen Berger's (KCB) assessment of conditions for the Shikano North Tailings Dam (SNTD) at the Quintette Coal Operations relative to the specific aspects raised by the MEM memo, based on a review of available documents. This assessment has been sealed by a qualified professional engineer and complies with generally-accepted professional practice common to the local area.

The report format is based on the MEM wording and numbering system, as requested by MEM. MEM items are shown in blue italicized text; KCB's response is shown in normal black text.

We consider this assessment to represent the knowledge of the facility available to KCB at the time of writing. Operating, inactive and closed facilities are subject to physical and geochemical changes over time. It is essential that monitoring and assessment of the facilities continue through regular surveillance, dam safety inspections, dam safety reviews and other stewardship activities.

¹ Independent Expert Engineering Investigation and Review Panel, 2015. *Report on Mount Polley Tailings Storage Facility Breach*. January 30, 2015.

1.1 Assessment Scope

The MEM memo asked that an assessment be undertaken to determine if the dams may be at risk due to the following three conditions:

1. undrained shear failure of silt and clay foundation;
2. water balance adequacy; and
3. filter adequacy.

KCB reviewed available historical information on foundation characterization, design, construction and operations records for the SNTD to prepare responses for sub-items listed in the MEM memo. A summary of the documents reviewed is included in Appendix II. Responses to the above three items are provided in Sections 3 to 5, respectively, following the numbering system used in the MEM memo.

2 SHIKANO NORTH TAILINGS DAM

The SNTD is located approximately 16 km south of the Municipality of Tumbler Ridge in the northeastern region of British Columbia. The dam was constructed between 1997 and 1999 between two walls of the mined-out Shikano North Pit to impound tailings for the Quintette Coal Operations. Mining operations were suspended in 2000 and since that time the facility has been in “care and maintenance”. Figure 1 shows the SNTD and the Shikano North Tailings Facility. When mining operations were suspended in 2000, tailings stored in the impoundment were well below design capacity. The tailings surface is approximately at elevation 796 m and there is currently 32 m of freeboard between the tailings level and the dam crest.

The SNTD was designed as a “flow-through” rockfill embankment with internal granular filters and a non-woven geotextile filter fabric to restrict fine coal tailings passing through the dam while purposely allowing seepage of water through the embankment. The seepage through the embankment discharges to Sedimentation Pond S3 (Figure 1) through a culvert constructed in the downstream shell of the embankment. SNTD was raised to its current crest elevation in two stages:

- Stage 1 (May to November 1996): Constructed to elevation 810 m.
- Stage 2 (December 1998 to March 1999): Crest raised to elevation 829 m (current elevation 828 m measured from 2014 survey monuments pins).

The maximum downstream slope height (crest to toe) of SNTD is 45 m and with 2H:1V downstream and 2.25H:1V upstream slope. The dam crest is 200 m long.

The SNTD is considered a Major Dam and a Major Impoundment under the Section 10.5.3 of the Health, Safety and Reclamation Code for Mines in British Columbia and classified as “Significant” consequence dam under CDA Dam Safety Guidelines (CDA 2013) as reported in the 2013 Dam Safety Review (KCB 2014a).

3 ITEM 1: UNDRAINED SHEAR FAILURE OF SILT AND CLAY FOUNDATION

According to the Panel Report the Mount Polley failure plane developed in a high plasticity glaciolacustrine unit (GLU) that had not been accounted for in the design.

a Including a determination with respect to whether or not similar foundation conditions exist below the dams on your site

The foundation of the SNTD does not contain glaciolacustrine deposits. The SNTD was constructed between two pit walls with bedrock exposed along the base and each abutment.

Within the bedrock foundation of the SNTD, clay seams (30 mm to 50 mm thick) were logged within a Sandstone unit at two drill holes. These clay seams are not glaciolacustrine deposits and undrained failure through these deposits is not a controlling factor in the dam stability.

b Whether or not sufficient site investigation (drill holes, etc.) has been completed to have confidence in this determination

The site investigation completed for the SNTD was sufficient to characterize the foundation to allow for safe construction and operation of the structure. The foundation information for the SNTD was gathered from two site investigation programs:

- A drilling program was completed by Quintette Coal Limited in 1985 (QCL 1985) and included two holes in the dam footprint.
- Geotechnical site investigation program in 1995 (KC 1996b): 5 drill holes were drilled and cored in the SNTD footprint. In addition to these holes a field reconnaissance of pit wall conditions at the right and left abutments was completed.

No issues of concern related to the foundation are noted in the inspection and construction documents reviewed for this assessment (Appendix II).

c If present, whether or not the dam design properly accounts for these materials

There are no glaciolacustrine deposits within the foundation of the SNTD that needed to be accounted for in the design.

d If any gaps have been identified, a plan and schedule for additional sub-surface investigation

No gaps have been identified related to the foundation characterization and design assessment, and therefore no additional site investigations are recommended.

4 ITEM 2: WATER BALANCE ADEQUACY

For the purpose of this assessment surplus water is defined as the volume of water that accumulates in the TSF over time because the inflow exceeds the outflow. The inflow could be from mine operations, a climatic event or combination of both.

a Including the total volume of surplus mine site water (if any) stored in the tailings storage facility

There is no surplus mine water in the SNTD impoundment. The SNTD is inactive and does not receive or hold any water from mining operations.

b The volume of surplus mine water that has been added to the facility over each of the past five years

No surplus water has been added to the SNTD over the last five years.

c Any plans that are in place or that are under development to release surplus mine water to the environment

There is no surplus mine water in the SNTD, hence no plan is in place or under development for release of surplus water to the environment.

d Recommended beach width(s), and the ability of the mine to maintain these widths

There is no recommended minimum beach width for the SNTD, because it is designed as a “flow-through” structure with the pond in contact with the upstream face of the embankment. The safety of the SNTD does not depend on the presence of a minimum width of tailings beach as per the “flow-through” design.

e The ability of the TSF embankments to undergo deformation without the release of water (i.e. the adequacy of the recommended beach width)

The potential for significant deformation at the SNTD due to static or seismic loading and resulting in the unintended or uncontrolled release of water is low due to the following:

- The SNTD is a rockfill embankment founded on bedrock with a downstream toe berm.
- The static loading of the impoundment is substantially complete.
- The impoundment is drained as it is designed as a “flow-through” structure to retain tailings solids while allowing water to seep through the embankment and report to the S3 seepage collection pond downstream.

The tailings are currently 28 m below the design level.

f Provisions and contingencies that are in place to account for wet years

As a “flow-through” dam, increased run-off from wet years would be safely passed through the structure as increased seepage and would not accumulate in the impoundment. As a point of comparison, the inflow for a “wet year” (assumed as the 100-year return period annual precipitation) was calculated as approximately 0.65 Mm³ (million cubic metres), compared to 1.1 Mm³ of seepage that passed safely through the dam during the last year of operations (1999).

g If any gaps have been identified, a plan and schedule for addressing these issues

No gaps have been identified related to the SNTD water balance and therefore no further action is recommended as a result of this assessment.

5 ITEM 3: FILTER ADEQUACY

a Including the beach width and filter specifications necessary to prevent potential piping

The SNTD embankment is designed as a “flow-through” structure with the entire embankment serving as a filter to retain tailings solids while allowing water to flow through the embankment for collection in the downstream S3 seepage collection pond. Therefore, the SNTD was designed with two layers of granular filters and a layer of geotextile filter fabric to trap or settle tailings particles while allowing water to flow through the embankment without piping or internal erosion of the embankment.

Design gradations specified for the fine and coarse filters were compared with the filter criteria outlined in the USACE (2004) to check filter adequacy. Design of the filter fabric was compared with the soil retention criteria outlined in Luettich et. al. (1992) and the early geotextile filter criteria ($0.15 \text{ mm} < \text{AOS}^2 < d_{85}$) that was used for the design (Giroud 2010).

Using these methods, both interfaces are filter compatible.

b Whether or not the filter has been constructed in accordance with the design

The SNTD filter zones were constructed in accordance with design with the following exceptions:

- The as-built gradations for Zone C (fine filter) of Stage 1 were finer than the design gradation; however, the filter interfaces are filter compatible based on the available data and using the same method described in Item 3a.

Three depressions are present on the tailings beach which were first noted in 2010 DSI (KCB 2014b). The size of the depressions did not significantly change between the 2013 and 2014 DSI. No evidence of tailings migration through the embankment has been observed and tailings have most likely migrated only into the coarse waste rock (Zone D) upstream of the fine filter. These depression features are visually monitored as part of the routine monitoring of the dam and this assessment will be reviewed as part of the dam safety inspections and reviews. This migration of fines into the coarse waste rock is considered a reclamation issue and not a dam safety issue.

c If any gaps have been identified, a plan and schedule for addressing these issues.

No gaps have been identified with respect to the SNTD filter design and as-built condition. The filter compatibility assessment indicates the coarse and fine filters are filter compatible to prevent internal piping and no further assessment is recommended on filter adequacy for SNTD.

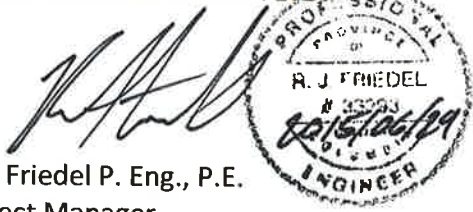
² AOS=Apparent Opening Size

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 Resources Limited (Client) for the specific application to the Quintette Coal Operations. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. The review is based on available information (Appendix II) at the time of writing. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

Yours truly,

KLOHN CRIPPEN BERGER LTD.



Rick Friedel P. Eng., P.E.
Project Manager

MK/MA/RF:cd

Attachments: Figure 1

Appendix I – MEM Letter to Teck

Appendix II – Summary of Documents Reviewed

REFERENCES

Refer to Appendix II for summary of available Shikano North Tailings Dam reference documents.

Canadian Dam Association. 2013. Dam Safety Guidelines 2007 (Revised 2013).

Fannin, J. 2008. "Karl Terzaghi: From Theory to Practice in Geotechnical Filter Design". *Journal of Geotechnical and Geoenvironmental Engineering*, v 134, n 3, March, 2008, p 267-276

Giroud, J.P. 2010. "Development of Criteria for Geotextiles and Granular Filters", Prestigious Lecture, *Proceedings of the 9th International Conference on Geosynthetics*, Brazil, May 2010, Vol. 1, pp. 45-64.

Luetlich, S.M., Giroud, J.P. and Bachus, R.C. 1992. Geotextile Filter Design Guide. *Geotextiles and Geomembranes*. 11 (1992) 335-370.

US Army Corps of Engineer (USACE). 2004. General Design and Construction Considerations for Earth and Rock-fill Dams. Engineering and Design. EM 1110-2-2300. July.

FIGURES



- LEGEND**
- Existing Road
 - Index Contour (50m)
 - Intermediate Contour (10m)

DRAFT

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED JUNE 2015.

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.

CLIENT

Teck

Klohn Crippen Berger

PROJECT
QUINTETTE COAL OPERATIONS
RESPONSE TO MEM MEMORANDUM - SHIKANO

TITLE
SHIKANO NORTH TAILINGS DAM

PROJECT No. M09684A11

FIG No. 1



APPENDIX I

MEM Memorandum to Teck



February 3, 2015

To: Rob Muise, Acting Mine Manager - Quintette – Teck Coal

As you know, the Expert Panel that was convened to examine the Mount Polley tailings dam breach has issued a report on their findings. This report has been made public and you may already be familiar with the conclusions of this report. Chief among these was the determination that the failure at Mount Polley was related to the presence of weak glacio-lacustrine soils in the dam foundation. The Panel also indicated that the severity of the consequence of failure was in large part owing to the quantity of stored water and the proximity of this water to the dam embankment (i.e. lack of beach). The Ministry of Energy and Mines (MEM) requires confirmation that the conditions that lead to the incident at Mount Polley are not present at other mines in B.C.

More specifically, you are required to undertake an assessment to determine if the dam(s) associated with your tailings storage facility/facilities may be at risk due to:

1. Undrained shear failure of silt and clay foundations;
 - a. Including a determination with respect to whether or not similar foundation conditions exist below the dams on your site,
 - b. Whether or not sufficient site investigation (drill holes, etc.) has been completed to have confidence in this determination,
 - c. If present, whether or not the dam design properly accounts for these materials, and
 - d. If any gaps have been identified, a plan and schedule for additional sub-surface investigation.

2. Water balance adequacy;
 - a. Including the total volume of surplus mine site water (if any) stored in the tailings storage facility,
 - b. The volume of surplus mine water that has been added to the facility over each of the past five years,
 - c. Any plans that are in place or that are under development to release surplus mine water to the environment,
 - d. Recommended beach width(s), and the ability of the mine to maintain these widths,
 - e. The ability of the TSF embankments to undergo deformation without the release of water (i.e. the adequacy of the recommended beach width),
 - f. Provisions and contingencies that are in place to account for wet years, and
 - g. If any gaps have been identified, a plan and schedule for addressing these issues.

3. Filter adequacy;
 - a. Including the beach width and filter specifications necessary to prevent potential piping,
 - b. Whether or not the filter has been constructed in accordance with the design, and
 - c. If any gaps have been identified, a plan and schedule for addressing these issues.

The Ministry is cognizant of the demands that were placed on your company by the Chief Inspector's Orders of August 18, 2014, and does not wish to place any additional undue burdens on your company. However, the previous Orders were issued before the mechanism of failure was known. Consequently, you are asked to provide a letter of assurance to respond to the items listed above. The letter is to be prepared and sealed by a qualified professional engineer, and is to be submitted to the Chief Inspector of Mines by June 30, 2015. To facilitate MEM's review, you are asked to maintain the above numbering system in your response to each item.

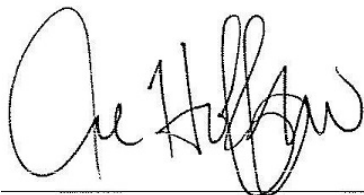
It is envisioned that the above items would best be addressed through a fulsome review of existing information. Where this information has not been compiled, it will be necessary to conduct a review of historical information to determine if any gaps remain in the understanding of the relevant conditions for the tailings storage facility dams on your site. Where appropriate, follow-up actions shall be identified that will be taken to address any opportunities for improvement.

Documents supporting the letter of assurance shall be maintained on-site and shall be made available to any Inspector of Mines upon request.

It should be noted that the Panel made a number of additional recommendations in Chapters 9 and 11 of their January 30, 2015 *Report on Mount Polley Tailings Storage Facility Breach*. MEM is in general agreement with all of the recommendations, and will be examining each of them to determine how they can be implemented over the coming weeks and months. You are asked to do the same.

Thank you for your prompt attention to these matters,

Regards,

A handwritten signature in black ink, appearing to read 'Al Hoffman', written over a horizontal line.

Al Hoffman, P. Eng.
Chief Inspector of Mines
Ministry of Energy and Mines

Cc: Diane Howe, Deputy Chief Inspector, Reclamation and Permitting, MEM
George Warnock, Manager, Geotechnical Engineering, MEM
Heather Narynski, Sr. Geotechnical Inspector, MEM

APPENDIX II

Summary of Documents Reviewed

Appendix II Summary of Documents Reviewed

Document Title	Author	Date of Issue
Shikano Geological Report Text	Quintette Coal Limited	May-85
Shikano North Tailings Impoundment - Design Report	Klohn Crippen (KC)	23-Jun-95
Shikano North Tailings Impoundment - Pervious Tailings Dam Option - Design Report	KC	09-Feb-96
Shikano North Tailings Impoundment - 1995 Geotechnical Investigations, Data Report	KC	09-Feb-96
Shikano North Tailings Impoundment 1996 As-Built Report	KC	14-Mar-97
Shikano North Tailings Impoundment 1997 Annual Review	KC	20-Feb-88
Shikano North Tailings Impoundment 1998 Annual Review	KC	05-Mar-99
Shikano North Tailings Impoundment - Stage 2 As-Built Report	KC	09-Jul-99
Shikano North Tailings Impoundment 1999 Annual Review	KC	06-Dec-99
Quintette Project - Baseline Climate & Hydrology Conditions	Clearwater Consultants Ltd.	17-Aug-11
Tailings Water Balance, Seepage Rates and Preliminary Seepage Reclaim Design	Klohn Crippen Berger (KCB)	30-Apr-13
2013 Dam Safety Inspections - Shikano North Tailings Dam - 2013 Dam Safety Inspection Report	KCB	18-Dec-13
Quintette Dam Safety Review Shikano North Tailings Storage Facility	KCB	27-May-14
Shikano North Tailings Dam - 2014 Dam Safety Inspection - Revision 1	KCB	26-Nov-14