Klohn Crippen Berger

Teck Resources Limited

Bullmoose Mine

Tailings Storage Dam

2014 Dam Safety Inspection

Revision 1

November 2014
M09893A02.730

November 26, 2014

Teck Resources Limited
Suite 3300, 550 Burrard Street
Vancouver, British Columbia
V6C 0B3

Mr. Bruce Donald, P.Eng.
Manager, Dormant Properties

Dear Mr. Donald:

Bullmoose Mine
Tailings Storage Dam - 2014 Dam Safety Inspection
Revision 1

We are pleased to submit an electronic copy of the 2014 Dam Safety Inspection Report for the Bullmoose Tailings Storage Dam.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

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

RF: cd

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Teck Resources Limited

Bullmoose Mine

Tailings Storage Dam

2014 Dam Safety Inspection

Revision 1

EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Resources Limited. (Teck) to complete the 2014 Dam Safety Inspection (DSI) of the Bullmoose Tailings Storage Dam (BTD), previously referred to as the South Fork Tailings Dam on the Bullmoose Coal mine site to comply with Section 10.5.3 of the Health, Safety and Reclamation Code for Mines in British Columbia (the Code) and the requirements specified in the "Guidelines for Annual Dam Safety Inspection Reports". The inspection was completed by Mr. Rick Friedel (P.Eng.) on July 23, 2014.

The BTD is considered a Major Dam and Major Impoundment under the Code. The BTD was classified as a "High" consequence classification structure (CDA, 2007) based on KCB (2014b). There have been no changes to the downstream environment or operation of the structure that would require a revision to this classification. A DSI was completed in 2013 by KCB (2014a). No dam safety review (DSR) has been completed on the BTD. A DSR is recommended in 2015 and should be done every 7 years for "High" consequence classification structures based on CDA (2007). KCB is the "Engineer of Record" for the BTD.

The tailings impoundment is located on the south flank of the broad valley bottom, with South Bullmoose Creek to the west and West Bullmoose Creek to the north. The foundation soils consist of alluvial sands and gravels with interbedded silts and glacial till. The tailings dam was constructed to a final crest elevation of 1122 m, with a maximum height of 38 m (crest to downstream toe). The design capacity of the facility is 4.6 Mm^3; based on existing contours 4.4 Mm^3 of tailings are stored.

The impoundment is formed by the horseshoe-shaped BTD on the north, east and west sides with the natural valley slope to the south. A starter embankment about 10 m high was constructed of borrow material for the first year of operations. The BTD has an upstream slope of 2H:1V and downstream slope of 2.5H:1V, and was constructed of coarse coal refuse compacted to varying densities to meet permeability and density requirements. A 15 m wide upstream zone was heavily compacted to achieve a zone of lower permeability and a drainage blanket beneath the downstream shell was constructed using only moderate compaction. A closure spillway was constructed in 2002 at the west abutment. There has been no construction activity since the mine was closed and spillway constructed.

No significant visual changes or indications of developing dam safety concerns were observed during the inspection. 2014 piezometer readings were below design thresholds and no significant unexpected increases since the previous readings (in 2004) were noted. The functional piezometers are sufficient for ongoing monitoring of the structure under closure conditions.

Teck does not have an operations, maintenance or surveillance (OMS) manual or an emergency preparedness plan (EPP) for the BTD. These documents are under development by Teck and are scheduled to be available in December 2014.

The BTD visually appears in good working condition and the observed performance is consistent with the expected design conditions. Comparison of the observed condition of the dam with the available design and inspection reports indicates there has been no significant change to the condition of the

structure since the site was closed in 2003. Recommendations regarding deficiencies, non-conformances and future work are summarized in Table 1.

Table 1 Summary of Recommendations for Deficiencies and Non-conformances

Number (Year Raised – Priority[(1)])	Deficiency/ Non-conformance	Regulation or OMS Reference	Recommended Action	Recommended Deadline (Status)
DSI-BTD-01 (2010)	*Design criteria not current.*	*HSRC Code*	*Complete a design review to confirm design compliance with CDA (2007).*	*CLOSED (refer to KCB, 2014c)*
DSI-BTD-02 (2010)	*Monitoring Records*	-	*Update and review monitoring records (piezometers).*	*CLOSED (included in this report.)*
DSI-BTD-03 (2012 – Priority 3)	Diversion maintenance.	-	Clear brush and small trees from diversion channel upslope of impoundment. 2014 Note: DSI-BTD-06 can include a review of whether this diversion is still required.	December, 2015 (pending outcome of DSI-BTD-06)
DSI-BTD-04 (2013- Priority 2)	No OMS manual and EPP.	HSRC Code	Prepare an OMS manual and EPP for the facility based on the MAC (2011) guidelines. The OMS should include: ▪ routine and event driven surveillance; ▪ instrument monitoring frequency (piezometer and survey monuments); ▪ Downstream slope erosion monitoring.	December, 2014 (Teck advise this is underway)
DSI-BTD-05 (2013 – Priority 4)	Lack of signage for public.	-	Impoundment surface should be assessed for soft areas and appropriate signage installed to warn recreational users of potential hazards. 2014 Note: Teck to review signage requirements and determine whether any action is required.	Complete review of signage requirements prior to June, 2015
DSI-BTD-06 (2014 – Priority 3)	Spillway IDF	CDA(2007)	KCB recommend Teck complete a design assessment with summary report to confirm the spillway is suitable for the IDF and no upgrade works are required.	December, 2015
DSI-BTD-07 (2014 – Priority 2)	Dam Safety Review	HSRC Code	Complete a dam safety review for the BTD.	December, 2015
DSI-BTD-08 (2014 – Priority 3)	Survey monuments and monitoring	n/a	Establish displacement monitoring of the BTD starting in 2015. During the first 12 months complete 3 surveys.	First set of surveys completed prior to August, 2015
DSI-BTD-09 (2014 – Priority 3)	Spillway channel maintenance	-	Removed vegetation from the spillway inlet area and channel. Any erosion protection works damaged during the maintenance should be reinstated.	December, 2015

Notes:

1. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   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 likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
   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 Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

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1 INTRODUCTION

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Resources Limited. (Teck) to complete the 2014 Dam Safety Inspection (DSI) of the dam structures on the Bullmoose Coal mine site. The Bullmoose Coal mine operated from December 1983 to March 2003 under the Ministry of Environment (MOE), Permit No. 6757.

This report presents the DSI for the Bullmoose Tailings Storage Dam (BTD), previously referred to as the South Fork Tailings Dam. The DSI was completed by Mr. Rick Friedel (P.Eng.) on July 23, 2014 between 12:00 pm and 4:30 pm. During the DSI the weather was cloudy with sunny periods and no precipitation. Refer to Figure 1 for an overview of the facility with inspection waypoints.

The inspection and this report were prepared to comply with Section 10.5.3 of the Health, Safety and Reclamation Code for Mines in British Columbia (the Code) and the requirements specified in the "Guidelines for Annual Dam Safety Inspection Reports" (Appendix III).

The BTD is considered a Major Dam and Major Impoundment under the Code. The BTD was classified as a "High" consequence classification structure (CDA, 2007) based on the inundation study and consequence classification review completed by KCB (2014b). A DSI was completed in 2013 by KCB (2014a). No dam safety review (DSR) has been completed on the BTD. A DSR is recommended in 2015 and are due every 7 years for "High" consequence classification structures based on CDA (2007). KCB is the Engineer of Record for the BTD.

Inspection observations are summarized in the following sections and photographs are included in Appendix I.

2 BACKGROUND AND RECENT ACTIVITY

The Bullmoose Mine is located about 30 km northwest of Tumbler Ridge, BC. The area is characterized by moderate topographic relief, with mountains several hundreds of meters above broad glacial and river formed valleys. The area is generally forested at lower elevations, with some ridgelines extending to above tree line.

Coal production at Bullmoose began in December 1983, and produced annually about 1.7 million tonnes of clean metallurgical coal and 600,000 tonnes of clean thermal coal. Waste from the coal preparation process included coarse and fine refuse. The BTD impoundment was active throughout mine operations. The fine refuse (tailings) was generally 95% by weight passing the 0.15 mm sieve size and was produced at an average rate of about 150,000 tonnes per year. Tailings production varied considerably depending on the ratio of thermal to metallurgical coal. Tailings was transported as slurry (35% solids by weight), to a single point discharge located at the northwest corner (closest to the mill) of the impoundment.

The following reports were available as reference material prior to and following the inspection:

- “Tailings Dam Annual Review of Operations”, November (BOC, 2004);
- “Bullmoose Coal Project Design Tailings Dam Design Report” (KL, 1982);
- “South Fork Tailings Dam - Seepage and Stabilty Review” (KC, 1996);
- “1998 Annual Review of Tailings Facility” (KC, 1998);
- “Bullmoose Tailings Facility Establishment of Threshold Warning Levels for Piezometers” (KC, 1999);
- “Tailings Impoundment Closure Spillway Design” (KC, 2001);
- “Tailings Impoundment Closure Spillway - Review of Proposed Layout” (KC, 2002a);
- “Tailings Impoundment Closure Spillway Site Inspection on September 27, 2002” (KC, 2002b);
- “Bullmoose Mine Review of 2002 Tailings Operations Report” (KC, 2002c);
- “Bullmoose Mine Review of 2003 Tailings Operations Report” (KC, 2003);
- “Bullmoose Tailings Facility Closure Spillway Inspection on September 22, 2004” (KC, 2004a);
- “Bullmoose Mine Review of 2004 Tailings Operations Report” (KC, 2004b);
- “Bullmoose 2010 Dam Safety Inspection and Consequence Classification” (KCB, 2011);
- “Bullmoose Mine 2013 Dam Safety Inspection” (KCB, 2014a);
- “Bullmoose Mine Tailings Storage Facility – Dam Breach and Inundation Study” (KCB, 2014b); and
- “Bullmoose Mine Tailings Dam Design Review” (KCB, 2014c).

The tailings impoundment is located on the south flank of the broad valley bottom, with South Bullmoose Creek to the west and West Bullmoose Creek to the north. The tailings dam was constructed to a final crest elevation of 1122 m, with a maximum height of 38 m (crest to downstream toe). The design capacity of the facility is 4.6 Mm^3; based on existing contours 4.4 Mm^3 of tailings are stored.

The impoundment is formed by the horseshoe-shaped BTD on the north, east and west sides with the natural valley slope to the south. A starter embankment about 10 m high was constructed of borrow material for the first year of operations. The BTD has an upstream slope of 2H:1V and downstream slope of ranging from 2.5H:1V to 3H:1V, and was constructed of coarse coal refuse compacted to varying densities to meet permeability and density requirements (refer to design drawings in Appendix II). A 15 m wide upstream zone was heavily compacted to achieve a zone of lower permeability and a drainage blanket beneath the downstream shell was constructed using only moderate compaction.

The foundation soils consist of alluvial sands and gravels with interbedded silts and glacial till. The alluvial soils are sufficiently pervious to allow pond water to seep from the impoundment. As the thickness of the deposited fine coal refuse increased the seepage rate decreased (Teck, 2012). There are two aquifers underlying the impoundment: surficial gravelly aquifer with piezometric level 4 m below the original ground approximately the elevation of Bullmoose Creek; and lower gravelly aquifer with piezometric level 8 m to 10 m below the original ground surface. The two aquifers are reported to be separated by a low permeability glacial till layer.

A closure spillway was constructed in 2002 at the west abutment. The spillway channel follows a southwesterly route from the tailings impoundment, discharging onto the natural ground at approximately elevation 1120 m.

No construction activity (raises, upgrades repairs) has been completed on the dam since the mine was closed and spillway constructed.

3 WATER MANAGEMENT

The catchment for the BTD impoundment is 38 ha: 17 ha tailings surface; and 21 ha of natural upslope catchment. A diversion ditch was constructed upslope of the impoundment to divert the 21 ha away from the impoundment for normal conditions. Under flood conditions, the entire 38 ha is included in design calculations. During operations the tailings were discharged from the southern ridge towards the BTD. The spillway is located at the west abutment. A pond has been noted in available inspection reports (El. 1115 m to 1116 m) along the eastern side of the impoundment.

The spillway was designed for the 1000-year 24-hour flood event (KC, 2001), 92.2 mm of precipitation and design flow of 1.0 m^3/s. CDA (2007) specifies the Inflow Design Flood (IDF) for a "High" consequence classification structure as 1/3rd between the 1000 year return period and probable maximum flood (PMF) events. Although not part of the standard DSI scope, KCB completed a simplified hydraulic review to assess spillway performance under the IDF. The analysis was completed using the software package HEC-HMS. KCB updated the 1000-year 24-hour and probable maximum precipitation (PMP) estimates based on the available data from Bullmoose climate station (Station number: 1181120, elevation 1102 m).

The calculated 1000-year 24-hour precipitation is 135.7 mm, nearly 50% greater than the original value used in design. The calculated probable maximum precipitation (PMP) is 363.7 mm. The equivalent precipitation rate for the IDF is 212 mm which is 2.3 times greater than the original design value. Results of the HEC-HMS model are summarized in Table 3.1. Despite the large increase in precipitation the peak spillway flow is equivalent to the original design value.

Table 3.1 Simplified Hydraulic Assessment of Spillway for IDF

Flow Condition	Spillway Flow (m^3/s)	Flow Depth (m)	Velocity (m/s)
Peak	0.8	0.2 to 0.3	0.7 to 0.8
Average	0.6	0.1 to 0.2	0.6 to 0.7

Notes:
1. 1000 year return period event = 135.7 mm; and PMP = 363.7 mm. Calculated based on climate data from Bullmoose climate station (Station number: 1181120, elevation 1102 m).

The spillway channel is founded in bedrock for its entire length (KC, 2002b). In some sections of the spillway, bedrock does not extend 1 m (vertical) above the spillway invert. These areas were covered with riprap (D50 = 200 mm). The erosion protection capacity of the riprap and bedrock both exceed the modest velocities predicted under the IDF. The flow depth for the IDF (up to 0.3 m) is greater than the design (0.1 m) but still leaves 0.7 m of freeboard which is suitable for this structure. Accumulation of vegetation in the spillway channel will reduce flow capacity which could raise the peak flood level but not significantly to overtop the dam under the IDF.

Based on this review, the spillway is suitable for the IDF for a "High" consequence classification structure. KCB recommend Teck complete a design assessment with summary report to confirm this analysis, the influence of vegetation on available freeboard and risk of potential blockage by a large tree.

No climate data is available from the Bullmoose climate station since 2003. Therefore, precipitation data was adopted from the Chetwynd Airport climate station (Station number: 1181508, elevation 610 m). Annual precipitation values for the Bullmoose and Chetwyn Airport climate stations were compared to determine the average ratio of measurements from each site. The precipitation Chetwynd Airport climate station from October, 2013 through September, 2014 was multiplied by the average ratio and adopted for this assessment (553 mm).

There is no visual evidence that water has flowed through the spillway and therefore all inflows to the impoundment are lost through evaporation or seepage. A simplified water balance calculation for the BTD impoundment for October, 2013 to September, 2014 is summarized below:

- Inflows:
  - Precipitation on pond surface = 9,408 m^3 (assumed pond surface on average is 10% of tailings beach); and
  - Precipitation on tailings surface = 84,675 m^3.
- Outflows:
  - Evaporation from pond surface = 8,551 m^3 (evaporation rate for this site 503 mm/yr adopted from another mine site in the region); and
  - Seepage losses from the impoundment = 85,533 m^3 (the remainder of inflows minus evaporation).

The average seepage rate from the impoundment is 2.7 l/s over the 12 month period. No seepage from the BTD toe or fill was observed during the inspection. The water balance is within the expected performance range for the BTD and consistent with previous observations in available DSI reports. There are no planned changes to surface water management that would alter this observation.

4 REVIEW OF MONITORING RECORDS AND DOCUMENTS

4.1 Monitoring Plan

An Operations, Maintenance and Surveillance (OMS) manual is not developed for the BTD. Teck is in the process of developing an OMS, planned completion December, 2014. The OMS document must meet the requirements specified in CDA (2007) and KCB recommends following the format proposed in MAC (2011).

4.2 Inspections

DSIs are the only documented inspections of the BTD which occurred regularly during the later stages of operations (1998 to 2004) and 4 of the last 5 years (no 2011 DSI was completed). No records are available from 2005 to 2009. Given the long performance history of the PTD, no large permanent pond and low piezometric levels in the dam (Section 4.3), annual DSIs are appropriate for ongoing formal geotechnical inspections. The OMS should include "event-driven" inspections following flood and seismic events.

Teck staff are currently visiting the Bullmoose site for water sampling and flow monitoring. KCB recommends that the OMS include documenting visual observations of the BTD (minimum monthly, recommended) and downstream area (with a checklist) during these site visits.

4.3 Pore Pressures

Piezometers were measured on July 23, 2014 (during DSI). These are the first documented readings from the piezometers since 2004. Figures 2 and 3 summarize piezometer readings with a comparison to historical readings and design threshold values (KC, 1999). The following observations are made based on the data:

- None of the measured piezometers exceed warning threshold Level I (KC, 1999). If a Level I threshold is exceeded both Teck and the design engineer (KCB) are to be notified.
- 17 of the 21 piezometers installed in the dam (KC, 1999) were identified and measured:
  - 6 of the instruments were not labelled and cannot be compared to historical readings. Based on their location the instruments can be narrowed down to two options. Regardless of which possible instrument is assumed, Level I thresholds are not exceeded.
  - 6 piezometers were 'dry' (water table below tip elevation).
- All measured piezometers have similar or lower pore pressure than last measurement with the exception of PA1 and PA2 but both readings are similar to average reading measured between 2001 and 2003 (refer to Figure 3).
- "Low" pore pressures in the downstream shell of the dam (at measured locations) indicate that dam drainage and foundation seepage capacity exceeds flow requirements.

The functional piezometers are sufficient for ongoing monitoring of the structure under closure conditions. KCB recommend annual reading of piezometers as part of the DSI.

4.4 Survey Monument Pins

No survey monuments are installed on the BTD and no historical monument survey data is included in the available design and inspection reports. Given the long performance history and unchanged conditions since the impoundment was closed in 2003, ongoing displacement should be small to insignificant. However, KCB recommends Teck undertake displacement monitoring (vertical and horizontal) of the BTD starting in 2015. Given ongoing displacements are expected to be small the selected monitoring method should have a target horizontal and vertical accuracy of +/- 5mm. During the first 12 months after installation, 3 survey readings are recommended to establish a baseline and resolve any survey error. Ongoing monitoring frequency should be confirmed pending results of the first year of monitoring data.

4.5 Water Quality

Groundwater sampling wells are installed downstream of the tailings dam, with samples collected for regular water quality analyses to monitor change in groundwater quality. Results are reported by Teck to MoE as specified in the Permit No. 6757.

5 VISUAL OBSERVATIONS AND PHOTOGRAPHS

The following observations were made during the DSI:

- **Dam Crest**: Good condition. No sign of lateral movement, significant differential settlement or cracking of the dam crest (Photos I-2, I-4 and I-8).
- **Downstream Slope**: Good condition. No visible sign of significant erosion or displacement, bulging at toe or crest settlement (Photos I-13 to I-18). Vegetation (grasses and moss) is well established (Photo I-9) and there is modest rilling of the downstream slope. No action required.
- **Upstream Slope**: Good condition. No visible sign of significant erosion or displacement (Photos I-1 to I-4).
- **West Abutment**: Good condition. The spillway is excavated through the West Abutment, no sign of erosion at abutment (Photo I-7).
- **East Abutment**: Good condition. No visible sign of significant erosion or displacement of the natural slope (Photos I-19 and I-20).
- **Tailings Impoundment and Pond**: The impoundment is well vegetated (Photos I-1, I-5 and I-6) except for the pond area (Photo I-2). Away from the pond the tailings surface is well drained and supports human traffic (Photos I-2 and I-12). The tailings pond elevation was approximately 1115 m which is similar to other available inspection records since 2004 (KC, 2004b).
- **Spillway:** Good condition. No obstruction at the inlet but the inlet and spillway channel is vegetated (grasses and bushes) which could slightly reduce flow capacity and should be removed.
- **Depressions and Gulleys in Tailings Beach:** The 2013 DSI (KCB, 2014a) noted potential development of sinkholes and erosion gulleys in the tailings surface and recommended annual monitoring. During the 2014 DSI, the depressions in the tailings surface were inspected; there is no visual change from 2013 or evidence to support these as sinkholes. These features are believed to be local depressions caused by ponded water or differential settlement. Based on the aerial image (Figure 1) a portion of the gulleys have a meandering alignment but the “v-shaped” cross-section (Photo I-5) has the appearance of an excavated channel. Regardless of whether they are naturally forming or excavated they are partially to well vegetated and pose no identifiable risk to dam safety.
- **Historic Slope Failure in South Slope:** a failure is present in the natural slope on the south side of the impoundment (waypoint TSF-2014-16) in the old pit wall. The failure is also visible in photos from previous inspection report(Teck, 2013; KCB, 2011; KCB, 2014a) indicating this has been present since at least 2010. The failed mass is overgrown with vegetation including small trees. A comparison of photographs between 2010 and 2014 do not indicate any significant change.

- **Upslope Diversion Ditch**: Poor condition. The ditch is heavily overgrown (Photo I-21) and was initially misinterpreted in the field as an old access road rather than the interceptor ditch. Visible signs of excessive erosion of the ditch and the area between the ditch and the impoundment. Similar pond elevation between the 2004 (KCB, 2004b) and more recent (2010 to 2014) site inspections indicate that if this ditch is not performing it is not impacting the BTD under normal flow conditions. The spillway was designed assuming that this ditch was not in place.

6 ASSESSMENT OF DAM SAFETY

The consequence classification for the BTD is "High" based on KCB (2014a). There have been no subsequent changes to the downstream environment or operation of the structure that justify a revision to the consequence classification.

No OMS manual or Emergency Preparedness Plan (EPP) have been prepared for the BTD. Teck advised that these documents are under development and will be available in December, 2014.

Based on the DSI and review of available documents regarding the BTB the potential failure modes included in CDA (2007) were reviewed:

- **Overtopping:** The pond level has been observed 5 m to 6 m below the spillway invert. At this level, the available storage is greater than 500,000 m3 which is significantly more than the IDF volume (approximately 80,000 m^3). In available inspection reports since 2004, the pond has been reported between 5 m and 6 m below the spillway invert. If the IDF event were to occur when the pond was at the spillway invert, the spillway would have sufficient capacity to pass the peak flow. Based on these factors the probability of an overtopping failure is low.
- **Internal Erosion and Piping:** The dam is a semi-pervious design (i.e. no compacted core or seepage barrier) which allows seepage flow through the dam fill. Filter performance has been demonstrated by clear seepage and retention of fine tailings in the impoundment during operations and closure. The potential sinkholes in the tailings beach noted in the 2013 DSI were re-visited and these features are believed to be local depressions caused by ponded water or differential settlement, not sinkholes.
- **Slope Instability:** The dam is a compacted fill with a free draining downstream shell and drainage layers. The downstream slope of the dam is 2.5 horizontal to 1 vertical. Slope stability analysis in the design had safety factors greater than 1.7 under the threshold Level I water levels and a crest elevation of 1124 m which complies with CDA (2007) (KC, 1996). 2014 piezometer readings indicate that the pore pressures in the dam are similar to or lowered since mine closure and are all below threshold Level I. This analysis and long performance history with no visible or documented displacements indicates the probability of failure due to slope instability is very low.
- **Foundation Irregularities:** The dam is constructed on non-liquefiable alluvial sands and gravels with interbedded silts and at least one lens of glacial till (KL, 1982). No weak layers are identified in the available design documents and organics and surficial unsuitable materials were excavated prior to fill placement. The probability of failure due to foundation irregularities is very low.
- **Surface Erosion:** Both the upstream and downstream slopes of the dam have a vegetation cover to protect against surface erosion. Some rilling of the downstream slope is present but is minor, and appears to be stable based on comparison with 2010 DSI photographs. The probability of failure due to surface erosion is very low.

- **Earthquakes:** Stability of the dam under seismic loading was considered in the original design (KL, 1982). The dam was noted to not be susceptible to failure or significant deformation during seismic events. KCB (2014c) reviewed the seismic acceleration using in the original design analysis (0.1g) and concluded it complies with CDA (2007) recommendations for this type of structure based on NBCC (2005, 2010).

The BTD visually appears in good working condition and the observed performance is consistent with the expected design conditions. Comparison of the observed condition of the dam with the referenced design and inspection reports indicates there has been no significant change to the condition of the structure since the site was closed in 2003. . Recommendations regarding deficiencies, non-conformances and opportunities for improvement are summarized in Table 6.1.

Table 6.1 Summary of Recommendations for Deficiencies and Non-conformances

Number (Year Raised – Priority[(1)])	Deficiency/ Non-conformance	Regulation or OMS Reference	Recommended Action	Recommended Deadline (Status)
DSI-BTD-01 (2010)	*Design criteria not current.*	*HSRC Code*	*Complete a design review to confirm design compliance with CDA (2007).*	*CLOSED (refer to KCB, 2014c)*
DSI-BTD-02 (2010)	*Monitoring Records*	-	*Update and review monitoring records (piezometers).*	*CLOSED (included in this report.)*
DSI-BTD-03 (2012 – Priority 3)	Diversion maintenance.	-	Clear brush and small trees from diversion channel upslope of impoundment. 2014 Note: DSI-BTD-06 can include a review of whether this diversion is still required.	December, 2015 (pending outcome of DSI-BTD-06)
DSI-BTD-04 (2013- Priority 2)	No OMS manual and EPP.	HSRC Code	Prepare an OMS manual and EPP for the facility based on the MAC (2011) guidelines. The OMS should include: ▪ routine and event driven surveillance; ▪ instrument monitoring frequency (piezometer and survey monuments); ▪ Downstream slope erosion monitoring.	December, 2014 (Teck advise this is underway)
DSI-BTD-05 (2013 – Priority 4)	Lack of signage for public.	-	Impoundment surface should be assessed for soft areas and appropriate signage installed to warn recreational users of potential hazards. 2014 Note: Teck to review signage requirements and determine whether any action is required.	Complete review of signage requirements prior to June, 2015
DSI-BTD-06 (2014 – Priority 3)	Spillway IDF	CDA(2007)	KCB recommend Teck complete a design assessment with summary report to confirm the spillway is suitable for the IDF and no upgrade works are required.	December, 2015
DSI-BTD-07 (2014 – Priority 2)	Dam Safety Review	HSRC Code	Complete a dam safety review for the BTD.	December, 2015
DSI-BTD-08 (2014 – Priority 3)	Survey monuments and monitoring	n/a	Establish displacement monitoring of the BTD starting in 2015. During the first 12 months complete 3 surveys.	First set of surveys completed prior to August, 2015
DSI-BTD-09 (2014 – Priority 3)	Spillway channel maintenance	-	Removed vegetation from the spillway inlet area and channel. Any erosion protection works damaged during the maintenance should be reinstated.	December, 2015

Notes:

2. Recommendation priority guidelines, specified by Teck and assigned by KCB:
   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 likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
   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 Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

7 CLOSING

We trust that this document meets the requirements for dam safety inspections specified by Teck and the Ministry of Energy, Mines and Natural Gas. Please contact the undersigned if you have any questions or comments.

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Teck Resources Ltd. (Client) for the specific application to the 2014 Dam Safety Inspection. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. 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.

KLOHN CRIPPEN BERGER LTD.

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Manager, Engineering

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KC. 2004b. “Bullmoose Mine Review of 2004 Tailings Operations Report”, December.

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FIGURES

596,500 597,000 597,500 598,000

6,111,000

N

TALISMAN SUB-STATION

BULLMOOSE RIVER

TSF-2014-28
TSF-2014-29
TSF-2014-12(PZ)
TSF-2014-11(PZ)
TSF-2014-27
TSF-2014-08
TSF-2014-07(PZ)
TSF-2014-30
TSF-2014-10(PZ)
TSF-2014-06
TSF-2014-09(PZ)
TSF-2014-26
TSF-2014-05(PZ)
TSF-2014-13
TSF-2014-25
TSF-2014-14
TSF-2014-03(PZ)
TSF-2014-02(PZ)
TSF-2014-01(PZ)
TSF-2014-24
TSF-2014-15
TSF-2014-16
TSF-2014-17
TSF-2014-04
SP2-2014-06
SP2-2014-07
TSF-2014-18
TSF-2014-23
TSF-2014-22
TSF-2014-19
DIVERSION CHANNEL
EMERGENCY SPILLWAY
TSF-2014-20
TSF-2014-21

596,500 597,000 597,500 598,000

LEGEND

TSF-2014-## 2014 WAYPOINT

TSF-2014-## (PZ) 2014 WAYPOINT AND PIEZOMETER LOCATION

ROAD

Notes:
1. Projection: NAD83 UTM Zone 10N.
2. Basedata: TRIM.
3. September 2013 imagery from Teck.
4. Contour Interval = 5 m.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED NOVEMBER 2014.

0 125m

CLIENT Teck

Klohn Crippen Berger

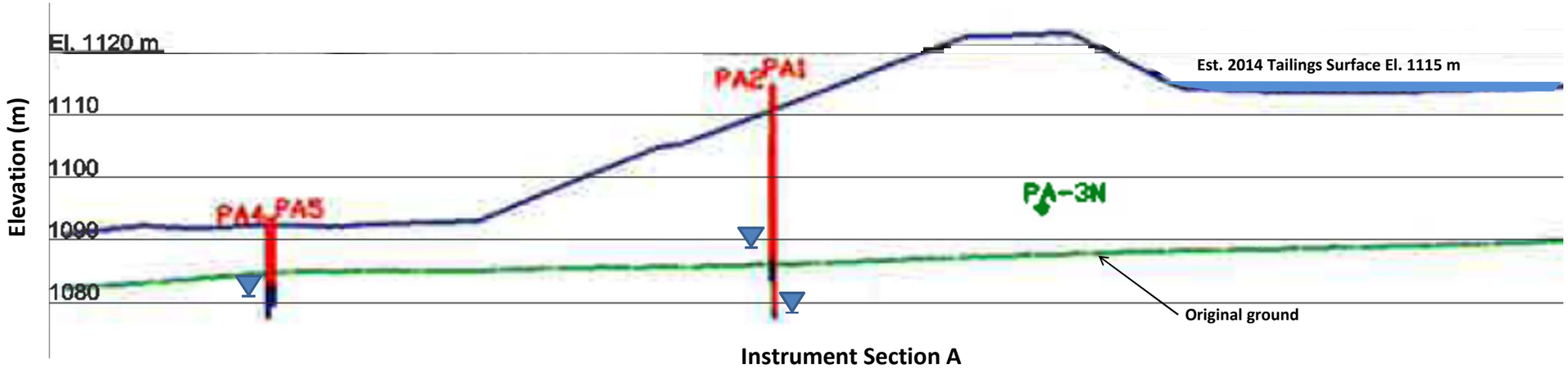
PROJECT
BULLMOOSE
2014 DAM SAFETY INSPECTION

TITLE
TAILINGS STORAGE DAM

PROJECT No. M09893A02

FIG No. 1

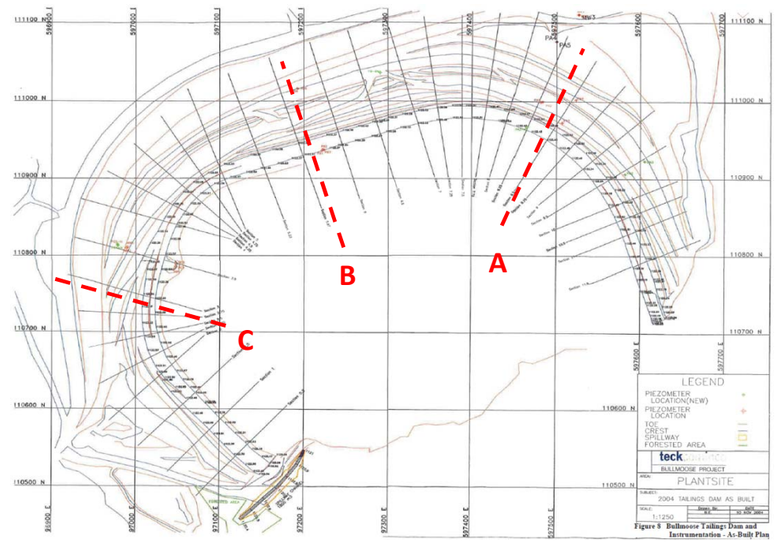
Path: Z:\MV\CR\M09893A02-TML-Bullmoose 2014 DSI\300 Design\AH_GIS FIGURES_OCT 2014\141006_Fig1_tailings.mxd



Instrument Section A

Summary Table - July 23, 2014 Readings

	Easting	Northing	ID	Original Ground	Existing Ground Elevation	Piezo Screen/Tip El.	Measured Stickup	Water El.	Water Level Above Original Ground	Piezometer Location	
	(m)	(m)		(m)	(m)	(m)	(m)	(m)	(m)	Section	Depth
Section A	597386	6111207	PA-1	1084	1112.5	1077.3	0.6	1077.9	-6.1	Downstream Slope	Foundation
			PA-2	1084	1112.5	1083.4	0.5	1088.9	4.9	Downstream Slope	Dam
	597401	6111282	PA-4	1081	1092.7	1077.3	1.8	1081.2	0.2	Downstream Slope	Foundation
			PA-5	1081	1092.7	1079	2	dry	unknown	Downstream Slope	Dam
	597368	6111172	PA-3N	1082	1123	1094.76	N/A	1096.5	14.5	Crest	Dam
	597430	6111316	No label	1076.7	1090	1068.3	1.5	1074.8	-1.9	Downstream Toe	Foundation
			No label	1076.7	1090	1053.7	1.5	1067.9	-8.8	Downstream Toe	Foundation
Section B	597124	6111143	No label	1086	1123	Unknown	1.2	dry	unknown	Crest	Unknown
			No label	1086	1123	Unknown	0.1	dry	unknown	Crest	Unknown
	597096	6111220	PB-4	1086	1100.5	1081.1	2.3	1082.2	-3.8	Downstream Slope	Foundation
			PB-5	1086	1100.5	1081.6	2.3	dry	unknown	Downstream Slope	Foundation
Section C	596948	6110984	PC-1	1091	1120.5	1083.7	0.97	1084.5	-6.5	Crest	Foundation
			PC-2	1091	1120.5	1090.3	1.75	dry	unknown	Crest	Dam
			PC-3	1091	1120.5	1101.8	1.41	dry	unknown	Crest	Dam
	596892	6111015	No label	1093.5	1111.5	Unknown	0.3	1089.5	-4.0	Downstream Slope	Foundation (MW1 or MW5)
			No label	1093.5	1111.5	Unknown	0.4	1093.4	-0.1	Downstream Slope	Foundation (MW1 or MW5)
	596882	6111018	PC-4N	1094	1109.5	1093.5	N/A	1095.6	1.6	Downstream Slope	Foundation



Plan
(nts)

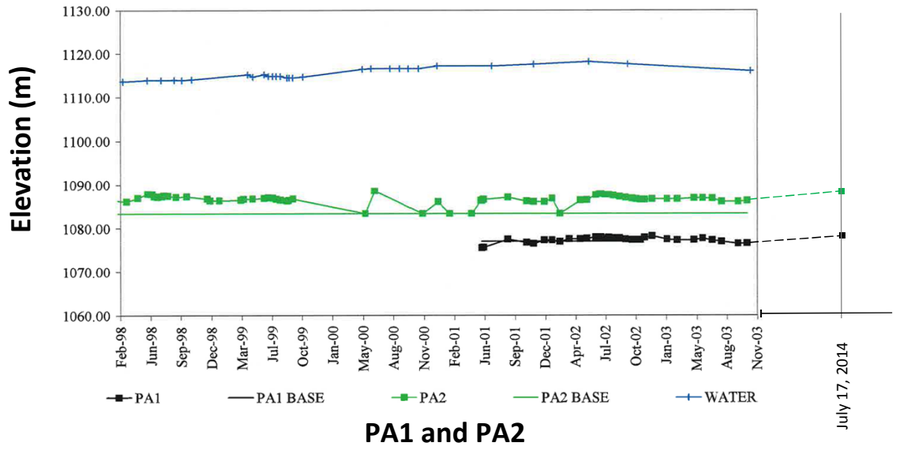
Notes:
1. Coordinate locations are from GPS readings (NAD83 UTM Zone 10N). Original ground elevation in table are from Klohn (1982). Existing ground elevations were provided by Teck Coal Ltd.
2. Section and plan drawings produced by Teck Coal Ltd. (2004).

Klohn Crippen Berger

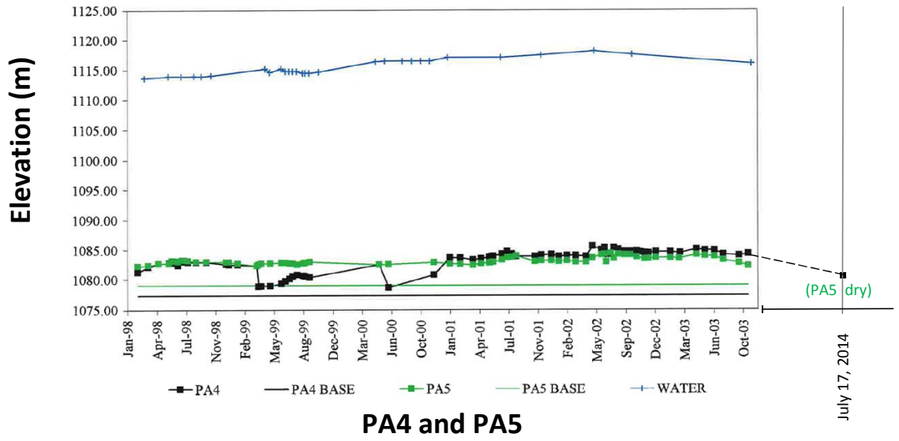
PROJECT:
Bullmoose
2014 Dam Safety Inspections

TITLE:
Tailings Storage Dam
2014 Piezometer Readings and Locations

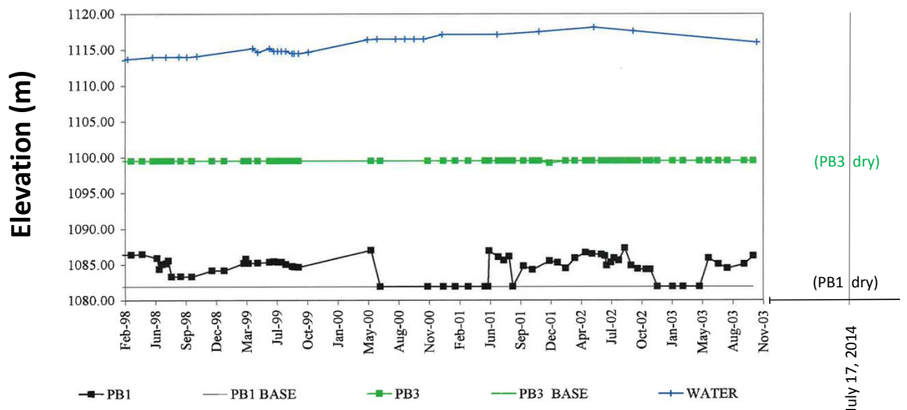
PROJECT NO. M09893A02 | FIGURE 2



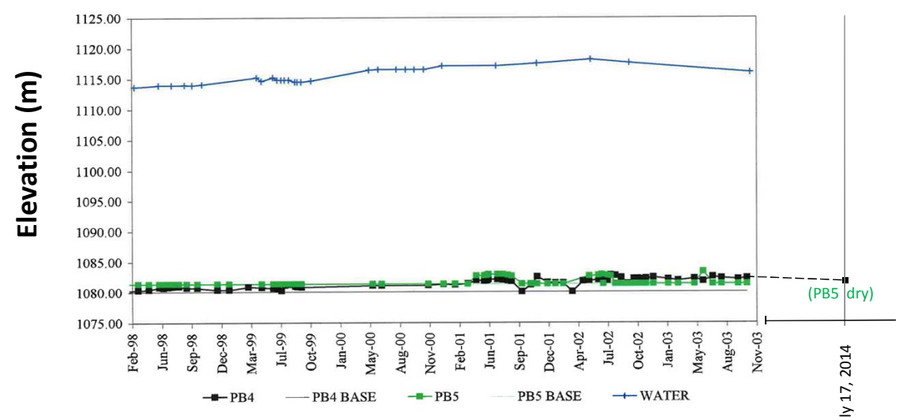
PA1 and PA2



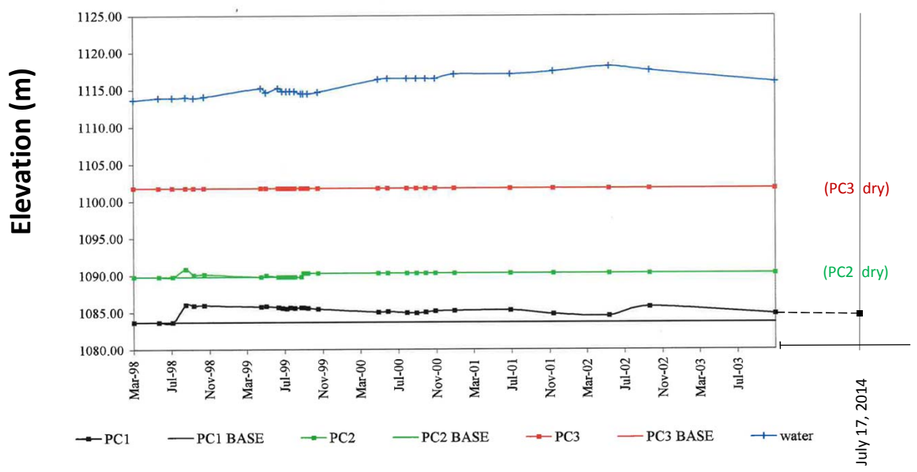
PA4 and PA5



PB1 and PB3



PB4 and PB5



PC1, PC2, and PC3

Note:

1. No historic data available for PA-3N,PC-3N, MW1, MW3, MW4 or MW5.
2. "BASE" refers to tip elevation of piezometer.

Klohn Crippen Berger

PROJECT: Bullmoose 2014 Dam Safety Inspections	
TITLE: Tailings Storage Dam Historical Piezometer Readings	
PROJECT NO. M09893A02	FIGURE 3

APPENDIX I

Inspection Photos

Appendix I
Bullmoose Tailings Dam Inspection Photographs

LEGEND:

- TSF-2014-## refers to 2014 DSI waypoint shown on Figure 1.
- All photographs taken during inspection on July 24, 2014.

Photo I-1 Overview of vegetated tailings surface from crest, looking east. (TSF-2014-05)

Photo I-2 Overview of dam crest and vegetated tailings surface, looking west. (TSF-2014-05)

Photo I-3 Pond on east side of impoundment, looking south. (TSF-2014-09)

Photo I-4 Dam crest, looking north. (TSF-2014-09)

Photo I-5 Typical vegetated gulley channel in tailings surface. This gulley drains to existing pond area. (TSF-2014-17)

Photo I-6 Spillway inlet area, vegetated by no obstructions. (TSF-2014-19)

Photo I-7 Section of spillway channel that is excavated through tailings surface and dam crest at West Abutment. (TSF-2014-19)

Photo I-8 **West Dam overview with spillway channel in foreground, looking north. (TSF-2014-20)**

Photo I-9 **Typical vegetation growth on downstream dam slopes. (TSF-2014-30)**

Photo I-10 Piezometer standpipes (PC1, PC2, PC3) in tailings beach. (TSF-2014-01)

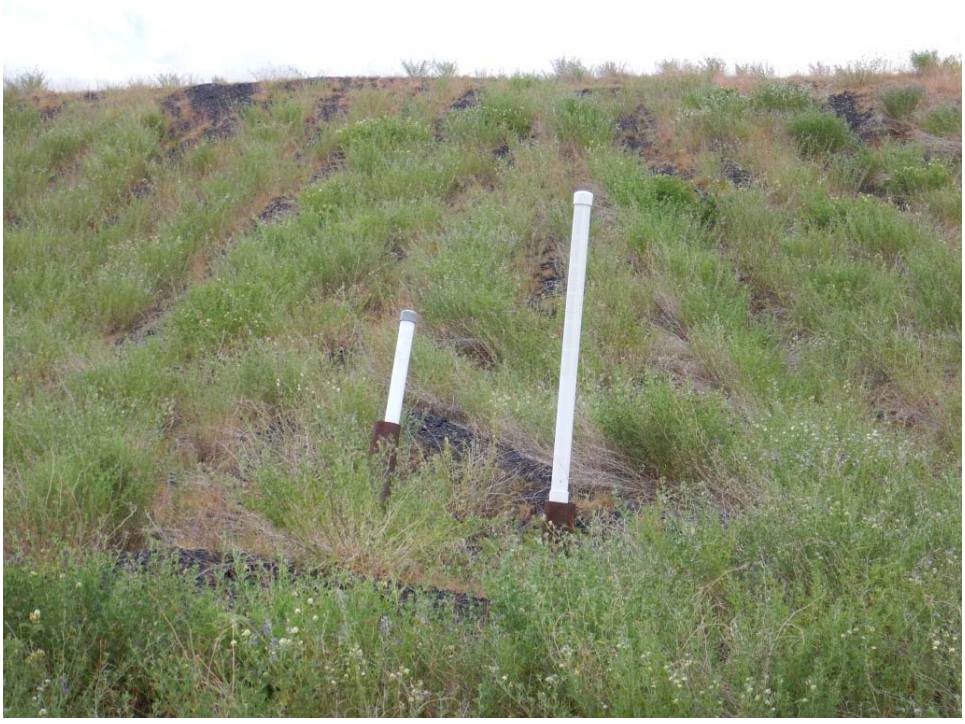


Photo I-11 Piezometer standpipes (no labels). Shallow rilling present (<1 m deep) in well vegetated downstream slope. (TSF-2014-02)

Photo I-12 Pneumatic piezometer (PC-4N). (TSF-2014-03)

Photo I-13 Standpipe piezometers (PB-4 and PB-5) and overview of downstream slope, looking south. (TSF-2014-08)

Photo I-14 Overview of downstream slope, looking east. (TSF-2014-06)

Photo I-15 Overview of downstream slope, looking south. (TSF-2014-10)

Photo I-16 **Downstream slope and toe area, looking east. Reclaimed structure, appears to be have been a pond, visible at dam toe. (TSF-2014-09)**

Photo I-17 **Overview of downstream slope, looking east. (TSF-2014-24)**

Photo I-18 Overview of downstream slope, looking west. (TSF-2014-24)

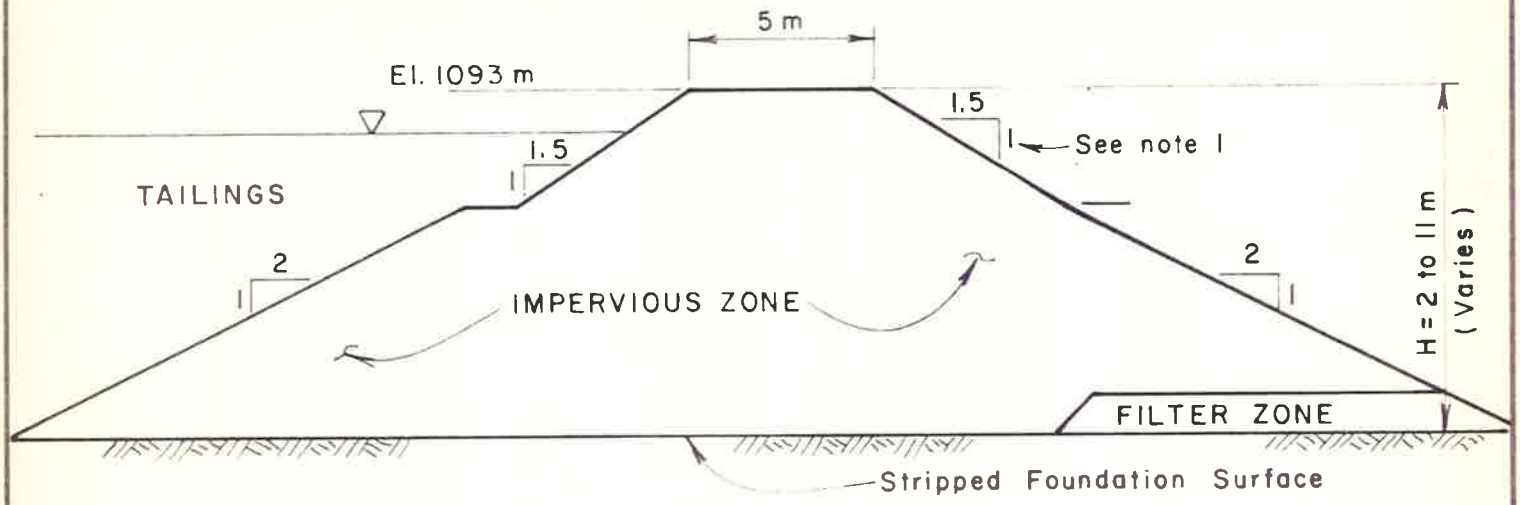
Photo I-19 East abutment downstream slope with mine road visible (light grey structure). Local surface water flows along contact between dam fill and native ground. The area is well vegetated and no visual sign of active significant erosion. (TSF-2014-15)

Photo I-20 East abutment upstream slope. (TSF-2014-15)

Photo I-21 Diversion channel upslope of impoundment. The diversion channel is so heavily overgrown it is difficult to identify in the field. (TSF-2014-18)

APPENDIX II

Dam Design Drawings



FOUNDATION SOILS

(Vary from medium dense sand and gravel to silty sands and sandy silts)

NOTES

1. Dam slope revised to 1.5 : 1, H:V over maximum top 5.0 metres of dam in October, 1984.
2. Impervious zone consists of silty sand and gravel compacted to 98 % of the Standard Proctor Density.
3. Filter zone consists of blasted mudstone and sandstone, moderately well graded; 15 percent greater than 150 mm.

SCALE 1:200

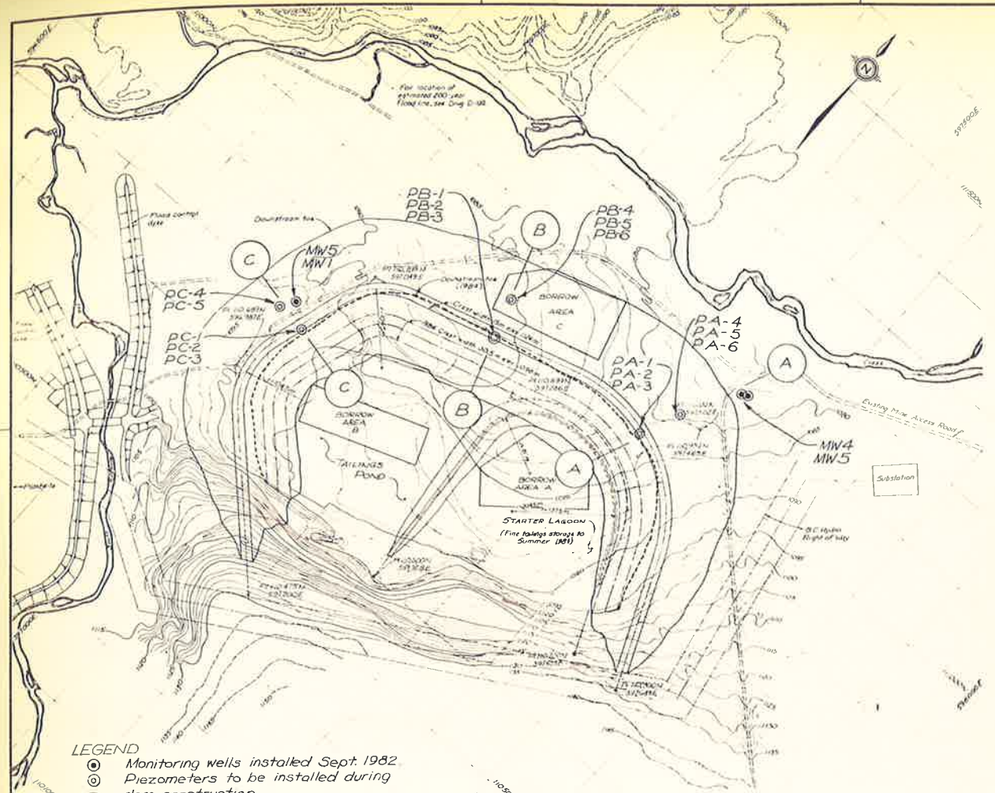
KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

TITLE: TAILINGS STARTER DAM
TYPICAL AS-BUILT SECTION

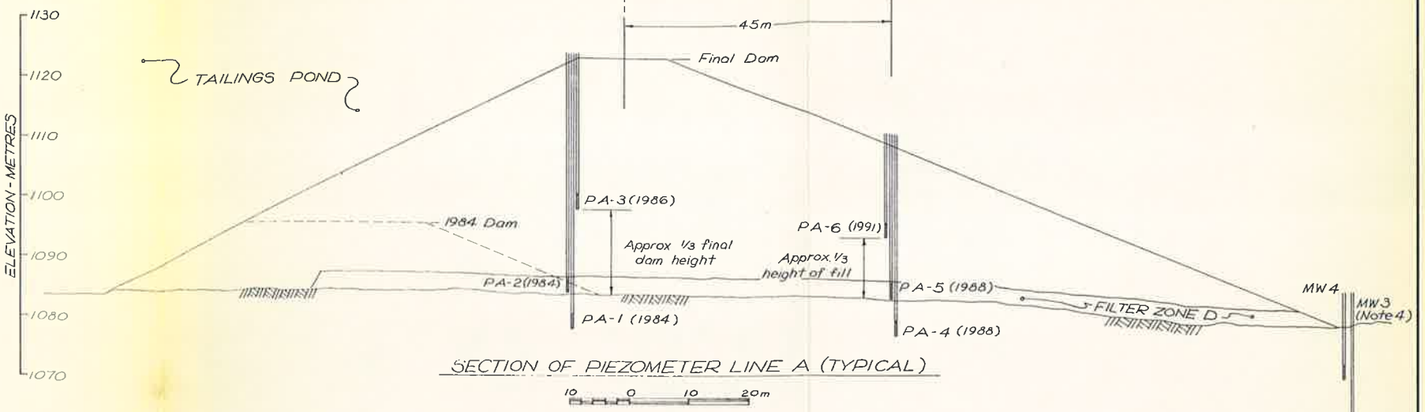
CLIENT: BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE	PROJECT No	DWG No	REV
MARCH 15, 1984	PB2971-02	A-117	
APPROVED			

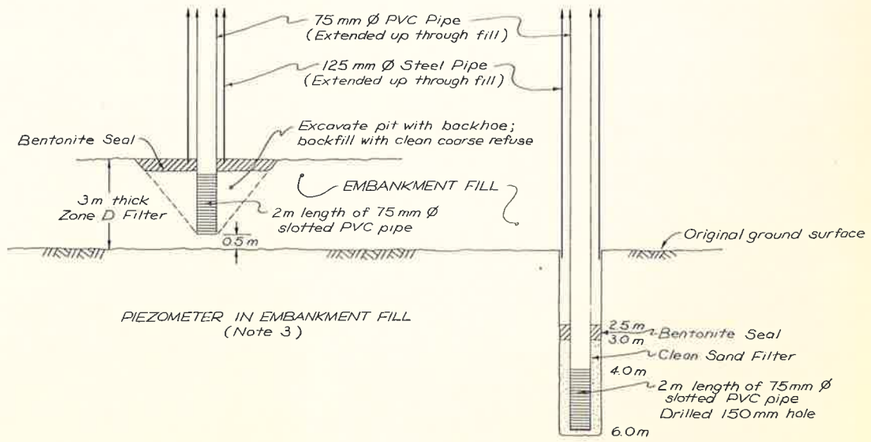


LEGEND
- ◉ Monitoring wells installed Sept 1982
- ◎ Piezometers to be installed during dam construction.
- (A) Piezometer Lines

LOCATION PLAN
50 0 50 100m



SECTION OF PIEZOMETER LINE A (TYPICAL)
10 0 10 20m



PIEZOMETER IN EMBANKMENT FILL (Note 3)

FOUNDATION PIEZOMETER (Note 1)

TYPICAL PIEZOMETER INSTALLATION DETAILS

N.T.S.

NOTES:

1. Standpipe piezometers will be installed during construction of the dam and will be extended up through the embankment fill. PA-1, PA-2 and PB-1, PB-2 and PC-1, PC-2 to be installed in 1984. Additional piezometers to be installed as shown during later construction.
2. Foundation piezometers to be installed with a drilling rig.
3. Piezometers in embankment fill to be installed with a backhoe.
4. Monitoring wells installed by Klohn Leonoff Ltd. in Sept. 1982.

TO BE READ WITH KLOHN LEONOFF REPORT DATED OCT. 22, 1982

SCALE: AS SHOWN

REV.	DATE	REVISION DETAILS

DESIGN	DRAWN	DATE	SCALES
H.M.	D.T.	OCT. 1982	AS SHOWN

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

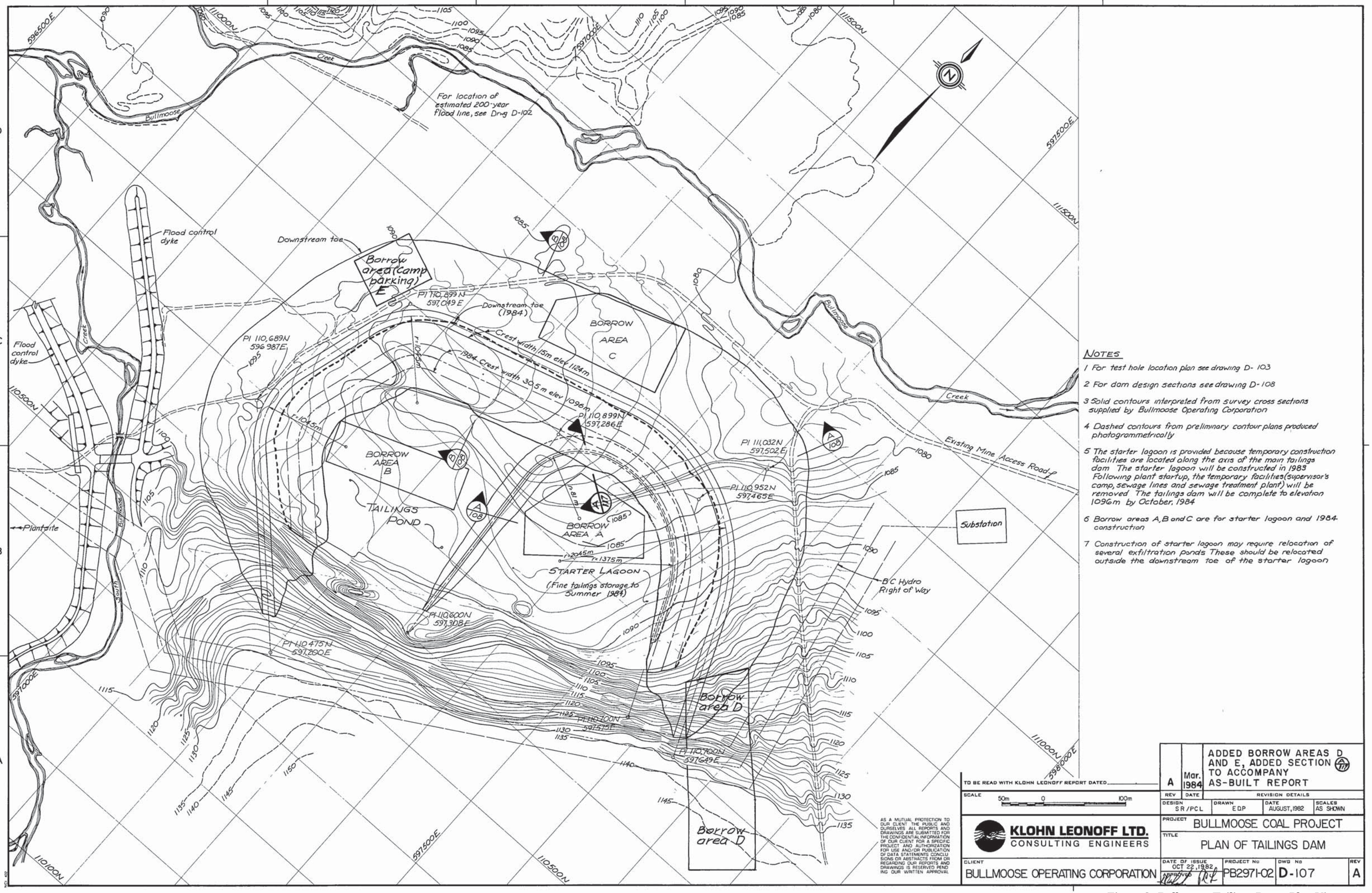
TITLE: PLAN, SECTION & DETAILS OF TAILINGS DAM PIEZOMETERS

CLIENT: BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
OCT. 22, 1982	PB2971-02	D-112	

APPROVED

P. C. LIGHTHALL
PROFESSIONAL ENGINEER
BRITISH COLUMBIA



NOTES

1 For test hole location plan see drawing D-103

2 For dam design sections see drawing D-108

3 Solid contours interpreted from survey cross sections supplied by Bullmoose Operating Corporation

4 Dashed contours from preliminary contour plans produced photogrammetrically

5 The starter lagoon is provided because temporary construction facilities are located along the axis of the main tailings dam The starter lagoon will be constructed in 1983 Following plant startup, the temporary facilities (supervisor's camp, sewage lines and sewage treatment plant) will be removed The tailings dam will be complete to elevation 1096m by October, 1984

6 Borrow areas A, B and C are for starter lagoon and 1984 construction

7 Construction of starter lagoon may require relocation of several exfiltration ponds These should be relocated outside the downstream toe of the starter lagoon

TO BE READ WITH KLOHN LEONOFF REPORT DATED

REV	DATE	REVISION DETAILS
A	Mar. 1984	ADDED BORROW AREAS D AND E, ADDED SECTION (A-111) TO ACCOMPANY AS-BUILT REPORT

SCALE 50m 0 100m

DESIGN	DRAWN	DATE	SCALES
SR/PCL	EDP	AUGUST, 1982	AS SHOWN

KLOHN LEONOFF LTD. CONSULTING ENGINEERS

PROJECT BULLMOOSE COAL PROJECT

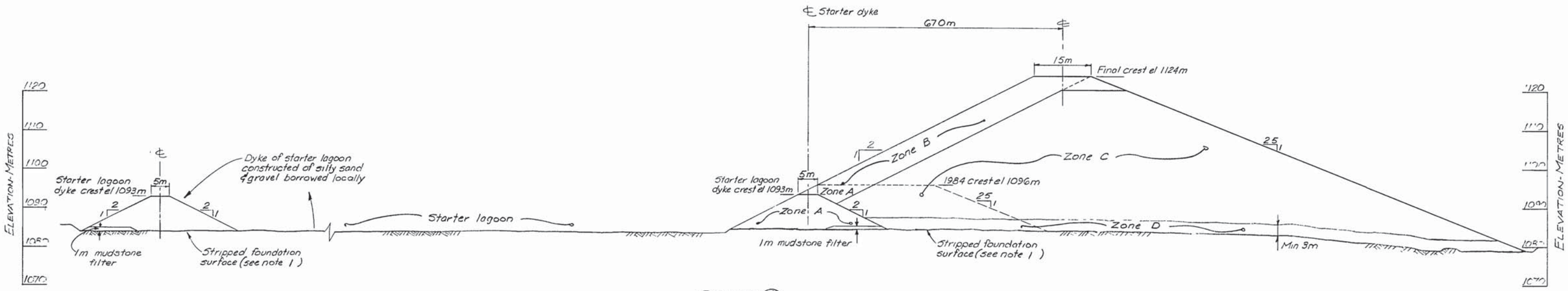
TITLE PLAN OF TAILINGS DAM

CLIENT BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE	PROJECT No	DWG No	REV
OCT 22, 1982	PB2971-02	D-107	A

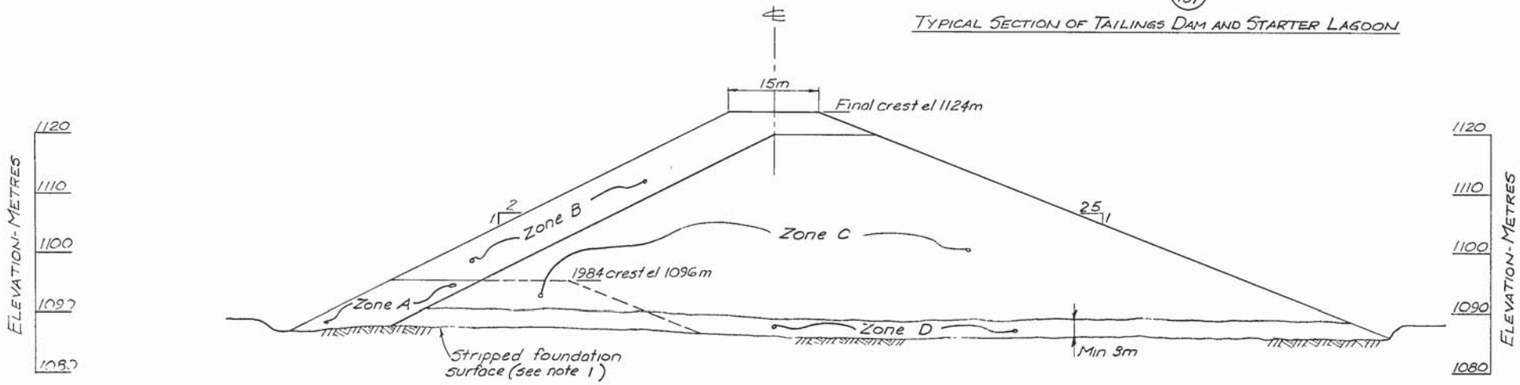
APPROVED

Figure 6 Bullmoose Tailings Dam - Plan View



SECTION A/107

TYPICAL SECTION OF TAILINGS DAM AND STARTER LAGOON



SECTION B/107

TYPICAL SECTION OF TAILINGS DAM

ZONE	MATERIAL	LIFT THICKNESS	COMPACTION* %Standard proctor
A Impervious	Silty sand & gravel (borrow)	0.3m	98 %
B Low permeability	Coarse refuse	0.15m	98 %
C General fill	Coarse refuse	0.5m	98 %
D Drainage	Coarse refuse	1.0m	95 %

* 98% standard proctor should be achieved with 4 passes with a large vibratory roller and 95 % with about 2 passes

CONSTRUCTION NOTES

1 FOUNDATION PREPARATION

All vegetation, organics and soft material shall be removed from the dam foundation area to expose silty sand and gravel soils Loose materials include areas where waste from the plantsite and construction camp excavation were placed during the 1982 site development The foundation surface should be heavily compacted prior to fill placement

2 CONSTRUCTION MATERIALS, PLACEMENT COMPACTION

GENERAL

Fill placement should be carried out during warmer parts of the year so that no frozen materials or lenses of ice or snow are incorporated in the fill

Where a vibratory roller is specified for compaction in following sections, the compactor should have a minimum static weight of 8 tonnes

ZONE A

Zone A material will be used for the starter dyke and for the upstream zone of the tailings dam for 1984 construction The material should consist of silty sand and gravel borrowed from the alluvial deposits within the tailings dam reservoir Zone A is intended to be a zone of low permeability and should have a minimum of 15 percent by weight passing the 0 075 mm sieve size

Zone A material should be placed in maximum loose lift thicknesses of 0 3 m and compacted to a minimum density equivalent to 98 percent of the maximum Standard Proctor density (ASTM D-698 Method D) This density should be achieved by compacting with at least four passes of a vibratory roller, provided the water content of the fill material is near optimum

ZONE B

Zone B is a 15 m wide zone of coarse refuse on the upstream side of the tailings dam which will be heavily compacted to provide a zone of low permeability The coarse refuse should be placed in maximum loose lift thicknesses of 0 15 m and compacted with at least 4 complete passes of a vibratory roller

ZONE C

Zone C is the general fill portion of the dam, constructed of compacted coarse refuse The coarser refuse should be placed in maximum loose lift thicknesses of 0 5 m and compacted with a minimum of 4 complete passes of a vibratory roller The fill surface should be scarified between lifts

ZONE D

Zone D is a drainage zone, constructed of loosely compacted, select coarse refuse

The coarse refuse used in Zone D should be selected to have the minimum amount of fines There should be a maximum of 5 percent, by weight, passing the 0 075 mm sieve size Coarse refuse should be placed in lifts 1 m thick Compaction should consist of 2 complete passes of a vibratory roller The fill surface should be scarified between lifts

3 QUALITY CONTROL AND TESTING

COMPACTION CONTROL

Standard Proctor compaction tests conforming to ASTM D-698 Method D should be carried out a minimum of once per week during construction or at any time when the material quality changes Compaction control should consist of frequent inspection of placement and compaction procedures, augmented by field density tests One field density test for every 1500 m^3 of fill placed should be performed Zones A, B and C should be compacted to 98% Standard Proctor density and the filter Zone D to 95% Standard Proctor

GRAIN SIZE ANALYSES

For Zone A, grain size analyses of the fill material should be performed at a minimum frequency of twice weekly For the coarse refuse, grain size analyses should be performed weekly on samples from the stockpile and the fill after compaction

4 TAILINGS DISCHARGE

Tailings may be deposited to the pond by a single point discharge, with the discharge point located at intervals along the dam crest Discharge should be adjusted so as to form a beach adjacent to the dam and to maintain the ponded water at the back of the pond adjacent to the hillside During freezing weather, tailings should be discharged near or beneath the surface of the water pond so as to minimize ice formation on the beaches.

TO BE READ WITH KLOHN LEONOFF REPORT DATED OCT 22, 1982

SCALE 10m 0 30m

REV	DATE	REVISION DETAILS

DESIGN	DRAWN	DATE	SCALES
SR/PCL	EDP	SEPT, 1982	AS SHOWN

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

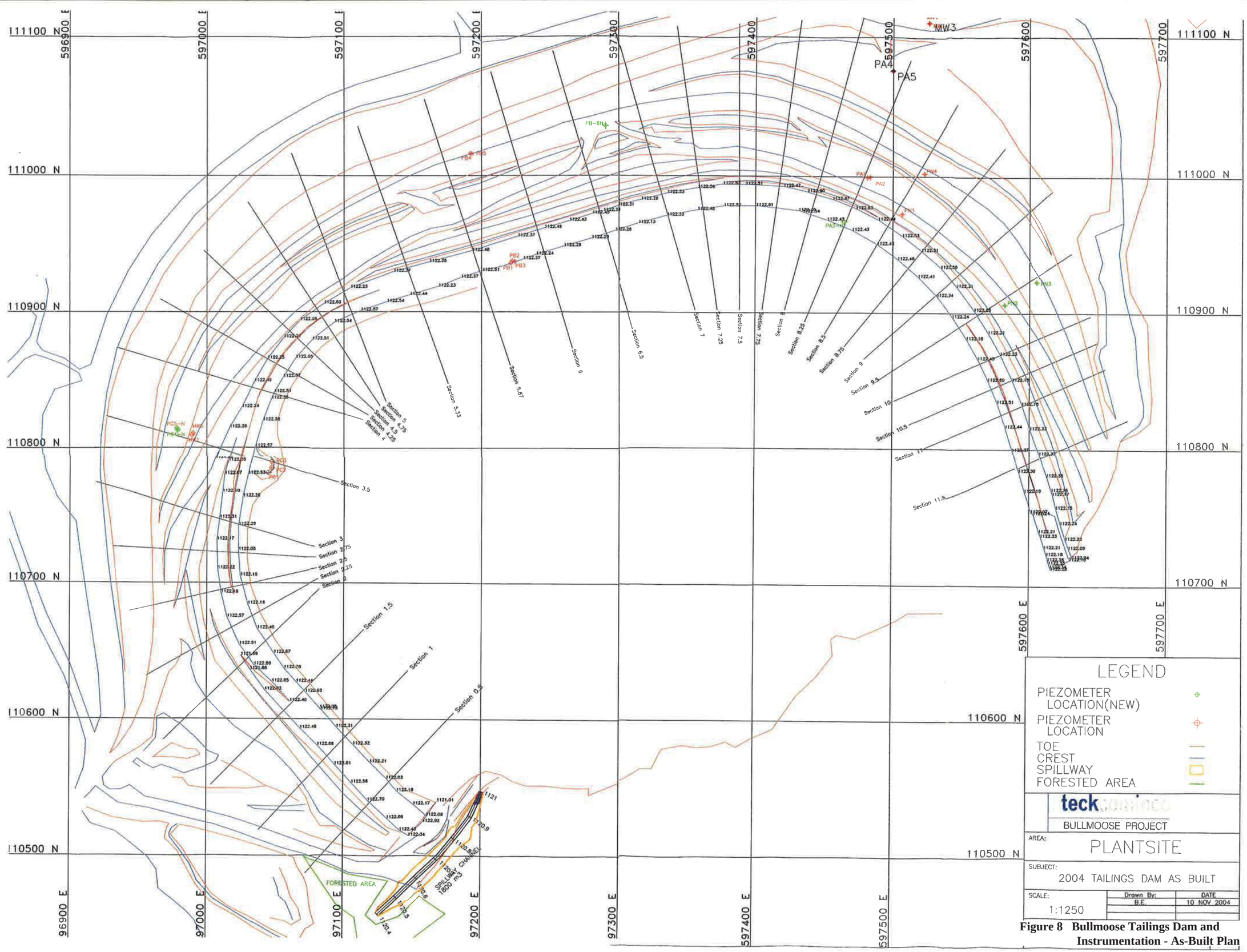
TITLE: TYPICAL SECTIONS OF TAILINGS DAM

CLIENT: BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE	PROJECT No	DWG No	REV
OCT 22, 1982	PB297-02	D-108	

APPROVED

Figure 7 Bullmoose Tailings Dam - Typical Sections



LEGEND

- PIEZOMETER LOCATION(NEW)
- PIEZOMETER LOCATION
- TOE
- CREST
- SPILLWAY
- FORESTED AREA

teck COMINCO

BULLMOOSE PROJECT

AREA: PLANTSITE

SUBJECT: 2004 TAILINGS DAM AS BUILT

SCALE:	Drawn By:	DATE
1:1250	B.E.	10 NOV 2004

Figure 8 Bullmoose Tailings Dam and Instrumentation - As-Built Plan

APPENDIX III

"Guidelines for Annual Dam Safety Inspection Reports"

Ministry of Energy and Mines

Ministry of Energy & Mines

GUIDELINES FOR ANNUAL DAM SAFETY INSPECTION REPORTS

Reference:

Health, Safety and Reclamation Code for Mines in British Columbia (Code) Section 10.5.3: *The manager shall submit an annual dam safety inspection report prepared by a professional engineer on the operation, maintenance and surveillance of the tailings and water management facilities and associated dams to the chief inspector.*

This Code reference applies to every operating and closed mine in BC.

The report shall provide the following information:

1. Executive Summary

   (a) Classification of the dam(s) in terms of Consequence of Failure in accordance with Table 2-1 of the CDA Dam Safety Guidelines (2007).

   (b) Significant changes in instrumentation and/or visual monitoring records.

   (c) Significant changes to dam stability and/or surface water control.

   (d) 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.

   (e) 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.

   (f) Scheduled date for the next formal Dam 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 are included in Section 5 of the CDA Dam Safety Guidelines. 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.

2. Summary of past years' construction (if any) with a description of any problems and stabilization.

3. Plan and representative cross sections.

4. Site photographs.

5. Review of climate data.

6. Water balance review.

7. Freeboard and storage availability (in excess of the design flood).

8. Water discharge system, volumes, and quality.

9. Seepage occurrence and water quality.

10. Surface water control and surface erosion.

11. Instrumentation review including:

    (a) Phreatic surfaces and piezometric data.

    (b) Settlement.

    (c) Lateral movement.

The report shall be submitted by a qualified geotechnical engineer registered as a Professional Engineer (P.Eng.) in British Columbia. The professional engineer will be deemed the Engineer of Record for the facility unless another engineer is identified within the Dam Safety Inspection report as having this responsibility.

Note, this document modified from the original by George Warnock, P.Eng. (Manager, Geotechnical Engineering) in August 2013. Original prepared by Chris Carr, P.Eng. (former Manager) in February 2002.