Klohn Crippen Berger

Teck Resources Limited

Bullmoose Mine

Bullmoose Tailings Storage Facility

2021 Annual Facility Performance Review

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March 2022

March 22, 2022

Teck Resources Limited
Legacy Properties
601 Knighton Road
Kimberley, British Columbia
V1A 1C7

Mr. Mark Slater, P.Eng.
Senior Geotechnical Engineer

Dear Mr. Slater:

Bullmoose Mine
Bullmoose Tailings Storage Facility
2021 Annual Facility Performance Review

We are pleased to submit the 2021 Annual Facility Performance Review report for the Bullmoose Tailings Storage Facility.

Please contact us if you have any questions regarding this report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Max Cronk, P.Eng.
Project Manager
Civil Engineer

MC/RWC:jc

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Teck Resources Limited

Bullmoose Mine

Bullmoose Tailings Dam

2021 Annual Facility Performance Review

EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Resources Limited (Teck) on behalf of the Bullmoose Operating Corporation to complete the 2021 Annual Facility Performance Review (AFPR) for the Bullmoose Tailings Storage Facility (BTSF).

The site visit was completed by the Engineer of Record (EoR), KCB representatives, Mr. Bob Chambers, P.Eng., and Mr. Max Cronk, P.Eng., on July 14, 2021. Mr. Mark Slater, P.Eng., of Teck attended the site visit, and is the Responsible Tailings Facility Engineer (RTFE) for the BTSF.

This report covers from September 2020 to August 2021, herein referred to as the "review period".

This summary section is provided in accordance with the Health, Safety and Reclamation Code (HSRC), and Teck's "Guideline for Tailings and Water Retaining Structures" (Teck 2019a). We also understand that Teck makes these annual reports available for public viewing prior to their full conformance with the Global Industry Standard on Tailings Management (GISTM) in 2023. This summary is provided solely for purposes of overview. Any party who relies on this report must read the full report. This summary omits a number of details, any one of which could be crucial to the proper application of this report.

Summary of Facility Description

Bullmoose Mine is an idle open pit coal mine located in the Peace River Coalfields district of northeastern British Columbia (Teck 2003). The mine was operated between 1983 and 2003 (Teck 2003). Reclamation activities were carried out in 2003, and the site has been inactive since that time. The mine site is about 45 km northwest of Tumbler Ridge in northeast BC. Key aspects of the BTSF include:

- The BTSF is a side-hill tailings storage facility that was used to store fine coal refuse tailings produced during operations. The BTSF is situated on the south flank of the broad valley bottom, with South Bullmoose Creek to the west and Bullmoose Creek to the north. The BSTSF was designed to store 4.6 Mm^3 of tailings. Approximately 4.4 million m^3 of tailings were deposited in the facility during operations from 1983 until 2003.
- Tailings are retained in the facility by the Bullmoose Tailings Dam (BTD), which is a downstream-raised zoned earthfill embankment constructed primarily of compacted coarse coal rejects (CCR). The starter dam was constructed in 1983 from alluvial borrow materials, and the embankment crest was raised progressively during operations. The maximum embankment height is 38 m from crest to toe. The downstream and upstream slopes are approximately 2.5H:1V and 2H:1V, respectively.
- Reclamation work on the BTSF has included re-seeding of the impoundment, re-sloping the embankment, and placing a vegetation cover.
- A closure spillway was constructed in 2002 at the left abutment of the BTSF (inlet El. 1,122 m). The spillway channel follows a southwesterly route from the tailings impoundment, discharging onto the natural ground at approximately El. 1,120 m, more than 50 m beyond the toe of the embankment.
- The impoundment has a catchment of 36 ha: 20 ha tailings impoundment and 16 ha upslope.

Summary of Key Potential Hazards and Failure Modes

KCB understands that Teck's long-term goal for all of their tailings facilities is to reach landform status with all potential failure modes that could result in catastrophic release of tailings and/or water being either not present or having been reduced to non-credible. Teck's long-term goal for the BTSF is for all potential failure modes to be non-credible based on extreme loading conditions, or loading conditions appropriate using the principles of ALARP (i.e., As Low as Reasonably Practicable) when it is not practical to consider extreme conditions. Evaluation of failure modes with respect to this goal is ongoing. Potential failure modes reviewed as part of this annual summary include overtopping, slope instability, internal erosion, and surface erosion. Based on 2021 conditions, failure modes that could result in an uncontrolled release of tailings are considered non-credible, under design loading, for the existing structure.

A risk register has been developed for the BTSF. The risk assessment was reviewed by Teck and KCB representatives in 2021. There have been no significant changes to the key hazards and the existing controls were adequate to manage potential failure modes within compliance and risk limits.

Potential Consequence of Failure

Teck provided the following statement regarding the consequence classification of the facility:

> *Teck are aligned with the most conservative interpretation of the GISTM which, in turn, is consistent with their safety culture. Commensurately, Teck has advised that consequence classification is not a part of their tailings management governance and has asked that it not be reported in this AFPR. Instead, Teck will adopt the extreme consequence case design loading for any facility with a credible catastrophic flow failure mode. For facilities without a credible failure mode in terms of a life safety issue, Teck will reduce credible risks to As Low As Reasonably Practicable (ALARP). This consequence case applies for both earthquake and flood scenarios for all tailings facilities, consistent with the GISTM. Adopting this approach meets or exceeds any regulatory requirements, aligns with Teck's goal to eliminate risk for loss of life, and is consistent with the GISTM. This approach is consistent with industry-leading best practices and has an added benefit of providing accurate narratives to communities about the safety of tailings facilities that could impact them and who share Teck's approach of one life is one too many to be at risk.*

The BTSF meets HSRC requirements, and as noted in the previous section, evaluations under extreme loading scenarios are on-going.

Instrumentation and/or Visual Monitoring

Overall, piezometer readings are consistent with typical performance (post-operation), and there were no threshold exceedances during the review period. No changes are recommended to the instrument reading frequency or threshold levels.

The survey monuments were not read in 2021, and Teck are reviewing alternative methods to monitor displacements, including InSAR. KCB supports this initiative.

A LiDAR survey was flown in June 2020. A comparison of the change in elevation between the 2020 LiDAR and the 2010 LiDAR does not indicate any changes of concern to the facility over that time period.

The routine inspections and annual site visit observations do not indicate any significant changes in the BTSF, or any facility safety issues.

Surface Water Management

There were no changes to surface water management during the review period. Estimated seepage rates based on a simplified water balance accounting calculation are consistent with readings since 2013 (KCB 2014a).

OMS Manual and EPRP

The Operation, Maintenance and Surveillance (OMS) Manual was being updated at the time of writing based on the template developed by Teck. Teck also developed a Mine Emergency Response Plan (MERP) in March 2019, which incorporates the tailings and sedimentation pond Emergency Preparedness and Response Plan (EPRP) components (Teck 2019b). The EPRP was reviewed and is suitable for the facility, although contact information should be updated to reflect current site personnel.

Dam Safety Review

The last dam safety review (DSR) was performed in 2020 by Thurber Engineering Ltd. The site visit was completed in September 2020 and the report was in progress at the time of writing this report. There were no issues of concern identified following the site visit. The next DSR should be scheduled to commence within 2025 to comply with the HSRC requirements.

Summary of Recommendations

The observed performance of the BTSF is consistent with past behavior and design requirements. There have been no significant changes to the condition of the structure during the review period.

Recommendations are summarized in Table E-1. There are no new recommendations for this AFPR, and all previous recommendations have been closed. Closed recommendations are shown in grey italics and will be removed from the table in the next AFPR report. Preliminary recommendations issued following the site visit were closed before this report was issued and are not shown in Table E-1. If and when there are recommendations in future reviews, each recommendation will be assigned a priority using the 2016 HSRC Guidance Document priority definitions:

- 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.

Table E-1 Summary of Recommendations

Structure	ID Number	Deficiency or Non-Conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline / Status
Previous Recommendations Closed / Superseded						
BTD	*2019-01*	*Piezometer Review and Decommissioning*	*n/a*	*Review which piezometers and wells are functioning and decommission those that are defunct. Re-label all active piezometers following the review.*	*4*	*CLOSED (piezometers re-labelled and defunct instruments are noted in the updated OMS Manual, decommissioning to be coordinated with drilling program)*
BTD	*2019-03*	*Survey Monuments*	*OMS Manual Section 6.3.3.2*	*Document the procedure used to survey the BTSF survey monuments and include in the OMS Manual.*	*4*	*SUPERSEDED (recommendation is no longer applicable given that the survey monuments are going to be replaced by an alternate method.)*
Previous Recommendations Ongoing - None						
2021 Recommendations – no new recommendation (preliminary recommendations from the site visit closed prior to the issue of this report)						

TABLE OF CONTENTS

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

CLARIFICATIONS

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Teck Resources Limited. (Client) for the specific application to the Bullmoose Mine, and it may not be relied upon by any other party without KCB's written consent.

KCB has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.

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

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The Executive Summary is a selection of key elements of the report. It does not include details needed for the proper application of the findings and recommendations in the report.
3. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
4. The report is based on information provided to KCB by the Client or by other parties on behalf of the client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy. KCB shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.
5. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

LIST OF ABBREVIATIONS

Abbreviation	Definition
AEP	Annual Exceedance Probability
AFPR	Annual Facility Performance Review
BOC	Bullmoose Operating Corporation
BTD	Bullmoose Tailings Dam
BTSF	Bullmoose Tailings Storage Facility
CCR	Coarse Coal Rejects
CDA	Canadian Dam Association
DSR	Dam Safety Review
EDGM	Earthquake Design Ground Motion
EMLI	Ministry of Energy, Mines, and Low Carbon Innovation
ENV	BC Ministry of Environment
EoR	Engineer of Record
EPRP	Emergency Preparedness and Response Plan
FSO	Facility Surveillance Officer
FoS	Factor of Safety
GISTM	Global Industry Standard on Tailings Management
HSRC	Health, Safety and Reclamation Code for Mines in BC
IDF	Inflow Design Flood
InSAR	Interferometric Synthetic Aperture Radar
KL	Klohn Leonoff
KCB	Klohn Crippen Berger Ltd.
LiDAR	Light Detection and Ranging
MEM	BC Ministry of Energy and Mines (now EMLI)
NOWL	Normal Operating Water Level
OMS	Operational, Maintenance and Surveillance
PGA	Peak Ground Acceleration
PMF	Probable Maximum Flood
RTFE	Responsible Tailings Facility Engineer
TSF	Tailings Storage Facility
TWRS	Tailings and Water Retaining Structures

1 INTRODUCTION

1.1 General

KCB was engaged by Teck Resources Limited (Teck) to complete the 2021 Annual Facility Performance Review for the Bullmoose Tailings Storage Facility (BTSF), also previously referred to as the South Fork Tailings Dam at the Bullmoose Mine.

This AFPR was undertaken to comply with Section 10.5.3 of the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (the Code) (EMLI 2021). This report covers the period from September 2020 to August 2021, herein referred to as the "review period," and was prepared following:

- Section 4.2 "Annual Tailings Facility and Dam Safety Inspection Report" of the 2016 HSRC Guidance Document (MEM 2016); and
- Guideline for Tailings and Water Retaining Structures (TWRS) (Teck 2019a).

The site visit was completed by the Engineer of Record (EoR), Mr. Bob Chambers, P.Eng., and Mr. Max Cronk, P.Eng., as representatives of KCB on July 14, 2021. Mr. Mark Slater, P.Eng., of Teck attended the site visit, and is the Responsible Tailings Facility Engineer (RTFE) for the BTSF.

We understand that Teck makes these annual reports available for public viewing prior to their full conformance with the Global Industry Standard on Tailings Management (GISTM) in 2023.

1.2 Facility Description

Bullmoose Mine is an idle open pit coal mine located in the Peace River Coalfields district of northeastern British Columbia (Teck 2003). Infrastructure and pre-stripping development began in the spring of 1982, and the mine was operated between 1983 and 2003 (Teck 2003). Reclamation activities were carried out in 2003, and the site has been inactive since that time. The mine site is about 45 km northwest of Tumbler Ridge in northeast BC as shown on Figure 1.

The BTSF is a side-hill tailings storage facility that was designed to store fine coal refuse tailings produced during operations. It is situated on the south flank of the valley bottom, with South Bullmoose Creek to the west and Bullmoose Creek to the north (Figure 2). Tailings are retained in the facility by the Bullmoose Tailings Dam (BTD). There is an open channel spillway located at the west abutment of the BTSF which was constructed in 2002 (BOC 2004). Key facility metrics are summarized in Table 1.1. Typical cross-sections and design drawings are included in Appendix III.

Table 1.1 Key Facility Characteristics

Item	Description
Embankment Type	Zoned earthfill (primarily coarse coal refuse) with a drainage blanket
Foundation	Silty sand and gravel, glacial till and alluvium
Construction Method	Staged construction, downstream raises
Operation	1983 to 2003
Maximum Embankment Height	38 m (crest to downstream toe)
Crest Elevation	1123 m
Crest Length	1050 m
Crest Width	10 m to 15 m
Slopes	Upstream 2H:1V; Downstream 2.5H:1V
Impoundment Area	20 ha (surface area of covered tailings plus 2 ha of pond)
Pond Volume	~26,000 m^3
Design Storage Capacity	4.6 million m^3
Volume of Tailings Stored	4.4 million m^3
Potential Consequence of Failure based on CDA (CDA 2013)	High
Inflow Design Flood (IDF)	$^2/_3$ between 1,000-year return period and Probable Maximum Flood (PMF) – 24 hour
Earthquake Design Ground Motions (EDGM)	½ between 2,475-year and 10,000-year return period earthquake
Water Management Structures (Open Channel Spillway)	Invert Elevation: 1122 m Grade: 1% to 3% Base Width: 3 m Erosion Protection: Riprap (D_{50} of 200 mm) and bedrock
Minimum Required Freeboard	0.2 m based on CDA (2013) wave setup + wave runup methodologies
Catchment Area	36 ha (16 ha upslope; 20 ha impoundment)
Access to Facility	Vehicle access to the mine from Tumbler Ridge, BC, is 27 km northwest along BC Highway 29, and then 18 km southwest along Bullmoose Road.

1.3 Background Information and History

Coal production at Bullmoose Mine began in December 1983; the mine produced about 1.7 million tonnes of metallurgical coal and 0.6 million tonnes of thermal coal annually. Waste from the coal preparation process included Coarse Coal Refuse (CCR) and fine coal refuse (i.e., tailings). Tailings production varied considerably depending on the ratio of thermal coal to metallurgical coal. Tailings were transported as slurry, 35% solids by weight, and deposited from a single discharge point located at the southern ridge of the impoundment.

Construction of the BTD began in 1983. A starter embankment, about 10 m high, was constructed of alluvial borrow material to store tailings from the first year of operations (KL 1984). Crest raises were constructed using downstream methodology to a final crest elevation of 1122 m. A layer of glacial till

was placed on the crest for erosion protection (BOC 2003), which raised the tailings dam to El. 1123 m (based on 2020 LiDAR). However, field observations suggest the glacial till placement was likely not consistent (in terms of thickness and coverage) across the full length and width of the crest.

During operations, a diversion ditch was constructed upslope of the impoundment to divert from approximately 14 ha of upslope catchment away from the impoundment under normal conditions. The diversion channel was observed to be overgrown in 2015 (KCB 2016). KCB reviewed the water management of the facility in 2015 (KCB 2015b) and concluded that the diversion channel was no longer required to maintain an adequate water balance in the facility or to manage flood flows for dam safety.

Mine operations ceased in 2003 and the BTSF was reclaimed that same year. Reclamation work completed on the BTSF included re-sloping of the downstream slope and seeding of the tailings surface and dam slopes (upstream and downstream) (BOC 2003). There has been no construction since 2003.

The 2020 LiDAR indicates the spillway invert and the crest elevations are 1 m higher than the post-construction as-built survey. This difference in survey does not impact this assessment as the difference in elevation between the crest and spillway invert (1 m) is the same for both surveys.

A summary of the available BTSF reference documents is included in Appendix I.

2 SUMMARY OF ACTIVITIES DURING THE REVIEW PERIOD

The BTSF is a closed facility and does not require operational intervention, except for routine surveillance and maintenance activities. There were no maintenance activities required or undertaken during the review period.

3 CLIMATE WATER MANAGEMENT AND WATER ACCOUNTING

3.1 Climate

There is no active climate station at the Bullmoose site. The nearest active climate station is the Environment Canada climate station at Chetwynd Airport (No. 1181508), which is located approximately 62 km north of the site at El. 610 m. There was a climate station on site during operations called the Bullmoose Climate Station (No. 1181120 at El. 1,102 m), which operated from 1982 to 2003. Precipitation and temperature data from Chetwynd Airport are adjusted based on correlation factors developed with the Bullmoose Climate Station which was operated until 2003. Further discussion of the correlation factors is provided in Appendix IV.

Corrected precipitation and temperature data for the BTSF during the review period, and climate normals[1] are summarized in Table 3.1. There was less precipitation during the review period than average.

Table 3.1 Climate Data for Bullmoose Site During the Review Period

Month	Average Monthly Precipitation[1] (mm)	Estimated 2020 - 2021 Precipitation[2] (mm)	Daily Average Temperature [1] (°C)	2020 - 2021 Daily Average Temperature[3] (°C)
September	66	47	8.2	9.5
October	83	145	2.5	0.6
November	82	104	-4.7	-3.8
December	54	22	-7.4	-3.0
January	69	37	-8.0	-4.9
February	50	45	-6.6	-13.3
March	50	28	-4.2	-1.9
April	37	12	1.7	1.1
May	45	67	6.9	7.2
June	94	9	11.0	13.8
July	91	38	13.3	15.2
August	72	61	12.8	14.0
Total	**793**	**615**		

Notes:
1. Environment Canada Record - climate normals record based on Bullmoose Climate Station available data from 1982 to 2003.
2. Annual and monthly precipitation were estimated using precipitation data from Chetwynd Airport Climate Station data and the precipitation correction factors summarized in Appendix IV.
3. Bullmoose site monthly temperatures were estimated by applying temperature difference to monthly temperatures obtained from Chetwynd Airport Climate Station.

[1] Environment Canada climate normals for the Bullmoose site are based on data taken from 1982 to 2003.

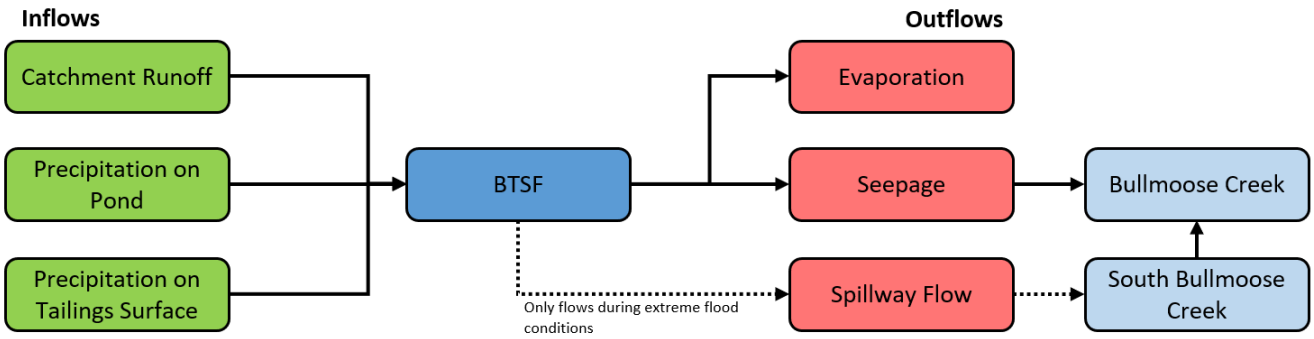
3.2 Water Management

Under normal conditions, water enters the facility as runoff from the catchment or precipitation on the tailings impoundment and pond. Water accumulates in the low point of the tailings surface on the east side of the impoundment and exits as either seepage or evaporation with no surface discharge. The pond level typically fluctuates between El. 1115 m and El. 1117 m and has an estimated volume of about 26,000 m^3 under normal conditions. The total catchment that reports to the BTSF under normal conditions is 36 ha: 2 ha pond area; 18 ha impoundment area; and 16 ha upslope natural catchment.

Under flood conditions, the gravel roads upslope of the impoundment are assumed to be overtopped which increases the upslope catchment by approximately 5 ha to 21 ha (KCB 2015b). Similar to normal conditions, flood flows are stored within the impoundment and exit as either seepage or evaporation. In the unlikely event that the pond was to rise above El. 1122 m, under extreme conditions, water would discharge from the open channel spillway into South Bullmoose Creek. There is no record of the spillway operating since construction in 2003.

A flow schematic is shown on Figure 3.1. The catchment, spillway, and diversion channel are shown on Figure 4.

Figure 3.1 Flow Schematic for Bullmoose TSF



3.3 Water Accounting

A simplified water accounting calculation for the review period is summarized in Table 3.2.

Table 3.2 Simplified Water Accounting

Inflow/Outflow		Value	Unit
Inflow	Runoff from Upstream Catchment[1]	39,800	m^3
	Precipitation on Tailings Beach (excluding Pond)[2]	111,100	m^3
	Precipitation on Pond[3]	12,500	m^3
Outflow	Evaporation from Pond Surface[4]	10,200	m^3
	Spillway Discharge	-	m^3
	Estimated Seepage Losses	153,200	m^3

Notes:

1. Assumed a runoff coefficient of 0.4.
2. Assumed a runoff coefficient of 0.6 to account for water lost to evaporation from the beach and evapotranspiration.
3. Assumed the pond surface on average s at El. 1115.5 m.
4. Evaporation rate for this site is 502 mm/year adopted from the Baseline Hydrology Report for the Quintette site (Teck 2013b).

Based on the water accounting calculation, average seepage losses from the impoundment are estimated at about 5 L/s over the review period. This is consistent with the estimated seepage rates over the past 6 years which ranged from 3 L/s (KCB 2014a) to 10 L/s (KCB 2019).

3.4 Freeboard and Flood Storage

3.4.1 Flood Storage

There is approximately 680,000 m^3 of flood storage in the facility between the Normal Operating Water Level (NOWL) (El. 1115 m) and the spillway invert (El. 1122 m) (KCB 2015b). The IDF for the BTSF is the $^2/_3$ between the 1,000-year return period and PMF, 24-hour duration event; the volume of the IDF is approximately 114,370 m^3 (KCB 2015b), which is less that one fifth of the available storage within the BTSF under normal conditions. This indicates that a storm event significantly larger than the IDF (e.g., greater than a 30-day PMF) would be required to raise the pond level to the spillway invert.

3.4.2 Freeboard

Freeboard requirements for the BTSF were estimated using the CDA Dam Safety Guidelines Wave Runup methodology (CDA 2013), which is in line with expectations noted in the HSRC Guidance Document (MEM 2016). The CDA (2013) method defines freeboard under two scenarios:

- Normal Freeboard: the difference in elevation between the lowest elevation of the crest of the embankment and the maximum NOWL; and
- Minimum Freeboard: the difference in elevation between the lowest elevation of the crest of the embankment and the peak pond level during the IDF.

Based on the CDA (2013) method, Normal Freeboard for the BSTF is 0.4 m, while the Minimum Freeboard is 0.2 m. There were no exceedances of freeboard criteria during the review period, and the freeboard observed during routine inspections ranged from 7 m to 8 m. The hydrotechnical assessment of the BSTF estimated that there would be at least 0.5 m of freeboard in the facility during the IDF assuming the pond level starts at the spillway invert (KCB 2015b); as noted in Section 3.4.1, a storm event significantly larger than the IDF would be required to reach the initial conditions assumed in the hydrotechnical assessment.

4 MONITORING PROGRAM AND SITE OBSERVATIONS

4.1 Overview

The BTSF monitoring program is summarized in Table 4.1, along with comments on activities during the review period. The monitoring program is appropriate for the BSTF under existing conditions BTSF given the long performance history of the facility, adequacy of instrumentation coverage, large flood storage capacity and provision of an open channel spillway.

Table 4.1 Summary of Monitoring Program

Surveillance Type/Task	Frequency	Responsible	OMS Manual Compliance Met?	Notes for Review Period
Water Quality	Three times per year[1]	Teck FSO	Yes	Reported separately by Teck to the Ministry of Environment (ENV).
Routine Inspections	Monthly – March to November[2]	Teck FSO	Yes	No inspection completed in March or November due to heavy snow cover.
Event-Driven Inspections	As required[3]	Teck FSO or Professional Geotechnical Engineer	Yes	No event-driven inspections were triggered.
Piezometers	Annual	Teck	Yes	Read by KCB on behalf of Teck during the annual site visit.
Survey Monuments	Annual	Teck	Yes	The latest update to the OMS Manual has removed the requirement to survey the monuments due to lack of consistency from annual measurements, and that it will be replaced with new alternatives starting in 2022.
Annual Facility Performance Review	Annual	EoR	Yes	This report
Dam Safety Review	Every 5 years	Third Party Consultant/ Qualified Registered Professional Engineer	Yes	Site visit completed in October 2020 by others. Reporting in progress at the time of writing.

Notes:

1. Three times per year – spring (freshet / high flow), summer, and fall (low flow).
2. Inspections are completed monthly when the site is accessible and when snow cover does not obstruct the inspection.
3. Triggers are defined for rainfall and earthquake events in the OMS Manual (Teck 2022).

4.2 Visual Inspections

There were no issues of concern noted during the routine and event-driven visual inspections. Inspection forms were provided by the FSO to KCB and the RTFE for review.

4.3 Annual Site Visit Observations

Figure 3 provides an overview of the facility with site visit photograph waypoints. Photographs are included in Appendix II. The following observations were made during the site visit:

- **Dam Crest**: Good condition. No signs of lateral movement, differential settlement, or cracking of the dam crest
- **Downstream Slope and Toe**: Good condition. No signs of significant erosion, displacement, or bulging. Vegetation (grasses and mosses) are well established.
  - No change to the erosion gulley observed at the toe near the right abutment (Photo II-26). The gulley was first observed in 2017 and has not changed significantly since that time. The likely cause was concentrated local flow during spring freshet. This feature continues to be monitored and inspected for signs of change during routine visual inspections and annual site visits.
  - There is a small wet area near the toe of the north arm of the BTSF (Photo II-30, II-33) which was first noted in 2019. There were no signs of seepage emerging from the downstream slope, and the wet area is believed to be due to ponding from snowmelt from the slopes.
- **Upstream Slope**: Good condition. No signs of significant erosion or displacement.
- **Left and Right Abutment**: Good condition. No signs of significant erosion or displacement of the natural slope. Vegetation is well established at the abutment and along the abutment/downstream slope contact.
- **Tailings Impoundment and Pond**: A pond (approximately 2 ha) is located on the east side of the impoundment and is approximately 400 m from the spillway inlet and 6 m lower. Outside of the pond, the impoundment surface is well vegetated. The exposed tailings surface appears well drained and supports human/animal traffic. The pond was below the pond level threshold stake at the time of the site visit.
- **Spillway:** Good condition. No signs of erosion or obstructions. There was some minor re-growth of vegetation observed, but none that would affect the performance of the spillway.
- **Historical Slope Failure on Natural Slope South of Impoundment:** A historical slope failure is present in the natural slope on the south side of the impoundment (Photo II-21). The failure is also visible in photographs from previous annual reports (Teck 2013a, KCB 2011, KCB 2014a, and KCB 2020a) indicating this has been present since at least 2010. The slide mass is overgrown with vegetation including small trees. Comparison of photographs between 2010

and 2020 does not indicate any visually identifiable changes, and the feature is not a risk to the facility.

4.4 Piezometers

There are 13 functional piezometers at the BTSF (11 standpipe piezometers and 2 pneumatic piezometers); installation details and threshold levels are summarized on Figure 5. The piezometer locations are shown on Figure 3. Figure 6 summarizes recent and historical piezometer readings, while Figure 7 shows piezometric levels at selected cross-sections of the facility. None of the measured piezometers exceed Threshold Level 1, and none of the piezometers indicate a trend of increasing pore pressures within the embankment or foundation. The piezometer data collected to date continues to show that the dam shell is drained with a low gradient of approximately 0.04 to 0.05 (KCB 2018b).

4.5 Survey Monuments

As noted in the latest OMS Manual update (Teck 2022), the survey monuments will no longer be read annually, and Teck will establish an alternative method for deformation monitoring starting in 2022.

In lieu of surveying monuments, Teck completed a LiDAR survey of the facility in 2020, and are planning to conduct a historical InSAR survey in 2022. The 2020 LiDAR survey is approximately 0.3 m higher than the 2010 survey across the site, including areas where little to no change would be expected (e.g., bedrock outcrops). This difference is likely due to a change in survey datum used between the two surveys. The only area of the TSF which shows movement beyond this offset is the tailings beach, indicating settlement between 0.5 m and 1 m, with the greatest settlement occurring near the ponded area on the east side of the impoundment. The survey comparison does not show displacement trends or magnitude of concern (i.e., no slumping or toe bulging).

4.6 Pond Level

Teck installed a pond level stake approximately 1 m above the NOWL as Threshold Level 1 marker. The pond level stake is checked visually during routine and event-driven inspections and is considered appropriate for ongoing monitoring of the pond level.

There were no freeboard exceedances noted during the review period. As noted in Section 3.4.2, the minimum freeboard observed during the review period was 7 m which greatly exceeds the minimum required freeboard.

4.7 Discharge Water Quality

Groundwater wells are installed downstream of the facility for water quality analyses. Teck have indicated that there have been no water quality exceedances and that the monitoring frequency meets their permit requirements. Teck reports the results to the BC Ministry of Environment (ENV) as specified in Permit No. PE-06757.

5 TAILINGS FACILITY SAFETY ASSESSMENT

5.1 Design Basis Review

KCB have performed engineering assessments of the existing facility (KC 1996, KCB 2015b, KCB 2017) which confirmed that it meets the key design criteria for flood and earthquake loading required under the HSRC. There were no changes to the design basis during the review period. HSR

5.2 Dam Safety Review

The latest dam safety review (DSR) was performed in 2020 by Thurber Engineering Ltd. The site visit was completed in September 2020 and the report was in progress at the time of writing this report. There were no issues of concern identified following the site visit.

The HSRC requires that DSRs be performed at least once every 5 years. The next DSR should be scheduled to be initiated within 2025.

5.3 Failure Modes Review

KCB understands that Teck's long-term goal for all of their tailings facilities is to reach landform status, with all potential failure modes that could result in catastrophic release of tailings and/or water being either not present or having been reduced to non-credible. Teck's long-term goal for the BTSF is for all potential failure modes to be non-credible based on extreme loading conditions, or loading conditions appropriate using the principles of ALARP (i.e., As Low as Reasonably Practicable) when it is not practical to consider extreme conditions. Evaluation of failure modes with respect to this goal is ongoing.

The BTSF risk register was reviewed by Teck and KCB representatives in 2021. There were no changes to the key hazards and the existing controls were adequate to manage potential failure modes. The following is a summary of the controls in place to manage the three key hazards / failure modes for tailings facilities identified in the ICMM Good Practice Guide (ICMM 2021):

- **Overtopping:** The pond level (visually estimated) is typically 6 m to 7 m below the spillway invert. At this level, the available flood storage before spilling is more than 5 times the IDF volume (KCB 2015b) (see Section 3.4.1 and Section 5.6.2 for more details). In addition, the spillway was designed to safely route the IDF, with freeboard, assuming the pond is at the spillway invert level at the start of the storm (KCB 2015b).
- **Internal Erosion and Piping:** The embankment is a semi-pervious design (i.e., no compacted core or seepage barrier),which allows seepage flow through the dam fill. The filter compatibility of the fill types and native materials was checked as part of the design process (KCB 2014c). The dam is constructed with zones of CCR, which were compacted with varying efforts and lift thicknesses to produce the internal zones. This includes a drainage blanket of lightly-compacted CCR in the downstream shell, which was designed to draw down the phreatic surface (BOC 1982). As-built gradations of the tailings and embankment fill materials were found to be filter compatible (KCB 2015a). Hydraulic gradients in the embankment

adjacent to the pond have been consistent over the past several years (approximately 0.04) and are below the average critical gradient of 0.11 required to erode the dam fill (KCB 2018b). Hydraulic gradients in other portions of the embankment that are not near the pond are much less than 0.04.

- **Slope Instability:**
  - The dam is composed of compacted fill with a free draining downstream shell and drainage layers. The downstream slope of the dam is 2.5H:1V (BOC 2003). The FoS reported in design was greater than 1.7 (KC 1996), which exceeds the HSRC requirements. This analysis and the long performance history with no visible or documented signs of instability indicates that the current condition of the structure is stable under normal loading.
  - Seismic stability was evaluated using a pseudo-static analysis (KL 1982), and indicated that the facility has a FoS of 1.4 with a horizontal seismic coefficient of 0.1 g (equivalent to a PGA of 0.2 g). This exceeds the PGA for a 10,000-year earthquake (0.16 g) based on the site-specific seismic hazard assessment (KCB 2020b) which indicates that deformations would be limited to less than 1 m under these conditions. The BTSF has approximately 8 m of freeboard under normal conditions, which is much greater than the anticipated displacements.
  - The potential for toe erosion to affect embankment stability was evaluated (KCB 2018a); the study indicates that the maximum flood level in Bullmoose Creek near the BTSF during the IDF[2] event is 2 m below Bullmoose Mine Road (see Figure 2 for Bullmoose Mine road location) and the flood inundation extent is at least 40 m (horizontal) from the BTSF toe (KCB 2018a).

Based on the above, key hazards related to the BTSF and the three potential failure modes are being managed effectively, and the BTSF is not seen as having the potential for a catastrophic flow failure in its current configuration under design flood and earthquake loading. Teck have indicated that the BTSF is a candidate for long-term landform status and KCB will be working with Teck over the near-term to establish the full nature of that candidacy.

5.4 Upstream and Downstream Conditions Review

5.4.1 Upstream

There have been no significant changes in the upstream condition since mine closure in 2003. No infrastructure is located upstream of the BTSF, with the exception of forest service and recreational roads.

[2] Two-thirds between 1,000-year and PMF event

5.4.2 Downstream

The downstream conditions were assessed as part of a flood inundation study (KCB 2014b) and there have been no significant changes since that time

5.5 Potential Consequence of Failure

Teck provided the following statement regarding the consequence classification of the facility:

> *Teck are aligned with the most conservative interpretation of the GISTM which, in turn, is consistent with their safety culture. Commensurately, Teck has advised that consequence classification is not a part of their tailings management governance and has asked that it not be reported in this AFPR. Instead, Teck will adopt the extreme consequence case design loading for any facility with a credible catastrophic flow failure mode. For facilities without a credible failure mode in terms of a life safety issue, Teck will reduce credible risks to As Low As Reasonably Practicable (ALARP). This consequence case applies for both earthquake and flood scenarios for all tailings facilities, consistent with the GISTM. Adopting this approach meets or exceeds regulatory requirements, aligns with Teck's goal to eliminate risk for loss of life, and is consistent with the GISTM. This approach is consistent with industry-leading best practices and has an added benefit of providing accurate narratives to communities about the safety of tailings facilities that could impact them and who share Teck's approach of one life is one too many to be at risk.*

The BTSF meets HSRC requirements, and as noted in the previous section, evaluations under extreme loading scenarios are on-going.

5.6 Physical Performance

5.6.1 Geotechnical

The facility has performed adequately for over 30 years and has shown no indications of geotechnical instability. There have been no significant changes to the geotechnical characteristics of the facility since operations ceased in 2003. As noted in Section 4, there were no threshold exceedances or unusual conditions observed during the review period, and instrumentation readings were consistent with historic trends and expected behaviour.

5.6.2 Hydrotechnical

The hydrotechnical performance of the facility during the review period was consistent with historic trends and expectations. There have been no significant changes to the spillway or water management system since operations ceased in 2003. As noted in Section 4, there were no pond level exceedances or unusual conditions observed during the review period.

5.7 Operational Performance

The BTSF has been closed since 2003 and there are no operational requirements.

5.8 Documentation Review

5.8.1 Operation, Maintenance and Surveillance Manual

The latest Operation, Maintenance, and Surveillance (OMS) Manual was issued in 2022 (Teck 2022) and is considered appropriate for the facility.

5.8.2 Emergency Preparedness and Response Plan

The EPRP was incorporated into the Bullmoose Mine MERP dated March 27, 2019 (Teck 2019b). BTSF management and incident command organization charts are up to date in the MERP document; however, contact information should be updated to reflect new personnel involved with the site. KCB understand that Teck are in the process of updating the MERP.

6 SUMMARY AND RECOMMENDATIONS

The observed performance of the BTSF is consistent with past behavior and design requirements. There have been no significant changes to the condition of the structure during the review period.

KCB identified no new deficiencies, non-conformances, or issues of concern in this years' review.

KCB has no new recommendations for 2021. A summary of past recommendations and their updated status is shown in Table 6.1. Closed recommendations are shown in grey italics and will be removed from the table in the next Annual Facility Performance Review report. Preliminary recommendations issued following the site visit were closed before this report was issued. When there are recommendations, each will have an assigned priority using the 2016 HSRC Guidance Document priority definitions:

- 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.

Table 6.1 Summary of Recommendations

Structure	ID Number	Deficiency or Non-Conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline / Status
Previous Recommendations Closed / Superseded						
BTD	*2019-01*	*Piezometer Review and Decommissioning*	*n/a*	*Review which piezometers and wells are functioning and decommission those that are defunct. Re-label all active piezometers following the review.*	*4*	*CLOSED (piezometers re-labelled and defunct instruments are noted in the updated OMS Manual, decommissioning to be coordinated with drilling program)*
BTD	*2019-03*	*Survey Monuments*	*OMS Manual Section 6.3.3.2*	*Document the procedure used to survey the BTSF survey monuments and include in the OMS Manual.*	*4*	*SUPERSEDED (recommendation is no longer applicable given that the survey monuments are going to be replaced by an alternate method.)*
Previous Recommendations Ongoing - None						
2021 Recommendations – no new recommendation (recommendations closed prior to the issue of this report)						

7 CLOSING

We thank you for the opportunity to work on this project. Should you have any questions, please do not hesitate to contact the undersigned.

Yours truly,
KLOHN CRIPPEN BERGER LTD.
B.C. Permit to Practice No. 1000171

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Project Manager
Civil Engineer

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PROVINCE OF BRITISH COLUMBIA
22 MAR 2022
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MC/RWC:jc

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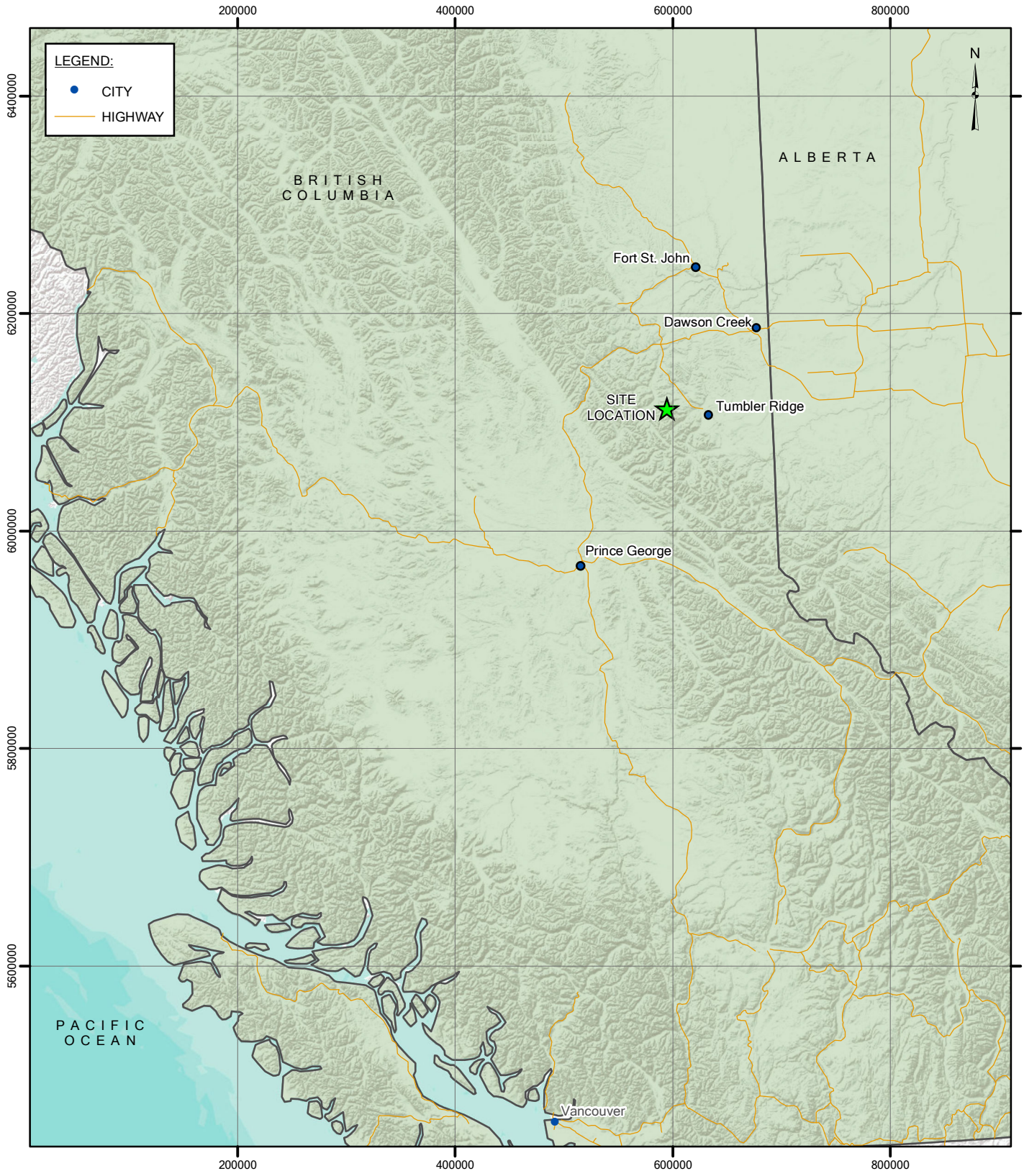
FIGURES



NOTES:
1. PROJECTION: NAD83 UTM ZONE 10N.
2. BASE DATA: ESRI.

SCALE 0 100,000 m

CLIENT: Teck

Klohn Crippen Berger

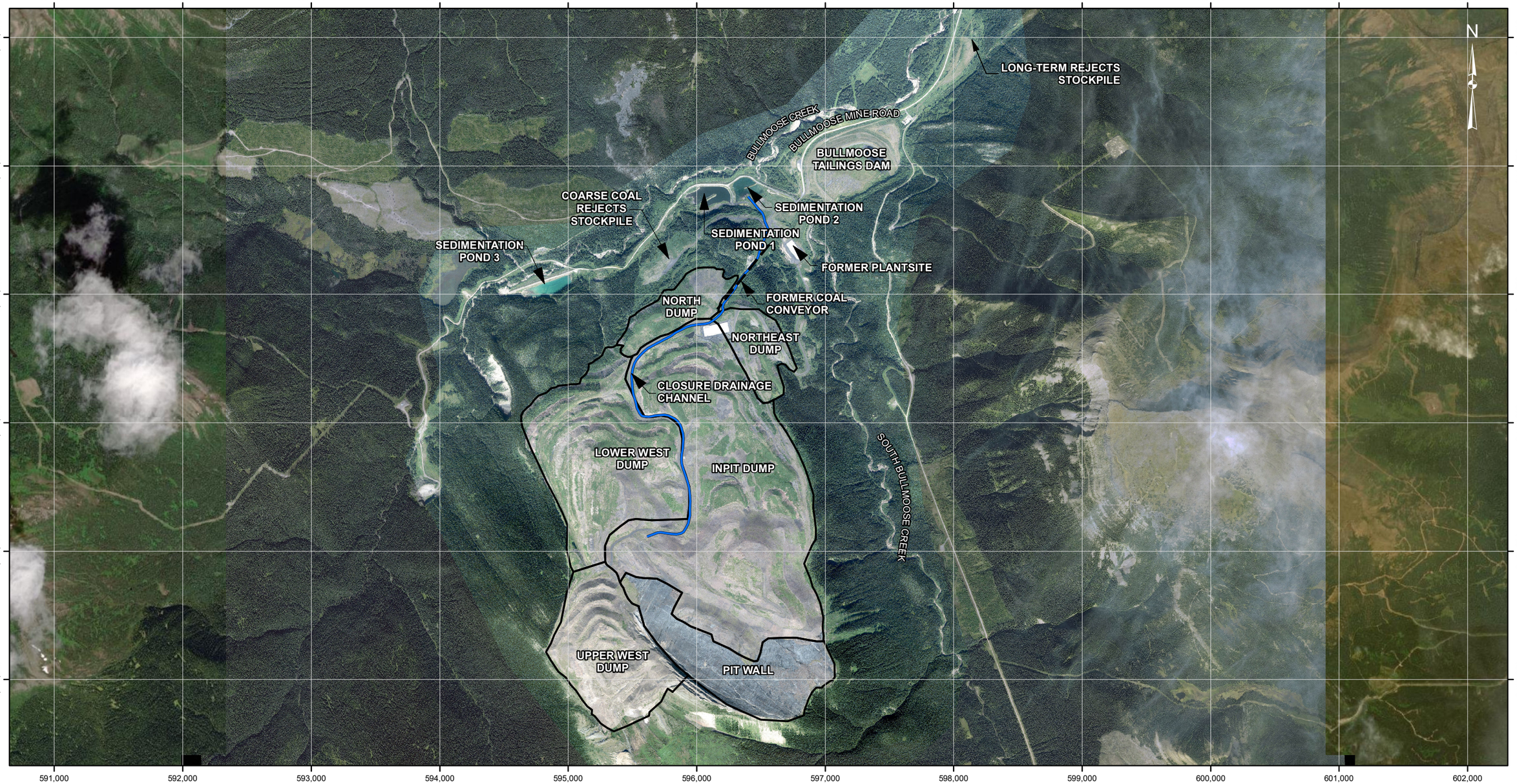
PROJECT: BULLMOOSE MINE
2021 ANNUAL FACILITY PERFORMANCE REVIEW

TITLE: SITE LOCATION

PROJECT No. M09893A12

FIG No. 1

Path: \\int.klohn.com\Proj\Data\M\VCR\M09893A12-TML-Bullmoose 2021 Consulting\400 Drawings\GIS\2021 Annual Review of Facility Performance\BTD\Fig1 BTD Site Location.mxd afischer



NOTES:
1. PROJECTION: NAD83 UTM ZONE 10N.
2. ORTHOPHOTO PROVIDED BY TECK.
   SOURCE: AIRBORNE IMAGING. 2020. "FINAL SURVEY REPORT: 15997 QUINTETTE/BULLMOOSE FOR TECK METALS". AUGUST 20.
   SUPPLEMENTAL IMAGERY FROM TECK DATED 2013.

LEGEND:

STRUCTURE BOUNDARY

SCALE 0 1,000 m

CLIENT: Teck

Klohn Crippen Berger

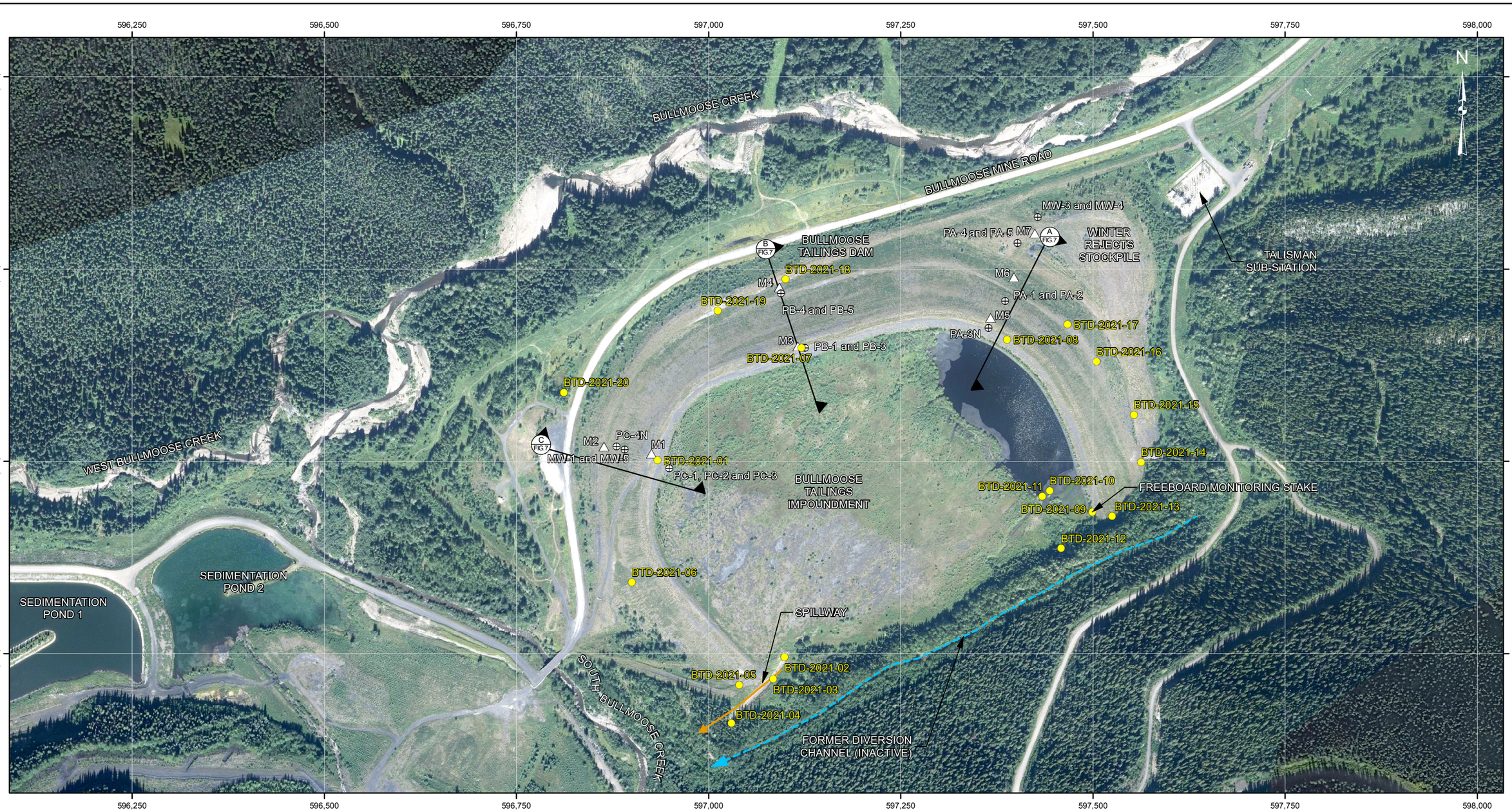
PROJECT: BULLMOOSE MINE
2021 ANNUAL FACILITY PERFORMANCE REVIEW

TITLE: GENERAL SITE PLAN

PROJECT No. M09893A12

FIG No. 2

Path: \\int.klohn.com\Proj\Data\MV\CR\M09893A12-TML-Bullmoose 2021 Consulting\400 Drawings\GIS\2021_Annual_Review_of_Facility_Performance\BTD\Fig2_BTD_General_Site_Plan.mxd



NOTES:
1. PROJECTION: NAD83 UTM ZONE 10N.
2. ORTHOPHOTO PROVIDED BY TECK.
   SOURCE: AIRBORNE IMAGING. 2020. "FINAL SURVEY REPORT: 15997 QUINTETTE/BULLMOOSE FOR TECK METALS". AUGUST 20.
   SUPPLEMENTAL IMAGERY FROM TECK DATED 2013.

LEGEND:

- BTD-2021-23 — 2021 SITE VISIT WAYPOINT
- M1 — SURVEY MONUMENT
- PC-4N — PIEZOMETER

SCALE 0 150 m

CLIENT: Teck

Klohn Crippen Berger

PROJECT: BULLMOOSE MINE
2021 ANNUAL FACILITY PERFORMANCE REVIEW

TITLE: BULLMOOSE TAILINGS DAM
GENERAL ARRANGEMENT

PROJECT No. M09893A12

FIG No. 3

Path: \\int.klohn.com\Proj\Data\MV\CR\M09893A12-TML-Bullmoose 2021 Consulting\400 Drawings\GIS\2021_Annual Review_of_Facility_Performance\BTD\Fig3_BTD_General_Arrangement.mxd

595,500 596,000 596,500 597,000 597,500 598,000 598,500 599,000

6,111,500 6,111,000 6,110,500 6,110,000

N

BULLMOOSE CREEK
BULLMOOSE MINE ROAD
TALISMAN SUB-STATION
BULLMOOSE TAILINGS DAM
WINTER REJECTS STOCKPILE
BULLMOOSE TAILINGS IMPOUNDMENT
WEST BULLMOOSE CREEK
SEDIMENTATION POND 2
SEDIMENTATION POND 1
SPILLWAY
FORMER DIVERSION CHANNEL (INACTIVE)
SOUTH BULLMOOSE CREEK

NOTES:
1. PROJECTION: NAD83 UTM ZONE 10N.
2. ORTHOPHOTO PROVIDED BY TECK.
SOURCE: AIRBORNE IMAGING. 2020. "FINAL SURVEY REPORT: 15997 QUINTETTE/BULLMOOSE FOR TECK METALS". AUGUST 20.
SUPPLEMENTAL IMAGERY FROM TECK DATED 2013.

LEGEND:
- Catchment Area – Normal Conditions
- Catchment Area – Flood Conditions

SCALE 0 250 m

CLIENT: Teck

Klohn Crippen Berger

PROJECT: BULLMOOSE MINE
2021 ANNUAL FACILITY PERFORMANCE REVIEW

TITLE: BULLMOOSE TAILINGS DAM CATCHMENT

PROJECT No. M09893A12

FIG No. 4

Path: \\int.klohn.com\Proj\Data\MV\CR\M09893A12-TML-Bullmoose 2021 Consulting\400 Drawings\GIS\2021_Annual Review_of_Facility_Performance\BTD\Fig4_BTD_Catchment.mxd

SECTION	PIEZOMETER	COORDINATES (m) (SEE NOTE 1)		ORIGINAL GROUND (masl) (SEE NOTE 2)	EXISTING GROUND ELEVATION (masl) (SEE NOTE 3)	PIEZO. SCREEN / TIP ELEVATION (masl)	MEASURED STICKUP (m)	2021 PNEUMATIC READING (PSI)	2021 STANDPIPE READING (m)	2021 WATER ELEVATION (masl)	WATER ELEVATION LOWER THAN (IF DRY)	THRESHOLD (LEVEL 1) (masl)	WATER LEVEL ABOVE ORG. GROUND (m)	2020 WATER ELEVATION (masl)	CHANGE FROM 2020 (m)	PIEZOMETER LOCATION	
		EASTING	NORTHING													LOCATION	UNIT
SECTION A	PA-1 (RELABELLED IN 2017)	597396	6111244	1084.0	1112.5	1077.3	0.76		35.0	DRY	1077.3	≥1100.0	N/A	1077.3	N/A	DOWNSTREAM SLOPE	FOUNDATION
	PA-2 (RELABELLED IN 2017)	597396	6111244	1084.0	1112.5	1083.4	0.71	-	27.7	1085.5	-	≥1100.0	1.5	DRY	N/A	DOWNSTREAM SLOPE	DAM
	PA-4	597402	6111284	1081.0	1092.7	1077.3	1.74	-	12.4	1082.0	-	≥1088.0	1.0	1083.4	-1.4	DOWNSTREAM SLOPE	FOUNDATION
	PA-5	597402	6111284	1081.0	1092.7	1079.0	1.83	-	12.7	1081.9	-	≥1088.0	0.8	1083.2	-1.4	DOWNSTREAM SLOPE	DAM
	PA-3N	597364	6111174	1082.0	1123.0	1094.8	-	0.5	-	1095.1	-	≥1107.0	13.1	DRY	N/A	CREST	DAM
	NO LABEL (MW-3)	597428	6111318	1076.7	1090.0	1053.7	1.30	-	23.1	1068.2	-	≥1095.0	-8.5	1069.0	-0.8	DOWNSTREAM SLOPE	FOUNDATION
	NO LABEL (MW-4)	597428	6111318	1076.7	1090.0	1068.3	1.23	-	16.2	1075.0	-	≥1095.0	-1.7	1075.6	-0.6	DOWNSTREAM SLOPE	FOUNDATION
	PN-2	597483	6111110	-	1114.0	1102.9	-	0.4	-	1103.2	-	≥1104.4	-	-	-	DOWNSTREAM SLOPE	DAM
SECTION B	NO LABEL (LIKELY PB-1)	597126	6111148	1086.0	1123.0	1081.9	0.20	-	40.0	DRY	1083.2	≥1107.0	N/A	DRY	N/A	CREST	FOUNDATION
	PB-3	597126	6111148	1086.0	1123.0	1099.5	1.06	-	24.2	DRY	1099.8	≥1107.0	N/A	DRY	N/A	CREST	DAM
	PB-4	597094	6111219	1086.0	1100.5	1080.1	1.33	-	20.3	1081.6	-	≥1095.0	-4.5	DRY	N/A	DOWNSTREAM SLOPE	FOUNDATION
	PB-5	597094	6111219	1086.0	1100.5	1081.6	1.36	-	20.2	1081.7	-	≥1095.0	-4.4	DRY	N/A	DOWNSTREAM SLOPE	FOUNDATION
SECTION C	PC-1	596949	6110991	1091.0	1120.5	1083.7	1.04	-	36.1	1085.4	-	≥1110.0	-5.6	DRY	N/A	CREST	FOUNDATION
	PC-2	596949	6110991	1091.0	1120.5	1090.3	1.74	-	30.6	DRY	1091.6	≥1110.0	N/A	DRY	N/A	CREST	DAM
	PC-3	596949	6110991	1091.0	1120.5	1101.8	1.38	-	19.6	DRY	1102.3	≥1110.0	N/A	DRY	N/A	CREST	DAM
	NO LABEL (MW-1/MW-5)	596891	6111015	1093.5	1111.5	UNKNOWN	0.68	-	23.3	1088.9	-	-	-4.6	DRY	N/A	DOWNSTREAM SLOPE	FOUNDATION
	NO LABEL (MW-1/MW-5)	596891	6111015	1093.5	1111.5	UNKNOWN	1.04	-	18.0	DRY	1094.5	-	N/A	DRY	N/A	DOWNSTREAM SLOPE	FOUNDATION
	PC-4N	596881	6111020	1094.0	1109.5	1093.5	-	0.9	-	1094.1	-	≥1100.0	0.1	DRY	N/A	DOWNSTREAM SLOPE	FOUNDTATION

NOTES

1. COORDINATES LOCATIONS ARE FROM GPS READINGS (NAD83 UTM ZONE 10N).
2. ORIGINAL GROUND ELEVATION IN TABLE ARE FROM KL (1982).
3. EXISTING GROUND ELEVATIONS WERE PROVIDED BY TECK.

CLIENT: Teck

Klohn Crippen Berger

PROJECT: BULLMOOSE MINE
2021 ANNUAL FACILITY PERFORMANCE REVIEW

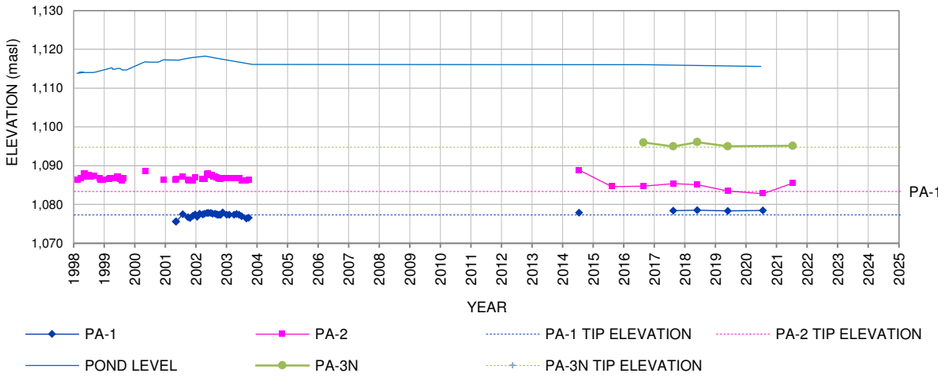
TITLE: BULLMOOSE TAILINGS DAM
2021 PIEZOMETER READINGS

PROJECT No. M09893A12

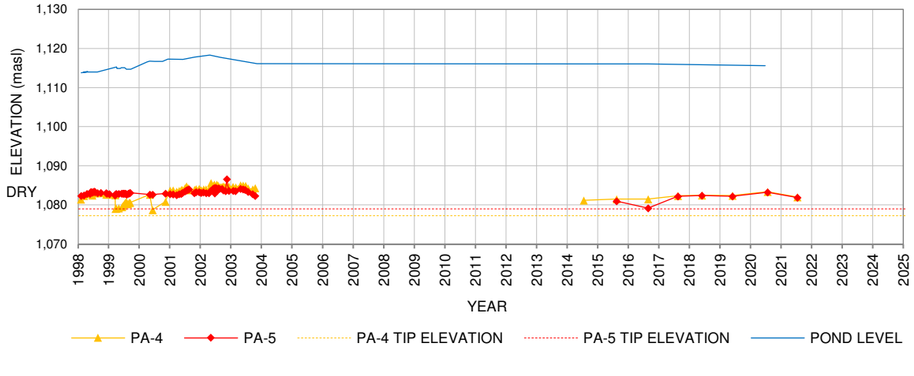
FIG. No. 5

Date & Time: 2021-11-15 6:31
Figure File: Z:\M\VCR\M09893A12-TML-Bullmoose 2021 Consulting\300 Design\01 AFPR\Piezometers\[Bullmoose Piezometer.xlsx]Figure B

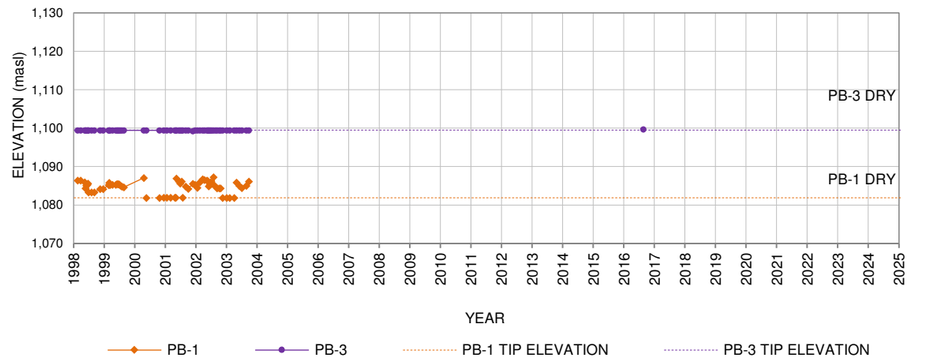
SECTION A - MID-SLOPE



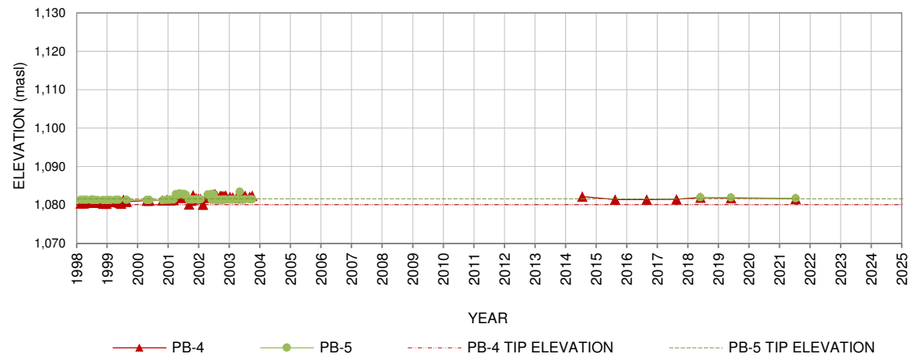
SECTION A - TOE



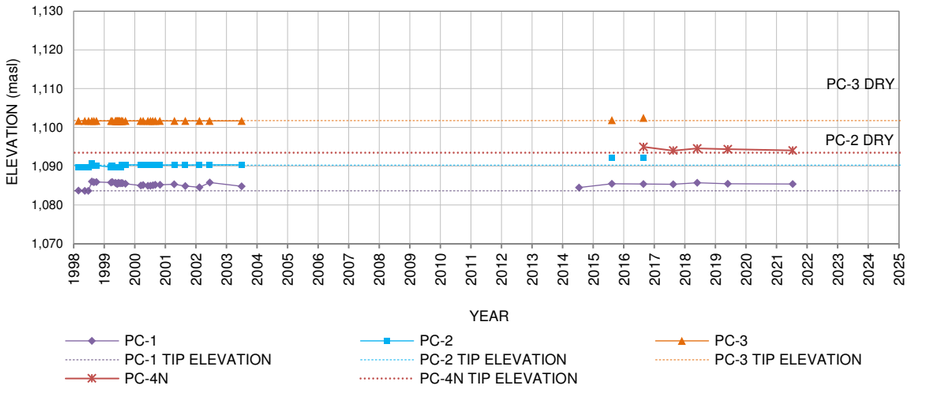
SECTION B - CREST



SECTION B - TOE



SECTION C - CREST



CLIENT

Teck

Klohn Crippen Berger

PROJECT

BULLMOOSE MINE
2021 ANNUAL FACILITY PERFORMANCE REVIEW

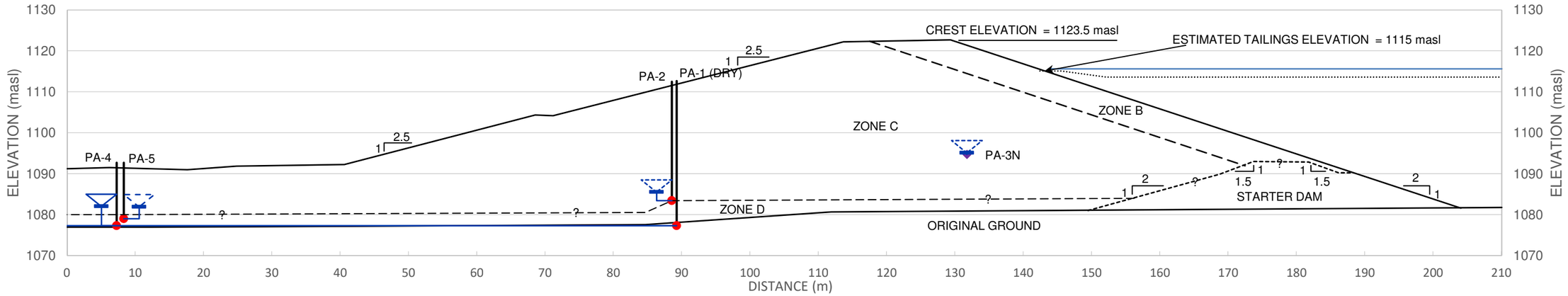
TITLE

BULLMOOSE TAILINGS DAM
HISTORICAL PIEZOMETER READINGS

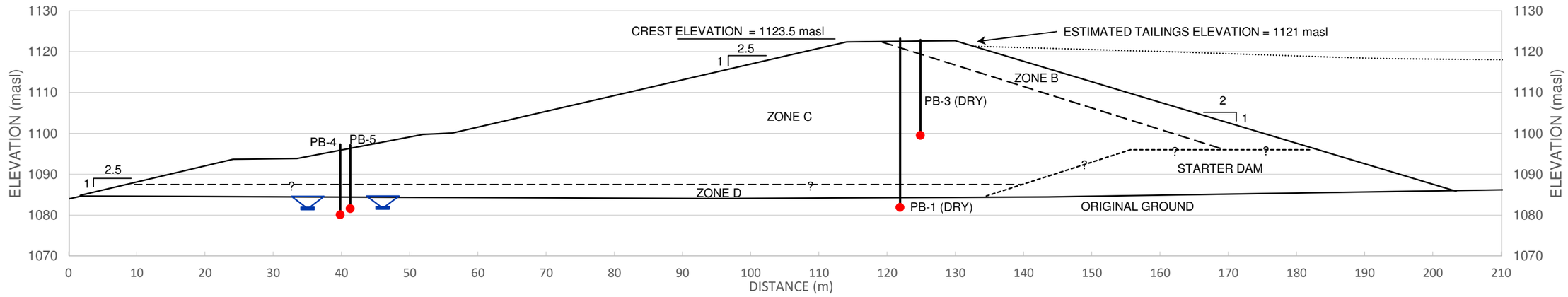
PROJECT No. M09893A12

FIG. No. 6

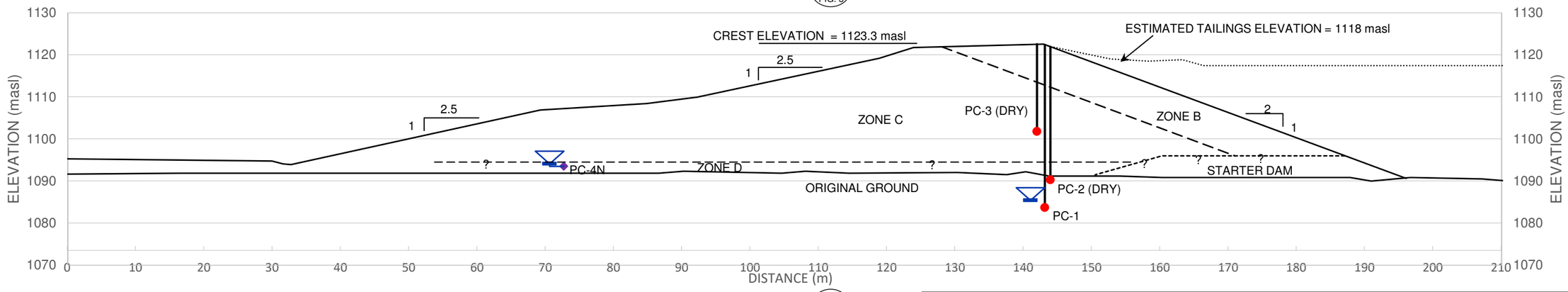
Date & Time: 2021-11-15 6:31
Figure File: Z:\M\VCR\M09893A12-TML-Bullmoose 2021 Consulting\300 Design\01 AFPR\Piezometers\[Bullmoose Piezometer.xlsx]Figure B



SECTION A (FIG. 3)



SECTION B (FIG. 3)



SECTION C (FIG. 3)

NOTES:

1. SECTION DRAWINGS PRODUCED BY TECK (2004).
2. STARTER DAM SECTION OBTAINED FROM KLOHN LEONOFF (1984).
3. ZONE B AS-BUILT PRODUCED BY TECK (2000).

LEGEND:

- STANDPIPE PIEZOMETER TIP
- PNEUMATIC PIEZOMETER TIP
- EMBANKMENT PIEZOMETER WATER LEVEL
- FOUNDATION PIEZOMETER WATER LEVEL

Klohn Leonoff 1982 Design Report:

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

CLIENT: Teck

Klohn Crippen Berger

PROJECT: BULLMOOSE MINE
2021 ANNUAL FACILITY PERFORMANCE REVIEW

TITLE: BULLMOOSE TAILINGS DAM INSTRUMENTATION SCHEMATIC SECTIONS A, B AND C

PROJECT No. M09893A12

FIG. No. 7

Date & Time: 2021-11-15 6:31
Figure File: Z:\MVCR\M09893A12-TML-Bullmoose 2021 Consulting\300 Design\01 AFPR\Piezometers\[Bullmoose Piezometer.xlsx]Figure B

APPENDIX I

Register of Reference Documents

Appendix I
Register of Reference Documents

Document Title	Author	Date of Issue
Bullmoose Coal Project - Phase II - Geotechnical, Hydrogeological and Water Management Study - Report II - Project Description, Geologic Setting and Phase II Field Investigation	Hardy Associates Ltd.	08-Jan-82
Bullmoose Coal Project - Phase II - Geotechnical, Hydrogeological and Water Management Study - Report VI - Tailings Disposal Facility Geotechnical Study	Hardy Associates Ltd.	23-Feb-82
Bullmoose Coal Project - Phase II - Geotechnical, Hydrogeological and Water Management Study - Report X - Construction Materials	Hardy Associates Ltd.	30-Mar-82
Sedimentation Ponds No. 1 and No. 2 Bullmoose Coal Project - Geotechnical Design Report	Klohn Leonoff	25-Jun-82
Bullmoose Coal Project - Tailings Dam Design Report	Klohn Leonoff	Oct-82
Bullmoose Coal Project - DESIGN: Sedimentation Pond No. 3	Klohn Leonoff	25-Feb-83
Bullmoose Tailings Disposal 1983 Starter Dam Construction	Klohn Leonoff	14-Mar-1984
Annual Review of Tailings Dam - 1984/85	Bullmoose Operating Corporation	Aug-85
Annual Review of Tailings Dam 1986/87	Klohn Leonoff	11-Aug-87
Report on Site Visit July 24, 1987 and Annual Review of Tailings Dam 1986/87	Klohn Leonoff	11-Aug-87
Bullmoose Coal Project Hydrogeology Study	Klohn Leonoff	Nov-87
Annual Review of Tailings Dams for 1987/88	Klohn Leonoff	09-Sep-88
Annual Review of Operations - 1987/88	Bullmoose Operating Corporation	Aug-88
Annual Review of Tailings Dams for 1988/1989	Klohn Leonoff	28-Aug-89
Annual Review of Operations - 1988/89	Bullmoose Operating Corporation	Aug-89
1989-90 Annual Review of Tailings Dam	Klohn Leonoff	30-Aug-90
Tailings Pond Annual Review of Operations - 1989/90	Bullmoose Operating Corporation	Aug-90
1990-91 Annual Review of Tailings Dam	Klohn Leonoff	29-Aug-91
Annual Review of Operations - 1990/91	Bullmoose Operating Corporation	Jul-91
1991-92 Annual Review of Tailings Dam	Klohn Leonoff	26-Aug-92
Annual Review of Operations 1991/92	Bullmoose Operating Corporation	Jul-92
1992-93 Annual Review of Tailings Dam	Klohn Crippen	30-Aug-93
Annual Review of Operations 1992/93	Bullmoose Operating Corporation	Jul-93
Annual Review of Operations 1993/94	Bullmoose Operating Corporation	Jul-94
May Site Visit: Tailings Dam Recommendations	Klohn Crippen	01-Jun-95
South Fork Tailings Dam - Seepage and Stability Review	Klohn Crippen	Oct. 1996
1996 Annual Review of Tailings Facility	Klohn Crippen	17-Dec-96
Density Comparison, Tailings Dam Construction - Bullmoose Mine, Tumbler Ridge, BC	Peace Country Materials Testing Ltd.	04-Jun-97
1997 Annual Review of Tailings Facility	Klohn Crippen	17-Dec-97
Annual Review of Operations 1997/98 Tailings Pond	Bullmoose Operating Corporation	Dec-98
1998 Annual Review of Tailings Facility	Klohn Crippen	13-Jan-99
Bullmoose Tailings Facility Establishment of Threshold Warning Levels of Piezometers	Klohn Crippen	Oct-99
Summary of Site Visit on September 23, 1999	Klohn Crippen	19-Nov-99
Annual Review of Operations 1998/99 Tailings Pond	Bullmoose Operating Corporation	Nov-99
Tailings Impoundment Closure Report - Draft	Bullmoose Operating Corporation	Jan-00
1999 Annual Review	Klohn Crippen	07-Feb-00
Annual Review of Operations	Bullmoose Operating Corporation	Nov-00
Review of 2000 Tailings Operations Report	Klohn Crippen	Dec-00
Annual Review of Operations	Bullmoose Operating Corporation	Nov-01
Tailings Impoundment Closure Spillway Design	Klohn Crippen	Dec-01
Review of 2001 Tailings Operations Report	Klohn Crippen	18-Dec-01
Tailings Impoundment Closure Spillway - Review of Proposed Layout	Klohn Crippen	Oct-02
Bullmoose Mine Review of 2002 Tailings Operations Report	Klohn Crippen	18-Dec-02
Annual Review of Operations	Bullmoose Operating Corporation	Nov-2003
Bullmoose Mine Review of 2003 Tailings Operations Report	Klohn Crippen	18-Dec-2003
Bullmoose Tailings Facility Closure Spillway Inspection on September 22, 2004	Klohn Crippen	Oct-2004
Tailings Dam Annual Review of Operations	Bullmoose Operating Corporation	01-Nov-04
Bullmoose Mine Review of 2004 Tailings Operations Report	Klohn Crippen	Dec. 2004
Bullmoose 2010 Dam Safety Inspection and Consequence Classification	Klohn Crippen Berger	01-Mar-11
Bullmoose Tailings Impoundment 2012 Dam Safety Inspection	Teck	Aug-13
Bullmoose Mine 2013 Dam Safety Inspection	Klohn Crippen Berger	25-Mar-14
Bullmoose Mine Tailings Dam Design Review	Klohn Crippen Berger	15-Aug-14
Bullmoose Mine Tailings Storage Dam 2014 Dam Safety Inspection Revision 1	Klohn Crippen Berger	26-Nov-14
Bullmoose Mine Tailings Storage Facility - Dam Breach and Inundation Study	Klohn Crippen Berger	27-Nov-14
Bullmoose Mine Tailings Storage Facility - Response to February 3, 2015 MEM Memorandum	Klohn Crippen Berger	29-Jun-15
Bullmoose Mine 2015 Consulting - Tailings Storage Facility Hydrotechnical Review	Klohn Crippen Berger	22-Dec-15
Bullmoose Mine Tailings Storage Dam – 2015 Dam Safety Inspection	Klohn Crippen Berger	22-Mar-16
Bullmoose Tailings Storage Facility Engineer of Record	Klohn Crippen Berger	23-Sep-16
Bullmoose Mine Tailings Dam - Water Management, Water Balance and Quantifiable Performance Objectives	Klohn Crippen Berger	22-Dec-16
Bullmoose Mine Tailings Storage Dam – 2016 Dam Safety Inspection	Klohn Crippen Berger	01-Mar-17
Bullmoose Tailings Dam - Review of Monument Survey Data - May, 2017	Klohn Crippen Berger	09-Jun-17
Survey Monuments Quantifiable Performance Objectives	Klohn Crippen Berger	25-Aug-17
Review of Seismic Hazard Assessment	Klohn Crippen Berger	13-Oct-17
Bullmoose Mine Tailings Storage Dam – 2017 Dam Safety Inspection - Revision 1	Klohn Crippen Berger	16-Mar-18
Bullmoose Tailings Dam – Closure Passive Care - Draft	Klohn Crippen Berger	26-Feb-18
Bullmoose Creek Flood Study	Klohn Crippen Berger	22-Jun-18
Bullmoose Tailings Dam - Internal Stability Assessment	Klohn Crippen Berger	03-Dec-18

APPENDIX II

Inspection Photographs

Appendix II
Inspection Photographs

LEGEND:

- BTD = Bullmoose Tailings Dam
- BTD-2021-## refers to the 2021 site visit photograph location, as shown on Figure 3

Photographs were taken during site inspection on July 14, 2021.

Photo II-1 BTD crest – Looking south (BTD-2021-01)

Photo II-2 Spillway Inlet – Looking downstream (BTD-2021-02)

Photo II-3 Spillway Inlet– Looking downstream (BTD-2021-02)

Photo II-4 Spillway Inlet – Riprap material (BTD-2021-02)

Photo II-5 Spillway – Looking upstream (BTD-2021-03)

Photo II-6 Spillway – Bedrock exposed along bank (BTD-2021-03)

Photo II-7 Spillway – Bedrock exposed along bank (BTD-2021-03)

Photo II-8 Spillway Outlet – Looking upstream (BTD-2021-04)

Photo II-9 Spillway Outlet – Looking downstream from discharge point (BTD-2021-04)

Photo II-10 Spillway Outlet – Riprap material (BTD-2021-04)

Photo II-11 BTD Downstream Slope – Looking north (BTD-2021-05)

Photo II-12 BTD Downstream Slope – Looking southeast (BTD-2021-06)

Photo II-13 BTD Downstream Slope – Looking north (BTD-2021-06)

Photo II-14 BTD Crest – Looking northeast (BTD-2021-07)

Photo II-15 BTD Impoundment – Looking east (BTD-2021-07)

Photo II-16 BTD Crest – Looking northwest (BTD-2021-08)

Photo II-17 BTD Pond – Looking south (BTD-2021-08)

Photo II-18 Water level stake (BTD-2021-09)

Photo II-19 Pond – High water mark indicated by edge of vegetation (BTD-2021-10)

Photo II-20 Pond – Edge of water (BTD-2021-11)

Photo II-21 Location of historic slide (BTD-2021-12)

Photo II-22 Pond– Looking northwest (BTD-2021-13)

Photo II-23 BTD Downstream Slope – Looking north (BTD-2021-13)

Photo II-24 BTD Downstream slope – Looking northwest (BTD-2021-14)

Photo II-25 BTD Toe – Ponded water at toe (BTD-2021-14)

Photo II-26 BTD Toe – Erosion gully at toe (BTD-2021-15)

Photo II-27 Piezometer PN-3 needs repair (BTD-2021-16)

Photo II-28 BTD Downstream slope – Looking south (BTD-2021-17)

Photo II-29 BTD Downstream slope – Looking northwest (BTD-2021-17)

Photo II-30 BTD Toe – Known wet area was dry at time of site visit (BTD-2021-18)

Photo II-31 BTD Downstream slope – Looking east (BTD-2021-18)

Photo II-32 BTD Downstream slope – Looking west (BTD-2021-18)

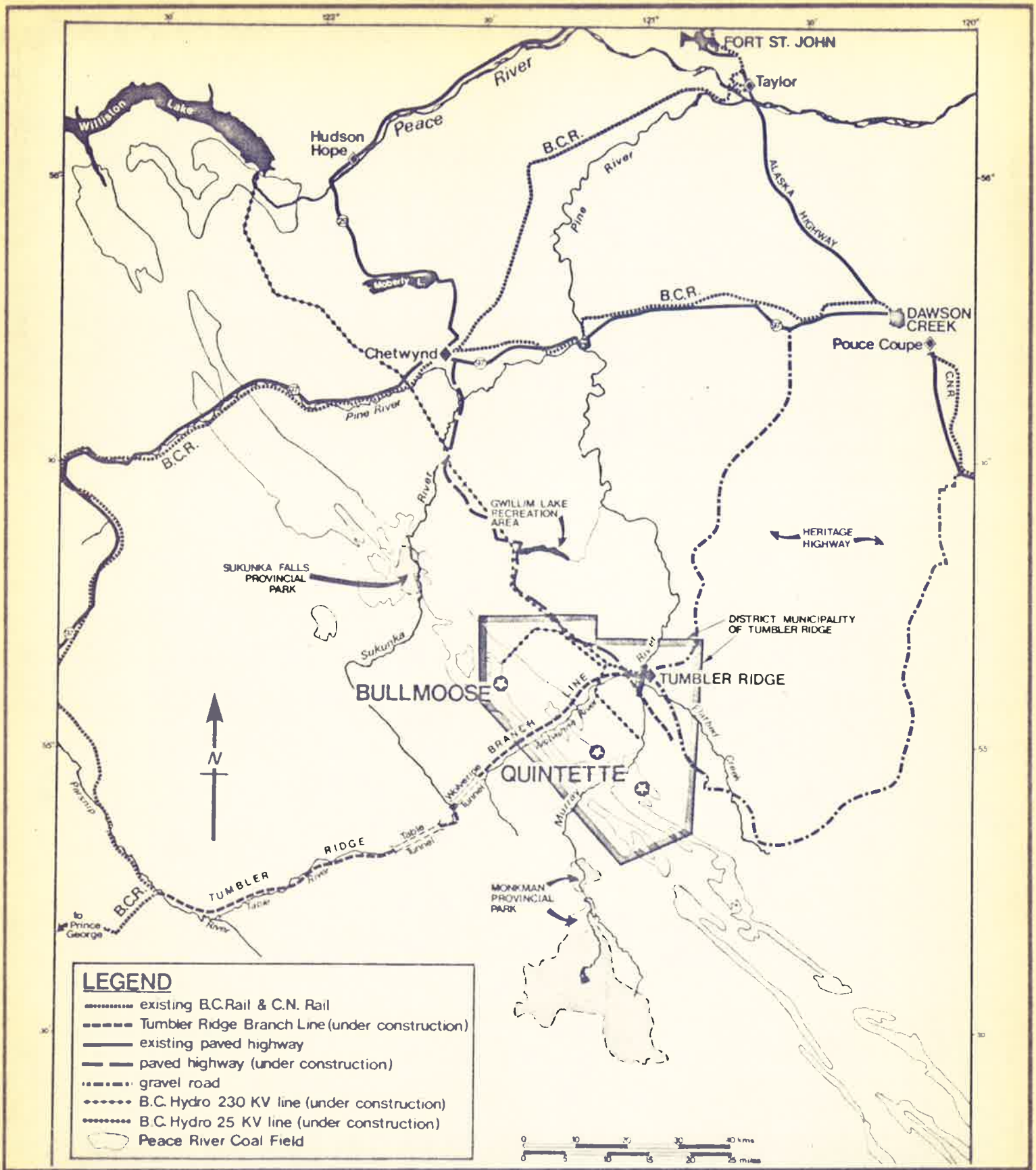
Photo II-33 BTD Toe – Known wet area was dry at time of site visit (BTD-2021-19)

Photo II-34 BTD Downstream slope – Looking east, known wet area was dry at time of site visit (BTD-2021-19)

Photo II-35 BTD Downstream slope – Looking west (BTD-2021-19)

APPENDIX III

Dam Design Drawings



KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

TITLE: LOCATION PLAN

CLIENT: BULLMOOSE OPERATING CORPORATION

DATE OF ISSUE: OCT. 22, 1982

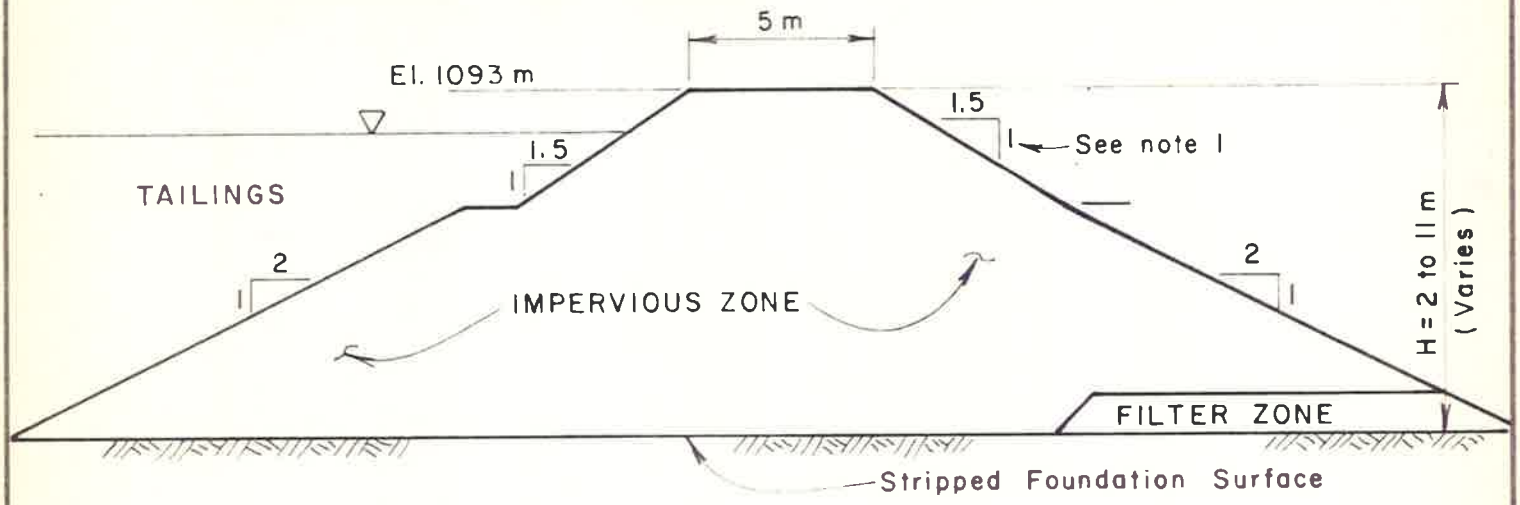
APPROVED: H. N. McLEOD

PROJECT No: PB2971-02

DWG No: A-101

REV:

PROFESSIONAL ENGINEER — BRITISH COLUMBIA



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

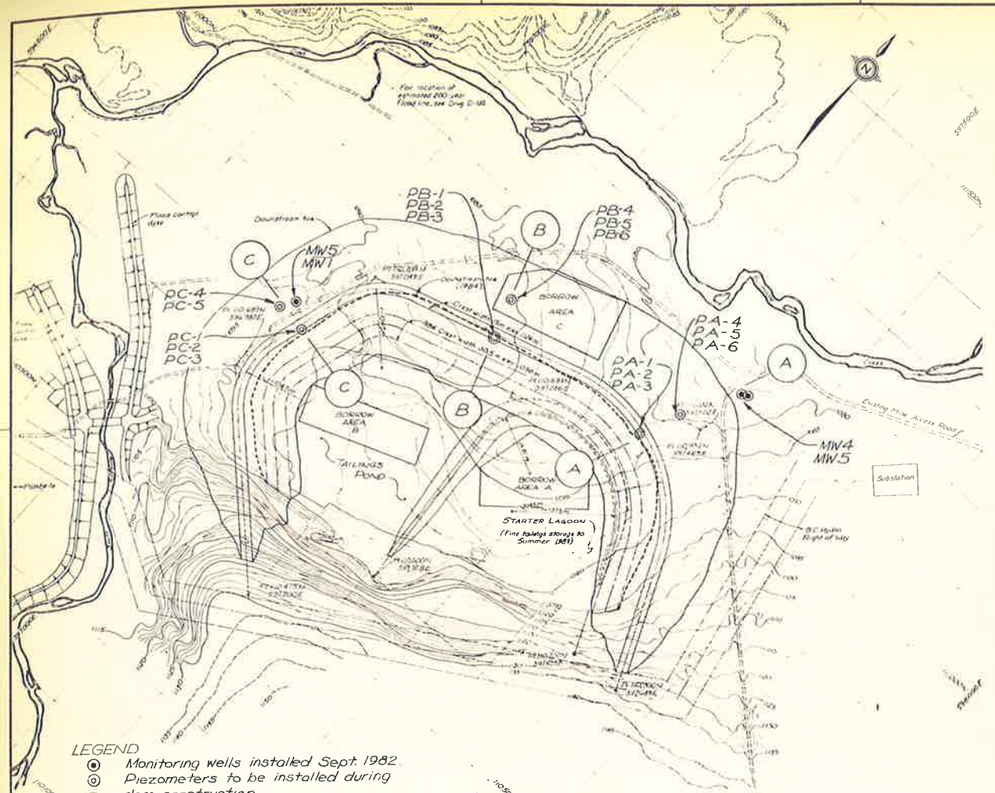
KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT: BULLMOOSE COAL PROJECT

TITLE: TAILINGS STARTER DAM
TYPICAL AS-BUILT SECTION

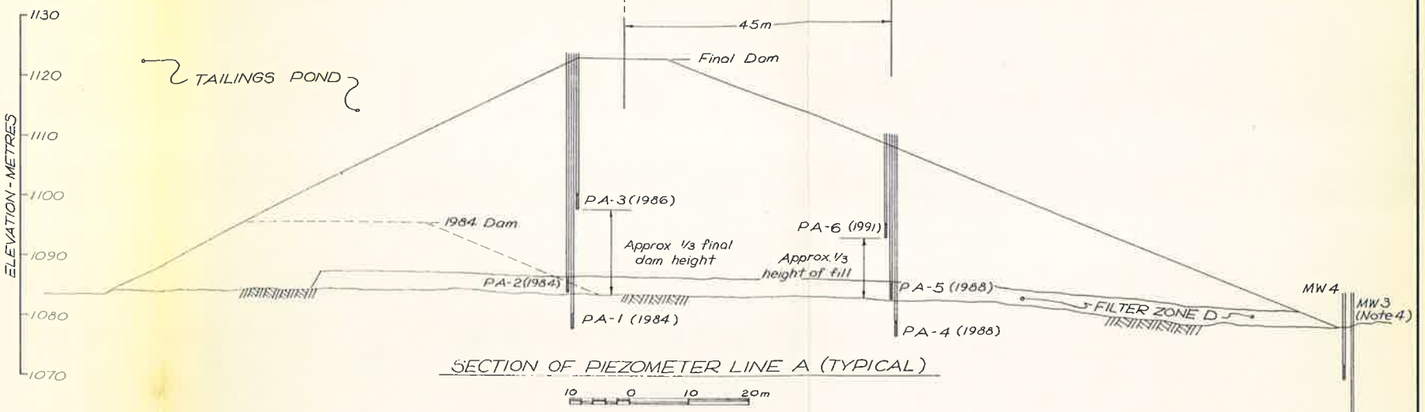
CLIENT: BULLMOOSE OPERATING CORPORATION

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

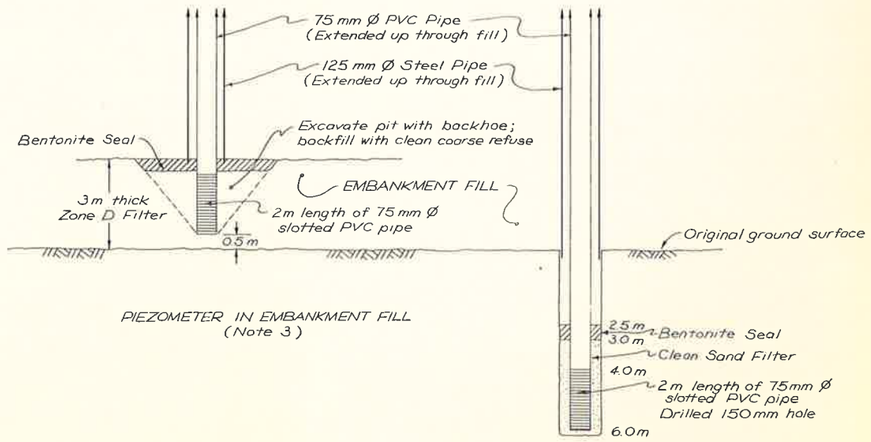


LEGEND
- ◉ Monitoring wells installed Sept 1982
- ◎ Piezometers to be installed during dam construction.
- (A) Piezometer Lines

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

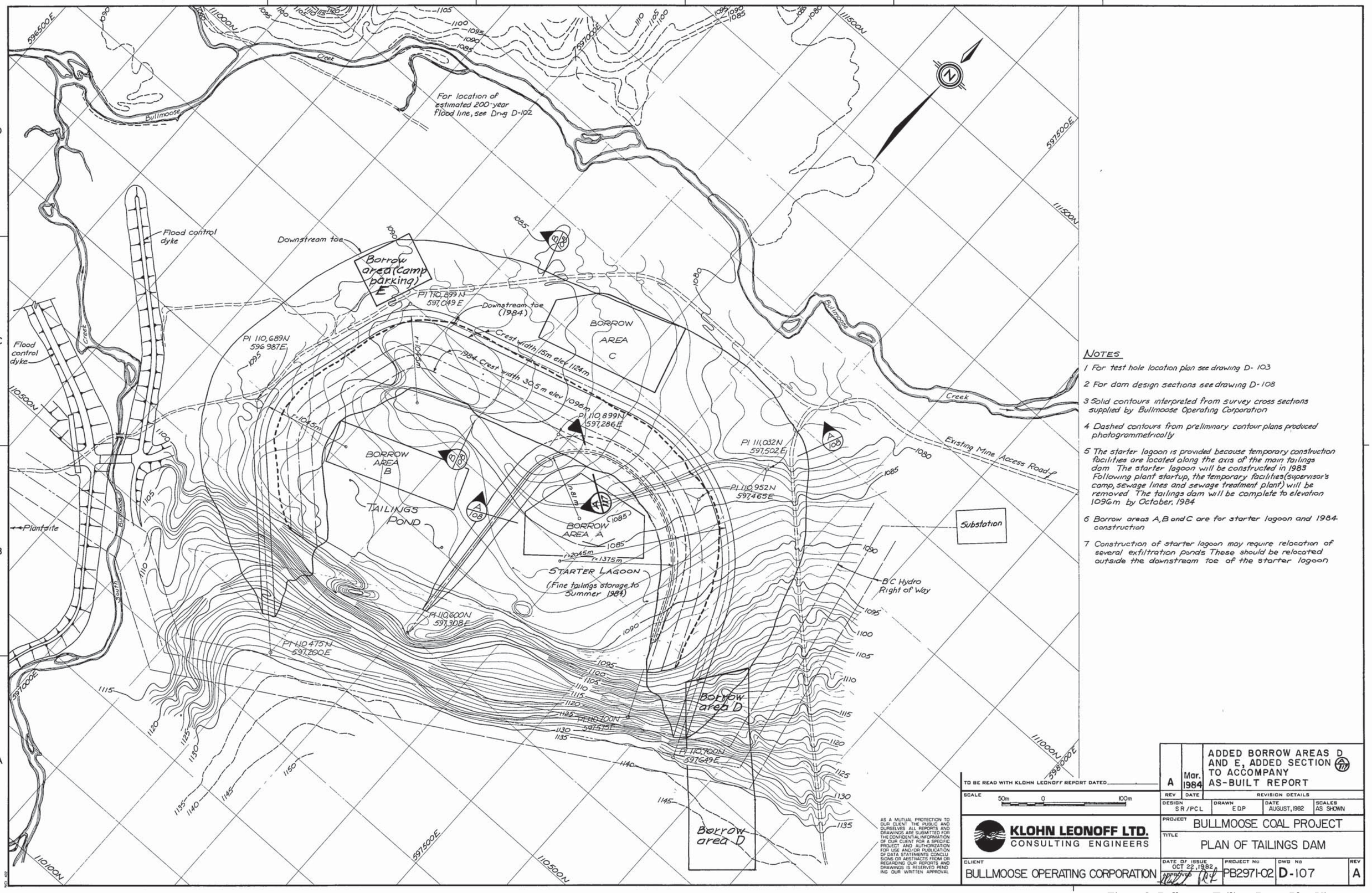
TITLE: PLAN, SECTION & DETAILS OF TAILINGS DAM PIEZOMETERS

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

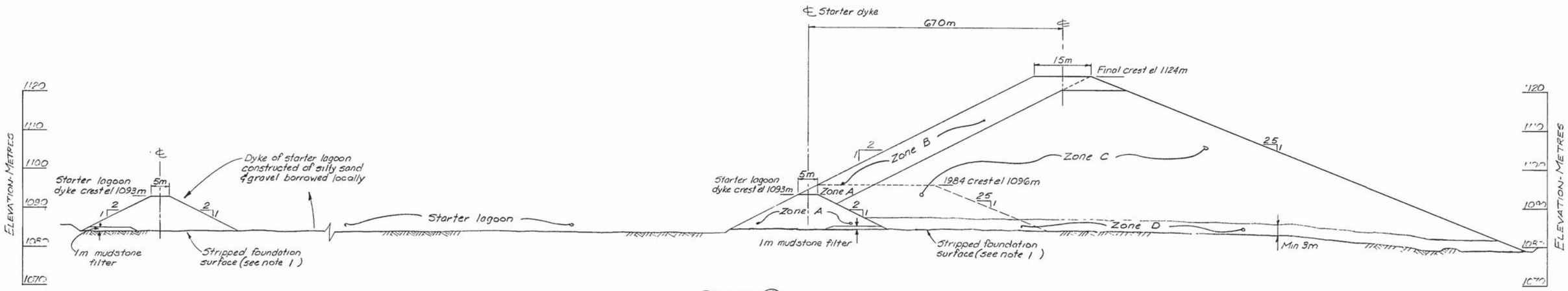
TITLE PLAN OF TAILINGS DAM

CLIENT BULLMOOSE OPERATING CORPORATION

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

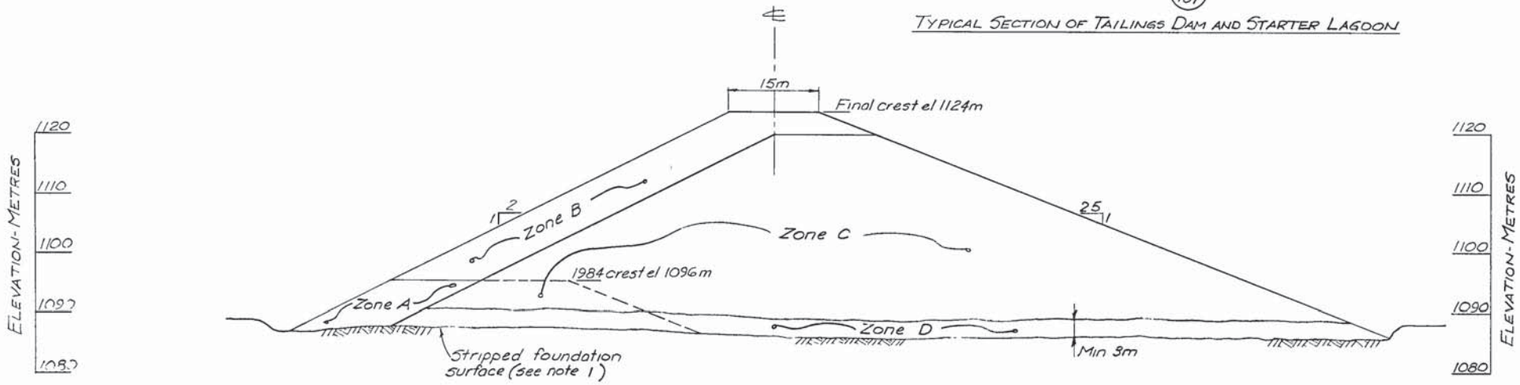
APPROVED

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

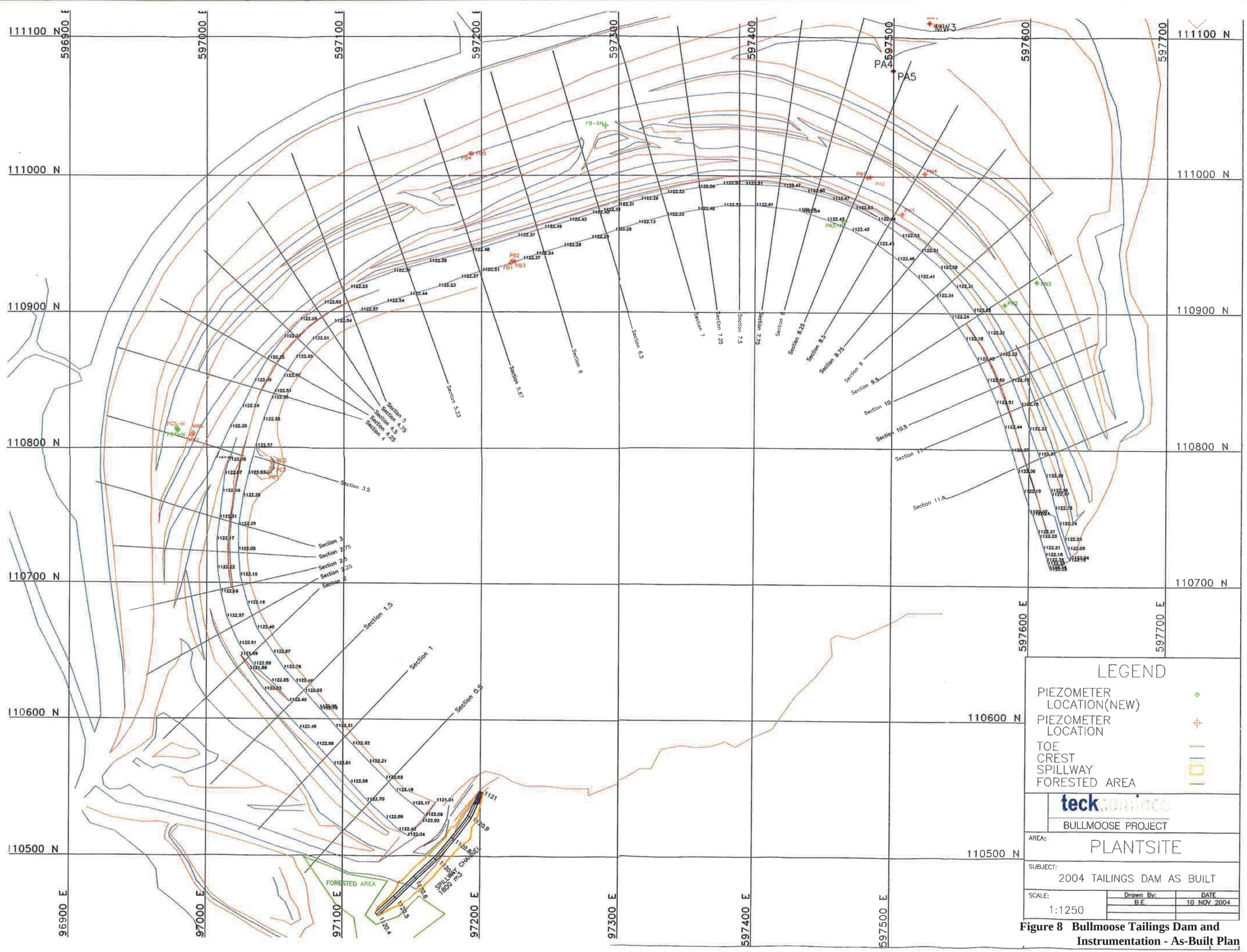
TITLE: TYPICAL SECTIONS OF TAILINGS DAM

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

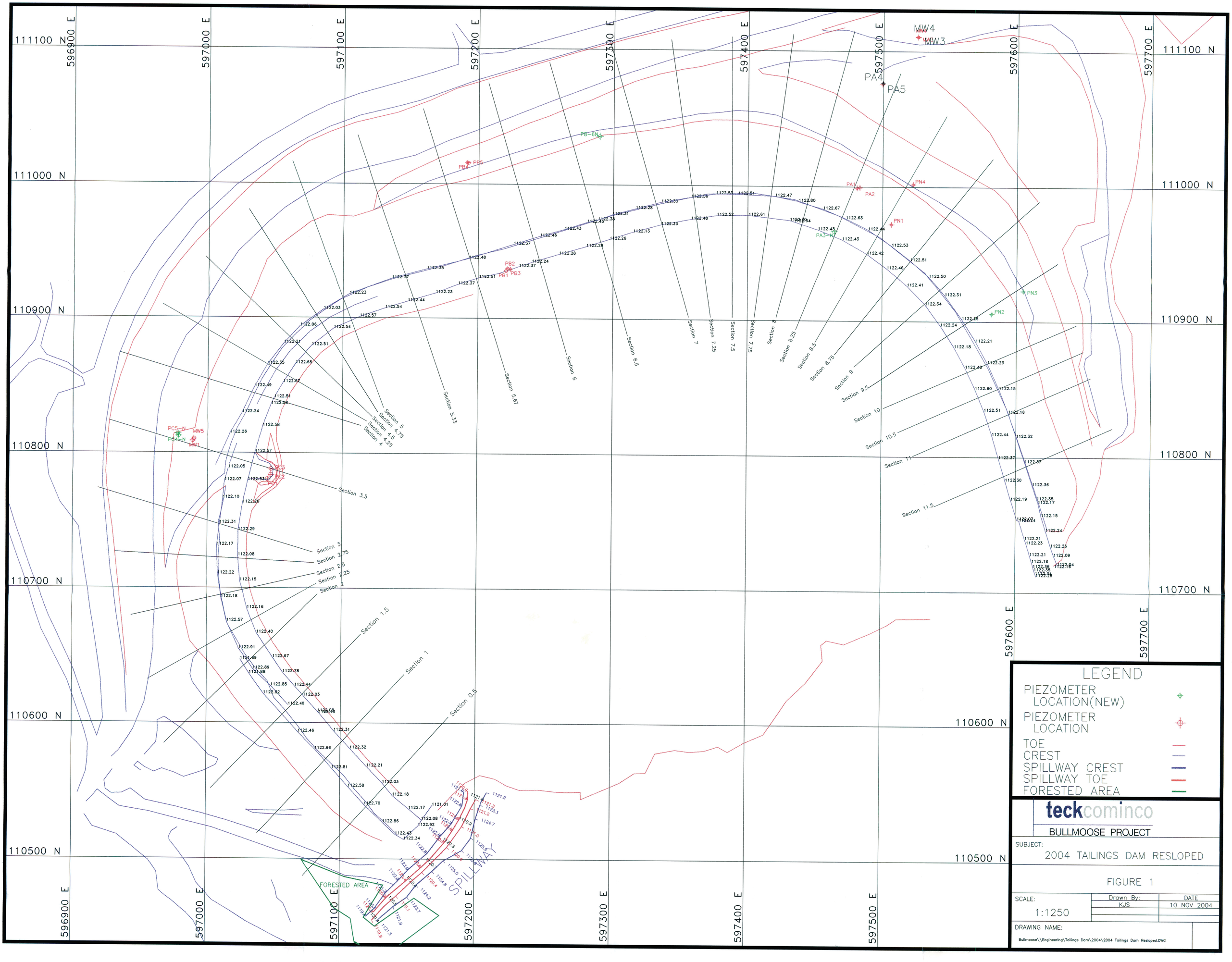
BULLMOOSE PROJECT

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



LEGEND

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

teckcominco

BULLMOOSE PROJECT

SUBJECT:

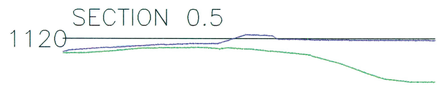
2004 TAILINGS DAM RESLOPED

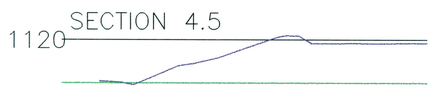
FIGURE 1

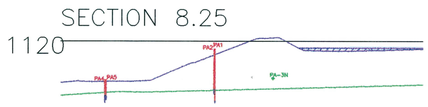
SCALE:	Drawn By:	DATE
1:1250	KJS	10 NOV 2004

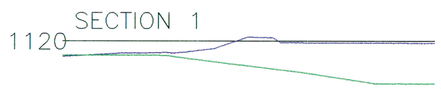
DRAWING NAME:

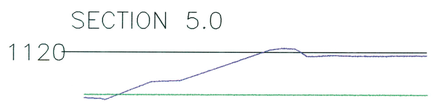
Bullmoose\\Engineering\Tailings Dam\2004\2004 Tailings Dam Resloped.DWG

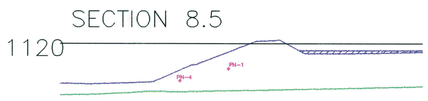


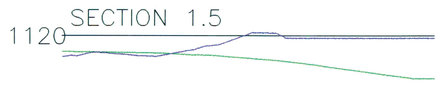


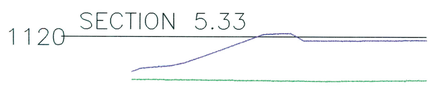


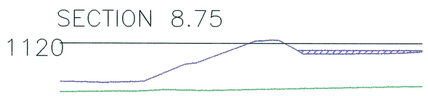


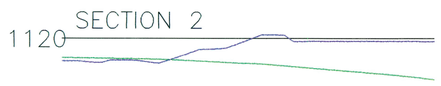


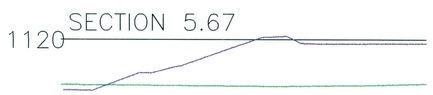


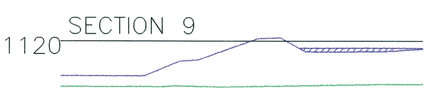


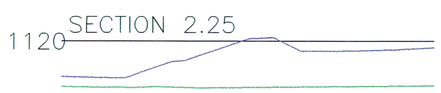


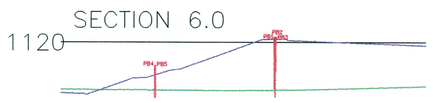


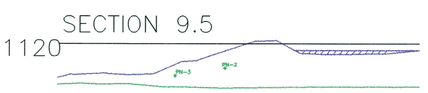


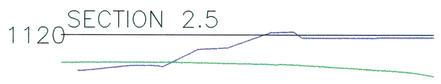


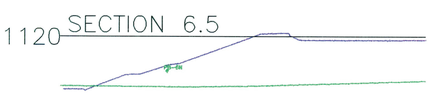


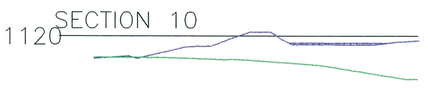


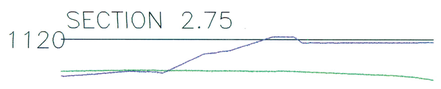


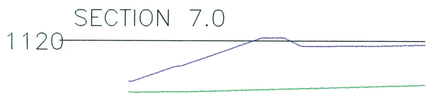


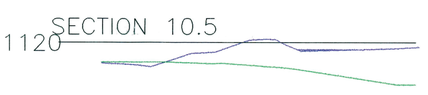


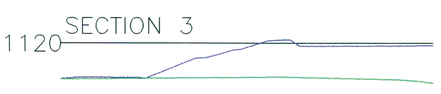


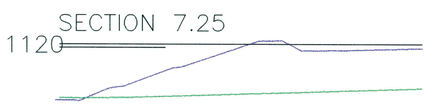


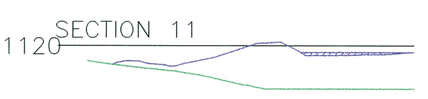


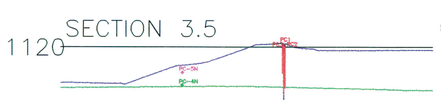


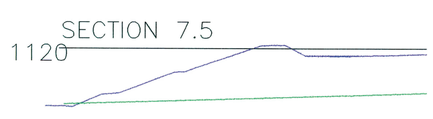


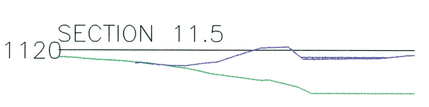


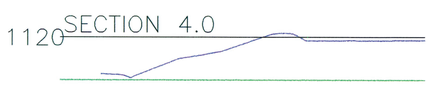


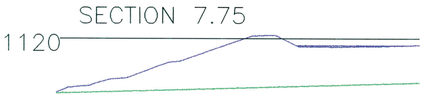


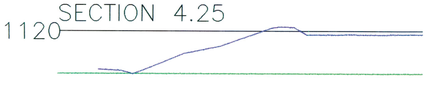


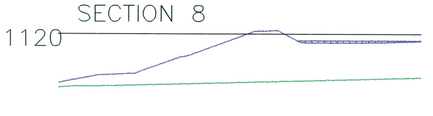












LEGEND

- Final Crest EOS 2003
- Original Ground
- PN–1 New Piezometer
- PB–6N Piezometer Location
- PB3 Standpipe
- Water Elev. Sep. 2004 Elev. 1115.2 m

0 125 m

1:2,500

teckcominco

BULLMOOSE PROJECT

SECTIONS OF TAILINGS DAM

DATE: NOVEMBER 10, 2004

Bullmoose:\\Engineering\TailingsDam\2004\Sections 2004.DWG

APPENDIX IV

Climate

Appendix IV
Climate

There is currently no active climate station at the Bullmoose site. The nearest active climate station is the Environment Canada climate station at Chetwynd Airport (No. 1181508) which is located approximately 62 km north of the site at El. 610 m. There was a climate station on site during operations called the Bullmoose Climate Station (No. 1181120 at El. 1,102 m), which operated from 1982 to 2003. Precipitation and temperature data from Chetwynd Airport are adjusted based on correlation factors developed with the Bullmoose Climate Station (No. 1181120 at El. 1,102 m) which was operated until 2003. Monthly precipitation correlation factors are summarized in Table IV-1.

Temperature climate normals at the Chetwynd Airport Climate Station were compared against climate normals from Bullmoose Climate Station. The temperature differences between the two stations for the period of overlap are summarized in Table IV-1.

Table IV-1 Chetwynd Airport/Bullmoose Precipitation and Temperature Correlation Factors

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Monthly Precipitation Correlation Factors												
Bullmoose climate station / Chetwynd Airport Climate Station[(1)]	3.3	3.6	2.9	1.7	1.3	1.3	1.2	1.5	1.9	3.3	3.3	3.1
Daily Average Temperature (°C)												
Chetwynd Airport Climate Station (1981-2010)	-10.2	-7.2	-2.9	4.6	9.5	13.4	15.4	14.5	9.9	4.1	-5.5	-9.1
Bullmoose Climate Station (1981-2003)	-8.0	-6.6	-4.2	1.7	6.9	11.0	13.3	12.8	8.2	2.5	-4.7	-7.4
Temperature Difference (Bullmoose – Chetwynd)	2.2	0.6	-1.3	-2.9	-2.6	-2.4	-2.1	-1.7	-1.7	-1.6	0.8	1.7
Daily Maximum Temperature (°C)												
Chetwynd Airport Climate Station (1981-2010)	-5.0	-1.4	2.9	11.2	16.6	20.1	22.2	21.6	16.3	9.4	-1.1	-4.1
Bullmoose Climate Station (1981-2003)	-3.4	-2.0	0.3	6.7	12.4	16.3	18.9	18.3	12.9	6.3	-1.0	-3.1
Temperature Difference (Bullmoose – Chetwynd)	1.6	-0.6	-2.6	-4.5	-4.2	-3.8	-3.3	-3.3	-3.4	-3.1	0.1	1.0
Daily Minimum Temperature(°C)												
Chetwynd Airport Climate Station (1981-2010)	-15.3	-12.9	-8.7	-2.1	2.4	6.6	8.5	7.4	3.5	-1.3	-10.0	-14.1
Bullmoose Climate Station (1981-2003)	-12.6	-11.2	-8.7	-3.4	1.5	5.6	7.8	7.2	3.4	-1.2	-8.5	-11.6
Temperature Difference (Bullmoose – Chetwynd)	2.7	1.7	0.0	-1.3	-0.9	-1.0	-0.7	-0.2	-0.1	0.1	1.5	2.5

Notes:
1. Excludes outliers and months with incomplete or missing data.