Klohn Crippen Berger

Teck Coal Limited

Quintette Coal Operations

2018 Dam Safety Inspection

Shikano North Tailings Dam

CANADA'S BEST MANAGED COMPANIES Platinum member

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March 2019

March 25, 2019

Teck Coal Ltd.
P.O. Box 1500
23097 Murray Forest Service Road
Tumbler Ridge, British Columbia
V0C 2W0

Mr. Rob Muise
Site Lead, Care and Maintenance

Dear Mr. Muise:

Quintette Coal Operations
Shikano North Tailings Dam
2018 Dam Safety Inspection

We are pleased to submit the 2018 Dam Safety Inspection Report for the Shikano North Tailings Dam.

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

Yours truly,

KLOHN CRIPPEN BERGER LTD.

Robert W. Chambers, P.Eng.
Project Manager
Senior Geotechnical Engineer, Principal

MC/NG:jc

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Teck Coal Limited

Quintette Coal Operations

2018 Dam Safety Inspection

Shikano North Tailings Dam

EXECUTIVE SUMMARY

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Coal Ltd. (Teck) to complete the 2018 Dam Safety Inspection (DSI) of the Shikano North Tailings Dam (SNTD) at the Quintette Coal Operations (QCO) mine site, to comply with Section 10.5.3 of the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (also referred to as the Code) (MEMPR 2017). This report was prepared following:

- Ministry of Energy, Mines and Petroleum Resources (MEMPR), British Columbia (BC) Section 4.2 "Annual Tailings Facility and Dam Safety Inspection Report" of the 2016 HSRC Guidance Document;
- Teck 2014 Guideline for Tailings and Water Retaining Structures (TWRS); and
- MEMPR Guidelines for Annual Dam Safety Inspection Report.

The 2018 inspection was completed by the Engineer of Record (EoR), KCB representative Mr. Bob Chambers, P.Eng., on May 28, 2018. Teck have designated Mr. Andrew Bidwell, P.Eng., as the Tailings Storage Facility (TSF) Qualified Person (as defined by the Code) for the SNTD.

The summary is provided solely for the purposes of overview. Any party who relies on this report must read the full report. The summary omits a number of details and context which are crucial to the proper application and interpretation of this report.

Summary of Facility Description

QCO has not been in operation since 2000. Portions of the site have been reclaimed, but otherwise the site has been under care and maintenance status since operations stopped. Under the current level of site presence, the SNTD is consistent with "Closure-Active Care" phase as defined by the Canadian Dam Association (CDA) Mining Dam Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (CDA 2014). During care and maintenance, Teck staff are onsite for environmental sampling, inspections and maintenance activities.

The SNTD is approximately 16 km south of the Municipality of Tumbler Ridge in northeastern BC. The SNTD is constructed across the mined-out Shikano North Pit. The SNTD crest is approximately 200 m long and at El. 827.7 masl. The SNTD has a maximum height of 45 m (crest to downstream toe) with 2H:1V downstream slope and 2.25H:1V upstream slope.

The dam was designed as a "flow-through" rockfill dam with internal granular filters and a non-woven geotextile to restrict fine coal tailings passing through the dam while allowing seepage through the structure. Seepage is routed to Sedimentation Pond S3 through a culvert before being discharged to the environment towards the Murray River (west of the SNTD). No construction has been carried out on the dam since 2000 and no construction is planned while the site remains in care and maintenance.

Summary of Key Hazards

Internal Erosion and Piping: Several sinkholes have been observed on the tailings beach since the 2010 DSI inspection but may have been present or started to develop prior to this date. Overall, an increase in size was observed for all sinkholes during the 2018 inspection when compared to 2017 observations. However, this is not a dam safety concern. The sinkholes are most likely a local condition where tailings are migrating into the upstream coarse rockfill shell or into "windows" of high permeability fill, but not through the internal filters into the downstream shell. The "windows" of high permeability fill on the upstream slope were introduced during construction to encourage seepage flow through the dam as per the overall design concept because the material available for the fine filter zone of the embankment had a permeability lower than expected. If piping of tailings into the downstream shell were to occur, the probability of triggering a dam failure is very low.

Other Hazards: such as overtopping, slope stability, foundation failure, surface erosion, rockfill degradation, and earthquakes are not considered "key hazards" for this facility and are discussed in the main text of this report.

Summary – no present dam safety concern indicated.

Consequence Classification of Dam

The SNTD was classified as having a "Significant" failure consequence (KCB 2014a), based on CDA (2013). The MEMPR permit C-156 (June 2013) for the restart of operations at the QCO site refers to the SNTD as a "High" consequence classification dam assuming active tailings deposition would resume with restart of mining. However, a "Significant" consequence classification is appropriate for the existing care and maintenance status of the dam and there have been no changes to the downstream environment or operation of the structure that would warrant a review of this classification.

Significant Changes in Instrumentation and/or Visual Monitoring Records

An event-driven inspection was trigged on July 23, 2018 following a significant rainfall (>57 mm within 24 hours). Teck's inspection observations indicate no dam safety issues or significant change to the SNTD following the event.

Overall piezometer readings are below historical levels during operations and there were no threshold exceedances in 2018. No continuous downstream movement or settlement of the crest has been observed since survey monument re-initiation in 2014. No changes are recommended to the current instrument reading frequency or threshold levels for 2019. However, the piezometer reading frequency should be reviewed before tailings discharge resumes at the SNTD.

Significant Changes to Surface Water Control

There were no changes to surface water control in 2018.

The catchment for the SNTD impoundment is 76.4 ha including the tailings beach and pond area. During operations, tailings were discharged from the eastern edge of the impoundment which

formed a tailings beach sloping towards the dam. Excess water would pond against the dam face and seep through the upstream filters.

A spillway is not required based on the large available storage capacity within the impoundment. Even during a 72-hour probable maximum flood (PMF), there would be approximately 18 m of freeboard, meeting the Code requirement for flood storage. As a result, a spillway is not required for the current dam condition.

Operation, Maintenance, and Surveillance Manual

The Operation, Maintenance and Surveillance Manual (OMS) manual was updated in March 2018. Quantifiable Performance Objectives (QPOs) (i.e., thresholds) and responses levels for piezometers, survey monuments and freeboard are included in the document.

Emergency Preparedness and Response Plan

There is currently no Emergency Preparedness and Response Plan (EPRP) developed for the SNTD. Teck have indicated that the EPRP should be available by the end of March 2019.

Dam Safety Review

The most recent DSR was completed in 2014 (KCB 2014a). Teck have indicated that the next DSR should be completed by July 2021, which is 5 years from effective date of the Code requirement for DSRs to be performed at least every 5 years.

2018 DSI Observations and Recommendations

The SNTD appears to be in good condition with respect to stability and water management. Comparison between available annual inspection reports indicates there have been no significant changes to the condition of the structure since 2000. Recent piezometer readings show a generally decreasing, favourable trend in pore pressures since the facility was put into care and maintenance status. Survey data collected in 2018 indicate no continuous crest movement or settlement.

Recommendations from previous DSI inspections are summarized in Table E-1. Recommendations resulting from the 2018 DSI are summarized in Table E-2. Closed recommendations are shown in grey italics and will be removed from the table in the next DSI report.

KCB have assigned priority to the various recommendations using the 2016 HSRC Guidance Document priority definitions, which are as follows:

- Priority 1: A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
- Priority 2: If not corrected could 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 Previous Recommendations

ID Number	Deficiency or Non-Conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline
SNTD-2016-01	Sinkhole Monitoring Program	OMS Manual	Establish a monitoring program (i.e. stakes) for the sinkholes within the tailings beach to determine if new ones are forming and/or if current ones are getting larger. To be conducted by Teck during the visual inspections and procedure included in the OMS manual. KCB to provide guidance on monitoring program.	3	March 2019 (in-progress - pending review of 2018 LiDAR for baseline readings)
SNTD-2017-01	Lack of an Emergency Preparedness and Response Plan (EPRP)	HSRC Code	Prepare an EPRP for the SNTD.	3	March 2019
SNTD-2017-02	*Lack of QPOs for Freeboard Thresholds and Responses*	*OMS Manual*	*Install physical indicators during routine visual inspection at the SNTD in spring of 2018. The indictors should be installed at the contact between dam upstream rockfill zone and tailings beach. The physical indicator should have a minimum of 1.5 m stickup and has a 1 m distant above tailings beach clearly marked.*	*4*	*CLOSED*

Table E-2 2018 Recommendations

ID Number	Facility	Deficiency or Non-Conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline (Status)
SNTD-2018-01	SNTD	Upper and Lower Met rain gauges unreliable in winter	n/a	Repair or improve the Upper and Lower Met climate station rain gauges to improve reliability of precipitation measurements during the winter months.	4	December 2019

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LIST OF ACRONYMS

Acronym	Definition
BC	British Columbia
CDA	Canadian Dam Association
DSI	Dam Safety Inspection
DSR	Dam Safety Review
EDGM	Earthquake Design Ground Motion
EoR	Engineer of Record
EPRP	Emergency Preparedness and Response Plan
FoS	Factor of Safety
HSRC	Health, Safety and Recreation Code for Mines in BC
IDF	Inflow Design Flood
KL	Klohn Leonoff
KCB	Klohn Crippen Berger Ltd.
MAC	Mining Association of Canada
MEMPR	Ministry of Energy, Mines and Petroleum Resources (BC)
MoE	Ministry of Environment (BC)
NBCC	National Building Code of Canada
OMS	Operational, Maintenance and Surveillance
PMF	Probable Maximum Flood
QCO	Quintette Coal Operations
QOC	Quintette Operating Corporation
QPO	Quantifiable Performance Objectives
SNTD	Shikano North Tailings Dam
TSF	Tailings Storage Facility

1 INTRODUCTION

Klohn Crippen Berger Ltd. (KCB) was engaged by Teck Coal Ltd. (Teck) to complete the 2018 Dam Safety Inspection (DSI) of the Shikano North Tailings Dam (SNTD) at the Quintette Coal Operations (QCO) mine site. The inspection and this report were prepared to comply with Section 10.5.3 of the Health, Safety and Reclamation Code (HSRC) for Mines in British Columbia (also referred to as the Code) (MEMPR 2017). This report was prepared following:

- Ministry of Energy, Mines and Petroleum Resources (MEMPR), British Columbia (BC) Section 4.2 "Annual Tailings Facility and Dam Safety Inspection Report" of the 2016 HSRC Guidance Document;
- Teck 2014 Guideline for Tailings and Water Retaining Structures (TWRS); and
- MEMPR Guidelines for Annual Dam Safety Inspection Report.

A site visit was completed on May 28, 2018 by the Engineer of Record (EoR), KCB representative Mr. Bob Chambers, P.Eng., along with Mr. Nat Gullayanon, P.Eng., of KCB. At the time of the inspection, the weather was sunny with cloudy periods with a temperature of 20 ^{o}C. No precipitation was recorded 24 hours prior to the inspection. Refer to Figure 1 and Figure 2 for general site location and layout, and Figure 3 for an overview of the facility and DSI inspection photograph locations. Inspection observations are summarized in the following sections of the report. DSI inspection photographs are provided in Appendix I.

During the inspection, KCB engineers were accompanied by Mr. Andrew Bidwell, P.Eng., Mr. Rob Muise, and Ms. Morgan Lypka, E.I.T., of Teck. Teck have designated Mr. Andrew Bidwell, P.Eng., as the Tailings Storage Facility (TSF) Qualified Person (as defined by the Code) for the SNTD. Mr. Rob Muise and Mr. Ray Proulx are the designated Dam Inspectors for the SNTD.

QCO has not been in operation since 2000. Portions of the site have been reclaimed, but otherwise the site has been under care and maintenance status since operations stopped. During care and maintenance, Teck staff are onsite for environmental sampling, inspections and maintenance activities. Under this level of site presence, the SNTD status is consistent with "Closure-Active Care" phase as defined by the Canadian Dam Association (CDA) Mining Dam Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014).

In 2013 and 2014, Teck received new permits for a restart of QCO mining operations:

- Ministry of Energy, Mines and Petroleum Resources (MEMPR), Permit No. C-156 (amended June 20, 2013); and
- Ministry of Environment (MoE), Permit No. PE-06739 (amended July 9, 2014).

Fine coal tailings from restart operations would be discharged into the SNTD impoundment. However, Teck have deferred the restart of operations pending an improvement in market conditions. The 2014 MoE permit amendment includes provisions for water quality monitoring of the SNTD that apply to care and maintenance as well as to restart operations. The DSI is based on the

condition of the structure on the inspection date and does not consider a potential future restart of the QCO.

The SNTD has a “Significant” consequence category based on CDA (2013) as reported in the most recent Dam Safety Review (DSR) (KCB 2014a). The factors considered in the classification of the SNTD are listed in Table 1.1.

Table 1.1 Classification of SNTD Based on Consequence Category (KCB 2014a)

Population at Risk	Loss of Life	Economic and Social Loss	Environmental and Cultural Losses
No Permanent Population	Significant	Low	Low to Significant

MEM permit C-156 (June 2013) for the restart of operations at the QCO site refers to the SNTD as a “High” consequence classification dam. The “High” consequence classification in the permit was appropriate because of the potential for increased downstream effects in the event of a SNTD failure with the tailings and pond volumes near ultimate capacity. However, a “Significant” consequence classification remains appropriate for the existing care and maintenance status of the dam.

Teck have indicated that the next DSR is scheduled for 2021, which is 5 years from effective date of the Code requirement for DSRs to be performed at least every 5 years.

2 BACKGROUND AND RECENT ACTIVITY

2.1 Background Information

The SNTD is approximately 16 km south of the Municipality of Tumbler Ridge in northeastern BC and is approximately 2.5 km west of the QCO plantsite and gatehouse. The dam is constructed across the mined-out Shikano North Pit to form the Shikano North Tailings Storage Facility. The SNTD is surrounded by Centre Waste Dump to the south, Seepage Collection Pond S3 and Murray River to the west, waste dump/natural slope to the east, and North East Dump to the north.

The facility was commissioned in 1997 when the Plantsite TSF reached capacity. No construction has been carried out on the dam since operations were suspended in 2000 and no construction is planned while the site remains in care and maintenance. A summary of available SNTD key reference documents is included in Appendix IV.

The SNTD was designed as a "flow-through" rockfill dam with internal granular filters and a non-woven geotextile filter fabric to restrict fine coal tailings passing through the dam while allowing seepage through the dam. "Windows" of high permeability gravel, upstream of the filters, were introduced as a design modification during construction to encourage seepage flow through the dam (as per design concept) because the material available for fine filter construction had a permeability lower than expected. Each window was approximately 1 m thick (KC 1997). The seepage discharges to S3 Pond through a culvert in the downstream shell of the dam (Figure 3).

The SNTD has a maximum downstream slope height of 45 m (crest to toe) with 2H:1V downstream and 2.25H:1V upstream slopes. The dam crest is 200 m long. The SNTD has a storage capacity of approximately 6 Mm^3 and has 2.8 Mm^3 of tailings and water stored to date (KCB 2014b).

The SNTD design was completed by Klohn Crippen Consultants Ltd. (KC) (1996). Select dam record drawings including cross sections of the SNTD are included in Appendix II. The SNTD was raised to the current crest elevation in two stages:

- Stage I (May to November 1996): crest elevation 810 masl.
- Stage II (December 1998 to March 1999): crest raised to elevation 829 masl.

Construction record reports were issued following each raise (KC 1997 and KC 1999b). No significant construction or performance related issues were noted in the construction record documents, 1999 Annual Review (AR) (KC 1999a) or DSI reports from 2010 to 2017. No recent construction has been carried out at the SNTD since completion in 1999.

When mining operations were suspended in 2000, tailings stored in the impoundment were well below design capacity. The current dam crest elevation, measured from survey monument pins in 2016, is 827.7 masl (KCB 2016b), 1.3 m lower than reported elevation in the Stage II construction record report. The current tailings are approximately at elevation 796 masl based on a 2010 LiDAR

survey (provided by Teck, survey completed by McElhanney Consulting Services Ltd.) which is more than 30 m below the crest.

2.2 Recent Activity

In 2018, Teck completed the following maintenance and surveillance activities, as specified in the Operation, Maintenance, and Surveillance (OMS) manual:

- Installed pond level indicators at the dam upstream slope/tailings contact in July 2018 (refer to Section 4.3.3 for more details).
- Inspected the SNTD following an exceedance in precipitation “Warning Level” trigger on July 23, 2018 (see Section 4.3.1 for more details on event-driven inspection).

3 WATER MANAGEMENT, CLIMATE AND WATER BALANCE

3.1 Overview

The SNTD is an inactive facility in care and maintenance. The catchment for the SNTD impoundment is 76.4 ha (Figure 4) including the tailings beach and pond area (8.3 ha).

During operations, tailings were discharged from the eastern edge of the impoundment which formed a tailings beach sloping towards the dam. Excess water would pond against the dam face and seep through the upstream filters. Water currently ponds in a shallow depression on the tailings beach formed by post-operations tailings consolidation. At the time of the inspection the pond was approximately 20 m upstream of the dam face (Photo I-1). An outflow channel in the tailings beach conveys water from the pond to the dam face where it seeps into the upstream rockfill shell (Photo I-13). The pond level appears to be elevated compared to 2017 DSI observation likely due to the DSI inspection being completed closer to spring freshet than previous years and the pond is retaining a larger portion of freshet runoff at the time of inspection.

Seepage through the dam accumulates in the coarse rockfill downstream shell. A 750 mm perforated corrugated steel pipe (CSP) buried in the coarse rockfill (invert El. 778 masl) is connected to a 750 mm solid pipe section buried beneath the haul road downstream and discharges into a channel that flows to S3 Pond (KC 1996) (Figure 3), before being released to the environment. Discharge from the S3 Pond is a monitoring location listed in the MoE Permit No. PE-06739 which requires quarterly water quality (suspended solids and metals) and weekly flow measurements between April and October of each year. There is no discharge from the SNTD to the M11/M15 Channel, therefore no monitoring is required as specified in the MoE Permit No. PE-06739.

3.2 Climate

Precipitation and temperature data at the site from September 1, 2017, to August 31, 2018 is summarized in Table 3.1. Climate data was measured at the Plantsite climate station (Lower Met climate station, elevation 914 masl), 3.8 km north of the SNTD but at similar elevation. However, the rain gauge is not heated so winter precipitation results are not reliable, but this is not a dam safety concern that requires immediate action. As a result, data from October 2017 to April 2018 from the Environment Canada Chetwynd Airport climate station (station No. 1181508; elevation 610 masl; and 86 km north of QCO) was used after being corrected for orographic effects using the mean annual precipitation and elevation relationship from the baseline hydrology study (Teck 2013). Average temperatures from 1991 to 2000, taken from baseline hydrology study (Teck 2013), are also summarized in Table 3.1 for comparison. KCB suggest that Teck repair the weather station for on-going, year-round monitoring of climate data; however, it is not a dam safety concern, and therefore, is not a time sensitive issue.

Seasonal snowpack data is measured digitally at the Plantsite climate station; however, data conversion details are not available. Therefore, snowpack information is not available for review.

Table 3.1 Precipitation and Temperature at Shikano North Tailings Dam

Month	Corrected SNTD Mean Annual Precipitation[1] Distribution (mm)	Corrected SNTD 2017-2018 Precipitation[2],[3] (mm)	Lower Met Station 1991-2000 Average Temperature[4] (°C)	Lower Met Station 2017-2018 Daily Max. Temperature[5] (°C)	Lower Met Station 2017-2018 Daily Min. Temperature[5] (°C)	Lower Met Station 2017-2018 Daily Average Temperature[5] (°C)
September	42	76	10.1	16.7	4.6	10.5
October	54	119	3.6	8.2	0.3	4.3
November	56	101	-3.7	-3.4	-11.6	-7.4
December	41	4	-6.8	-2.5	-9.2	-6.0
January	44	54	-10.7	-3.8	-11.6	-7.6
February	36	50	-5.4	-7.2	-15.9	-11.4
March	33	60	-2.1	0.9	-10.0	-4.6
April	27	25	3.5	5.6	-5.3	0.6
May	32	11	8.3	17.9	5.7	12.4
June	71	49	12.3	18.8	7.3	13.2
July	75	162	14.5	21.4	9.0	15.3
August	50	38	13.9	21.0	9.8	15.6
Total	**561**	**750**				

Notes:

1. Monthly precipitation values are based on the mean annual precipitation-elevation relationship and monthly distribution outlined in the 2013 Baseline Hydrology and Design Basis Report (Teck 2013).
2. October 2017 to April 2018 precipitation values were interpreted from Chetwynd Airport climate station (station No. 1181508; elevation 610 masl; and 86 km north of QCO) data, with mean annual precipitation and elevation correction from Teck (2013).
3. September 2017, and May 2018 to August 2018 precipitation values were interpreted from Plantsite climate station data with mean annual precipitation and elevation correction from Teck (2013).
4. Average monthly temperatures are from the Quintette Plantsite as outlined in the 2013 Baseline Hydrology and Design Basis Report (Teck 2013).
5. Daily maximum, minimum, and average temperatures are based on daily temperature readings that were taken at the Lower Met climate station.

The following observations are made based on the data from September 1, 2017 to August 31, 2018:

- Total precipitation at the SNTD (750 mm) was higher than the estimated Mean Annual Precipitation (561 mm).
- Summer months (May to August) were warmer than normal, and winter months (November to April) were colder than normal.
- An event-driven inspection was triggered on July 23, 2018 following a precipitation event of 57 mm, exceeding the "Warning Level" threshold (52 mm). Refer to Section 4.3.1 for more details on event-driven inspection.

3.3 Water Balance

Under existing conditions, inflows to the impoundment are predominantly from surface water runoff with limited observed contribution from pit wall seepage. Outflows from the impoundment are predominately seepage through the "flow-through" dam and evaporation from the pond. The size of the pond has been observed to change seasonally indicating there is some retention time in the impoundment. However, total water that enters the impoundment leaves the impoundment and does not accumulate on an annual basis.

A simplified water balance calculation for the SNTD impoundment from September 1, 2017 to August 31, 2018 is summarized below:

- Inflows:
  - Precipitation on pond surface = 8,000 m^3 (assumed average pond elevation of 797 masl);
  - Runoff from tailings impoundment (including impoundment slopes and tailings beach, excluding pond area) = 105,000 m^3 (assumed average runoff coefficient of 0.6); and
  - Runoff from upstream catchment = 157,000 m^3 (assumed average runoff coefficient of 0.4).
- Outflows:
  - Evaporation from pond surface = 6,000 m^3 (evaporation rate for this site is 548 mm/yr based on evaporation-elevation relationship from Teck (2013)); and
  - Seepage losses from the impoundment = 264,000 m^3 (estimated from inflows minus evaporation).

The seepage losses from the impoundment are estimated at an average flow rate of 8 L/s over the 12-month period. The flow rate during the DSI inspection was estimated 9 L/s (Photo I-28 and Photo I-29), similar to the average flow. The average flow estimate includes the winter period when flows are likely zero. The water balance is within the expected performance range for the "flow-through" design and there are no planned changes to surface water management that would alter this observation.

3.4 Flood Routing

During flood events, the runoff accumulates on the tailings surface. Because of the large freeboard present (approximately 32 m) when operations were suspended a spillway was not constructed and the inflow will be stored rather than being routed through the impoundment and discharged. The SNTD hydrotechnical assessment indicates that SNTD has the capacity to store the PMF of 336,200 m^3 with approximately 25 m of freeboard (KCB 2016c).

The recommended design event specified in the Code for a dam without a spillway is 72-hour PMF. A conservative estimate of 72-hour PMF (calculated by multiplying 3 to the 24-hour PMF volume) resulted in 18 m of freeboard. As a result, a spillway is not required for the current dam condition.

4 REVIEW OF MONITORING RECORDS AND DOCUMENTS

4.1 Operations, Maintenance and Surveillance Manual

The Operations, Maintenance and Surveillance (OMS) manual was updated by Teck in March 2018. The OMS manual specifies monitoring programs for the structure that include routine and event driven inspections, and reviews of instrumentation readings (piezometers and survey monuments).

Piezometer, survey monument and freeboard threshold values (i.e., Quantifiable Performance Objectives (QPOs)) and response actions are defined in the updated OMS manual. KCB recommends that during the next update, the OMS manual structure be revised to follow the updated Mining Association of Canada (MAC) Guidelines, if they become available.

4.2 Emergency Preparedness and Response Plan

There is currently no Emergency Preparedness and Response Plan (EPRP) developed for the SNTD. Teck have indicated that the EPRP, which is required under Section 10.4.2 (1) (e) of the Code, should be available by the end of March 2019.

4.3 Monitoring Program

4.3.1 Visual Inspections

The SNTD monitoring program includes the following visual inspections (Teck 2018):

- Annual DSI (this report) – completed by the EoR.
- Routine – monthly inspections of the downstream slope area when visiting the area for S3 Pond water sampling and flow monitoring. Inspections of the SNTD are completed three times per year by Teck's Dam Inspector: spring (after snowmelt), mid-summer, and fall (before first snowfall). Routine inspections were completed three times in 2018 (May 28, August 7, and September 21). The DSI inspection was counted as the spring inspection. Teck's inspection checklists (Appendix III) do not indicate any dam safety issues.
- Event-driven – completed by Teck staff following:
  - A 24-hour rainfall event either greater than the 10-year return period (52 mm – "Warning Level") or the 50-year return period (67 mm – "Alarming Level"). Follow up inspections are to occur within 36 hours for a 50-year return period event, or within 3 days for a 10-year return period event; or
  - An earthquake event either magnitude 5 or greater within 100 km of the site, or a smaller event but significant enough to be felt on site and/or in Tumbler Ridge.

  In 2018, an event-driven inspection was initiated on July 23 after a precipitation of 57 mm was recorded on site. Teck's inspection checklist (Appendix III) does not indicate any dam safety

issue. No earthquakes with a magnitude of M5 or greater were recorded by the Geological Survey of Canada within 100 km of the site in 2018.

In 2017, KCB recommended a sinkhole monitoring program be established and conducted in conjunction with the routine visual inspections at the SNTD. The sinkholes should be shown on a drawing for future reference. The monitoring program should include the installation of stakes or wooden posts along the outside of the sinkholes to determine if there is growth and the rate of the growth (KCB to provide further guidance). Alternatively, an aerial survey or LiDAR may be utilized to capture the development of the sinkholes.

In 2018, Teck retained UAViation of Coquitlam, BC, to complete a LiDAR topographic survey of SNTD to monitor sinkholes. The topography survey was completed in October 2018 and the data was sent to KCB in December 2018. KCB is currently in the process of verifying data suitability for repeat drone surveys to monitor sinkhole development.

Given the long performance history of the SNTD, flow-through design and large freeboard, the current inspection program is appropriate for the existing condition.

4.3.2 Instrumentation

4.3.2.1 Piezometers

Of the 16 piezometers installed at SNTD, 10 are functional, (refer to Table 4.1 and Figure 3). Annual readings of the functioning pneumatic piezometers are to be taken once a year by Teck's Dam Inspector. 2018 pore pressure readings were collected on May 31. 2018 piezometer readings are plotted in Figures 5 and 6.

Piezometric levels measured since operations were suspended have not exceeded the thresholds. Threshold Level 1 – "Warning Level" are summarized in Table 4.1. Threshold Level – 2 "Alarming Level" is triggered if there are Threshold Level 1 exceedance of two or more piezometers in the same instrumentation section, or if there are two instrumentation sections with observed exceedance of one or more piezometers. Recommended threshold responses are summarized in Table 4.2. These threshold values and responses are included in 2018 OMS manual.

Table 4.1 Piezometer Threshold Values and 2017 Versus 2018 Piezometer Readings

Piezometer	Status	Tip Elevation (masl)	Threshold Level 1 "Warning Level" Elevation (masl)	August 14, 2017		May 31, 2018	
				Pressure Readings (psi)	Piezometric Level (masl)	Pressure Readings (psi)	Piezometric Level (masl)
P96-1	Not Functional	767.2	-	No measurement taken, noted as leaking in 2016.			
P96-2	Not Functional	777.2	-	No measurement taken, noted as plugged in historical readings (KC 1999a).			
P96-3	Not Functional[1]	770.0	786.0	34 psi measured; unable to stabilize.			
P96-4	Operational	780.1	-	0	780.1	No measurement taken, fitting was leaking	
P96-5	Operational	780.0	797.0	12.3	788.6	9.4	780.0
P96-6	Operational	780.0	797.0	2.9	782.0	3.1	780.0
P96-7	Operational	790.1	803.0	0.6	790.5	0.5	790.1
P96-8	Operational	790.2	803.0	3.8	792.9	2.9	790.2
P96-9	Operational	800.0	805.0	3.2	802.3	0.1	800.0
P96-10	Operational	800.0	805.0	0.9	800.6	0	Dry
P95KC-2A	Operational	755.4	790.0	0.3	755.6	0	Dry
P95KC-2B	Operational	776.2	790.0	2.0	777.6	0.6	776.2
P95KC-3A	Not Functional	762.8	790.0	Readings unable to stabilize, <35 psi			
P95KC-3B	Operational	781.3	795.0	0.9	781.9	0	Dry
P98-1	Unknown	810.5	-	Instrument has not been located.			
P98-2	Unknown	810.5	-	Instrument has not been located.			

Notes:

1. P96-3 instrument cable was noted as plugged in KC (1999a) and the instrument continued to give unreasonable reading (+34 psi) in 2018, so it has been disregarded. Refer to 2017 DSI Report (KCB 2018) for P96-3 and P96-4 piezometer data verification details.

Table 4.2 Piezometers Threshold Responses

Thresholds	Threshold Exceedance	Action
Level 1 "Warning Level"	Exceedance of a threshold in an individual piezometer	▪ Notify EoR within 24 hours upon verification of reading exceedance. ▪ EoR to evaluate data for reliability, and review piezometric data (and survey data if available) within the general vicinity of the individual piezometer in question. EoR may recommend repeat measurement and increased on-going monitoring frequency.
Level 2 "Alarming Level"	Trend of threshold exceedances in a group of piezometers	▪ Notify EoR within 24 hours upon verification of reading exceedance. ▪ Repeat reading within 1 week. ▪ EoR to assess dam integrity and may recommend stability analysis, site visit, or other action.

The following observations are made based on the 2018 piezometer readings:

- All piezometer readings are below the established threshold levels. No significant changes in established trends were observed.
- Instruments are accessible and functioning with the exceptions of those noted in Table 4.1:
  - Teck managed to find P95KC-3B after it has been reported as “not found” in previous DSI reports. The instrument location and its water levels are shown in Figures 5 and 6. P95KC-3B was dry during May 2018 inspection.
- P96-6 measured water level has been slightly lower than other upstream piezometers installed below the current tailings level, but it has been consistent since 2014. This may be due to blockage in the instrument cable, or leakage in the instrument fitting.
- The reason why the measured pressure for P96-9 is above the current pond and tailings level is not known but its readings have been consistent since 2013. There is no visible seepage from the upstream face of the dam and P96-4 historical readings indicate the water level in the dam fill is below tailings level. Instrument error or locally entrained water around the instrument tip is the most likely cause for the readings. This is not a dam safety concern and no follow up action is required.
- P96-10 historical readings showed similar trend to that of P96-9; however, May 2018 reading indicates the instrument was dry.
- In general, May 2018 readings are slightly lower than August 2017 readings despite being read during spring freshet with a larger pond in the impoundment.
- The pore pressure measured for piezometers at the same elevation upstream of the filter zones generally show a downward gradient in the upstream rockfill zone, as expected.

Based on the review of the available instrumentation data, the suite of instruments is sufficient for the existing condition of the SNTD. MEMPR permit for the restart of operations at the QCO site includes a requirement for an assessment of the adequacy of the existing instrumentation prior to reactivation of the facility and the installation of replacement or additional instrumentation as appropriate. MEMPR also requires the assessment be submitted to the Chief Inspector for review within 3 months of re-activation of the facility.

4.3.2.2 Survey Monument Pins

The monuments consist of steel pins with plates attached to the base, buried 1 m below the crest surface (KC 1999b).

Monitoring pins were originally installed along the SNTD dam crest in 1999 for displacement monitoring and surveyed during operations until the end of 1999. Monitoring of the pins was re-initiated in 2014 and the pins were surveyed 3 times until 2017 (Figure 7). 2017 DSI report recommended reducing the survey reading frequency from three times a year to once a year due to lack of a trend in observed horizontal movement or crest settlement (KCB 2018). Teck adopted this in the 2018 OMS manual.

Threshold levels, first established in 2016, as defined in the OMS manual are summarized below:

- Threshold Level 1 – "Warning Level" was developed based on the maximum observed survey measurement to date plus 20%. The Threshold is exceeded if:
  - Horizontal movement ≥ 40 mm from the initial reading;
  - Vertical movement ≥ 70 mm from the initial reading; and
  - Vertical movement ≥ 80 mm between successive readings.
- Threshold Level 2 – "Alarming Level" is exceeded if:
  - There is a trend of threshold exceedances in the monitoring pins.

The responses for each of the threshold levels are summarized in Table 4.3.

Table 4.3 Survey Monument Threshold Response

Threshold Level	Exceedance Threshold	Action
1 "Warning Level"	Exceedance of established threshold in an individual survey pin	▪ Inspect the area around the pin. ▪ Measure again within 1 week and increase monitoring frequency to weekly. ▪ Notify EoR within 24 hours of second reading. ▪ EoR to evaluate data for reliability, and review survey data within the general vicinity of the individual survey pin in question.
2 "Alarming Level"	Common trend of threshold exceedances in a group of pins	▪ Increase monitoring frequency of the survey pins as needed based on assessment of common trend. ▪ EoR to assess stability, stability analysis may be initiated.

Comparison of the October 2017 and June 2018 survey measurements is summarized in Figure 7. The observed movements are plotted on Figures 8 and 9.

From a review of the available data since 2014, none of the monuments indicates a trend of horizontal movement or significant crest settlement. Incremental movement is more likely attributed to survey accuracy than dam movement. There was no exceedance of thresholds in 2018 (Figures 8 and 9).

There are discrepancies between the historical and recent survey data of the SNTD:

- the as-built dam crest elevation was stated as 829 masl (KC 1999b);
- the 2010 LiDAR shows the dam crest elevation at 827.5 masl; and
- the crest ranges from 827.7 masl to 828.5 masl based on the most recent monitoring pin survey data (adjusting the data to account for stick-up), which are consistent with LiDAR crest elevations at these monitoring pin locations (i.e., 827.9 masl to 828.4 masl).

The SNTD is a rockfill dam founded on bedrock, limited to no post-closure settlement is expected. The discrepancies in crest elevation could be the result of survey accuracy, datum changes or settlement. This is not a dam safety concern given the large existing freeboard (>30 m).

Based on the review of the available instrumentation data, the suite of instruments is sufficient for the existing condition of the SNTD.

4.3.3 Freeboard

Although the SNTD has significant flood storage, changes in pond size/level, which may indicate a change in dam condition/performance, should be monitored as required. In July 2018, Teck installed a physical indicator at the location where tailings beach meets the upstream rock fill zone. The physical indicator has a minimum of 1.5 m stickup above tailings surface. The distance of 1 m above tailings surface was clearly marked such that it is visible when looking from the top of the dam, or from the abutments. Freeboard QPOs, as defined in the OMS manual, for the SNTD under existing conditions and are summarized below:

- Threshold Level 1 – "Warning Level" is exceeded if the water level reaches the contact between dam upstream face and tailings beach.
- Threshold Level 2 – "Alarming Level" is exceeded when pond level reaches 1 m mark on the physical indicator.

The recommended responses for the Threshold Levels are summarized in Table 4.4.

Table 4.4 Response to Freeboard Threshold Exceedances

Response Level	Exceedance Threshold	Action
1 "Warning Level"	Pond level reaches the bottom of the Physical Indicator	▪ Notify EoR within 1 week upon verification of pond level exceedance. ▪ EoR may recommend increased monitoring of pond level.
2 "Alarming Level"	Pond level reaches 1 m mark on the Physical Indicator	▪ Notify EoR within 24 hours upon pond level exceedance. ▪ Increased monitoring frequency as directed by the EoR. ▪ EoR to investigate the increase of the pond level.

The pond level indicator is adequate for the existing condition of the SNTD.

4.4 Water Quality

A water quality monitoring point included in MoE Permit No. PE-06739 is the outflow from S3 Pond downstream of the SNTD. Monitoring at S3 Pond includes:

- Weekly: Flow rate (April 1 to October 31); and
- Quarterly: Field turbidity; lab turbidity and total suspended solids; and metal and non-metal parameters as defined by the permit.

Water quality monitoring data is submitted to MoE for compliance reporting and will be summarized in a Teck prepared annual report in March 2019. The water quality of the S3 Pond outflow is not representative of SNTD seepage because surface water from other catchments also report to S3 Pond. Teck have confirmed that there have been no non-conformances and that monitoring frequency meets permit requirements.

5 VISUAL OBSERVATIONS AND PHOTOGRAPHS

No significant changes related to dam safety were observed between the 2018 and 2017 DSI observations. The following observations were made during the 2018 inspection:

- **Historic Slumping of Pit Wall:** A historic slumping failure is present on the eastern side of the impoundment (Photo I-30) in the old pit wall (approximately 480 m southeast from the upstream face of the dam). No significant changes were observed in the area since the 2012 DSI.
- **Dam Crest**: Good condition. No signs of lateral movement, significant differential settlement or cracking of the dam crest (Photo I-3).
- **Downstream Slope**: Good condition. No signs of significant erosion or displacement and no vegetation cover (Photos I-4, I-5, I-24 and I-27).
- **Upstream Slope**: Good condition. No signs of significant erosion or displacement and no vegetation cover (Photos I-1, I-7, and I-11).
- **West Abutment**: Abutment appears stable and in good condition. Ravelling of the exposed rock face upstream of the west abutment caused by weathering of alternating beds of sandstone and shale. No significant changes since first noted in the 2014 DSI report. No signs of displacement of the pit wall (Photo I-6). A small erosion gully along the upstream slope and west abutment wall contact (Photo I-23), appears to be unchanged. Ravelling of upstream rock face does not pose a dam safety concern to the SNTD; no action is required.
- **East Abutment**: Good condition. Minor ravelling of pit wall above the crest, appears predominantly surficial. No signs of significant erosion or displacement of the pit wall (Photo I-10). Ravelling of the pit wall does not pose a dam safety concern to the SNTD; no action is required.
- **Tailings Impoundment**: The impoundment area was sparsely vegetated near the pond and dam. Away from the pond the tailings surface is well drained and supports human traffic (Photos I-2 and I-8). The 2018 pond area appears to be larger than that of the 2017 due to the inspection being done closer to spring freshet. The pond was approximately 20 m offset from the upstream slope of the dam (Photo I-1) and well below the pond threshold levels.
- **Sinkhole Depressions in Tailings Beach:** Refer for Figure 3 and Photo I-8 for sinkholes general location. These features have been noted since 2010 (KCB 2011), but when they started to form is not known. There was a notable increase in size between the 2012 and 2013 inspections, and between 2016 and 2018.
    - A cluster of 3 sinkholes (Sinkhole 6) appear to have been merged into a single large sinkhole in 2018 (Photo I-20). The sinkhole is approximately 9.4 m by 7.4 m and 0.5 m deep and water was observed at one of the sinkholes bottom.
    - Sinkholes 2 and 3 were first documented in 2015 (KCB 2016a) and appear to have increased in size in 2018 (Photos I-15 and I-16). Settled tailings surface (1.5 m wide by 2 m long) adjacent to Sinkhole 3 was observed (Photo I-17), indicating the feature may be increasing in size.

- Sinkhole 1 was first documented in 2016 and appears to have slightly increased in size in 2018 (Photos I-14).
- Smaller sinkholes 4, 5, and 7 through 10 were first documented during the 2017 DSI site visit (Photo I-18, Photos I-19, and I-22) and appear to be unchanged in 2018. Sinkholes 7 through 10 are located between SNTD-2018-07 and SNTD-2018-08, refer to Figure 3.
- Sinkhole 11 (Photo I-12) was first documented during the 2018 inspection and is the first sinkhole where apparent flowing of water into the coarse rockfill overlying filters and geotextile was observed. Inspection of the downstream seepage indicated flow was clear (Photo I-28) (i.e., no indication of internal erosion).

The cause of these features is most likely the migration of tailings into the upstream coarse rockfill shell and “windows” of high permeability gravel (Figure 5) which are upstream of the filters. Sinkholes are considered a local condition and not a risk to the SNTD integrity.

6 ASSESSMENT OF DAM SAFETY

The potential failure modes included in the CDA Dam Safety Guidelines (2013) were reviewed based on the inspection observations and review of available documents. No significant changes to 2017 assessment were observed in 2018.

- **Overtopping:** Given the large freeboard available in the dam (approximately 18 m after a 72-hour PMF event) and "flow-through" design, the probability of overtopping failure is negligible.
- **Internal Erosion and Piping:** The dam is a "flow-through" design with a rockfill core, two upstream filter zones and a geotextile. Filter performance has been demonstrated by clear seepage and retention of fine tailings in the impoundment during operations and care and maintenance periods. Sinkholes observed in tailings beach will continue to be monitored for changing conditions during annual inspections. They are most likely a local condition where tailings are migrating into the upstream coarse rockfill shell and "windows" of high permeability fill, not the internal filters. If some piping of tailings were to occur, the probability of it triggering a dam failure is very low.
- **Slope Instability:** The dam is a coarse rockfill structure founded on bedrock at the base and abutments. The downstream slope of the dam is 2H:1V. Slope stability analysis in the design had factor of safety (FoS) greater than 1.6 under the full pond and tailings levels (KC 1996) which complies with the Code. 2018 piezometer readings indicate that the pore pressures in the dam are below design levels. The safety factor under the current tailings and pond levels will be greater than the ultimate design condition and the probability of failure due to slope instability is very low.
- **Foundation Failure:** The dam is constructed across an old open pit and is founded on rock. In the design, a risk of failure along weak planes in the abutment rock was identified and slope inclinometers were installed to monitor movement. No significant movement was observed in the inclinometers which were monitored until 1998. The probability of failure due to foundation failure is negligible.
- **Surface Erosion:** Both the upstream and downstream slopes of the dam are covered with a coarse rockfill to protect against surface erosion. A small erosion gully was observed during 2017 inspection on the upstream slope and west abutment wall contact. 2018 observations show no significant changes in the gully conditions (Photo I-23). This feature is not a dam safety concern. The probability of failure due to surface erosion is very low.
- **Rockfill Degradation:** The SNTD upstream and downstream rockfill shells were constructed with selected competent rock material from Shikano South Pit (KC 1996). Signs of rock degradation were observed during DSI inspections. Based on visual assessment, the degradation is limited to surficial materials that are subjected to freeze and thaw cycles. Degradation of surficial rockfill on the dam embankment would have no impact on the overall dam safety.

- **Earthquakes:** Stability of the dam under seismic loading was reviewed as part of the design (KC 1996) for a seismic acceleration of 0.15g, which is greater than the Code's recommended earthquake design ground motion (EDGM), 2475-year return period event (i.e., 0.082g), based on National Building Code of Canada (NBCC) (2015). The design analysis and lower EDGM relative to design assumptions indicate the probability of a failure during the EDGM is very low.

The SNTD appears in good condition and the observed performance is consistent with design requirements. Comparison of available annual inspection reports and piezometer measurements indicate there have been no significant changes to the condition of the structure since 2000.

Recommendations from previously DSI inspections are summarized in Table 6.1. Recommendations resulting from the 2018 DSI are summarized in Table 6.2. Recommendation on the OMS manual restructuring to follow the MAC Guidelines is not a dam safety related recommendation. Closed recommendations are shown in grey italics and will be removed from the table in the next DSI report.

KCB have assigned priority to the various recommendations using the 2016 HSRC Guidance Document priority definitions, which are as follows:

- Priority 1: A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
- Priority 2: If not corrected could 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 Previous Recommendations

ID Number	Deficiency or Non-Conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline
SNTD-2016-01	Sinkhole Monitoring Program	OMS Manual	Establish a monitoring program (i.e. stakes) for the sinkholes within the tailings beach to determine if new ones are forming and/or if current ones are getting larger. To be conducted by Teck during the visual inspections and procedure included in the OMS manual. KCB to provide guidance on monitoring program.	3	March 2019 (in-progress - pending review of 2018 LiDAR for baseline readings)
SNTD-2017-01	Lack of an Emergency Preparedness and Response Plan (EPRP)	HSRC Code	Prepare an EPRP for the SNTD.	3	March 2019
SNTD-2017-02	*Lack of QPOs for Freeboard Thresholds and Responses*	*OMS Manual*	*Install physical indicators during routine visual inspection at the SNTD in spring of 2018. The indictors should be installed at the contact between dam upstream rockfill zone and tailings beach. The physical indicator should have a minimum of 1.5 m stickup and has a 1 m distant above tailings beach clearly marked.*	*4*	*CLOSED*

Table 6.2 2018 Recommendations

ID Number	Facility	Deficiency or Non-Conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline (Status)
SNTD-2018-01	SNTD	Upper and Lower Met rain gauges unreliable in winter	n/a	Repair or improve the Upper and Lower Met climate station rain gauges to improve reliability of precipitation measurements during the winter months.	4	December 2019

7 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Teck Coal Ltd. (Client) for the specific application to the 2018 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.

Yours Truly,

KLOHN CRIPPEN BERGER LTD.

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Project Engineer
Geotechnical Engineer

Robert W. Chambers, P.Eng.
Project Manager
Senior Geotechnical Engineer, Principal

NG:jc

REFERENCES

Canadian Dam Association (CDA). 2013. “Dam Safety Guidelines 2007 – Revised 2013”, January.

Canadian Dam Association (CDA). 2014. “Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams”.

Klohn Crippen Consultants Ltd. (KC). 1996. “Shikano North Tailings Impoundment – Pervious Tailings Dam Option Design Report” February.

Klohn Crippen Consultants Ltd. (KC). 1997. “Shikano North Tailings Impoundment – 1996 As-Built Report”, March.

Klohn Crippen Consultants Ltd. (KC). 1999a. “Shikano North Tailings Impoundment – 1999 Annual Review”, December.

Klohn Crippen Consultants Ltd. (KC). 1999b. “Shikano North Tailings Impoundment – Stage 2 As-built Report”, July.

Klohn Crippen Berger Ltd. (KCB). 2011. “Quintette 2010 Dam Safety Inspection and Consequence Classification”, March.

Klohn Crippen Berger Ltd. (KCB). 2012. “Quintette Coal Project: Mines Act Permit Amendment Application Site Water Management Plan and Technical Data Report – Revision 1”, June.

Klohn Crippen Berger Ltd. (KCB). 2013. “Shikano North Tailings Dam - 2013 Dam Safety Inspection Report” December.

Klohn Crippen Berger Ltd. (KCB). 2014a. “Quintette Dam Safety Review: Shikano North Tailings Storage Facility”, May.

Klohn Crippen Berger Ltd. (KCB). 2014b. “Shikano North Tailings Dam – 2014 Dam Safety Inspection Report – Revision 1”,

Klohn Crippen Berger Ltd. (KCB). 2016a. “Shikano North Tailings Dam – 2015 Dam Safety Inspection Report”, March.

Klohn Crippen Berger Ltd. (KCB). 2016b. “Shikano North Tailings Dam – 2016 Dam Safety Inspection Report”, December.

Klohn Crippen Berger Ltd. (KCB). 2016c. “Quintette Coal Operations – Shikano North Tailings Dam Water Management, Water Balance and Quantifiable Performance Objectives”, December.

Klohn Crippen Berger Ltd. (KCB). 2018. “Shikano North Tailings Dam – 2017 Dam Safety Inspection Report”, March 16.

Mining Association of Canada (MAC). 2011. “Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities”.

Ministry of Energy, Mines and Petroleum Resources of British Columbia (MEMPR). 2016. “Health, Safety and Reclamation Code for Mines in British Columbia Guidance Document”, July.

Ministry of Energy, Mines and Petroleum Resources of British Columbia (MEMPR). 2017. “Health, Safety and Reclamation Code for Mines in British Columbia”.

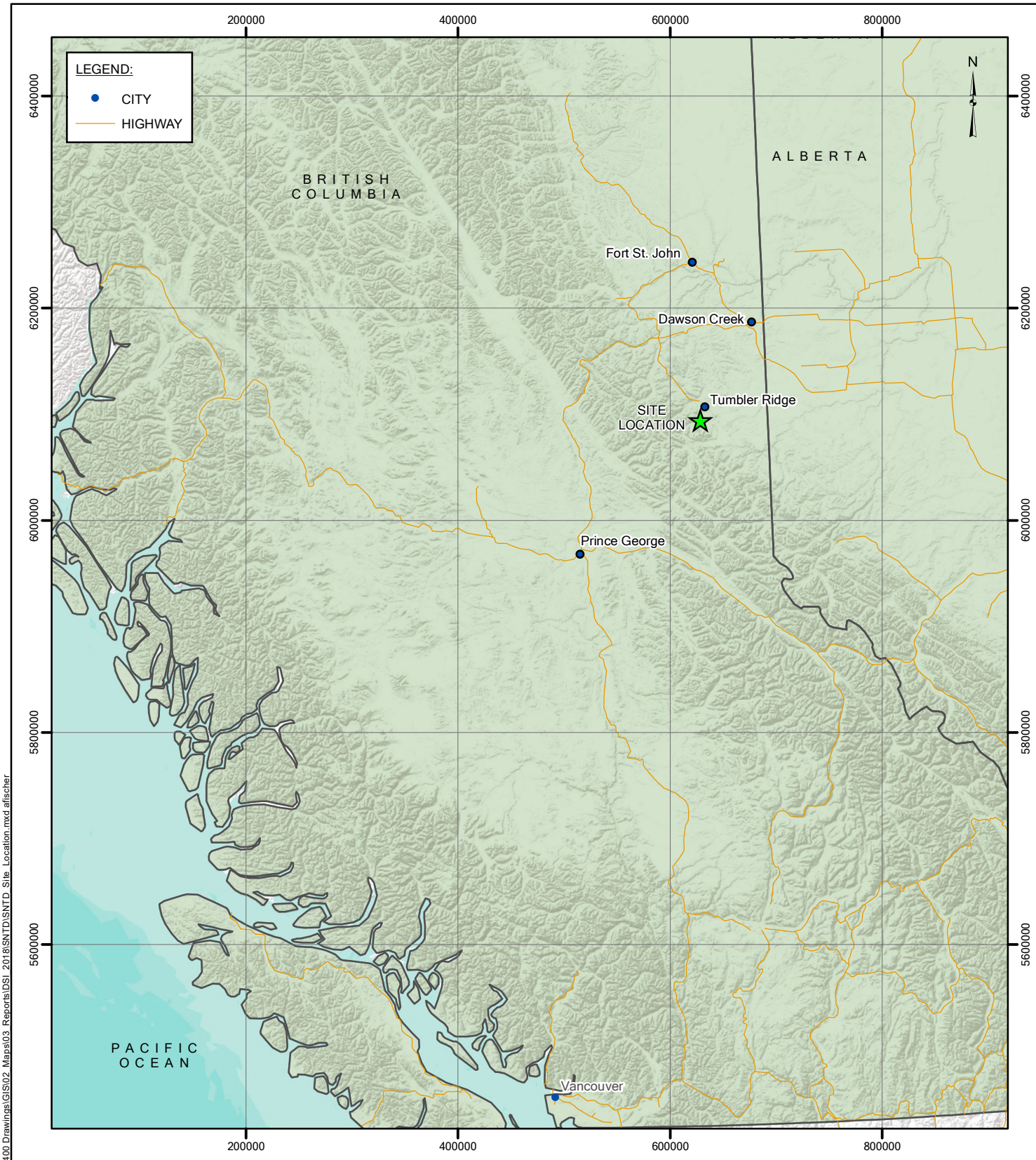
Teck Coal Ltd. (Teck). 2013. “Baseline Hydrology and Design Basis”, January.

Teck Resources Ltd. (Teck). 2014. “Guideline for Tailings and Water Retaining Structures”.

Teck Coal Ltd. (Teck). 2018. “Quintette Coal Operation Shikano North Tailings Operations, Maintenance, and Surveillance Manual”, March.

National Building Code of Canada (NBCC). 2015. National Research Council of Canada.

FIGURES



NOTES:
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2. BASE DATA: ESRI.

SCALE 0 100,000 m

CLIENT: Teck

Klohn Crippen Berger

PROJECT: QUINTETTE COAL OPERATIONS
2018 DAM SAFETY INSPECTION

TITLE: SITE LOCATION

PROJECT No. M09684A15

FIG No. 1

Path: Z:\M\VCR\M09684A15 - TCL-Quintette 2018 Services\400 Drawings\GIS\02_Maps\03_Reports\DSI_2018\SNTD\SNTD_Site_Location.mxd afischer

616,000 620,000 624,000 628,000

6,108,000 6,104,000 6,100,000 6,096,000 6,092,000 6,088,000

Tumbler Ridge

N

29

MESA POND A

MESA
PITS/DUMPS

PLANTSITE
TAILINGS DAM

S4

S3

QUINTETTE
PLANTSITE

B1

SHIKANO PIT

M11 DIVERSION DAM

B2

Murray Forest Service Road

Murray River

DUMPS

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

LEGEND:

STRUCTURE BOUNDARY

SCALE 0 2,500 m

CLIENT Teck

Klohn Crippen Berger

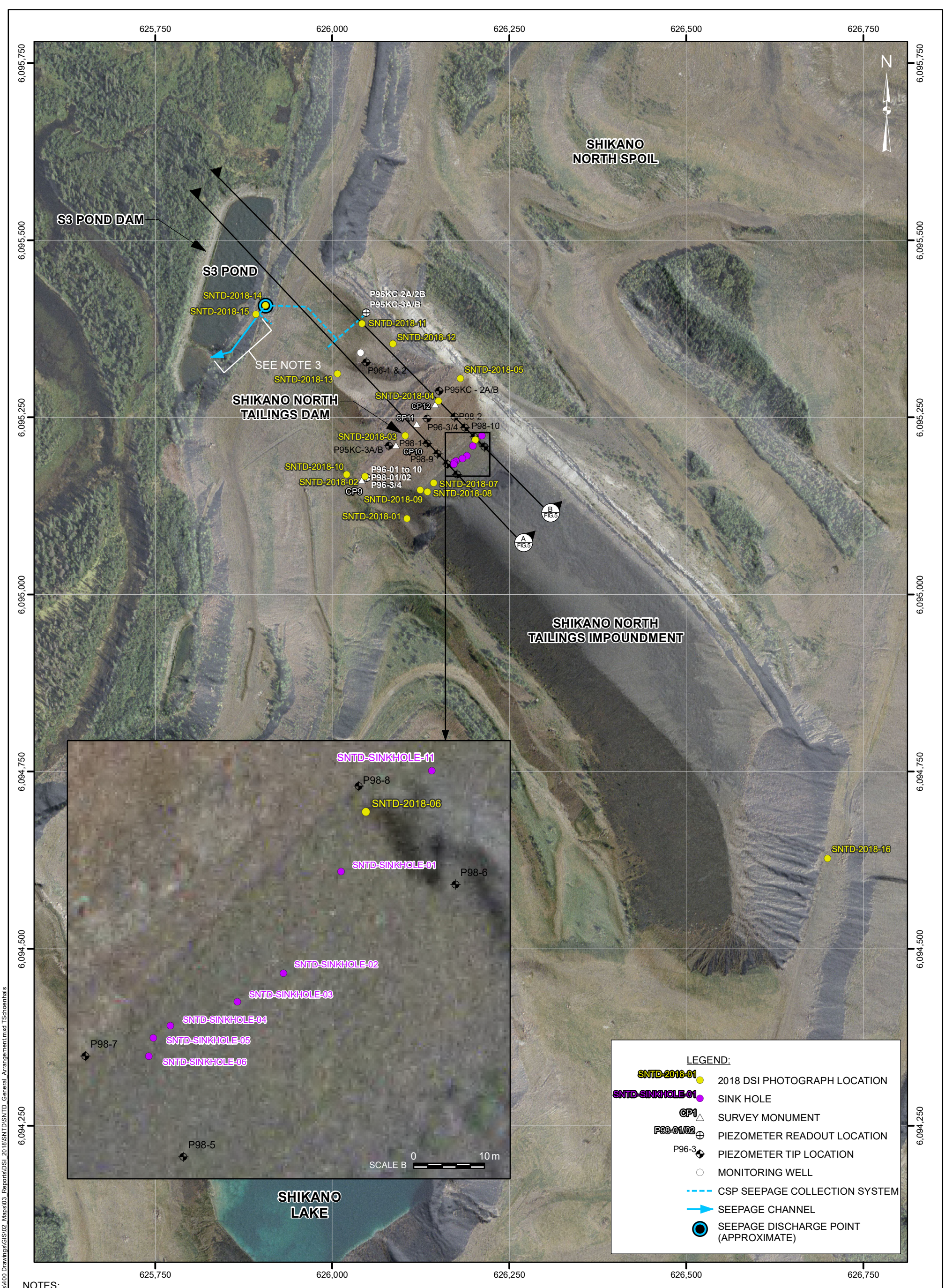
PROJECT
QUINTETTE COAL OPERATIONS
2018 DAM SAFETY INSPECTION

TITLE
GENERAL SITE PLAN

PROJECT No. M09684A15

FIG No. 2

Path: Z:\M\VCR\M09684A15 - TCL-Quintette 2018 Services\400 Drawings\GIS\02_Maps\03_Reports\DSI_2018\General_SitePlan.mxd TSchoenhals



NOTES:
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2. 2010 ORTHOPHOTO PROVIDED BY TECK.
3. THIS PART OF SEEPAGE COLLECTION PIPE WAS LIKELY REPLACED WITH OPEN CHANNEL.

SCALE A 0 150 m

CLIENT: Teck

Klohn Crippen Berger

PROJECT: QUINTETTE COAL OPERATIONS 2018 DAM SAFETY INSPECTION

TITLE: SHIKANO NORTH TAILINGS DAM GENERAL ARRANGEMENT

PROJECT No. M09684A15

FIG No. 3

Path: Z:\M\VCRM09684A15 - TCL-Quintette 2018 Services\400 Drawings\GIS\02_Maps\03_Reports\DSI_2018\SNTD\SNTD_General_Arrangement.mxd TSchoenhals

626,000 626,250 626,500 626,750 627,000

6,095,500 6,095,250 6,095,000 6,094,750 6,094,500 6,094,250 6,094,000

N

SHIKANO NORTH
TAILINGS DAM

SHIKANO NORTH
TAILINGS IMPOUNDMENT

76.4 ha

LEGEND:
CATCHMENT AREA

NOTES:
1. PROJECTION: NAD83 UTM ZONE 10N.
2. 2010 ORTHOPHOTO PROVIDED BY TECK.
3. THIS PART OF SEEPAGE COLLECTION PIPE WAS LIKELY REPLACED WITH OPEN CHANNEL.

SCALE 0 150 m

CLIENT Teck

Klohn Crippen Berger

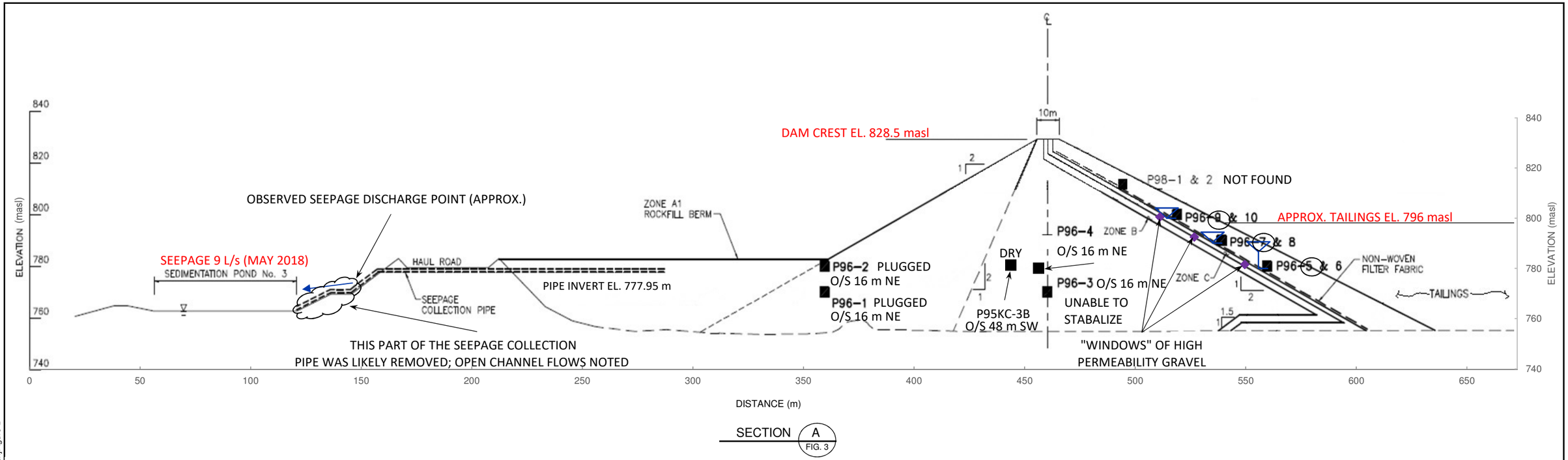
PROJECT
QUINTETTE COAL OPERATIONS
2018 DAM SAFETY INSPECTION

TITLE
SHIKANO NORTH TAILINGS DAM
CATCHMENT

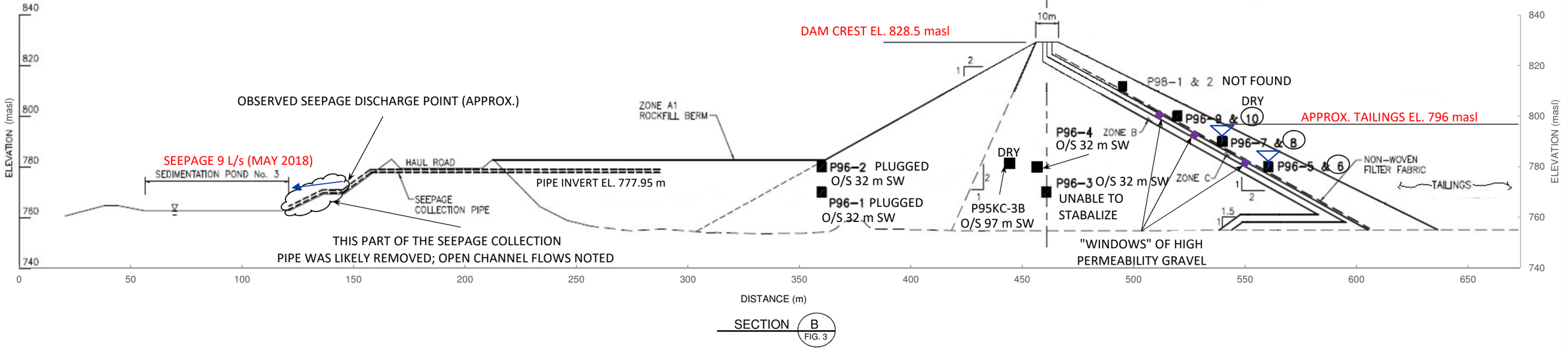
PROJECT No. M09684A15

FIG No. 4

Path: Z:\M\VCRM09684A15 - TCL-Quintette 2018 Services\400 Drawings\GIS\02_Maps\03_Reports\DSI_2018\SNTD\SNTD_Catchment.mxd TSchoenhals



SECTION A
FIG. 3



SECTION B
FIG. 3

NOTES:

TRESHOLD VALUES WERE ADJUSTED BASED ON RECOMMENDATIONS FROM 1990 ANNUAL REVIEW (KC 1990).

LEGEND:

MAY 31, 2018 WATER LEVEL

CLIENT: Teck

Klohn Crippen Berger

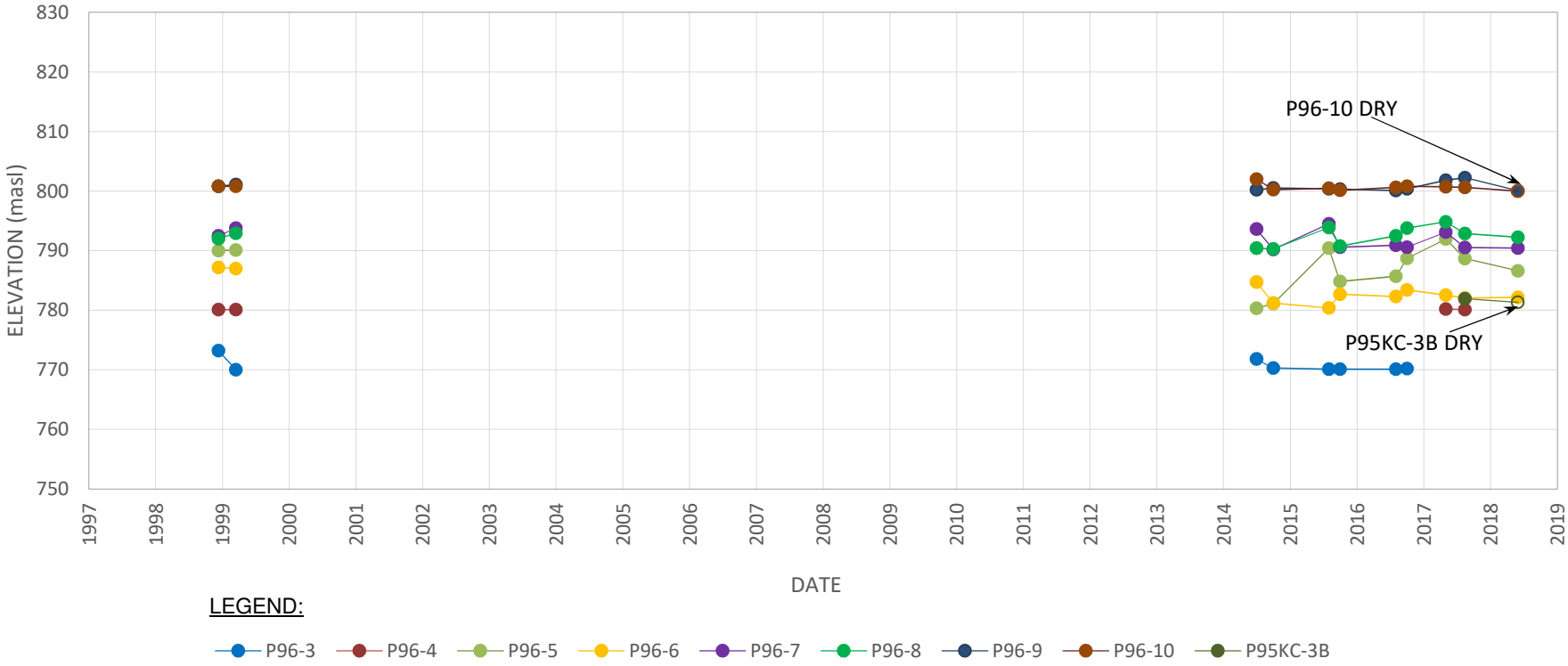
PROJECT: QUINTETTE COAL OPERATIONS
2018 DAM SAFETY INSPECTION

TITLE: SHIKANO NORTH TAILINGS DAM
SCHEMATIC SECTIONS A AND B
WITH 2018 PIEZOMETER READINGS

PROJECT No. M09684A15

FIG. No. 5

Date & Time: 2019-02-13 16:40
Figure File: Z:\M\VCR\M09684A15 - TCL-Quintette 2018 Services\300 Design\301 Instrumentation\SNTD\Piezometer\190125 Shikano Piezometer.xlsx]Figure B



CLIENT: Teck

Klohn Crippen Berger

PROJECT: QUINTETTE COAL OPERATIONS
2018 DAM SAFETY INSPECTION

TITLE: SHIKANO NORTH TAILINGS DAM
HISTORICAL PIEZOMETER DATA

PROJECT No. M09684A15

FIG. No. 6

Date & Time: 2019-02-11 16:00
Figure File: Z:\M\VCR\M09684A15 - TCL-Quintette 2018 Services\300 Design\301 Instrumentation\SNTD\Piezometer\[190125 Shikano Piezometer.xlsx]Project & Figure Info.

MONUMENT	NORTHING (m)		CHANGES BETWEEN READINGS AND PREVIOUS YEAR (mm)
	October 4, 2017	June 21, 2018	October 4, 2017
CP9	6095161.136	6095161.126	-10
CP10	6095210.845	6095210.857	12
CP11	6095240.668	6095240.662	-6
CP12	6095268.247	6095268.258	11

MONUMENT	EASTING (m)		CHANGES BETWEEN READINGS AND PREVIOUS YEAR (mm)
	October 4, 2017	June 21, 2018	October 4, 2017
CP9	626041.801	626041.797	-4
CP10	626090.116	626090.131	15
CP11	626119.195	626119.210	15
CP12	626145.421	626145.435	15

MONUMENT	ELEVATION (masl)		CHANGES BETWEEN READINGS AND PREVIOUS YEAR (mm)
	October 4, 2017	June 21, 2018	October 4, 2017
CP9	828.510	828.515	5
CP10	828.070	828.069	-1
CP11	828.127	828.107	-20
CP12	827.969	827.974	6

NOTES:

1. LATEST SURVEY DATA PROVIDED BY QUINTETTE COAL OPERATIONS ON JUNE 21, 2018.

SURVEY ACCURACY:
HORIZONTAL: +/- 5 mm to 10 mm
VERTICAL: +/- 8 mm to 15 mm

CLIENT: Teck

Klohn Crippen Berger

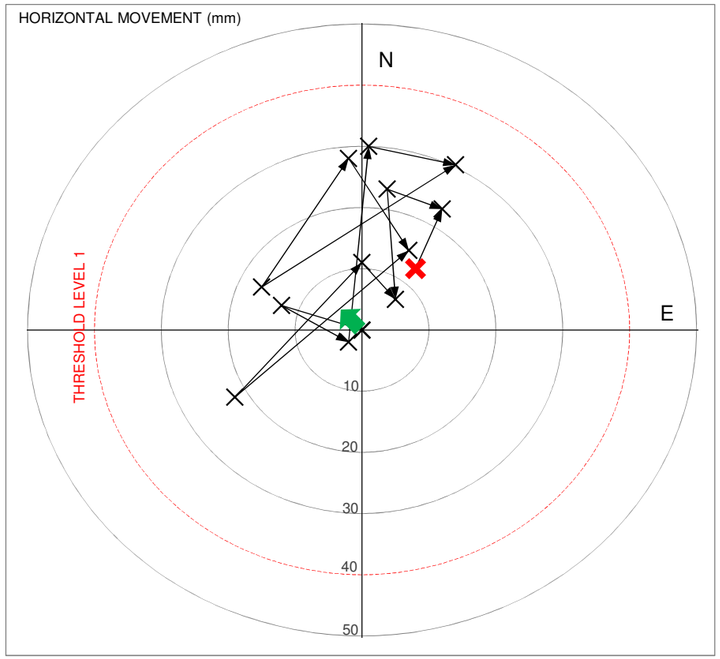
PROJECT: QUINTETTE COAL OPERATIONS
2018 DAM SAFETY INSPECTION

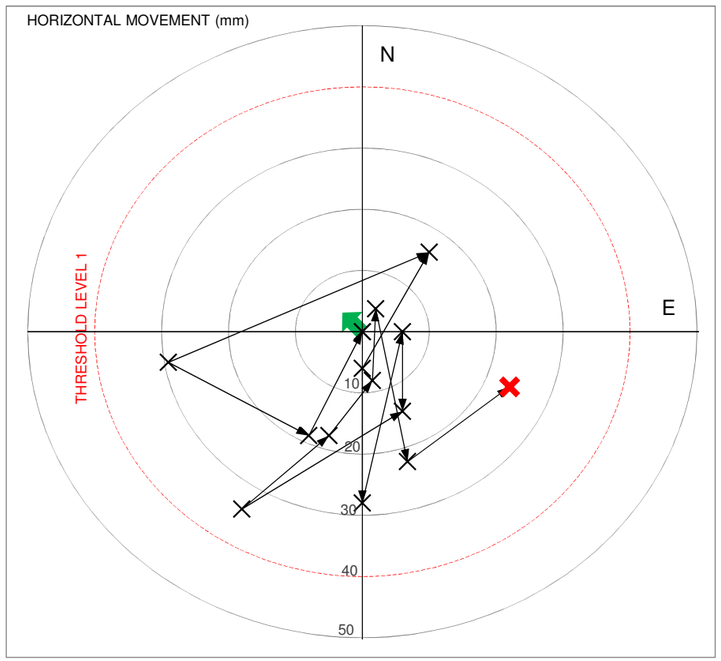
TITLE: SHIKANO NORTH TAILINGS DAM
2018 SURVEY MONUMENT DATA

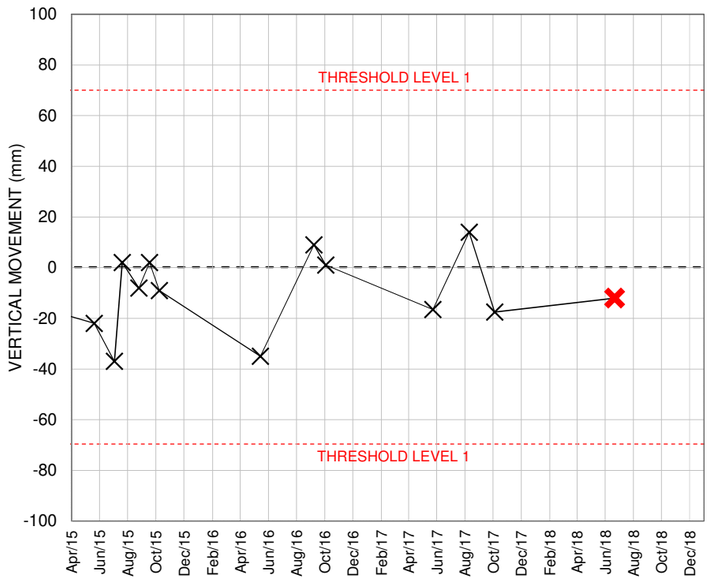
PROJECT No. M09684A15

FIG. No. 7

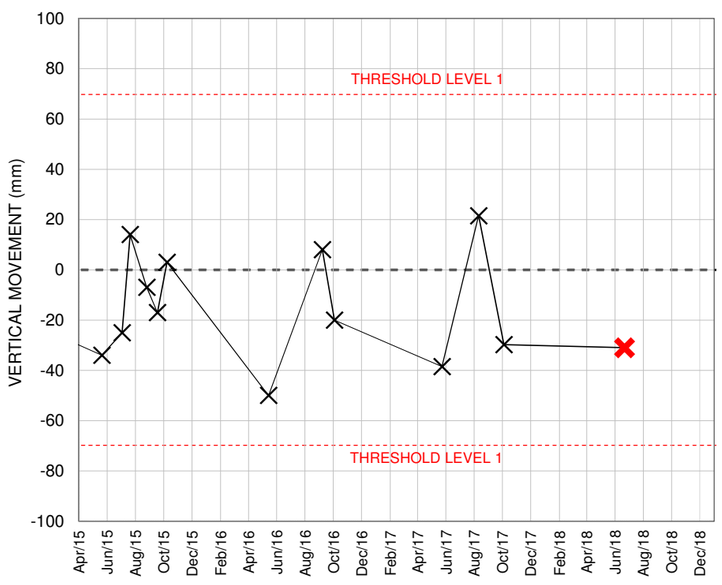
Date & Time: 2019-02-11 16:07
Figure File: Z:\MVCR\M09684A15 - TCL-Quintette 2018 Services\300 Design\301 Instrumentation\SNTD\Survey Monument\[180626 Shikano Survey.xlsx]Project & Figure Info.







CP9 SURVEY RECORDS



CP10 SURVEY RECORDS

NOTES:

1. LATEST SURVEY DATA PROVIDED BY QUINTETTE COAL OPERATIONS ON JUNE 21, 2018.

LEGEND:

DOWNSTREAM DIRECTION

LATEST SURVEY READING

SURVEY ACCURACY:
HORIZONTAL: +/- 5 mm to 10 mm
VERTICAL: +/- 8 mm to 15 mm

THRESHOLD VALUES:
THRESHOLD LEVEL 1: ≥ 40 mm OF HORIZONTAL MOVEMENT FROM INITIAL READING;
≥ 70 mm OF VERTICAL MOVEMENT FROM INITIAL READING; OR
IF VERITICAL MOVEMENT ≥ 80 mm BETWEEN SUCCESSIVE READINGS
THRESHOLD LEVEL 2: IF THERE IS A TREND OF THRESHOLD EXEEDANCE IN THE MONITORING MONUMENTS.

CLIENT: Teck

Klohn Crippen Berger

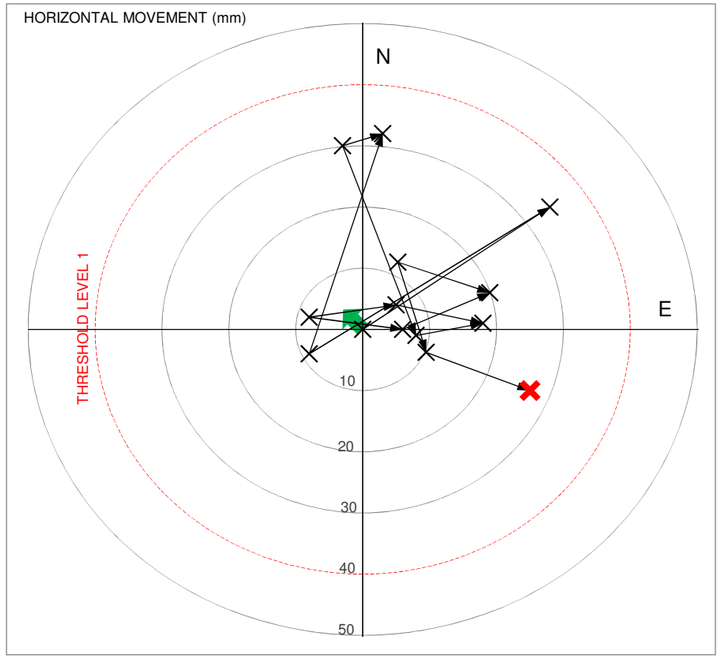
PROJECT: QUINTETTE COAL OPERATIONS
2018 DAM SAFETY INSPECTION

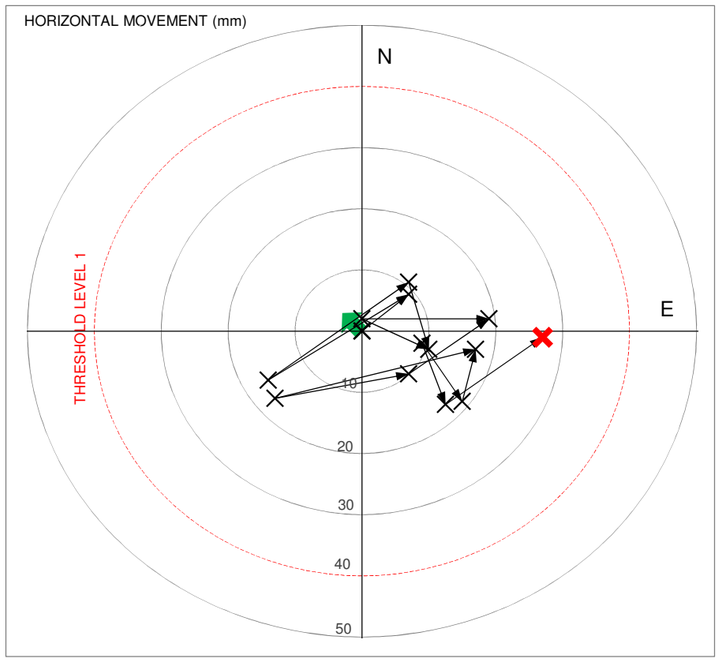
TITLE: SHIKANO NORTH TAILINGS DAM
2018 SURVEY MONUMENT PLOTS
CP9 AND CP10

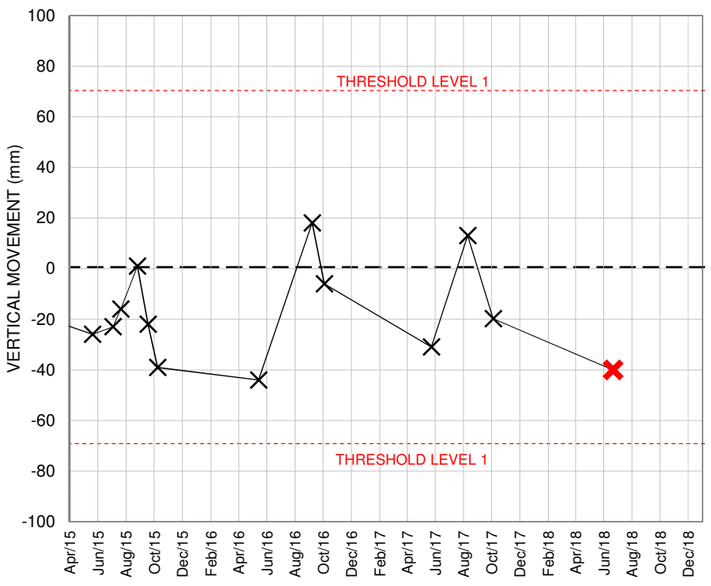
PROJECT No. M09684A15

FIG. No. 8

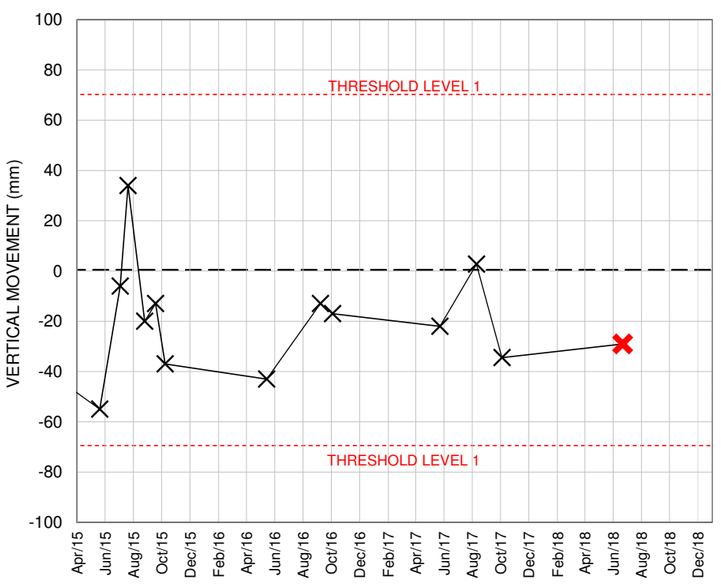
Date & Time: 2019-02-11 16:07
Figure File: Z:\M\VCR\M09684A15 - TCL-Quintette 2018 Services\300 Design\301 Instrumentation\SNTD\Survey Monument\[180626 Shikano Survey.xlsx]Project & Figure Info.







CP11 SURVEY RECORDS



CP12 SURVEY RECORDS

NOTES:

1. LATEST SURVEY DATA PROVIDED BY QUINTETTE COAL OPERATIONS ON JUNE 21, 2018.

LEGEND:

DOWNSTREAM DIRECTION

LATEST SURVEY READING

SURVEY ACCURACY:
HORIZONTAL: +/- 5 mm to 10 mm
VERTICAL: +/- 8 mm to 15 mm

THRESHOLD VALUES:
THRESHOLD LEVEL 1: ≥ 40 mm OF HORIZONTAL MOVEMENT FROM INITIAL READING;
≥ 70 mm OF VERTICAL MOVEMENT FROM INITIAL READING; OR
IF VERITICAL MOVEMENT ≥ 80 mm BETWEEN SUCCESSIVE READINGS
THRESHOLD LEVEL 2: IF THERE IS A TREND OF THRESHOLD EXEEDANCE IN THE MONITORING MONUMENTS.

CLIENT: Teck

Klohn Crippen Berger

PROJECT: QUINTETTE COAL OPERATIONS
2018 DAM SAFETY INSPECTION

TITLE: SHIKANO NORTH TAILINGS DAM
2018 SURVEY MONUMENT PLOTS
CP11 AND CP12

PROJECT No. M09684A15

FIG. No. 9

Date & Time: 2019-02-11 16:07
Figure File: Z:\M\VCR\M09684A15 - TCL-Quintette 2018 Services\300 Design\301 Instrumentation\SNTD\Survey Monument\[180626 Shikano Survey.xlsx]Project & Figure Info.

APPENDIX I

Inspection Photographs

Appendix I
Inspection Photographs

LEGEND:

- SNTD = Shikano North Tailings Dam
- SNTD-2018-## refers to 2018 DSI photograph location, as shown on Figure 3

Photographs were taken during site inspection on May 28, 2018.

Photo I-1 **Upstream slope taken from the west abutment – looking northeast. Slope appears to be in good condition with no signs of erosion or movement (SNTD-2018-01)**

Photo I-2 **North abutment – looking northeast. Pit wall erosion appears unchanged from 2017 condition (SNTD-2018-01)**

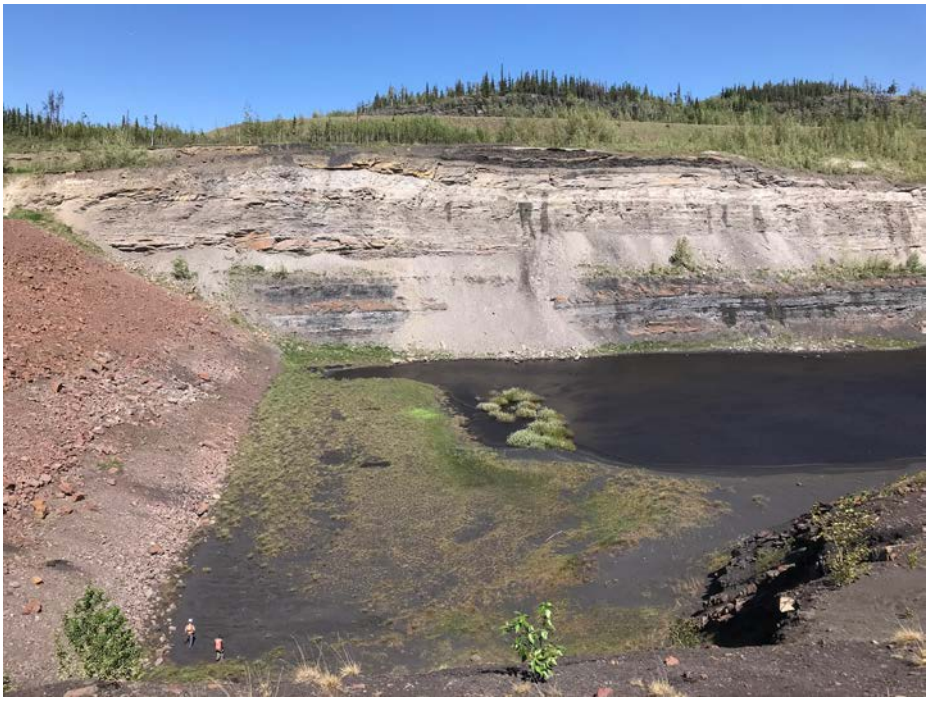


Photo I-3 **Dam crest from east abutment – looking northwest. No signs of dam safety issues (e.g., sinkholes, cracks, settlement, etc.) (SNTD-2018-02)**

Photo I-4 **Downstream slope taken from west abutment – looking northwest. Slope appears to be in good condition (SNTD-2018-02)**

Photo I-5 **Downstream slope and west abutment contact – looking west. No signs of erosion or movement (SNTD-2018-03)**

Photo I-6 **West abutment, continued ravelling of shale slope upstream of abutment. No significant changes from 2017 condition (SNTD-2018-03)**

Photo I-7 **Upstream slope taken from mid-length of the crest – looking north. Slope appears to be in good condition (SNTD-2018-03)**

Photo I-8 **Upstream slope taken from mid-length of the crest – slope appears to be in good condition. General area where sinkholes are observed is shown in red box (SNTD-2018-03)**

Photo I-9 **Downstream slope taken from the east abutment – looking northwest. Slope appears to be in good condition with no signs of erosion or movement (SNTD-2018-04)**

Photo I-10 East abutment – minor ravelling of material from slope above onto the crest – appears to be in similar condition as previous year's (SNTD-2018-05)

Photo I-11 **Upstream slope and impoundment overview from east abutment – looking southeast; no signs of erosion or movement (SNTD-2018-05)**

Photo I-12 **Sinkhole 11 – first observed in 2018. Approximately 5.0 m x 3.0 m x 1.0 m deep. Flow of water into the underlying rockfill was observed – not a dam safety concern (SNTD-SINKHOLE-11)**

Photo I-13 Drainage channel inside the impoundment (SNTD-2018-06)

Photo I-14 Sinkhole 1 – first observed in 2016. Approximately 1.9 m x 1.7 m x 1.0 m deep (SNTD-SINKHOLE-01)

Photo I-15 Sinkhole 2 – approximately 3.2 m x 3.0 m x 0.6 m deep (SNTD-SINKHOLE-02)

Photo I-16 Sinkhole 3 – approximately 3.0 m x 2.5 m x 0.6 m deep (SNTD-SINKHOLE-03)

Photo I-17 Sinkhole 3 – settled tailings surface immediately adjacent to Sinkhole 3, indicating Sinkhole 3 may be increasing in size (SNTD-SINKHOLE-03)

Photo I-18 Sinkhole 4 – first observed in 2017. Approximately 0.2 m x 0.1 m x 0.3 m deep (SNTD-SINKHOLE-04)

Photo I-19 Sinkhole 5 – first observed in 2017. Approximately 0.2 m x 0.1 m x 0.2 m deep (SNTD-SINKHOLE-05)

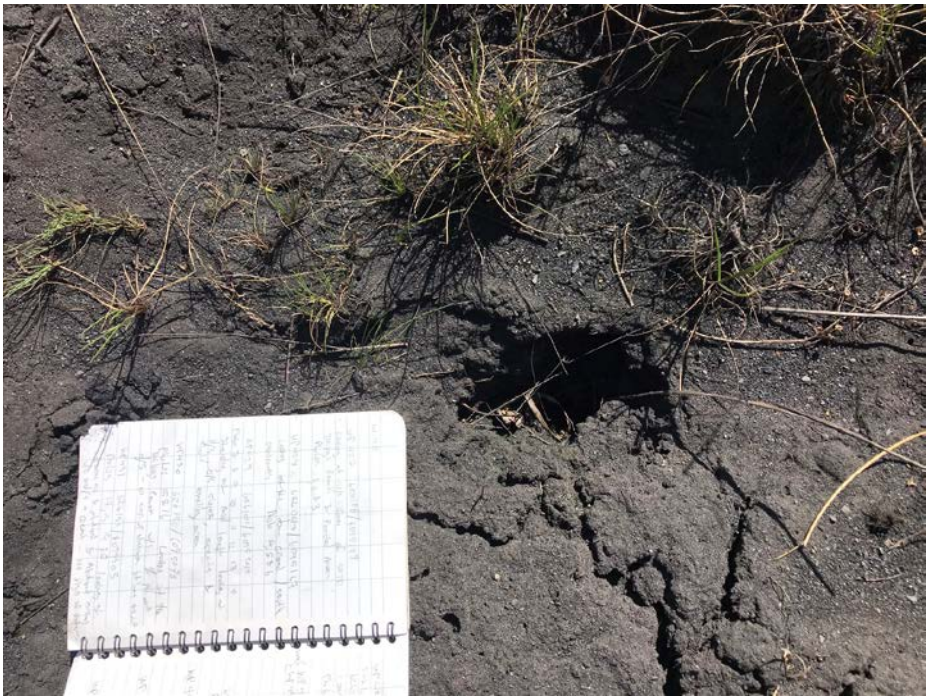


Photo I-20 **Sinkhole 6 used to be a cluster of three sinkholes up to 2017. In 2018, all three sinkholes have developed into one large sinkhole approximately 9.4 m x 7.4 m x 0.5 m deep (SNTD-SINKHOLE-06)**

Photo I-21 **Sinkhole 6 – water noted at the bottom of one of the sinkholes (SNTD-SINKHOLE-06)**

Photo I-22 Sinkholes 7 to 10 - typical smaller sinkholes noted along the southern half of the tailings beach (between SNTD-2018-07 and SNTD-2018-08)

Photo I-23 **SNTD west abutment - upstream contact with the Shikano pit west wall – small erosion gully noted but appears to be unchanged from 2017 condition (SNTD-2018-09)**

Photo I-24 Downstream slope taken from west abutment – looking north; no signs of erosion or movement (SNTD-2018-10)

Photo I-25 Downstream east abutment – looking east. No changes in condition when compared to 2017 observation (SNTD-2018-11)

Photo I-26 Downstream contact with east abutment – looking east. No changes in condition from previous year (SNTD-2018-12)

Photo I-27 Downstream, access ramp and downstream slope – looking north. No significant signs of erosion or movement (SNTD-2018-13)

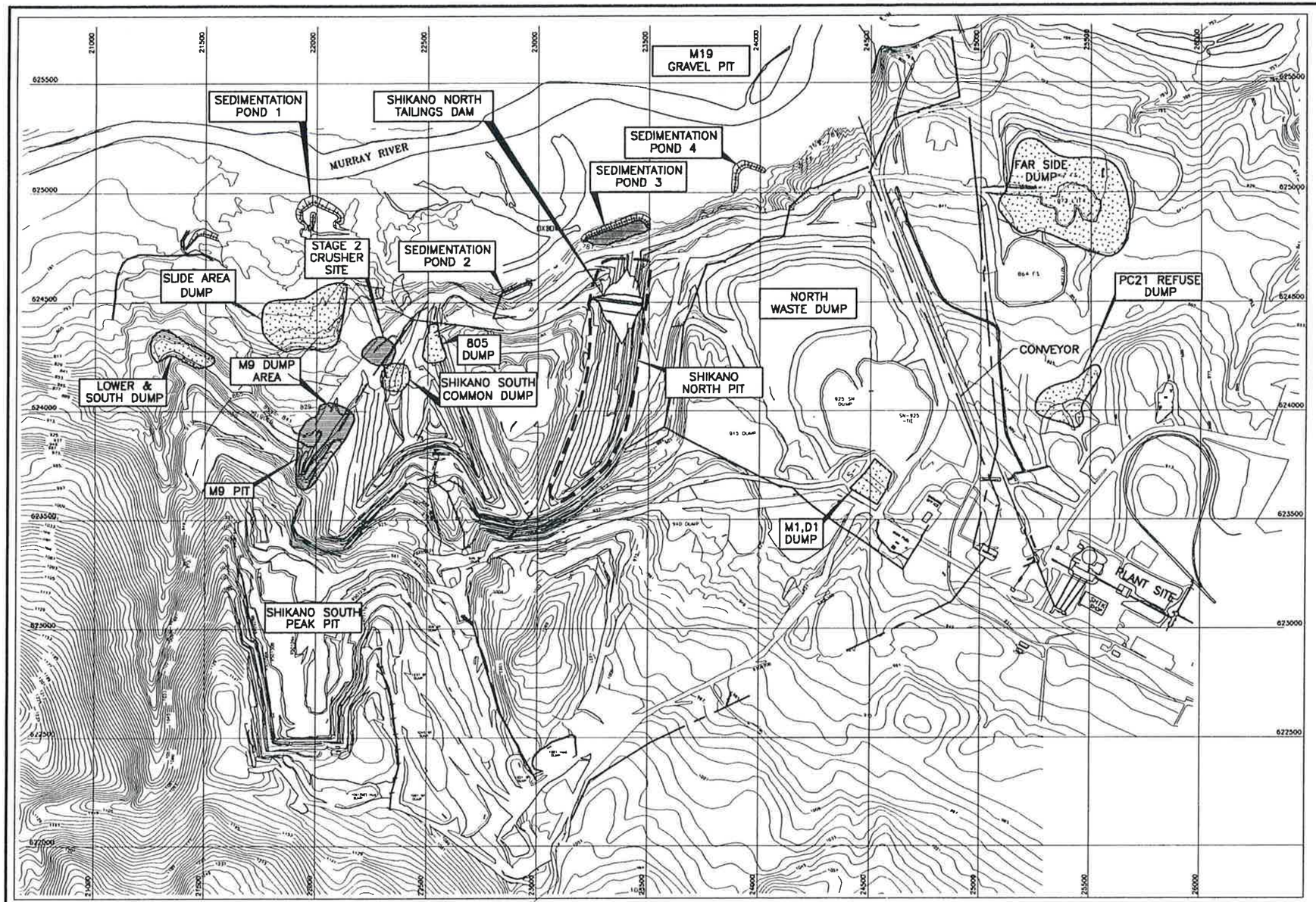
Photo I-28 Seepage from low level outlet downstream of the dam (SNTD-2018-14)

Photo I-29 Seepage channel, which flows into Sediment Pond S3 – flow estimate: 9 L/s (SNTD-2018-15)

Photo I-30 Shikano North Tailings Dam – looking northwest. Historic slumping failure circled with red dash line. No significant changes since 2012 (SNTD-2018-16)

APPENDIX II

Select Dam Record Drawings



LEGEND

SHIKANO NORTH PIT \ WORK AREA

DISPOSAL AREA

ISSUED FOR AS-BUILT

200m 0 600m
SCALE

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
H. D. PLEWES
Jul-7/99

NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D
2	JULY 99	ISSUED FOR AS-BUILT	ENL	TDP	HDP	HDP
1	OCT 98	ISSUED FOR CONSTRUCTION	PSK	TDP	HDP	HDP
0	OCT 98	ISSUED FOR TENDER	PSK	TDP	HDP	HDP

DRAWING NO. | REFERENCE DRAWING

SEAL

CLIENT: Quintette Operating Corp.

KLOHN-CRIPPEN

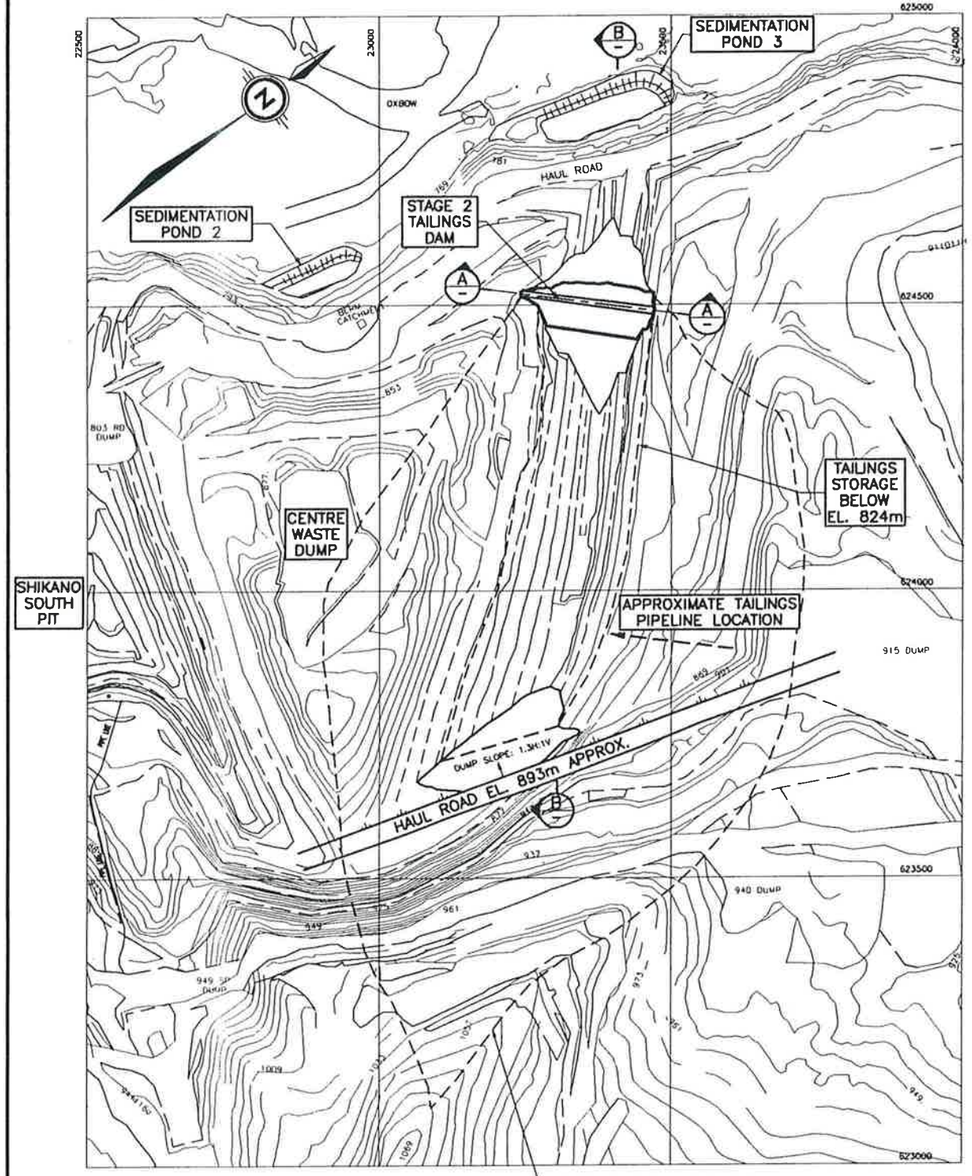
PROJECT: SHIKANO NORTH TAILINGS IMPOUNDMENT

TITLE: GENERAL SITE ARRANGEMENT

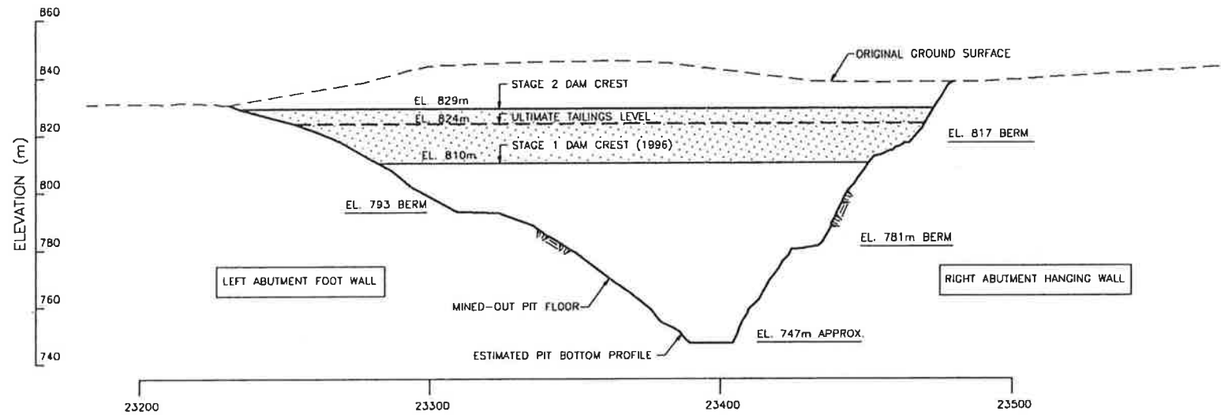
SCALE	PROJECT No.	DWG. No.	REV
AS SHOWN	PM6970 16	D-16000	2

CANCEL PRINTS BEARING PREVIOUS

KCC-A3



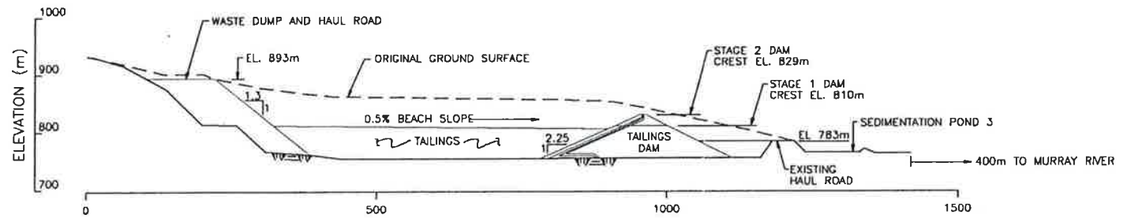
PLAN
SCALE: A



SECTION A
SCALE: B

LEGEND:

STAGE 2 DAM RAISE



SECTION B
SCALE: A

ISSUED FOR AS-BUILT

SCALE B: 20m 0 60m

SCALE A: 100m 0 300m

SCALE

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA H. D. PLEWES 7/99

NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D
2	JULY 99	ISSUED FOR AS-BUILT	ENL	TDP	HDP	HDP
1	OCT 98	ISSUED FOR CONSTRUCTION	PSK	TDP	HDP	HDP
0	OCT 98	ISSUED FOR TENDER	PSK	TDP	HDP	HDP

DRAWING NO. | REFERENCE DRAWING

SEAL

CLIENT: Quintette Operating Corp.

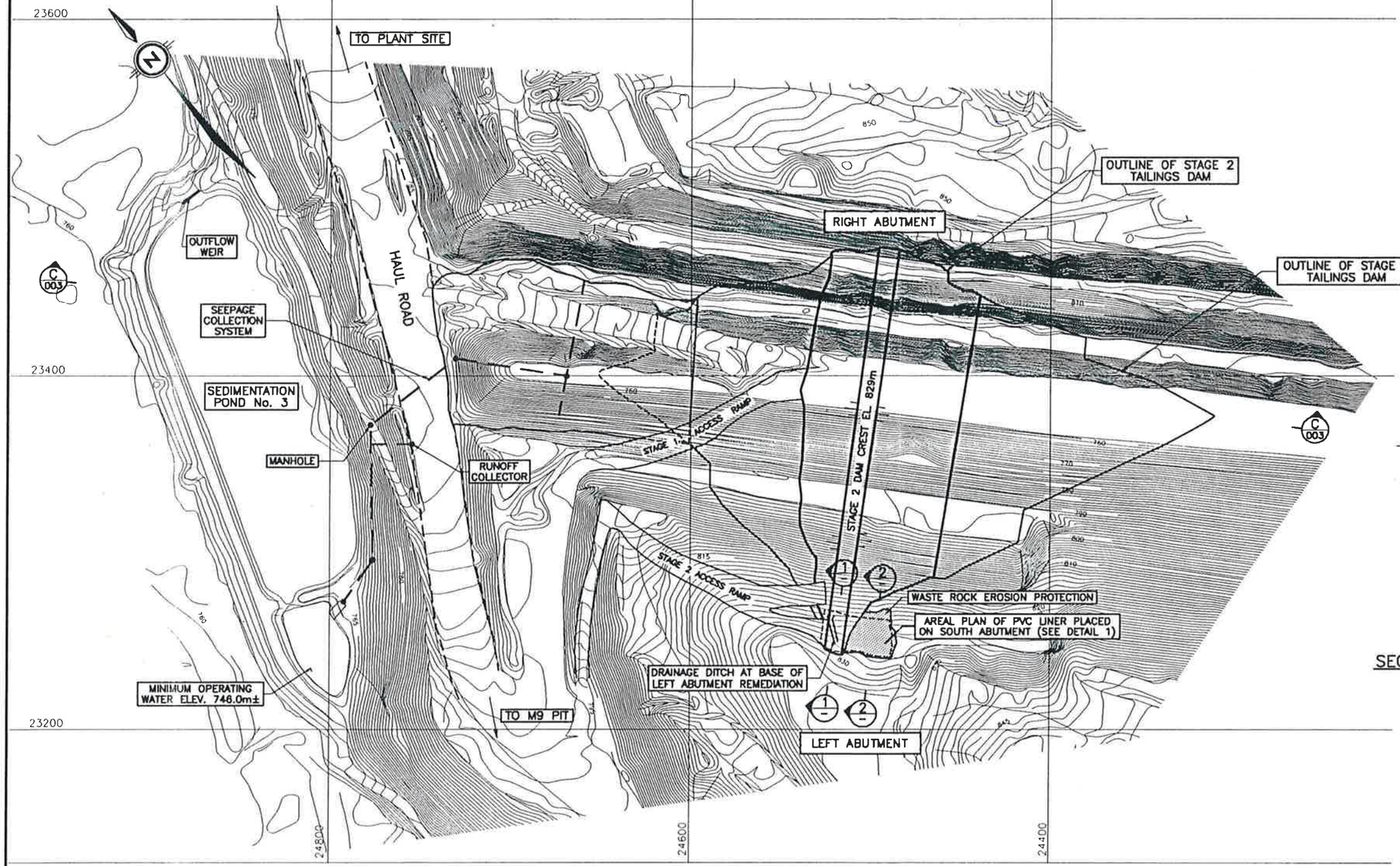
KLOHN-CRIPPEN

PROJECT: SHIKANO NORTH TAILINGS IMPOUNDMENT

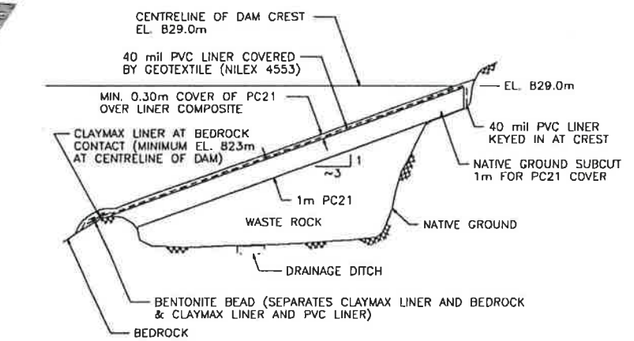
TITLE: ARRANGEMENT PLAN AND SECTIONS OF TAILINGS IMPOUNDMENT SITE

SCALE	PROJECT No.	DWG. No.	REV.
AS SHOWN	PM6970 16	D-16001	2

CANCEL PRINTS BEARING PREVIOUS



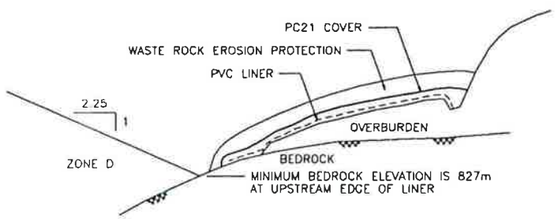
PLAN



SECTION (1) TYPICAL LEFT ABUTMENT REMEDIATION
N.T.S.

NOTES:

1. TOPOGRAPHY ACQUIRED FROM AERIAL PHOTOGRAPHY TAKEN SEPT.8, 1995 AND SUPPLIED BY QUINTETTE OPERATING CORPORATION.
2. TOPOGRAPHY FOR LEFT ABUTMENT REMEDIATION SUPPLIED BY CONTRACTOR.



SECTION (2) TYPICAL LEFT ABUTMENT LINER EXTENSION
N.T.S.

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. D. PLEWES — 7/99

ISSUED FOR AS-BUILT

0 100m
SCALE

NO	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D
2	JULY 99	ISSUED FOR AS-BUILT	ENL	TDP	HDP	HDP
1	OCT 98	ISSUED FOR CONSTRUCTION	PSK	TDP	HDP	KDP
0	OCT 98	ISSUED FOR TENDER	PSK	TDP	HDP	KDP

DRAWING NO. | REFERENCE DRAWING

SEAL

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

CLIENT: Quintette Operating Corp.

KLOHN-CRIPPEN

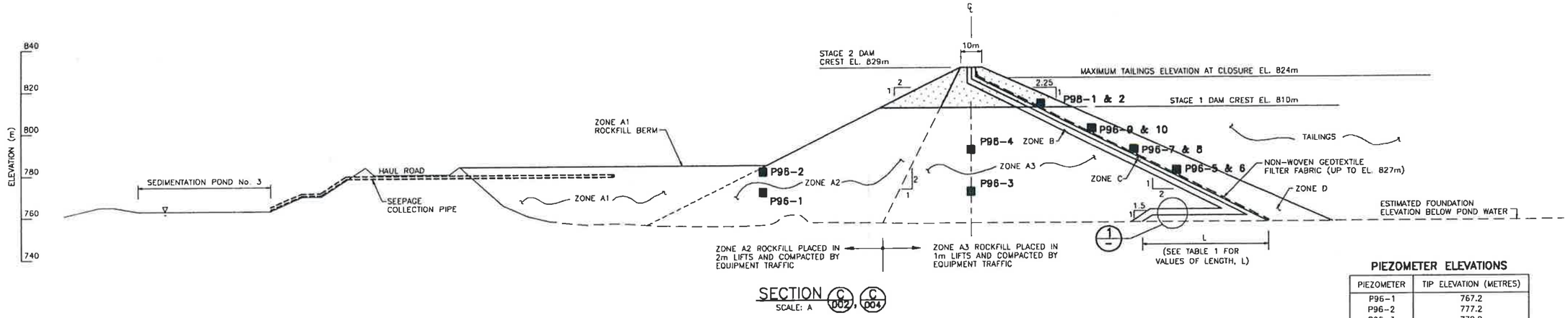
PROJECT: SHIKANO NORTH TAILINGS IMPOUNDMENT

TITLE: STAGES 1 AND 2 TAILINGS DAM PLAN

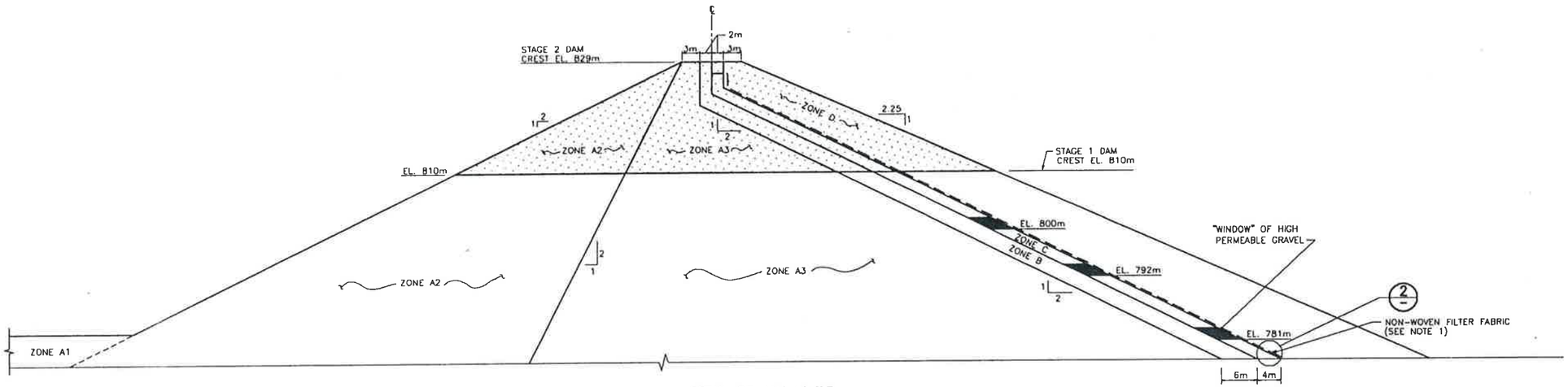
SCALE	PROJECT No.	DWG No.	REV
AS SHOWN	PM6970 16	D-16002	2

CANCEL PRINTS BEARING PREVIOUS

KCC-A3



SECTION ℄ (C/002, C/004)
SCALE: A



DETAIL OF DAM CREST
SCALE: B

PIEZOMETER ELEVATIONS

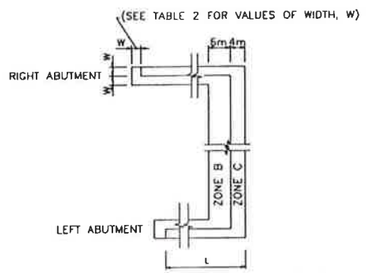
PIEZOMETER	TIP ELEVATION (METRES)
P96-1	767.2
P96-2	777.2
P96-3	770.0
P96-4	780.1
P96-5	780.0
P96-6	780.0
P96-7	790.1
P96-8	790.2
P96-9	800.0
P96-10	800.0
P98-1	810.5
P98-2	810.5

LEGEND:

96-10
■ PIEZOMETERS INSTALLED IN TAILINGS DAM

NOTES:

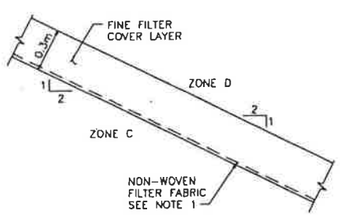
1. FILTER FABRIC LAID ON THE UPSTREAM SIDE OF ZONE C FINE FILTER. FILTER FABRIC OVERLAP > 0.3m ON DAM FACE, AND EXTENDS 1m UP DAM ABUTMENTS. FILTER FABRIC COVERED BY 0.3m OF ZONE C FINE FILTER.
2. PIEZOMETER LEADS FOR P96-3 AND 4 AND P98-1 AND 2 EXTENDED TO LOCATION OF PIEZOMETER LEADS FOR P96-5 TO 10.
3. PIEZOMETER LEADS FOR P96-3 TO P96-10 AND P98-1 AND 2 ARE EXTENDED IN A PVC CONDUIT UP THE LEFT ABUTMENT TO THE STAGE 2 DAM CREST.



(SEE TABLE 1 FOR VALUES OF LENGTH, L)

DETAIL (1) (C)
SCALE: C

PLAN VIEW OF FILTER ZONES AGAINST ABUTMENT WALLS



DETAIL (2) (-)
SCALE: D

GEOTEXTILE PROTECTIVE COVER

TABLE 1
FILTER ARM EXTENSION LENGTHS

FOUNDATION ELEVATION (m)	LENGTH, L (METRES) RIGHT ABUTMENT	LENGTH, L (METRES) LEFT ABUTMENT
810.0 - 815.5	30	20
815.5 - 816.5	28	20
816.5 - 817.5	26	20
817.5 - 818.5	24	20
818.5 - 819.5	22	20
819.5 - 820.5	20	20
820.5 - 821.5	18	18
821.5 - 821.6	15	15
821.6 - 822.5	13	13
822.5 - 823.5	11	11
823.5 - 824.5	9	9
824.5 - 825.5	9	9
825.5 - 825.6	7	7
825.6 - 826.5	7	7
826.5 - 827.5	7	7
827.5 - 828.5	7	7
828.5 - 829.0	6	6

TABLE 2
FILTER ARM WIDTHS

FOUNDATION ELEVATION (m)	WIDTH , W (METRES)* LEFT ABUTMENT	WIDTH , W (METRES)* RIGHT ABUTMENT
810.0-829.0	2.5	1.677

* EQUIVALENT HORIZONTAL THICKNESS. PERPENDICULAR THICKNESS TO ABUTMENT WALL IS 1.5m

STAGE 2 DAM RAISE MATERIAL ZONES

ZONE	DESCRIPTION	MATERIAL DESCRIPTION
A2	DOWNSTREAM SHELL	WASTE ROCK < 2m
A3	ROCKFILL SELECT	WASTE ROCK < 1m
B	COARSE FILTER	150mm MINUS
C	FINE FILTER	38mm MINUS
D	UPSTREAM SHELL	WASTE ROCK < 2m

ISSUED FOR AS-BUILT

SCALE D: 0 2m
SCALE C: 0 80m
SCALE B: 0 40m
SCALE A: 0 100m
SCALE

NO	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D
2	JULY 99	ISSUED FOR AS-BUILT	ENL	TDP	HDP	
1	OCT 98	ISSUED FOR CONSTRUCTION	PSK	TDP	HDP	
0	OCT 98	ISSUED FOR TENDER	PSK	TDP	HDP	

DRAWING NO. | REFERENCE DRAWING

SEAL: PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, H. D. PLEWES, 1999

CLIENT: Quintette Operating Corp.

KLOHN-CRIPPEN

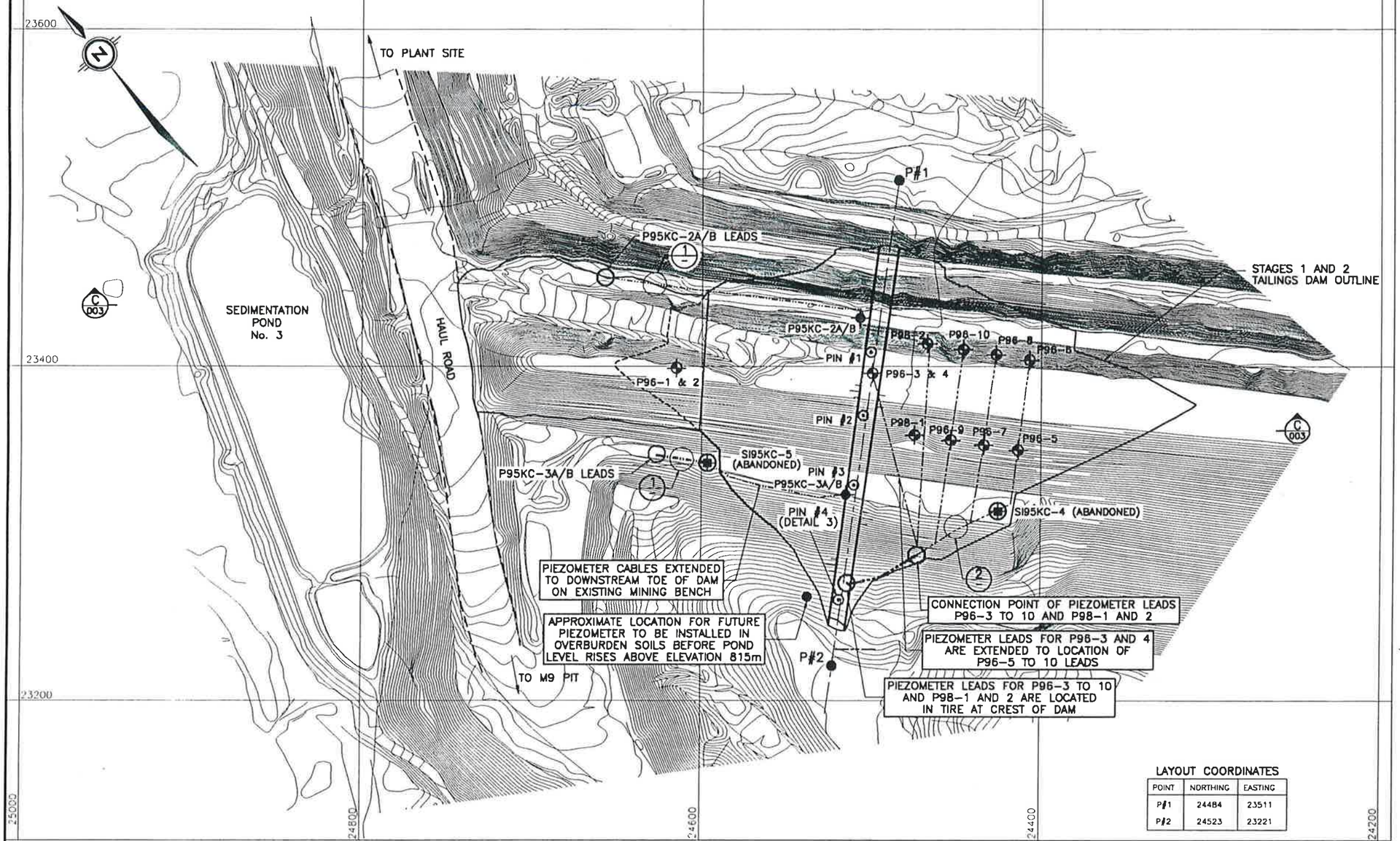
PROJECT: SHIKANO NORTH TAILINGS IMPOUNDMENT

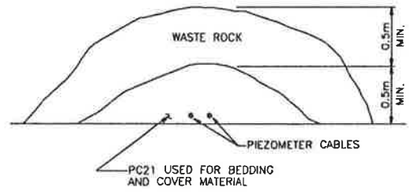
TITLE: STAGES 1 AND 2 TAILINGS DAM SECTIONS AND DETAILS

SCALE	PROJECT No.	DWG No.	REV
AS SHOWN	PM6970 16	D-16003	2

CANCEL PRINTS BEARING PREVIOUS

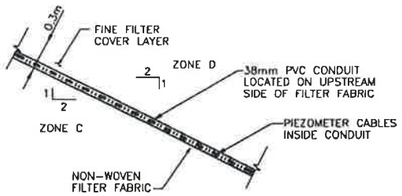
A2C-A3





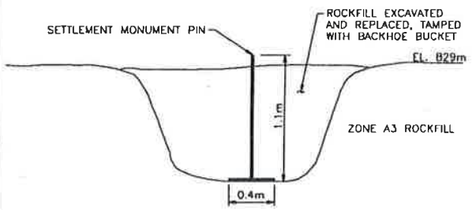
DETAIL 1
SCALE: B

BEDDING AND COVER MATERIAL FOR EXTENSION OF EXISTING PIEZOMETERS P95KC-3A/B



DETAIL 2
SCALE: B

EXTENSION OF PIEZOMTERS UP LEFT ABUTMENT



DETAIL 3
SCALE: N.T.S.

DETAIL OF SURVEY MONUMENTS INSTALLED ON STAGE 2 DAM CREST

LAYOUT COORDINATES

POINT	NORTHING	EASTING
P#1	24484	23511
P#2	24523	23221

NOTES:

1. TOPOGRAPHY ACQUIRED FROM AERIAL PHOTOGRAPHY TAKEN SEPT. 8, 1995 AND SUPPLIED BY QUINTETTE OPERATING CORPORATION (QOC).
2. TOPOGRAPHY FOR LEFT ABUTMENT REMEDIATION SUPPLIED BY CONTRACTOR.

LEGEND:

- P96-5 — LOCATION OF PIEZOMETERS INSTALLED IN STAGE 1
- EXISTING PIEZOMETERS P95KC-2A/B AND P95KC-3A/B
- EXISTING SLOPE INCLINOMETER SIKC95-5
- TIRE LOCATIONS TO PROTECT END OF PIEZOMETER CABLES AND SLOPE INCLINOMETERS.
- PIEZOMETER CABLES
- PIEZOMETER CABLES ENCLOSED IN PVC
- PIN #1 — DAM SETTLEMENT MONUMENTS SURVEY POINTS

ISSUED FOR AS-BUILT

SCALE B: 0 2m
SCALE A: 0 100m
SCALE

NO.	DATE	ISSUE / REVISION	DRAWN	CHK'D	DESIGN	APP'D
2	JULY 99	ISSUED FOR AS-BUILT	ENL	TDP	HDP	HDP
1	OCT 98	ISSUED FOR CONSTRUCTION	PSK	TDP	HDP	HDP
0	OCT 98	ISSUED FOR TENDER	PSK	TDP	HDP	HDP

DRAWING NO. | REFERENCE DRAWING

SEAL: PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. D. PLEWES

CLIENT: Quintette Operating Corp.

KLOHN-CRIPPEN

PROJECT: SHIKANO NORTH TAILINGS IMPOUNDMENT

TITLE: STAGES 1 AND 2 TAILINGS DAM INSTRUMENTATION PLAN AND DETAILS

SCALE	PROJECT No.	DWG. No.	REV.
AS SHOWN	PM6970 16	D-16004	2

CANCEL PRINTS BEARING PREVIOUS

APPENDIX III

Teck's Shikano North Tailings Dam
2018 Event-Driven and Routine Inspection Checklists

Shikano North Tailings Dam – Overall Inspection

	Date: July 23/18
Property:	Quintette Coal Operations (QCO)
Structure:	Shikano North Tailings Dam
Function (tailings, water, etc.):	Tailings storage facility
Consequence Classification:	Significant
Inspection Performed By:	Rob Muise
Inspection Type (circle one):	Routine (Event-Driven (Rainfall)) Event-Driven (Earthquake)

57mm July 20/18

Conditions at Time of Inspection		
Conditions	☒Sunny ☐Scattered Clouds ☐Overcast ☐Raining ☐Snowing Comments:	
Temperature	20°C	
Winds	☐None ☒Light ☐Moderate ☐High	From:
Snow Cover	☒None ☐Slight ☐Drifts ☐Melting Comments:	
Pond	☐None ☒Open Water ☐Partially Frozen ☐Frozen ☐High Turbidity Comments:	
Wave Action:	☒None ☐Light ☐Moderate ☐High ☐Causing Erosion Comments:	

Shikano North Tailings Dam – Overall Inspection

DAM STRUCTURE	Visible for Inspection	Cracks	Settlement	Sloughing, Slides or Sinkholes	Surficial Erosion or Rutting	Seepage Breakout, Turbidity or Discoloration	Excessive Vegetation	Excessive Debris	Animal Burrows
Crest	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒		Yes ☐ No ☒		Yes ☐ No ☒
	Comments or Unusual Conditions:								
Upstream Slope	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒		Yes ☐ No ☒		Yes ☐ No ☒
	Comments or Unusual Conditions:								
Downstream Slope	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒		Yes ☐ No ☐
	Comments or Unusual Conditions:								
Tailings Beach	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☒ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
	Comments or Unusual Conditions: Sinkholes / Seepage pipe running but Zero Turbidity								
Downstream Toe & Area	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒
	Comments or Unusual Conditions:								
Seepage Collection Pipe Outlet	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒
	Approximate flow rate and clarity of discharge:								
Other	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
	Comments or Unusual Conditions:								

Comment [BAC21]: Andrew to update this form re. tailings beach inspections, once a plan for installing reference stakes around the sinkholes has been finalized based on feedback from site and KCB.

Shikano North Tailings Dam – Overall Inspection

Date:	August 7/2018
Property:	Quintette Coal Operations (QCO)
Structure:	Shikano North Tailings Dam
Function (tailings, water, etc.):	Tailings storage facility
Consequence Classification:	Significant
Inspection Performed By:	Rob Muise
Inspection Type (circle one):	(Routine) Event-Driven (Rainfall) Event-Driven (Earthquake)

Conditions at Time of Inspection		
Conditions	☐Sunny ☐Scattered Clouds ☒Overcast ☐Raining ☐Snowing Comments:	
Temperature	18°C	
Winds	☐None ☐Light ☐Moderate ☒High	From:
Snow Cover	☒None ☐Slight ☐Drifts ☐Melting Comments:	
Pond	☐None ☒Open Water ☐Partially Frozen ☐Frozen ☐High Turbidity Comments:	
Wave Action:	☐None ☐Light ☒Moderate ☐High ☐Causing Erosion Comments:	

Shikano North Tailings Dam – Overall Inspection

DAM STRUCTURE	Visible for Inspection	Cracks	Settlement	Sloughing, Slides or Sinkholes	Surficial Erosion or Rutting	Seepage Breakout, Turbidity or Discoloration	Excessive Vegetation	Excessive Debris	Animal Burrows
Crest	Yes ☑ No ☐	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑		Yes ☐ No ☑		Yes ☐ No ☑
	Comments or Unusual Conditions:								
Upstream Slope	Yes ☑ No ☐	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑		Yes ☐ No ☑		Yes ☐ No ☑
	Comments or Unusual Conditions:								
Downstream Slope	Yes ☑ No ☐	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑		Yes ☐ No ☑
	Comments or Unusual Conditions:								
Tailings Beach	Yes ☑ No ☐	Yes ☒ No ☐	Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒
	Comments or Unusual Conditions: Sink holes remain the Same Size/No change.								
Downstream Toe & Area	Yes ☑ No ☐	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑
	Comments or Unusual Conditions:								
Seepage Collection Pipe Outlet	Yes ☑ No ☐	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☐	Yes ☐ No ☑	Yes ☐ No ☑	Yes ☐ No ☑
	Approximate flow rate and clarity of discharge: Clear Flow								
Other	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐	Yes ☐ No ☐
	Comments or Unusual Conditions:								

Comment [BAC21]: Andrew to update this form re. tailings beach inspections, once a plan for installing reference stakes around the sinkholes has been finalized based on feedback from site and KCB.

Shikano North Tailings Dam – Overall Inspection

Date:	Sept 20/18
Property:	Quintette Coal Operations (QCO)
Structure:	Shikano North Tailings Dam
Function (tailings, water, etc.):	Tailings storage facility
Consequence Classification:	Significant
Inspection Performed By:	Rob Muise
Inspection Type (circle one):	(Routine) Event-Driven (Rainfall) Event-Driven (Earthquake)

Conditions at Time of Inspection		
Conditions	☐Sunny ☐Scattered Clouds ☒Overcast ☐Raining ☐Snowing Comments:	
Temperature	+1°C	
Winds	☐None ☒Light ☐Moderate ☐High	From:
Snow Cover	☒None ☐Slight ☐Drifts ☐Melting Comments:	
Pond	☐None ☒Open Water ☐Partially Frozen ☐Frozen ☐High Turbidity Comments:	
Wave Action:	☐None ☒Light ☐Moderate ☐High ☐Causing Erosion Comments:	

Shikano North Tailings Dam – Overall Inspection

DAM STRUCTURE	Visible for Inspection	Cracks	Settlement	Sloughing, Slides or Sinkholes	Surficial Erosion or Rutting	Seepage Breakout, Turbidity or Discoloration	Excessive Vegetation	Excessive Debris	Animal Burrows
Crest	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒		Yes ☐ No ☒		Yes ☐ No ☒
	Comments or Unusual Conditions:								
Upstream Slope	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒		Yes ☐ No ☒		Yes ☐ No ☒
	Comments or Unusual Conditions:								
Downstream Slope	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒		Yes ☐ No ☒
	Comments or Unusual Conditions:								
Freeboard Monitoring	Is there ponded water on the tailings beach? (Circle one)						(Yes)	No	
	If "yes", is the water level at or above the bottom of the reference marker (i.e. the top of the tailings beach)? (Circle one)						Yes	(No)	N/A
	If "yes", is the water level at or above the 1m mark on the reference marker? (Circle one)						Yes	(No)	
Tailings Beach	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☑
	Comments or Unusual Conditions: 4 sinkholes → No Progression from last INSP.								
Downstream Toe & Area	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒
	Comments or Unusual Conditions:								
Seepage Collection Pipe Outlet	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒
	Approximate flow rate and clarity of discharge: 0.005 m3/sec								

APPENDIX IV

Register of Reference Documents

Appendix IV
Register of Reference Documents

Document Title	Author	Date of Issue
Shikano Geological Report Text	Quintette Coal Limited	May-85
Shikano North Tailings Impoundment - Design Report	Klohn Crippen	23-Jun-95
Shikano North Tailings Impoundment - Pervious Tailings Dam Option - Design Report	Klohn Crippen	09-Feb-96
Shikano North Tailings Impoundment - 1995 Geotechnical Investigations, Data Report	Klohn Crippen	09-Feb-96
Shikano North Tailings Impoundment 1996 As-Built Report	Klohn Crippen	14-Mar-97
Shikano North Tailings Impoundment 1997 Annual Review	Klohn Crippen	20-Feb-88
Shikano North Tailings Impoundment 1998 Annual Review	Klohn Crippen	05-Mar-99
Shikano North Tailings Impoundment - Stage 2 As-Built Report	Klohn Crippen	09-Jul-99
Shikano North Tailings Impoundment 1999 Annual Review	Klohn Crippen	06-Dec-99
Quintette Project - Baseline Climate & Hydrology Conditions	Clearwater Consultants Ltd.	17-Aug-11
Quintette Coal Project: 2012 Dam Inspections: Plantsite Tailings Dam, M11 Diversion Dam, Shikano North Tailings Dam	Klohn Crippen Berger Ltd.	Dec-12
Tailings Water Balance, Seepage Rates and Preliminary Seepage Reclaim Design	Klohn Crippen Berger Ltd.	30-Apr-13
Shikano North Tailings Dam - 2013 Dam Safety Inspection Report	Klohn Crippen Berger Ltd.	09-Dec-13
Quintette Dam Safety Review Shikano North Tailings Storage Facility	Klohn Crippen Berger Ltd.	27-May-14
Shikano North Tailings Dam – 2014 Dam Safety Inspection Report – Revision 1	Klohn Crippen Berger Ltd.	26-Nov-14
Shikano North Tailings Dam - Response to February 3, 2014 MEM Memorandum	Klohn Crippen Berger Ltd.	29-Jun-15
Shikano North Tailings Dam – 2015 Dam Safety Inspection Report	Klohn Crippen Berger Ltd.	04-Mar-16
Shikano North Tailings Storage Facility Engineer of Record	Klohn Crippen Berger Ltd.	23-Sep-16
Quintette Coal Operations – Shikano North Tailings Dam Water Management, Water Balance and Quantifiable Performance Objectives	Klohn Crippen Berger Ltd.	22-Dec-16
Shikano North Tailings Dam – 2016 Dam Safety Inspection Report	Klohn Crippen Berger Ltd.	22-Dec-16
Shikano North Tailings Dam – 2017 Dam Safety Inspection Report	Klohn Crippen Berger Ltd.	16-Mar-18