Tailings Storage Facility – Emergency Preparedness Plan

September, 2014

Copy No.________

Emergency Preparedness Plan - Revisions

Revision	Issued As	Date	Approved By
Update distribution list, update communication directory Section 10	Gibraltar TSF EPP Sept. 23, 2014	Sept. 23, 2014	Pat Gannon

Emergency Preparedness Plan – Distribution List

Copy No.	Name	Position	Organization
01	Richard Tremblay	General Manager	Taseko Gibraltar
02	Pat Gannon	Manager, Mill Operations	Taseko Gibraltar
03	Dale Lawson	Loss Prevention Supervisor	Taseko Gibraltar
04	Todd Wambolt	Sr. Environmental Engineer	Taseko Gibraltar
05	John Purdy	General Foreman, Mill Operations	Taseko Gibraltar
06	Katherine Gizikoff	Director, Government and Environmental Affairs	Taseko
USB	Steve Rothman	Sr. District Mines Inspector	MEM, Kamloops
USB	Jack Green	Environmental Protection Officer	MoE, Williams Lake
USB	Rowena Bastien	Manager of Protective Services	Cariboo Regional District
USB	Sylvain Gauthier	Fire Chief	City of Quesnel
USB	On-call binder		Taseko Gibraltar
USB	Taseko Head Office		Taseko
	Gibraltar Intranet - Document Index		Taseko Gibraltar

EXECUTIVE SUMMARY

The Executive Summary is provided solely for purposes of overview. Any party who relies on this report must read the full report. The Executive Summary omits a number of details, any one of which could be crucial to the proper application of this report.

This document is the Emergency Preparedness Plan (EPP) for the Gibraltar Tailings Storage Facility (TSF) focusing specifically on incidents that may lead to a breach in the tailings dams, and taking into account the facility's current configuration, and its projected changes to the end of the mine's life. In August 2012, Gibraltar Mine completed a long-term deposition plan for the TSF. Cyclone sand deposition will be restarted in order to maximize the storage capacity of the existing tailings facility.

The TSF is retained by the Main Dam, the North Earthfill Dam, and the East Saddle Dam. The East Cuisson Creek, Cuisson Creek, and Fraser River are located downstream of the Main Dam and the North Earthfill Dam. A release from the Main Dam or the North Earthfill Dam would flow along East Cuisson Creek, Cuisson Creek, and enter the Fraser River. The East Saddle Dam is located on Arbuthnot Creek. A release from the East Saddle Dam would flow along Arbuthnot Creek, Beedy Creek, Beaver Creek, and Quesnel River, and eventually enter the Fraser River at the City of Quesnel.

KCB conducted a dam breach and inundation study in 2012 for the purpose of ascertaining the potential impacts of a dam failure at the TSF. Piping failure of the East Saddle Dam, occurring under 'sunny day' conditions would result in worse case incremental impacts, in terms of increase in river level over and above the natural concurrent conditions. Development of a full breach after piping was estimated to take as little as 50 minutes, and the peak flood wave would reach the City of Quesnel approximately 9 hours 50 minutes following the start of the breach. Overtopping of the East Saddle Dam would result in higher breach outflows. This occurrence is extremely unlikely because a precipitation event in excess of the Probable Maximum Precipitation over a period of 30 days would be required for overtopping to occur. Development of a full breach after overtopping was estimated to take as little as 1 hour 50 minutes, and the peak flood wave would reach the City of Quesnel approximately 6 hours 30 minutes following the start of the breach. Overtopping failure is likely to occur when there is major flooding downstream from natural river flows. Therefore, overtopping failure would lead to less incremental impacts, in terms of increase in river level over and above the natural concurrent conditions, compared to a piping failure.

The worst case scenario for the Main Dam is run-out of the dam and the tailings caused by liquefaction. This is an extremely unlikely scenario because the runout would require an earthquake in excess of the Maximum Credible Earthquake. The Main Dam would slump and extend out by approximately 1,150 ft. The damage caused by the runout would be limited to within the mine property. However, some of the dam fill and tailings would be carried towards the Fraser River by the rainfall and/or streamflow occurring during or after the run-out event.

Gibraltar Mines is responsible for the co-ordination of emergency response at the site, issuing alerts to off-site agencies, and advising disaster service organizations of the actual or expected magnitude and progress of flooding. The Gibraltar Crisis Management Team will set up a Crisis Control Centre to liaise with all outside agencies, and to monitor and assess the emergency and implement any

mitigation works. The British Columbia Provincial Emergency Program (PEP) co-ordinates emergency operations of the response teams from government agencies, and also provides advice to local municipal emergency response organizations. PEP regional office representatives will travel to the Municipality and the Gibraltar Crisis Control Centre when deemed necessary. Local Emergency Operations Centres of each municipality are responsible for co-ordinating and activating the emergency response plans for their community. During an emergency, each of these agencies will need to interact, exchange information and co-ordinate their operations. Gibraltar Mines should discuss the roles and responsibilities presented in this EPP with the provincial, municipal and regional agencies, and all parties must agree to the assigned roles and responsibilities before this plan can be finalized.

Conditions, accidents or events occurring at the Gibraltar TSF which may have implications to dam safety were categorized into potential dam safety problems, and other types of emergency situations which do not threaten the safety of the dam. A list of unusual occurrences include: flooding causing an excessive rise in pond levels; any seismic event; abnormally high piezometric levels in the cyclone sand or earthen dams; settlement, cracks or slumping in any of the dams; sinkholes on any of the dams, tailings beach or Step-Back Embankment; slope failure of or abnormal seepage flows from any of the dam slopes; increased or contaminated flow from the finger drains or relief wells; sabotage or other criminal activity; and damage to any component of the TSF.

Upon detection of an unusual occurrence, the Gibraltar Crisis Management Team will meet to confirm the occurrence and decide on the alert classification of the situation. If the trigger occurrence is confirmed, then the Gibraltar Crisis Coordinator will assume responsibility for managing the emergency situation, and will oversee the Crisis Control Centre.

Potential danger to the safety of the TSF and/or the downstream infrastructure and population are expressed as three levels of alert:

- Yellow Alert indicates that an unusual occurrence has occurred.
  - This alert level does not pose a hazard to people at the dam or to downstream populations at risk at the time of observation. The occurrence is to be monitored, and mitigation should be done to bring the situation to below trigger levels. Populations at risk and outside agencies will not be notified during a Yellow Alert. As a result, only the Gibraltar Crisis Coordinator and the Crisis Control Centre will be active during a Yellow Alert.
- Amber Alert indicates that a dam is unstable but breach is not imminent.
  - Relevant agencies and populations at risk must be notified and placed on standby status. The populations at risk should be prepared to evacuate areas potentially impacted by flood or tailings runout. The Gibraltar Crisis Coordinator will establish the Crisis Control Centre to manage the emergency situation.
- Red Alert indicates that that a dam breach is imminent or has occurred.
  - Notification for immediate evacuation is to be issued by the Crisis Control Centre. The evacuation notice would include information on what areas could be impacted, the nature of the impact, when the impact will occur, and instructions on what the populations at risk

should and should not do. The responsible agencies need to initiate evacuation of all populations at risk.

Exercises should be developed and conducted in an ascending order of complexity, starting with an Orientation Seminar to familiarize the emergency responders with the EPP and the roles, responsibilities, and procedures of those involved, progressing to a Full Scale exercise. Communications testing should be conducted by Gibraltar Mine staff on an annual basis and operational testing of the EPP should be carried out every 5 years. The EPP should be updated based on results from training and testing. A communications directory is included in Section 10 of this EPP and should be updated on a semi-annual basis.

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

List of Tables

List of Figures

1 INTRODUCTION

1.1 General

This Emergency Preparedness Plan (EPP) has been prepared to assist emergency responders who will jointly manage any emergency situation created by a problem threatening or causing a breach of the Tailings Storage Facility (TSF) dams at the Gibraltar Mine. Gibraltar Mines Ltd. will initiate emergency notification procedures if such an emergency should ever occur.

Gibraltar Mines Ltd. is responsible for providing all administrative support for this plan, including documenting the inputs of other emergency responders, and maintaining, testing and upgrading this plan in accordance with joint arrangements agreed to by the emergency responders.

This plan specifically addresses the following:

- what would happen to the stored water and tailings in the TSF if any of the dams were to breach;
- how people and property would be affected;
- what potential hazards would be created;
- procedures to be followed in the event of an emergency situation; and,
- agencies involved with the emergency response.

The plan includes information enabling the emergency responders to communicate with each other and to effectively integrate their operations where required during an emergency. A dam breach and inundation assessment was completed by Klohn Crippen Berger Ltd. (KCB) and is included in the Appendix 1 of the report Tailings Storage Facility Emergency Preparedness Plan, February 2013 (Klohn Crippen Berger Ltd., 2013) (as part of preparation of this plan. This is included as Appendix I. Note that the main text of this report references many of the figures included in Appendix I.

Gibraltar Mines Ltd. and each agency involved will base their own emergency operations plans on the roles and protocols described in this plan. The emergency responders can use this EPP document to ensure their staff are familiar with:

- conditions under which stakeholders would be notified about problems at the Gibraltar Mine TSF that could lead to a breach;
- procedure for notifying stakeholders;
- the emergency response issues (affected population centres, affected roads and bridges, location and type of pipeline and power line crossings, affected agricultural areas, flood travel times, emergency notification protocol and responsibilities, etc.); and,
- who would address each of these issues during each type of emergency condition.

2 THE TAILINGS STORAGE FACILITY

2.1 Description of the Tailings Storage Facility

2.1.1 General

Gibraltar Mine is located approximately 60 km north of Williams Lake, near McLeese Lake in the southern interior of British Columbia as shown in Appendix I. Access to the mine site is by way of an 18 km paved road that joins Highway 97 near McLeese Lake. The mine produces copper-molybdenum. The TSF is located immediately north of the mine's plant site (Figure I-2), and is retained by the Main Dam, the North Earthfill Dam, and the East Saddle Dam, as shown in Figure I-3. The Main Dam is also referred to as the Cycloned Sand Dam in this report. The bulk of the tailings are deposited against the Main Dam and the south abutment of the TSF. The supernatant (free) water pond is located at the east end of the tailings impoundment and is retained by the North Earthfill Dam and the East Saddle Dam. Relevant details of the three dams are summarized in the following sections. Further details of the dams may be found in the TSF's Long Term Deposition Plan (Klohn Crippen Berger Ltd., 2012), and in the Operation, Maintenance and Surveillance Manual – Revision 4 (Klohn Crippen Berger Ltd., 2012).

The Long Term Deposition Plan includes details on how the configuration of the TSF will change from 2012 to 2027. Gibraltar proposes to store an additional 455 million tons of dry tailings by 'stacking' tailings on top of the existing tailings beach using cyclone sand deposition. The stack will be built using the cyclone underflow (coarse sand), and the overflow (fine sand) will be discharged into the tailings pond. This minimizes the volume of tailings deposited in the pond, thereby limiting future pond level raises and required dam raises. The proposed re-design addresses the geotechnical stability and water management of the facility, and follows the Canadian Dam Association Dam Safety Guidelines (2007) and the British Columbia Dam Safety Regulation (2011). Figure I-4 shows the current configuration and the projected ultimate configuration of the TSF, based on the Long Term Deposition Plan.

2.1.2 Main Dam

The Main Dam is located approximately 3 km from the mine Plantsite, and is reached via a gravel road from the Plantsite. The dam was commissioned in 1972 by construction of a 100 ft high starter dam of compacted glacial till across the outlet of the East Cuisson Creek valley. Subsequent dam raises were performed using the centreline method of construction. Tailings underflow from cyclones located across the crest of the dam was deposited directly onto the centreline and downstream slope of the dam. The cyclone overflow and "bleed" from the end of the tailings pipeline were discharged onto the tailings beach upstream of the dam centreline.

Proposed changes to the Main Dam over the remaining life of the mine are included in the Long Term Deposition Plan. The goal of the tailings deposition plan is to contain the Life-of-Mine tailings volumes, to minimize the ultimate pond elevation and to isolate the tailings pond from the Main Dam and North Earthfill Dam to minimize water levels and seepage gradients in the structures.

2.1.3 North Earthfill Dam

The North Earthfill Dam is a compacted till embankment comprising the saddle dams previously referred to as Saddle Dams A and B. Construction of the North Earthfill Dam began in 1990, when the western portion was built to elevations between 3,544 ft and 3,546 ft. The two saddle dams (A and B) were constructed in 1998 to extend the overall dam to the east. The three separate dam segments were joined together with a subsequent raise to elevation 3,561 ft in 2007. In 2011, the upstream toe (centerline raise) and the downstream toe (downstream raise) were extended for a crest elevation of 3,570 ft. Also in 2011, the drainage blanket was re-constructed and the ditch was extended to connect with the seepage recovery pond west of the Main Dam.

According to the Long Term Deposition Plan, the North Earthfill Dam will continue to be raised using compacted till from 2012 to 2014 to a crest elevation of 3,581 ft.

2.1.4 East Saddle Dam

The East Saddle Dam confines the eastern side of the tailings pond and is located approximately 8.5 km from the mine Plantsite. It is reached via a gravel road from the Plantsite. This dam was initially built in two stages in 1985 and 1986. Figure I-11 shows the as built plan and section from the initial construction, and also some of the details used in the assessment of a hypothetical breach of the dam (Appendix I). The dam was raised in 2007 and 2008, and has subsequently had annual raises since 2010. The dam was raised in late 2012 to a minimum elevation of 3,572 ft and a height of approximately 90 ft. A plan and cross section of the dam under the current configuration are presented in Figure I-5.

According to the Long Term Deposition Plan, the dam will be raised annually, to an ultimate crest elevation of El. 3,630 ft (1106.4 m). The ongoing raise of the East Saddle Dam will follow the downstream construction method. Figure I-6 shows the section of the proposed End of Mine Life (2027) configuration of the East Saddle Dam.

2.1.5 Tailings Pond Water Volume and Level

The tailings pond was at an elevation of approximately 3,559 ft in August 2012. The tailings pond elevation is predicted to rise by 55.9 ft (17.0 m) to the ultimate pond elevation of 3,615 ft (1101.8 m) from 2012 to 2027, while the freewater pond volume is predicted to decrease by 68 Mm^3 during the same period. The tailings pond elevation is predicted to increase at an average rate of 4.7 ft (1.4 m) per year from 2013 to 2016, and increase at an average rate of 3.4 ft (1.0 m) per year from 2017 to 2027. Variations in pond water volume and level through the predicted remaining life of the mine are shown on Figure I-7.

2.1.6 Diversion Ditches

A diversion ditch system is present around the TSF to divert clean surface runoff away from the tailings pond. The diversion ditches are shown on Figure I-3.

Runoff from the catchment to the north of the TSF is currently intercepted by a diversion ditch and directed towards Cuisson Creek. However, the diversion will be covered by tailings deposition by

2016. After 2016, most of the north catchment will report to the tailings pond. Runoff from the catchment to the south of the TSF is currently intercepted by several diversion ditches and directed away from the tailings facility to Cuisson Creek in the west and Arbuthnot Creek in the east.

2.1.7 Seepage Collection Pond

Seepage flow from the TSF is collected within the seepage return collection pond located to the west and downstream of the Main Dam, as shown on Figure I-3. The pond is bounded by the walls of the East Cuisson Creek valley and by an earthfill dam originally constructed in 1971. The seepage collection dam was designed and constructed for water retention.

The seepage pond pumphouse is located on the south side of the seepage pond, from where the collected seepage is conveyed to the tailings impoundment by two pipelines. The seepage return pumping system operates automatically throughout the year. Pump control is regulated by pond water levels.

2.1.8 Reclaim Water Reservoir

A Reclaim Water Reservoir was constructed in 2012 to replace the reclaim system. The previous system consisted of an electrical substation, pumphouse barge, return pipeline, and storage tank. The construction program for the new Reclaim Water Reservoir facility involved the excavation and shaping of the reservoir, raising two earthfill dams, placing liner and scour protection layers, building inlet and outlet structures, interceptor ditches, spillway, pipes and auxiliary structures.

The Reclaim Water Reservoir is located south of the TSF, on higher ground.

2.2 Operation, Maintenance and Surveillance of the TSF

The operation, maintenance, and surveillance of the TSF are the responsibility of the Gibraltar Crisis Management Team. This group is comprised of various individuals from the mine site plus the consulting geotechnical engineer. The Manager of Milling acts as the group coordinator and is ultimately responsible to ensure that all aspects of operation, maintenance, and surveillance of the TSF are met.

A table listing members of the Gibraltar Crisis Management Team, their positions, and responsibilities is included under Section 10.

The Operation, Maintenance and Surveillance Manual – Revision 4 (Klohn Crippen Berger Ltd., 2012) details surveillance parameters and schedules for the TSF. The overall objective of surveillance is to identify unusual conditions or deviations from expected performance and to determine appropriate actions for response.

3 AREAS DOWNSTREAM OF TAILINGS STORAGE FACILITY

3.1 Areas Downstream of East Saddle Dam

A plan showing the TSF and downstream areas is presented in Figure I-9. The East Saddle Dam is located on Arbuthnot Creek. A release from the dam would flow along Arbuthnot Creek, Beedy Creek, Beaver Creek, and Quesnel River, and eventually enter the Fraser River at the City of Quesnel. There is also a low divide along Arbuthnot Creek, approximately 6.5 km downstream of the dam, where water may overflow to the south towards the headwaters of Fredy Creek if the water level rises high enough. This overflow would flow along Fredy Creek, Beedy Creek, and then rejoin the main flow from Arbuthnot Creek and continue onto Beaver Creek and Quesnel River. Quesnel River joins the Fraser River at the City of Quesnel, approximately 91 km downstream from the dam.

KCB has previously carried out a ground and air reconnaissance of the areas downstream of the East Saddle Dam. This was conducted on 12 and 13 October, 2004 as part of the dam break inundation study completed in 2005. The reconnaissance included on the ground examination of the Fraser and Quesnel Rivers in the vicinity of the City of Quesnel, and readily accessible upstream reaches of the Quesnel River up to the confluence of the Quesnel River and Beaver Creek. The air reconnaissance was conducted from a helicopter, which followed a route from the East Saddle Dam down Arbuthnot, Beedy and Beaver Creeks, and then downstream along the Quesnel River to the City of Quesnel. The air reconnaissance also covered the Fraser River for a few kilometres upstream and downstream of the confluence of the Fraser and Quesnel Rivers. Photographs taken during the air reconnaissance are shown in Appendix II.

The area downstream of the East Saddle Dam is mostly unpopulated. The main population centre is at the City of Quesnel, some 90 km downstream of the dam. There are also a number of farm houses and farm buildings in the Sardine Flats (Gravelle Ferry) area along the Quesnel River about 50 km to 55 km downstream of the dam.

TRIM data covering the creek and river system from the TSF to the Fraser River was obtained. The TRIM data was assessed using GIS techniques in combination with observations made in the 2004 ground and air reconnaissance. There are local (small) road crossings on Arbuthnot and Beedy Creeks between the East Saddle Dam and Beaver Creek. These were noted in the 2004 ground and air reconnaissance as consisting of small timber bridges. A typical bridge on local roads is shown in Photo II-39. The first major road crossing downstream of the dam is on Beaver Creek immediately upstream of the Quesnel River, followed by larger bridges further downstream. The locations of the major river crossings, including road bridges and powerline and pipeline crossings, are shown in Figures I-9 and I-10. A brief description of these river crossings is provided below.

Beaver Creek Bridge

- The bridge is located on Beaver Creek immediately upstream of the Quesnel River and Beaver Creek confluence. It is a single-lane steel and concrete structure, approximately 35 m long and 6.5 m high (Photo II-10). The bridge is supported on two piers in the stream consisting of steel pipes and steel cladding. The bridge abutments consist of bin-walls.

Gravelle Bridge on Quesnel River

- This bridge is located on the Quesnel River in the Sardine Flats area at Gravelle Ferry, about 30 km upstream of the City of Quesnel. This is a single-lane Bailey bridge with four steel piers in the river (Photos II-14 to II-16). The piers have triangular nosings upstream and downstream. The two centre piers also have triangular shaped steel ice breakers on the upstream side. The pier on the left (west) bank has staff gauge markings for measurement of river level at the bridge.
- The bridge was being inspected during the October 2004 site visit. According to the inspection crew, the river freezes up almost every year. There had been no discharge problems at the bridge, but the broken ice does tend to jam in the canyon further downstream.

Power Transmission Line Crossing across Quesnel River

- A major power transmission line crosses over the Quesnel River approximately 12 km upstream of the Fraser/Quesnel River confluence (Photo II-20). The towers supporting the line are located on high ground and are not expected to be affected by a flood in the river.

Power Line and Pipeline Crossings across Quesnel River

- A power line and a pipeline cross over the Quesnel River near the City of Quesnel's eastern municipal boundary, approximately 8 km upstream of the Fraser/Quesnel River confluence (Photos II-21 and II-22). The footings for the power line and the pipeline support towers appear to be located low enough to be possibly affected by a flood.

Railway Bridge on Quesnel River Upstream of Highway 97

- The bridge is located within the City of Quesnel, about 300 m upstream of the Highway 97 crossing. The bridge has four spans supported on single, round concrete piers. The west half of the bridge, which spans the main river channel, has the longest span and consists of a truss section. The bridge also supports a pipeline, about 0.6 m in diameter, strung along the south side of the bridge deck. (Photos II-25, II-26 and II-29).

Highway 97 Bridge on Quesnel River

- This is a two-lane concrete bridge across the Quesnel River. The bridge has four dumb-bell shaped concrete piers in the river. The bridge deck is relatively high above the river and is not expected to be affected by river flooding (Photos II-25, II-30 and II-32).

Johnston Avenue Bridge on Quesnel River

- This is a two-lane bridge with a steel grating deck. The bridge has three piers in the river with round nosing (Photo II-33).

Railway Bridge on Quesnel River Upstream of Quesnel/Fraser Confluence

- The single-track bridge is located immediately upstream of the Fraser River / Quesnel River confluence (Photos II-34 and II-35). It has two round piers in the river. The road to Johnston Avenue passes under the bridge on the north (right) bank of the Quesnel River.

Carson Avenue Pedestrian Bridge on Fraser River

- This is an old truss bridge across the Fraser River, with four 1.5 m wide (approximate) concrete piers in the river. The bridge is currently used as a pedestrian crossing. The bridge deck level is close to the ground level at the left and right abutments. The deck is cambered slightly such that the deck level is higher at mid-span (Photo II-36).

Marsh Drive Vehicle Bridge on Fraser River

- This is a two-lane concrete bridge across the Fraser River, with four 1.5 m wide (approximate) piers in the river. It is located upstream of the Fraser/Quesnel confluence. The bridge deck is high above the river and is not expected to be affected by floods. (Photo II-37).

3.2 Areas Downstream of the Main Dam

The Main Dam is located in the Cuisson Creek catchment which drains towards the west. A description of the areas downstream of the Main Dam is summarized in Table 3.1.

Table 3.1 Areas Downstream of the Main Dam

Location	Distance From Dam Crest (km)
Several access roads	<0.5
Seepage collection ditches	<0.5
Seepage Recovery Pond, Dam, and Pump House	0.8
Junction of East Cuisson Creek and Cuisson Creek	4.3
Unnamed Lake	4.4
Power Transmission Lines	12.4
BC Railway Line	17.3
Caribou Highway (97)	18.0
Junction of Cuisson Creek and the Fraser River	18.5

The Main Dam and Set-Back-Embankment will be maintained at a higher elevation than the East Saddle Dam, so the possibility of overtopping the Main Dam due to flood events is eliminated. With elimination of an overtopping failure mechanism to release the tailings pond (see Appendix I), the downstream influence of a tailings dam flowslide is much more limited. The effects of such a slide would be restricted to the catchment of East Cuisson Creek upstream of its confluence with Cuisson Creek (distance of approximately 4.3 km from the dam toe).

Preliminary review of this downstream area indicates the following infrastructure maybe affected:

- seepage collection ditches and pond at the Seepage Collection Dam;

- Seepage Pump House No. 6 with associated pipelines and power supply lines; and,
- miscellaneous access roads and forestry roads.

Gibraltar Mine reports that there are no permanent inhabitants in this area, but it is used to graze cattle on a semi-permanent basis.

4 EFFECTS OF INUNDATION

4.1 The Dam Breach and Inundation Study

KCB has completed a dam breach and inundation assessment for the TSF Klohn Crippen Berger 2013). As indicated in Section 2, the Gibraltar tailings impoundment is retained by the East Saddle Dam on the east side and the Main Dam on the west side. Any release from the East Saddle Dam would first flow east into Arbuthnot Creek and then northwards towards Quesnel River, and eventually enter the Fraser River at the City of Quesnel. Any release from the Main Dam would travel west towards East Cuisson Creek. Relevant details of the dam breach and inundation analyses are summarized in the following sub-sections.

4.2 East Saddle Dam Failure

4.2.1 HEC-RAS Dam Break and Inundation Model

The dam breach and inundation assessment report (Klohn Crippen 2013) includes a description of the HEC-RAS modeling undertaken, and the results obtained. In the event of a breach of the East Saddle Dam, the supernatant water, cyclone overflow tailings and some of the cyclone underflow tailings may be released. The HEC-RAS modeling assumed that all the released material will behave as water.

Two modes of failure were considered for the East Saddle Dam: piping failure and overtopping failure.

- A piping failure of a dam is considered to be a “sunny day” failure which is normally assumed to occur when the pond is at its normal operating level. The inundation impacts of a piping failure were estimated assuming a failure would occur concurrent with mean annual flows (MAF) in the downstream river system.
- Overtopping of dams typically occurs during large flood inflow conditions, where the pond water level rises high enough to overtop the dam. The TSF is designed to store the 30 day Probable Maximum Flood (PMF). Overtopping is therefore considered unlikely to occur except under extreme flood conditions. Inundation impacts of an overtopping failure were assessed assuming concurrent PMF flows in the downstream river system.

As noted under Section 2.1, the TSF’s long term deposition plan is such that the free water pond size will progressively be reduced, while the height of the East Saddle Dam will increase. To estimate worst case conditions through the remaining life of the TSF, the modeling considered TSF’s current condition, and that at the projected end of the mine’s operational life, in 2027. Figure I-8 shows the stage-storage relationships used in the model to represent the current conditions and those at the end of the mine’s life. East Saddle Dam is founded on bedrock, which is expected to limit the breach geometry in the event of a failure. The estimated bedrock location and the assumed breach geometry are shown in Figure I-11.

4.2.2 Results of HEC-RAS Model

Figures I-12 and I-13 show the estimated breach outflow at the dam and the flood hydrographs at selected points along the flood route for a piping failure; the estimated inundation areas are shown on Figures I-14, I-15 and I-17.

Figures I-17 and I-18 show the estimated breach outflow at the dam and the flood hydrographs at selected points along the flood route for an overtopping failure; Figures I-19, I-20 and I-21 show the estimated inundation areas.

Results of the peak breach flow at the dam were compared against empirical relationships. Also, a comparison was made with flood extent mapping produced by the B.C. Ministry of Environment, Lands and Parks (MELP). The comparisons are shown on Figures I-22 and I-23, and discussed in more detail in the dam break and inundation report in Appendix I.

4.2.3 Likely Inundation Impacts

GIS assessment of TRIM data was undertaken, to complement information gathered in the 2004 ground and air reconnaissance, and to identify buildings and key infrastructure within the estimated inundation extents. The following is a summary of the likely impacts to key infrastructure and population centres, based on the results of the HEC-RAS modeling.

The key flood inundation characteristics are presented as Figure I-24 for piping failure, and Figure I-25 for overtopping failure. It should be noted that for piping failure, MAF conditions are assumed in the downstream river system at the time of failure, and overtopping failure is assumed to occur with PMF conditions downstream.

Road bridge on Arbuthnot Creek approximately 2.8 km downstream of East Saddle Dam

- The bridge deck is quite low and is likely to be washed away. The bridge is near the dam, such that there will be little warning time. A rise in water level of as much as 16.0 m could occur within 1 hour from the start of a breach, and the flood wave is estimated to arrive within about 10 minutes following the start of a breach at the dam. The roads leading to the Arbuthnot Creek crossing will require closing if an advance warning of an impending failure is available.

Buildings on right bank of Fredy Creek downstream of Philemon Lake

- Two clusters of buildings, one approximately 2.7 km, and another 6 km downstream of the divide from Arbuthnot Creek fall within the predicted inundation extents. These may include residential properties. There may also be potential flood hazards to recreational users of the lakes along Fredy and Beedy Creeks. The rise in water levels could be as much as 5.6 m, and this would occur in about 1 hour 10 minutes from the start of a breach. It is recommended that these properties immediately downstream receive their warnings directly from Gibraltar Mine as the short travel time will limit effective communication through the local authorities' emergency responders.

Road crossings along Beedy Creek

- Four road crossings along Beedy Creek were identified from available mapping. The roads will likely be impassable following a dam break. Some of the crossings are low level bridges, which are likely to be washed away. As quickly as is practicable, the local road network leading towards Beedy Creek will need to be closed, and motorists in the area warned.

Bridges along lower Arbuthnot Creek

- After the flow split with Fredy Creek, there are at least three bridges along Arbuthnot Creek. The first of these is about 9.7 km downstream of the dam. The local road crossings noted during the 2004 site reconnaissance consist of small timber bridges. The bridges are likely to be washed away in the event of flood flows from a dam breach. Flood arrival at the first of the bridges is estimated at about 45 minutes after the start of a breach at the dam. This would give a short warning time. The local road leading to the bridge will need to be closed, and warnings given to motorists in the area.

Beaver Creek Bridge upstream of confluence with Quesnel River

- The bridge is a single-lane steel and concrete structure. At approximately 6.9 m high, the bridge deck is likely to be flooded and be impassable, and it should be closed when a warning of an impending failure is issued.

Buildings on left bank of River Quesnel upstream of Sardine Flats

- A set of buildings is located approximately 42.2 km downstream of the dam, and a second set about 3.4 km further downstream. These may include farmhouses. The second set of buildings is located very close to the river and is therefore likely to flood to significant depth, since river water level rises of as much as 5.2 m are expected at this location. There is therefore likely risk to people and extensive damage to property. River water levels would start to rise in about 2 hours 10 minutes, and peak flood levels are expected after approximately 3 hours 15 minutes after the start of a breach. Warning and evacuation from the potentially affected areas should be undertaken.

Sardine Flats area

- Sardine Flats is one of the two main population centers along the potential flooding route. Figures I-15 and I-20 show estimated inundation extents in the Sardine Flats area. On both the left and right banks, along approximately a 5 km reach, there are a number of buildings within the estimated inundation extent. The majority of these are expected to be residential. The Gravelle Bridge is also likely to be inundated. River water level rises of about 3.3 m, about 4 hours 35 minutes from the start of a breach, and flood arrival within 2 hours 40 minutes after the start of a breach at the dam are estimated. Warning and evacuation from the potentially affected areas should be undertaken.

City of Quesnel

- The City of Quesnel is the largest population centre along the river system likely to be impacted by flooding from a breach of the East Saddle Dam. Key infrastructure within the city is discussed under Section 3.1. Figures I-16 and I-21 show estimated inundation extents in the City of Quesnel area. Piping failure, assumed to occur under 'sunny day' conditions could result in river water level rises of about 2.7 m above the MAF. Flooding along the river is expected to occur. However, from the observations made and photographs taken and in the 2004 reconnaissance (Appendix II), bridge decks appear to be high above the river and the bridges are not expected to be affected by piping failure flood flows.
- Overtopping failure is likely to be concurrent with severe flooding conditions, which would affect a considerable part of the city without the impact of a dam breach. A substantial area of the city along the Quesnel River and the Fraser River will be flooded, and will require evacuation. Bridges across the Quesnel and Fraser Rivers will also be flooded in this scenario. Dam breach flows are estimated to cause up to an additional 1.1 m rise in river flood levels over and above the natural PMF. It is estimated that flood levels could start to rise in about 4 hours 50 minutes, and peak flood arrival will be about 8 hours after the start of a breach at the dam.

Table 4.1 and Table 4.2 present inundation characteristics at selected locations downstream of the dam, such as: the estimated peak flood level caused by the release of water at the East Saddle Dam; the estimated water level without a dam breach; the rise in water level resulting from the breach flood flows; the time to reach peak water level from the start of dam breach; and the travel time of the peak from the dam.

Table 4.1 Inundation Characteristics at Selected Locations – Piping

Location	Distance d/s of Dam (km)	Estimated Flood Level for MAF only without Dam Breach (m)	Peak Flow following a Breach including the MAF (m^3/s)		Peak Flood Level, Breach plus MAF Flows (m)		Estimated Rise in Water Level above MAF (m)		Estimated Time for Arrival of Flood from Start of Breach (hr min)		Time to Peak Flood Level from Start of Breach (hr min)		Travel Time of Peak Flood Level from the Dam (hr min)	
			Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)
East Saddle Dam	0	1062.6	4800	10600	1074.3	1079.1	11.7	16.5	-	-	1hr 50min	50min	-	-
Bridge at upper Arbuthnot Creek	4.9	933.6	4700	10100	941.1	944.7	7.5	11.1	35min	25min	2hr 00min	1hr 00min	10min	10min
Buildings immediately downstream of Philemon Lake	9.8	832.5	440	1490	835.1	836.6	2.6	4.2	1hr 40min	1hr 00min	2hr 35min	1hr 15min	45min	20min
First Bridge on lower Arbuthnot Creek	9.7	832.8	3940	6880	840.6	841.9	7.8	9.1	1hr 40min	45min	2hr 20min	1hr 15min	30min	20min
Beaver Creek bridge u/s of confluence with Quesnel River	33.1	579.0	3310	4230	585.3	586.0	6.2	6.9	3hr 10min	2hr 20min	3hr 50min	2hr 40min	2hr 00min	1hr 55min
Buildings upstream of Sardine Flats	42.4	560.9	3080	3130	566.0	566.1	5.2	5.2	3hr 50min	2hr 50min	5hr 05min	3hr 45min	3hr 15min	2hr 55min
Sardine Flats area	51.2	541.4	2740	2400	544.8	544.5	3.3	3.1	4hr 50min	3hr 50min	6hr 30min	5hr 10min	4hr 40min	4hr 20min
Gravelle Bridge at Sardine Flats	52.2	541.3	2740	2400	544.4	544.2	3.1	2.9	4hr 50min	3hr 50min	6hr 30min	5hr 10min	4hr 40min	4hr 20min
Pipeline crossing u/s of City of Quesnel	82.2	484.8	2080	1570	488.9	488.1	4.1	3.3	8hr 40min	7hr 30min	11hr 10min	9hr 50min	9hr 20min	9hr 00min
Railway Bridge u/s of Highway 97 at Quesnel	87.5	476.7	2080	1550	479.5	478.8	2.7	2.1	9hr 10min	8hr 10min	11hr 30min	10hr 20min	9hr 40min	9hr 30min
Quesnel and Fraser River confluence	90.2	473.4	1960	1450	475.4	474.8	2.0	1.4	9hr 40min	8hr 40min	12hr 45min	11hr 20min	10hr 55min	10hr 30min
Fraser River, 4km downstream of confluence	94.7	470.7	3000	2470	472.5	472.1	1.8	1.3	10hr 00min	9hr 00min	13hr 10min	11hr 45min	11hr 20min	10hr 55min

Table 4.2 Inundation Characteristics at Selected Locations – Overtopping

Location	Distance d/s of Dam (km)	Estimated Flood Level for PMF only without Dam without Breach (m)	Peak Flow following a Breach including the PMF (m^3/s)		Peak Flood Level, Breach plus PMF Flows (m)		Estimated Rise in Water Level above PMF (m)		Estimated Time for Arrival of Flood from Start of Breach (hr min)		Time to Peak Flood Level from Start of Breach (hr min)		Travel Time of Peak Flood Level from the Dam (hr min)	
			Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)
East Saddle Dam	0	1062.6	7900	16200	1077.2	1082.5	14.7	20.0	-	-	1hr 50min	50min	-	-
Bridge at upper Arbuthnot Creek	4.9	933.6	7800	16200	943.1	949.6	9.4	16.0	15min	15min	1hr 55min	55min	10min	10min
Buildings immediately downstream of Philemon Lake	9.8	832.5	1200	3700	836.3	838.1	3.8	5.6	1hr 40min	55min	2hr 20 min	1hr 10min	35min	20min
First Bridge on lower Arbuthnot Creek	9.7	832.8	6090	10200	841.6	843.1	8.8	10.3	55min	45min	2hr 15 min	1hr 10min	30min	20min
Beaver Creek bridge u/s of confluence with Quesnel River	33.1	579.0	6000	7240	588.6	589.3	3.7	4.4	2hr 50min	1hr 55min	3hr 40min	2hr 30min	1hr 50min	1hr 40min
Buildings upstream of Sardine Flats	42.4	560.9	12500	12700	573.5	573.6	2.7	2.8	3hr 10min	2hr 10min	4hr 35min	3hr 15min	2hr 50min	2hr 30min
Sardine Flats area	51.2	541.4	11050	10600	550.0	549.7	1.9	1.5	3hr 40min	2hr 40min	6hr 35min	4hr 35min	4hr 50min	3hr 45min
Gravelle Bridge at Sardine Flats	52.2	547.8	11000	10600	549.8	549.5	2.0	1.6	3hr 40min	2hr 40min	6hr 40min	4hr 40min	4hr 55min	3hr 50min
Pipeline crossing u/s of Quesnel	82.2	496.3	10700	10100	497.7	497.3	1.4	1.0	5hr 00min	4hr 00min	9hr 25min	7hr 15min	7hr 40min	6hr 30min
Railway Bridge u/s of Highway 97 at Quesnel	87.5	494.5	10500	9800	495.6	495.2	1.1	0.8	5hr 30min	4hr 50min	10hr 15min	8hr 10min	8hr 25min	7hr 20min
Quesnel and Fraser River confluence	90.2	494.4	10500	9800	495.4	495.1	1.1	0.7	5hr 40min	5hr 00min	10hr 20min	8hr 10min	8hr 35min	7hr 20min
Fraser River, 4km downstream of confluence	94.7	490.4	39950	39300	491.5	491.1	1.1	0.7	5hr 40min	5hr 00min	10hr 25min	8hr 15min	8hr 40min	7hr 30min

4.3 Main Dam Failure

The Main Dam is currently maintained at a higher elevation than the East Saddle Dam. When construction of the Step-Back Embankment starts, from 2013, its elevation will be maintained higher than the East Saddle Dam. Therefore, the possibility of overtopping the Main Dam due to flood events is eliminated.

In the absence of an overtopping failure mechanism for the Main Dam, a liquefaction flowslide induced by an extreme earthquake is considered to be the worst case scenario for dam stability.

A 2-D run-out assessment using DAN-W was conducted for 3 scenarios and is summarised in Figure 1-26. Figure I-27 shows the plan of the Cycloned Sand Dam, and the cross-section that was used in the DAN-W analysis. A total of five rheological models were run in order to estimate the debris flow run-out pattern. These cases are described below, and the model parameters and results are summarized in Table 4.3 and are based on the model parameters utilized in the KCB 2012 Long-Term Tailings Deposition Plan (KCB, 2012):

- Run-out Scenario 1 – This case represents an upper-bound liquefied basal strength, based on the estimated Post-Earthquake strengths presented in the 2005 Inundation Study Report (KCB). In that report, a generalized ratio between residual strength and effective stress was found to be approximately S_r/σ_{vo}' = 0.15, based on correlations to SPT-blow counts.
- Run-out Scenario 2 – This case represents a lower-bound liquefied basal strength, based on the estimated Post-Earthquake strengths (S_r/σ_{vo}' = 0.10) presented in the 2012 Long-Term Deposition Plan (KCB) for "Existing Tailings – Section B". Note that this tailings beach value was applied to the entire Cyclone Sand Dam foundation.
- Run-out Scenario 3 – This case represents an extreme lower-bound liquefied basal strength (S_r/σ_{vo}' = 0.06), based on the weakest tailings area near the North Earthfill Dam presented in the 2012 Long-Term Deposition Plan (KCB) for "Existing Tailings – Section D". Note that this strength value was taken from an area located about 6,000 ft away from the dam cross-section used in the model.

As the latest build of DAN-W does not allow for the input of strength ratios in this format, the equivalent friction angle was used.

Table 4.3 Model Rheological Input Parameters and 2-D Model Analysis Results

Run-out Scenario	Condition	Model Strength Parameters, ϕ	Equivalent S_r/σ_{vo}'	Runout Distance, L (ft)	Equilibrium Slope
1	"Upper Bound Basal Strength"	8.5°	0.15	90 ft.	2.7H:1V
2	"Lower Bound Basal Strength"	5.7°	0.10	390 ft.	4.0H:1V
3	"Extreme Lower Bound Basal Strength"	3.4°	0.06	1145 ft.	8.0H:1V

For all run-out scenarios, the assumed unit weight of the slide mass is assumed to be 19.3 kN/m^3, as used in previous analysis, and the inter-slice friction angle used in the analysis is assumed to equal 32^o, equal to the static friction angle. This value is slightly below the "default value" as noted in the documentation for DAN-W (O. Hungr Geotechnical Research, 2003); however, as noted in that text, "generally, the model is not sensitive to [this parameter]".

The extreme lower bound scenario indicates a run-out of approximately 1,150 ft. This run-out would impact the Seepage Recovery Pond located 1,100 ft downstream of the tailings dam toe, but would not reach the Seepage Recovery Dam, which is located 1,600 ft downstream of the tailings dam toe. The back-scarp would extend approximately 1,150 ft into the tailings beach, but the current tailings pond would still be 1,000 ft away from the back-scarp. This confirms that the possibility for release of the tailings pond is remote.

The tailings pond would be pushed to approximately 10,000 ft away from Main Dam crest by the end of operations. As a result, the potential for release of the tailings pond reduces further with the development of the tailings facility.

5 OVERVIEW OF EMERGENCY RESPONSE

5.1 Overview of Responsibilities

Gibraltar Mines is responsible for co-ordination of emergency response at the site, issuing alerts to off-site agencies, and advising disaster service organizations of the actual or expected magnitude and progress of flooding. For emergencies such as a tailings dam failure, the Provincial Emergency Program (PEP) is notified. PEP and the Cariboo Regional District will take over command of the emergency and will notify residents according to their policies and procedures. Gibraltar Mines will assist as required. This level of emergency will be considered a crisis by the company and any further communications (i.e., media, regulators, residents, public) will be guided by the Taseko Mines Corporate Crisis Communications Team and the Gibraltar Crisis Management Team. Gibraltar Mines will respond to an emergency of the Gibraltar TSF dams using primarily their own or contracted resources. This will involve undertaking preventative and mitigating measures that are feasible.

This plan is based upon discussions with provincial government agencies, local authorities and companies that provide emergency services. It involves informing members of the general public who could be affected by such an emergency and adjusting plans according to the feedback received.

The PEP co-ordinates emergency operations of the response teams from government agencies, and also provides advice to local municipal emergency response organizations. PEP regional office representatives will travel to municipality and company emergency operations centres when deemed necessary.

Local Emergency Operations Centres of each municipality are responsible for co-ordinating and activating the emergency response plans for their community.

During an emergency, each of these agencies will need to interact, exchange information and co-ordinate their operations.

5.2 Overview of Organizational Structure

The major components for an emergency response at the Gibraltar TSF are described below:

- Gibraltar Crisis Management Team oversees the operation, maintenance and surveillance of the TSF, and is responsible for identifying a situation as being an emergency. In an emergency, the Gibraltar Crisis Coordinator and Gibraltar Crisis Control Centre will be comprised of members from this group.
- Gibraltar Crisis Management Team will establish the Gibraltar Crisis Control Centre to monitor and assess the emergency and implement any mitigation works. Also, the Gibraltar Crisis Control Centre will liaise with outside agencies, where required.
- Gibraltar Crisis Coordinator directs communications and all technical activities during an emergency.

- Gibraltar Crisis Control Centre is responsible for monitoring, assessments, and mitigation works.
- Gibraltar Crisis Control Centre is responsible for communications with populations at risk in the vicinity of the TSF, and with outside agencies. The PEP Emergency Coordination Centre, located in Victoria, will manage the effects of the emergency, at the provincial government level.
- PEP Emergency Coordination Centre collects and collates information on the situation at the dam-site, issues forecasts of how and when the flood wave will impact downstream areas, answers inquiries on the effects of possible inundation and how damage might be mitigated, and gives the PEP's perspective of the emergency to the media. Depending on the circumstances and if time permits, PEP may open a Provincial Regional Emergency Operations Centre (PREOC) in Prince George to assist with some of the above tasks.
- City of Quesnel Emergency Operations Centre manages the effects of the emergency at the local level for its municipality.
- Cariboo Regional District manages the effects of the emergency in any areas impacted outside the mine and the City of Quesnel.
- Media Rooms set up at the Gibraltar Mine offices in Williams Lake or Vancouver, and at the (PREOC) and the City of Quesnel Emergency Operations Centre will manage the rapid response to public inquiries and the rapid release of accurate information to the public.

Major emergency responders will send representatives to the appropriate operations and public media access rooms to:

- Provide their specialized expertise, skills and abilities.
- Provide emergency access to their employer's resources (staff, equipment, expertise, information collection capabilities, communications capabilities, search and rescue capabilities, etc.).
- Provide emergency operations staff in the field who will:
    - perform the specific duties assigned to them by this Emergency Preparedness Plan (EPP) or by the more detailed emergency response plan their organization may have prepared in compliance with this EPP; and,
    - keep the Gibraltar Crisis Control Centre fully informed of the situation downstream of the Gibraltar TSF, the deployment of personnel and equipment, and the actions which were taken or are being taken. Report instances of people or animals in need of rescue to the relevant Municipal EOC.

5.3 Standards and Conventions

5.3.1 Communications, Conventions and Procedures

Key emergency responders should follow the following conventions and standards to ensure that emergency response operations flow smoothly:

- Voice Message Backup Procedures:
  - If contacted by someone not personally known, verify the identity of the contact by returning the call. At the same time verify the content of the message.
  - Use faxes and/or emails to verify verbal message content where there is time.
- Communications Logging Procedures:
  - Each party will log all communications between agencies and Emergency Operations Centres.

5.3.2 Media Release Procedures

The news media can play a very crucial role in relaying information to the public regarding an emergency situation at the Gibraltar TSF. In general, emergency announcements through the local media will be the responsibility of PEP, the RCMP and/or local officials. Gibraltar's Crisis Coordinator will be the main Gibraltar Mines contact for the media and public officials.

6 HAZARDOUS CONDITIONS

6.1 Unusual Occurrences

Conditions, accidents or events occurring at the Gibraltar TSF which may have implications to dam safety have been categorized into potential dam safety problems, and other types of emergency situations which do not threaten the safety of the dam.

The Operation, Maintenance and Surveillance (OMS) Manual for the Gibraltar TSF (KCB, 2012) lists occurrences which would trigger an alert. These include:

- flooding causing an excessive rise in pond levels;
- failure of any of the diversion ditches;
- a seismic event;
- abnormally high piezometric levels in the dams;
- settlement, cracks or slumping in the dams;
- sinkholes along any slope of the dams;
- sinkholes in the tailings beach or tailings Step-Back Embankment;
- slope failure of any dam slope;
- abnormal seepage flows from any dam slope;
- increased or contaminated flow from the finger drains or relief wells;
- sabotage or other criminal activity; and,
- damage to any component of the TSF.

In accordance with the OMS Manual, Gibraltar employees are expected to continually monitor regular operations, dam raising activities, environmental performance, overall structural integrity and site safety. Should any of the above events occur, they should be immediately reported to the mine management and be addressed by the Gibraltar Crisis Management Team.

6.2 Actions to Stabilize Dams

The OMS Manual also presents general approaches for stabilizing the tailings dams during an emergency situation. Specific actions to stabilize the tailings dams during an emergency response will be developed and directed by the Gibraltar Crisis Control Centre.

A dam breach could be triggered by piping or overtopping. It is difficult to predict where a breach would be initiated and precisely what corrective actions would be required. Nevertheless, to assist the mine in dealing with emergency situations threatening the dams at the Gibraltar TSF, this section outlines potential courses of action that could be taken promptly to stabilize the dam. These actions could be summarized as:

- stop tailings discharge;
- lower the tailings pond level;
- place filter sand material that will arrest or retard dam internal erosion;
- place sand and gravel material that will arrest or retard dam external erosion; and,
- rearrange spigotting locations.

7 EMERGENCY RESPONSE

7.1 Initial Response

The Gibraltar Mine TSF OMS Manual (KCB, 2012) contains procedures on surveillance and the reporting of unusual occurrences. Geotechnical and visual inspections are undertaken to confirm that the construction and performance of the tailings dam meets the design requirements. All Gibraltar tailings and water management personnel are expected to immediately report to mine management, any suspect or unusual conditions at this facility. Upon detection of an unusual occurrence, this should be reported immediately to mine management, and the Gibraltar Crisis Management Team notified. Following notification of an unusual occurrence, the Gibraltar Crisis Management Team will meet to confirm the occurrence and decide on the alert classification of the situation. If the trigger occurrence is confirmed, then the Gibraltar Crisis Coordinator will assume responsibility for managing the emergency situation.

Potential danger to the safety of the TSF, and/or the downstream infrastructure and population are expressed as three levels of alert:

- Yellow Alert – an unusual occurrence had occurred.
- Amber Alert – a dam is unstable but breach is not imminent.
- Red Alert – a dam breach is imminent or has occurred.

Procedural guidelines and notification systems have been established which are dependent on the declared alert level. Notification flow charts for the three alert levels are presented in Figure 7.1.

For contact information see the Section 10 - Communications Directory

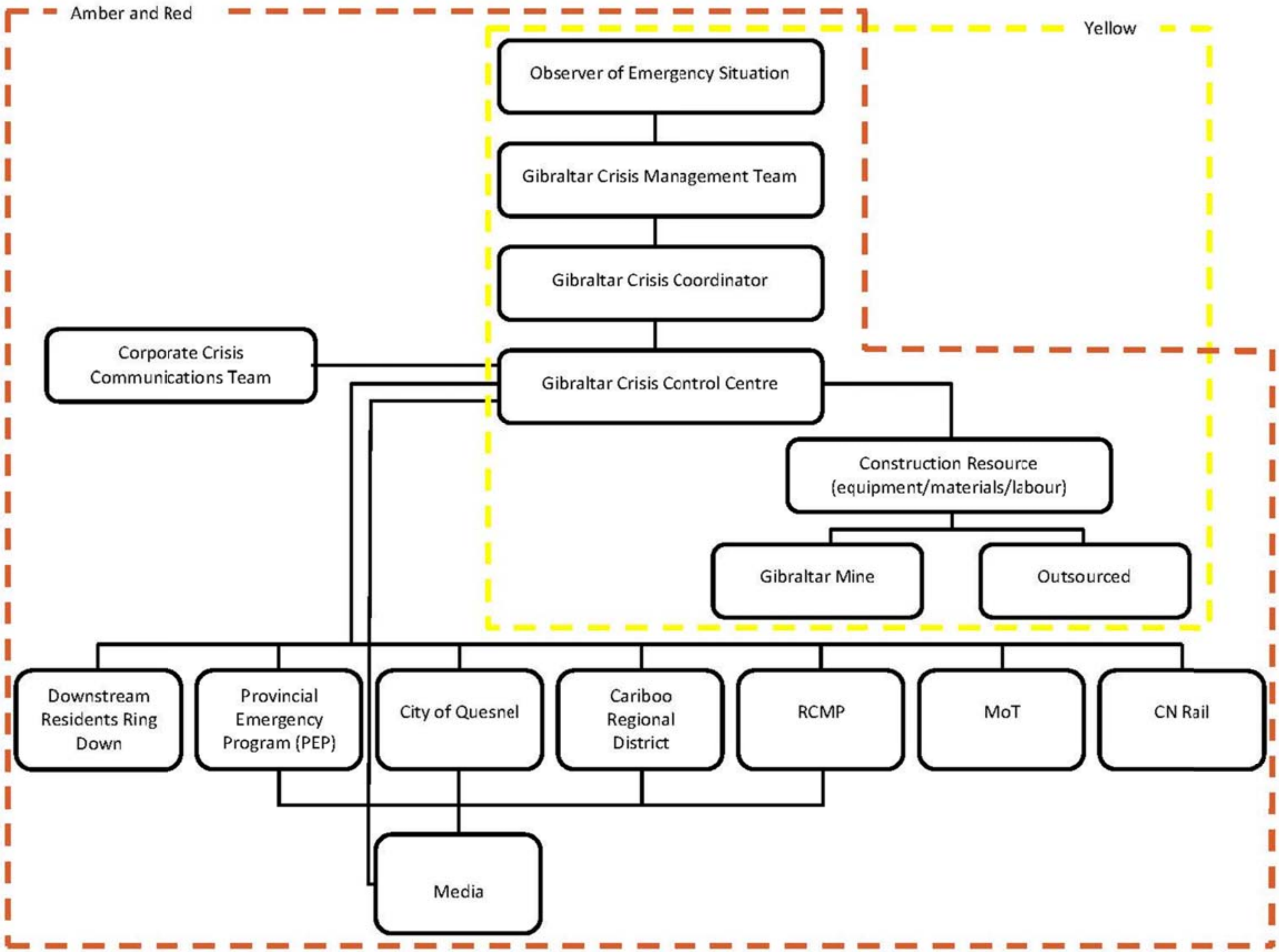


Figure 7.1 Alert Notification Flow Chart

7.2 Yellow Alert

7.2.1 General

Yellow Alert signifies that an unusual occurrence has occurred, but the dam is stable and not at risk of imminent failure. This alert level does not pose a hazard to people at the dam or to downstream populations at risk at the time of observation. The occurrence is to be monitored, and mitigation should be undertaken to bring the situation to below trigger levels. Yellow Alert involves procedures and activities primarily internal to Gibraltar Mine. Any event classified under the Yellow Alert will be considered to be such that it can be managed and controlled by Gibraltar Mine, with no negative impacts downstream.

Populations at risk and outside agencies will not be notified during the Yellow Alert. As a result, only the Gibraltar Crisis Coordinator and the Gibraltar Crisis Control Center will be active during a Yellow Alert.

7.2.2 Gibraltar Crisis Coordinator

The Gibraltar Emergency Coordinator will take the following actions:

- decide when to set up and provide staff, security, and logistical support to the Crisis Control Centre;
- decide with the Crisis Control Centre when the Yellow Alert could be removed; and,
- Summarize and incorporate the Yellow Alert in the annual tailings dam safety report.

7.2.3 Gibraltar Crisis Control Centre

Gibraltar Mine staff assigned to the Crisis Control Centre will be responsible for the following:

- Monitor, interpret and report technical data on the problem to the Gibraltar Crisis Coordinator.
- Use manpower, equipment and materials where feasible to minimize the likelihood of damage and/or dam failure, and to take measures that would stabilize the dam. Measures to stabilize the dam are outlined in Section 6.2.
- Control access to the TSF so that unauthorized visitors do not interfere with emergency operations personnel nor create additional public safety problems.

7.3 Amber Alert

7.3.1 General

Amber Alert signifies that the dam is unstable but failure is not imminent. Dam instability may be identified at the time of the triggering occurrence, or while monitoring during a Yellow Alert.

Declaration of an Amber Alert means that relevant agencies and populations at risk must be notified and placed on standby status. The populations at risk should be prepared to evacuate areas potentially impacted by flood or tailings runout. Amber Alert also means that conditions could worsen leading to an evacuation (Red) alert.

7.3.2 Gibraltar Crisis Coordinator

The Gibraltar Crisis Coordinator, will take the following actions:

- Establish the Gibraltar Crisis Control Centre and provide staff, security, and logistical support. Gibraltar Crisis Control Centre to act as a point-of-contact to manage the collection, collation and distribution of information at the local level on the potential downstream flooding situation.
- Issue Amber Alert warning through the Crisis Control Centre for potential dam breach. Include information on what areas will be impacted, the nature of the impact, when the impact will occur, and instructions on what the populations at risk should and should not do.
- Analyze alternative operational strategies to minimize increases in downstream flows (priority #1) and downstream flooding (priority #2).
- Decide with the Crisis Control Centre when to issue an "all clear" notification if the risk of dam breach has passed without incident.
- Decide when to issue a Red Alert if the emergency situation worsens.

7.3.3 Gibraltar Crisis Control Centre

Gibraltar Mine staff assigned to the Crisis Control Centre will take the following actions:

- Assess if a dam breach is likely to occur.
- Estimate when the dam breach could occur.
- Determine which areas would be impacted by the runout or inundation.
- Report all monitoring data, assessments, and technical information to the Crisis Coordinator.
- Without comprising safety of staff, assess and implement possible measures to halt or impede the breach. Some measures which could be taken are broadly outlined in Section 6.2.
- Provide security and control access to:
  - the TSF;
  - instrument reading sites; and,
  - associated access corridors (roads and footpaths).
- In case of exceptional physical circumstances at the damsite(s), Gibraltar Mines will have procedures in place for dealing with darkness during an emergency, and procedures for dealing with adverse weather conditions during an emergency.

- Direct a search for any visitors in the vicinity of the TSF who should be escorted to safety.
- Collect and collate information received. This will include: summaries and/or interpretations of instrument readings; forecasts of reservoir storage and outflows; and forecasts of the likelihood of dam failure.
- Issue a standby for evacuation alert. Include information on what areas may be impacted and the nature of the impact.
- The alert should go to the PEP, local municipalities and regional district, Ministry of Transportation and Infrastructure (MoT), CN Rail, RCMP, and nearby populations at risk. Gibraltar Mines keeps an up-to-date list of primary contacts that staff would have to notify and alternates who may have to be notified if any primary contacts are missed.
- Establish Media Rooms to facilitate the distribution and collection of information.

7.3.4 Provincial Emergency Program (PEP)

The PEP personnel will take the following actions:

- notify residents according to their policies and procedures;
- assist the Gibraltar Crisis Control Centre with the public communications process during the emergency;
- co-ordinate air-borne operations through Provincial Emergency Program Air (PEP Air), if required; and,
- co-ordinate the procurement of additional resources to assist and support the emergency response efforts.

7.3.5 Ministry of Transportation and Infrastructure (MoT)

Each District and Area office potentially affected will be on standby to take the following actions:

- close, on a priority basis, primary and secondary roads and bridges under their jurisdiction, which are or will be inundated;
- re-route non-local highway traffic; and,
- assess the safety of surviving bridges for relief operations and re-open where feasible on a priority basis.

7.3.6 CN Rail

CN Rail will be on standby to evacuate and secure its rail yard on the bank of the Quesnel River in the City of Quesnel. CN rail will also be on standby to close the following bridges:

- the railway bridge on Quesnel River upstream of Highway 97; and,
- the railway bridge on Quesnel River upstream of the Quesnel River and Fraser River confluence.

7.3.7 Local Authorities

Each local authority will be on standby to take the following actions:

- set up its Municipal Emergency Operations Centre from which to manage the local municipal response to the emergency;
- alert emergency services personnel within its jurisdiction;
- evacuate downstream residents, farmers and ranchers close to the dam(s) and along the flood route, if deemed necessary;
- make public safety announcements on local radio and television stations;
- alert utility companies with facilities that may be disrupted; and,
- alert Public Health Officials.

7.3.8 RCMP

Police forces will take the following actions:

- visit local residents, business owners, farmers and ranchers within the limited warning area who cannot be contacted by local authorities; and,
- if required, provide a RCMP representative to the Gibraltar Crisis Control Centre for facilitating communications with RCMP detachments involved in emergency operations in the vicinity of the TSF.

7.4 Red Alert

7.4.1 General

Red Alert signifies that dam failure is imminent or has occurred. Imminent dam failure may be identified initially, or while monitoring during an Amber or Yellow Alert. For this alert level, major structural damage to one or more of the Gibraltar TSF dams has occurred, or the physical condition of the dam has deteriorated such that stabilization is not possible and the dam will fail.

The responsible agencies need to initiate evacuation of populations at risk.

A Red Alert may develop from such things as an unusually high pond water level; uncontrolled piping through the dam or its foundation; or slumping and continuing deterioration of the scarp of the slump. A declaration of a Red Alert and the implementation of an evacuation plan do not mean that attempts to save the dam should be abandoned. Any emergency repair that has some potential to avert, delay or retard the rate of failure should be undertaken.

7.4.2 Gibraltar Crisis Coordinator

The Gibraltar Crisis Coordinator, will take the following actions:

- Verify and initially evaluate reports of problems at the dam(s).

- Establish the Gibraltar Crisis Control Centre and provide staff, security, and logistical support.
- Gibraltar Crisis Control Centre to act as a point-of-contact to manage the collection, collation and distribution of information at the local level on the potential downstream flooding situation.
- Issue alert for immediate evacuation through the Crisis Control Centre. Include information on what areas will be impacted, the nature of the impact, when the impact will occur, and instructions on what the populations at risk should and should not do.
- Issue updates regarding status of the dam(s) periodically through the Crisis Control Centre.

7.4.3 Gibraltar Crisis Control Centre

Gibraltar Mine staff assigned to the Crisis Control Centre will be responsible for the following:

- Estimate when the dam breach would occur.
- Determine which areas would be impacted by the runout or inundation.
- Estimate when the flood wave would be expected.
- Monitor, interpret and report technical data on status of breach.
- Report all monitoring data, assessments, and technical information to the Crisis Coordinator.
- Without comprising safety of staff, assess and implement possible measures to halt or impede the breach.
- Provide security and control access to:
    - the TSF;
    - instrument reading sites; and,
    - associated access corridors (roads and footpaths).
- Issue alert for immediate evacuation. Include information on what areas would be impacted, the nature of the impact, and when the impact will occur.
- Collect and collate information on the developing emergency. Before the dam breach starts to develop this would include: summaries and/or interpretations of instrument readings; forecasts of reservoir storage and outflows; and forecasts of the time of dam failure. After the dam breach starts to develop this would include: summaries and/or interpretations of changes in reservoir levels; and the magnitude and rate of development of the dam breach.
- The alert should go to the PEP, local municipalities and regional district, MoT, CN Rail, RCMP, media, and nearby populations at risk on up-to-date information on the situation at the TSF. Gibraltar Mines keeps an up-to-date list of primary contacts that staff would have to notify and alternates who may have to be notified if any primary contacts are missed.
- At earliest convenience, establish Media Rooms to facilitate the distribution and collecting of information.

- Collect and collate information on downstream flooding (rate of rise in water level, time of flood wave arrival and flood wave peak) from local authorities, police, search and rescue aircraft, local residents, and water survey personnel.
- Although municipal authorities and the RCMP have primary responsibility for rescue, the Crisis Control Centre may assist in the following ways:
    - warn isolated local residents, farmers, ranchers and staff close to the dam of the potential breach;
    - assist with search and rescue;
    - conduct aerial reconnaissance; and,
    - obtain and utilize helicopters and fixed-wing aircraft for both day time and night time flying to monitor the progress of the flood wave.

7.4.4 Provincial Emergency Program

The PEP personnel will take the following actions:

- Notify residents according to their policies and procedures.
- Co-ordinate the relief efforts downstream of the dam.
- Assist Gibraltar Mines with the public communications process during the emergency.
- Co-ordinate emergency radio communications through Provincial Emergency Radio Communications Service (PERCS), if required.
- Co-ordinate air-borne operations through PEP Air, if required.
- Decide whether to activate the Provincial Regional Emergency Operations Centre (PREOC) in Prince George.
- Staff and support the PREOC, if activated, to:
    - collect, collate and assess the information provided by the Gibraltar Crisis Control Centre;
    - brief senior government officials on the emergency situation;
    - co-ordinate the response of senior government officials;
    - send senior government policy directives, information requests and unusual authorizations to the other Emergency Control Centres that may have been established by the Local Authorities; and,
    - facilitate requests from the public and media to have access to senior government officials.
- Request the assistance of federal resources, if necessary.
- Procure outside resources when requested by Local Authorities.

7.4.5 Ministry of Transportation and Infrastructure (MoT)

Each District and Area office affected will take the following actions:

- close, on a priority basis, primary and secondary roads and bridges under their jurisdiction, which are or will be inundated;
- re-route non-local highway traffic; and,
- assess the safety of surviving bridges for relief operations and re-open where feasible on a priority basis.

7.4.6 CN Rail

CN Rail will evacuate and secure its rail yard on the bank of the Quesnel River in the City of Quesnel. CN Rail will also monitor river flood levels, and close as appropriate, the following bridges:

- the railway bridge on Quesnel River upstream of Highway 97; and,
- the railway bridge on Quesnel River upstream of the Quesnel River and Fraser River confluence.

7.4.7 Local Authorities

Each local authority will take the following actions:

- set up its Municipal Emergency Operations Centre from which to manage the local emergency response;
- alert and/or evacuate downstream residents, visitors, businesses, farmers and ranchers based on information provided by the Gibraltar Crisis Control Centre, and inundation maps or predicted flood elevations;
- monitor the progress in notifying local residents, visitors, businesses, farmers and ranchers, and clear unsuccessful phone contacts with site visits (by road or air);
- alert emergency services personnel under its jurisdiction;
- rescue residents, visitors, businesses, farmers and ranchers in conjunction with emergency workers in its jurisdiction;
- monitor the evacuation of all downstream residents, visitors, businesses, farmers and ranchers in its jurisdiction;
- determine the status and location of downstream residents, visitors, farmers and ranchers in the aftermath;
- declare a state of local emergency, if necessary;
- make public safety announcements on local radio and television stations;
- alert utility companies with facilities that may be disrupted;
- alert public health officials;

- alert District Agriculturists;
- monitor Quesnel River intakes and sewage lagoons that could be affected;
- provide emergency social services within its district boundaries; and,
- co-ordinate air-borne operations over the floodpath, if required.

7.4.8 RCMP

The police force will take the following actions:

- assist local authorities in evacuation;
- visit local residents, visitors, businesses, farmers and ranchers with whom local authorities cannot communicate;
- provide a representative to the Gibraltar Crisis Control Centre for facilitating communications with RCMP detachments and involved in emergency operations below the dam;
- provide supplemental radio communications from emergency locations and/or the dam as necessary if the telephones are inoperative or unavailable;
- aid in closing roads and bridges. The RCMP shall on their own authority close roads as required; and,
- provide security to areas that have been evacuated.

7.4.9 Media

The media will take the following actions:

- send reporters and/or news teams to the Media Rooms in the Crisis Control Centre and Municipal Emergency Operations Centres to obtain accurate information about the emergency;
- relay information about the nature of the emergency to the general public; and,
- rapidly relay, as a public service, public safety and emergency measures announcements on the radio and TV.

8 CONSTRUCTION MATERIALS, EQUIPMENT, LABOUR AND ENGINEERING RESOURCES

Response procedures for this plan involve repairs to the tailings dams, and/or measures to alleviate potential flooding downstream from the TSF. Thus, access to construction materials, equipment, emergency power sources, labour and engineering expertise is required. The Crisis Control Centre will identify equipment requirements for emergency works that need to be undertaken. Gibraltar Mine's equipment on-site will be made available to the Crisis Control Centre. The Crisis Control Centre will procure equipment from off-site suppliers, if required.

A list of equipment available onsite is presented in Table 8.1, and names and contact numbers for off-site service and equipment suppliers and contractors is presented in Table 8.2. Contact information for engineering resources is presented in the Communications Directory under Gibraltar Crisis Management Team.

Table 8.1 Onsite Equipment List

Description	Quantity	Location	Maintenance	Comment	Fire	Injury	Spills	MVA	Geotechnical Failures	Explosions	Essential Services	Acts of Nature	Terrorism	Structural Collapse	Evacuation	Water
General																
Fire and chemical pre-plans	1	Mine Rescue Truck; Security Building	annually or as required (Loss Prevention)		X	X	X			X	X		X	X	X	
Gas detection equipment	Multiple	Mine Rescue Center; Mill Shift Foreman's office; Pit Shop Electrical Foreman's Office; Pit Shop Maintenance Foreman's Office; Security Building	as required (monthly calibration)		X		X			X	X			X	X	
Plant site back up power generator	1	Pit shop	PM - biannually		X			X		X	X	X	X	X		
Portable Generators (1000-300W), lights, ladders	Multiple	Pit shop; Carpenter Shop	as required		X		X	X	X	X	X	X	X	X		
4095 Portable (trailer mounted) generator (4160V, 3ph, 1.2MW)	1	Mine	PM - biannually		X		X	X	X	X	X	X	X	X		
Storage drums and totes	Multiple	Pit shop, mill, SX-EW					X									
Communications																
2 way radios	Multiple	property	monthly PM of repeater stations (2, UPS system)	6 channels	X	X	X	X	X	X	X	X	X	X	X	X
Phones (internal), IP phones	Multiple	property	as required	phone exchange in office	X	X	X	X	X	X	X	X	X	X	X	X
Phone/fax (external) IP phones - Main	23 lines	Phone exchange in Admin. Building	monthly PM of cell tower (UPS system)	TELUS Wireless service from Quesnel to Gibraltar cell tower, to phone exchange in Admin.	X	X	X	X	X	X	X	X	X	X	X	X
Phone/fax (external) IP phones - Secondary	10 phone lines, 3 fax lines	Phone exchange in Admin. Building	as required	Service from McLeese Lake via landline. Phone lines via phone exchange in Admin. Fax lines are stand alone.	X	X	X	X	X	X	X	X	X	X	X	X
Phone/fax (external) IP phones - Tertiary		TELUS: Property except in lower areas of Pit Rogers: Main Office	monthly PM of cell tower (UPS system)	Cell service via Telus through Gibraltar cell tower. Cell service via Rogers from McLeese Lake and repeater in Gibraltar Main office	X	X	X	X	X	X	X	X	X	X	X	X
Internet - Main		Admin. Building		10 Mb/s Telus connection from Quesnel to Gibraltar cell tower (TELUS)	X	X	X	X	X	X	X	X	X	X	X	X
Internet - Secondary		Admin. Building		2 Mb/s Telus wireless connection from Quesnel via antenna in Boneyard (ABC Communications)	X	X	X	X	X	X	X	X	X	X	X	X
Internet - Tertiary		Property except in lower areas of Pit		Access over cell network via wireless cards	X	X	X	X	X	X	X	X	X	X	X	X
Pumps																
2" Honda semi-trash pumps with suction and discharge hoses	2	Carpenter shop	as required	pump	X		X		X		X	X	X	X		
3" Honda trash pumps with suction and discharge hoses	2	Carpenter shop	as required	pump	X		X		X		X	X	X	X		
Gorman Rupp trash pump, diesel	1	Rebuild Shop	as required	pump	X		X		X		X	X	X	X		
Tsurumi diesel trash pump EPT2-150DD, 32Hp	2	Pit de-watering, rebuild shop	as required	pump	X		X		X		X	X	X	X		
Gorman Rupp 30hp submersible pumpS4G1, 600V	1	Pit de-watering, rebuild shop	as required	pump	X		X		X		X	X	X	X		
2hp submersible well pumps	2	Pit de-watering	as required	pump			X		X		X	X	X	X		
Monarch gas pump 3"X3", 330 USGPM @ 90' head	1	Rebuild shop	as required	pump	X		X		X		X	X	X	X		
Flygt submersible pump, 30 HP, 550 V	1	Quonset hut	as required	pump	X		X		X		X	X	X	X		

Description	Quantity	Location	Maintenance	Comment	Fire	Injury	Spills	MVA	Geotechnical Failures	Explosions	Essential Services	Acts of Nature	Terrorism	Structural Collapse	Evacuation	Water
Crown Submersible pump, 6H-300-3A, 575V, 316 SS, 15 HP, 4: FPT discharge, 400USPM @100 ft, 150USPGM @200 ft	1	SX-EW Plant	as required	pump	X		X		X		X	X	X	X		
Reagent Barrel pumps, 110 V, 20 USGPM	3	Mill reagent area	as required	pump			X									
Flex 3" quick couplings in 50' lengths	Multiple	Carpenter shop		pump	X		X		X		X	X	X	X		
Flygt Submersible pump, BS-2125, 316 SS 4" connection, 600V/3ph/60Hz, 160 USGPM @106 ft, 90 USGPM @ 240 ft	1	SX-EW Plant	as required	pump	X		X		X		X	X	X	X		
Flygt Submersible pump, 2060, 316 SS, 575V/3ph/60Hz, 3" flanged elbow reduced to 2" nipple, 300 USGPM @10 ft, 60 USGPM @ 70 ft	1	SX-EW Plant	as required	pump	X		X		X		X	X	X	X		
Well Pump, 3.5" GrundFoss, 230V/1ph/60Hz, 10 USGPM @233 ft	1	SX-EW Plant	as required	pump	X		X		X		X	X	X	X		
Spills & Releases																
Spill Kits	5	Mine rescue bldg.(2), each fuel island; Warehouse	fuel islands - weekly or as required (Mine Operation - Site Services)				X									
absorbents, bulk	Multiple	Warehouse	warehouse stock item				X									
Spill response trailer, see Spill Trailer inventory	1	Mine Rescue Center	annually or as required (Loss Prevention)				X									
Injury/Rescue																
Class C Industrial Ambulance	1	Gatehouse	daily check (first aid attendants), monthly PM			X										
First aid room (conforms to BC Occupational Health and Safety Regulation 296/97)		Gatehouse	supplies are checked and maintained daily or as required.			X										
Basket stretcher w spine board	1	Mine Rescue Truck				X										
O2 system	Multiple	Mine Rescue Truck: Ambulance ;First aid room				X										
cervical collars	Multiple	Mine Rescue Truck; Ambulance; First aid room				X										
Rescue rope and rigging	Multiple	Mine Rescue Truck; Mine Rescue Center	rigging hardware non destruction tested annually			X										
extrication tools	Multiple	Pit shop		air chisels, cutting torches, come-alongs, porta-power rams		X										
tripods w rescue winches and self-retracting lanyards	2	Mill; Mine Rescue Center		confined space rescue		X										
Davit arm with winches and self-retracting lanyard	1	Mill		confined space rescue		X										
Supplied air system	1	Mine Rescue Center		confined space rescue		X										
Fire-Fighting																
Fire turnout gear	4	Mine Rescue Truck			X		X			X					X	
SCBA	6	Mine Rescue Truck	annual certification inspection		X		X			X					X	
SCBA spare cylinders	6	Mine Rescue Truck			X		X			X					X	
SCBA	5	Mine Rescue Center	annual certification inspection		X		X			X					X	
SCBA spare cylinders	10	Mine Rescue Center			X		X			X					X	
Fire hoses, valves, nozzles (1.5 and 2.5")	Multiple	Mine Rescue Truck; Mine Rescue Center			X		X			X					X	
Forestry hoses (1")	Multiple	Mine Rescue Center			X		X			X					X	

Description	Quantity	Location	Maintenance	Comment	Fire	Injury	Spills	MVA	Geotechnical Failures	Explosions	Essential Services	Acts of Nature	Terrorism	Structural Collapse	Evacuation	Water
Miscellaneous hand tools	Multiple	Mine Rescue Truck		pry bars, sledge hammers, picket pegs	X	X	X	X		X				X		
Miscellaneous hand tools	Multiple	Warehouse		water cans, pry bars, sledge hammers, picket pegs	X	X	X	X		X				X		
Hydrant tools	Multiple	Mine Rescue Truck		valves and wrenches	X											
Fire extinguishers - ABC, CO2	Multiple	Warehouse, Mine Rescue Truck., site-wide	monthly and annual inspection, 6 yr. service, 12 yr. hydrostatic pressure test		X											
Fire extinguishing system - AFFF	1	SX-EW Plant	daily check, annual inspection/PM		X					X						
Fire water system - General	1	Plant site	hydrants and sprinkler systems - annually	Head tank, distribution system, hydrants	X					X						
Fire water system - Fire stations	Multiple	Site-wide	monthly inspections; annual service	Hoses	X					X						
Fire water system - Sprinkler systems	Multiple	Site-wide	annual service		X											
Water Rescue																
12 ft boat, gas motor, electric motor, heaving ropes, life jackets	1	Landfill building	as required			X	X	X								X
Surface Equipment																
4104 – Cat 928HZ	1	Mine / blaster crew	PM – 400 hrs	Loader	X		X	X	X	X	X	X	X	X		
4108 – Michigan L90B	1	Mine	PM – 400 hrs	Loader	X		X	X	X	X	X	X	X	X		
4111 - Volvo L90F	1	Site Services	PM – 400 hrs	Loader	X		X	X	X	X	X	X	X	X		
4137 - Cat 994D	1	Mine	PM – 400 hrs	Loader	X		X	X	X	X	X	X	X	X		
4138 - Komatsu WA700	1	Mine	PM – 400 hrs	Loader	X		X	X	X	X	X	X	X	X		
4141 – Komatsu WA 800	1	Mine	PM – 400 hrs	Loader	X		X	X	X	X	X	X	X	X		
4032 / 4033 / 4034 / 4037 / 4038 - Bobcat Loaders	5	Mill, Mine	PM – 12 weeks	Loader	X		X	X	X	X	X	X	X	X		
4035 – Bobcat excavator	1	Site Services	PM –12 weeks	Excavator	X		X	X	X	X	X	X	X	X		
4479 / 4480 / 4481 / 4482 / 4483 / 4486 – Cat D10	6	Mine	PM – 400 hrs	Dozer	X		X	X	X	X	X	X	X	X		
4484 / 4485 – Cat D11T	2	Mine	PM – 400 hrs	Dozer	X		X	X	X	X	X	X	X	X		
4335 – Cat 824C cable reeler	1	Mine operations	PM – 400 hrs	Cable Reeler	X		X	X	X	X	X	X	X	X		
4336 - Cat 992D Rubber Tired Dozer	1	Mine	PM – 400 hrs	Dozer	X		X	X	X	X	X	X	X	X		
4109 - Komatsu PC400LC	1	Site Services	PM – 400 hrs	Excavator	X		X	X	X	X	X	X	X	X		
4112 - Cat 345	1	Site Services	PM – 400 hrs	Excavator	X		X	X	X	X	X	X	X	X		
4110 - Komatsu PC220LC-7	1	Site Services	PM – 400 hrs	Excavator	X		X	X	X	X	X	X	X	X		
4028 - Lorain 28 Ton	1	Pit shop	PM – 400 hrs	Crane	X		X	X	X	X	X	X	X	X		
Forklifts	Multiple	SX, Mill, Pit shop	PM – 12 weeks	Forklift	X		X	X	X	X	X	X	X	X		
100 T trucks 7,200 Imp.Gal	1	Pit shop	PM – 400 hrs	Water truck	X		X	X	X	X	X	X	X	X		
4050 - Bucket truck (electrical)	1	Pit shop	PM – 12 weeks	Bucket Truck	X						X	X	X	X		
4004 Dump truck	1	Site Services	PM – 8 weeks	Dump Truck			X		X	X	X	X	X	X		
4009 Service Truck	1	Mechanics	PM – 12 weeks	Service Truck			X		X	X	X	X	X	X		
4015 Dump Truck	1	Site Services	PM – 8 weeks	Dump Truck			X		X	X	X	X	X	X		
4010 Dump Truck	1	Site Services	PM – 8 weeks	Dump Truck			X		X	X	X	X	X	X		
Crew Buses	9	Mine	PM – every 6 weeks	Pit Crew Bus			X		X	X	X	X	X	X	X	
4099 – Cube Van	1	Mine Rescue	PM – every 12 weeks	Mine Rescue			X		X	X	X	X	X	X		
4011 Crane Truck	1	Site Services	PM – every 12 weeks	Crane Truck			X		X	X	X	X	X	X		
4012 Lube Truck	1	Mine Ops	PM – every 8 weeks	Lube Truck			X		X	X	X	X	X	X		
4014 / 4016 Service Trucks	2	Mechanics	PM – every 8 weeks	Service Truck			X		X	X	X	X	X	X		
4017 Hi-way Tractor / tri-axle	1	Site Services	PM – every 8 weeks	Tractor			X		X	X	X	X	X	X		
4018 Water Truck / 1,000 gallon water tank	1	Mine Ops	PM – every 8 weeks	Water Truck			X		X	X	X	X	X	X		

Table 8.2 Offsite Suppliers and Contractors

Service	Supplier/Contractor	Location	Contact Person	Phone Numbers
Excavating/Surface Equipment and Operator	Paterson Contracting Ltd	Williams Lake	Wayne Paterson	(250) 392-3292 [redacted]
Equipment and Operator	Lake Excavating Ltd			(250) 392-6291
Crane Rental and Operator	Lucas Cranes	Williams Lake		(250) 392-5863 (250) 296-3248
Municipal Road Service	Interior Road Services	McLeese Lake		(250) 297-6497
		Quesnel		(250) 992-8809
All Terrain Vehicles - Rental	100 Mile Recreational Sales and Service	100 Mile		(250) 392-2550
Helicopters	Highland Helicopters	Williams Lake		(250) 398-7142
	Arduini Helicopters	Williams Lake	Tom Arduini	(250) 398-5551
Divers	R. D. Van Der Maaten	Wildwood		(250) 989-5541
Industrial Suppliers	Tasco Supplies Ltd (generators, etc.)	Williams Lake	Rick Weil	(250) 392-6232 [redacted]
	Acklands Ltd	Williams Lake	Ian Sopp	(250) 392-7132 [redacted]
	Highlands Irrigation Ltd	Williams Lake	Dick Ford Vern Winger	(250) 392-2321 [redacted]
Portable Generators (Purchase)	Williams Lake Honda	Williams Lake	Ryan Watt	(250) 392-2300 [redacted]
Rental/Lease Equipment	Broadway Rentals (pumps, generators, etc.)	Williams Lake	Art Erickson	(250) 392-2662 [redacted]
	Gordon Rent-All (good selection of pumps and generators	Williams Lake	Gordo Rauch	(250) 392-4222 [redacted]
Towing Companies	Bee Jays Auto Towing	Williams Lake		(250) 398-9311 (24 hrs)
	Downtown Service	Williams Lake		(250) 392-7515 (24 hrs)
Hydro Services	BC Hydro	Williams Lake		1 (888) 769-3766
Natural Gas services	Fortis BC			1 (888) 663-9911

9 REVIEW, TESTING, UPDATING OF EPP, AND REPORTING

Ongoing training of staff, testing of the communications set up, and operational tests of the plan are required to ensure the effectiveness of the response. The Gibraltar Mine staff should conduct communications testing on an annual basis. An operational test, which will include staff from emergency responders, should be performed every five years. The results from the training and testing will then be used to update the EPP as required.

Gibraltar Mines will be responsible for reporting on the operational tests, and for updating the EPP. The updating of the EPP will be in a written form, and will be forwarded to all plan holders.

FEMA (2004) guidance recommends five types of exercises. The emergency exercises should be developed and conducted in an ascending order of complexity. Brief descriptions of the five exercise types, listed from simplest to most complex, are provided below. Further guidance on conducting the exercises may be found in the FEMA (2004) document, which is available online at http://www.fema.gov/library/viewRecord.do?id=1672.

- Orientation Seminar - This exercise would be a seminar that involves bringing together Gibraltar Mine and the emergency responders identified under Section 10, to discuss the EPP and enable each participant to become familiar with the EPP, and the roles, responsibilities, and procedures of those involved. Plans for an annual drill or more in-depth comprehensive exercise will be agreed at this seminar.
- Drill - A drill is the lowest level exercise that involves an actual exercise. It tests, develops, or maintains skills in a single emergency response procedure. An example of a drill is an in-house exercise performed to verify the validity of telephone numbers and other means of communication along with Gibraltar's response.
- Tabletop Exercise - The tabletop exercise is a higher level exercise than the drill. The tabletop exercise involves a meeting of the dam owner and the provincial and local emergency management officials in a conference room environment. The exercise usually begins with the description of a simulated event and proceeds with discussions by the participants to evaluate the EPP and response procedures and to resolve concerns regarding coordination and responsibilities.
- Functional Exercise - The functional exercise is the highest level exercise that does not involve the full activation of the dam owner and provincial and local emergency management agency field personnel and facilities, or test evacuation of residents downstream of the dam. It involves the various levels of the emergency responders and is designed to evaluate both the internal capabilities and responses of the dam owner and the workability of the information in the EPP used by the emergency management officials to carry out their responsibilities. The functional exercise also is designed to evaluate the coordination activities between the dam owner and emergency management personnel.

Full Scale Exercise - The full scale exercise is the most complex level of exercise. It evaluates the operational capability of all facets of the emergency management system interactively in a stressful environment with the actual mobilization of personnel and resources. It includes field movement and deployment to demonstrate coordination and response capability. Actual evacuation of critical residents may be exercised if previously announced to the public.

10 COMMUNICATIONS DIRECTORY

The communications directory, presented in this section, should be reviewed and updated semi-annually.

Table 10.1 gives the telephone numbers to be used to report an unusual occurrence. The telephone numbers may also be used by other emergency responders to contact the Gibraltar Crisis Coordinator.

Table 10.1 Gibraltar Mine Emergency Contact Details

Gibraltar Mines	Contact	Office Phone	Cell Phone	Email
Gibraltar Mine	Security	(250) 992-1800		
Gibraltar Crisis Coordinator	Dale Lawson	(250) 992-1800, local 227	[redacted]	dlawson@gibraltarmine.com
Crisis Control Centre	-	(250) 992-1800		

The number of an additional line should be kept confidential so that fast communications can be maintained between key stakeholders. This number could be put only on select copies of the directory, perhaps in hand-written form, or transmitted to those who require it at the start of the emergency. Consideration should also be made to the use of social media.

Contact details of key individuals or agencies are given in Table 10.2.

Table 10.2 Gibraltar Crisis Management Team (Tailings)

Name	Position	Responsibility
Pat Gannon	Manager, Mill Operations	Oversees all aspects of tailings management.
Vacant	Superintendent, Mill Operations	
Gord Simms	Superintendent, Mine Engineering	Surveying, mapping.
Kelly Parker	Manager, Mine Operations	Surface drainage control, mobile equipment.
John Purdy	General Foreman, Mill Operations	Operation of tailings pumping and deposition systems.
Linda Green	General Foreman, Mill Maintenance	Planning, implementation and supervision of mechanical maintenance.
Todd Wambolt	Senior Environmental Engineer	Permitting and regulatory requirements, geotechnical monitoring.
Chris Krystia	Sr. Metallurgist	Technical support, project scheduling.
Tim Potter	Superintendent, Projects	Construction management.
Bob Chambers	Consulting Geotechnical Engineers Klohn Crippen Berger Ltd.	Dam design annual compliance reporting, geotechnical analysis, and risk assessment.

EMERGENCY MANAGEMENT BC (Formerly PROVINCIAL EMERGENCY PROGRAM)

24-Hour Emergency Number (Victoria) 1-800-663-3456
North East Region Office (Prince George) phone (250) 612-4172
Fax (250) 612-4171

CN RAIL

24-Hour Emergency Number 1-800-465-9239

MINISTRY OF AGRICULTURE AND LANDS

Williams Lake (250) 398-4500
1 (800) 474-6133

MINISTRY OF ENERGY, MINES AND NATURAL GAS

District Inspector (Kamloops)
Steve Rothman (250) 371-3780 (work)
[redacted]
Email: Stephen.Rothman@gov.bc.ca

George Warnock, Manager, Geotechnical Engineering (250) 565-4327 (work)
Email: George.Warnock@gov.bc.ca

MINISTRY OF ENVIRONMENT

Jack Green (250) 398-4544 (work)
Email: Jack.Green@gov.bc.ca

Dam Safety Officer (Williams Lake)
Connie Haeussler (250) 398-4893 (work)
[redacted]
Email: Connie.Haeussler@gov.bc.ca

MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE (MoT)

Provincial Highway Communications Centre
24-Hour, Burnaby (604) 660-9771

Cariboo District Office, Williams Lake
Phone: (250) 398-4519
Fax: (250) 398-4454

Quesnel Area Office, Quesnel
Phone: (250) 992-4412
Fax: (250) 992-4436

MEDIA (RADIO AND TELEVISION)

Radio

'The Wolf' - 100 Mile House (CKBX 840AM), Williams Lake (CKWL 570AM), and Quesnel (CKCQ 100.3FM)
'The Rush' - Williams Lake (97.5FM), Quesnel (94.9FM), and 100 Mile House (99.7)

Quesnel Station (250) 992-7046 (phone)
(250) 992-2354 (fax)
After hours Gary Long (Manager) [redacted]
Prince George Station (250) 564-2524 (head office)

Williams Lake Station	(250) 392-6551 (phone) (250) 392-4142 (fax)
100 Mile House Station	(250) 395-3848 (phone) (250) 392-4147 (fax)

Television

CFJC Television (Kamloops)	1 (888) 522-2288

MUNICIPALITIES AND REGIONAL DISTRICT

City of Quesnel, Williams Lake and the Caribou Regional District have 911 emergency numbers.

City of Quesnel

24 Hour Emergency no.	911
Emergency Program Coordinator	(250) 992-5121

Caribou Regional District

24 Hour Emergency no.	911
Emergency Program Coordinator	(250) 392-3351

City of Williams Lake

24 Hour Emergency no.	911
Emergency Program Coordinator	(250) 392-1794

UTILITIES AND PIPELINES

BC Hydro	24-Hour Emergency Number	1 (888) 769-3766
Fortis BC	24-Hour Emergency Number	1 (800) 663-9911
TELUS Communications	Customer Service	310-3100
	Repair Service	1 (800) 663-0333

RCMP

Williams Lake	(250) 392-6211
Quesnel	(250) 992-9211

AMBULANCE

Williams Lake	(250) 392-5402
Quesnel	(250) 992-3211

HOSPITALS

Williams Lake	Cariboo Memorial Hospital 517 North 6th Avenue Williams Lake, BC V2G 2G8	(250) 392-4411
Quesnel	G.R. Baker Memorial Hospital 543 Front Street, Quesnel, BC V2J 2K7	(250) 992-0600

CONSULTING ENGINEERS

Klohn Crippen Berger

Bob Chambers	(604) 251-8435 (office) [redacted] Email: Bob.Chambers@Klohn.com

REFERENCES

B.C. Reg. 163/2011. (2011). “British Columbia Dam Safety Regulation”, deposited November 30.

CDA, 2007. “Dam Safety Guidelines”, Canadian Dam Association, January.

FEMA, 2004. “Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners”, April.

Klohn Crippen Berger Ltd. (2012). 2012 Long-Term Tailings Deposition Plan, October 26.

Klohn Crippen Berger Ltd. (2012). “Gibraltar Mine Tailings Storage Facility - Operation, Maintenance and Surveillance Manual. Revision 4”, April 3.

Klohn Crippen Berger Ltd. (2013). “Gibraltar Mine Tailings Storage Facility – Emergency Preparedness Plan. February 5.

APPENDIX I

Dam Breach and Inundation Assessment

Appendix I
Dam Break Inundation Assessment

TABLE OF CONTENTS

List of Tables

List of Figures

Figure I-11 East Saddle Dam – As-Built Plan and Sections (1986)

I-1 INTRODUCTION

I-1.1 General

The Gibraltar Mine is located approximately 60 km north of Williams Lake, near McLeese Lake in the southern interior of British Columbia as shown in Figure I-1 and Figure I-2. Access to the mine site is by way of an 18 km paved road that joins Highway 97 near McLeese Lake. The Tailings Storage Facility (TSF) at the Gibraltar Mine is located immediately north of the mine's plant site. The tailings impoundment is retained by the Main Tailings Dam on the west side of the impoundment and the East Saddle Dam on the east side as shown in Figure I-3.

This report presents the results of a dam breach and inundation study, undertaken by Klohn Crippen Berger (KCB) in 2012, for the Tailings Storage Facility (TSF) at the Gibraltar Mine in British Columbia. The TSF is essentially impounded by two dams: the Main Dam and the East Saddle Dam. The Dam Safety Guidelines published by the Canadian Dam Association (CDA, 2007) form the basis for the current dam safety regulations in Canada. In British Columbia, dam safety is also regulated by the British Columbia Dam Safety Regulation (B.C. Reg. 163/2011).

The Main Dam was commissioned in 1972 by construction of a 100 ft high starter dam of compacted glacial till across the outlet of the East Cuisson Creek valley. Subsequent dam raises were performed using the centreline method of construction. Tailings underflow from cyclones located across the crest of the dam was deposited directly onto the centreline and downstream slope of the dam. The Main Dam is also referred to as the Cycloned Sand Dam in this report.

The East Saddle Dam consists of a compacted till embankment and was initially built in two stages in 1985 and 1986. The dam was raised in 2007 and 2008, and has subsequently had annual raises since 2010.

In a previous dam failure classification assessment, the TSF at the Gibraltar Mine was classified as an “Extreme” consequence facility (KCB, 2011), where a potential failure of the dam(s) could lead to substantial downstream economic losses, significant environmental and cultural losses, and possible loss of life. In accordance with CDA Dam Safety Guidelines and the BC Dam Safety Regulation, owners of Extreme consequence dams are required to have an Emergency Preparedness Plan (EPP) in place. The EPP is typically developed based on the results of a dam breach and inundation study, the main purpose of which is to:

- Provide a quantitative simulation of the dam failure mode(s), such as changes in geometrical characteristics of the breach over time.
- Provide a quantitative simulation of the time history of the outflow through the breached section.
- Provide a flow routing simulation of the outflow hydrograph through the downstream valley, to identify changes to the flow hydrograph due to valley storage and frictional resistance, to estimate water surface elevation (stage) hydrographs that could be expected at key locations, to estimate the time of travel of the peak flow, and to estimate the time required for the flows to spill over the banks at key downstream sites. The flow routing usually extends

downstream to a point where the water level rise does not have an impact on infrastructure or public safety.

This dam breach and inundation study forms part of a study to update the EPP for the Gibraltar Mine TSF, which was prepared by KCB in 2010 and submitted to the Ministry of Energy, Mines and Natural Gas (MEMNG).

I-1.2 Methodology

In August 2012, Gibraltar Mine completed a long-term deposition plan for the TSF (KCB, 2012). Cyclone sand deposition will be restarted in order to maximize the storage capacity of the existing tailings facility. The facility currently stores approximately 380 million tons of dry tailings. The proposed mine plan requires the tailings facility to store an additional 455 million tons of dry tailings from 2012 to 2027, the anticipated end of the mine's operational life.

The long-term deposition plan will result in continual changes to the TSF configuration, and the geometry of both the Main Dam and the East Saddle Dam. The supernatant (free water) pond elevation is predicted to rise by 55.9 ft (17.0 m) to the ultimate pond elevation of 3,614.7 ft (1101.8 m) from 2012 to 2027. The East Saddle Dam will be raised in accordance with the predicted pond elevation increases. At the Main Dam, a tailings stack will be constructed on top of the existing tailings beach. This will enable tailings to be spigotted onto the top of the TSF over the coming years, to an estimated maximum elevation of 3,740 ft (1,140.0 m) in 2027.

The free water pond will continue to be retained by the East Saddle Dam through the remaining life of the mine. The East Saddle Dam will be raised annually to maintain a minimum freeboard of 5 ft (1.5 m) above the flood level, except for the final year of operation (2027). A closure spillway with the capacity to pass a 24-hr Probable Maximum Flood (PMF) event will be installed prior to 2027. The step-back embankment near the Main Dam and the North Earthfill Dam are expected to maintain the minimum freeboard of 10 ft (3.0 m) into post-closure. Therefore, there will be no overtopping mechanism possible for the Main Dam. As such, a conventional dam break analysis was used to study the hypothetical failure of the East Saddle Dam only. The HEC-RAS hydrodynamic model was used to simulate the breach for the East Saddle Dam and the resulting inundation of downstream areas.

With the planned tailings deposition, the western edge of the free water pond will progressively move eastwards, further away from the Main Dam and the North Earthfill Dam. By the estimated end of the TSF's operational life, in 2027, the western edge of the free water pond is expected to be more than 3 km away from the Main Dam and more than 1.5 km away from the eastern end of the North Earthfill Dam. The tailings underflow stack, which will be located between the Main and North Earthfill Dams and the tailings pond, will be more than 30 m higher than the pond top water level. In the absence of an overtopping failure mechanism for the Main Dam and the North Earthfill Dam, a liquefaction flowslide induced by an extreme earthquake is considered to be the worst case scenario for dam stability. Such an event would cause a slump of the outer dam slope but the extent of a tailings flowslide runout will be restricted by the unsaturated outer cyclone sand dam which is not capable of flow liquefaction.

In late 2012, raises to the East Saddle Dam and Main Dam were undertaken, giving a configuration that will be maintained until September 2013. The East Saddle Dam 2012 -2013 configuration was taken to represent the current conditions in this dam breach and inundation assessment, and the projected 2027 configuration taken to represent the end of mine life condition. The configurations are based on the long-term deposition plan (KCB, 2012). In both cases, two hypothetical modes of dam failure (i.e., overtopping and piping) were considered for the East Saddle Dam.

The ultimate configuration of the Main Dam was used for a run-out assessment due to full liquefaction of the tailings beach and saturated foundation of the cycloned sand Main Dam.

According to assessments undertaken as part of the long-term deposition plan, the facility is designed to store the 30 day PMF, which is comprised of the 30 day Probable Maximum Rainfall (709 mm) in combination with a 100 year return snowmelt (294 mm water equivalent). The design freeboard values above the flood storage level are 5 ft (1.5 m) for earthfill dams and 10 ft (3.0 m) for sand dams. This freeboard accounts for wind-induced waves, and settlement. Therefore, the likelihood of the East Saddle Dam being overtopped is small. A piping failure of the dam is also unlikely because the dam has operated at approximately the current full supply level for a number of years and routine inspection and monitoring of the dam have not indicated any problems to date.

I-1.3 Organization of Appendix

Section I-1 of the appendix provides introductory information for the dam breach and inundation study. Section I-2 describes the tailings impoundment and the areas downstream of the two dams. The conventional dam breach and inundation study for the East Saddle Dam is presented in Section I-3, and the assessment of tailings flow from the Main Dam is presented in Section I-4. And finally, the conclusions and recommendations for the study are presented in Section I-5.

I-1.4 Units

Historically, the Gibraltar Mine has employed Imperial units for dimensions and elevations. Topographic data covering the study area is available in Metric units. Both Imperial and Metric units are used in relation to the East Saddle Dam design dimensions, while Metric units are used to present the East Saddle Dam breach and inundation results.

I-1.5 Limitations of Report

The methods of analyses and computer simulation models used for the study, as described in this report, involve simplified assumptions in both the method of solution and preparation of input data. Because it is not possible to predict accurately the mode and development of a dam breach and because of the uncertainty of the associated initial hydrologic conditions, this study is based on assumptions that are believed to be conservative. However in the unlikely event of a dam breach, actual conditions and hence the subsequent flooding could differ from that indicated by this study. The results presented herein are, nevertheless, considered to be adequate for use in emergency planning.

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Gibraltar Mines Ltd (Client) for the specific application to the Tailings Storage Facility. 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.

I-2 THE TAILINGS IMPOUNDMENT AND THE STUDY AREA

I-2.1 The Tailings Storage Facility

I-2.1.1 The Impoundment

The location of Gibraltar Mine and the TSF are shown in Figure I-1 and Figure I-2. Access to the mine site is by way of an 18 km paved road that joins Highway 97 near McLeese Lake. The TSF is retained by the Main Tailings Dam on the west side of the impoundment and the East Saddle Dam on the east side as shown in Figure I-3.

The TSF currently stores approximately 380 million tons of dry tailings. The proposed mine's long term deposition plan is to store an additional 455 million tons of dry tailings from 2012 to 2027. The re-designed facility will include a step-back embankment constructed along the Cyclone Sand Dam and North Earthfill Dam, using compacted whole tailings. The East Saddle Dam will be raised with till and bulk fill using the downstream centerline method. The supernatant (free) water pond will continue to be located at the east end of the tailings impoundment and retained by the East Saddle Dam. Additional relevant details of the two dams are presented in the following sections.

I-2.1.2 East Saddle Dam

The East Saddle Dam consists of a compacted till embankment, with a 3H:1V upstream slope and a 2.5H:1V downstream slope. The upstream slope is protected against erosion by a 2 ft (0.6 m) thick riprap layer underlain by a granular filter. The dam has a low point in the foundation located at an estimated El. 3,485 ft (1062.2 m). Part of the north abutment of the dam is founded on exposed bedrock. The dam is located at a natural saddle at El. 3,490 ft (1063.8 m). Over time, the dam has been constructed and raised in stages by the downstream construction method. Bedrock exists at shallow depth (approximately 5 ft (1.5 m)) below the prepared dam foundation surface at mid-valley and at the south abutment

The dam break assessment considers the current situation, and the end of the mine's operational life. Figure I-4 is a section through the TSF showing both the Current (2012 - 2013) and End of Mine Life (2027) configurations. A dam raise is planned towards the end of 2012, to give a dam configuration that will be in place at least up to September 2013. This will include the raising the dam from El. 3,570 ft (1088.1 m) to El. 3,572.2 ft (1088.8 m) with till and random fill. The planned September 2013 configuration was used to represent the current conditions in this dam break assessment. This is shown on Figure I-5.

Based on the proposed long term deposition plan (KCB, 2012), a number of subsequent dam raises will be carried out to raise the existing dam crest to an ultimate crest El. 3,630 ft (1106.4 m). The ongoing raise of the East Saddle Dam will follow the existing downstream construction method. Figure I-6 shows the section of the proposed End of Mine Life (2027) configuration of the East Saddle Dam.

I-2.1.3 The Main Tailings Dam

The tailings impoundment was commissioned in 1972 by construction of a 100 ft high starter dam of compacted glacial till across the outlet of the East Cuisson Creek valley. Subsequent dam raising with cycloned sand was performed using the centreline method of construction. Tailings underflow from on-dam cyclones located across the crest of the Cycloned Sand Dam was deposited directly onto the centreline and downstream slope of the dam, up until the temporary mine closure in December 1998. The cyclone underflow consisted of relatively free draining sand with fines contents historically ranging between 7% and 13%. No mechanical compaction was applied to the cycloned sand deposited on the slope of the dam. The cyclone overflow and "bleed" from the end of the tailings line were discharged onto the tailings beach upstream of the dam centreline.

Dam construction was typically carried out from March to November each year. During the winter months, unclassified whole tailings were discharged from a point near the south abutment of the tailings dam onto the upstream tailings beach. The historical rate of rise of the dam crest was about 8 ft/year with the cyclones making one complete pass along the dam crest every 4 years. The average rate of pond level rise in the 1990's prior to temporary closure was 4 ft/year to 5 ft/year. Cycloned sand production stopped in December 1998.

After the mine was re-opened in October 2004, whole tailings were discharged primarily from the south abutment. For most of 2008, tailings were discharged from the northern portion of the dam crest. The dam was raised using compacted cycloned sand borrowed from higher crest elevation locations towards the south.

The configuration of the tailings facility shown in Figure I-3 is based on an aerial photography survey in July 2008 and a survey done in 2011. The Cycloned Sand Dam was raised in 2010 and 2012, and is currently at an elevation of 3,575 ft. At the centre of the pre-existing creek valley, the maximum height of the dam is roughly 350 ft.

A network of finger drains was constructed beneath the exterior Cycloned Sand Dam shell. The finger drains consist of coarse mine waste rock fill covered by graded sand and gravel filter material.

Future development of the dam includes the following:

- Raise the Cyclone Sand Dam to El. 3,587 ft and the North Earthfill Dam to El. 3,581 ft. This provides security during initial development of the Step-Back Embankment.
- The set-back embankment is constructed with underflow tailings. The key elements of the embankment are the overall downstream slope angle, the freeboard for flood management, and the set-back of the tailings pond from the crest of the embankment.

- The maximum allowable downstream slopes are 10% along the west portion of the embankment 4% along the north portion of the embankment.
- The total storage heights (flood storage above operating pond level plus freeboard) range between 17.4 ft to 26.7 ft over the life-of-mine.
- The minimum set-back of the pond from the embankment crest is 1,500 ft.
- The toe of the embankment is located a minimum 500 ft from the Cycloned Sand Dam crest, and minimum 200 ft from the North Earthfill Dam crest.

I-2.1.4 Tailings Pond Water Levels and Volumes

I-2.1.4.1 Free water pond levels and volumes

According to the long term deposition plan, the TSF will be operated such that the aerial footprint of the free water pond is progressively reduced. The beach from the tailings underflow stack deposition will advance eastwards with time, towards the East Saddle Dam. Figure I-7 shows the predicted pond elevation and freewater pond volume from 2012 to 2027. The tailings pond elevation is predicted to rise by 55.9 ft (17.0 m) to the ultimate pond elevation of 3,614.7 ft (1101.8 m) from 2012 to 2027, while the freewater pond volume is predicted to decrease by 68 Mm^3 during the same period. The tailings pond elevation is predicted to increase at an average rate of 4.7 ft (1.4 m) per year from 2013 to 2016, and increase at an average rate of 3.4 ft (1.0 m) per year from 2017 to 2027.

I-2.1.4.2 Potential tailings release with dam breach flows

As shown on Figure I-3, a plan of the existing TSF, the tailings beach is at least 2.5 km from the East Saddle Dam. Figure I-4 shows the profile of the assumed tailings beach, at a slope of 5%. The angle of repose following failure of tailings impoundments is assumed to be in the order of 5° (about 9%), based on a tailings dam failure flow study by Lucia (1981), which listed final observed angles for various types of tailings inside and outside tailings impoundments. For release of tailings to occur, the tailings failure surface at the angle of repose should intercept the dam at above its failure elevation. Taking into account the current assumed overflow tailings beach slope of 5%, the distance from the overflow tailings deposit to the East Saddle Dam, and that the tailings beach surface is lower than the minimum likely failure surface sloped at 5% from the East Saddle Dam, it is considered that release of the bulk of the underflow tailings would not occur if the East Saddle Dam failed. However, some tailings might be mobilized and carried with the water as the water is released from the pond.

In the 2027 configuration, it is estimated the supernatant will form a relatively shallow pond, about 15 m deep. The free water will be underlain by overflow tailings from the cyclone tailings deposition. This is expected to be largely a solids-liquid suspension with some variably consolidated tailings. In this study, KCB has assumed that all the overflow tailings underneath the free water will be released with the free water in the event of a breach of the East Saddle Dam.

In the long term deposition plan (KCB, 2012), the Muck3D tailings deposition software was used to estimate the stage-storage relationship for the free water through the remaining life of the mine. For the 2027 case, an additional assessment, using Muck3D, was carried out to estimate the volume that will be occupied by the free water pond and cyclone overflow tailings.

The estimated water storage volumes for pond levels above the assumed East Saddle Dam breach bottom elevation of 1062.2 m are shown in Table I-1. Only the volume of water above the breach bottom is included in the table because water stored below the breach level would not be released in the event of a failure of the dam. Figure I-8 shows the stage-storage relationships for the Current (2012 - 2013) and End of Mine Life (2027) situations which have been used in assessing breach outflow rates and volumes, as discussed under Section I-3.2.

Table I-1 Pond Level vs. Pond Water Volume

Water Level		Volume of Water Above Breach Bottom		Comments
ft	m	Acre-ft	million m^3	
3,485	1062.2	0	0	at breach bottom
3,560	1085.3	44,895	55.4	at Current (2012 - 2013) Operating Level
3,572	1088.8	59,700	73.6	at Current (2012 - 2013) Dam Crest
3,610	1100.3	31,690	26.0	at End of Mine Life (2027) Operating Level
3,630	1106.4	39,090	39.1	at End of Mine Life (2027) Dam Crest

Notes:
End of Mine Life (2027) estimates include cyclone overflow tailings.

I-2.2 Areas Downstream of the East Saddle Dam

KCB previously undertook a dam break and inundation assessment for East Saddle Dam in 2005. In the assessment, TRIM and NTS maps, as well as floodplain maps for the City of Quesnel published by the B.C. Ministry of Environment, Lands and Parks (MELP), were used. The tiles of TRIM maps were available in digital format for a part of the study area. The floodplain maps were published by the B.C. MELP, and they show the potential inundation areas for the 20-year and the 200-year floods in the City of Quesnel (MELP, 1992).

For this study, carried out in 2012, TRIM data in digital format was obtained for those areas not previously covered by the digital TRIM data to complement the data above.

A plan showing the study area is presented in Figure I-9. The East Saddle Dam is located on Arbuthnot Creek. A release from the dam would flow along Arbuthnot Creek, Beedy Creek, Beaver Creek, and Quesnel River, and eventually enter the Fraser River at the City of Quesnel. There is also a low divide along Arbuthnot Creek, approximately 6.5 km downstream of the dam, where water may overflow to the south towards the headwaters of Fredy Creek if the water level rises high enough. This overflow would flow along Fredy Creek, Beedy Creek, and then rejoin the main flow at the confluence of the Arbuthnot and Beedy Creeks. The flow route along Fredy and Beedy Creeks includes several small lakes. The estimated distances along the main flow path from the East Saddle Dam are as follows:

- East Saddle Dam to Arbuthnot Creek / Beedy Creek confluence 18 km
- East Saddle Dam to Beaver Creek / Quesnel River confluence 33 km

- East Saddle Dam to Quesnel River / Fraser River confluence 91 km

KCB has previously carried out a ground and air reconnaissance of the areas downstream of the East Saddle Dam. This was conducted on 12 and 13 October, 2004, respectively, as part of the dam break inundation study completed in 2005. The observations made during the reconnaissance have been combined with information from available mapping.

The Arbuthnot Creek and Beedy Creek channels downstream of the East Saddle Dam are relatively small. The ground is heavily timbered along the first 7 km of Arbuthnot Creek. The remaining terrain along Arbuthnot, Beedy and Fredy Creeks is somewhat swampy with meandering stream channels. Beaver Creek has a well-defined channel with timbered banks above the bank full level. The Quesnel River has a wide flow channel, typically with sand and gravel banks. Except for the City of Quesnel and Sardine Flats areas, the river banks are generally covered with trees above the bank-full level. The Fraser River is the largest river in the study area. Its banks in the Quesnel area generally consist of sand and gravel, and riprap in some sections.

Figure I-10 shows the major crossing located immediately upstream, and within the City of Quesnel.

I-2.3 Areas Downstream of the Main Tailings Dam

With elimination of an overtopping failure mechanism to release the tailings pond, the downstream influence of a tailings dam flowslide is much more limited. The effects of such a slide (confirmed in Section I-4) would be restricted to the catchment of East Cuisson Creek upstream of its confluence with Cuisson Creek (distance of approximately 4.3 km from the dam toe).

Preliminary review of this downstream area indicates the following infrastructure may be affected:

- seepage collection ditches and pond at the Seepage Recovery Dam located about 0.5 km (1,600 ft) downstream from the toe of the tailings dam;
- seepage Pump House No. 6 with associated pipelines and power supply lines; and,
- miscellaneous access roads and forestry roads.

Gibraltar Mine reports that there are no permanent inhabitants in this area, but it is used to graze cattle on a semi-permanent basis.

I-3 EAST SADDLE DAM BREACH AND INUNDATION ASSESSMENT

I-3.1 Dam Failure Modes

The CDA Dam Safety Guidelines (CDA, 2007) suggest that the following conditions be considered when determining the potential extent of the downstream areas subject to inundation in the event of a dambreak:

- “Sunny day failure” – These are sudden dam failures that result during normal operations and may be caused by earthquake, misoperation of the dam, or other event.
- “Flood induced failures” – These are failures of the dam coincident with a flood of magnitude greater than the dam can safely pass.

Two modes of failure were considered for the East Saddle Dam, namely: piping failure and overtopping failure. A piping failure of a dam is considered to be a “sunny day” failure which is normally assumed to occur when the pond is at its normal operating level. An overtopping failure is considered to be a “rainy day” or “flood induced” failure. Overtopping of dams typically occurs during large flood inflow conditions, where the pond water level rises high enough to overtop the dam.

I-3.2 The HEC-RAS Model

The HEC-RAS hydrodynamic computer model and the HEC-GeoRAS pre-and post-processor developed by the US Army Corps of Engineers were used for this study. HEC-GeoRAS simplifies the model data input and processing of the results. It allows importation of topographic data into the HEC-RAS model, and the HEC-RAS results can be exported to HEC-GeoRAS for production of flood inundation maps using GIS software.

HEC-RAS has a parametric dam breach routine that can calculate a breach outflow hydrograph within an unsteady flow simulation. HEC-RAS can also be used to simultaneously perform flood routing of the hydrograph downstream, to estimate the hydraulic conditions at critical downstream locations.

The HEC-RAS model created for this study includes the TSF, represented by stage-storage relationships for the current situation, and the end of the mine’s operational lifetime. Downstream of the dam the model simulates flow along the creek and river systems, as described under Section I-2.2 and as shown on Figure I-9. The model consists of the Arbuthnot Creek, Fredy Creek, Beaver Creek, Quesnel River and Fraser River as follows:

- Approximately 6.5 km of Arbuthnot Creek, from the East Saddle Dam to a flow split, with some flow continuing along the Arbuthnot Creek to the west, and some flowing onto Fredy Creek to the east.
- About 23 km of Fredy and Beedy Creek, from the flow split to rejoin with the Arbuthnot Creek.

- Approximately 15 km consisting of the Beedy Creek reach downstream of the confluence with Arbuthnot Creek, and Beaver Creek from its confluence with Beedy Creek to the confluence with the Quesnel River.
- Approximately 57 km of the Quesnel River to its confluence with the Fraser River. A reach of the River Quesnel, extending approximately 5km upstream of the confluence with the Beaver Creek was also included.
- About 4 km of the Fraser River downstream of the confluence with the Quesnel River. A reach of the Fraser River, extending approximately 6km upstream of the confluence was included.

I-3.2.1 Topography and Other Physical Features

Topography is input to HEC-RAS via the use of cross-sections drawn across the river or creek. These cross-sections and their spacing along the river determine the geometric and hydraulic parameterization of the numerical model.

The TRIM data was used to set up the HEC-RAS model for the area downstream of the dam. The data was preprocessed in the Geo HEC-RAS package, and a total of 376 cross-sections were sampled across the model domain. Numerous other cross sections were introduced through interpolation, primarily to obtain model numerical stability.

Bridges and other inline structures downstream of the East Saddle Dam were not included in the HEC-RAS flood routing analyses. Based on the 2004 ground and air reconnaissance, the small wooden bridges on local roads downstream of the East Saddle Dam, the Beaver Creek Bridge and the Gravelle Bridge appear to be low enough to be inundated by the flood resulting from a breach at the dam. These bridges and the road embankments will tend to retain a small amount of flood water, if they are not washed out.

The bridges in Quesnel appear to be elevated such that it is less likely they would retain water, or be washed out, particularly as the model results discussed later under Section I-3.3 show that flood flows from a dam failure are significantly attenuated when they reach these locations.

I-3.2.2 Initial and Concurrent Flows in Streams and Rivers

With the current TSF operation, no flows are discharged through the East Saddle Dam into the Arbuthnot Creek. The TSF is designed to store the 30 day PMF, and at closure, a spillway will be constructed. Since the HEC-RAS program cannot simulate a dry flow channel downstream of the dam, a nominal lateral inflow (i.e., a base flow) of 20 m^3/s was artificially provided immediately downstream of the dam to facilitate model simulations. Although this fictitious flow may appear to be high for the stream immediately downstream of the dam, it is very small compared to the flow that would be released due to a dam breach and would have negligible effect on the discharge and water levels downstream of the dam.

The CDA Dam Safety Guidelines (CDA, 2007) state that downstream tributary flow conditions in a dam break inundation assessment should be those most probable to occur coincident with the breach event.

Mean annual flows (MAF) were assumed to be the concurrent flows for the “sunny day” piping failure dam breach and inundation model runs. The streams between the East Saddle Dam and the Quesnel River are relatively small, and concurrent flows in those streams have been assumed to be 20 m^3/s, which is the assumed base flow in the HEC-RAS model.

In the dam failure classification, undertaken in accordance with the CDA Dam Safety Guidelines (CDA, 2007), and based on the results of the 2005 dam break inundation study, the TSF was classified as an “Extreme” consequence facility (KCB, 2011). It is considered likely the facility will remain in the “Extreme” category, as higher breach flows are expected to result from the larger water volume, or East Saddle Dam height, compared to those considered in the 2005 dam break inundation assessment. The Inflow Design Flood for dams with Extreme classification is the Probable Maximum Flood (PMF). The “rainy day” overtopping failure scenarios were therefore run coincident with PMF conditions downstream.

Flows in the Quesnel River were historically measured at stream gauging station 08KH006 (Quesnel River near Quesnel), which is located in the Sardine Flats area approximately 35 km upstream of the confluence of the Quesnel and Fraser Rivers (see Figure I-9). Flows in the Fraser River were measured at gauging station 08KE002 (Fraser River at Quesnel), which is located about 0.5 km upstream of the confluence the Fraser and Quesnel Rivers.

Table I-2 below gives the flow estimates used for the analyses. The MAF and PMF flows were used in the dam breach model runs. The coincident flow was entered into the model as constant flows in all cases.

The 1 in 20 year and 1 in 200 year flood flow estimates were used to compare the predicted flows following a dam break, with the naturally occurring flood flows in the Quesnel and Fraser Rivers.

Although the gauging station on the Quesnel River is about 35 km upstream of the City of Quesnel, the catchment area between the gauging station and the City of Quesnel is only 2% larger than that at the station (MELP, 1992). Therefore, the local inflow between the gauging station and City of Quesnel is considered to be negligible, and the flow estimates for the stream gauging station 08KH006 were used without further adjustment.

Table I-2 Estimated Naturally Occurring Flows in the Rivers

Location	Catchment Area (km^2)	Flow (m^3/s)			
		MAF	20-Year	200-Year	PMF
Beaver Creek u/s of Quesnel River	450	20*	-	20*	965
Quesnel River at Station No. 08KH006 near Quesnel	11050	250	1060	1300	7370
Fraser River at Station No. 08KE002 at Quesnel	97900	1090	5520	6100	29460

Notes:
Mean annual and 200-year flows in Quesnel and Fraser Rivers are based on flow records at Water Survey of Canada hydrometric station nos. 08KH006 and 08KE002, respectively, as assessed in the MELP (1992) study.
The PMF values are based on the Probable Maximum Flood Estimator for British Columbia (AAFC, 2010). The PMF values shown are from the best-fit curve for Zone 12A as defined in the estimator.
*Minimum flow required to run model.

The Dam Safety Guidelines indicate that the term “consequence” refers to the damage above and beyond the damage that would have occurred in the same event or conditions had the dam not failed. These may also be called incremental consequences of failure. To enable assessment of incremental damages, the model was also run for MAF and PMF scenarios but without a dam breach.

I-3.2.3 Dam Breach Parameters

Input parameters for simulating an overtopping dam failure in HEC-RAS include final breach bottom width, final breach bottom elevation, breach side slopes, breach formation time and weir discharge coefficient. The breach formation time is the time required for the breach in the dam to reach its specified final breach width and breach bottom level. Input parameters for simulating a piping failure include the parameters listed for an overtopping failure plus the initial piping elevation and the piping discharge coefficient.

The HEC-RAS User Manual identifies empirical formulae as a suitable approach for estimating the key breach parameters. The empirical formulae were used, as well as selected guidance documents followed. Key guidance used includes the Guidelines for Dam Breach Analysis by the State of Colorado (2010), which presents a relatively up to date literature review of the current state-of-the-practice, and available methods for performing dam breach analyses. The breach formation times for the base case analyses were estimated using Froehlich (2008) equations, as recommended by the Colorado (2010) guidelines. The breach and flood routing parameters selected for the Current (2012 - 2013) and End of Mine Life (2027) base case model runs are presented in Table I-3 below. A number of additional model runs were also completed to test the sensitivity of model results to these parameters. The sensitivity test runs are discussed later, under Section I-3.4 of this report.

Table I-3 Dam Breach Parameters – Base Case

Breach Parameters	Base Case Dam Break Model Runs			
	Current (2012 - 2013)		End of Mine Life (2027)	
Failure mode	Overtopping	Piping	Overtopping	Piping
Dam crest elevation (m)	1088.8	1088.8	1106.4	1106.4
Pond water elevation (m)	1089.11	1085.3	1106.7	1100.3
Final bottom breach width (m)	20	20	20	20
Final bottom breach elevation (m)	1062.3	1062.3	1062.3	1062.3
Left and right breach slopes	1.0H: 1V	0.7H: 1V	1.0H: 1V	0.7H: 1V
Breach weir discharge coefficient	1.7	1.7	1.7	1.7
Breach formation time (hours)	1.8	1.8	1.8	1.8
Piping coefficient of discharge	-	0.7	-	0.7
Initial piping elevation (m)	-	1062.3	-	1062.3
Concurrent flow in river downstream of dam	PMF	MAF	PMF	MAF
Manning’s roughness coefficient, n	0.05	0.05	0.05	0.05

Notes:
MAF: Mean annual flow
PMF: Probable Maximum Flood.

Based on empirical formulae, the breach bottom width would be in the order of 100 m for the dam height and storage capacity at the East Saddle Dam. But, the dam is founded on bedrock and a review of drill hole data indicates that the bedrock geometry would limit the opening to only about 20 m width. The estimated bedrock location, and the assumed breach geometry, are shown in Figure I-11. Since the available breach bottom width is much smaller than the theoretical width, a breach bottom width of 20 m was selected for the dam breach analysis. No sensitivity analysis for the breach dimensions (i.e., breach bottom width and breach bottom elevation) was carried out since the breach size would be restricted by the bedrock under the dam.

I-3.3 Dam Breach and Inundation Analyses Results

I-3.3.1 Piping Failure

The results for the Current (2012 - 2013) and End of Mine Life (2027) Base Case piping failure model runs are shown in Table I-4. The table gives inundation characteristics at selected points along the downstream flood route, showing the estimated peak flood level caused by the release of water at the East Saddle Dam; the estimated MAF water level without a breach; the rise in water level above the MAF water level; the time to reach peak water level from the start of dam breach; and the travel time of the peak from the dam.

Figure I-12 and Figure I-13 show the flood hydrographs at selected points along the flood route, showing how the breach flows are attenuated along the flood path. For the End of Mine Life (2027) Base Case, the peak outflow at the dam is estimated at 10,600 m^3/s. The Current (2012 - 2013) scenario gives a lower peak outflow, about 4800 m^3/s. Results indicate there is limited flow attenuation in the first steep reach of Arbuthnot Creek up to the flow split into Fredy Creek. However, by the time the flood reaches the mouth of the Quesnel River, the peak flow attenuates to approximately 1960 m^3/s for the Current (2012 - 2013) scenario, and 1450 m^3/s for the End of Mine Life (2027). The estimated flood flows in the Quesnel River include the estimated MAF of 250 m^3/s, as indicated on Table I-2. The peak flow with dam breach flows in Quesnel is approximately 1.1 to 1.5 times the river's natural flows from a 1 in 200 year event, the standard to which flood risk management measures are generally designed to in British Columbia. In the Sardine Flats area, the peak flow is estimated at about 10 times the 1 in 200 year flow. Therefore, additional measures, including evacuation, will be required with an onset of flood flows from a breach of the East Saddle Dam.

The combined flow in the Fraser River consisting of the assumed MAF during the dam break, and the attenuated dam break flows discharging from the Quesnel River, is estimated at 3000 m^3/s. This is about 54% of the river's 1 in 20 year flood flows. Therefore, a breach of the East Saddle Dam is expected to have minimal impact on the Fraser River.

Table I-4 shows that while the End of Mine Life (2027) scenario gives higher peak breach flow rates, maximum flood levels towards the downstream extent of the model, including through the City of Quesnel, are higher for the Current (2012 - 2013) scenario. This corresponds to the estimated peak flow rates at the downstream extent, and is considered to be due to the much larger flow volumes in the Current situation, compared to the End of Mine Life situation. The Quesnel River would be more capable of attenuating the lower flow volumes from an End of Mine Life scenario. However, the End of Mine Life (2027) scenario gives quicker peak flood arrival times. The peak of the flood is estimated to reach the Quesnel and Fraser River confluence approximately 10 hours 55 minutes after the peak outflow at the dam in the Current (2012 - 2013) condition, while for the End of Mine Life (2027) scenario, the travel time is 10 hours 30 minutes.

Figure I-14 is map showing the estimated areal flood inundation extent from a piping failure for the study area. Figure I-15 and Figure I-16 show the Sardine Flats and Quesnel areas respectively, at a larger scale.

Table I-4 Inundation Characteristics at Selected Locations – Piping Failure Base Case

Location	Distance d/s of Dam (km)	Estimated Flood Level for MAF only without Dam Breach (m)	Peak flow following a Breach including the MAF (m^3/s)		Peak Flood Level, Breach plus MAF Flows (m)		Estimated Rise in Water Level above MAF (m)		Time to Peak Flood Level from Start of Breach (hr min)		Travel Time of Peak Flood Level from the Dam (hr min)	
			Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)
East Saddle Dam	0	1062.6	4800	10600	1074.3	1079.1	11.7	16.5	1hr 50min	50min	-	-
Arbuthnot Creek at divide with Fredy Creek	6.9	845.5	4700	10100	849.1	850.6	3.6	5.1	2hr 05min	1hr 00min	15min	10min
Fredy Creek upstream of Philemon Lake	8.9	833.1	440	1510	836.5	838.4	3.4	5.3	2hr 35min	1hr 15min	45min	20min
Beedy Creek, d/s of Arbuthnot Creek	18.2	741.4	3540	5340	747.8	749.1	6.4	7.7	2hr 55min	1hr 45min	1hr 05min	1hr 00min
Quesnel River at confluence with Beaver Creek	32.3	577.1	3550	4450	581.2	581.9	4.0	4.7	3hr 55min	2hr 40min	2hr 05min	1hr 55min
Quesnel River at Gravelle Bridge, Sardine Flats	52.2	541.3	2740	2380	544.4	544.2	3.1	2.9	6hr 30min	5hr 10min	4hr 40min	4hr 20min
Quesnel River at pipeline crossing u/s of City of Quesnel	82.2	484.8	2080	1570	488.9	488.1	4.1	3.3	11hr 10min	9hr 50min	9hr 20min	9hr 00min
City of Quesnel (Railway Bridge u/s of Highway 97)	87.5	476.7	2080	1550	479.5	478.8	2.7	2.1	11hr 30min	10hr 20min	9hr 40min	9hr 30min
Quesnel and Fraser River confluence	90.2	473.4	1960	1450	475.4	474.8	2.0	1.4	12hr 45min	11hr 20min	10hr 55min	10hr 30min
Fraser River, 4km downstream of confluence	94.7	470.7	3000	2470	472.5	472.1	1.8	1.3	13hr 10min	11hr 45min	11hr 20min	10hr 55min

I-3.3.2 Overtopping Failure

Table I-5 shows the results for the Current (2012 - 2013) and End of Mine Life (2027) Base Case overtopping failure model runs. The estimated peak flood level caused by the release of water at the East Saddle Dam; the estimated PMF water level without a breach; the rise in water level above the PMF water level; the time to reach peak water level from the start of dam breach; and the travel time of the peak from the dam, are given for selected points along the downstream flood route.

For the End of Mine Life (2027) Base Case, the peak outflow at the dam resulting from an overtopping failure is estimated at 16200 m^3/s, while for the Current (2012 - 2013) scenario, it is estimated at 7900 m^3/s. Figure I-17 and Figure I-18 show the flood hydrographs at selected points along the flood route. For the overtopping scenarios, failure is assumed to be coincident with relatively large PMF flows downstream. The PMF values are based on the Probable Maximum Flood Estimator for British Columbia (AAFC, 2010). As shown on Table I-5, combined flows as high as 13,400 m^3/s for the Current (2012 - 2013) and 14,500 m^3/s for the End of Mine Life (2027) are estimated where the dam breach flows enter the Quesnel River. By the time the flood reaches the mouth of the Quesnel River, the peak flow attenuates to approximately 10,500 m^3/s and 9800 m^3/s, respectively. The overtopping scenarios are assessed concurrent with PMF flows, which would cause extensive flood damage on their own, without a dam breach.

Table I-4 and Table I-5 indicate that the incremental flood depths are expected to be lower in the overtopping case coincident with PMF, compared to the 'sunny day' piping failure case discussed under Section I-3.3.1 above.

Again in this case, although the End of Mine Life (2027) scenario gives higher peak breach flow rates, maximum flood levels towards the downstream extent of the model, including through the City of Quesnel, are higher for the Current (2012 - 2013) scenario.

The peak of the flood is estimated to reach the Quesnel and Fraser River confluence about 9 hours 35 minutes after the peak outflow at the dam in the Current (2012 - 2013) condition, 7 hours 15 minutes in the End of Mine Life (2027) scenario.

The estimated areal flood inundation extent from the dam to the overtopping failure is shown on Figure I-19. Inundation Extents for the Sardine Flats and City of Quesnel areas at a larger scale are presented in Figures I-20 and I-21 respectively.

Table I-5 Inundation Characteristics at Selected Locations – Overtopping Failure Base Case

Location	Distance d/s of Dam (km)	Estimated Flood Level for PMF only without Dam Breach (m)	Peak Flow following a Breach including the PMF (m^3/s)		Peak Flood Level, Breach plus PMF Flows (m)		Estimated Rise in Water Level above PMF (m)		Time to Peak Flood Level from Start of Breach (hr min)		Travel Time of Peak Flood Level from the Dam (hr min)	
			Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)	Current (2012 - 2013)	End of Mine Life (2027)
East Saddle Dam	0	1062.6	7900	16200	1077.2	1082.5	14.7	20.0	1hr 50min	50min	-	-
Arbuthnot Creek at divide with Fredy Creek	6.9	845.5	7800	16200	850.1	851.9	4.6	6.4	2hr 00min	55min	15min	10min
Fredy Creek upstream of Philemon Lake	8.9	833.1	1180	3770	838.0	840.7	4.9	7.6	2hr 20min	1hr 10min	35min	20min
Beedy Creek, d/s of Arbuthnot Creek	18.2	741.4	5440	7700	749.1	750.4	7.8	9.0	2hr 45min	1hr 40min	1hr 00min	50min
Quesnel River at confluence with Beaver Creek	32.3	584.7	13400	14500	587.6	588.2	2.8	3.5	3hr 45min	2hr 30min	2hr 00min	1hr 40min
Quesnel River at Gravelle Bridge, Sardine Flats	52.2	547.8	11000	10600	549.8	549.5	2.0	1.6	5hr 45min	4hr 40min	4hr 00min	3hr 50min
Quesnel River at pipeline crossing u/s of City of Quesnel	82.2	496.3	10700	10100	497.7	497.3	1.4	1.0	10hr 05min	7hr 05min	8hr 20min	6hr 20min
City of Quesnel (Railway Bridge u/s of Highway 97)	87.5	494.5	10500	9800	495.6	495.2	1.1	0.8	10hr 50min	8hr 00min	9hr 05min	7hr 10min
Quesnel and Fraser River confluence	90.2	494.4	10500	9800	495.4	495.1	1.1	0.7	11hr 20min	8hr 05min	9hr 35min	7hr 15min
Fraser River, 4km downstream of confluence	94.7	490.4	39950	39300	491.5	491.1	1.1	0.7	11hr 35min	8hr 10min	9hr 50min	7hr 20min

I-3.3.3 Comparison of Breach Outflow Results to Case History Derived Relations

A number of empirical relationships relating dam size, stored volume, and breach type have been developed by others based on review of failure case history data. The empirical relationships were derived, almost exclusively, from water retaining dam failures. Figure I-22 presents a comparison of the peak breach flow estimates from the HEC-RAS assessment, with the empirical relations from Costa (1985) and Froehlich (1995).

As can be seen on Figure I-22, the empirical relationships show significant scatter. However, the peak outflow estimates from the HEC RAS assessment lie reasonably close to the trendlines representing the derived empirical relationships. Accordingly, the HEC-RAS breach outflow estimates are judged to be reasonable, based on comparison with these empirically-derived relationships.

I-3.3.4 Comparison of Flow Routing Results with City of Quesnel Flood Mapping

Floodplain maps, showing the potential inundation areas for the 1 in 20 year and the 1 in 200 year floods in the City of Quesnel were obtained. The floodplain maps were published by the B.C. MELP, and background information on the floodplain mapping may be found in the Design Brief (MELP, 1992) which originally accompanied the maps.

KCB has compared the MELP floodplain maps with the model run for the scenario with 1 in 200 flows in the Quesnel and Fraser Rivers, but without a dam breach. Detailed comparison or calibration with the MELP mapping is largely limited by the fact that the topographic data in this HEC-RAS model and in the MELP study have different resolutions. Additionally, river cross sections for the MELP study included bathymetric survey data, which was not be available for HEC-RAS model study reach. However, an overlay of the 2 floodplain extents was prepared, for comparison purposes. This is shown on Figure I-23. The flood extents closely match, with the HEC-RAS extent generally slightly wider. Thus, although detailed calibration of the HEC-RAS model could not be undertaken, it is considered that the predicted flood extents and estimated incremental flood impacts are sufficiently representative.

I-3.4 Model Sensitivity Analyses

I-3.4.1 Sensitivity Model Run Scenarios

The model results, discussed under Section I-3.3, indicate that the Current (2012 - 2013) condition would result in higher flood levels in the main populated areas of Sardine Flats and City of Quesnel downstream, compared to the End of Mine Life (2027) condition. Incremental impact, in terms of water level rise, would be higher with a piping failure compared to an overtopping failure. The Current (2012 - 2013) piping failure scenario was therefore selected for sensitivity testing. Table I-6 shows the main breach and flood flow routing parameters used in the sensitivity test runs.

Table I-6 Dam Breach Parameters – Sensitivity Runs, Current (2012 - 2013)

Breach Parameters	Base Case	Sensitivity Runs				
		Shorter Breach Formation Time	Longer Breach Formation Time	Higher Manning's 'n'	Lower Manning's 'n'	Flatter Breach Side Slopes
Failure mode	piping	piping	piping	piping	piping	piping
Dam crest elevation (m)	1088.8	1088.8	1088.8	1088.8	1088.8	1088.8
Pond water elevation (m)	1085.3	1085.3	1085.3	1085.3	1085.3	1085.3
Final bottom breach width (m)	20	20	20	20	20	20
Final bottom breach elevation (m)	1062.3	1062.3	1062.3	1062.3	1062.3	1062.3
Left and right breach slopes	0.7H: 1V	0.7H: 1V	0.7H: 1V	0.7H: 1V	0.7H: 1V	1.0H: 1V
Breach weir discharge coefficient	1.7	1.7	1.7	1.7	1.7	1.7
Breach formation time (hours)	1.8	1.5	2.0	1.8	1.8	1.8
Piping coefficient of discharge	0.7	0.7	0.7	0.7	0.7	0.7
Initial piping elevation (m)	1062.3	1062.3	1062.3	1062.3	1062.3	1062.3
Concurrent flow in Quesnel and Fraser River	MAF	MAF	MAF	MAF	MAF	MAF
Manning's roughness coefficient, n	0.05	0.05	0.05	0.06	0.04	0.05

Notes:
MAF: Mean annual flow
PMF: Probable Maximum Flood.

I-3.4.2 Sensitivity Model Run Results

A summary of the results from the sensitivity tests carried out is presented in Table I-7. To give an indication of the sensitivity of the predictions at Quesnel, where impact to people and property would be highest in the event of a dam failure, a location immediately upstream was selected for analysis. The table shows the peak breach outflow variation, and the variation in peak flow, peak flood level, and peak flood travel time at the pipeline crossing just upstream of the City of Quesnel.

Results from the sensitivity tests indicate that, overall, there is negligible impact on flood levels in the Quesnel area. Manning's 'n' variation gives small corresponding variations in flood levels.

As shown in Table I-7, peak flood travel time for locations as far downstream as Quesnel could also be sensitive to the Manning's 'n' roughness coefficient, with a lower Manning's 'n' giving quicker flood peak arrival times. However, based on guidance such as the HEC-RAS Reference Manual Table 3.1, the Manning's 'n' value of 0.05 that was used is considered representative. The reconnaissance visit previously undertaken by KCB indicated that the ground is heavily timbered along the first 7 km of Arbuthnot Creek, and that further downstream, Beaver Creek, has timbered banks above the bank full level, and except for the City of Quesnel and Sardine Flats areas, the Quesnel River banks are generally covered with trees above the bank-full level. The observed bank conditions indicate a Manning's 'n' value less than the 0.05 used is unlikely to be applicable.

Table I-7 Summary of Sensitivity Analysis – Current (2012 - 2013) Piping Failure

Model run	Peak Breach Flow at Dam		Inundation Characteristics at Pipeline Crossing Approximately at the Start of the City of Quesnel				
	Peak flow (m^3/s)	Difference Compared to Base Case (m^3/s)	Peak Flow (m^3/s)	Peak Flood Level (m)	Difference in Estimated Peak Water Level (m)	Time to Peak Flood Level from Start of Breach (hr min)	Difference in Travel Time of Peak Flood Level from the Dam (hr min)
Base Case	4800	-	2080	488.9	0.0	11hr 10min	-
Shorter Breach Formation Time	5060	+260 (5%)	2080	488.9	0.0	11hr 00min	-10min
Longer Breach Formation Time	4690	-110 (-2%)	2080	488.9	0.0	11hr 20min	+10min
Lower Manning's 'n'	4740	-60 (-1%)	2290	488.6	-0.3	9hr 45min	-1hr 25min
Higher Manning's 'n'	4770	-30 (-1%)	1910	489.1	0.3	12hr 35min	+1hr 25min
Flatter side slopes	4320	-480 (-10%)	2160	489.0	0.1	12hr 00min	+50min

I-3.5 Model Limitations

There are numerous uncertainties inherent in dam break modelling and routing of extreme floods caused by a dam break. Some of these are:

- Dam breach parameters – The dam breach parameters, such as breach formation time, and breach depth, width and side slopes, are usually selected based on historical data and require a fair amount of judgment.
- Tailings dam vs. earthfill dams – Most methodologies were developed based on a sample of breached water-retaining dams for which the dam geometry could be reasonably defined. Tailings dams, however, often exhibit a poorly defined upstream face with uncertain structural characteristics.
- Lack of calibration of model – Measured water level versus discharge data from a streamflow station is required to calibrate the model. Such data is often not available and, even if it is available, the data would cover only the range of flows recorded during the life of the station and not the extreme flood flows expected due to a dam break. Therefore, the model cannot be calibrated for extreme flood flows.
- Roughness coefficients – Since the model cannot be calibrated, values of the Manning's roughness coefficient cannot be determined with certainty. Usually a best estimate of the roughness coefficient is used and a sensitivity analysis with various roughness values is carried out.

Additionally, the HEC-RAS model constructed for this study utilized TRIM data, which has a vertical accuracy of +/- 10m. There are therefore associated limitations in the accuracy of the predicted flood levels, and the mapped inundation extents.

Given the above uncertainties, the flood inundation limits produced from dam break and inundation modelling should be regarded as approximate and this limitation should be kept in mind in the development and execution of emergency planning procedures.

I-3.6 Flood Inundation Details Recommended for EPP

To assist in emergency response planning, key flood inundation characteristics at selected locations downstream of the dam are also presented as Figure I-24 for piping failure, and Figure I-25 for overtopping failure. From assessment of TRIM data and the information gathered in the 2004 ground and air reconnaissance, buildings and key infrastructure was identified at these locations. It should be noted that other locations of property and key infrastructure may be present, and are not shown.

As shown on Table I-4 and Table I-5, while the End of Mine Life (2027) scenario gives higher peak breach flow rates, maximum flood levels towards the downstream extent of the model, including through the City of Quesnel, are higher for the Current (2012 - 2013) scenario. Flood arrival times are quicker for the End of Mine Life (2027) scenario. The details on Figure I-24 and Figure I-25 are for the larger inundation extent at each location and the quicker End of Mine Life (2027) scenario flood arrival times, to give the more critical considerations for each of the failure cases.

I-4 MAIN DAM TAILINGS RUNOUT ASSESSMENT

I-4.1 General

This section estimates the deformations of the Main Tailings Dam in the event of earthquake induced liquefaction of both the upstream tailings beach and the zone of saturation at the base of the cyclone sand dam. In the absence of an overtopping failure mechanism, a liquefaction flowslide is considered to be the worst case scenario for dam stability. The deformations of the dam can be used to evaluate the potential consequences of a berm failure in terms of physical damage and environmental impact.

At the time of this analysis, the Gibraltar Main Dam crest, at the area of interest, was at an elevation of approximately 3,577 ft, or a dam height of approximately 350 ft.

A run-out assessment is not needed for the North Earthfill Dam, located at the north end of the Main Dam because it is constructed with compacted till, and not susceptible to liquefaction.

I-4.2 Conditions and Method for the Run-Out Assessment

I-4.2.1 Stability Analyses According to CDA Guidelines

Stability analyses presented in KCB (2012) and KCB (2008) confirmed that this dam would be stable in the event of the Maximum Considered Earthquake (MCE). The geotechnical parameters used for the stability analyses were developed from site investigation programs and laboratory testing summarized in Klohn Crippen (1996) and KCB (2012), and are presented as follows:

- The base of the Cycloned Sand Dam consists of a saturated layer approx. 10 ft thick.
- The cycloned sand has a friction angle of 36 degrees.
- An Ru value of 0.5 was applied to the saturated cycloned sand.
- The tailings beach had a strength of $Sr/\sigma_{vo}' = 0.1$.

I-4.2.2 2005 Run-Out Assessment

Since the dam would be stable in the event of the MCE, hypothetical geotechnical conditions beyond the requirements of CDA guidelines are needed to conduct the run-out assessment.

Previously, KCB estimated the run-out from the Gibraltar Main Dam through application of the empirical method presented by Lucia et al. (1981), and compared the results to case histories (Klohn Crippen, 2005). The method from Lucia et al. (1981) assumes that all tailings in the impoundment liquefy and flow and is strictly applicable only to upstream constructed impoundments with high phreatic levels and no outer compacted shell or berm.

The Klohn Crippen (2005) assessment assumed the following conditions:

- The liquefied tailings beach and the saturated zone at the base the Cycloned Sand Dam become fully liquefied.
- The liquefied tailings had a residual strength of $Sr/\sigma vo' = 0.10$.

- The saturated zone at the base of the Cycloned Sand Dam had a residual strength of $S_r/\sigma_{vo}' = 0.15$.
- The maximum dam height was 300 ft.

The results of the analyses are as follows:

- The equilibrium slope was 6.5H:1V.
- The runout was calculated to be 1,900 ft.
- The backscarp of the runout was 630 ft.

I-4.2.3 2012 Run-Out Assessment

The software DAN-W (O. Hungr Geotechnical Research, 2010) was used for the current run-out assessment. DAN-W is a 2-D analysis developed by Professor O. Hungr of the University of British Columbia. The theoretical basis of the software was originally presented in Hungr (1995), and has been updated and refined significantly since then.

The dam cross-section used in the assessment is for the ultimate tailings facility at year 2027 (see Figure I-27). The Cyclone Sand Dam height would be 360 ft high, and a stack of underflow tailings would be developed on the tailings beach offset 500 ft from the Cycloned Sand Dam. The underflow tailings stack on top of the tailings beach would have an ultimate height of 170 ft.

For the 2-D section, a model sliding surface was input into the DAN-W model for run-out analysis. This sliding surface was based on the minimum factor-of-safety (FS) surface calculated for Dam Section B, as presented in KCB 2012 Long-Term Tailings Deposition Plan (KCB, 2012) for the Post-Earthquake Condition. The FS against failure calculated for this surface through use of the Slope/W (Geo-Slope International, 2012), as presented in KCB (2012) was 1.2.

The geotechnical conditions used for the assessment are as follows:

- The cyclone sand and tailings had an internal friction angle of 32 degrees.
- The sliding mass had a unit weight of 19.3 kN/m^3.
- The basal friction angle represented the strength of the contact between the tailings mass and the underlying foundation. The basal friction angles considered were 8.5°, 5.7° and 3.4°, which corresponded to S_r/σ_{vo}' values of 0.15, 0.10, and 0.06, respectively. As the latest build of DAN-W does not allow for the input of strength ratios in this format, the equivalent friction angle was used.

I-4.3 Results of the 2012 Run-Out Assessment

The three scenarios assessed are as follows:

- Scenario 1 – This case represents an upper-bound liquefied basal strength, based on the estimated Post-Earthquake strengths presented in the 2005 Inundation Study Report (KCB). In that report, a generalized ratio between residual strength and effective stress was found to be approximately $Sr/\sigma_{vo}' = 0.15$, based on correlations to SPT-blow counts.

- Scenario 2 – This case represents a lower-bound liquefied basal strength, based on the estimated Post-Earthquake strengths ($Sr/\sigma_{vo}' = 0.10$) for the existing tailings beach presented in the 2012 Long-Term Deposition Plan (KCB) for "Existing Tailings – Section B". Note that this tailings beach value was applied to the entire Cyclone Sand Dam foundation.
- Scenario 3 – This case represents an extreme lower-bound liquefied basal strength ($Sr/\sigma_{vo}' = 0.06$), which was based on the weakest tailings area near the North Earthfill Dam presented in the 2012 Long-Term Deposition Plan (KCB) for "Existing Tailings – Section D". Note that this strength value was taken from an area 6,000 ft away from the dam cross-section used in the model.

A summary of the results of the three scenarios is presented in the following table, and in Figure I-26.

Table I-8 Cycloned Sand Dam 2-D Run-Out Analysis Results

Run-out Scenario	Condition	Model Strength Parameters φ	Equivalent S_r/σ_{vo}'	Runout Distance, L	Equilibrium Slope
1	"Upper Bound"	8.5^o	0.15	90 ft	2.7H:1V
2	"Lower Bound"	5.7^o	0.10	390 ft	4.0H:1V
3	"Extreme Lower Bound"	3.4^o	0.06	1,150 ft	8H:1V

The run-out of the Main Dam for the assumed "Upper Bound" basal friction angle is quite short, with the leading edge of the dam moving a total of 90 ft down slope, and the equilibrium slope angle not significantly changing from the initial condition, flattening from approximately 2.3H:1V to 2.7H:1V.

Similar to run-out Scenario 1, the run-out distance for the "Lower Bound" Scenario 2 is relatively short, with the leading edge of the dam moving a total of 390 ft down slope. The equilibrium slope angle is observed to flatten to approximately 4.0H:1V.

The third run-out scenario had a leading edge of the dam moving a total distance of 1,150 ft down slope, and the slope angle is observed to flatten to approximately 8H:1V.

The runout assessment provides support to previous stability analyses conducted in KCB (2008) and KCB (2012) showing that minimal movement would occur as a result of a MCE. The results of the upper bound case, which are based on conditions worse than the MCE, indicate a run-out of only 90 ft. This would affect the access road located at the toe of the tailings dam.

The lower bound case indicates a run-out of approximately 390 ft. This run-out would affect several access roads located downstream of the tailings dam.

The extreme lower bound indicates a run-out of approximately 1,150 ft. This run-out would impact the Seepage Recovery Pond located 1,100 ft downstream of the tailings dam toe, but would not reach the Seepage Recover Dam, which is located 1,600 ft downstream of the tailings dam toe. The back-scarp would extend approximately 1,150 ft into the tailings beach. The current tailings pond would still be 1,000 ft away from the back-scarp. The tailings pond would be pushed to approximately 10,000 ft away from the Cyclone Sand Dam crest by the end of operations. The potential for release of the tailings pond reduces with the development of the tailings facility.

I-5 CONCLUSIONS AND RECOMMENDATIONS

I-5.1 General

The analyses and conclusions presented in this report are based on conditions believed to exist downstream of the dams at the time the analyses were completed. Schedule I-2 of the BC Dam Safety Regulations requires dam owners to conduct an annual review of conditions downstream of their dams. The results of this study should be re-evaluated should a significant change be noted in the downstream conditions during the annual review.

I-5.2 East Saddle Dam Break Study

The East Saddle Dam inundation study presented in this report was largely based on TRIM data with horizontal and vertical accuracy of ±10 and ±5 m, respectively. Nevertheless, given the air and ground reconnaissance previously conducted to confirm relevant topographic features and given the large distance between the dam and populated areas such as the Sardine Flats and the City of Quesnel, the results of the study are considered to be adequate for emergency planning purposes. Our observations, conclusions and recommendations for the dam breach and inundation analyses for the East Saddle Dam are summarized below:

- The TSF is designed to store the 30 day PMF, with design freeboard above the flood storage level that accounts for wind-induced waves, and settlement. At closure, a spillway designed to handle PMF conditions will be constructed. Therefore, the likelihood of the East Saddle Dam being overtopped is small. Overtopping failure is considered likely to occur coincident with PMF flows downstream. Piping failure could occur under 'sunny day' conditions, with MAF conditions downstream.
- Results of the dam break modeling indicate that piping failure at the pond operating water level would result in higher incremental impacts, in terms of flood depth, compared to overtopping failure. The flood flows will be larger than the natural 1 in 200 year flood flows in the Quesnel River, the design event generally considered for flood management measures in the region. Since the peak flows resulting from a breach at the East Saddle Dam are either equal to or larger than the natural 200-year flood in the Quesnel River, low lying roads and bridges downstream of the dam are expected to be affected by the dam breach flood. Low lying areas along Sardine Flats and in the City of Quesnel are also expected to be affected.
- The combined flow in the Fraser River consisting of the assumed MAF during the dam break, and flows from a piping failure is about 54% of the river's 1 in 20 year flood flows. Therefore, a breach of the East Saddle Dam is expected to have minimal impact on the Fraser River.
- The environmental impacts resulting from a breach at the East Saddle Dam have not been studied, but large debris flows will likely be initiated particularly as the flood moves through the smaller streams upstream of the Quesnel River.
- The Quesnel River usually freezes during the winter. River ice might exacerbate the flooding caused by a breach at the East Saddle Dam.

- The flood inundation limits produced from dam break and inundation modelling should be regarded as approximate and this limitation should be kept in mind in the development and execution of emergency planning procedures.
- The TSF configurations and East Saddle Dam geometry used is based on the designs presented in the Long Term Tailings Deposition Plan (KCB, 2012). If there are changes to the designs, the analyses and the results of this study must be re-evaluated.

I-5.3 Main Dam Tailings Runout Assessment

A 2-D run-out assessment using DAN-W was conducted for 3 scenarios. The extreme lower-bound case had a liquefied basal strength of Sr/σ_{vo}' = 0.06. This strength value was based on the weakest tailings area near the North Earthfill Dam located 6,000 ft away from cross-section used in the model.

The extreme lower bound scenario indicates a run-out of approximately 1,150 ft. This run-out would impact the Seepage Recovery Pond located 1,100 ft downstream of the tailings dam toe, but would not reach the Seepage Recover Dam, which is located 1,600 ft downstream of the tailings dam toe. The back-scarp would extend approximately 1,150 ft into the tailings beach, but the current tailings pond would still be 1,000 ft away from the back-scarp. This confirms that the possibility for release of the tailings pond is remote.

The tailings pond would be pushed to approximately 10,000 ft away from the Cyclone Sand Dam crest by the end of operations. As a result, the potential for release of the tailings pond reduces further with the development of the tailings facility.

REFERENCES

Agriculture and Agri-Food Canada (AAFC), 2010. Probable Maximum Flood Estimator for British Columbia.

B.C. Reg. 163/2011. (2011). British Columbia Dam Safety Regulation, deposited November 30.

CDA (2007). "Dam Safety Guidelines", Canadian Dam Association, January.

Costa JE. (1985). "Floods From Dam Failures", Open-File Report No. 85-560, United States Department of the Interior, USGS. Denver, Colorado.

Froehlich, D.C. (1995). "Embankment Dam Breach Parameters Revisited", Water Resources Engineering, Proc. of 1995 ASCE Conference on Water Resources Engineering, San Antonio, Texas, August 14-18, pp. 887-891.

Froehlich, D. C. (2008). "Embankment Dam Breach Parameters and Their Uncertainties". Journal of Hydraulic Engineering, Vol. 134, No. 12, pp 1708-1720.

Klohn Crippen Ltd. (2005). Gibraltar Tailings Facility Dam Breach and Inundation Study, March 31.

Klohn Crippen Berger Ltd. (2011). Gibraltar Mines Tailings Facility - Dam Failure Classification, January 17.

Klohn Crippen Berger Ltd. (2012). 2012 Long-Term Tailings Deposition Plan, October 26

Lucia P, Duncan JM, Seed HB. 1981. "Summary of Research on Case Histories of Flow Failures of Mine Tailings Impoundments". Mine Waste Disposal Technology, Proceedings of the Bureau of Mines Technology Transfer Workshop. Denver, Colorado. July 16.

MacDonald, T. C. and Monopolis, J. L. (1984). Breaching Characteristics of Dam Failures, Journal of Hydraulic Engineering, Vol. 110, No. 5, May.

State of Colorado. (2010) "Guidelines for Dam Breach Analysis". Division of Water Resources, February.

US Army Corps of Engineers (USACE) (2010a). HEC-RAS Applications Guide, Version 4.1, January.

US Army Corps of Engineers (USACE) (2010b). HEC-RAS Hydraulic Reference Manual, Version 4.1, January.

US Army Corps of Engineers (USACE) (2010c). HEC-RAS User's Manual, Version 4.1, January.

FIGURES

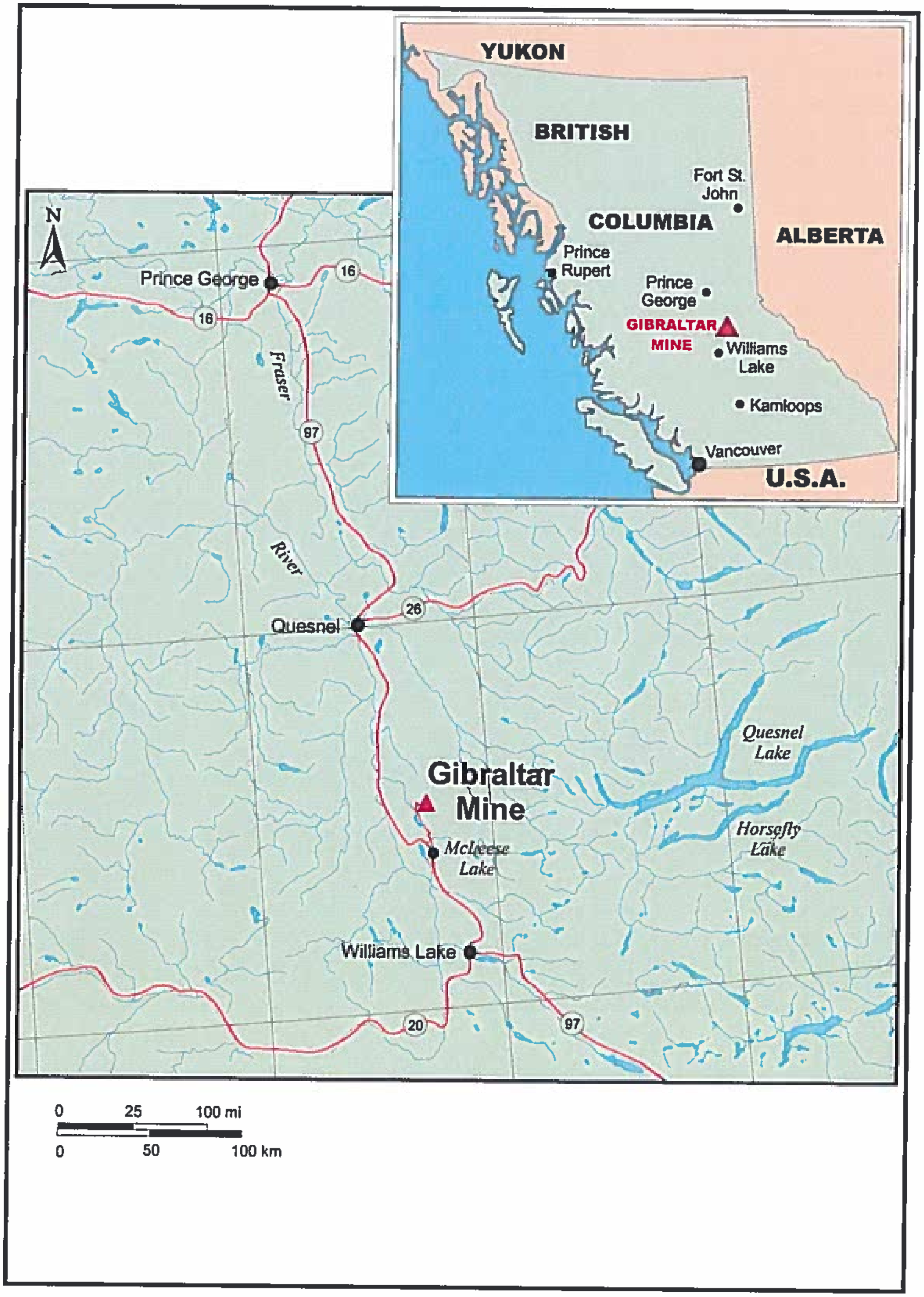
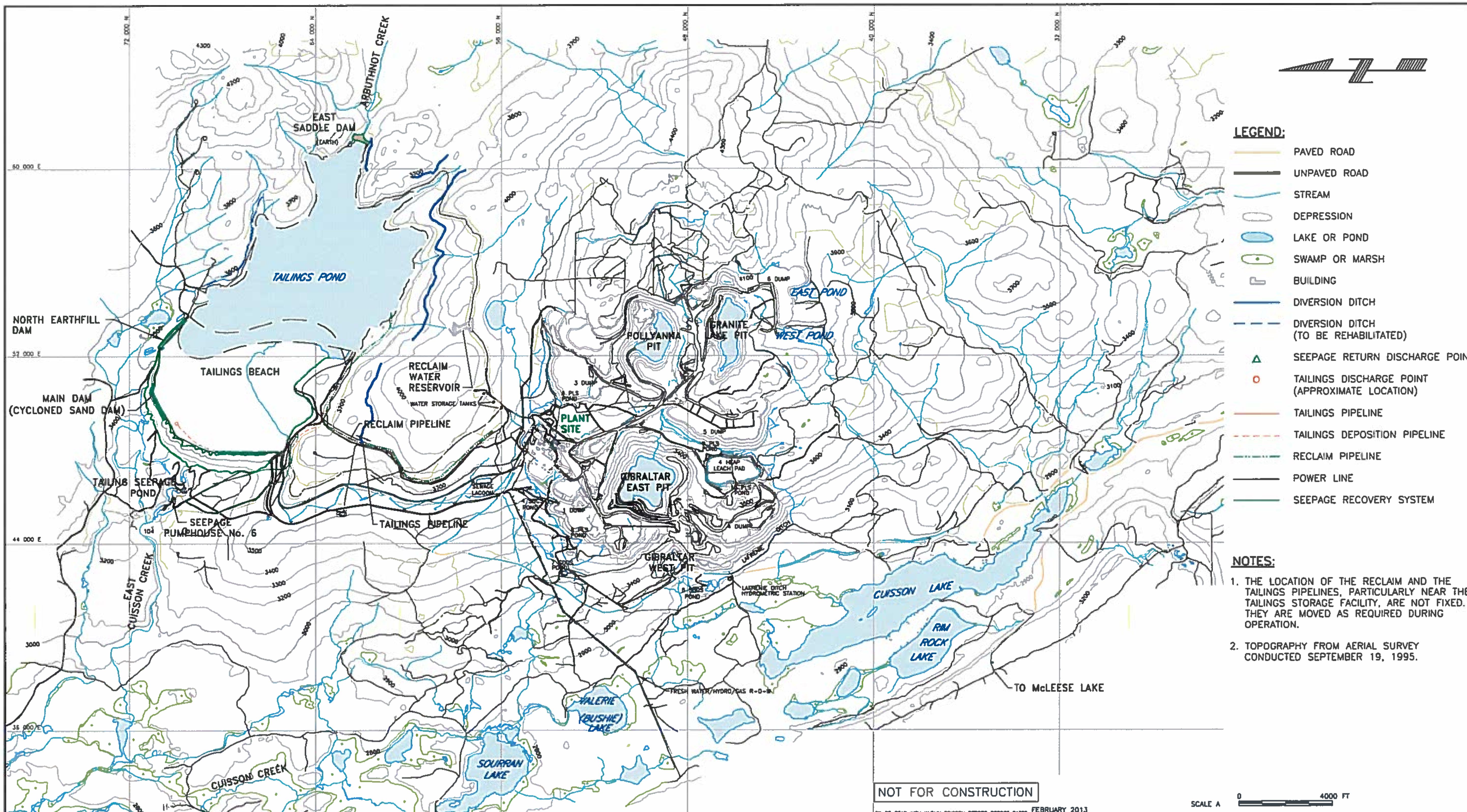


Figure I.1 Gibraltar Mine Location



NOTES:

1. THE LOCATION OF THE RECLAIM AND THE TAILINGS PIPELINES, PARTICULARLY NEAR THE TAILINGS STORAGE FACILITY, ARE NOT FIXED. THEY ARE MOVED AS REQUIRED DURING OPERATION.
2. TOPOGRAPHY FROM AERIAL SURVEY CONDUCTED SEPTEMBER 19, 1995.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

CLIENT: Taseko Gibraltar

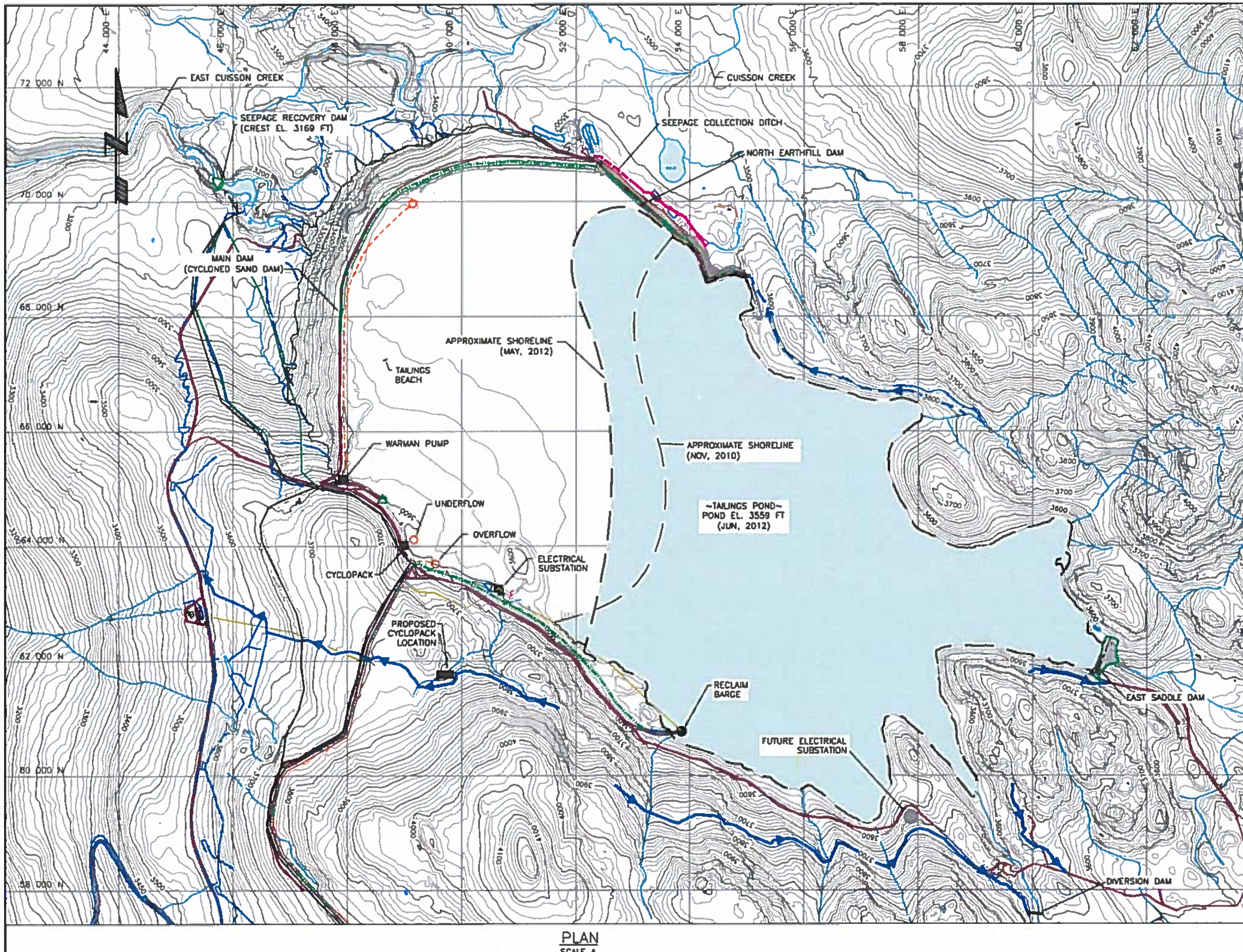
Klohn Crippen Berger

PROJECT: GIBRALTAR MINE TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: MINE SITE PLAN

PROJECT No. M01527A68 | FIG. No. I-2

Time: 10:55:28
Date: 2/7/2013
Scale: 1:2.5849(PS)
Drawing File: Z:\M\VCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\CAD\MEMO\FIG_I-2_r.A.dwg (mwong)
Xref File(s): BM_Gibraltar_tmp_June_2000
Image File(s): Gibraltar Mines _new



PLAN
SCALE A

LEGEND

- △ SEEPAGE RETURN DISCHARGE POINT
- ○ TAILINGS DISCHARGE POINT (APPROXIMATE LOCATION)
- TAILINGS PIPELINE
- TAILINGS DEPOSITION PIPELINE
- RECLAIM PIPELINE
- DIVERSION DITCH
- DIVERSION DITCH (TO BE REHABILITATED)
- POWER LINE
- SEEPAGE RECOVERY SYSTEM
- ROAD / DITCH
- CULVERT

NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN FEET UNLESS NOTED OTHERWISE.
2. TOPOGRAPHY SUPPLIED BY EAGLE MAPPING LTD., PRODUCED FROM AERIAL PHOTOGRAPHY: JULY 23, 2008.

SCALE A 0 — 2000 FT.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

CLIENT: Taseko Gibraltar

Klohn Crippen Berger

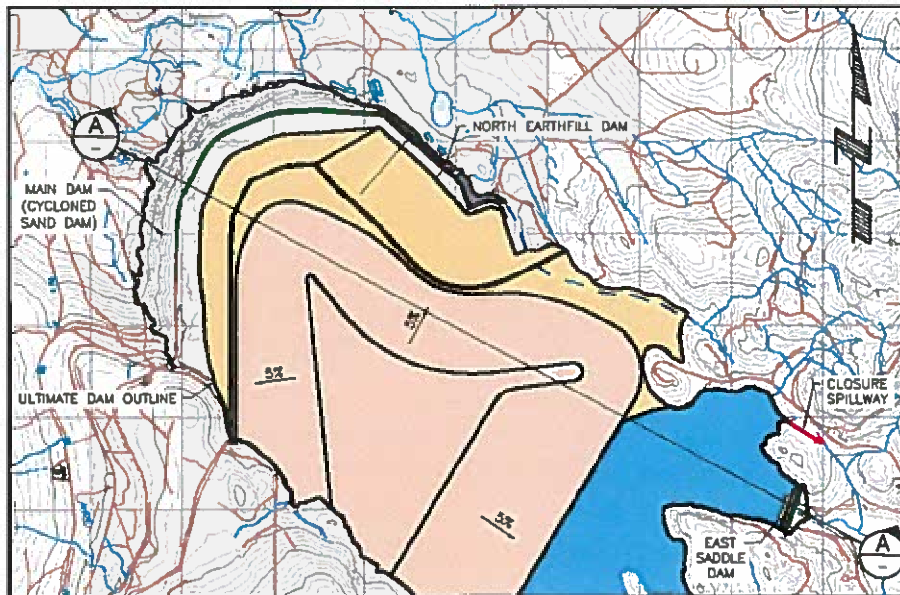
PROJECT: GIBRALTAR MINE TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: SITE PLAN – EXISTING CONDITIONS

PROJECT No. M01527A68

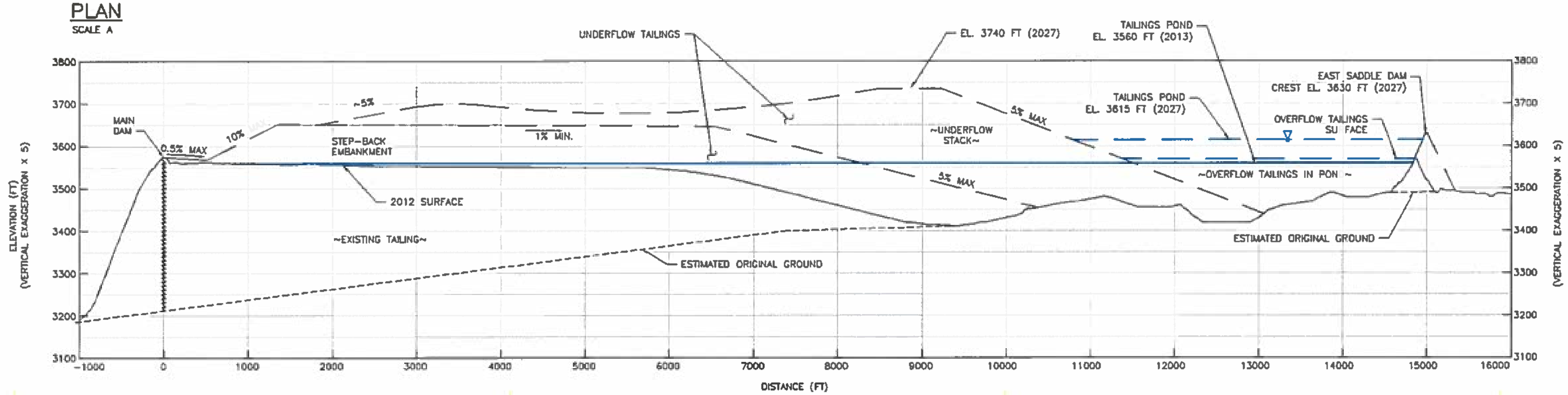
FIG. No. I-3

Date:6/20/2012 Time:17:04:54 Scale: 1:2
Filename:Z:\M\VCR\M01527A68 - GIBRALTAR-TSF EMERG\400 DRAWINGS\CAD\MEMO\FIG_I-3_RA_SITE_PLAN_EX_COND.DWG
Xref File(s): BM GIBRALTAR-MAY 2012
Image File(s): Gibraltar Mines _new

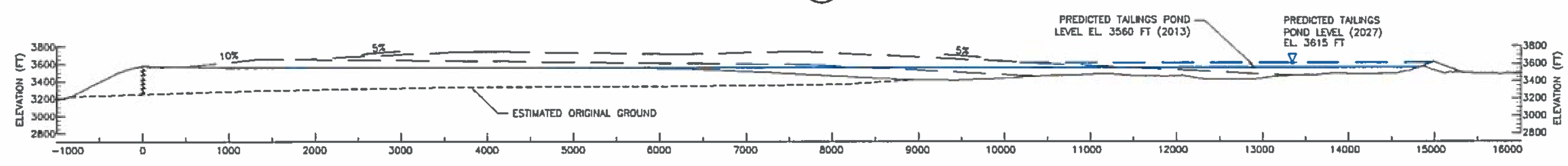


PLAN
SCALE A

LEGEND
- TILL
- STEP-BACK EMBANKMENT (CYCLONED SAND)
- UNDERFLOW STACK (CYCLONED SAND)
- TAILINGS POND
- SPILLWAY
- DIVERSION DITCH



SECTION A



SECTION A

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

SCALE A 0 4000 FT

NOTE:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN FEET UNLESS NOTED OTHERWISE.

CLIENT: Taseko Gibraltar

Klohn Crippen Berger

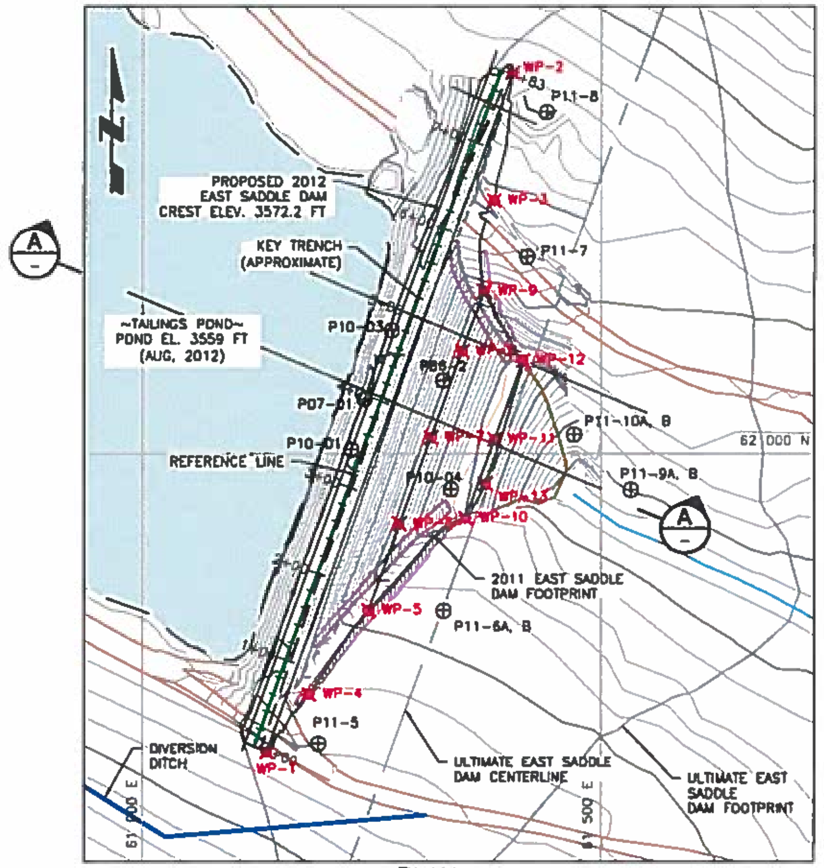
PROJECT: GIBRALTAR MINE
TAILINGS FACILITY EMRGENCY PREPAREDNESS PLAN

TITLE: TAILINGS STORAGE FACILITY PLAN AND SECTIONS

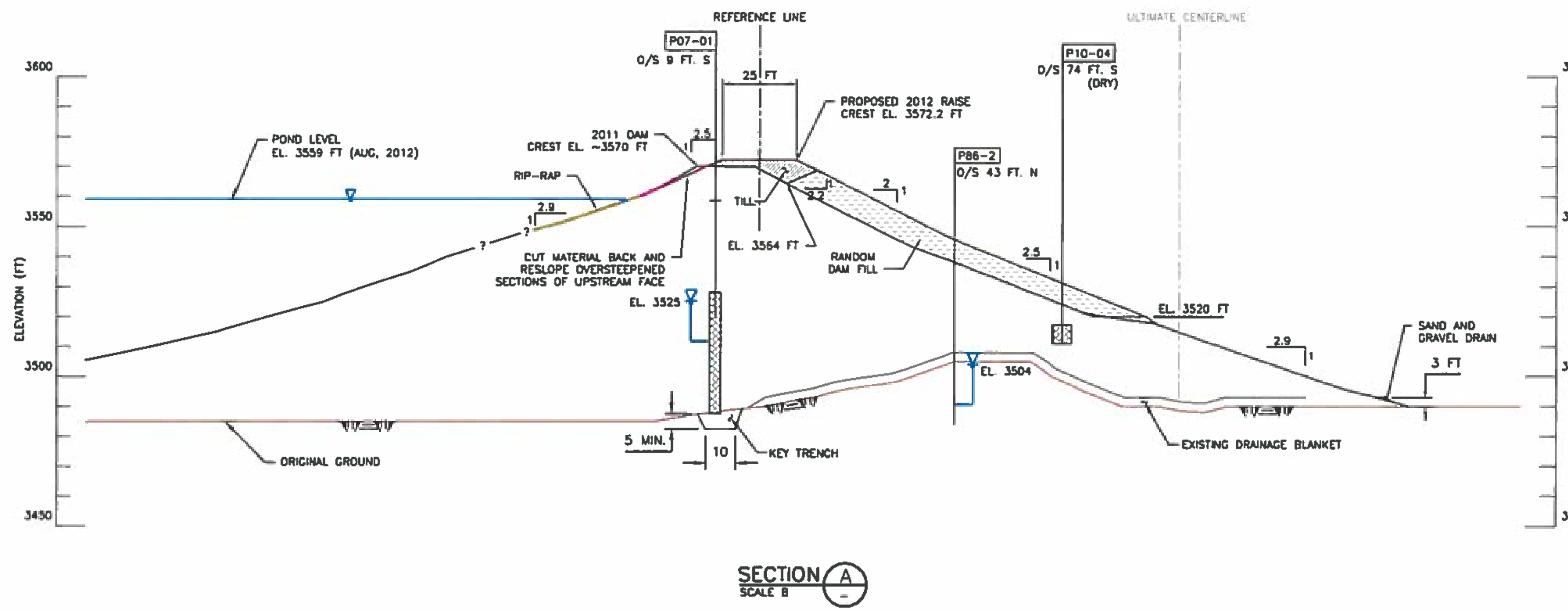
PROJECT No. M01527A68

FIG. No. I-4

Date:6/21/2012 Time:13:43:37 Scale: 1:2
Filename:Z:\M\VCR\M01527A68 - GIBRALTAR-TSF EMERG\400 DRAWINGS\CAD\MEMO\FIG_I-4_PA.DWG
Xref File(s): BM GIBRALTAR MAY 2012_OL.dwg
Image File(s): Gibraltar Mines _new



PLAN
SCALE A



SECTION A
SCALE B

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

NOTES:

1. BASED ON 2012 DAM RAISES DETAILS ISSUED FOR CONSTRUCTION, OCTOBER 2012.
2. ALL DIMENSIONS AND ELEVATIONS ARE IN FEET UNLESS NOTED OTHERWISE.
3. TOPOGRAPHY SUPPLIED BY EAGLE MAPPING LTD., PRODUCED FROM AERIAL PHOTOGRAPHY: JULY 23, 2008.
4. LATEST EAST SADDLE DAM SURVEY DATA SUPPLIED BY GIBRALTAR: MAR 30, 2012.

LEGEND

▽ PIEZOMETRIC LEVELS FOR AUG 23, 2012

SCALE A 0 — 200 FT
SCALE B 0 — 50 FT

CLIENT: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE
TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: EAST SADDLE DAM
PLAN AND SECTION
(2012–2013)

PROJECT No. M01527A68

FIG. No. I-5

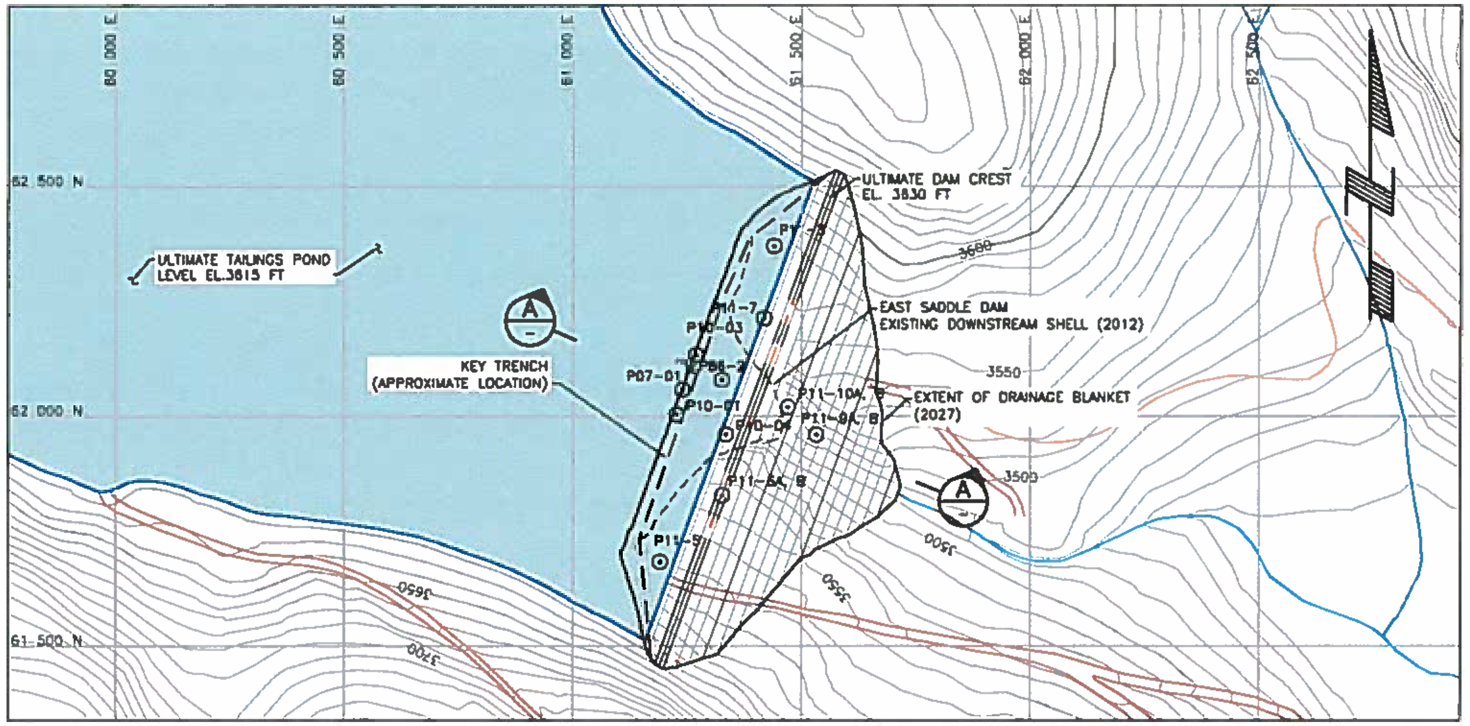
Time: 09:38:03
Date: 2/1/2013
Scale: 1:2.5849(PS)
Drawing File: Z:\M\VCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\CAD\MEMO\FIG_I-5_rA.dwg (rwong)
Xref File(s): BM GIBRALTAR may 2012_OL.dwg
Image File(s): Gibraltar Mines _new

LEGEND

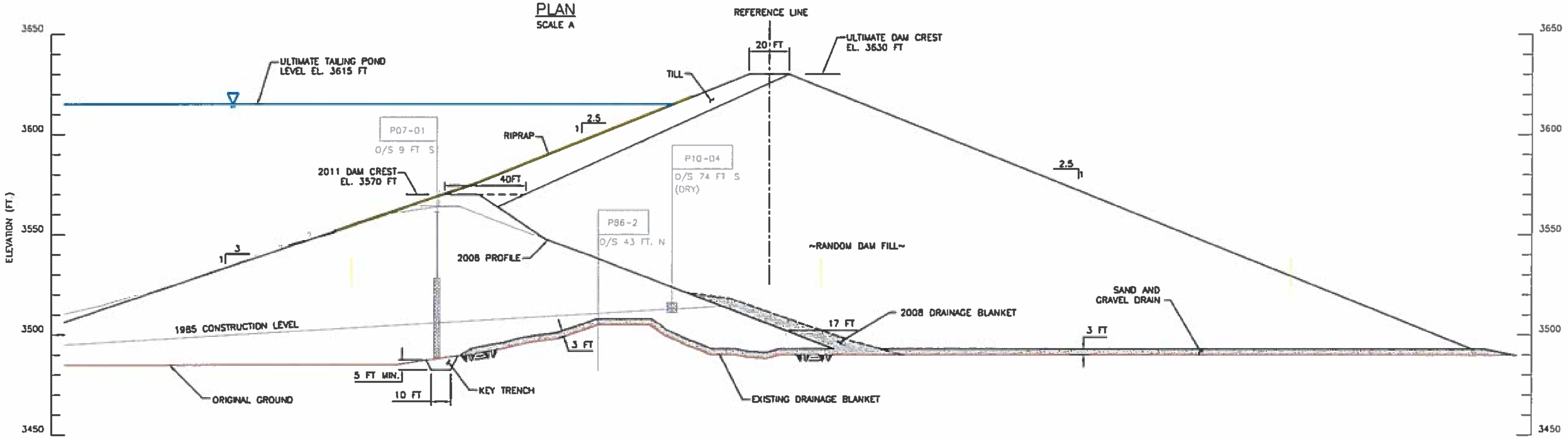
∇ WATER LEVELS

NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN FEET UNLESS NOTED OTHERWISE.



PLAN
SCALE A



SECTION A
SCALE B

SCALE A 0 — 400 FT

SCALE B 0 — 50 FT

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: EAST SADDLE DAM PLAN AND SECTION (2027)

PROJECT No. M01527A68

FIG. No. I-6

Time: 09:44:29
Date: 2/7/2013
Scale: 1:2.5849(PS)
Drawing File: Z:\V\VCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\CAD\MEMO\FIG_I-6_A.dwg (rwong)
Xref File(s): EastSaddle Dam Ultimate Aug 2012
Image File(s): Gibraltar Mines _new

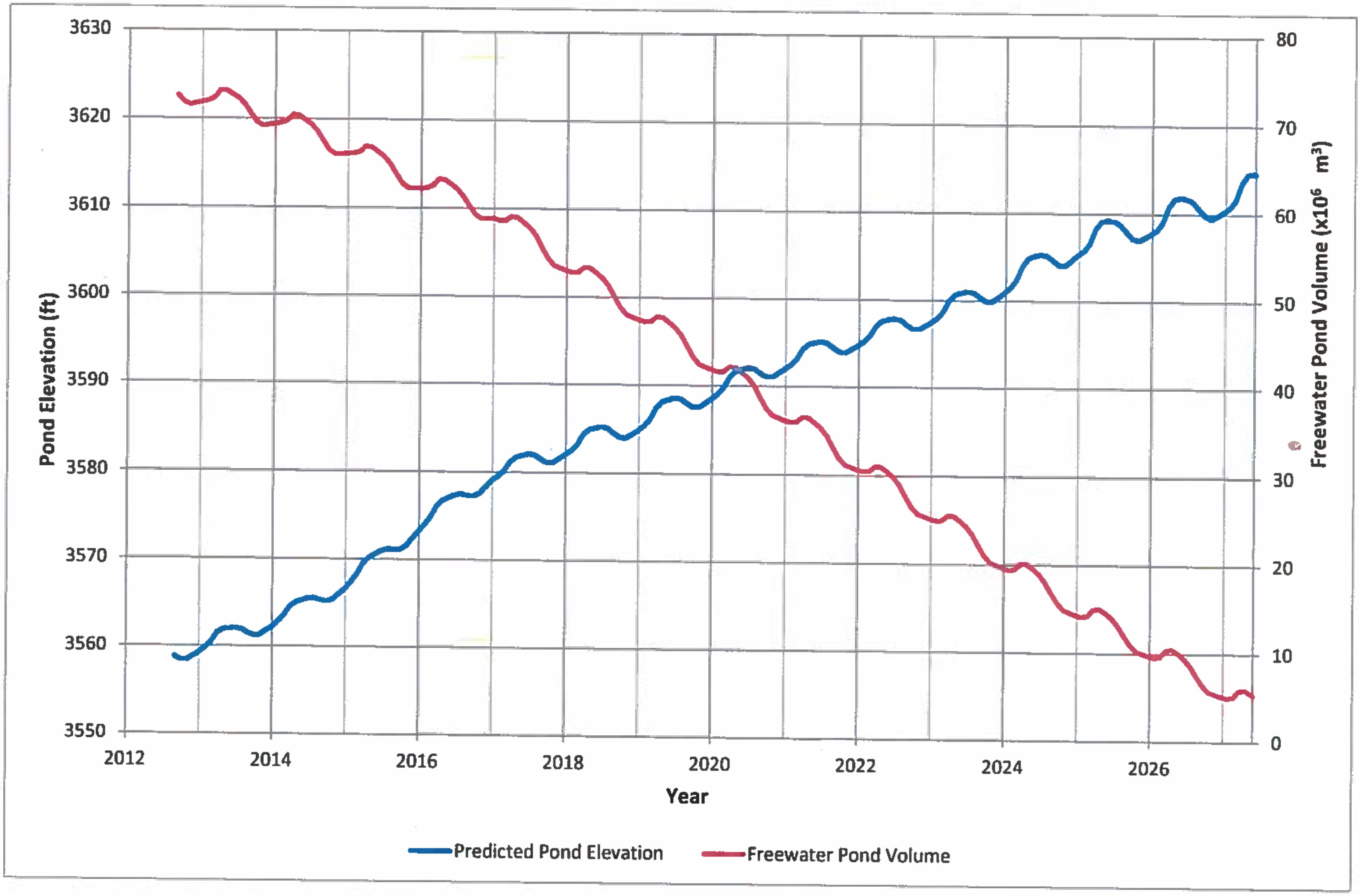


Figure I-7 **Predicted Pond Elevation and Freewater Pond Volume, 2012 – 2027**

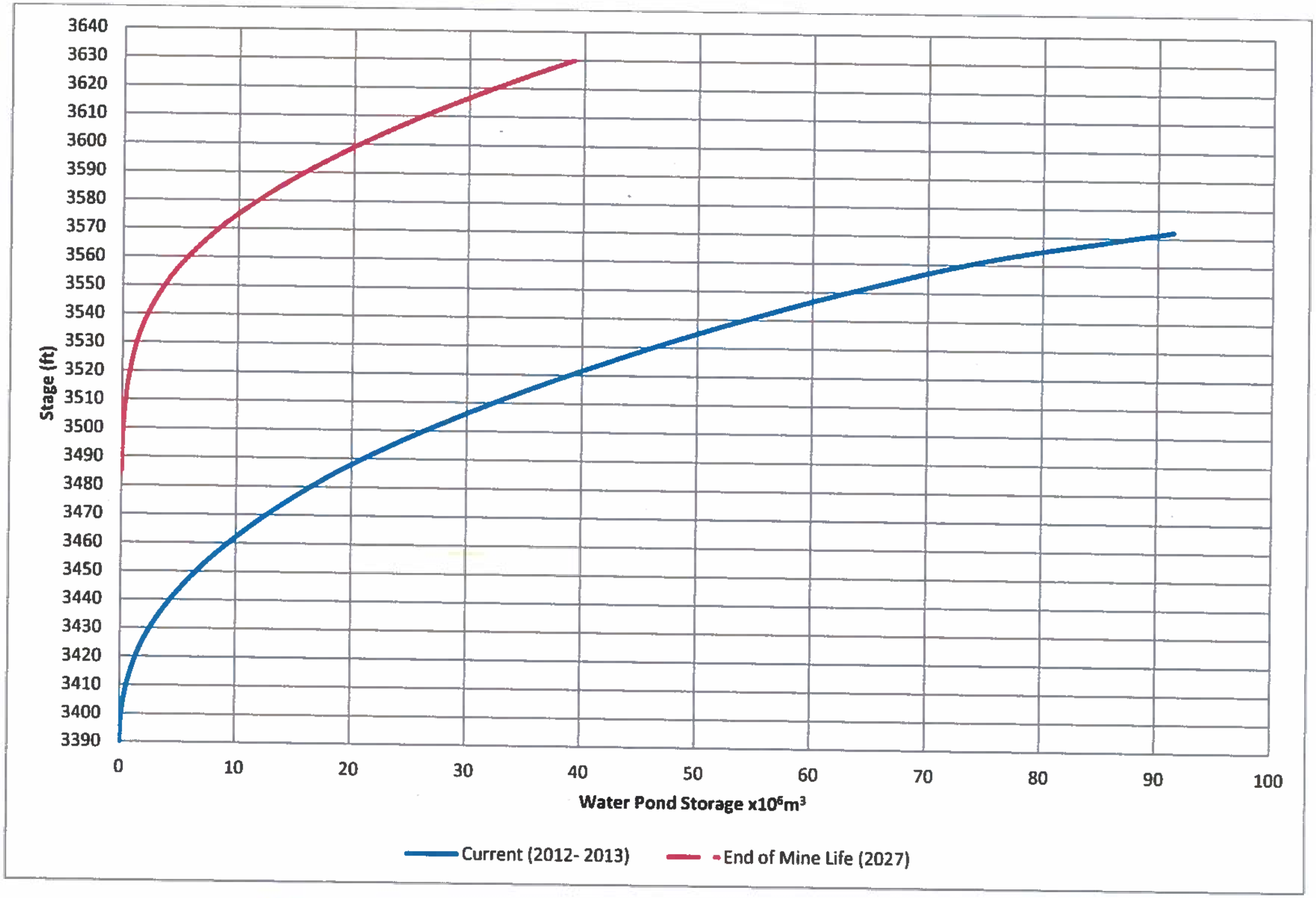
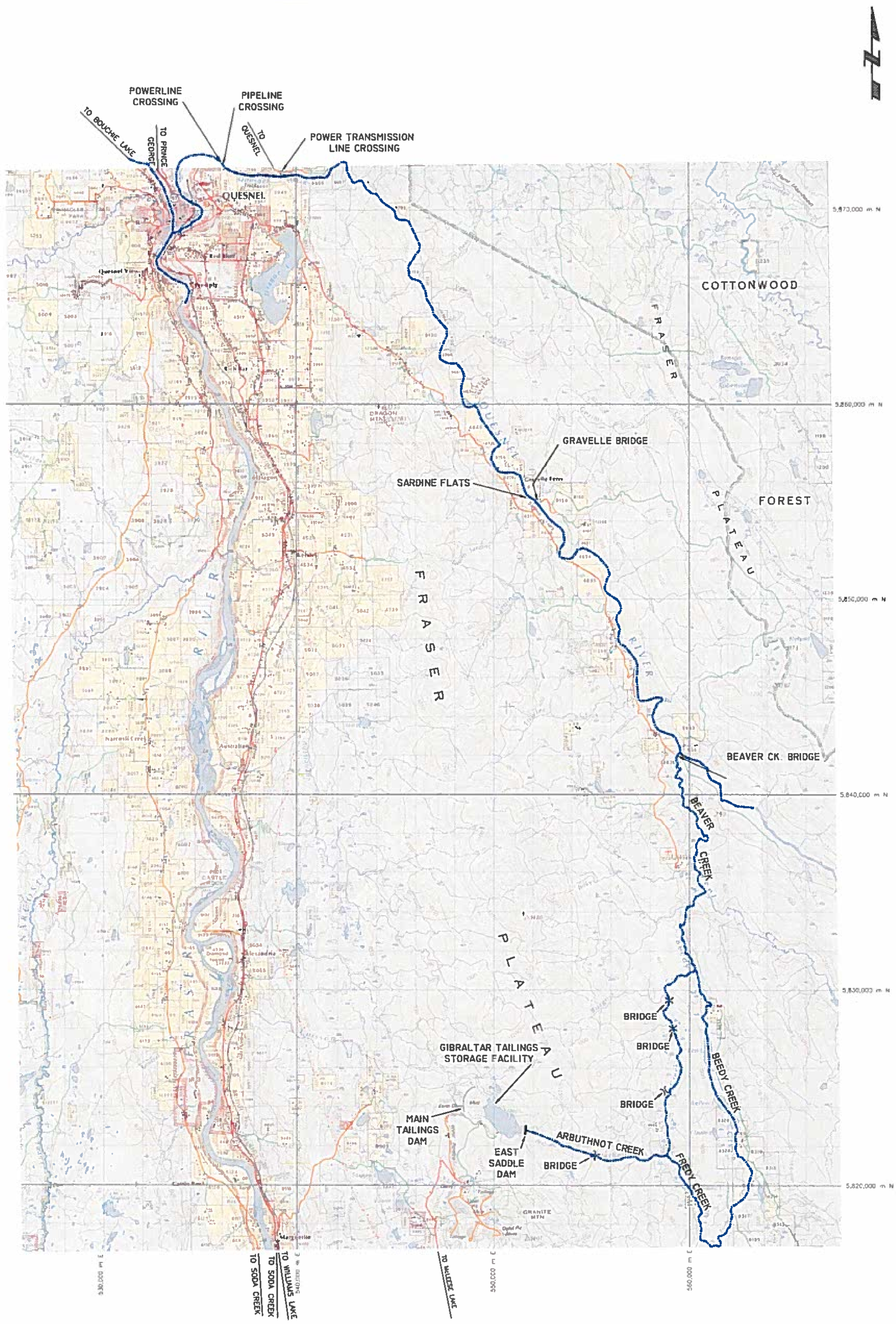


Figure I-8 Supernatant Pond Stage – Storage Relationship, Current (2012 - 2013) and End of Mine Life (2027)

Time: 10:13:11
Date: 2/1/2013
Scale: 1:2.5849(PS)
Drawing File: Z:\M\VCR\M01527A68 – Gibraltar-TSF Emerg\400 Drawings\CAD\MEMO\FIG_I-9_rA.dwg (rwwong)
Xref File(s):
Image File(s): Gibraltar Mines _new NarcosliCreek_a NarcosliCreek_b



LEGEND

REACH IN HEC-RAS MODEL FOR EAST SADDLE DAM BREACH

NOTES

1. BASE MAP IS TAKEN FROM 1:100,000 NTS MAP SHEET NO. 93B/NE DATED 1981.
2. THIS PLAN DOES NOT SHOW ALL BRIDGES AND/OR RIVER CROSSINGS.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

SCALE: 0 – 3 Mi; 0 – 5 km

CLIENT: Taseko Gibraltar

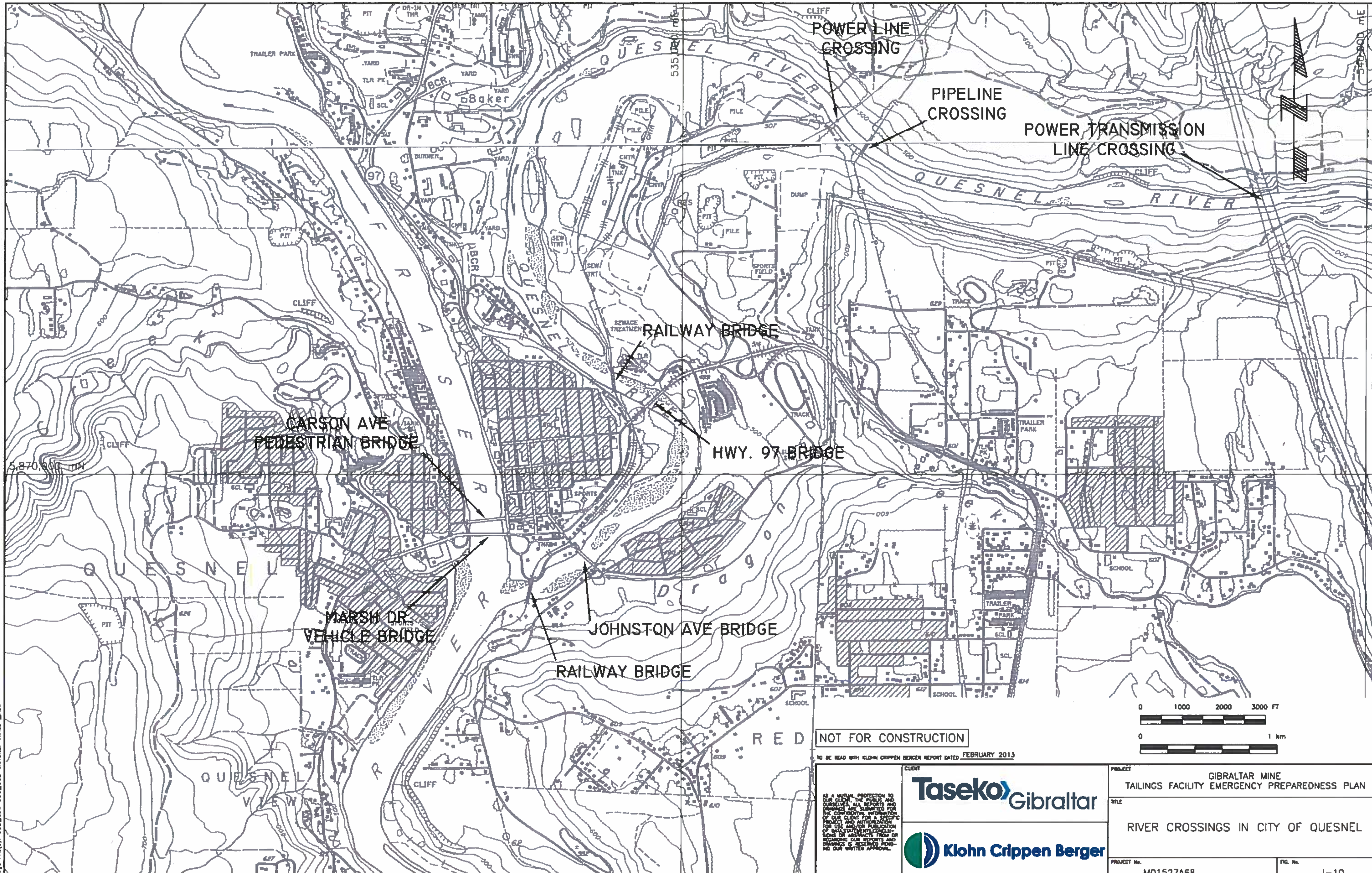
Klohn Crippen Berger

PROJECT: GIBRALTAR MINE
TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: GENERAL PLAN OF
TSF AND DOWNSTREAM AREAS

PROJECT No. M01527A68

FIG. No. I-9



NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

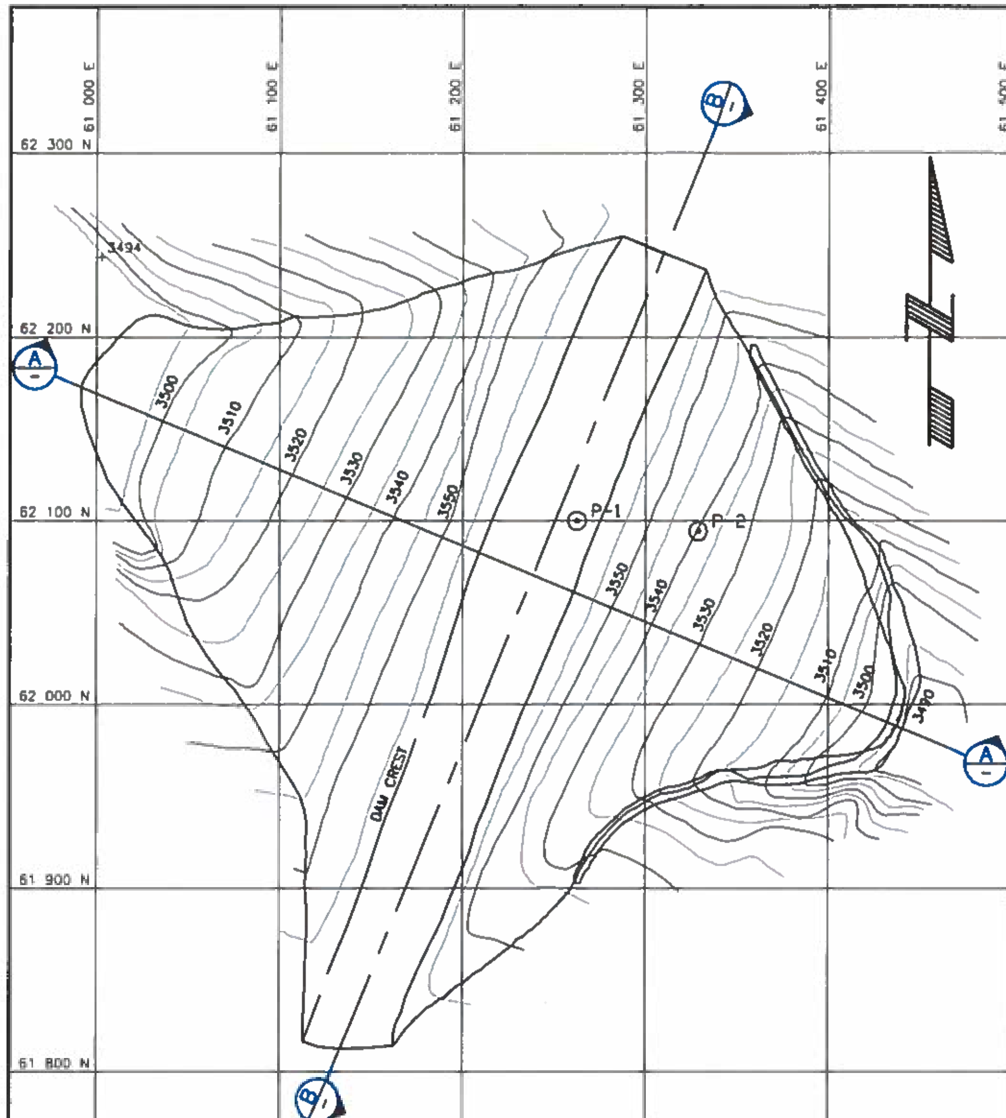
PROJECT: GIBRALTAR MINE TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: RIVER CROSSINGS IN CITY OF QUESNEL

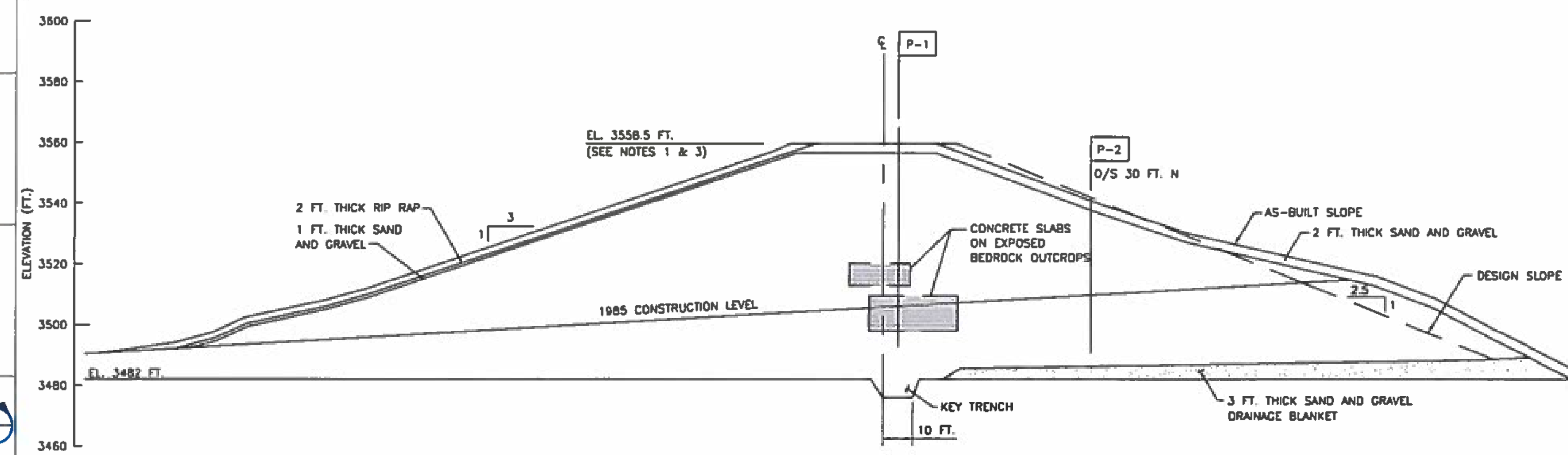
PROJECT No. M01527A68

FIG. No. I-10

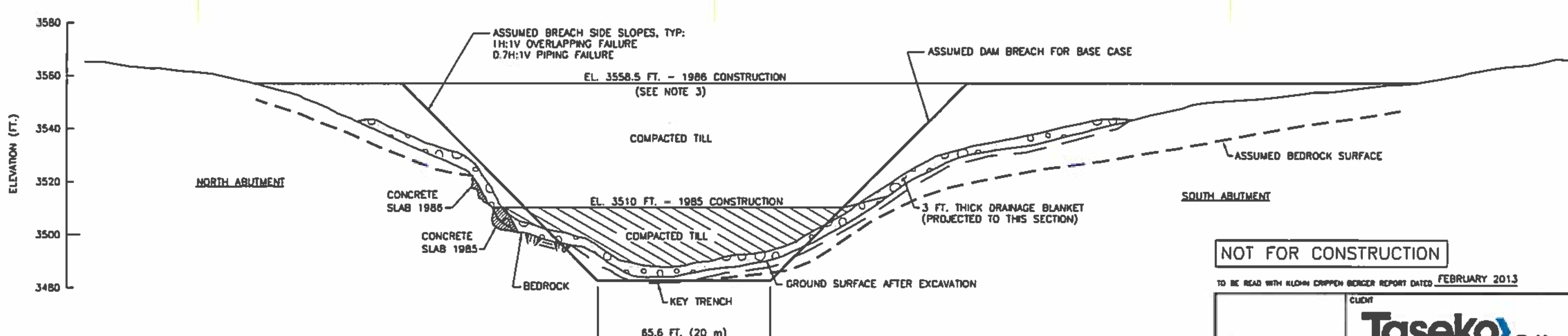
Time: 10:20:21
Date: 2/7/2013
Scale: 1:2.5849(PS)
Drawing File: Z:\M\VCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\CAD\MEMO\FIG_I-10_r.A.dwg (rwoong)
Xref File(s):
Image File(s): 93B_096 93C_008 Gibraltar Mines _new



PLAN
SCALE A



SECTION A
SCALE B



SECTION B - PROFILE ALONG DAM CENTRELINE
SCALE B

LEGEND:

P-1 PIEZOMETER LOCATION

NOTES:

1. AS-BUILT INFORMATION TAKEN FROM GIBRALTAR MINE DRAWING No. E24-43-4717 AND D24-43-4717. BOTH DATED 26/02/86.
2. DAM BUILT IN TWO STAGES IN 1985 AND 1986.
3. ACTUAL DAM CREST ELEVATION IS APPROXIMATELY 7FT. LOWER THAN SHOWN ON THE AS-BUILT DRAWINGS.

SCALE A 0 — 100 FT

SCALE B 0 — 50 FT

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

CLIENT: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE
TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: EAST SADDLE DAM
AS-BUILT PLAN AND SECTIONS
(1986)

PROJECT No. M01527A68

FIG. No. I-11

Time: 10:36:29
Date: 2/1/2013
Scale: 1:2.5849(PS)
Drawing File: Z:\M\VCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\CAD\MEMO\FIG_I-11_rA.dwg (rewong)
Xref File(s): BASEPLAN
Image File(s): Gibraltor Mines _new

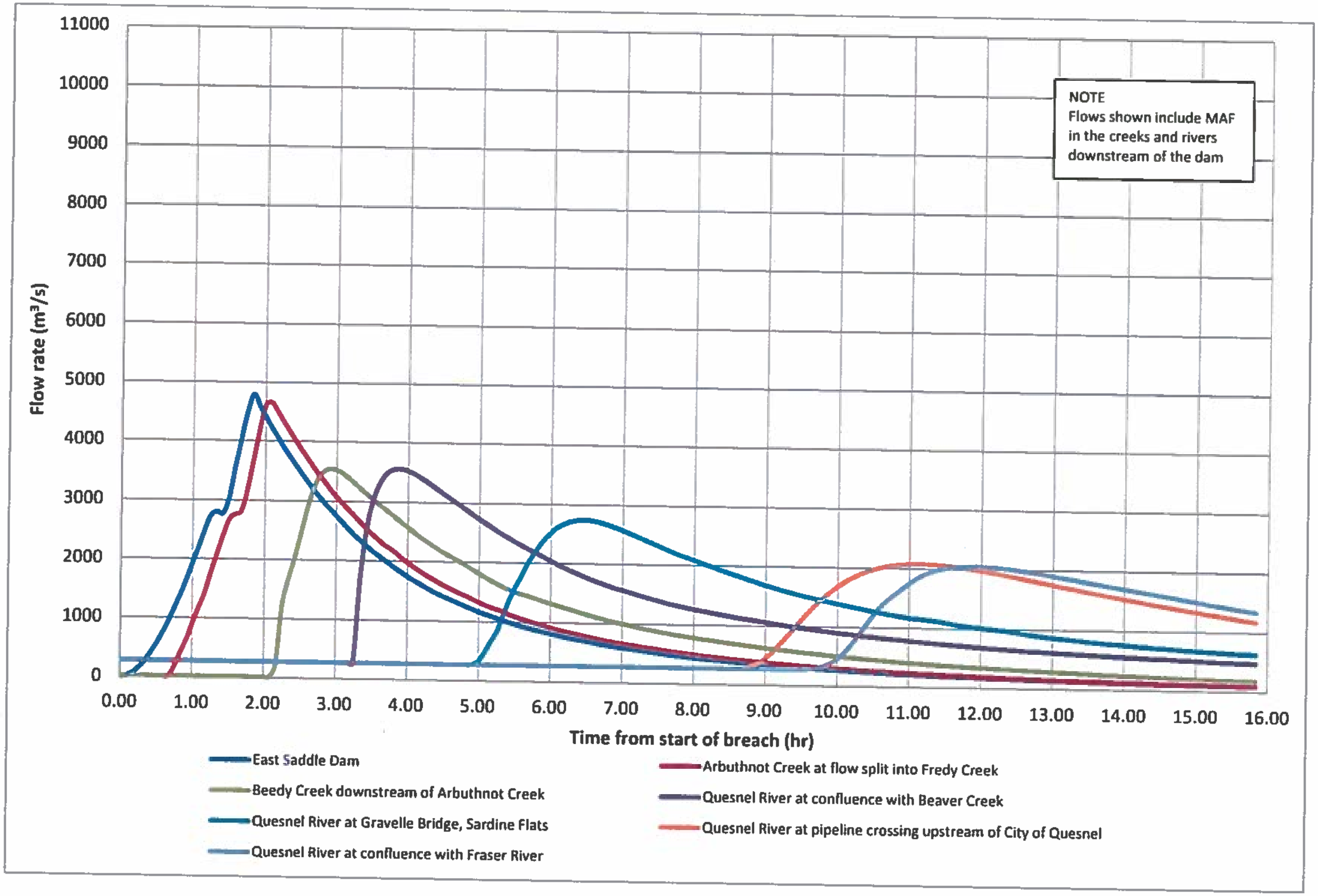


Figure I-12 Flow Hydrographs Along Flood Route – East Saddle Dam Piping Failure Base Case, Current (2012 - 2013)

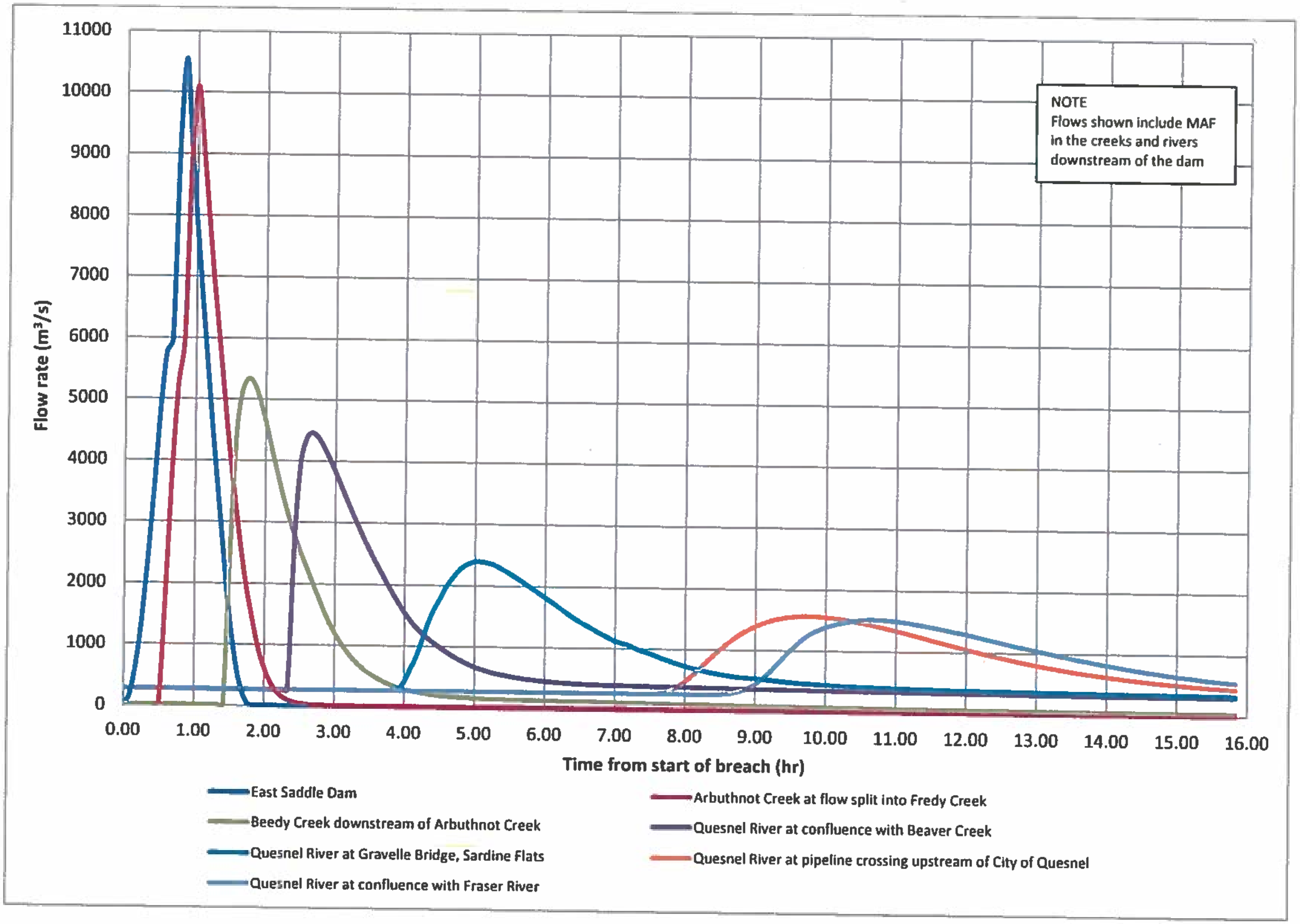
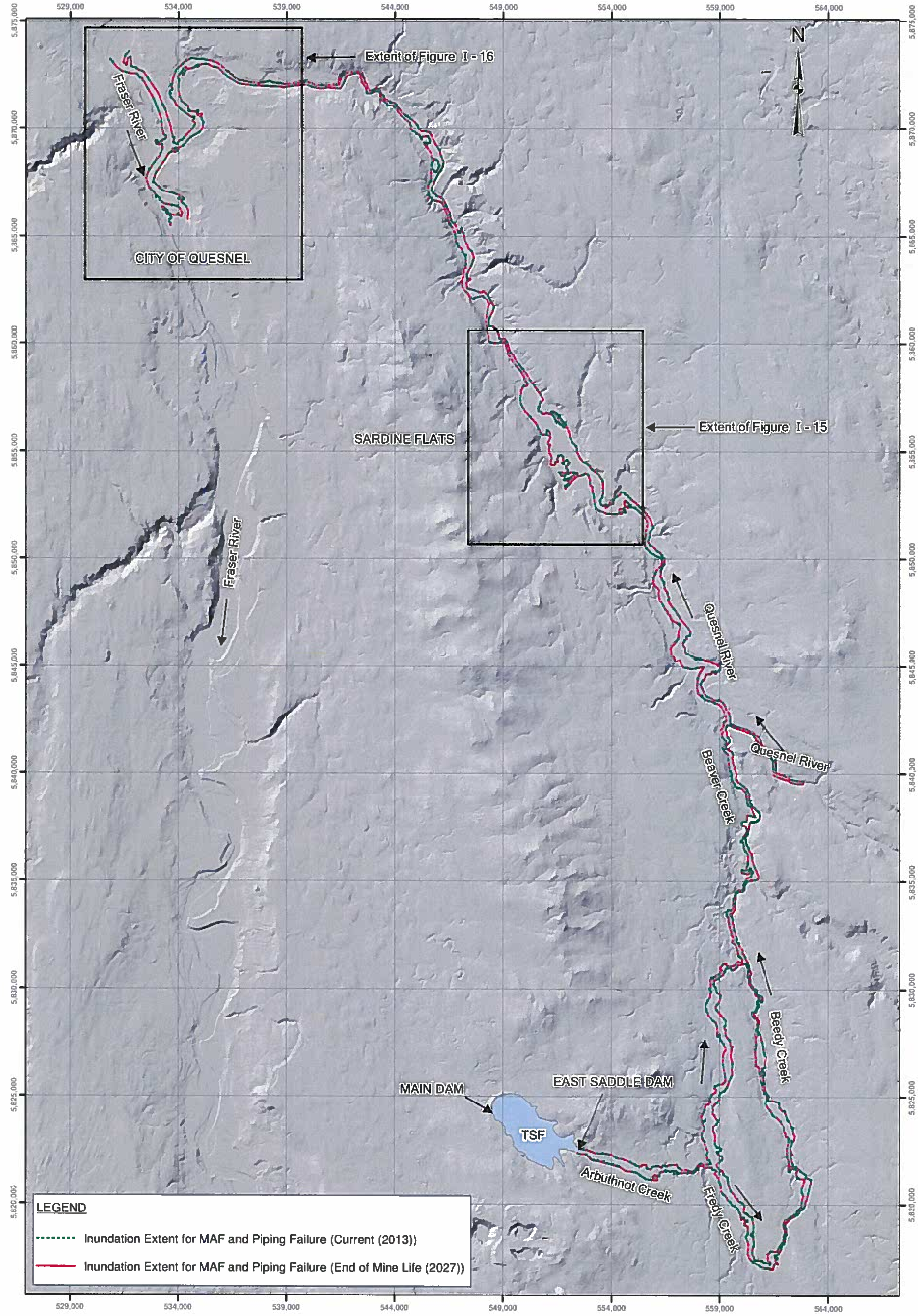


Figure I-13 Flow Hydrographs Along Flood Route – East Saddle Dam Piping Failure Base Case, End of Mine Life (2027)



0 2,000 Meters

0 10,000 Feet

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE TSF EMERGENCY PREPAREDNESS PLAN

TITLE: ESTIMATED FLOOD INUNDATION EXTENTS - PIPING FAILURE BASE CASE

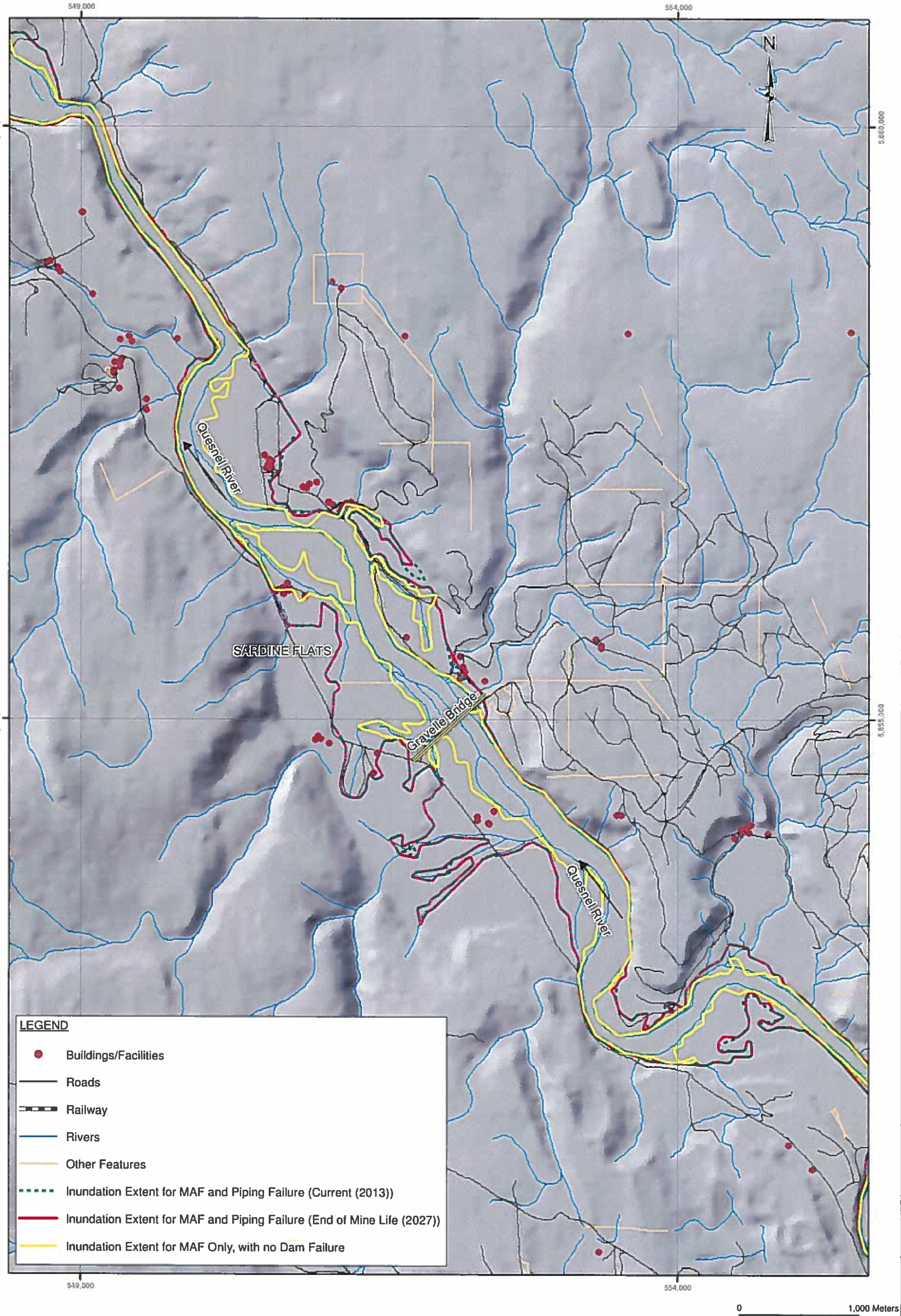
PROJECT No. M01527A68

FIG No. I - 14

NOTES:

DATA SOURCE:
BASE MAP:TRIM POSITION MAP, BC

OEC
Z:\M\VCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\GIS\Mxd\NewMxds\Figure I_14.mxd



NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE
TSF EMERGENCY PREPAREDNESS PLAN

TITLE: ESTIMATED FLOOD INUNDATION EXTENTS, SARDINE FLATS PIPING FAILURE BASE CASE

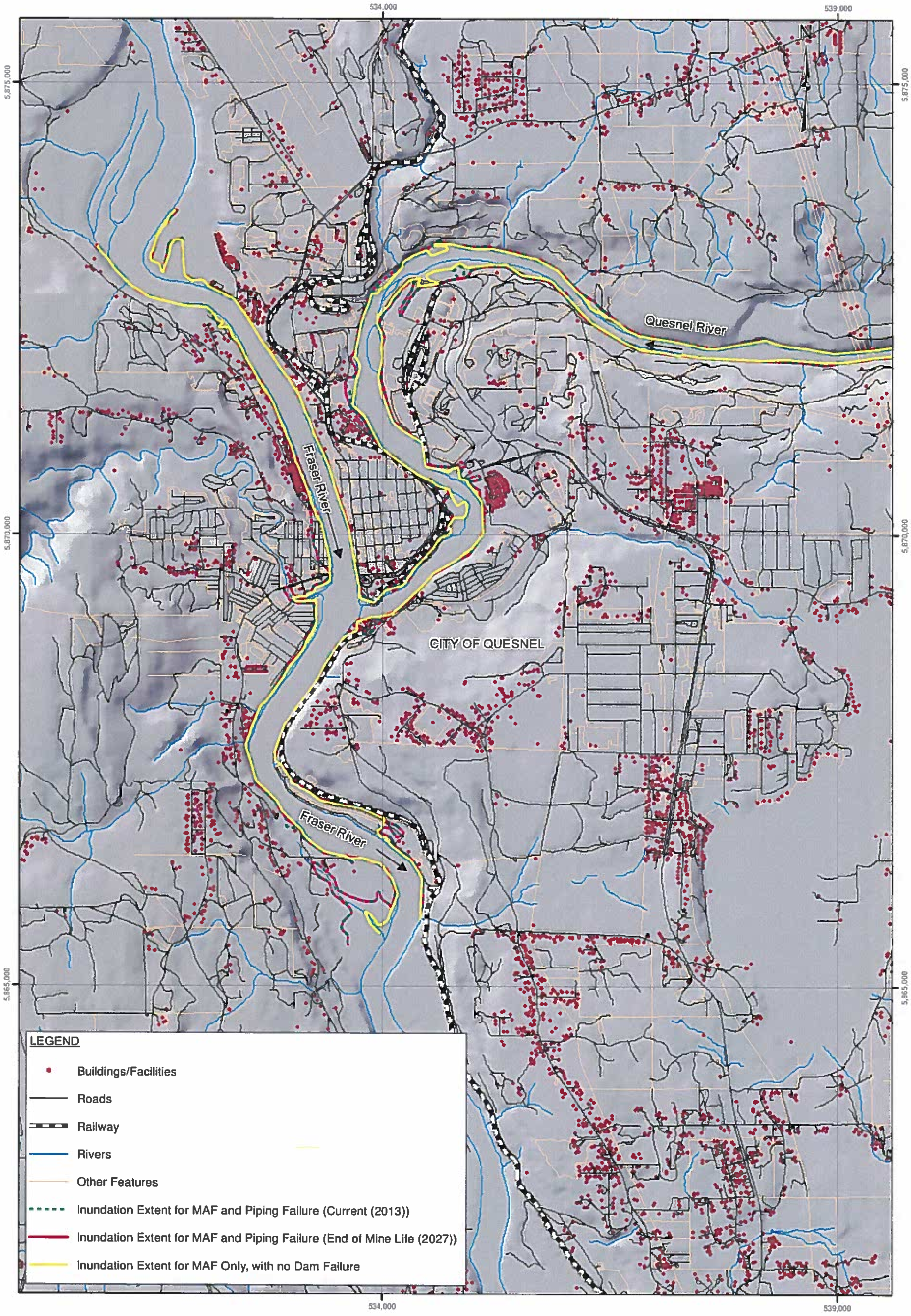
PROJECT No. M01527A68

FIG No. I - 15

NOTES:

DATA SOURCE:
BASE MAP:TRIM POSITION MAP, BC

OEC
Z:\MVCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\GIS\Mxd\NewMxds\Figure I_15.mxd



NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE
TSF EMERGENCY PREPAREDNESS PLAN

TITLE: ESTIMATED FLOOD INUNDATION EXTENTS, CITY OF QUESNEL PIPING FAILURE BASE CASE

PROJECT No. M01527A68

FIG No. I - 16

NOTES:

DATA SOURCE:
BASE MAP: TRIM POSITION MAP, BC

OEC
Z:\M\VCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\GIS\Mxd\NewMxds\Figure I_16.mxd

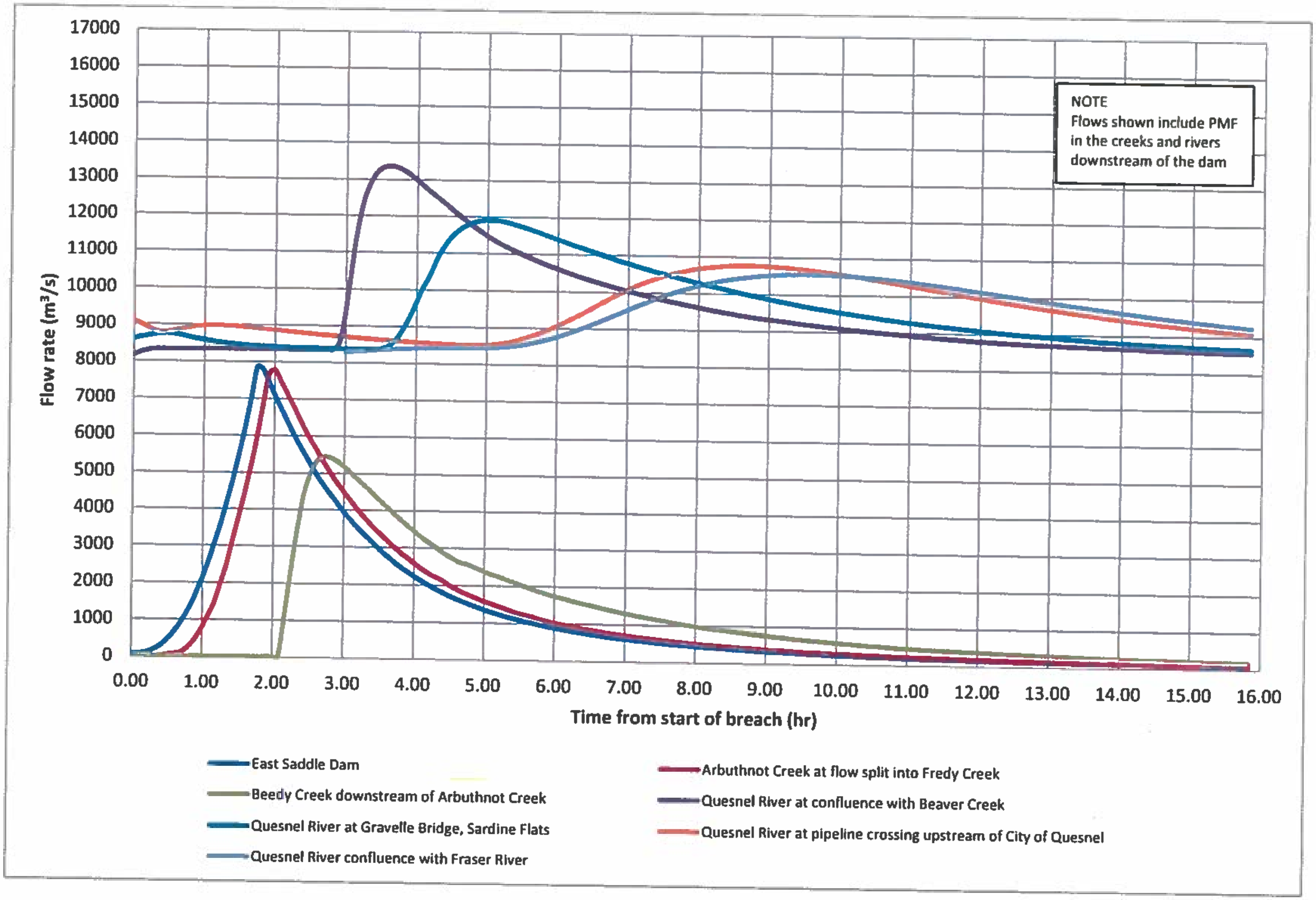


Figure I-17 Flow Hydrographs Along Flood Route – East Saddle Dam Overtopping Failure Base Case, Current (2012 - 2013)

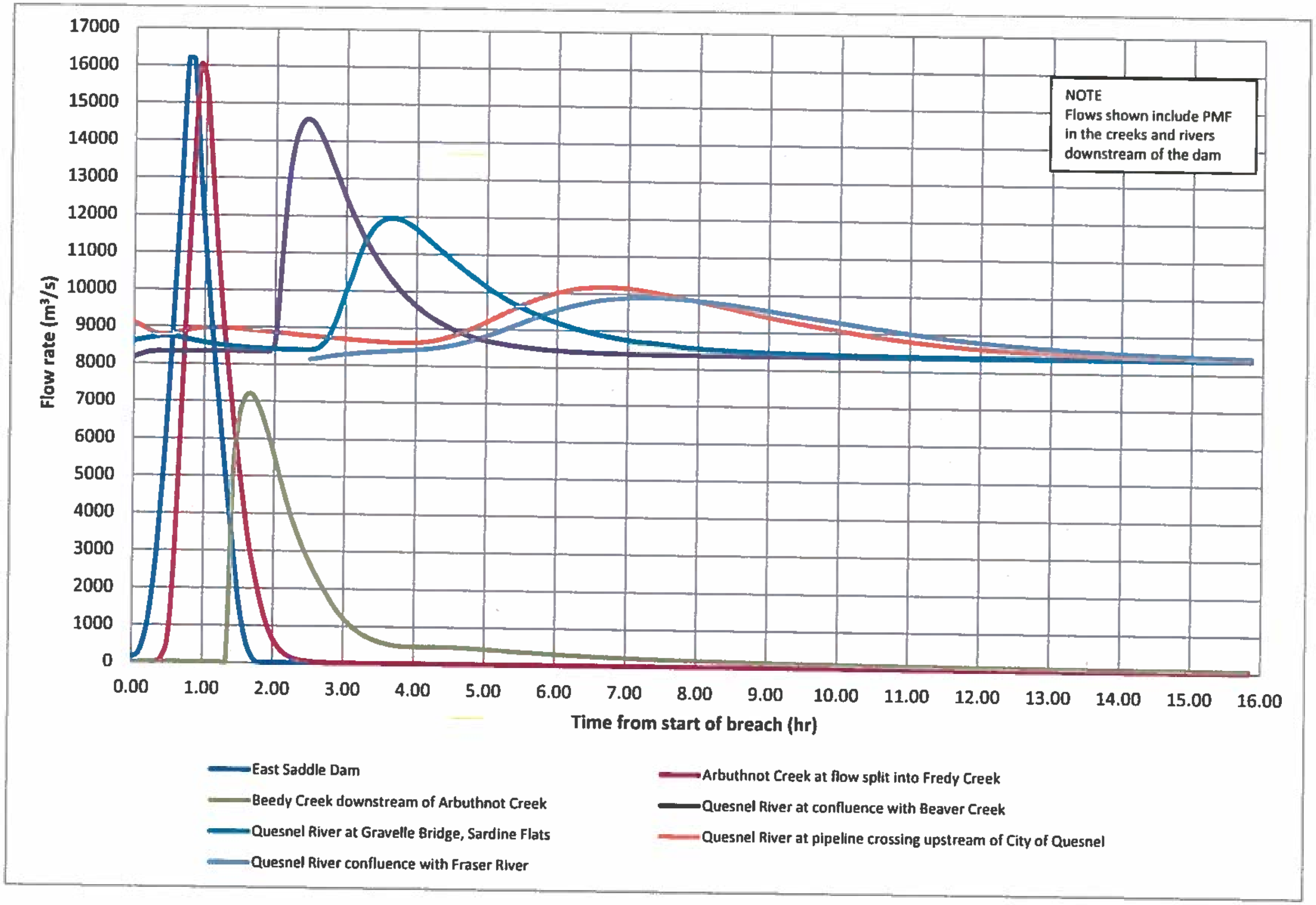
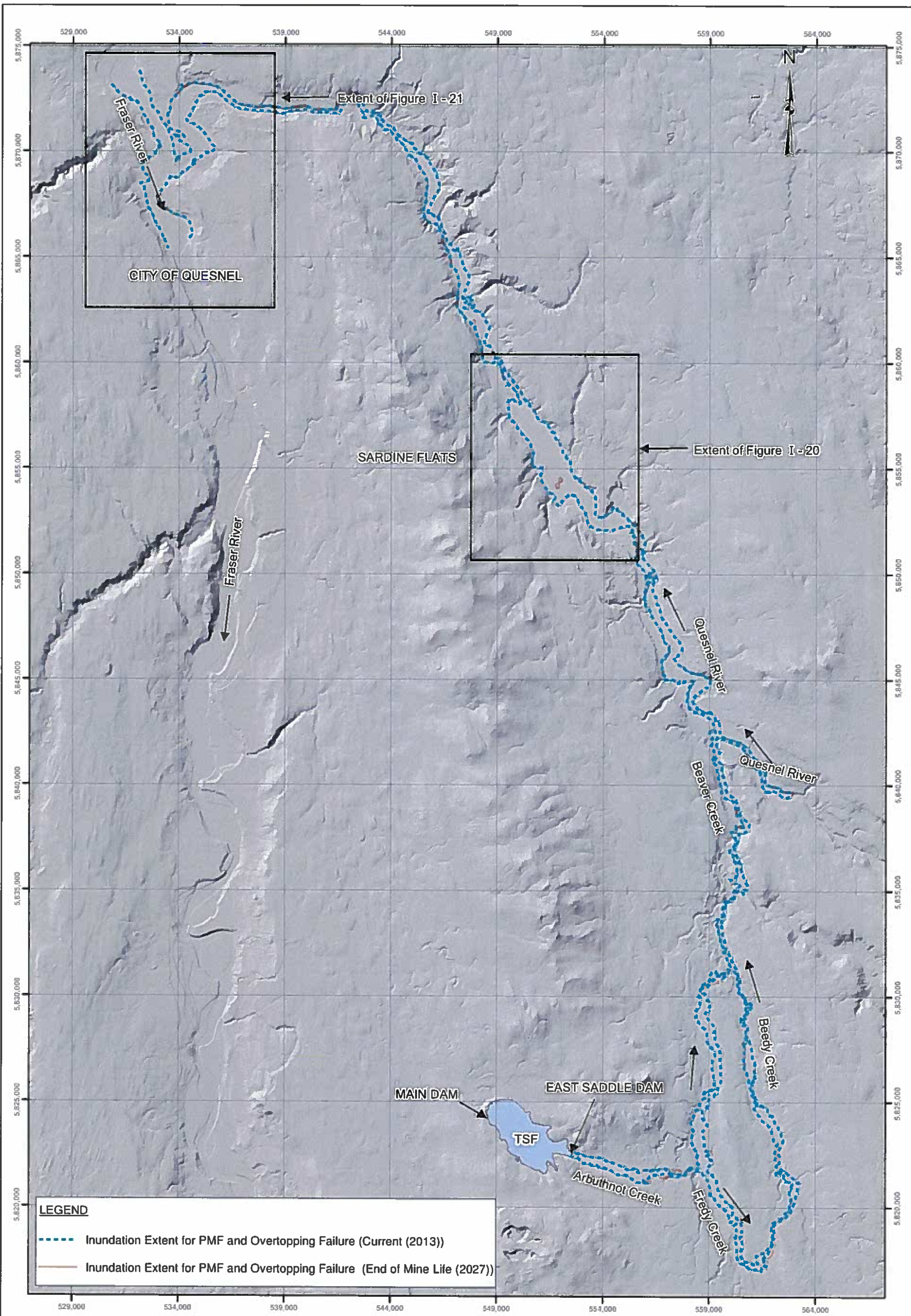


Figure I-18 Flow Hydrographs Along Flood Route – East Saddle Dam Overtopping Failure Base Case, End of Mine Life (2027)



NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE
TSF EMERGENCY PREPAREDNESS PLAN

TITLE: ESTIMATED FLOOD INUNDATION EXTENTS - OVERTOPPING FAILURE BASE CASE

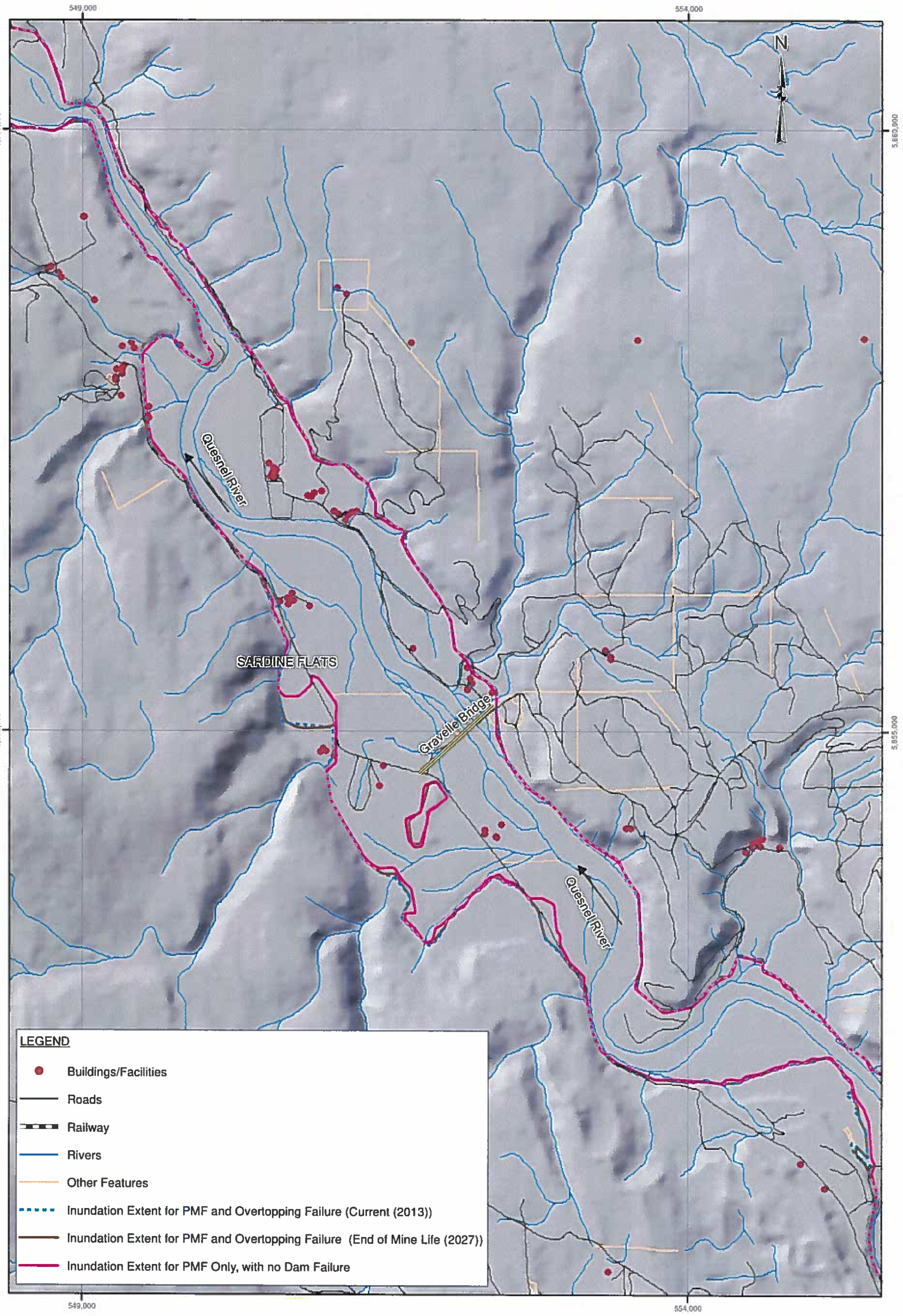
PROJECT No. M01527A68

FIG No. I - 19

NOTES:

DATA SOURCE:
BASE MAP: TRIM POSITION MAP, BC

OEC
Z:\MVCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\GIS\Mxd\NewMxds\Figure I_19.mxd



NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

CLIENT: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE
TSF EMERGENCY PREPAREDNESS PLAN

TITLE: ESTIMATED FLOOD INUNDATION EXTENTS, SARDINE FLATS OVERTOPPING FAILURE BASE CASE

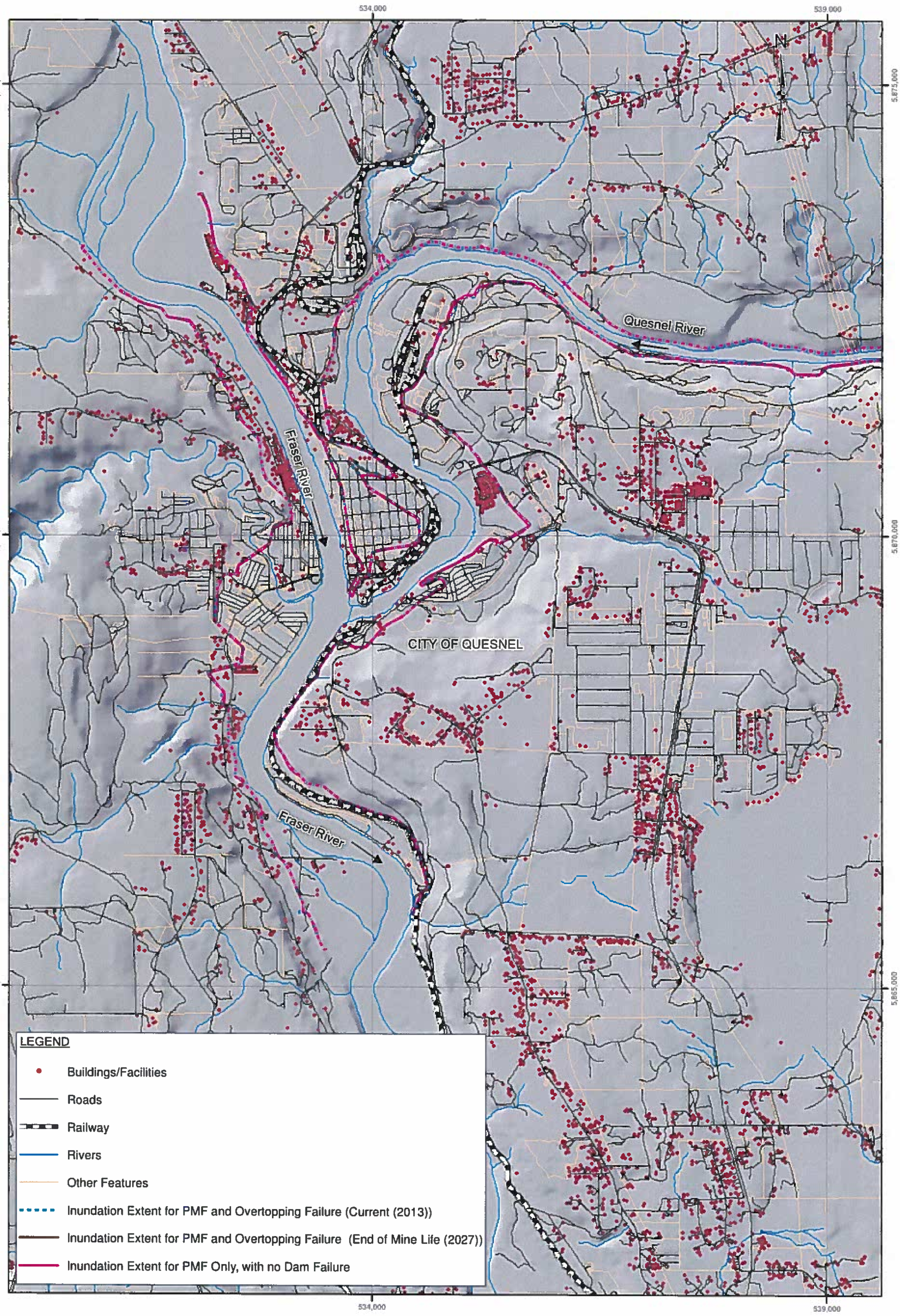
PROJECT No. M01527A68

FIG No. I - 20

NOTES:

DATA SOURCE:
BASE MAP TRIM POSITION MAP, BC

OEC
Z:\M\VCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\GIS\Mxd\NewMxds\Figure I_20.mxd



NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE TSF EMERGENCY PREPAREDNESS PLAN

TITLE: ESTIMATED FLOOD INUNDATION EXTENTS, CITY OF QUESNEL OVERTOPPING FAILURE BASE CASE

PROJECT No. M01527A68

FIG No. I - 21

NOTES:

DATA SOURCE:
BASE MAP: TRIM POSITION MAP, BC

OEC
Z:\MVCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\GIS\Mxd\NewMxds\Figure I_21.mxd

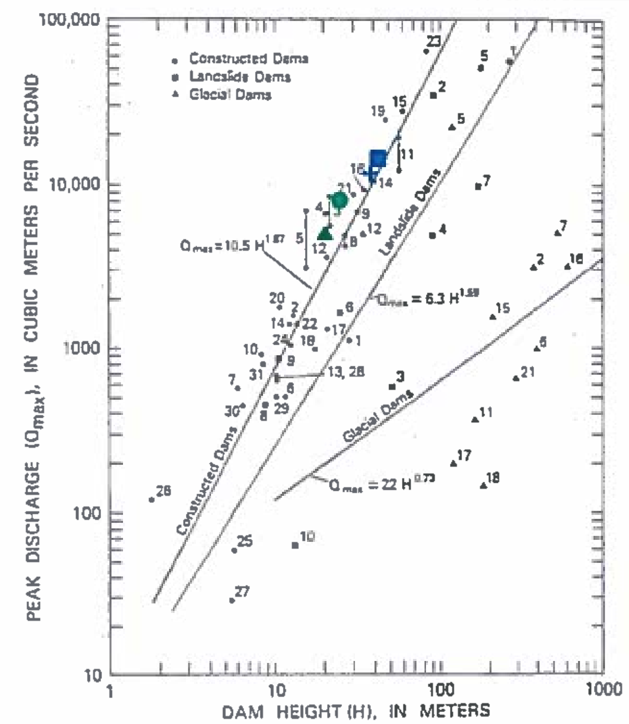


Figure 4. Graph showing dam height (H, in meters) versus peak discharge (Q_{max} in cubic meters per second) for constructed, glacial, and landslide dams with numbers keyed to tables 3, 5 and 6.

(a)

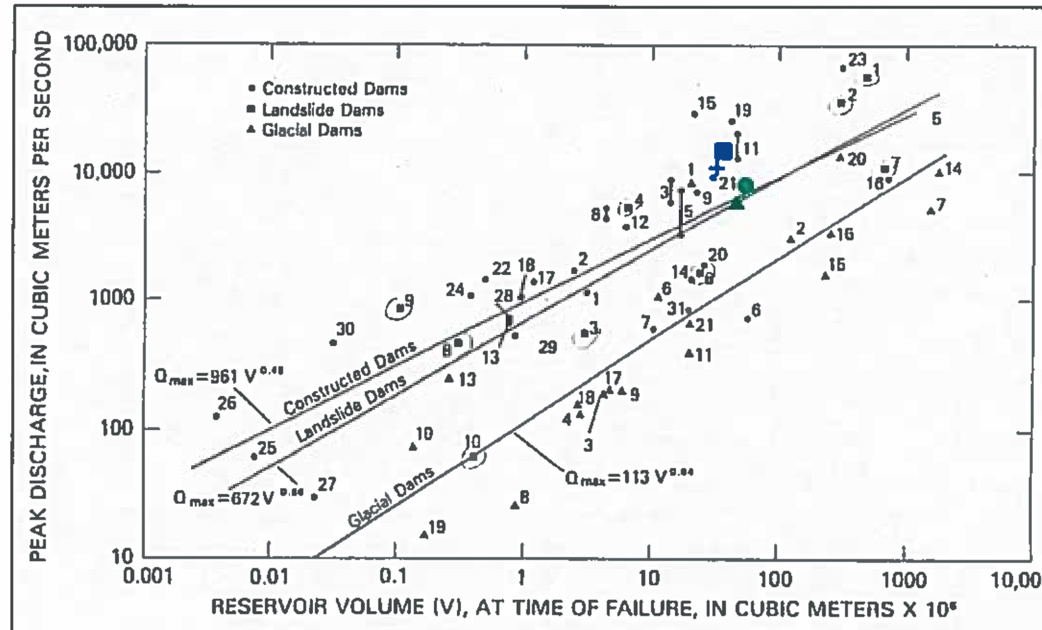
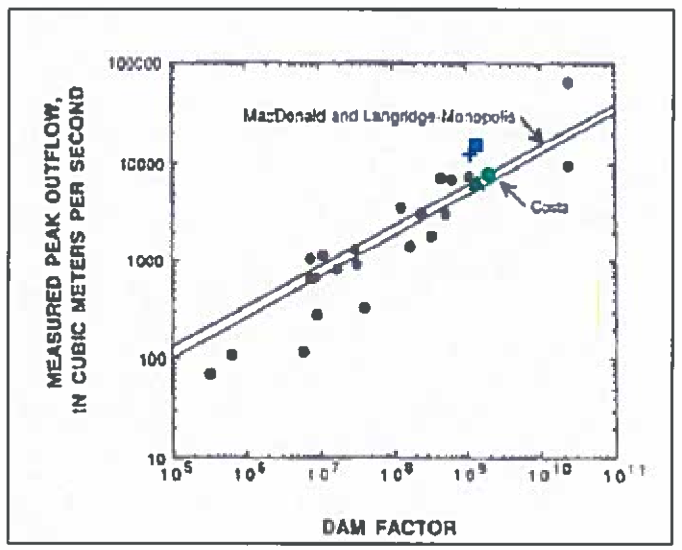


Figure 5. Graph showing reservoir volume (V, in $m^3 \times 10^6$) versus peak discharge (Q_{max} in cubic meters per second) for constructed, glacial, and landslide dams with numbers keyed to tables 3, 5 and 6.

(b)



(c)

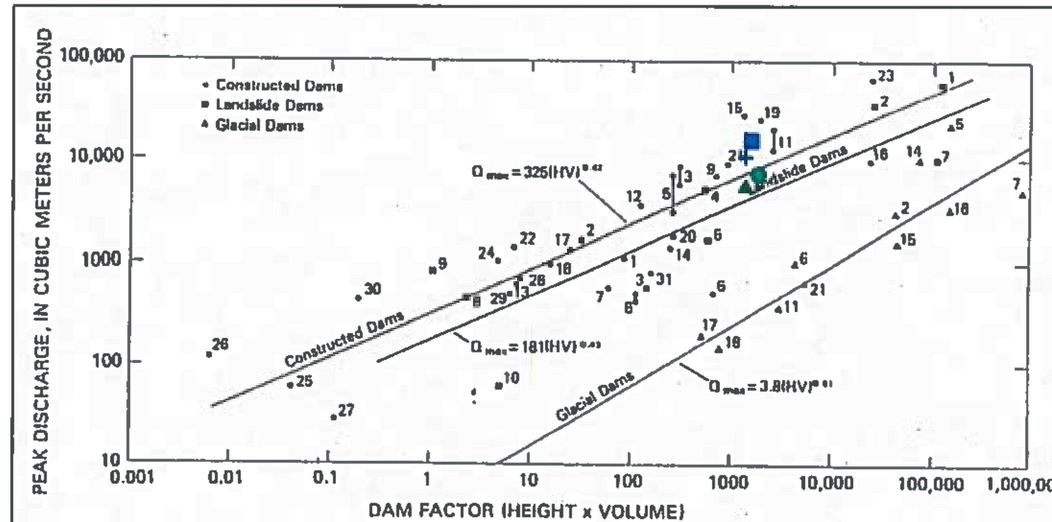


Figure 7. Graph showing dam-factor (H x V) versus peak discharge (Q_{max}) for 29 dam failures with numbers keyed to table 3, 5 and 6.

(d)

LEGEND

- ▲ BASE CASE PIPING–CURRENT (2013) SCENARIO
- ● BASE CASE OVERTOPPING–CURRENT (2013) SCENARIO
- + BASE CASE PIPING–END OF MINE LIFE (2027) SCENARIO
- ■ BASE CASE OVERTOPPING–END OF MINE LIFE (2027) SCENARIO

SCENARIO	WATER DEPTH (m)	STORED VOLUME ($10^6 m^3$)	DAM FACTOR (Costa)	DAM FACTOR (Froehlich)	PEAK OUTFLOW (m^3/s)
CURRENT (2013) – PIPING	23.0	55.4	1274	1.3×10^9	4800
CURRENT (2013) – OVERTOPPING	27.1	73.6	1995	2.0×10^9	7900
END OF MINE LIFE (2027) – PIPING	39.6	29.6	1172	1.2×10^9	10600
END OF MINE LIFE (2027) – OVERTOPPING	44.2	39.1	1728	1.7×10^9	16200

References:

(a),(b),(d) Costa JE. 1985. "Floods from Dam Failures", Open File Report No. 85-560, United States Department of the Interior, USGS. Denver, Colorado.
(c) Froehlich DC. 1995. "Peak Outflow from Breached Embankment Dam", Journal of Water Resources Management, Volume 121, No. 1.

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

CLIENT: Taseko Gibraltar

Klohn Crippen Berger

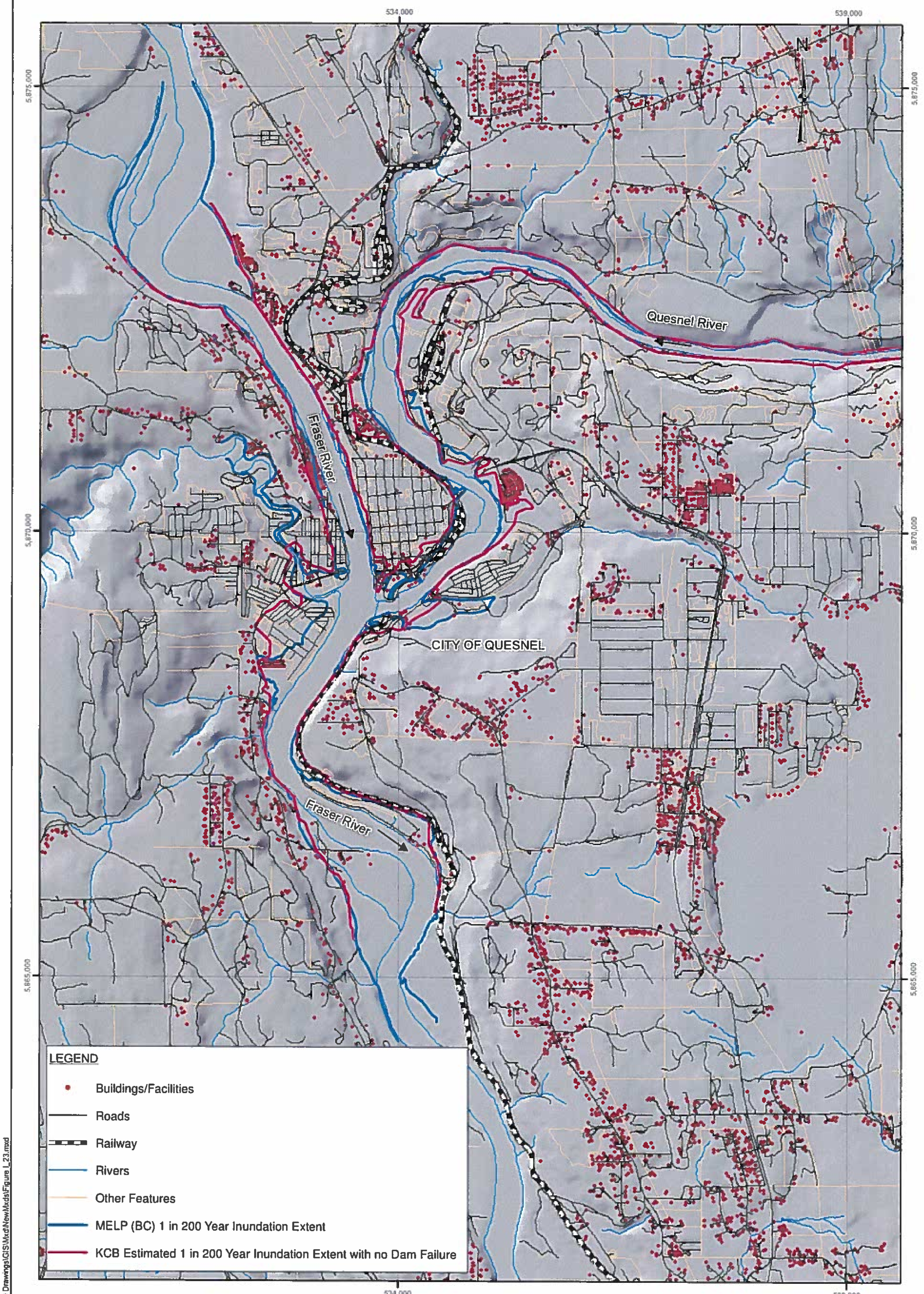
PROJECT: GIBRALTAR MINE TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: BREACH OUTFLOW RESULTS COMPARED TO EMPIRICAL RELATIONS

PROJECT No. M01527A68

FIG. No. I-22

Time: 10:42:54
Date: 2/1/2013
Scale: 1:2.5849(PS)
Drawing File: Z:\M\VCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\CAD\MEMO\FIG_I-22_A.dwg (rewang)
Xref File(s):
Image File(s): Fig 4 Fig 5 Fig 7 Figure Gibraltar Mines _new



NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE
TSF EMERGENCY PREPAREDNESS PLAN

TITLE: COMPARISON WITH MELP 1 IN 200 YEAR FLOODPLAIN MAP

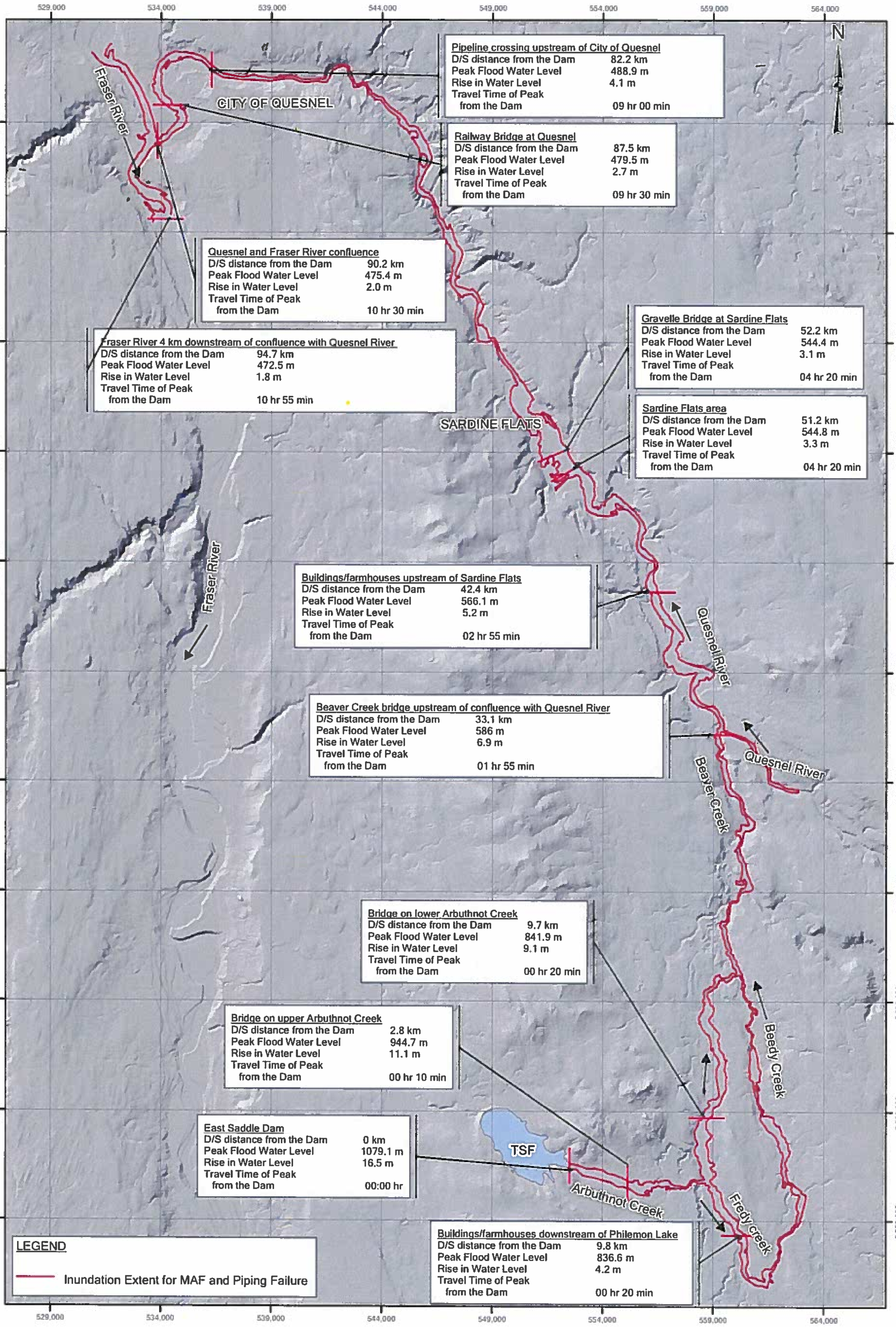
PROJECT No. M01527A68

FIG No. I-23

NOTES:

DATA SOURCE:
1. BASE MAP:TRIM POSITION MAP, BC
2. MELP INUNDATION EXTENT:BC, 1992

OEC
Z:\MVCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\GIS\Mxd\NewMxds\Figure I_23.mxd



0 2,000 Meters

0 10,000 Feet

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE TSF EMERGENCY PREPAREDNESS PLAN

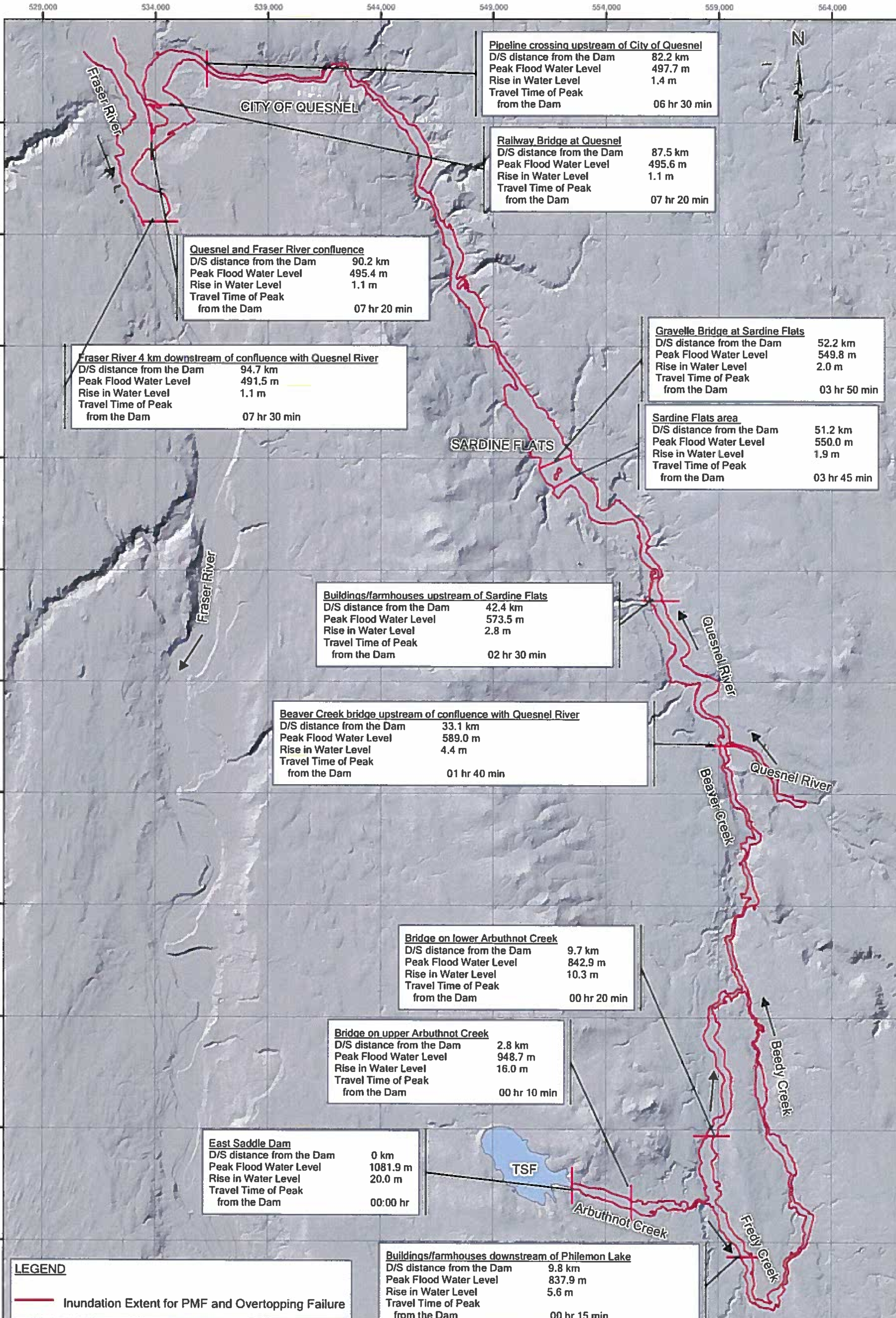
TITLE: EAST SADDLE DAM PIPING FAILURE BASE CASE INUNDATION DETAILS

PROJECT No. M01527A68

FIG No. I - 24

NOTES:
1. DATA SOURCE: BASE MAP: TRIM POSITION MAP, BC
2. INUNDATION EXTENT FROM WORST CASE OF CURRENT (2013) AND END OF MINE LIFE (2027) MODEL RUNS
3. FLOOD ARRIVAL TIME FROM END OF MINE LIFE (2027) MODEL RUN
4. RISE IN WATER LEVEL IS CHANGE IN WATER LEVEL ABOVE PMF

DEC
Z:\MVCRM01527A68 - Gibraltar-TSF Emerg\400 Drawings\GIS\Mxd\NewMxds\Figure I_24.mxd



0 2,000 Meters

0 10,000 Feet

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

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: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE TSF EMERGENCY PREPAREDNESS PLAN

TITLE: EAST SADDLE DAM OVERTOPPING FAILURE BASE CASE INUNDATION DETAILS

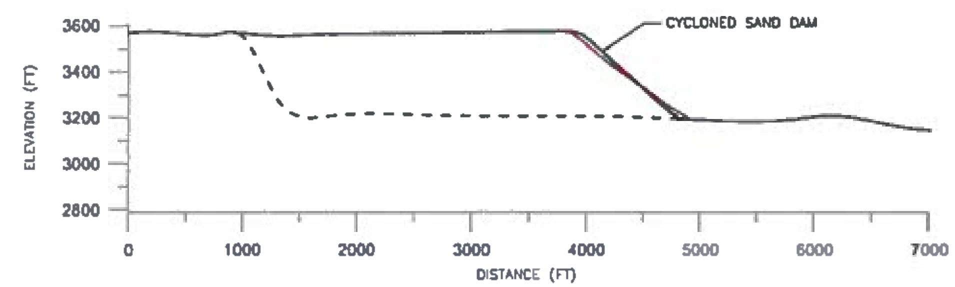
PROJECT No. M01527A68

FIG No. I - 25

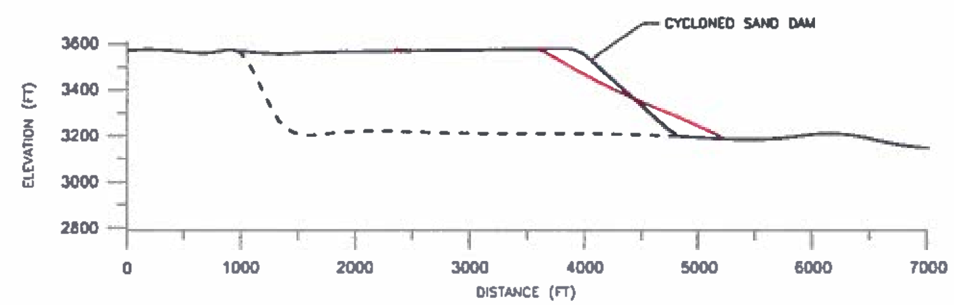
NOTES:

1. DATA SOURCE: BASE MAP: TRIM POSITION MAP, BC
2. INUNDATION EXTENT FROM WORST CASE OF CURRENT (2013) AND END OF MINE LIFE (2027) MODEL RUNS
3. FLOOD ARRIVAL TIME FROM END OF MINE LIFE (2027) MODEL RUN
4. RISE IN WATER LEVEL IS CHANGE IN WATER LEVEL ABOVE PMF

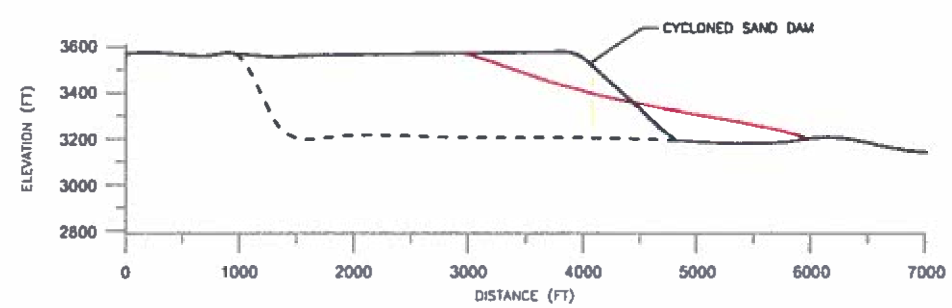
OEC Z:\MVCR\M01527A68 - Gibraltar-TSF Emerg\400 Drawings\GIS\Mxd\NewMxds\Figure I_25.mxd



Scenario 1 - "Upper Bound" - $S_r / \sigma_{vo}' = 0.15$
(Note: 2x Vertical Exaggeration)



Scenario 2 - "Lower Bound" - $S_r / \sigma_{vo}' = 0.10$
(Note: 2x Vertical Exaggeration)



Scenario 3 - "Extreme Lower Bound" - $S_r / \sigma_{vo}' = 0.06$
(Note: 2x Vertical Exaggeration)

LEGEND:

- - - - - - FAILURE SURFACE
—— PRE–RUNOUT
—— POST–RUNOUT

NOTE:

MODELLED SECTION EXTEND ALONG SECTION A–A ON FIGURE I–27

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

CLIENT: Taseko Gibraltar

Klohn Crippen Berger

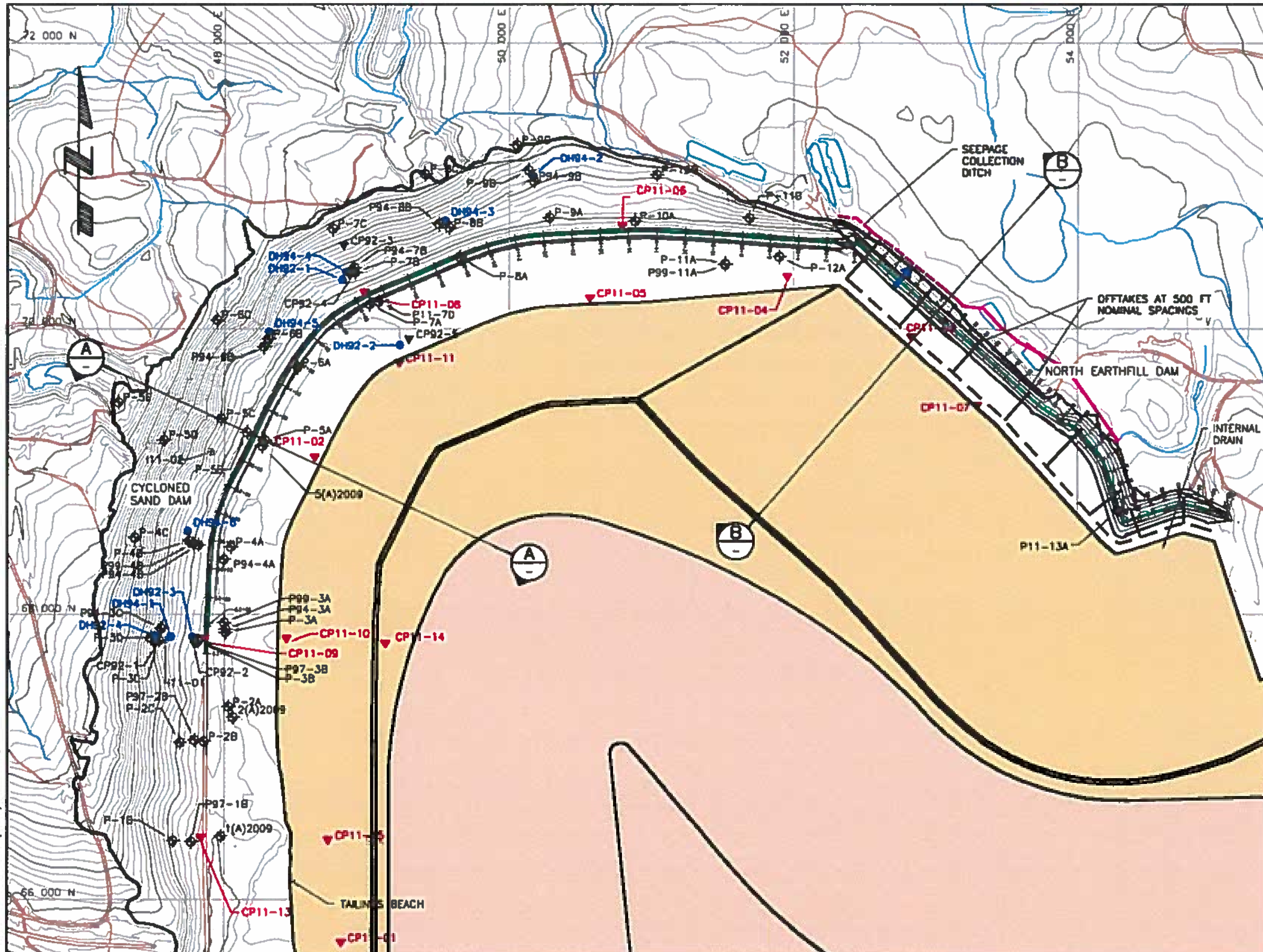
PROJECT: GIBRALTAR MINE TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: CYCLONED SAND DAM TAILINGS RUNOUT ASSESSMENT DETAILS

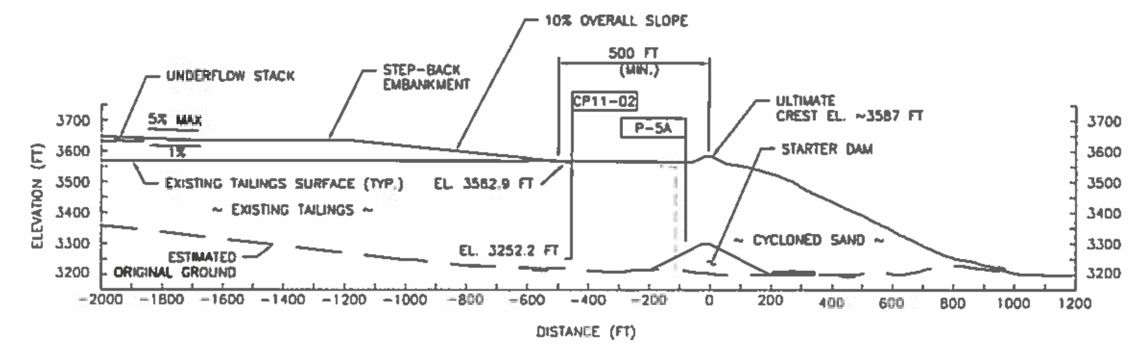
PROJECT No. M01527A68

FIG. No. I–26

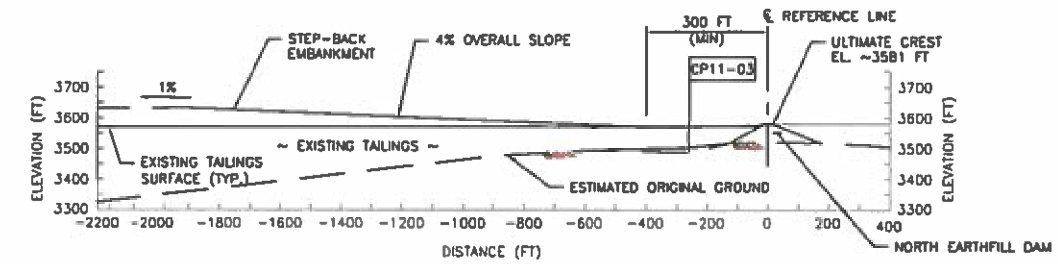
Date:6/21/2012 Time:13:43:37 Scale: 1:2
Filename: Z:\M\VCR\M01527A68 - GIBRALTAR-TSF EMERG\400 DRAWINGS\CAD\MEMO\FIG_I-26_RA.DWG
Xref File(s):
Image File(s): Gibraltar Mines _new Scenario 1 (0.15) - Profile Scenario 2 (0.10) - Profile Scenario 3 (0.06) - Profile



PLAN
SCALE A



SECTION A
SCALE B



SECTION B
SCALE B

SCALE A 0 — 1000 FT

SCALE B 0 — 800 FT

NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN FEET UNLESS NOTED OTHERWISE.
2. COORDINATES OF INCLINOMETERS INSTALLED IN 2011 WERE MEASURED USING A HANDHELD GPS UNIT.

LEGEND

- I11-01 — 2011 BOREHOLE (WITH INCLINOMETER AND VIBRATING WIRE PIEZOMETER)
- P11-7D — BOREHOLE (WITH PIEZOMETER)
- TP12-01 — 2012 TEST PIT
- CP11-01 — 2011 CONE PENETRATION TEST HOLE
- CP92-01 — 1992 CONE PENETRATION TEST HOLE
- DH92-1 — 1992/1994 DRILL HOLE
- INTERNAL DRAIN
- TILL
- STEP-BACK EMBANKMENT (CYCLONED SAND)
- UNDERFLOW STACK (CYCLONED SAND)
- TAILINGS POND
- RIPRAP CHANNEL
- SEEPAGE COLLECTION DITCH

NOT FOR CONSTRUCTION

TO BE READ WITH KLOHN CRIPPEN BERGER REPORT DATED FEBRUARY 2013

CLIENT: Taseko Gibraltar

Klohn Crippen Berger

PROJECT: GIBRALTAR MINE TAILINGS FACILITY EMERGENCY PREPAREDNESS PLAN

TITLE: CYCLONED SAND DAM AND NORTH EARTHFILL DAM PLAN AND SECTIONS

PROJECT No. M01527A65

FIG. No. I-27

Date:6/21/2012 Time:13:43:37 Scale: 1:2
Filename: Z:\M\VCR\M01527A68 - GIBRALTAR-TSF EMERG\400 DRAWINGS\CAD\MEMO\FIG_I-27_RA.DWG
Xref File(s): BM GIBRALTAR MAY 2012_OL.dwg
Image File(s): Gibraltar Mines _new Scenario 1 (0.15) - Profile Scenario 2 (0.10) - Profile Scenario 3 (0.05) - Profile

APPENDIX II

October 2004 Site Reconnaissance Photographs

Appendix II
October 2004 Site Reconnaissance Photographs

Photo II-1 Gibraltar tailings pond, looking towards Main Tailings Dam.

Photo II-2 Main Tailings Dam as seen from north side of tailings pond.

Photo II-3 East Saddle Dam as seen from downstream.

Photo II-4 East Saddle Dam as seen from north abutment.

Photo II-5 Arbuthnot Creek below East Saddle Dam, looking downstream.

Photo II-6 Fredy Creek, looking downstream about 2 km southwest of Philmon Lake.

Photo II-7 Looking downstream at Beedy Creek. Skelton Lake in background.

Photo II-8 Beedy Creek downstream of Arbuthnot Creek.

Photo II-9 Beaver Creek, looking downstream near the falls at the old diversion weir.

Photo 10 Beaver Creek bridge upstream of Beaver Creek and Quesnel River confluence, as seen from left bank.

Photo II-11 Beaver Creek looking downstream from Beaver Creek bridge.

Photo II-12 Quesnel River, looking downstream below the Beaver Creek confluence.

Photo II-13 **Quesnel River upstream of Gravelle Ferry. Photo shows steep, eroding bank on right side of river.**

Photo II-14 **Gravelle bridge across Quesnel River, as seen from right bank.**

Photo II-15 Gravelle bridge across Quesnel River as seen from left bank.

Photo II-16 Gravelle bridge as seen from left bank. Note triangular steel ice breakers upstream of bridge.

Photo II-17 Quesnel River through Sardine Flats, looking upstream.

Photo II-18 Quesnel River in Sardine Flats area.

Photo II-19 Quesnel River upstream of Quesnel, looking upstream.

Photo II-20 Quesnel River at power transmission line crossing.

Photo II-21 Pipeline crossing on Quesnel River at eastern municipal boundary of City of Quesnel.

Photo II-22 Powerline and pipeline crossing on Quesnel River at eastern municipal boundary of City of Quesnel.

Photo II-23 Quesnel River at City of Quesnel downstream of pulp mill, looking downstream.

Photo II-24 Right bank of Quesnel River approximately 0.8 km upstream of Highway 97. Quesnel River channel in foreground and Fraser River at mid-photo.

Photo II-25 **Quesnel River, looking upstream. Highway 97 bridge in foreground, railway bridge at mid-photo.**

Photo II-26 **City of Quesnel as seen from left bank of Quesnel River upstream of Highway 97.**

Photo II-27 **Quesnel River, looking downstream at confluence with Fraser River. Johnston Ave. bridge and railway bridge upstream of confluence.**

Photo 28 **City of Quesnel, looking downstream at Fraser River. Carson Ave. and Marsh Dr. bridges can be seen at mid-photo.**

Photo II-29 Railway bridge across Quesnel River upstream of Highway 97, looking upstream from left bank. Note pipeline strung along the side of bridge.

Photo II-30 Highway 97 bridge on Quesnel River, looking upstream from left bank.

Photo II-31 Highway 97 bridge on Quesnel River, looking upstream from left bank.

Photo II-32 Looking upstream at Quesnel River from Johnston Ave. bridge.

Photo II-33 Johnston Ave. bridge across the Quesnel River, looking upstream from right bank.

Photo II-34 Railway bridge across the mouth of the Quesnel River, as seen from right bank of Fraser River.

Photo II-35 Railway bridge at the mouth of the Quesnel River, as seen from the right bank of the river. Flow is left to right.

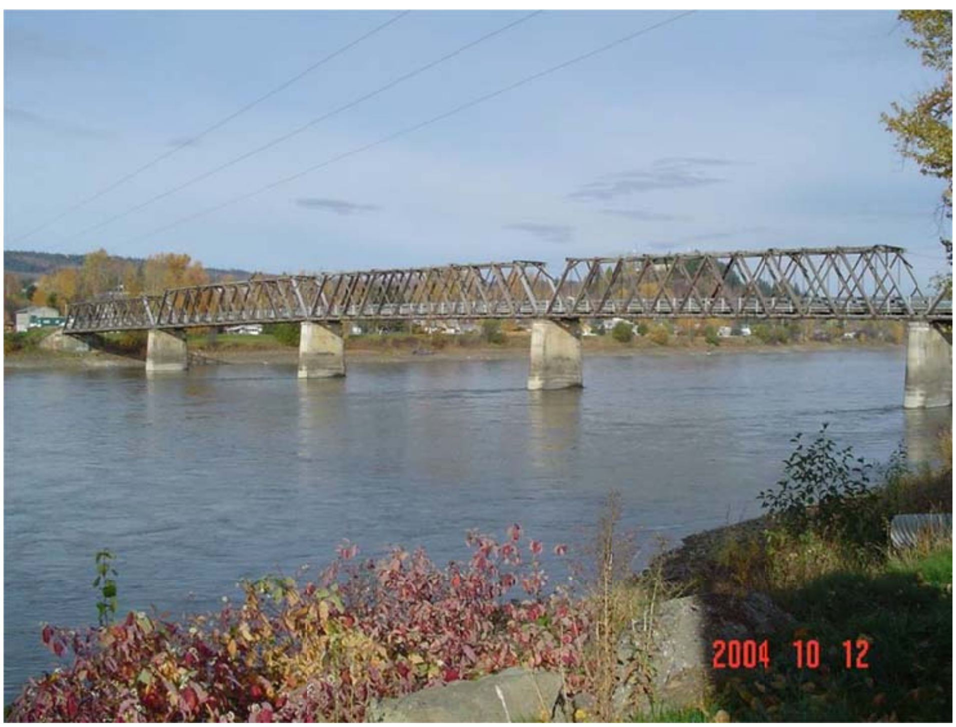


Photo II-36 Carson Ave. pedestrian bridge across Fraser River, looking upstream from left bank.

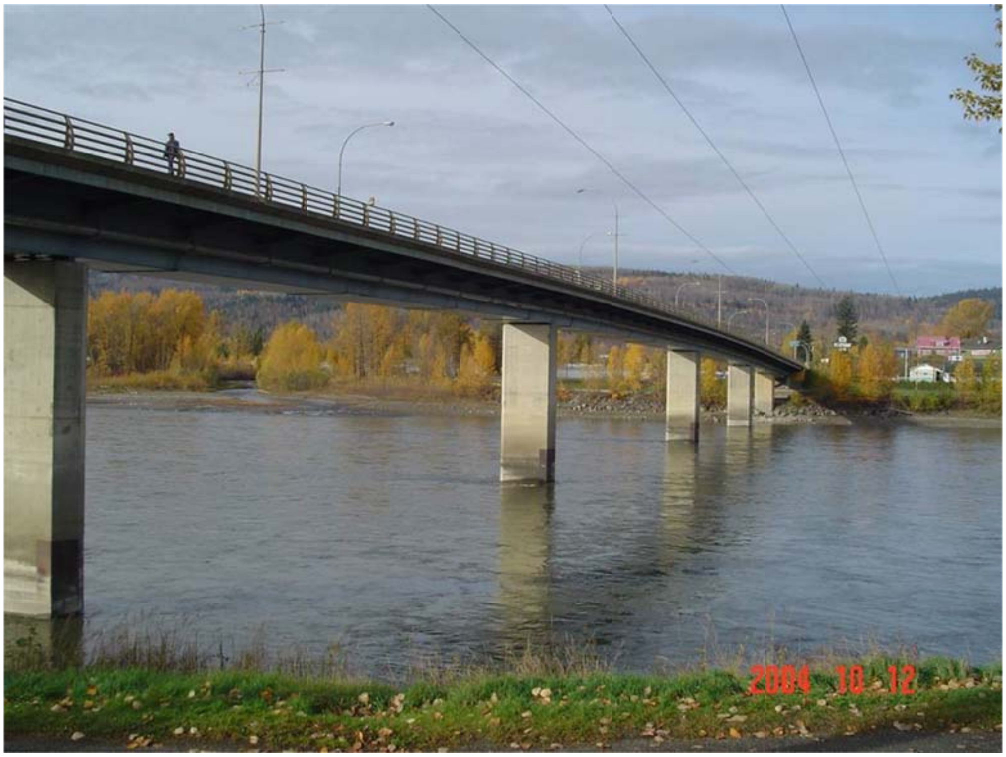


Photo II-37 Marsh Dr. bridge across Fraser River, as seen from left bank.

Photo II-38 Fraser River looking upstream from Carson Ave. pedestrian bridge.

Photo II-39 Typical wooden bridge on local roads.