Appendix 3-F

Jacko Lake and Peterson Creek Downstream Pond Engineering – Preliminary Design

AJAX PROJECT

Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study

Jacko Lake and Peterson Creek Downstream Pond Engineering – Preliminary Design – Rev 0

Submitted to:
KGHM Ajax Mining Inc.

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C135-KA39-RPT-00-003

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Approver: [signature]	Date: 28 Aug 15	

KGHM review of consultant's drawings shall in no manner alleviate the consultant from their responsibility as engineer of record. The review or approval of Consultant's drawings does not constitute confirmation of satisfaction of waiver of any term of Consultant's work. These drawings remain the responsibility of Consultant.

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EXECUTIVE SUMMARY

The Ajax Mine Project is a copper-gold project located near Kamloops British Columbia. The development of the resource will be by open pit mining methods at milled rate of 65,000 tonnes per day over an approximate 20 year mine life. Several water management structures are required to be in place prior to production within Jacko Lake and Peterson Creek in order to facilitate the current mine plan. These include engineered dams on Jacko Lake (JLD1 to JLD4) and Peterson Creek Downstream Pond, a diversion system (Peterson Creek Diversion System) and a new pond within Peterson Creek (Peterson Creek Downstream Pond). This report outlines the preliminary design for the Jacko Lake and Peterson Creek water management structures in support of further engineering design and environmental permitting.

The Ajax site is located within the semi-arid steppe climate of the South-Central Interior of British Columbia, and is characterised by generally low annual precipitation and high evaporation. Rainfall runoff values within the proposed watershed are relatively low compared to most other areas of BC due to in part the extremely dry and absorbent soils. Jacko Lake and the Peterson Creek Downstream Ponds have catchment areas of approximately 40 km^2 and 103 km^2, respectively. A review of the regional hydrology was undertaken and the Probable Maximum Precipitation (PMP) value was determined to be 226mm for the area. Inflow design floods corresponding to the Probable Maximum Flood (PMF) were used for the preliminary design of both Jacko Lake dams and the Peterson Creek Downstream Pond.

Jacko Lake comprises four small engineered dams each having a crest elevation of 895.5m during operations and designed to contain the PMF. Allowances for wave run-up and additional freeboard were also made to determine dam crest elevations. The Jacko Lake dams are classified as a “Very High” consequence structures according to the Canadian Dam Safety Guidelines (CDA, 2013). The normal water level of Jacko Lake will be maintained at 892.0m using the pumping and diversion system (design by others) which pumps Jacko Lake water to the Peterson Creek Downstream Pond. West Dam (JLD3) is located on a catchment divide between the Jacko Lake and Inks Lake watersheds and has a maximum height of 3.5m. Northeast Dam (JLD2) and the southeastern dams (JLD4and JLD1) are located on the east side of Jacko Lake closest to the open pit and range up to 6.3m in height. Engineered fill sourced from local borrow will be used to construct the dams. Allowance has been made for an emergency spillway on the southeast arm to divert unforeseen flood water into the open pit area. An existing dam along the southeast arm will be removed after construction of the dam on the southeast arm. Removal of the existing Kinder Morgan pipeline and construction of the Northeast Dam (JLD2) necessitates the use of a temporary shoring system which requires further consideration during the detailed design phase of the project.

Peterson Creek Downstream Pond comprises a lined impoundment and dam structure with a capacity of 68,000m^3. The dam is a low height broad-crested overflow weir with a downstream spillway chute that discharges into Peterson Creek. Peterson Creek Downstream Pond is classified as a "High" consequence structure according to the Canadian Dam Safety Guidelines (CDA, 2013). A low level decant provides flow control for downstream licensees.

Upon closure, the diversion system will be removed with flow re-established close to the current Peterson Creek alignment by constructing a closure channel south of the proposed open pit. The closure channel will carry flow back to the natural Peterson Creek drainage. Jacko Lake dams will be left in place with modifications to west of the Southeast Dam (JLD1) to allow flow into the closure channel. Pit backfill will be available to buttress the west side of the open pit in order to provide long term stability of Jacko Lake. Peterson Creek Downstream Pond will be left in place at closure and will be operated by the British Columbia Water Steward.

Key items to be addressed during the next phase of design are listed below:

- Completing planned site investigations to further define foundation stratigraphy between Jacko Lake and the open pit, beneath the Jacko Lake dams, and beneath the Peterson Creek Downstream Pond.
- Integrate Jacko Lake operational and closure designs with the pit slope and backfill design.
- Integrate Peterson Creek closure channel designs with the pit slope and backfill design.
- Undertake detailed stability and seepage analyses for the Jacko Lake dams and the Peterson Creek Downstream Pond.
- Undertake a Failure Modes and Effects Analysis (FMEA) for pit slope interaction with the lake, dams and re-constructed Peterson Creek channel at closure.
- Review and optimise key construction methodologies:
    - Kinder Morgan pipeline removal and Northeast Dam (JLD2) construction.
    - Removal of the existing Jacko Lake dam.
- Develop operational and long term (closure) monitoring plans.

1 INTRODUCTION

KGHM Ajax Mining Inc. (KAM) retained Norwest Corporation (Norwest) to complete the engineering design for Jacko Lake and Peterson Creek Downstream Pond dams for the Ajax Project in support of their EA application. The contract to complete the work was awarded to Norwest on November 28, 2015 under contract # KA39-KGHM-CON-000135.

The reporting structure used to develop this design report is as follows:

- Data developed by others was provided by KAM's engineering manager, Daniel Lefebvre to support the dam designs.
- The geology review, geotechnical analyses and report preparation was completed by Norwest's senior geotechnical engineer, Christopher Klassen, P.Eng..
- The hydrological evaluation analyses was completed by senior water resource engineer, Brian LaCas, P.Eng.
- The design provided in this report was reviewed by Sean Ennis, P.Eng., P.E.

1.1 Project Description

The Ajax Mine is a copper-gold project located near Kamloops British Columbia. The project site is located in the South-Central Interior of British Columbia, southeast of the junction of the Trans-Canada Highway No. 1 and the Coquihalla Highway (No. 5), within the Thompson Nicola Regional District. The development of the resource will be by open pit mining methods over an approximate 20 year mine life. Tailings will be managed in a Tailings Storage Facility (TSF) located south of the deposit. Mine rock from open pit operations will be stored in mine rock storage facilities located to the east (EMRSF) and south (SRMSF and MRSF) of the deposit. The south mine rock storage facility (SMRSF) and the west mine rock storage facility (WMRSF) are integrated into the downstream zone of the TSF embankments.

Prior to production, it is planned to construct a number of water management structures within Jacko Lake and Peterson Creek in order to facilitate the current mine plan. These include engineered dams on Jacko Lake, a diversion system and a new pond within Peterson Creek. The new dams at Jacko Lake are required to provide flood containment on the northeastern, southeastern and western arms during operations. The diversion system (design by others) will provide baseline flow as well as route surplus water within Jacko Lake around the mine site and discharge into Peterson Creek at a point downstream of key mine facilities. A new pond will also be constructed within the Peterson Creek drainage to capture discharge from the diversion system for release to downstream water licensees. The new pond will include a dam structure with low level flow control and will be operated to meet the requirements set by the British Columbia Ministry of Environment (Water Management and Stewardship Branch).

A general arrangement of the proposed Jacko Lake dams and Peterson Creek Downstream Pond is presented on drawing C135-KA39-5600-00-002.

1.2 Scope of Work

This report outlines the preliminary design for the Jacko Lake and Peterson Creek water management structures in support of further engineering design and environmental permitting. Design of the pumping and diversion system will be carried out by others. The work includes the baseline hydrology design for stormwater storage in Jacko Lake, setback criteria for the open pit, preliminary designs for four small dam structures on the lake, and preliminary design of a pond and overflow structure within Peterson Creek. There is also a conceptual layout for re-locating Peterson Creek at the end of mining.

1.3 Data Sources

A summary of the key data, existing infrastructure, and planned infrastructure used for the preliminary design study is presented in Table 1.1.

Table 1.1
Summary of Key Data Sources for Preliminary Design Study

Type	Item	Date Received (Source)
Survey Data	Topography Survey (April 2013)	4-Nov-2014 (KGHM)
	Bathymetry Survey (Final)	13-Jan-2015 (KGHM)
	Existing Drainage	16-Dec-2014 (KGHM)
Site Investigation Information	Jacko Lake Hydrogeology Assessment, Site Investigation Draft Report (Klohn Crippen Berger, 2014)	3-Dec-2014 (KGHM)
Existing Infrastructure	Existing Kinder Morgan Pipeline Route	4-Nov-2014 (KGHM)
	Existing Jacko Lake Southeast dam survey	4-Dec-2014 (KGHM)
Planned Infrastructure	Peterson Creek Diversion System	21-Oct-2014 (KGHM)
	General Site Infrastructure	30-Oct-2014 (KGHM)
	Proposed Kinder Morgan Pipeline Route	4-Nov-2014 (KGHM)
	Property Boundaries	16-Dec-2014 (KGHM)
	Open Pit (based on November 2014 mine plan)	20-Feb-2015 (KGHM)

2 SITE CHARACTERISTICS

2.1 General

The Ajax Mine Site is accessed by the old Afton mine haul road, which crosses the Lac Le Jeune Highway approximately 8.3 km south of the intersection of Lac Le Jeune Road and Copperhead Drive off of Highway 1, west of Kamloops. Currently, the common land use in the area is ranching. Surface rights are privately owned, and the main water bodies at the area are Jacko, Inks, Goose and Wallender lakes. The lakes are reserved for ranching and recreation. The Ajax area consists of rolling grasslands with timber at the higher elevations. Elevations range from 800 to 1100 masl. Sugarloaf Hill is the prominent landform in the area and has an elevation of 1130 masl. The area has been glaciated and numerous drumlins are present. At lower elevations, the vegetation is typically bunchgrass, sagebrush, and prickly pear cacti. Higher elevations commonly sustain growths of Lodge Pole Pine, Douglas Fir, and Ponderosa Pine.

2.2 Climate

The site is located within the semi-arid steppe climate of South-Central Interior of British Columbia. The climate of this region is characterized by the generally low annual precipitation and high evaporation resulting in relatively low inflow rates into the proposed water management structures. The winters are usually cool and dry and the summers hot and dry with relatively low humidity and high evaporation rates. Rainfall runoff values within the proposed watershed are relatively low compared to most other areas of BC due to in part the extremely dry and absorbent soils. There are several endorheic (closed) lakes in the vicinity; however Jacko Lake presently outflows to Peterson Creek at its south-eastern arm.

2.3 Hydrology

The following sections describe the local watershed characteristics along with key hydrology information used for the Jacko Lake and Downstream Pond preliminary designs. Detailed hydrology memorandums are presented in Appendices A1 and A2.

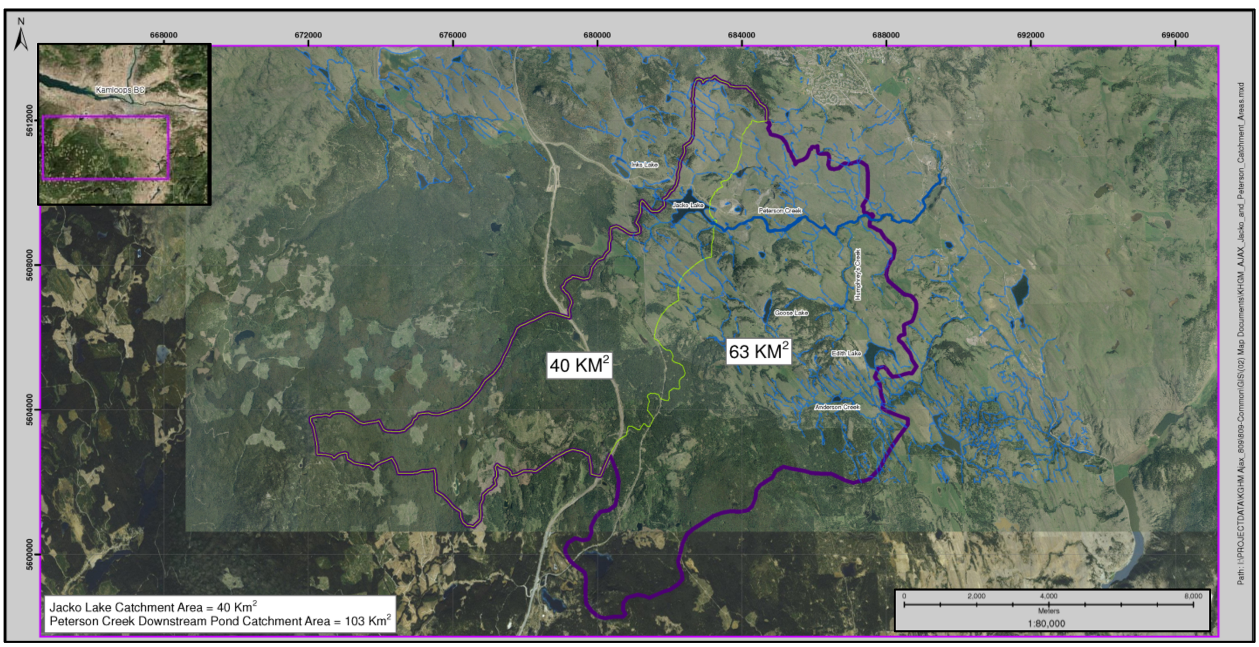
2.3.1 Jacko Lake Watershed

Jacko Lake collects runoff from the headwaters of Jacko Creek to the south and a smaller catchment north of Jacko Lake which drains into an unnamed creek, as shown on Figure 2.1. The total catchment area of Jacko Lake is approximately 40km^2. The outlet of Jacko Lake is controlled by an existing dam and overflow spillway (invert elevation 892 m), which discharges into Peterson Creek on the east side of the lake. At the dam location, there is also a low level outlet and concrete weir structure, which allows for regulated releases of water from Jacko Lake to Peterson Creek during periods when there is no flow over the spillway. The low level outlet is controlled by the British Columbia Water Steward, who releases water to the downstream licensees as required. The western arm is close to a catchment divide, with the adjacent catchment draining toward the Lac Le Jeune public access road and Inks Lake. A bathymetry survey of the lake was undertaken by Frontier Geosciences in the summer of 2014. The survey indicates the lake has a depth up to 25m. Storage filling curves for Jacko Lake is provided in Section 3.4.

2.3.2 Peterson Creek Downstream Pond Watershed

The main tributaries to Peterson Creek up to the proposed downstream pond location are from the Jacko Lake southeastern arm, and from Humphrey Creek to the south as shown on Figure 2.1. There is also a smaller catchment to the north. Headwaters of Humphrey Creek include Edith Lake, the level of which is controlled by an inlet diversion structure adjacent to Anderson Creek. The total catchment area of the Peterson Creek Downstream Pond watershed is approximately 103 km^2 and includes the Jacko Lake catchment area.

Figure 2-1
Jacko Lake and Peterson Creek Catchment Areas



2.3.3 Regional Climate Stations

Precipitation analyses were undertaken based on review of regional climate stations from the Meteorological Services of Canada shown on Table 2.1. The selected station for the precipitation frequency analysis was Kamloops A which has a short intensity duration frequency curve based on rainfall data from 1965 to 2013.

Table 2.1
Regional Climate Stations

Station No.	Name	Lat. / Long.	Elevation (masl)	Proximity (km)	Intensity Duration Frequency Curves	Record	Years
1163780	Kamloops A	50^{o} 42' N 120^{o} 26' W	345	12.61	Yes	1953 - 2013	61
1164LH5	Knutsford 2S	50^{o} 36' N 120^{o} 19' W	899	8.22	No	1986 - 1997	12
1163790	Kamloops Afton Mines	50^{o} 40' N 120^{o} 30' W	701	11.34	No	1977 - 1993	17
116C8P0	Kamloops Pratt Road	50^{o} 36' N 120^{o} 12' W	640	18.24	No	1986 - 2013	28
1124668	Logan Lake	50^{o} 30' N 120^{o} 49' W	1101	36.35	No	1971 - 2005	35

2.3.4 Probable Maximum Precipitation (PMP)

The Probable Maximum Precipitation (PMP) for was determined for Jacko Lake and the Peterson Creek Downstream Pond. It is generally defined as theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location at a certain time of the year. For the Jacko Lake and Peterson Creek catchments, the summer PMP was selected as the worst case scenario and using the information from the Rainfall Atlas for Canada from 1985. The PMP (the summer PMP in the current analysis) was determined using the Hershfield Method as recommended in the Rainfall Frequency Atlas for Canada (1985). However, since the reference was published in 1985, a comparison of the average maximum daily rainfall at Kamloops A station from 1965 to 1985 and that from 1965 to 2013 was determined. Results indicate that there is an increase in the maximum daily rainfall total by 7%, which was applied to the preliminary PMP. Furthermore, a slight elevation adjustment was made in this case to take into account the relatively higher elevation at Jacko Lake. The average elevation of the selected regional stations was used as the base elevation, and a 6% increase in the preliminary PMP was applied for every 100m increase in elevation. The resulting 24-hour Spring PMP and Summer-Autumn PMP for the Ajax Mine including was 125mm and 226mm respectively. A value of 226mm was used as the design 24-hr PMP for the site.

2.3.5 Regional Flood Frequency Analysis

A hydrometric analysis was carried out based on the review of regional hydrometric stations from the Water Survey of Canada as shown on Table 2.2. A number of regional stations were found, but local stations were either inactive or with limited peak flow data. Three regional hydrometric stations were selected for the current analysis in view of their close proximity to Jacko Lake, long periods of record, and comparable drainage areas. Peak flow data at the three hydrometric stations were used in a flood frequency analysis. Results from the flood frequency analysis were used in the regional analysis using the Index Flood Method.

Table 2.2

Regional Hydrometric Stations

Station No.	Name	D.A. (km^2)	Selected
08LB024	Fishtrap Creek Near Mclure	135	Y
08LB038	Blue River Near Blue River	272	
08LB069	Barriere River Below Sprague Creek	624	
08LB076	Harper Creek Near The Mouth	166	
08LC040	Vance Creek Below Deafies Creek	70.9	
08LE024	Eagle River Near Malakwa	932	
08LE027	Seymour River Near Seymour Arm	805	
08LE077	Corning Creek Near Squilax	26.2	Y
08LE108	East Canoe Creek Above Dam	20.8	Y
08LG008	Spius Creek Near Canford	775	
08LG016	Pennask Creek Near Quilchena	87.6	Y
08LG048	Coldwater River Near Brookmere	316	
08LG056	Guichon Creek Above Tunkwa Lake Diversion	78.2	Y

2.3.6 Probable Maximum Flood (PMF)

The Probable Maximum Flood (PMF) was determined for both Jacko Lake and the Peterson Creek Downstream Pond. The PMF is generally defined as the largest flood that may reasonably be expected to occur at a given point on a watercourse from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible on a particular watershed. This term identifies estimates of hypothetical flood characteristics that are considered to be the most severe "reasonably possible" at a particular location. This is based on relatively comprehensive hydrometeorological analyses of critical runoff-producing precipitation and hydrologic factors favorable for maximum flood runoff.

Regional relationships were applied between the catchment area and flood peak for Jacko Lake and the Peterson Creek Downstream Pond (which is within BC Southern Interior Hydrologic Zone 12B) based on the Probable Maximum Flood Estimator for British Columbia (2010). For the purpose of preliminary design, the PMF for Jacko Lake was estimated to be $63m^3/s$ with an associated run-off volume of approximately $0.8Mm^3$. The PMF for the proposed Peterson Creek Downstream Pond was estimated to be $153m^3/s$. Table 2.3 summarizes the design flood information used for the Jacko Lake and Peterson Creek Downstream Pond designs.

Table 2.3
Inflow Design Flood Information

Structure	Catchment Area (km^2)	Design Flood Volume (24hr-PMF) (Mm^3)	Design Peak Flow (24-hr PMF) (m^3/s)
Jacko Lake	40	0.8 (1)	63
Peterson Creek Downstream Pond	103	N/A (2)	153

1. Based on a PMF safety factor of 1.0.
2. Flood volumes to be passed through overflow spillway.

2.4 Regional Geology

The Ajax Project is located within the Thompson River watershed and the Thompson-Okanagan Plateau Ecoregion. Retreat of glacial ice during the Pleistocene resulted in a landscape of gently rolling plateaus, incised river valley systems and large glacial lakes such as Kamloops Lake and Okanagan Lake. The peaks in the vicinity of the Ajax property consist of rock, including areas of outcrop, and the valleys are characterized as morainal deposits consisting of drumlinized glacial till. Remnant glaciolacustrine deposits occur just north of the Afton pit and coarse colluvium deposits occur near Sugarloaf Hill. Three main rock units have been identified from 22 recognized rock types in the Ajax area. These main rock units are composed of the Iron Mask Hybrid, the Sugarloaf Diorite, and Nicola Volcanics.

2.5 Seismicity

The Kamloops region is characterized by a low level of historical seismicity. Seismic hazard values for the site are available from the Natural Resources Canada (NRC) website (NRC, 2010) for earthquakes up to the 1/2,475 return period. Firm ground peak horizontal ground accelerations and the associated return periods from NRC are summarized in Table 2.4 below. Seismic hazard values for greater return periods are not provided by Natural Resources Canada. A peak ground acceleration of 0.34g for the 1/10,000 year return period was reported by Knight Piésold for preliminary design of the nearby tailings storage facility (Knight Piésold, 2014). The 1/10,000 year earthquake was also reported by Knight Piésold to be the Maximum Credible Earthquake (MCE) for the Ajax site. For preliminary design purposes, Norwest have used the same seismic hazard values and MCE determination for consistency with other site structures (i.e. the tailings storage facility). A site specific seismic hazard assessment should be completed prior to detailed design to confirm these preliminary design assumptions.

Table 2.4
Ajax Seismic Hazard Values (1)

Earthquake Return Period (Years)	Annual Exceedance Probability (AEP)	Peak Ground Acceleration (g)
100	1%	0.034
475	0.21%	0.072
1,000	0.1%	0.097
2,475	0.0404%	0.138
10,000 (2)	0.01%	0.340 (2)

Notes:
1. Preliminary values. To be confirmed upon site specific seismic hazard assessment.
2. Based on values used by Knight Piésold for the preliminary tailings storage facility design.

2.6 Dam Classification

Following the revised 2007 Canadian Dam Safety Guidelines (CDA, 2013), the Jacko Lake dams and the Peterson Creek Downstream Pond are classified as “Very High” and “High” respectively.

Table 2.5 summarises the CDA dam classification and consequence description.

Table 2.5
Canadian Dam Association Classification

Structure	CDA Classification [1]
Jacko Lake Dams (JLD1 to JLD4)	"**VERY HIGH**" – consequences of failure includes loss of life of 100 or fewer, significant loss of *critical* habitat, and very high economic losses.
Peterson Creek Downstream Pond	"**HIGH**" – consequences of failure includes loss of life of 10 or fewer, significant loss of *important* habitat, and high economic losses.

1. As defined in the Canadian Dam Association Dam Safety Guidelines (CDA, 2013).

2.7 Design Criteria

Design criteria were developed in concert with project requirements and industry standards. A summary of the design earthquake, flood, storage and stability analyses criteria used for Jacko Lake and the Peterson Creek Downstream Pond are presented in Table 2.6.

Table 2.6
Key Design Criteria

Design Criteria	Jacko Lake	Peterson Creek Downstream Pond
Maximum Design Earthquake (MDE)	½ between 1/2475 and 1/10,000 year return period or Maximum Credible Earthquake (MCE), which corresponds to an PGA = 0.24g (for VERY HIGH dam classification)	1/2475 year return period (for HIGH dam classification) which corresponds to an PGA = 0.138g
Inflow Design Flood	Probable Maximum Flood (PMF) (1,2)	Probable Maximum Flood (PMF) (1,3)
Additional Storage Requirement	None	61,670m^3 (provided by KGHM)
Stability Analysis Factor of Safety Criteria	According to CDA guidelines (See Table 2.7)	

Notes:

1. Despite the differences in Jacko Lake (VERY HIGH) and Peterson Creek (HIGH) dam consequence classifications, these dams were designed for the most extreme design flood events, which is the highest design standard defined by CDA Dam Safety Guidelines.
2. A 'Very High' dam according to CDA guidelines requires an inflow design flood of 2/3 between the 1/1000 year event and the PMF.
3. A 'High' dam according to CDA guidelines requires an inflow design flood of 1/3 between the 1/000 year event and the PMF.

The dams at Jacko Lake and the Peterson Creek Downstream will be designed to meet minimum required factor of safety criteria as shown on Table 2.7. These factor of safety criteria are based on the revised 2007 Canadian Dam Association Dam Safety Guidelines (CDA, 2013).

Table 2.7

Slope Stability Design Criteria

Phase	Minimum Factor of Safety Criteria [1]
End of Construction	1.3
Long Term	1.5
Seismic (Pseudostatic Conditions)	1.0
Full/Partial Rapid Drawdown	1.2-1.3

1. As provided in the Canadian Dam Association Dam Safety Guidelines (CDA, 2013).

3 WATER MANAGEMENT PLAN

This section describes the preliminary water management plan for the Jacko Lake Dams and the Peterson Creek Downstream Pond. The dams and other water management facilities for these two areas are required for the development of the open pit. It is planned to construct these facilities prior to the start of mine production. This section describes the design and operational features of the structures. Construction guidelines are provided in Section 5 and closure considerations are discussed in Section 6. The water management plan for Jacko Lake and Peterson Creek includes engineered dams on Jacko Lake, a diversion system and a new pond within Peterson Creek. Design of the diversion system will be carried out by others. The water management plan seeks to address the following key objectives:

- Facilitate removal of the existing Kinder Morgan gas pipeline during the construction phase which will assist development of the open pit.
- Upgrade existing Jacko Lake facilities and provide design flood storage during mine operations.
- Divert water from Jacko Lake around the open pit area, discharging downstream into Peterson Creek during operations (diversion designed by others).
- Supply water to downstream water license holders during operations.

The following sections provide an overview of the water management plan and the key design elements.

3.1 Overall Description

Drawing C135-KA39-5600-00-002 shows the general arrangement of the Jacko Lake and the Peterson Creek Downstream Pond. During mining operations, runoff into Jacko Lake will be diverted around the open pit using the Peterson Creek Diversion System (designed by others). After the mine closes the creek will be re-located to more closely preserve the original drainage course.

Engineered dams will be constructed to a crest elevation of 895.5m on the western, northeastern and southwestern arms of Jacko Lake. The normal water level of Jacko Lake will be maintained at an elevation of 892.0m using a diversion pumping system (Peterson Creek Diversion System). The purpose of the dams are to manage stormwater that causes the lake to rise above the normal water level of 892.0m during large rainfall/runoff events. The Inflow Design Flood (IDF) is 0.8Mm^3 based on the Probable Maximum Flood (PMF) as described in Section 2. Design freeboard for the dams above the normal lake water elevation is 3.5m based on the following:

- IDF storage: 1.5m
- Wave run-up: 0.3m
- Additional storage: 1.7m

Based on the Jacko Lake storage filling curve (Figure 3-1), the volume between the operating level of 892m, and the design crest elevation of 895.5m is approximately 2.2Mm^3. Therefore the dams have been designed to manage runoff into Jacko Lake greater than twice the estimated IDF to provide a level of conservatism. There is an allowance for an emergency spillway to divert water into the open pit.

The determination of the PMF generally includes establishing a rainfall/runoff model of the watershed. The PMF estimate is therefore sensitive to the runoff coefficients that are assumed. The upper Peterson Creek catchment extends as far as 15km southwest of Jacko Lake. At this design stage, the soil cover and associated runoff potential across the whole contributing catchment is not fully understood. An assessment of historical flow gauge data (BGC, 2015), as well as results from the Norwest 2015 site investigations indicate the catchment area is relatively permeable and has low runoff coefficients. PMF estimates are sensitive to the run-off characteristics and configuration of the catchment area, which may change over the course of the project's twenty year lifespan. If inflows higher than assumed in this design were to occur, the emergency spillway will enable safe management of such events including the peak inflow estimate by directing any excess water into the open pit, and preventing overflow to other areas. Design for the spillway is pending further site investigation work.

The Peterson Creek Diversion System (PCDS) comprises an intake structure and pump house, a pipeline along the north of the Ajax site, with discharge into Peterson Creek at an outlet structure located at the Goose Lake access road crossing. Flow from the diversion system will be conveyed into a new pond downstream of the outlet structure (Peterson Creek Downstream Pond). The Peterson Creek Downstream Pond comprises a dam and a natural lined water storage pond. Water from the PCDS outlet structure will be discharged upstream and flows into the pond. The dam is located approximately 350m downstream of the Humphrey Creek tributary confluence, near an existing access road crossing. Design of the pond provides for water storage up to the normal water level of 865.5m, which equates to 68,000m^3 of storage capacity. This capacity was based on minimum storage requirements provided by KGHM. The dam will be a broad-crested weir structure with an overflow spillway chute that passes excess pond inflows downstream into Peterson Creek. The sill of the weir and the spillway chute is designed to pass the Inflow Design Flood (IDF) flow of 153 m^3/s, based on the Probable Maximum Flood (PMF) as described in Section 2. Maximum water level during flood was determined to be 867.4m. A low level decant system will be installed to provide flow control for the British Columbia Water Steward.

3.2 Jacko Lake

Drawings C135-KA39-5620-10-001, C135-KA39-5620-10-002 and C135-KA39-5620-10-003 show the general arrangement of the Jacko Lake dams along with profiles and sections illustrating the design concepts.

Four dams will be constructed: the West Dam (JLD3), the Northeast Dam (JLD2), the Southeast Saddle Dam (JLD4), and the Southeast Dam (JLD1). West Dam is located on a catchment divide between the Jacko Lake and Inks Lake watersheds and has a maximum height of 3.5m. Northeast Dam and the southeastern dams (JLD4 and JLD1) are located on the east side of Jacko Lake closest to the open pit and range up to 6.3m in height. The dams will be constructed from engineered fill sourced from local borrow and will incorporate drainage features to control seepage through the dams. All dams will be constructed to a crest elevation of 895.5m, with minimum crest widths of 5m and design slopes of 3H:1V (upstream and downstream). Additional site investigation work is planned to confirm preliminary design assumptions and provide information for detailed design.

Fill volumes and key metrics for each of the dams are presented in Table 3.1.

Table 3.1
Jacko Lake Dam Configuration Summary

Item	JLD3 (West Dam)	JLD2 (Northeast Dam)	JLD4 (Southeast Saddle Dam)	JLD1 (Southeast Dam)
Crest Length (m)	40	252	73	136
Approximate Base Elevation (m)	892.0	889.4	890.3	889.2
Ultimate Crest Elevation (m)	895.5	895.5	895.5	895.5
Maximum Dam Height (m)	3.5	6.1	5.2	6.3
Approximate Dam Fill Volume [1] (m^3)	1,800	25,100	2,750	9,200

Notes:
1. Includes additional volume for an estimated one metre depth of sub-excavation for foundation preparation.

The east side of Jacko Lake is particularly sensitive to the development of the open pit, given its close proximity. A preliminary study was undertaken to address this issue and provide KGHM's mine planning group with guidelines on open pit offset criteria from Jacko Lake. A technical memorandum outlining Norwest's recommendations was presented to KGHM and is provided in

Appendix B for reference. Drawing C135-KA39-5600-00-002 shows the recommended offset accordingly. Additional site investigation work is planned to confirm the offset location.

Northeast Dam (JLD2) will cut off a portion of the Jacko Lake northern arm to facilitate removal of the existing Kinder Morgan Pipeline and mining of the adjacent open pit. Options for the removal methodology are presented in Section 5.1.5.

Southeast Dam (JLD1) will be constructed immediately downstream of the existing Jacko Lake dam. The existing dam will require removal as part of the Southeast Dam construction. Options for construction methodology are presented in Section 5.1.4.

3.3 Peterson Creek Downstream Pond

Drawing C135-KA39-5640-00-001 shows the general arrangement of the Peterson Creek Downstream Pond during operations. Drawing C135-KA39-5640-10-001 shows profiles and sections through the Peterson Creek Downstream Pond. Key components of the pond and dam are described below. Additional site investigation work is planned to confirm preliminary design assumptions and provide information for detailed design.

The pond extends approximately 700m upstream of the broad-crested weir and spillway, and has a maximum width of about 150m. Surface area of the pond is approximately 6.1 ha at the normal water level of 865.5m. The pond basin is currently planned to be fully lined with a compacted low permeability earthen liner to minimize seepage losses into the underlying foundation. Low permeability compacted material will be constructed up to the maximum water elevation of 867.4m. The broad-crested weir is 70m wide and up to 5.6m high at the abutments. Weir crest elevation at the abutments is 868.3m, with a sill elevation of 865.5m and width of 38m. (equal to the normal water level of the pond).

The spillway chute will be an armoured trapezoidal channel with 3H:1V side slopes and a base width of 38m. The chute will be tied into the existing Peterson Creek water course, with appropriate energy dissipation and erosion/scour protection works to be determined during the detailed design phase. An access road immediately downstream of the spillway chute will also be moved or redesigned to pass appropriate flood flows.

The low level decant system comprises of an intake valve on the upstream side of the broad-crested weir, a buried pipeline, and an outlet structure downstream of the spillway chute. Intake elevation of the low level decant system will be 863.0m and comprise of a gate valve in order to control discharge to the downstream side. Access to the gate valve will be from a walkway adjacent to Goose Lake road. Flow will be conveyed along a pipeline trenched into the foundation and discharged to a smaller flow measurement weir structure downstream of the spillway chute. The flow measurement weir will comprise of a v-notch steel plate or similar to enable flow rate monitoring. Further construction details are provided in Section 5.2.4.

Key metrics for the Peterson Creek Downstream pond are summarised in Table 3.2.

Table 3.2
Peterson Creek Downstream Pond Configuration Summary

Design Component	Design Characteristic	Peterson Creek Downstream Pond
General	Catchment Area, (Including Pond) (km^2)	103
	Design Capacity Between elevation 863-865.5 (m^3)	68,000
Dam (Broad-crested Weir)	Maximum Crest Elevation (m)	868.3
	Total Crest Length (m)	70
	Minimum Crest Width (m)	5.0
	Maximum Crest Width (m)	21.8 to 22.3 (varies)
	Maximum Dam Height (m)	5.6
	Minimum Original Ground Elevation (m)	863.2
	Upstream Slope	3H:1V
	Downstream Slope	3H:1V
Pond	Normal Water Level (N.W.L.) (m)	865.5
	Maximum Water Level (Max. W.L.) (m)	867.4
	Minimum Water level (Min. W.L) (m)	863.0
	Minimum Basin Elevation (m)	862.0
	Maximum Water Depth (m)	3.5m (includes 1m sediment capacity)
Spillway Chute	Spillway Sill Elevation (m)	865.5
	Spillway Base Width (m)	38
	Spillway Crest Width (m)	44.6
	Spillway Chute Grade (%)	8.5
Low Level Decant System[1]	Pipe Intake Elevation (m)	863.0
	Pipe Grade (m)	0.6% (0.75% hyd. gradient)
	Approx. Pipe Length (m)	400.0
	Outlet Elevation (m)	860.0

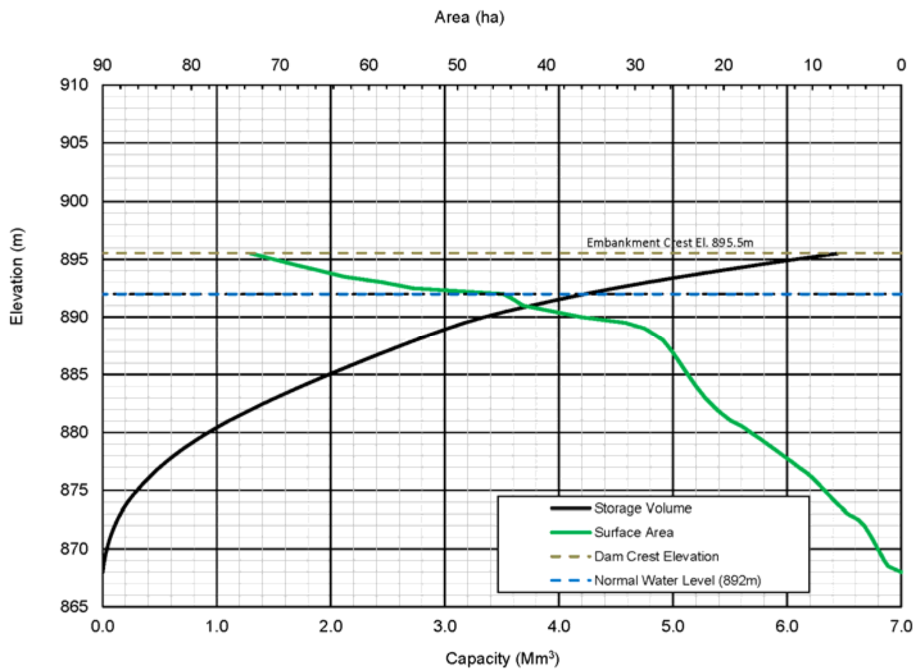
1. Low level decant line to be fitting with a riser with geosynthetic and end cap to prevent fines from entering pipe and blocking the flow. Pipe sizing, riser and end cap details to be provided in detailed design.

3.4 Storage Filling Curves

Area and storage curves are presented for both Jacko Lake and the Peterson Creek Downstream Pond on Figures 3.6 and 3.7.

Figure 3-1

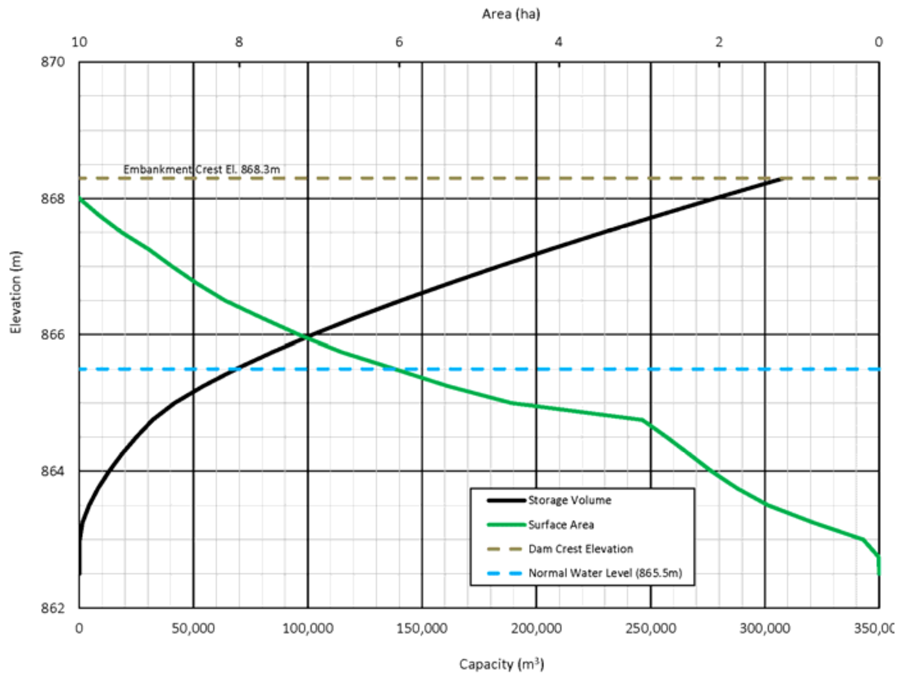
Jacko Lake Storage Filling Curve



Note: Storage volumes are based on bathymetry survey data

Figure 3-2

Peterson Creek Downstream Pond Storage Filling Curve



4 SITE GEOTECHNICAL

4.1 Available Foundation Information

This section discusses available foundation information in the Jacko Lake and Downstream pond areas to date. Site specific geotechnical drilling for Jacko Lake dams and Peterson Creek Pond have not yet been carried out. A program is planned for August 2015 and a memorandum outlining the work plan along with drill hole and test pit locations is included in Appendix C.

4.1.1 Jacko Lake

A drilling investigation was completed by Klohn Crippen Berger (KCB, 2014) between February and May 2014 as part of a hydrogeological assessment for the design of a dam on the northeastern arm of Jacko Lake (Northeast Dam). The 2014 KCB investigation consisted of five drill hole locations with standard penetration profiles (KAX-14-107, 108, 114, 121 and 128). Standpipe piezometers provide the static water level. No laboratory information was available at the time of this study. Drill hole logs indicate that the majority of the overburden is of glacial origin. The KCB site investigation was mainly focused on bedrock hydrogeology and only a brief summary of overburden stratigraphy was included in the report (See drawing C135-KA39-5600-00-006 for locations of the drill holes). The main geotechnical units identified below are based on Norwest's review of the drill hole log descriptions.

Overburden thickness in the area varies between approximately 10m in the north (near the northeastern arm of Jacko Lake) to almost 40m (near the southeastern arm of Jacko Lake). KCB reported that the "overburden consists of clay till, with sand/gravel layers of varying thickness" and that "horizons that contain sand and gravel typically have higher hydraulic conductivity than silt and clay dominated horizons". Norwest reviewed the available overburden information from the drill hole logs (KAX-14-107, 108, 114, 121 and 128) and identified the main units that are typically present throughout each hole:

- **Topsoil.** Topsoil is described as a thin organic silt (OL) layer less than 0.1m thick.
- **Upper Sand/ Gravel Unit (Inferred Glacial Till):** The upper sand / gravel unit is typically described as compact to dense, well graded, fine to coarse grained sand or sand and gravel (SW, SM, SC), and is likely of glacial origin. Occasional gravel or silt dominated layers are present within the logs. Standard Penetration Test (SPT) blow counts are typically in range N = 28 to 65, with an average of N = 40. The upper sand/gravel unit ranges from about 7 to 14 m in thickness.
- **Silt / Clay Unit (Inferred Glacial Till):** The silt /clay unit is generally described as a firm to very stiff, low to high plasticity clay (CL) with some sand and gravel overlying

a stiff to very stiff homogeneous low plasticity silt (ML). This unit is likely to be a glacial deposit. SPT blow counts are typically in range N = 20 to 70, with an average of N = 45. Firm, high plasticity clay was noted in borehole KAX-14-114, with blow counts in the range N = 8 to 40. The silt / clay unit typically ranges from about 3 to 12 m in thickness.

- **Lower Sand / Gravel Unit (Inferred Glacial Till):** The lower sand and gravels are typically described as very dense, well graded, fine to coarse grained sandy gravel or gravelly sand (GM, GP, SM, SW), and has been identified as a glacial deposit. SPT's blow counts are typically advanced to refusal. The lower sand/gravel unit typically ranges from about 10 to 21 m in thickness, with a thinner deposit noted in borehole KAX-14-121. This unit overlies bedrock.

KCB installed a number of standpipes within the overburden in drill holes KAX-14-107, 108, 114, and 128. Table 4.1 summarizes the static water level measurements (taken May 7, 2014). The groundwater table is close to or slightly higher than the Jacko Lake surface (El. 892m).

Table 4.1
Standpipe Water Level Measurements in Overburden[1]

Drill Location	Water Level (masl)
KAX-14-107	893.3
KAX-14-108	892.1
KAX-14-114	893.0
KAX-14-121	no data
KAX-14-128	892.1

1. Measurements taken on May 7, 2014.

4.1.2 Peterson Creek Downstream Pond

Subsurface site investigations have not yet been undertaken at the Peterson Creek Downstream Pond site. A site investigation has been proposed which includes a number of drill holes along the dam alignment and test pits within the proposed basin area. Details of the site investigation plan are presented in Appendix C.

Historical site investigations have been completed by both Knight Piésold and BGC Engineering Inc. at a distance from the planned Peterson Creek downstream pond. Foundation conditions near the surface of Peterson Creek Downstream Pond probably consist of alluvial deposits from Peterson Creek. An alluvial fan is evident at the Humphrey Creek confluence based on inspection of the topography data and aerial photos. Depth to bedrock is not fully defined but drill hole information (closest to the site; ~300m away) indicate bedrock is approximately 35 to 65 metres below ground surface.

4.2 Material Properties for Preliminary Design

4.2.1 Foundation

Material properties for the foundation materials were developed using the descriptions provided in KCB drill hole logs and associated in-situ field testing (KCB, 2014), and experience with similar materials on other projects. Additional in-situ field and laboratory testing will be conducted to confirm design assumptions. Foundation material strength properties provided in this report are preliminary at this time.

Table 4.2
Foundation Material Strength Properties

Foundation Unit	Unit weight kN/m^3	Effective stress parameters*
Upper Sand/Gravel Till	20	c'=0 Φ'= 33°
Silt / Clay Till	20	c'=0 Φ'=30°
Lower Sand / Gravel Till	20	c'=0 Φ'=35°

* c' = effective cohesion (kPa)
* Φ' = effective friction angle (degrees)

4.2.2 Engineered Fill

The current plan for the dam construction is based on using locally sourced glacial till material or quarried rock fills. The excavated till used for dam construction will be selected and compacted according to generally accepted engineering practices. Testing of the fill materials will be conducted to confirm design assumptions. Material properties are preliminary at this time.

Table 4.3
Engineered Fill Strength Properties

Fill Zone	Material Type	Unit weight kN/m^3	Effective stress parameters*
Compacted Dam Fill	Glacial Till	20	c'=0 Φ'=30°
Drainage	Sand and Gravel	20	c'=0 Φ'=35°
Riprap Slope Protection	Graded Rock	20	c'=0 Φ'=35°

* c' = effective cohesion (kPa)
* Φ' = effective friction angle (degrees)

4.3 Seepage Controls

The following section describes the seepage controls envisaged for the Jacko Lake and Peterson Creek Downstream Pond structures.

4.3.1 Jacko Lake

Seepage control measures for the dams at Jacko Lake include engineered drains within the embankments and seepage cut-offs with the foundation below the dams. Design of these features will be developed during detailed design. Seepage cut-offs may include grout injection or slurry walls between Jacko lake and the open pit which will require evaluation during detailed design.

4.3.2 Peterson Creek Downstream Pond

The Peterson Creek Downstream Pond will be a lined facility to minimize seepage losses into the underlying foundation, which is anticipated to be comprised of permeable alluvial deposits. A compacted soil mixture is planned to be used to create a low permeability liner in the basin area and along the upstream slope of the broad-crested weir structure.

4.4 Preliminary Stability Analyses

Two-dimensional limit equilibrium stability analysis were performed on representative cross-sections through the Jacko Lake dams (West, Northeast and Southeast). The Southeast Saddle Dam is a small structure (less than 1m in height and 30m long) and was not considered in the stability assessment. Stability analyses were also not carried out for the Peterson Creek Downstream Pond at this stage due to the low height of the structure within the creek centreline (<2.5m), the shallow fill slopes (minimum 3H:1V), the downstream buttressing influence of the spillway chute (8.5% slope). Detailed stability analyses will be conducted for each structure during the next phase of design once additional site investigation information becomes available.

Slope stability analyses for Jacko Lake were completed to evaluate five different loading conditions:

- End of construction.
- Long term.
- Pseudostatic conditions (using seismic co-efficient of 0.16).
- Rapid Drawdown.

Factor of safety criteria are presented in Table 2.7 for each of the different loading conditions. Factors of safety were computed using Slope/W (GeoStudio International Ltd, 2012) using the Spencer method. Minimum calculated factors of safety for each of the loading scenarios are provided in Table 4.4. Details of the Jacko Lake stability analysis are presented in Appendix D.

Table 4.4
Jacko Lake Preliminary Slope Stability Results Summary

Loading Scenario	Required Factor of Safety	Northeast Dam	Southeast Dam	West Dam	Meets Criteria
End of Construction (Free Standing Structure) (1)	1.3	1.3	N/A (2)	N/A (2)	Yes
End of Construction (Normal Water Level)	1.3	1.7	1.7	1.8	Yes
Long Term (Steady State)	1.5	1.7	N/A (2)	N/A (2)	Yes
Pseudo-static	1.0	1.1	N/A (2)	N/A (2)	Yes
Rapid Drawdown	1.2-1.3	1.2	N/A (2)	N/A (2)	Yes

1. Construction pore pressures were applied to the dam fill.
2. All four dam structures were evaluated for the end of construction loading condition because this case often governs dam stability. Long term, rapid drawdown and pseudostatic loading conditions were evaluated for Northeast Dam only to confirm the configuration met the minimum factor of safety and to demonstrate the other cases did not govern dam stability. These other cases will be evaluated for all four dams in the next level of design.

5 CONSTRUCTION RECOMMENDATIONS

General construction recommendations for the development of Jacko Lake Dams and Peterson Creek Downstream Pond are summarized in this section. These are meant to provide an overview of the key construction issues and construction methods. Estimated material quantities and footprint requirements are also provided.

5.1 Jacko Lake Construction Plan

The following sections discuss the construction plan for the Jacko Lake dams, which includes:

- Foundation preparation.
- Seepage cut-off construction.
- Dam and spillway construction.
- Decommissioning of existing Jacko Lake dam structure.
- Kinder Morgan pipeline removal through the northeast arm.

5.1.1 Foundation Preparation

The construction area will be cleared of vegetation, trees, stumps, branches and other woody materials. Topsoil will be removed and stockpiled. The foundation for the dam will be prepared by excavating down approximately one (1) metre or until a competent in-situ glacial till material is reached, and any soft or wet zones will be removed and replaced with suitable compacted fill.

The abutment treatment will be to clear unsuitable debris and loose materials. The dam will be keyed into the abutments a minimum of 2m into competent intact native material.

The total Jacko Lake dam footprint areas for foundation and abutment preparation is estimated to be:

- West Dam (JLD3): 730m^2.
- Northeast Dam (JLD2): 6,900m^2.
- Southeast Saddle Dam (JLD4): 1,500m^2.
- Southeast Dam (JLD1): 3,000m^2.

5.1.2 Seepage Cutoff Construction

A seepage cut-off will be constructed to manage seepage beneath the embankments. As a minimum, the cut-off will be excavated into competent impervious soils. There may also be requirements for grouting into bedrock. The seepage cut-off footprint will be excavated through the weaker saturated foundation soils expected beneath the currently submerged area of the northeastern Jacko Lake arm to a competent material, which is expected to be the glacial till unit. Any unsuitable material will be excavated or, if suitable, scarified to the top 0.15m parallel to the dam centreline and re-compacted. The seepage cut-off will be constructed as close as possible to the centreline of the dam.

5.1.3 Dam Construction

Construction details to develop the Jacko Lake dams are summarized below.

Jacko Lake Dams: Earth fill materials will be used for the construction of the four Jacko Lake dams from local borrow sources and/or pre-stripping during initial development of the open pit. It is expected that dam material will be placed and compacted to a minimum density of 95% Standard Proctor. Compacted fill shall be homogeneous and free from lenses, pockets, voids, laminations and other imperfections.

Spillways: Two spillways will be constructed as part of the Jacko Lake Dam design:

- Operational Spillway: Located on the southeast arm of Jacko Lake with excess flows over the IDF directed into the open pit.
- Closure Spillway: Located at to the west of the Southeast Dam (JLD1) to restore natural outflow (i.e. prior to mine development) into Peterson Creek.

The operational spillway will be constructed with concrete cloth, rip rap and non-woven geotextile. The closure spillway will be constructed using compacted engineered fill, rip rap and non-woven geotextile. Details will be provided during the next phase of design.

5.1.4 Decommissioning of Existing Jacko Lake Dam Structure

Construction of the Southeast Dam (JLD1) requires removal of the existing Jacko Lake Dam, which is located approximately 50m upstream of the proposed dam. A summary of the proposed methodology is presented in the following section.

Existing Dam Description

The existing dam is listed as the Jacko Lake Dam in the British Columbia Ministry of Environment dam registry (Dam File#: D120211-00). It is an earth fill dam with the following characteristics:

- Maximum height: 3m
- Crest length: 62.5m
- Average crest width: 6m

- Crest elevation: 892.3m
- Dam slopes: 2H:1V

There is a low level discharge pipe through the dam near its eastern abutment which discharges immediately downstream of the dam. The discharge pipe flows into a small concrete weir structure approximately 30m downstream of the dam which overflows into the natural Peterson Creek drainage. The inlet to the emergency overflow spillway is adjacent to the western abutment. The emergency spillway is lined with riprap and discharge into Peterson Creek downstream of the concrete weir.

Proposed Construction Methodology

Removal of the existing Jacko Lake dam could be carried out either of two conditions: a “wet” removal operation or a “dry” removal operation. Both options would require that a single of double line of floating silt curtains be installed upstream of the existing dam to prevent the contamination of the main body of Jacko Lake with turbid water from the excavation operations. Floating silt curtains would installed across the width of the southeast arm of Jacko Lake and would be anchored on either bank.

- **Wet Removal:** The wet removal would involve allowing water to discharge from Jacko Lake into the area contained between the new downstream dam and the existing structure. Water would be allowed to discharge until the water level on both sides of the dam was equalized. Assuming removal was scheduled for the summer, it is expected the lake level would be between an elevation of 891m and 892m. A lower lake level would facilitate removal activities but is not required.
- **Dry Removal:** Dry removal would require the installation of a temporary dam (i.e. cofferdam) upstream of the existing Jacko Lake Dam. Relatively shallow depths in the southeast arm (1 to 2m) make the use of removable water filled temporary dykes feasible. These structures are intended to function as short-term water barriers to allow for construction activities within shallow waterways and water bodies such as Jacko Lake. Following initial installation of the temporary dam approximately 10m upstream of the Jacko Lake Dam, the water between the dam and the temporary structure would be discharged or pumped out and dam removal operations could be carried out.

Dam excavation operations would be similar for both options but the dry removal option would allow operations to be carried out more efficiently due to enhanced access and visibility. This would come at an increased cost due to the need to purchase and install the temporary dam structure.

Additional information to do with the proposed excavation and removal sequence is presented in Appendix E.

5.1.5 Kinder Pipeline Removal along the Northeast Dam

The existing Kinder Morgan Pipeline (KMP) is located within the footprint of the Jacko Lake Northeast Dam (JLD2). This pipeline will be removed and relocated to the west, at least 100m away from the mine development area (see Figure C135-KA39-5600-00-002). One of the methods being considered for removing the pipeline is to use a temporary sheet pile wall for isolating and dewatering the northeastern arm of Jacko Lake. This would allow for safe removal of the pipeline and construction of the new dam. A conceptual design for the temporary sheet pile option was initially presented by Klohn Crippen Berger (KCB, 2015). Norwest have provided a summary below.

Sheet Pile Concept

Sheet piles would be driven from the banks of Jacko Lake and from a floating barge within inundated areas of the northeastern arm. Piles would be driven through softer sediments and into denser till to establish temporary shoring for subsequent excavation works related to dam construction and pipeline removal. Klohn Crippen Berger's conceptual design suggests pile embedment depth into dense till will be up to 10m. Bracing of the sheet piles may also be required. A site investigation plan is required to determine whether the foundation conditions are suitable for sheet pile wall installation. Other options are also being considered.

5.2 Peterson Creek Downstream Pond Construction Plan

The following sections discuss the construction plan for the Peterson Creek Downstream Dam, which includes:

- Temporary diversion of the creek.
- Foundation and abutment preparation.
- Basin preparation.
- Seepage cut-off construction.
- Pond and dam construction.
- Spillway structure.
- Decant system.

5.2.1 Temporary Diversion of the Creek

Prior to construction, a temporary sump and diversion pipe system will be installed to divert flow around the construction area. Construction will be scheduled during low flow periods.

5.2.2 Foundation and Abutment Preparation

The dam foundation will be prepared by clearing and/or excavating unsuitable material down to a competent base. All unsuitable materials whether wet, frozen, rock or otherwise, will be removed or excavated. The total dam footprint areas for foundation and abutment preparation is estimated to be 1750m^2.

The abutment treatment will be to clear unsuitable debris and loose materials. The dam will be keyed into the abutments a minimum of 2m into competent intact native material. Additional seepage cutoff requirements will be reviewed during detailed design.

5.2.3 Basin Preparation

The basin will be prepared by clearing and/or excavating unsuitable material down to a competent base. All unsuitable materials whether wet, frozen, rock or otherwise, will be removed or excavated. The total pond footprint area for basin preparation is estimated to be 112,000m^2.

5.2.4 Pond and Dam Construction

A summary of fill zone, material type and general placement locations are summarized in Table 5.1. Construction details to develop the Peterson Creek Downstream Pond dam, impoundment, spillway chute and low level decant system are summarized below.

- **Dam:** Earth fill materials compose the Peterson Creek Downstream Pond dam and are sourced locally from suitable glacial till material or pre-stripping of the open pit. The thin layer of topsoil and organics over the planned pond area will be stripped and stockpiled prior to construction. It is expected that dam material will be placed and compacted to a minimum density of 95% Standard Proctor in lifts of 0.3m. Compacted fill shall be homogeneous and free from lenses, pockets, voids, laminations and other imperfections.
- **Impoundment:** Naturally low permeability earthen material will be used to line the impoundment of the Peterson Creek Downstream Pond to form a liner to store ponded water.

- **Spillway Chute**: A spillway will be constructed at the Peterson Creek Downstream dam to:
  - Manage flood flows up to the PMF.
  - Satisfy the water license requirements for the downstream users.

  It is currently envisaged that the spillway will be constructed with concrete cloth, engineered fill, rip rap and non-woven geotextile as shown on drawing C135-KA39-5640-10-001 . The spillway preliminary design is provided in Section 4.3.2.

- **Low Level Decant System:** Concrete and piping will be used to construct the decant system. The decant system will allow flow control to downstream water licensees requirements for the downstream users.

  The decant system will comprise of a screened vertical intake at elevation 863.0m attached to a steel pipe that drains to a discharge point approximately 400m downstream at an outlet elevation of approximately 860.0m. The decant pipe will be sloped at 0.6% with a riser pipe at its inlet resulting in in a minimum hydraulic gradient of approximately 0.75%. A valve setup at the upstream end of the decant pipe will be designed to open and shut the pipe. A flow measurement device will be installed to measure the flows through the decant system. This will likely comprise of a concrete weir structure with a ‘v’-notch steel plate at the outlet point.

  The Peterson Creek Downstream Pond is designed to allow flow through the spillway structure when the pond level exceeds elevation 865.5m. The decant pipe system will be capable of lowering the pond to the 863.0 m elevation.

Table 5.1

Construction Material Types

Zone	Type	Source / Material	Placement Locations
Dam	Impervious Fill	Local borrow (glacial till)	Dams, diversion structures, decant pipe trench backfill, low permeability zones, excavation backfill.
Drain Rock	Pervious Fill	Crushed rock fill, screened alluvial sediments.	Embankment internal drainage.
Riprap	Pervious Fill	Non-acid generating mine rock or quarried rock.	Upstream dam slopes, spillway channels, erosion protection systems.
Basin (Impoundment)	Impervious Fill	Local borrow (glacial till)	Basin footprint

5.3 General Instrumentation and Monitoring Plan

A monitoring plan will be developed to assess the performance of dams throughout construction. This monitoring plan includes construction and instrumentation monitoring for QA/QC to ensure construction work is in compliance with the geotechnical engineering design.

Construction and instrumentation monitoring covers the following areas:

- Installation and monitoring of geotechnical instruments in the foundation and fill.
- Visual monitoring of the dams during construction to identify any geotechnical issues. This may include cracking, incorrect material type/zone placement, ponded water, placement of frozen material, snow removal, foundation preparation, etc.
- Coordination of laboratory testing to verify construction materials are placed in the designated dam zones and meet construction specifications.
- Compaction testing to ensure that construction fill is compacted to design specifications.

5.4 Construction Monitoring

KGHM will provide construction monitors to identify and document that the construction satisfies the technical specifications and to identify, communicate and address when non-conformances are detected throughout the construction process.

Basic responsibilities of the construction monitor include:

- Carrying out quality control testing and visual inspections of all fill types/clean up activity as required by the technical specifications, as shown on the drawings.
- Collating and analyzing all quality control test results and implementation of any remedial actions that may be required or considered appropriate.
- Coordination of all quality control test results for further review and analysis.
- Preparation of daily construction reports and/or as-built construction. This will include:
  - As-built drawings and construction photographs.
  - Any potential difficulties and an assessment of any critical design items that may have arisen or may arise in the near future.
  - Safety Performance Reporting.
- Water quality monitoring, especially where coffer dams are required for in-stream work and where any dams are removed.

5.5 Instrumentation Monitoring

Geotechnical instrumentation will be installed within the dam fill and foundation. The instrumentation will be monitored by KGHM instrumentation monitors and provided to Norwest to assess dam performance and identify any conditions that may be different to those assumed during design and analysis. Performance monitoring specifications and guidelines will be developed for monitoring trigger levels.

Geotechnical instrumentation will include:

- <u>Slope Inclinometers (SI)</u> to monitor any deformations in the dam fill and/or movement in the underlying foundation materials. These instruments will be installed during initial dam construction and will extend a minimum of 10m into a competent foundation unit. The instruments will be raised as the dams are constructed.
- <u>Vibrating Wire Piezometers (VWP)</u> will be installed in the dam and foundation (Upper Sand/Gravel Unit, Silt/Clay Unit and Lower Sand/Gravel Unit) to measure piezometric levels and in-situ pore pressures during operations. The piezometer leads will be appropriately routed from these areas to read-out panels for ease of monitoring.

- Standpipes (SP) will be used as required within the permeable units downstream of dams, as required. The standpipes will be used to monitor water quality and as an alternative method to the VWP to measure piezometric levels.

5.6 Construction Water Control

The construction water management strategy is to minimize disturbed areas, implement Best Management Practices (BMP's) as construction progresses and to develop with KAM's environmental team a water quality monitoring program where required during construction The sources of water during construction of the Jacko Lake and Peterson Creek structures are as follows:

- Precipitation runoff from disturbed areas.
- Water from dewatering construction activities.

Activities that may require sediment and erosion control include clearing vegetation, stripping topsoil, stockpiling topsoil, and constructing roads and infrastructure. Potential hazards from these activities, in the absence of planned mitigation measures, include increased surface erosion from disturbed areas, increased sediment load to downstream receiving environments, and siltation or erosion of downstream watercourses or water bodies.

Sediment mobilization and erosion will be managed throughout the site by:

- Installing sediment controls prior to construction activities.
- Limiting disturbance as much as possible.
- Reducing water velocity across the ground, particularly on exposed surfaces and in areas where flow tends to concentrate.

Installation of temporary erosion and sediment control features or BMPs will be the first step towards controlling sediment and erosion during construction. All temporary sediment and erosion control features will require regular maintenance. The temporary erosion and sediment control features associated with BMPs will be reclaimed after achieving soil and sediment stabilization.

5.6.1 Best Management Practices

Erosion control BMPs reduce erosion potential by stabilizing exposed soil or reducing surface runoff flow velocities. There are generally two types of erosion control BMPs that are used:

- Source control BMPs for protection of exposed surfaces.

- Conveyance BMPs for control of runoff.

Experience and adaptive management are integral to the successful selection of the appropriate BMPs and the design and implementation of an overall erosion and sediment control plan. Erosion control BMPs are typically implemented during the construction phase, although they may also be implemented during operation, reclamation, and closure phases, as required, to minimize erosion and sediment discharge into surrounding areas. Typical BMPs that may be used at the project are:

- Runoff collection ditches.
- Energy dissipaters.
- Sediment traps.
- Slope drains.
- Surface roughening.
- Filter bags.
- Water bars.
- Diversion structures.
- Silt fences.
- Sediment basins.
- Temporary seeding, and
- Mulching

5.7 Operational Water Control

The goals of the water management plan during the operations phase are to keep non-contact water clean and to minimize water withdrawals or discharges outside of the project footprint. Using water from within the project area to the maximum practical extent and constructing clean water diversion ditches are vital to achieving these goals.

Water within the project area will be recycled and used to the maximum practical extent by collecting and managing site runoff from both undisturbed and disturbed areas. A detailed water management plan will be developed as the designs are advanced further.

6 CLOSURE CONSIDERATIONS

The Jacko Lake dams and Peterson Creek Downstream Pond are permanent facilities and will remain after the mine closes. The Peterson Creek Diversion System (designed by others) will be removed with outflow from Jacko lake to be directed back into a re-constructed Peterson Creek waterway. The closure plan concept is provided on drawing C135-KA39-5600-00-003.

The general closure sequence is described below:

1. Backfill open pit to support long term closure plan objectives.

2. Remove / modify the Central Collection Pond to convey flows into the open pit.

3. Construct a new channel from the Jacko Lake southeastern arm and tie into Peterson Creek downstream of the proposed Central Collection Pond. The channel will be lined with natural low permeability compacted fill.

4. Construct a spillway to the west of the Southeast Dam (JLD1) to allow overflow from Jacko Lake at water levels above El. 892m with a low level outfall system to control water levels downstream of Jacko Lake and into a earthen lined channel within Peterson Creek. Any flows from the MRSF will be directed through a water management system that conveys this water into the open pit.

5. Decommission the Peterson Creek Diversion System.

The following sections describe closure configuration and long term monitoring considerations for Jacko Lake and the Peterson Creek Downstream Pond.

6.1 Jacko Lake

6.1.1 Closure Configuration

The dams on Jacko Lake will be left in place at closure. The normal lake level will remain at an elevation of 892.0m. Slopes will be progressively reclaimed during the operational period so as to minimize long term erosion. No major structural changes will be made to the West, Northeast and Southeast Dams (JLD3 ,JLD2, JLD4 and JLD1).

Modifications will be made to the west of the Southeast Dam (JLD1), allowing for a spillway to be constructed. Excess flows over the 892.0m normal water level will passed into Peterson Creek (similar to pre-mining conditions). A low level decant system at JLD1, will be commissioned (installed during construction of JLD1) to enable flow control capability. This feature is provided to enable flow control at Jacko Lake for the British Columbia Water Steward. Flow from the spillway and from the decant system will discharge into a closure channel, constructed to re-establish the existing Peterson Creek waterway. The closure channel will tie in to Peterson Creek downstream of the proposed Central Collection Pond. Channel alignment will be positioned in accordance with appropriate pit offset guidelines as determined by geotechnical design during further studies. The spillway and closure channel will be designed to accommodate the closure design flood criteria for Jacko Lake. Adjustments to the operational emergency spillway will be made as necessary to accommodate the closure arrangement. Drawing C135-KA39-5640-00-003 shows a conceptual alignment of the closure channel.

Long term stability of Jacko Lake will be an important aspect of the closure arrangement of the Ajax site. The current mine plan shows the ultimate open pit crest in close proximity to the east side of Jacko Lake with a portion of the west pit backfilled. Further design work is required to re-configure the backfill for long term slope stability at closure. The approximate extent of the backfill is shown on drawing C135-KA39-5600-00-003.

6.1.2 Long Term Monitoring

Dams will be visually inspected by a qualified geotechnical person on a regular basis according to provincial requirements, to monitor for any uncontrolled seepage exiting on downstream areas and to check the overall performance and stability of the structure and its related facilities. An operation, maintenance and surveillance (OMS) manual will be developed by KGHM, which will detail long term monitoring and record-keeping procedures for the structure. Monitoring procedures will be developed in line with Provincial and CDA Guidelines.

6.1.2.1 Roles and Responsibilities

<u>Owner</u>: KAM is the dam owner. The Owner is responsible for the appointment of the project team and retains suitable companies for different aspects of the project such as construction management, design, and QA/QC. The responsibilities of the Owner may include, but are not limited to:

- Dam safety reviews on their dams with certain classifications and at the intervals provided in the British Columbia Dam Safety Regulation (for water reservoir dams).
- Delivery of all required land tenures and project approvals.

- Delivery of the sites to construction management and contractors.
- Liaison with government agencies.
- Liaison with the local communities and land owners.
- Communications control.

Engineer of Record (EOR): The EOR is the qualified geotechnical engineer for the design and construction of the Jacko Lake water management structures for the Ajax Project. The responsibilities of the EOR may include, but are not limited to:

- The Jacko Lake water management structures design, design changes, completion of regular field reviews throughout construction to ensure a quality end product by ensuring construction is carried out in accordance with the construction design drawings and technical specifications.
- Review and audit of QC processes and results, daily reports, weekly construction plans and mine plans and related documentation for any deficiencies or issues.
- Written documentation of regular field reviews in accordance to the standard regulatory requirements.

6.2 Peterson Creek Downstream Pond

6.2.1 Closure Configuration

The current plan is to retain the Peterson Creek Downstream Pond at closure. No structural changes will be made to the pond and dam structures. Design of the overflow spillway during operations incorporates the closure catchment area and no adjustments to the overflow spillway hydrotechnical design would be required.

The pond will remain in order to provide the British Columbia Water Steward with a captured water source and flow control capability. Inflow to the pond will include flow from the re-established upstream portion of Peterson Creek, along with flow from HumphreyCreek. The Peterson Creek Diversion System (designed by others) will be decommissioned following the re-establishment of Peterson Creek and does not provide any inflow at closure.

6.2.2 Long Term Monitoring

The dam will be visually inspected by a qualified geotechnical person on a regular basis, to monitor for any uncontrolled seepage exiting downstream areas and to check the overall performance and stability of the structure and its related facilities. Periodic checks will be needed to establish if the pond liner is functioning as intended but because of the use of a natural liner, maintenance should not be required during the long term assuming adequately low permeable material is used. An operation, maintenance and surveillance (OMS) manual will be developed by KGHM, which will detail long term monitoring and record-keeping procedures for the structure. Monitoring procedures will be developed in line with Provincial and CDA Guidelines.

6.2.2.1 Roles and Responsibilities

Owner: KAM is the dam owner. The Owner is responsible for the appointment of the project team and retains suitable companies for different aspects of the project such as construction management, design, and QA/QC. The responsibilities of the Owner may include, but are not limited to:

- Dam safety reviews on their dams with certain classifications and at the intervals provided in the British Columbia Dam Safety Regulation (for water reservoir dams).
- Delivery of all required land tenures and project approvals.
- Delivery of the sites to construction management and contractors.
- Liaison with government agencies.
- Liaison with the local communities and land owners.
- Communications control.

Engineer of Record (EOR): The EOR is the qualified geotechnical engineer for the design and construction of the Peterson Creek water management structures for the Ajax Project. The responsibilities of the EOR may include, but are not limited to:

- The Peterson Creek water management structures design, design changes, completion of regular field reviews throughout construction to ensure a quality end product by ensuring construction is carried out in accordance with the construction design drawings and technical specifications.

- Review and audit of QC processes and results, daily reports, weekly construction plans and mine plans and related documentation for any deficiencies or issues.
- Written documentation of regular field reviews in accordance to the standard regulatory requirements.

7 FURTHER WORK

Norwest completed a preliminary design for the Jacko Lake and Peterson Creek water management structures in support of further engineering design and environmental permitting. The preliminary design comprises four small engineered dams at Jacko Lake and a lined pond and dam structure on Peterson Creek. Upon closure, the diversion system will be decommissioned with flow re-established close to the current Peterson Creek alignment. Key items to be addressed during the next phase of design are listed below:

- Completing planned site investigations to further define foundation stratigraphy between Jacko Lake and the open pit, beneath the Jacko Lake dams, and beneath the Peterson Creek Downstream Pond.
- Integrate Jacko Lake operational and closure designs with the pit slope and backfill design.
- Integrate Peterson Creek closure channel designs with the pit slope and backfill design.
- Undertake detailed stability and seepage analyses for Jacko Lake and the Peterson Creek Downstream Pond.
- Undertake a Failure Modes and Effects Analysis (FMEA) for pit slope interaction with the lake, dams and re-constructed Peterson Creek channel at closure.
- Review and optimise key construction methodologies:
  - Kinder Morgan pipeline removal and Northeast Dam (JLD2) construction.
  - Removal of the existing Jacko Lake dam.
- Develop operational and long term (closure) monitoring plans.

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9 CLOSURE

This report has been prepared for KGHM Ajax Mining Inc. to provide a preliminary engineering design for the Jacko Lake and Peterson Creek water management structures at the Ajax Project, located near Kamlooops, British Columbia. This document represents the opinion of Norwest based on information provided by KGHM Ajax Mining Inc and observations made during limited site visits.

All geotechnical data contained herein has been prepared and directly supervised by Christopher Klassen, P.Eng., with hydrological design completed by Brian La Cas, P.Eng. Senior review for the project was carried out by Sean Ennis, P.Eng., P.E. As mutual protection to KGHM Ajax Mining Inc., the public, and Norwest Corporation , this report, its figures and appendices are submitted for exclusive use by KGHM Ajax Mining Inc. We specifically disclaim any responsibility for losses or damages incurred through the use of our work for a purpose other than as described in the report. Our report and recommendations should not be reproduced in whole or in part without out express written permission.

August 28, 2015.

"original signed and sealed by author"

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Appendix A– Baseline Hydrology Studies

APPENDIX A1 HYDROLOGICAL REVIEW OF JACKO LAKE

1 INTRODUCTION

KGHM Ajax Mining Inc. (KGHM) retained Norwest Corporation (Norwest) to carry out a hydrological review of Jacko Lake as part of the proposed Ajax Mine project, near Kamloops, British Columbia.

Appendix A1 provides an updated peak flow hydrological baseline flood storage design criteria for the preliminary design of the Jacko Lake dams. The hydrological baseline focused on the determination of the 1000-year flood and Probable Maximum Flood (PMF) flows entering Jacko Lake and the associated 24-hour estimated volume of the PMF.

Jacko Lake and its catchment are located within the semi-arid steppe climate of South-Central Interior of BC. The climate of this region is characterized by the generally low annual precipitation and high evaporation resulting in relatively low inflow rates into Jacko Lake. The winters are usually cool and dry and the summers hot and dry with relatively low humidity and high evaporation rates.

Rainfall runoff values within the Jacko Lake watershed are relatively low compared to most other areas of BC due to in part by the extremely dry and absorbent soils and its location in a rain shadow.

There are several endorheic (closed) lakes in the vicinity; however Jacko Lake presently outflows to Peterson Creek through its south-eastern arm.

2 PRECIPITATION FREQUENCY ANALYSIS

A precipitation analysis was carried out based on the review of regional climate stations from the Meteorological Services of Canada. The selected station for the precipitation frequency analysis was Kamloops A, which has a short intensity duration frequency curve (IDF) based on rainfall data from 1965 to 2002.

Table A1
Regional Climate Stations

Station No.	Name	Lat. / Long.	Elevation (masl)	Proximity (km)	IDF Curves	Record	Years
1163780	Kamloops A	50° 42' N 120° 26' W	345	12.61	Yes	1953 - 2013	61
1164LH5	Knutsford 2S	50° 36' N 120° 19' W	899	8.22	No	1986 - 1997	12
1163790	Kamloops Afton Mines	50° 40' N 120° 30' W	701	11.34	No	1977 - 1993	17
116C8P0	Kamloops Pratt Road	50° 36' N 120° 12' W	640	18.24	No	1986 - 2013	28
1124668	Logan Lake	50° 30' N 120° 49' W	1101	36.35	No	1971 - 2005	35

Due to the various ranges of record periods, the main hydrological analysis was based on Kamloops A and Kamloops Pratt Road; Kamloops Afton Mines was used as secondary data. The overlapping period of record of the main data set is 1986 to 2005 (20 years). Since the IDF data was based on hourly rainfall data up to 2002, a check was made to determine the difference in the average annual maximum daily rainfall from 1965 to 2002 and that from 1965 to 2013. Results indicate that there is no significant difference with the inclusion of the additional data points. Based on other previous reports provided by KGHM, climate data has been recorded at site since August 2010. However, the dataset has inconsistencies and a relatively short period of record. Therefore, the regional stations were used in the determining the precipitation amounts representing the project site.

The 1000-year, 24-hour precipitation totals were extrapolated from the IDF curve. Since the Kamloops A station is situated at EL. 345m (lower than the Ajax Mine project reference elevation of EL 895m), an elevation adjustment was made to the extrapolated rainfall totals. A regional average maximum daily rainfall versus elevation relationship was developed using the selected regional daily climate data sets (the overlapping period is from late 1980's to mid-1990's). The regional extreme rainfall vs. elevation relationship is approximately a 6% increase in rainfall for every 100m of increase in basin elevation. The maximum daily rainfall was determined at Jacko Lake and a ratio of this to the maximum daily rainfall at Kamloops A station was calculated. The extrapolated rainfall totals were then adjusted to the Jacko Lake elevation using the aforementioned ratio. Finally, the 1000-year 24-hour rainfall total depth for the vicinity of Jacko Lake was estimated to be about 90mm.

The Probable Maximum Precipitation (PMP) for the Ajax project site was also determined. It is generally defined theoretically, as the greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location at a certain time of the year. The PMP was determined using the Hershfield Method as recommended in the Rainfall Frequency Atlas for Canada (1985). However, since the reference was published in 1985, a comparison of the average maximum daily rainfall at Kamloops A station from 1965 to 1985 and that from 1965 to 2013 was determined. Results indicate that there is an increase in the maximum daily rainfall total by 7%, which was applied to the preliminary PMP. Furthermore, a slight elevation adjustment was made in this case to take into account the relatively higher elevation at Jacko Lake. The average elevation of the selected regional stations was used as the base elevation, and a 6% increase in the preliminary PMP was applied for every 100m increase in elevation.

The 100-year snowmelt water equivalent estimated by Knight Piesold (April 2015) was 108mm. The Spring PMP plus 100-year snowmelt and Summer-Autumn PMP for 24-Hour for the Ajax Mine are shown in Table A2.

Table A2
Spring PMP and Summer-Autumn PMP at Jacko Lake

24-Hour PMP Period	Rainfall (mm)
Spring	125
Spring + 100-year snow water equivalent	233
Summer-Autumn	226

If warranted, the Spring PMP can be combined with the design snowmelt condition such as the 100-year snowmelt; however combining snowmelt condition with the Summer-Autumn PMP would not be acceptable in this case due to lack of evidence of snowpack in the summer-autumn period.

The 226mm value for the Summer-Autumn PMP is very close to the 221mm value provided by Knight Piesold. The reason for the discrepancy is the latest figure has an extended data set, which updates the PMP value. Therefore, the updated PMP of 226mm should be used in the hydrological review.

Since the Ajax project site is located within a special relatively dry hydrological region, it is important to review historical storms in the region. A review of the highest recorded maximum daily rainfall events at Kamloops A climate station, indicates that the highest rainfall events have occurred in late spring and summer as shown in Table A3:

Table A3

Highest Recorded Daily Rainfall

Date of MDR	Rainfall (mm)
August 16, 1976	48
June 29, 1986	36.8
September 6, 1985	28.8

Almost all of the spring maximum daily rainfall events occurred in late April and May, with the top three historical storms in spring at Kamloops A climate station as shown in Table A4:

Table A4

Highest Spring Daily Rainfall

Date of MDR	Rainfall (mm)
April 25, 1983	27.8
May 17, 1996	20.6
April 30, 1987 and May 14, 2002	19.4

The top 3 historical storms occurring during the winter at Kamloops A climate station are shown in Table A5:

Table A5

Highest Winter Daily Rainfall

Date of MDR	Rainfall (mm)
2/4/2005	13.8
2/28/1980	13.3
2/6/1995	9.6

Average daily rainfall depth for all the maximum daily rainfall in winter (December to February) at the Kamloops A climate station is 4.2mm.

The historical snowpack data was analyzed from Pass Lake Manual Snow Survey Station (CO4) at EL. 870m, approx. 27.5km NW of Jacko Lake. From this data, it was evident that the local snowpack is the greatest in March and most of the snowpack is melted in April.

The historical average temperatures at Kamloops A station during snow on ground (Pass Lake snow survey station from January to April), shown in Table A6:

Table A6
Average Temperatures with Snow on Ground

Month	Avg. (°C)
January	-4.0
February	-0.3
March	4.8
April	9.7

Therefore, it is likely that there was no snow cover on the ground or the ground being frozen when the three maximum rainfall events occurred in late spring and summer. The highest recorded maximum daily rainfall recorded in the winter from Kamloops A climate station is 13.8mm, which is expected to have an insignificant impact as a rain-on-snow event. Furthermore, rapid melting of ice and snow within 24-hours typically depends on the snowmelt simulation as a function of the design temperature sequence and wind speed (adding 108mm to Spring PMP makes sense if you can prove that 108mm is the amount of design snowmelt, which is a function of rainfall, temperature sequence and wind speed).

To summarize, even though the Spring PMP plus 100-yr snow melt equivalence is marginally higher than the Summer-Autumn PMP, historical precipitation data illustrates that the likelihood of a PMP occurrence would be during the Summer-Autumn period, hence the Summer-Autumn PMP of 226mm in 24-Hours was selected for the preliminary design criterion for precipitation which is 2.5 times the estimated 1000-year 24-hour precipitation.

3 REGIONAL FLOOD FREQUENCY ANALYSIS

A hydrometric analysis was carried out based on the review of regional hydrometric stations from the Water Survey of Canada (Table A7). A number of regional stations were found, but local stations were either inactive or had limited peak flow data. Three regional hydrometric stations were selected for the analysis in view of their close proximity to site, long periods of record and comparable drainage areas. Peak flow data at the three hydrometric stations was used in a flood frequency analysis. Results from the flood frequency analysis were used in the regional analysis using the Index Flood Method, which is a standard method in determining flood peak flows at project site without long-term streamflow data.

Table A7

Regional Hydrometric Stations

Station No.	Name	D.A. (km^2)	Selected
08LB024	Fishtrap Creek Near Mclure	135	Yes
08LB038	Blue River Near Blue River	272	
08LB069	Barriere River Below Sprague Creek	624	
08LB076	Harper Creek Near The Mouth	166	
08LC040	Vance Creek Below Deafies Creek	70.9	
08LE024	Eagle River Near Malakwa	932	
08LE027	Seymour River Near Seymour Arm	805	
08LE077	Corning Creek Near Squilax	26.2	Yes
08LE108	East Canoe Creek Above Dam	20.8	Yes
08LG008	Spius Creek Near Canford	775	
08LG016	Pennask Creek Near Quilchena	87.6	Yes
08LG048	Coldwater River Near Brookmere	316	
08LG056	Guichon Creek Above Tunkwa Lake Diversion	78.2	Yes

The 2.33-year peak flow was selected as the Index Flood and a unit index flood was plotted against drainage area. An envelope curve was derived for the region. The unit index flood for Jacko Lake was determined using the envelope curve. The unit index flood was converted to the 2.33-year peak flow, and the 200-year peak at the site of interest was determined by using the median ratio of the 200-year peak flow to the 2.33-year peak flow for the region. From the results, the estimated 1000-year maximum instantaneous peak inflow at Jacko Lake (JACLAKE gauging station with a catchment area of 39.6 km^2) was determined to be 25.2m^3/s. This analysis confirms that the rainfall runoff values within the Jacko Lake catchment are relatively low compared to most other areas of BC due to in part by the extremely dry and absorbent soils and its location in a rain shadow.

The Probable Maximum Flood (PMF) was also determined for Jacko Lake. The PMF is generally defined as the largest flood that may reasonably be expected to occur at a given point on a watercourse from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible on a particular watershed. This term identifies estimates of hypothetical flood characteristics that are considered to be the most severe and "reasonably possible" at a particular location. This PMF design criteria is based on relatively comprehensive hydrometeorological analyses of critical runoff-producing precipitation and hydrologic factors favorable for maximum flood runoff.

Regional relationships were applied between catchment area of 39.6km^2 and flood peak for Jacko Lake which is within BC Southern Interior Hydrologic Zone 12B (a very unique hydrological region in BC, based on the Probable Maximum Flood Estimator for British Columbia (2010), where the project is located. Using other regions of BC for a comparison is irrelevant since the project site flows are a function of local climate, soils and landforms in the project area.

It should be mentioned that the meteorological phenomenon characterized by a strong and persistent flow of atmospheric moisture and associated with heavy precipitation from the waters adjacent to the Hawaiian Islands to the Pacific coast of North America, is an example of an atmospheric river or locally referred to as "The Pineapple Express", has not been considered in this analysis since it is apparent that there has not been an historical precedent in Kamloops, BC.

To surmise a likely PMF for Jacko Lake, it should be based on its catchment area characteristics and historical data within the BC Southern Interior Hydrologic Zone 12B, and it was estimated to be 63.1m^3/s. A factor of safety should be applied to the PMF during the final design phase of emergency spillways for the storage structure.

4 HYDROLOGICAL MODEL

The Summer - Autumn PMP 24-hr rainfall of 226mm was used in the detailed hydrological analysis using the US Army Corps of Engineers HEC-HMS model to determine the inflow design flood using the PMF at Jacko Lake. The PMF storage for conceptual design was predicated on the US Army Corps of Engineers, HEC-HMS model including the detailed input parameters for surface soils, runoff values, time of concentration, initial abstraction, input hydrograph refinement and reservoir routing analysis of the Jacko Lake based on the catchment condition as of December 2014.

The Jacko Lake catchment was subdivided into 6 sub-catchment areas and overlain on a surficial soils map in order to provide proper representation of the Jacko Lake catchment parameters. The soils varied from gravel/sandy gravel, sand/gravel/silt, sand/silt and till with minor gravel. The catchment average estimated runoff curve number was 43.2, which is consistent with runoff coefficients observed in similar semi-arid climates with low precipitation combined with high evaporation rates with soils in relatively good hydraulic condition during a short-duration summer-autumn convective storm. This would explain the relatively low runoff rates in this hydrological region whereby stormwater runoff saturating the ground, rather than flowing into creeks due to extremely dry and absorbent soils.

Sensitivity testing was carried out on the hydrological parameters. Further calibration of the model is recommended during the design phase once the facilities have been designed and hydrological design criteria are established. The hydrological model was calibrated with a 10,000-year regional hydrological stream flow analysis as well as sub-regional PMF studies in BC dated 2010. PMF runoff flows were determined for each sub-catchment and were combined in a US Army Corps of Engineers HEC-HMS model

The PMF of Jacko Lake of 63.1m^3/s appears to be reasonable since the 1000-year inflow was estimated to be 25.2m^3/s (a factor of 2.5 times the 1000-year inflow).

An emergency spillway is recommended for Jacko Lake to pass the PMF inflow design flood, and it is recommended that the final design include a factor of safety along with adequate freeboard in accordance with the most current Canadian Dam Association's Dam Safety Guidelines.

Wind setup and wave runup estimates for the proposed Jacko Lake dams is found in Section 6.

5 JACKO LAKE MINIMUM PMF STORAGE ESTIMATES

The hydrological model indicated that a 24-Hour PMF design inflow design flood storage volume of 0.8Mm^3 based on Jacko Lake conditions as of December 2014. It is recommended that a factor of safety of 2 be applied to the storage volume for hydrological uncertainties. The resulting recommended minimum storage volume is 1.6Mm^3.

Any alteration of the watershed including additional drainage areas, road building, drainage ditches, or any activity that could conceivably increase the peak inflows to Jacko Lake and the attendant PMF storage volume Jacko Lake will require a review by a qualified Professional Engineer.

The final design of the Jacko Lake storage facility will require the confirmation of storage volumes in accordance with most current Canadian Dam Association's Dam Safety Guidelines.

6 PROPOSED JACKO LAKE WIND SETUP/WAVE RUNUP

A wind setup and wave runup analysis was carried out on Jacko Lake for all three proposed dams: JDL1 (West Dam), JDL2 (NE Dam), JDL4 (SE Dam). According to the Canadian Dam Association Dam Safety Guidelines, the crest level of an embankment structure should be set so that the structure is protected against the most critical of the following cases:

- **Case 1**: No overtopping by 95% of the waves caused by the most critical wind with a frequency of 1/1000 year when the reservoir is at its maximum normal elevation.

- **<u>Case 2:</u>** No overtopping by 95% of the waves caused by the most critical wind when the reservoir is at its maximum extreme level during the passage of the IDF. For High, Very High and Extreme Consequence Dam the design return period of wind speed used for calculation of freeboard during IDF is 2 years.

The following methodology for the wind setup and wave runup analysis of Jacko Lake was carried out:

1. Detailed review and analysis of 61 years of raw hourly wind data (1953-2013) recorded at Kamloops Airport Climate Station (1163781).
2. Conduct a detailed storm sorting which shows the number of storms per wind direction bin.
3. Prepare a wind rose for the period of record.
4. Prepare a table of storms per direction bin.
5. Data screening for possible outliers.
6. Analyze data for determination of threshold velocity.
7. Conduct a Peak over Threshold analysis (Goda Method) to calculate 2-year and 1000-year return periods.
8. Determination of critical fetch and depth.
9. Determination of wave setup and wave runup for the proposed downstream dam.

The results of the wave setup and wave runup analyses are as follows illustrated in Tables A7 and A8:

Table A7

Wind Setup/Wave Runup (Case 1*)

Dam	Wind Setup (m)	Wave Runup (m)	Total (m)
JDL1 (West Dam)	0.017	0.348	0.51
JDL2 (NE Dam)	0.021	0.399	0.42
JDL4 (SE Dam)	0.024	0.409	0.43

*No overtopping by 95% of the waves caused by the most critical wind with a frequency of 1/1000 year when the reservoir is at its normal elevation.

Table A8

Wind Setup/Wave Runup (Case 2)**

Dam	Wind Setup (m)	Wave Runup (m)	Total (m)
JDL1 (West Dam)	0.007	0.255	0.26
JDL2 (NE Dam)	0.009	0.283	0.29
JDL4 (SE Dam)	0.007	0.260	0.27

**No overtopping by 95% of the waves caused by the most critical wind when the reservoir is at its maximum extreme level during the passage of the IDF. For High, Very High and Extreme Consequence Dams the design return period of wind speed used for calculation of freeboard during IDF is 2 years.

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APPENDIX A2 HYDROLOGICAL REVIEW OF THE PROPOSED PETERSON CREEK DOWNSTREAM DAM

1 INTRODUCTION

KGHM Ajax Mining Inc. (KGHM) retained Norwest Corporation (Norwest) to carry out a hydrological review of the proposed Peterson Creek Downstream Dam as part of the proposed Ajax Mine project, near Kamloops, British Columbia.

Appendix A2 provides an updated peak flow hydrological baseline flood storage design criteria for the preliminary design of the proposed Peterson Creek Downstream Dam. The hydrological baseline focused on the determination of the 1000-year flood and Probable Maximum Flood (PMF) flows entering the proposed Peterson Creek Downstream Dam.

The proposed Peterson Creek Downstream Dam and its catchment are located within the semi-arid steppe climate of South-Central Interior of BC. The climate of this region is characterized by the generally low annual precipitation and high evaporation resulting in relatively low inflow rates into the proposed Peterson Creek Downstream Dam. The winters are usually cool and dry and the summers hot and dry with relatively low humidity and high evaporation rates.

Rainfall runoff values within the proposed Peterson Creek Downstream Dam watershed are relatively low compared to most other areas of BC due to in part by the extremely dry and absorbent soils and its location in a rain shadow.

2 PRECIPITATION FREQUENCY ANALYSIS

A precipitation analysis was carried out based on the review of regional climate stations from the Meteorological Services of Canada. The selected station for the precipitation frequency analysis was Kamloops A, which has a short intensity duration frequency curve (IDF) based on rainfall data from 1965 to 2002.

Table A1

Regional Climate Stations

Station No.	Name	Lat. / Long.	Elevation (masl)	Proximity (km)	IDF Curves	Record	Years
1163780	Kamloops A	50° 42' N 120° 26' W	345	12.61	Yes	1953 - 2013	61
1164LH5	Knutsford 2S	50° 36' N 120° 19' W	899	8.22	No	1986 - 1997	12
1163790	Kamloops Afton Mines	50° 40' N 120° 30' W	701	11.34	No	1977 - 1993	17
116C8P0	Kamloops Pratt Road	50° 36' N 120° 12' W	640	18.24	No	1986 - 2013	28
1124668	Logan Lake	50° 30' N 120° 49' W	1101	36.35	No	1971 - 2005	35

Due to the various ranges of record periods, the main hydrological analysis was based on Kamloops A and Kamloops Pratt Road; Kamloops Afton Mines was used as secondary data. The overlapping period of record of the main data set is 1986 to 2005 (20 years). Since the IDF data was based on hourly rainfall data up to 2002, a check was made to determine the difference in the average annual maximum daily rainfall from 1965 to 2002 and that from 1965 to 2013. Results indicate that there is no significant difference with the inclusion of the additional data points. Based on other previous reports provided by KGHM, climate data has been recorded at site since August 2010. However, the dataset has inconsistencies and a relatively short period of record. Therefore, the regional stations were used in the determining the precipitation amounts representing the project site.

The 1000-year, 24-hour precipitation totals were extrapolated from the IDF curve. Since the Kamloops A station is situated at EL. 345m (lower than the Ajax Mine project reference elevation of EL 895m), an elevation adjustment was made to the extrapolated rainfall totals. A regional average maximum daily rainfall versus elevation relationship was developed using the selected regional daily climate data sets (the overlapping period is from late 1980's to mid-1990's). The regional extreme rainfall vs. elevation relationship is approximately a 6% increase in rainfall for every 100m of increase in basin elevation. The maximum daily rainfall was determined at the proposed Peterson Creek Downstream Dam and a ratio of this to the maximum daily rainfall at Kamloops A station was calculated. The extrapolated rainfall totals were then adjusted to the proposed Peterson Creek Downstream Dam elevation using the aforementioned ratio. Finally, the 1000-year 24-hour rainfall total depth for the vicinity of The proposed Peterson Creek Downstream Dam was estimated to be about 90mm.

The Probable Maximum Precipitation (PMP) for the Ajax project site was also determined. It is generally defined theoretically, as the greatest depth of precipitation for a given duration that is physically possible over a given storm area at a particular geographical location at a certain time of the year. The PMP was determined using the Hershfield Method as recommended in the Rainfall Frequency Atlas for Canada (1985). However, since the reference was published in 1985, a comparison of the average maximum daily rainfall at Kamloops A station from 1965 to 1985 and that from 1965 to 2013 was determined. Results indicate that there is an increase in the maximum daily rainfall total by 7%, which was applied to the preliminary PMP. Furthermore, a slight elevation adjustment was made in this case to take into account the relatively higher elevation at the proposed Peterson Creek Downstream Dam. The average elevation of the selected regional stations was used as the base elevation, and a 6% increase in the preliminary PMP was applied for every 100m increase in elevation.

The 100-year snowmelt water equivalent estimated by Knight Piesold (April 2015) was 108mm. The Spring PMP plus 100-year snowmelt and Summer-Autumn PMP for 24-Hour for the Ajax Mine are shown in Table A3.

Table A3

Spring PMP and Summer-Autumn PMP at the proposed Peterson Creek Downstream Dam

24-Hour PMP Period	Rainfall (mm)
Spring	125
Spring + 100-year snow water equivalent	233
Summer-Autumn	226

If warranted, the Spring PMP can be combined with the design snowmelt condition such as the 100-year snowmelt; however combining snowmelt condition with the Summer-Autumn PMP would not be acceptable in this case due to lack of evidence of snowpack in the summer-autumn period.

The 226mm value for the Summer-Autumn PMP is very close to the 221mm value provided by Knight Piesold. The reason for the discrepancy is the latest figure has an extended data set, which updates the PMP value. Therefore, the updated PMP of 226mm should be used in the hydrological review. Since the Ajax project site is located within a special relatively dry hydrological region, it is important to review historical storms in the region. A review of the highest recorded maximum daily rainfall events at Kamloops A climate station, indicates that the highest rainfall events have occurred in late spring and summer as shown in Table A3:

Table A3
Highest Recorded Daily Rainfall

Date of MDR	Rainfall (mm)
August 16, 1976	48
June 29, 1986	36.8
September 6, 1985	28.8

Almost all of the spring maximum daily rainfall events occurred in late April and May, with the top three historical storms in spring at Kamloops A climate station as shown in Table A4:

Table A4
Highest Spring Daily Rainfall

Date of MDR	Rainfall (mm)
April 25, 1983	27.8
May 17, 1996	20.6
April 30, 1987 and May 14, 2002	19.4

The top 3 historical storms occurring during the winter at Kamloops A climate station are shown in Table A5:

Table A5
Highest Winter Daily Rainfall

Date of MDR	Rainfall (mm)
2/4/2005	13.8
2/28/1980	13.3
2/6/1995	9.6

Average daily rainfall depth for all the maximum daily rainfall in winter (December to February) at the Kamloops A climate station is 4.2mm.

The historical snowpack data was analyzed from Pass Lake Manual Snow Survey Station (CO4) at EL. 870m, approx. 27.5km NW of The proposed Peterson Creek Downstream Dam. From this data, it was evident that the local snowpack is the greatest in March and most of the snowpack is melted in April.

The historical average temperatures at Kamloops A station during snow on ground (Pass Lake snow survey station from January to April), shown in Table A6:

Table A6

Average Temperatures with Snow on Ground

Month	Avg. (°C)
January	-4.0
February	-0.3
March	4.8
April	9.7

Therefore, it is likely that there was no snow cover on the ground or the ground being frozen when the three maximum rainfall events occurred in late spring and summer. The highest recorded maximum daily rainfall recorded in the winter from Kamloops A climate station is 13.8mm, which is expected to have an insignificant impact as a rain-on-snow event. Furthermore, rapid melting of ice and snow within 24-hours typically depends on the snowmelt simulation as a function of the design temperature sequence and wind speed (adding 108mm to Spring PMP makes sense if you can prove that 108mm is the amount of design snowmelt, which is a function of rainfall, temperature sequence and wind speed).

To summarize, even though the Spring PMP plus 100-yr snow melt equivalence is marginally higher than the Summer-Autumn PMP, historical precipitation data illustrates that the likelihood of a PMP occurrence would be during the Summer-Autumn period, hence the Summer-Autumn PMP of 226mm in 24-Hours was selected for the preliminary design criterion for precipitation which is 2.5 times the estimated 1000-year 24-hour precipitation.

3 REGIONAL FLOOD FREQUENCY ANALYSIS

A hydrometric analysis was carried out based on the review of regional hydrometric stations from the Water Survey of Canada (Table A7). A number of regional stations were found, but local stations were either inactive or had limited peak flow data. Three regional hydrometric stations were selected for the analysis in view of their close proximity to site, long periods of record and comparable drainage areas. Peak flow data at the three hydrometric stations was used in a flood frequency analysis. Results from the flood frequency analysis were used in the regional analysis using the Index Flood Method, which is a standard method in determining flood peak flows at project site without long-term streamflow data.

Table A7
Regional Hydrometric Stations

Station No.	Name	D.A. (km^2)	Selected
08LB024	Fishtrap Creek Near Mclure	135	Yes
08LB038	Blue River Near Blue River	272	
08LB069	Barriere River Below Sprague Creek	624	
08LB076	Harper Creek Near The Mouth	166	
08LC040	Vance Creek Below Deafies Creek	70.9	
08LE024	Eagle River Near Malakwa	932	
08LE027	Seymour River Near Seymour Arm	805	
08LE077	Corning Creek Near Squilax	26.2	Yes
08LE108	East Canoe Creek Above Dam	20.8	Yes
08LG008	Spius Creek Near Canford	775	
08LG016	Pennask Creek Near Quilchena	87.6	Yes
08LG048	Coldwater River Near Brookmere	316	
08LG056	Guichon Creek Above Tunkwa Lake Diversion	78.2	Yes

The 2.33-year peak flow was selected as the Index Flood and a unit index flood was plotted against drainage area. An envelope curve was derived for the region. The unit index flood for the proposed Peterson Creek Downstream Dam was determined using the envelope curve. The unit index flood was converted to the 2.33-year peak flow, and the 200-year peak at the site of interest was determined by using the median ratio of the 200-year peak flow to the 2.33-year peak flow for the region. From the results, the estimated 1000-year maximum instantaneous peak inflow at the proposed Peterson Creek Downstream Dam (Catchment Area 103 km^2 including Jacko Lake catchment) was determined to be $33m^3/s$. This analysis confirms that the rainfall runoff values within the proposed Peterson Creek Downstream Dam catchment are relatively low compared to most other areas of BC due to in part by the extremely dry and absorbent soils and its location in a rain shadow.

The Probable Maximum Flood (PMF) was also determined for the proposed Peterson Creek Downstream Dam. The PMF is generally defined as the largest flood that may reasonably be expected to occur at a given point on a watercourse from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible on a particular watershed. This term identifies estimates of hypothetical flood characteristics that are considered to be the most severe and "reasonably possible" at a particular location. This PMF design criteria is based on relatively comprehensive hydrometeorological analyses of critical runoff-producing precipitation and hydrologic factors favourable for maximum flood runoff.

Regional relationships were applied between catchment area of 103km^2 and flood peak for The proposed Peterson Creek Downstream Dam which is within BC Southern Interior Hydrologic Zone 12B (a very unique hydrological region in BC, based on the Probable Maximum Flood Estimator for British Columbia (2010), where the project is located. Using other regions of BC for a comparison is irrelevant since the project site flows are a function of local climate, soils and landforms in the project area.

It should be mentioned that the meteorological phenomenon characterized by a strong and persistent flow of atmospheric moisture and associated with heavy precipitation from the waters adjacent to the Hawaiian Islands to the Pacific coast of North America, is an example of an atmospheric river or locally referred to as “The Pineapple Express”, has not been considered in this analysis since it is apparent that there has not been an historical precedent in Kamloops, BC.

To surmise a likely PMF for the proposed Peterson Creek Downstream Dam, it should be based on its catchment area characteristics and historical data within the BC Southern Interior Hydrologic Zone 12B, and it was estimated to be 153m^3/s. A factor of safety should be applied to the PMF during the final design phase of emergency spillways for the storage structure.

4 HYDROLOGICAL MODEL

The Summer - Autumn PMP 24-hr rainfall of 226mm was used in the detailed hydrological analysis using the US Army Corps of Engineers HEC-HMS model to determine the inflow design flood using the PMF at The proposed Peterson Creek Downstream Dam. The PMF storage for conceptual design was predicated on the US Army Corps of Engineers, HEC-HMS model including the detailed input parameters for surface soils, runoff values, time of concentration, initial abstraction, input hydrograph refinement and reservoir routing analysis of the proposed Peterson Creek Downstream Dam based on the catchment condition as of December 2014.

The proposed Peterson Creek Downstream Dam catchment was subdivided into 22 sub-catchment areas and overlain on a surficial soils map in order to provide proper representation of the proposed Peterson Creek Downstream Dam catchment parameters. The soils varied from gravel/sandy gravel, sand/gravel/silt, sand/silt and till with minor gravel. The catchment average estimated runoff curve number was 44.3, which is consistent with runoff coefficients observed in similar semi-arid climates with low precipitation combined with high evaporation rates with soils in relatively good hydraulic condition during a short-duration summer-autumn convective storm. This would explain the relatively low runoff rates in this hydrological region whereby stormwater runoff saturating the ground, rather than flowing into creeks due to extremely dry and absorbent soils.

Sensitivity testing was carried out on the hydrological parameters. Further calibration of the model is recommended during the design phase once the facilities have been designed and hydrological design criteria are established. The hydrological model was calibrated with a 10,000-year regional hydrological stream flow analysis as well as sub-regional PMF studies in BC dated 2010. PMF runoff flows were determined for each sub-catchment and were combined in a US Army Corps of Engineers HEC-HMS model

The PMF of the proposed Peterson Creek Downstream Dam of 153m^3/s appears to be reasonable since the 1000-year inflow was estimated to be 33m^3/s (a factor of 4.6 times the 1000-year inflow). Any alteration of the watershed including additional drainage areas, road building, drainage ditches, or any activity that could conceivably increase the peak inflows will require a review by a qualified Professional Engineer.

An emergency spillway is recommended for the proposed Peterson Creek Downstream Dam to pass the PMF inflow design flood, and it is recommended that the final design include a factor of safety along with adequate freeboard in accordance with the current Canadian Dam Association's Dam Safety Guidelines. The proposed Peterson Creek Downstream Dam will be a run-of-the-river type dam whereby little or no water storage is provided.

Wind setup and wave runup estimates for the proposed the proposed Peterson Creek Downstream Dam dams is found in Section 5.

5 PROPOSED PETERSON CREEK DOWNSTREAM DAM RESERVOIR WIND SETUP/WAVE RUNUP

The purpose of the wind setup and wave runup analysis for the proposed Peterson Creek Downstream Dam during designated design levels is to assist in the determination of freeboard for the dam. According to the Canadian Dam Association's Dam Safety Guidelines, the crest level of an embankment structure should be set so that the structure is protected against the most critical of the following cases:

- **Case 1:** No overtopping by 95% of the waves caused by the most critical wind with a frequency of 1/1000 year when the reservoir is at its maximum normal elevation of El. 865.5m.
- **Case 2**: No overtopping by 95% of the waves caused by the most critical wind when the reservoir is at its maximum extreme level of EL 867.4m during the passage of the IDF.

For High, Very High and Extreme Consequence Dam the design return period of wind speed used for calculation of freeboard during IDF is 2 years.

The following methodology was carried out:

1. Detailed review and analysis of 61 years of raw hourly wind data (1953-2013) recorded at Kamloops Airport Climate Station (1163781).
2. Conduct a detailed storm sorting which shows the number of storms per wind direction bin.
3. Prepare a wind rose for the period of record.
4. Prepare a table of storms per direction bin.
5. Data screening for possible outliers.
6. Analyze data for determination of threshold velocity.
7. Conduct a Peak over Threshold analysis (Goda Method) to calculate 2-year and 1000-year return periods.
8. Determination of critical fetch and depth.
9. Determination of wave setup and wave runup for the proposed downstream dam.

The results of the wave setup and wave runup analysis are as follows:

Table A7
Wind Setup/Wave Runup Case 1*

Dam	Wind Setup (m)	Wave Runup (m)	Total (m)
Peterson Creek D/S Dam	0.038	0.27	0.31

*No overtopping by 95% of the waves caused by the most critical wind with a frequency of 1/1000 year when the reservoir is at its normal elevation.

Table A8
Wind Setup/Wave Runup Case 2**

Dam	Wind Setup (m)	Wave Runup (m)	Total (m)
Peterson Creek D/S Dam	0.011	0.15	0.2

**No overtopping by 95% of the waves caused by the most critical wind when the reservoir is at its maximum extreme level during the passage of the IDF. For High, Very High and Extreme Consequence Dams the design return period of wind speed used for calculation of freeboard during IDF is 2 years.

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Appendix B– Preliminary Pit Slope Offset Study

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APPENDIX B JACKO LAKE PRELIMINARY PIT SLOPE OFFSET AND OVERBURDEN SLOPE GUIDELINES

Please refer to Document Number C135-KA39-MEM-00-005

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Appendix C – Proposed Site Investigation Plan

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APPENDIX C JACKO LAKE PROPOSED SITE INVESTIGATION PLAN

Please refer to Document Number C135-KA39-LTR-00-001

Appendix D – Slope Stability Analyses

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APPENDIX D JACKO LAKE PRELIMINARY STABILITY ANALYSIS

1 INTRODUCTION

Engineered dams will be constructed on the western, northeastern and southeastern arms of Jacko Lake. Preliminary stability analyses were required to confirm design embankment slopes for the Jacko Lake preliminary water management design. Stability analyses were not undertaken for the Peterson Creek Downstream Pond at this stage due to the low height of the structure within the creek centreline (<2.5m), the shallow fill slopes (minimum 3H:1V), the downstream buttressing influence of the spillway chute (8.5% slope). Detailed stability analyses will be conducted for each structure during the next phase of design once additional site investigation information becomes available.

Two dimensional stability analyses were undertaken for three typical cross sections through each dam. Stability analyses were carried out with the computer program Slope/W 2012 (Version 8.14), which uses the method of slices to calculate the Factor of Safety (FOS). FOS is specified using Spencer's Method to solve for force and moment equilibrium.

2 MATERIAL PROPERTIES

Stratigraphy of the foundation material was based on the 2014 Klohn Crippen Berger (KCB) site investigation report (KCB, 2014). Overburden materials were classified as follows based on the KCB descriptions:

- Upper sand & gravel till layer
- Silt / clay till layer
- Lower sand and gravel till layer

A discussion of detailed stratigraphy can be found in the preliminary design report. Where drilling information was not available, an undifferentiated overburden material with strengths similar to that of the silt/clay layer was used. Material parameters used in this analysis are presented in Table D1.

Table D1
Material Parameters for Stability Analysis

	Material	Bulk Unit Weight (kN/m^3)	Effective Friction Angle (°)	Cohesion (kPa)	Pore Pressure Parameter (ru / b-bar)
Fill	Compacted Fill	20	30	0	ru=0.25
	Drain Rock	20	35	0	-
Foundation	Upper Sand & Gravel Till	20	33	0	-
	Silt / Clay Till	20	30	0	B-bar=0.3
	Lower Sand & Gravel Till	20	35	0	-
	Bedrock	Impenetrable			

Material properties are preliminary at this time. Parameters will be updated as site specific geotechnical investigation information becomes available.

3 DESIGN BASIS AND ASSUMPTIONS

3.1 Dam Geometry

The dam geometry used for the stability analyses is shown below:

- 3H:1V slope for both upstream and downstream slope.
- Dam crest width: 5m.
- Normal Water Level EL. 892m

3.2 3.3 Seismic Parameters

Seismic hazard values for the site are available from the Natural Resources Canada (NRC) website (NRC, 2010) for earthquakes up to the 1/2,475 return period. Firm ground peak horizontal ground accelerations and the associated return periods from NRC are summarized in Table D2 below. Seismic hazard values for greater return periods are not provided by Natural Resources Canada. A peak ground acceleration of 0.34g for the 1/10,000 year return period was reported by Knight Piésold for preliminary design of the nearby tailings storage facility (Knight Piésold, 2014).

Table D2
Ajax Seismic Hazard Values [1]

Earthquake Return Period (Years)	Annual Exceedance Probability (AEP)	Peak Ground Acceleration (g)
100	1%	0.034
475	0.21%	0.072
1,000	0.1%	0.097
2,475	0.0404%	0.138
10,000 [2]	0.01%	0.340 [2]

1. Preliminary values. To be confirmed upon site specific seismic hazard assessment.
2. Based on values used by Knight Piésold for the preliminary tailings storage facility design.

The Jacko Lake dams are currently classified as “Very High” consequence dam as defined by the CDA 2007 Dam Safety guidelines. A “Very High” dam structure requires an earthquake design ground motion that is ½ between the 1/2475 year and the 1/10,000 year return period or MCE. For consistency with the preliminary tailings storage facility design (Knight Piésold, 2014), the 1/10,000 year earthquake was selected for the Maximum Credible Earthquake (MCE). Knight Piésold reported the 1/10,000 year earthquake to have a Peak Ground Acceleration (PGA) of 0.34g for the tailings facility. The value for the 1/2475 year earthquake was report by NRC as 0.138g. Based on these values, a PGA of 0.24g was obtained for the “Very High” dam classification. For pseudostatic analyses, 2/3 of the PGA was used to obtain the horizontal seismic co-efficient (i.e. k_h = 0.16).

3.4 Factor of Safety Criteria

The dams at Jacko Lake and the Peterson Creek Downstream will be designed to meet minimum required FOS criteria as shown on Table D3. These factors of safety criteria are based on the revised 2007 Canadian Dam Association Dam Safety Guidelines (CDA, 2013).

Table D3
Slope Stability Design Criteria [1]

Phase	Minimum Factor of Safety Criteria 1
End of Construction	1.3
Long Term	1.5
Seismic (Pseudostatic Conditions)	1.0
Full/Partial Rapid Drawdown	1.2-1.3

4 STABILITY ANALYSIS RESULTS

The results of the analyses are presented below. Table D4 shows the calculated FOS for the downstream slope of each dam section. All calculated FOS exceeded design criteria.

Table D4
Factor of Safety – Downstream Slope

Section	Factor of Safety Results		
	End of Construction (Normal Water Level)	Long Term (Steady State)	Pseudo-static
Northeast Dam	1.7	1.7	1.1
Southeast Dam	1.7	N/A [1]	N/A [1]
West Dam	1.8	N/A [1]	N/A [1]

1. Long term and pseudostatic analyses for the Southeast Dam and West Dam were not considered critical cases and were not presented at this preliminary stage.

Two upstream stability cases were completed for the upstream slopes of the Northeast Dam:

- Free Standing: No water level and the dam is a free standing structure
- Rapid Drawdown: The water level drops from the normal water elevation of 892m to a minimum elevation of 891m within a short period of time. To model the internal pore pressures during the rapid drawdown period, a transient seepage analysis was completed. The stability analysis was then completed using the pore water pressure conditions developed from this seepage analysis.

Calculated factors of safety for the free standing and rapid drawdown loading scenarios are provided in Table D5. Slope/W outputs are shown from Figure 2 to Figure 8. All calculated FOS met or exceeded design criteria.

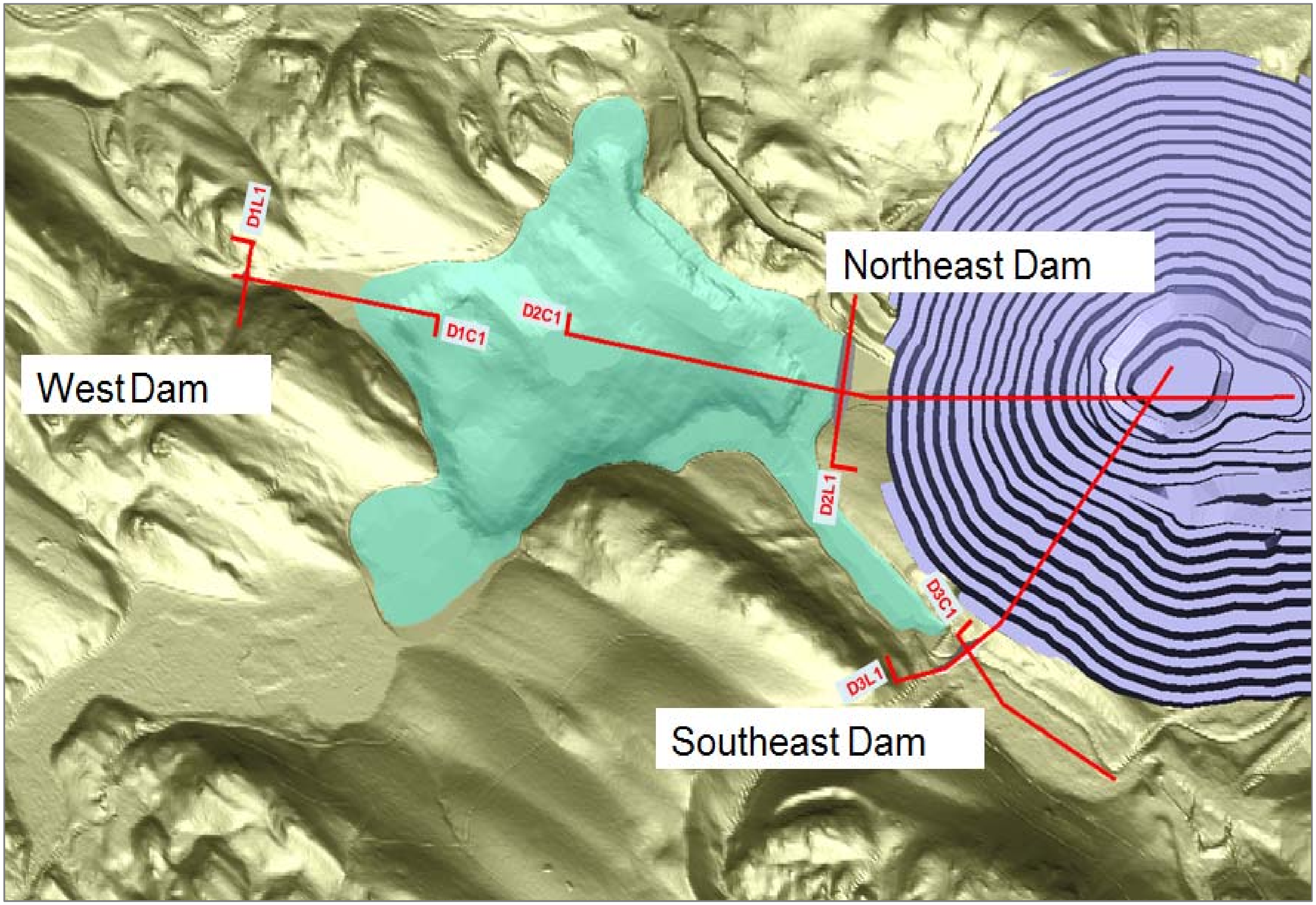
Table D5
Factor of Safety – Upstream Slope

Section	FOS	
	Free Standing	Rapid Drawdown
Northeast Dam	1.3	1.2

5 CONCLUSIONS AND RECOMMENDATIONS

Preliminary stability analyses results demonstrate that the slope configuration (3H:1V slope with a 5m crest width) meets or exceeds the minimum FOS criteria for all of the Jacko Lake Dams.

The stability of the area between Jacko Lake to the west pit was evaluated separately (See Appendix B) and not presented herein. It is recommended that detailed stability and seepage analyses be undertaken once more geotechnical information becomes available during the next phase of design.



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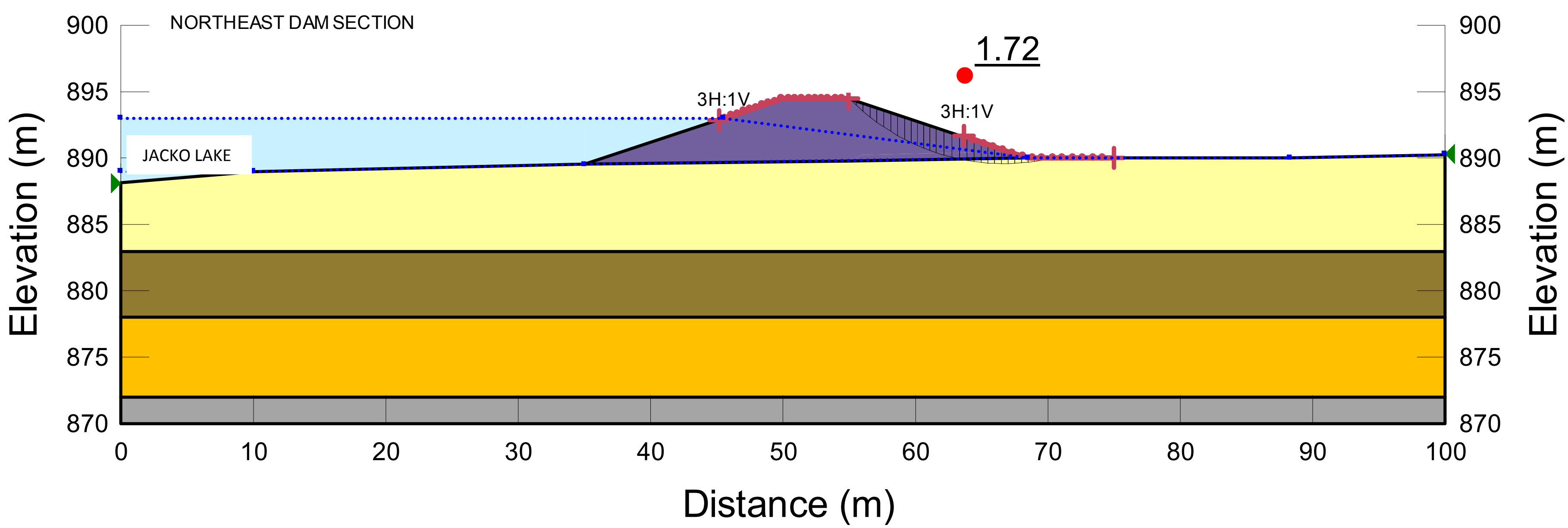
Dam Stability Analysis
Section Locations

NORWEST	809-3	FIGURE 1	REV. 0

Material Type		Unit Weight (kN/m^3)	Strength Parameters
	Dam Fill	20	φ' = 30°, c' = 0 kPa
	Upper Sand & Gravel	20	φ' = 33°, c' = 0 kPa
	Silt / Clay Till	20	φ' = 30°, c' = 0 kPa
	Lower Sand & Gravel	20	φ' = 35°, c' = 0 kPa
	Bedrock	Bedrock (Impenetrable)	



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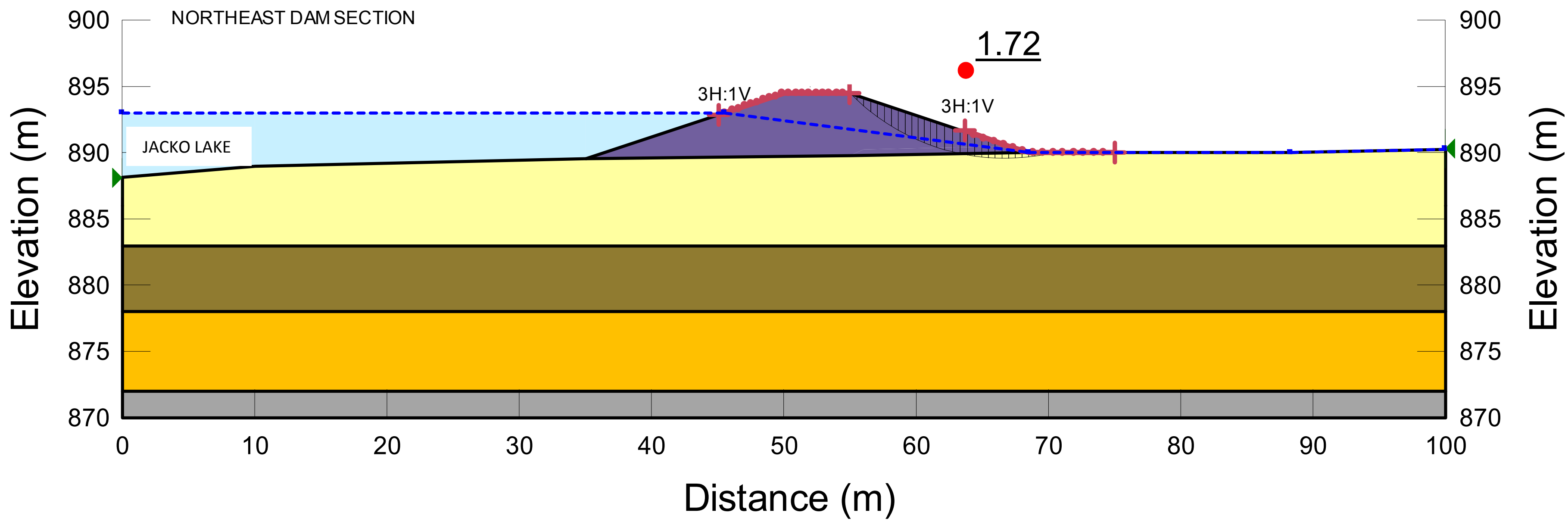
Dam Stability Analysis
Northeast Dam
End of Construction (Normal Water Level)

NORWEST	809-3	FIGURE 2	REV. 0

Material Type		Unit Weight (kN/m³)	Strength Parameters
	Dam Fill	20	φ' = 30°, c' = 0 kPa
	Upper Sand & Gravel	20	φ' = 33°, c' = 0 kPa
	Silt / Clay Till	20	φ' = 30°, c' = 0 kPa
	Lower Sand & Gravel	20	φ' = 35°, c' = 0 kPa
	Bedrock	Bedrock (Impenetrable)	



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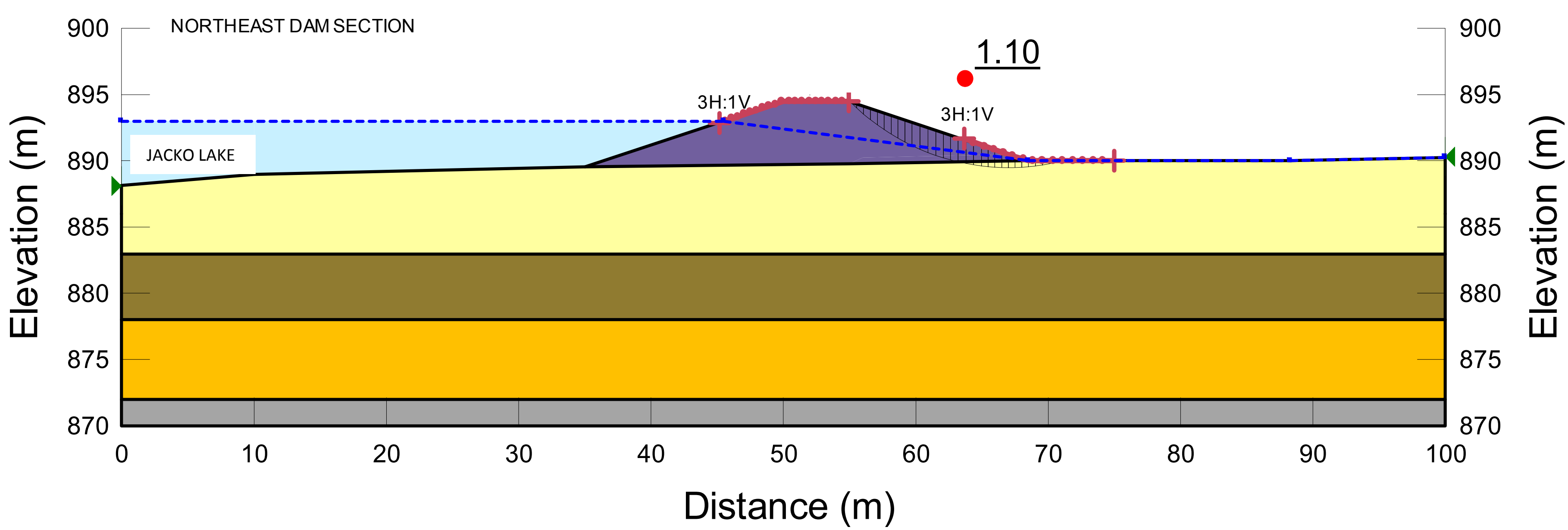
Dam Stability Analysis
Northeast Dam
Long Term

NORWEST	809-3	FIGURE 3	REV. 0

Material Type		Unit Weight (kN/m^3)	Strength Parameters
	Dam Fill	20	φ' = 30°, c' = 0 kPa
	Upper Sand & Gravel	20	φ' = 33°, c' = 0 kPa
	Silt / Clay Till	20	φ' = 30°, c' = 0 kPa
	Lower Sand & Gravel	20	φ' = 35°, c' = 0 kPa
	Bedrock	Bedrock (Impenetrable)	



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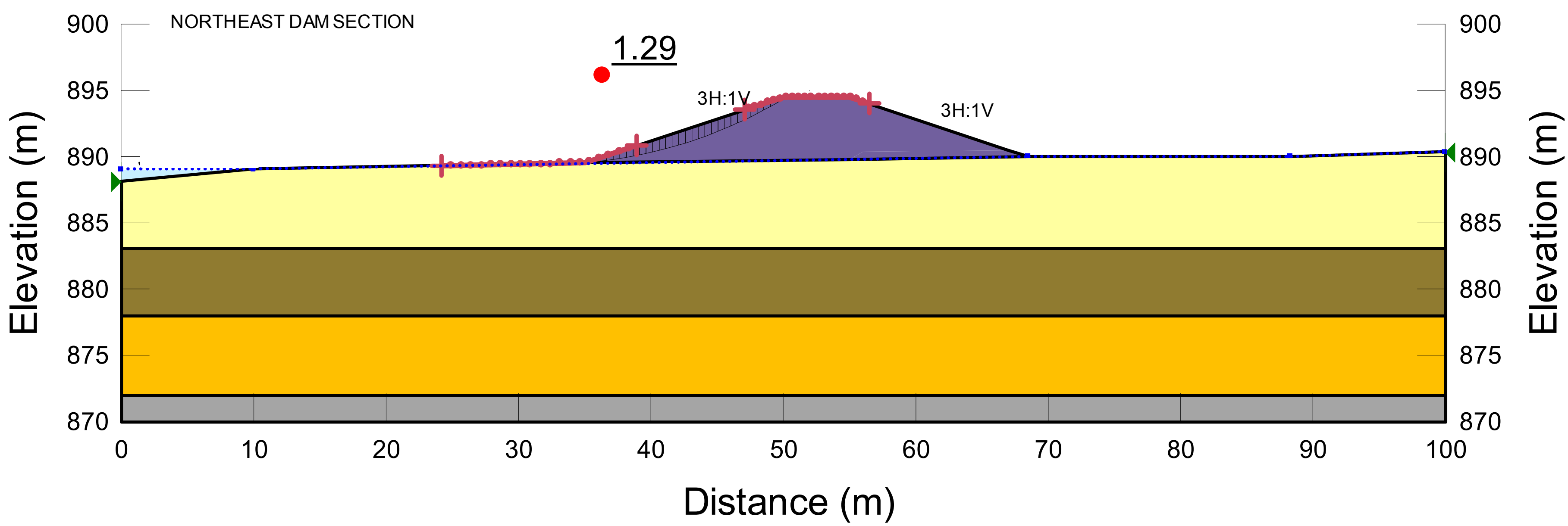
Dam Stability Analysis
Northeast Dam
Pseudo Static

NORWEST	809-3	FIGURE 4	REV. 0

Material Type		Unit Weight (kN/m^3)	Strength Parameters
	Dam Fill	20	φ' = 30°, c' = 0 kPa
	Upper Sand & Gravel	20	φ' = 33°, c' = 0 kPa
	Silt / Clay Till	20	φ' = 30°, c' = 0 kPa
	Lower Sand & Gravel	20	φ' = 35°, c' = 0 kPa
	Bedrock	Bedrock (Impenetrable)	



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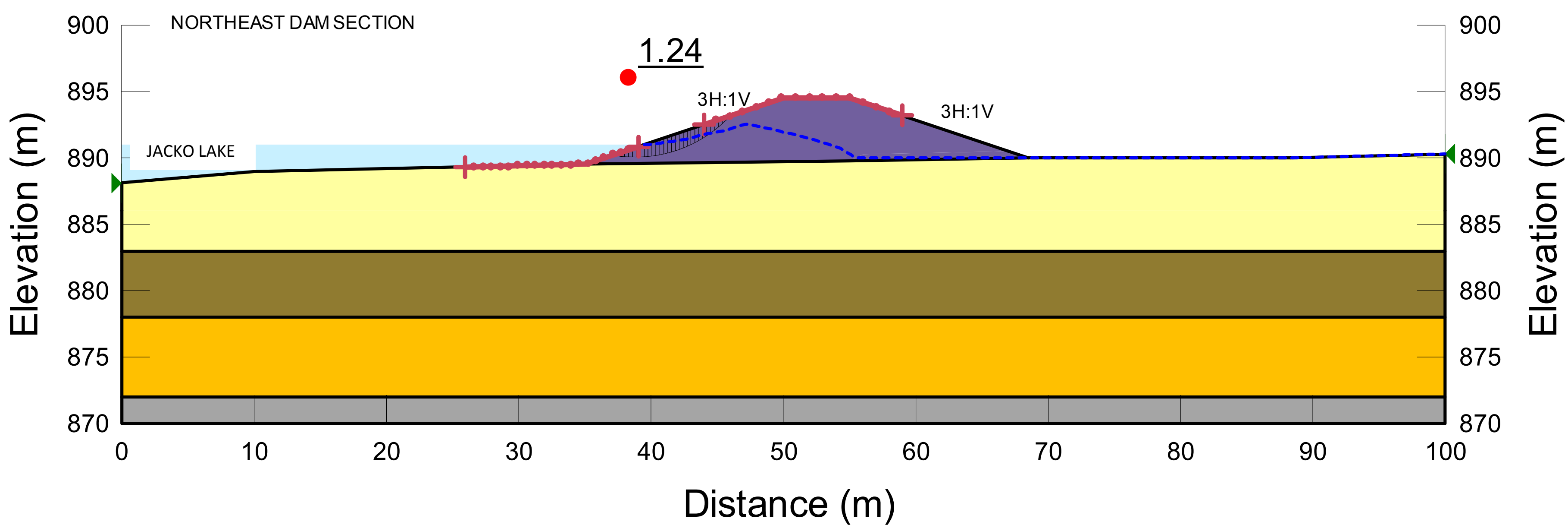
Dam Stability Analysis
Northeast Dam
Upstream Free Standing

NORWEST | 809-3 | **FIGURE 5** | REV. 0

Material Type		Unit Weight (kN/m^3)	Strength Parameters
	Dam Fill	20	φ' = 30°, c' = 0 kPa
	Upper Sand & Gravel	20	φ' = 33°, c' = 0 kPa
	Silt / Clay Till	20	φ' = 30°, c' = 0 kPa
	Lower Sand & Gravel	20	φ' = 35°, c' = 0 kPa
	Bedrock	Bedrock (Impenetrable)	



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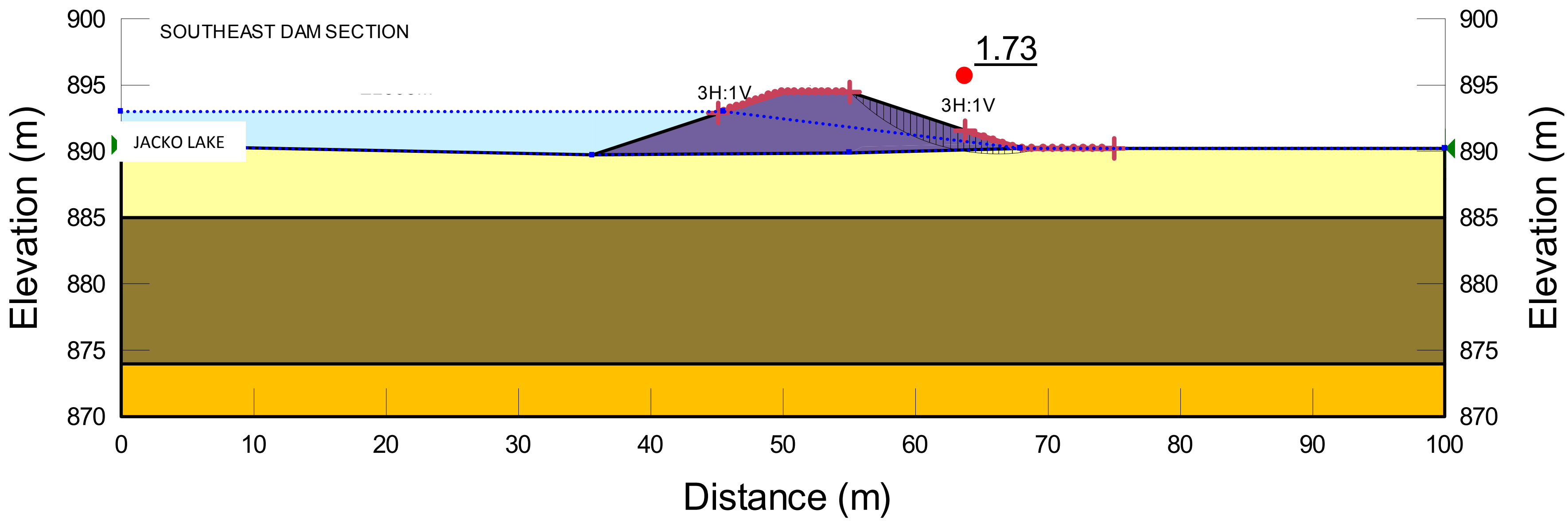
Dam Stability Analysis
Northeast Dam
Upstream Rapid Drawdown

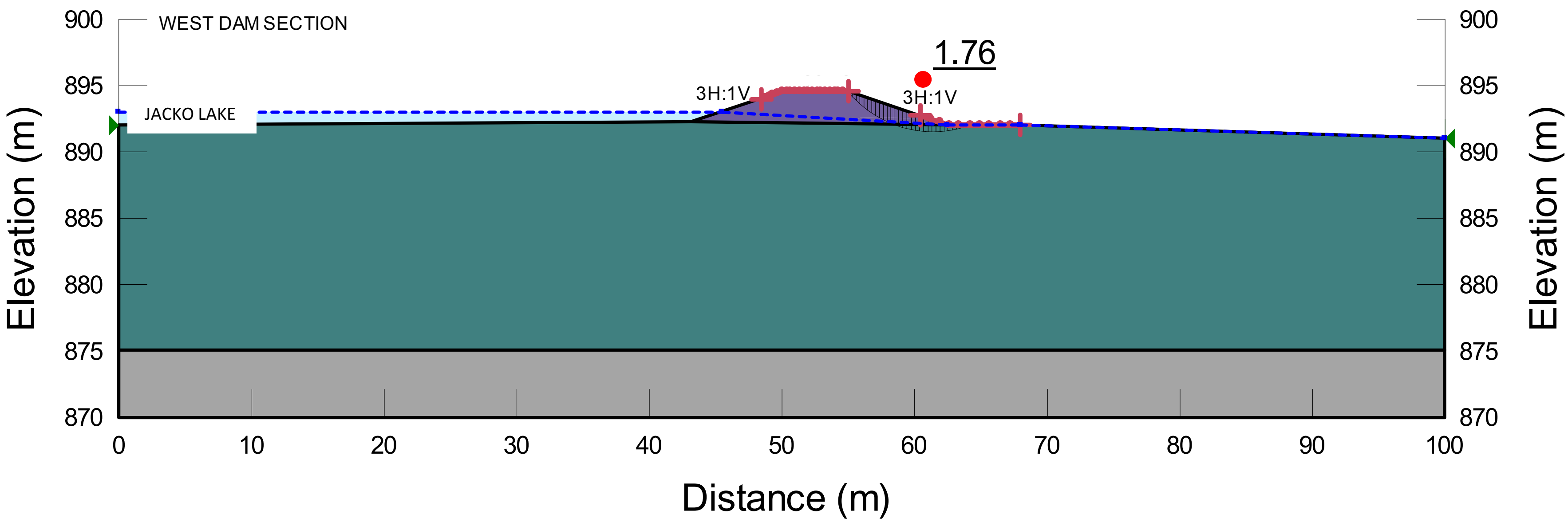
NORWEST	809-3	FIGURE 6	REV. 0

	Material Type	Unit Weight (kN/m³)	Strength Parameters
	Dam Fill	20	φ' = 30°, c' = 0 kPa
	Upper Sand & Gravel	20	φ' = 33°, c' = 0 kPa
	Silt / Clay Till	20	φ' = 30°, c' = 0 kPa
	Lower Sand & Gravel	20	φ' = 35°, c' = 0 kPa
	Bedrock	Bedrock (Impenetrable)	



KGHM	KGHM AJAX MINING INC.		
	AJAX PROJECT		
Dam Stability Analysis Southeast Dam End of Construction (Normal Water Level)			
NORWEST	809-3	FIGURE 7	REV. 0

Material Type		Unit Weight (kN/m³)	Strength Parameters
	Dam Fill	20	φ' = 30°, c' = 0 kPa
	Undifferentiated Overburden	20	φ' = 30°, c' = 0 kPa
	Bedrock	Bedrock (Impenetrable)	



KGHM	KGHM AJAX MINING INC.		
	AJAX PROJECT		
Dam Stability Analysis West Dam End of Construction (Normal Water Level)			
NORWEST	809-3	FIGURE 8	REV. 0

Appendix E – Existing Dam Removal

APPENDIX E EXISTING JACKO LAKE DAM REMOVAL

1 INTRODUCTION

Norwest is preparing preliminary designs for the containment dams around Jacko Lake which are required to facilitate the current mine plan. As part of this reconfiguration of Jacko Lake, a new dam will be constructed downstream of the existing Jacko Lake Dam on the southeastern arm of the lake (see Figure 1.1 in the preliminary design report). Once the new dam is constructed, KGHM would like to remove the existing dam structure and its ancillary facilities to the extent practical. This memorandum describes the methodology for decommissioning of the existing dam structure.

2 DESCRIPTION OF THE EXISTING SMALL DAM

The existing dam is listed as the Jacko Lake Dam in the British Columbia Ministry of Environment dam registry (Dam File#: D120211-00). A survey was completed by Underhill and Underhill Professional Land Surveyors (April 8, 2013) which was provided by KGHM during December 2014. It is an earth fill dam with the following characteristics:

- Maximum height = 3m
- Crest length = 62.5m
- Average crest width = 6m
- Crest elevation = 892.3m
- Dam slopes = 2H:1V

There is a low level decant pipe through the dam near its northeastern abutment which discharges immediately downstream of the dam. The decant pipe flows into a stilling basin and small concrete overflow weir structure approximately 30m downstream of the dam. Overflow from the weir discharges into the natural Peterson Creek drainage. An emergency spillway is located on the southwestern abutment. The spillway is vegetated but likely lined with riprap until where it discharges downstream of the concrete weir. An aerial view of the Jacko Lake Dam configuration is shown in Photo 1.

3 CONSTRUCTION OF DOWNSTREAM DAM

The current water management plan for the development of the Ajax Mine requires the construction of a new and larger dam across Peterson Creek downstream of the existing Jacko Lake Dam. The proposed dam (JLD4) would be located approximately 50m downstream of the existing dam and would have a crest elevation of 894.5m. Normal operating level of Jacko Lake would remain at 892.0m. Engineered fill sourced from local borrow areas would be used to construct the new dam. The current plan is to construct the dam in parallel with other new containment dams around Jacko Lake (JLD1, JLD2 and JLD3). All new dams would be completed prior to mine start-up and before the removal of the existing Jacko Lake Dam.

Access to the base of the Peterson Creek channel would be required for construction of the new dam. It is expected that this access would include a ramp down the channel slope and a small culvert crossing over the Peterson Creek channel. This access infrastructure should be left in place until removal of existing Jacko Lake Dam downstream structures (concrete weir, emergency spillway riprap) is completed.

4 Preparation for Dam Removal

The removal of the existing Jacko Lake Dam could be carried out either of two conditions: a "wet" removal operation or a "dry" removal operation. These are described in the following sub-sections. Both options would require a single or double line of floating silt curtains installed upstream of the existing dam. The curtains would minimize contamination of the main body of Jacko Lake with turbid water from the excavation operations. The floating silt curtains would be installed across the width of the southeastern arm of Jacko Lake anchored into either bank. A typical installation of a floating silt fence is shown in Photo 2.

- Wet removal: The wet removal would involve allowing water to discharge from Jacko Lake into the area contained between the new downstream dam and the existing structure. Water would be allowed to discharge until the water level on both sides of the dam was equalized. Assuming removal was scheduled for the summer, it is expected the lake level would be between 891 – 892masl. A lower lake level would facilitate removal activities but is not required.

- Dry removal: Dry removal would require the installation of a temporary dam (aka cofferdam) upstream of the existing Jacko Lake Dam. The relatively shallow depths in the southeastern arm (1 – 2m) make the use of removable water filled temporary dams feasible. These structures are intended to function as short-term water barriers to allow for construction activities within shallow waterways and water bodies such as Jacko Lake (see photo 3 for typical installation). Following initial installation of the temporary dam approximately 10m upstream of the existing Jacko Lake Dam, the water between the dam and the temporary structure would be discharged or pumped out to enable removal operations.

Dam excavation would be similar for both options but the dry removal option would allow operations to be carried out more efficiently due to enhanced access and visibility. This would come at an increased cost due to the need to purchase and install the temporary dam structure.

5 DAM EXCAVATION AND REMOVAL OPERATIONS

The relatively small size of the Jacko Lake Dam structure constrains the size and capacity of the excavation equipment that can be used. Dam removal would be carried out using a tracked hydraulic backhoe and rigid body rear dump trucks or smaller articulated haul trucks (20-25t capacity). The backhoe would require a reach of approximately 7m horizontally and 4m vertically. A unit of this size would be equivalent to a Caterpillar 324E with a bucket capacity in the range of $2m^3$.

The backhoe would be positioned on the crest of the dam for excavation of the fill material. Trucks would reverse onto the dam from the northeastern abutment and position themselves for loading adjacent to the backhoe. Estimated bank volume of fill to be removed is approximately $2,500m^3$. The sequence of dam removal is expected to proceed as follows:

1. Installation of floating silt curtains (and temporary dam if selected).
2. Prior to dam excavation activities:
    a. Remove steel walkway over the intake structure and the downstream concrete weir. An impact hammer unit may be required to break-up this structure to allow it to be removed by a backhoe.
    b. Remove riprap covering the emergency spillway channel (if required). This material could be removed by backhoe and small haul trucks. It may be advantageous to remove this material during construction of the new downstream dam as it could be utilized for some portion of that structure.
3. Commence excavation of earth fill near the southeastern abutment of the dam with trucks accessing the dam from the northeastern side. Fill would be hauled to a designated stockpile within the ultimate pit footprint.
4. Excavation would progress to the northeast with the fill being removed to an elevation of approximately 891m which is equivalent to the surrounding natural ground level.
5. Once excavation of the fill has reached the point where the decant pipe intersects the dam, the backhoe would expose the pipe. An impact hammer may be required to break-up any surrounding concrete to enable removal by the backhoe.
6. Following removal of the decant pipe, excavation of the dam fill would continue until the northeastern dam abutment was reached and all fill material was removed.

Based on the estimated volume of fill and expected productivity of the excavator unit, it is expected that fill removal could be completed in 4 to 7 days depending upon equipment fleet composition and productivities achieved. Time required for initial site preparation or demolition of concrete has not been included.

If the wet removal option is selected, excavated fill will be saturated limiting loading of the trucks as material will not be able to be heaped above the edge of the box. If articulated trucks were to be used, tailgates are recommended in order to increase truck capacity and limit spillage of the saturated material. Saturated fill would also require additional stockpile footprint area and water management however given the large footprint of the planned open pit, these may not be significant constraints.

6 Final Decommissioning Activities

Removal of the earth fill dam and its associated structures represent the major portions of decommissioning work. Following completion of construction activities, a number of final decommissioning activities should also be undertaken:

- The floating silt fence should remain in place until sediments within the contained impoundment have settled out and water quality (turbidity, total suspended solids) is at a level that will allow it to mix with the main body of Jacko Lake.
- An assessment of the natural side slopes on either side of the expanded lake impoundment should be completed to determine if shoreline protection is required to protect the slopes from fluctuating Jacko Lake water levels.
- If the dry removal option was selected, water should be pumped from the upstream side of the temporary dam until water levels upstream and downstream are equalized prior to removal of the temporary dam.

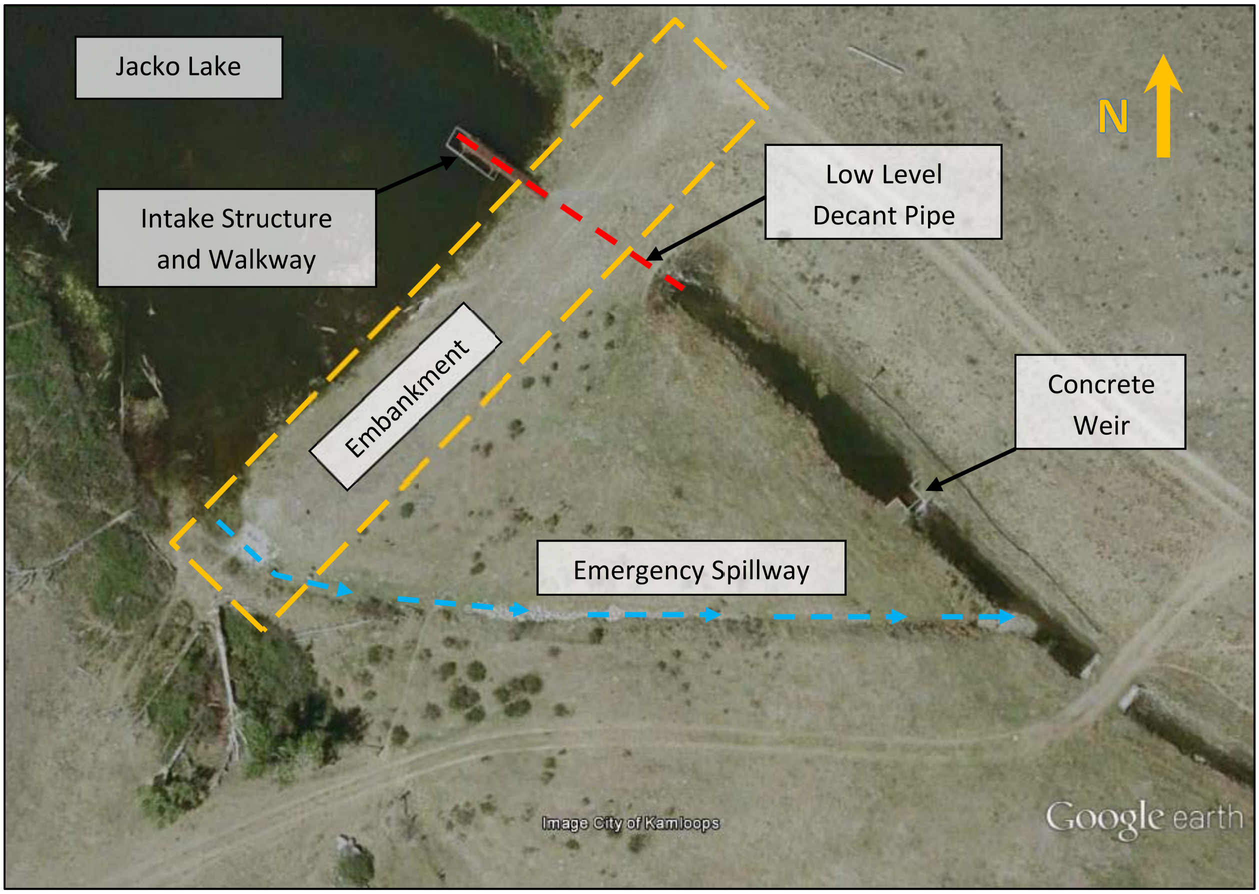
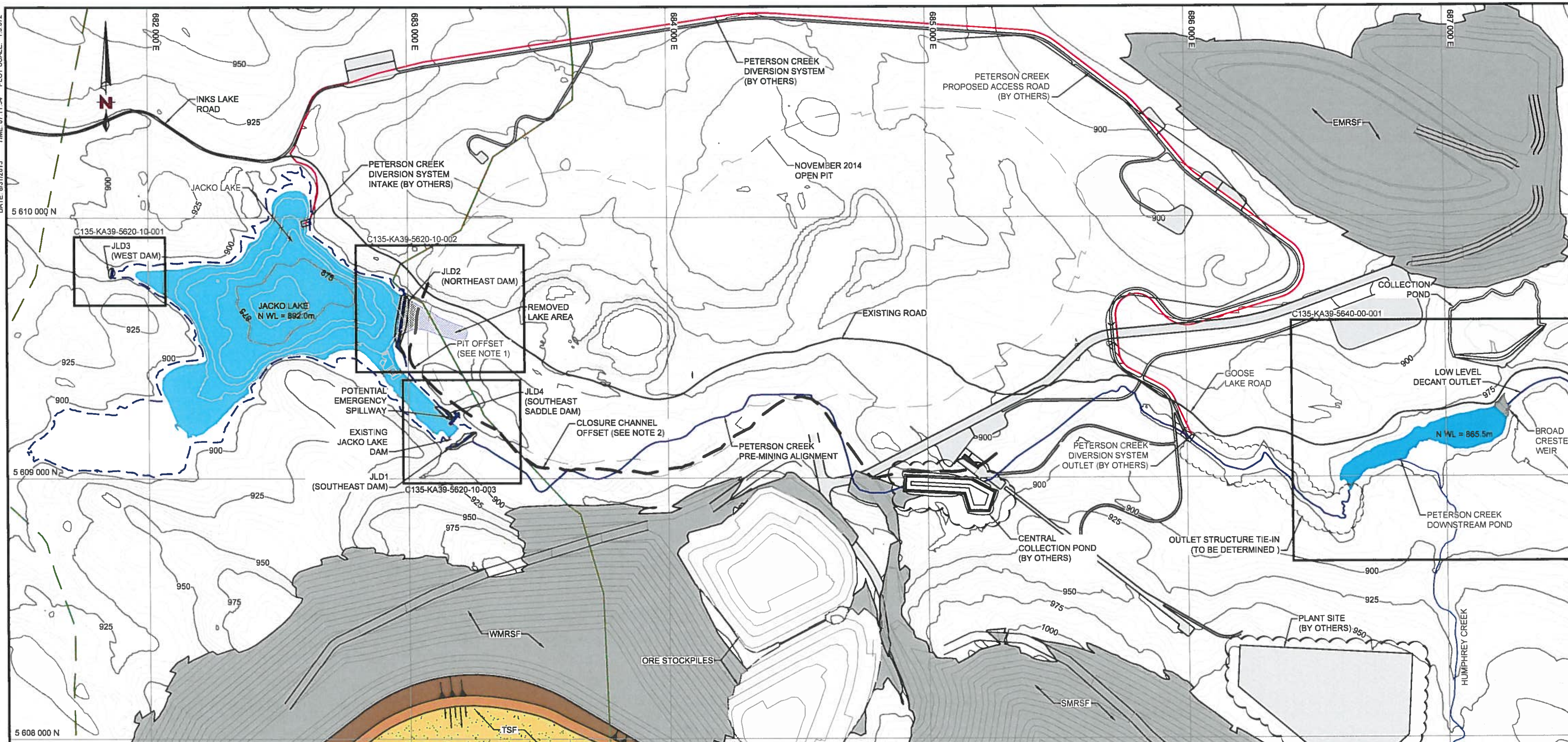


Photo 1 - Aerial View of Existing Jacko Lake Dam

Photo 2 – Floating silt curtain installation (Nilex example)

Photo 3 – Temporary water filled dam installation (Nilex example)



LEGEND:

- DESIGN FLOOD LEVEL
- PROPOSED KINDER MORGAN PIPELINE
- EXISTING KINDER MORGAN PIPELINE (TO BE REMOVED)
- OPEN PIT EXTENT FROM NOVEMBER 2014 MINE PLAN
- PETERSON CREEK DIVERSION SYSTEM (BY OTHERS)
- EXISTING ROAD
- PROPOSED HAUL ROADS (BY FLUOR)
- OPEN PIT (NOVEMBER 2014 MINE PLAN)
- TAILINGS (BEACH ABOVE WATER)
- COMPACTED MINE ROCK
- MINE ROCK BUTTRESS
- MINE ROCK STORAGE FACILITY (BY KGHM)

Status	Status Title	Check
A	Approved (No Further Action Required)	✓
B	Proceed - (Revise and Resubmit Final)	
C	Do Not Proceed (Revise and Resubmit)	
I	Information Only	

Approver: [signature] Date: AUG 31/15

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NOTES:

1. PIT OFFSET GUIDELINES PRESENTED IN TECHNICAL MEMORANDUM C135-KA39-RPT-00-01.
2. BASED ON 40 m OFFSET FROM CLOSURE CHANNEL CREST. OFFSET TO BE CONFIRMED DURING THE DETAILED DESIGN PHASE.

REFERENCES:

1. ALL DESIGN COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON LIDAR PROVIDED BY KGHM (APRIL 2013).
3. JACKO LAKE BATHYMETRY SURVEY BASED ON DATA PROVIDED BY KGHM ON JANUARY 13, 2015.
4. KINDER MORGAN PIPELINE ALIGNMENTS PROVIDED BY KGHM ON NOVEMBER 4, 2014.
5. GENERAL SITE INFRASTRUCTURE BASED ON LAYOUTS PROVIDED BY KGHM ON OCTOBER 30, 2014.
6. OPEN PIT OUTLINE BASED ON NOVEMBER 2014 MINE PLAN PROVIDED BY KGHM ON FEBRUARY 20, 2015.

100m 0 100 200 300 400 500 1000m

SCALE 1:15,000

SCALES INDICATED BASED ON AN 11"x17" PLOT CONFIGURATION

KGHM | KGHM AJAX MINING INC.

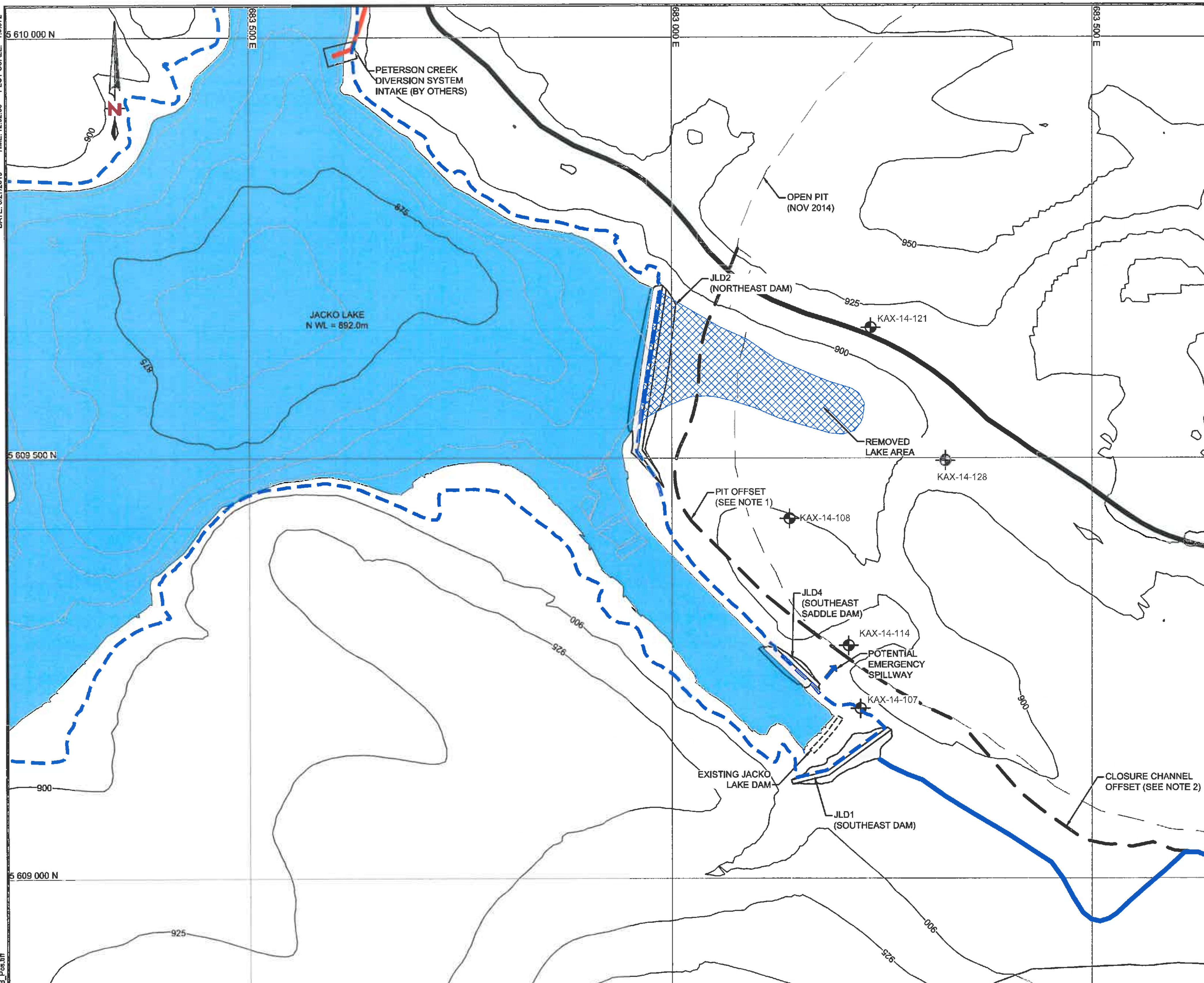
AJAX PROJECT

JACKO LAKE AND PETERSON CREEK GENERAL ARRANGEMENT PLAN

SCALE	AS SHOWN
DATE	2015-08-21
CO-ORD SYS	UTM-NAD83 ZONE 10
DRWN BY	SC	REV'D BY	CK
DSGN BY	KP	APP'D BY	SE

NORWEST | DRAWING NO: C135-KA39-5600-00-002 | REV: 0

REV.	DATE	DESCRIPTION	DWN	DSG	CHK	APR
0	2015-08-21	PRELIMINARY DESIGN DRAWING	SC	KC	CK	SE



LEGEND:

- DESIGN FLOOD LEVEL
- OPEN PIT EXTENT FROM NOVEMBER 2014 MINE PLAN
- PETERSON CREEK DIVERSION SYSTEM (BY OTHERS)
- EXISTING ROAD
- COMPLETED 2014 DRILL HOLE (KLOHN CRIPPEN BERGER)

NOTES:

1. PIT OFFSET GUIDELINES PRESENTED IN TECHNICAL MEMORANDUM C135-KA39-RPT-00-01.
2. BASED ON 40 m OFFSET FROM CLOSURE CHANNEL CREST. OFFSET TO BE CONFIRMED DURING THE DETAILED DESIGN PHASE.
3. 2014 DRILL HOLES COMPLETED BY KLOHN CRIPPEN BERGER.

REFERENCES:

1. ALL DESIGN COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON LIDAR PROVIDED BY KGHM (APRIL 2013).
3. JACKO LAKE BATHYMETRY SURVEY BASED ON DATA PROVIDED BY KGHM ON JANUARY 13, 2015.
4. GENERAL SITE INFRASTRUCTURE BASED ON LAYOUTS PROVIDED BY KGHM ON OCTOBER 30, 2014.
5. OPEN PIT OUTLINE BASED ON NOVEMBER 2014 MINE PLAN PROVIDED BY KGHM ON FEBRUARY 20, 2015.

Status	Status Title	Check
A	Approved (No Further Action Required)	X
B	Proceed - (Revise and Resubmit Final)	
C	Do Not Proceed (Revise and Resubmit)	
I	Information Only	
Approver:	Date: 28 Aug 15	

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SCALE 1:5000

SCALES INDICATED BASED ON AN 11"x17" PLOT CONFIGURATION

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IMAGE FILE(S): KGHM_Logo_NonMet_RGB_Pos.tiff

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SCALE:	AS SHOWN
DATE:	2015-08-21
CO-ORD. SYS.:	UTM-NAD83 ZONE 10
DRWN BY:	SC / REV'D BY: CK
DSGN BY:	KP / APP'D BY: SE

KGHM AJAX MINING INC.

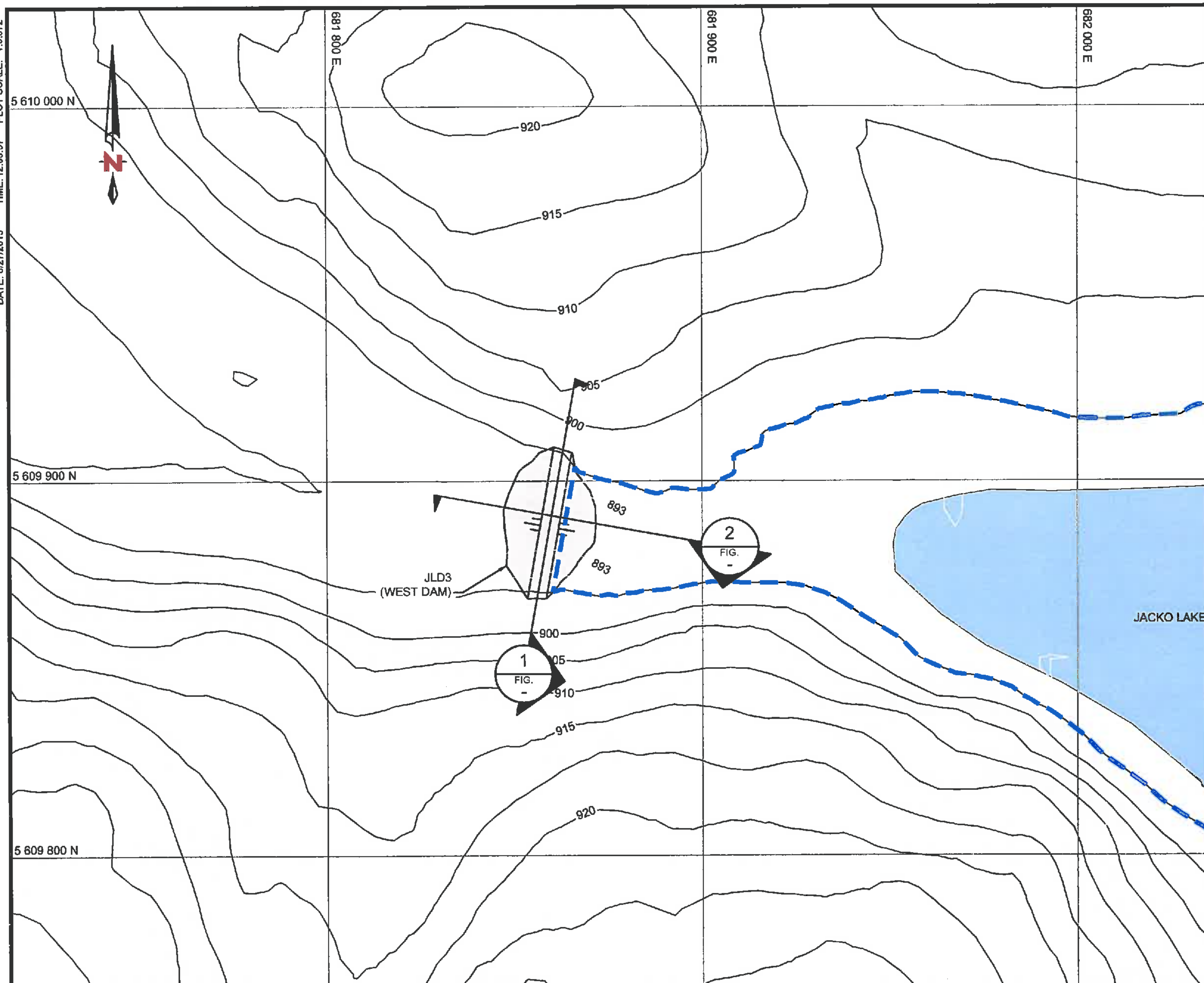
AJAX PROJECT

COMPLETED 2014
DRILL HOLE LOCATIONS

NORWEST

DRAWING NO.: C135-KA39-5600-00-006

REV.: 0



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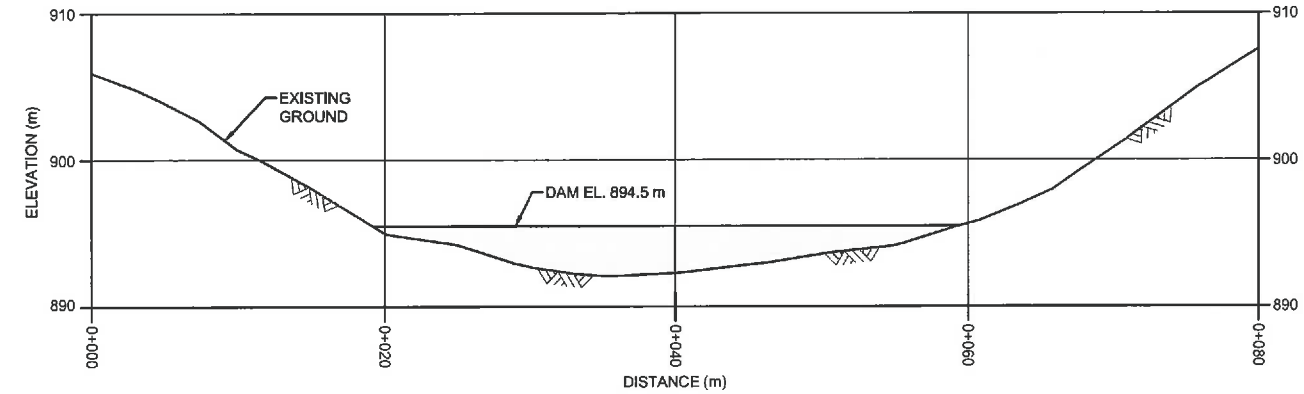

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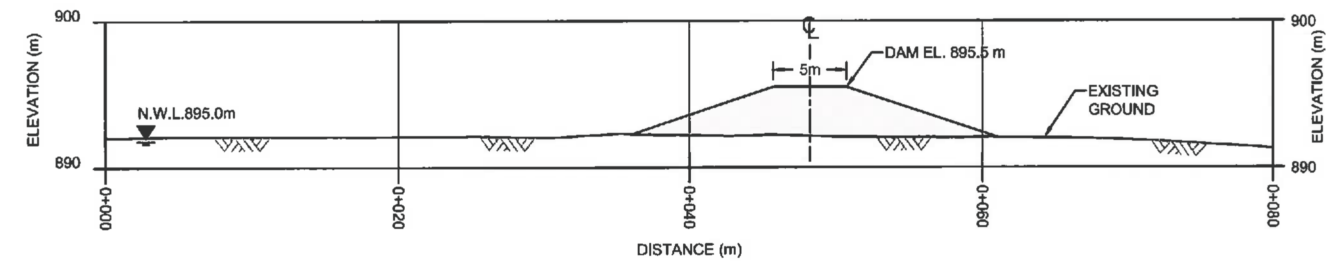

SECTION 2
SCALE 1:500

NOTES:

1. JACKO LAKE DAM LAYOUTS ARE PRELIMINARY DESIGNS ONLY. DETAILED ANALYSIS TO BE COMPLETED TO CONFIRM LAYOUTS.
2. SEE TABLE 1 FOR WATER LEVELS, DAM CREST ELEVATION.

TABLE 1:

NORMAL WATER LEVEL EL.	892.0 m
DAM CREST EL.	895.5 m

Status	Status Title	Check
A	Approved (No Further Action Required)	✗
B	Proceed - (Revise and Resubmit Final)	
C	Do Not Proceed (Revise and Resubmit)	
I	Information Only	
Approver: [signature]	Date: 28 Aug 15	

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REFERENCES:

1. ALL DESIGN COORDINATES PROVIDED ARE IN METRES.
2. THE COORDINATE SYSTEM IS IN UTM NAD 83 ZONE 10.
3. TOPOGRAPHY DATA BASED ON APRIL 2013 LIDAR PROVIDED BY KGHM.
4. JACKO LAKE BATHYMETRY SURVEY BASED ON DATA PROVIDED BY KGHM ON JANUARY 13, 2015.

LEGEND:

- ENGINEERED FILL
- JACKO LAKE NWL 892.0 m
- DESIGN FLOOD LEVEL

10m 0 10 20 30 40 50 100m
SCALE 1:1500

10m 5 0 10 20 30m
SCALE 1:500

SCALES INDICATED BASED ON AN 11"x17" PLOT CONFIGURATION

SCALE:	AS SHOWN		
DATE:	2015-08-21		
CO-ORD. SYS.:	UTM-NAD83 ZONE 10		
DRW'N BY:	SC	REV'D BY:	CK
DSG'N BY:	KP	APP'D BY:	SE

KGHM — KGHM AJAX MINING INC.

AJAX PROJECT

JACKO LAKE JLD3 (WEST DAM) PLAN, PROFILE AND SECTION

NORWEST

DRAWING NO.: C135-KA39-5620-10-001 | REV.: 0

REV.	DATE	DESCRIPTION	DWN	DSG	CHK	APR
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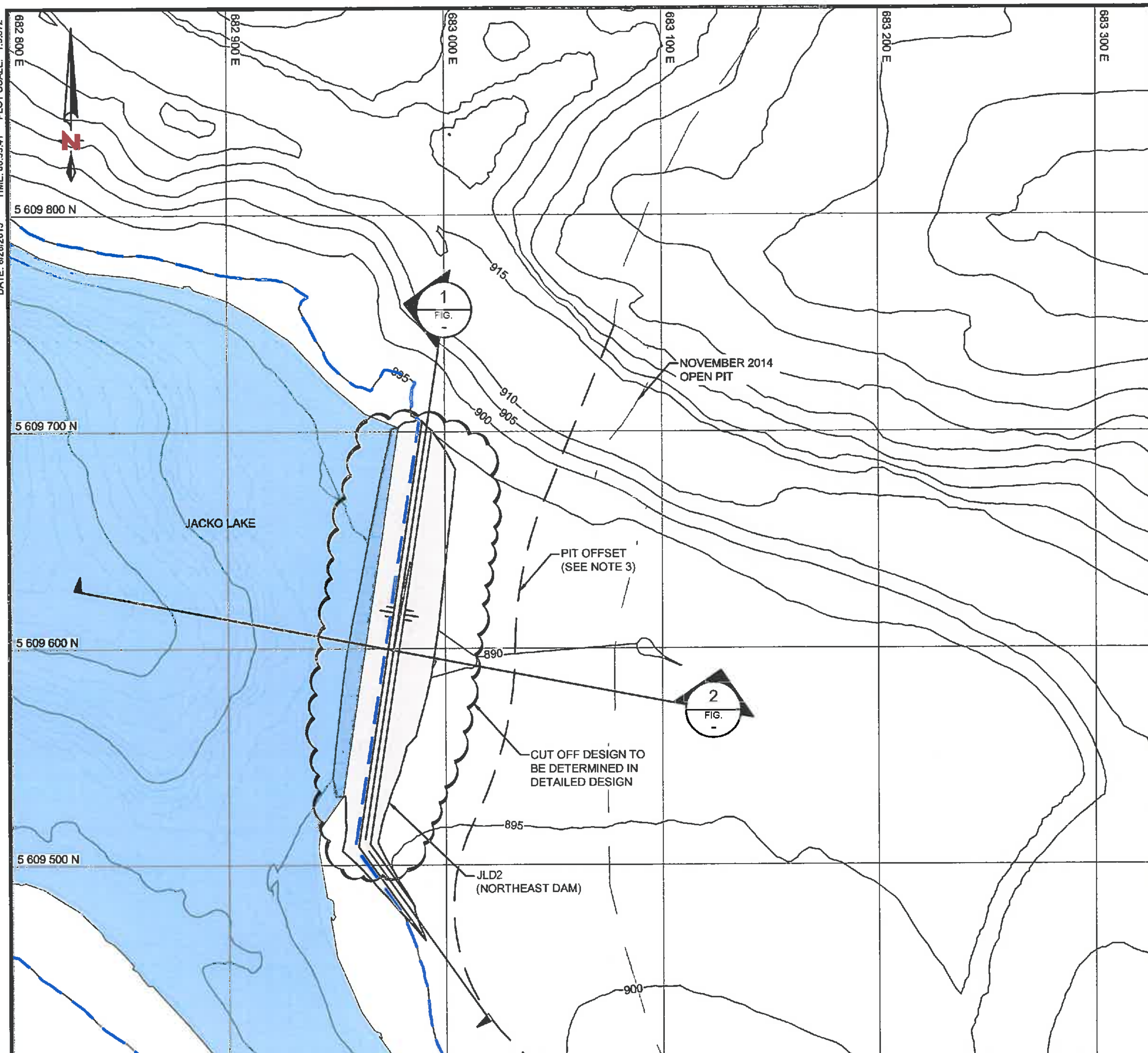

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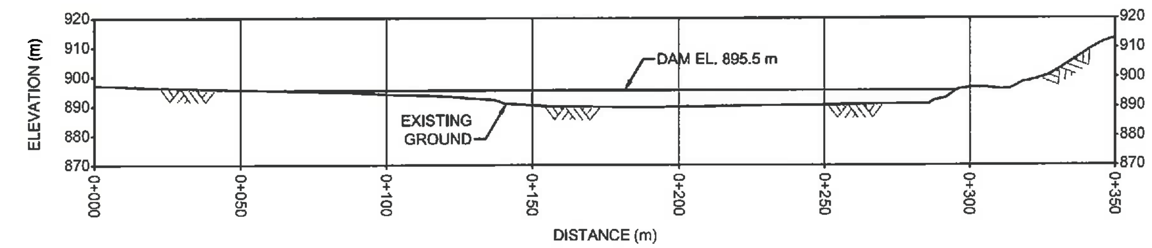
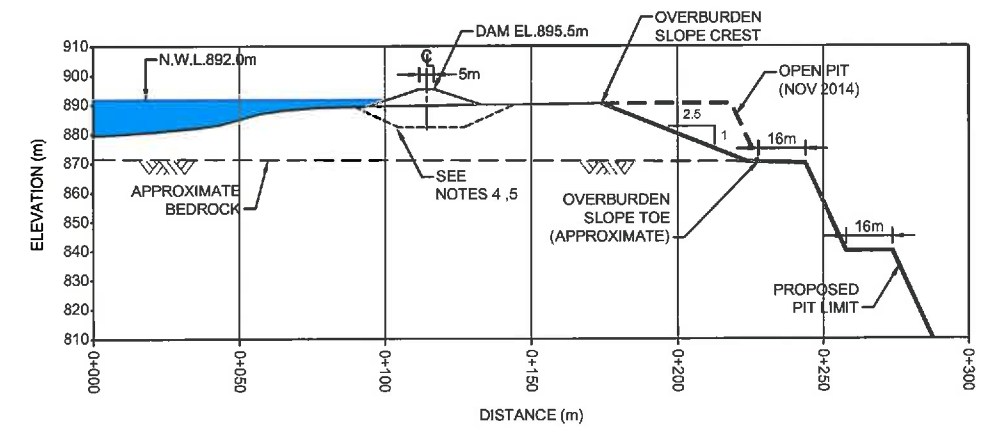


SECTION 1
SCALE 1:2000



SECTION 2
SCALE 1:2000

Status	Status Title	Check
A	Approved (No Further Action Required)	X
B	Proceed - (Revise and Resubmit Final)	
C	Do Not Proceed (Revise and Resubmit)	
I	Information Only	

Approver: [signature] Date: 28 Aug 15

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LEGEND:

- ENGINEERED FILL
- JACKO LAKE NWL 892.0 m
- DESIGN FLOOD LEVEL

NOTES:

1. JACKO LAKE DAM LAYOUTS ARE PRELIMINARY DESIGNS ONLY. DETAILED ANALYSIS TO BE COMPLETED TO CONFIRM LAYOUTS.
2. SEE TABLE 1 FOR WATER LEVELS, DAM CREST ELEVATION.
3. PIT OFFSET GUIDELINES PRESENTED IN TECHNICAL MEMORANDUM C135-KA39-RPT-00-01.
4. FOUNDATION EXCAVATION SPECIFICATION TO BE CONFIRMED AFTER PROPOSED SITE INVESTIGATION WORK IS COMPLETED.
5. CONSTRUCTION SPECIFICATION, THAT MAY INCLUDE SHEET PILING, TO BE COMPLETED UPON REVIEW OF THE SITE INVESTIGATION DATA AND AT THE DETAILED DESIGN PHASE.

REFERENCES:

1. ALL DESIGN COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON APRIL 2013 LIDAR PROVIDED BY KGHM.
3. JACKO LAKE BATHYMETRY SURVEY BASED ON DATA PROVIDED BY KGHM ON JANUARY 13, 2015.
4. OPEN PIT OUTLINE BASED ON NOVEMBER 2014 MINE PLAN PROVIDED BY KGHM ON FEBRUARY 20, 2015.

TABLE 1:

NORMAL WATER LEVEL EL.	892.0 m
DAM CREST EL.	895.5 m

50m 0 50 100m
SCALE 1:2500

50m 0 50 100m
SCALE 1:2000

SCALES INDICATED BASED ON AN 11"x17" PLOT CONFIGURATION

SCALE:	AS SHOWN		
DATE:	2015-08-21		
CO-ORD. SYS.:	UTM-NAD83 ZONE 10		
DRW'N BY:	SC	REV'D BY:	CK
DSG'N BY:	KP	APP'D BY:	SE

KGHM — **KGHM AJAX MINING INC.**

AJAX PROJECT

JACKO LAKE JLD2 (NORTHEAST DAM)
PLAN, PROFILE AND SECTION

NORWEST

DRAWING NO.: C135-KA39-5620-10-002 REV.: 0

REV.	DATE	DESCRIPTION	DWN	DSG	CHK	APR
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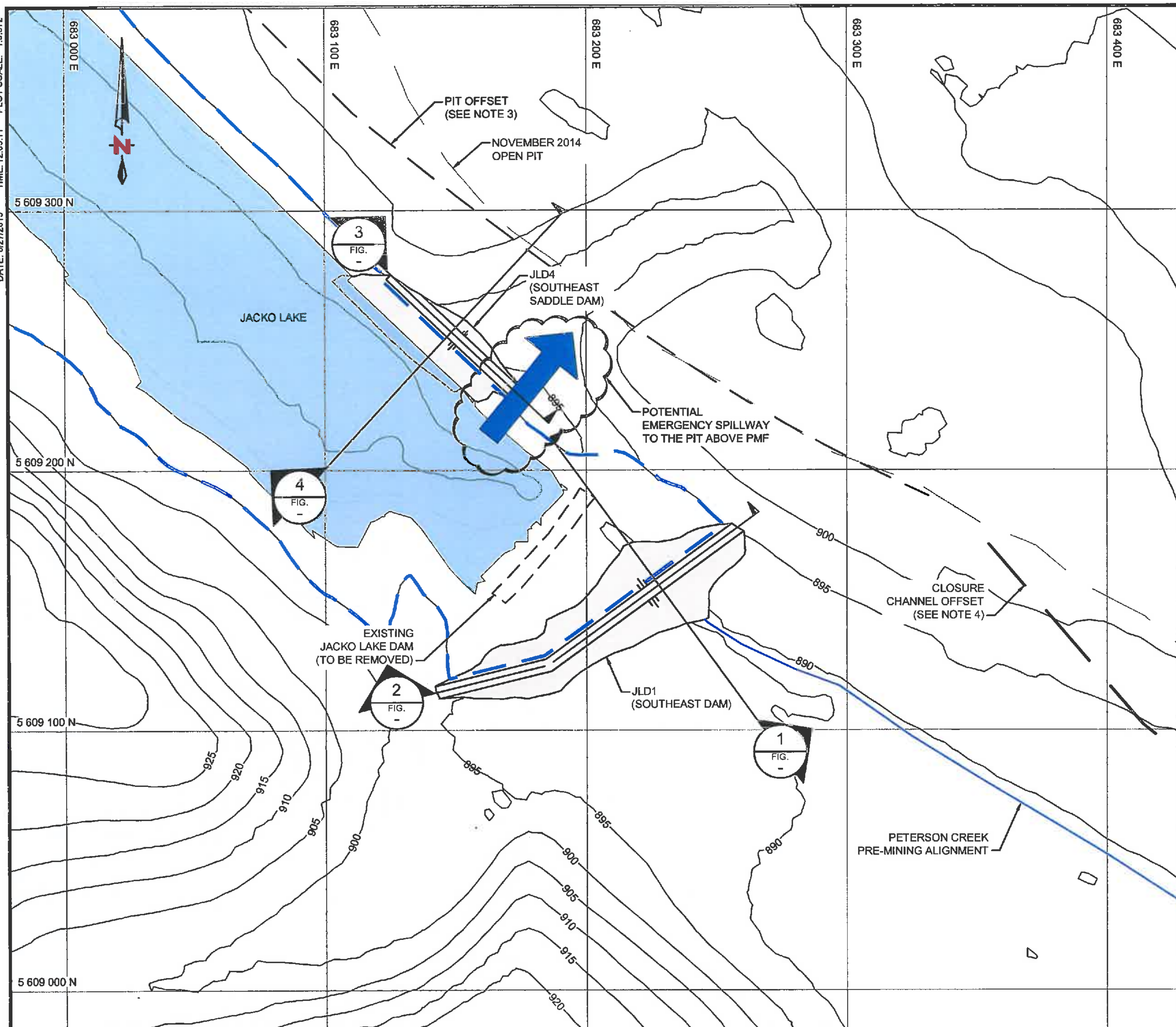
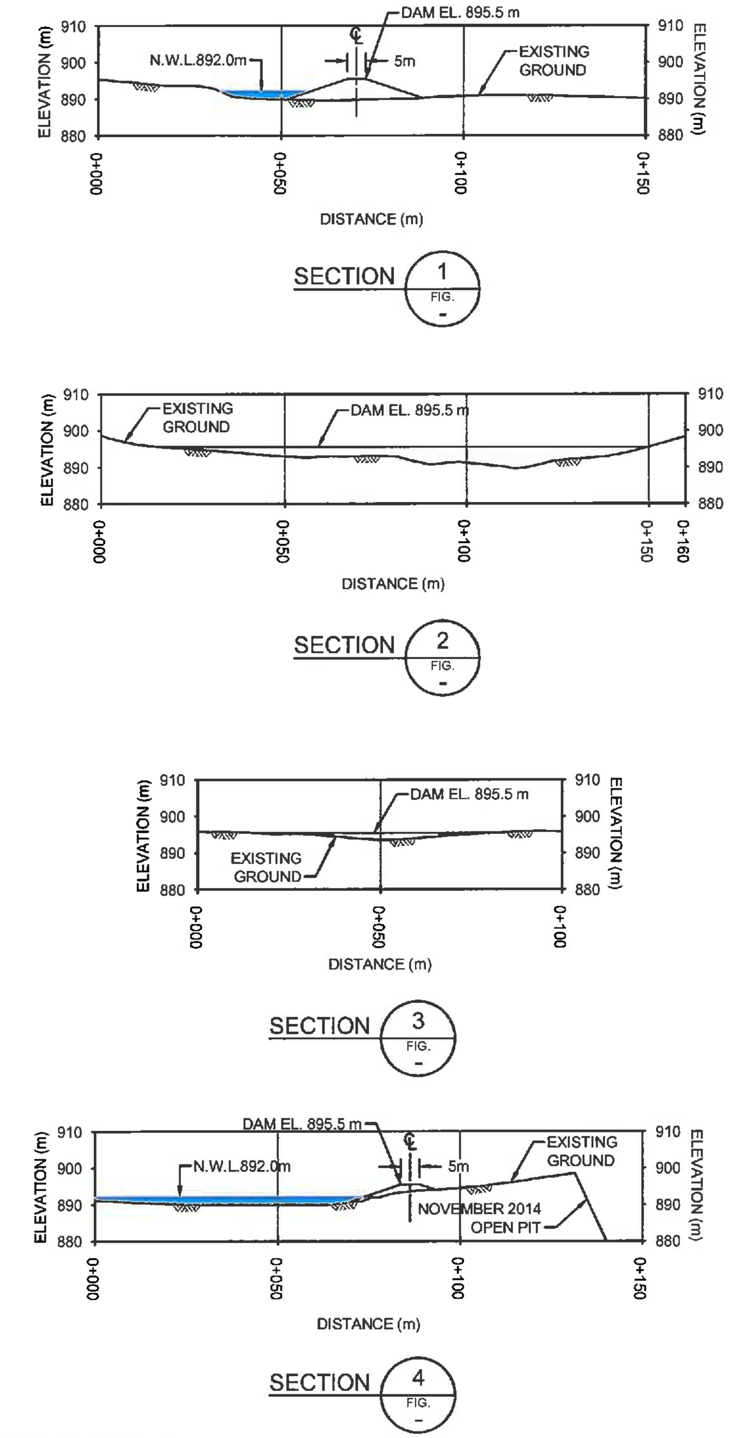


PLAN



SCALE 1:2000

SCALES INDICATED BASED ON AN 11"x17" PLOT CONFIGURATION

LEGEND:

- ENGINEERED FILL
- JACKO LAKE NWL 892.0 m
- DESIGN FLOOD LEVEL

TABLE 1:

NORMAL WATER LEVEL EL.	892.0 m
DAM CREST EL.	895.5 m

NOTES:

1. JACKO LAKE DAM LAYOUTS ARE PRELIMINARY DESIGNS ONLY. DETAILED ANALYSIS TO BE COMPLETED TO CONFIRM LAYOUTS.
2. SEE TABLE 1 FOR WATER LEVELS AND DAM CREST ELEVATION.
3. PIT OFFSET GUIDELINES PRESENTED IN TECHNICAL MEMORANDUM C135-KA39-RPT-00-01.
4. BASED ON 40 m OFFSET FROM CLOSURE CHANNEL CREST. OFFSET TO BE CONFIRMED DURING THE DETAILED DESIGN PHASE.

REFERENCES:

1. ALL DESIGN COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON APRIL 2013 LIDAR PROVIDED BY KGHM.
3. JACKO LAKE BATHYMETRY SURVEY BASED ON DATA PROVIDED BY KGHM ON JANUARY 13, 2015.
4. GENERAL SITE INFRASTRUCTURE BASED ON LAYOUTS PROVIDED BY KGHM ON OCTOBER 30, 2014.
5. OPEN PIT OUTLINE BASED ON NOVEMBER 2014 MINE PLAN PROVIDED BY KGHM ON FEBRUARY 20, 2015.
6. EXISTING JACKO LAKE DAM BASED ON UNDERHILL AND UNDERHILL SURVEY ON APRIL 4, 2013

Status	Status Title	Check
A	Approved (No Further Action Required)	✓
B	Proceed - (Revise and Resubmit Final)	
C	Do Not Proceed (Revise and Resubmit)	
I	Information Only	
Approver: (signature)	Date: 28 Aug 15	

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REV.	DATE	DESCRIPTION	DWN	DSGN	CHK	APR
0	2015-06-21	PRELIMINARY DESIGN DRAWING	SC	KC	CK	SE

KGHM AJAX MINING INC.

AJAX PROJECT

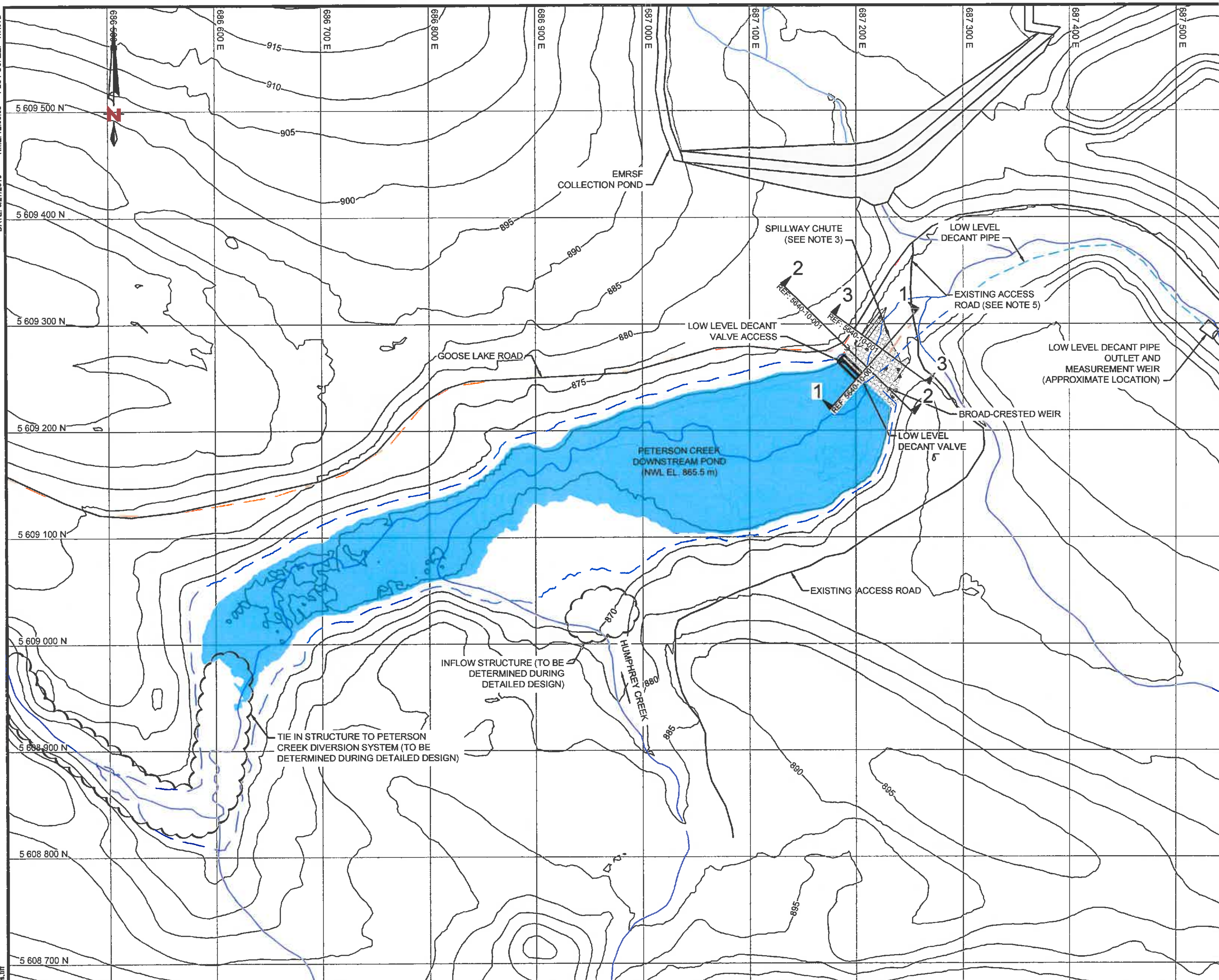
JACKO LAKE JLD4 AND JLD1 (SOUTHEAST SADDLE DAM AND SOUTHEAST DAM PROFILE AND SECTIONS)

SCALE:	AS SHOWN
DATE:	2015-06-21
CO-ORD. SYS.:	UTM-NAD83 ZONE 10
DRWN BY: SC	REV'D BY: CK
DSGN BY: KP	APP'D BY: SE

NORWEST

DRAWING NO.: C135-KA39-5620-10-003

REV: 0



PLAN
SCALE 1:4000

LEGEND:

- MAX. WATER LEVEL
- LOW LEVEL DECANT PIPE
- EXISTING ACCESS ROADS
- PROPOSED ACCESS/CONSTRUCTION ROADS (BY NORWEST)
- EXISTING WATERWAYS
- CONCRETE CLOTH

NOTES:

1. PETERSON CREEK DOWNSTREAM POND LAYOUT TO BE CONFIRMED FOLLOWING SITE INVESTIGATIONS AND SUBSEQUENT DESIGN .
2. SEE TABLE 1 FOR WATER LEVELS AND DAM CREST ELEVATION.
3. SPILLWAY CHUTE TIE-IN DETAILS TO BE DETERMINED DURING DETAILED DESIGN PHASE.
4. PETERSON CREEK DOWNSTREAM POND TO BE LINED WITH GEOSYNTETIC MATERIALS. FINAL LINER CREST ELEVATION TO BE DETERMINATED DURING DETAILED DESIGN.
5. EXISTING ACCESS ROAD ON DOWNSTREAM SIDE OF SPILLWAY CHUTE TO BE RELOCATED OR UPGRADED. DETAILS TO BE PROVIDED DURING NEXT PHASE OF DESIGN.

TABLE 1:

NORMAL WATER LEVEL EL.	865.5 m
SPILLWAY CREST EL.	865.5 m
DAM CREST EL.	868.3 m

REFERENCES:

1. ALL DESIGN COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON APRIL 2013 LIDAR PROVIDED BY KGHM.
3. JACKO LAKE BATHYMETRY SURVEY BASED ON DATA PROVIDED BY KGHM ON JANUARY 13, 2015.

Status	Status Title	Check
A	Approved (No Further Action Required)	✓
B	Proceed - (Revise and Resubmit Final)	
C	Do Not Proceed (Revise and Resubmit)	
I	Information Only	

Approver: [signature] Date: 28 Aug 15

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100m 50 0 100 200m
SCALE 1:4000

SCALES INDICATED BASED ON AN 11"x17" PLOT CONFIGURATION

DATE: 8/27/2015 TIME: 12:06:05 PLOT SCALE: 1:3.872

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IMAGE FILE(S): KGHM_Logo_NonMet_RGB_Pos.tif

REV.	DATE	DESCRIPTION	DWN	DSG	CHK	APR
0	2015-08-21	PRELIMINARY DESIGN DRAWINGS	SC	KC	CK	SE

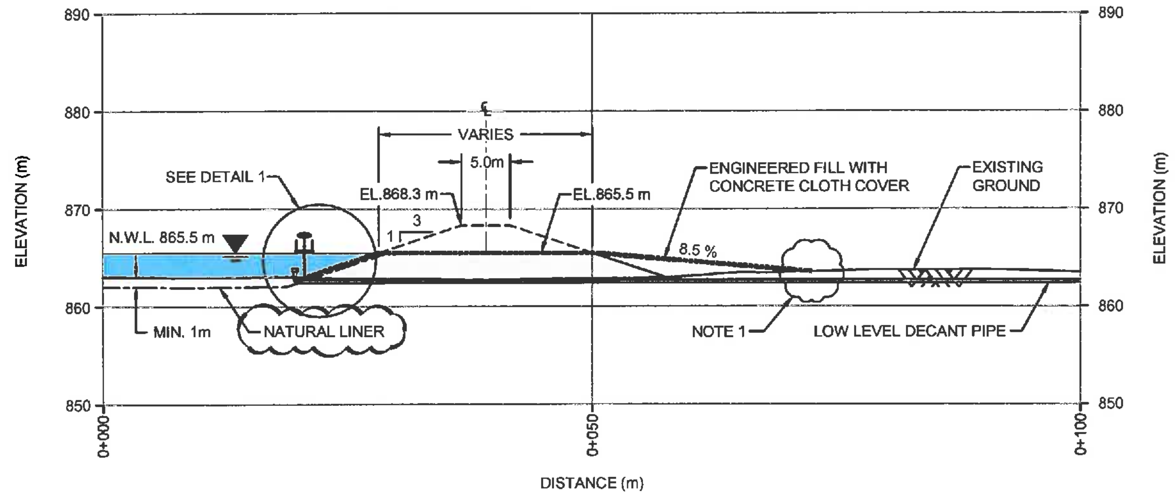
SCALE:	AS SHOWN
DATE:	2015-08-21
CO-ORD. SYS.:	UTM-NAD83 ZONE 10
DRWN BY:	SC — REV'D BY: CK
DSGN BY:	KP — APP'D BY: SE

KGHM — KGHM AJAX MINING INC.

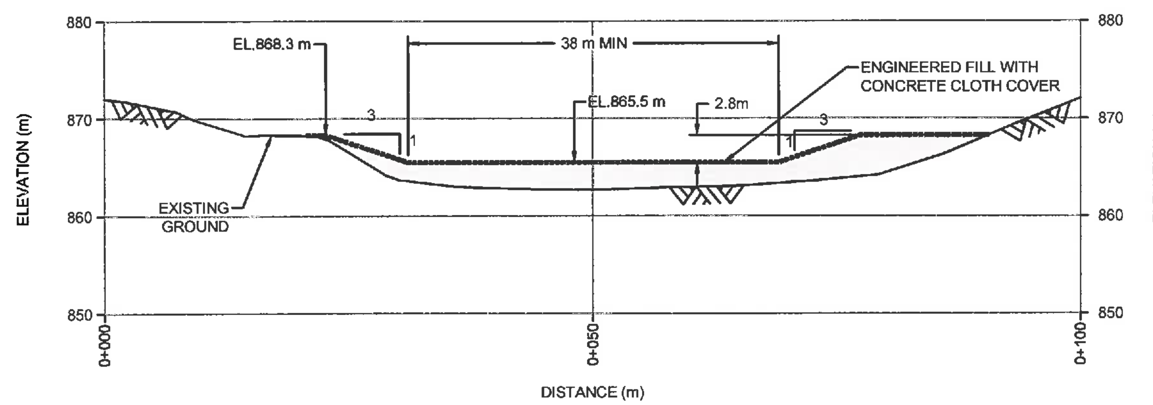
AJAX PROJECT
PETERSON CREEK DOWNSTREAM POND
GENERAL ARRANGEMENT PLAN

NORWEST

DRAWING NO.: C135-KA39-5640-00-001
REV.: 0



SECTION 1
REF: 5640-00-001 SCALE 1:750



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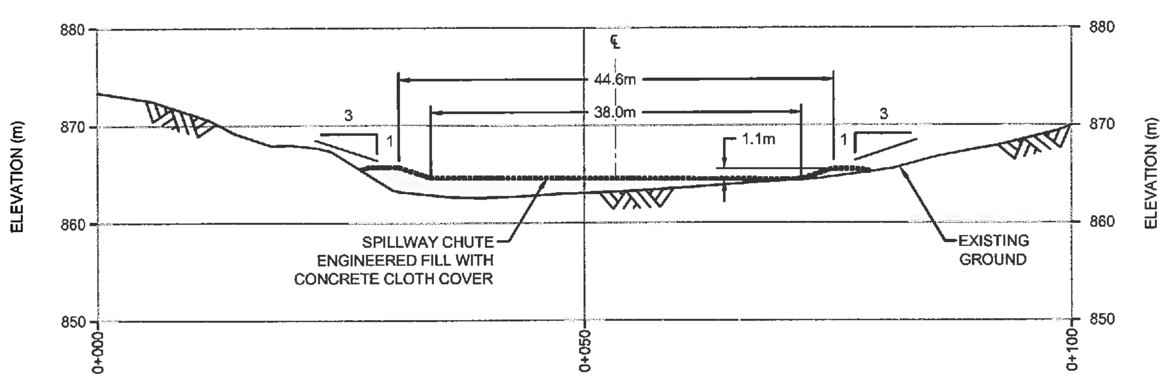
REF: 5640-00-001 SCALE 1:750



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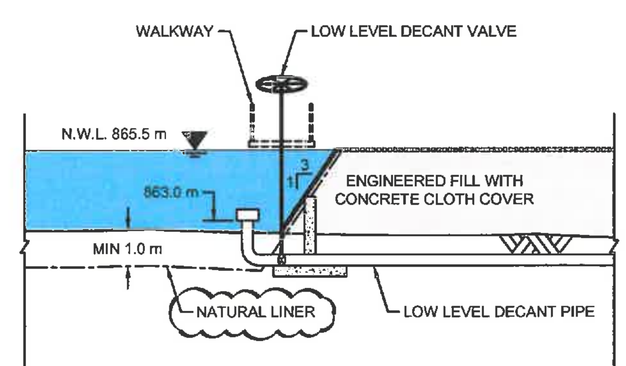
REF: 5640-00-001 SCALE 1:750



DETAIL 1
NOT TO SCALE

LEGEND:

- ENGINEERED FILL WITH CONCRETE CLOTH COVER
- LOW PERMEABLE LINER

NOTES:

1. TIE-IN DETAILS WITH NATURAL SLOPE TO BE DETERMINED IN DETAILED DESIGN PHASE.
2. SEE TABLE 1 FOR WATER LEVELS, DAM CREST ELEVATION AND LOW LEVEL DECANT PIPE ELEVATION.

TABLE 1:

NORMAL WATER LEVEL EL.	865.5 m
SPILLWAY CREST EL.	865.5 m
LOW LEVEL DECANT PIPE INTAKE EL.	863.0 m
LOW LEVEL DECANT PIPE OUTLET EL.	860.0 m
DAM CREST EL.	868.3 m

REFERENCES:

1. ALL DESIGN COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON APRIL 2013 LIDAR PROVIDED BY KGHM.

Status	Status Title	Check
A	Approved (No Further Action Required)	✓
B	Proceed - (Revise and Resubmit Final)	
C	Do Not Proceed (Revise and Resubmit)	
I	Information Only	

Approver: [signature] Date: 28 Aug 15

KGHM review of consultant's drawings shall in no manner alleviate the consultant from their responsibility as engineer of record. The review or approval of Consultant's drawings does not constitute confirmation of satisfaction of waiver of any term of Consultant's work. These drawings remain the responsibility of Consultant.

10m 0 10 20 30 40 50m
SCALE 1:750

SCALES INDICATED BASED ON AN 11"x17" PLOT CONFIGURATION

KGHM — KGHM AJAX MINING INC.

AJAX PROJECT
PETERSON CREEK DOWNSTREAM POND
PROFILE AND SECTIONS

SCALE:	AS SHOWN		
DATE:	2015-08-21		
CO-ORD. SYS.:	UTM-NAD83 ZONE 10		
DRWN BY:	SC	REV'D BY:	CK
DSG'N BY:	KP	APP'D BY:	SE

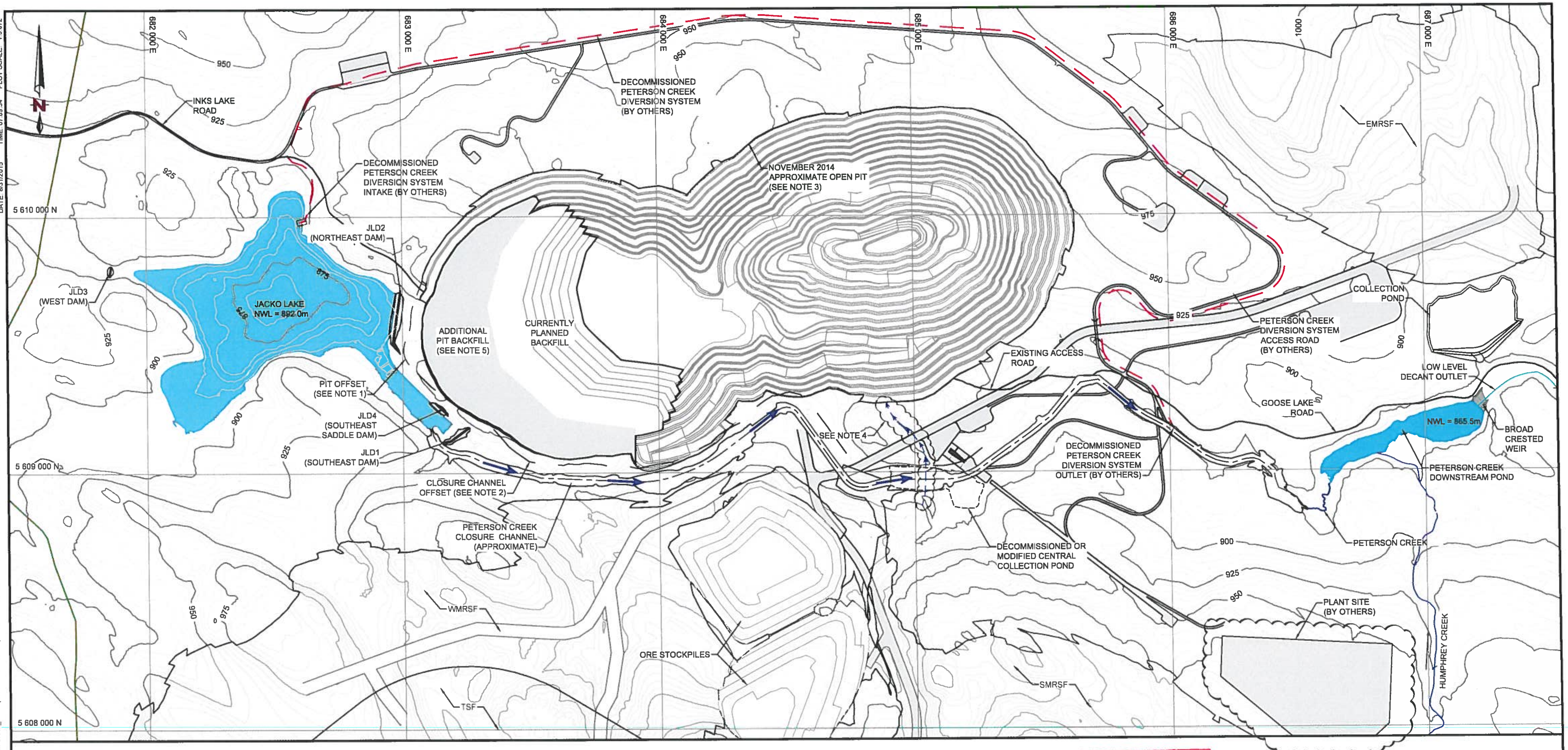
NORWEST

DRAWING NO.: C135-KA39-5640-10-001 REV.: 0

REV.	DATE	DESCRIPTION	DWN	DSG	CHK	APR
0	2015-08-21	PRELIMINARY DESIGN DRAWINGS	SC	KC	CK	SE

DATE: 8/27/2015 TIME: 10:50:01 PLOT SCALE: 1:3.672

FILENAME: I:\PROJECT DATA\KGHM AJAX_8091809-3_JACKO LAKE\DISC\DRAFTING\PRODUCTION\PRELIMINARY DESIGN DRAWINGS - REV 0\C135-KA39-5640-10-001.DWG
XREF FILE(S):
IMAGE FILE(S): KGHM_Logo_NonMet_RGB_Pos.tiff



LEGEND:

- KINDER MORGAN RELOCATED PIPELINE
- DECOMMISSIONED PETERSON CREEK DIVERSION SYSTEM (BY OTHERS)
- EXISTING ROAD
- CLOSURE CHANNEL FLOW DIRECTION

NOTES:

1. PIT OFFSET GUIDELINES PRESENTED IN TECHNICAL MEMORANDUM C135-KA39-RPT-00-01.
2. BASED ON 40 m OFFSET FROM CLOSURE CHANNEL CREST. OFFSET TO BE CONFIRMED DURING THE DETAILED DESIGN PHASE.
3. ULTIMATE OPEN PIT AND BACKFILL TO BE CONSTRUCTED TO MEET PIT AND CLOSURE CHANNEL OFFSET GUIDELINES.
4. A CULVERT AND ENGINEERED CHANNEL BENEATH THE PETERSON CREEK WILL BE DEVELOPED AT CLOSURE TO DIRECT ANY CONTACT WATER UPSTREAM TOWARDS THE OPEN PIT.
5. ADDITIONAL PIT BACKFILL REQUIREMENTS TO BE DETERMINED IN DETAILED DESIGN.

REFERENCES:

1. ALL DESIGN COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON LIDAR PROVIDED BY KGHM (APRIL 2013).
3. JACKO LAKE BATHYMETRY SURVEY BASED ON DATA PROVIDED BY KGHM ON JANUARY 13, 2015.
4. GENERAL SITE INFRASTRUCTURE BASED ON LAYOUTS PROVIDED BY KGHM ON OCTOBER 30, 2014.
5. OPEN PIT OUTLINE BASED ON NOVEMBER 2014 MINE PLAN PROVIDED BY KGHM ON FEBRUARY 20, 2015.
6. OPEN PIT BACKFILL BASED ON INFORMATION PROVIDED BY KGHM.

Status	Status Title	Check
A	Approved (No Further Action Required)	✓
B	Proceed - (Revise and Resubmit Final)	
C	Do Not Proceed (Revise and Resubmit)	
I	Information Only	

Approver: [signature] Date: AUG 31/15

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100m 0 100 200 300 400 500 1000m

SCALE 1:15,000

SCALES INDICATED BASED ON AN 11"x17" PLOT CONFIGURATION

KGHM | KGHM AJAX MINING INC.

AJAX PROJECT

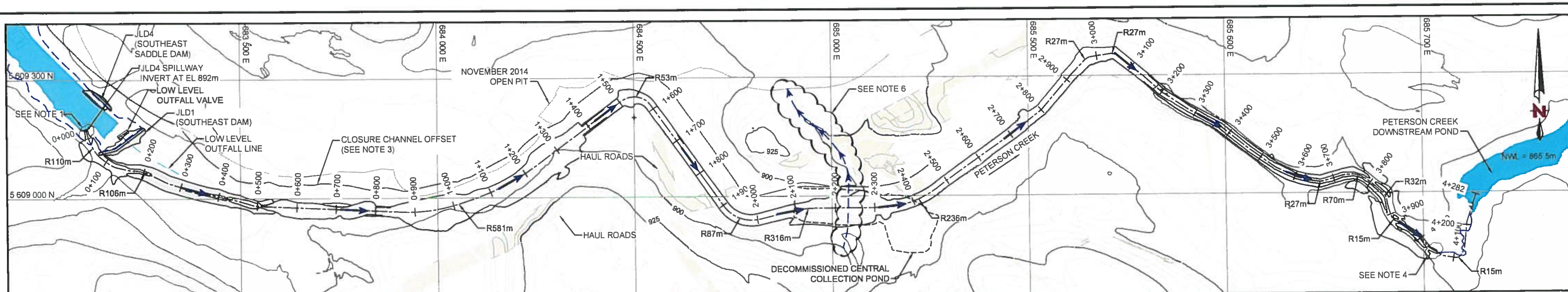
JACKO LAKE AND PETERSON CREEK
OVERALL CLOSURE CONCEPT PLAN

SCALE	AS SHOWN		
DATE	2015-08-21		
CO-ORD. SYS.	UTM-NAD83 ZONE 10		
DRWN BY	SC	REV'D BY	CK
DSG'N BY	KP	APP'D BY	SE

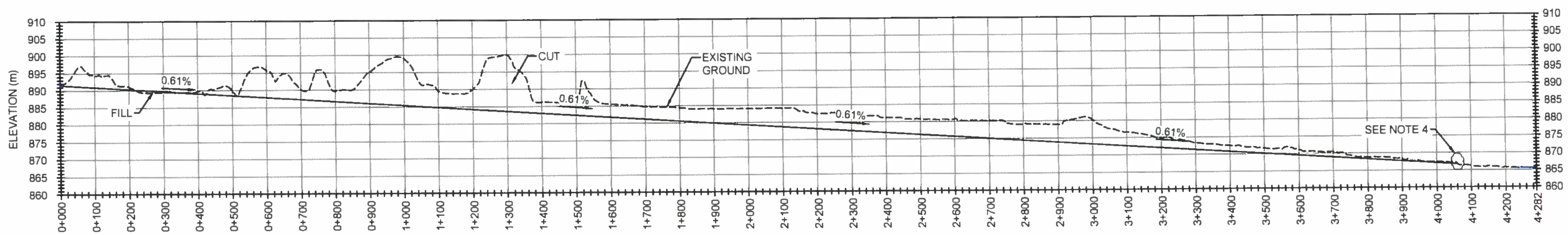
NORWEST

DRAWING NO.: C135-KA39-5600-00-003 REV.: 0

REV.	DATE	DESCRIPTION	DWN	DSG	CHK	APR
0	2015-08-21	PRELIMINARY DESIGN DRAWING	SC	KC	CK	SE



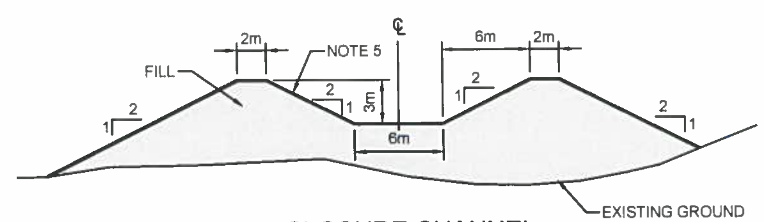
PLAN VIEW
SCALE 1:10000



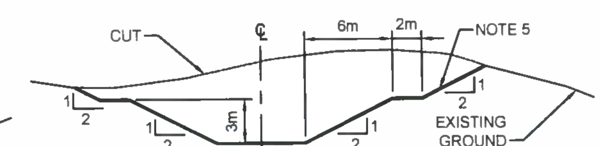
PROFILE
HORIZONTAL SCALE 1:15000
VERTICAL SCALE 1:1500

CO-ORDINATES		
CHAINAGE	EASTING (m)	NORTHING (m)
0+000	683109	5609176
0+100	683161	5609094
0+200	683256	5609067
0+300	683348	5609030
0+400	683445	5609005
0+500	683542	5608981
0+600	683642	5608977
0+700	683742	5608972
0+800	683842	5608968
0+900	683942	5608965
1+000	684040	5608981
1+100	684135	5609014
1+200	684223	5609061
1+300	684304	5609120
1+400	684384	5609179
1+500	684464	5609239
1+600	684549	5609222
1+700	684607	5609141
1+800	684666	5609060
1+900	684724	5608978
2+000	684811	5608941
2+100	684908	5608965

CO-ORDINATES		
CHAINAGE	EASTING (m)	NORTHING (m)
2+200	685008	5608970
2+300	685108	5608970
2+400	685206	5608986
2+500	685291	5609038
2+600	685373	5609095
2+700	685455	5609153
2+800	685534	5609214
2+900	685599	5609289
3+000	685676	5609349
3+100	685764	5609321
3+200	685840	5609256
3+300	685925	5609203
3+400	686010	5609151
3+500	686090	5609091
3+600	686176	5609041
3+700	686273	5609036
3+800	686367	5609025
3+900	686417	5608944
4+000	686494	5608884
4+100	686575	5608834
4+200	686609	5608916
4+282	686634	5608994



CLOSURE CHANNEL
TYPICAL CROSS SECTION IN FILL
SCALE 1:500



CLOSURE CHANNEL
TYPICAL CROSS SECTION IN CUT
SCALE 1:500

Status	Status Title	Check
A	Approved (No Further Action Required)	✓
B	Proceed - (Revise and Resubmit Final)	
C	Do Not Proceed (Revise and Resubmit)	
I	Information Only	

Approver: [signature] Date: AUG 31/15

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LEGEND:

- EXISTING GROUND
- SPILLWAY INVERT
- ENGINEERED FILL
- CLOSURE CHANNEL FLOW DIRECTION
- HAUL ROADS/ ROADS

NOTES:

1. SPILLWAY AND TIE-IN DETAILS WITH TO BE DETERMINED DURING DETAILED DESIGN PHASE.
2. PIT OFFSET GUIDELINES PRESENTED IN TECHNICAL MEMORANDUM C135-KA39-RPT-00-01.
3. BASED ON 40 m OFFSET FROM CLOSURE CHANNEL CREST, OFFSET TO BE CONFIRMED DURING DETAILED DESIGN PHASE.
4. TIE-IN TO PETERSON CREEK TO BE DETERMINED DURING DETAILED DESIGN PHASE.
5. RIPRAP DESIGN TO BE DETERMINED DURING DETAILED DESIGN PHASE.
6. A CULVERT AND ENGINEERED CHANNEL BENEATH THE PETERSON CREEK WILL BE DEVELOPED AT CLOSURE TO DIRECT ANY CONTACT WATER UPSTREAM TOWARDS THE OPEN PIT.

REFERENCES:

1. ALL DESIGN COORDINATES PROVIDED ARE IN METRES.
2. TOPOGRAPHY DATA BASED ON APRIL 2013 LIDAR PROVIDED BY KGHM.
3. JACKO LAKE BATHYMETRY SURVEY BASED ON DATA PROVIDED BY KGHM ON JANUARY 13, 2015.
4. OPEN PIT OUTLINE BASED ON NOVEMBER 2014 MINE PLAN PROVIDED BY KGHM ON FEBRUARY 20, 2015.

SCALE 1:500 (10m 5 0 10 20 30m)

SCALE 1:15,000 (100m 0 100 200 300 400 500 1000m)

SCALE 1:10,000 (100m 0 100 200 300 400 500m)

SCALES INDICATED BASED ON AN 11"x17" PLOT CONFIGURATION

REV.	DATE	DESCRIPTION	DWN	DSG	CHK	APR
0	2015-08-21	PRELIMINARY DESIGN DRAWINGS	SC	KC	CK	SE

KGHM — KGHM AJAX MINING INC.

AJAX PROJECT

PETERSON CREEK - CONCEPTUAL CLOSURE CHANNEL
PLAN, PROFILE AND SECTIONS

SCALE	AS SHOWN
DATE	2015-08-21
CO-ORD. SYS.	UTM-NAD83 ZONE 10
DRWN BY	SC
REV'D BY	CK
DSGN BY	KP
APP'D BY	SE

NORWEST

DRAWING NO. C135-KA39-5640-00-003 REV 0