Appendix 17.4-B

Tailings Disposal Best Available Technology Assessment

AJAX PROJECT

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

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NORWEST
CORPORATION

m3
ARCHITECTURE
ENGINEERING
CONSTRUCTION MANAGEMENT

Ajax Project

Tailings Disposal Best Available Technology Assessment

Prepared For:

KGHM

ORIGINAL SIGNED

[redacted]

AJAX PROJECT
TAILINGS DISPOSAL BEST AVAILABLE TECHNOLOGY ASSESSMENT

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EXECUTIVE SUMMARY

The Ajax Project is planned to be a 65,000 tonnes per day copper/gold open pit mining operation near Kamloops, British Columbia. Life of mine is approximately 20 years with approximately 400 M tonnes of total ore extraction. Management of the plant tailings produced as a by-product of the ore processing is a key consideration for the project. Un-thickened slurry tailings disposal is commonly used as a cost effective method for tailings storage and has been evaluated as part of the Ajax Project's feasibility study (KGHM, 2014). However, a recent tailings dam failure at Mount Polley Mine resulted in a breach of containment and subsequent discharge of tailings and water to the surrounding environment. An independent review panel completed a follow-up study on this failure and recommended determining Best Available Technology (BAT) for tailings disposal specific to each project site. Filtered tailings disposal was specifically identified as an option that should be considered when determining site specific BAT. As a result, M3 Engineering & Technology Corp. (M3) and Norwest Corporation (Norwest) were retained by KGHM Ajax Mining Inc. (KAM) to undertake a high level evaluation of available tailings disposal technologies for the Ajax Project in order to provide a recommendation for BAT for the project. It should be noted that in addition to the incident at Mount Polley, similar reviews and design updates are part of normal design evolution. As projects proceed through design and permitting phases it is anticipated that overall and individual project components will be optimized. The four technologies considered in this report are those commonly used in the mining industry:

- Un-thickened slurry tailings.
- Thickened tailings.
- Paste tailings.
- Filtered dry stack tailings.

The scope of this report addresses conceptual level engineering for filtered tailings and paste thickened tailings, and preliminary engineering for un-thickened slurry and thickened tailings. It includes technical discussions and comparative analysis of tailings management alternatives for each of the four tailings deposition methods. Also included in this report are high-level economic comparisons for examining of the financial effect of each option on the project economics. A preliminary design was previously completed by others for the un-thickened slurry tailings option and this design forms the basis for this evaluation. The key considerations, based on technical, community, Aboriginal, and economic factors include:

- Dewatering process, transport and deposition of tailings.
- Process make-up water requirements.
- Disturbed surface area.
- Risk/consequence of breach failure.
- Air quality/dust potential.
- Power requirements.
- Seepage.
- Visual impact of facility.
- Reclamation considerations.
- High-level capital and operating cost estimates.
- Proven technology at proposed production rates.

Ultimately, the purpose of this report is to provide a basis and framework to assess site specific Best Available Technology (BAT) for the Ajax Project by evaluating the three additional technologies listed above against the un-thickened slurry tailings method for future design. The assessment is not intended to be a detailed engineering study of each of the tailings technology options and thus it includes qualitative comparisons where appropriate.

Recommended best available technology for tailings disposal at Ajax is as follows:

Thickened Slurry Tailings (60% solids) – this is the preferred option based on the evaluation of the technical, environmental/social, economic and project risks summarized in Table ES-0-1. Storage of thickened tailings has increased environmental and perceived social implications compared to filtered tailings but is preferable versus un-thickened slurry tailings storage. The use of containment dykes would still be required for this option but a lower volume of stored water is required. Construction of the mine rock buttress on the downstream side of the main embankment will significantly reduce the risk of a breach failure. The detailed phasing of the integrated design will ensure this buttress is constructed at each stage of TSF development. Benefits of thickened tailings include:

a. Requires less make-up water resulting in a smaller volume of water stored in an impoundment, less fresh water taken from Kamloops Lake and lower pumping costs.
b. Lower risk of breach failure than un-thickened tailings, this risk includes both the consequence and probability of breach failure. Thickened tailings has a lower consequence than un-thickened tailings as the lower water content results in reduced mobility of the tailings mass. The significantly smaller supernatant pond means there is also less water available to transport tailings material. The probability of a breach failure is reduced for each tailings disposal option, including thickened tailings, due to the inclusion of the mine rock buttressing in the design.
c. Less impounded water and higher initial placement density reduces seepage losses into the foundation.
d. Improved air quality over un-thickened or filtered options. Thickened tailings tend to be non-segregating due to the addition of flocculent during the thickening process. This flocculent binds the fine particles to coarser particles which results in less fine particulate at surface available for transport as dust.
e. Lower visual impact as limited lighting is required for nighttime operation of the facility (versus filtered dry stack).
f. Reduced challenges and costs associated with placement of a final dry cover (versus un-thickened) due to the higher initial solids content and lower segregation potential.
g. Proven technology both in general and at high production rates similar to the 65,000 tonnes per day proposed for Ajax.

For all TSF alternatives considered, there is a direct effect to Goose Lake; either by burial by tailings material, or for use as a water management pond. Goose Lake is a shallow waterbody in a closed basin whose water quality is affected by evaporative concentration. It is not fish bearing, but does support local biodiversity values associated with wetlands and wildlife habitat.

Closing Statement

The Mount Polley report recommended projects review potential options for tailings treatment and management as part of the project evaluation process with the goal of selecting the best available technology for each site. The Panel identified filtered tailings as a prime candidate to be considered but a range of technologies were to be included in the evaluation. Previous studies using un-thickened tailings had been completed for the project and these formed the basis for comparison to other technologies. The British Columbia Environmental Assessment Office (BCEAO) issued a subsequent letter to the Panel finding on March 19th, 2015 emphasizing that site specific considerations are key in identifying BAT for each project. The evaluation completed in this study has identified thickened tailings, with mine rock buttressing, as the site specific BAT for the Ajax Project.

Table ES-0-1: Tailings Technology Comparative Assessment[1]

AREA:	TECHNICAL		ENVIRONMENTAL/SOCIAL								ECONOMIC		PROJECT RISK	
				Disturbed Surface Area (ha)										
Tailings Disposal Method [2]	Dewatering of Tailings [3]	Tailings Deposition [4]	Process Make-Up Water (m^3/hour)	Total	Tailings Surface Area	Risk of Breach Failure [5]	Dust Potential	Seepage	Visual Impact [6, 9]	Reclamation	CAPEX	OPEX	Proven Technology at 65,000 tonnes/day	Regulatory Concern
Conventional Un-thickened (32% solids) Un-buttressed Facility	Most Favorable	Most Favorable	🟥 1.087	🟥 700	🟥 589 (326 beach, 263 pond)	Least Favorable	Less Favorable	Least Favorable	More Favorable (1,060m)	Less Favorable	🟩 $223 M	🟩 $123 M	Most Favorable	Less Favorable
Conventional Un-thickened (32% solids) Buttressed Facility [7]	Most Favorable	Most Favorable	🟥 1.087	🟥 700	🟥 589 (326 beach, 263 pond)	Less Favorable	Less Favorable	Least Favorable	More Favorable (1,060m)	Less Favorable	🟩 $223 M	🟩 $123 M	Most Favorable	Less Favorable
Thickened (60% solids) Buttressed Facility [7]	More Favorable	More Favorable	🟨 764	🟨 690	🟨 550 (450 beach, 100 pond)	More Favorable	More Favorable	Less Favorable	Most Favorable (1,056m)	More Favorable	⬜ $226 M [8]	⬜ $132 M [8]	Most Favorable	More Favorable
Paste (75% solids) Buttressed Facility [7]	Less Favorable	Less Favorable	⬜ 730	⬜ 603	⬜ 461 (411 beach, 50 pond)	More Favorable	Most Favorable	More Favorable	Least Favorable (1,095m)	Least Favorable	🟨 Expected to be higher than thickened	🟨 Expected to be higher than thickened	Least Favorable	Least Favorable
Dry Stack (85% solids) Buttressed Facility [7]	Least Favorable	Least Favorable	🟩 400	🟩 429	🟩 362	Most Favorable	Least Favorable	Most Favorable	Least Favorable (1,055)	Most Favorable	🟥 $442 M	🟥 $430 M	Least Favorable	Most Favorable

Notes:

1. Qualitative ranking in order of preferred option is: 🟩 Most Favorable -> ⬜ More Favorable -> 🟨 Less Favorable -> 🟥 Least Favorable
2. Percent solids is by weight.
3. Relates to amount of dewatering required and potential issues that could occur during process.
4. Relates to the ability and level of effort required to achieve design configuration (i.e., design slope for thickened or paste options).
5. Downstream consequence related to mobility of the tailings flow if containment is lost.
6. Visual impact includes the height of the facility and also the amount of lighting required during night operations that would be visible at distance.
7. Assumes mine rock used for buttress and is primarily a mining cost.
8. Thickened costs are based on a rough order estimate relative to the conventional un-thickened tailings option.
9. Maximum elevation of embankment crest (un-thickened and thickened) or tailings material (paste and dry stack) included in brackets

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

KGHM Ajax Mining Inc. (KGHM) is planning to develop the Ajax Project, which will be a 65,000 tonnes per day copper/gold open pit mining operation near Kamloops, B.C. The mine plan is based on the extraction of approximately 400 Mt of ore for processing during approximately 20 years of operation. The initial preliminary design of the mine site included three mine rock storage facilities and one slurry tailings storage facility (TSF).

An Independent Expert Engineering Investigation and Review Panel report was released on January 30, 2015 (Independent, 2015) regarding the August 2014 TSF embankment failure at the Mount Polley Mine (conventional tailings). The report recommended Best Available Technology (BAT) for tailings containment and storage, and identified filtered tailings technology as a prime candidate for BAT. Based on this recommendation, KGHM has requested Norwest Corporation (Norwest) and M3 to complete a conceptual level design of a filtered dry stack facility (completed in a separate report) along with a site specific trade-off study of tailings containment options for the Ajax Project.

In a letter submitted to KGHM, by the British Columbia Environmental Assessment Office, the Associate Deputy Minister provided guidance for determination of BAT:

> “Specifically, in order to ensure that environmental assessments (EA) on mining projects in British Columbia appropriately consider the implications of the Panel findings and recommendations, I am requiring that proposed mining projects that have new proposed tailings dams provide the following information:
>
> Proponents must provide a description and an assessment of alternative means of undertaking the proposed project with respect to options for tailings management that considers technology, siting and water balance.
>
> The assessment must present and compare best practices and best available technologies for tailings management for the project, along with options for managing water balance to enhance safety and reduce the risk (likelihood and consequence) of a tailings dam failure during all phases of mine life (construction, operations, closure, post-closure). The assessment must present and compare technically and economically viable engineering solutions that are available to adequately address site conditions.
>
> The assessment must provide a clear and transparent evaluation of the factors that supported the selection of the most suitable option. Factors that will be taken into consideration in the evaluation include safety, technical and financial aspects, and implications for environmental, health, social, heritage and economic values. The assessment must consider these factors in relation to tailings management options in both the short and long-term context. Life cycle cost assumptions (construction, operations, closure, post-closure) must be included in the analysis of options...”

This report contains the site specific tailings BAT assessment for the Ajax project.

1.2 SCOPE OF WORK

This report outlines a study of four available technologies for consideration at Ajax. It presents an overview of the available technical information and existing surface and seepage water management system provided in reports from Knight Piésold Ltd. (KPL). The key tasks in the combined M3 and Norwest scope of work include:

- Overview of tailings technology options.
- Conceptual tailings storage facility layout designs.

- Energy and reclamation considerations
- A very high level economic comparison of tailings disposal capital and operating costs.
- Environmental considerations within the technical expertise of the study participants.

Technical discussion and comparative analysis of alternatives including un-thickened tailings, thickened tailings, paste tailings and filtered dry stack tailings deposition.

1.3 TAILINGS TECHNOLOGIES

Slurry tailings are the major by-product from the wet processing of most metal bearing ore. In a simplistic description, tailings are the result of grinding of the ore in a comminution circuit to liberate the desired mineral products from the non-mineral particles (also known as gangue), in order to separate or concentrate the desired product. These processes typically involve mixing with water. The process for metal recovery to be employed at Ajax is flotation, and the resulting waste mixture will consist of finely ground rock and water.

This by-product is known as plant tailings and disposal and containment of this material is a key challenge for the mining industry. The selected tailings treatment and disposal method for any project must provide for stable, long-term containment and minimize impacts to the surrounding environment while still allowing the operation to be economical viable. Four (4) tailings treatment and disposal methods are:

- Un-thickened Slurry Tailings
- Thickened Slurry Tailings
- Paste Thickened Tailings
- Filtered Tailings/Dry Stack

In this report, the terms “filtered tailings” and “dry stack tailings” are interchangeable. General information on these treatments and disposal methods is discussed in Section 2.

1.4 UNITS AND ABBREVIATIONS

This report uses metric units expressed in metric tonnes, and metres consistent with metric standards. The monetary units are expressed in US dollars. The important terms used in this report are presented in Table 1-1.

Table 1-1: Units and Abbreviations

Acid Base Accounting	ABA
Acid Rock Drainage	ARD
Atomic absorption	aa
Bank cubic metres	BCM
Bed Volume	BV
Best Available Technology	BAT
Canadian Dollars	$CAD
Celsius	C
centimetres	cm^3
centimetres squared	cm^2
copper	Cu
cubic centimetres	cm^3
cubic metres per second	m^3/s
cubic metres	m^3
Degrees	°
Dry Metric Tonnes per Day	dmtpd
Dry Stack Tailing Facility	DSTF
Environmental Impact Analysis	EIA
Factors of Safety	FOS
feet	ft
gallons	gl
gallons per cubic centimetre	g/cm^3
gram	g
grams per litre	g/l
grams per tonne	g/t
hectares	ha
High Density Polyethylene Pipe	HDPE
inches	in
KGHM Ajax Mining Inc.	KAM
kilograms	kg
kilometre	km
Kilowatt hours	kWh
Knight Piésold Ltd.	KPL
Low voltage motor control centre	LV/MCC
M3 Engineering & Technology Corp.	M3
Mean Annual Precipitation	MAP
Mean Annual Unit Run Off	MAUR
medium voltage motor control centre	MV/MCC
metre	m
megawatt	MW
megawatt hour	MWh
metres above sea level	masl
metres per second	m/s
metric tonnes per day	mtpd
milligrams per litre	mg/l
millimetre	mm
millimetre per year	mm/y
Million cubic metres	Mm^3

million	M
million tonnes	Mt
Mobile Stacking Conveyor	MSC
parts per million	ppm
Potential Evaporation	PET
percent	%
Positive displacement	PD
pound	lb
pounds per square inch	psi
Rough Order of Magnitude	ROM
Solvent Extraction/Electrowinning	SX/EW
Stk'emlupsemc te Secwepemc Nation	SSN
Supervisory Control and Data Acquisition	SCADA
Tailing Storage Facility	TSF
thousand tonnes per year	Kt/y
thousands of an inch	Mil
tonnes per day	tpd
US Currency	$USD
Variable Frequency Drive	VFD

1.5 SLURRY AND FILTER CAKE MOISTURES

For purposes of this report, percent water and percent solids calculations are expressed as total water and solids mass basis as shown below.

1. $\% \text{ Water by weight} = \frac{\text{Mass of Water}}{\text{Mass of Water + Mass of Solids}}$
2. $\% \text{ Solids by weight} = \frac{\text{Mass of Solids}}{\text{Mass of Water + Mass of Solids}}$

These numbers are different from the typical geotechnical basis which is expressed as a ratio of the components.

2 TAILINGS DISPOSAL OPTIONS

A description of each of the four tailings disposal options are discussed below, including process descriptions, process and energy considerations, and mass balance calculations used for water and energy requirements.

2.1 UN-THICKENED SLURRY TAILINGS

Un-thickened slurry tailings are generally stored within a prepared impoundment basin which is located as close as practical to the process plant in order to minimize pumping/transport costs. Engineered embankments or dams can be constructed in selected topographical locations in order to increase storage capacity while taking advantage of natural topography in order to minimize cost. This impoundment facility is referred to as the Tailings Storage Facility (TSF). It is worth noting that containment dams can be constructed in phases throughout the mine life in order maintain the required tailings storage capacity, optimize construction with mine development and operation, and to spread the capital costs of construction over a longer period.

Flotation tailings are produced as slurry (commonly 30-35% solids content by weight), pumped from the process plant and discharged into the tailings pond. Deposition of tailings slurry is often by spigot (discharge via a pipe nozzle) from around the perimeter of the containment basin. Spigotted tailings form a shallow beach slope (1 to 2%) as the tailings solids drop from solution and the excess water flows down the beach and forms a settling pond at the low point of the basin. This excess water (also known as supernatant water) can be recycled to the process plant using a barge or decant pumping system in order to reduce fresh water make-up requirements. Otherwise, when safe and practical, excess water may be treated and released back into the environment.

Due to the nature of their deposition, an un-thickened slurry tailings deposit will initially have a high water content (25-35% solids by weight) but will consolidate over time to a lower water content (20% range) assuming saturated conditions. It is often the case that deposited tailings solids form a relatively low density fill and can be vulnerable to liquefaction if a triggering event such as seismic acceleration (i.e., earthquake event) or similar disturbing force. Additional water losses that affect requirements for process make-up water are evaporation, interstitial water loss (water retained in the tailings mass), and seepage.

Progressive reclamation for slurry tailings facilities is generally not an option as the entire tailings deposit is typically built-up throughout the mine life until closure. This results in longer exposure of the tailings beach area. At the end of mine operations, reclamation of a tailings facility can require re-sloping of the downstream faces of impoundment embankments (if necessary) and placement of a cover over the tailings beach. Cover systems can range from a simple earth cover to multiple layers of synthetic and natural materials, depending upon site specific closure requirements and the behaviour of the tailings materials. The ponded water on the surface of the tailings facility needs to be pumped down as much as possible and either a wet or dry cover system constructed. Due to segregation and migration of fines material during tailings deposition, there is a usually a layer of saturated and low density, silt to clay sized material below the pond which makes reclamation more challenging.

Slurry tailings deposition has been the standard method for hard rock mineral recovery for more than 150 years and represents the vast majority of the world's operating mines. No statistics were encountered to quantify the number of slurry deposition TSF's, nor the number of thickened tailings deposition TSF's.

A block diagram depicting the traditional un-thickened slurry deposition process is shown in Figure 2-1 below.

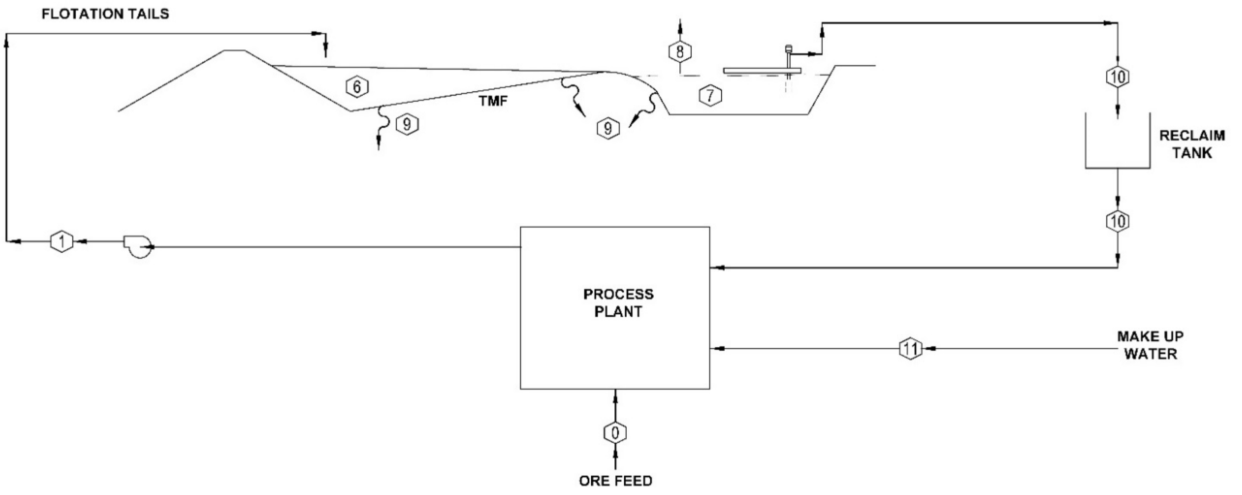


Figure 2-1: Process Diagram: Un-Thickened Slurry Tailings

Mass balance calculations for the un-thickened slurry process are shown in Table 2-1

Table 2-1: Mass Balance: Un-Thickened Tailings to TSF

Un-Thickened Tailing to TSF	"Plant" Feed	Tailing Leaving Process Plant	Thickener Underflow	Thickener Overflow	Filter Cake	Filtrate	TSF Settled Solids	TSF Water Available for Return	TSF Net Evaporation	TSF Seepage	Reclaim Water to Process Plant	Raw Water Make-up Requirement
Stream	0	1	2	3	4	5	6	7	8	9	10	11
MTPH, Solids	2,708	2,708	-	-	-	-	2,708	-	-	-	-	-
MTPH, Aqueous	113	5,755	-	-	-	-	1,002	4,753	83	115	4,555	1,087
MTPH, Total	2,821	8,464	-	-	-	-	3,710	4,753	83	115	4,555	1,087
% Solids (w/w)	96	32	-	-	-	-	73	-	-	-	-	-
SG, Solids	2.80	2.80	-	-	-	-	2.80	-	-	-	-	-
SG, Aqueous	1.00	1.00	-	-	-	-	1.00	1.00	1.00	1.00	1.00	1.00
SG, Total	2.61	1.26	-	-	-	-	1.88	1.00	1.00	1.00	1.00	1.00
m^3/h, Solids	967	967	-	-	-	-	967	-	-	-	-	-
m^3/h, Aqueous	113	5,755	-	-	-	-	1,002	4,753	83	115	4,555	1,087
m^3/h, Total	1,080	6,722	-	-	-	-	1,969	4,753	83	115	4,555	1,087

*Note – Mass balance based on estimates excluding process plant availability

The un-thickened process scheme conceptually would be direct pumping of mill tailings discharge (32% solids) over a high elevation location near the mill, where it would be allowed to gravity flow to the TSF. The deposition of tailings would be managed through flow from nozzles placed around perimeter of the TSF dam containment wall. A channel would be cut to allow decanted water in the tailings pool to flow to the southeast, away from the main embankment of the TSF. A floating barge would pump process water back to a reclaim water tank located at the elevation high point. This tank would gravity flow to supply make-up water for the milling operation.

In the general arrangement, the pipeline route to the high elevation point would be considered the same in all of the BAT options evaluated and is show in Figure 2-6. The footprint for traditional slurry deposition would be larger than that depicted for dry stack. The slurry deposition pipe line would extend around most of the North perimeter of the TSF. A channel would be cut to allow water drainage back to the southeast away from the main TSF embankment.

In the traditional tailings scenario the tailings slurry pipeline would continue from the reclaim tank area to a point north of the tailings dam and discharge spigots and would be generally located along the northern sections of the tailings containment. This would force the water pool to the rear or southeasterly corner of the TSF area. The conceptual tailings footprint for un-thickened deposition was provided by others and is shown in Figure 5-1.

2.2 THICKENED SLURRY TAILINGS

Thickened slurry tailings refer to tailings material that has been mechanically dewatered (potentially with the use of settling additives) to create a denser slurry than is seen in un-thickened tailings. This heavier slurry is typically non-segregating and has solids content in the range of 55-70% solids by weight. The thickeners used to increase the solids content from the 30-35% range to the higher density tailings can be located at the process plant or closer to the tailings storage facility (TSF) and flocculent can be added to the thickening process in order to increase the rate of particle settlement. One of the main advantages of thickened tailings production is the recovery of water during the thickening process. Process make-up water requirements are reduced because water is recovered prior to placement in the impoundment and a higher volume is recovered than from un-thickened tailings. This results in a smaller volume of stored water within the TSF which, in turn, results in less water loss to evaporation and seepage. Seepage can still occur although the rate would be lower than for un-thickened tailings.

Similar to un-thickened TSF, engineered embankments or dams can be constructed in strategic topographical locations in order to increase storage capacity while taking advantage of natural topography in order to minimize cost. Starter dams are generally smaller, which can reduce capital cost. The as-placed and final densities of tailings at discharge are higher which increases the storage capacity of the TSF for a given footprint (Engels, 2014).

Thickened tailings can be discharged from a single location or multiple discharge points. Selection of the deposition plan is influenced by the viscosity of the tailings and achievable slope angles (typically 1-3%). Understanding the achievable tailings slope is a key design consideration for thickened tailings. Thickened tailings performance relies on both the material being processed as well as the performance of the thickener.

Environmental risk is reduced as water content is lowered because the water is not present to transport tailings farther downstream of the TSF in the event of a dam breach. Thickened tailings deposits may still be vulnerable to liquefaction and therefore some level of containment is required. Progressive reclamation is generally not possible as the entire facility would be raised together.

A block diagram depicting thickened slurry deposition process is shown in Figure 2-2 below.

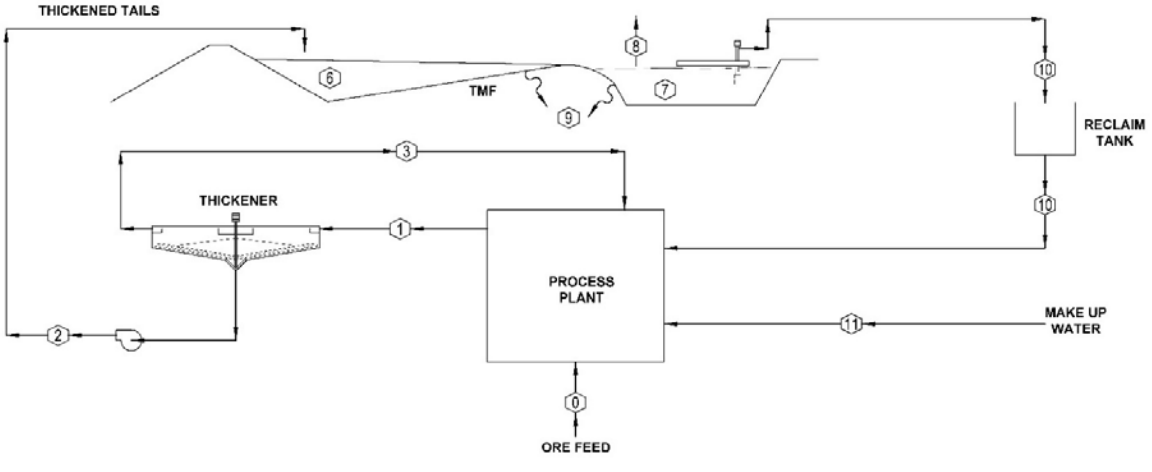


Figure 2-2: Process Diagram: Thickened Slurry Tailings

Mass balance calculations for the thickened tailing process are shown in Table 2-2.

Table 2-2: Mass Balance: Thickened Tailings to TSF

Thickened Tailing to TSF	"Plant" Feed	Tailing Leaving Process Plant	Thickener Underflow	Thickener Overflow	Filter Cake	Filtrate	TSF Settled Solids	TSF Water Available for Return	TSF Net Evaporation	TSF Seepage	Reclaim Water to Process Plant	Raw Water Make-up Requirement
Stream	0	1	2	3	4	5	6	7	8	9	10	11
MTPH, Solids	2,708	2,708	2,708	-	-	-	2,708	-	-	-	-	-
MTPH, Aqueous	113	5,755	1,806	3,950	-	-	809	997	32	36	929	764
MTPH, Total	2,821	8,464	4,514	3,950	-	-	3,517	997	32	36	929	764
% Solids (w/w)	96	32	60	-	-	-	77	-	-		-	-
SG, Solids	2.80	2.80	2.80	-	-	-	2.80	-	-	-	-	-
SG, Aqueous	1.00	1.00	1.00	1.00	-	-	1.00	1.00	1.00	1.00	1.00	1.00
SG, Total	2.61	1.26	1.63	1.00	-	-	1.98	1.00	1.00	1.00	1.00	1.00
m^3/h, Solids	967	967	967	-	-	-	967	-	-		-	-
m^3/h, Aqueous	113	5,755	1,806	3,950	-	-	809	997	32	36	929	764
m^3/h, Total	1,080	6,722	2,773	3,950	-	-	1,776	997	32	36	929	764

*Note – Mass Balance based on estimates excluding process availability.

The thickened option would conceptually include a 64 meter diameter thickener located near the flotation plant discharge. Thickener overflow water would be recovered immediately to the mill process water circuit. Thickener underflow (60% solids), would be pumped to the TSF. The water reclaim system from the TSF would be similar to the un-thickened case, although pipe sizing and pumping requirements are substantially decreased because of lesser mass flows of water.

This study contemplates that thickened slurry arrangements would be nearly identical in route as the un-thickened slurry. The thickener would be located adjacent to the flotation mill discharge.

2.3 PASTE THICKENED TAILINGS

Paste thickened tailings require specialized high density thickeners. They are generally described as tailings thickened (dewatered) to a point where they can still be pumped but high slurry viscosity may limit the range and flexibility of discharges of the slurry. Typical solids contents for paste tailings are 70-75% and the material is non-segregating with a consistency similar to toothpaste. Capital cost of pumps and ongoing energy and operating costs are higher than for the technologies previously discussed. A higher percentage of water is reclaimed at the paste thickener meaning it cannot be lost to evaporation or seepage and does not need to be stored in the TSF pond. This water is recycled through the process plant.

Higher beach slopes in the range of 3-6% can be achievable and can reduce the required storage footprint for a given volume of tailings depending on discharge location (central versus perimeter). Similar to the discussion for thickened tailings, the design slope is a key consideration. Paste tailings performance relies on both the material being processed as well as the performance of the high density thickener. Depending on fines content of the tailings stream, it may also be necessary to amend the tailings with ash or other fine material in order to consistently produce the desired paste product.

Environmental risk is further reduced as water content is lowered because the water is not present to transport tailings farther downstream of the TSF in the event of a dam breach. Paste tailings deposits may still be vulnerable to liquefaction and therefore some level of containment is required. Progressive reclamation may be possible depending on the tailings deposition plan and can reduce the time of exposure of tailings to the environment. However, industry experience is limited and there is risk associated with this uncertainty.

Paste thickened tailings can be very challenging from the standpoint of operations. Viscous paste creates pumping issues. High production mines such as Ajax would require multiple high density thickeners and positive displacement pumping stations to manage the tailings discharge operations. In recent years, operational challenges have made paste thickening less popular in general mine tailings deposition. Paste operations are more commonly where tailings paste is pumped into underground mines as backfill material.

Paste deposition is a more recent practice (1980’s). Although some advantages over slurry deposition could be realized, there are a number of technical and economic issues which limit its application. A broad generality is that paste thickening is utilized primarily where the material can be pumped to serve as fill in completed mine voids in underground operations and is not preferable in large surface storage facilities.

A block diagram depicting the paste thickening process is shown in Figure 2-3 below.

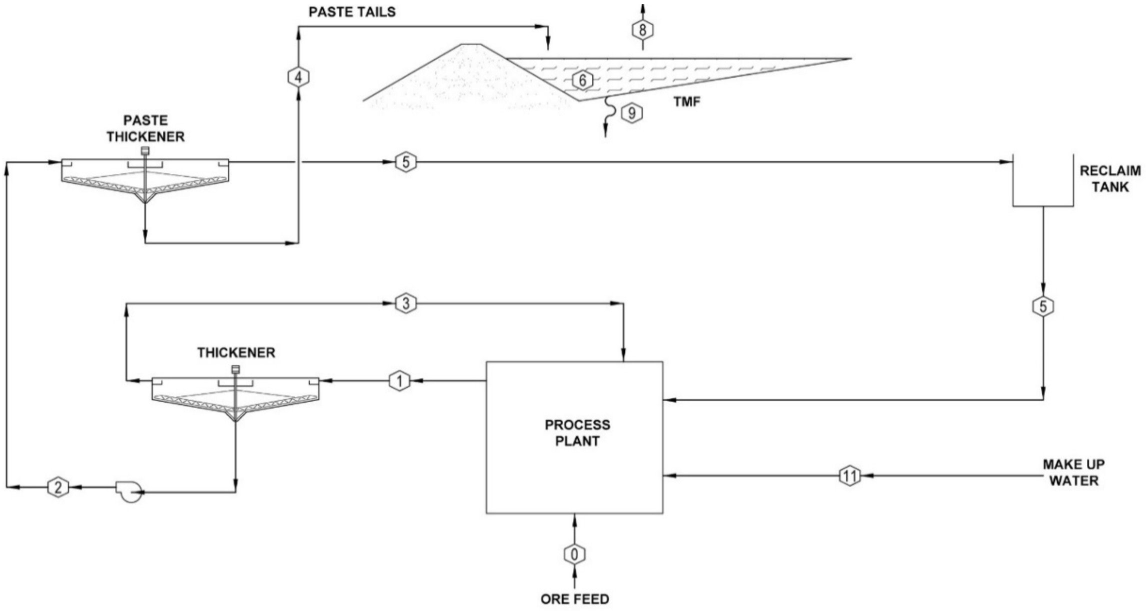


Figure 2-3: Process Diagram: Paste Thickened Tailings

Mass balance calculations for the paste thickened tailings process are shown in Table 2-3.

Table 2-3: Mass Balance: Paste Thickened Tailings to TSF

Thickened & Paste Tailing to TSF	"Plant" Feed	Tailing Leaving Process Plant	Thickener Underflow	Thickener Overflow	Paste Thickener Underflow	Paste Thickener Overflow	TSF Settled Solids	TSF Water Available for Return	TSF Net Evaporation	TSF Seepage	Reclaim Water to Process Plant	Raw Water Make-up Requirement
Stream	0	1	2	3	4	5	6	7	8	9	10	11
MTPH, Solids	2,708	2,708	2,708	-	2,708	-	2,708	-	-	-	-	-
MTPH, Aqueous	113	5,755	1,806	3,950	903	903	809	94	16	18	60	730
MTPH, Total	2,821	8,464	4,514	3,950	3,611	903	3,517	94	16	18	60	730
% Solids (w/w)	96	32	60	-	75	-	77	-	-	-	-	-
SG, Solids	2.80	2.80	2.80	-	2.80	-	2.80	-	-	-	-	-
SG, Aqueous	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
SG, Total	2.61	1.26	1.63	1.00	1.93	1.00	1.98	1.00	1.00	1.00	1.00	1.00
m^3/h, Solids	967	967	967	-	967	-	967	-	-	-	-	-
m^3/h, Aqueous	113	5,755	1,806	3,950	903	903	809	94	16	18	60	730
m^3/h, Total	1,080	6,722	2,773	3,950	1,870	903	1,776	94	16	18	60	730

*Note – Mass balance based on estimates excluding process plant availability.

The process scheme for paste tailings is challenging to clearly define without significant material testing information and engineering study detail. A high level conceptual plan would be to take the thickener underflow slurry (60%) as described in the thickened option followed by:

- The gravity feed would be to one of multiple (3-4) specially purposed thickener mechanisms. These thickeners would likely be located at different points around the upstream perimeter allowing multiple discharge points into the TSF. The paste thickener is a high side wall which allows much more retention time and slurry is allowed to consolidate at much higher solids content (70-75%). The thickener mechanical mechanism is much heavier duty to withstand higher torque requirements caused by much more viscous slurry.
- Paste thickener overflow water would be returned in multiple pipe lines back to a reclaim water tank.
- The thickener underflow is highly viscous (sometimes described as like toothpaste) and require special pumping requirements to deposit the material. Pumping may likely require positive displacement pumps to move the material and booster pump stations can be required for larger distances. .
- The material would be allowed to move downhill in plastic flow. Desiccation would occur, and little water would separate from the paste. Bleed water recovered through consolidation would be minimal, but would be collected and recovered to the process plant as possible.

2.4 FILTERED TAILINGS AND DRY STACK

Over the past 15 year, tailings filtration plants have been gathering more interest, with advances in technology and successful operations at an increasing number of sites around the globe. Filtration is capital and energy intensive and most of the early projects have been smaller facilities, justified by water source issues in desert or arctic climates, where the cost of the water supply and water issues drive the economic viability.

2.4.1 Filtration

Filtration in mineral processing has been utilized for hundreds of years, and the current state of the art tends to principally be one of following forms:

- Vacuum belt filters – These filters use long horizontal surfaces (160 m^2) using a continuous filter cloth, with a vacuum applied below to remove water. This filter type lends itself well to washing or detoxification processes because of the staged process as the filtered product moves across the belt. The disadvantage is that the pressure differential to drive the filtering process is limited by atmospheric pressure. This characteristic normally limits the moisture content achievable on a vacuum belt filter to typically 20% moisture by total slurry weight (80% solids). These high moisture contents limit the applications to those where compaction of tailings is not required or the presence of other special material handling challenges.
- Disc filters – these are well developed technologies consist of a rotating disk under vacuum or pressurized atmospheres. This technology does not lend itself well to large scale operations such as Ajax because of the large number of units required to supply sufficient filter surface area for the throughput volume. The more common vacuum disk filters commonly have issues with blinding of the filter pores.
- Pressure filter press – These filters consist of a large number of vertically mounted plates with a filter media attached to the plate surface. The filtered material is pumped into a chamber between two plates, when the chamber is full, compressed air is used to dry the filter cake, and an opening mechanism pulls the plates apart allowing material to drop onto a conveyor belt below. Steps of shaking the plates to remove material stuck to the surface, and washing the filter cloths to prevent premature failure from fouling follow. The press is closed (normally by hydraulic piston), and the cycle begins again. High differential pressure of 3 to 5 atmospheres drive the drying process to achieve typical filter cake moisture content in the range of 18 to 20%. An additional step can be added to the filter process, in that expandable membranes on the surface of the filter plates are pressurized with water or air and squeeze residual water out of the chamber before the cake blow cycle. This additional process is costlier, but can decrease the retained moisture content by an additional 2 to 5%. Pressure filtration with membrane squeeze is recommended for Ajax because of the target moisture content of 15%. This low moisture content is to achieve the optimal compaction for structural stability on the supporting walls of the tailings stack.

  A disadvantage to pressure filtration is that it is a batch process, whereas other ore processing components are a continuous process. This creates a challenge to operations to maintain high production rates through the process. These issues can be mitigated with engineering controls and management diligence.

Filtration and dry stack operations application are typically utilized when severe water supply challenges drive the economic requirements. Most dry stack operations are located in very arid climates or very cold areas. Descriptions of several operations around the world are available in the literature. Most of these operations are constructed in the range of 3,000 mptd to 15,000 mtpd in gold and silver mining operations. The largest similar process known is a 30,000 mptd iron ore process plant located in Australia. The filtration characteristics of this iron ore compared to the Ajax tailings is unknown. At a production rate of 65,000 mtpd, Ajax would clearly be the world's largest tailings filtration plant in the world.

A serious economic (and environmental) issue associated with dry stack tailings is the significant energy consumption required. Energy consumption can also result in significant upstream greenhouse gas production and so the power source needs to be considered.

2.4.2 Material Handling System

Material handling of filtered material typically consists of collection conveyors under the filters onto a conveying system onto the stacking area. Multiple options are available for stacking systems and vary depending on processing rates, characteristics of the material, topography of the area to be stacked, and the shape of the final tailings facility.

Generally, most of the systems comparable to Ajax are designed for placement of precious metal or copper ores on impermeable liners for the process known as heap leaching. Generally this material is tertiary crushed rock material typically 0.5 to 3" size. Copper ore moistures usually run from 2 to 5% moisture from the pit. The ore is placed in lifts of 10 to 30 meters, and percolation leached to recover metal values.

Stacking and conveying equipment are often classified as advance stacking and retreat stacking. An advance stacker system would typically consist of a conveying system "walking" on recently placed tailings material, and filling in the space in windrows in front of the machine. Concerns with design of this system includes stability of recent placed material to support the load of the equipment, and safety issues with stability of slopes with heavy equipment working close to a working edge. If a starter position is available, the unit can fill in highly variable topography in the first lift without impacting the machinery. Because conveyor lengths are relatively fixed compared to a retreat stacker, there is less interruption of the operations as the unit advances.

In the selected stacker for Ajax, and independent "belt wagon" and "spreader" mounted on tracks distribute the tailings material in arks as the spreader boom rotates up to 180 degrees while advancing forward.

A retreat stacking system is accomplished by a linear conveyor with a tripper as in an advance stacker, or can be a large radial stacker which sits on the floor and fills in as the machine retreats in steps as its mechanical limitations are reached.

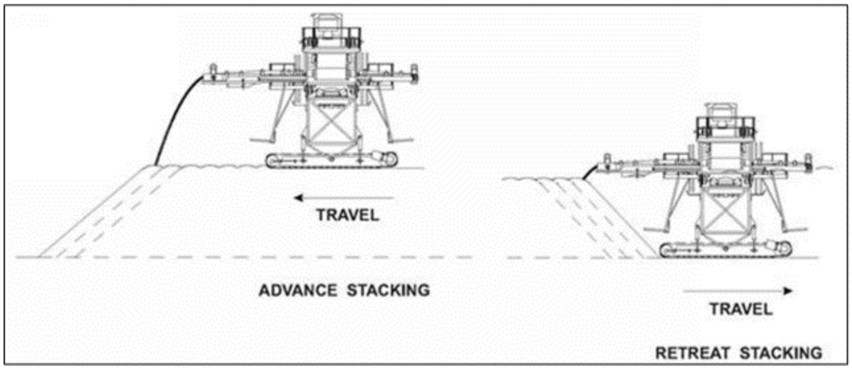


Figure 2-4: Filtered Tailings: Stacking System

A radial stacker lends itself well to irregular shapes, but prefers a level working area. Over the life of a stack, working on previous placed fill, a level surface is not a problem, but the initial lift can be problematic on rough topography. System interruptions as conveyors are removed and repositioned are much more common, additionally more manpower is generally required for handling movements. An important concern is that upsets in the mechanical conveying process will adversely affect upstream process operations. The milling/flotation circuit of the size of Ajax has very little buffer to absorb such a system upsets on the discharge side.

At points of time, the ore feed to the mill will be variable producing upsets to the filtration process. It is necessary to anticipate the occasional production of "non-spec" filter product. A high moisture content or even tailings sludge may need to be located apart from the general stacking plan to allow drying or special handling conditions. Additionally, an alternative stacking system may allow for continuous operation of the milling circuit and filtration plant during conveyor movements and maintenance. These issues may be resolved with the addition of a reversible conveyor or systems to allow for alternate disposals.

2.4.3 Ajax Specific Process Description

The process scheme conceived for the Ajax Best Available Technology assessment order to evaluate filtration and dry stack tailings follows the process scheme of traditional flotation processing. The study case process is summarized as follows.

- The initial material dealt with in this study is the tailings material as received from bulk rougher flotation from a 65,000 tonne per day copper flotation plant. The flotation plant design is by others and represents well established technical process, supported by metallurgical testing. The material discharged is estimated at 32% solids with a particle size of p80 214 microns.
- The flotation tail reports to a 64 metre conventional thickener located adjacent to the flotation plant. Settling in the thickener with the aid of a flocculent produces an underflow of 60 % solids. The water in the thickener overflow reports to a thickener overflow tank and pumps (1 operating, 1 standby), and returns the water back to the process water circuit (by others).
- The underflow pumps (three pumps in series, three pumps in standby) pump the thickened slurry from the thickener to the crest of the hill adjacent to the reclaim water tank. Slurry then reports to the filter plant by gravity flow.
- Eleven filters will process the slurry in individual batch operations. The filters will complete a full operational cycle every 15 minutes. This includes filling and filtering in the press, (a squeezing of filter cake in the chambers) air blowing of the cake, opening & discharging, washing the filter cloths, and closing the press.
- Reclaim water from the tailings filtrate is routed for re-use in the process plant. The filtrate reports to a filtrate surge tank then a reclaim sump.
- Fresh water stored in Goose Lake will be recovered as needed to the reclaim sump as well.
- The reclaim return pumps will be vertical turbine pumps reporting to the reclaim water tank on the crest of the hill returning to the plant. The reclaim water tank will then feed by gravity flow to the process water system near the mills, or process water (cloth wash water) in the filter plant.
- Filter cake discharge from each filter will fall to a collection feeder belt below the filter.
- The eleven filter belt feeders report to a collection conveyor which removes the filter cake from the building.
- The collection conveyor reports to a “ramp” conveyor. The ramp conveyor begins the vendor package material handling system.
- The ramp conveyor passes to a the “Re-locatable Conveyor” passing to the track mounted “Shiftable Conveyor”, a separate rail mounted Tripper Car operates in conjunction with the Shiftable conveyor to pass material to the mobile track mounted “Belt Wagon”, which serves as a feeder belt to the “Spreader Conveyor”.
- The spreader conveyor is an independent track mounted mobile unit with a discharge boom of 35 metres length capable of slewing 180 degrees.

A block diagram depicting the filtered dry stack tailing process is shown in Figure 2-5 below.

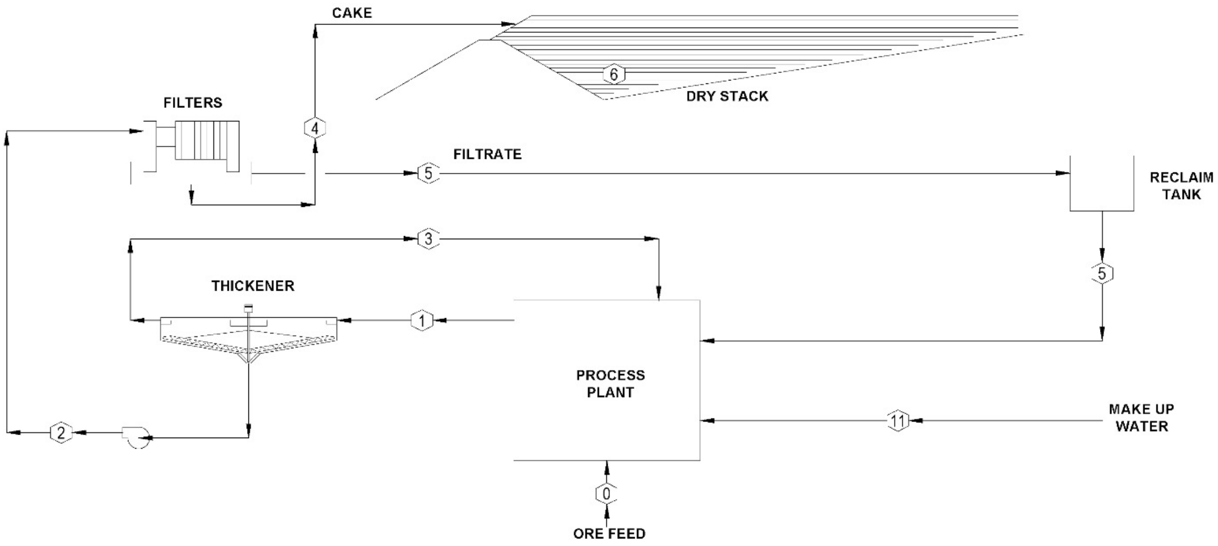


Figure 2-5: Process Diagram: Filtered Tailings

Mass balance calculations for the filtered tailing process is shown in Table 2-4.

Table 2-4: Mass Balance: Filtered Tailings to TSF

Thickened & Filtered Tailing to TSF	"Plant" Feed	Tailing Leaving Process Plant	Thickener Underflow	Thickener Overflow	Filter Cake	Filtrate	TSF Settled Solids	TSF Water Available for Return	TSF Net Evaporation	TSF Seepage	Reclaim Water to Process Plant	Raw Water Make-up Requirement
Stream	0	1	2	3	4	5	6	7	8	9	10	11
MTPH, Solids	2,708	2,708	2,708	-	2,708	-	2,708	-	-	-	-	-
MTPH, Aqueous	113	5,755	1,806	3,950	478	1,328	478	-	-	-	-	365
MTPH, Total	2,821	8,464	4,514	3,950	3,186	1,328	3,186	-	-	-	-	365
% Solids (w/w)	96	32	60	-	85	-	85	-	-	-	-	-
SG, Solids	2.80	2.80	2.80	-	2.80	-	2.80	-	-	-	-	-
SG, Aqueous	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	-	-	-	1.00
SG, Total	2.61	1.26	1.63	1.00	2.20	1.00	2.20	-	-	-	-	1.00
m^3/h, Solids	967	967	967	-	967	-	967	-	-	-	-	-
m^3/h, Aqueous	113	5,755	1,806	3,950	478	1,328	478	-	-	-	-	365
m^3/h, Total	1,080	6,722	2,773	3,950	1,445	1,328	1,445	-	-	-	-	365

*Note – Mass balance based on estimates excluding process plant availability.

The slurry pipeline route selected replicates the route contemplated for tailings as far as the filter plant site. To conserve energy, a tailings thickener to be located adjacent to the flotation rougher tailings discharge will thicken tailings to 60% solids density.

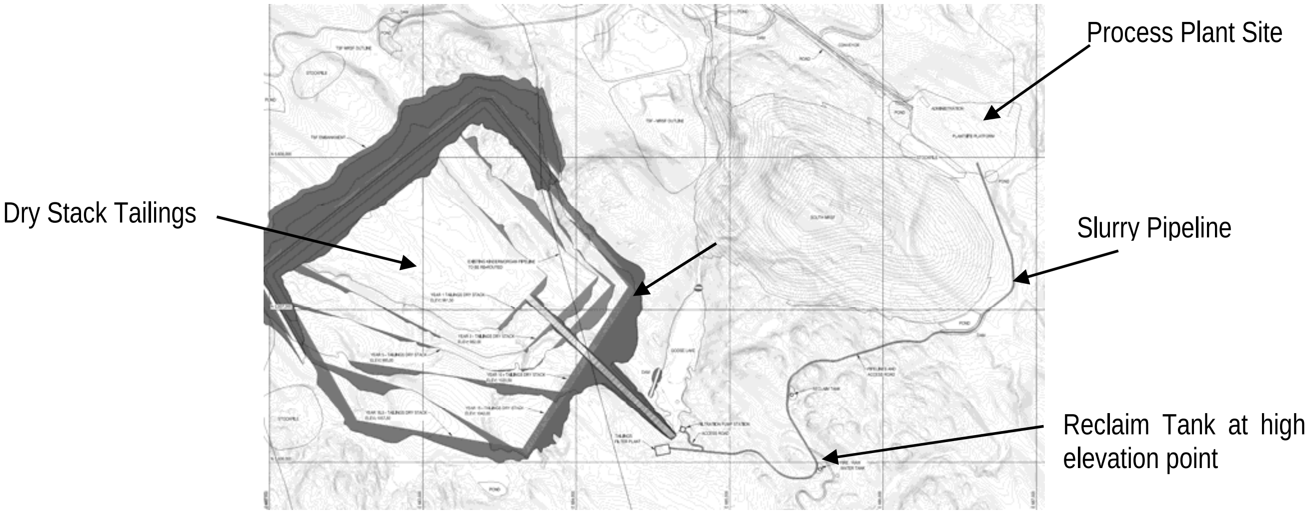


Figure 2-6: Filtered Tailings: Dry Stack General Arrangement (End of Mine)

The slurry pipeline passes to the south and east climbing 110 metres elevation. The crest of the hill is the location of the reclaim water tank which provides a storage vessel with natural gravity head to supply the process plant or filtration plant, and fire water requirements for the filter plant.

The initial conceptual design of the filter plant considered maintaining most of the equipment under a building in order to avoid winter temperature issues. The building layout dimensions were set in relatively even proportions to minimize building size. This layout lends itself to two bridge cranes offering access to all filters and major pumps. The large air compressors are set in an adjacent building to minimize noise issues, but yet allow waste heat recovery for general building heating. The filters are arranged in pairs, to facilitate the future addition of a 12th filter. The control room is located on an upper level allowing viewing over the filter deck, as well as viewing of the conveying system removing material from the building.

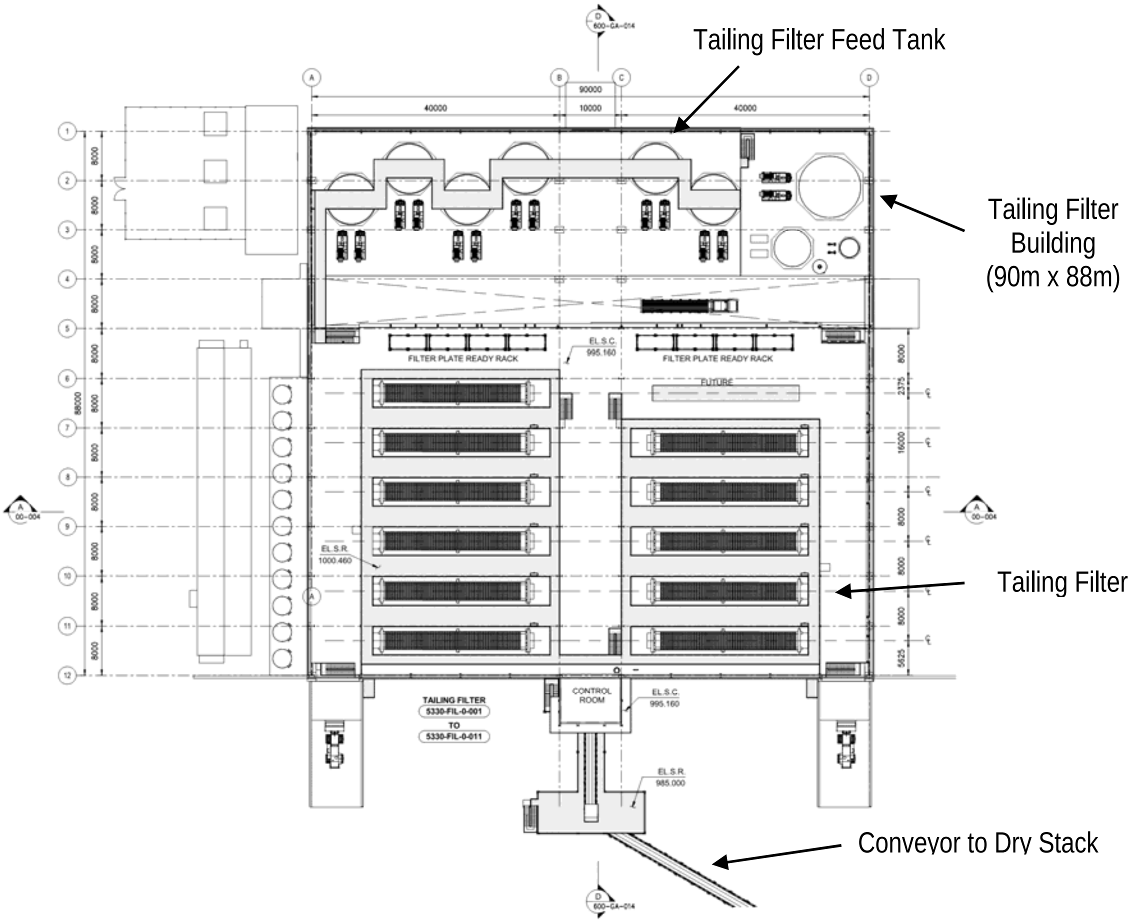


Figure 2-7: Filter Plant General Arrangement

The dry stack conveying and stacking system is a large material handling system with flexibility to stack the filter cake as needed under a planned stacking schedule. In later life of the project the material leaving the filter plant will need to ramp up to the upper lifts of the TSF. The plant location is sufficiently outside the TSF footprint to allow future ramps to be constructed for the ramp conveyors.

3 SITE CONDITIONS

3.1 SITE DESCRIPTION

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, BC. Currently, the common land use in the area is ranching. Surface rights are privately owned, and the main water bodies in the area are Jacko, Inks, and Wallender lakes. These lakes are reserved for ranching and recreation.

Goose Lake is a shallow waterbody in a closed basin whose water quality is affected by evaporative concentration. It is not fish bearing, but does support local biodiversity values associated with wetlands and wildlife habitat. The Stk'emlupsemc te Secwepemc Nation (SSN) have emphasized the importance of the Jacko Lake area, also known as Pípsell. This area, which in addition to Jacko Lake includes Jacko Creek, Goose Lake, Peterson Creek, is considered an important cultural landscape and place with spiritual and cultural value for the SSN.

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.

3.2 SITE CLIMATE AND HYDROLOGY

3.2.1 General

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 water bodies or impoundments. 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 in part to the extremely dry and absorbent soils.

3.2.2 Precipitation

The long-term Mean Annual Precipitation (MAP) is estimated to be 336 mm, with approximately 30% of the annual value expected to fall as snow. The extreme rainfall values, including the Probable Maximum Precipitation (PMP) for the project area, are summarized in Table 3-1.

Table 3-1: 24-Hour Extreme Rainfall Values

Return Period (years)	Extreme Event (mm)
100	62.8
200	68.5
PMP	219.1

*From Knight Piésold, 2014-1

3.2.3 Evapotranspiration

The long-term mean annual Potential Evapotranspiration (PET) is estimated to be 603 mm, which is defined as the amount of evapotranspiration that would occur given an infinite supply of water from a crop surface. This value is believed to be reasonably representative for open water evaporation rates at the site. It is evident from the MAP and the PET that the project is located in a dry, arid climate.

3.2.4 Runoff

Knight Piésold Ltd. (KPL) calculated a mean annual runoff coefficient of 0.08 for naturally vegetated areas based on the estimated MAP and Mean Annual Unit Runoff (MAUR) of 310 mm and 26 mm, respectively.

3.3 SITE SEISMICITY

Seismic hazard values for the site were obtained from Natural Resources Canada (NRC, 2010) for earthquakes up to the 1 in 2,475 year return period. The peak horizontal ground accelerations for firm ground and different return periods are summarized in Table 3-2 below.

Table 3-2: Ajax Seismic Hazard Values

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

3.4 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.

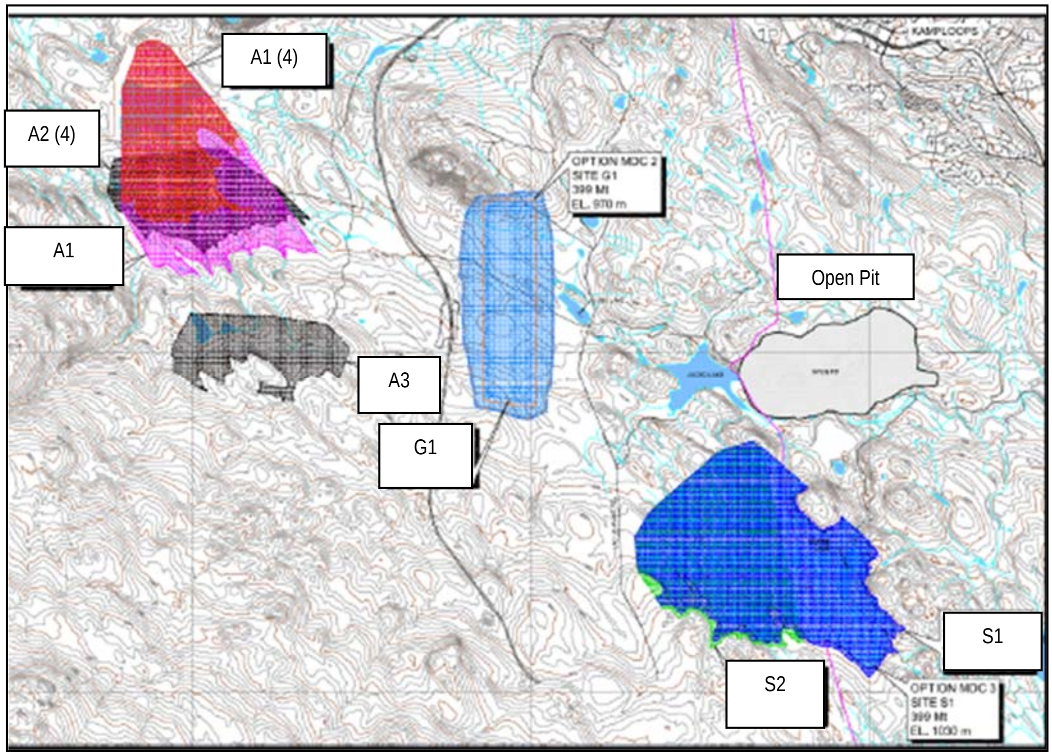
3.5 TSF SITE SELECTIONS

A high-level tailings storage facility location alternatives assessment was completed by Knight Piésold (2013). The locations considered are shown in Figure 3-1 and a description of the preferred location is shown below. The complete alternatives assessment report should be referenced for additional background details. The assessment indicated that using Site S1 (Figure 3-1) and relocating the existing Kinder Morgan pipeline is the preferred option. Significant benefits attributed to the location include:

- The TSF can be integrated into the mine rock storage facility.
- The majority of the embankment construction can be carried out using mine rock and mine haul trucks.
- All of the impacts of associated with the Ajax mine development can be confined into a single watershed, that of Peterson Creek draining to the east.

- The TSF embankment can be constructed to its final outside slope from the start allowing for on-going reclamation of the downstream slope.
- With relocation of the plant site to the south side of Peterson Creek, the entire project footprint could be outside of the Kamloops city limits.

These benefits apply to the proposed Ajax TSF regardless of the tailings technology implemented. As a result, the current proposed footprint for the un-thickened tailings option has been used as the preferred location throughout this study.



Site	Location	Capacity (Mm^3)
A1	Existing Afton TSF	322+
A1(4)	Existing Afton TSF and limited to 4 years operation	56
A2(4)	Upstream of existing Afton TSF & Limited to 4 years operation	56
A3(4)	Upstream of existing Afton TSF & Limited to 4 years operation	56
G1	Existing Golder design	322+
S1	Area south of Ajax pit with oil pipeline relocation	322+
S2	Area south of Ajax pit without oil pipeline relocation	322+

Figure 3-1: Location of Tailings Storage Facilities (KPL, 2013)

3.6 FOUNDATION CONDITIONS

Overburden thickness in the area is variable ranging from less than one metre to greater than 40 m; with an average thickness of 15-20 m. Topsoil found at the site varies from 0.1 to 0.55 m thick and consists of moist, dark brown, silty sand with organics. This is underlain by a glacial till that is the dominant surficial material type. The glacial till is comprised of silt, sand and gravel and has been described as a 'blanket layer' of varying thickness. Standard

Penetration Tests (SPT) and laboratory testing indicate the till is generally compact to dense, firm to hard, with low plasticity. Occasionally eolian sediments overlie the glacial till to form a surficial cover up to 5 m thick in the main TSF valley and are more prevalent on the northwest facing slopes. Colluvium deposits are commonly found on hillside spurs below bedrock outcrops. Bedrock consists of competent, low permeability Nicola Group volcaniclastic and sedimentary rocks.

Previous mapping also identified glaciofluvial and glaciolacustrine deposits. Glaciofluvial deposits of coarse-grained soils with sand were identified; typical of the kames and eskers mapped on the project site. These were located to the west and south of Goose Lake within the proposed TSF footprint. The glaciolacustrine deposits nearest the TSF preliminary design footprint were mapped in the vicinity of the East Mine Rock Storage Facility (EMRSF) toe and below the TSF South Embankment. Material was noted to be fine-grained with ‘fine laminated layers or weaker, clayey laminations’.

Detailed information including test pit logs, borehole logs and laboratory test results can be found in the geotechnical report (KPL, 2015).

A high level review from Norwest also identified a 4 m thick clay layer located downstream of the main embankment of the TSF (borehole DH14-031). The continuity of this layer and material strength parameters will be further defined during the 2015 site investigation.

4 DESIGN BASIS

The design basis and associated references to be used for the BAT assessment are presented in Table 4-1 below.

Table 4-1: Design Basis

ITEM	DESIGN CRITERIA	SOURCE
1.0 GENERAL		
Site Coordinates	Latitude: 50°37’ North; Longitude: 120°24’ West	KGHM Ajax Mining Inc.
Project Site Elevation	Varies (934 – 1080 masl)	KGHM Ajax Mining Inc.
Review Periods	1, 3, 5, 10, 15, Life of Mine	KGHM Ajax Mining Inc.
Pre-production Period	2 years	KGHM Ajax Mining Inc.
2.0 MINE PRODUCTION		
Total Ore Milled	440 M tonnes (June 2014 mine plan)	KPL Design Basis
Total Tailings Produced	420 M tonnes	KPL Design Basis
Mill Throughput	65,000 tonnes per day (capacity)	KGHM Ajax Mining Inc.
Life of Mine (LOM)	20 years (approximately)	KGHM Ajax Mining Inc.
Tailings Specific Gravity	2.8	Golder and FLSmidth Lab Reports
3.0 WATER MANAGEMENT		
Water Collection Ponds	Manage runoff water collected by diversion ditches. Baseline layout is from KPL design.	KPL Preliminary TSF Design
Sediment Containment Structures	Manage runoff water sediment prior to water reaching collection ponds or Goose Lake Reservoir.	Norwest Corporation
Permanent Diversion Ditches	Collect and divert runoff water from undisturbed areas.	Norwest Corporation
Temporary Diversion Ditches	Manage runoff water from disturbed areas around the dry stack.	Norwest Corporation
Design Storm Events	1 in 200 year, 24-hr rainfall (P = 68.5 mm) for ponds and permanent ditches; and 1 in 5 year, 24-hr rainfall (P = 37 mm) for temporary ditches	BGC Engineering Inc. Ajax Water Balance Model, 2015.
3.1 ESTIMATED START-UP WATER REQUIREMENT		
Un-thickened Tailings	13 Mm^3	KPL Preliminary TSF Design
Thickened Tailings	2 Mm^3	Norwest Corporation
Paste Thickened Tailings	1 Mm^3	Norwest Corporation
Filtered Tailings	1 Mm^3	Norwest Corporation
4.0 TAILINGS STORAGE		
4.1 GENERAL		
Rock Buttress Specifications		

Material	Mine rock from open pit area	KGHM Ajax Mining Inc.
Crest Elevation	Can be optimized based on compacted shell phasing	Norwest Corporation
Crest Width	39 m	KPL Preliminary TSF Design
Side Slopes	2.4H:1V downstream, 2H:1V upstream (starting point - to be confirmed during stability analyses)	KGHM Ajax Mining Inc.
Seepage Control Measures	Underdrain system at base of facility.	Norwest Corporation
Staged Expansion Construction	Rock buttress to be progressively raised based on expected tailings storage height during operations.	Norwest Corporation
4.2 UN-THICKENED TAILINGS		
Target Solids Content	32%	KGHM Ajax Mining Inc.
Tailings Placement Dry Density	1.4 t/m^3 (used for storage volumetrics)	KPL Preliminary TSF Design
Expected Beach Slope	1% sub-aerial, 10% sub-aqueous	KPL Preliminary TSF Design
Storage Capacity	315 Mm^3	KPL Preliminary TSF Design
4.3 THICKENED TAILINGS		
Target Solids Content	60%	KGHM Ajax Mining Inc.
Tailings Placement Dry Density	1.55 t/m^3 (used for storage volumetrics)	Norwest Corporation
Expected Beach Slope	1.5% sub-aerial, 10% sub-aqueous	Norwest Corporation
Storage Capacity	275 Mm^3	Norwest Corporation
4.4 PASTE THICKENED TAILINGS		
Target Solids Content	75%	KGHM Ajax Mining Inc.
Tailings Placement Dry Density	1.55 t/m^3 (used for storage volumetrics)	Norwest Corporation
Expected Beach Slope	5% sub-aerial	Norwest Corporation
Storage Capacity	275 Mm^3	Norwest Corporation
4.5 FILTERED TAILINGS		
Target Solids Content	85% (expected optimum moisture content is 15%))	Norwest Corporation
Tailings Placement Dry Density	1.7 t/m^3	Norwest Corporation
Tailings Side Slopes	3H:1V (suitable for closure)	Norwest Corporation
Total Storage Capacity	250 Mm^3 (approximate)	Norwest Corporation
Compacted Shell	Constructed from compacted tailings material	Norwest Corporation
5.0 INSTRUMENTATION AND MONITORING		
Geotechnical Instrumentation and Monitoring	Vibrating wire piezometers to measure pore water pressure in dams and tailings	KPL
	Inclinometers as required.	KPL

	Flow monitoring for embankment and foundation drains	KPL
	Flow monitoring for underdrain	Norwest Corporation
6.0 CLOSURE REQUIREMENTS		
Closure Type	Dry	Norwest Corporation
Reclamation Slopes	3H:1V (tailings), minimum 2.4H:1V (other)	Norwest/KGHM
Overburden Thickness	50 – 65 cm	KGHM Ajax Mining Inc.
Topsoil Thickness	35 cm	KGHM Ajax Mining Inc.
Frequency	Years 1, 3, 5, 10, 15, Life of Mine	KGHM Ajax Mining Inc.
Cover System	Vegetated cover promoting run-off; consider geosynthetics	Norwest Corporation
Water Management	Diversion ditches and other erosion protection as required and grading of final platform.	Norwest Corporation

Each option will work within the currently proposed footprint for the conventional storage facility design which was the preferred location based on the KPL siting study.

Cost estimates will be prepared for pre-production and production phases including initial and sustaining Capital Expenditures (CAPEX), and Operating Expenditures (OPEX). When possible, costing will be estimated on an incremental basis from the un-thickened tailings base case estimate.

5 TAILINGS STORAGE FACILITY LAYOUTS

Proposed layouts for each of the four tailings technologies being considered are shown in the following sub-sections. It is expected that the preferred option will be further refined and optimized in greater detail during future engineering studies.

5.1 LAYOUT: UN-THICKENED TAILINGS

The layout for the un-thickened tailings case is taken from the preliminary design completed by KPL (2014-2) and is shown in Figure 5-1. The TSF covers an area of 700 ha including embankment footprints; of this 326 ha is tailings beach and 263 ha is pond surface area. The ultimate elevation of the tailings dam is 1,060 m. However, the mine rock buttress could be constructed higher in order to provide additional capacity, assuming geotechnical design requirements could be satisfied. The KPL design requires four (4) embankments for containment which have been designated:

- North Embankment
- East Embankment
- South Embankment
- Southeast Embankment

The North and East embankments are buttressed with mine rock for improved embankment stability. Four (4) collection ponds specific to the TSF are also required in addition to the TSF pond:

- North Embankment Seepage Collection Pond 1
- North Embankment Seepage Collection Pond 2
- South Embankment Seepage Collection Pond
- Southeast Embankment Seepage Collection Pond

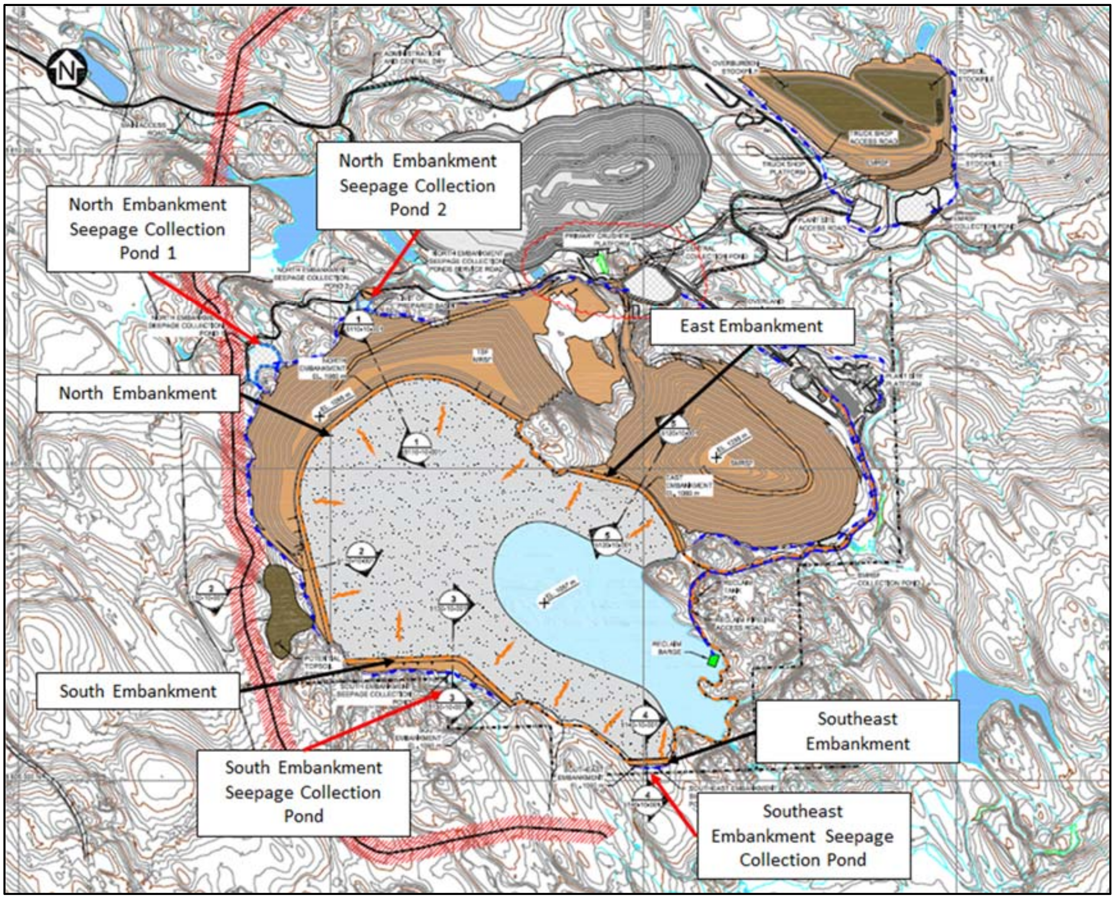


Figure 5-1: Layout: Un-Thickened Tailings

5.2 LAYOUT: THICKENED TAILINGS

The layout for the thickened tailings case is shown below Figure 5-2. The thickened slurry tailings TSF footprint covers an area of 690 ha of which 450 ha is tailings beach and 100 ha is pond surface area. The ultimate elevation of the tailings dam is 1,056 m. The mine rock buttress could be constructed higher in order to provide additional capacity, assuming geotechnical design requirements could be satisfied. Containment requires four (4) embankments

- North Embankment
- East Embankment
- South Embankment
- Southeast Embankment

It should be noted that the North and South Embankments become linked to each other as the dykes are raised over the life of the structure. The North and East embankments are also buttressed with mine rock for improved TSF stability. There are three (3) external water collection ponds (surface run-off and seepage water) associated with the TSF:

- North Embankment Seepage Collection Pond 1
- North Embankment Seepage Collection Pond 2
- South Embankment Seepage Collection Pond

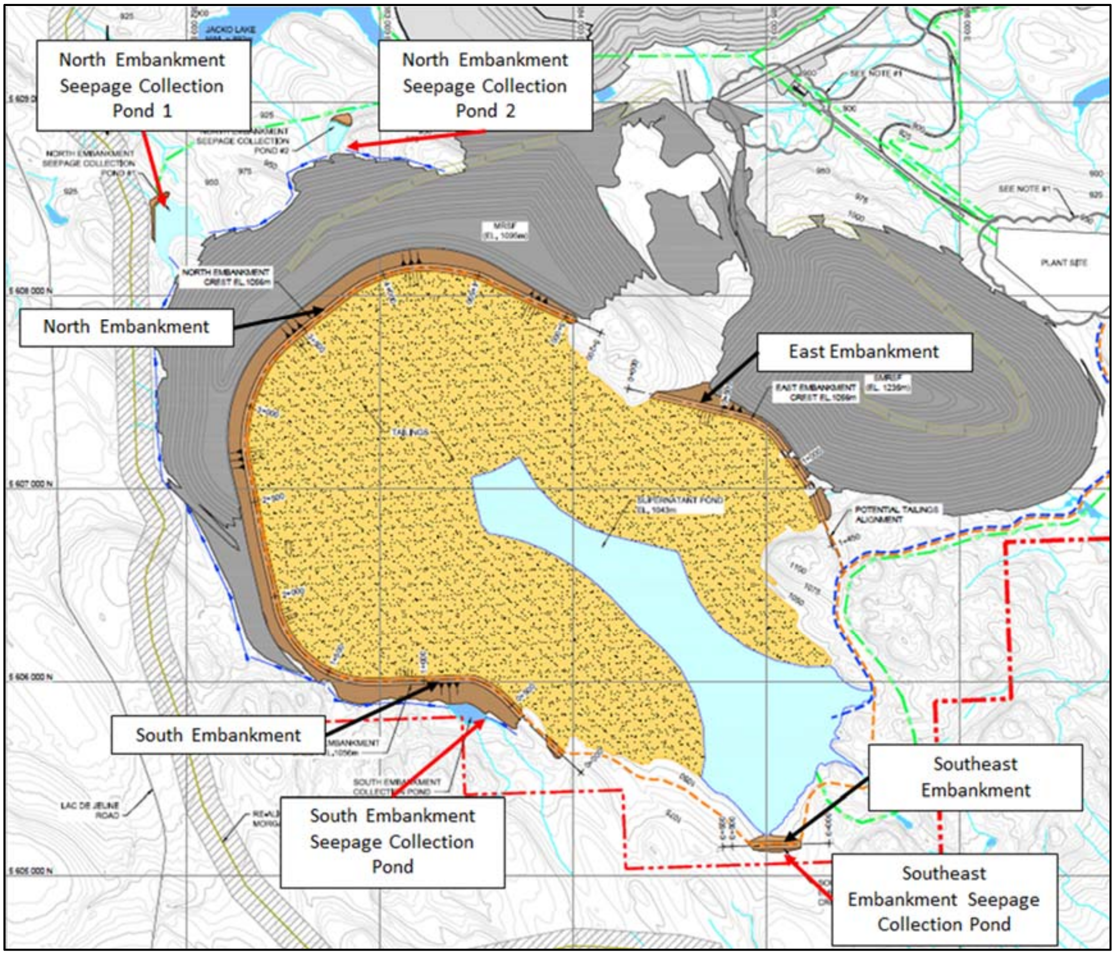


Figure 5-2: Layout: Thickened Tailings

5.3 LAYOUT: PASTE THICKENED TAILINGS

The layout for the paste thickened tailings case is shown below Figure 5-3. The paste thickened TSF footprint covers an area of 603 ha including embankment footprints with 411 ha of tailings beach and 50 ha of supernatant pond surface area. The ultimate elevation of the tailings dam is 1,051 m while the ultimate elevation of the paste tailings is 1,095 m. However, the mine rock buttress could be constructed higher in order to provide additional capacity, assuming geotechnical design requirements could be satisfied. Containment of the paste tailings requires three (3) embankments:

- North Embankment
- East Embankment
- South Embankment

The North and East embankments are also buttressed with mine rock for improved TSF stability. Three (3) external water collection ponds are required to manage surface run-off and seepage water:

- North Embankment Seepage Collection Pond 1

- North Embankment Seepage Collection Pond 2
- South Embankment Seepage Collection Pond

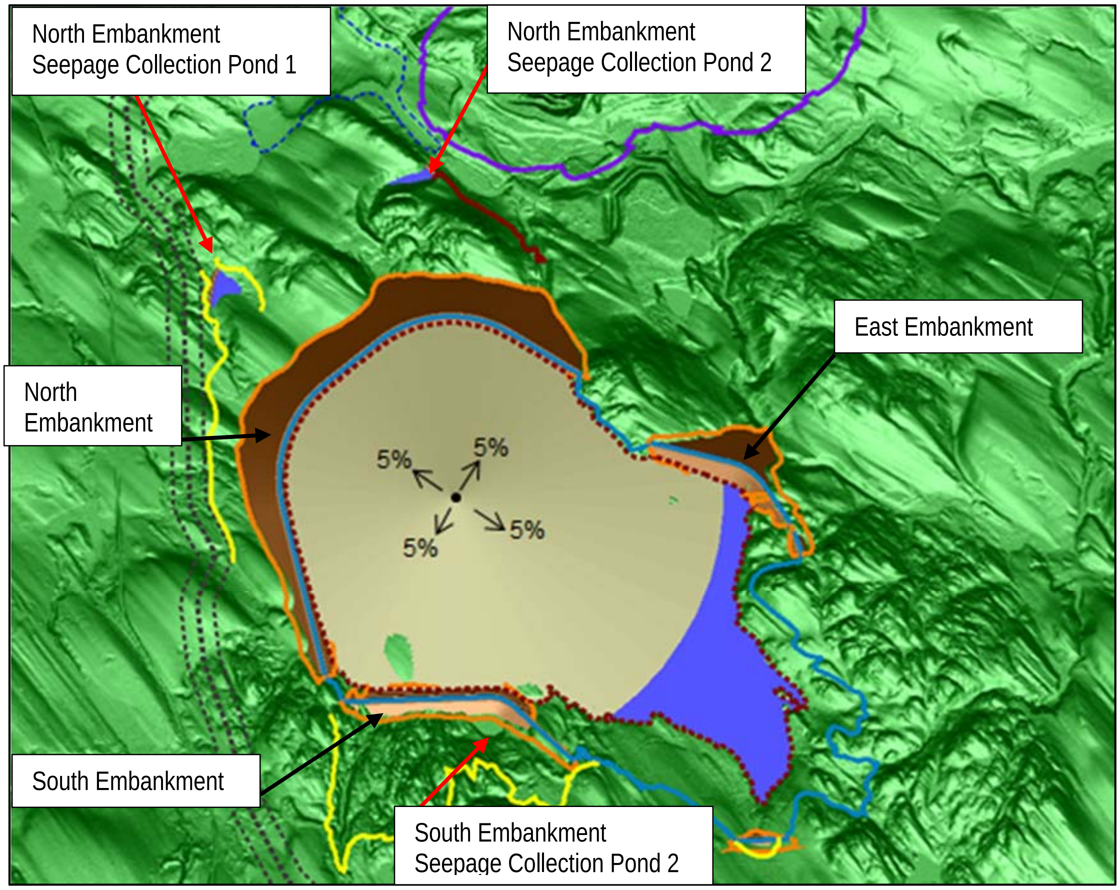


Figure 5-3: Layout: Paste Thickened Tailings

5.4 LAYOUT: FILTERED DRY STACK TAILINGS

The layout for filtered dry stack tailings is shown in Figure 5-4. The filtered TSF footprint covers an area of 429 ha of which 362 ha is tailings surface area. The ultimate elevation of the tailings stack is 1,055 m. The ultimate elevation of the embankments is lower than the tailings material; however, the mine rock buttress could be constructed higher in order to provide additional capacity, assuming geotechnical design requirements could be satisfied.

The filtered dry stack configuration does not engulf Goose Lake within the tailings storage footprint. However, the dry stack option does not provide a water storage reservoir (i.e., supernatant pond) similar to that of a conventional TSF. The current dry stack option proposes using Goose Lake as a water reservoir (Figure 5-4). Use of Goose Lake in this way requires constructing dams to increase the capacity to allow for storage of process make-up water and storm water run-off from the 1 in 200 year rainfall. It should be noted that a larger dry stack footprint was considered as it would reduce the overall height of the facility. However, the smaller footprint was selected in order to allow for the return of Goose Lake to pre-mining condition (as much as practicable) at closure.

- The proposed design includes a rock buttress along the western and northwestern slopes of the TSF as additional mitigation against a potential down valley failure and improves TSF stability for the highest slopes.

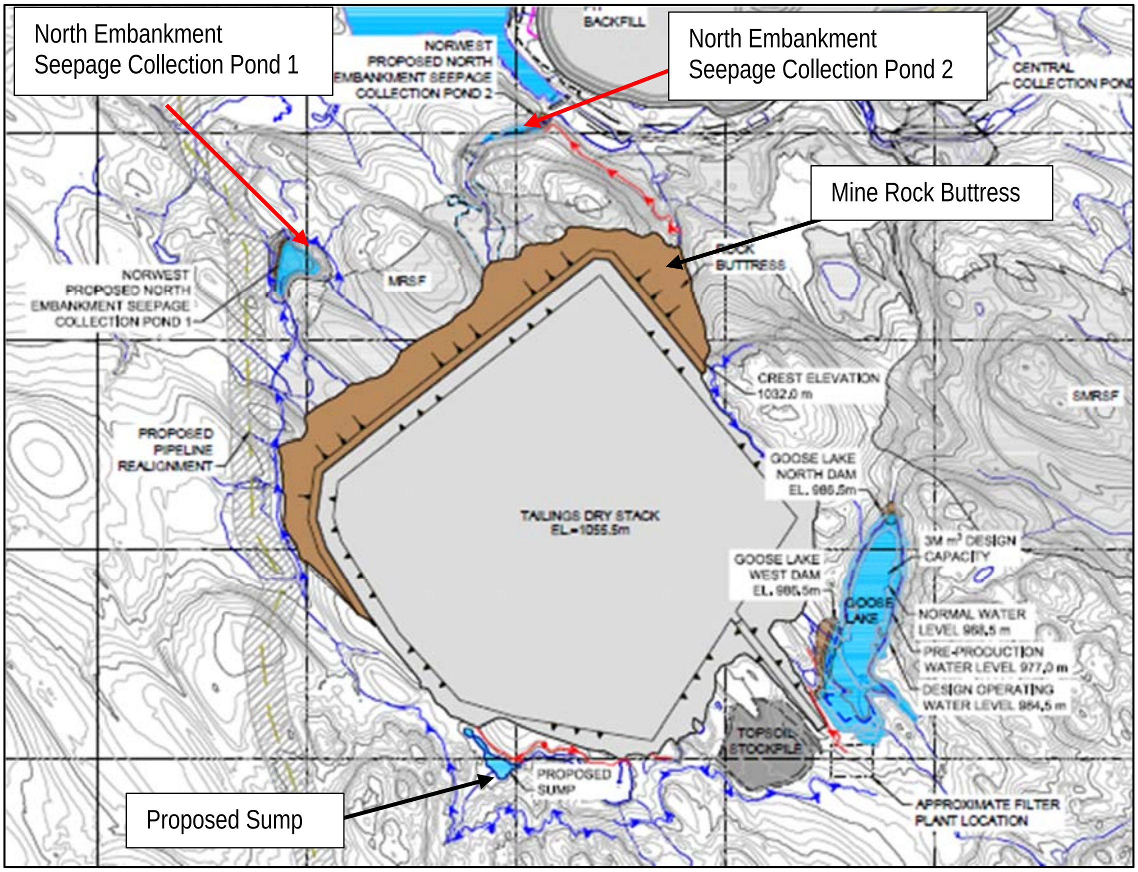


Figure 5-4: Layout Filtered Dry Stack Tailings

6 TECHNICAL ASPECTS

6.1 TAILINGS DEWATERING

An important technical consideration is the ability to dewater tailings (increase percent solids by decreasing water content) to the design specified target solids/water content. In general, the higher the design water content specification, the simpler the option is from a dewatering process perspective (i.e. the tailings material is similar in composition to the raw tailings stream coming from the plant). This results in un-thickened slurry tailings being the most favorable option with regards to dewatering processes as essentially no additional thickening or filtering is required. Achieving lower specified design water content values becomes more challenging as increased dewatering effort is required on the continuum of moisture contents from thickened to paste to filtered tailings. Achieving increasingly lower levels of moisture in the tailings stream requires additional components, additives and processes as part of the selected dewatering system. Each additional system or process increases the tailings treatment system's complexity and reduces system reliability and availability. Specific comments for each tailings technology considered are as follows:

- **Un-thickened Slurry Tailings (32% solids)** – limited or no thickening is involved as the slurry from the process plant is transported directly to the TSF.
- **Thickened Slurry Tailings (60% solids)** – slurry from the process plant is transported to a thickener for dewatering. Achieving the target solids/water content requires successful performance at the thickener which can include ongoing adjustments (flocculent levels, retention time, throughput) to account for material variability.
- **Paste Thickened Slurry (75% solids)** – slurry from the process plant is transported to a conventional thickener for first stage dewatering followed by further dewatering in specialized high density thickeners to achieve target specifications. Material variability can create challenges in producing a consistent paste product.
- **Filtered Dry Stack Tailings (85% solids)** - slurry from the process plant is transported to a conventional thickener for initial dewatering. The thickened slurry is then transported to the filter plant where a series of filter presses (vacuum or pressure) dewater the tailings to a "filter cake" product. Tailings material variability can create challenges in producing a consistent filtered tailings product that meets design specifications.

6.2 TAILINGS DEPOSITION

Tailings deposition includes both the transport from the treatment facility to the containment area as well as the ability to achieve the required design configuration within the TSF footprint. Similar to the dewatering scenarios, the increasing handling complexity encountered when moving from un-thickened tailings technology through thickened and paste tailings into filtered tailings transport and placement brings with it issues related to system reliability and maintenance.

- **Un-thickened Slurry Tailings (32% solids)** - is the most favorable for deposition as it is pumped using centrifugal pumps to the TSF and discharged from spigots around the perimeter of the facility. The range of potential beach deposition slopes is narrow (typically 1-2%) which means the design configuration is more easily achieved.
- **Thickened Slurry Tailings (60% solids)** - can still be pumped using centrifugal pumps and discharged from spigots around the perimeter of the facility (central discharge can also be used to increase storage capacity but can create challenges in achieving deposition due to fewer discharge points). Design slopes for thickened tailings are typically 1-5% with steeper design slopes being more challenging to consistently achieve.

- Paste Thickened Tailings (75% solids) - can still be pumped; however, the high tailings mixture viscosity requires a transition from centrifugal to more expensive positive displacement pumps. Discharge of paste tailings can be from a single or multiple locations and design slopes are typically 3-10%. Similar to the thickened slurry options, steeper design slopes are more challenging to consistently achieve, especially at high production levels like those proposed for Ajax (65,000 tonnes per day).
- Filtered Dry Stack Tailings (85% solids) - would involve pumping thickened tailings to the filter plant and then using a conveyor to transport the ‘dry’ material to the stack. At 65,000 tpd, trucking the dry tailings would not be economically viable and would also cause significantly more dusting potential than a conveyor. A benefit of filtered tailings is that the stack is trafficable which allows more control for achieving the design configurations by secondary construction activities (ex. dozer pushing/grading or compaction of material). These secondary construction activities can include contouring to manage surface water and compaction of an outer shell zone for improved stability. The deposition plan for a filtered tailings stack would include a number of support activities as follows:
    - Compaction – tailings material for use in the compacted shell zone will need to be tested to ensure it meets design specifications. After on-specification tailing material reaches the compacted shell zone via conveyor, it will need to be spread into thin lifts and compacted. The compaction specification is performance based and will require reaching a density of 90% standard proctor maximum dry density (or higher, confirm with site specific testing). It is expected that spreading and compaction will require on-going support from a D10 dozer and one vibratory compaction roller. Quality control and quality assurance monitoring of this zone will include testing for as-placed moisture content and post-compaction testing for moisture content and density. Construction monitoring of the shell zone will be required throughout the life of mine.
    - Surface Water Management – surface grading may be required to prevent ponded water on the surface and erosion of the stack through channelized runoff flow (Engels, 2014). It is expected that the same equipment listed under ‘Compaction’ can complete this work during the on-going support.
    - Trafficability – in general, filtered dry stack facilities will be trafficable. However, increased rainfall in either isolated events or seasonal trends can lead to reduced trafficability and the ability to meet performance specifications required for stability. This issue can be managed by placing thinner lifts and allowing additional time for material to dry or re-handling, if necessary. Additional costs for the potential re-handling of material would be difficult to estimate and represent an operational risk.

Regardless of the technology considered, operation during the winter season can present difficulties for tailings transport and deposition. Un-thickened tailings systems may have issues with freezing pipes or with tailings backing up close to the discharge point (although backing up is not expected to be an issue at the expected discharge rates). With filtered tailings, it may be challenging to construct the compacted shell zone during the winter. Material should be spread and compacted prior to freezing which means the material must meet moisture content design specification when discharged from the conveyor. For any of the examined technologies, operating procedures will need to be designed to accommodate winter conditions. Additional procedures and costs associated with mitigation options are outside the scope of this study.

7 ENVIRONMENTAL/SOCIAL ASPECTS

Environmental and social considerations have been combined into one section due to significant overlap between them and are discussed in the following sub-sections. Specific assessments related to heritage and health aspects for TSF structures are outside the scope of this study and should be addressed by others.

7.1 PROCESS MAKE-UP WATER REQUIREMENTS

Although fresh make-up water supply may not be a controlling factor in the selection of BAT tailings technology for Ajax, reducing the requirements remains an overall environmental benefit. Make-up water is defined in this report as the amount of water required to compensate for water losses that occur in the TSF. Losses at the grinding and flotation portion of the facility have been estimated as relatively minor. They include evaporation from flotation cells and water contained in the concentrate. Water from leaks, spills, and overspray in a concentrator is generally recovered from sumps and reused.

The most significant factors that contribute to make-up water requirements result from the loss of water in the TSF caused by evaporation, seepage and water retained within the tailings (interstitial loss). Water make-up rates are the sum of interstitial water losses, seepage and evaporation, less 4% moisture assumed as originating in the ore itself. Comments for each technology are listed below and estimated make-up requirements are shown in Table 7-1.

- **Un-thickened Slurry Tailings (32% solids)** – this option does not recycle water at the plant as the un-thickened slurry is transported to the TSF. This results in a larger volume of water in the TSF, meaning there is more water available for evaporation and seepage losses. The lower initial solids content tailings also takes longer to settle and consolidate, which leaves more water trapped in the tailings voids as interstitial losses. Tailings test data (KPL, 2015-2) indicates the un-thickened slurry will settle to 73% solids in a relatively short time (less than two weeks) and this has been used to calculate interstitial water loss.
- **Thickened Slurry Tailings (60% solids)** – thickened tailings recovers a significant portion of the process water during the thickening process (the thickener overflow). This results in less water being transported and stored in the TSF which leads to lower evaporation and seepage losses. The increase in initial solids content provides a denser initial tailings beach which acts as a seepage barrier reducing seepage water losses. Tailings test data (KPL, 2015-2) indicates the thickened slurry will settle to 77% solids in a relatively short time (less than two weeks) and this has been used to calculate interstitial water loss.
- **Paste Thickened Tailings (75% solids)** – paste thickened tailings will recover water at the thickener overflow from both the initial thickening stage and the high density thickening. This water is recovered prior to reaching the TSF which reduces losses to evaporation and seepage. However, there is also minimal water available for reclaim from the TSF as the majority of that transported within the paste thickened tailings will remain trapped as interstitial loss. Interstitial losses were calculated assuming the same settled solid content as stated above for thickened tailings.
- **Filtered Dry Stack Tailings (85% solids)** – a dry stack facility should not have seepage due to excess water and does not have a supernatant pond or reclaim pool, and thus does not have said seepage and evaporation losses. The filtrate fluid (water squeezed from the filter presses) returns directly to the process circuit. The make-up water required is equal to the interstitial loss in the unsaturated filter cake deposit.

The following table shows the water losses for the various cases. Evaporation is based on the net annual precipitation and the pond surface area. Seepage has been assumed to be 2% of free water (underflow to TSF).

Table 7-1: Make-Up Water Requirements

Tailings Case	Losses (m^3/hr)				4% Ore Moisture (m^3/hr)	Process Make-Up Water (m^3/hr)
	Interstitial	Evaporation	Seepage	Total		
Un-thickened Slurry (32% solids)	1,002	83	115	1,200	113	1,087
Thickened Slurry (60% solids)	809	32	36	877	113	764
Paste Thickened (75% solids)	809	16	18	843	113	730
Filtered Dry Stack (85% solids)	478	-	-	478	113	365

7.2 DISTURBED SURFACE AREA

Placement of tailings at steeper slope angles and reducing the required size of containment structures results in a smaller footprint being needed to store a given volume of tailings. As a result, filtered tailings is the most favorable (33% deposit slope) followed by paste (3-6% slope), thickened (1-3%) and un-thickened slurry (1-2%). It should be noted that a filtered dry stack does not include an internal water storage pond unlike the other options but one must be included outside of the dry stack footprint. For the Ajax Project, it is proposed that dams be constructed as required at Goose Lake to provide this water storage for the filtered option. In comparison, Goose Lake is absorbed into the overall TSF footprint for the un-thickened, thickened and paste options due to their larger footprints.

For all TSF alternatives considered, there is a direct effect to Goose Lake; either by burial by tailings material, or for use as a water management pond. Goose Lake is a shallow waterbody in a closed basin. Water quality shows high dissolved solids as a result of evaporative concentration. It is not fish bearing, but does support local biodiversity values associated with wetlands and wildlife habitat. The Stk'emlupsemc te Secwepemc Nation (SSN) have emphasized the importance of the Jacko Lake area, also known as Pípsell. This area, which in addition to Jacko Lake includes Jacko Creek, Goose Lake, Peterson Creek, is considered an important cultural landscape and place with spiritual and cultural value for the SSN. The SSN believe there is an interconnectedness between these geographic components and that interconnectedness plays an important role in their worldview and cultural values, practices, and traditions. KAM's current understanding of the importance of Goose Lake to these Aboriginal values is related to the habitat it provides which supports overall biodiversity in the traditional territory, and also supports traditional hunting and gathering practices across the area (Ignace, 2014).

It should also be noted that the current conventional and filtered dry stack TSF designs are similar in ultimate crest height (conventional is 1060 m while filtered is 1055 m). A larger dry stack footprint was considered as it would reduce the overall height of the facility. However, the smaller footprint was selected in order to allow for the return of Goose Lake to pre-mining condition (as much as practicable) at closure. Conceptual level paste and thickened options have ultimate crest elevations of 1095 m and 1056 m, respectively. A summary of disturbed area is presented in Table 7-2.

Table 7-2: TSF Disturbed Area

Tailings Case	Disturbed Area (ha)	Other Areas (ha)	
		Exposed Tailings	Pond Surface
Un-thickened Slurry (32% solids)	700	326	263
Thickened Slurry (60% solids)	690	450	100
Paste Thickened (75% solids)	603	411	50
Filtered Dry Stack (85% solids)	429	362	-

7.3 CONSEQUENCE OF BREACH FAILURE

Downstream consequence of breach failure is related to the mobility of the tailings flow as well as the volume of water and fluid impounded within the tailings impoundment. Essentially, the higher the water content of the tailings and the more water stored within the TSF means increased mobility of the tailings-water mixture and larger released volumes and therefore the higher the consequence of a breach failure. It should be noted that the probability of a breach failure can be significantly reduced with a proper and robust containment design; for example by designing and constructing a large buttress on the downstream side of containment dams. It should be noted that the placement of the buttress is being considered as part of the integrated design, regardless of the tailings disposal technology being reviewed. The buttress must be properly designed and constructed to mitigate the potential for failure within the mine rock; however, with a large enough buttress the likelihood of a failure progressing through the buttress and the tailings dam to allow a release of tailings and supernatant water becomes non-credible.

The consequence of failure from most favorable to least favorable is considered to be filtered dry stack, paste, thickened and then un-thickened. This assessment is based on the type and quantities of tailings material and water stored within the TSF. Comments specific to each of these technologies are as follows:

- **Un-thickened Slurry Tailings (32% solids)**
    - **Un-buttressed Facility** – this is included for reference only. As mentioned previously, placement of the buttress is being considered as part of the integrated design, regardless of the tailings disposal technology. This would be the worst case in terms of risk of failure. The un-thickened tailings mass has the highest volume of stored water and lowest density of as-placed tailings (i.e., highest mobility). The higher water level also increases the seepage gradient through the embankment which could potentially lead to a progressive piping failure, the likelihood of which increases without the downstream mine rock buttress.
    - **Buttressed Facility** – this option is better than an un-buttressed facility but still has a higher risk of failure than thickened, paste thickened, or filtered dry stack tailings. The un-thickened tailings mass has the highest volume of stored water and lowest density of as-placed tailings (i.e., highest mobility). The higher water level also increases the seepage gradient through the embankment which could potentially lead to a progressive piping failure, the likelihood of which is reduced with the construction of the downstream mine rock buttress.
- **Thickened Slurry Tailings (60% solids)** – thickened tailings would be similar to paste thickened tailings and both would be considered more favorable than un-thickened but less favorable than filtered dry stack tailings. Thickened tailings material is placed at a much higher initial density and reduced water content than un-thickened which results in a less mobile mass. The start-up water and on-going pond volume is significantly lower which reduces the wetted area and head on the TSF embankment. As thickened tailings material is

deposited, it provides a seepage barrier (of tailings material) against the upstream face of the embankment and pushes the supernatant pond further away from the embankment.

- **Paste Thickened Tailings (75% solids)** – paste thickened tailings would be similar to thickened tailings and both would be considered more favorable than un-thickened but less favorable than filtered dry stack tailings. Paste thickened tailings material is placed at a much higher initial density and reduced water content than un-thickened which results in a less mobile mass. The start-up water and on-going pond volume is significantly lower which reduces the wetted area and head on the TSF embankment. As paste thickened tailings material is deposited, it provides a seepage barrier (of tailings material) against the upstream face of the embankment and pushes the supernatant pond further away from the embankment.
- **Filtered Dry Stack Tailings (85% solids)** – this is the most favorable option with respect to risk of failure. Filtered tailings material is placed at lower moisture content and there is no supernatant pond within the TSF which results in the lowest mobility. Material placed is expected to be non-liquefiable as long as design specifications are being met. An outer shell of on-specification tailings material (confirmed through field testing) is placed and compacted to mitigate the potential for instabilities resulting from localized volumes of off-specification (wetter) material. Filtered dry stack tailings requires a separate water storage pond which has its own risk of failure; however this risk is considered low as this option has the lowest water storage requirements.

7.4 DUST

These comments relating to dust generated from the TSF are provided without the benefit from specific air quality modelling and should be treated as general in nature.

- **Un-thickened Slurry Tailings (32% solids)** - beaches are saturated during initial deposition on the beach, however, fines in the slurry tend to segregate and can be exposed on the lower portions of the beach. Exposed fines on the beach surface are more readily available to generate dust as the beach surface dries.
- **Thickened Slurry Tailings (60% solids)** – the flocculent added during the thickening process binds the finer particles to the coarser particles. This creates a non-segregating tailings mass (i.e., the fines do not separate from the coarser material in the deposit matrix) which tends to form a crust as the beach surface desiccates following deposition. This does not completely eliminate dust but will result in less dust potential when compared to an un-thickened tailings beach.
- **Paste Thickened Tailings (75% solids)** – the flocculent added during the thickening processes binds the finer particles to the coarser particles. This binding along with the reduction in water content creates a non-segregating tailings mass which tends to form a crust as the beach surface desiccates following deposition. This does not completely eliminate dust but will result in less dust potential than from an un-thickened tailings beach.
- **Filtered Dry Stack Tailings (85% solids)** – tailings are placed at a lower moisture content as a ‘dry’ material which means dust will be generated sooner than with the other tailings options. However, the fines do not segregate in the filtered option and mitigation would be less challenging as the surface is trafficable and more easily accessed. Dry stack phasing can also be optimized to allow for progressive reclamation of final slopes as they are constructed. Progressive reclamation reduces exposure time of the tailings material and allows for detailed test programs to optimize the cover design early in the mine life.

Dust mitigation is expected to be required for any of the four options considered.

7.5 SEEPAGE

Seepage estimates are based on expected pond size and as-placed tailings density. A larger supernatant pond will increase seepage and a higher settled tailings density will act as a seepage barrier. Detailed seepage analysis will be completed for the selected option but the lowest expected seepage is for filtered dry stack tailings, followed by paste thickened, thickened slurry and un-thickened slurry, respectively.

7.6 VISUAL IMPACT

The visual impact considers both the overall facility height of each TSF as well as expected lighting required for nighttime operations. This information is presented in Table 7-3.

Table 7-3: Visual Impacts

Tailings Case	Maximum Elevation [1] (masl)	Lighting Requirements at Night
Un-thickened Slurry (32% solids)	1,060	Minimal (spigotting from perimeter)
Thickened Slurry (60% solids)	1,056	Minimal (spigotting from perimeter)
Paste Thickened (75% solids)	1,095	Moderate lighting required for access to discharge location (assumed central discharge point(s))
Filtered Dry Stack (85% solids)	1,055 [2]	Significant lighting requirements for conveyor and equipment working on TSF surface (compaction and contouring)

Notes:

1. Maximum elevation of embankment crest (un-thickened and thickened) or tailings material (paste and dry stack)
2. It should be noted that a larger dry stack footprint was considered as it would reduce the overall height of the facility. However, the smaller footprint was selected in order to allow for the return of Goose Lake to pre-mining condition (as much as practicable) at closure.

7.7 RECLAMATION

General comments on reclamation for the various options are as follows:

- Un-thickened Slurry Tailings (32% solids) – due to the perimeter discharge the entire facility is essentially raised together and there is no option for progressive reclamation of the deposit. Reclamation will occur at the end of mine life and challenges include drawdown of the supernatant pond, achieving a trafficable surface and settlement (particularly of the layer of saturated and low density, silt to clay sized segregated material that forms below the pond). The conventional slurry TSF also has the largest footprint to be reclaimed.
- Thickened Slurry Tailings (60% solids) – due to the perimeter discharge the entire facility is essentially raised together and there is no option for progressive reclamation of the deposit. Reclamation will occur at the end of mine life and challenges include drawdown of the supernatant pond, achieving a trafficable surface and settlement (particularly of the layer of saturated and low density, finer saturated material that forms below the pond). Trafficability and settlement should be improved over the un-thickened slurry option.
- Paste Thickened Tailings (75% solids) – paste thickened tailings may have advantages over un-thickened and thickened slurry tailings relating to reclamation due to the higher initial density at placement; however, due to the lack of industry experience and associated uncertainty with paste deposits of the scale projected for Ajax, paste thickened tailings is considered the least favorable regarding reclamation. Scale of the deposit is important due to the challenges in achieving a consistent paste product at high production rates over a

large area which can result in challenges meeting the design layout and dealing with differential settlement due to insitu variability of the deposit.

- **Filtered Dry Stack Tailings (85% solids)** – filtered tailings stacks tend to be easier to reclaim as their surfaces are trafficable as constructed and can be progressively reclaimed as the final outer slopes are constructed. This means reclamation costs are incurred earlier in the project life but the exposure of tailings to the surrounding environment is reduced. The filtered dry stack also has the smallest footprint to reclaim. The 3H:1V side slopes can subject to erosion from surface run-off during precipitation events if left exposed and would need to be repaired prior to final cover construction.

7.8 ENERGY REQUIREMENTS

Estimated energy loads have been calculated for three of the tailings options discussed in this report, and are summarized in Table 7-4 as kilowatt hours per year.

Filtered tailings deposition is the most energy intensive of all the options. No estimate was made for paste thickened process operations, but it would be expected to be higher than un-thickened tailings, and lower than the filtered option.

Table 7-4: Annual Energy Consumed

Annual Energy Consumed (kWh /year)			
	Un-thickened Tailings	Thickened Tailings	Filtered Tailings
Plant Operations	60.1 M	39.3 M	133.5 M
Water Supply	26.1M	18.4M	8.8M

Beside the economic burden of energy requirements, there is also a related issue of greenhouse gas emissions. Greenhouse gas was not estimated but would be proportional to each of the energy consumptions listed in Table 7-4.

8 ECONOMICS

This economic analysis discussion is based on a Technical Study made for KGHM Ajax project by M3 and Norwest to evaluate the capital and operating costs for filtration and dry stack tailings, and a comparison to an un-thickened tailings dam with reclaimed process water as designed in the Ajax feasibility level engineering by Knight Piésold (KPL).

Thickened costs discussed in this report were derived from a high level rough order of magnitude (ROM) incremental cost analysis comparing capital and operating costs for thickened tailings. The values given here for thickened slurry deposition is based on those evaluated incremental costs combined with an adjusted KPL estimate.

Paste thickened tailings are discussed on a relative basis to the other three cases. Additional laboratory test work and engineering detail would be required to define and quantify the costs for paste thickened deposition.

The total Life of Mine (LOM) costs for the three options with no cost escalation are summarized in Table 8-1.

Table 8-1: Cost Summary

	Un-Thickened Option	Thickened Option	Filter/Dry Stack Option
Initial Capital	$87.8 M	$91 M	$354.6 M
Sustaining Capital	$134.9 M	$134.9 M	$86.9 M
OPEX LOM	$122.6 M	$132 M	$430.1 M
Reclamation	$75.6 M	$75.6 M	$46.9 M
Salvage	0	0	$(47.3) M
LOM Tailings Cost	$420.9 M	$434 M	871.2 M

8.1 CAPITAL COSTS

The following table summarizes capital, operating, and reclamation costs associated with three of the options discussed in this report. These capital requirements include water supply considerations.

The cost of fresh water supply system was included in the overall capital costs discussed. Water supply requirements would be reduced relative to the water balance calculations.

Paste thickening is much more difficult to define. At least three paste thickeners would be required. At a minimum 6 pumps would be required. The piping requirements would require smaller bore, but the pipe length requirements much longer than for conventional deposition and return water. The initial capital of the tailings impoundment required may compensate some for the equipment cost, as capital could be deferred as sustaining capital for future tailings for raises.

8.2 OPERATING AND MAINTENANCE COST ESTIMATE

The unit operating cost of the un-thickened case considering labour, reagents, and energy, is estimated as $0.257 USD per tonne of ore processed, while thickened tailings would cost $0.28 per tonne. An analysis of filter plant and dry stack operations gives a unit rate cost for LOM of $0.977 per tonne of ore processed. The incremental operating cost for dry stack tailings may have significant economic impacts on ore reserve estimations which are not addressed in this study.

Energy costs due to make-up water volumes is included, as well as the additional flocculent and operating costs associated with the thickener. Thickened energy costs were estimated to be $3.0 M per year versus $4.5 M for un-thickened tailings discharge.

8.2.1 Labour Schedule

Labour requirements for the un-thickened and thickened option would be expected to be 1 operator per shift. It is assumed that the thickener operations would be covered by existing mill operator labour. An additional 0.5 mechanic/electrical man day for each operator would be required for maintenance activity on the tailings system. (6 total).

Paste operations require multiple remote thickener and pumping stations. It is labour intensive, as additional equipment would require approximately 2 operators per shift, as well as 1 maintenance person per shift for routine system maintenance (12 total).

Table 8-2 represents the labour requirements for operation of a filtration/dry stack tailings disposal for 24 hour continuous operations.

Table 8-2: Incremental Manpower Schedule

Tailings Position	Number Of Personnel
Tailings Filter Operator	8
Stacker Operator	4
Ground man	8
Mill Maintenance	
Plant Maintenance Mechanic/Welder	9
Electrical/Instrument Tech	2
Total Filter Plant	31

8.2.2 Reclamation and Salvage Value

Table 8-1 demonstrates estimated reclamation and salvage value costs. In the case of filtered /dry stack tailings, a high salvage value for recovered process equipment provides a credit which largely offsets the reclamation costs at end of mine life.

8.3 NET PRESENT VALUE

Evaluation of overall project economics considering the time value of money was calculated. Annualized cash flow estimates were analyzed based on various cash flow discount rates as seen in Table 8-3. The economic analysis indicates that the Project NPV (negative NPV = Net Present Cost) is -$204 million for the traditional tailings case (base case) versus -$551 million for the filtered tailings (study case), and -$211 million for the thickened case utilizing a cash discount rate of 8% per annum.

Net Present Cost of paste thickening was not calculated, but basic assumptions would place paste thickening much higher cost than thickened, but below the cost of filtered tailing with dry stack.

Table 8-3: NPV Analysis with Base and Study Case

NPV	Un-Thickened Case	Thickened Case	Filtered Case
NPV (0)	($420.9)M	($434 M)	($871.2)M
NPV (5%)	($256.3)M	($265 M)	($637.0)M
NPV (8%)	($203.6)M	($211 M)	($550.9)M
NPV (10%)	($178.6)M	($185 M)	($506.7)M

9 PROJECT RISK

9.1 PROVEN TECHNOLOGY

Based on industry knowledge and experience, M3 and Norwest believe that un-thickened slurry, thickened and filtered dry stack tailings are all proven technologies for surface tailings disposal. Paste is more commonly used as a backfill material in underground mines and would likely be difficult to develop a facility for large scale surface paste storage. Even at low production rates, mines using surface paste disposal have difficulty achieving design slopes which would create significant operational risk at the Ajax production rates and facility size. The authors of this report are not aware of a surface paste tailings storage facility that has been designed or constructed with similar or higher production rates.

It is also important to consider whether the selected technology is proven at the proposed Ajax production rate of 65,000 tonnes per day. Un-thickened and thickened tailings options are proven at production rates similar to, or greater than, those proposed for the Ajax Project. Conventional thickened tailings deposition is the most common surface storage method currently in use by the mining industry over a wide range of production rates. Filtered dry stack tailings facilities have been designed for production rates similar to those planned for Ajax, but have not currently been constructed or operated; therefore, there are risks associated with this scale-up.

It is believed the technical risks of unit operations involving filtered tailings/dry stack could be minimised through engineering, but there remains a considerable operational risk. At 65,000 tonnes per day, the Ajax Project would be considered the largest tailings filtration plant in the world. There is little operational buffer in the process chain from mill through tailings discharge. Storage tanks, surge tanks, and thickeners would have the capacity to absorb only a few minutes of process upset conditions or conveyor downtime in the downstream filter operations and material handling. Risks of safety mishaps, environmental discharges, mineral recovery loss, and energy consumption all increase in unplanned plant shutdown and restart operating conditions. These issues and risks can be mitigated somewhat through additional storage tanks, stand-by conveying/stacking systems etc. These engineered measures come at significant capital cost.

9.2 REGULATORY CONCERNS

From the perspectives of safety, environmental and social license, it is expected that lower moisture content tailings facilities (resulting in reduced tailings mobility in the event of a breach failure) will be considered more favorably. Taking into consideration the recent failure of the slurry tailings dam at the Mount Polley Mine, it is expected that the un-thickened slurry tailings option will be perceived as the greatest risk to external stakeholders and would require demonstration of a robust design with significant risk mitigation measures in place. The current design for each tailings disposal option already includes a mine rock buttress downstream of the main embankment. This buttress is a key component of the robust design(s) considered in order to reduce the risk of a breach failure occurring. In general, opposition to the project's tailings management plan and TSF is expected to be reduced as one moves up the dewatering continuum from un-thickened, to thickened, and then to filtered dry stack tailings. The uncertainty around paste thickened tailings performance at large scale and high production rates is thought to create additional concerns around this disposal method. Especially since operations at small production rates have difficulty achieving design paste consistency and deposition slopes.

10 ALTERNATIVES ASSESSMENT

The alternatives assessment for BAT is based on information provided in previous sections of this report which includes a combination of high level assessments and industry experience. The goal of this assessment is to identify the tailings technology that represents Best Available Technology for the Ajax project. The assessment is not intended to be a detailed engineering study of each of the tailings technology options and thus it includes qualitative comparisons, where judged appropriate. Once BAT has been selected for Ajax, additional engineering studies will be required to confirm, refine and optimize the layout and information presented in this study.

Topics considered were separated into four (4) categories (as presented in Section 6 through 9):

- Technical Aspects (Section 6)
- Environmental / Social (including Aboriginal concerns; Section 7)
- Economic (Section 8)
- Project Risk (Section 9)

These areas have been selected in order to help organize the discussion. They are not intended to be definitive and it should be noted that overlap between the areas exists. A summary of the evaluation and assessment of each tailings technology with regards to the categories listed is presented below in Table 10-1.

Table 10-1: Tailings Technology Comparative Assessment

AREA:	TECHNICAL		ENVIRONMENTAL/SOCIAL								ECONOMIC		PROJECT RISK	
Tailings Disposal Method [2]	Dewatering of Tailings [3]	Tailings Deposition [4]	Process Make-Up Water (m^3/hour)	Disturbed Surface Area (ha)		Risk of Breach Failure [5]	Dust Potential	Seepage	Visual Impact [6, 9]	Reclamation	CAPEX	OPEX	Proven Technology at 65,000 tonnes/day	Regulatory Concern
				Total	Tailings Surface Area									
Conventional Un-thickened (32% solids) Un-buttressed Facility	Most Favorable	Most Favorable	1.087	700	589 (326 beach, 263 pond)	Least Favorable	Less Favorable	Least Favorable	More Favorable (1,060m)	Less Favorable	$223 M	$123 M	Most Favorable	Less Favorable
Conventional Un-thickened (32% solids) Buttressed Facility [7]	Most Favorable	Most Favorable	1.087	700	589 (326 beach, 263 pond)	Less Favorable	Less Favorable	Least Favorable	More Favorable (1,060m)	Less Favorable	$223 M	$123 M	Most Favorable	Less Favorable
Thickened (60% solids) Buttressed Facility [7]	More Favorable	More Favorable	764	690	550 (450 beach, 100 pond)	More Favorable	More Favorable	Less Favorable	Most Favorable (1,056m)	More Favorable	$226 M [8]	$132 M [8]	Most Favorable	More Favorable
Paste (75% solids) Buttressed Facility [7]	Less Favorable	Less Favorable	730	603	461 (411 beach, 50 pond)	More Favorable	Most Favorable	More Favorable	Least Favorable (1,095m)	Least Favorable	Expected to be higher than thickened	Expected to be higher than thickened	Least Favorable	Least Favorable
Dry Stack (85% solids) Buttressed Facility [7]	Least Favorable	Least Favorable	400	429	362	Most Favorable	Least Favorable	Most Favorable	Least Favorable (1,055)	Most Favorable	$442 M	$430 M	Least Favorable	Most Favorable

Notes:

1. Qualitative ranking in order of preferred option is: 🟩 Most Favorable -> ⬜ More Favorable -> 🟨 Less Favorable -> 🟥 Least Favorable
2. Percent solids is by weight.
3. Relates to amount of dewatering required and potential issues that could occur during process.
4. Relates to the ability and level of effort required to achieve design configuration (i.e., design slope for thickened or paste options).
5. Downstream consequence related to mobility of the tailings flow if containment is lost.
6. Visual impact includes the height of the facility and also the amount of lighting required during night operations that would be visible at distance.
7. Assumes mine rock used for buttress and is primarily a mining cost.
8. Thickened costs are based on a rough order estimate relative to the conventional un-thickened tailings option.
9. Maximum elevation of embankment crest (un-thickened and thickened) or tailings material (paste and dry stack) included in brackets.

Results of the assessment are as follows:

- **Un-thickened Slurry Tailings (32% solids; un-buttressed)** – Not considered BAT for Ajax. This option was originally developed as the project's base case and has been included for comparison purposes only. The intent for whichever option selected was to include the buttressing as it provides both improved stability and is a good location for mine rock storage at the project site. The un-buttressed, un-thickened slurry tailings option is not recommended.
- **Un-thickened Slurry Tailings (32% solids; with buttress)** – Not considered for BAT for Ajax. This option was originally considered as the base case for the project in the feasibility study. This option is considered as the second recommendation option. Tailings storage using un-thickened slurry has the highest water requirements and contains the tailings mass with the highest mobility. Mitigation of the breach risk is included in the design as embankment buttressing using mine rock. It should be noted that make-up water is not a limiting factor at this project site but that reduced fresh water usage is an environmental benefit (and also reduces pumping costs). The advantages of un-thickened slurry tailings versus the other options are that it has a lower level of operational complexity and risk, and may provide the lowest cost option for start-up and operations.
- **Thickened Slurry Tailings (60% solids; with buttress)** – BAT for Ajax Project. The assessment presented in this study has resulted in this option being recommended as best available technology for Ajax project. The advantages and disadvantages included in this decision are discussed in detail in Section 11.
- **Paste Thickened Tailings (70% solids; with buttress)** – Not considered BAT for Ajax. This option is unproven at high production rates, presents significant challenges in meeting consistent product/deposit specifications and has high costs for high density thickeners and positive displacement pump systems.
- **Filtered Dry Stack Tailings (85% solids; with buttress)** – Not considered BAT for Ajax. Filtered tailings disposal was singled out for recommendation as one of the BAT options that should be considered by Mount Polley review report. Filtered tailings were evaluated for the Ajax Project in this report and in an internal study. The following conclusions may be drawn with respect to filtered tailings as a technology for the Ajax site:
  - Continuously producing filtered tailings at the design specification moisture content is challenging but limited volumes of off-specification material can be managed.
  - The technology is proven but has not been implemented at the proposed production rates therefore there is a significant operational risk factor.
  - It is expected that scaling up to these production rates is achievable but would likely result is significant operational and cost implications.

Although cost alone is not meant to be the deciding factor, discussions with KGHM personnel have identified the cost for filtered dry stack tailings to be prohibitive within the overall project economics. As such, the cost of this option is considered a Fatal Flaw.

11 RECOMMENDED BAT FOR AJAX PROJECT

Thickened Slurry Tailings (60% solids) – this is the preferred option based on the balance obtained through the technical, environmental/social, economic and project risks summarized in Table 10-1. Storage of thickened tailings has increased environmental and perceived social implications compared to filtered tailings but is preferable versus un-thickened slurry tailings storage. The use of containment dykes would still be required for this option but a lower volume of stored water is required. Construction of the mine rock buttress on the downstream side of the main embankment will reduce the risk of a breach failure. The detailed phasing of the integrated design will ensure this buttress is constructed at each stage of TSF development. Benefits of thickened tailings include;

a. Requires less make-up water resulting in a smaller volume of water stored in an impoundment, less fresh water taken from Kamloops Lake and lower pumping costs.

b. Lower risk of breach failure than un-thickened tailings, this risk includes both the consequence and probability of breach failure. Thickened tailings has a lower consequence than un-thickened tailings as the lower water content results in reduced mobility of the tailings mass. The significantly smaller supernatant pond means there is also less water available to transport tailings material. The probability of a breach failure is reduced for each tailings disposal option, including thickened tailings, due to the inclusion of the mine rock buttressing in the design.

c. Less impounded water and higher initial placement density reduces seepage.

d. Improved air quality over un-thickened or filtered options. Thickened tailings tend to be non-segregating due to the addition of flocculent during the thickening process. This flocculent binds the fine particles to coarser particles which results in less fine particulate at surface available for transport as dust.

e. Lower visual impact as limited lighting is required for nighttime operation of the facility (versus filtered dry stack tailings).

f. Reduced challenges and costs associated with placement of a final dry cover (versus un-thickened) due to the higher initial solids content and lower segregation potential.

g. Proven technology both in general and at high production rates similar to the 65,000 tonnes per day proposed for Ajax.

Closing Statement

The Mount Polley report recommended projects review potential options for tailings treatment and management as part of the project evaluation process with the goal of selecting the best available technology for each site. The committee identified filtered tailings as a prime candidate to be considered but a range of technologies were to be included. Previous studies using un-thickened tailings had been completed for the project and these formed the basis for comparison to other technologies. The British Columbia Environmental Assessment Office (BCEAO) issued a subsequent letter to the Panel finding on March 19, 2015 emphasizing that site specific considerations are key in identifying BAT for each project. The evaluation completed in this study has identified thickened tailings, with mine rock buttressing, as site specific BAT for the Ajax Project.

12 REFERENCES

AMEC Earth & Environmental, Inc., Rosemont Copper Company Filtered Tailings Dry Stacks Current State of Practice Final Report. Paper prepared for Rosemont Copper Company, November, 2008

Bhide, Alysha. Laboratory Test Report for Ajax Sedimentation, Rheology, and Filtration on Copper Concentrate and Bulk Tailings. October, 2014.

Brackelbusch, F and Shilllabeer J, Use of Paste for Tailings Disposal. Minefill '98 conference, April 1998.

Canadian Dam Association Guidelines (2007).

Davies, Lupo, et all, Tailings and Mine Waste'10, Dewatered Tailings Practice – Trends and Observations, CRC Press, 2010.

Engels, Jon (2014). Information taken from www.tailings.info. (April 2015).

Environment Australia (1998). Best Practice Environmental Management in Mining – Dust Control. Department of Environment.

Graber, G, Osterloh, A, and Schmalze, M., Large Scale Stacking system at the Freeport- McMoran Mine.

Hore & Luppnow, Karara Iron Ore TSF – Design Considerations for a Unique Large Scale Dry Stack Facility. Tailings and Mine Waste 14 Conference n Keystone Colorado, October, 2014.

Hynes-Griffen, M. E. and Franklin, A. G. (1984). Rationalizing the Seismic Coefficient Method. Paper prepared by the US Army Corps of Engineers (July).

Independent Expert Engineering Investigation and Review Panel (2015). Report on Mount Polley Tailings Storage Facility Breach. Report prepared for Province of British Columbia (January 30).

Ignace, M. (2014). SSN Cultural Heritage Study. Prepared for Stk'emlupsemc te Secwépemc by Marianne Ignace, D. Marshall, M. Anderson, and C. Nord.

Knight Piésold Ltd. (2013). Ajax Project – Tailings Management, High-Level Tailings Alternatives Assessment. Reference VA101-246/15. Draft letter report prepared for KGHM International (April 19).

Knight Piésold Ltd. (2014-1). Preliminary Water Management Plan. Reference VA101-246/26-3. Draft report prepared for KGHM Ajax Mining Inc. (October 20).

Knight Piésold Ltd. (2014-2). Tailings Storage Facility & Water Management Preliminary Design Report. Reference VA101-246/26-1. Draft report prepared for KGHM Ajax Mining Inc. (December 11).

Knight Piésold Ltd. (2015-1). Preliminary Geotechnical Report – Tailings Storage and Mine Rock Storage Facilities. Reference VA101-246/26-11. Draft report prepared for KGHM Ajax Mining Inc. (February 27).

Knight Piésold Ltd. (2015-2). Report on Laboratory Geotechnical Testing of Tailings Materials and Tailings Consolidation Modelling. Reference VA101-246/26-13. Draft report prepared for KGHM Ajax Mining Inc. (May 15).

Norwest Corporation (2014). Life of Mine Cost Estimate Review – Tailings and Water Management Structures. Draft report prepared for KGHM Ajax Mining Inc. (December 10).

Robertson, P.K. (2012). Evaluating flow (static) liquefaction using CPT: an update. From Proceedings Tailings and Mine Waste 2012.

Robinsky, E.I. (1999). Thickened Tailings Disposal in the Mining Industry. Published by E.I. Robinsky Associates Ltd. Toronto, Canada.

13 CLOSURE

This report has been prepared for KGHM Ajax Mining Inc. to provide a recommendation for Best Available Technology for tailings disposal at the Ajax Project, located near Kamloops, British Columbia. This document represents the opinion of M3 Engineering & Technology Corp. and Norwest Corporation based on information provided by KGHM Ajax Mining Inc. along with industry experience. The assessment is not intended to be a detailed engineering study of each of the tailings technology options and thus it includes qualitative comparisons where appropriate. As mutual protection to KGHM Ajax Mining Inc., the public, M3 Engineering & Technology Corp and Norwest Corporation, this report is 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 described in the report. Our report and recommendations should not be reproduced in whole or in part without our express written permission.

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