Memorandum

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Date:	July 10, 2015
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Subject:	Water Balance and Water Quality Modelling related to the Jay Project- Revised July 2015

1. INTRODUCTION

The development of Jay Project will extend the life of the Ekati Diamond Mine. Fine Processed Kimberlite (FPK) produced during the mining of the Jay Pipe is planned to be discharged into the exhausted Panda and Koala open pits and underground workings. This has the potential to impact water quality in the Long Lake Containment Facility (LLCF) and downstream lakes by:

- Extending the lifetime of mining operations at the Ekati Diamond Mine.
- Requiring reclaim water to be pumped from the LLCF while Panda and Koala pit lakes are being filled with FPK.
- Discharging excess supernatant water from Panda and Koala pit lakes into Cell D of the LLCF.

To assess the effect of development of the Jay Project on water quality in the LLCF and lakes downstream of the LLCF (to Slipper Lake) an update to existing water balance and water quality models of the LLCF and downstream lakes and Panda and Koala pit lakes (Rescan 2012 and 2013) was completed. The model update therefore included the infilling of Panda and Koala pits with FPK from the Jay Pipe.

The Jay Project is modelled to 2030 (10 years).

2. MODELLING APPROACH

A water balance and water quality model of the LLCF and the chain of lakes lying between the LLCF and Lac de Gras has been developed, tested and used for predicting future water quality at the Ekati Diamond Mine. Full details of the model are provided in Rescan (2012). Ongoing (unpublished) modelling work considers the evolution of water quality in the LLCF and downstream during the closure period when discharge of mine water to the LLCF ceases.

Models that consider the infilling of exhausted pits at the Ekati Diamond Mine during closure have also been developed (Rescan 2013). The modelling work undertaken in Rescan (2013) included mass balance modelling approaches and more complex multi-layer models representing the formation of stratification in the infilling pit lakes at closure.

The model developed to incorporate the Jay Project builds on the work undertaken in Rescan (2012) and Rescan (2013) and links a mass balance model of Panda and Koala pits to the water balance and water quality model of the LLCF and downstream lakes. In this way predictions of the timing of infilling and water quality in Panda and Koala pits can be made, linking the impact of discharging FPK to Panda and Koala pits to predictions of water quality and water quantity in the LLCF.

The model does not consider detailed multi-layered modelling of Panda or Koala pit lakes. During infilling of the pits with FPK, layering is not expected to form because the deposition of FPK solids would be expected to breakdown any stratification forming in free water above the solids. This is an assumption based on calculations of energy imparted by water entering pit lakes (Rescan 2013).

3. MODEL SET-UP AND ASSUMPTIONS

3.1 Overview and Timescales

The model considers FPK slurry produced during the mining of the Jay Project discharged into Panda and Koala pits and underground workings. The general timescale to be considered is summarized in Table 3.1-1. The model assumes that solids will be discharged equally (50:50) into each of the Koala and Panda pits. Operational plans for sequencing of FPK placement into the pits and underground workings would be finalized in future.

Table 3.1-1. Development Time Scale to be Considered in the Koala Watershed Model

Dates	Description of Model Inputs
To end 2019	Modelled in Rescan (2012). This includes accounting for future development of Pigeon Pit and the infilling of Beartooth Pit with FPK and underground water.
Begin 2020	No Process Plant Discharge (PPD) or FPK slurry to the LLCF; instead PPD and FPK to Panda and Koala pits. Reclaim water to be drawn from LLCF.
2030	End of discharge of PPD to Panda and Koala pits.
Once Panda and Koala pit reaches operating level	Reclaim water drawn from Panda and Koala pit lakes. Excess water to LLCF (possible depending on actual water levels experienced).
2030	End of operations.
2030 - 2130	Closure Period.

The modelling work focusses on the operational period at the Ekati Diamond Mine, i.e., until 2030 with development of the Jay Pipe; however, the model runs were continued for up to

100 years after the end of operations to provide input into a larger scale modelling study of Lac de Gras.

The water balance and water quality model for the LLCF and downstream lakes contains components that simulate:

- Mine water outflows to LLCF during operations including FPK supernatant, underground water and sump water;
- LLCF, including sub-models of Cells C, D and E;
- Lakes lying between LLCF and Lac de Gras;
- Infilling of Beartooth Pit with mine water and FPK; and
- Pit lake inflows during closure.

Details of the model inputs and modelling approaches of this complex model are described in detail in Rescan (2012). An overview of closure modelling for the LLCF is provided in Section 3.6.

The Panda and Koala pits will be filled through a combination of the following:

- FPK solids and supernatant;
- Natural runoff entering the pits from adjacent watershed areas;
- Groundwater inflows; and
- Precipitation on pit lake surface as the pit lakes fill.

Key losses from the pits will be:

- Water pumped from the pit lake for reclaim or to LLCF to create additional storage for solids; and
- Evaporation from pit lake surface.

Modelling of the infilling of Panda and Koala pits with water (i.e., the current closure plan for the Panda and Koala pits) are described in Rescan (2013). Details of model inputs related to Panda and Koala pits are presented in Sections 3.2 to 3.7.

Flows from the LLCF model to the Panda and Koala pits models are generally one way, i.e., from the LLCF to the open pits. In addition, FPK (solids and supernatant water) will not be allowed to spill from the pit lake. An appropriate freeboard between the FPK water level and spill level will be calculated based on the volume of surface water runoff able to enter the pit lake during an extreme rainfall event. If the water level approaches the freeboard to the spill level, water will be pumped to the LLCF or to the Process Plant in lieu of reclaim water from the LLCF.

3.2 Key Physical Data for Panda and Koala Pits

Open pit mining at Panda and Koala pits began in 1999, and was completed in 2003 at Panda Pit and in 2005 in Koala Pit. Underground mining was completed in Panda Underground between 2005 and 2010 and mining was initiated in Koala Underground in 2004 and is ongoing. The general relationships between the open pit and underground workings at Panda and Koala are provided in Figure 3.2-1. The underground workings are linked at depth through tunnels created to allow access to underground operations.

Pit volume/level and surface area/level curves were developed for Panda and Koala/Koala North pits based on analysis of available GIS data for the open pits. These curves were extrapolated to depth into the underground workings based on estimated final depths of the workings and underground volumes. General physical details for Panda and Koala pits and underground workings are provided in Table 3.2-1, with the storage/elevation curves summarized in Table 3.2-2.

Table 3.2-1. Key Physical Data for Panda and Koala/Koala North Pit Lakes

Pit	Max Expected Diameter (m)	Max Open Pit Surface Area (m^2)	Expected Volume Open Pit to Spill Point (m^3)
Koala/Koala North			
Koala Pit	700	380,000	38,900,000 [a]
Koala Underground	-	-	5,300,000
Koala North	270	50,000	1,450,000
Koala North Underground	-	-	650,000
Panda			
Panda Pit	650	328,000	39,310,000 [a]
Panda Underground	-	-	1,800,000

[a] *Total volume including underground workings.*

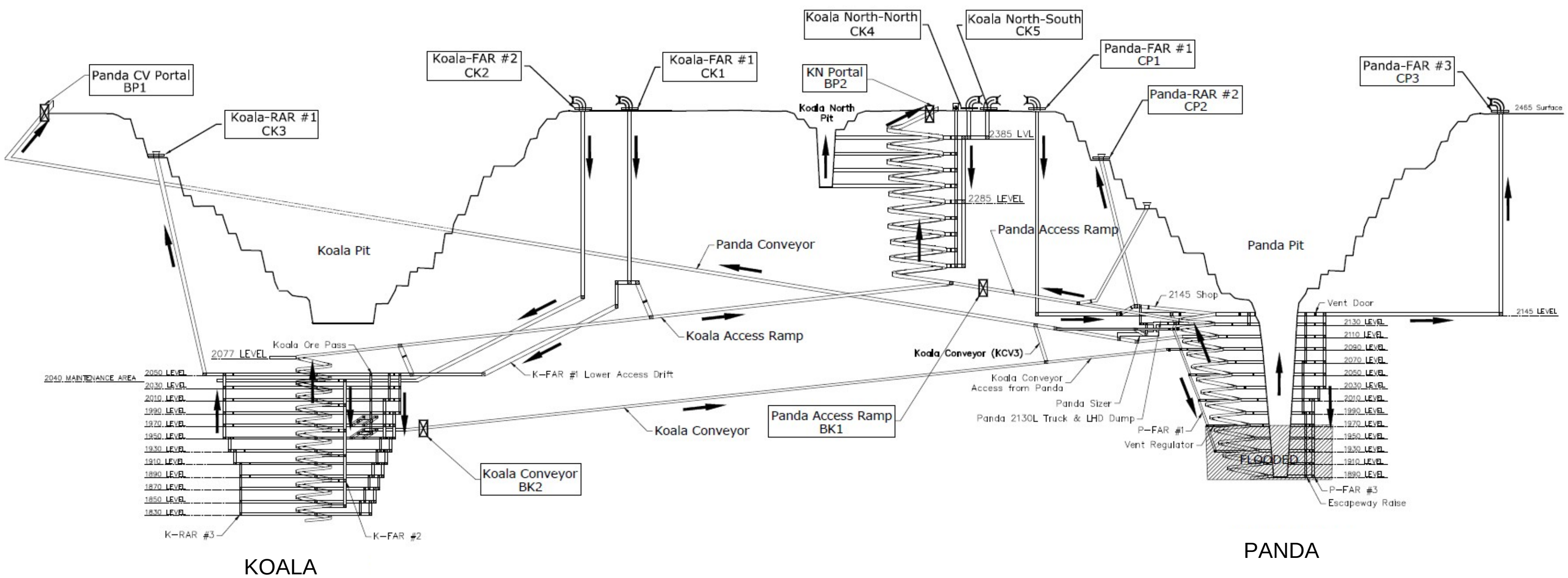


Figure 3.2-1. Schematic of Layout of Panda and Koala pits and Underground Workings

Table 3.2-2. Storage/Elevation/Area Curves for Panda and Koala Pit Lakes

Panda			Koala		
Elevation (masl)	Pit Lake Area (m²)	Volume (m³)	Elevation (masl)	Pit Lake Area (m²)	Volume (m³)
170	12,873	1,880,565 [a]			
180	16,502	2,023,567			
190	20,577	2,209,280			
200	26,933	2,445,914			
210	33,975	2,739,625	210	2,248	5,302,514 [b]
220	37,776	3,100,566	220	8,351	5,365,461
230	41,235	3,495,322	230	16,311	5,488,346
240	52,988	3,939,300	240	30,263	5,694,607
250	64,164	4,530,309	250	38,084	6,048,163
260	69,707	5,200,127	260	43,748	6,458,169
270	79,350	5,928,555	270	54,680	6,928,563
280	91,203	6,800,717	280	60,353	7,512,212
290	96,523	7,737,811	290	64,271	8,134,665
300	112,926	8,747,894	300	75,923	8,816,837
310	121,314	9,929,216	310	90,277	9,667,554
320	127,445	11,170,037	320	102,905	10,630,999
330	143,927	12,487,504	330	120,535	11,727,547
340	152,559	13,985,134	340	132,399	13,008,401
350	159,611	15,542,629	350	140,090	14,371,053
360	178,075	17,185,014	360	153,797	15,819,321
370	190,757	19,057,348	370	165,370	17,433,868
380	199,250	21,003,937	380	174,175	19,128,216
390	217,653	23,047,972	390	189,491	20,916,527
400	228,306	25,289,925	400	205,750	22,931,860
410	239,910	27,625,569	410	230,160	25,096,785
420	260,155	30,085,421	420	258,331	27,529,084
430	278,037	32,800,923	430	289,882	30,313,235
440	294,070	35,653,092	440	331,024	33,401,920
450	316,763	38,695,581	450	432,525	36,936,886
459	345,268	41,671,243	454	522,378	38,859,102

masl- meters above sea level.
[a] Includes 1,800,000 m³ for underground workings below this level.
[b] Includes 5,300,000 m³ for underground workings below this level.

The current Interim Closure Research Plan (ICRP) for Koala and Panda pits envisages that the pits and underground operations will be flooded to produce a pit lake (BHP Billiton 2011). Because of the connections between underground workings in Panda and Koala pits the water levels within Panda and Koala pit lakes would be expected to be the same during infilling and post-filling with a hydrostatic balance between the pit lakes maintained by the open tunnels. However, if the tunnels are filled with FPK, it is unclear whether a hydraulic connection will continue to exist between the pit lakes. The model assumes there is a connection.

The natural catchment areas providing runoff into Panda and Koala pits are shown in Figure 3.2-2, with information summarized in Table 3.2-3. Each pit is surrounded by land that slopes towards the pit lakes, including a Waste Rock Storage Areas (WRSA).

Table 3.2-3. Hydrological Connections for Panda and Koala/Koala North Pit Lakes

Pit	Inflowing Watershed Area, during operations (m^2)	Inflowing Pit	Outflows to	Full Pit Lake Spill Elevation (masl)
Panda				
Pit Area	328,000	None	Koala/Koala North pit	453.4
Natural Catchment Area	471,000			
WRSA	220,000			
Koala/Koala North				
Pit Area	508,000	Panda pit	Kodiak Lake	453.4
Natural Catchment Area	943,000			
WRSA	660,000			

masl- meters above sea level

3.3 FPK Solids and Slurry

Based on operational experience at the Ekati Mine, the model assumes that the FPK slurry is around 17% solids by volume. Based on drilling investigation data completed by EBA in 2006 an average dry density value of 1.35 t/m^3 for consolidated LLCF tailings can be obtained (EBA 2007). Using the average dry density and an average kimberlite solids density of 2.72 t/m3 a consolidated tailings solids by volume of around 50% was calculated. An estimate of 6.0 Mm^3 of FPK sent to Koala and Panda pits annually, was used based on previous experience. The model also assumed that the annual average reclaim volume is 4.6 Mm^3/year, based on observed data. The model assumes that reclaim is pumped from the LLCF.

It is assumed that discharges to Koala and Panda pits will begin in 2020 and will continue until the end of the Jay Project in 2030.

It is assumed that other mine water (sump and sewage) that does not pass through the Process Plant will continue to be discharged into the LLCF.

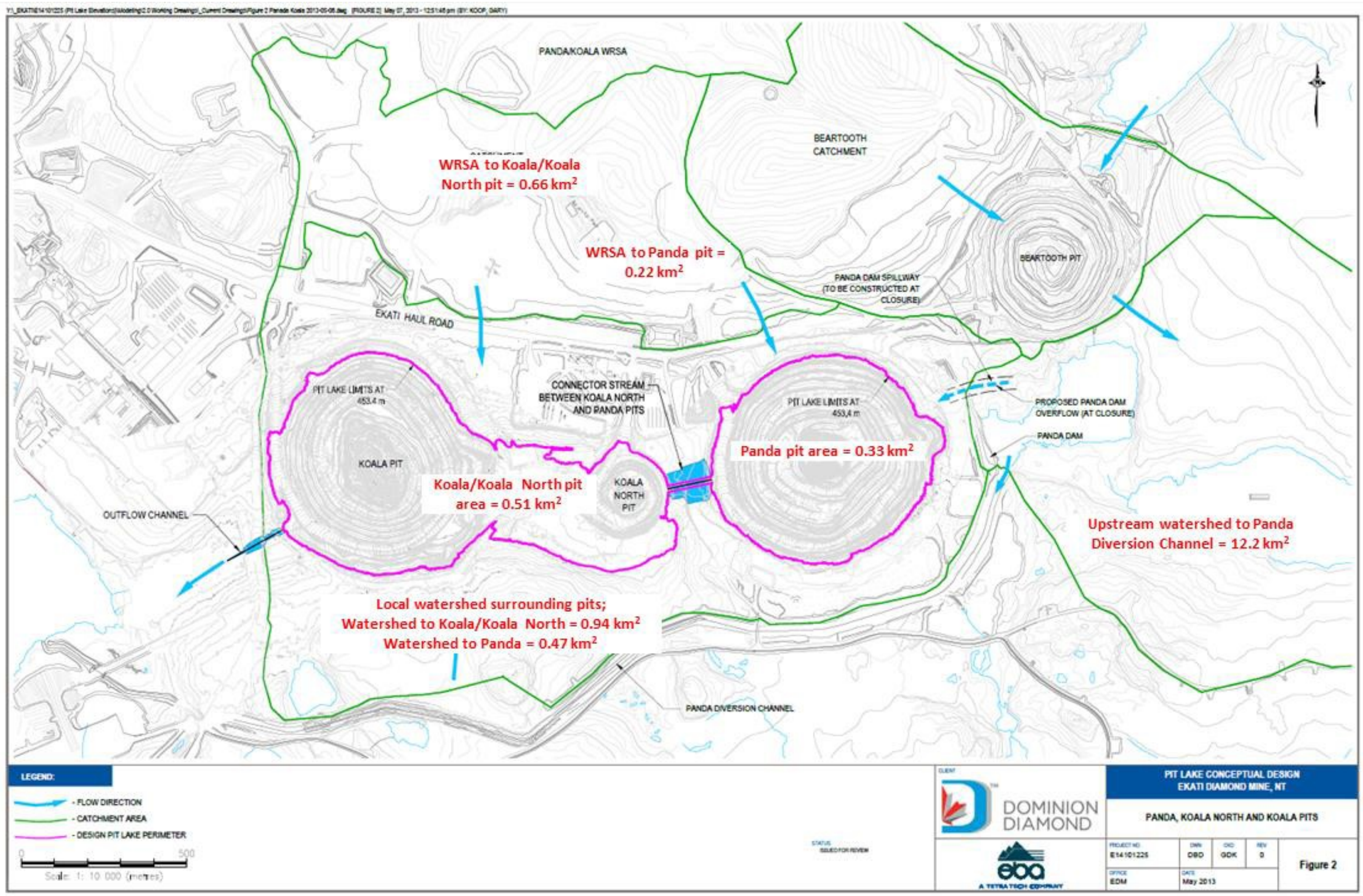


Figure 3.2-2. Catchments flowing into Panda and Koala/Koala North pits

3.4 Natural Inflows to Pit Lakes

3.4.1 Hydrological and Meteorological Data

Hydrological and meteorological parameters used in the model were based on observations at the Ekati Diamond Mine obtained as part of the Aquatic Effects Monitoring Program (AEMP) and the Air Quality Monitoring Program. The values presented below are based on a review of data up to 2009 and the values have been used in a number of recent modelling studies, including Rescan (2012 and 2013).

Return period precipitation estimates for the Ekati Diamond Mine site are summarized in Table 3.4-1.

Table 3.4-1. Ekati Diamond Mine Return Period Precipitation Estimates

Return Period	[a]Annual Precipitation (mm)
1 in 100 dry year	234
1 in 50 dry year	242
1 in 20 dry year	256
1 in 10 dry year	270
Average year	338
1 in 10 wet year	451
1 in 20 wet year	495
1 in 50 wet year	554
1 in 100 wet year	598

[a] Return period analysis was undertaken based on on-site Koala Meteorological Station data supplemented by Environment Canada Lupin data. For the period 1994 to 2009 data from Koala Meteorological Station were used. For the period 1982 to 1994 Lupin data were used scaled by the average ratio of Koala and Lupin annual precipitation totals for the period of overlapping data (1994 to 2005). This gives a combined dataset of 28 years.

Annual flow rates for watersheds within the study area are calculated using Equation (1) below:

$$\text{(1) Total Annual Flow } (m^3/year) =$$
$$\text{Total Annual Precipitation } (m/year) \times \text{Runoff Coefficient} \times \text{Watershed Area } (m^2)$$

Equation (1) is applicable for all types of watersheds (e.g., natural, disturbed by mining activities, pit walls) with the value of the runoff coefficient varying for each watershed type, as per Table 3.4-2.

Monthly inflows are modelled as in Equation (2) below.

$$\textit{(2) Average Monthly Inflow } (m^3/month) = \textit{Total Annual Flow Volume } (m^3) \times \textit{Proportion of Annual Flow Occurring in Month } (/month)$$

Annual net inflows due to precipitation on, and evaporation from, the surface of a pit lake are based on Equation (3) below:

$$\textit{(3) Annual Net Flow to Lake Surface } (m^3/year) = (\textit{Total Annual Precipitation } (m/year) - \textit{Total Annual Evaporation } (m/year)) \times \textit{Lake Area } (m^2)$$

Table 3.4-2. Runoff Coefficients for Different Watersheds/Source Areas

Input	Runoff Coefficient	Comment
Natural catchments	0.5	Value based on average of all observed stream flow data.
Disturbed catchments	0.5	Insufficient data to allow different value for disturbed versus natural watersheds.
Runoff on pit walls	0.85	Tested/calibrated against observed sump flow data (Rescan 2013).
Waste Rock Storage Area (WRSA)	0.2	Tested/calibrated against observed runoff rates from Misery WRSA.
Precipitation on lake surface	1	Losses from lakes due to evaporation are accounted separately.

Constant runoff coefficients are used within the models for all years.

Monthly precipitation and evaporation totals modelled as Equation (4) below.

$$\textit{(4) Average Monthly Inflow/Outflow } (m^3/mon) = [(\textit{Total Annual Precipitation } (m) \times \textit{Proportion of Effective Precipitation Occurring in Month } (/month)) - (\textit{Total Annual Evaporation } (m) \times \textit{Proportion Evaporation Occurring in Month } (/month)] \times \textit{Lake Area } (m^2)$$

The monthly distribution of the annual totals is provided in Table 3.4-3. An "effective" precipitation monthly distribution is also provided in Table 3.4-3, which reflects the impact of snowmelt and rainfall on the lake surface. All precipitation falling in the winter months is assumed to be snow, and snow melts during May and June. Thus, the winter monthly percentages equal zero (i.e., precipitation is stored as snow) and the high monthly percentages in May and June reflect snowmelt.

Table 3.4-3. Estimates of Ekati Monthly Precipitation, Runoff and Evaporation

Variable	Percentage by Month (%)						
	May	Jun	Jul	Aug	Sep	Oct	Total
Effective Precipitation[1]	5	55	9	21	6	4	100
Runoff[2]	7	53	23	8	8	1	100
Evaporation[3]	0	40	30	22	7	1	100

[1] *Based on Ekati data from 2004 to 2009, assuming that precipitation in winter is retained as snow and melts during freshet.*
[2] *Based on the Ekati Diamond Mine stream flow data from 1994 to 2009.*
[3] *Based on observed the Ekati Diamond Mine data from 2004 to 2007.*

3.4.2 *Groundwater*

Most of the Ekati Diamond Mine area is underlain by permafrost, which can extend to around 300 to 500 m depth. Typically pits that do not extend below the permafrost zone experience no groundwater inflows. However, Panda and Koala pits, extend to a depth that groundwater inflows can occur. Underground workings extend below the permafrost and receive groundwater inflows.

Between 2004 and 2012 observed annual average flow rates from the Panda and Koala underground ranged between 9.6 L/s to 17.8 L/s, with an average of 13.7 L/s over these years (Rescan 2012). The groundwater inflow rate to Panda and Koala pits is based on the average of the observed data.

The groundwater flow rates described above are for an open pit and underground workings that are not filled with FPK or water. The model assumes that groundwater inflows tend to zero (linearly from the maximum rate to zero) as the pits fills.

The assumption above does not consider the impact of FPK solids filling the underground workings and the base of the pit. The FPK solids may 'seal' the bottom of the pit lake to some extent, limiting or preventing groundwater inflows once the FPK solids have filled to a certain depth in the pit lake. Hence, actual groundwater inflow rates may decrease to zero more quickly than considered in the model.

3.5 Water Quality Inputs for Panda and Koala Pits

The sources of key water quality inputs to Panda and Koala pit lakes as they fill are summarized in Table 3.5-1.

The model assumes that most water quality variables are conservative and do not decay or react over time. The exceptions to this assumption are nutrients (ammonia, nitrate, nitrite and phosphate) that are modelled using a first order decay function to account for losses as these water quality variables are cycled by organisms (i.e., taken up by living plankton and released by decaying plankton) in natural water bodies or volatilized at the lake surface (i.e., ammonia) (Table 3.5-2). The decay rates for these nutrients were calibrated in Rescan (2012) and the calibrated values are used in the current model.

During infilling the water quality model assumes that free water sitting above the FPK will be fully mixed. This is considered a reasonable assumption given the energy imparted by the inflowing FPK slurry.

Table 3.5-1. Natural Inflows and Outflows to Panda and Koala Pits

Water Quality Input	Source
Natural Runoff	AEMP water quality sampling program. Values are constant over time.
Quality of rainfall falling on pit walls	Pit wall runoff predictions in Rescan (2012). Values are constant over time Although water quality is constant over time, the area of pit wall exposed will vary over time as the pit lake fills.
Underground Water	Based on analysis of underground water data from recent samples obtained for discharge stream to Beartooth pit (i.e., prior to FPK discharge). Values are constant over time.
FPK Supernatant Water	Based on methods used for LLCF water quality modelling work and summarized in Rescan (2012). For this work historical Process Plant Discharge water quality data were analyzed and statistical distributions were developed for each water quality variable. In the model inputs for each month are varied stochastically by selecting values from the statistical distributions.
Leaching from FPK solids	The model assumes that FPK solids are submerged, and therefore no reactions within pore water of submerged FPK.

Table 3.5-2. Calibrated Decay Rates for Non-conservative Water Quality Variables

Variable	Calibrated Half-life for Water Quality Variable[1]
Phosphate	11.1 months
Nitrate	No decay
Nitrite	8.3 months
Ammonia	4.2 months

[1]*First Order decay equation: Concentration at Time t = Initial Concentration x* $(0.5)^{t/\text{half-life}}$

The water quality variables modelled in the current model, incorporating the Jay Project, included a similar suite of water quality variables considered in Rescan (2012) and Rescan (2013):

- Aluminum
- Ammonia-N
- Antimony
- Arsenic
- Barium
- Boron
- Cadmium
- Calcium
- Chloride
- Chromium
- Copper
- Iron

- Lead
- Manganese
- Magnesium
- Molybdenum
- Nickel
- Nitrate-N
- Nitrite-N
- Phosphate-P
- Potassium
- Selenium
- Strontium
- Sodium
- Sulphate
- Total Dissolved Solids (TDS)
- Uranium
- Vanadium
- Zinc

The selected water quality variables are those that have Water Quality Benchmarks (i.e., a concentration above which risk of adverse effects may become elevated) and those required for the calculation of density and salinity within the pit lakes (e.g., TDS). All water quality variables are considered in the LLCF and downstream lakes model, however nitrite-N and uranium are not considered in the Panda and Koala model as there are no predictions for these variables for key inputs (e.g., pit wall runoff) as outlined in Rescan (2013).

3.6 Closure Modelling for Panda and Koala Pits and the LLCF

It is assumed that excess supernatant water in Panda and Koala pits is pumped to the LLCF, lowering water levels in the pit lakes to a level 30 m below the spill level. This may be undertaken as an operations activity prior to closure, but is conservatively as taking place after closure in the current model (i.e., beginning 2030). The pits are then refilled through pumping of clean lake water to the pit, to provide a 30 m thick freshwater cap above the remaining supernatant and solids. This is consistent with the closure approach for exhausted pits in the ICRP. It is assumed that water is discharged at 0.2 m^3/s into each of Panda and Koala pit lakes for 5 months a year (June to October), equivalent to 2.6 $Mm^3/year$ into each pit. Calculations indicate the two pits are infilled around 4 years after the beginning of pumping.

At mine closure discharge of mine solids and mine water will cease. At this time (and prior to closure) exposed FPK beaches in the LLCF will be reclaimed with rock coverings (non- or low-reactivity rock) and vegetation. During closure, spillways will be created in the dykes between Cells C and D, between Cells D and E and in the ice-core dam at the downstream end of Cell E. As a result, there will be a free through-flow of water within the LLCF, with no control of discharges from the facility. The hydrology of the LLCF will return close to natural pre-development conditions. With no additional discharge of mine waters to the LLCF during closure water quality in the facility will be expected to improve through dilution with natural runoff and precipitation.

3.7 Summary of inputs

A summary of key model inputs is provided in Table 3.7-1 for the model.

Table 3.7-1. Summary of Key Model Inputs and Assumptions

Model Parameter	Methodology
WATER BALANCE	
Surface Water Inflows	Average annual precipitation and evaporation in every year, divided into monthly totals based on Table 3.4-3. Catchment areas and runoff coefficients as per Tables 3.2-3 and 3.4-2.
Groundwater to Panda and Koala pits	Model inputs are based on average of recorded pumped flow data from Panda and Koala underground workings 14 L/s. Model assumes groundwater inflow rate tends to zero as pit lakes fill, i.e., the FPK does not seal groundwater inflows.
Storage in Panda and Koala pits	Pit lakes fill over time according to water balance and storage/elevation curve for each pit lake.
Full water level	453.4 m
Subsurface Connections between Pit Lakes	Hydraulic connectivity assumed, so water levels in pit lakes will be the same as they fill. Water transfers will take place between pit lakes to maintain same water level.
Other Mine Water	Sump and sewage produced within the mine site assumed to be discharged to LLCF.
Annual Reclaim Volume	4.6 Mm^3/year, taken from LLCF Cell D until water level in Panda and Koala pits reaches spill level minus freeboard.
LLCF inflows	Consistent with assumptions in Rescan (2012)
Flows from LLCF to downstream lakes	During operations outflows are assumed to be pumped from Cell E to Leslie Lake with monthly distribution consistent with that during operations. At closure assumed that spillway is placed in ice-core dam and there is free flow from LLCF to Leslie Lake.
Inputs to pits during closure	Once FPK ceases to be pumped to pits, water levels in the pits will be lowered to a level 30 m below the spill level. The pits will then be filled through pumping of fresh water from donor lakes as per ICRP
SOLIDS BALANCE	
Water Content of FPK	On discharge FPK is 16.9% solids by volume. On consolidation FPK is 50% solids by volume.
Split between Panda and Koala	Assumed to be 50:50 spilt between pit lakes.

(continued)

Table 3.7-1. Summary of Key Model Inputs and Assumptions (complete)

Model Parameter	Methodology
SOLIDS BALANCE (continued)	
Timetable for Infilling	It is assumed that FPK discharges to Panda and Koala will begin in 2020 and last for 10 years.
WATER QUALITY	
Natural runoff directly entering pit lake from upstream watersheds	Assumed equal to typical natural stream water from AEMP dataset.
Pumped water from source lakes	Assumed to be natural lake water from AEMP dataset.
Leaching from pit walls	Water quality data based on median of observed Panda and Koala sump water quality. Values constant over time.
FPK Supernatant	Zero, assumption from geochemical analyses is that waste rock and walls are flushed of available leach product on an annual basis, so no additional loading is available at submergence.
Leaching from submerged pit walls /FPK	Zero, once walls are submerged there is zero additional loading.
Leaching from sub-aerially exposed FPK	Assumed zero.
Groundwater	Average underground water quality data for water being pumped from underground workings to Beartooth Pit.
Chemical Reactions/Decay of Parameters	All parameters are assumed conservative and inert except for nutrients.
Inputs during closure	It is assumed that Panda and Koala pit lakes will have freshwater cap (30 m) over FPK solids and supernatant. It is assumed that mine water discharges to LLCF cease at closure and there are inputs from seepage from FPK pile and loadings released as FPK pile freezes.

4. MODEL RESULTS

4.1 Panda and Koala Water Balance

4.1.1.1 Freeboard Calculation

Water within the infilling Panda and Koala pits will not be allowed to spill from the pits during operations. This was completed to ensure the water level will be maintained below the spill level of the pits plus an appropriate freeboard.

Based on the local catchment flowing to the Panda and Koala pits hydrological calculations indicate that:

- Volume of water during a 1 in 100 year 24-hour extreme rainfall event (72.9 mm) is predicted to be 190,000 m^3;
- Volume of water during an average year is predicted to be 340,000 m^3; and
- Volume of water during 1 in 100 year extreme wet year is predicted to be 790,000 m^3.

The spill level of Koala Pit is 453.4 masl. Based on the storage curves in Table 3.2-2, the top 1 m of the pit (from level 452.4 to 453.4 masl) has a volume of 810,000 m^3. The top 2 m has a volume of 1,600,000 m^3.

Based on these calculations a freeboard of 2 m would be conceptually sufficient to prevent overtopping of Panda and Koala pits even during some extreme hydrological events.

4.1.1.2 Water Level Predictions

Predicted mass balance results for Panda and Koala pits for the model are provided in Figure 4.1-1. The results are presented as a single, averaged water level for the two pits because the pits are assumed linked at depth and storage/elevation curves are similar for the two pits (Figure 4.1-1).

The results indicate supernatant water does rise above the 30 m level, but does not reach the 2 m freeboard from the spill level of the pits. At the end of operations, the water level is predicted to be greater than the critical 30 m level thus water is pumped from the pits to the LLCF, providing space for the filling of the pit lakes with a freshwater cap during closure. Assuming a pumping rate of 0.3 m^3/s during open water season months it is assumed that the pumping of water from the pit to the LLCF will take around 3 to 4 years. This pumping activity may occur earlier as an operational activity.

During closure, and once the water level in the Panda/Koala pit lakes have been pumped to a level 30 m below the spill level, a freshwater cap will then be placed on top of the supernatant. The time to fill will depend on the pumped infilling rate. It is assumed in the model that infilling begins, as soon as water levels in the pits have fallen to 30 m below the spill level. This may occur sooner if the in-pit water level is drawn down as an operations activity.

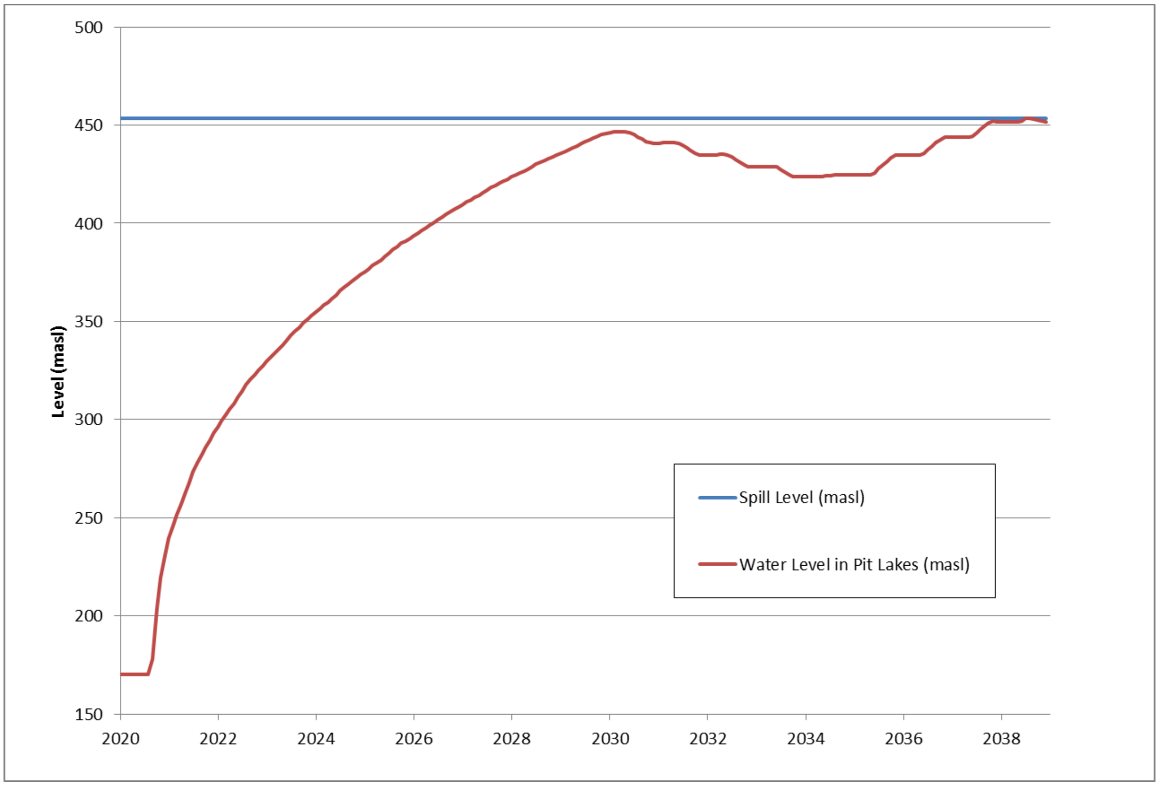


Figure 4.1-1. Predicted Water Level in Panda and Koala Pits

4.2 LLCF and Downstream Lakes Model

4.2.1 Water Balance

Predicted monthly flow volumes at Slipper Lake are presented in Figure 4.2-1. As the model is run for average flow conditions in every year, the predicted monthly flows are constant over time during three main flow periods:

1. Pre-Jay Project when FPK is discharged to the LLCF;
2. During Jay Project when FPK is discharged to Panda and Koala pits; and
3. Post-closure when flows return close to natural/baseline conditions.

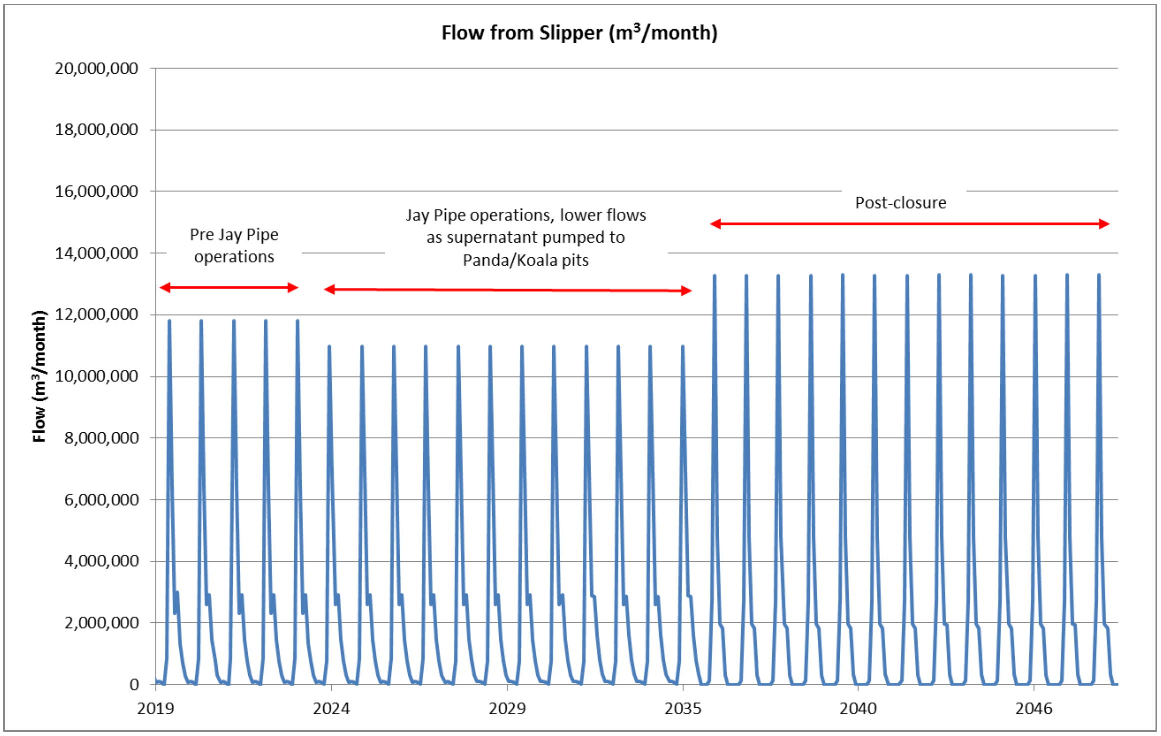
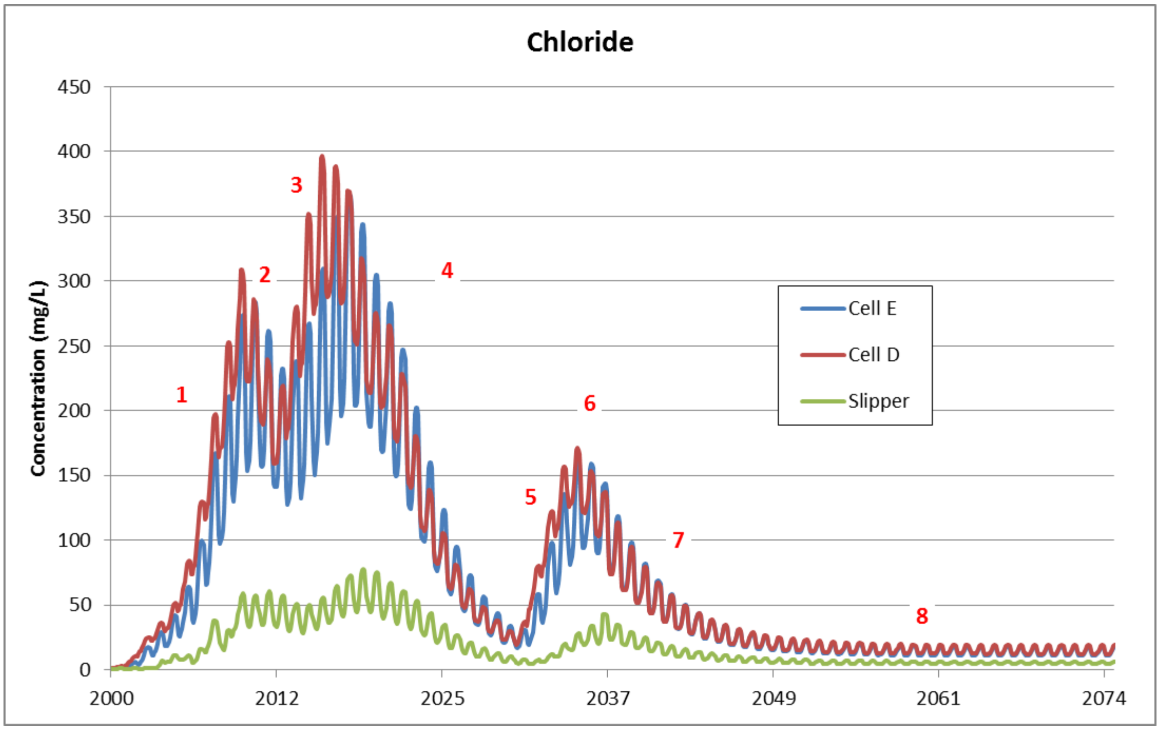


Figure 4.2-1. Prediction of Monthly Flows from Slipper Lake

4.2.2 *Water Quality*

The predicted water quality in Cells D and E of the LLCF and Slipper Lake followed a similar pattern for which a general interpretation is provided in Figure 4.2-2.

Generally, peak concentrations in the LLCF are predicted to occur prior to the discharge of supernatant from Jay Pipe to Panda and Koala pits. Concentrations in the LLCF during the Jay Project are not predicted to exceed concentrations at around 2020, associated with pumping of excess water from Beartooth Pit to the LLCF. The predicted peak concentrations during the model run are similar to those presented in Rescan (2012).



KEY TO WATER QUALITY PREDICTION GRAPHS

1 - Rising concentrations from baseline conditions as Process Plant Discharge (PPD) enters LLCF.
2 - Falling concentration as underground water and FPK is sent to Beartooth Pit.
3 - Rising concentrations as water is pumped from Beartooth Pit to LLCF.
4 - Falling concentrations as PPD enters Panda/Koala and there is no pumping from Panda/Koala back to the LLCF.
5 - Rising concentrations as excess water from Panda/Koala is pumped to LLCF.
6 - Concentrations stabilise.
7 - Concentrations decrease in closure period as all pumping of mine water to LLCF ceases.
8 - Concentrations continue to fall at lower rate towards steady state consistent with post-closure state.

Figure 4.2-2. Key Responses in Water Quality as Predicted in the LLCF (Cells E and D) and Slipper Lake.

5. UNCERTAINTIES

The modelling work presented in this note is based on a model scenario that corresponds to the current best estimate of operations and model inputs during the lifetime and closure of the Ekati Diamond Mine. Most variables and parameters are sourced from analysis of observed data at the Ekati Diamond Mine and are considered robust estimates. However, even for robust estimates there will still be uncertainties. As a result, there are a number of uncertainties associated with model inputs and model predictions. As with the development of the main pits, and later the Beartooth Pit, life of mine model predictions can be further refined based on observed monitoring data collected during for the Jay Project development.

6. SUMMARY

This technical note provides details of inputs, assumptions and results of a linked water balance and water quality prediction model of the LLCF, downstream lakes and Panda and Koala pits. The model was used to predict the impact of discharging FPK from Jay Project into Panda and Koala pits on water quality in the LLCF. Model results were provided as inputs to a wider study of the impact of the Jay Project on water quality in Lac de Gras.

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