Flinders In-Pit TSF
Groundwater Impact Assessment

Report Prepared for

Report Prepared by

SRK Consulting (Australasia) Pty Ltd

FMG007

March 2014

Flinders In-Pit TSF

Groundwater Impact Assessment

Fortescue Metals Group Ltd

Level 2, 87 Adelaide Terrace, East Perth WA 6004

SRK Consulting (Australasia) Pty Ltd

10 Richardson Street, West Perth WA 6005

Tel: 08 9288 2000
Fax: 08 9288 2001

SRK Project Number FMG007

March 2014

Compiled by

Sylvie Ogier-Halim
Senior Consultant

Email: sogier-halim@srk.com.au

Peer Reviewed by

David Whiting
Principal Consultant Hydrogeology

John Chapman
Principal Consultant Environment

Authors:

Sylvie Ogier-Halim, Caroline Holmes

Executive Summary

Fortescue Metals Group (FMG) is considering the development of the Flinders in-pit TSF (disposal into exhausted mining strips FLI_S14 to S19) at the Christmas Creek Mine. SRK has been appointed to undertake an evaluation of the impact of in-pit disposal below the pre-mining water table (~ 410 m RL) on the local ground water regime. The objective of the evaluation is to provide FMG with an opinion on the feasibility of tailings deposition from the base of the pit.

FMG has utilised exhausted pits for tailings disposal at the Christmas Creek operation before, but tailings disposal in all of these has been above the pre-mining water table (WT). The Flinders in-pit TSF would be the first to also contain tailings below the WT.

To assess the potential impacts from tailings disposal below the WT, SRK undertook water balance and salinity load (TDS concentration) modelling using a Dynamic Systems Model (DSM), for three scenarios:

(i) No backfill (Reference Case);

(ii) Waste rock backfill to WT and tailings backfill above (Permitted Base Case); and

(iii) Complete tailings backfill (Alternative Case).

For the **Reference Case (no backfill)** the pit void is left open and the modelling results confirm that a pit lake will form in the void. The pit lake level is predicted to stabilise between 400.8 and 401.8 m RL for the different climatic scenarios which is well below the regional groundwater elevation (~ 410 m RL). The pit lake should remain a long term groundwater sink as evaporative losses exceed inputs from runoff, precipitation and groundwater inflows. As a result, the pit water TDS concentration will increase continually over time. However, the saline pit lake will not impact local and regional aquifers as the pit will remain a terminal sink. The primary impacts on the groundwater system will be localised drawdown (i.e. lowering of the water table) and a net loss of about 1.4 Mm^3/year which is equivalent to 0.5% of the local groundwater flow through (~ 275 Mm^3/year). No significant impact on the regional groundwater flow and the downstream marsh is therefore expected.

For the **Permitted Base Case (waste rock backfill to WT and tailings backfill above),** modelling results indicate that the water level will rise rapidly and that the waste rock would be inundated as it is deposited. As soon as the water level in the pit reaches the natural groundwater elevation (~ 410 m RL), the backfilled pit would act as groundwater 'flow through' system as the permeability of the waste rock is very high and exceeds that of the surrounding rock (ranges between 10^{-4} and 10^{-3} m/s). In the absence of increased recharge from the surface, the rate of pore water displacement through the waste rock would be at the same rate as the local groundwater flow.

In the short term, during waste deposition, the TDS concentrations in the waste rock pore water would be controlled by the TDS concentrations of the groundwater and the waste rock leaching. In the longer term, groundwater would displace all of the readily soluble solutes and the pore water quality would return to local groundwater quality.

During tailing deposition above ~ 410 m RL, seepages would occur at a rapid rate through the pit walls to the underlying groundwater system. Tailings pore water will also be released through the contact between the tailings and waste rock backfill. The seepage rates from the pond will be dictated by the pond elevation and the permeability of the disturbed/blast damaged pit wall, while seepage rates from the tailings will be driven by the phreatic surface elevation within the tailings, and the low permeability of the tailings (k ~ 10^{-9} m/s). This will cause local mounding of the water table (in the immediate surrounds of the pit) and an increase in groundwater flow.

At completion of tailings deposition, the modelling results indicate that the groundwater would be mounded within the tailings due to their low permeability. The raised phreatic surface would dissipate over a long time (decades to centuries).

The TDS concentration in the tailings pore water would be controlled mainly by the tailings supernatant water quality (TDS ~ 6,400 mg/L). The TDS of the tailings pore water is well below that of the local groundwater (10,000 < TDS < 70,000 mg/L). The tailing seepage rates post-deposition (< 1,000 m^3/year) would be less than 0.01 % of the groundwater flow through the waste rock (about 275 Mm^3/year) underlying the tailings. As a result, no impact on the regional groundwater flow would occur. The seepage would lower the TDS (i.e. provide dilution), however, this would be insignificant due to the low flow rates. No net impact on the local and regional groundwater system is indicated.

For the Alternative Case (complete tailings backfill) the pit would be backfilled with tailings to 424 m RL (0.5 m below the lowest pit rim elevation) and the backfilled void would no longer act as a groundwater sink. Seepage would occur only once tailings deposition exceeds the regional pre-mining groundwater elevation (~ 410 m RL). Once the regional water table is re-established, groundwater flows would tend to flow around the tailings deposit rather than through it due to the significantly lower permeability of the tailings when compared to the surrounding rock. Flows through the tailings would be expected to be about 2,800 m^3/year.

At the completion of tailings deposition, as for the partial tailings backfill case, the modelling results indicate that the water table will be mounded locally within the tailings deposit. The mound would be expected to dissipate over a long time (decades to centuries).

Prior to deposition, the quality of the pit water would be controlled by groundwater inflow (10,000 < TDS < 70,000 mg/L). Once tailings deposition commences, the TDS will decrease to that of the tailings supernatant (TDS ~ 6,400 mg/L).

For the tailings below the regional water table, due to the slow rate of water displacement, no significant change in the tailings pore water TDS would be expected to occur within the timeframe of the modelling. However, as described for the previous case, seepage would occur at a rapid rate through the pit wall rocks to the underlying groundwater system. The seepage rates from the pond will be dictated by the pond elevation and the permeability of the disturbed/blast damaged pit wall. The net impact on groundwater elevations and flows, and groundwater quality would be indistinguishable from that predicted for the partial waste rock backfill case.

At the regional scale, the groundwater flow will not be detrimentally affected and no change in water quality (i.e. TDS concentration) of the local and regional groundwater system is expected to occur. No impact on the downstream marsh is therefore expected.

It is the opinion of SRK that the consequences of the Alternative Case (complete tailings backfill) of the Flinders pit would be indistinguishable from the partial backfill option (i.e. permitted base case) and should not have any significant impacts on the regional groundwater system and its groundwater dependant ecosystems (e.g. the downstream marsh).

Table of Contents

1 Introduction ... 1

2 Study Approach ... 2

3 Pit Water Balance Model ... 3

4 Model Inputs ... 6

4.1 Water balance ... 6

4.1.1 Pit geometry ... 6

4.1.2 Climate data ... 8

4.1.3 Surface water inflow ... 9

4.1.4 Groundwater inflow ... 9

4.1.5 Groundwater outflow ... 10

4.1.6 Backfill inflow ... 11

4.2 Total dissolved solid ... 11

4.2.1 Precipitation ... 11

4.2.2 Pit wall runoff ... 11

4.2.3 Backfilled tailings ... 13

4.2.4 Groundwater inflow ... 13

5 Water Balance and TDS Concentration Results ... 15

5.1 Scenario 1 - Reference case (no backfill) ... 15

5.2 Scenario 2 - Permitted base case (waste rock backfill to WT, tailings above) ... 18

5.3 Scenario 3 - Alternative case (complete tailings backfill) ... 22

6 Impacts on Groundwater Regime and Mitigation Measures ... 25

6.1 Scenario 1 - Reference case (no backfill) ... 25

6.2 Scenario 2 - Permitted base case (waste rock backfill to WT, tailings above) ... 25

6.3 Scenario 3 - Alternative case (complete tailings backfill) ... 25

7 Concluding Remarks ... 26

8 References ... 27

List of Tables

Table 4-1: Monthly average precipitation (mm) 8

Table 4-2: Monthly average pan evaporation (mm) 9

Table 4-3: Summary of groundwater inflow estimations versus elevation 10

Table 4-4: Tailings porosity for different dry density 11

Table 4-5: Average, minimum and maximum EC and TDS values recorded for Flinders Pit monitoring and production wells 13

Table 5-1: Final pit lake levels and equilibrium times 16

Table 5-2: Simulated water balance at steady state conditions (100 year simulation) 17

Table 5-3: Waste rock and tailing deposition time, phreatic surface elevation and equilibrium times 18

Table 5-4: Tailing deposition time, phreatic surface elevation and equilibrium times 22

List of Figures

Figure 3-1: Conceptual hydrologic model for reference case (no backfill) 4

Figure 3-2: Conceptual hydrologic model for permitted base case (waste rock and tailings backfill) 4

Figure 3-3: Conceptual hydrologic model for alternative case (tailings backfill only) 5

Figure 4-1: Change in pit surface area versus elevation 7

Figure 4-2: Change in pit volume versus elevation 7

Figure 4-3: pH, EC, alkalinity and TDS of the sample leachates from WRD and tailings 12

Figure 4-4: 2013 OPF EC record 14

Figure 5-1: Simulated pit lake elevation for 50 year period 15

Figure 5-2: Simulated water balance for first 10 years (reference case) 16

Figure 5-3: TDS concentration for 100 year simulation (reference case) 17

Figure 5-4: Pit water level, tailing level, pit water volume and tailing volume for 10 year simulation (permitted base case) 18

Figure 5-5: Pit water level, tailing level, pit water volume and tailing volume for 100 year simulation (permitted base case) 19

Figure 5-6: Transient relationships between water balance components for 10 year simulation (permitted base case) 19

Figure 5-7: Simulated TDS concentration in saturated waste rock for 100 year simulation (permitted base case) 21

Figure 5-8: Simulated TDS concentration in tailing pore water for 100 year simulation (permitted base case) 21

Figure 5-9: Pit water level, tailing level and pit water volume for 20 year simulation (alternative case) 22

Figure 5-10: Pit water level, tailing level, pit water volume and tailing volume for 100 year simulation (alternative case) 23

Figure 5-11: Transient relationships between water balance components for first 20 years of simulation (alternative case) 23

Figure 5-12: TDS concentration for 100 year simulation (alternative case) 24

List of Appendices

Appendix A: Rainfall Sequences

Appendix B: Water Balance and TDS Concentration Summary Results

Appendix C: Electronic Data

Disclaimer

List of Abbreviations

Abbreviation	Meaning
BCM	Billion cubic metres
BOM	Bureau of Meteorology
CR	Runoff coefficient
DSM	Dynamic Systems Model
EC	Electrical Conductivity
FEFLOW	Groundwater modelling software
FMG	Fortescue Metals Group Ltd
TSF	Tailings Storage Facility
GoldSim	Monte Carlo simulation software
GW	Groundwater
K	Hydraulic conductivity
kPa	kilopascal
L	Litre
L/s	litres per second
m	metre
m bgl	metres below ground level
m^3	Square metres
m^3/mon	Cubic metres per month
m^3/year	Cubic metres per annum
mg/kg/month	Milligram per kilogram per month
mg/L	Milligram per litre
mm	millimetre
ml	millilitre
m RL	metres reduced level
M	Million
NAF	Non-acid forming
m/s	Metre per second
OPF	Ore processing facility
SRK	SRK Consulting (Australasia) Pty Ltd
SG	Specific gravity
TDS	Total dissolved solid
TSF	Tailings Storage Facility
t/m3	Tonne per cubic metre
us/cm	Microsiemens per centimetre
UC	Uncertain acid potential
WT	Water table

1 Introduction

Fortescue Metals Group Ltd (FMG) appointed SRK Consulting (Australasia) Pty Ltd (SRK) to provide a short- to medium-term (5 to 10 year) tailings storage strategy for its Christmas Creek operation in the Pilbara region of Western Australia.

Christmas Creek currently operates two ore processing facilities each with a dedicated Tailings Storage Facility (TSF). The Vasse In-pit/paddock TSF services Ore Processing Facility 1 (OPF1) and the Windich In-pit TSF1 (strips 8 and 9) receive tailings from Ore Processing Facility 2 (OPF2).

Additional facilities will be required once the Vasse and Windich TSFs have reached capacity. SRK identified the development of the Flinders In-pit TSF (disposal into exhausted mining strips FLI_S14 to S19) as the preferred short - to medium-term tailings storage option for OPF1 (i.e. alternate for the Vasse TSF). This option is subject to further evaluation which is primarily related to the impact of in-pit disposal on the local ground water regime.

FMG is currently utilising exhausted pits for tailings disposal at the Christmas Creek operation, but deposition occurs from above the pre-mining water table only. The Flinders In-pit TSF would be the first partially filled below the water table.

The evaluation scope includes the confirmation of the extent of the groundwater rebound based on current mining and production schedules, the prediction of the groundwater recovery with tailings deposition from the base of the pit and the potential impacts and mitigation measures required. The objective of the evaluation is to provide FMG with an opinion on the feasibility of developing an in-pit facility with tailings deposition from the base of the pit by assessing the potential impacts for the backfilling options. An assessment of the reference case (no backfill) was also completed to determine potential benefits/disadvantages of each option.

2 Study Approach

An indicative assessment of the post-mining pit lake formation (i.e. reference case) has been conducted as part of the evaluation of the Flinders In-pit TSF options evaluation. This assessment is based on the results from the regional groundwater model developed by FMG in 2012 (FMG, 2012) for the Christmas Creek Project.

The groundwater inflows derived from the groundwater model were used to evaluate the potential groundwater inflow to the Flinders pit lake and water level rebound following mine closure.

Once mining activities cease, dewatering of the open pit will be terminated and the local water table will rebound from its operational, drawdown (lowered) condition. Water from the surrounding aquifer and direct precipitation will report to the pit void and a lake will begin to form in the bottom of the open pit.

The rate at which the various water sources report to the pit will change over time. A Dynamic Systems Model (DSM) developed in GoldSim™ has been used to simulate the rates of inflow of the various hydrologic components of the pit over time.

The objectives of the model were to predict:

- The post-closure pit water balance over time with and without waste rock backfill and/or tailings deposition; and
- Total dissolved solid (TDS) concentrations in the pit void over time with and without waste rock backfill and/or tailings deposition.

Three scenarios were considered as follows:

Scenario 1 Leaving the pit as open pit void at closure (reference case).

Scenario 2 Backfilling with waste rock to pre-mining water level (~ 410 m RL) and tailings above (permitted base case).

Scenario 3 Backfilling from the base of the pit with tailings only (alternative case).

The rise of water level in the pit void would take time to reach its steady state level. Therefore modelling water inflow over time has been simulated using a series of discreet time steps (i.e. months).

The following sections outline i) the hydrological and TDS load components derived for the post-closure pit water balance, ii) the model set-up and iii) summarise the results of the simulations.

3 Pit Water Balance Model

During the post-closure stage of the project, a lake is expected to form in the pit void. The rate of pit filling and the ultimate level of the pit lake will be controlled by the post-closure water balance.

A conceptual post-closure water balance is as follows:

Change in pit lake volume over time =∑ inflows – ∑(outflows and losses)

which can be expressed as:

$$\Delta_{pit\ lake\ volume} = P_{precip} + R_{runoff} + GW_{inflow} - E_{pit} - B_{Dep}$$

Where:

- P_{precip} is the inflow from direct precipitation falling on the surface of the lake (m^3/time step).
- R_{runoff} is the inflow from surface runoff consisting of a) upgradient drainage and b) pit wall runoff (the fraction of precipitation falling on the pit walls that ultimately reports to the pit lake).
- GW_{inflow} is the groundwater inflow to the pit lake (m^3/time step) and is positive when the water level of the lake is below the local water table, zero when it is at the same elevation, and becomes negative (i.e. outflow) when the level rises above the local water table. (Note that density effects have not been considered herein.).
- E_{pit} is the open water evaporation from the pit lake surface based on a modified pan evaporation rate applied to the pit lake surface area (m^3/time step).
- B_{Dep} is the total volume of backfilled deposited in the pit (m^3/timestep).

Figure 3-1 to Figure 3-3 presents the interaction between the hydrological components of the conceptual water balance of the Flinders Pit with and without backfill deposition.

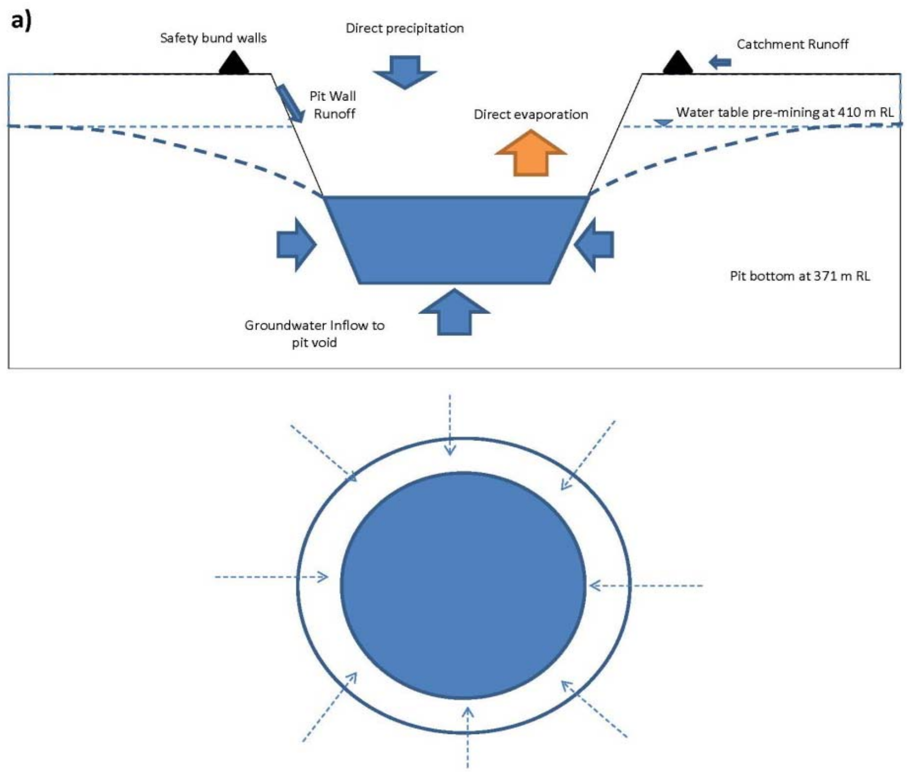


Figure 3-1: Conceptual hydrologic model for reference case (no backfill)

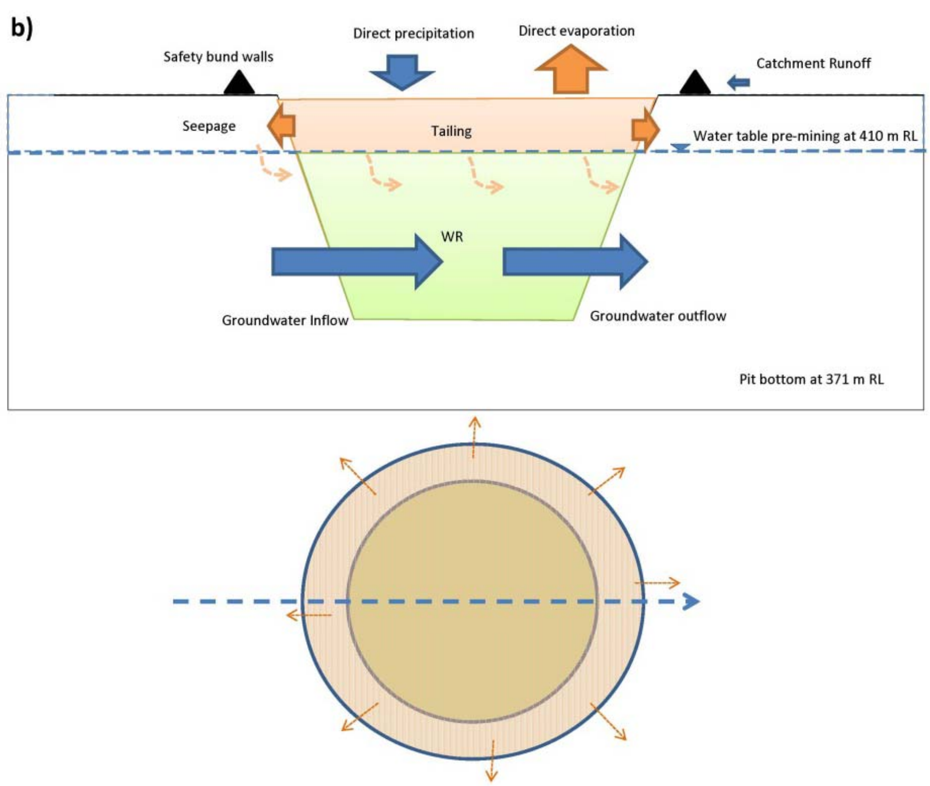


Figure 3-2: Conceptual hydrologic model for permitted base case (waste rock and tailings backfill)

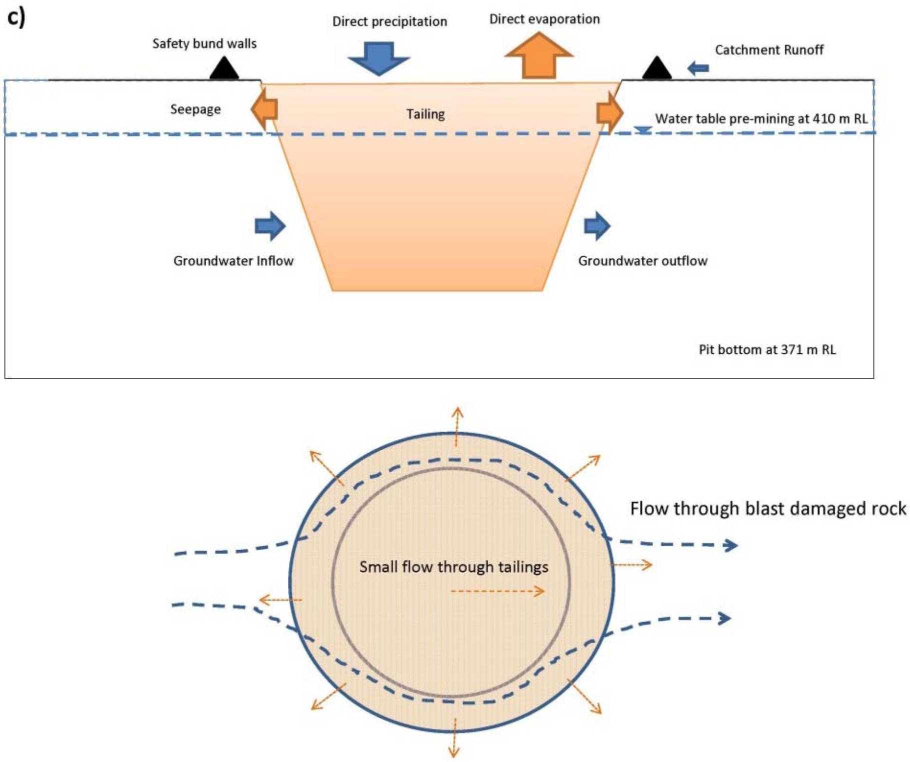


Figure 3-3: Conceptual hydrologic model for alternative case (tailings backfill only)

Note: Catchment runoff will be diverted around the pit as indicated by the bund in the figure and discussed later.

A description of the different hydrological components of the pit water balance is provided in the following section.

4 Model Inputs

A simple dynamic system computer model for the anticipated Flinders pit was developed in GoldSim™ to predict the post-closure pit water balance and TDS concentration over time. Each hydrological component of the pit water balance model was incorporated into the DSM; the components were organised in different modules:

- Pit geometry
- Climate data
- Surface water inflow
- Groundwater inflow
- Groundwater outflow
- Tailings inflow

The DSM includes only deterministic (fixed) parameters. The model was allowed to run for a 100 year period. In this water balance, monthly time steps were chosen to calculate the changes in the volume of the pit water.

4.1 Water balance

4.1.1 Pit geometry

The pit geometry was simulated with lookup tables of the mine pit elevation versus area and volume that were based on the final pit geometry supplied by FMG (referred to as "FLI_14-19_BOSM_SURFACE".dxf).

In the simulation, the base of the Flinders Pit was cut at 371 m RL, as a potential mine out and because the groundwater inflow estimates below 371 m RL may be overestimated. The topology of the Flinders Pit was used to calculate the pit volume and pit area for each pit water level stage using Rift TD software. The relationships used in the model between pit water level versus pit area and elevation versus water volume capacity are shown in in Figure 4-1 and Figure 4-2 respectively. It can be seen from these plots that the relationship is not linear due to the irregular shape of the open pit.

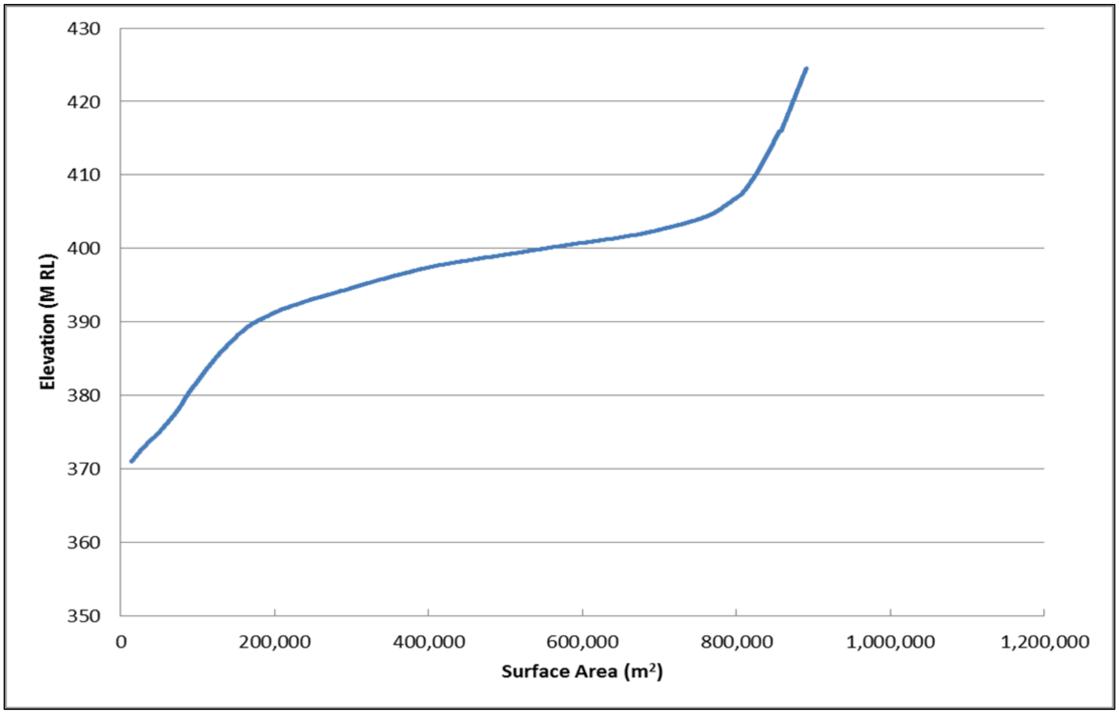


Figure 4-1: Change in pit surface area versus elevation

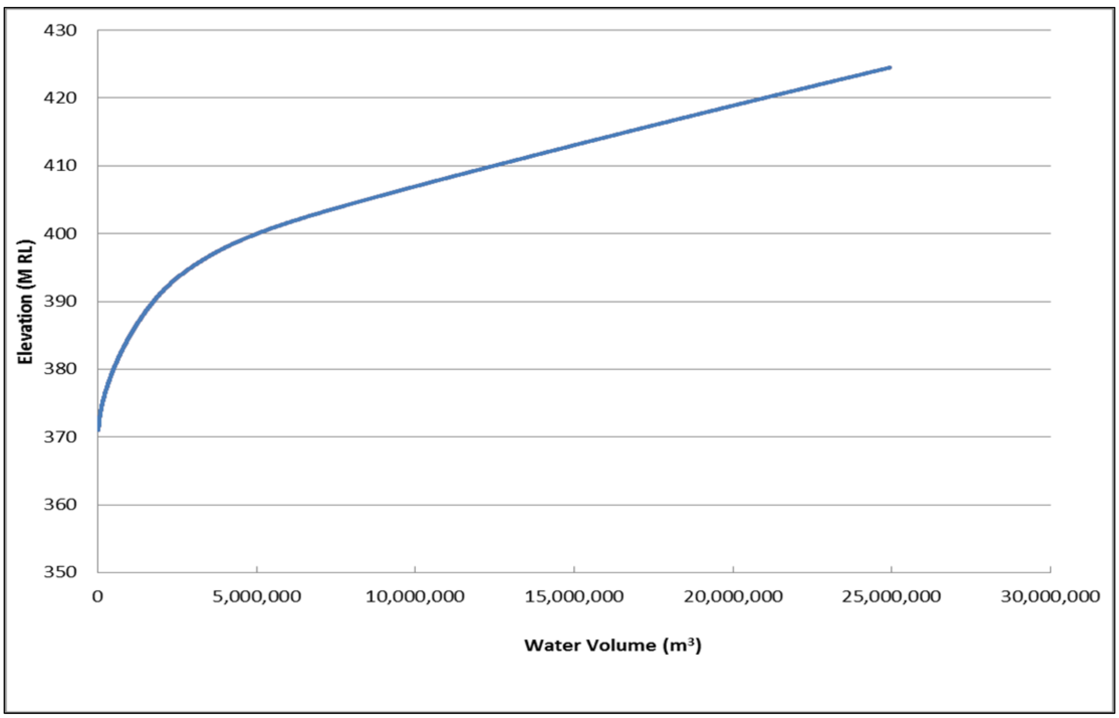


Figure 4-2: Change in pit volume versus elevation

4.1.2 Climate data

Simulated rainfall sequences (base case, wet case and dry case) and average monthly evaporation data were used as inputs in the model (deterministic values).

Direct precipitation to the lake

Precipitation which falls directly onto the lake surface will contribute to the pit water balance.

Monthly average precipitation values from the Newman (Bureau of Meteorology (BOM) station 7176) climate station are presented in Table 4-1.

Table 4-1: Monthly average precipitation (mm)

Month	Precipitation (mm)
January	57.2
February	77
March	40.7
April	19.6
May	18.1
June	14.2
July	14.9
August	7.7
September	3.4
October	4.9
November	10.5
December	37.4
Annual	**310.1**

Newman (BOM station 7176) climate station (1994-2010)

Most of the summer precipitation is from scattered thunderstorms and occasional tropical cyclones (FMG, 2012).

Rainfall data from the Newman weather station (Bureau of Meteorology (BOM) station 7176) dating back to 1971 were used to create three rainfall sequences representing average, wet and dry rainfall climatic scenarios, respectively. They were used in the regional numerical groundwater flow model developed by FMG (2012). The three rainfall sequences are provided in Appendix A while method to generate the synthetic rainfall sequences is provided in the Hydrogeological Assessment Report for Christmas Creek Life of Mine Water Management Scheme (FMG, 2012). For consistency, the same rainfall sequences were applied in this study (i.e. base case, dry case and wet case).

Direct precipitation to the lake was calculated for each time step as multiplying the rate of precipitation by the surface area of the lake.

Evaporation

Direct evaporation from the pit lake surface is the primary cause of water loss. Pan evaporation was extracted from the BOM 1961-1990 spatial evaporation dataset (Table 4-2; FMG, 2012). The quantity of water lost to the atmosphere via evaporation is proportional to the area of the pit lake and varies with time. As indicated in Table 4-2, total annual average evaporation (3,038 mm; Table 4-2) exceeds the annual average rainfall (310 mm; Table 4-1) by a factor of 10.

The monthly average pan evaporation is converted to a lake evaporation using a coefficient to account for the fact that an evaporation pan has far less heat-storage capacity (i.e. shallow depth of water compared to pit lake). A common value for converting pan evaporation to lake evaporation is 0.7 (Kohler and Parmele, 1967). In the FMG report (2012), a coefficient of 0.75 was used to convert pan evaporation to lake evaporation when water level was at or above the Fortescue Marsh land surface. For consistency, the same factor (i.e. 0.75) was applied in this study.

Table 4-2: Monthly average pan evaporation (mm)

Month	Pan Evaporation (mm)
January	390
February	310
March	290
April	205
May	138
June	100
July	110
August	165
September	230
October	315
November	380
December	405
Annual	**3,038**

Extracted from BOM 1961-1990 spatial Evaporation dataset

4.1.3 Surface water inflow

Upgradient runoff

According to FMG, surface water runoff from upgradient catchment areas or existing drainages will be diverted away from the pit. Therefore, no upgradient drainage runoff was incorporated into the model.

Pit wall runoff

A portion of the precipitation which falls in the pit area will fall on pit walls and contribute to the development of the pit lake/pond as wall runoff. The amount of runoff depends on temperature, precipitation rate and duration (on individual storm basis), soil saturation and local slope gradient.

The volume of wall runoff which enters the pit will be proportional to the total area of exposed wall rock and the precipitation. The contribution of the pit wall runoff to the pit lake/pond will decrease over time as the water level rises.

The runoff coefficient (ratio between surface runoff to the lake and rainfall over the area) can vary between 0.25 and 1; it is highly time-variable and uncertain. Runoff coefficients of 0.25 and 1 were used.

4.1.4 Groundwater inflow

A regional numerical groundwater flow model was developed by FMG (2012) in FEFLOW. The model simulates dewatering and post-mining pit filling based on the Christmas Creek mine LoM 8.4 plan, July 2011 (*Internal Reference Number CC_i8.4b_55Mtpa_LOM_Sequence*). The numerical model set up and results are explained in detail in the FMG report (2012).

Groundwater inflow will vary as the water level rises since it is a function of the hydraulic gradient between the pre-mining regional groundwater levels and water level in the pit (or below the pit during operations). The highest inflows are expected to occur at cessation of mining during the initial recovery in groundwater levels, when the hydraulic gradient will be at a maximum. The groundwater inflows will be controlled by aquifer hydraulic conductivity, pressure head and storage.

The pre-mining water table in the area of the pit was at ~410 m RL while the final pit floor is estimated at ~ 371 m RL.

The groundwater inflow component herein was estimated using a simplified relationship between groundwater levels versus pit volume stage curve which has been derived from the outputs from the 50 years post-mining simulation undertaken with the FMG groundwater model.

Groundwater inflows as a function of water elevation are presented in Table 4-3.

Table 4-3: Summary of groundwater inflow estimations versus elevation

Water elevation (m RL)	Pit dimensions			Groundwater inflow (l/s)
	Depth (m)	Volume (m^3)	Area (m^2)	
376.00	5.00	202,360	58,740	242.9
385.25	14.25	1,048,487	124,720	166.0
396.00	25.00	3,259,463	346,258	78.8
399.50	28.50	4,740,817	521,651	51.0
401.60	30.60	5,973,801	654,434	34.4
402.40	31.40	6,514,633	694,687	28.1
403.30	32.30	7,155,184	728,923	21.0
403.80	32.80	7,523,651	745,688	17.1
404.00	33.00	7,673,341	751,144	15.5
404.50	33.50	8,052,127	763,644	11.6
404.60	33.60	8,128,597	765,744	10.8
404.70	33.70	8,205,273	767,742	10.0
404.85	33.85	8,320,683	770,932	8.9
405.45	34.45	8,786,115	780,340	4.2
405.85	34.85	9,099,314	785,673	1.1
406.90	35.90	9,931,577	800,376	0.9

4.1.5 Groundwater outflow

While the water level in the pit remains below the regional groundwater level, no groundwater outflow is anticipated. For the Reference Case (no backfill) the water level is not expected to reach the water table due to the high evaporation rates; consequently the hydraulic gradient is expected to remain towards the pit. However, where the tailings deposition occurs above the water table (Permitted Base Case and Alternative Case), groundwater outflows occur when the phreatic water level in the pit rises above the pre-mining groundwater level (~ 410 m RL). Seepage through the pit wall and to the groundwater system underneath will occur from any intermittent pond developed along the pit wall and from the tailings itself. Variable seepage rates per unit of surface ($m^3/s/m^2$) are applied based on the water head for the lake/pond developed along the pit wall and for phreatic surface within the tailings.)

4.1.6 Backfill inflow

Tailings Deposition

Based on the average production rate for the current mine plan, the tailings deposition rate is estimated at 270,000 dry tonnes per month.

Geotechnical testing undertaken for the Windich In-Pit TSF (Golder Associates, 2012) indicates that the tailings permeability range is estimated between 1.5×10^{-9} and 7.5×10^{-9} m/s, and that the tailings are likely to achieve a settle dry density of 1.1 t/m^3 upon initial deposition, increasing to a maximum of 2 t/m^3 under a load of ~ 600 kPa. The solids Specific Gravity (SG) is 3.8.

For the purpose of the modelling it was assumed that a settled dry density of 1.1 t/m^3 will be achieved on deposition increasing to average settled dry density of 1.5 t/m^3 after deposition. If the tailings remain saturated, the calculated corresponding tailings porosity values are provided in Table 4-4.

Table 4-4: Tailings porosity for different dry density

Scenario	Settled dry density (t/m^3)	Porosity of saturated tailings
Immediately on deposition	1.1	0.7
Average after deposition	1.5	0.6

Waste rock deposition

Based on a waste placement rate of 600 k BCMs per month, the waste rock deposition rate is estimated at 780,000 m^3 per month, assuming a swelling factor of 30%. A porosity of 40% was used for modelling purposes.

4.2 Total dissolved solid

The concentrations of chemical constituents in the pit represent the combined effects of geochemical and hydrological processes acting in the system. Total dissolved solid (TDS) is added to the pit from component inflow inputs. TDS concentration for any given constituent is calculated conservatively as the product of the flux of water into the pit lake and the TDS concentration in the water source.

Each of the Flinders Pit hydrological components has an associated chemical mass loading component. In the model, the source waters with their respective TDS concentrations were mixed together according to their relative proportions. The methods used to define the TDS concentration associated with each of the hydrological components are described in the following sections.

4.2.1 Precipitation

Incident rainfall can be considered as “distilled water” with negligible solute concentrations and as such does not introduce any TDS concentration to the system.

4.2.2 Pit wall runoff

Runoff from the pit walls will dissolve chemical mass from the wall rocks. The quality of the total wall runoff will be proportional to the exposed areas of the various rock types in the pit wall. The TDS contribution from the wall runoff would be expected to decrease with time, as the pit filling progresses and less wall rock is above the pit lake or the backfilling, and as reactive mineral phases on the wall rocks are depleted.

Estimates of TDS concentration from geological materials have been generated from the results of geochemical testing undertaken on the waste rock samples for the Windich In-pit TSF characterisation (Golder Associates, 2013). Static tests and short-term leaching tests have been conducted to characterise the geological materials. The waste rock material samples were classified as NAF or UC according to the AMIRA classification system and the initial TDS reading for the waste rock sample leachates, corresponding to the first flush of the solute salt, range up to 3,200 mg/L or a maximum average of 1,986 mg/kg/month (Figure 4-3).

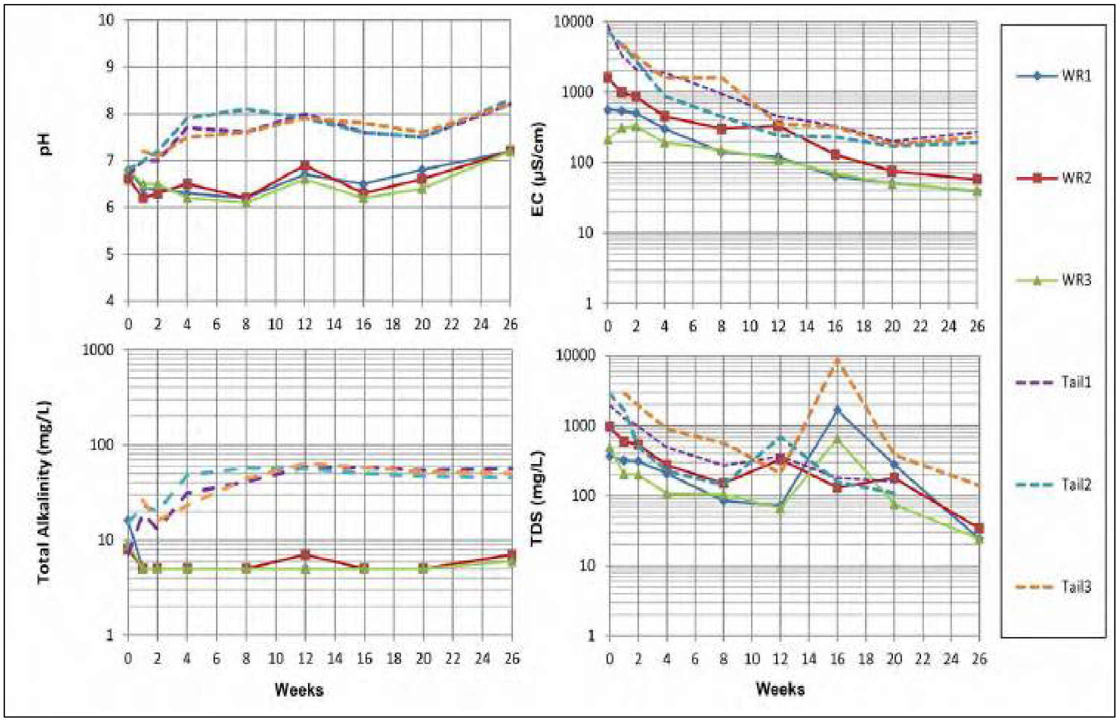


Figure 4-3: pH, EC, alkalinity and TDS of the sample leachates from WRD and tailings

Source: Golder Associates (2013), short term leaching tests

Although these readings do not represent long term release rate, they have been used in the model as the maximum potential TDS load from the pit wall. The TDS concentration from the short-term leaching tests was then adjusted to account for the differences in scale between humidity cells and ambient conditions, and combined with the expected runoff water volumes to develop TDS estimates over time. For the calculation, it is assumed that any weathering products generated are flushed from the pit wall during runoff events. The rate of solute generation (estimated from kinetic tests) is multiplied by the mass of rock exposed to weathering in the pit wall (using surface area and assumed oxidation depth).

It is assumed that any weathering products generated are flushed from the pit wall during runoff events. Depth of reactive wall rock (i.e. blast damaged or fractured) was assumed to be about 1 m. This depth was then multiplied by the exposed surface area to calculate the equivalent volume of rock that would contribute solutes. A bulk density of 2,700 kg/m^3 was used for the purpose of the calculation. A surface area correction factor (dimensionless) of 0.01 was applied to the mass-based constituent loading rates calculated from the kinetic tests to account for channelling of water in fractures and the much lower surface area to mass ratio of the rock in pit walls when compared to that of kinetic test material (typically crushed to < 5 mm). Conservatively, no solubility controls were imposed to the solute release.

4.2.3 Backfilled tailings

Estimates of TDS concentration from tailings materials were obtained from geochemical testing undertaken on tailings samples (Golder Associates, 2013). Static tests and short-term leaching tests have been conducted to characterize the tailings. The tailings solids were classified as NAF according to the AMIRA classification system and are not expected to be acid generating in the long term. The TDS concentrations for the initial flush, which in general were the most elevated, were used to estimate the TDS release from the tailings solids.

The TDS concentrations for the first flush from the tailings were as high as 3,200 mg/L or a maximum average of 3,620 mg/kg/month. Although, these readings do not represent long term release rate, they have been used in the model as the maximum potential TDS concentrations that can be released from the tailings. The rate of solute generation (estimated by kinetic test in units of mg/kg/month) was multiplied by the quantity of tailings present in the backfilling above the phreatic surface. Only the non-saturated tailings, exposed to oxidising conditions, would be expected to generate solutes.

According to the 2013 OPF EC record (Figure 4-4) and the leached concentration of the Christmas Creek tailings samples (Tetra Tech, 2013), the tailings supernatant water is approximately 10,000 us/cm or about 6,400 mg/L. The rate of solute generation was obtained by multiplying the concentration with the quantity of supernatant discharged from the facility.

4.2.4 Groundwater inflow

The EC and TDS of the groundwater is presented as the average, minimum and maximum concentrations recorded to date from monitoring and production wells located in the vicinity of the Flinders Pit (Table 4-5).

Table 4-5: Average, minimum and maximum EC and TDS values recorded for Flinders Pit monitoring and production wells

Parameter	Unit	Average	Minimum	Maximum
EC	uS/cm	37,270	15,949	112,420
TDS (recalculated)	mg/L	10,200	23,800	71,900

Source: FMG

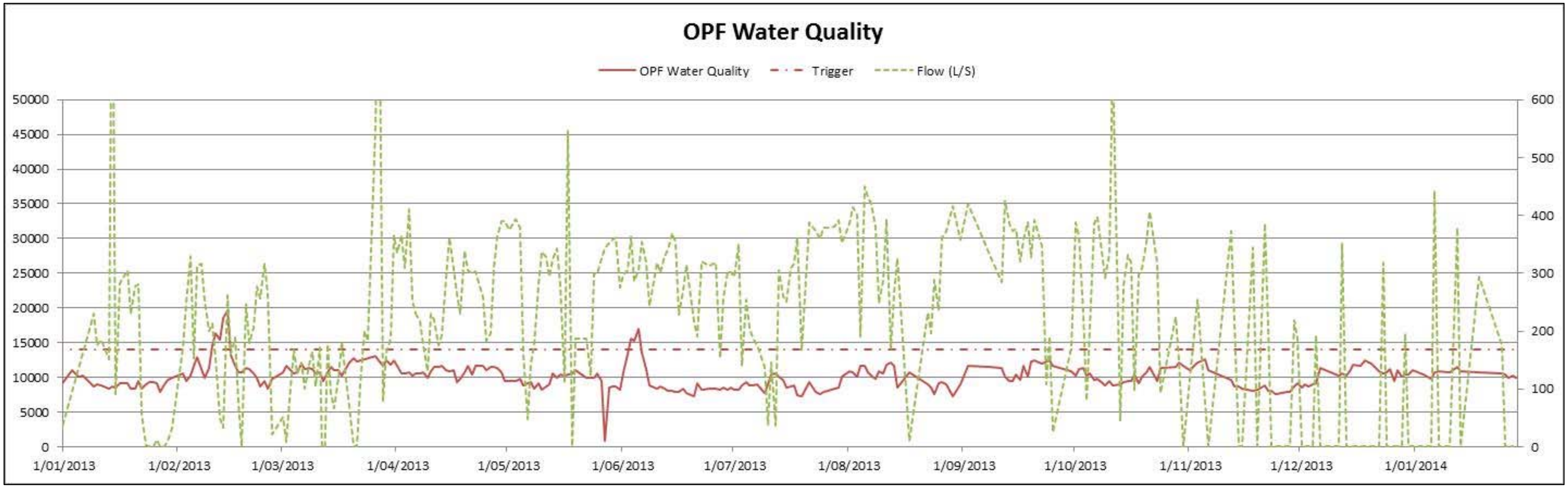


Figure 4-4: 2013 OPF EC record

Source: FMG

5 Water Balance and TDS Concentration Results

Based on 100 year simulation period, model results were generated for all flow components of the water balance. The EC was used to infer the TDS present in each flow when TDS values were not available. It should however be noted that the correlation between EC and TDS is not absolute and varies based on actual dissolved species and concentrations. Three scenarios were considered as follows:

Scenario 1 Leaving the pit as open pit void at closure (reference case).

Scenario 2 Backfilling with waste rock to pre-mining water level (~ 410 m RL) and tailings above (permitted base case).

Scenario 3 Backfilling from the base of the pit with tailings only (alternative case).

The results of the different scenario are summarised in Appendix B while all model output is presented in electronic form in Appendix C.

5.1 Scenario 1 - Reference case (no backfill)

The model results indicate that a pit lake would form in the open pit for the different rainfall climatic scenarios (Figure 5-1). The water level would stabilise at about 400 to 402 m RL, which is about 8 m below the pre-mining water table elevation. The results indicate that inward hydraulic gradients would persist so that the pit lake would be expected to remain a water sink indefinitely.

The sensitivity analysis undertaken for the wall rock runoff coefficients indicated steady state water level could vary to a maximum of 0.3 m (Table 5-1). The final water level can therefore be considered relatively insensitive to the change in runoff coefficient. In the subsequent sections, only the results of the model with a runoff coefficient of 0.25 are presented.

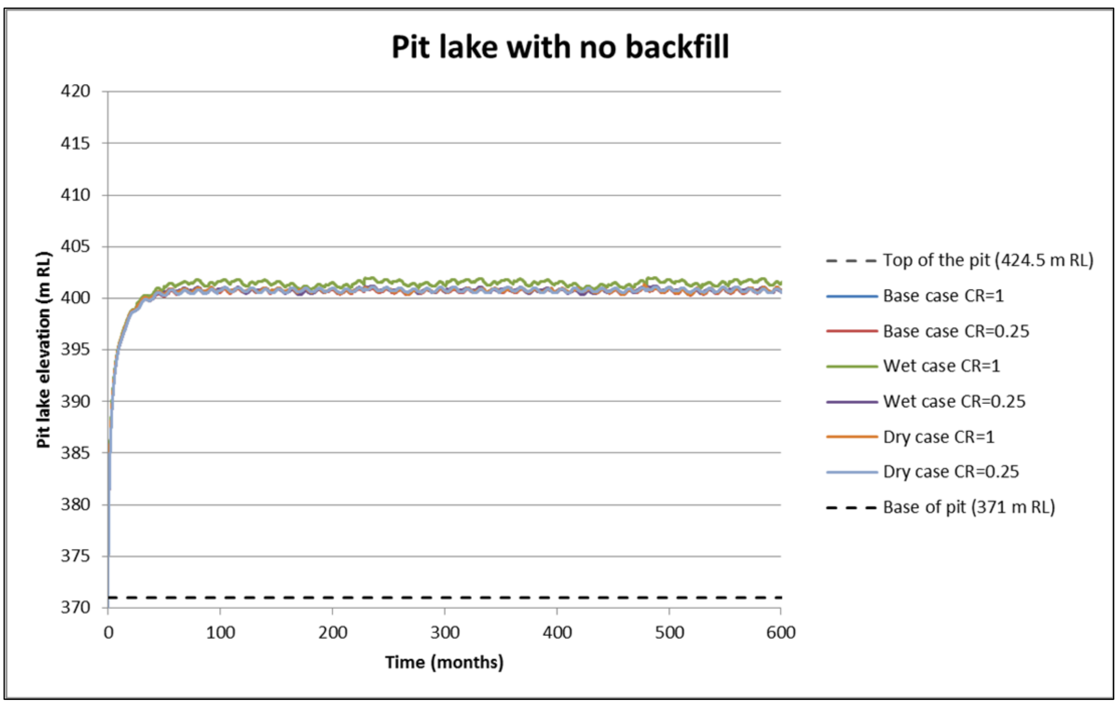


Figure 5-1: Simulated pit lake elevation for 50 year period

Note: C_R = Pit runoff coefficient

Table 5-1: Final pit lake levels and equilibrium times

Rainfall climatic scenario	Runoff coefficient	Final (equilibrium) pit water elevation (m RL)	Time to reach equilibrium (months)
Base case	1	401.0	92
	0.25	400.9	92
Dry case	1	400.9	56
	0.25	400.8	56
Wet case	1	401.8	79
	0.25	401.1	80

The results indicate that the steady-state lake level would be reached in approximately 90 months (7.5 years) for the base rainfall climatic scenario, approximately 80 months (6.5 years) for the wet rainfall climatic scenario, and approximately 55 month (4.5 years) for the dry rainfall climatic scenario.

Figure 5-2 illustrates the transient relationships between the inflows and water loss through evaporation for the first 10 years of simulation.

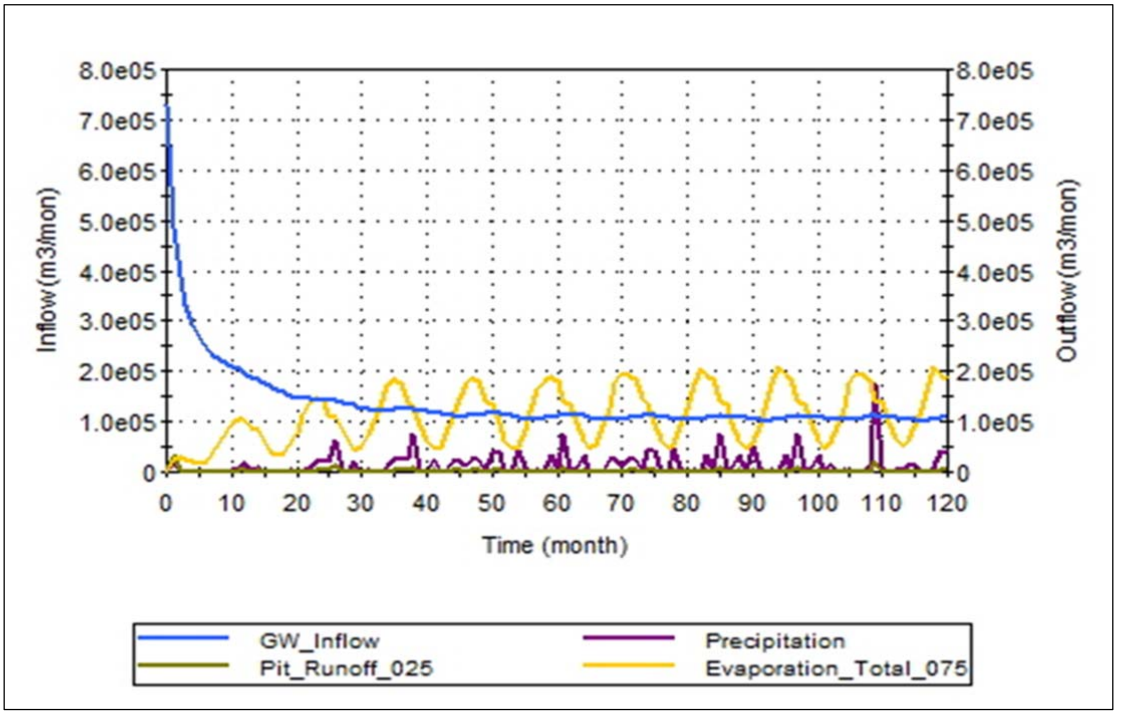


Figure 5-2: Simulated water balance for first 10 years (reference case)

Note: Base case rainfall scenario, CR = 0.25

As a result of the monthly time-step, these relationships vary seasonally.

The lake water balance is largely controlled by the water elevation which dictated the:

- Groundwater inflow rate; and
- Rate of evaporation.

The volume of pit wall rock runoff is minor in comparison with other inflows.

The water balance representing steady-state conditions at 100 year for the three rainfall climatic scenarios (base case, dry case and wet case) is presented in Table 5-2.

Table 5-2: Simulated water balance at steady state conditions (100 year simulation)

Rainfall climatic scenario	Runoff coefficient	Steady state water elevation (m RL)	Direct precipitation (m^3/month)	Pit wall runoff (m^3/month)	Groundwater inflow (m^3/month)	Total inflow (m^3/month)	Total outflow /evaporation (m^3/month)
Base case	1	401.0	25,675	11,047	1.09×10^5	1.46×10^5	1.83×10^5
	0.25	400.9	25,576	2,787	1.10×10^5	1.39×10^5	1.82×10^5
Dry case	1	400.9	11,203	4,901	1.11×10^5	1.27×10^5	1.82×10^5
	0.25	400.8	11,175	1,232	1.12×10^5	1.24×10^5	1.82×10^5
Wet case	1	401.8	27,509	10,807	1.07×10^5	1.45×10^5	1.88×10^5
	0.25	401.1	26,853	2,866	1.09×10^5	1.38×10^5	1.84×10^5

As noted before, the pit void would remain a long term groundwater sink due to evaporation exceeding the combined inflows.

As a result water would not leave the pit, and solute concentrations would be expected to increase over time due to evapo-concentration. Figure 5-3 presents the result of the predicted total dissolved solute concentrations in the pit lake over time for the base climatic scenario and various groundwater TDS concentrations (minimum TDS ~ 10,000, average TDS ~ 24,000 mg/L; and maximum TDS ~70,000 mg/L).

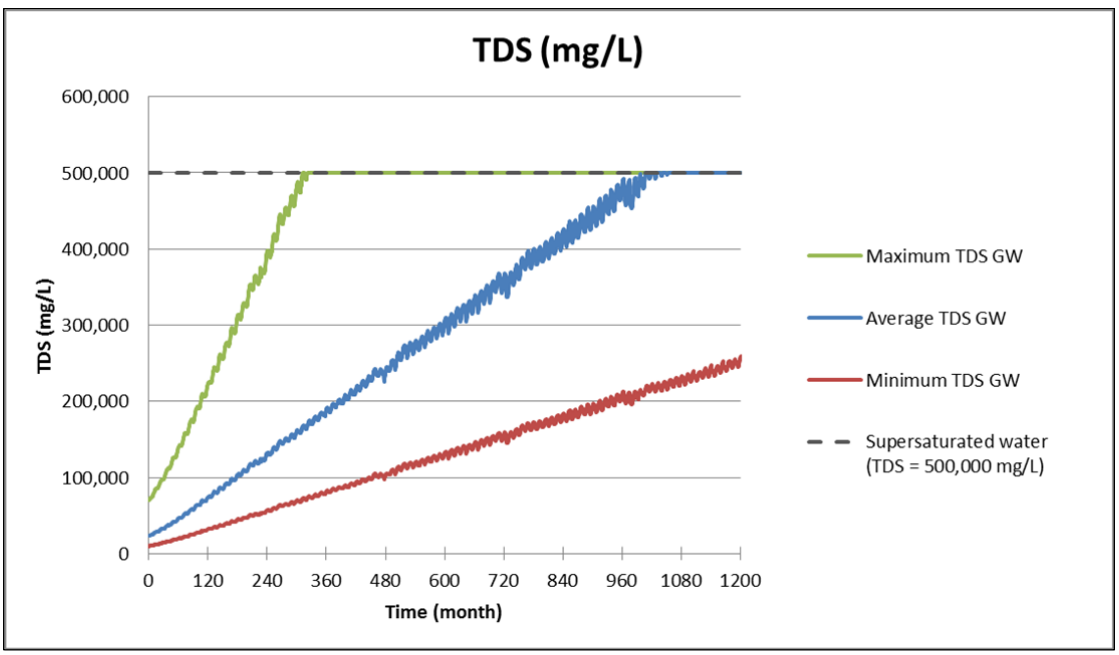


Figure 5-3: TDS concentration for 100 year simulation (reference case)

Note: Base case rainfall scenario, C_R = 0.25

5.2 Scenario 2 - Permitted base case (waste rock backfill to WT, tailings above)

This scenario represents the current FMG permitted pit void backfilling option. It has the pit backfilled with waste rock to the pre-mining water level (~ 410 m RL), with tailings placed above the water table to an elevation of 424.5 m RL. In this scenario waste rock deposition occurs at a rate of 780,000 m^3 per month for a swelling factor of 30% and a porosity of 40%.

Details of waste rock and tailings deposition, phreatic surface elevation and time to reach equilibrium are summarised in Table 5-3. The modelled phreatic surface and tailings elevation with time are presented in Figure 5-4 and Figure 5-5. Figure 5-6 illustrates the transient relationships between the components of the water balance for the first 10 years of simulation.

Table 5-3: Waste rock and tailing deposition time, phreatic surface elevation and equilibrium times

Waste rock deposition time (month)	Tailings deposition time (month)	Total deposition time (months)	Water level at end of deposition (m RL)	Phreatic surface elevation (m RL) at 100 years	Phreatic surface elevation at equilibrium (m RL)	Time to reach equilibrium (years)
1 to 16	17 to 89	89	424.5	424.42	410	100,000 <

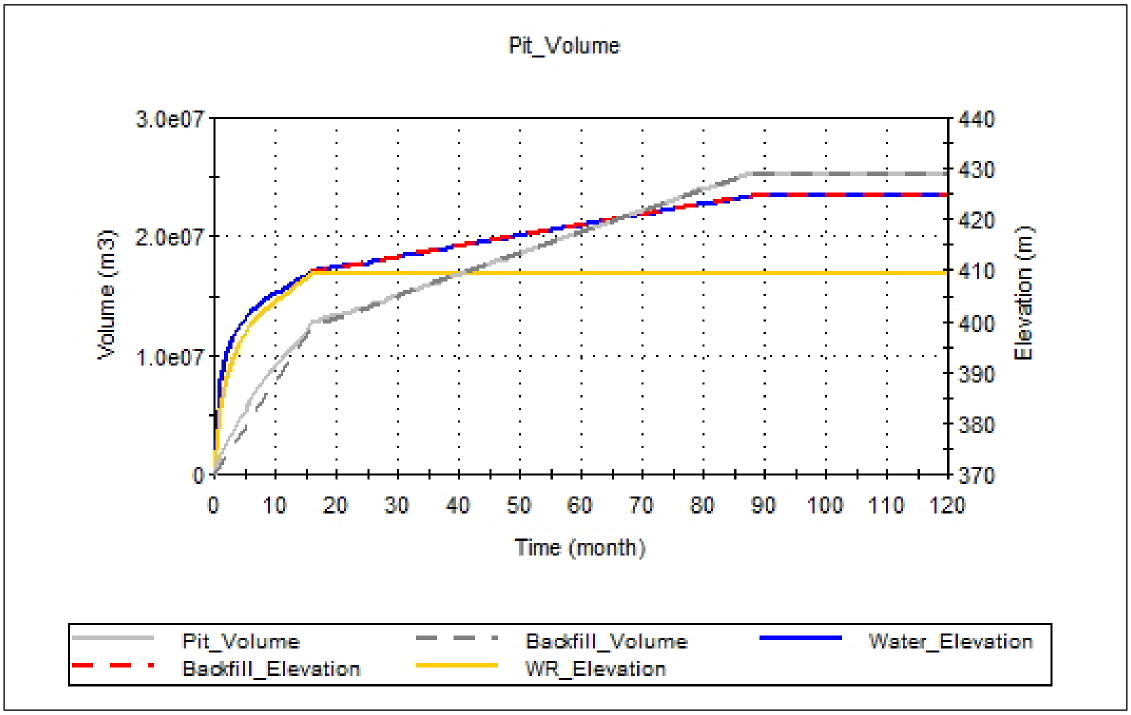


Figure 5-4: Pit water level, tailing level, pit water volume and tailing volume for 10 year simulation (permitted base case)

Note: Base case rainfall scenario, C_R = 0.25

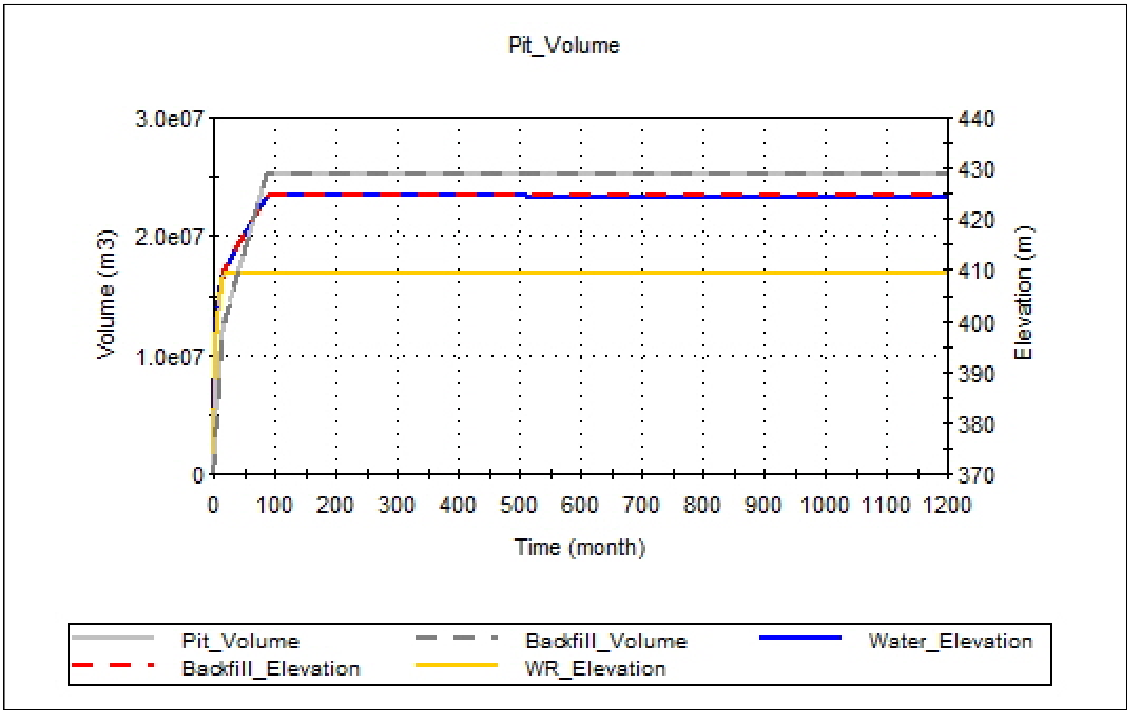


Figure 5-5: Pit water level, tailing level, pit water volume and tailing volume for 100 year simulation (permitted base case)

Note: Base case rainfall scenario, C_R = 0.25

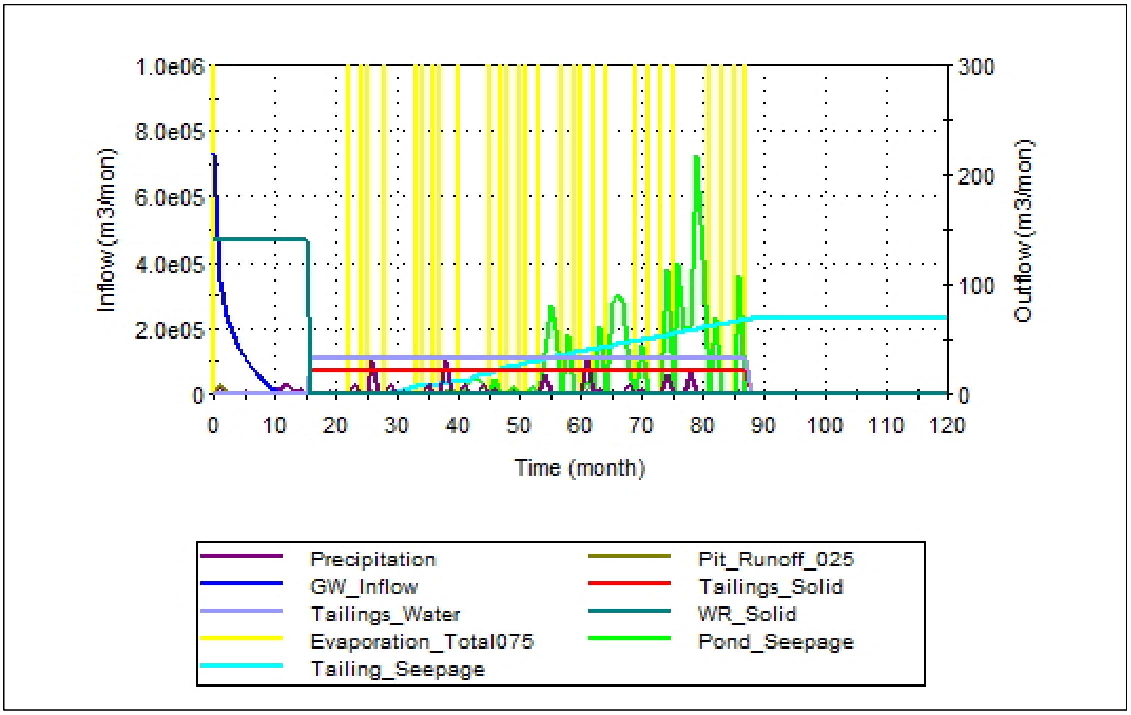


Figure 5-6: Transient relationships between water balance components for 10 year simulation (permitted base case)

Note: Base case rainfall scenario, C_R = 0.25

The model results indicate that the waste rock deposition would occur under water as the groundwater inflow rapidly inundates the pit (Figure 5-4). Waste rock deposition would take approximately 16 months. As soon as the phreatic surface reaches the natural groundwater elevation (~ 410 m RL), the pit filled with waste rock would act as a groundwater flow-through system. The permeability of the waste rock deposit would be expected to be higher than the surrounding bedrock ($10^{-4} < K_{\text{Marra Mamba Fmn}} < 10^{-3}$ m/s, FMG, 2012), therefore the pore water displacement through the waste rock would be at the same rate as the local groundwater flow.

Tailings deposition above ~ 410 m RL would take approximately 72 months (6 years) to reach the final elevation of 424.5 m RL. During tailings deposition, seepage through the pit wall above the water table to the groundwater system underneath would occur from intermittent ponds developed along the pit wall and from the tailings deposit itself. The seepage rates from the pond would be driven by the pond elevation and the high permeability of the pit wall. The seepage rate from the tailings would be driven by the elevation of the phreatic surface within the tailings and the low permeability of the tailings ($K \sim 10^{-9}$ m/s).

At the end of the tailing deposition, the phreatic surface would be at ~ 424.5 m RL, well above the regional pre-mining groundwater level (~ 410 m RL) due to the low permeability of the tailings. This water mound would be expected to dissipate over a long time (decades to centuries) and the phreatic water level will equilibrate with the regional groundwater level (~ 410m RL) in the very long term. The seepage rate from the tailings post-deposition is estimated at less than 840 m^3/year.

Figure 5-7 and Figure 5-8 present the results for the predicted total dissolved solute concentrations in the backfill waste rock and tailings over time for the base climatic scenario and various groundwater TDS concentrations (minimum TDS ~ 10,000, average TDS ~ 24,000 mg/L; and maximum TDS ~70,000 mg/L).

The TDS concentrations in the waste rock pore water (Figure 5-7) would initially be controlled by the TDS concentrations of the groundwater and the solute release from the waste rock. In the longer term (i.e. after a complete pore water displacement) the pore water in the waste rock would approximate the quality of the local groundwater.

The TDS concentrations in the tailings pore water (Figure 5-8) are mainly controlled by the tailing supernatant (TDS ~ 6,400 mg/L), which presents TDS concentrations well below that of the local groundwater (10,000 < TDS < 70,000 mg/L). The initial small increase shown in the concentration profile occurs as a result of evaporation from the pond during active deposition. Thereafter the pore water is released.

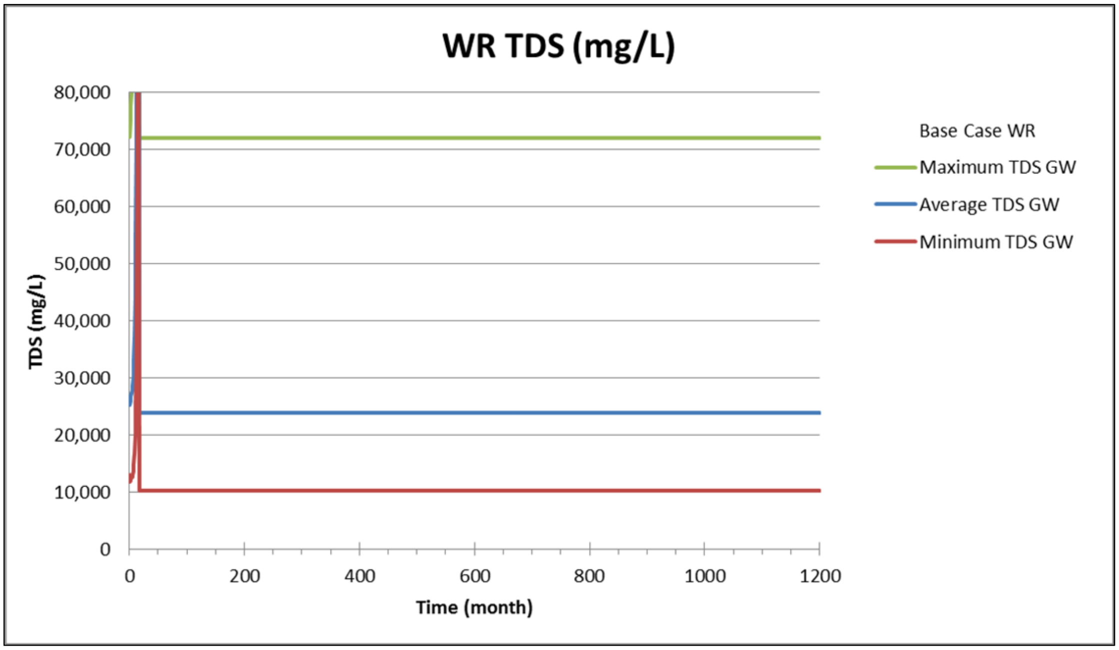


Figure 5-7: Simulated TDS concentration in saturated waste rock for 100 year simulation (permitted base case)

Note: Base case rainfall scenario, C_R = 0.25

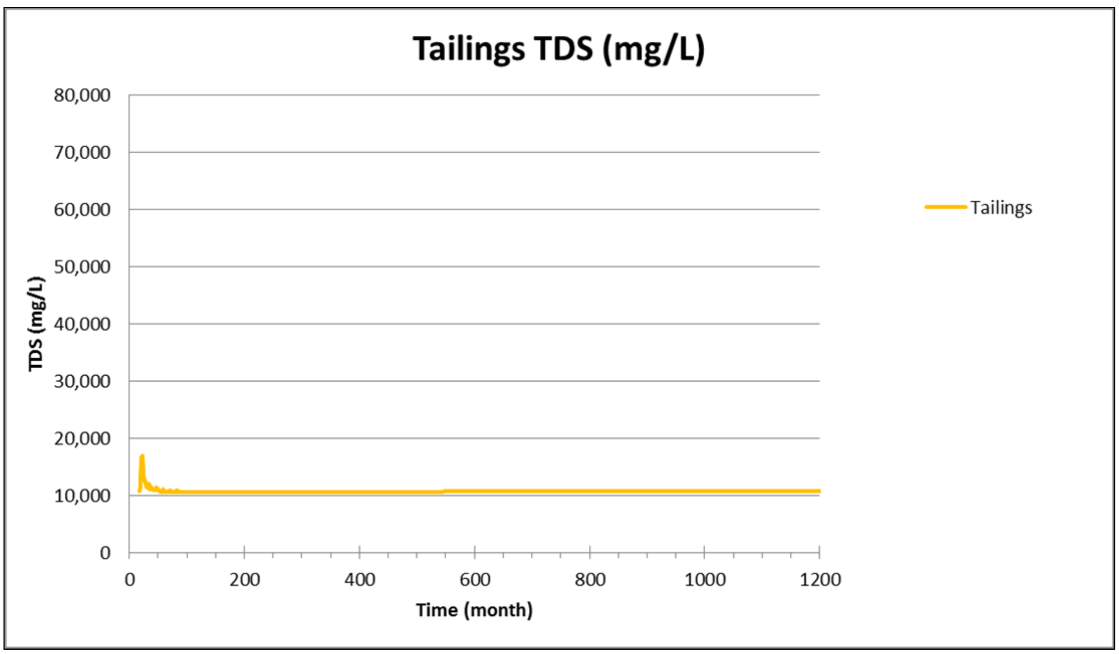


Figure 5-8: Simulated TDS concentration in tailing pore water for 100 year simulation (permitted base case)

Note: Base case rainfall scenario, C_R = 0.25

5.3 Scenario 3 - Alternative case (complete tailings backfill)

This scenario has the pit completely backfilled with tailings to 424.5 m RL (top of the pit area).

In this scenario, tailings deposition occurs at a rate of 270,000 dry tonnes per month.

Details of tailings deposition, phreatic surface elevation and time to reach equilibrium are summarised in Table 5-4. The estimated elevation of the phreatic surface and tailings elevation with time are shown in Figure 5-9 and Figure 5-10. Figure 5-11 illustrates the transient relationships between the components of the water balance for the first 20 years of simulation.

Table 5-4: Tailing deposition time, phreatic surface elevation and equilibrium times

Tailings deposition time (month)	Total deposition time (months)	Water level at end of deposition (m RL)	Phreatic surface elevation (m RL) at 100 years	Phreatic surface elevation at equilibrium (m RL)	Time to reach equilibrium (years)
1 to 121	121	424.5	424.42	410	100,000 <

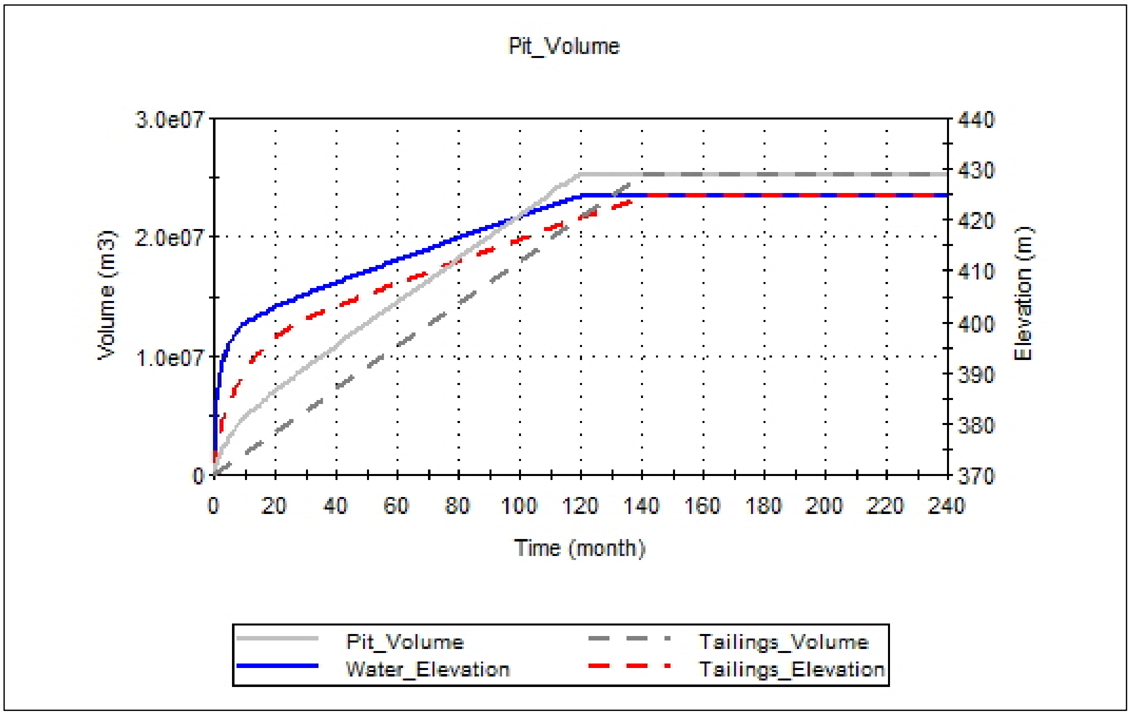


Figure 5-9: Pit water level, tailing level and pit water volume for 20 year simulation (alternative case)

Note: Base case rainfall scenario, C_R = 0.25

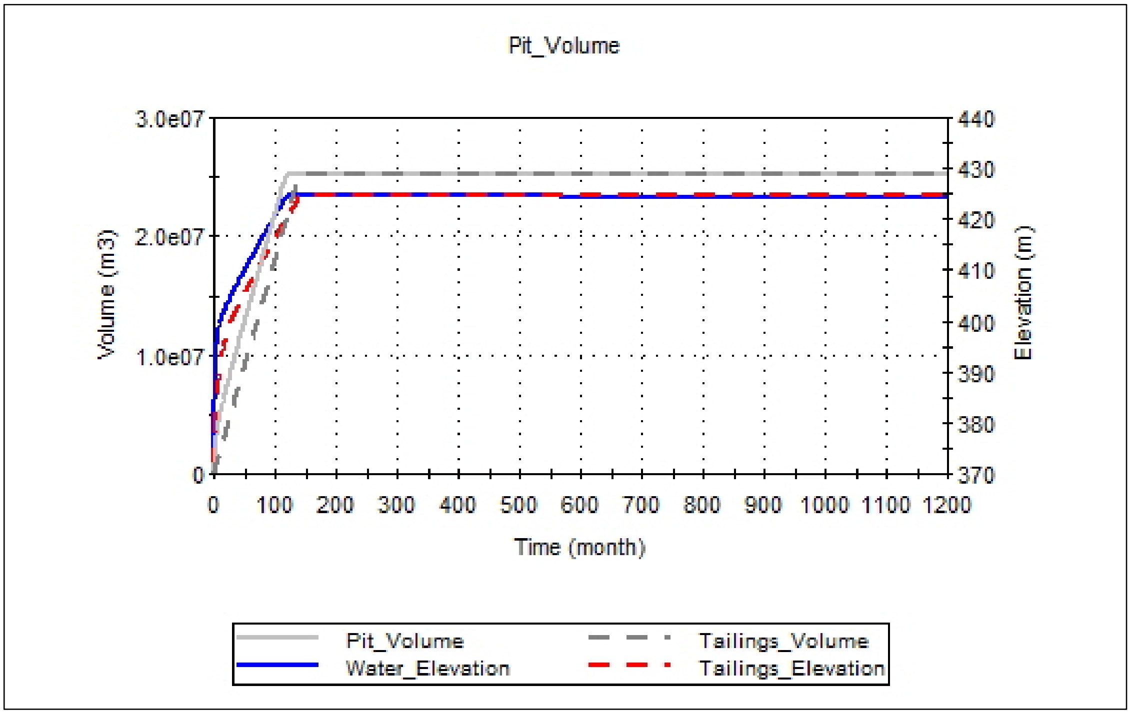


Figure 5-10: Pit water level, tailing level, pit water volume and tailing volume for 100 year simulation (alternative case)

Note: Base case rainfall scenario, C_R = 0.25

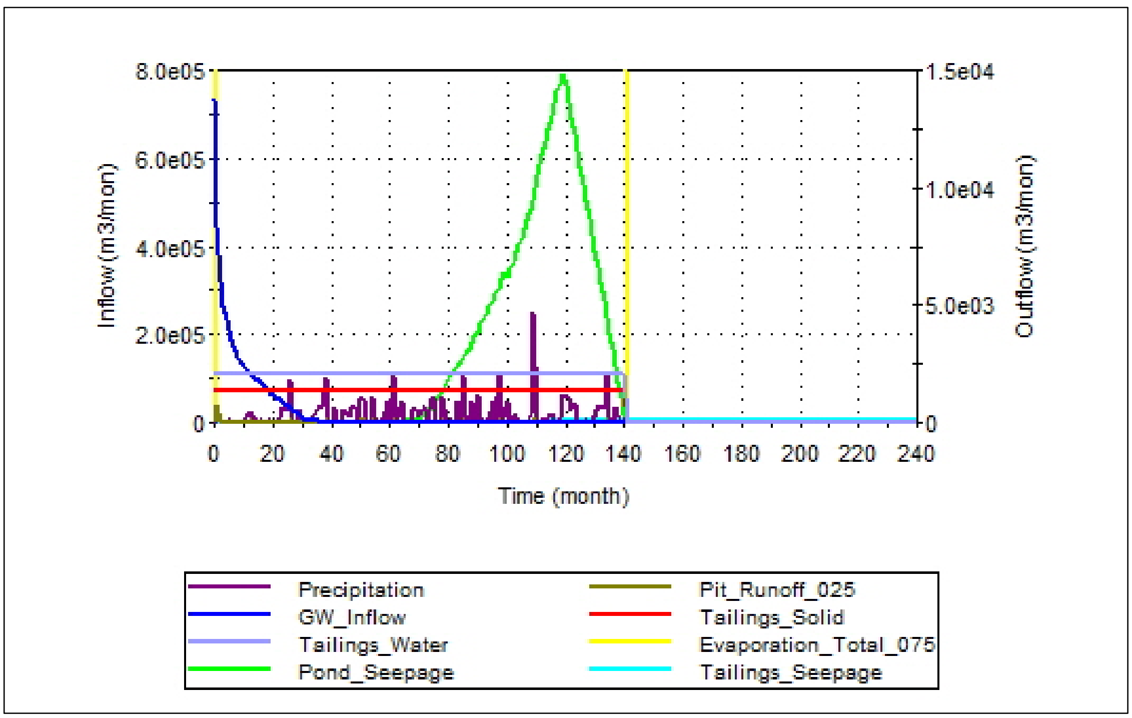


Figure 5-11: Transient relationships between water balance components for first 20 years of simulation (alternative case)

Note: Base case rainfall scenario, C_R = 0.25

The modelling results indicate that the tailings deposition would occur under water at all times as, initially the groundwater inflow rapidly inundates the pit void (Figure 5-9). Tailings deposition would take approximately 121 months (10 years). As for Scenario 2, at the end of deposition the phreatic surface would be at 424.5 m RL well above the regional pre-mining groundwater level (~ 410 m RL) due to the low permeability of the tailings (K ~ 10^{-9} m/s). Over time (decades to centuries), this raised phreatic surface would be expected to dissipate and the water level would equilibrate with the regional groundwater level (~ 410 m RL).

The backfilled void would no longer act as a sink and seepage would occur above the regional pre-mining groundwater level (~ 410 m RL). The tailings seepage rate post deposition would be expected to occur at a very low rate (< 840 m^3/year) due to the low hydraulic conductivity of the tailings material (K ~ 10^{-9} m/s). The groundwater flow would also tend to flow around the tailings deposit as a result of the low permeability of the tailings. This would continue to occur even after the phreatic surface reaches the regional groundwater elevation. The estimated flow through the tailings backfill would occur at a limited rate (about. 2,800 m^3/year compared to about 275 Mm^3/year through the waste rock) due to the low permeability of the tailings.

Figure 5-12 presents the predicted total dissolved solute concentrations in the pit backfilled with tailings over time for the base climatic scenario and various groundwater TDS concentrations (minimum TDS ~ 10,000, average TDS ~ 24,000 mg/L; and maximum TDS ~70,000 mg/L).

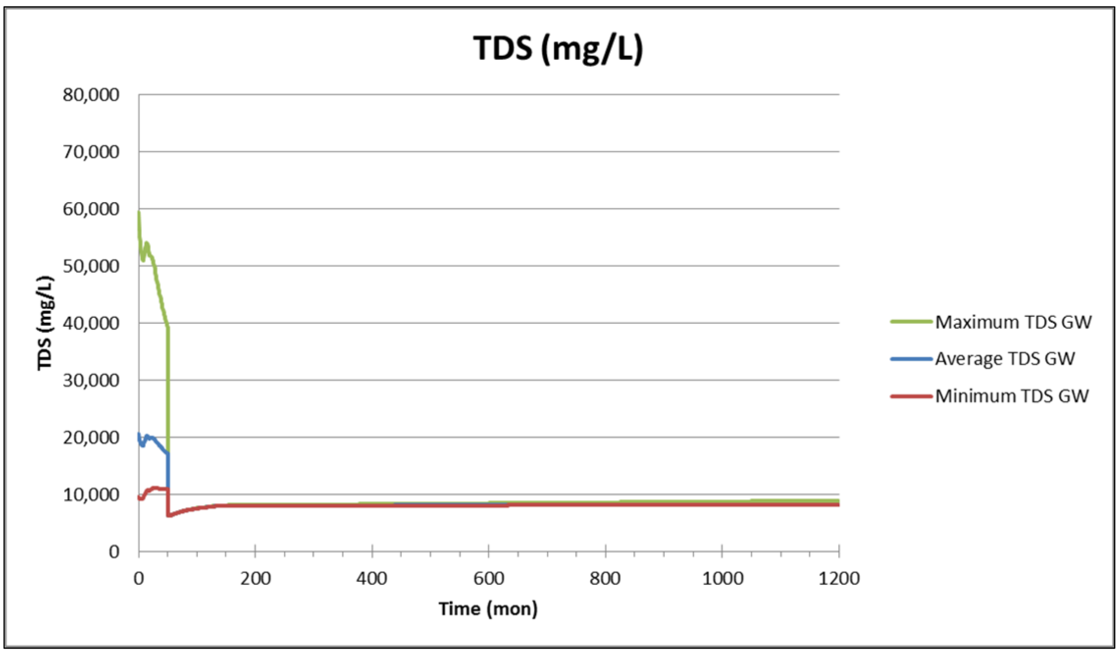


Figure 5-12: TDS concentration for 100 year simulation (alternative case)

Note: Base case rainfall scenario, C_R = 0.25

The quality of the water within the confines of the pit (i.e. pond and then pore water in the backfill) is initially controlled by the groundwater inflow (10,000 < TDS < 70,000 mg/L), after which the quality is improved through the introduction of tailings supernatant (TDS ~ 6,400 mg/L), surface water runoff and direct precipitation during deposition. At the end of the tailings deposition, the TDS concentrations in the backfill pore water has improved to that of the tailings supernatant and the TDS concentration is below the surrounding groundwater environment. With time the slight displacement of the pore water from the tailings with local groundwater would increase the TDS concentrations.

6 Impacts on Groundwater Regime and Mitigation Measures

6.1 Scenario 1 - Reference case (no backfill)

In this scenario, the pit void should remain a long term groundwater sink as evaporation outputs are greater than likely inputs from runoff, rainfall and groundwater inflow. A pit lake will therefore form.

Although the surrounding aquifers are not expected to be impacted in terms of groundwater quality due to groundwater flowing toward the void, water loss through pit lake evaporation is an irreversible loss of groundwater in an arid region for the groundwater system and evapo-concentration of the pit lake water over time would increase the TDS concentration. However, because of the pit would remain and indefinite sink, none of the TDS would be released to the receiving environment.

Mitigation, if required, could include backfilling of the pit void to above the regional groundwater table in order to avoid evaporative losses.

6.2 Scenario 2 - Permitted base case (waste rock backfill to WT, tailings above)

In this scenario the pit void acts as a flow through facility as soon as the phreatic surface in the backfill reaches the regional groundwater level (~420 m RL). The groundwater would flow through the waste rock backfill at the same rate as the local groundwater flow due to the high permeability of the waste rock.

The pore water displacement through the waste rock is estimated to be at 275 Mm^3/year, which would mean that the TDS concentrations would tend to approximate the groundwater concentrations. The tailing pore water TDS concentrations would be lower than the surrounding groundwater (10,000 < TDS < 70,000 mg/L) and the tailing seepage rate post-deposition (< 840 m^3/year) would be far less than the groundwater flow through the waste rock underneath the tailings. Consequently the impact of the seepage would be minimal.

As a result, no impact on the regional groundwater flow and TDS concentrations would be expected at a local and regional scale due to low tailing seepage rate, and the fact that evaporative losses would not be a factor.

6.3 Scenario 3 - Alternative case (complete tailings backfill)

As in the previous scenario, the backfilled void would no longer act as a sink and seepage would occur from the tailings above the regional pre-mining groundwater level (~ 410 m RL). Groundwater flows though the tailings below 410 m RL would occur at a limited rate (i.e. 2,800 m^3/year) due to the low permeability of the tailings (K ~ 10^{-9} m/s).

The long-term tailing seepage volume (< 840 m^3/year) and quality (~6,400 mg/L) is not expected to have any impact on the quality of the receiving waters (i.e. regional groundwater systems; 10,000 < TDS < 70,000 mg/L). Only, the very local groundwater flow would be affected, with a decrease in TDS indicated.

At the regional scale, the groundwater flow would not be affected detrimentally and no change in water quality (i.e. TDS concentration) of the local and regional groundwater flow system is expected to occur in the future. No impact on the downstream marsh is therefore expected.

7 Concluding Remarks

Not backfilling the pit would result in the formation of a pit lake that would represent an indefinite groundwater sink. This would lead to a net loss of groundwater and an increasing saline pit lake. However, the increased salinity would not impact on the groundwater system as it would be contained within the drawdown zone. The net loss of groundwater (about 0.5 % of local groundwater flow) would not be expected to result in any significant impacts on the downstream environment.

In contrast, neither backfill option would cause a long term loss of groundwater. Both backfill options are expected to cause localised groundwater mounding during operations, with a longer term dissipation of a phreatic surface that would persist in the tailings deposit above the water table. Due to the lower TDS concentration of the tailings, the TDS of the groundwater locally may be lowered. However, the effect is expected to be minimal.

It is the opinion of SRK that the consequences of the Complete Tailings Backfill of the Flinders pit would be indistinguishable from the partial back fill option (i.e. currently permitted case) and should not have any significant impacts on the regional groundwater system and its groundwater dependant ecosystems (e.g. the downstream marsh).

Compiled by

Sylvie Ogier-Halim
Senior Consultant

Peer Reviewed by

David Whiting
Principal Consultant (Hydrogeology)

John Chapman
Principal Consultant (Environment)

8 References

FMG, 2012. Hydrogeological assessment of the Christmas Creek life of mine water management scheme. June 2012.

FMG, 2012. Hydrogeological assessment of the Christmas Creek life of mine water management scheme. June 2012.

Golder Associates, 2013. Windich In-pit TSF Waste rock and tailings static geochemical characterisation. March 2013.

Golder Associates, 2013. Windich In-pit TSF Waste rock and tailings static geochemical characterisation. March 2013.

Golder, Associates, 2012. Geotechnical Laboratory Testing Results for Windich In-pit TSF, August 2012.

Golder, Associates, 2012. Geotechnical Laboratory Testing Results for Windich In-pit TSF, August 2012.

Kohler, M A and Parmele, L H, 1967. Generalized estimates of free-water evaporation. *Water Resources Research*, 3 (4): 997-1005.

Niccoli, W L, 2009. Hydrologic characteristics and classifications of pit lakes, in Castendyk D, Eary T, (Eds), *2009 Mine Pit Lakes: Characteristics, Predictive Modeling, and Sustainability,* Colorado, USA, Society for Mining Engineering (SME), pp 33-43.

Tetra Tech (2013). Cloudbreak and Christmas Creek Tailings Static Testing Report. December 2013.

Appendices

Appendix A: Rainfall sequences

Date	Base Scenario	Dry Scenario	Wet Scenario
15/07/2007	7.2	4.176	9.936
15/08/2007	0	0	0
15/09/2007	0	0	0
15/10/2007	2.8	1.624	3.864
15/11/2007	2.2	1.276	3.036
15/12/2007	28.8	16.704	39.744
15/01/2008	49.5	28.71	68.31
15/02/2008	55.5	32.19	76.59
15/03/2008	66	38.28	91.08
15/04/2008	2.5	1.45	3.45
15/05/2008	0	0	0
15/06/2008	49	28.42	67.62
15/07/2008	0	0	0
15/08/2008	0	0	0
15/09/2008	3	1.74	4.14
15/10/2008	11	6.38	15.18
15/11/2008	1	0.58	1.38
15/12/2008	73	42.34	100.74
15/01/2009	31	17.98	42.78
15/02/2009	165.5	95.99	228.39
15/03/2009	23	13.34	31.74
15/04/2009	0	0	0
15/05/2009	3	1.74	4.14
15/06/2009	7.5	4.35	10.35
15/07/2009	2	1.16	2.76
15/08/2009	0	0	0
15/09/2009	0	0	0
15/10/2009	0	0	0
15/11/2009	8	4.64	11.04
15/12/2009	21	12.18	28.98
15/01/2010	41	23.78	56.58
15/02/2010	7.5	4.35	10.35
15/03/2010	17.5	10.15	24.15
15/04/2010	2	1.16	2.76
15/05/2010	4.5	2.61	6.21
15/06/2010	1.5	0.87	2.07
15/07/2010	14	8.12	19.32
15/08/2010	2	1.16	2.76
15/09/2010	29	16.82	40.02
15/10/2010	0	0	0
15/11/2010	15.8	9.164	21.804
15/12/2010	5.5	3.19	7.59
15/01/2011	95.7	55.506	132.066
15/02/2011	178	103.24	245.64
15/03/2011	44	25.52	60.72

Date	Base Scenario	Dry Scenario	Wet Scenario
15/04/2011	29	16.82	40.02
15/05/2011	17	9.86	23.46
15/06/2011	17.5	10.15	24.15
15/07/2011	22.9	13.282	31.602
15/08/2011	0	0	0
15/09/2011	0	0	0
15/10/2011	0	0	0
15/11/2011	55.2	32.016	76.176
15/12/2011	13	7.54	17.94
15/01/2012	409.1	237.278	564.558
15/02/2012	13	7.54	17.94
15/03/2012	42.5	24.65	58.65
15/04/2012	1.4	0.812	1.932
15/05/2012	0	0	0
15/06/2012	0	0	0
15/07/2012	7.2	4.176	9.936
15/08/2012	0	0	0
15/09/2012	0	0	0
15/10/2012	2.8	1.624	3.864
15/11/2012	2.2	1.276	3.036
15/12/2012	28.8	16.704	39.744
15/01/2013	49.5	28.71	68.31
15/02/2013	55.5	32.19	76.59
15/03/2013	66	38.28	91.08
15/04/2013	2.5	1.45	3.45
15/05/2013	0	0	0
15/06/2013	49	28.42	67.62
15/07/2013	0	0	0
15/08/2013	0	0	0
15/09/2013	3	1.74	4.14
15/10/2013	11	6.38	15.18
15/11/2013	1	0.58	1.38
15/12/2013	73	42.34	100.74
15/01/2014	31	17.98	42.78
15/02/2014	165.5	95.99	228.39
15/03/2014	23	13.34	31.74
15/04/2014	0	0	0
15/05/2014	3	1.74	4.14
15/06/2014	7.5	4.35	10.35
15/07/2014	2	1.16	2.76
15/08/2014	0	0	0
15/09/2014	0	0	0
15/10/2014	0	0	0
15/11/2014	8	4.64	11.04
15/12/2014	21	12.18	28.98

Date	Base Scenario	Dry Scenario	Wet Scenario
15/01/2015	41	23.78	56.58
15/02/2015	7.5	4.35	10.35
15/03/2015	17.5	10.15	24.15
15/04/2015	2	1.16	2.76
15/05/2015	4.5	2.61	6.21
15/06/2015	1.5	0.87	2.07
15/07/2015	0	1.537	0
15/08/2015	6.2	0.768	8.75
15/09/2015	0.8	0	0
15/10/2015	1	0	0
15/11/2015	17.8	0.22	20.923
15/01/2016	41.6	27.771	18.64
15/01/2016	39	70.123	35.092
15/02/2016	42.2	18.631	260.14
15/03/2016	122.8	16.665	39.294
15/04/2016	8.2	0	18.071
15/05/2016	0	0	10.086
15/06/2016	39.2	27.525	0
15/07/2016	0	0	13.869
15/08/2016	6.2	0	0
15/09/2016	0.8	22.282	2.101
15/10/2016	1	0	16.18
15/11/2016	17.8	0	9.666
15/01/2017	41.6	0.936	56.315
15/01/2017	39	21.252	27.23
15/02/2017	42.2	92.465	62.239
15/03/2017	122.8	3.883	58.683
15/04/2017	8.2	8.378	0
15/05/2017	0	81.942	88.358
15/06/2017	39.2	46.59	0
15/07/2017	0	3.269	76.688
15/08/2017	0	36.373	10.892
15/09/2017	35.6	0	2.779
15/10/2017	32	0	3.557
15/11/2017	17.8	8.174	0
15/01/2018	41.6	7.765	61.128
15/01/2018	41.2	30.251	41.166
15/02/2018	6.6	4.35	338.181
15/03/2018	64.6	29.262	36.518
15/04/2018	66	0.297	35.412
15/05/2018	0	32.03	23.46
15/06/2018	0	76.912	19.034
15/07/2018	69	24.913	24.788
15/08/2018	9.8	0	0
15/09/2018	2.5	0	4.648

Date	Base Scenario	Dry Scenario	Wet Scenario
15/10/2018	3.2	0	1.328
15/11/2018	0	0	0.443
15/01/2019	55	7.513	1.107
15/01/2019	8.1	0	229.433
15/02/2019	124.5	0	57.307
15/03/2019	7.4	0	105.956
15/04/2019	14.6	0	37.517
15/05/2019	55.6	0	0
15/06/2019	1.2	1.367	1.237
15/07/2019	0	0	0
15/08/2019	0	0	0
15/09/2019	35.6	0	36.693
15/10/2019	32	0	32.982
15/11/2019	17.8	0	18.346
15/01/2020	41.6	61.18	42.877
15/01/2020	41.2	7.599	160.698
15/02/2020	6.6	6.231	123.778
15/03/2020	64.6	14.893	2.988
15/04/2020	66	1.216	95.608
15/05/2020	0	4.59	62.956
15/06/2020	0	0	1.28
15/07/2020	69	1.216	7.683
15/08/2020	9.8	0	2.134
15/09/2020	2.5	0.608	8.963
15/10/2020	3.2	9.058	5.549
15/11/2020	0	0	0
15/12/2020	55	1.185	1.921
15/01/2021	8.1	3.366	31.576
15/02/2021	124.5	89.21	8.037
15/03/2021	7.4	0	2.488
15/04/2021	14.6	0	5.932
15/05/2021	55.6	0	2.488
15/06/2021	1.2	8.416	57.027
15/07/2021	69	0	49.755
15/08/2021	9.8	0	27.94
15/09/2021	2.5	0	0
15/10/2021	3.2	3.179	0.191
15/11/2021	0	0	14.927
15/12/2021	55	1.87	199.213
15/01/2022	8.1	21.938	164.568
15/02/2022	124.5	278.865	171.211
15/03/2022	7.4	12.253	61.689
15/04/2022	14.6	0	17.842
15/05/2022	55.6	4.546	0
15/06/2022	1.2	7.905	0

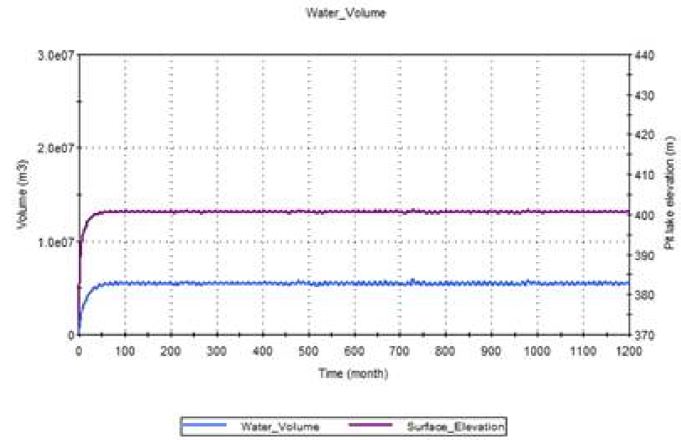
Date	Base Scenario	Dry Scenario	Wet Scenario
15/07/2022	22.4	0	0
15/08/2022	0	0	0
15/09/2022	4.2	0	0
15/10/2022	1.2	0	0.19
15/11/2022	0.4	3.162	13.287
15/12/2022	1	40.911	58.083
15/01/2023	22.2	18.535	34.901
15/02/2023	282.2	41.099	286.712
15/03/2023	12.4	20.751	30.96
15/04/2023	0	45.33	30.022
15/05/2023	4.6	0	19.89
15/06/2023	8	1.511	16.137
15/07/2023	17.9	0	21.016
15/08/2023	23.7	0.806	0
15/09/2023	0	1.007	3.94
15/10/2023	2.5	0.604	1.126
15/11/2023	10.1	11.484	0.375
15/12/2023	69.4	57.72	0.938
15/01/2024	62.6	17.657	33.452
15/02/2024	61.6	14.479	8.515
15/03/2024	30.8	34.607	2.636
15/04/2024	45.8	2.825	6.285
15/05/2024	4	10.665	2.636
15/06/2024	0.8	0	60.416
15/07/2024	0	2.825	52.712
15/08/2024	6.2	0	29.6
15/09/2024	0.8	1.413	0
15/10/2024	1	21.047	0.203
15/11/2024	17.8	0	15.814
15/12/2024	41.6	2.754	211.05
15/01/2025	39	0	142.392
15/02/2025	42.2	0	148.14
15/03/2025	122.8	0	53.376
15/04/2025	8.2	0	15.438
15/05/2025	0	0	0
15/06/2025	39.2	0.378	0
15/07/2025	22.4	0	0
15/08/2025	0	0	0
15/09/2025	4.2	0	0
15/10/2025	1.2	0	0.164
15/11/2025	0.4	0	11.496
15/12/2025	1	16.913	50.256
15/01/2026	22.2	3.882	39.092
15/02/2026	282.2	102.877	42.3
15/03/2026	12.4	0	123.09

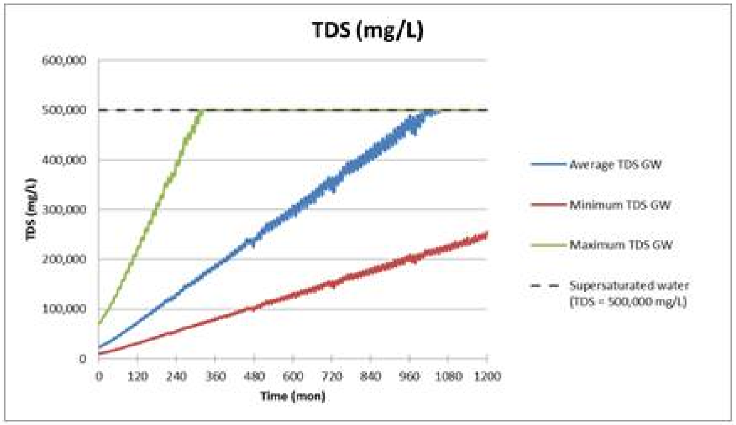
Date	Base Scenario	Dry Scenario	Wet Scenario
15/04/2026	0	0	8.219
15/05/2026	4.6	0	0
15/06/2026	8	9.705	39.293
15/07/2026	17.9	0	1.804
15/08/2026	23.7	0	0
15/09/2026	0	0	0.401
15/10/2026	2.5	3.666	0.401
15/11/2026	10.1	0	65.354
15/12/2026	69.4	2.157	1.804
15/01/2027	62.6	33.092	16.771
15/02/2027	61.6	4.758	3.144
15/03/2027	30.8	32.011	121.587
15/04/2027	45.8	0.324	0
15/05/2027	4	35.039	0
15/06/2027	0.8	84.136	0
15/07/2027	22.4	27.252	12.788
15/08/2027	0	0	0
15/09/2027	4.2	0	0
15/10/2027	1.2	0	0
15/11/2027	0.4	0	0
15/12/2027	1	8.219	3.983
15/01/2028	22.2	59.77	2.476
15/02/2028	282.2	48.998	65.627
15/03/2028	12.4	17.254	0
15/04/2028	0	0	0
15/05/2028	4.6	0	0
15/06/2028	8	5.72	6.191

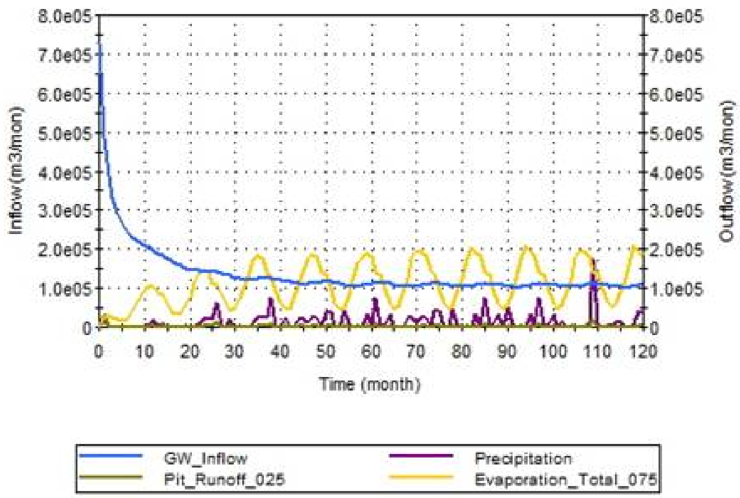
Appendix B: Water Balance and TDS Concentration Summary Results

Reference Case (no backfill)

Base case scenario

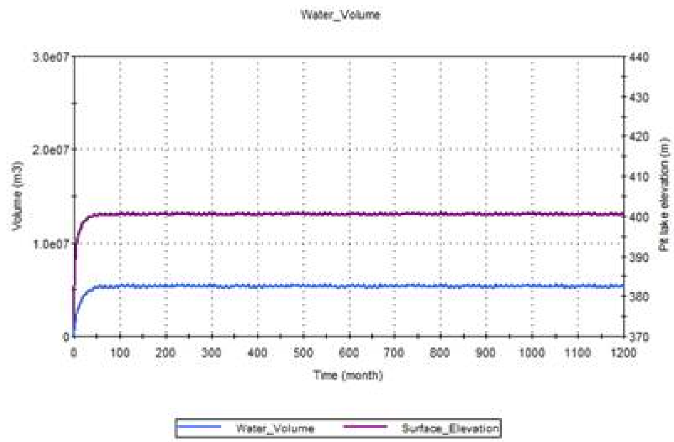


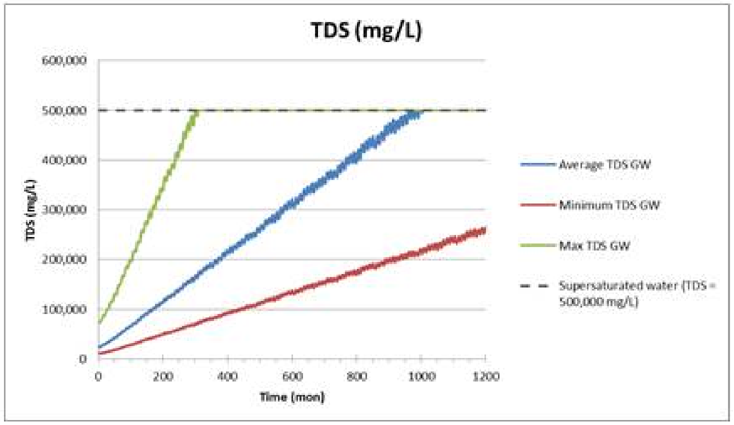


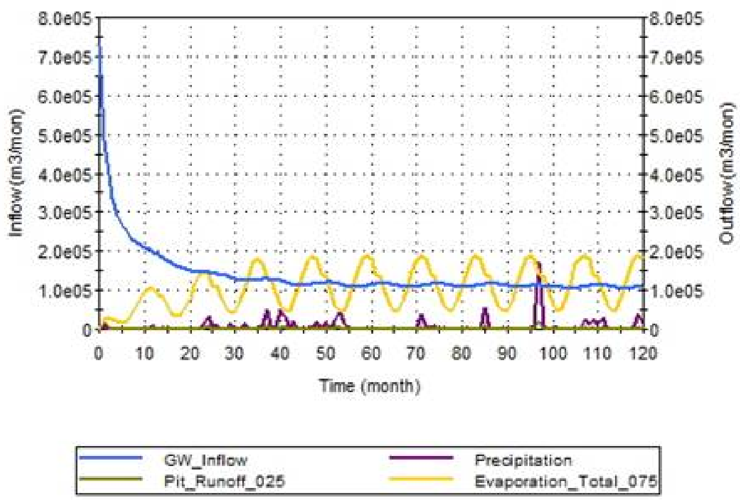


Reference Case (no backfill)

Dry case scenario

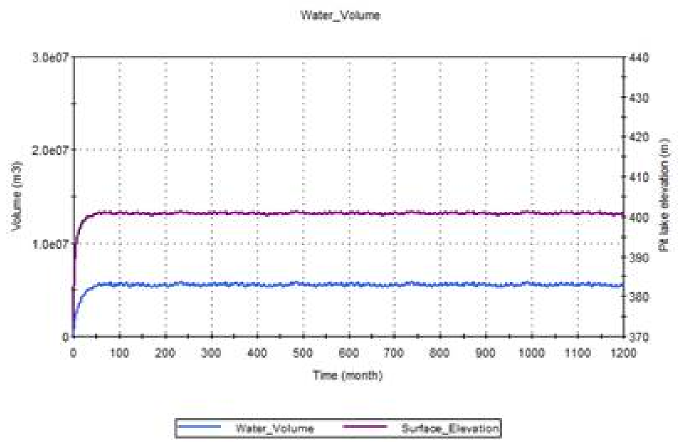


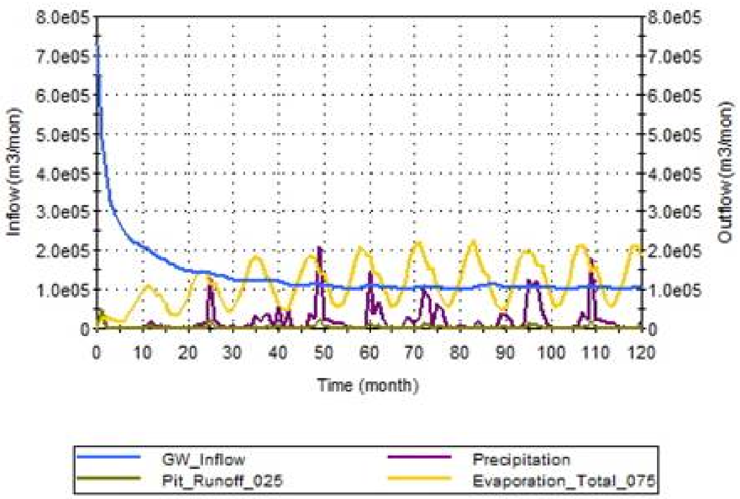


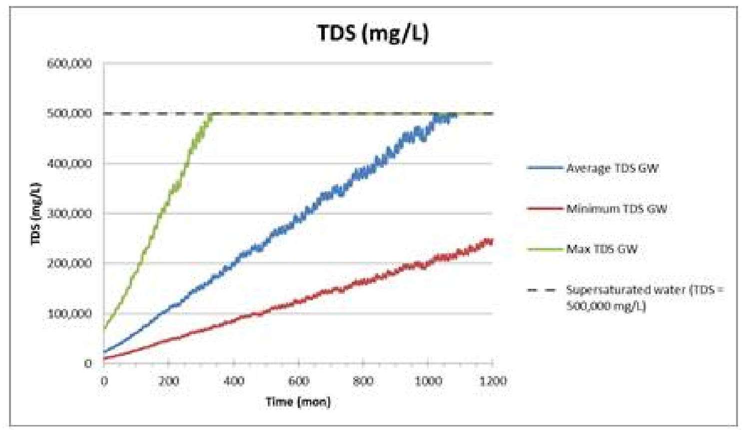


Reference Case (no backfill)

Wet case scenario

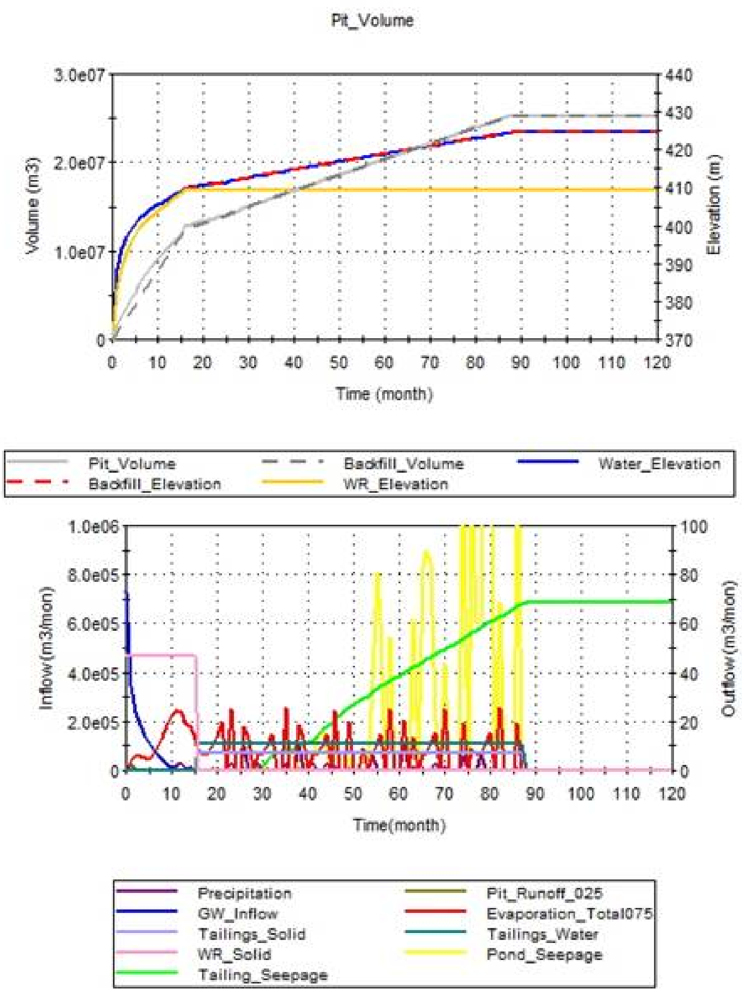


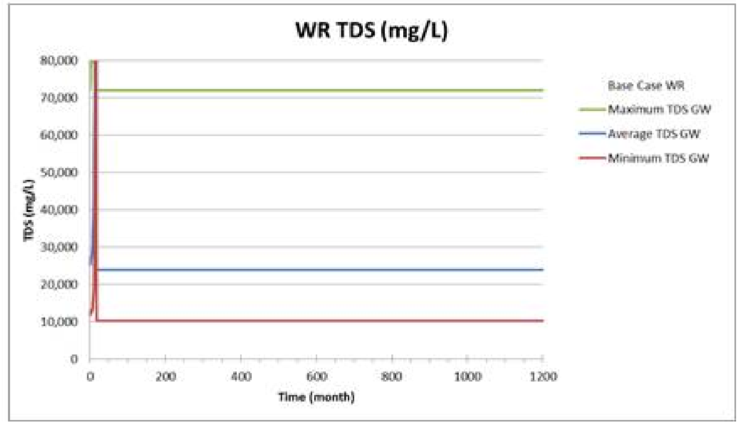


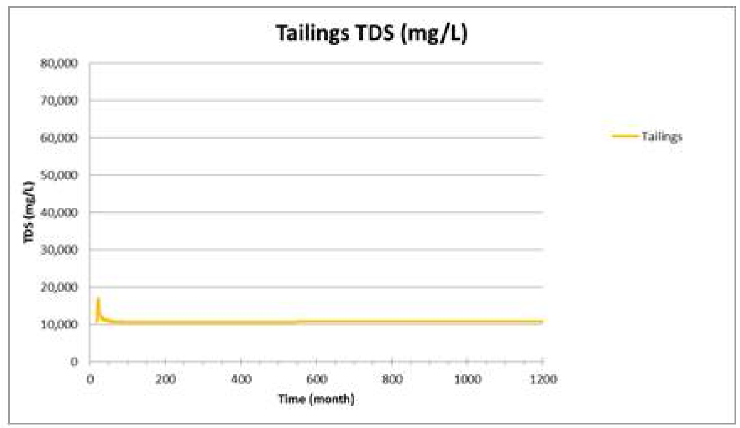


Permitted Base Case (waste rock backfill to WT and tailings backfill above)

Base case scenario

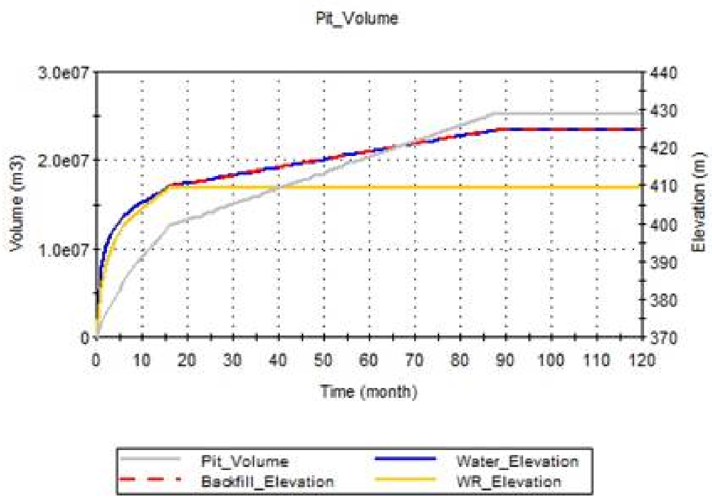


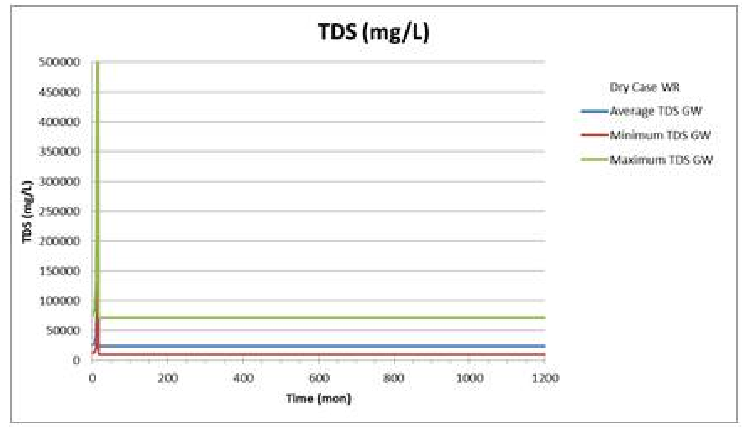


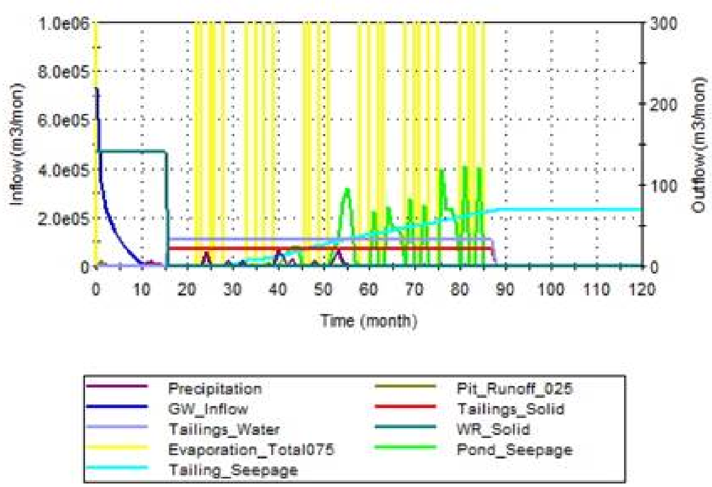


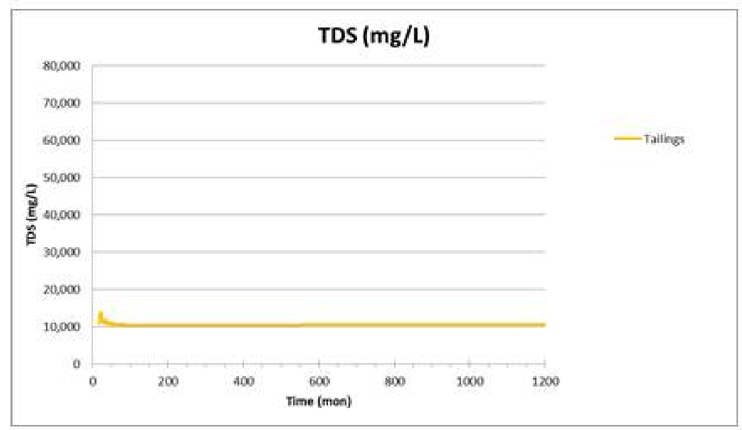
Permitted Base Case (waste rock backfill to WT and tailings backfill above)

Dry case scenario



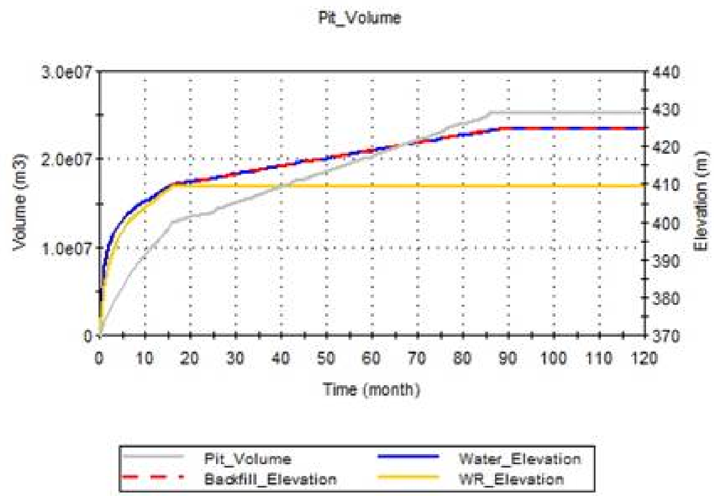


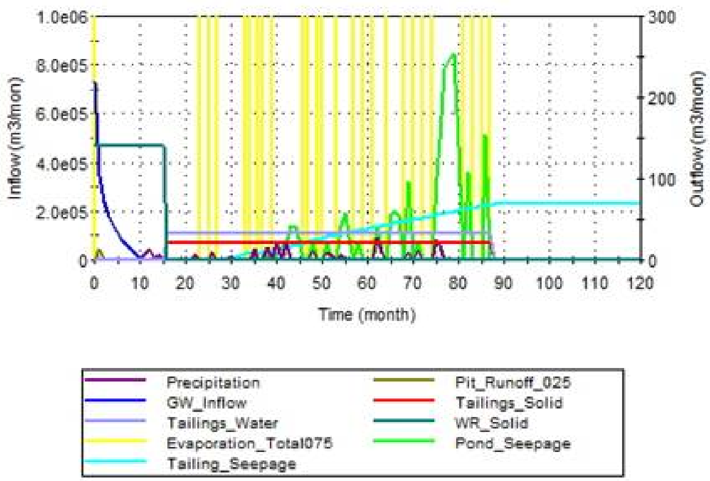


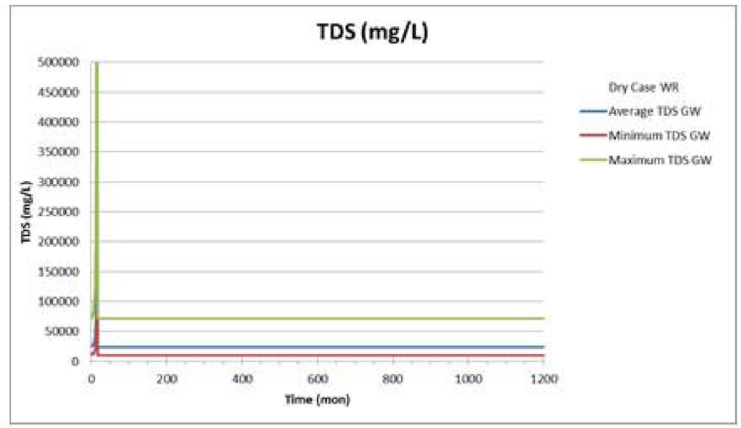


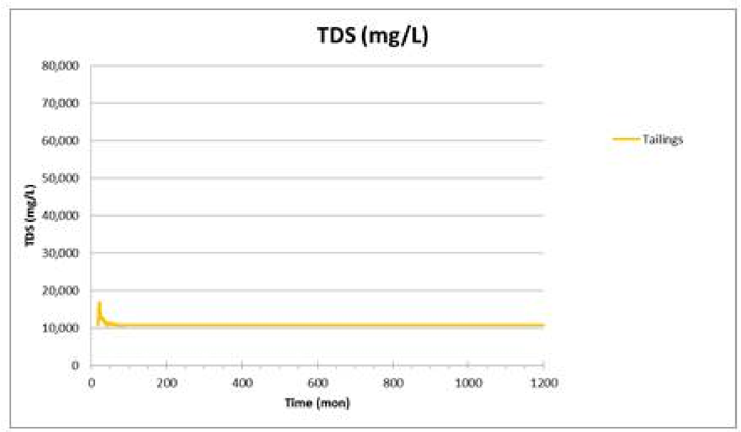
Permitted Base Case (waste rock backfill to WT and tailings backfill above)

Wet case scenario



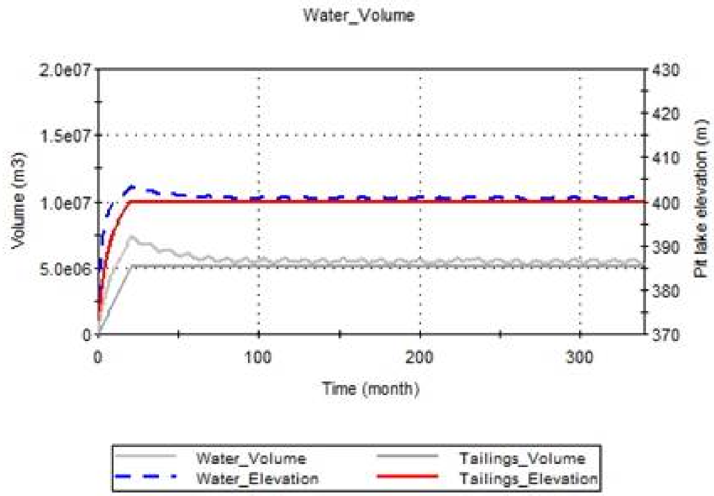


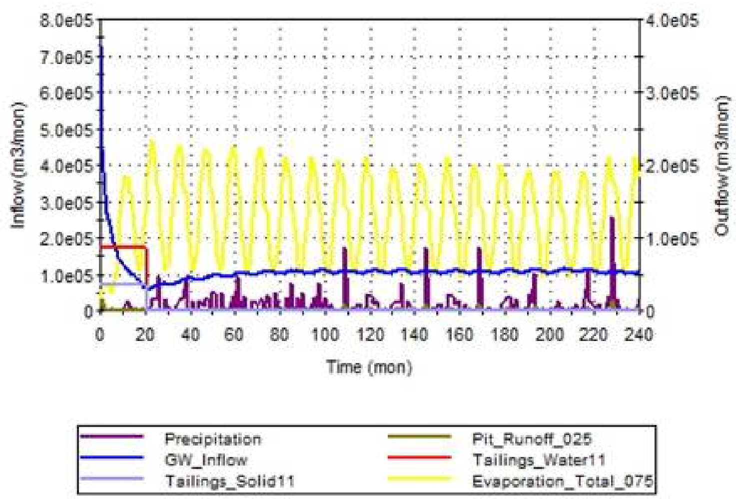


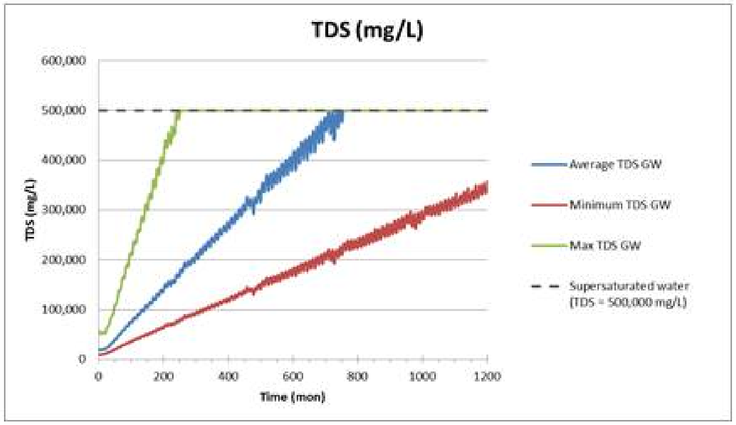


Alternative Case (partial backfill)

Base case scenario

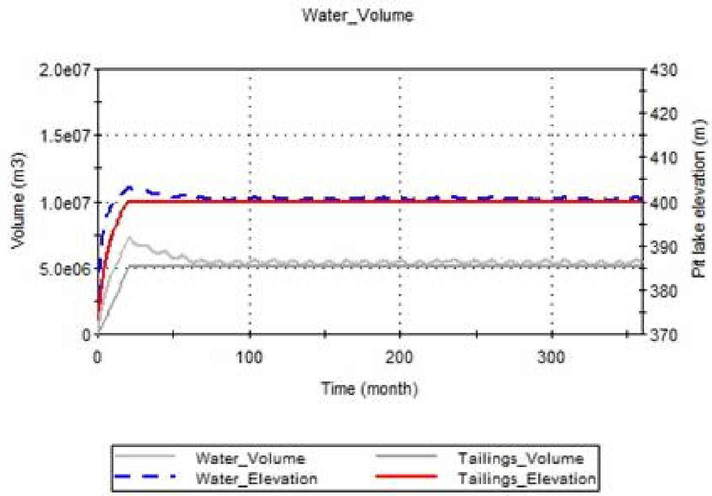


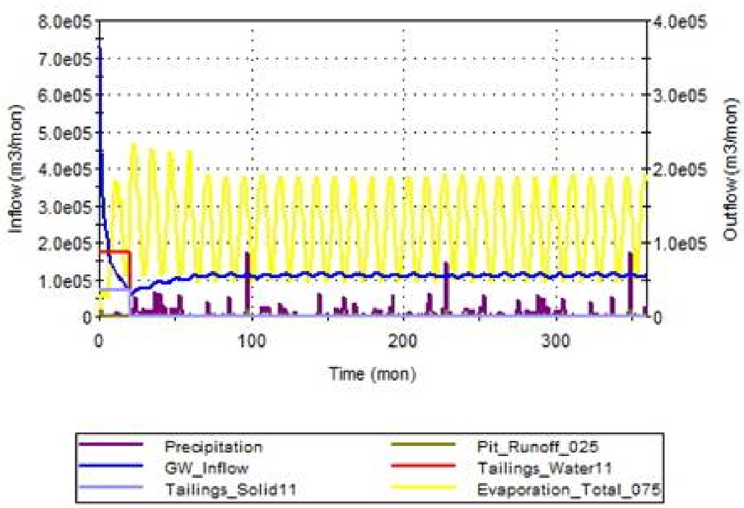


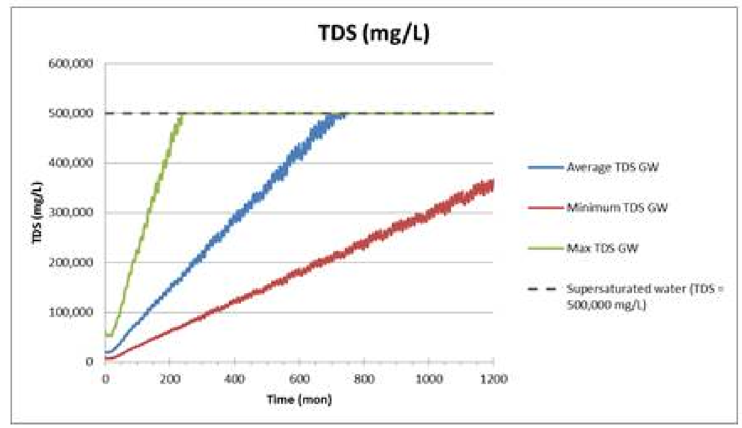


Alternative Case (partial backfill)

Dry case scenario

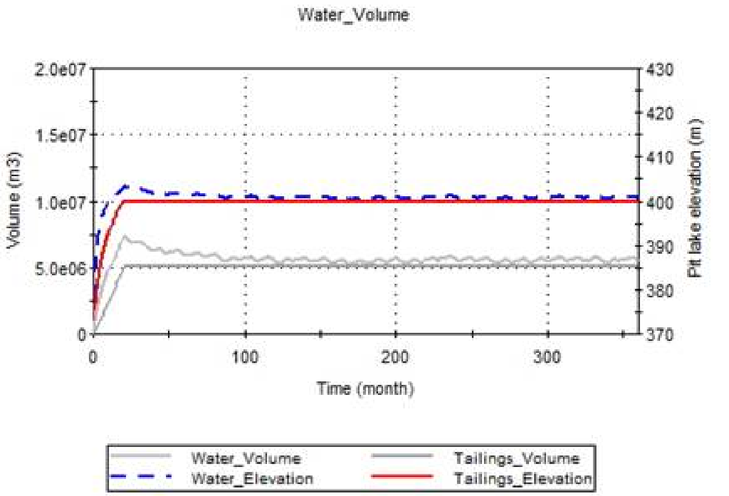


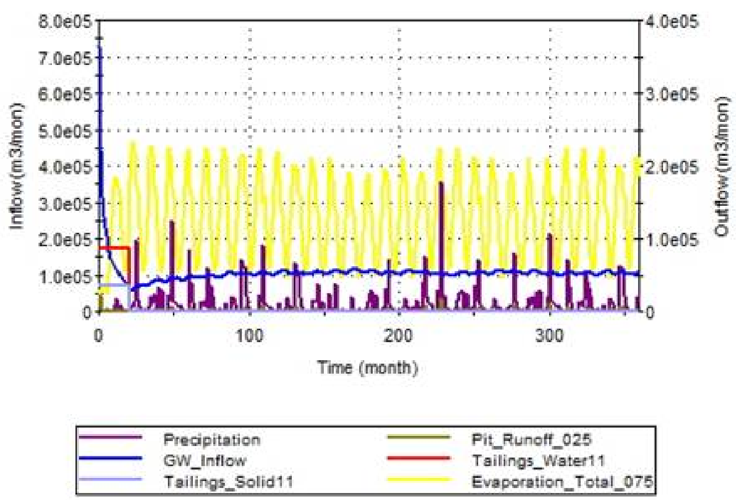


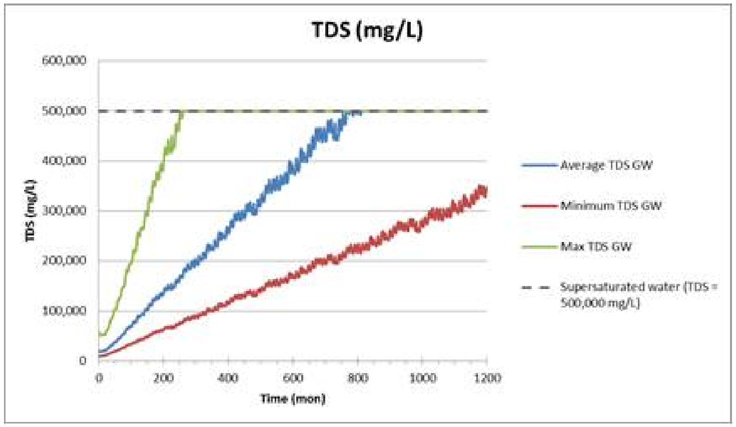


Alternative Case (partial backfill)

Wet case scenario

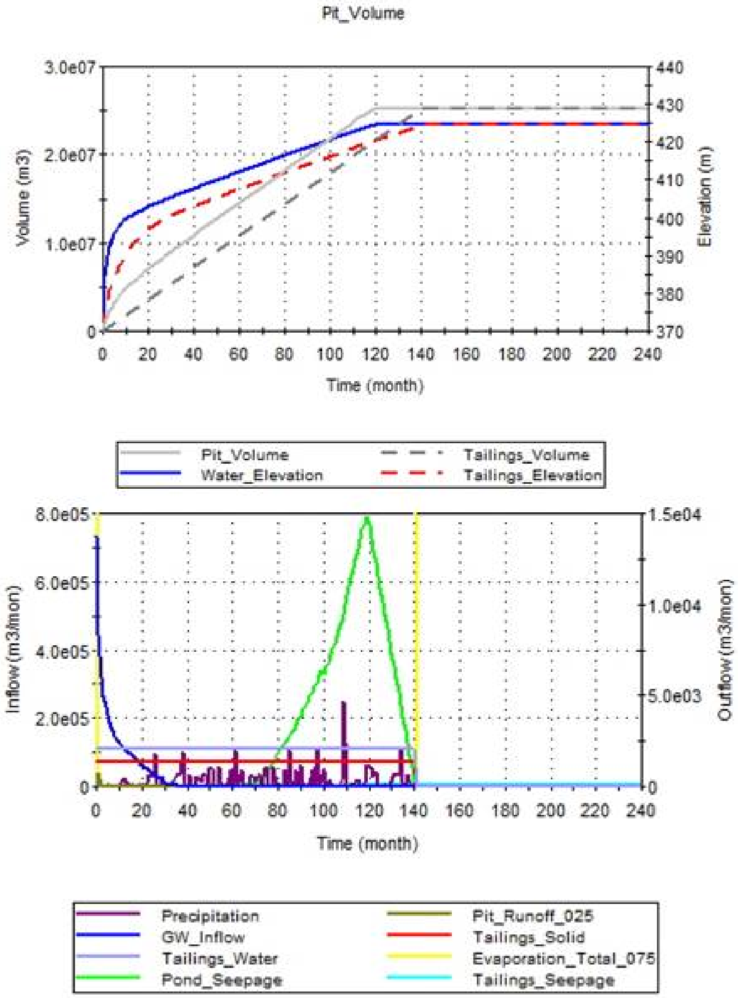


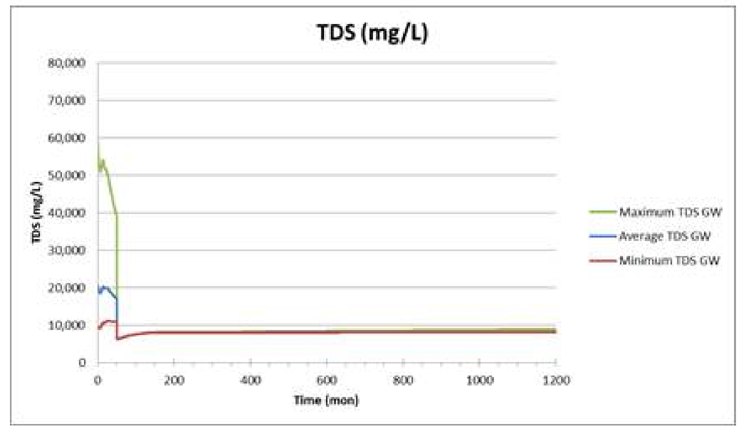




Alternative Case (complete backfill)

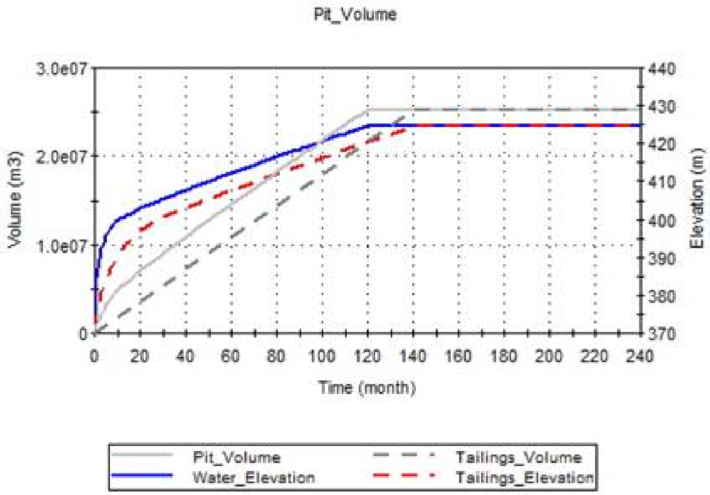
Base case scenario

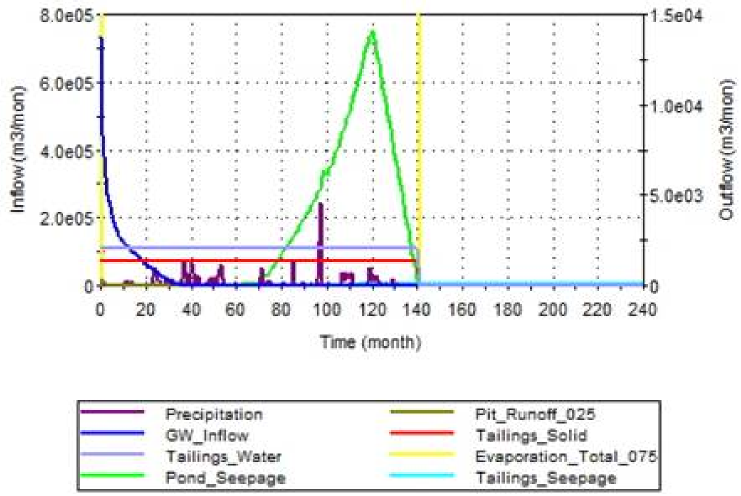


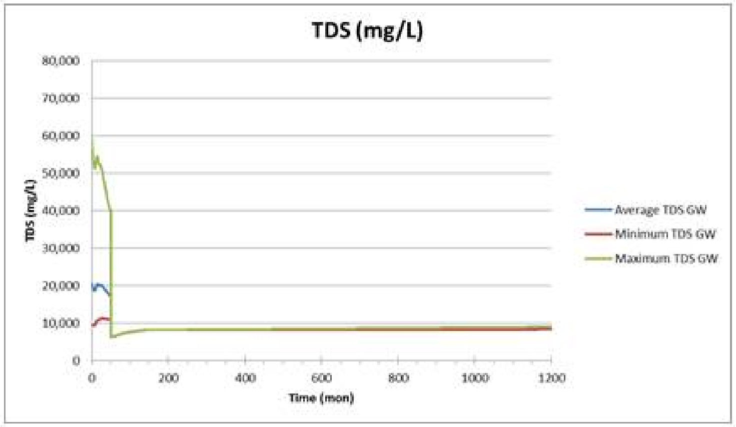


Alternative Case (complete backfill)

Dry case scenario

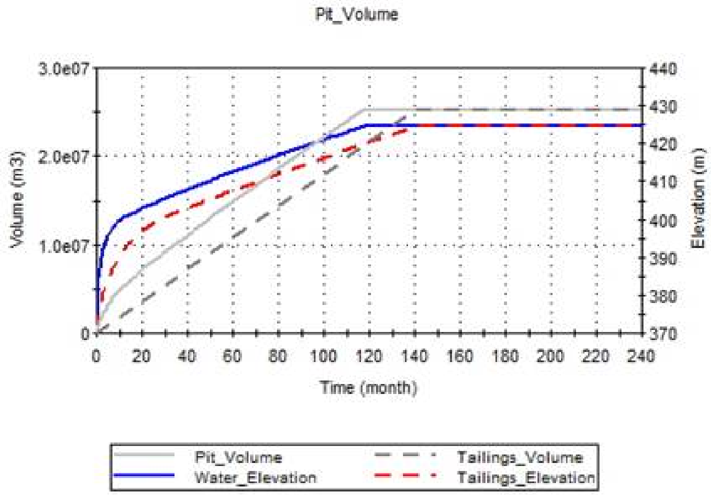


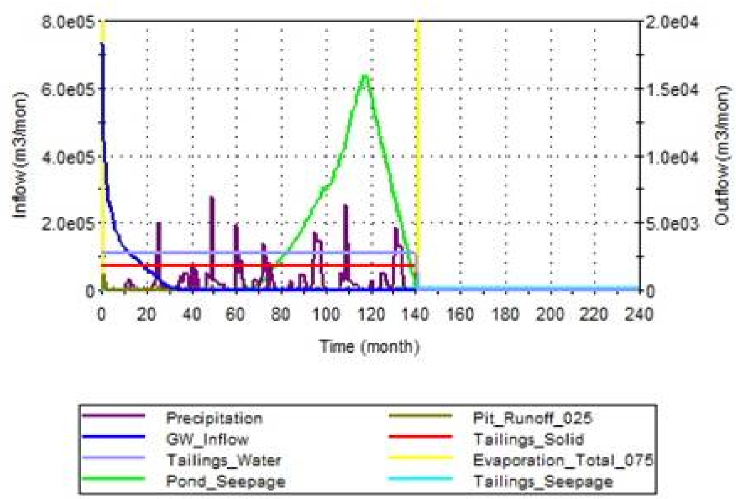


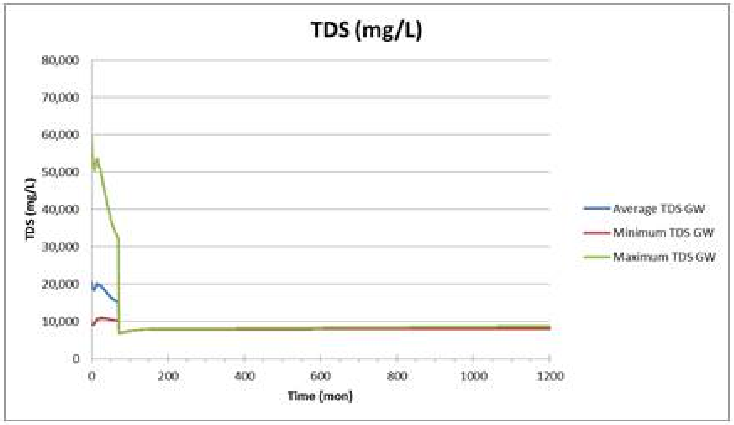


Alternative Case (complete backfill)

Wet case scenario







Appendix C: Electronic data

SRK Report Client Distribution Record

Project Number: FMG007

Report Title: Flinders In-Pit TSF Groundwater Impact Assessment

Date Issued: 6 March 2014

Name/Title	Company
Laila Burger	FMG

Rev No.	Date	Revised By	Revision Details
0	10/02/2014	Caroline Holmes	Draft Report
1	11/02/2014	Caroline Holmes	Updated Draft Report
2	06/03/2014	Caroline Holmes	Final Report