APPENDIX I

Water Management Assessment
(GHD)

Oceana Gold New Zealand Limited

Project Martha

Water Management

May 2018

Executive summary

The current mine plan for the Waihi based Correnso, Daybreak and Empire projects is to complete production by the end of 2019. Successful exploration and optimisation work has identified further mineral resources suitable for Oceana Gold NZ Ltd (OGNZL) to extend the life of the mine. A proposal, named Project Martha, has been developed to access these resources through developing the Martha Underground including the Rex orebody and undertaking stabilisation of the Martha Pit's north wall that will then allow recovery of the remaining Martha pit reserve (known as Martha Phase 4).

This report has been produced by GHD for OGNZL to deliver the following studies relating to site water management for Project Martha:

- A water balance analysis to estimate the quantities and quality of water across the site for the proposed life of mine, with a key objective being to assess whether dewatering requirements for the project can be managed within the water treatment plant capacity and current consent conditions.
- Review of the post closure pit lake outlet structure design for the Martha Phase 4 Pit and potential flooding impacts of outlet discharge on the Mangatoetoe Stream.
- Development of stochastic models, based on hydrogeological properties estimated by GWS. These models are to provide a means to predict the range of potential dewatering requirements, rewatering rates and a water balance for the long term condition of Martha Lake.
- Review of Ohinemuri River abstraction requirements to accelerate filling of the pit lake post closure.

This report also provides an overview of the current approach taken by OGNZL to site water management to provide context.

Water balance analysis

A calibrated water balance model has been used to assess site wide water management through Monte-Carlo analysis. Based on the water balance analysis the existing water treatment plant is sufficient for Project Martha, as predictions for the life of mine indicate that suitable capacity is available and that water can be treated to meet existing discharge consent conditions.

The water balance model has shown that the storage within the tailings storage facilities is adequate to manage the predicted water gains without overflow.

Pit lake outlet

A MIKE21 model has been developed to assess the likely impact of the pit lake outlet on flood levels within the Mangatoetoe Stream. The modelling indicates that the proposed pit lake outlet will have no significant effect on flood levels within the Mangatoetoe Stream.

Pit lake refilling and Ohinemuri River abstraction

A hydrogeological model was developed to estimate the likely filling duration of the pit lake once dewatering has finished; and to estimate the long term water balance of the lake.

Addition of river water will significantly decrease the duration time to form the lake.

OGNZL plan to seek consent to allow up to 20% of the Ohinemuri River flow to be taken when the flow rate is above 2×Mean Annual Low Flow (MALF). With this volume available and an abstraction pump capacity of 270 L/s, an average take of 15,000 m^3/d can be be diverted to the pit. Statistical analysis indicates that with this water take from the Ohinemuri River, a filling duration of 9.4 years is predicted, with a 5th to 95th percentile confidence interval of ±0.7 years due to variations in climate and underground (including rock mass) storage estimates.

Without any river contribution to pit lake filling, the lake will take approximately 39 to 43 years to fill.

Long term analysis of the pit lake water balance shows a positive mean discharge from the lake, with potential for the discharge to cease during long dry periods.

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1. Project Description

1.1 General Project Description

The current Waihi life of mine plan for Correnso / Daybreak / Empire is to complete production by the end of 2019. Production rates diminish after mid 2019 as production ore sources reduce. Some small extensions to these resources are likely to be identified but these are expected to only provide an additional few months of mine life.

Successful exploration and optimisation work now means the opportunity exists for OceanaGold NZ Ltd. (OGNZL) to extend the life of mine with a new underground mine and extension of the open pit.

The combined project is referred to as Project Martha and includes the following key components:

- The Phase 4 cutback – which comprises a small extension to the north wall of the Martha pit to enable the wall to be left in a stable and safe condition and to restore access to the remaining ore reserves in the pit.
- An underground mine located below the current Martha pit.
- Underground development of the Rex lode, located south of the open pit, as part of the Martha Underground.
- Tailings storage within existing Tailings Storage Facilities (TSF's).

Project phasing will involve the early development of the Martha Underground including the Rex lode followed by the Martha Phase 4 Pit. The Martha Underground is sustained over the life of the project with a slow ramp up due to the required mine development. The Rex underground is completed in Year 3. Phase 4 pit development is carried out at a low rate to provide backfill for the underground mine and to limit the size of stockpiles.

Project Martha will rely partly on the use of existing consented facilities and infrastructure including:

- The Process Plant;
- The Water Treatment Plant (WTP);
- Access drives and shafts associated with the underground mines of Favona, Trio, Correnso, SUPA and the recently developed exploration drives under the Martha pit (Martha Drill Drive Project, MDDP);
- The existing Martha open pit surface facilities area (SFA);
- The crusher and conveyor from the Martha pit to the rock and tailings storage area (RTSA); and
- The existing RTSA.

Additional facilities will include ventilation shafts, portals, escapeways, new haul roads and temporary stockpile areas.

Figure 1 shows key features of Project Martha.

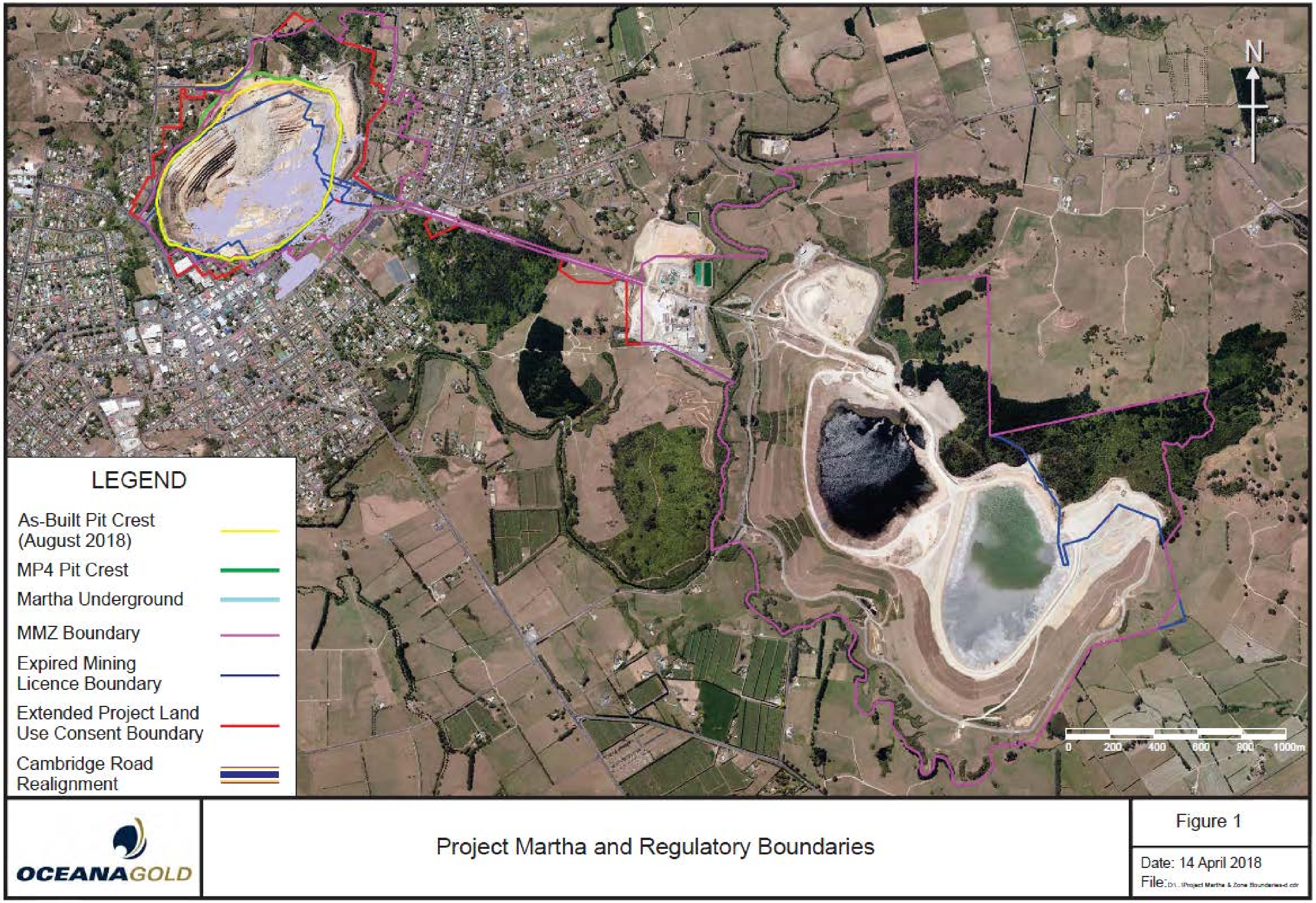

Figure 1 Project Martha Site Plan

1.2 Report Scope

GHD was commissioned by OGNZL to deliver the following studies relating to site water management for Project Martha:

- Water balance analysis – covering estimation of quantities and quality of water for the Life of Mine (LOM) requiring treatment; considered in relation to available site storage, treatment and discharge constraints. A key objective of this study is to assess whether additional water from deeper underground mine dewatering can be managed within the capacity of the water treatment plant (WTP) and current discharge consent conditions.
- Review of the post closure pit lake outlet structure design for the Martha Phase 4 Pit and potential impacts of outlet discharge on the Mangatoetoe Stream.
- Development of stochastic models, based on hydrogeological properties estimated by GWS. These models are to provide a means to predict the range of potential dewatering requirements, rewatering rates and a water balance for the long term condition of the pit lake (post closure).
- Review of Ohinemuri River abstraction requirements to accelerate the pit lake filling post closure.

This report also provides an overview of the current approach taken by OGNZL to site water management to provide context.

1.3 Water Management Approach

The current water management system is designed to capture and treat all water impacted by mining activity; and divert clean water where practicable. While some water is re-used as process water there is always a net gain of water on site due to the high rainfall experienced in Waihi. The basic rules applied to site water management that have been effective in nearly 30 years of operation to date include:

- Natural water is diverted away from areas disturbed by mining activities wherever practicable in order to reduce the volumes of water affected by the mining activities.
- All water from areas disturbed by mining activities is directed to appropriate collection and treatment facilities prior to discharge off-site.
- Where practicable, OGNZL endeavours to reduce the volumes of water requiring treatment. An extensive programme of water quality monitoring is key to checking what water sources do require treatment.
- Disturbed areas are progressively rehabilitated at the earliest practicable time to minimise silt losses and improve runoff water quality.

The volume of water that can be discharged on any given day is limited to an allowable discharge; which forms part of a suite of resource consents and is related to both the flow in the river and the treatment regime in operation (refer section 2.2).

There are some sources of water requiring treatment that are relatively constant and need to be treated at all times. This applies in particular to water pumped from underground workings that need to be maintained dry for safety and operational purposes. Seepage collected from the TSF's underdrains, toe drains and other sources also requires ongoing treatment since it cannot be stored.

The site WTP operators manage the system such that sufficient freeboard is maintained in collection ponds and the active TSF to provide buffer storage over periods where the allowable discharge is less than the volume of water requiring treatment. For example where there is high rainfall followed by dry periods and low river flows (reducing the allowable discharge), water gains will be held in ponds and the TSF and treated and released over time.

General rules outlined by OGNZL in their Site Water Management Plan (2017) that apply to water treatment include:

- Apply ongoing optimisation and improvement to the WTP performance
- Regularly update the water balance model to predict future site water management requirements, and implement actions necessary to effectively manage the predicted volumes of water.
- Maintain effective buffer storage, so that water can be stored on site as necessary e.g. during wet months and/or years.
- Ensure through potential acid forming rock (PAF) slurry testing, that adequate limestone is added to the rock stacks to ensure that the collection pond water pH remains above 6.5 thus providing an opportunity for direct discharge,
- Prioritise on a daily basis, waters to be treated.

Later report sections provide a more detailed description of the various sources of water around the site and the related control/management systems. Implementation of the activities associated with Project Martha will retain proven site water management practices.

1.4 Limitations

This report: has been prepared by GHD for Anderson Lloyd on behalf of OGNZL and may only be used and relied on by OGNZL for the purpose agreed between GHD and OGNZL. GHD otherwise disclaims responsibility to any person other than OGNZL arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible. The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report.

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2. Background Information

2.1 General

Areas that currently generate water requiring treatment in the site WTP are listed below:

1. Martha Open Pit – stormwater runoff and groundwater (“minewater”)
2. Correnso underground workings – groundwater dewatering (”minewater”)
3. Process plant and WTP area runoff
4. Decant pond water – from TSF1A
5. Collection pond water – stormwater runoff from overburden storage areas
6. Seepage – from TSF1A and TSF2 including embankment structures

Decant water from TSF2 has not been treated since October 2007 when testing showed that the pond water quality was suitable for direct discharge to the Ohinemuri River. Tailings deposition to TSF2 had ceased in July 2005.

The TSF2 decant pond currently discharges to the river through an unnamed tributary to the north of the Waste Disposal Area under Resource Consent 971323. Treatment of TSF2 decant pond water will resume when tailings deposition re-starts in that impoundment.

For treatment, water is defined based on whether it requires treatment for

1. Metal and trace ion removal only; or
2. The above plus cyanide destruction.

Cyanide is used in the gold recovery process and is present in the tailings that are pumped to the active TSF. TSF decant water thus contains cyanide as does seepage from the TSF’s; there is also potential for cyanide content in the ponds that collect stormwater runoff from the process area.

Water sources listed that do not have any contact with cyanide can require treatment due to contact with acid forming rock. When acid forming rocks are exposed to oxygen, sulphates and metals are released into solution. The geochemistry of the materials found on site are described fully by AECOM (2018). Minewater pumped from the open pit via underground workings, and water captured in some collection ponds is characterised by low pH and elevated metal content, particularly manganese. The water quality of all water sources requiring treatment is described in more detail in section 3.

Figure 2 provides a schematic representation of the current water management system with TSF2 decant water overflowing to the Ohinemuri River.

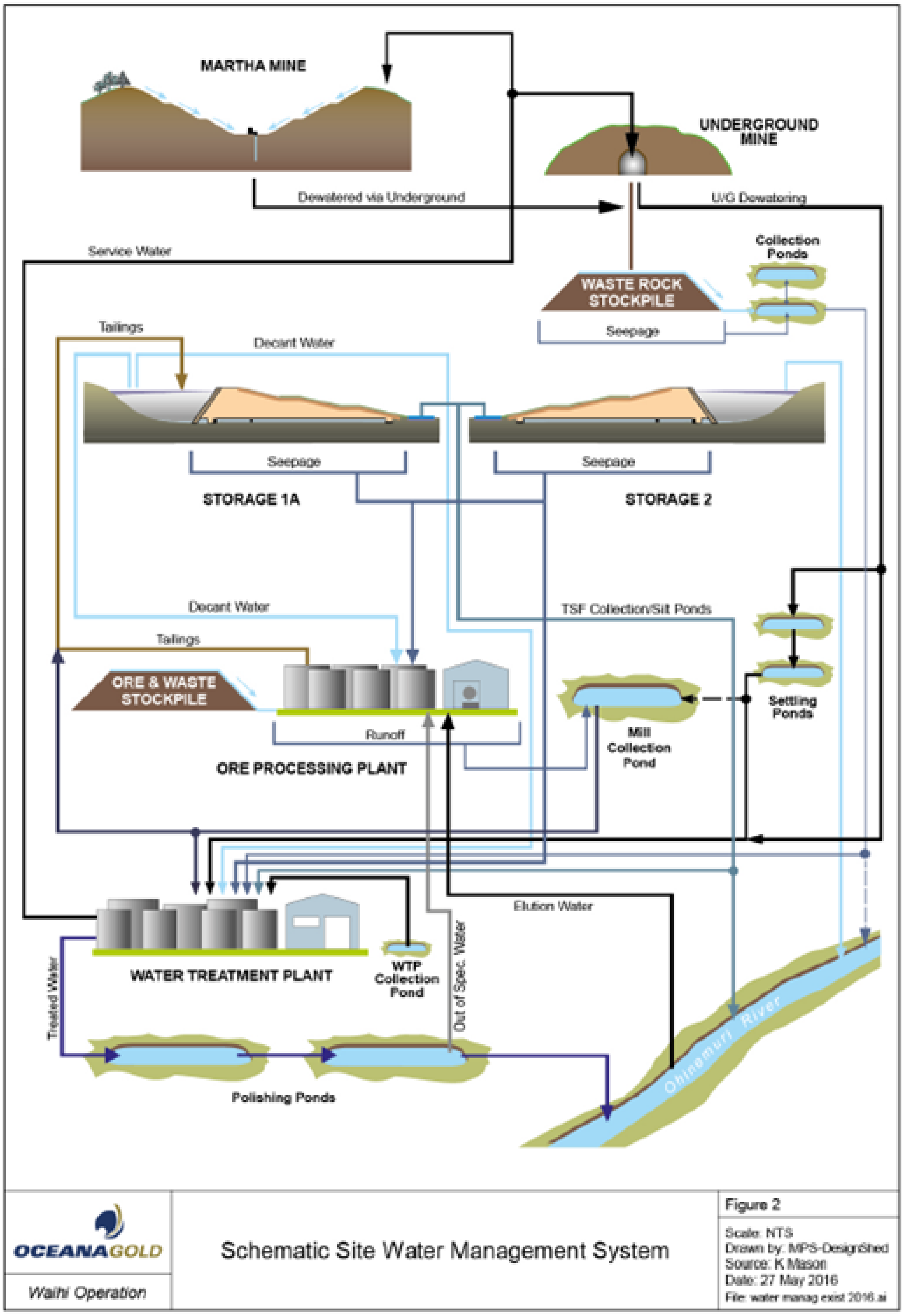


Figure 2 Schematic Site Water Management System

The nature of mining is such that the volumes of water requiring treatment from the various water sources change based on the stage of mine development.

The water balance analysis described in section 5 was undertaken to predict how volumes from each source will vary over time for Project Martha. The volumes requiring treatment each year are compared to the WTP capacity, receiving water discharge constraints and site buffer storage in order to check there is enough capacity in the system to treat and discharge all water requiring treatment that is generated.

Buffer storage is available within the active TSF impoundment areas, collection ponds and to a degree within the pit and underground workings (since dewatering pumps can be turned down or off). There are limits on storage capacity in the TSFs and collection ponds hence to avoid overflow the WTP operation takes account of available storage and prioritises treatment of the various sources as required. Further detail on treatment prioritisation is provided in section 5.

Project Martha will not result in any different types of water requiring treatment. However the volume of minewater will increase to allow for dewatering of the new underground workings and the volume of decant water will increase following re-activation of TSF2.

2.2 WTP Description

2.2.1 General

The WTP has been in operation since 1988 and has been subject to upgrades in 1999 and 2011. A reverse osmosis (RO) plant was built and commissioned in 2008 to provide an additional treatment option for metals removal. The WTP has performed consistently well with no recorded non compliances with consent conditions.

The WTP incorporates four parallel streams with three of these dedicated to soluble metals removal only. The fourth stream has two phases of treatment; oxidation of cyanide to destroy the cyanide complexes followed by metals precipitation and removal.

- **Cyanide oxidation** is achieved using a combination of hydrogen peroxide, copper sulphate and lime. A series of tanks are used for reagent mixing followed by retention to provide time for chemical reaction. Hydrogen peroxide in the presence of copper destroys all free cyanide through chemical oxidation. Weak acid dissociable (WAD) cyanide is also oxidised during the process. On oxidation, cyanide yields simple carbon and nitrogen compounds.
- Lime and ferric chloride are added to all four water streams to facilitate **metals precipitation and removal.** Metals tend to occur in a soluble form when the pH of water is low and raising the pH with lime in the presence of ferric chloride creates insoluble hydroxides and carbonates to form. Following mixing and retention a polyelectrolyte (flocculant) is added along with more lime to form flocs that can be settled out.

Clarifiers at the end of the treatment process allow the suspended solids and metals to be removed from the water. The suspended solids and metals fall to the bottom of the clarifiers forming a slurry. The slurry is pumped to the tailings pond via a thickener. Carbon dioxide is added to the clean water overflow from the clarifier to reduce the pH of the water to meet the compliance limits.

There are two polishing ponds that hold the treated water for approximately 16 hours prior to discharge to the river. This provides time for the treated water to be tested, and the results to be received and interpreted prior to the water discharging to the Ohinemuri River.

Water that meets the discharge criteria is discharged to the Ohinemuri River (see Table 2). If the water does not meet the discharge criteria, it is recycled back through the plant, used in processing, or piped to the tailings storage facility.

2.2.2 Operating Regimes

There are four operating regimes and each provides for a different combination of water requiring cyanide destruction versus metals removal only. These operating regimes recognise that the proportion of water being treated for cyanide destruction impacts the treated water quality. In addition the water quality varies based on whether the RO plant is used. The resultant treated water quality in turn influences the volume of treated water that can be discharged since mixing with river water is required to meet receiving water quality targets.

Table 1 summarises the operating regimes and Table 2 presents the associated WTP discharge compliance limits. These tables are sourced from the Resource Consent 971318, which provides for discharge from the WTP to the Ohinemuri River.

Table 1 WTP Operating Regimes

Criteria	Operating Regime A	Operating Regime B	Operating Regime C	Operating Regime D
Daily Discharge	20,000 m^3/d	26,000 m^3/d	5,200 m^3/d	26,000 m^3/d
Discharge Rate	235 l/sec	301 l/sec	60 l/sec	301 l/sec
Percentage of river flow	15%	20%	10%	40%

The WTP operators select the operating regime based on a combination of river flow and treatment campaigns that will vary over any given year.

Treatment campaigns take account of buffer storage availability and operational requirements (e.g. an underground dewatering target water level to be achieved). This is discussed further in section 5.

Table 2 WTP Compliance Limits (Source Resource Consent 971318)

Parameter	Treated Water Concentration- (g/m^3 unless otherwise stated)							
	Operating Regime A		Operating Regime B		Operating Regime C		Operating Regime D	
	Normal Compliance(1)	Maximum (1)	Normal Compliance(1)	Maximum(1)	Normal Compliance(1)	Maximum(1)	Normal Compliance(1)	Maximum(1)
pH	6.5-9.5		6.5-9.5		6.5-9.5		6.5-9.5	
Temperature	<3°C rise	<3°C rise	<3°C rise	<3°C rise	<3°C rise	<3°C rise	<3°C rise	<3°C rise
Total Suspended Solids	10	50	8	40	5	10	8	40
Cyanide (WAD)	0.25	0.71	0.2	0.56	0.36	1.02	0.11	0.32
Iron	1.0	6.7	0.8	5.0	0.1	0.3	0.5	3.1
Manganese	1.0	1.3	0.8	1.0	0.1	0.4	0.5	0.6
Copper	0.07(2)	0.13(2)	0.055(3)	0.10(3)	0.031(4)	0.054(4)	0.033(4a)	0.06(4a)
Nickel		1.2(2)		0.94(3)		0.64(4)		0.55(4a)
Zinc		0.8(2)		0.61(3)		0.38(4)		0.36(4a)
Ammonia	*Refer Table 3* 1		*Refer Table 3* 1		*Refer Table 3* 1		*Refer Table 3* 1	
Silver	0.02(2)	0.03(2)	0.017(3)	0.024(3)	0.005(4)	0.005(4)	0.01(4a)	0.014(4a)
Antimony		0.23	0.1(5)	0.18	0.07(5)	0.33	0.06(5)	0.10
Arsenic		1.45		1.14		0.02		0.66
Selenium	0.15	0.27	0.12(5)	0.2(5)	0.22(5)	0.38(5)	0.07(5)	0.12(5)
Mercury		0.0005(6)		0.0005(6)		0.0005(6)		0.0005(6)
Cadmium		0.008(2)		0.007(3)		0.004(4)		0.004(4a)
Chromium (VI)		0.08		0.06		0.05(6)		0.04
Lead		0.02(2)		0.018(3)		0.006(4)		0.011(4a)
Hardness Assumption	670		530		200(4)		*315*	

1. Ammonia compliance criteria defined in Table 3: Compliance Criteria for Total Ammonia, Resource Consent 971318

2. The values in the above table for metals are based on an assumed hardness values. The consent conditions provide for variable hardness in Table 2 of Resource Consent 971318.

Table 3 Summary of Treated Discharge Water Quality Data

Operating Regime A

AM Usage Count: 493
PM Usage Count: 87

	Range of Conc.		Consented Water Quality	
Chemical Parameter	Mean	Max	Normal Compliance	Maximum Compliance
pH (pond)	8.54	9.50	9.5	9.5
TSS (g/m^3)	2.87	10.0	10	50
Copper (g/m^3)	0.019	0.128	0.07	0.13
Manganese (g/m^3)	0.036	0.197	1	1.3
Iron (g/m^3)	0.054	0.680	1	6.7
Silver (g/m^3)	0.005	0.028	0.02	0.03
Ammonia (g/m^3)	5.20	17.0	Varies[1]	
Cyanide (WAD) (g/m^3)	0.033	0.290	0.25	0.71
Selenium (g/m^3)	0.024	0.040	0.15	0.27
Antimony (g/m^3)	0.028	0.066	0.23	0.23

Operating Regime B

AM Usage Count: 2031
PM Usage Count: 1506

	Range of Conc.		Consented Water Quality	
Chemical Parameter	Mean	Max	Normal Compliance	Maximum Compliance
pH (pond)	8.58	9.50	9.5	9.5
TSS (g/m^3)	2.67	11.0	8	40
Copper (g/m^3)	0.007	0.102	0.055	0.1
Manganese (g/m^3)	0.036	0.750	0.8	1
Iron (g/m^3)	0.042	0.850	0.8	5
Silver (g/m^3)	0.001	0.049	0.017	0.024
Ammonia (g/m^3)	3.66	27.0	Varies[1]	
Cyanide (WAD) (g/m^3)	0.016	0.220	0.2	0.56
Selenium (g/m^3)	0.012	0.100	0.12	0.2
Antimony (g/m^3)	0.011	0.067	0.1	0.18

Operating Regime D

AM Usage Count: 878
PM Usage Count: 878

	Range of Conc.		Consented Water Quality	
Chemical Parameter	Mean	Max	Normal Compliance	Maximum Compliance
pH (pond)	8.47	9.2	9.5	9.5
TSS (g/m^3)	2.51	13.00	8	40
Copper (g/m^3)	0.004	0.061	0.033	0.06
Manganese (g/m^3)	0.024	0.580	0.5	0.6
Iron (g/m^3)	0.028	0.4	0.5	3.1
Silver (g/m^3)	0.002	0.080	0.01	0.014
Ammonia (g/m^3)	2.33	12.0	Varies[1]	
Cyanide (WAD) (g/m^3)	0.010	0.210	0.11	0.32
Selenium (g/m^3)	0.008	0.037	0.07	0.12
Antimony (g/m^3)	0.007	0.073	0.06	0.1

1. Ammonia compliance criteria defined in Table 3: Compliance Criteria For Total Ammonia, Resource Consent 971318.

2.2.3 Overview of Performance

Treated water quality records from 2008 to 2017 were collated and summarised in Table 3. The table includes consented water quality values based on hardness as listed in Table 4.

Table 4 Consented Water Quality Hardness Assumptions

Regime	Consented Water Quality Assumed Hardness
Regime A	670
Regime B	530
Regime D	315

Consented metals values are calculated based on two stated hardness concentrations and in general the WTP discharge hardness concentration is higher (>900). When adjusted appropriately for hardness, there have been no non-compliant discharges. Compliance with ammonia targets has also been met across the period of record.

The data also show that Operating Regimes B and D have dominated over the period of record. For reference the volumes of water treated and discharged over the last 3 years is summarised in Table 5. Note that 2015 was a particularly dry year and 2016 and 2017 were wet compared to the annual average rainfall of 2110 mm (refer section 4.2) and this impacts the water volumes requiring treatment.

Table 5 Annual Treated Discharge Volumes

Value	2015	2016	2017
Annual Rainfall (m)	1,451	2,689	2,875
Volume Treated Water for Cyanide Destruction (Mm^3)	0.4	1.5	1.1
Volume Treated Water for Metals Removal (Mm^3)	1.9	2.9	3.7
Volume Total Treated Water (Mm^3)	2.3	4.4	4.8
Volume Average Treated Water (m^3/d)	6,300	12,100	13,151

2.3 Collection and Contingency Ponds

2.3.1 Background

At the time the collection pond design criteria was devised in 1996, the potential for low pH and elevated metals content in the pond discharge water was a key consideration since there had been instances of pond water quality exhibiting these characteristics in earlier years of operation (1993/94). This was due to contact of runoff with PAF rock. In response to pond water quality the site changed PAF rock management practises; in particular through the use of limestone addition during conveying of PAF rock and in placement. This change in practise in combination with progressive rehabilitation of catchment areas has resulted in gradual improvement in collection pond water quality.

Over time a number of collection ponds have been reclassified as “silt ponds” and allowed to discharge directly to either the Ohinemuri River or Ruahorehore Stream where water quality and river flow parameters are met.

All of these modifications have been subject to review of long term water quality datasets, continuous monitoring of pH and turbidity, and flow monitoring, and approval from Waikato Regional Council. Continuous monitoring of discharge water quality applies to check for any changes in water quality that would result in redirection of pond water to the WTP.

A number of contingency ponds are located in the process plant/WTP area including the Mill Contingency pond (MCP), Tailings Contingency Ponds (TCP, TCP2, TCP1a) and WTP Contingency Pond (WTPCP). These ponds collect runoff from the ore stockpiles and conveyor, while also providing containment of any chemicals used for processing ore and water treatment in the event of spillage. These ponds will remain active until mine closure.

Figure 3 shows the locations of existing collection and contingency ponds and associated catchment areas and Table 6 summarises the current status of collection ponds in relation to direct overflow:

Table 6 Collection Pond Status

Collection Pond	Direct Overflow Allowed	Since
Northern Collection Pond (NCP)	No	NA
Western Silt Pond (WSP)	Yes	Construction
Collection Pond S3	Yes[1]	July 2014
Collection Pond S4	Yes[1]	July 2014
Collection Pond S5	Yes[1]	July 2014
Mill Contingency Pond (MCP)	No	NA
WTP Contingency Pond (WTPCP)	No	NA
Tailings Contingency Ponds (TCP,TCP2,TCP1A)	No	NA
Favona Portal Contingency Ponds (FSPCP, FSPCP2)	No	NA

1. Reclassification of a number of collection ponds to silt ponds was approved on 17 July 2014.

In accordance with condition 13 of Resource Consent 971312, direct discharges from S3, S4 and S5 to the Ohinemuri River and Ruahorehore Stream was approved; with discharge consent being transferred and covered by Resource Consent 971311 (subject to condition 8b) from that time.

In applying for this, (OGNZL’s predecessor) proposed the following controls:

- in order for the collection ponds to be classified as silt ponds and allowed to direct discharge, the water quality within the individual ponds must have pH in the range of 6.5 to 9, and turbidity must be less than or equal to 110 NTU (equivalent to 100 g/m^3 suspended solids);

- flow from S3, S4 and S5 either individually (if discharged one at a time) or in combination will be managed such that it does not exceed 13% of the flow measured at the Ruddock's flow gauge in the Ruahorehore Stream,
- provided the above two conditions are met, the Silt Pond Discharge Consent 971311 will apply and the conditions of that consent (which includes the receiving water standards) will be complied with;
- if the ponds do not meet these conditions then they will be classified as collection ponds and the conditions of the Collection Ponds consent 971312 will apply;

A monitoring regime was also agreed at that time and since the direct discharge has been underway modifications to this have been made progressively. This has included a change from reliance on sample collection during direct discharge events to the use of automatic monitoring data (pH, turbidity) which was approved in June 2016.

2.3.2 Design Criteria

Collection ponds are currently designed to contain rainfall volumes equivalent to a 10 year return period, 72 hour duration event. The large volume of storage provided for by this design criteria was intended to provide containment for all but high rainfall conditions. The criteria also recognised that the catchment response for the Ohinemuri River and Ruahorehore Stream differs to the smaller collection pond catchments. The intent of the design was to time overflow from the collection ponds to coincide with peak flows in the receiving water, thus maximising the opportunity for dilution of the overflow water.

2.3.3 With Project Martha

While Project Martha extends the life of the operation, there is little change in the impacted catchment areas with only an incremental increase to the northern side of the Martha pit.

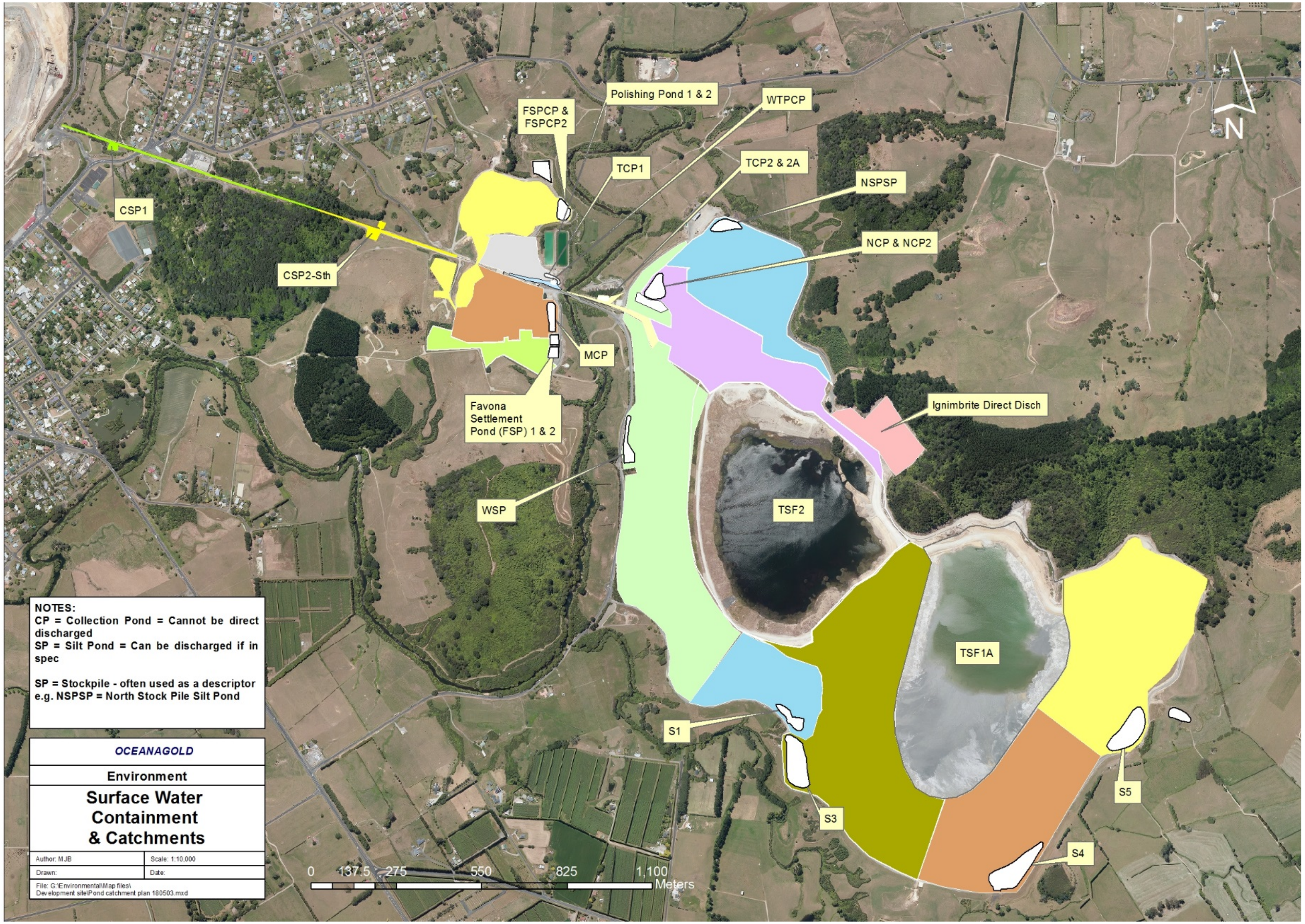


Figure 3 Existing Collection and Containment Pond Locations

2.4 Mine Dewatering

2.4.1 Current

Minewater from the Martha pit is made up of surface runoff and groundwater which is removed continuously to keep the pit dewatered. Experience has shown that once groundwater levels have been initially reduced, pump rates tend to stabilise until further drawdown is required.

Mine dewatering is currently undertaken with pumps located in the underground Correnso mine. The Martha pit is hydraulically linked to the underground workings. Although mining in the pit has been on hold, the pit has not filled because it is connected to the underground Correnso workings, and the pumping of water to keep the water level in the Correnso workings down has the effect of preventing the accumulation of water in the base of the pit.

When the Correnso Project was consented, it was anticipated that the Martha Pit dewatering pumps would be upgraded to allow the groundwater level to be lowered to RL 700m (Resource Consent 124860). Until recently, the water level has been held at around RL 792m, which is the lowest level that can be achieved with the current mine dewatering pumps.

OGNZL intends to dewater to 730 mRL within the next twelve months. To achieve this, the flow will increase from approximately 70-80 L/s to 150 L/s (13,000m^3/d). OGNZL recently activated the Correnso Resource Consent to allow for this dewatering rate.

2.4.2 With Project Martha

GWS Ltd has completed a study (GWS 2018) on the groundwater system and has assessed the dewatering rates that will be needed over time to allow for development of the Martha Underground Mine.

The study shows that an average rate of 15,500 m^3/d needs to be achieved starting from January 1 2020 through to early 2026 to dewater from an assumed starting level of 700m RL to the final target level of 500 m RL.

There are constraints on the rate treated water can be discharged when flows in the Ohinemuri River are low, and this average dewatering rate is too high to discharge through such periods under conditions in the current resource consent (971318). To compensate for this, it is proposed that dewatering will be undertaken at higher than the average rates where the operating regimes defined in Table 1 allow. A water balance model was used to assess the pumping rate required to meet groundwater level targets over the LOM taking into account treated water discharge constraints and variable rainfall conditions. This analysis is summarised in section 5.

2.5 Seepage

An extensive seepage collection system exists beneath both TSF's. This system is designed to capture upwelling groundwater, seepage from tailings, and leachate from the rock used to construct the TSF embankments. The term "seepage" describes the combined flows from these sources.

The characteristics of seepage depend on the source, quality and quantity of the individual flows as follows:

- **Tailings underdrains** collect seepage from the tailings as well as upwelling groundwater. During the initial period of tailings placement in TSF2 and TSF1A, the flow from tailings was relatively high and contained elevated levels of cyanide and soluble metals. As the tailings volume has increased, the permeability of the tailings mass has reduced significantly, resulting in a decrease in flow and an improvement in quality. The characteristics of underdrain flows now approaches those of natural groundwater.

- **Upstream cutoff drains** collect tailings seepage and groundwater. Experience has shown that tailings liquor concentrations in these drains are highest when decant pond water is standing against the embankment, and reduce as tailings levels rise and consolidate to provide a low permeability barrier. The source of tailings liquors in the drains is typically from the areas adjacent to the embankment abutments where water levels are highest and tailings levels are low.
- **Leachate drain flows** depend on the rainfall volumes that fall on the embankment between the time that the rock is placed and capped. Leachate drains collect water from overburden, much of which is PAF, and contain elevated concentrations of sulphate and soluble metals. As the embankments are completed, and capping is constructed reducing the exposed overburden areas open to rainfall infiltration; the volume of leachate from this source reduces. Over time, with the completion of capping, air will be excluded from the rock mass reducing sulphide oxidation and an improvement in leachate quality is expected based on observations from TSF2.
- **Toe drains** carry mainly groundwater that wells up below the embankment structure, but may contain some overburden seepage. Initial toe drains pick up seepage from the starter embankment.

Seepage flows enter the WTP in a single pipe hence it is the water quality of the mix that is currently important in determining required treatment.

Seepage flows from TSF1A and TSF2 currently average 364 m^3/d (based on 2015 and 2016 calibration data). These flows are used in the process plant or treated for metal and trace ion removal at the WTP.

2.6 Tailings Storage Facilities

2.6.1 General

The TSF embankments are constructed in stages making use of overburden from the pit. Careful planning of material quantities is undertaken to ensure that the storage available in the active TSF (i.e. embankment height above tailings level) is sufficient to contain planned tailings deposition.

A freeboard above the tailings approaching 3 m is provided at all times to conservatively provide for storage of an extreme rainfall event without overflow. The freeboard provides for the Probable Maximum Precipitation (PMP) plus 1 m contingency. The PMP is a theoretically derived value for a 1 in 10,000 year rainfall event.

As part of the WTP operation the storage available in the active TSF is monitored and if necessary decant water treatment is prioritised to ensure freeboard is maintained. There have been no overflows from an active TSF since the mine has been in operation. Decant water is pumped to the process plant for re-use or to the WTP.

2.6.2 Process Water Recycle

Process water requirements are based on production rates. Tailings slurry consists of approximately 16% tailings solids by volume and the water component is made up of a small amount of river water (elution water) plus recycled decant and seepage water. Collection pond or minewater is used for top-up when needed.

3. Water Quality

3.1 Background

The water quality associated with the current water sources that require treatment around the site is well understood and there have been no issues with achieving required discharge water quality from the WTP.

OGNZL has an extensive water quality monitoring program in place which includes collection of data on the water sources requiring treatment. This data is used to inform the water treatment plant operation and in particular to identify any changes in water quality. In relation to source water quality the following general comments apply:

- Mine dewatering – the water quality associated with dewatering has been relatively constant over time.
- Seepage – the seepage flow that enters the WTP combines a number of sources. The proportion of this flow that requires treatment for cyanide destruction has reduced over time as the tailings underdrain contribution has dropped off. As noted prior this is due to tailings consolidation in the tailings impoundments reducing the amount of tailings liquor reporting to seepage over time.
- Decant pond water – The water quality of the decant water is reasonably constant, however some variability has been experienced based on the source of the ore in the tailings. The changes in water quality that do apply are within the ranges the WTP can process to meet the required standard.
- Collection pond water – the quality of water in these ponds is shown to improve over time once active placement of overburden is completed and rehabilitation established. As discussed in section 2.3 a number of collection ponds are now operating as silt ponds and overflow directly to receiving waters.
- Contingency ponds – the containment ponds contribute a very small quantum to the treatment stream. The quality of the water depends on activity in the upstream catchments and can be quite variable. The primary purpose of some of the ponds (e.g. the mill pond) is to prevent any spillages entering the river. Other ponds collect runoff from ore stockpiles and are impacted by both acidity and suspended solids. Containment pond water is generally included in the minewater stream for treatment.

3.2 Current Source Water Quality Summary

Table 7 provides a summary of “typical” water quality characteristics of the various water sources that are currently treated. The data presented is the median values for the period Jan 2016 to July 2017.

Table 7 Summary of source water quality (median values Jan 2016 to July 2017)

Parameter	Units	TSF1A Seepage	TSF2 Seepage	Collection Pond Water	TSF1A Decant Pond	Mine Dewatering
pH	-	6.9	6.5	7.7	8	7.1
TSS	g/m^3	17	4	24	17	965
Dissolved Ni	g/m^3	0.044	0.116	0.0034	0.027	0.054
Dissolved Se	g/m^3	0.0017	<0.007[1]	<0.007[1]	<0.007[1]	0.0094
Dissolved Cu	g/m^3	<0.00098[1]	<0.00098[1]	<0.00098[1]	0.45	0.0037
Dissolved As	g/m^3	0.001	0.001	0.001	0.0065	0.009
Dissolved Pb	g/m^3	0.0001	0.0001	0.0001	0.0023	0.0002
Dissolved Sb	g/m^3	<0.0046[1]	<0.0046[1]	<0.0046[1]	<0.0046[1]	0.0048
Dissolved Al	g/m^3	0.005	0.099	0.089	0.008	0.015
Dissolved Hg	g/m^3	0.00008	0	0.00008	0.00008	0
CN_WAD	g/m^3	0.052	<0.007[1]	<0.007[1]	0.31	<0.007[1]
Dissolved Zn	g/m^3	0.127	0.075	0.001	0.179	1.04
SO4	g/m^3	700	350	151	920	1600
Dissolved Fe	g/m^3	1.43	3.2	0.02	0.02	<0.008[1]

1. Values below minimum detection limit (MDL) as defined by SGS New Zealand Limited.

3.3 Project Martha Source Water Quality

The quantities of water requiring treatment will increase with Project Martha, however the source water quality characteristics are not expected to change to a degree that any changes are needed to the WTP process. AECOM (2018) has completed a study on the geochemistry of the ore body to be extracted in the new underground mine, and this confirms the geochemical characteristics are similar to ore previously mined from the open pit.

Quantity increases are related to increased mine dewatering and the need to treat two TSF decant ponds for a period during the LOM. Previous management of TSF2 has shown that the water quality improved sufficiently inside 2.5 years to allow for direct discharge (Section 2.1). An extended 3 year treatment period has been conservatively assumed for future water management scenarios.

4. Hydrological and Climatic Data

4.1 Hydrology

Waihi town is located in the upper catchment of the Ohinemuri River. This is also the location of existing mining infrastructure, with TSF's to the east of the Ohinemuri River and plant areas and mines to the west of the river. The Ohinemuri River has a total catchment area of 290 km^2. The upper catchment to the east consists of the predominantly flat farmland of the Waihi Plains. Numerous tributaries join the river as it flows west, with upper catchments becoming steep and forested further inland. The Ohinemuri River flows through the narrow Karangahake Gorge prior to joining the Thames/Waihou River in the west. Figure 4 shows the Ohinemuri River catchment.

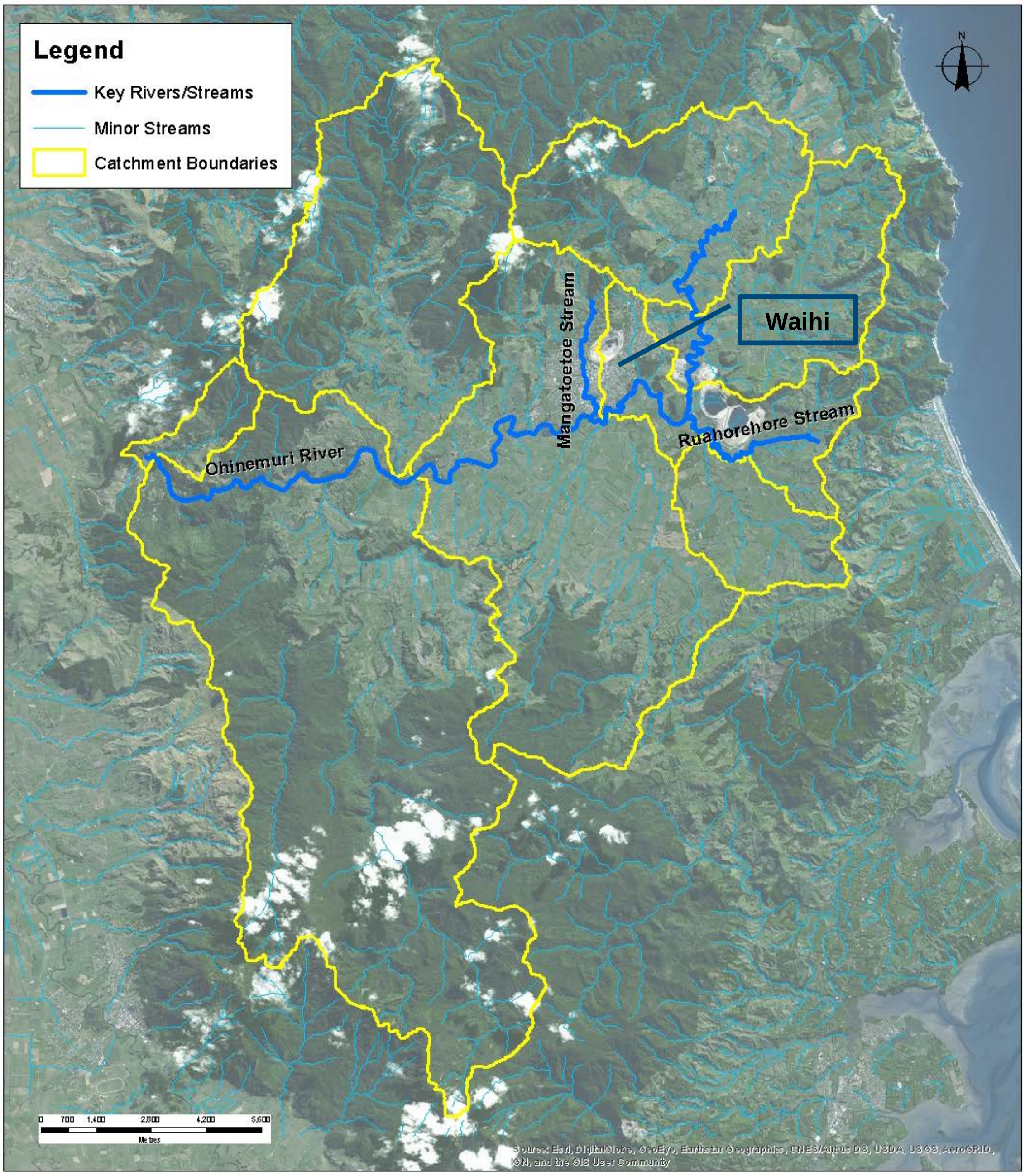


Figure 4 Ohinemuri River and Sub-catchments

Discharges from site are all to the Ohinemuri River or its tributary the Ruahorehore Stream. Figure 5 shows the river in relation to the existing TSF’s, the open pit and Waihi town. Figure 5 also shows the locations of the two flow gauges used for water management studies; the OGNZL gauge located upstream of the Ruahorehore Stream confluence and in the vicinity of the process plant area (Frendrups) and the Ruddock gauge located in Ruahorehore Stream.

The Waikato Regional Council gauge at Queen’s Head is also considered in this study and is located in the Ohinemuri River downstream and west of the mapped area.

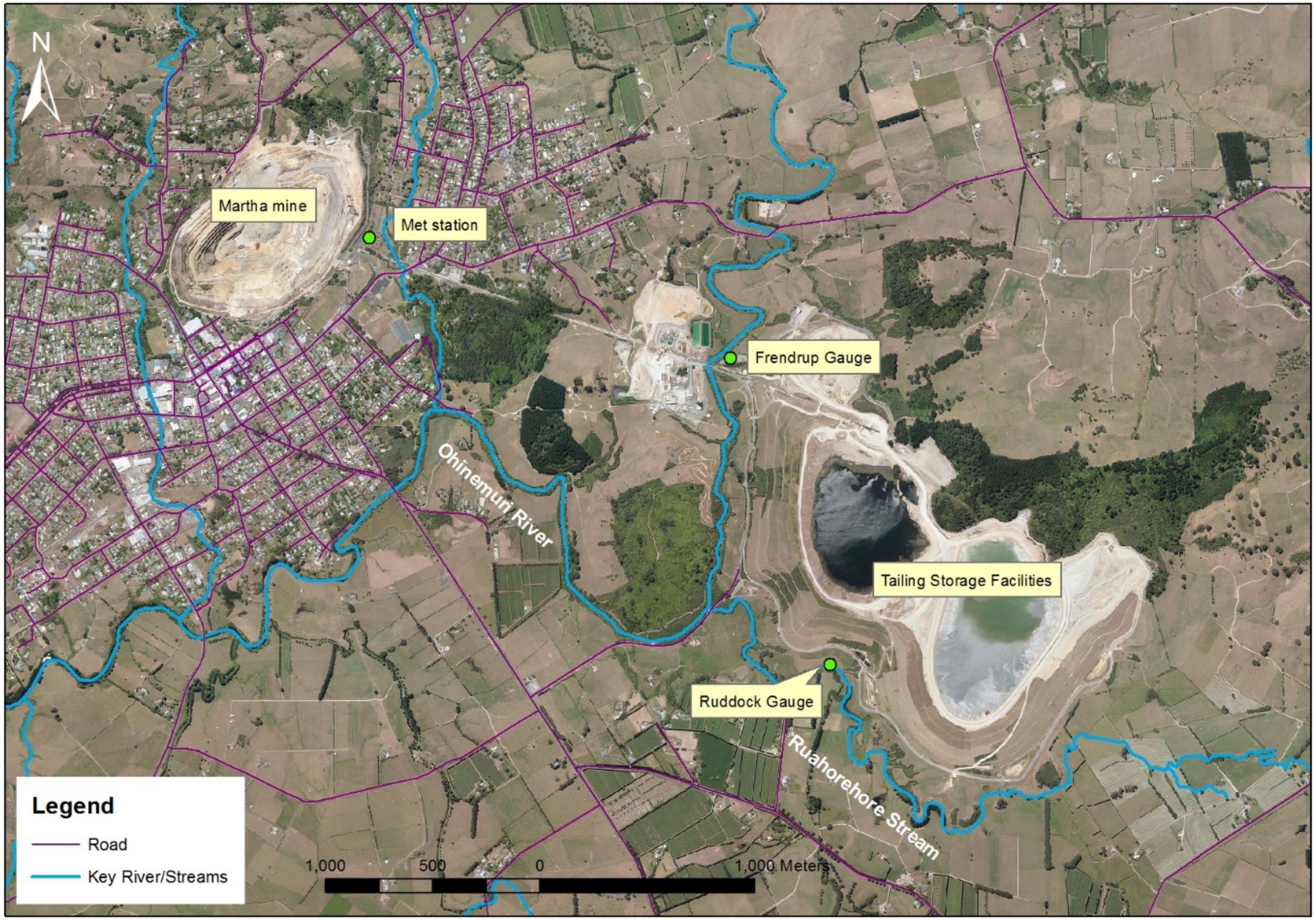


Figure 5 Ohinemuri River and Tributaries in the vicinity of Waihi

4.1.1 Flood Flow Estimates

Return period flow information for the Ohinemuri River at Queens Head was provided by Waikato Regional Council and is included in Table 8 below along with the stage that corresponds to those flows.

This analysis is based on a WISKI (Water Information System KISTERS) calculation for the period 1984 to 2017 and includes the recent large March 2017 event. The 100 year Annual Recurrence Interval (ARI) peak flow derived from this analysis is 485 m^3/s.

Table 8 Queen's Head Flood Estimates

Annual Recurrence Interval	Flow (m^3/s)	Corresponding Level (m)
5 Year	267	5.85
10 Year	320	6.44
20 Year	370	6.89
50 Year	436	7.40
100 Year	485	7.71

The Frendrups flow gauge has a catchment area of approximately 50 km^2 and has collected 15 min interval data since 1985. Flow frequency analysis of this gauge undertaken by Hydro Logic NZ Ltd for OGNZL is reproduced in Table 9.

Table 9 Frendrups Flood Estimates

Annual Recurrence Interval	Flow (m^3/s)
5 Year	80
20 Year	108
100 Year	147

4.1.2 Low Flow

Estimates of the mean annual low flow (MALF) and five year return period low flow (Q_5) developed by Woodward Clyde for the Extended Martha Project (Martha Mine Extension Site Water Management) were updated for Queens Head and Frendrups sites using the 32 years of data collected since 1985.

The updated values are provided in Table 10.

Table 10 Low Flow Estimates

Factor	Frendrups	Queens Head
Catchment Area (km^2)	50	135
MALF (m^3/s)	0.303	0.657
Q_5 (m^3/s)	0.263	0.514

4.2 Rainfall

The location of the Waihi Town rain gauge is shown on Figure 5. The gauge has been in operation since 1907. Table 11 provides a summary of annual rainfall data and Figure 6 shows annual rainfall depths measured over time.

Table 11 Waihi Annual Rainfall

Condition	Annual Rainfall (mm)	Year
Mean	2110	-
Minimum	1265	1919
Maximum	3235	1928

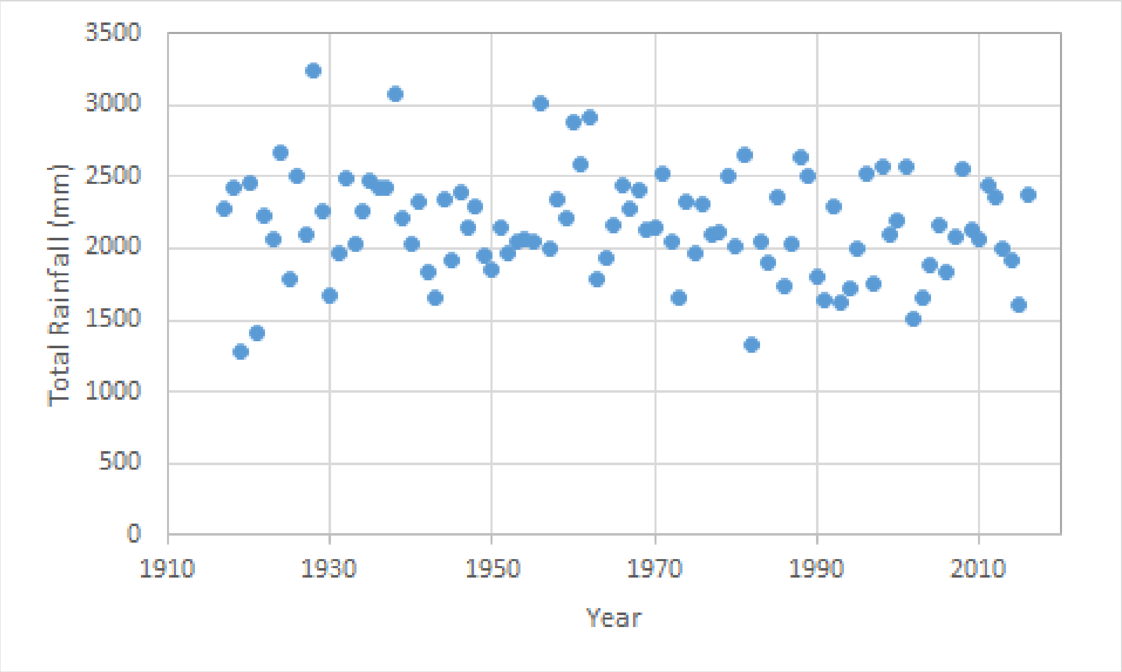


Figure 6 Annual Measured Rainfall Depths for Waihi

5. Site Water Balance

5.1 Model Overview

A water balance model (WBM) was used to assess how water gains change over the life of the mine and to check that proposed infrastructure for conveyance, storage and treatment will be adequate. This is carried out using the Goldsim (refer www.goldsim.com) software package which is designed to run Monte Carlo simulations for probabilistic analysis of dynamic systems.

The WBM was first developed in 2012 as an initiative of the site environmental team. The objective in building the model was to have a tool to forecast storage requirements in the TSF's and as an ongoing check that the site water management infrastructure as a whole had capacity for ongoing mine development. The model was also used to predict water treatment requirements post closure as a component of annual bond calculations.

The WBM has been further developed to represent Project Martha and aims to capture all significant water movements across the site affected by mine operations. The model is run as a probabilistic analysis based on 100 years of measured rainfall data, corresponding Ohinemuri River flow rates and the projected mine plan for Project Martha. A full description of how Project Martha is represented in the WBM is given in Appendix A.

A calibration of the WBM was completed with measured river flow data and recorded operation data from the WTP and mine site. This calibration is summarised in Appendix B. Given the model has been calibrated against the site water balance and in use for some time there is confidence that it does represent well the quantities of water generated from the different water sources that require treatment.

Overall, the model is considered to provide a good representation of site conditions and based on the calibration is conservative.

5.2 WBM Outputs

5.2.1 Mine Dewatering

The WBM was used to predict the dewatering rate that can be achieved under the current consented WTP discharge conditions and capabilities. The consented discharge (971318) to the Ohinemuri River is a constraint to achieving the required average rate of 15,500 m^3/d (refer Section 2.4.2) consistently since in low flow periods this can be less than the dewatering rate target. As a consequence peak dewatering rates need to be increased to make use of periods when there is a greater capacity in the river for treated water discharge.

The WBM was used to assess minewater dewatering rate requirements to meet dewatering targets over the life of the mine; which accounts for periods when minewater treatment may be constrained by the need to prioritise treatment of water from other sources.

An analysis of the peak dewatering rates required to meet dewatering targets is included in Appendix D. Figure 7 demonstrates that with a peak dewatering rate of 18,000 m^3/d the 95th percentile results use full pump capacity on any given day. The 50th percentile results typically operate under peak capacity. An exception to this is Year 2, where increased abstraction targets exceed WTP discharge and pump capacities. Figure 8 demonstrates that a mitigation strategy for this dewatering deficit can involve allowing the dewatering schedule to fall behind target during Year 2, then making up the deficit through Year 3. The 95th percentile deficit through this period accounts for a level approximately 5 m above the target, however based upon the mine development plan this is unlikely to impact operations.

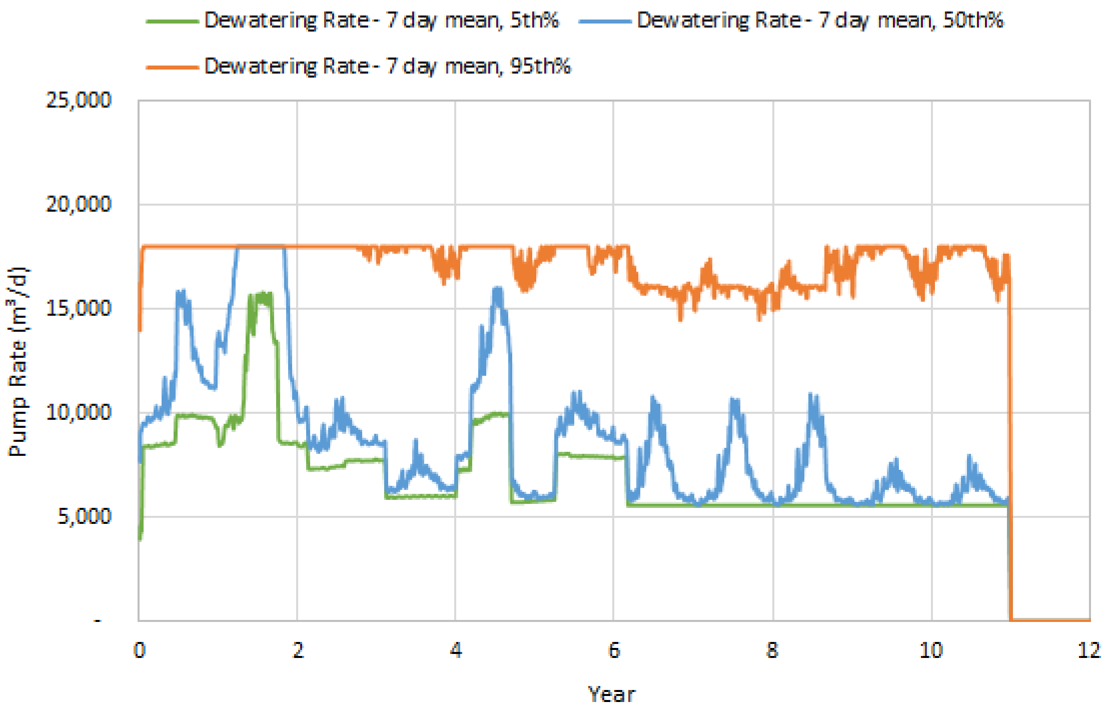


Figure 7 Dewatering pump rates, based on a maximum pump capacity of 18,000m^3/d

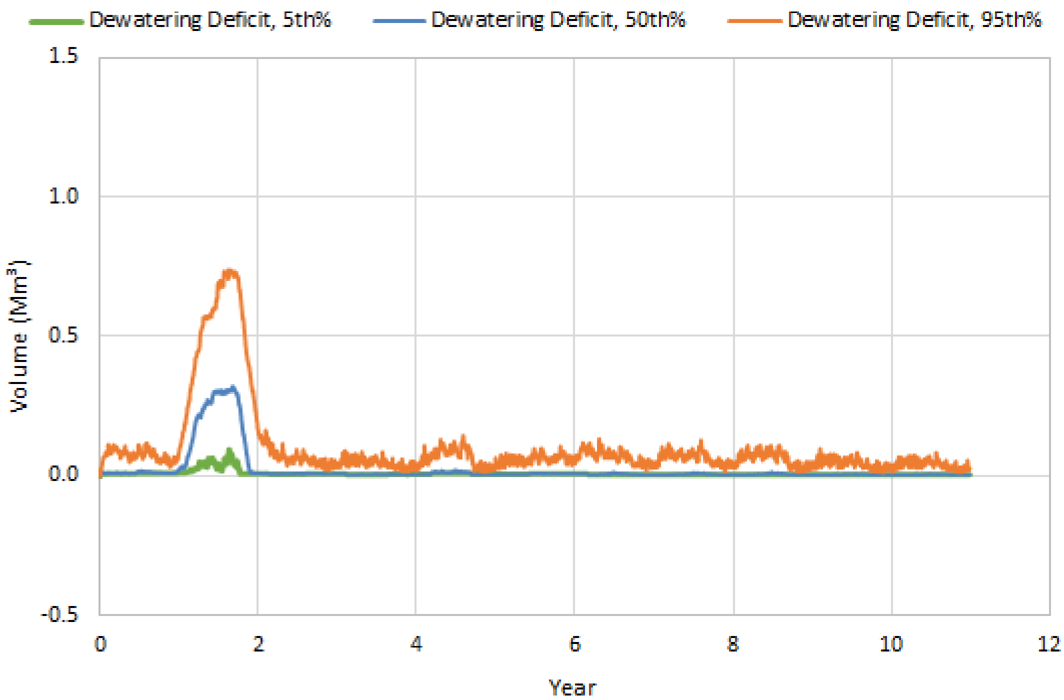


Figure 8 Dewatering deficit, based on a maximum pump capacity of 18,000m^3/d

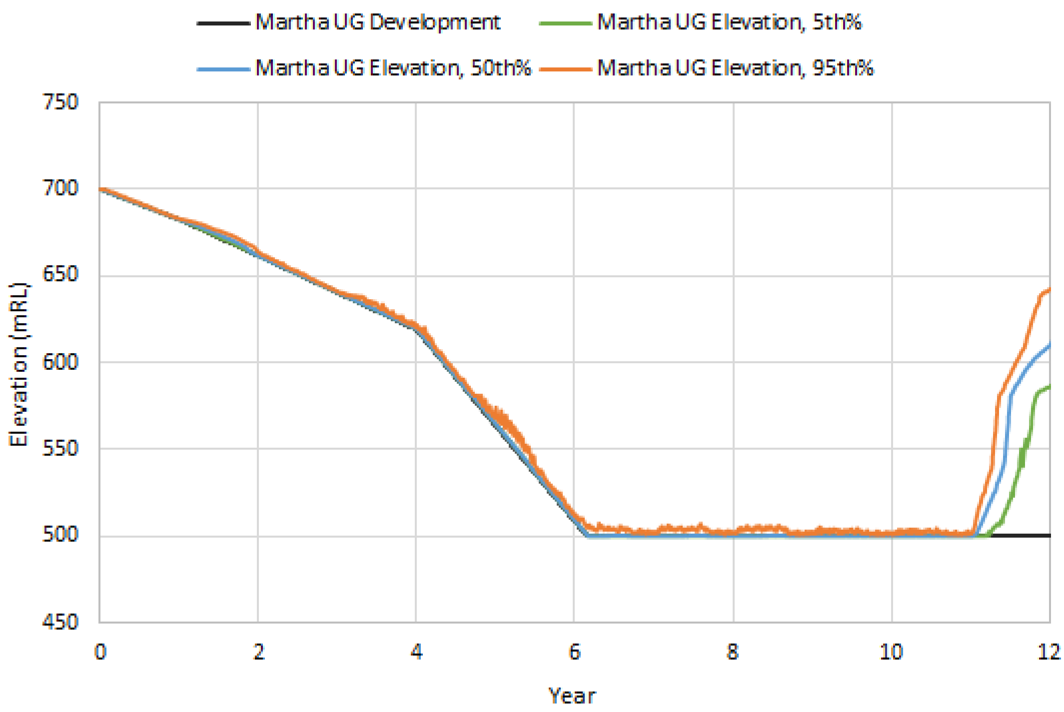


Figure 9 Projected Water Table Drawdown

5.2.2 Annual Water Balance

A forecast of water gains for each year of mining is summarised from the daily model data. These gains have been compared to the allowable discharge and based on this comparison the current WTP has sufficient capacity to treat and discharge water gains for all years of mining. The model assumes a maximum dewatering capacity of 18,000 m^3/d based on the analysis noted above.

The volumes of water requiring treatment will be greater than currently experienced and operators will need to maximise opportunity to treat and discharge water when river flows are high. Figure 10 shows the allowable discharge against mean water gains predicted over the life of the mine and Figure 11 shows the same data over Year 2, which is the worst year in terms of predicted water gains due to the high dewatering rate requirements. Overall, the projected gains of treatable water on site fall comfortably within the WTP discharge allowances.

Based on the predicted cumulative tailings deposition Figure 12 indicates TSF2 will be activated near the end of Year 6. Thus, during Years 7 to 9 impounded water from both TSF's require treatment, increasing the quantity of cyanide water to be managed through the WTP. This occurs in conjunction with decreasing dewatering rates, such that the cyanide water to mine water ratio increases, resulting in greater use of Regime B in the WTP as shown in Figure 13.

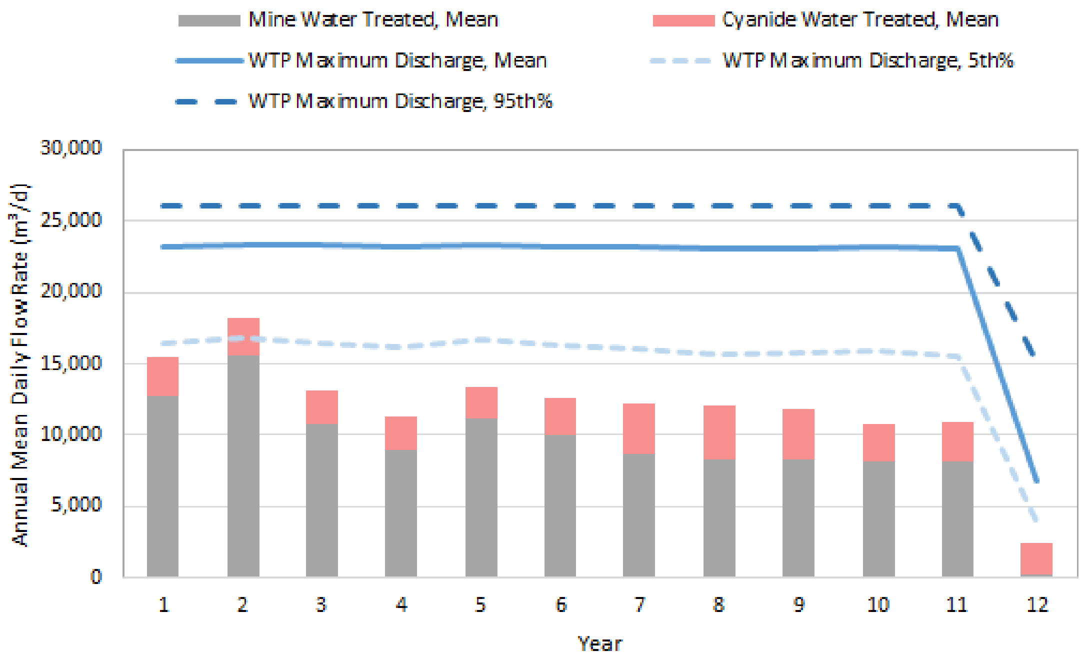


Figure 10 Annual Water Treatment Summary

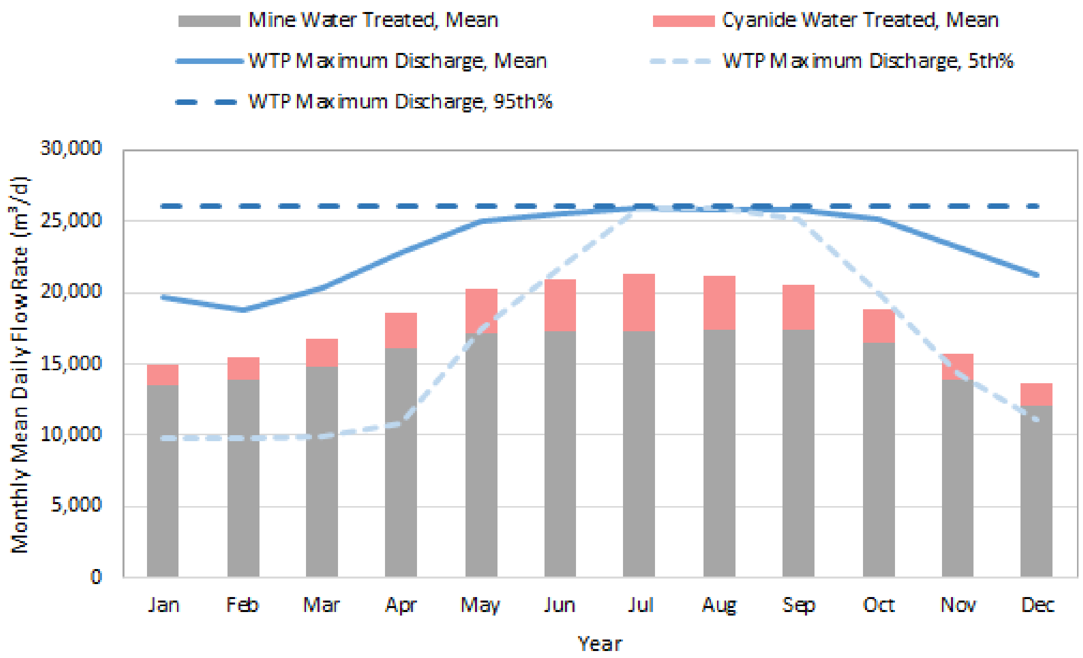


Figure 11 Monthly Water Treatment Summary, Year 2

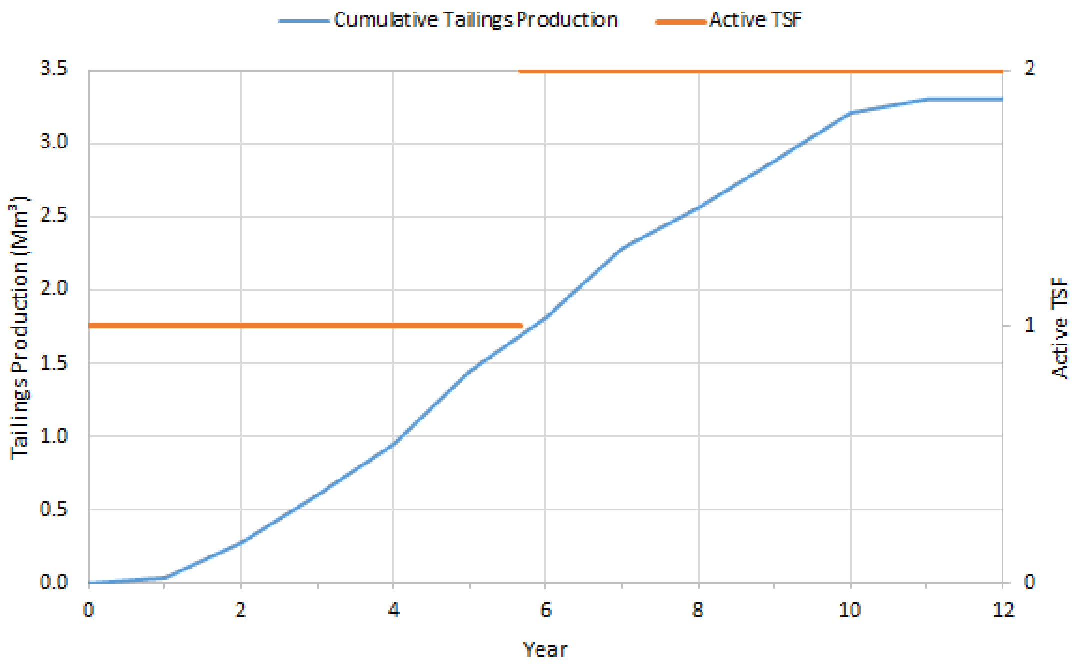


Figure 12 Tailings Production and TSF Allocation

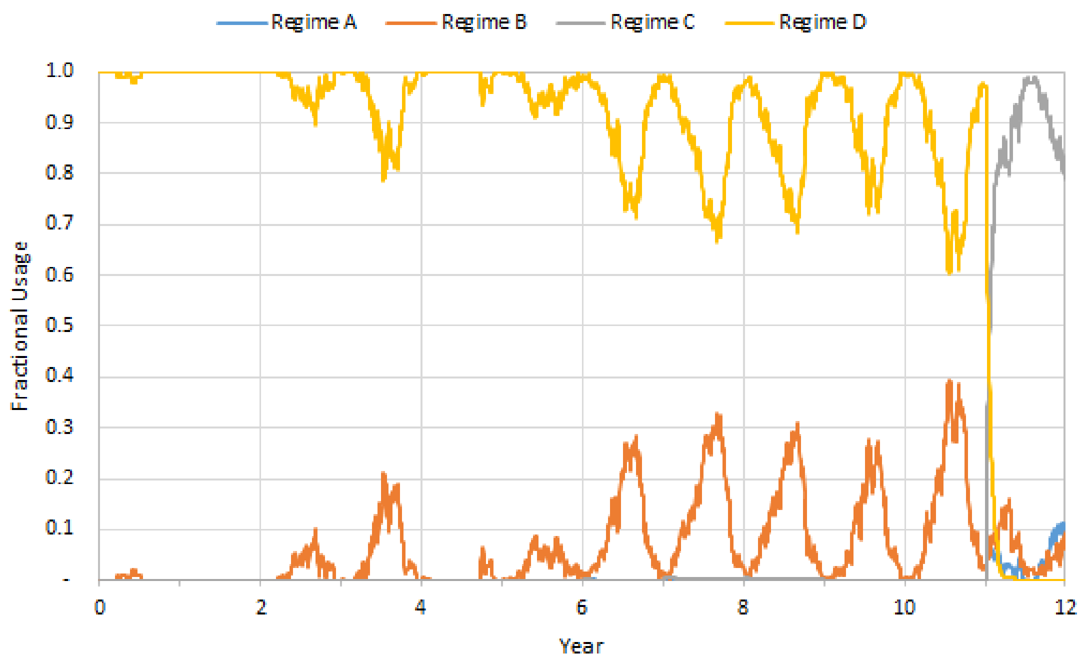


Figure 13 WTP Regime Selection

5.2.3 TSF Overflow Potential

The tailings storage ponds are designed with a freeboard allowance that must contain the PMF with an additional 1 m contingency above the normal operating levels. The level of this freeboard is 174.62 mRL for TSF1A and 158.00 mRL for TSF2, providing a freeboard of 2.63 m and 3.00 m respectively. The site water balance model has been used to test the compliance with these levels with acceptable results.

Figure 14 and Figure 15 show the projected live water surface elevations for TSF1A and TSF2 respectively. The peak water levels from the statistical model were 174.64 mRL for TSF1A in Year 6 and 158.26 mRL for TSF2 in Year 12. This indicates that the freeboard elevation was exceeded by 0.02 m in TSF1A and 0.26 m in TSF2 during high rainfall events. In both cases standard water management practices represented in the model suitably returned the water level below the freeboard allowance as required.

It is assumed that excess water will be direct discharged from; TSF2 prior to activation in Year 6 and TSF1A from Year 9 under the current discharge permit (971323). This will reduce the quantity of water requiring treatment following initial tailings deposition.

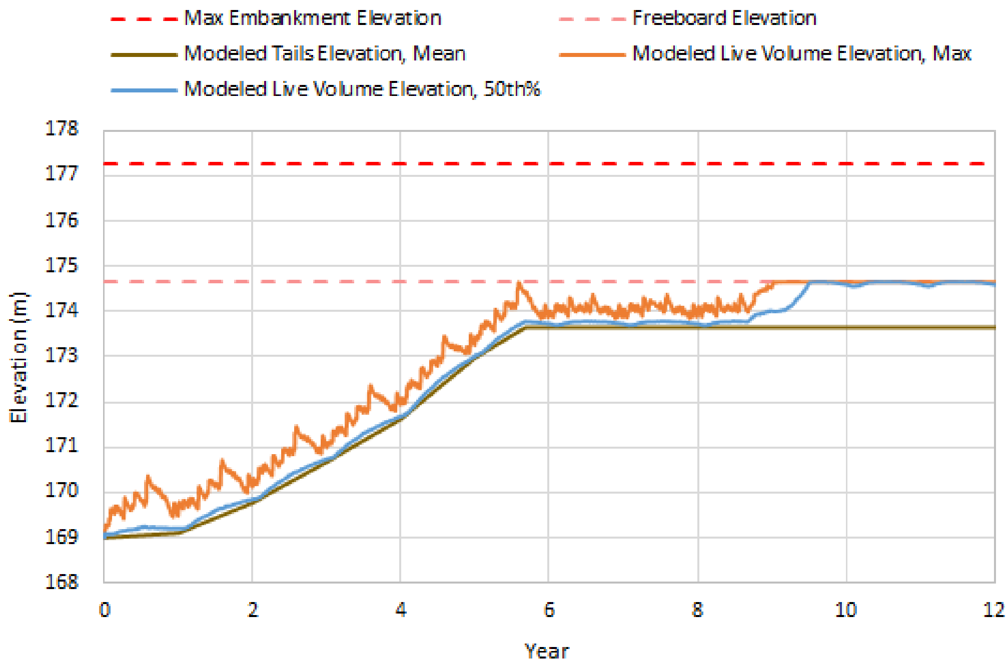


Figure 14 TSF1A Water and Tailings Elevations

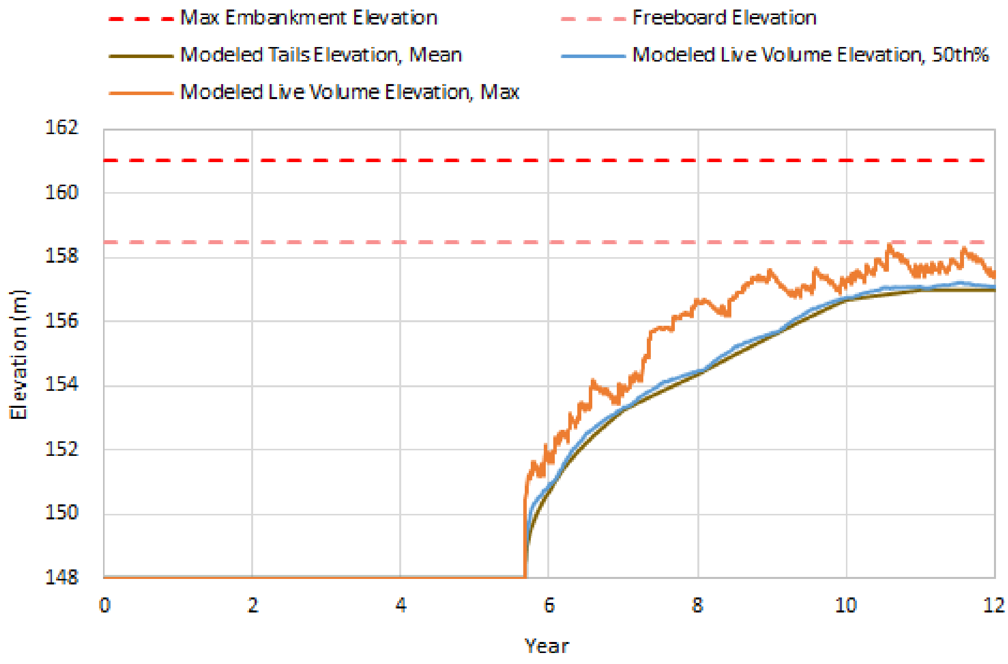


Figure 15 TSF2 Water and Tailings Elevations

5.2.4 Collection Pond Overflow Potential

The water balance model indicates that the probability of the process area ponds overflowing during the mine life is once every 2 years.

Consent conditions recognise that the collection ponds are designed to contain the runoff associated with a 10 year return period 72 hour duration event. An overflow occurring in a lesser event is considered "unpermitted". Modelling indicates the probability of unpermitted collection pond overflow during the mine life is once every 3 years.

The overflow potential indicated by the model is conservative, as the model does not have the ability to recognise when high rainfall events or overflow potential will occur. As such, the model will not take pre-emptive action to mitigate the risk as would be done in practice.

In practice the level of compliance has been very high.

5.2.5 Discharge Water Quality

A contaminant mass balance has been conducted in parallel with the WBM.

The purpose of this analysis is to identify where variations in volume and composition of waters received by the WTP could result in discharge consent breaches.

The average water quality from each source is calculated from recent site measurements as summarised in Table 7. The treated water quality is derived based on contaminant removal efficiency.

The treatment efficiencies applied by the model are summarised in Table 12. These values were provided by OGNZL. To determine compliance of the modelled WTP discharge the following conditions are applied:

- Normal compliance values are to be met by 97% of samples within each quarter.
- Maximum compliance values should never be exceeded.
- Water hardness of 670 g/m³ assumed for Regime B, and 315 g/m³ for Regime D (which targets an in-river hardness of 100 g/m³ or higher).

Table 12 Contaminant Removal Efficiency Assumptions

Contaminant	WTP Removal Efficiency
Nickel (Ni)	0.9984
Selenium (Se)	0.6
Copper (Cu)	0.98
Arsenic (As)	0.6
Lead (Pb)	0.9975
Antimony (Sb)	0.63
Aluminium (Al)	0
Mercury (Hg)	0
Cyanide (Cn)	0.87
Zinc (Zn)	0.998
S04	0
Iron (Fe)	0.98

The modelled discharge quality results are presented in Table 13 and Table 14 for Regimes B and D respectively. The average and maximum values presented are calculated across all model simulations and for the complete LOM. The consented and measured values shown for comparison are described in section 2.2.3.

The modelled results comply with existing discharge consent conditions, indicating that the current consented WTP operating regimes suit the expected changes in operation for Project Martha.

The discharge water quality analysis does not incorporate the higher contaminant removal rates that can be achieved when the RO plant is in operation.

The RO plant was constructed with the intent that it will be used where there is insufficient minewater to dilute water received by the WTP needing cyanide destruction. To represent current mine operation the RO capabilities are not included in this water quality analysis. However, it does provide a contingency should mine dewatering rates be reduced or curtailed from the modelled rates.

Table 13 Treated Water Quality Discharge under Regime B

	Consented Water Quality		Modelled Quality		Measured Quality		Compliant	
Chemical Parameter	**Normal (g/m^3)**	**Maximum (g/m^3)**	**Average (g/m^3)**	**Maximum (g/m^3)**	**Average (g/m^3)**	**Maximum (g/m^3)**	**Normal**	**Maximum**
Arsenic (As)	1.14	1.14	0.005	0.022	-	-	Yes	Yes
Cyanide (Cn)	0.2	0.56	0.015	0.047	0.016	0.22	Yes	Yes
Copper (Cu)	0.007	0.102	0.003	0.007	0.055	0.1	Yes	Yes
Iron (Fe)	0.8	5	0.069	0.565	0.042	0.85	Yes	Yes
Mercury (Hg)	0.0005	0.0005	5E-5	0.0002	-	-	Yes	Yes
Lead (Pb)	0.018	0.018	2E-6	5E-6	-	-	Yes	Yes
Antimony (Sb)	0.1	0.18	0.005	0.012	0.011	0.067	Yes	Yes
Selenium (Se)	0.12	0.2	0.009	0.021	0.012	0.1	Yes	Yes
Zinc (Zn)	0.61	0.61	0.002	0.003	-	-	Yes	Yes

Table 14 Treated Water Quality Discharge under Regime D

	Consented Water Quality		Modelled Quality		Measured Quality		Compliant	
Chemical Parameter	**Normal (g/m^3)**	**Maximum (g/m^3)**	**Average (g/m^3)**	**Maximum (g/m^3)**	**Average (g/m^3)**	**Maximum (g/m^3)**	**Normal**	**Maximum**
Arsenic (As)	0.66	0.66	0.005	0.023	-	-	Yes	Yes
Cyanide (Cn)	0.11	0.32	0.006	0.051	0.01	0.21	Yes	Yes
Copper (Cu)	0.004	0.061	0.001	0.008	0.033	0.6	Yes	Yes
Iron (Fe)	0.5	3.1	0.065	0.603	0.028	0.4	Yes	Yes
Mercury (Hg)	0.0005	0.0005	3E-5	0.0002	-	-	Yes	Yes
Lead (Pb)	0.011	0.011	1E-6	5E-6	-	-	Yes	Yes
Antimony (Sb)	0.06	0.1	0.003	0.013	0.007	0.073	Yes	Yes
Selenium (Se)	0.07	0.12	0.005	0.022	0.008	0.037	Yes	Yes
Zinc (Zn)	0.36	0.36	0.002	0.003	-	-	Yes	Yes

5.3 Risk Review

Based on the WBM analysis the quantity of water requiring treatment generated over the life of Project Martha can be contained, treated and discharged within the constraints of existing resource consents and current WTP capacity. Key differences to current operation that will need to be managed include:

- The rate of mine dewatering will be consistently higher than what currently applies. Since 2015 mine dewatering has averaged 7,350 m^3/d, with a peak of 15,550 m^3/d. Dewatering targets will increase this rate up to 18,000 m^3/d through some periods on the mine development. To meet these dewatering targets WTP operation will need to focus on maximising the treatment and discharge of minewater when river flows allow. If dewatering targets are not met the impact will be on mine development.
- Increased rates of mine dewatering are expected to lift treatment rates about 40% higher than has applied in the past.
- There will be a three year period where two TSF decant ponds require treatment and the rate of mine dewatering drops as target depths have been met (~Year 6). As the proportion of cyanide water increases over this period regular use of Regime B may be required.
- An RO plant is installed on site, providing a further level of contingence that has not been included in the analysis presented in this report. Should water contaminants exceed expected levels activation of the RO plant can assist in mitigating any consequences.

6. General Stormwater Management

6.1 Relevant Resource Consents

Resource consents held by OGNZL relevant to erosion and sediment control include:

- Resource Consent 971311 provides for the discharge of settled stormwater from silt ponds into the Ohinemuri River and the Ruahorehore Stream.
- Resource Consent 971312 provides for the discharge of water from the collection ponds within Area D, to the Ohinemuri River and to the Ruahorehore Stream.

The following consent condition is common to both of these consents:

- *The consent holder shall ensure that sediment losses to natural water from the exercise of this consent are minimised and that silt control measures are in place prior to the exercise of this consent. In this respect, sediment control practices shall be undertaken in accordance with the principles outlined in the Waikato Regional Council 'Design Guidelines for Earthworks, Tracking and Crossings', dated 1995, or updates.*
- *For suspended solids there shall be no greater than a 10% increase compared with upstream concentrations for rainfall events greater than the design storm.*

For the silt ponds suspended solids must meet the following conditions in a rainfall event less than or equal to a 2-year return period:

- *Have a suspended solids concentration of no greater than 100 g/m^3.*

For the collection ponds suspended solids must meet the following:

- *For upstream concentrations of less than or equal to 100 g/m^3 the increase shall be no greater than 10 g/m^3. For upstream concentrations of greater than 100 g/m^3 the increase shall be no greater than 10%.*

For silt ponds the design storm is defined as follows:

- *Silt ponds shall be designed and constructed to have a minimum live storage capacity equivalent to the volume of run-off generated during a 2-year return period, 2-hour duration, design storm. Whilst required to stay in service to treat water containing elevated suspended solids concentrations, these ponds shall be regularly maintained so as to retain the design capacity.*

With the site being well established, areas that do not currently drain to either a collection pond or silt pond are minimal. Where minor earthworks are undertaken the general principles of minimising disturbed areas, diverting clean runoff where practicable and providing temporary silt barriers (e.g. silt fences) are applied. Compliance has been achieved to date with consent conditions relating to discharge of sediment to receiving waters.

7. Post Mining Water Management

7.1 Pit Lake Description

Post closure the pit will be filled to form a pit lake. The lake will be filled with a combination of natural inflows from groundwater and surface runoff and water pumped from the Ohinemuri River. OGLNZ may choose to further augment pit filling with treated water; this volume is not accounted for in our pit filling analysis.

Table 15 summarises the extent and volume of the proposed pit lake.

The lake level has been set at RL 1104m since 1996 and remains unchanged. The lake level was set to provide a 2 m buffer depth to the nearest known historic adit level. While no direct connections to this adit are known; this buffer has been applied as a contingency against uncontrolled discharge from the adit. The lake will overflow to the Mangatoetoe Stream through a piped outlet and the location of this in relation to the lake is shown on Figure 18.

The size of this outlet pipe is estimated based on limiting lake rise in a storm event to within the buffer depth noted above and this analysis is summarised in section 7.2. The impact of the lake discharge on flood levels in the Mangatoetoe Stream was also assessed and this is covered in section 7.3.

Table 15 Pit Lake Dimensions

Item	Unit	Existing	Proposed
Lake Area	Ha	35.4	40.13
Lake Level	mRL	1,104	1,104
Pit Floor	mRL	910	875
Lake Volume	Mm^3	35.4	43

7.2 Pit Lake Outlet

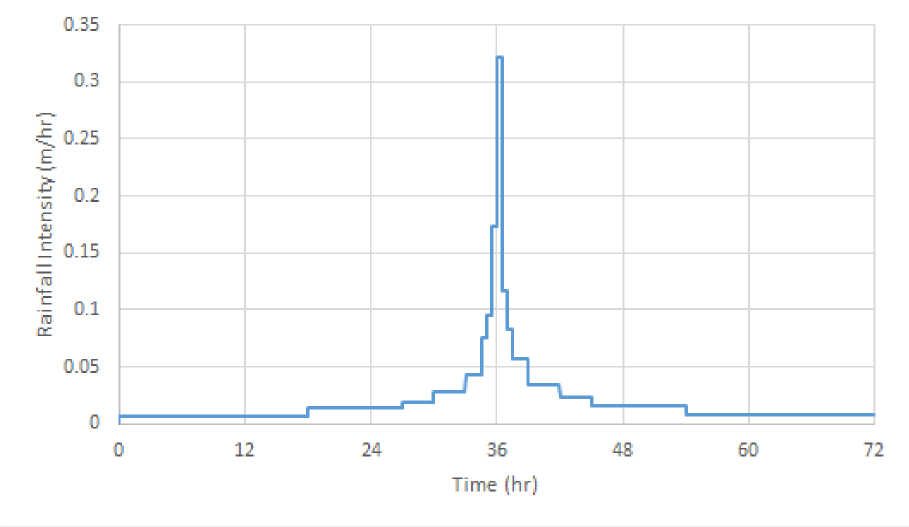
7.2.1 Outlet Sizing

A conservative approach was taken to sizing the pit lake outlet since there is no alternate constructed overflow point. The outlet has been sized assuming a worst case rainfall event; this being the PMP and with allowance for partial blockage due to debris. The analysis conservatively applies a 20% contingency to the rainfall depth and a 40% blockage of the pipe inlet.

The design criterion is summarised as limiting water level rise to 1 m in a PMP event.

The PMP analysis adapts the Auckland Council TP108 rainfall distribution in lieu of a site specific distribution. Analysis inputs and outputs of the routing analysis are provided in Figure 16. With a 1.8 m diameter outlet pipe water level rise is restricted to 1 m. The peak discharge from the pit lake outlet is predicted to be 4.32 m^3/s (Figure 16), this is based on the PMP (72 hr duration) rainfall with an additional 20% allowance for climate change which is considered to be an extreme and unlikely storm.

PMP Assumed Rainfall Distribution



Routing Inputs			
A_{lake}	40.13	ha	*Lake area at 104 mRL*
$A_{catchment}$ =	57.49	ha	*Area of Catchment*
$C_{catchment}$ =	1	-	*Runoff Coef.*
L =	147.7	m	*Pipe length*
H_1 =	100.5	mRL	*Bottom Invert of Pipe*
H_2 =	103.5	mRL	*Top Invert of Pipe*
H_3 =	104	mRL	*Intake Weir Level*
D =	1.8	m	*Diameter*

Routing Outputs			
$Q_{outflow,max}$ =	4.32	m^3/s	*Maximum outflow from lake*
$Q_{inflow,max}$ =	51.45	m^3/s	*Maximum rate of rainfall on lake catchment*
L_{max} =	105.02	mRL	*Maximum water level*

Lake Level and Discharge

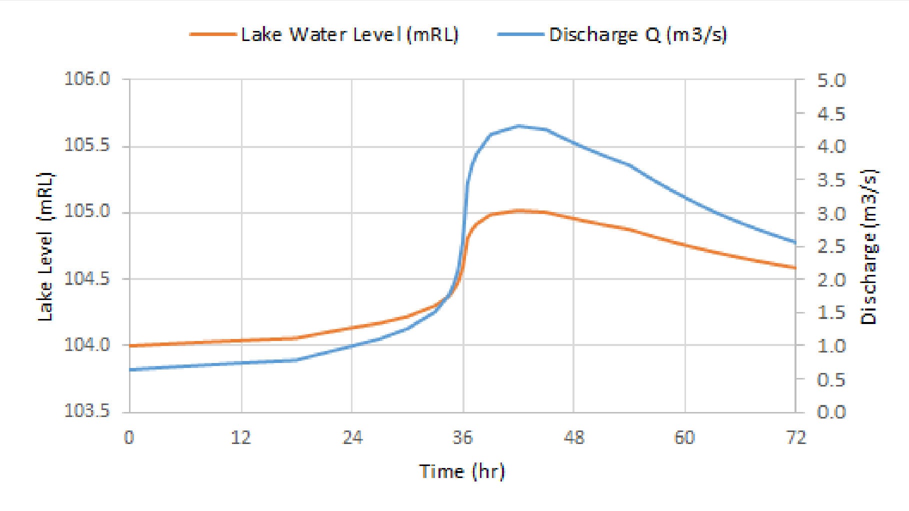


Figure 16 PMP Rainfall Distribution Applied to Pit Lake Outlet Sizing

7.3 Pit Lake Discharge to Mangatoetoe Stream

The Mangatoetoe Stream has a history of flooding. In July 2005 one dwelling flooded and there was overtopping of the culvert located at the junction of Consols St and Baber St following heavy rainfall.

The Waikato Regional Council undertook a study of this event (Technical Report 2005/32) and as part of the study reviewed 50 year ARI flood levels and stream channel condition. The study concluded that the July 2005 event was equivalent to a 20 year ARI event and that blockage of the steam channel from debris contributed to flood levels. The report also provided recommended design floor levels for Baber St based on estimated 50 year ARI flood levels.

The pit lake outlet will discharge to the Mangatoetoe Stream and a hydraulic model of the stream was developed by GHD to check that the discharge will not worsen existing flood inundation.

The Waikato Regional Council report indicated a 100 year ARI flood flow of 48.9 m^3/s at Consols St (based on a Regional Frequency Analysis) and this value has been adapted for our analysis.

7.3.1 MIKE21 Model Description

A hydraulic model of the Ohinemuri River was developed in MIKE 21. Surveyed cross-section data for the Mangatoetoe Stream provided by OGNZL was used to replicate the stream channel in the model. Catchment hydrology is defined in the model using a series of sub-catchment hydrographs. These hydrographs connect to the MIKE 21 grid at sub-catchment discharge points along the stream as shown in Figure 17.

The shape of the flow hydrograph used for the Mangatoetoe Stream catchment was developed considering the time of concentration and runoff volumes of the Mangatoetoe Stream catchment, and effects of flow attenuation in the Mangatoetoe Stream.

The modelled peak flow hydrograph from each sub-catchment is approximated as a trapezoidal distribution with a total duration of 2.5 hours with 1 hour to the peak. All sub-catchments were assumed to peak at the same 1 hour duration even though the sub-catchments are expected to peak at differing times in practise.

The sub-catchment peak flows for the Mangatoetoe Stream used in the model are listed in Table 16.

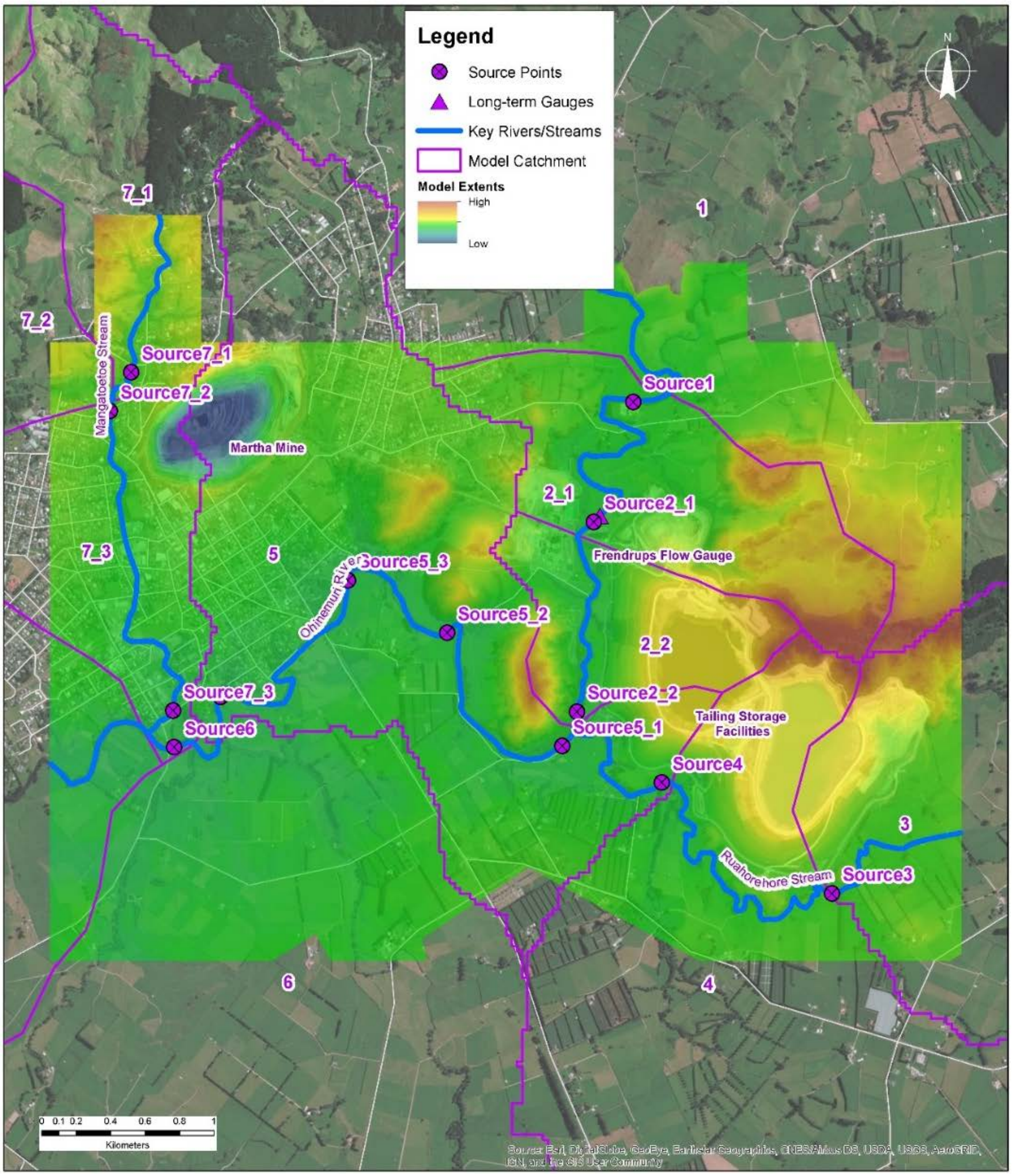


Figure 17 MIKE 21 Grid Extent

Table 16 Mangatoetoe Stream 100 Year ARI Peak Flows

Catchment	Area (km^2)	100 Year ARI (m^3/s)	100 Year ARI + 10% Climate Change (m^3/s)	100 Year ARI + 10% Climate Change +Contingency (m^3/s)
Existing Development:				
Source7_1	2.0	23	25	30
Source7_2	1.0	11	12	15
Source7_3	1.3	15	17	20
Martha Pit	0.6	N/A	N/A	N/A
Total	**4.9**	**49**	**54**	**65**
Proposed Development:				
Source7_1	2.0	23	25	30
Source7_2	1.0	11	12	15
Source7_3	1.2	13	15	18
Martha Pit	0.7	12	13	16
Total	**4.3**	**59**[1]	**65**[1]	**79**[1]

A roughness coefficient of Mannings n 0.05 was used in the model for the Mangatoetoe Stream considering the moderately vegetated channel and banks.

MIKE URBAN software by DHI was used to model the pit lake outlet. MIKE FLOOD software by DHI links the pit lake outlet model (MIKE URBAN) and Mangatoetoe Stream model (MIKE 21) for simulation. A 1.8 diameter outlet pipe was assumed.

7.3.2 Effects of Pit Lake Outlet on Mangatoetoe Stream Flood Levels

The proposed pit lake outlet flows will have no discernible effect on the flood levels in the Mangatoetoe Stream based on the findings of this study.

This is evident by comparing existing and future development floodplain maps for the area of interest (refer Figure 18) and floodwater levels with and without the lake discharge as listed in Table 17.

Table 17 Mangatoetoe Stream 100 year ARI analysis

Scenario	Peak Water Level in Mangatoetoe Stream (mRL)	Peak Flow in Outlet Pipe (m^3/s)	Peak Water Level in Martha Pit (mRL)
Existing :		N/A	N/A
Walker Street	102.7		
Seddon Street	100.7		
Roberts Street	96.4		
Future with discharge :		0.75	104.2
Walker Street	102.7		
Seddon Street	100.7		
Roberts Street	96.4		

7.3.3 Sensitivity Analysis

The effects of a longer duration storm response from the Mangatoetoe Stream catchment was analysed as a sensitivity analysis to compare the effects of the pit lake discharge on the Mangatoetoe Stream for a longer duration storm. The modelled peak flow hydrograph from each sub-catchment was approximated as a triangular distribution with a total duration of 20 hours with 8 hours to the peak. This analysis showed no change in stream water levels due to the pit lake outlet discharge. Analysis showed the pit lake outlet peak flow to be 7 hours behind the stream peak flow in this scenario.

Table 18 Sensitivity Analysis (20 hour duration) - Mangatoetoe Stream 100 Year ARI findings

Scenario	Peak Water Level in Mangatoetoe Stream (mRL)	
	Existing Development	Future Development
Walker Street	102.4	102.5
Seddon Street	100.4	100.4
Roberts Street	96.1	96.1

7.3.4 Conclusions

The proposed pit lake outlet discharge will have no discernible effect on flood levels in the Mangatoetoe Stream based on the findings of this study.

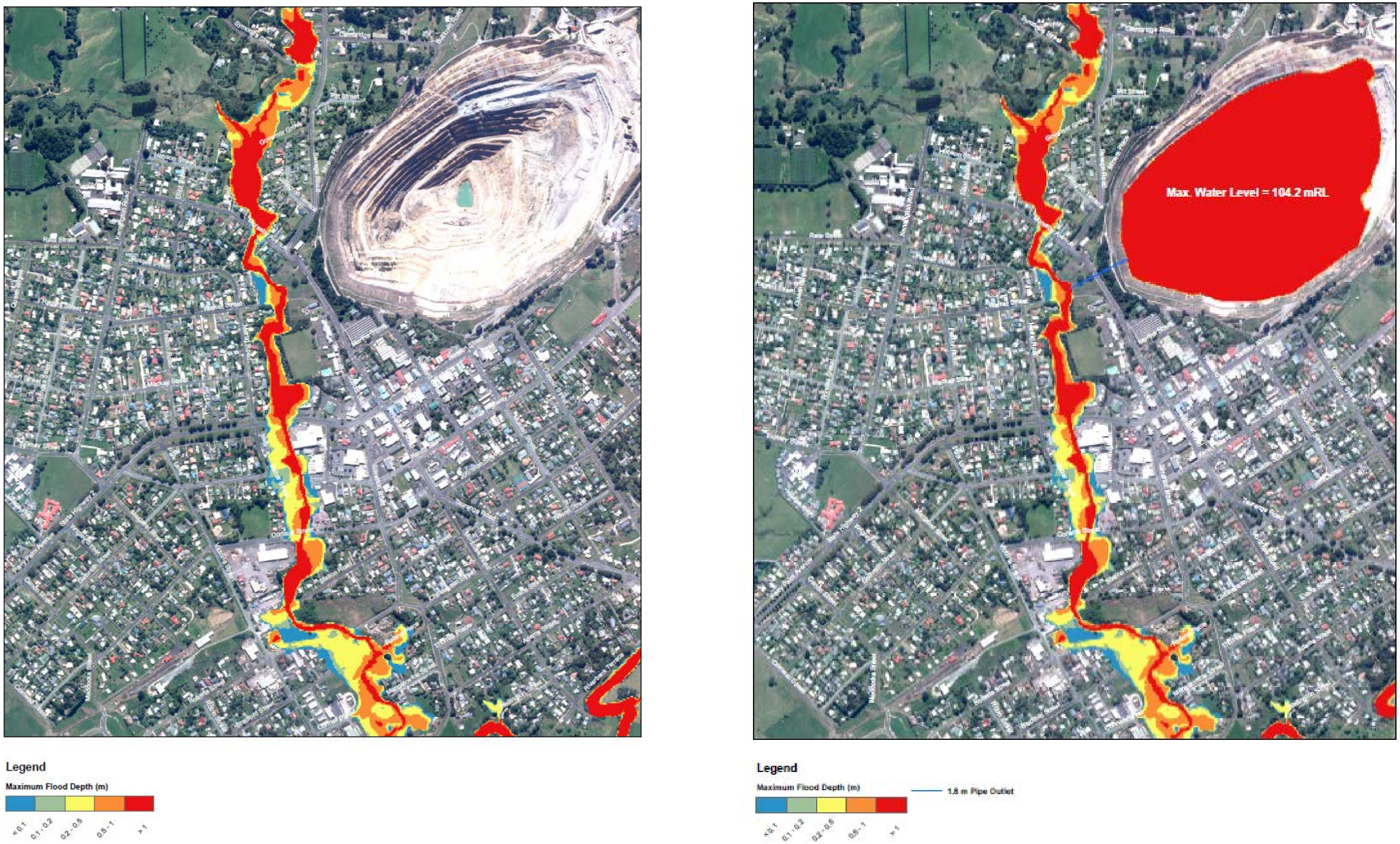


Figure 18 Mangatoetoe Stream Flood Inundation map with and without Pit Lake Discharge (100 year ARI event)

7.4 Pit Lake Filling Analysis

7.4.1 Model Overview

A stochastic water balance model simulating the Martha pit catchment and connected groundwater systems has been developed in the Goldsim modelling platform. The model allows statistical prediction of mine dewatering requirements, rewatering rates, pit lake filling rates and provides a lake water balance from which water quality assessment can be undertaken.

The model is based on the groundwater assessment, detailed by GWS (2018) which utilises documented pumping rates and mine development plans to provide an estimate of water taken to achieve dewatering at specific elevations. The water balance is based on the underground storage volumes and ground water inflows presented in this study, along with the historical rainfall and evaporation rates described in Appendix A and a proposed water take from the Ohinemuri.

The model calculates a daily water balance, predicting water levels within the pit lake and the underground mines, and the flow of water between these. Monte Carlo analysis, utilising 1,000 realisations was carried out, providing the predicted statistical distribution of filling times and water balance. A detailed description of the model and analysis results is given in Appendix D.

7.4.2 Pit Lake Filling Results Summary

The predicted filling rate of the pit lake with a proposed average contribution of 15,000 m^3/d from the Ohinemuri River is given in Figure 19. The model predicts a median filling duration of 9.4 years from the time at which dewatering finishes. The influence of rainfall and river flow conditions are shown to vary the filling duration by ±0.7 years between the 5^{th} and 95^{th} percentile of model results. There is a small variability in underground working and rock mass storage estimates (GWS 2018) also included in analysis.

Water level recovery is not expected to be visible in the Martha pit for approximately 3.5 years once dewatering has concluded, as water additions prior to this will recharge the underground mine areas. Further details of the proposed water take is given in Section 7.5.

For comparison, without including the contribution from the Ohinemuri River the time to fill could range between 39 and 43 years.

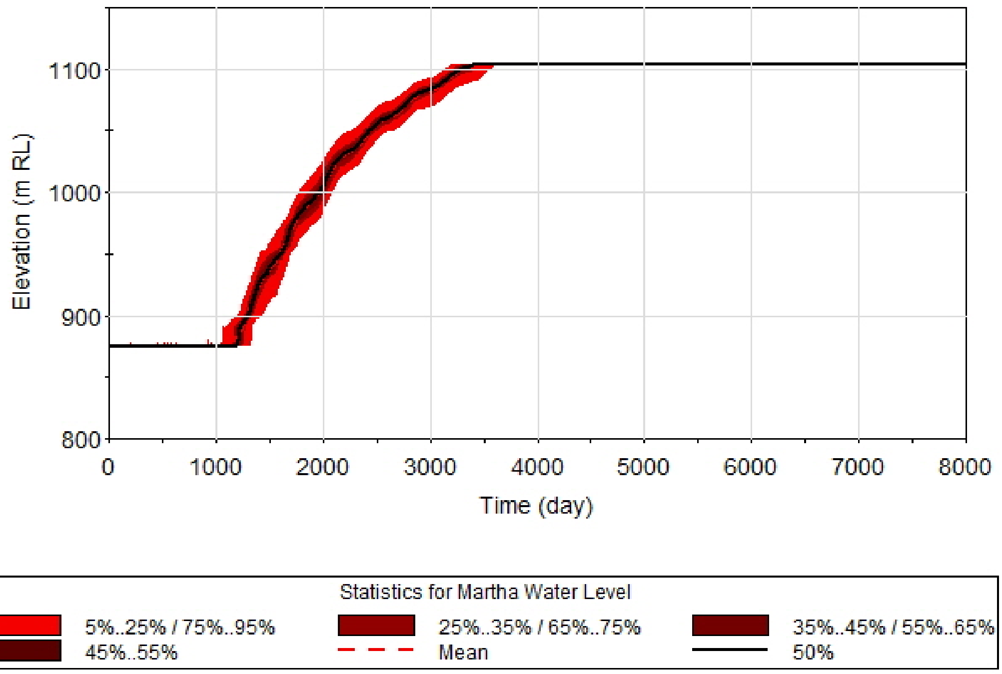


Figure 19 Filling Rates of the Pit Lake with annual average river water contribution of 15,000 m^3/d

On completion of filling, the addition of Ohinemuri River water will cease and the lake level will be controlled at the overflow level of 1104 mRL. A long term water balance analysis shows that average inflows into the lake exceed evaporation, providing a regular discharge from the overflow at an average rate of 31 L/s. However, during prolonged dry periods, evaporation may temporarily exceed water inputs. During such times the rate of discharge from the lake will decrease and may temporarily cease. A summary of the contributions and withdrawals from the lake are given in Table 19.

Table 19 Average Daily Water Balance for the Pit Lake following filling

Water Component	Average Input (m^3/day)	Average Withdrawal (m^3/day)
Rainfall	3,165	-
Groundwater	509	-
Evaporation	-	1,007
Overflow	-	2,667

7.5 Ohinemuri River Water Abstraction

7.5.1 Background

Analysis undertaken in support of the Extended Project (Woodward Clyde 1996) showed that a maximum abstraction capacity of 15,000 m^3/d (175 l/s) yielded an average supply of 9,000 m^3/d (105 l/s) when low flow take restrictions were taken into account. Abstraction is not permitted when the river flow is at less than twice the MALF. The abstraction relates to an abstraction point located downstream of the Ruahorehore Stream and Ohinemuri River confluence as shown on Figure 20.

The pit lake volume to fill at the end of Project Martha is larger than that considered for the Extended Project at 43 Mm^3. In addition as outlined by GWS (2018) there is a considerable drawdown volume outside and below the pit that will need to be rewatered before the lake will start to develop. Overall GWS estimates a total volume of 69 Mm^3 applies to the pit lake and surrounding country below the final lake level of 1104 mRL.

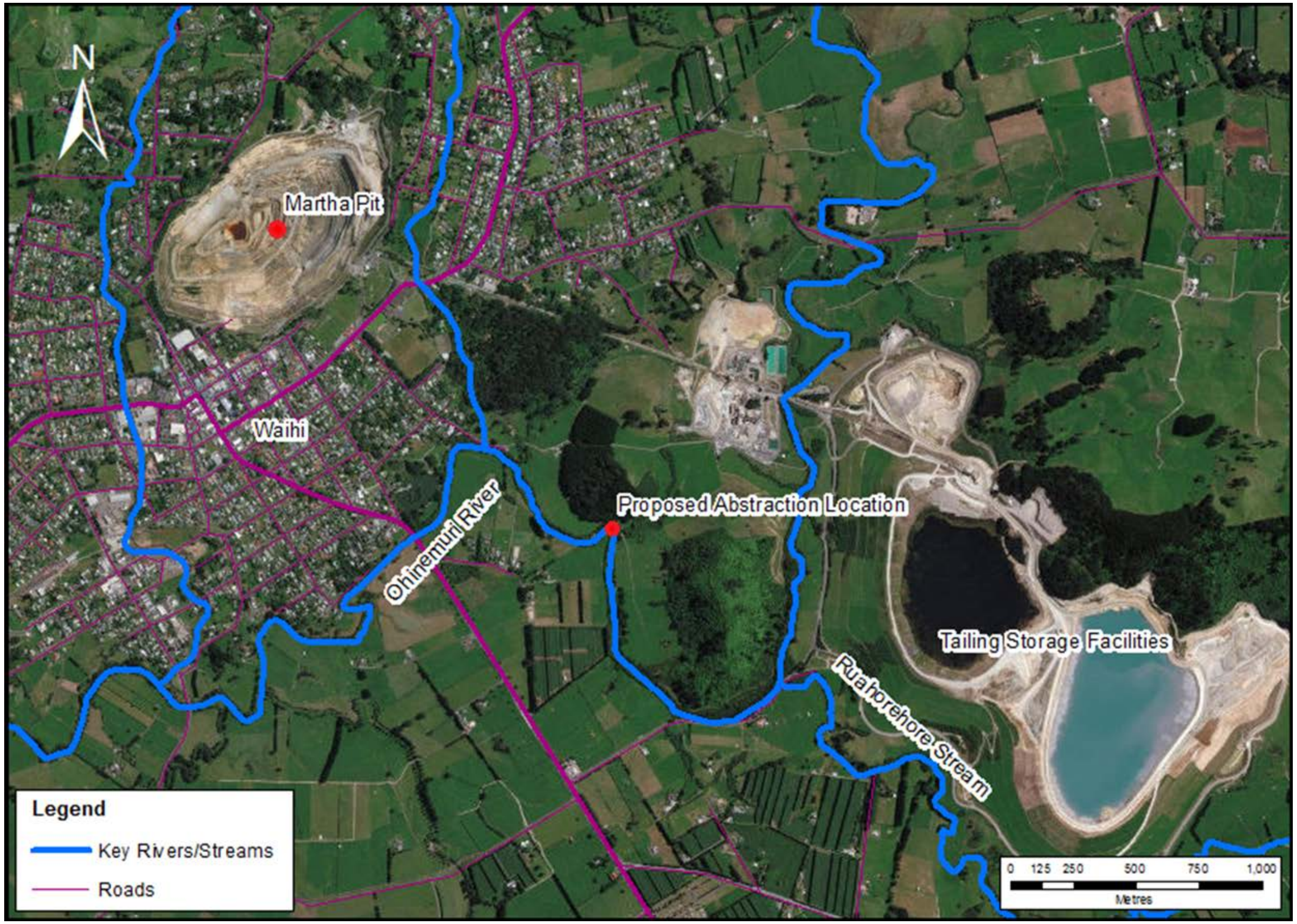


Figure 20 Ohinemuri River Water Abstraction Location

7.5.2 Abstraction Analysis

To investigate opportunities to reduce the pit lake filling time the long term river flow record was used to analyse the effects of the pump capacity and a limit on the proportion of flow to be taken. The range of possible rates applied were 10 to 20% of river flow (when flows above 2×MALF). It is assumed in the analysis that if the river flow meets the minimum flow for abstraction, the full portion of the flow will be used. Figure 21 shows the results of different percentage takes of river flow for a range of pump capacities without a restriction of maximum take rate.

For comparison Figure 22 shows the same graph with a peak pump rate of 270 l/s.

To achieve the proposed average river water contribution of 15,000 m^3/d with a pump capacity of 270 l/s, Figure 22 shows that a take of 20% of the river flow above 2×MALF is required.

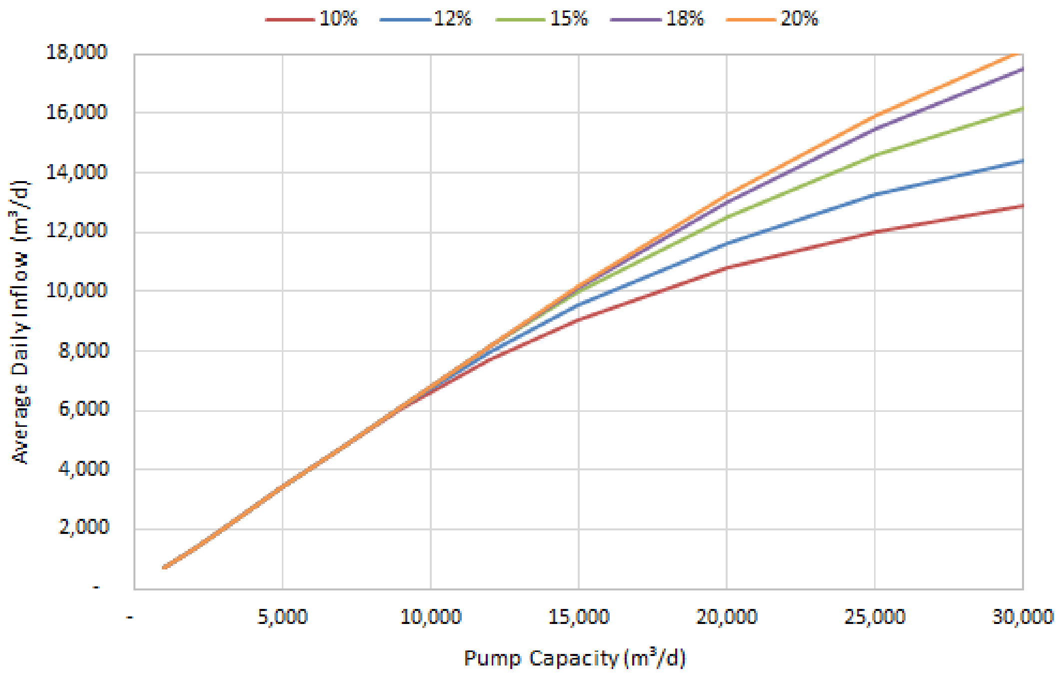


Figure 21 Varying the extraction proportion without limits on the pump capacity

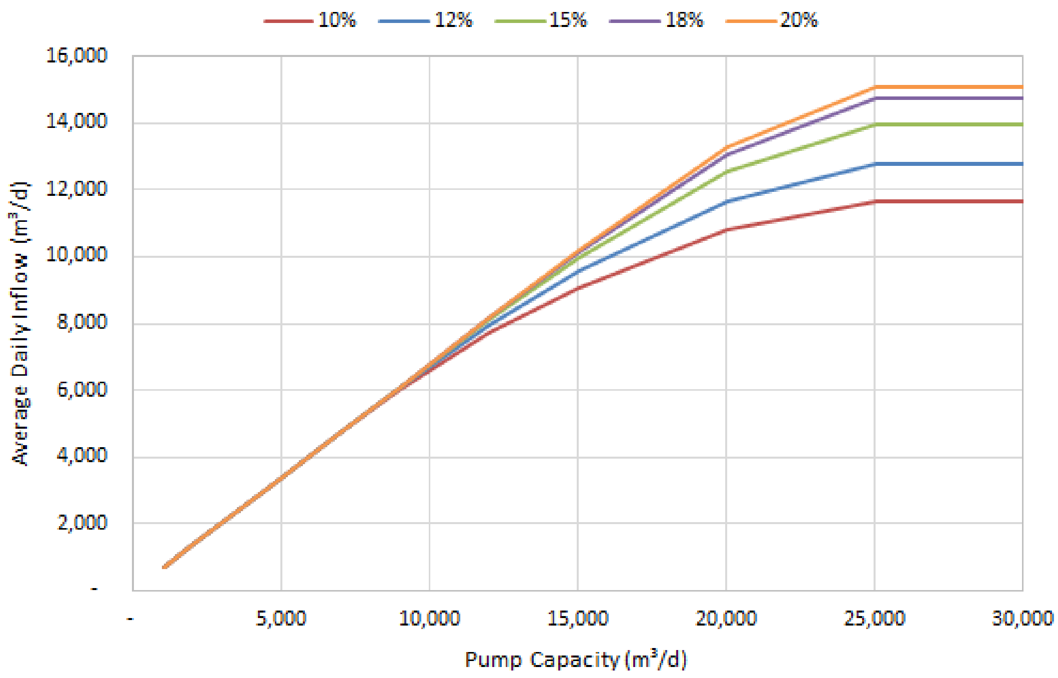


Figure 22 Varying the extraction proportion with a pump capacity of 270 L/s

7.5.3 Discussion

OGNZL advise that a reduction in pit filling time is considered important to the community and AECOM advise it would also be beneficial for pit lake water quality.

The previous abstraction analysis by Woodward Clyde (1996) considered a maximum extraction rate of 175 l/s and an allocation of 10% of the river flow above 2×MALF. Of relevance to this study is that the existing maximum abstraction rate was not set on the basis of protecting any specified values of the Ohinemuri River. Rather, it was based on the pump rate of 175 l/s. The rate was selected on the basis that there were diminishing returns in investing in a larger pump due to the “peaky nature” of the river i.e. a higher pump capacity would be infrequently used and thus inefficient. The 10% allocation limit also was not imposed in order to protect any specified values in the receiving water – the value was selected at the time as a “reasonable” rate to consent based on achieving at the time (1996) a 5 year fill time.

Based on the above there is no known environmental constraint to authorising an abstraction subject to an allowable take of 20% of river flow (above 2×MALF) and the pump selected will ultimately constrain the abstraction amount that can be taken.

A statutory plan analysis of the policies and rules that would be applied in assessing this proposed increase in the rate and volume of take from the Ohinemuri has not been undertaken in this report. This analysis is given in the Project Martha Assessment of Environmental Effects (Mitchell Daysh 2018).

7.6 TSF Post Mining Discharge Plan

Site experience has shown that it takes approximately 2.5 years for TSF decant water to reach receiving water quality standards once tailings deposition has ceased (based on TSF2 clean up between July 2005 and October 2007). Given there is no change in predicted tailings characteristics for Project Martha it is expected that the same period will apply for each of the TSFs and a contingency is included in this report by adopting a 3 year clean up period.

Overflow from TSF1A could commence after Year 6 and overflow from TSF2 could follow 3 years after mine closure (and final tailings deposition) in Year 15.

Overflow will be subject to pond water quality meeting receiving water quality standard as was required for overflow of TSF2.

7.7 Collection Ponds

All collection ponds are expected to be overflowing direct to receiving waters before mine closure.

7.8 Seepage Post Mining

Treatment of seepage water will continue through the WTP until water quality is suitable for direct discharge. Given seepage rates are relatively small OGNZL may choose post closure to implement a passive treatment system for seepage only and decommission the WTP.

8. Conclusions

8.1 Water Balance

Based on the water balance analysis completed by GHD Project Martha can be implemented using the existing WTP.

Water quality predictions for the LOM indicate compliance with discharge consent conditions and that the current consented WTP operating regimes suit the expected changes in operation for Project Martha. If water quality parameters are encountered that are worse than those anticipated in this report there is opportunity to utilise the RO plant to mitigate the impact.

The storage available within the collection ponds and TSF's is also shown to be adequate to contain predicted water gains without overflow.

The model is conservative, and where it has shown potential for overflow of collection and process ponds; it is considered that in practice these can be prevented through appropriate management (i.e. maintaining buffer storage in advance of storm events).

Key differences to current operation that will need to be managed by OGNZL include:

- The rate of mine dewatering will be consistently higher than what currently applies. Since 2015 mine dewatering has averaged 7,350 m^3/d, with a peak of 15,550 m^3/d. Dewatering targets will increase this rate up to 18,000 m^3/d through some periods on the mine development. To meet these dewatering targets WTP operation will need to focus on maximising the treatment and discharge of minewater when river flows allow. If dewatering targets are not met the impact will be on mine development.
- There will be a three year period where two TSF decant ponds require treatment. In combination with the higher level of mine dewatering the impact of this is to lift treatment rates to about 40% higher than has applied in the past. As the fraction of the cyanide water has increased regular use of Regime B may also be required.

8.2 Pit Lake Outlet

The proposed pit lake outlet discharge will have no discernible effect on flood levels in the Mangatoetoe Stream based on the findings of this study.

8.3 Pit Lake Filling and Ohinemuri River Abstraction

Statistical analysis based on the pit lake filling water balance model indicates that with the consented take from the Ohinemuri River, a filling duration of 9.4 years is expected. When considering variations in climate data and underground storage to be refilled (including rock mass) a 5^{th} to 95^{th} percentile confidence interval of ±0.7 years applies to this prediction.

This analysis is based upon an abstraction pump being operated with a capacity of 270 L/s and allowance to take 20% of the river flow when the flow rate is above 2×MALF for the duration of pit filling.

Without any river contribution to pit lake filling, the lake will take approximately 39 to 43 years to fill.

Long term analysis of the pit lake water balance shows a positive mean discharge from the lake of 31 L/s, with potential for the discharge to cease during long dry periods.

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9. References

1. OGNZL,Water Management Plan, Martha,Favona, Trio and Correnso Mines, 2 September 2016
2. AECOM, Project Martha Geochemical Assessment - Geochemistry of Tailings and Overburden, Treatment and Mitigation, April 2018
3. URS, Martha Mine Extension Site Water Management, June 1997
4. GWS Ltd, Martha Pit Dewatering Study, April 2018
5. EGL 2018 *(title to add)*
6. Mitchell Daysh, Project Martha Assessment of Environmental Effects, 2018.

Appendices

Appendix A – Site Water Balance Model

A 1 Model Description

A water balance model was used to assess how water gains change over the life of the mine and to check that proposed infrastructure for conveyance, storage and treatment will be adequate. The Goldsim water balance model described in this section was first developed in 2012 as an initiative of the site environmental team. The objective in building the model was to have a tool to forecast storage requirements in the TSF's in the future (i.e. to check embankment construction was aligned) and as an ongoing check that the site water management infrastructure as a whole had capacity for ongoing mine development. The model was also used to predict water treatment requirements post closure as a component of annual bond calculations.

Given the model has been calibrated against the site water balance and in use for some time there is confidence that it does represent well the quantities of water generated from the different water sources that require treatment.

The model has been recalibrated against 2015 to 2017 site operation data and modified to represent the changes to the mine plan development timeframe and additional water quantities requiring treatment for Project Martha.

A 2 Introduction to Goldsim

Goldsim (refer www.goldsim.com) is a software package designed to run Monte Carlo simulations for probabilistic analysis of dynamic systems. The software package essentially provides a visual interface for an excel spreadsheet type programming environment. Within the visual interface, elements are created to represent processes and events using equations and logic based decisions.

Goldsim allows user interfaces (dashboards) to be created which are used to specify model inputs and variable data before or during simulations. Models developed in Goldsim with appropriate dashboards can be exported as an executable program that can be run with the freely available Goldsim player software.

Goldsim includes features which make it a suitable tool for water balance modelling. These include; user specified time stepping, dimensional awareness and a range of programmed elements that can be implemented. Model updates can be scheduled to occur at user specified time steps for the duration of a simulation and these can be specified to complement input data resolution such as rainfall or river flow. To improve modelling accuracy unscheduled model updates are also included to capture dynamic processes such as the time at which a reservoir begins to overflow or a discrete event is triggered.

Dimensions are specified for all input data and an internal database is applied to unit conversions to ensure consistency throughout the model. Within the Goldsim interface programmed elements are implemented to simulate a variety of dynamic and discrete events.

The range of elements that are useful for water balance modelling include;

- Containers – allow a model to be subdivided into sub-systems, for example, individual catchments or processes.
- Inputs – this category of elements allow initial conditions to be specified and lookup tables to be defined containing information such as daily rainfall.
- Stocks – these elements capture how the state of a system changes with time and can represent reservoirs, ponds or other stores.

- Functions – these elements define processes or decisions at each model update, for example, calculating catchment runoff or the current discharge quality. Scripts can also be written to simulate complex behaviour or iterative processes.
- Events – events can be set to occur at a given point in time or can be triggered where specified conditions are met. This allows conditions within the simulation to be changed, such as specifying a date from which a pond can safely overflow.
- Delays – delay elements account for the time that it takes information or material to pass from one point to another, for example, water to be treated then discharged.
- Results – results can be recorded to display final model conditions or the dynamic behaviour of a system over the simulation period. Goldsim enables model results to be viewed as deterministic for individual realisations or probabilistic where multiple model realisations have been run.

Using these features detailed water balance models can be produced which simulate short term system responses and long term behaviour under a range of conditions.

A 3 Project Martha Water Balance Model

A 3.1 Model Categories

The aim of the Project Martha Water Balance Model (WBM) is to capture all significant water movements across the site affected by mine operations. This is achieved through accounting for water sources, sinks and processes within the WBM that are summarised in the following categories:

- Sources
    - Rainfall on catchment areas
    - Ohinemuri River flow
    - Mine dewatering
    - Seepage flow
- Sinks
    - Evaporation
    - Retained moisture
- Processes
    - Pump rates
    - Overflow rates
    - Ore processing
    - Water treatment rates

The WBM is run as a probabilistic simulation for the duration of Project Martha where the sources and model time step are defined at daily intervals. For each year modelled an annual rainfall time series is randomly selected from the database of daily rainfall records between 1916 and 2016. The model is run for 1000 realisations of the full project duration and statistical results are generated considering all realisations.

Figure A-1 shows a schematic of the WBM where each of the elements represents a container enclosing a model to represent the localised system. Linking each of the containers are arrows, which indicate the flow of water through the model.

The colour coding of the arrows indicates the water type, where water requiring cyanide removal is red, minewater is grey, tailings slurry is brown and clean river water is blue. The following sub-sections contain a description of each of these containers and their functions.

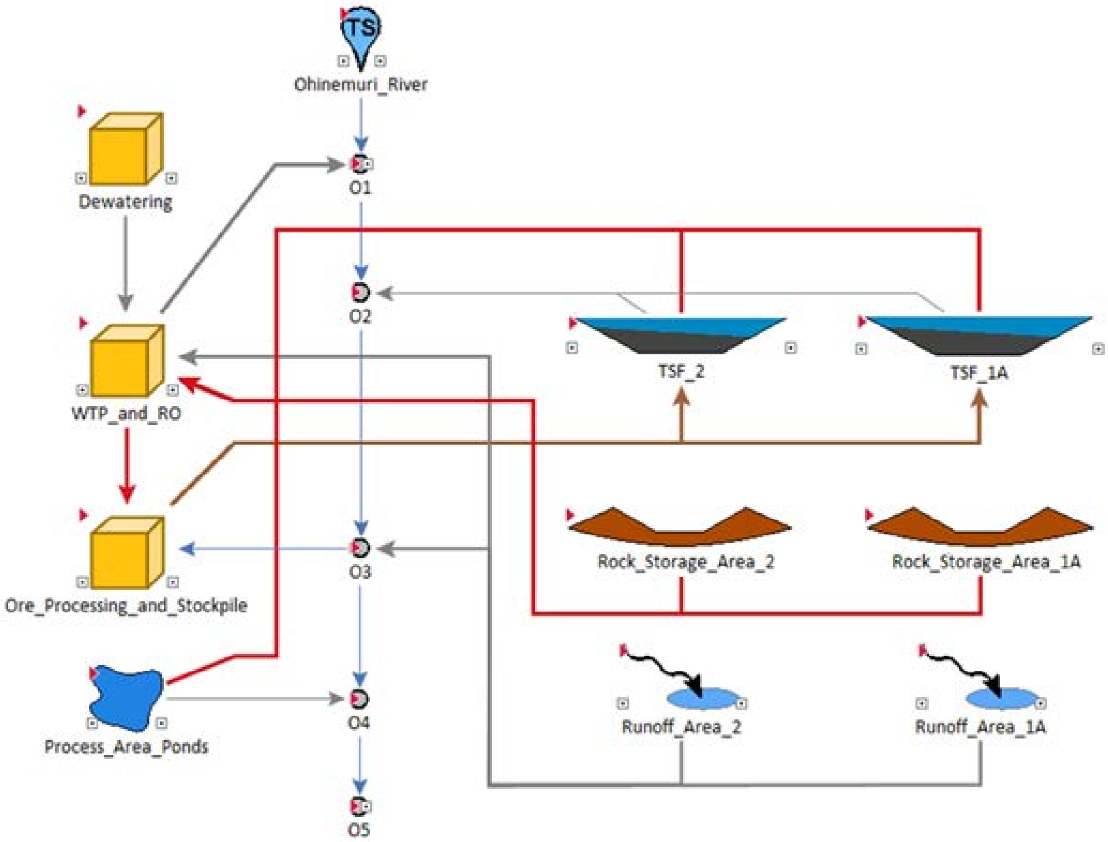

Figure A-1 Model Schematic of Project Martha Water Balance Model

The WBM also includes functions to model water quality within the water management system. Contaminant concentrations are modelled from each source and a mass balance determines the discharge quality of water processed through the WTP.

A 3.2 Sources

Rainfall

Measured rainfall data is used to calculate runoff for each catchment area included in Project Martha. Daily rainfall data was sourced from local rain gauges for the 100 simulation years between 1917 and 2016. Measurements are taken from; Cliflow agent 1550 (station B75381) for the period of 1/1/1917 to 1/1/1990, Newmont data for 1990 to 2010 infilled with Cliflow VCS (station P198205) data, and the Waihi met station for 2011 to 2016 in-filled with B75495 and Mill gauge data.

Runoff Areas

Daily rainfall on each catchment area determines the flow into associated ponds.

All collection ponds identified in the model are pumped to the WTP as Priority One (refer section A 3.4) and the aim is to keep the level of these ponds low to maintain capacity for high rainfall events. Table A-2 provides a summary of the maximum catchment areas considered in the WBM for each area and the corresponding runoff coefficients. Each of these catchment areas drain to a collection pond or sump with a defined volume and pumping rate. In the model there is some variation applied to account for catchment development over time.

Runoff from the TSF1A and TSF2 embankments is captured within the collection ponds as defined in Table A-2 and is treated as minewater in the WTP. Where the river flow is above the 80th percentile or when the ponds are re-designated as silt ponds via consent they can overflow to the river if full.

The process area ponds collect runoff from the catchments around the WTP and process area and are treated as cyanide water in the model (note this is a conservative assumption since in actuality treatment through the minewater stream generally applies). Overflow of these ponds is not permitted before the date specified in the model. There is provision on site for water to be pumped between these ponds and with consideration to this the process area ponds' volume and catchment areas are amalgamated in the model. During high rainfall events water from the process area ponds can also be pumped into the active TSF as an emergency storage facility, then later treated as decant water.

River Flow

River flow data is derived using the Australian Water Balance Model (AWBM) (Boughton 2004[1]) based on the measured daily rainfall data. The model is calibrated to Ohinemuri River and Ruahorehore River flow data measured at the Frendrups and Ruddock gauges between 28/3/1985 and 19/4/2017. Calibration of the model places emphasis on periods where flow rates affect the consented discharge regimes (section 2.2.2). Refer Appendix B for more detail on the AWBM calibration.

Four separate discharge locations (O1 to O4 in Figure A-1) are modelled to maintain clarity of the discharge from each source, though these are not necessarily representative of site layout. The WTP discharges into O1. Overflow from the TSF's, collection ponds and process area ponds discharges into O2, O3 and O4 respectively and the resultant river flow is defined at O5.

Dewatering and Dust Suppression

The WBM allows dewatering to be represented by two methods. The first method specifies a mean annual dewatering rate and the WTP aims to treat the flow where capacity allows. Where the WTP does not have the required capacity the excess is identified as a deficit on the extraction target. A cumulative deficit is indicative that the chosen pump rate is too low to meet dewatering targets.

The second method calculates dewatering based on a model of the Martha underground water system and a target dewatering level described in Appendix D. A maximum dewatering pump capacity is specified and the model aims to meet the dewatering targets within the constraints of the dewatering pump capacity and the WTP discharge capacity. Drawdown of the water table is determined by the actual volume of water extracted, such that the pumps and WTP will work at full capacity until the target level is reached.

Dust suppression for the site is deducted from the dewatering flows prior to treatment in the WTP and this is specified by a fixed average rate for the life of the mine.

Seepage (rock stacks and embankment)

Seepage flows as described in section 2.5 are each defined by a daily average value for the duration of the model. These flows gravitate to the WTP without the ability for intermediate storage. As there is no storage modelled these flows are treated as Priority One and are treated immediately.

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[1] Boughton, W. 2004. The Australian water balance model, *Environmental Modelling & Software*. 19(10), 943-956.

A 3.3 Sinks

Evaporation

The WBM assumes that water will evaporate from the TSF ponds where decant water is available. Evaporation is calculated daily based on average monthly Penman open-water evaporation rates. These are taken from Cliflow Station B75381 records from 26/4/1971 to 30/7/2001.

Retained Moisture

When the tailings is placed in the TSF impoundment a small component of tailings liquor is retained as porewater (~24% depending upon slurry makeup) and the remainder is released to decant water or seepage.

A 3.4 Processes

Water Treatment Plant

The central component of the WBM is the WTP which aims to treat all minewater and cyanide impacted water generated or captured across the site. The consented discharge of the WTP is governed by the operating regimes described in section 2.2.2 and the daily flowrate of the Ohinemuri River. The operating regime is determined by the ratio of minewater to cyanide water to be treated. The model is restricted from switching between treatment regimes more than once within a 7 day period to represent the practicalities of the change. The maximum discharge of the WTP is set to 90% of the daily permitted discharge. This reduction factor is applied to recognise that the WTP cannot consistently operate at an efficiency to achieve the maximum consented discharge each day.

To make up the consented discharge, water is requested from each of the sources based on a set of priorities. These priorities reflect the ability to control or importance of controlling each water source:

Priority 1 - Process area runoff, seepage and collection ponds

Priority 2 - Decant water from the TSF’s

Priority 3 - Mine dewatering

Priority One flows are those with little or no storage capacity and the model reports an error if these sources cannot be treated and/or contained. Priority Two flows are allocated to the active and unclean TSF ponds. The remaining capacity is allocated to Priority Three flows, which attempt to satisfy mine dewatering rates.

Ore Processing and Stockpile

Daily ore volumes are calculated from the mine plan production schedule.

The volume of water required to process ore on a daily basis is calculated based on the average fraction of tails in the slurry mix. The required volume of processing water is requested from available sources based on the following order of preference.

3. Elution flow - extracted at a fixed daily rate from the Ohinemuri River where flow conditions allow.
4. Decant water - from the active tailings pond.
5. Seepage flow.
6. Mine dewatering flow - to satisfy the remaining demand.

Tailings are distributed to the active TSF and split into two components; tails solids with retained moisture, and decant water.

Tailings Storage Facilities

The WBM accounts for the two existing TSF's and makes provision for changes in their active status. Through the model run, tailings are deposited into the TSF defined as the "active" pond.

Once the calculated tailings capacity of TSF1A is reached, the active pond definition is updated to TSF2. Based on previous experience with TSF2, a period of 3 years is applied to each TSF from when it was last active to when it can be considered "clean" and direct discharge is allowed.

Each TSF is represented in the model by two mass sources and one sink as follows:

- The first source is the rainfall on the pond catchment area which is defined as the pond surface area and the area of embankment that drains into the pond.
- The second source is the volume of slurry added to the pond, which is divided into two components; decant water and tailings volume including retained moisture.
- The mass sink accounts for evaporation from each pond surface.

The daily decant water gain is calculated as the sum of rainfall and decant water added less evaporation.

Decant water is withdrawn from the TSF's to satisfy a demand from the WTP based on the available treatment capacity. The WTP allocates a demand to each TSF that aims to remove the previous day's rainfall, up to the smallest of the Priority Two flow capacity and defined decant pump capacity. A minimum of 20% of the Priority Two flow capacity is allocated to the active pond in order to remove any accumulated volume. The remaining flow capacity is allocated to the non-active TSF (if treatment is required) based on proportional catchment area. This distribution of demands prioritises withdrawal from the non-active TSF ponds for treatment.

Further withdrawals from the active TSF pond are requested to satisfy slurry makeup requirements in the ore processing area. The demands from the WTP and ore processing area for each TSF are only fulfilled if there is a suitable volume of water available to satisfy the flow.

The accumulation of tailings and decant water within each TSF is monitored against a stage-volume relationship for each TSF. This allows the remaining capacity and freeboard of each pond to be determined throughout each of the modelled scenarios.

A 4 Model Calibration

A calibration of the WBM was completed with measured river flow data and recorded operation data from the WTP and mine site. This calibration is summarised in Appendix B.

For the given calibration period the WBM is shown to provide a reasonable representation of the water balance and treatment requirements across the mine site. A degree of conservativeness is represented as the model has over predicted the minewater and cyanide water treatment requirements. Further to this, the collection pond overflow predicted is higher than measured.

Overall, the model is considered to provide a good representation of site conditions and based on the calibration is conservative.

A 5 Representation of Project Martha in the WBM

The WBM was modified to represent the changes associated with Project Martha as summarised below.

A 5.1 TSF Operation and Capacity

It is assumed for the purpose of this assessment that TSF1A will be constructed to its consented height of 176.25 mRL, which is about 5 m higher than at present, and that a 5 m raise will be constructed on TSF2 to provide for a further 1.90 Mm^3 of tailings storage. Table A-1 shows the total available capacity for both TSFs.

Figure A-2 shows how the tailings generated are expected to relate to tailings storage capacity over time.

Table A-1 TSF capacity

	Tailings Storage Capacity (m^3)
TSF1A	1,693,711
TSF2	1,896,000

Tailings volumes calculated in the WBM are allocated to TSF1A and TSF2 successively until the specified capacity is reached and the active pond status is changed. Filling of the TSF's is modelled based on pre-determined stage volume relationships (Appendices B2 and B3). The surface level of the tailings is determined from this stage volume relationship and water level is calculated by adding the volume of free water within the TSF on top of the tailings. The water level is monitored to identify freeboard encroachment or overflow potential. There is no provision to increase abstraction rates through manual intervention when large volumes of water accumulate through a model run as would be done in practice. Therefore, overflow potential predicted by the model provides a conservative indication of risk. Once a TSF pond has been classified as clean it can fill and overflow from the freeboard level.

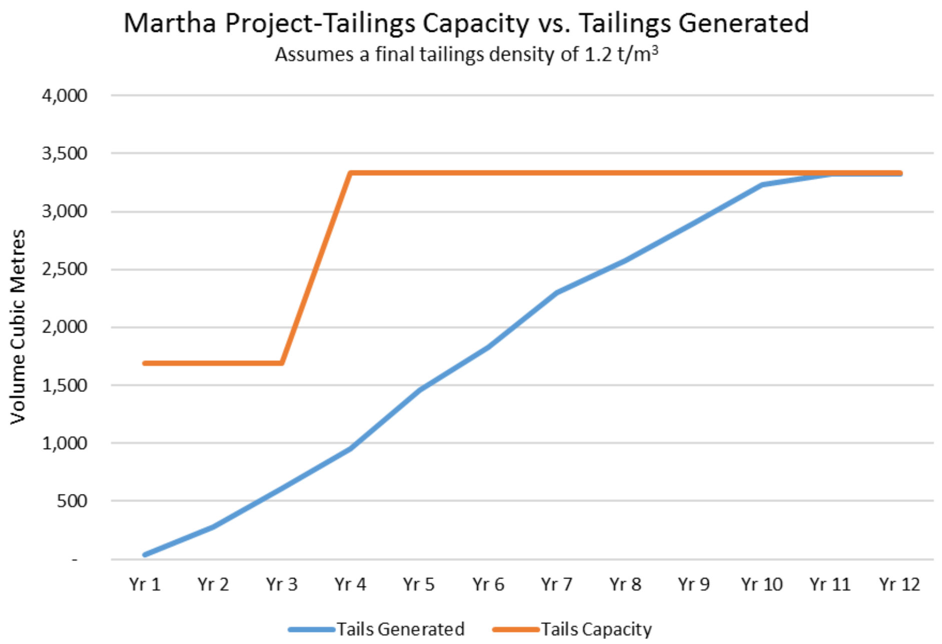

Figure A-2 Tailings Capacity vs. Tailings Generated Curve

A 5.2 Catchment Areas and Runoff

Table A-1 provides a summary of the maximum catchment areas considered in the WBM for each area. Each of these catchment areas drain to a collection pond or sump with a defined volume and pumping rate. In the model there is some variation applied to account for catchment development over time.

The catchment areas given for the TSF's include the pond surface area and the surrounding embankments that drain into the pond. It is assumed that all of the runoff ends up in the pond so the runoff factor is taken as 1. Rainfall runoff to collection ponds from the process areas use an area weighted runoff factor of 0.78 to account for all cyanide affected water and recognising that the surface of the process area is well compacted or sealed and has low permeability.

Runoff from the remaining areas is accounted for by a runoff factor of 0.7.

A 5.3 Seepage Rates

Seepage rates from TSF1A and TSF2 are modelled as 364 m^3/d combined and these are determined from mine operation data for 2015 and 2016.

A 5.4 Dewatering Rates

To achieve the target water table drawdown rates annual average extraction rates between 10,000 m^3/d and 17,000 m^3/d are expected (GWS Ltd 2018).

To represent the practicalities of achieving this rate under variable WTP discharge conditions and fluctuating flows from other sources, a variable pump rate is applied. Through model analysis described in Appendix D a peak pump rate was determined to achieve the target extraction.

Dust suppression is taken at a constant daily rate that is assumed to be 500 m^3/d.

A 5.5 Production Rates

Production rates and ore sources for the LOM were provided by OGNZL and are reproduced in Appendix C for reference.

Table A-2 Catchment Areas

Name	Description	Area (ha)	Runoff Factor	Volume (m^3)	Modelled Pumping Withdrawal Rate (m^3/d)	Water Treated For
TSF1A	Tailings storage facility 1A	38.8	1.0	See stage-volume relationships	6,000	Cyanide
TSF2	Tailings storage facility 2	41.5	1.0	See stage-volume relationships	6,000	Cyanide
West Silt Pond	Runoff from TSF2 embankments	28.72	0.7	12,472	23	Mine
S3	Runoff from TSF1A embankments	27.46	0.7	44,688	1,651	Mine
S4	Runoff from TSF1A embankment	17.61	0.7	45,100	597	Mine
S5	Runoff from TSF1A embankment	20.5/0	0.7	34,465	1,283	Mine
Mill Pond	Process area ponds	8.6	1.0	21,132, combined	526, combined	Cyanide
Favona Stockpile Area		9.81	0.6			Cyanide
TCP1		0.46	0.7			Cyanide
TCP2		1.03	0.7			Cyanide
WTP		1.79	0.8			Cyanide
Notes: Martha pit is accounted for in the dewatering calculations.						

Appendix B – Site Water Balance Model Calibration

B 1 River Flow Calibration

A central component of the WBM is the river flow rate of the Ohinemuri River as this determines allowable WTP discharge and pond overflow rates. River flow data is not available for each of the 100 years of simulation so it is modelled based on measured rainfall data.

To model the river flow a calibrated version of the AWBM (Boughton 2004) is used and described in this section.

B 1.1 Input Data

Calibration of the AWBM requires two sets of data, the first is historic daily rainfall measurements and the second is river flow gauge data. The source of the rainfall data is described in Appendix A, section A 3.2 .

The calibration river flow data for the Ohinemuri River is sourced from the Frendrup and Ruddock gauges between 2000 and 2017 (Waikato Regional Council).

B 1.2 Results

The AWBM river flow is calibrated by minimising an objective function calculated by the sum of squared residuals. Calibration of the model places emphasis on periods where flow rates affect the consented discharge regimes. This is achieved through applying a weighting factor to the objective function where the measured results are below 133,333 m^3/d, which corresponds to maximum discharge of Regime A at 20,000 m^3/d or 15% of the river flow. Table B-1 provides a summary of the input and calibrated variables used in the AWBM.

To account for spatial variability within the catchment and provide an improved representation of the river flow rates, two additions to the AWBM are made. The first is an addition to the river base flow to represent the low flow rates observed. The second splits the surface runoff between two stores instead of one with different recession constant applied to each.

Table B-1 Summary of AWBM Input and Calibrated Variables

Variable	Value	Description
Precipitation (mm/d)	Daily TS	Measured data
Evap. Potential (mm/d)	Penman Monthly Mean	Sourced from NIWA
Catchment Area (km^2)	52	Catchment area estimate
BFI	0.28	Base flow index
SFI	0.26	Ratio of surface runoff to surface store 1
k_{s1}	0.35	Surface runoff store 1 recession constant
k_{s2}	0.93	Surface runoff store 2 recession constant
RBF (mm/d)	0.45	River base flow addition
A_n	[0.134, 0.433, 0.433]	Catchment fractional areas
C_n (mm)	[2, 95, 175]	Catchment storage capacities

Figure B-1 shows a comparison between the calibrated AWBM and the measured gauge data. The model is shown to conservatively estimate (under predict) the expected flow rates in the river across the flow spectrum; particularly below the critical flow rate which can affect WTP discharge conditions. Across the critical flow data range the model under predicts total runoff by 7% when compared to the estimated mean daily flow rates and this is considered acceptable for model purpose.

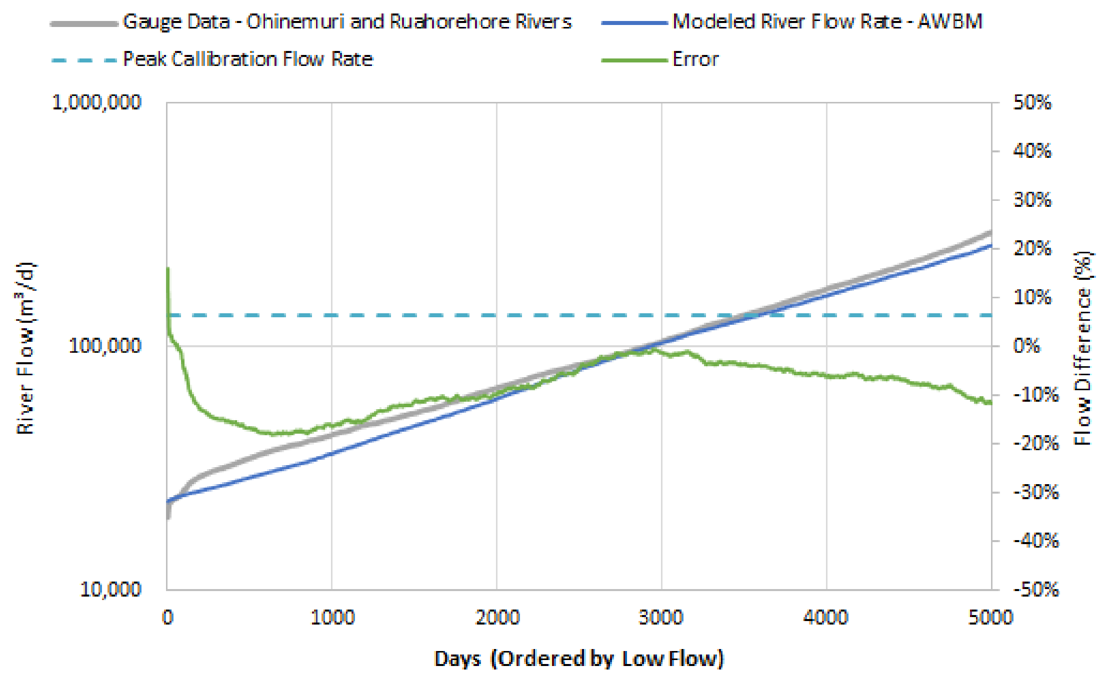

Figure B-1 Ohinemuri River Flow Calibration

B 2 WBM Verification

The validity of the WBM was checked through comparison with WTP and site operation data collected over the period of 1/1/2015 to 18/4/2017. This check provides an indication of the accuracy at which the model can represent the processes on site. The verification uses measured and assumed model inputs and compares the model outputs with measured results. The comparison of modelled and measured results focuses on the WTP flows and discharges and the potential for overflow of the collection ponds.

B 2.1 Inputs

Table B-2 summarises the key model inputs determined from the recorded operational data. Where required the resolution of the measured data is reduced to an average value or monthly average values to portray the certainty of the inputs used for predictive model runs. In this summary the two model inputs that differ from those applied to predictive model runs are the tails production and dewatering sources, which are both controlled variables in the future management of the mine.

Table B-2 Key Model Inputs for Calibration

Variable	Value	Description
Tails Production	Monthly averages determined from daily site data.	Monthly time series
Dewatering Sources	Daily rates applied from site data.	Daily time series
Rainfall	WBM input data applied as described in section A 3.2.	Daily time series
River Flow	AWBM derived data as described in section A 3.2.	Daily time series
Evaporation	Monthly averages determined from meteorological stations as described in section A 3.2.	Monthly average value
Seepage Flow	Average flow rate determined from daily site data.	362 m^3/d, Combined TSF1A and TSF2
Elution Flow	Average flow rate determined from daily site data.	159 m^3/d
Dust suppression flows	Assumed value.	500 m^3/d
Specific Gravity of Rock	Assumed value	2.74
Slurry (% solids by volume)	Average proportion determined from daily site data.	16 %

Variable	Value	Description
Moisture retained by tails	A calculated value, based on fully saturated and consolidated tails.	24.4 %
Tails dry density	Assumed value	1.2 tonne/m^3
Collection ponds runoff factor	Assumed value	0.7
Process area runoff factor	Assumed value	0.78

B 2.2 Results

This verification considers five key model outputs that are displayed in Figure B-2 to B-5 with a summary of errors displayed in Table B-3. In addition, model warnings indicating potential compliance breaches are considered.

Figure B-2 shows the daily comparison of minewater treated by the WTP. This is displayed as a 7 day average to remove the high frequency variations in both data sets for clarity.

The difference in modelled and measured results is 3%, this is small and the accuracy can be partly attributed to the main source of minewater being the dewatering flows specified from the mine operation data. Differences in the rates are attributed to deviations from the mean dust suppression flows, water used in the process area for slurry make up and collection pond runoff.

Dewatering flows are considered low priority for treatment in the WTP and the model will reduce these flows as require to meet discharge allowances. For the period modelled, the flow was partially reduced on 72 days.

Dewatering rates were subsequently increased following each of these days where discharge conditions allow to balance the total water abstraction.

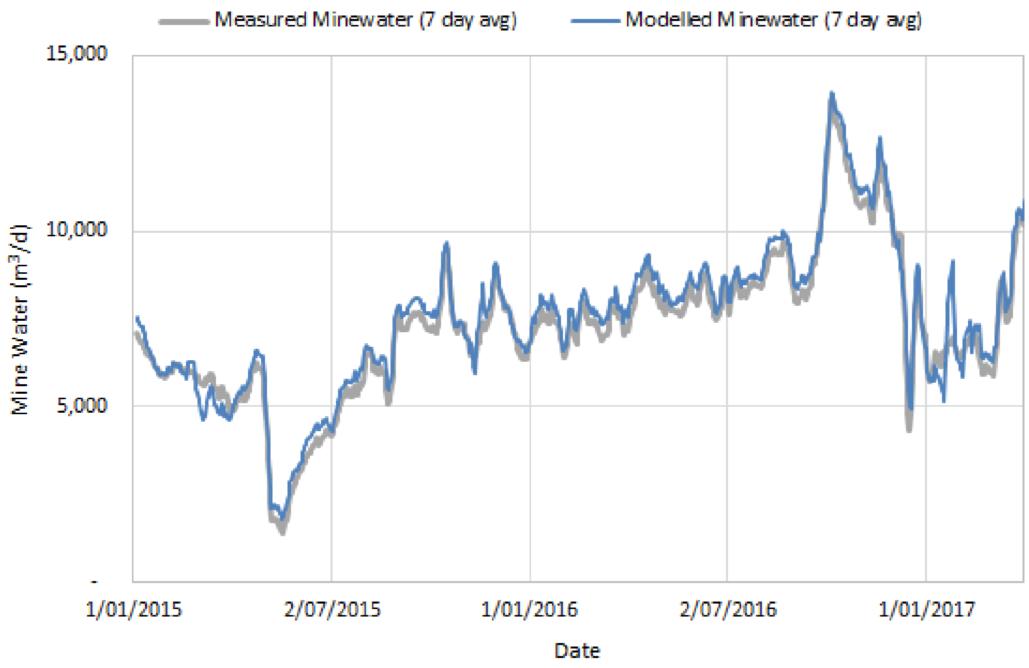

Figure B-2 Measured and Modelled Treated Minewater

Figure B-3 shows the comparison of modelled and measured cyanide water treated by the WTP. The modelled results show variability to the measured rates on a daily comparison basis as the model does not have provision for input from an operator to moderate treatment rates from day to day. However annual quantums compare well and this is the key factor for model use. For the duration of the model run, the model predicts a 3% higher treatment rate than measured. This indicates that the sum of the process area runoff and decant water less evaporation is conservatively represented in the model.

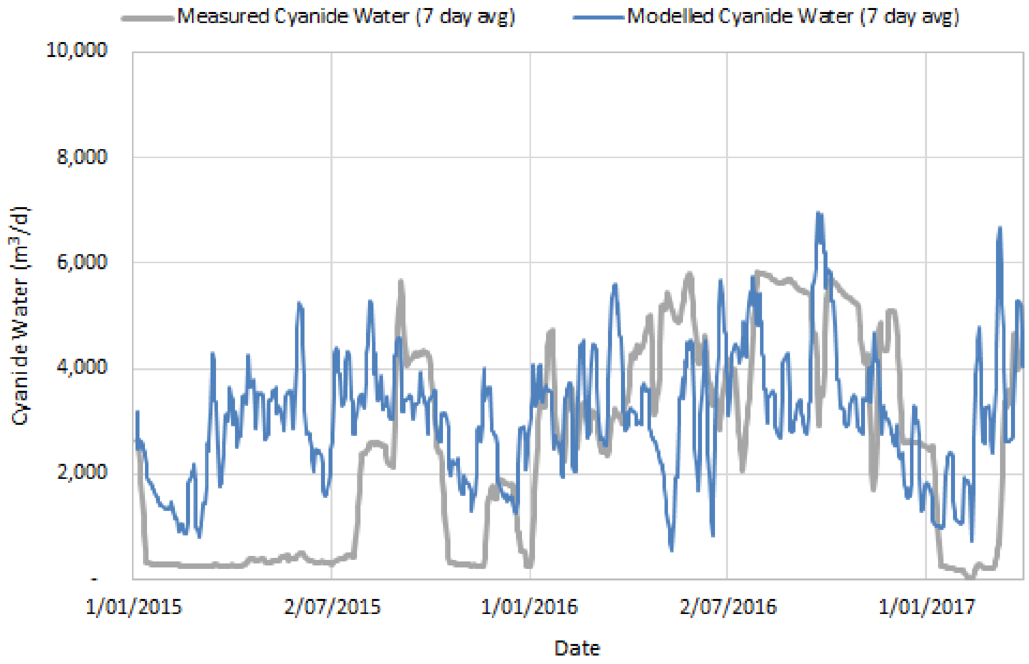

Figure B-3 Measured and Modelled Treated Cyanide Water.

The total flow discharge to the Ohinemuri river from the WTP is shown in Figure B-4.

The discharge is conservatively represented in the model at an average rate 14% higher than the measured data. This is predominantly attributed to the conservative (higher) cyanide water volumes predicted by the model.

Analysis of the peak discharge rates indicate that the WTP peak efficiency maximum of 90% is appropriate.

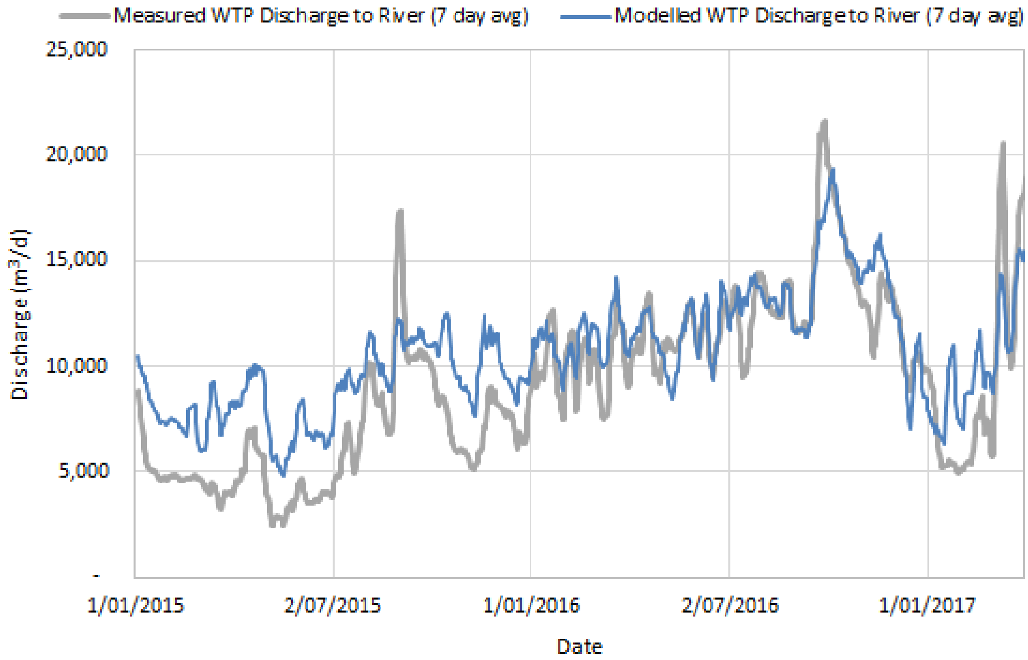

Figure B-4 Measured and Modelled WTP Discharge to River.

Figure B-5 shows the modelled and measured allowable discharge from the WTP, which is a function of the river flow and operating regime.

The model has over predicted the allowable discharge by 6%, though this comparison is affected by differences in operating regimes specified in the WTP. The data indicates that for some periods the WTP was operating in Regime B while the ratio of flows allowed the model to operate in Regime D which has a higher discharge allowance.

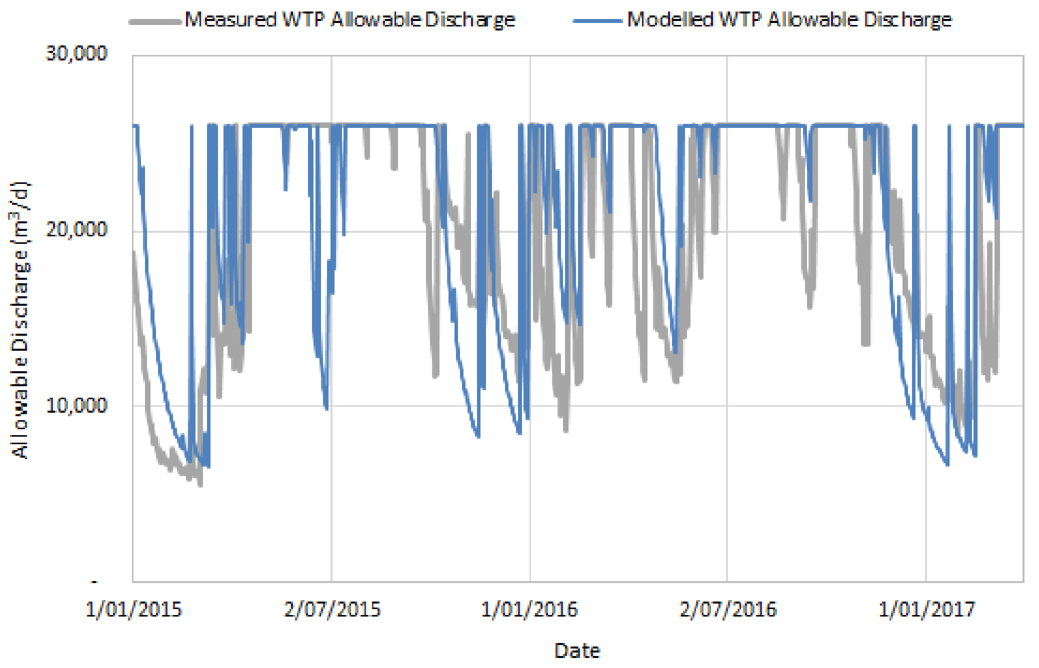

Figure B-5 Measured and Modelled WTP Maximum allowed discharge under the active operating regime

The collection pond overflow from S3, S4 and S5 is shown in Figure B-6 and is a function of the defined catchment areas, rainfall and runoff coefficients.

For the modelling period these ponds are operating as silt ponds such that they are not treated and overflow to the river. The model conservatively estimates the collection pond overflow to be 40% higher than the measured site data.

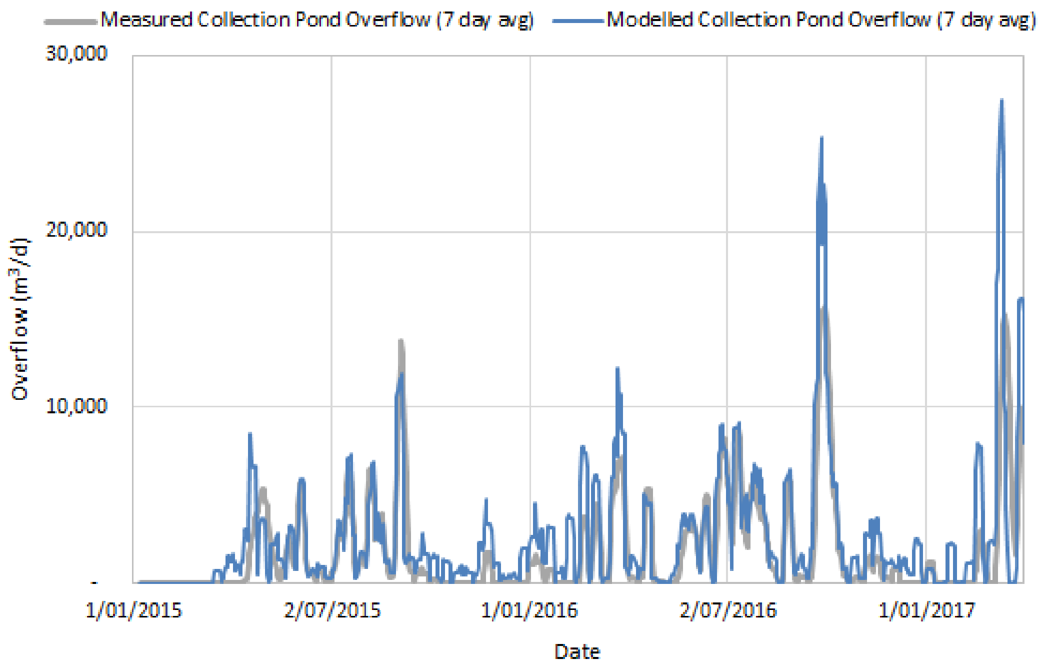

Figure B-6 Measured and Modelled Collection Pond Overflow

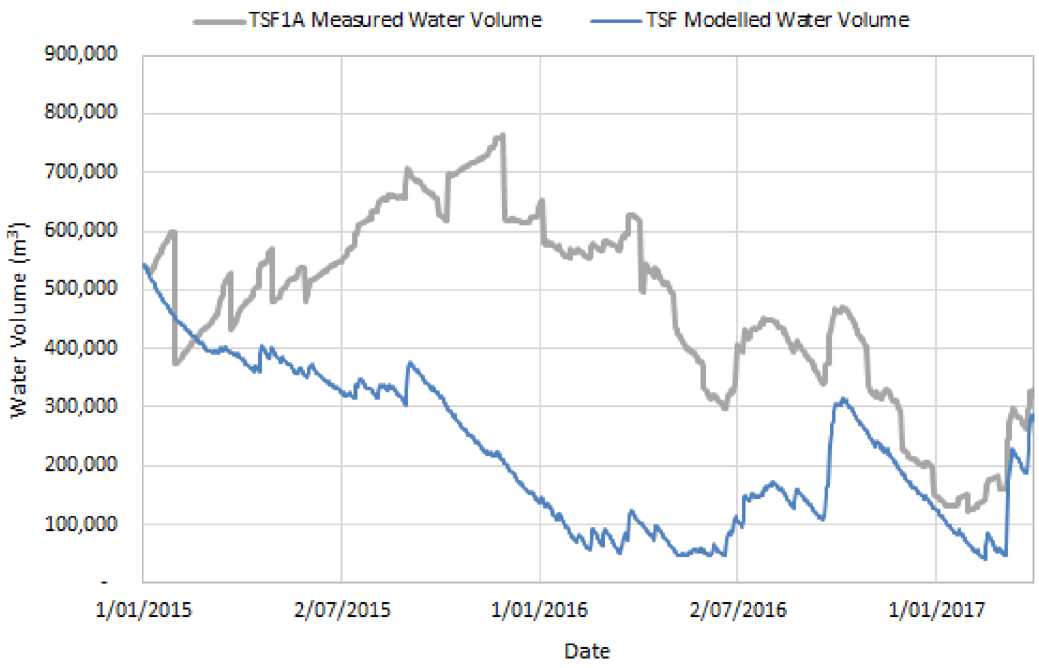

Figure B-7 Measured and Modelled Water Volume in TSF1A

The measured operating water volume over the calibration period showed a net reduction of 145,654 m^3. For comparison, the model indicated a net reduction of 125,333 m^3 corresponding to a difference of 24 m^3/d. Onsite operating decisions can have a significant impact on the day to day difference between measured and modelled water volumes.

This is shown in Figure B-7 where the model demonstrates a more consistent draw down of water. These operating decisions are reflected in the difference in modelled treatment rates of cyanide water as shown in Figure B-3. However, the net gain of cyanide water on site indicates that the model conservatively represents the treatment rates required.

Table B-3 Summary of Calibration Results and Errors

Calibration Parameter	Measured (m^3/d)	Modelled (m^3/d)	Error (%)
Mine Water	7,354	7,597	3%
Cyanide Water	2,509	3,116	24%
WTP Allowable Discharge	20,135	21,274	6%
WTP Discharge to River	9,357	10,712	14%
Collection Pond Overflow	2,051	2,864	40%
Note: Flow rates are given as daily average values.			

During the simulation, the model results indicate 2 instances of potential compliance breach caused by the process area catchment ponds overflowing. These were a 1,203 m^3 overflow on the 24th September 2017 and 5,216 m^3 on the 7th March 2017. These overflows correspond to 72 hr rainfall events of 213 mm and 301 mm respectively. Through this period there were no recorded compliance breaches on site; this indicates that the model provides a conservative warning of potential overflow. The WBM aims to treat all Priority One flows received by the WTP as there is no model function to delay or reduce these flows, where this cannot be achieved the model presents a warning and discharges the additional flow to the river.

For the simulation there was no warnings given indicating that the flows were managed appropriately.

B 2.3 WBM Validation Summary

For the given calibration period the WBM is shown to provide a reasonable representation of the water balance and treatment requirements across the mine site. A degree of conservativeness is represented as the model has over predicted the minewater and cyanide water treatment requirements. Further to this, the collection pond overflow predicted is higher than measured.

Overall, the model is considered to provide a good representation of site conditions and based on the calibration is conservative.

Appendix C – Water Balance Input Tables

Table C-1 is based on the mine plan for Project Martha.

Table C-1 Processed Tonnes

Area	Martha P4 Pit (Mt)	Rex UG (Mt)	Martha UG (Mt)	Combined (Mt)
Yr 1	-	-	0.044	0.044
Yr 2	-	0.110	0.178	0.288
Yr 3	-	0.110	0.281	0.391
Yr 4	-	-	0.415	0.415
Yr 5	-	-	0.598	0.598
Yr 6	-	-	0.437	0.437
Yr 7	-	-	0.567	0.567
Yr 8	0.012	-	0.320	0.333
Yr 9	0.073	-	0.310	0.384
Yr 10	0.154	-	0.239	0.393
Yr 11	-	-	0.112	0.112
TOTAL:	0.240	0.219	3.503	3.962

Tables C-2 and C-3 are based on TSF designs by EGL 2018

Table C-2 TSF1A Height Storage Table

TSF1A			
Column 1		Column 2	
Volume (m^3)	Elevation (mRL)	Volume (m^3)	Elevation (mRL)
-	155.1	3,136,000	166.5
2,000	155.5	3,309,000	167
24,000	156	3,483,000	167.5
73,000	156.5	3,659,000	168
146,000	157	3,835,000	168.5
245,000	157.5	4,012,000	169
370,000	158	4,191,000	169.5
509,000	158.5	4,369,000	170
655,000	159	4,550,000	170.5
812,000	159.5	4,731,000	171
971,000	160	4,914,000	171.5
1,131,000	160.5	5,097,000	172
1,293,000	161	5,281,000	172.5
1,455,000	161.5	5,466,000	173
1,619,000	162	5,652,000	173.5
1,784,000	162.5	5,839,000	174
1,949,000	163	6,027,000	174.5
2,116,000	163.5	6,216,000	175
2,284,000	164	6,406,000	175.5
2,452,000	164.5	6,597,000	176
2,622,000	165	6,789,000	176.5
2,792,000	165.5	6,982,000	177
2,963,000	166	7,078,000	177.25

Table C-3 TSF2 Height Storage Table

TSF2			
Column 1		Column 2	
Volume (m3)	Elevation (mRL)	Volume (m3)	Elevation (mRL)
-	148	1,034,585	155
2	148.5	1,170,101	155.5
6,118	149	1,311,478	156
25,041	149.5	1,458,552	156.5
53,486	150	1,612,398	157
93,909	150.5	1,771,018	157.5
149,451	151	1,932,385	158
220,887	151.5	2,095,280	158.5
307,877	152	2,258,979	159
410,639	152.5	2,424,141	159.5
528,222	153	2,590,214	160
650,343	153.5	2,757,198	160.5
775,195	154	2,925,100	161
903,270	154.5		

Appendix D – Hydrogeological Model

D 1 Model Description

A stochastic water balance model simulating the Martha pit catchment and connected groundwater systems has been developed in the Goldsim modelling platform. The model allows statistical prediction of mine dewatering requirements, rewatering rates, Martha Lake filling rates and to provide a Martha Lake water balance from which water quality assessment can be undertaken.

The model is based on the ground water assessment, detailed by GWS (2018), which utilises documented pumping rates and mine development plans to provide an estimate of water taken to achieve dewatering at specific elevations.

The model brings together the following:

- Estimated aquifer/working storage and groundwater inflow rates, from the GWS (2018) report.
- Interconnection between the Martha pit, Martha underground and Favona, consistent with the conceptual understanding outlined in GWS (2018).
- The proposed expanded Martha pit shape (volume, lake area and catchment area).
- Stochastic rainfall and river flow data, utilising historical rainfall records.

The model calculates a daily water balance, predicting water levels within the Martha Lake (pit lake) and the underground mines, and the flow of water between these. Monte Carlo analysis, utilising 1,000 realisations was carried out, providing the predicted statistical distribution of filling times and water balance.

The following key components form the Goldsim water balance model:

Water Reservoirs/Storage

- Martha pit – proposed pit expansion to MP4 pit shape.
- Favona – incorporating the Waihi east ore bodies and areas that have historically shown natural hydraulic connection (Favona, Gladstone and moonlight). Refer GWS (2018).
- Martha underground – incorporating the vein systems and workings of the Waihi Ore body that have historically shown strong interconnection (Martha, Empire, Royal, Trio and Correnso). Refer GWS (2018).

Water Sources

- Groundwater inflow for Martha underground.
- Groundwater inflow for Favona.
- Run-off generated by rainfall to Martha pit walls and catchment.
- Rainfall direct to pit lake surface.
- Ohinemuri River water diverted to Martha pit (rewatering model).

Water Sinks

- Evaporation from the pit lake surface

- Evaporation from Martha pit surface – approximated by applying a rainfall run-off coefficient of 0.9.
- Pumped extraction from the Martha underground (dewatering model)

Two forms of the model are applied for Project Martha, a dewatering model and a rewatering model, with an adjustment in the setup to suit each.

D 1.1 Mine Dewatering

The Martha pit is currently dewatered through a combination of underdrainage by the Correnso underground mine activities and horizontal drains installed through the pit face, where seepage is likely to develop. Dewatering of the expanded Martha pit will occur in the same manner. Dewatering for the Martha underground will occur via sump pumps as mine development progresses.

Dewatering requirements for Project Martha are represented in the model by allowing for water abstraction from the Martha underground. The WBM described in Appendix A then extracts water from the Martha underground to achieve the required drawdown specified by the mine plan within constraints of the WTP.

On completion of mining, dewatering will cease and groundwater levels will recover, as with previous mining activities.

D 1.2 Rewatering

Rewatering of the mine will occur through natural groundwater inflow and rainfall on the Martha Lake catchment area. To increase rewatering rates consent will be sought to take water from the Ohinemuri River, and discharged into the Martha pit. Details of this are outlined in Section 7.5.

The rewatering model accounts for the river water addition by including a discharge into the Martha pit. The discharge rate is calculated from daily river flow data (Appendix B) based on consent conditions. Incorporation of randomly selected historical rainfall and river flow data series allow the model to estimate the time to fill Martha Lake and indicate the expected distribution in likely filling times due to variation of climate conditions.

D 2 Model Inputs

D 2.1 Groundwater Storage

Estimated daily groundwater inflow rates for both Martha underground and Favona, as well as their respective storage estimates from the GWS (2018) assessment are represented within the Goldsim rewatering model.

The storage volume for each of the mine areas is given in Table D-1 and the cumulative storage with elevations is outlined in Figure D-1. Ground water inflows range between 518 m^3/d and 4,000 m^3/d depending upon the ground water elevation and a breakdown of these are given in the GWS (2018) report.

Table D-1 Summary of Storage Volumes

Mine Area	Storage Volume to 1104 m RL (m^3)
Martha pit	31,729,800
Martha underground	35,522,800
Favona	1,295,400
Total	68,548,000

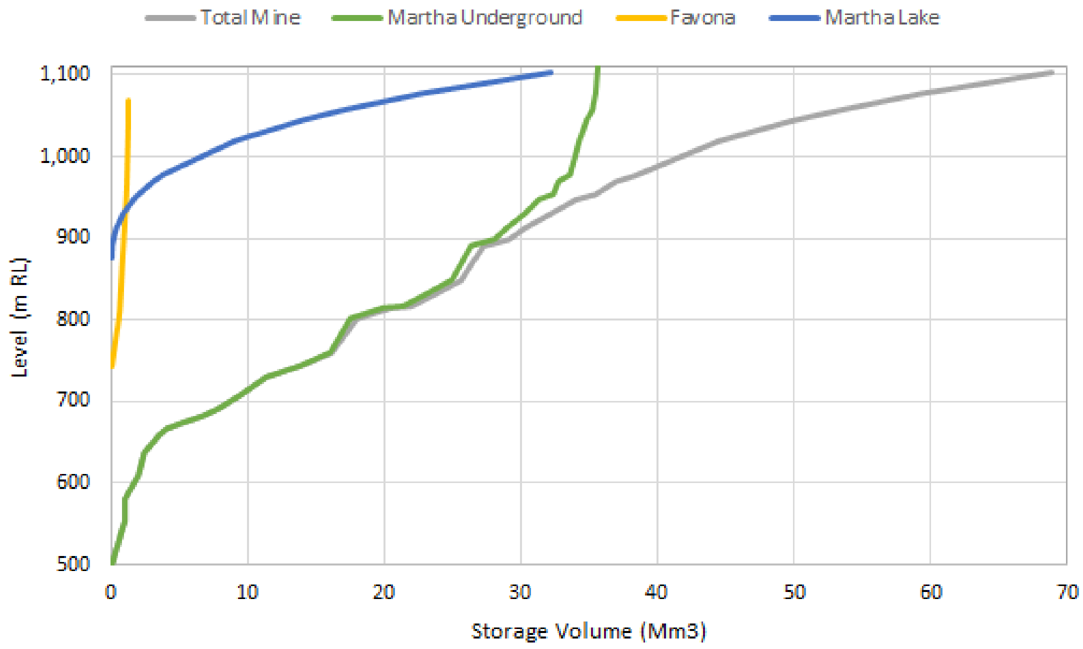

Figure D-1 Cumulative Storage Volumes

D 2.2 Pit Lake and Catchment

The proposed expansion of Martha Pit will take the future lake surface area up to approximately 401,300 m^2.

The lake surface is represented as a lake area by elevation function (Figure D-2)

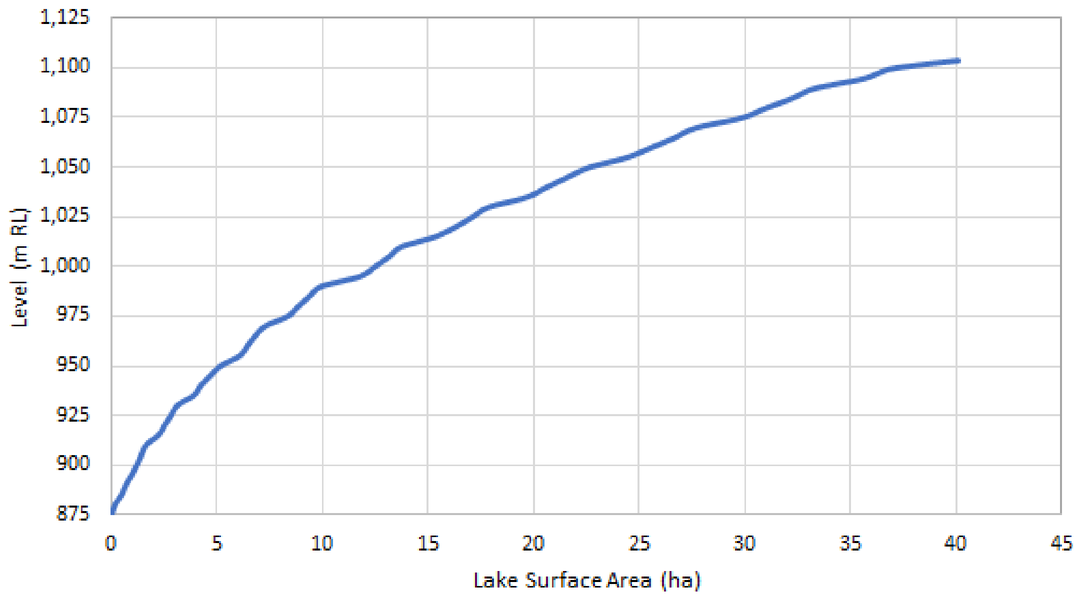

Figure D-2 Martha Lake Surface Area by Elevation

D 2.3 Stochastic Model Inputs

Historical daily rainfall and river flow data is used as model inputs to consider the sensitivity of the model filling predictions to weather conditions. This input data is described in detail in Appendix A.

D 3 Dewatering Analysis

The WBM was used to determine the likely dewatering rates required to achieve the water table reductions necessary for the Martha underground development. To simulate the dewatering requirements for the LOM the dewatering model has been integrated with the WBM.

Figure D-3 shows the targeted water table reduction over the first 6 years of the mine plan and the mean dewatering rates required to achieve this is shown in Figure D-4. To achieve the required drawdown, weekly mean dewatering rates between 7,400 m^3/d and 20,300 m^3/d are required, as discussed in section 2.4.2.

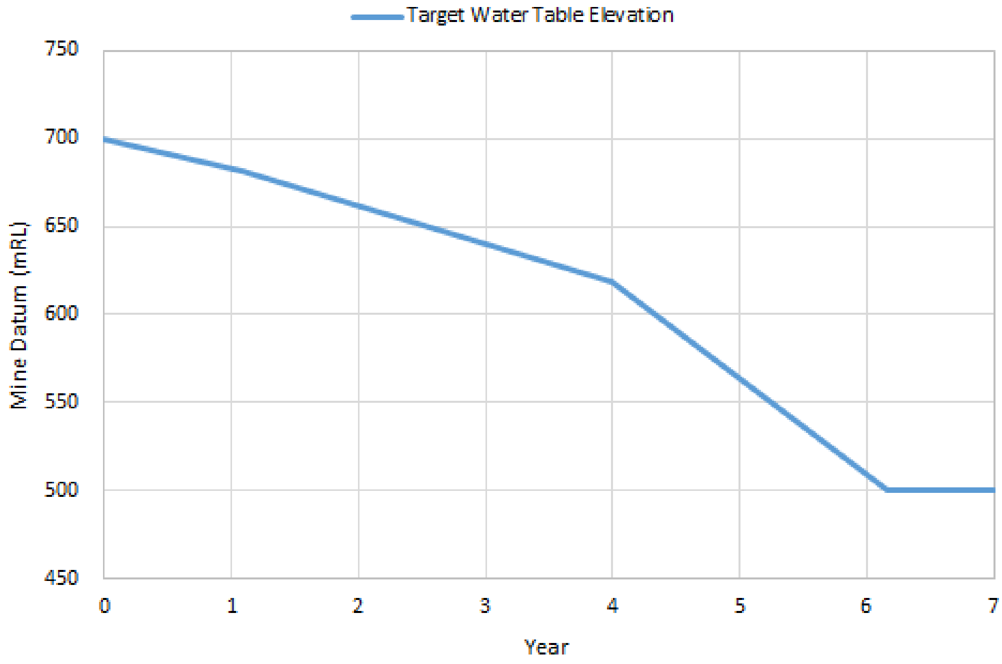

Figure D-3 Target water table elevation based on mine development schedule

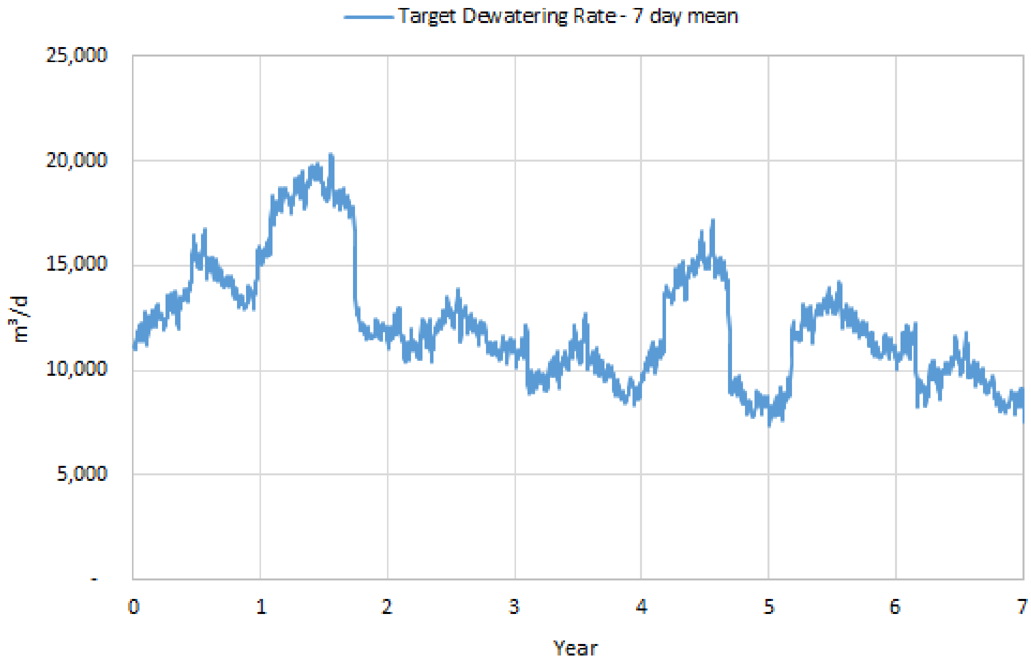

Figure D-4 Mean dewatering rates to achieve target water table draw down

To determine the required dewatering pump capacity, the WBM has been run through a number of scenarios with a variable pumping rate up to a maximum specified pump rate. This allows the dewatering rates to be optimised based upon allowable discharge conditions from the WTP.

Four scenarios were tested with peak pumping rates of 14,000, 16,000, 18,000 and 20,000 m^3/d. The modelled drawdown is compared with target drawdown through considering the dewatering deficit volume for each of these scenarios. A positive dewatering deficit indicates the extraction rate has fallen behind the target rate.

Figure D-5 indicates that at a peak pumping rate of 14,000 m^3/d there will be a significant extraction deficit through years 2 and 3. The cause of this is demonstrated in Figure D-6, this shows that the 5th and 50th percentile dewatering rates are often limited by the pump rate through to year 5 as the model attempts to make up for the deficit generated in year 2.

At a peak dewatering rate of 18,000 m^3/d, Figure D-9 indicates a 50th percentile dewatering deficit of 0.5 Mm^3 near the end of year 2, this corresponds to a lag of 3 m in elevation and 2 months in the dewatering schedule. Figure D-10 indicates that the pump capacity of 18,000 m^3/d is often operated at full capacity for the 95th percentile of results. Moreover comparison with the 20,000 m^3/d pump capacity in Figure D-11 and Figure D-12 suggest that the higher capacity is not warranted as discharges are often limited by WTP discharge capacity and extraction requirements.

Based on the dewatering analysis it is recommended that **dewatering capacity of 18,000 m^3/d** is available for the first 3 years of the mine plan and extraction ahead of target is made through year 1 where possible. Following year 3 there may be provision to progressively reduce the peak pump capacity while maintaining drawdown targets. For the purposes of the WBM a peak abstraction rate of 18,000 m^3/d is used.

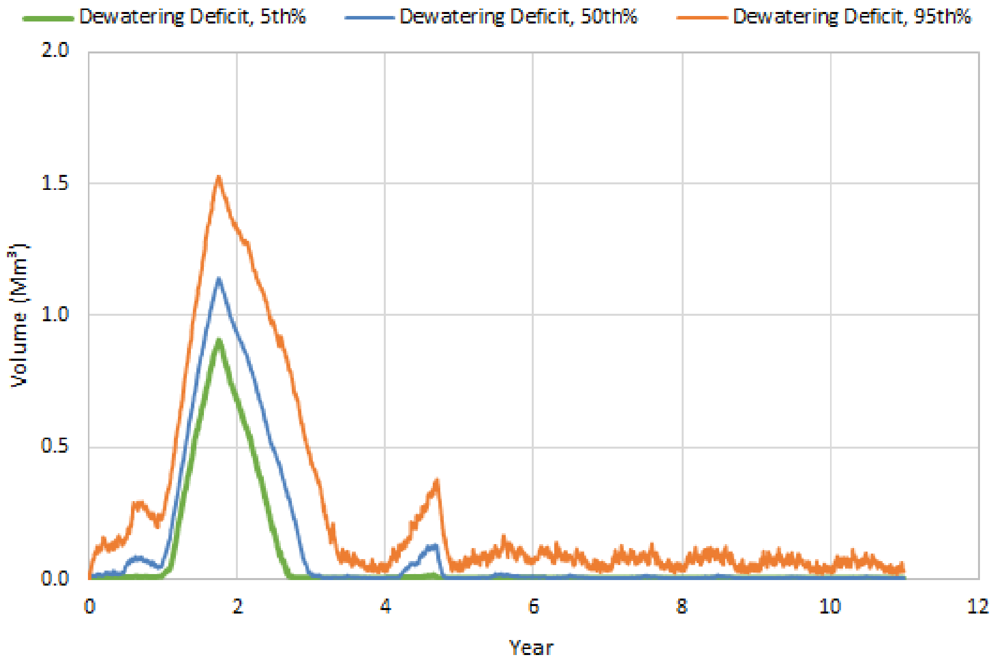

Figure D-5 Dewatering deficit, based on a peak dewatering capacity of 14,000 m^3/d

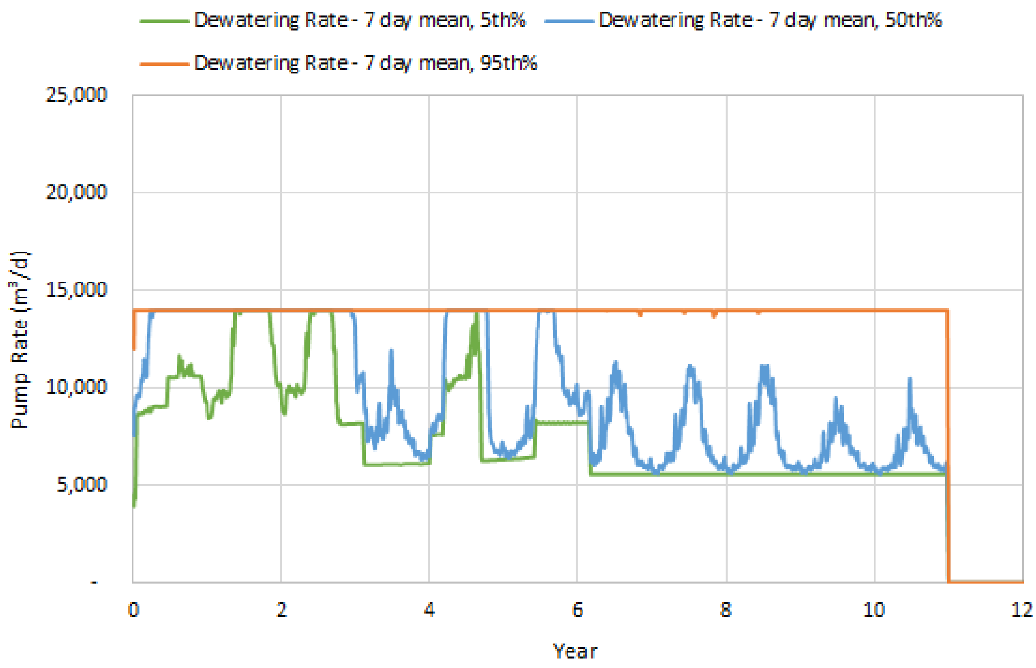

Figure D-6 Dewatering rates with peak dewatering capacity of 14,000 m^3/d

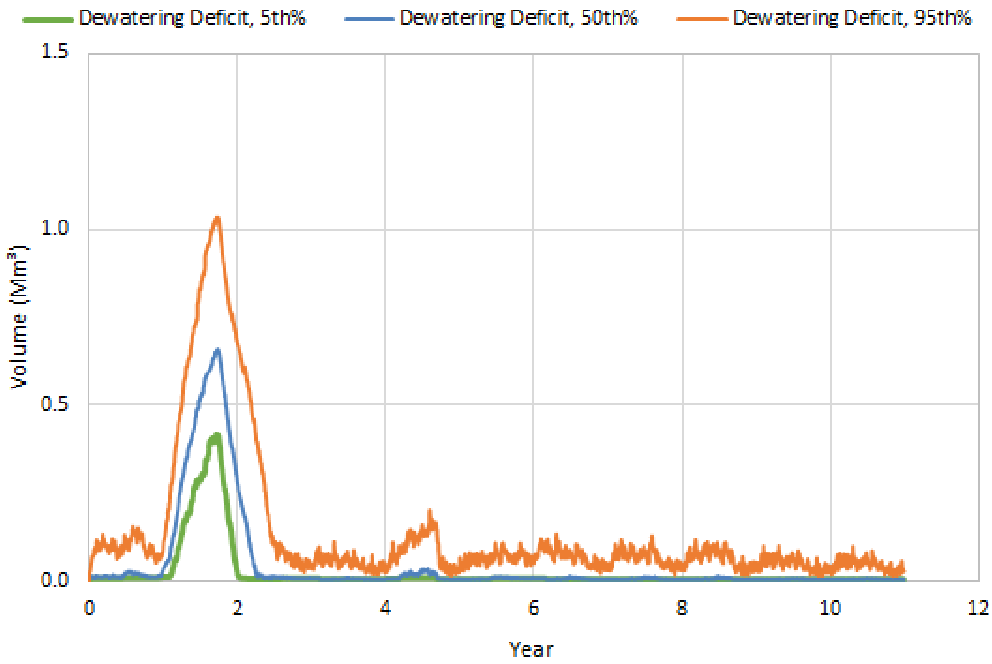

Figure D-7 Dewatering deficit, based peak dewatering capacity of 16,000 m^3/d

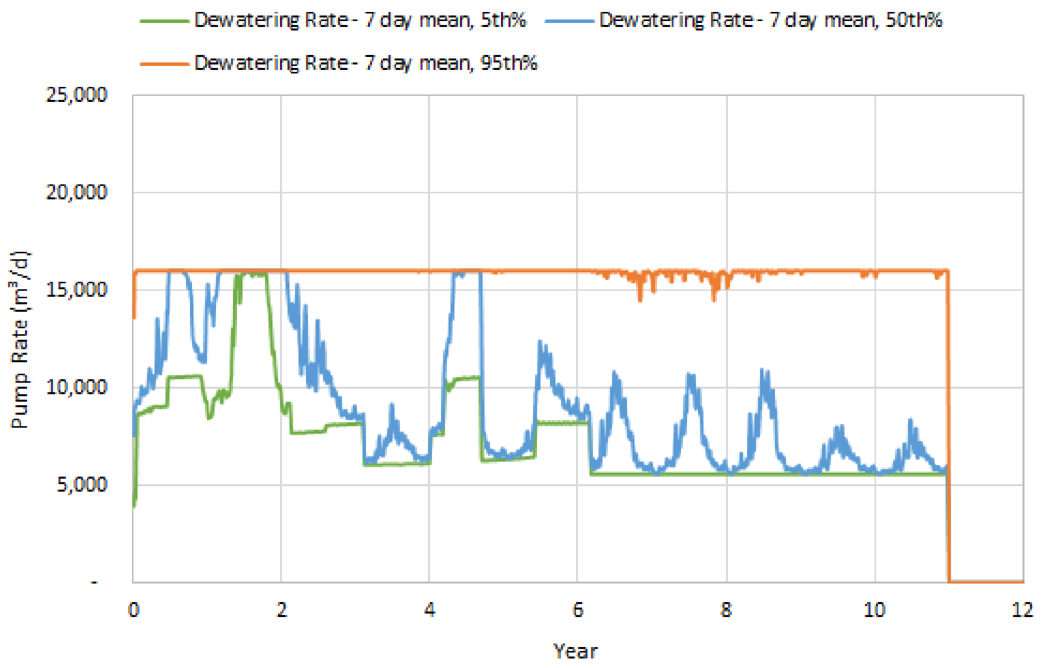

Figure D-8 Dewatering rates with peak dewatering capacity of 16,000 m^3/d

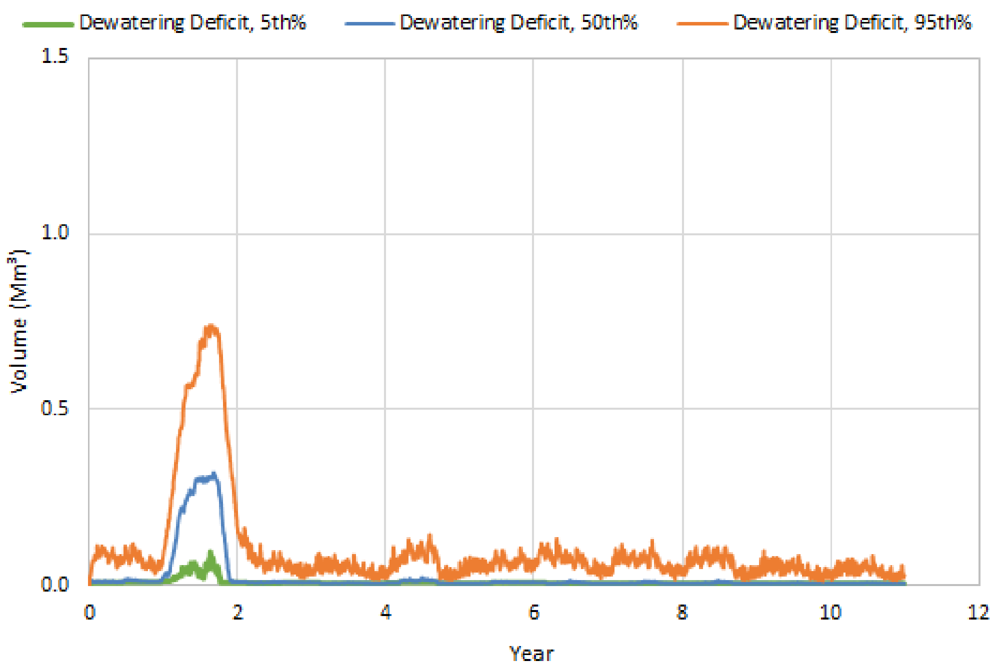

Figure D-9 Dewatering deficit, based on a peak dewatering capacity of 18,000 m^3/d

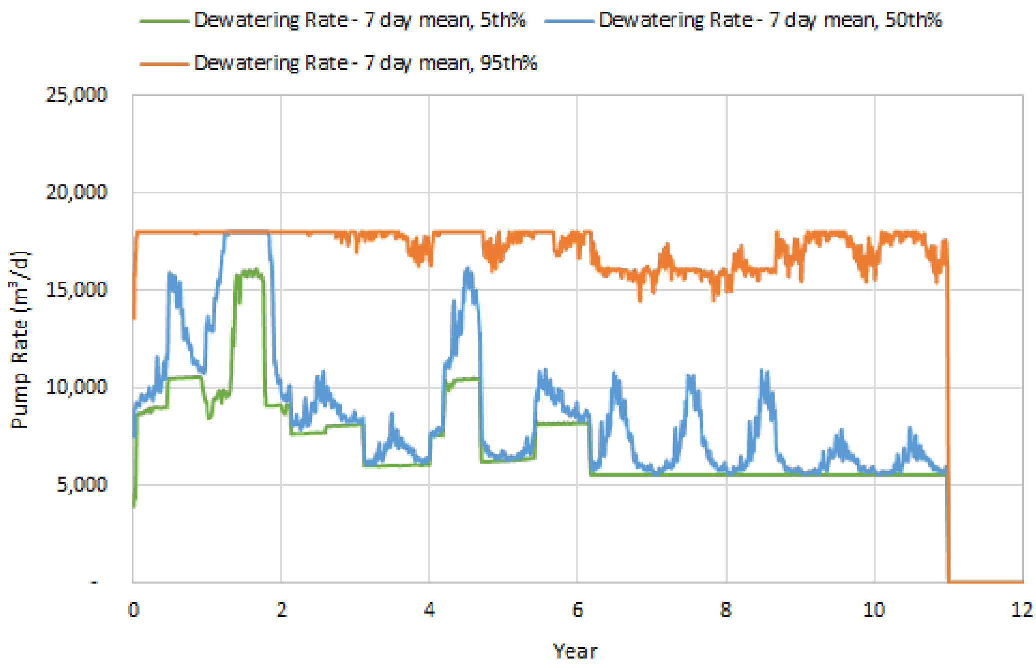

Figure D-10 Dewatering rates with peak dewatering capacity of 18,000 m^3/d

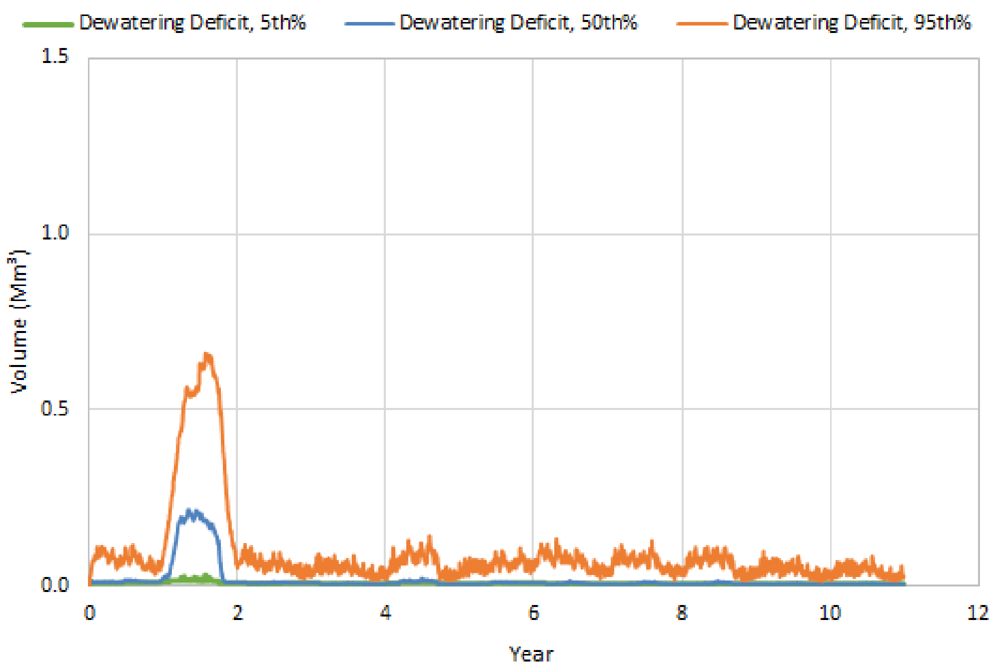

Figure D-11 Dewatering deficit, based peak dewatering capacity of 20,000 m3/d

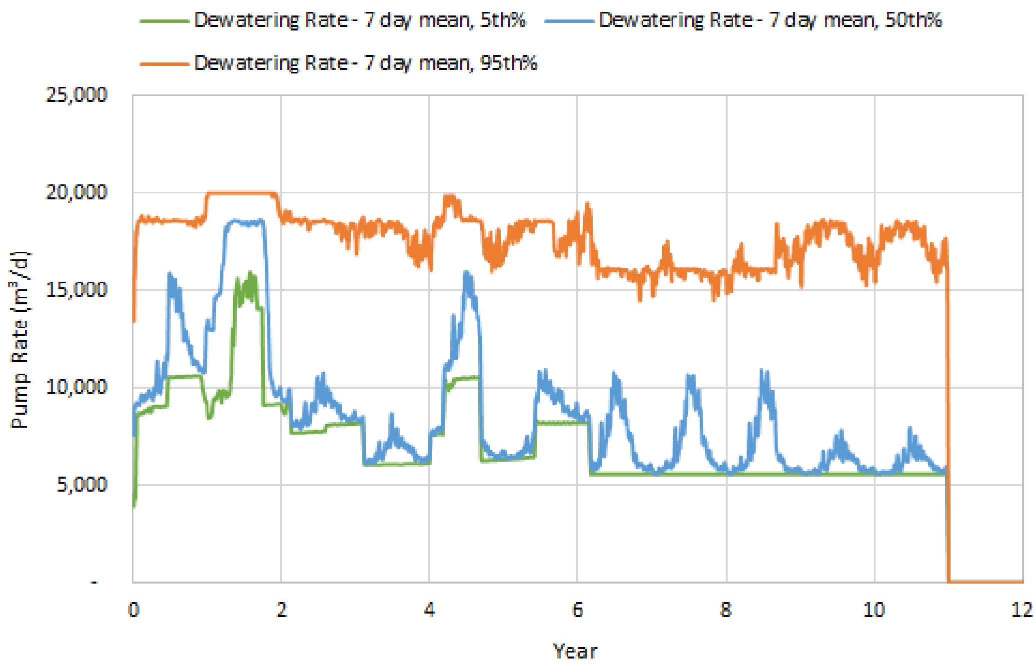

Figure D-12 Dewatering deficit, based on a peak dewatering capacity of 20,000 m3/d

Limitations of Dewatering Analysis

- It is assumed that the pump rate can be varied quickly so that the WTP is discharging treated water at the maximum specified efficiency of 90% so long as the peak pump rate is not exceeded.
- It is assumed that the peak pump rate can be maintained for some time without periodic down time.
- The dewatering analysis is based upon statistical analysis of rainfall inputs and assumed underground storage capacities and inflows. Variations of these inputs outside of the assumed statistical ranges could affect the results.

D 4 Rewatering Analysis

The stochastic water balance provides a range of potential rewatering rates and relative contributions of water, depending upon the variability of weather conditions. There is a small variability in underground working and rock mass storage estimates (GWS 2018) also included. The median rate of rewatering for each of the mine areas is illustrated in Figure D-13.

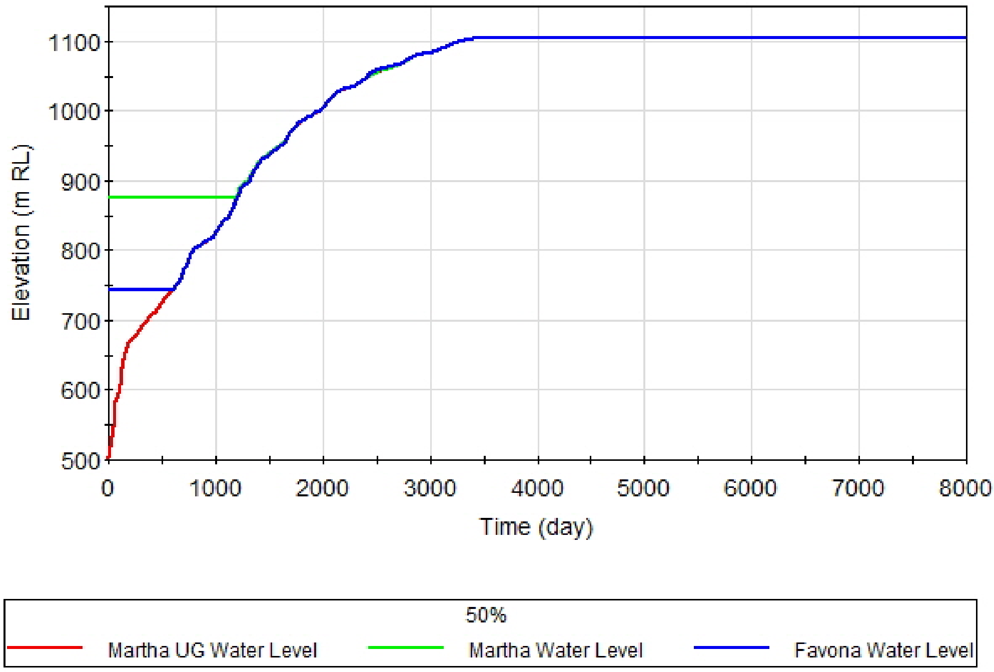

Figure D-13 Median Water Level Recovery with Time

The average contributions of river water, rainwater and groundwater are outlined in Table D-2, with the distribution of predicted contributions, resulting from the Monte Carlo analysis, illustrated in Figure D-14.

Table D-2 Summary of Rewatering Contributions

Water Component	Average Volume (Mm^3)	Average Rewatering Contribution
Rainfall	10.41	15.2%
Ohinemuri River Addition	51.35	74.9%
Groundwater Inflow	7.87	11.5%
Evaporation	-1.08	-1.6%
Total Storage (to 1104 m RL)	68.55	-

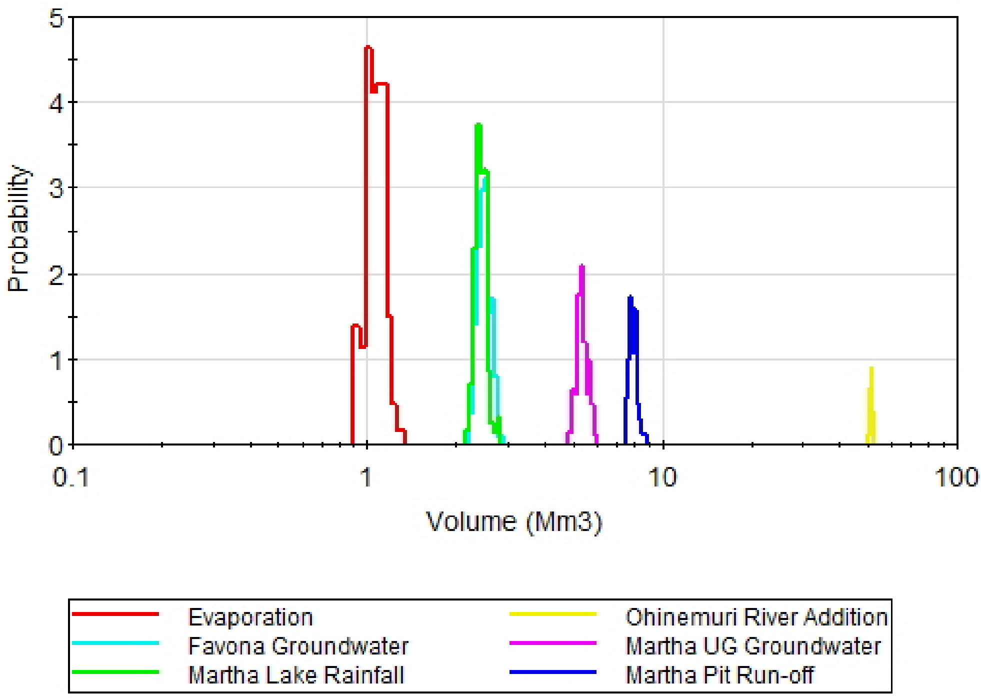

Figure D-14 Distribution of water contribution by source or sink

During the initial stages of filling, water is predicted to drain from both Favona and Martha pit, via connected workings and interconnected vein structure to the deeper Martha underground. Once the water level in Martha underground, reaches that of the deep Favona workings (approximately 785 m RL), water levels within each of these underground mines rise at an equivalent rate. When mine water levels reach the base of the Martha pit, lake levels begin to rise.

Figure D-15 illustrates the movement of water between the mine areas, the Martha pit - Martha underground and Martha underground - Favona interconnections are represented separately. During rewatering, flow is predominantly driven by drainage from Martha pit. Water drains into the Martha underground and subsequently to the Favona underground. Once lake level reaches approximately 1050 m RL, the direction of flow becomes more balanced, with intermittent reversal of flow i.e. from Favona to Martha underground and Martha underground to Martha pit. Net direction of flow is however, towards the underground workings until lake filling is concluded.

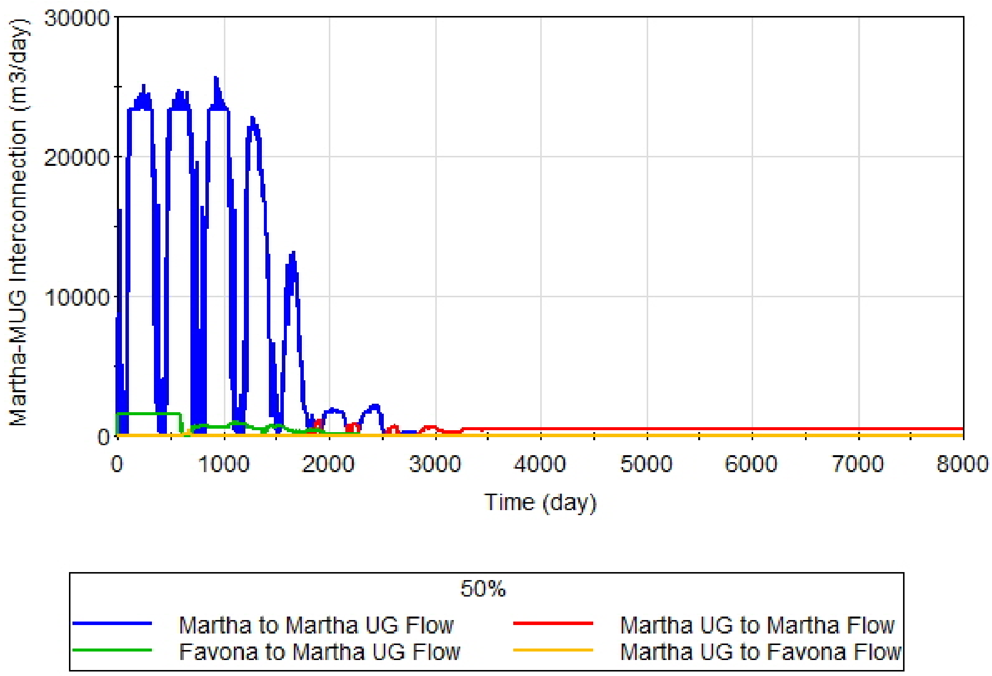

Figure D-15 Martha underground water balance (median results)

Lake filling

The rate of lake filling, as with rewatering of the underground, will be influenced by weather conditions. Figure D-16 illustrates the predicted distribution of filling times, dependent upon rainfall and the consented water contribution from the Ohinemuri River. Over 1,000 model realisations the median filling duration is 9.4 years with the 5^{th} and 95^{th} percentile falling within a range of ± 0.7 years.

The average daily contribution of Ohinemuri River water to the pit (15,000 m^3/day) dominates the lake water balance during filling. Much of this added water drains to the Martha underground until the lake level reaches approximately 1000 m RL. During the later stages of lake filling the water balance predictes a more subdued movement of water from the lake to Martha underground, with some limited periods of reversal occuring. Such periods are relatively minor in the context of net discharge to the underground.

Run-off contribution to the lake water balance during lake filling is significantly greater than that of direct rainfall to the lake surface. As lake level rises, the surface area of the lake increases and the pit wall area decreases, resulting in greater rainfall than run-off contribution by the time filling is concluded.

The ongoing net drainage of lake water to Martha underground ensures that groundwater doesn’t contribute notably to the lake water balance. Instead, the lake on completion of filling is predicted to comprise Ohinemuri River water, rainfall and run-off.

Analysis without the contribution from the Ohinemuri River indicates a filling time of 39 to 43 years, highlighting the improvement from the contribution.

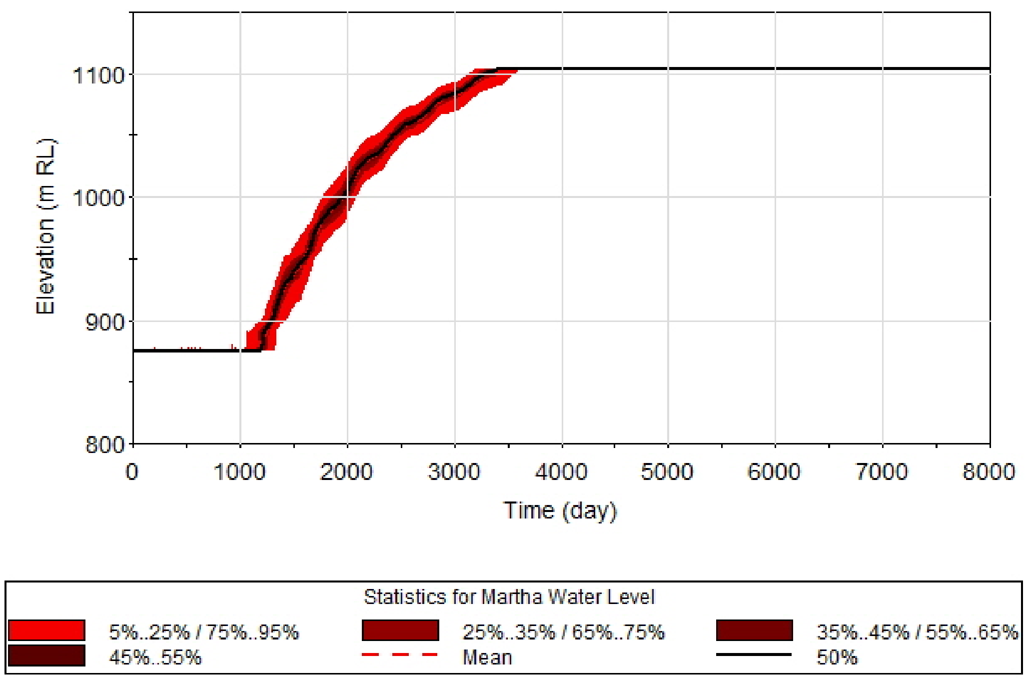

Figure D-16 Filling rates of Pit Lake

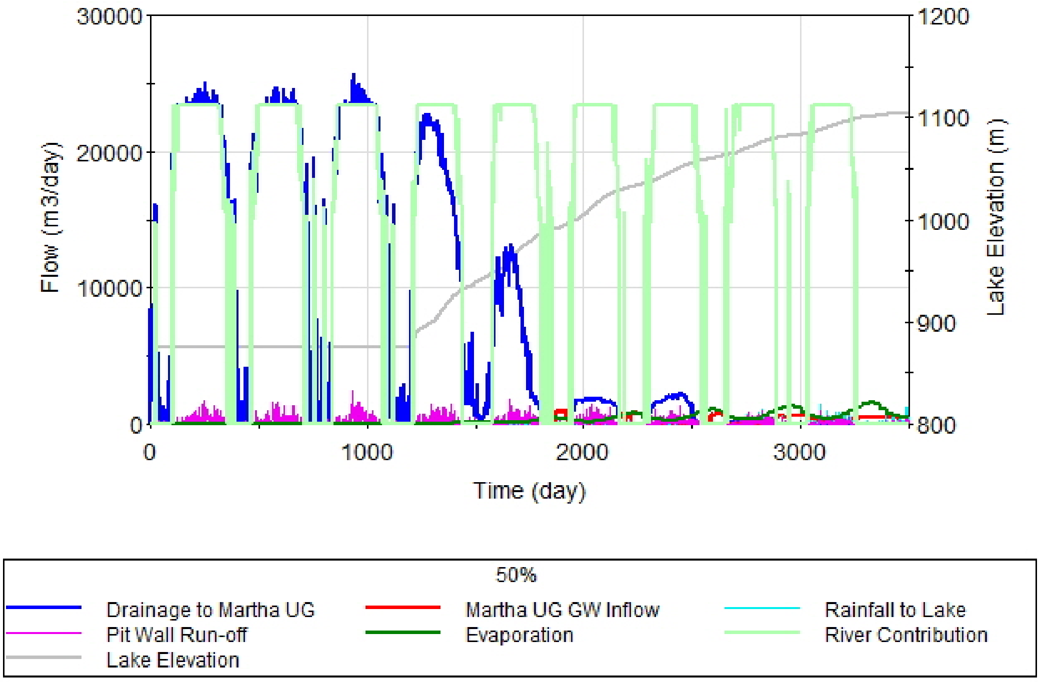

Figure D-17 Martha pit water balance (median results)

Long term

On completion of filling, the addition of Ohinemuri River water will cease and the lake level will be controlled at the overflow level of 1104 m RL.

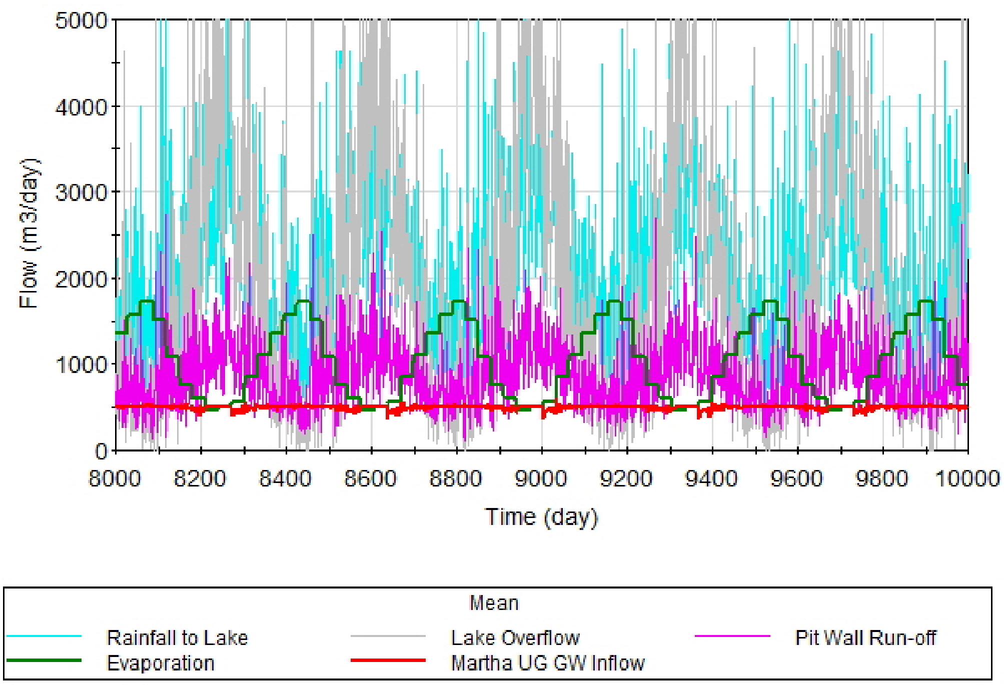

Figure D-18 Long term water balance of Martha Lake (mean results)

The predicted long term pit lake water balance shows strong seasonality (Figure D-18), with rainfall to the lake surface and run-off being the drivers for overflow. Average inflows to the lake exceed evaporation from the lake surface, providing regular discharge from the overflow. However, during prolonged dry periods, evaporation may temporarily exceed water inputs. During such times the rate of discharge from the lake will decrease and may temporarily cease.

Groundwater levels in the Favona and Martha underground workings are predicted to increase above those of the lake, creating a hydraulic gradient that generates groundwater flow towards the lake. Long term inflow of groundwater is, however, predicted to be relatively limited compared to other water inputs to the lake, averaging approximately 509 m^3/day. This groundwater contribution is most likely to be made through the deeper parts of the lake, where the hydraulic connection to the Martha underground is greatest.

Table D-3 outlines the predicted average daily water balance for the pit lake following filling.

Table D-3 Average daily water balance for Martha Lake following filling

Water Component	Average Input (m^3/day)	Average Withdrawal (m^3/day)
Rainfall	3,165	-
Groundwater	509	-
Evaporation	-	1,007
Overflow	-	2,667

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