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Vista Gold Australia Pty Ltd

Mt Todd Gold Project

Surface Water Assessment - Hydrology

May 2013

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Contents

Table Index

Figure Index

Executive Summary

This report considers the water management issues relating to the re-establishment and renewed operation of the Mt Todd Gold Project. Its scope includes an assessment of existing water containment infrastructure through water balance modelling and an appraisal of flood risk and existing stormwater management. Issues relating to water quality are addressed in a separate report.

Vista Gold Australia Pty Ltd proposes to re-establish and operate the Mt Todd Gold Mine, located 55km north of Katherine and 250km south of Darwin.

The Mt Todd Gold Mine was most recently mined for gold in the 1990s. Mining operations ceased in the 2000s and have been in a care and maintenance phase since then. Existing mine site infrastructure comprises an open cut pit, tailings dam, waste rock dump (WRD), heap leach pad (HLP) and the remains of processing facilities. Water retention ponds are located downstream of the WRD, HLP and processing plant to capture surface runoff and seepage. The operation of this infrastructure to contain runoff from disturbed and undisturbed areas of the mine has been investigated by means of water balance models.

It has been suggested that storm rainfall during the last two wet seasons has been in excess of a 100-year ARI and is therefore likely to exceed the design criteria of water management infrastructure on the site. An examination of rainfall records at Katherine shows that the total wet season rainfall between Nov 2010 and May 2011 was only the 5th highest of the 139 years on record and the following wet season was only the 63rd highest. In terms of monthly rainfall, December 2010 has a total that is equivalent to about a 5-year ARI and the December 2011 is more frequent than this ARI. It is possible that shorter duration rainfall events were more extreme in terms of the expected frequency of occurrence.

Significant hazard water storage infrastructure is likely to be designed for the containment of at least monthly and preferably extreme wet season rainfall and should therefore be able to contain rainfall such as that falling in 2010 and 2011, which records at Katherine suggest was not as extreme as suggested. Shorter duration rainfall is of more consequence to water conveyance infrastructure and it is possible that channel capacities and less significant storages may have been exceeded by short duration high intensity rainfall during 2010 and 2011.

Water Balance

Production phase water balance modelling is based on a 12-year sequence of daily rainfall and pan evaporation compiled from on-site records (1993 to 2010). Statistics from the rainfall record have been used in conjunction with a stochastic model to prepare 100 x 12 year daily sequences of rainfall for input to the water balance model. The use of stochastic sequences provides a robust assessment of the performance of water containment infrastructure. A separate post closure phase water balance model contains mean monthly values of rainfall and evaporation which are recursively applied to a 600 year period of simulation.

Water balance models simulate runoff from undisturbed areas of the mine and local upstream catchments by means of the USDA Curve Number method. The AWBM method has been implemented for the Edith River catchment. Seepage from the WRD and HLP is modelled as a proportion of daily rainfall lagged by a specified number of days. The HLP includes a decay function to represent the reduction in seepage after rehabilitation. Estimates of seepage from the tailings storage facility (TSF) have been obtained from an external finite element analysis. Groundwater flows in to or out of storage

facilities and the pit have not been represented in water balance models. Recent studies have shown that groundwater inflows will range from a few litres per second at the start of mining to approximately 31 L/s during the final months of mining and values are likely to be in excess of 13 L/s for most of the production period.

The mine site currently has nine storage facilities which hold water as their primary or secondary function and many are linked by a network of pipes. The water management strategy during mine operation is to eliminate overflows to the downstream environment in all but extreme storm rainfall events by transferring stored water to the WTP for treatment and subsequent re-use or discharge to the downstream environment under discharge licence conditions.

Water balance models have been created by previous studies:

1. GoldSim Model, December 2010 - MtToddWB 10.6Mtpy Pre-&Production&Clsure JAN2011.gsm – simulates the performance of water containment infrastructure during pre-production, production and closure phases of the mine's life cycle.
2. Goldsim Model, January 2012 - MtToddWB_LOM2011Update _Phase1&2_120118b_FLOW – is an update of the Goldsim model in (1) and simulates the production phase, only.
3. Spreadsheet Models - Water Balance_12-08-10_100MT.xls and Water Balance_12-08-10_BIG.xls – both models are restricted to an assessment of the performance of tailings storage facilities during the production phase of the mine's life cycle i.e. dam crest level requirements and plant make-up water.
4. Goldsim Model, December, 2010 - MtToddWB 10.6Mtpy Post-Closure 12Dec2010.gsm – focuses on quantifying the treatment stream during the post closure phase of the mine's life cycle.
5. A recent water balance has been carried out by Tetra Tech and is summarised in 'Mt Todd Gold Project, Hydrogeology', May 2013. The water balance covers a 500-year period representative of the post closure phase of the mine and focuses on inflows and outflows to Batman Pit including groundwater.

The performance of water management infrastructure during the production phase was assessed from output generated by the latest Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013 and MtToddWB_LOM2011Update_Post-Closure_PPT_Chooser, May 2012, 2010.

The capacity of the equalisation pond (30,000m^3, source 2013 Goldsim model) in conjunction with a WTP capacity of 300 m^3/h (years 1 to 3) and 500 m^3/h (years 4 to 12) is sufficient to receive transfers from Batman Pit (RP3), WRD retention pond (RP1), heap leach pad (HLP) and the low grade ore retention pond (RP2) to prevent overflows from these facilities during normal operating conditions. However, the model results show instances of overflow at RP1, RP2, HLP and RP5 which are likely to be the result of insufficient pump capacity on pipelines to the equalisation pond during high intensity rainfall events. Overflows from the stormwater sediment pond (RP5) are to be expected given its function as a sediment trap rather than a water retention pond. Simulations indicate no overflow from Batman Pit.

It should be noted that the water management procedure leading up to and during extreme peak rainfall is likely to invoke different operating rules to those represented in the Goldsim water balance which are representative of normal operating conditions. This could involve measures such as the temporary transfer of excess water to the TSF. Furthermore, because simulated overflows from retention ponds to the downstream environment occur as a consequence of extreme rainfall, it is likely that such events will

involve widespread rainfall and therefore flow within receiving waters will also be elevated. In this situation high dilution ratios will help reduce the impact of mine water discharge to the Edith River.

The results of the water balance also show that estimates of reclaim water and seepage from the TSF together with a similar magnitude of contribution from the RWD and WTP will be sufficient in meeting mine water demands over the life of mine (LOM). However, this assessment assumes the RWD is an unlimited water resource. The risk of shortfall in water supply is considered to be an economic risk rather than an environmental impact

The simulated annual average output of water treatment plant varies from 2.6 to 4.4 GL/yr over the LOM and assumes transfers from RP1, RP2, RP5 and RP3 occur whenever there is spare storage capacity within the equalisation pond. The model shows that a relatively small amount of excess water may be discharged from the WTP to the Edith River during the first three years of operation. This is most probably caused by the adoption of a fixed water transfer operating rule regardless of mine production and is not expected to occur during actual operations when rates of transfer will be dynamically controlled.

The water balance during production years makes a number of assumptions. No net groundwater inflow to Batman Pit and the pit is assumed to contain 1799 ML of water at the commencement of the production phase. The rates of reclaim water and seepage outflow from the TSF have been determined independently of the Goldsim water balance. Diversion drains around the WRD are assumed to have been constructed and will divert 29% of catchment runoff away from the retention pond.

Some discrepancies exist between modelled and reported areas of development footprints for the Low Grade Ore Stockpiles, Batman Pit, to a lesser extent the Waste Rock Dump, and the proposed period of mine production. Underestimation of the development footprint of the pit will have a significant impact on expected inflow and this may affect assumptions regarding transfer rates to the WTP from the pit which may then impact transfers from other areas of the mine.

The results of a Goldsim post closure water balance indicate that water levels in Batman Pit are expected to reach equilibrium at a level of between 975 m and 977 m (169 m and 167 m below the 1144 m top of pit level). However, this assumes no groundwater inflow which recent investigations indicate could be up to 31L/s.

The results of a more recent water balance for the post closure period includes groundwater inflows (Tetra Tech, May 2013) and suggests that the pit lake water level will rise relatively rapidly following cessation of pit dewatering and reach equilibrium after 345 years at an elevation of approximately -15 mAHD. At this elevation the surface area of ponded water is expected have evaporation rates which balance inflows from rainfall and groundwater.

Stormwater Management

The Mt Todd Mine is traversed by four creeks which drain into the Edith River to the south of the mine. Horseshoe and Batman Creeks feed Stow Creek which borders the proposed TSF and then flows into the Edith River. Horseshoe Creek flows along the eastern boundary of the mine, Batman Creek flows through the centre of the mine and Burrell Creek flows along the south western corner of the mine.

Flooding along these creeks has the potential to encroach on storage embankments, plant, pit and other infrastructure. Hydrologic modelling in conjunction with 1-D hydraulic models has been used to extend the existing flood outlines from previous studies and to assess flood immunity and impacts on existing and proposed mine infrastructure, particularly storage embankments.

Flood modelling has shown that most of the existing mine infrastructure is located outside the 100-year ARI design flood extent of creeks passing through the mine area. The notable exceptions are the future TSF2 which encroaches on the area of flooding along Horseshoe Creek and Stow Creek, also the area of proposed Low Grade Ore Stockpiles and ROM which encroach on the flood extent of Batman Creek.

The design of the new TSF2 includes diversion channels and levees along Horseshoe Creek and Stow Creek to protect the embankment from flooding and erosion. Diversion channels have been designed for 100-year ARI flood events and comprise lined rip-rap channels with a width and length on Stow Creek of approximately 60m and 850m, respectively, and a nominal depth of 4.2m. The width and length of the diversion channel on Horseshoe Creek will be approximately 40m and 550m, respectively, with a nominal depth of 2.5m.

The existing TSF1 is protected from flooding along Horseshoe Creek by means of a creek diversion channel which modelling shows has sufficient capacity to accommodate the 100-year ARI design flood event.

Upgrade or re-design of existing drains and levees to protect areas of the processing plant against the 100-year ARI flood event along Batman Creek is required. Drainage across the processing plant site will be limited by the installation of cut-off drains to divert uncontaminated runoff from around the site and into Batman Creek via a settling pond. All stormwater runoff from within the site will be directed toward the existing drainage channel on the east side of the proposed process plant.

Run-of-Mine and additional Low Grade Ore Stockpiles will require collection ditches to capture runoff and seepage from stockpiles for conveyance to retention ponds. The location and quantity of runoff is not yet known and will need to be assessed during the design phase to determine the required channel and storage embankment height.

Mitigation includes diversion structures to limit the runoff from undisturbed areas of the mine and upstream catchments from reaching water containment and plant infrastructure. Diversions are also present upstream of the low grade ore stockpiles and around the HLP with the purpose of collecting runoff from these disturbed areas of the mine and directing it into storage ponds for transfer to the waste water treatment plant. Diversion drains have been constructed around the western and eastern margins of the WRD retention pond (GHD, Nov 2010) to divert uncontaminated runoff away from the pond and thereby reduce the risk of overtopping. Diverted water will report to local creeks downstream of the pond.

Overtopping of cross drainage structures and haul roads is likely to be an infrequent occurrence but upgrades to existing stormwater drainage, erosion and sediment controls, including the vegetation of verges, will be necessary to minimise damage during less extreme but more frequent storm events.

Locations where flood peak velocities are expected to exceed 2m/s and thus have the potential to cause scouring of unlined channels have been identified. Whilst the majority of these locations are sufficiently distant from mine infrastructure to be of no immediate risk, the section of Batman Creek adjacent to the processing plant is likely to experience high velocity flows during extreme flood events. Rip-rap protection to earthwork embankments adjacent to the existing drainage channel on the east side of the proposed process plant will be installed for channel protection. Sections of Stow Creek in the vicinity of the proposed embankment of TSF2 are also expected to experience high flow velocity during extreme flood events. Scour protection measures will include placement of rip-rap in association with proposed channel diversion works.

The following additional mitigation measures are proposed for the management of storm water runoff:

- Ensure flood immunity by siting mine infrastructure outside the 100-year ARI flood extent;
- The potential for contamination of receiving waters has been reduced by segregation of “clean” stormwater runoff from “dirty” stormwater runoff and the collection and treatment of “dirty” stormwater runoff from areas within the mine site;
- The amount of pit water needing treatment has been reduced by minimising the stormwater runoff entering the pit by construction of bunds around the pit perimeter;
- The amount of stormwater runoff from material stores has been minimised through appropriate design of batter slopes and drainage collection systems;
- During rainfall events that exceed the design capacity of water containment infrastructure, excess inflow may need to be redirected back into the active TSF up to the height of beached tailings or allowed to overflow to the environment. It is assumed that retention ponds have been designed to overflow whilst maintaining the safety of embankment structures.

Monitoring

Water monitoring stations are required to obtain the rate of surface water runoff entering and exiting the mine site to assist with the efficient operation of water management infrastructure and to demonstrate compliance with discharge licence conditions. In addition, it would be advantageous to obtain data that could be used to validate parameters used in water balance models; this would comprise storage levels, runoff from disturbed areas of the mine and pumping rates between storage infrastructure.

Monitoring has been carried out at a number of locations throughout the mine site. Whilst this provides valuable information for the operation of infrastructure its value to the long-term management and planning of water containment is often impaired by a lack of information on the duration and rate of flow. Recommended improvements to monitoring during operation of the mine include:

- Monitoring of water levels at locations on Batman Creek and Horseshoe Creek just upstream of mine infrastructure together with the derivation of stage – discharge relationships for existing monitoring sites just downstream of the mine site;
- Installation of hourly or continuous monitoring of water levels at the weirs downstream of the WRD would assist with the estimation of seepage rates from the waste rock dump. However, this information could also be obtained from existing monitoring of water levels in the retention pond so long as monitoring of transfers and any other outflows is carried out in tandem.

1. Introduction

1.1 Overview

Vista Gold Australia Pty Ltd (Vista Gold) proposes to re-establish and operate the Mt Todd Gold Mine, located 55km north of Katherine and 250km south of Darwin. The mine site is accessed via Jatbula Road (restricted mine access road), approximately 10km west of the Stuart Highway (the main highway between Darwin and Adelaide).

The Mt Todd Gold Mine site was most recently previously mined for gold in the 1990s. Mining operations ceased in the 2000s and have been in a care and maintenance phase since that time. Mining infrastructure such as tailings dams, WRDs, mine pit and remains of processing facilities remain on site.

The new mining operation will be by conventional open-pit truck and shovel methods, using large haul trucks, hydraulic shovels and front-end loaders to transport material to the crusher, ore stockpiles and waste dump facilities. Approximately 17.8 million tonnes per annum (Mtpa) of ore will be carbon in leach (CIL) leached leading to recovery of gold dore (unrefined gold). The CIL tailings will be detoxified and sent to an impoundment from which plant process water will be recycled.

A number of previous studies have investigated the design and operation of water management infrastructure, the most recent being Envirotech Monitoring's Mt Todd Water Management Plan 2011/12.

This report provides information in support of the Mt Todd Gold Project Environmental Impact Statement and addresses the Guidelines for the Preparation of a Draft Environmental Impact Statement, Mt Todd Gold Project Katherine Region, NRETAS (2011) i.e.

- Description of catchments, their boundaries, area and topography. Indicate location of infrastructure footprints;
- An estimate of the effects from current and future pits, water stores and operational processes on surface water distribution;
- Areas of inundation, drainage lines, surface-water flow directions, creeks and receiving waterways. Existing surface drainage patterns, flows (including flood level contours) and discharge rates;
- Size of drainage lines, creeks and waterways, and frequency of extreme rainfall events; and
- Describe the current surface water monitoring program, any proposed modifications to the program.

The report is based on the descriptions of the mine footprint as provided by Vista Gold Australia Pty Ltd and contained within the models:

- GoldSim Pro (Version 10.5) simulation software MtToddWB_Production_PFS_45K.gsm; and
- MtToddWB_LOM2011Update_Post-Closure_PPT_Chooser.

This report considers water management issues relating to the re-establishment and renewed operation of the mine. The report is divided into two main sections which:

- Assess the performance of water containment infrastructure; and
- Appraise stormwater management.

The operation of infrastructure to contain runoff from disturbed and undisturbed areas of the mine has been investigated by means of water balance models

Previous flood mapping studies are available and have been used to assist with the appraisal of stormwater management.

1.2 Key Elements of the Project

The key elements of the Project include:

Mining and Mining Infrastructure

- Extension of the existing Batman Pit from its current depth of 114m to approximately 588m and surface area of 40 hectares (ha) to approximately 137ha;
- Expansion of the existing waste rock dump (WRD) from a height of 24m to approximately 350m, and a footprint of 70ha to approximately 217ha. The dump currently contains 16Mt of waste rock and the expansion will provide total capacity of up to 510 Mt;
- Construction of a Run of Mine (ROM) pad and ore stockpile;
- Construction of an ANFO (Ammonium Nitrate and Fuel Oil (ANFO) Facility;
- Construction of heavy and light vehicle workshop and administration offices, and facilities comprising wash down area, tyre change facility, lube storage facility etc.; and
- Construction of haul roads and access roads.

Process Plant and Associated Facilities

- Ore Processing Plant capable of processing approximately 50,000 tonnes per day (tpd) of ore;
- Processing and / or reclamation of the existing low grade ore (LGO) stockpile and scats stockpile, and construction and processing of new LGO stockpile with a footprint of 25ha;
- Raising the existing tailings storage facility (TSF1) from 16m to approximately 34m;
- Construction of a new TSF2, approximately 300ha in area and up to 60m high;
- Diversion of Horseshoe Creek and Stow Creek adjacent to TSF2 to provide flood protection;
- Rehabilitation of the existing heap leach pad (HLP) if residual HLP material is not processed through the new plant;
- Chemical and reagent storage and handling facility; and
- Process plant workshops, administration offices, control room etc.

Other Infrastructure

- Gas fired Power Station, including re-routing of the existing gas pipe line;
- Anaerobic treatment wetlands, approximately 10ha in area;
- A 2m high raising of the raw water dam (RWD) and an increase in the area of inundation;
- Construction of saddle dams at the RWD and TSF1;
- Construction of three coffer dams at Retention Pond 1 (RP1) and deepening of RP1;

- 500 m^3/h capacity water treatment plant;
- Security gate house;
- Potential re-alignment of access roads;
- Site wide drainage; and
- Modification to existing fuel storage and distribution facility.

The construction and operations workforces are expected to peak at approximately 450 and 350 personnel, respectively.

The Project, based on current known data, will have a life of around 19 years inclusive of construction, operations and closure. Construction is anticipated to commence in the first quarter of 2014 and take two years, including 6 months pre-production. The mine is scheduled to operate for a further 13 years. Closure and rehabilitation of the mine is expected to take four years.

2. Water Containment

2.1 Infrastructure

The mine site contains infrastructure including a mine pit, tailings dam, WRD and the remains of processing facilities together with a number of water storage retention ponds. A map showing the layout of existing and proposed infrastructure is shown in Figure 1.

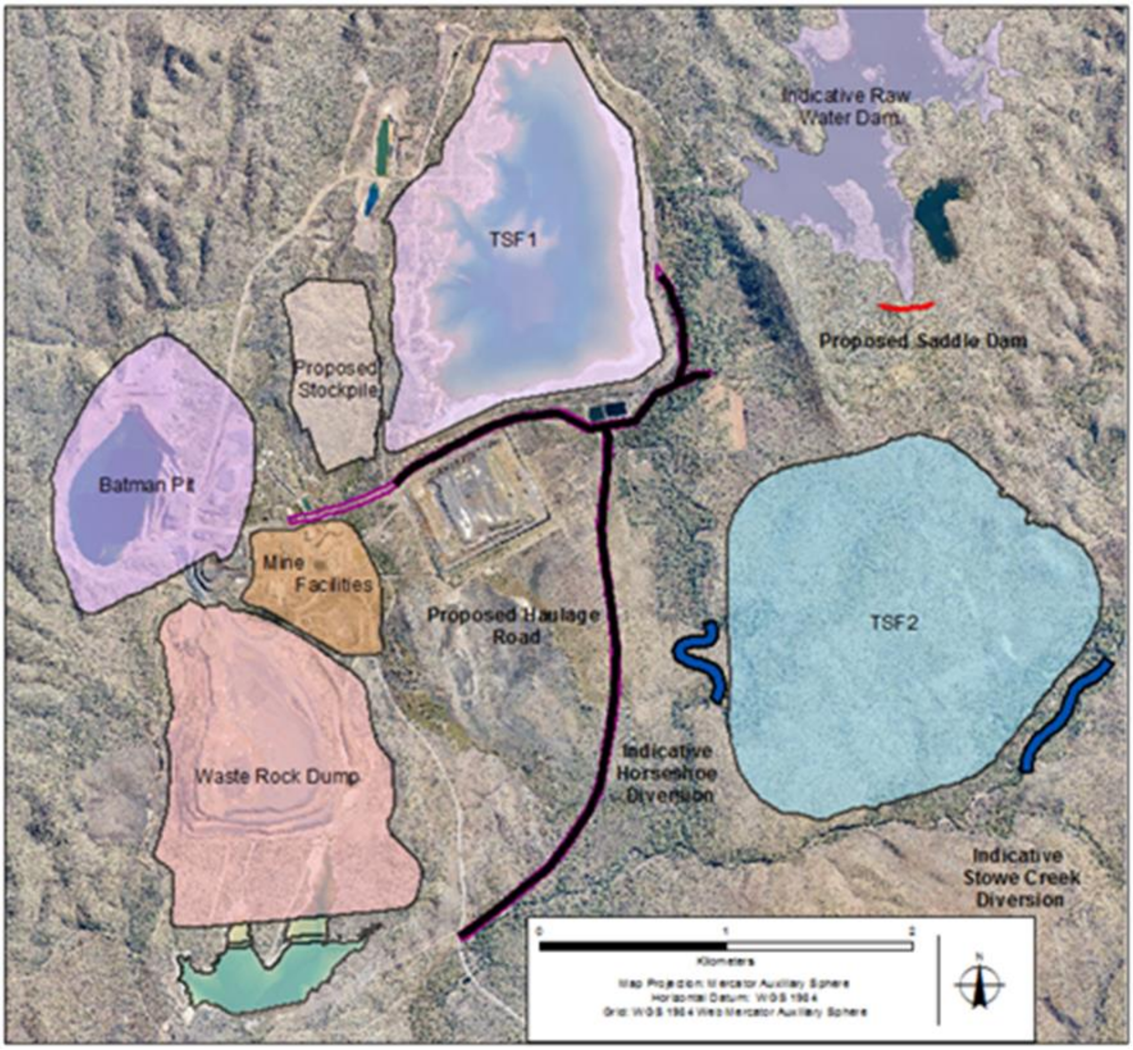

Figure 1 Mine Footprint

Source: Vista Gold Australia Pty Ltd, 2012.

The area of each development footprint is available from a number of sources and the values which have been used in the Goldsim model (MtToddWB_Production_PFS_45K) are listed in Table 1. Given the dynamic nature of mine planning a number of discrepancies exist between the parameters describing the latest known development and values contained within the water balance model. Its impact on the water balance has been highlighted where necessary.

Table 1 Development Footprints

Facility	Area (ha)
Waste Rock Dump	61 to 202.5[a]
Low Grade Ore Stockpile	11.3 [a b]
Batman Pit	32.5 [a]
Heap Leach Pad	37
Plant, WTP, Operations and administration	22
Tailings Storage Facility TSF1 (RP7)	156.0
Tailings Storage Facility TSF2 (RP8)	300.0

Source: Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013

Notes: [a] proposed maximum development footprints WRD = 217ha LGOS = 47ha Batman Pit = 137ha [b] excludes LGOS pad

The mine site consists of nine storage facilities which will store water as their primary or secondary function (Table 2) and a pipe/pumping network (Table 3) that aims to eliminate overflows from retention ponds to the downstream environment during all but extreme storm rainfall events. Whilst the pit is not strictly speaking a storage facility it has been included in the table.

Pit dimensions will change during the life of mine from a current depth of 114m (RL 74 m) to a final depth of 588m (RL -400m). The storage characteristics of the expanded pit during future development phases are shown in Figure 2. The results of Goldsim Model water balance modelling are available for the existing pit storage characteristics (pit area 32.5 ha), only.

Table 2 Water Storage Characteristics

Retention Pond	Storage Capacity (ML)	Maximum Storage Level (m)	Initial Storage Volume (ML)
WRD RP1	1226	1119.00	926.8
Low Grade Ore Pad RP2	10.4	1130.00	2.5
Batman Pit RP3	11970	1144.00	1799.1 [b]
HLP	67.5	1135.50	31.8
Stormwater Sediment Pond RP5	13.7	1128.00	3.1
TSF1 RP7	4680	1136.50	0
TSF2	unknown	unknown	unknown
Raw Water Dam	Infinite [a]	infinite	infinite
Equalisation pond	30 [c]	1128.00	0

Source: Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013 Notes: [a] Goldsim Model assumes infinite storage source due to lack of reliable data to establish storage curve [b] based on output from Pre-production model which in turn relies on observed water elevations and dewatering rules based on current discharge permit (ref Tetra Tech memo 21/2/2013) [c] storage is reported to be equivalent to 5 days water treatment capacity (36 ML) but in fact is only 30 ML within the Goldsim model

Table 3 Pump Capacity

Source	Destination	Capacity (m^3/h)	Time Scaling Factor applied to Pump capacity
WRD RP1	WTP	443	1
Raw Water Dam	Dust suppression	50	1
Low Grade Ore Pad RP2	WTP	266	0.3
Stormwater Runoff RP5	WTP	70	0.5
HLP Facility	WTP	194	1
Batman Pit RP3	WTP	443	1
Tailings Storage Facility TSF1	WTP	360	1
WTP	Dust suppression	50	1

Source: Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013

Discrepancies exist between modelled and reported areas of development footprints for the Low Grade Ore Stockpile, Batman Pit and to a lesser extent the Waste Rock Dump. Inflow to their respective retention ponds comprises external catchment runoff, seepage from material stores (or pit wall runoff in the case of Batman Pit) and direct rainfall over ponds each of which involves a different method of calculation and magnitude of unit runoff depth. The greatest unit runoff is generated by direct rainfall over ponds and pit walls. These two sources exhibit 5 times the runoff depth per unit area than is generated by rainfall over catchment areas (surface runoff) or material stores (seepage).

The underestimation of pit area by the Goldsim model may result in an underestimate of the pit wall area and ponded water area whilst overestimating the area of catchment runoff. This will result in a significant underestimate of pit inflow due to the differences in unit runoff depth. Therefore a water balance on an expanded pit is likely to change the assumptions regarding required transfer rates to the WTP from the pit and possibly transfers from other areas of the mine.

The underestimation of the Low Grade Stockpile footprint is not expected to cause a significant impact on the water balance. As mentioned above seepage and catchment runoff have a similar unit runoff depth and therefore changes to the areas will not significantly affect the water balance.

Discrepancies in the final footprint of the Waste Rock Dump are of less significance to the overall water balance.

Diversion channels isolate runoff from undisturbed areas, such as the upper reaches of Horseshoe Creek and Burrell Creek, and thereby reduce the amount of water entering the mine site water management system (Table 4). Diversions are used to divert runoff from disturbed areas of the mine and direct it into water retention ponds. Other diversion structures are used to protect infrastructure by re-aligning the course of creeks and do not alter the water balance of the mine site e.g. proposed diversions along Horseshoe and Stow Creeks.

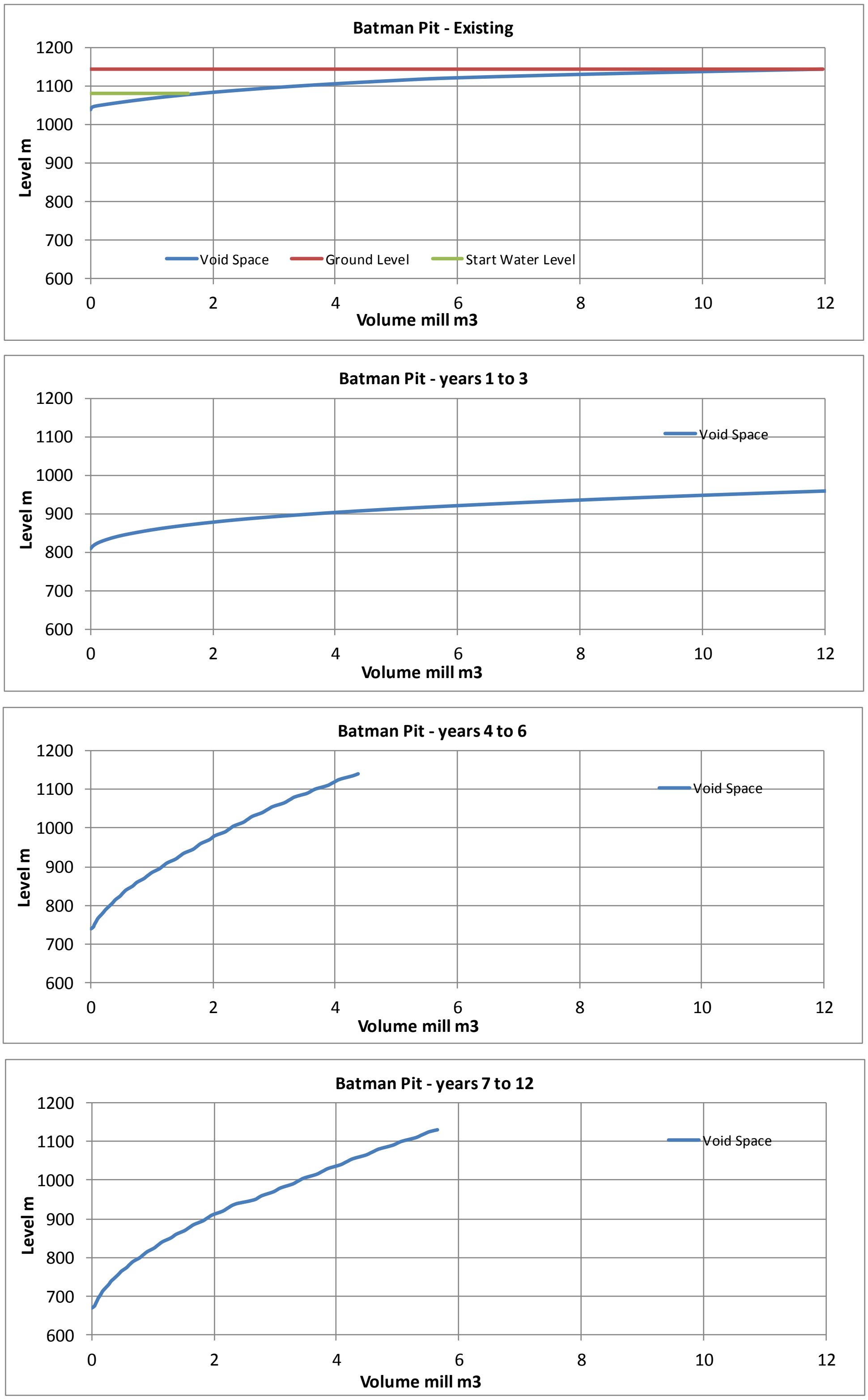

Figure 2 Batman Pit Void Space

Table 4 Creek Catchment Diversions

Creek	Location	Status	Capacity (m^3/h)
Burrell Creek catchment	Western margin of WRD	Existing	Unknown
Burrell Creek catchment	West drain - WRD retention pond	Existing	29,160
Burrell Creek catchment	East drain - WRD retention pond	Existing	15,120
Batman Creek	Between Low Grade Ore Stockpile and its pond	Existing	Unknown

Notes: these diversions are limited to those that change the quantity of runoff in the downstream channel

Schematics of the layout of pipelines can be found in Figures 2-1 to 2-5 of 'Mt Todd Gold Project Water Management Update – Appendix I-M' (Jan 2011, Vista Gold). A summary of the water containment management system is given in Table 5 and aims to transfer excess water from all retention ponds to the equalisation pond at the WTP, so long as the equalisation pond is not in danger of overflowing. Treated water in excess of processing plant and dust suppression requirements is discharged to the Edith River. This means that retention ponds are allowed to overflow in exceptional circumstances.

Table 5 Water Management Operating Rules

Source	Destination	Rule
Burrell Creek	West Creek	WRD will progressively fill to occupy its own catchment thereby replacing catchment runoff with rainfall seepage.
Burrell Creek	West Creek	Runoff from 29 % of catchment and up to 10-year 24-hour storm volume will be diverted in drains around WRD retention pond.
WRD Pond (RP1)	WTP	Pump to WTP if Equalisation Pond freeboard is less than 0.5m threshold.
Low Grade Ore Stockpile Pond (RP2)	WTP	Pump to WTP if Equalisation Pond freeboard is less than 0.5m threshold.
Stormwater Sediment Pond (RP5)	WTP	Pump to WTP if Equalisation Pond freeboard is less than 0.5m threshold.
Heap Leach Pad (HLP)	WTP	Pump to WTP if Equalisation Pond freeboard is less than 0.75m threshold.
Batman Pit (RP3)	WTP	Pump to WTP if Equalisation Pond freeboard is less than 0.5m threshold.
WTP	Batman Creek/Edith River	Discharge water in excess of processing plant and dust suppression requirements via monitoring pond (pond not modelled in Goldsim).

Source: Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013

It is understood that in exceptional circumstances water can be temporarily transferred to the TSF should retention ponds be in danger of overflowing and there is insufficient capacity in the WTP. This option was not included in the Goldsim water balance.

2.2 Climate

The production phase water balance model has been set up to run with a stochastic precipitation model which is able to generate multiple sequences of daily rainfall covering the life of mine production (12 years). This provides an envelope of expected conditions representative of overly dry years ranging to overly wet years.

The stochastic model uses a Weibull distribution with a slope parameter value of 1 that causes it to collapse to an exponential distribution. The distribution is defined by a minimum daily rainfall of 0 mm; a mean daily rainfall based on defined mean monthly rainfall totals for the wet season (Table 6) factored upwards by 1.2 (dry season rainfall is 0 mm); and, a maximum daily rainfall of 257 mm which is the 100-year 24-hour design storm rainfall (source published Bureau of Meteorology IFD database). Rainfall is generated for randomly determined durations with a target mean length of 3 days and a defined target probability of occurrence (Table 6). The source of mean monthly rainfall values and target probabilities is not stated but it is assumed to have been extracted from historical on site rainfall records. It has been stated by Tetra Tech that on-site records (1993 to 2010) have been in-filled and extended using adjusted records from Katherine (rainfall increased by 19%).

Table 6 Stochastic Rainfall Model Parameters

Parameter	October	November	December	January	February	March	April
Mean Monthly Rainfall [a] (mm)	35	111	239	292	259	193	38
Expected Probability	0.12	0.26	0.44	0.49	0.52	0.36	0.13

Source: Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013. Notes: [a] rainfall is multiplied by 1.2 in model

The relatively low variability in evaporation permits the use of mean monthly pan evaporation adjusted by a pan factor of 0.9, which delivers a slightly conservative estimate. The Goldsim model contains data representing three alternative climatic conditions termed; dry, average and wet (Table 7). However, the model has been run using an average climatic condition where annual evaporation is 2574 mm. The source of evaporation data is not stated but it is believed to be based on mine site records.

Table 7 Mean Monthly Evaporation

Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Dry (mm/day)	7.3	8.5	8.7	9.0	8.5	8.2	8.2	7.5	6.3	4.9	5.5	5.7
Ave. (mm/day)	7.0	8.1	8.6	8.5	8.2	7.7	7.6	6.9	5.9	5.1	5.3	5.8
Wet (mm/day)	6.6	7.8	8.7	8.6	7.6	7.6	7.8	6.6	5.5	4.8	4.7	5.5

Source: Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013 Notes: [1] rainfall is multiplied by 1.2 in model

A post closure phase water balance model (Goldsim model - MtToddWB_LOM2011Update_Post-Closure_PPT_Chooser) contains the following two options for representing future rainfall conditions both of which are based on a rainfall sequence developed from the record at Katherine and updated with recent site records:

- Sampled over the entire 137-year record (1873 to 2012) and repeated approximately 4 times to achieve a 600 year period; and
- Sampled over the most recent 20-year subset of the 137-year sequence and repeated 30 times to achieve a 600 year period.

Rainfall data does not include any adjustment for climate change as there is no official means of adjusting long term sequences of daily rainfall.

A daily sequence of evaporation has been compiled from monthly evaporation which is believed to be based on mine site records. A pan factor of 0.78 has been used to adjust the data to rates of evaporation from an open water surface.

The mean annual rainfall for the period 2010-2030 at the mine site is 1280 mm and the mean annual potential evaporation is 2470 mm (excluding pan factor of 0.78). Including the pan factor of 0.78, adjusted evaporation becomes 1926.6 mm annually.

It has been suggested that storm rainfall during recent wet seasons has been in excess of a 100-year ARI and is therefore likely to exceed the design criteria of most water management infrastructure on the site. Examination of rainfall records show that the total wet season rainfall between Nov 2010 and May 2011 was only the 5th highest at Katherine (available record 1873 to 2012 at gauge number 14902) which equates to about a 30-year ARI (using Log Pearson distribution), whilst the following wet season was only the 63rd highest out of the 139 year record at Katherine and has a more frequent 2-year ARI. In terms of monthly rainfall, December 2010 has a total that is equivalent to about a 5-year ARI and December 2011 is more frequent than this ARI. It is possible that shorter duration rainfall events were more extreme in terms of frequency of occurrence. However, major water storage infrastructure is likely to be designed for the containment of at least monthly and preferably wet season rainfall which records at Katherine suggest was not as extreme as suggested for these longer durations in 2010 and 2011. Shorter duration rainfall is of more consequence to water conveyance infrastructure and it is possible that channel capacities and smaller storages (RP2 and RP5) may have been exceeded by short duration high intensity rainfall events in the 2010 and 2011 wet seasons.

2.3 Surface Runoff

Runoff is captured in retention ponds from a significant area within the mine lease boundary (Table 8) and has been represented within the water balance model by means of the USDA Curve Number method. Land use and the characteristics of soil texture are used to select a ‘curve number’ which is input to empirical formulae to calculate the depth of runoff from daily rainfall and evaporation. Curve numbers for the mine site vary between 80 and 95 and were calibrated by previous studies using rainfall and runoff records for the period October 2008 to September 2010 (Tetra Tech memorandum Dec, 2010). Curve numbers have recently been checked using site conditions and processes as they occurred in real time from 2008 to present and synthetically extended to October 2012 (Goldsim Model MtToddWB_Calibration Model_20120518_FINAL - Vista Gold Australia Pty Ltd, 2012).

Table 8 Catchment Areas for Retention Ponds

Retention Pond	Catchment area [ha]
Waste Rock Dump RP1 – Production start to end	177 to 35
Low Grade Ore Pad RP2	32
Stormwater Sediment Pond RP5	33
Batman Pit RP3 – including pit and pit walls	24
Raw Water Dam [a]	-
Total	266 to 124

Source: Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013

Notes [a] RWD is modelled as an infinite resource

The calibration of curve numbers relies on water balance calculations using detailed records of inflows, outflows and changes in pond storage. The absence of continuous records of flow rates through pipelines and the coarse time resolution of water level records at weirs prevent an accurate appraisal of curve numbers.

Whilst it is reported that flows within the Edith River have been modelled by the Australian Water Balance method (AWBM) this information is not used by the model as controlled discharges only occur from the water treatment plant and are therefore not controlled by the dilution capacity of the Edith River.

The AWBM model rainfall – runoff parameters (Soil storage capacity = 50, BFI = 0.1, Ks = 0.25 and Kb = 0) were obtained by calibration using an unspecified set of observed Edith River flows, rainfall and evaporation records. The performance of the calibrated model has been reported to be generally conservative (lower than observed flow) in terms of simulated flow especially for baseflows. It is also reported that the "…the ratio of annual totals between observed and modelled results equal to 1.2" (Tetra Tech memo 14/1/2013).

The capacity of water storage facilities to contain runoff from mine affected areas has been investigated by water balance modelling and the results summarised in Section 2.8. The combined mean annual inflow to retention ponds has been estimated from the 100 x 12 year stochastic simulations to be 2.6 GL/year.

2.4 Seepage

Seepage occurs from the WRD, HLP and Low Grade Ore Stockpiles and is modelled in the water balance as a proportion of daily rainfall lagged by a specified number of days (Table 9). No description of the method to obtain these parameters by previous studies has been found.

Estimates of seepage from the WRD can be derived from the water level records at v-notch weirs located downstream of the dump. However, a relationship between seepage and rainfall requires the comparison of flow at the v-notch weir with coincident records of rainfall over the WRD. A comparison has not been made due to the difference in time resolution between the two records. Water levels at the v-notch weirs are recorded once daily whereas rainfall is monitored continuously.

Table 9 Seepage Parameters

Facility		Parameters	
		Proportion of rainfall	Lag time (days)
Waste Rock Dump	uncovered	0.25	30
Heap Leach Pad	covered	0	0
	uncovered wet season	0.8	25 – 65
	uncovered dry season	0.5	25 – 65
Tailings Storage Facility 1	uncovered	[a]-	[a]-
Low Grade Ore Stockpiles	uncovered	0.25	0

Source: Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013

Notes: [a]estimated as 10% of reclaim water

The HLP may be decommissioned in the first year (if ore is not re-processed), and a decay function attempts to simulate the achievement of a steady-state infiltration. After a period of time the amount of water seeping into the pile reaches equilibrium as the pad dries out. An estimate of the time it takes to reach this equilibrium is obtained from a decay function using a factor of -0.46, and achieves an infiltration rate equal to 10% of the initial rate after 10 years.

Seepage from the tailings storage facilities (existing and future) will be transferred to the water treatment plant. A SeepW finite element analysis was carried out by a previous study (Tetra Tech memorandum, Sep 2010) to determine seepage rates from the existing TSF. Seepage rates from the future TSF have been scaled from those determined for the existing TSF. The water balance assumes a seepage rate equal to 10% of reclaimed water is sent to the WTP and values are given in Table 10. The remaining volume of reclaimed water is sent to the processing plant.

Groundwater seepage in to, or out of, the pit has not been included in the water balance of the mine. A recent study indicates that “Predicted groundwater inflows ranged from a few litres per second at the start of mining to approximately 31 L/s during the final months of mining” (Section 6.2.1 ‘Mount Todd Gold Project, Hydrogeology’. Tetra Tech. May 2013). The exclusion of groundwater inflows to the pit may alter the assumptions regarding required transfers to the WTP.

The ability of water storage facilities to contain seepage inflow from mine dumps and stockpiles has been investigated by water balance modelling and results are summarised in Section 2.8. The combined mean annual seepage has been estimated from 100 x 12 year stochastic rainfall simulations to be 0.8 GL/year.

2.5 Tailings Reclaim Water

Table 10 lists the estimated quantity of water that is expected to be reclaimed from the TSF for use in the plant. Any residual plant water requirement will be made up by transfers from the Raw Water Dam.

Table 10 Tailings Reclaim Water

Year	Estimated Reclaim Water from Tailings during Dry and Wet Seasons (m^3/day)
1	0
2	0
3	9600 - 19200
4	9600 - 19200
5	9600 - 19200
6	9600 - 19200
7	9600 - 19200
8	10200 - 19200
9	10200 - 19200
10	10200 - 19200
11	10200 - 19200
12	10200 - 19200
13	10200 - 19200
14	10200 - 19200
15	10200 - 19200

Source: Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013

The TSF will comprise two dams. The existing dam (TSF1) will be raised in six stages to a level approximately 34m above ground level. A second dam (TSF2) will be constructed to the south east and will have a height of about 60m above ground level.

The projected heights of the TSFs as they are raised to accommodate the volume of tailings over the life span of the mine production phase were previously investigated by water balance models (HydroGeoLogica, December 2010). No description of the water balance models is known to exist and it is assumed that one model (Water Balance_12-08-10_BIG.xls, HydroGeoLogica 2010) represents TSF1 up to production year 7 and the second model (Water Balance_12-08-10_100MT.xls HydroGeoLogica 2010) represents TSF2 for production years 7 to 17. It is assumed that the TSF water balance models have been updated with the latest mine development information.

2.6 Water Demands

2.6.1 Construction Phase

Water will be sprayed onto unsealed roads to suppress dust by means of water carts. It is assumed that this will be treated water of an acceptable quality or failing this supplied directly or indirectly from the Raw

Water Dam. Also, potable water will be required for an expected workforce of up to 450 people (estimated rate of 45 m^3/day based on assumed consumption of 100 L/person/day).

The capacity of the raw water dam should be more than sufficient to meet water demands during the construction phase.

2.6.2 Operational Phase

A new ore processing plant will be constructed and its water requirements are estimated to be 24,230 m^3/day (30,000 tpd production) for the first three years and thereafter 36,409 m^3/day (45,000 tpd production) (source Tetra Tech memo, 14/1/2013 and Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013) (The actual water demand for the processing plant based on a production of 50,000tpd is 30,000m^3/day). 16% of this amount is assumed to be needed for elution/potable (Tetra Tech Memo 14/1/2013). Raw water will be utilised for crusher sprays, reagent make-up, potable water production, process water make-up, gland water, filter plant seal water make-up, and fire water reserve. The processing plant demand is scheduled to be supplied from one or more of the following sources whilst elution/potable would be supplied from the Raw Water Dam:

- TSF reclaim water
- Water Treatment Plant
- Raw Water Dam.

A small quantity of water will be required for fire-fighting purposes and for use by on-site personnel in the plant and control area (35 m^3/day and 1.7 m^3/h, respectively). Water will be obtained from the Raw Water Dam and treated via filtration, chlorination and ultra violet sterilisation at an on-site facility.

Water is also required for cooling purposes in the electrical power generation plant and its quantity is estimated to be about 20 m^3/h.

The demand for water for the purpose of dust suppression is estimated to vary between 220 m^3/day and 1153 m^3/day (Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013) depending on the season and is supplied from the WTP in the first instance and thereafter from the RWD.

The capacity of water storage facilities to meet water demands for the abovementioned purposes has been investigated by water balance modelling and its results are summarised in Section 2.8.

2.7 Water Balance Modelling

2.7.1 Available Models

The operation of infrastructure to contain runoff from disturbed and undisturbed areas of the mine has been investigated by means of water balance models.

Previous studies have created a number of water balance models which are largely independent and focus on different phases of the mine's life cycle. The exception is the use of outputs from the spreadsheet models of the TSF, which calculate the demand for plant make-up water, and its input to the production phase Goldsim model. Available models consist of:

1. Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013 – this updated version of a previous Goldsim Model - MtToddWB_LOM2011Update_Phase1&2_120118b_FLOW simulates the performance of water containment infrastructure during the production phase of the mine’s life cycle (the model outputs results for a 12 year period).
2. Spreadsheet Models - Water Balance_12-08-10_100MT.xls and Water Balance_12-08-10_BIG.xls – both models are restricted to an assessment of the performance of tailings storage facilities during the production phase of the mine’s life cycle i.e. dam crest level requirements and plant make-up water.
3. Goldsim Model - MtToddWB_LOM2011Update_Post-Closure_PPT_Chooser.gsm is an update of a previous model MtToddWB 10.6Mtpy Post-Closure 12Dec2010.gsm and focuses on quantifying the treatment stream during the post closure phase of the mine’s life cycle.
4. A further model is available for the pre-production phase (previously defined as October 1, 2012 to August 1, 2014) - MtToddWB_PreProduction_20120523_Final. The model is used to assess the dewatering time for RP3, water treatment for ponds RP3, RP7 and RP1 and the frequency of overtopping events during the pre-production phase. The model uses wet, dry and average climate scenarios. The wet scenario is based on rainfall for the year 2011/12 and Edith River flows from the year 2008/09 with the data repeated for each of the two years of simulation. Years with the driest and average rainfall were determined from a synthetic rainfall record (length 2000-10). The chosen scenarios are largely synthetic due to the mixture of data source time lines and the repetition of data in successive years and this makes an assessment of the severity of the scenarios by statistical frequency analysis, problematic.

The updated production phase water balance model (Goldsim Model MtToddWB_Production_PFS_45K) is described in Tetra Tech memo 14/1/2013 and by comments within the code of the model. A previous Goldsim model of the production phase was documented in the following reports:

- ‘Mt Todd Water Balance - Care and Maintenance Model Calibration and Forward Modeling Predictions', Hydrogeologica and Tetra Tech, December 2010; and
- 'Mt Todd Mine Life Water Balance, 10.6 Mtonnes/year Mine Plan', Hydrogeologica, December 2010.

A more recent water balance has been carried out by Tetra Tech and is summarised in Mt Todd Gold Project, Hydrogeology, May 2013. The water balance covers a 500-year period representative of the post closure phase of the mine and focuses on inflows and outflows to Batman Pit including groundwater inflow.

A brief description of available water balance models is given in the following sections and the simulation results from the models are summarised in Section 2.8.

2.7.2 Production Phase Goldsim Model

The Goldsim model represents the daily containment and transfer of rainfall, seepage and runoff from catchment areas during the production phase of the mine (12 years) using stochastically generated daily rainfall sequences. The assumed mine production period differs from the latest proposal which is for a 13-year production period. Given the use of a probabilistic approach to rainfall it is considered unlikely that the extension of the simulation would significantly alter the study outcome.

The stochastic model differs from those proposed for use in Australia by eWater (Stochastic Climate Library) but it is beyond the scope of this report to assess the significance of any differences resulting

from the application of the selected stochastic model. The following is a brief description of the main components of the model:

- The model assumes that the water treatment plant is implemented within the first year of mine production. Transfers to the water treatment plant equalisation pond from the TSF (reclaimed water and seepage), WRD retention pond, low grade ore pond, stormwater retention pond, Batman Pit and the HLP retention pond (seepage) are determined by the model using inputs of daily climate data, rainfall-runoff coefficients and required freeboard criteria. Transfers to the equalisation pond proceed so long as water level remains below the prescribed freeboard within the equalisation pond otherwise uncontrolled discharges from retention ponds throughout the mine are permitted. The size of the water treatment plant equalisation pond has been determined by model simulation to reduce the risk of overflows.
- The model relies on an external calculation of available reclaim water from the TSF. Outflows of seepage and reclaimed water from the TSF are obtained from a SeepW analysis which was carried out by previous studies and the output from a spreadsheet water balance model described in Section 2.7.3. It is assumed that the spreadsheet models have been updated in tandem with the Goldsim model to be representative of the latest mine development plan.
- Water supply from the RWD is assumed to be infinite due to the problems encountered in calculating a storage curve because of uncertainties in topographic data for the storage basin.
- The HLP may be closed at the beginning of the production phase and seepage flows which are transferred to the water treatment plant are reduced accordingly.
- Modelling of Batman Pit assumes that groundwater inflows and outflows are negligible and are not included in the water balance. Recent work by hydrogeologists indicates that average groundwater inflow could vary between a few litres per second and 31 L/s over the production period of the mine. Model simulations for the production period commence with a pit water level equivalent to about 1.8 million m^3 (1081 m) which is about 15% of the reported maximum volume of 12 million m^3 (1144 m). The selected start level is reported to have been obtained from the results of the Pre-production Goldsim model.
- Water in excess of processing plant and dust suppression requirements is pumped from the WTP via a monitoring pond to Batman Creek/Edith River throughout the year.

Validation of the water balance model has involved comparison of the date, layout and operation of water containment infrastructure with reported information. The absence of continuous records of transfers between water management facilities, together with periodic rather than continuous recording of runoff from disturbed areas (e.g. v-notch weirs downstream of WRD) have prevented a meaningful validation of rainfall-runoff coefficients or seepage rates.

2.7.3 Production Phase Spreadsheet Model of TSFs

Spreadsheet models represent a monthly water balance of inflows to the existing and future tailings storage facilities comprising dry tailings, entrained water and rainfall, and outflows comprising evaporation and reclaim water. Models representative of simulations carried out in the past were available for review and represent the period of mine production.

The primary output of the model is a time series of the dam crest levels that will be required to contain projected inflows of dry tailings and entrained water, together with output of the quantity of accumulated

free water during each month of the production period. Also available are time series of simulated monthly volumes of dry tailings and entrained water within both tailings storage facilities (TSF1 and TSF2), together with the surface area of free water and its distance from the dam.

Outputs which are available for use in Goldsim model water balances comprise free water volume at the time of closure of both tailings storage facilities, also the plant water requirement for the calculation of make-up water demand on the equalisation pond during times when the raw water dam is empty.

Two spreadsheets are available (Water Balance_12-08-10_100MT.xls and Water Balance_12-08-10_BIG.xls) and represent the staged construction of storage capacity (embankment lifts) during the following periods:

- Oct 2012 to Jul 2018 – representing six 'lifts' (2012, 2014, 2015, 2016, 2017, 2018); and
- Aug 2018 to Jan 2028 – representing four 'lifts' (2018, 2019, 2022, 2025).

There appears to be no formal documentation for the spreadsheet models.

The model contains mean monthly values of rainfall and evaporation (adjusted by a constant pan factor of 0.72) which are recursively applied in each year of the simulation to calculate the volume of free water. A Probable Maximum Precipitation (PMP) 24-hour storm volume has been included in the water balance to assess dam crest elevation requirements. No seepage into or out of the tailings storage facilities has been included. The model appears to assume that seepage inflows and outflows are balanced.

A catchment and impoundment area of 75.318 ha is assumed for the existing TSF which excludes the proportion (~70%) of the Horseshoe Creek catchment that is diverted around the eastern side of the facility. An area of 1.65ha has been used for the future facility.

Tailings production is defined within the model for the purposes of calculating the volume of dry tailings and entrained water. Monthly production has been pro-rated from an annual value of 10,650,000 tonnes (Tom Dyer, MDA, Oct 2010). The slurry solids by weight is assumed to be 50%.

Water use by the plant is assumed to be 1,536m^3/h (Tom DeMull, Nov 2010) less reclaim water which varies between 500m^3/h and 1,000m^3/h. The tailings water facility does not include inflows from the water treatment plant.

The model contains storage curves for various levels of tailings deposits ranging between 133.5m to 158.0m in the first TSF1 (RP7) and 118.0m to 183.6m in the second TSF2 (RP8). No details are available regarding the source of this data and it is therefore assumed to be correct.

The lack of formal documentation regarding the source of model contents hampered a thorough validation of the models.

Model assumptions regarding the balance of seepage inflows and outflows along with the source of information used to compile storage curves, tailings production and water use data have not been reviewed. Given the changes to mine development it is assumed that the reviewed spreadsheet models have been superseded and that the required data for input to the Goldsim water balance model relating to TSF reclaim water has been obtained from an alternative source.

2.7.4 Post Closure Phase Goldsim Model

This Goldsim model estimates the annual treatment stream during the post closure phase of the mine's life cycle determined over a period of 600 years. It is unclear why this particular length of simulation was chosen. The treatment stream comprises:

- Seepage flows from the WRD;
- Seepage flows from the HLP; and
- Seepage flows from TSF.

Runoff from the low grade ore stockpiles and the plant area are not included, presumably because these areas will be decommissioned and allowed to drain untreated into Batman Creek.

The model has been implemented within Goldsim and uses a monthly time step. Some model details are given in 'Mt Todd Mine Life Water Balance – 10.6 Mtpy Mine Plan', Hydrogeologica, December 2010.

The model contains daily values of rainfall and evaporation (adjusted by a constant pan factor of 0.78) for two alternative periods of 137 years and 20 years. The user can recursively apply either period of daily values to achieve a simulation of 600 years. It is unclear why these periods are applied recursively as other model inputs are fixed and thus the response of the system does not change after the first period of simulated rainfall.

Climate change is an emerging issue and the effects are, at this stage, complex to quantify. The absence of a representation of the year on year variability in rainfall or the effects of climate change prevent a robust assessment of water management performance or an assessment of specific drivers to mitigate climate change.

The water balance of Batman Pit includes runoff from the pit walls and is modelled as a percentage (75%) of rainfall. This is a conservatively high runoff factor commensurate with the purposes of the water balance in determining potential overflows from the pit. The calculation of the exposed area of pit wall takes into account the changing water level in the pit.

Surface runoff and seepage flow from the WRD are modelled by means of a combined runoff factor which specifies that during the wet season (November to April) outflows amount to 5% of rainfall and will take 30 days to reach the WRD outlet. It is assumed that seepage during the dry period is insignificant.

Surface runoff and seepage from the HLP is also modelled as a combined percentage of rainfall. It is assumed that 5% of rainfall would drain from the pad during all months and take between 25 and 65 days to reach the outlet. It is understood that these values were obtained by model calibration (Tetra Tech memo, Dec 2010).

A SeepW finite element seepage analysis has been carried out (Tetra Tech memo, Sep 2010) to determine rates of seepage from the first TSF1 (RP7). Seepage rates from the second TSF2 (RP8) have been scaled from these rates. Given the changes to the design of the second TSF2 estimates of seepage may need to be revised.

The potential for overflows from Batman Pit are assessed by means of a daily water balance of inflows (rainfall over water surface and runoff from pit walls) and outflows (evaporation from water surface). Groundwater inflows and outflows are assumed to be negligible and have not been included. Recent work by hydrogeologists indicates that average groundwater inflow could vary between a few litres per second and 31L/s.

The simulation makes the assumption that 5.09 million m^3 of water will be present within the pit at the beginning of the simulation. The model shows the pit as having a maximum storage capacity of just over 222 million m^3 and a maximum footprint of 117.4ha. This differs from the latest proposed footprint of 137ha and will therefore cause an underestimation of pit inflow. However, it is unlikely to significantly alter the outcome of the water balance.

The lack of records for transfers from the HLP pond make further checks on the validity of seepage rates and response times problematic.

2.7.5 Post Closure Phase Tetra Tech Groundwater Model

A recent water balance involving the simulation of groundwater inflows to Batman Pit during a post closure period of 500 years has been carried out by Tetra Tech, May 2013.

Modelling has represented inflows to the pit from groundwater seepage, direct rainfall and runoff from pit walls. Evaporation from the ponded surface represents the only pit outflow. Details of the extent of pit excavation and areas of external catchment, pit wall and ponded surface are not provided. Groundwater inflows were obtained from the results of a MODFLOW groundwater model.

The lack of details regarding the extent of excavated pit makes a comparison with the results of Goldsim modelling problematic. Given that this modelling was carried out more recently it is assumed its results will be more representative of the latest mine development plan.

2.8 Summary of Water Balance Results

It has been assumed that the proposed system will consist of infrastructure and operations in line with those described in Table 5 of this report as represented by the contents of available water balance models. Some discrepancies exist between modelled and reported areas of development footprints for the Low Grade Ore Stockpile, Batman Pit, to a lesser extent the Waste Rock Dump, and in the expected period of mine production. Differences in the development footprint of the pit will have a significant impact on expected inflow and may alter the assumptions regarding transfer rates to the WTP from the pit which may then impact transfers from other areas of the mine.

The following summary of water management performance during the production phase is extracted from the Goldsim Model - MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013 and is based on probabilistic output (100 x 12-year daily sequences). No assessment regarding the validity of the stochastic rainfall generation model has been made.

The performance during post closure is obtained from the Goldsim model – ‘MtToddWB_LOM2011 Update_Post-Closure_PPT_Chooser, July 2012.

2.8.1 TSF Production Phase

Available water reclaim rates during the dry season increase slightly from 9,600 m^3/day to 10,200 m^3/day after seven years and is assumed to reflect the change from TSF1 to TSF2. Wet season water reclaim rates remain constant throughout the production period (19,200 m^3/day). Ninety percent of this total is transferred to the equalisation pond and 10 percent is sent directly to the WTP (Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013).

2.8.2 TSF Post-closure Phase

Water reclaim rates from the future TSF1 are estimated to vary between 6.5 m^3/day and 52.5 m^3/day whilst those of TSF2 will vary between 25 m^3/day and 176 m^3/day. This water will need to be transferred to the water treatment plant until a passive treatment cell has been constructed.

2.8.3 Water Containment Facilities - Production Phase

An equalisation pond with a capacity of 30,000 m^3 in association with a WTP rate of 300 m^3/h (years 1 to 3) and 500 m^3/h (years 4 to 12) is sufficient to receive transfers from the WRD retention pond (RP1), low grade ore retention pond (RP2), stormwater sediment pond (RP5), TSF1/2, HLP and Batman Pit (RP3) to prevent uncontrolled overflows from these facilities and the equalisation pond during normal operation. However, the model results show instances of overflow at the WRD retention pond (RP1), low grade ore retention pond (RP2) and stormwater sediment pond (RP5) (Table 14). This is most likely the result of insufficient pump capacity on pipelines to the equalisation pond during high intensity rainfall events. The water management strategy leading up to and during extreme peak rainfall is likely to invoke different operating rules to those that are represented in the Goldsim water balance which are representative of normal operating conditions. This could involve measures such as the temporary transfer of excess water to the TSFs.

Overflows from the stormwater sediment pond (RP5) are to be expected given its function as a sediment trap rather than a water retention pond.

Overflows from the WRD retention pond (RP1) are less likely during later years of production because the WRD progressively fills the catchment and surface runoff is replaced by less intense seepage flow.

A maximum storage capacity in the HLP of 67,545 m^3 is assumed by the water balance model and the model indicates a number of spills during the first three years. After year 3 the model estimates a maximum storage of only 7,615 m^3 is utilised on any one day which reflects the decommissioning and the consequent reduction in seepage inflow.

2.8.4 Water Containment Facilities - Post-Closure

Seepage rates from the WRD are estimated to range between 0 and 2304 m^3/day and will be treated at the water treatment plant until a passive treatment cell has been constructed.

Water levels in Batman Pit are estimated to rise over a long period of time before reaching equilibrium (Figure 3) at which point evaporation balances inflow from groundwater, surface runoff and rainfall.

The results of a Goldsim water balance indicate that water levels in Batman Pit are expected to reach equilibrium at a level of between 975 m and 977 m (169 m and 167 m below the 1144 m top of pit level). However, this assumes no groundwater inflow which recent investigations indicate could be up to 31L/s.

The results of a more recent water balance for a 500 year post closure period which included groundwater inflows of between a few litres per second and 31 L/s show that "….pit lake water level rose relatively rapidly following cessation of pit dewatering and after 345 years had reached approximate steady-state at an elevation of approximately -15 mAHD and with the water surface covering an area of approximately 656,250 m^2 (65.625 ha). Starting at that time, the modelled water surface elevation fluctuated between approximately -15.054 and -14.941 mAHD …." (Section 6.2. Tetra Tech. May 2013).

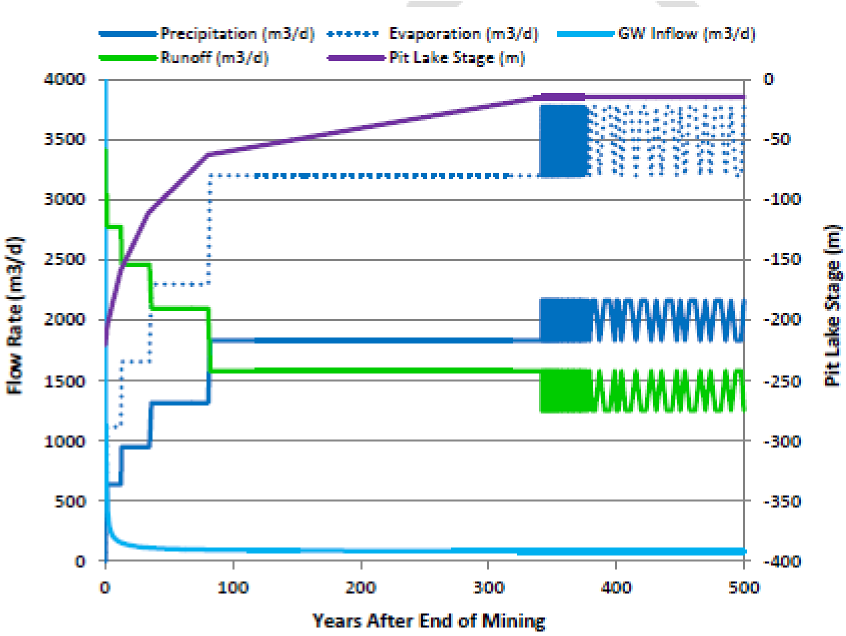

Figure 3 Simulated Post Closure Water Levels in Batman Pit (Tetra Tech May 2013, Figure 6.5)

2.8.5 Water Supply - Construction Phase

No details have been found but water demands are expected to be relatively small and given the relatively large size of the raw water dam are expected to be met without difficulty.

2.8.6 Water Supply - Production Phase

Water demands comprise mainly of the requirements for:

- processing - 24,230 m^3/day for years 1 to 3 and 36,409 m^3/day for years 4 to 12; and
- dust suppression – average daily demand of 562 m^3/day where the monthly demand has a maximum of 1153 m^3/day in July/August and a minimum of 220 m^3/day between November and March.

A schematic of the mine infrastructure and transfers associated with the supply of these demands is shown in Figure 4.

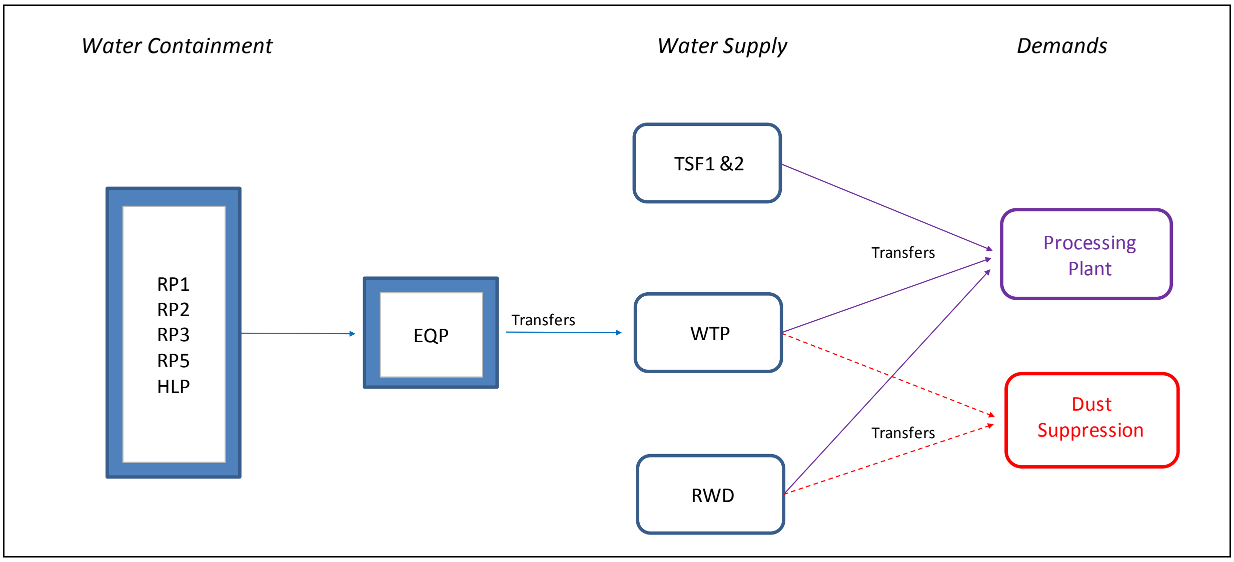

Figure 4 Schematic of Mine Water Supply System

The simulated minimum and maximum daily rates of supply to meet processing plant and dust suppression demands are summarised in Table 11 and Table 12. The results have been extracted from 100 simulations of stochastically generated 12 year sequences of daily rainfall input. Therefore, maximum or minimum values for each water source do not necessarily occur on the same day and thus the values from individual resources do not necessarily add up to the reported combined inflow total.

The simulation results confirm that processing plant water demands can be supplied without failure by a combination of supply from the WTP, RWD (assuming an infinite resource) and reclaim water from the TSF. The WTP contributes a minimum daily flow of 6,950 m^3/day during years 1 to 3 and 12,000 m^3/day during years 4 to 12. Shortfalls in the processing plant demand are made up by transfers from the RWD and/or TSF at maximum rates of 17,030 m^3/day and 17,280 m^3/day, respectively.

Table 11 Simulated Rates of Water Supply to Processing Plant and Percentage Days Failure

Component	Year											
	1	2	3	4	5	6	7	8	9	10	11	12
Maximum from WTP (m^3/day)	7200	7200	7200	12000	12000	12000	12000	12000	12000	12000	12000	12000
Minimum from WTP (m^3/day)	6950	6950	6950	6950	12000	12000	12000	12000	12000	12000	12000	12000
Maximum from RWD (m^3/day)	17030	8390	8390	8390	15769	15229	15229	15229	15229	15229	15229	15229
Minimum from RWD (m^3/day)	0	0	0	0	7129	7129	7129	7129	7129	7129	7129	7129
Maximum from TSF (m^3/day)	17280	17280	17280	17280	17280	17280	17280	17280	17280	17280	17280	17280

Component	Year											
	1	2	3	4	5	6	7	8	9	10	11	12
Minimum from TSF (m^3/day)	0	8640	8640	8640	8640	9180	9180	9180	9180	9180	9180	9180
Maximum combined inflow (m^3/day)	24230	24230	24230	36409	36409	36409	36409	36409	36409	36409	36409	36409
Minimum combined inflow (m^3/day)	24230	24230	24230	24230	36409	36409	36409	36409	36409	36409	36409	36409
% No days with failure in supplying demand	0	0	0	0	0	0	0	0	0	0	0	0

Source: 100 x 12 year sequences generated by Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013 Note: maximum values do not necessarily occur on the same day and therefore rows are not additive.

Water supply for dust suppression is obtained from the WTP and RWD. Transfers will be made to a storage tank with a capacity equivalent to two days maximum dust suppression (2 days x 1153 m^3/day x 0.95 = 2191 m^3). The simulation results in Table 12 include both the requirement for tank top-up water and dust suppression. The simulation shows that the majority of water requirements are sourced from the RWD and that after year 3 a failure in supply can be expected in approximately 4 percent of days in each year and is most probably the consequence of limitations in the assumed transfer infrastructure.

Table 12 Simulated Rates of Water Supply for Dust Suppression and Percentage Days Failure

Type	Year											
	1	2	3	4	5	6	7	8	9	10	11	12
Maximum supplied from RWD (m^3/day) [b]	2651	2651	2609	2647	2645	2631	2644	2637	2622	2649	2638	2651
Maximum from WTP (m^3/day)	250	250	250	250	0	0	0	0	0	0	0	0
Maximum combined from RWD+WTP (m^3/day) [a b]	2651	2651	2609	2647	2645	2631	2644	2637	2622	2649	2638	2650
% No days with failure in supplying demand [b]	0.3	0.0	0.0	2.9	3.6	3.5	3.6	3.7	3.5	3.6	3.6	3.7

source: 100 x 12 year sequences generated by Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013 Note: [a] maximum values do not necessarily occur on the same day and therefore rows are not additive [b] includes top up water for dust tank

2.8.7 Water Supply - Post-closure Phase

No details were reported and it is assumed that there will be no on-going demand for water.

2.8.8 Overflows to the environment - Production Phase

Model simulations have assumed a WTP with a capacity of 300 m^3/h for years 1 to 3 and 500 m^3/h for years 4 to 12, in association with an equalisation pond capacity of 30,000 m^3 and a combined pump capacity for transfers from retention ponds (including TSF) to the equalisation pond of 37,315 m^3/day (Table 3).

The simulated maximum rate of inflow to the equalisation pond (Table 13) is constant (30,595 m^3/day) during production years and is controlled by a combination of equalisation pond capacity and its net rate of evaporation together with available treatment capacity. A relatively small amount of excess water is discharged from the WTP during the first three years of operation (maximum 250 m^3/day). This is most probably caused by the adoption of a fixed water transfer operating rule regardless of mine production and is not expected to occur during actual operations when rates of transfer will be dynamically controlled.

Simulations show that the EQP and WTP are able to prevent overflows from retention ponds during normal operating conditions. However, the results also show that overflow from the WRD retention pond (RP1), low grade ore retention pond (RP2), HLP and stormwater sediment pond (RP5) can occur during high intensity storms and is possibly the result of insufficient pump capacity on pipelines to the equalisation pond. The simulated frequency and maximum rate of overflow during the production period is reported in Table 14.

The water management strategy leading up to and during extreme peak rainfall is likely to invoke different operating rules to those represented in the Goldsim water balance which are representative of normal operating conditions. This could involve measures such as the temporary transfer of excess water to the TSFs. Also, given the occurrence of overflows during periods of extreme rainfall it is likely that flows within the Edith River will also be higher than normal and the dilution criteria for discharge may not be contravened.

No overflows from Batman Pit were predicted by the water balance simulation during production or post closure phases as evaporation is expected to balance inflows. Any net groundwater inflows have not been included in the water balance during production years.

Table 13 Simulated Rates of Transfer to Equalisation Pond

Type	Year											
	1	2	3	4	5	6	7	8	9	10	11	12
Maximum combined inflow (m^3/day)	30595	30595	30595	30595	30595	30595	30595	30595	30595	30595	30595	30595
Minimum combined inflow (m^3/day)	0	960	960	960	960	1020	1020	1020	1020	1020	1020	1020
Maximum discharge to Edith River (m^3/day)	250	250	250	250	0	0	0	0	0	0	0	0
Minimum discharge	0	0	0	0	0	0	0	0	0	0	0	0

Type	Year											
	1	2	3	4	5	6	7	8	9	10	11	12
to Edith River (m^3/day)												

Source: 100 x 12 year sequences generated by Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013

Table 14 Simulated Percentage Days when Untreated Water Overflows to Creeks

Pond	Year												
	1	2	3	4	5	6	7	8	9	10	11	12	Max. Spill (m^3/day)
RP1	5.2	8.3	9.5	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	329,400
RP2	1.5	2.5	1.9	1.5	0.7	0.6	0.7	0.5	0.7	0.6	0.7	0.7	48,018
RP3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
RP5	2.3	3.2	2.8	2.4	1.2	1.1	1.2	1.0	1.1	1.1	1.2	1.2	52,036
HLP	6.1	14.6	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9,226

Source: 100 x 12 year sequences generated by Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013

2.8.9 Over Flows to the Environment - Post-closure Phase

Daily treatment rates are estimated to vary from 180 m^3/day during early times after pit closure to rates approaching 39 m^3/day at much later times.

2.8.10 Model Assumptions

The water present in Batman Pit at the commencement of the production phase is 1.8 million m^3 (1081 m) which is about 15% of the reported maximum volume of about 12 million m^3 (1144 m). Simulations have not considered groundwater inflows or outflows and recent investigations indicate that groundwater inflows could occur up to 31L/s.

The west catchment diversions at the WRD are constructed and will capture and divert runoff away from the pond from 22% of the catchment and up to a 10-year, 24-hour storm event (12.3m^3/s) (GHD, 2010).

The WRD will reach a maximum footprint of 202.5 ha after two years of production.

Discharge into the Edith River of excess water from the WTP can occur at any time of the year.

The RWD has been modelled as an infinite resource due to uncertainties in topographic data preventing the calculation of a storage curve.

Reclaim water from the TSF (TSF1 and TSF2) is estimated to be 19,200m^3/day during the wet season and between 9,600m^3/day and 10,200m^3/day in the dry season. Bleed water from the TSF is estimated to be 1,920m^3/day in the wet season and 960m^3/day during the dry season.

2.9 Summary

2.9.1 Production Phase

The performance of water containment infrastructure has been assessed by means of a Goldsim water balance model (Goldsim Model MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013). A water balance representing the 12-year production phase of the mine has been simulated using stochastic methods to generate rainfall input. The assumed mine production period differs from the latest proposal which is for a 13-year production period. With the exception of the discrepancies in the development footprint of the Low Grade Ore Stockpiles and Batman Pit (Table 1) the model appears to have represented the physical extent of proposed mine development albeit in a shorter than expected time schedule. This broadly faithful representation in partnership with a probabilistic approach represents a reasonably robust assessment of water containment capacity. It is unlikely that the extension of the simulation by three years would significantly alter the study outcome in terms of WTP capacity or annual frequency of retention pond overflow.

The water balance demonstrates that a WTP with capacity of 300 m^3/h in years 1 to 3 and 500 m^3/h is able to limit the incidence of overflows from retention ponds to periods of high intensity rainfall which are likely to have a relatively low frequency of occurrence during the life of mine. Simulated overflows to the downstream environment will occur as a consequence of extreme rainfall that exceeds the design criteria of infrastructure and it is likely that such events will involve widespread rainfall. Therefore, it is also likely that at the same time flows within receiving waters and the Edith River will also be elevated due to high rainfall over their own catchments. As a result the dilution criteria to allow mine water discharge may not be contravened.

The water balance has also shown that process water demands can be met without failure from combined transfers from the WTP, RWD and TSF. However, this assessment has not investigated any limits to the available supply from the RWD.

The following summary is limited to the reporting of averages calculated from the output of all 100 stochastic simulations:

- Catchment draining into mine affected areas (RP1, RP2, RP5) – 266ha decreasing to 124ha over LOM;
- Combined surface runoff entering retention ponds (RP1, RP2, RP5, excluding the TSF where runoff is not modelled explicitly in the water balance and is assumed to be represented by tailings reclaim water) – 2.6 GL/yr;
- Estimated reclaim water from tailings – 5.2 GL/yr;
- Combined seepage from material stores entering retention ponds (RP1, HLP, TSF) – 0.8 GL/yr;
- Combined water retention and sediment pond storage (RP1, RP2, HLP, RP5, TSF) – 18 GL;
- Total water demand (process plant) – 8.8 increasing to 13.2 GL/yr during LOM and supplied from:
  - Average supply from WTP – 2.6 to 4.4 GL/yr
  - Average supply from TSF – 4.7 to 4.8 GL/yr
  - Average supply from RWD – 1.5 to 4.0 GL/yr
- Total water demand (dust suppression) – 0.2 GL/yr and supplied mainly from RWD:

- Average supply from WTP – <0.01 GL/yr
- Average supply from RWD – 0.2 GL/yr
- Average excess discharge from WTP to the downstream environment – 0.02 GL/yr during first 3 years and thereafter 0 GL/yr;

- Combined average uncontrolled overflow from retention ponds to the downstream environment – between 0.02 and 0.06 GL/yr.

The Goldsim water balance makes a number of assumptions which include no net groundwater inflow to Batman Pit. Also, the quantity of reclaim water available from the TSF for use in water supply has been determined externally to the Goldsim model and has not involved a water balance of the TSF within the model. Furthermore, the simulation of water supply assumes an unlimited water supply from the RWD. The risk of shortfall in water supply is considered to be an economic risk rather than an environmental impact.

It is unclear what design storm rainfall event was used in the original design of the water management system, however, it is unlikely that design criteria exceeded a 100-year ARI as this is a generally accepted upper limit for the design of water containment storage. The severity of long duration storm rainfall during recent wet seasons is unlikely to have been in excess of a 100-year ARI (see Section 2.2) and it can be expected that the performance of larger storage infrastructure would not have been compromised. However, it is possible that shorter duration storm events were more extreme and smaller storage together with conveyance infrastructure might have been compromised.

2.9.2 Post-Production Phase

The following results of a water balance for the post closure phase were obtained from the Goldsim model - MtToddWB_LOM2011Update_Post-Closure_PPT_Chooser, July 2012:

- Seepage rates from the TSF are estimated to decrease to 39m^3/day;
- Seepage rates from the WRD are estimated to be up to 2304m^3/day; and
- Water levels in Batman Pit are expected to reach equilibrium level of between 975 m and 977 m (relative to 1144 m top of pit) where evaporation equals inflow from rainfall. However, this assumes no groundwater inflow which recent investigations indicate could be up to 31L/s.

A more recent water balance carried out by Tetra Tech (May 2013) has included groundwater inflow to Batman Pit and suggests that water levels will reach equilibrium after 345 years at an elevation of approximately -15mAHD.

The water balance simulation for the post closure phase does not include adjustments to rainfall that represent the effects of climate change, natural or otherwise.

3. Stormwater Management

3.1 Introduction

The Mt Todd Mine is traversed by four creeks which drain into the Edith River to the south. Horseshoe Creek and Batman Creek flow through the centre of the mine whilst West Creek passes close to the western boundary and Stow Creek flows along the southern edge of the mine.

Storm rainfall during recent wet seasons has reportedly been in excess of a 100-year Average Recurrence Interval (ARI) which likely exceeds the design criteria of most water management infrastructure on site. It is therefore to be expected that the performance of existing stormwater conveyance infrastructure has been compromised (Section 3.2).

An assessment of the potential impacts of flooding from Horseshoe Creek, Batman Creek, West Creek and Stow Creek was undertaken to confirm the adequacy of existing/proposed stormwater management measures from an environmental perspective. This assessment included:

- Extending the description of flood peak and flood levels provided by previous studies through new modelling;
- Delineating catchment areas and identifying key catchment properties;
- Evaluating the hydraulic performance of creeks flowing through the site;
- Indicating critical regions for flood management based on inundation and scour risk; and
- Recommending flood management strategies.

A number of studies have previously been carried out for the mine site and details are summarised in Section 3.3. Where existing information was inadequate new modelling was carried out consisting of a hydrological assessment to determine flood peak discharge and hydraulic flood routing to derive an indication of flood immunity and the potential for scour (Section 3.4).

3.2 Existing infrastructure

Diversion structures exist along Horseshoe Creek, Batman Creek and Burrell Creek and are used to limit the runoff from undisturbed areas of the mine and their upstream catchments from reaching existing water containment and plant infrastructure.

Diversions are also present upstream of the low grade ore (LGO) stockpile and around the heap leach pad (HLP) but with the purpose of collecting runoff from disturbed areas of the mine and directing it into storage ponds for transfer to the water treatment plant.

Diversion drains have been constructed around the western margins of the existing waste rock dam (WRD) retention pond (GHD, Nov 2010). The drains reduce the volume of uncontaminated runoff entering the pond and thereby reduce the risk of overtopping. Diverted water will report to local creeks downstream of the pond.

3.3 Previous Flood Studies

Three hydrological studies of the mine area are known to have been carried out and a summary of their purpose and significant results are given below. Previous studies have limited their assessment of flood

inundation to reaches in the lower half of the mine area. In order to extend an understanding of flooding extent, levels and velocities additional hydrological and hydraulic flood modelling has been undertaken for the 10 and 100 year ARI design events.

AGC Woodward-Clyde (Oct 1992) – This study estimated the extent of flood inundation along the lower sections of Batman Creek and Horseshoe Creek during a 100-year ARI storm event. Flood peak discharge was estimated by means of the Rational Method and flood extents derived from water levels modelled by HEC2 and interpolation within 2m contour maps. Whilst a map of flood extents (Figure 5) was produced values of flood peak discharge and flood level were not reported.

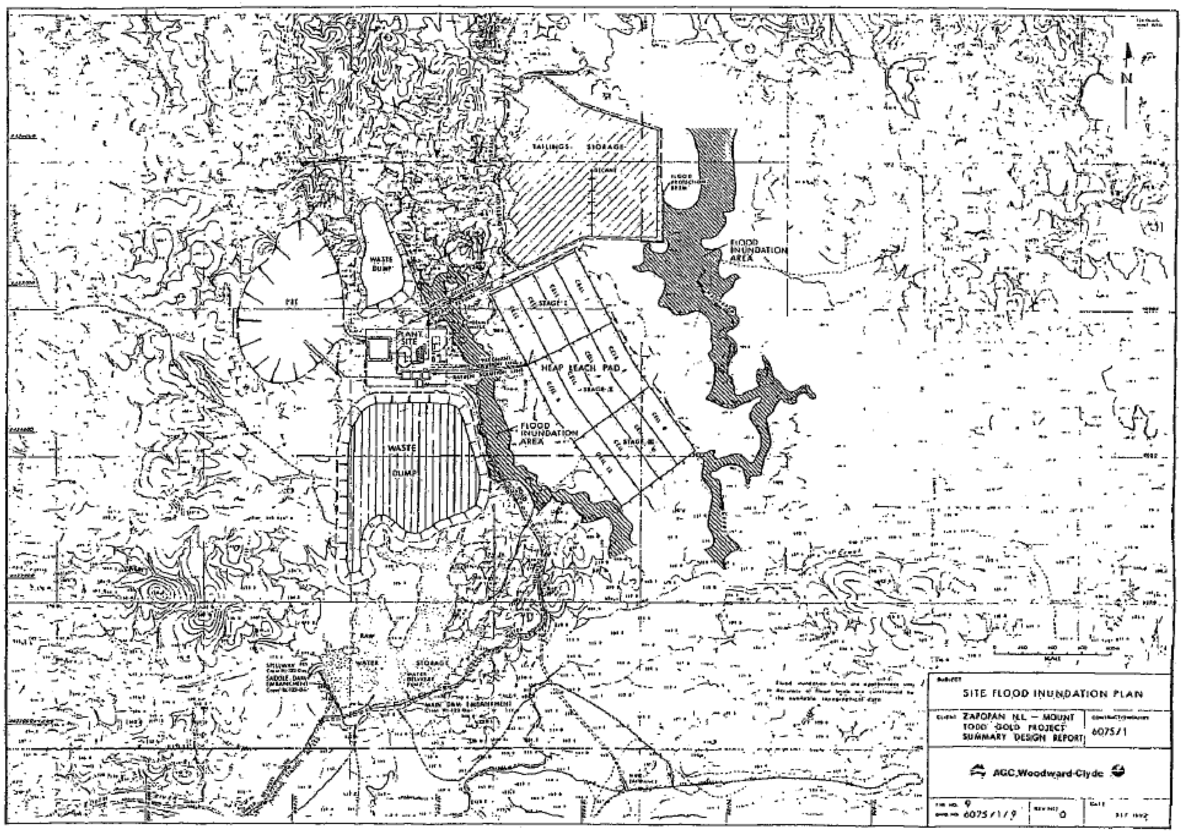

Figure 5 AGC Woodward-Clyde Study Modelled Flood Extents

Knight Piesold (July 1995) – This study estimated flood levels along Horseshoe Creek adjacent to the site of the TSF to assist with the design of engineering works to protect the tailings embankment. Flood discharges for 10-year, 20-year and 100-year ARI storm events were calculated by means of RORB modelling software and flood levels determined with a HEC-2 water surface profile model. Flood discharges were calculated for both the north-west tributary upstream of the TSF and the north -east tributary which is now occupied by the Raw Water Dam. Modelling took into consideration the attenuating effects of the dam in deriving flood peaks in Horseshoe Creek downstream of the confluence. The flood peak discharges determined by the study are reported in Table 15 and flood levels determined by the study are reproduced in Table 16.

Table 15 Knight Piesold Study Flood Peaks

ARI (yrs)	North-west tributary (m^3/s)	North-east tributary (m^3/s)	Downstream of confluence (m^3/s)
10	75	52	127
20	90	64	154
100	135	92	227

Source: Knight Piesold, July 1995 and includes attenuating effect of RWD

Table 16 Knight Piesold Study Flood Levels

ARI (yrs)	Northern end of TSF	Confluence of tributaries	Southern end of TSF
10	131.3	125.5	122.3
20	131.3	125.7	122.4
100	131.7	126.1	122.8

Source: Knight Piesold, July 1995

The report indicated that flood depths next to the tailings embankment would be 1 to 1.9 m during a 100-year ARI event with velocities in the channel of between 2 and 3 m/s reducing to 1 m/s over the floodplain. The study proposed the diversion of the north western creek by means of a 420 m long channel along the northern end of the TSF. It also recommended the re-alignment of the creek to further protect the embankment but no maps illustrating this alignment have been found.

GHD (Nov 2010) – This study calculated the capacity of drains to reduce the volume of runoff entering the WRD retention pond from undisturbed areas to the east and west (Figure 6). Flood discharges from surrounding catchments during 10-year ARI storm event were calculated by means of the Rational Method (Table 17). Drains were sized using standard open channel flow calculations. The drains have been designed with a capacity to divert flows up to a 10-year ARI storm event as the volume of overflow during more severe events is considered to be insignificant relative to the pond capacity due to the infrequency and shortness of such extreme events. The drains are considered to be effective in reducing the catchment area contributing runoff to the pond by 20% during storm events with a magnitude of less than a 10-year ARI.

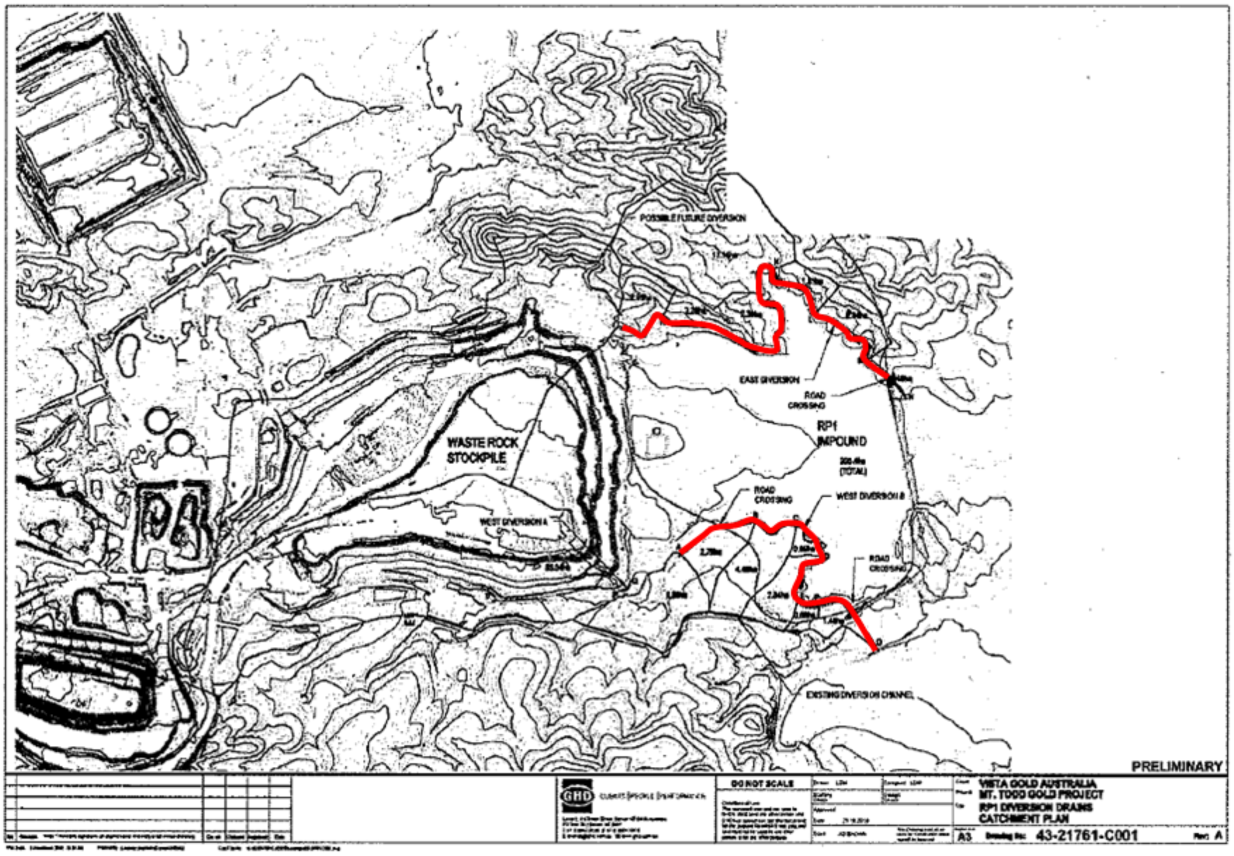

Figure 6 Diversions at the WRD

Table 17 GHD Flood Discharge

ARI (yrs)	Western Drain m^3/s	Eastern Drain m^3/s
10	8.1	4.2

Source: GHD, November 2010

3.4 New Design Flood Modelling

3.4.1 Approach

Hydrologic modelling of the catchments has been undertaken to augment previous study findings by generating flood peak discharges at significant locations within the mine area for 10-year and 100-year ARI design storm events.

Design criteria based on these two ARI is compatible with generally accepted guidelines. A 10-year ARI event will help assess the adequacy of cross drainage and diversion structure capacities where an exceedance of capacity is not expected to cause major or sustained impacts, whilst the 100-year ARI event provides a more robust assessment of the mine site's flood immunity.

Where possible design flood peak information has been taken from previous studies and augmented by new analyses. A summary of the source of flood peak information is as follows:

- Horseshoe Creek, with flood peaks at locations downstream of the confluence of the north-western and north-eastern (including Raw Water Dam) tributaries, also along the north-western tributary at the northern end of the TSF, extracted from the previous study by Knight Piesold (July 1995).
- Batman Creek at a location just upstream of Batman Pit was calculated by the Rational Method.
- Catchments draining into Burrell Creek were also calculated with the Rational Method.
- Catchments draining into Stow Creek calculated by the Rational Method.

In the absence of flood peak estimates for most of the catchments, recourse to new modelling involving the application of the Rational Method was required. The Australian Rainfall and Runoff (ARR) from Engineers Australia (1987) provides slightly different methodologies for the application of the Rational Method in different areas of Australia. Due to the sparseness of recorded flood frequency information, runoff coefficients have only been defined for flood events up to and including the 10-year ARI. The calculation of design flood peaks for more extreme events relies on frequency factors to scale up the 10-year ARI event.

Figure 7 shows the catchments for which flood peaks have been determined and the following sections provide a description of model input data and results.

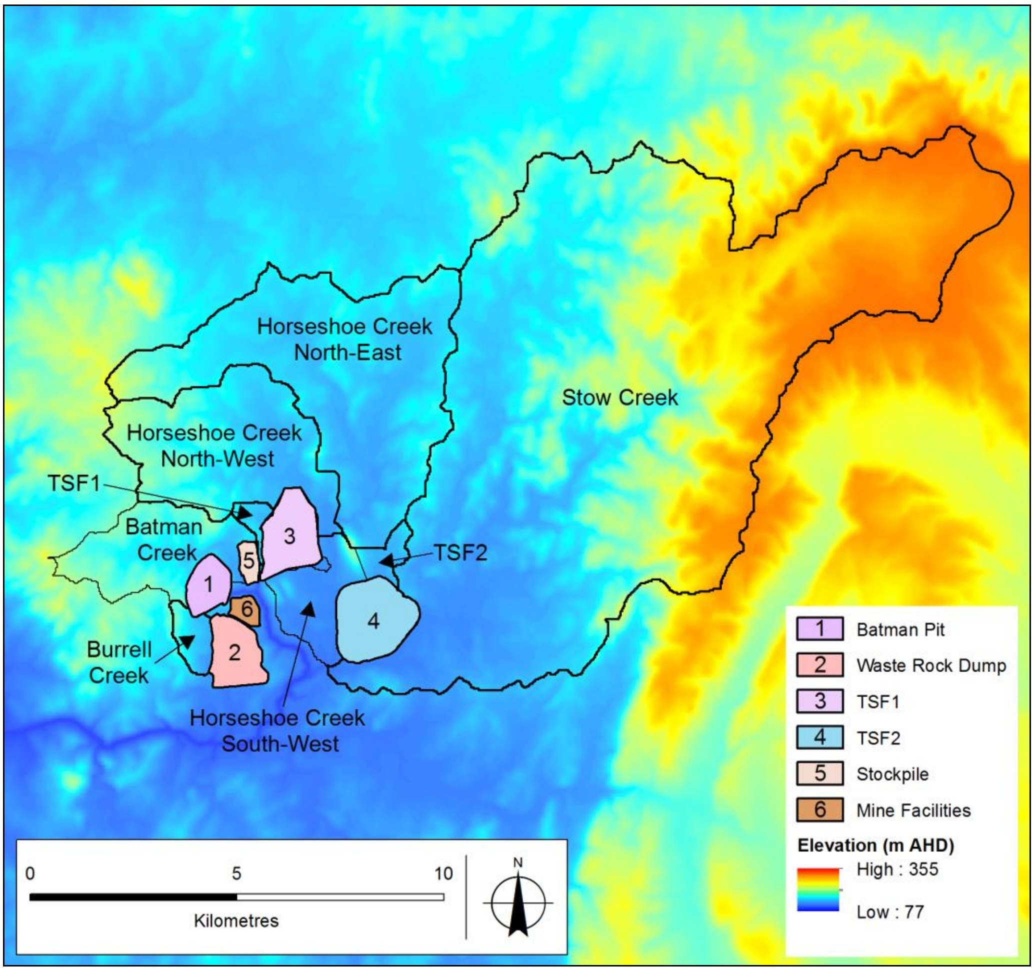

Figure 7 Modelled Catchments

3.4.2 Input Data

Design storm rainfall for 10-year and 100-year ARIs was obtained for the mine site from the Bureau of Meteorology website for standard design storm durations ranging from 15 minutes to 72 hours (Table 18). The Intensity-Frequency-Duration (IFD) values are determined from the bureau's rainfall database which includes interpolated data for areas which have not benefited from continuously recording rain gauges such as the mine site.

Storm durations have been determined on the basis of the concept of catchment 'Time of Concentration'. The Bransby-Williams formula was used to determine the time of concentration at each location and values are reported in Table 19.

Table 18 IFD Rainfall Data for Mt Todd Mine

Storm Duration	Average Recurrence Interval						
	1-year	2-years	5-years	10-years	20-years	50-years	100-years
5 minutes	116	149	186	209	241	283	317
6 minutes	108	139	174	195	225	265	296
10 minutes	89.9	115	144	161	186	218	244
20 minutes	68.9	88	109	122	140	163	182
30 minutes	57.3	73	90.3	101	115	134	150
1 hour	38.7	49.3	60.8	67.7	77.4	90.4	101
2 hours	23.7	30.3	37.4	41.7	47.7	55.7	62
3 hours	17.3	22.1	27.3	30.5	34.9	40.8	45.4
6 hours	9.89	12.6	15.7	17.6	20.2	23.6	26.4
12 hours	5.84	7.49	9.4	10.6	12.2	14.3	16
24 hours	3.68	4.75	6.07	6.88	7.99	9.5	10.7
48 hours	2.37	3.09	4.04	4.64	5.45	6.57	7.47
72 hours	1.72	2.26	3	3.47	4.11	4.99	5.71

Table 19 Rational Method Inputs for Flood Peak Estimation

Parameter	Batman Creek	West/ Burrell Creek	Stow Creek	Horseshoe Creek {north west tributary}	Horseshoe Creek {north east tributary} [1]
Area (km^2)	6.58	1.16	101.27	13.06	24.70
Flow Path Length (km)	5.59	1.34	24.68	8.25	12.01
Flow Path Slope (m/km)	11.56	13.56	6.45	5.72	2.68
Time of Concentration (hrs)	2.74	0.76	10.35	4.35	6.92
100-year ARI Runoff Coefficient	0.99	0.99	0.99	0.99	0.99
100-year ARI Rainfall Intensity (mm/h)	57	98.4	19.6	- [2]	- [2]
10-year ARI Rainfall Intensity (mm/h)	32	67.6	-	- [2]	- [2]

Notes: [1] includes RWD basin [2] flood peaks sourced from Knight Piesold report (1995)

The extent of upstream catchments for creeks intersecting the site was delineated with Arc-Hydro® using the 30 m Shuttle Radar Topography Mission (SRTM) digital elevation model acquired from Geoscience Australia (2011). Local sub-catchment areas within the mine site have not been included; this will not affect design flood peak estimates due to relatively small extent of these sub-catchments compared to upstream areas and their shorter response times. The lengths of the main channels and the equal area slopes as required for application of the Rational Method were calculated using the same SRTM elevation data set.

The catchment areas surrounding the mine comprise low lying hills with rural land use and land cover consisting of scrub and long grass. Runoff coefficients for the Rational Method calculations were determined using the Department of Main Roads Road Drainage and Design Manual (2007), assuming 100% rural catchments and are listed in Table 19.

3.4.3 Design Flood Peak Results

Design flood peak discharges are available for Horseshoe Creek from a previous study by Knight Piesold (1995) and are considered to be adequate for the purposes of this assessment. New design flood peak modelling based on the Rational Method was required for the catchments of Batman Creek, Burrell/West Creek and Stow Creek (see catchments shown in Figure 7).

A summary of the adopted design flood peaks for each of the creeks is given in Table 20. The results for Horseshoe Creek as derived from the Knight Piesold (1995) study do not include the likely additional attenuating effects created by the proposed 2m increase in dam height and are therefore slightly conservative in terms of downstream flood magnitude.

Table 20 Design Flood Peak Estimates

Parameter	Batman Creek	West / Burrell Creek	Stow Creek	Horseshoe Creek {north west tributary} [1]	Horseshoe Creek {north east tributary} [1]	Horseshoe Creek {downstream of confluence} [1]
10-year Peak (m^3/s)	58	20	-	75	52	127
100-year Peak (m^3/s)	103	34	546	135	92	227

[1] source Knight Piesold report (1995)

3.5 Hydraulic Flood Routing

3.5.1 Approach

Maps showing the outline of the 100-year design flood event are available from the previous study of AGC Woodward-Clyde (1992) but are limited in geographical extent (Figure 5). Therefore the results of new hydraulic flood routing using inputs from hydrologic modelling (Table 20) have been used to extend existing flood outlines and to assess likely velocities. This information will be used to assess flood immunity and impacts on existing and proposed mine infrastructure and the potential for scour.

A steady state 1-D hydraulic model was constructed for each creek using HEC-RAS vers 4.1 (United States Army Corps of Engineers, 2013). A 1-D steady state model has been selected because flows occur in well-defined channels and the inter-change of flows between channel and floodplain is not expected to be significant.

3.5.2 Hydraulic Model Data

The geometry of channels and floodplains for Batman, West/Burrell and Horseshoe Creeks was defined at cross sections along each watercourse from a 1 m digital elevation map of the mine area (Figure 8). This was augmented by 5 m digital elevation data to define the geometry of channels and floodplains along Stow Creek.

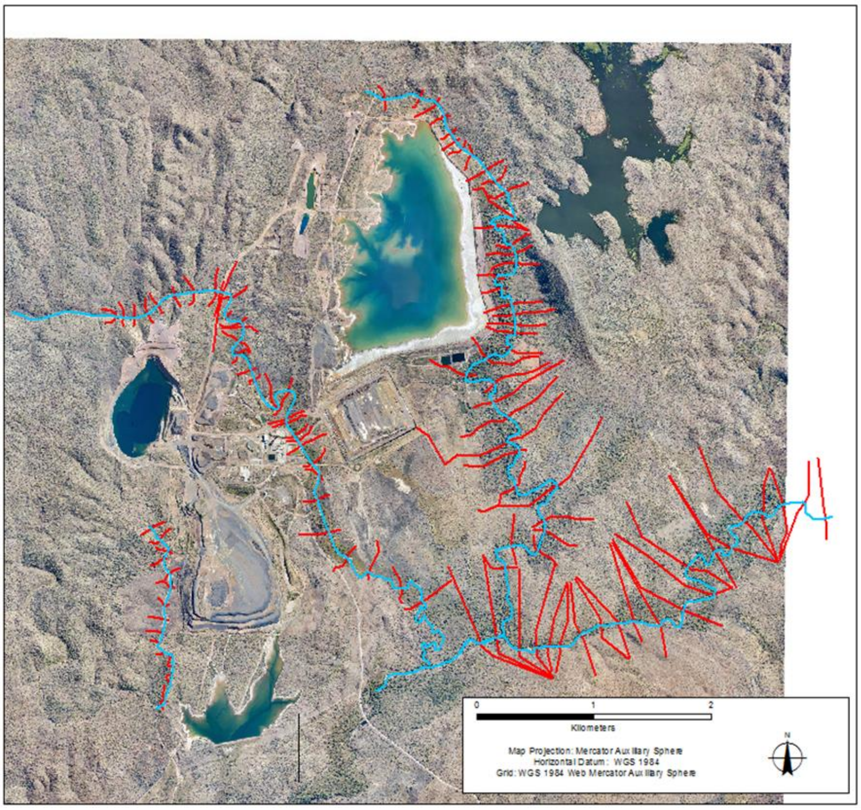

Figure 8 Extent of Hydraulic Flood Routing Models

The Manning's 'n' roughness coefficient has been used to represent the effects of surface friction on the conveyance flood peak flows through channels and over floodplains. Estimates for roughness coefficients were determined by analysis of aerial photography and with reference to industry standard tables (Chow, 1959). A value of 0.04 was applied to the main channel and a value of 0.08 was used for the floodplain.

Within the mine area two road crossings exist on Batman Creek and they comprise circular culverts of 2 x 1.6m diameter for the northern crossing and circular culverts of 8 x 1.1m diameter for the southern crossing.

The upstream boundary condition in hydraulic models is obtained from the design flood peaks estimated by hydrologic modelling (Table 20).

The downstream boundary representative of tailwater conditions in the lower reaches of Batman Creek, Horseshoe Creek and Stow Creek has been represented by a water level of 120.5m. This level corresponds to a level extrapolated from Stow Creek during what was calculated to be a 100-year event (Knight Piesold, 1995). A normal flow depth specified by the stream bed slope was used in Burrell Creek since the lower end of the model is not expected to have significant backwater effects from West Creek or the Edith River due to the relatively steep terrain.

Any errors due to the assumptions regarding downstream boundary conditions are not expected to significantly impact water levels in the vicinity of mine infrastructure due to the distance involved. Details of the channel alignments and the extents of the cross-sections of the simulated channels and floodplains are provided in Figure 8 and Figure 9.

3.5.3 Hydraulic Model Results

Flood Immunity

The results of hydraulic flood routing have been used to create an outline defining the extent of flooding during a 100-year ARI design event. Overlaying this outline onto the footprint of mine infrastructure allows an assessment of flood immunity (Figure 9). This indicates:

- Significant encroachment of flood waters into the proposed TSF2, to a lesser extent into the LGO Stockpile and to a minor extent into the mine facilities;
- The capacity of the diversion channel which collects uncontaminated runoff from catchments of Burrell Creek to the west of the WRD is exceeded at some locations along its length;
- Inundation of significant reaches of the realigned site access road; and
- The culverts on Batman Creek create a significant flow obstruction and backwater effect.

Given the absence of surveyed spot heights of infrastructure together with the approximation of flood outlines between the locations of model cross sections this analysis is not suitable for design of structures associated with flood mitigation.

Flood Velocity

Channel scour and degradation is dependent on the channel flow velocities. Commonly accepted guidelines indicate that flows with a velocity in excess of 2 m/sec have the potential to cause scouring in unlined channels. The locations where flow velocities are simulated to exceed this threshold are depicted in Figure 10. Whilst this includes reaches on Batman Creek adjacent to mine facilities and along Horseshoe Creek adjacent to site access and haul roads areas of potential significance are along Stow Creek next to the proposed location of the embankment for the TSF2.

3.6 Potential Stormwater Drainage Impacts

Construction and operation of the mine has the potential to create the following hydrologic impacts:

- Inundation of mine infrastructure due to flooding from local runoff;
- Change in local flow regime due to creek diversions; and
- Change in local flow regime due to construction of haulage roads across waterways.

Flood hazards within the mine site comprise:

- Accumulation of direct rainfall in Batman Pit and the Heap Leach Pad creating a pond of potentially contaminated water requiring disposal;
- Inundation of Batman Pit and the Heap Leach Pad should the flood levees be breached;
- Accumulation of direct rainfall in the Tailings Storage Facilities and Equalisation Pond resulting in a breach of embankments and discharge of contaminated water;
- Excessive runoff from the WRD and LGO Stockpile and accumulation of direct rainfall in the respective Retention Ponds resulting in uncontrolled discharges of potentially contaminated water;
- Erosion of the embankments and batters of the WRD, LGO Stockpile and Tailings Storage Facilities possibly resulting in increased sediment loads and a deterioration of downstream water quality; and

- Erosion of flood levees and increased sediment loads in runoff.

Construction of cross drainage structures such as culverts and causeways may result in:

- Obstruction of natural waterways due to the build-up of sediment and/or debris resulting in an increase in upstream water levels due to a reduction of existing flow area;
- Increase in outlet velocities and therefore scouring; and
- Changes in waterway sediment load.

Scour protection will be required at:

- Locations where a narrowing of flow paths or an abrupt change in flow path direction or steep gradients occur, either within channels due to cross drainage structures and natural features or on floodplains due to obstacles or prominent landforms; however
- Potential future flood management interventions such as culverts, channel diversions and flood levees have not been assessed but may alter existing flow paths and could result in other areas requiring erosion protection.

It should be noted that some storm rainfall events during recent wet seasons have reportedly been in excess of a 100-year ARI design storm event, and likely exceed the design criteria of most water management infrastructure on site. Therefore, it is to be expected that the performance of existing storage and conveyance infrastructure has been compromised.

3.6.1 Potential Surface Water Contamination

Material Storage Dump Areas

Spoil dump areas may contain contaminated soil particles that can reduce surface water quality if allowed to discharge into the natural environment.

Excess water accumulation around the outside of the spoil dump areas could potentially erode the inert spoil banks, causing sediment-laden runoff into natural channels.

Process Plant Areas

Surface water runoff from the plant areas may contain traces of heavy metals and soil particles that can reduce surface water quality if allowed into natural watercourses.

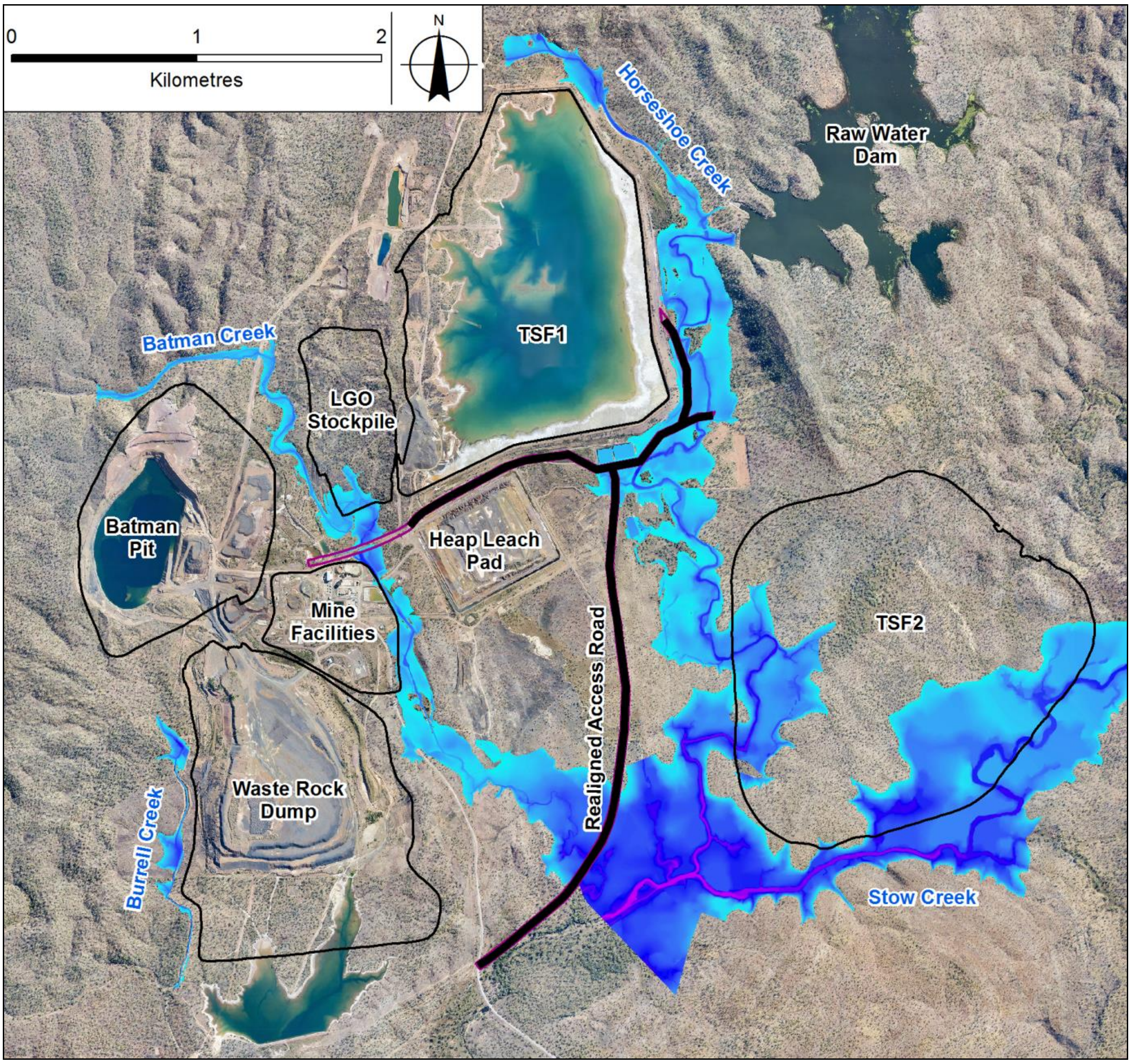

Figure 9 Modelled 100-year ARI Flood Extent

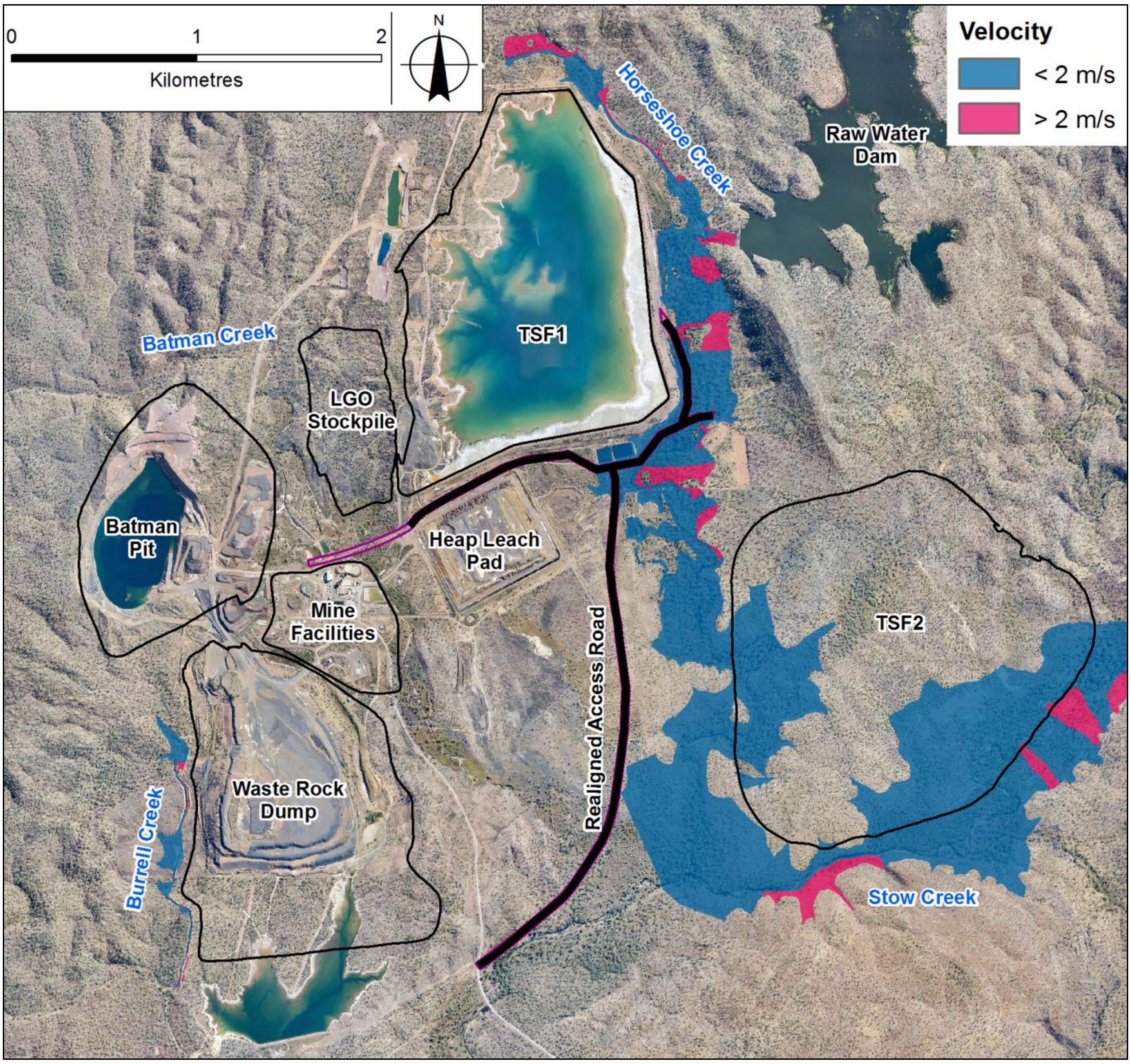

Figure 10 Simulated Channel Flow Velocities for the 100-year ARI event

4. Flood Management Measures

The following mitigation measures are proposed to minimise potential impacts during the production phase.

4.1 Flooding

Batman Creek, Horseshoe Creek, Burrell Creek and Stow Creek flow through or next to the mine area and therefore have the potential to encroach on storage embankments and to inundate plant, pit and other mine infrastructure. Potential flooding of the pit, process plant area and material storage dumps has been minimised during their design by siting these facilities away from flood inundation areas or through the construction of flood protection barriers/levees around each mine area. No further mitigation measures are required.

Whilst it is recommended that proposed infrastructure is located outside the 100-year ARI flood extent to minimise flood risk it is recognised that this is not always practical. For example, the proposed footprint of the TSF2 and LGO Stockpiles will encroach on the 100-year ARI design flood extent. Construction of diversion channels or flood protection levees will be required around these areas and other proposed infrastructure at risk.

4.2 Diversion Channels and Levees

Diversion channels already exist at the following locations:

- LGO Stockpile has a diversion structure that diverts water from the stockpile and conveys it to a retention pond and away from Batman Creek. Erosion of this channel has occurred during storm events although it is reported that the quality of the embankment has been improved following the 2008-09 wet season;
- HLP generates runoff and seepage which is collected by a moat. The pad will either be reprocessed or decommissioned and the site rehabilitated after the return to operations;
- WRD has a diversion channel which collects uncontaminated runoff from catchments of Burrell Creek to the west. The design capacity of this channel is not known but flood modelling shows that the channel capacity may be less than the 10-year ARI flood event at some locations along its length (Figure 11);
- TSF1 embankment is protected against flood flows in Horseshoe Creek by means of a diversion channel which flood modelling shows has a capacity equivalent to the 100-year design flood event. Diversion channels are also located to the west of TSF1 and divert runoff northwards towards Horseshoe Creek; and
- In addition to diversion channels at the WRD, diversion channels have recently been constructed at WRD retention pond to collect uncontaminated water from surrounding catchments. The WRD retention pond has diversion channels for the collection of uncontaminated runoff to its west and east (Figure 6). The channels have a capacity equivalent to 10-year ARI catchment runoff and thereby reduce the catchment area contributing runoff to the pond by 20% during storm events with a magnitude of less than a 10-year ARI.

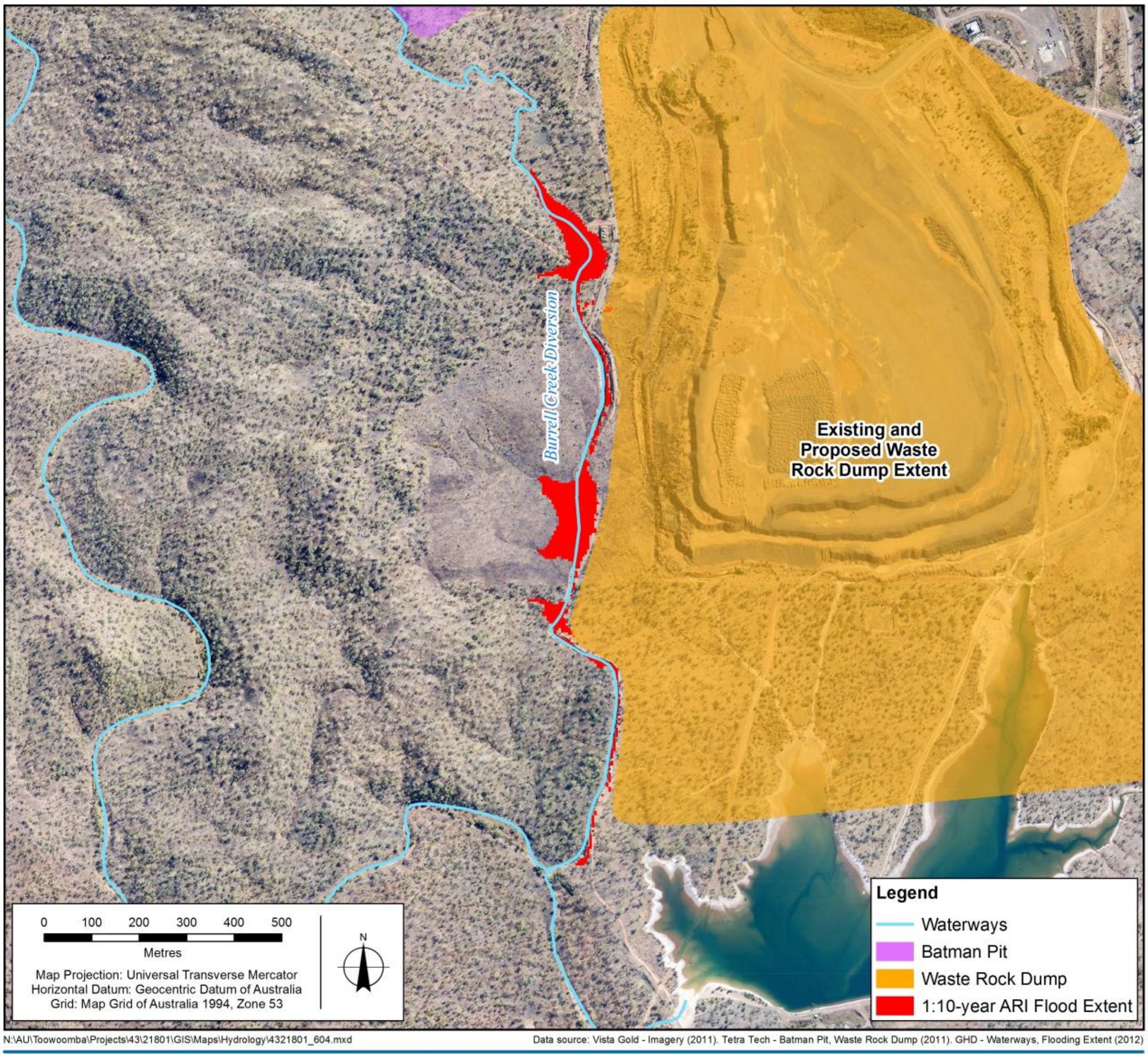

Figure 11 Modelled 10-year ARI Flood Extent

Diversion channels are proposed at the following facilities and will be designed to minimise channel side slopes, to keep maximum velocities below 2.0m/s and channel depths below 2.5m:

- Run-of-Mine and additional LGO Stockpile will require collection ditches to capture runoff and seepage from stockpiles for conveyance to retention ponds. The location and quantity of runoff is not yet known and will need to be assessed during the design phase to determine the required channel and storage embankment height:
  - Cut-off perimeter drains with a capacity equivalent to the 10-year design storm event will be required for the diversion of uncontaminated runoff around stockpiles and into Batman Creek.
  - Hydraulic modelling has demonstrated that small areas of the proposed stockpiles will encroach on the 100-year flood extent of Batman Creek and will require mitigation measures to reduce flood risk. The backing-up of flood water behind culverts on Batman Creek is likely to be a contributing factor and therefore re-design of culverts may assist in reducing flood risk.

Alternatively, construction of a levee with a height equivalent to the 100-year flood peak level plus freeboard or construction of a stream diversion to bypass the portion of Batman Creek which loops back toward the stockpile;

- Clay borrow area will require erosion protection and sediment control structures to manage runoff from the low permeability area.
- New diversion channels and levees along Horseshoe Creek and Stow Creek have been designed to protect the embankment of TSF 2 from flooding and erosion. Diversion channels have been designed for the following 100-year ARI flood events:
  - Stow Creek (Figure 12) designed for a peak flow of approximately 656m^3/s. The channel will be lined with rip-rap to reduce potential scour and erosion. The channel will have a width and length of approximately 60m and 850m, respectively, and a nominal depth of 4.2m.
  - Horseshoe Creek (Figure 13) designed to accommodate a peak flow of approximately 182m^3/s comprising 100m^3/s of runoff from the Horseshoe Creek catchment and 82m^3/s of overflow from the existing raw water supply dam. The channel will be lined with rip-rap to reduce scour and erosion and have a width and length of approximately 40m and 550m, respectively, and a nominal depth of 2.5m.
- Upgrade or re-design of existing drains and levees in limited areas of the processing plant to cope with a 100-year ARI flood event plus freeboard from Batman Creek.
  - Drainage across the processing plant site will be limited by the installation of cut-off drains to divert uncontaminated runoff from around the site and into Batman Creek via a settling pond.
  - Stormwater vee-drains will be designed to collect water alongside plant roads and with drainage conveyed beneath the roads via corrugated steel culverts to prevent scouring of plant roads. All stormwater runoff will be directed toward the existing drainage channel on the east side of the proposed process plant.

4.3 Cross Drainage Structures and Haul Roads

Flood modelling shows that these existing cross drainage structures on Batman Creek and Horseshoe Creek will be overtopped during the 10-year and 100-year ARI flood events, also a significant length of the road adjacent to the TSF1 will be inundated. The model results also show that these culverts cause backwater effects upstream but this does not appear to cause inundation of mine infrastructure. Furthermore, this backwater effect only occurs during extreme flood events and is therefore unlikely to be a frequent occurrence.

Overtopping of cross drainage structures and haul roads is likely to be an infrequent occurrence but upgrades to existing stormwater drainage, erosion and sediment controls, including the vegetation of verges, will be necessary to minimise damage during less extreme but more frequent storm events. Similar protection measures will be required for new roads with suitable cross drainage structures to convey drainage beneath roads to prevent scour.

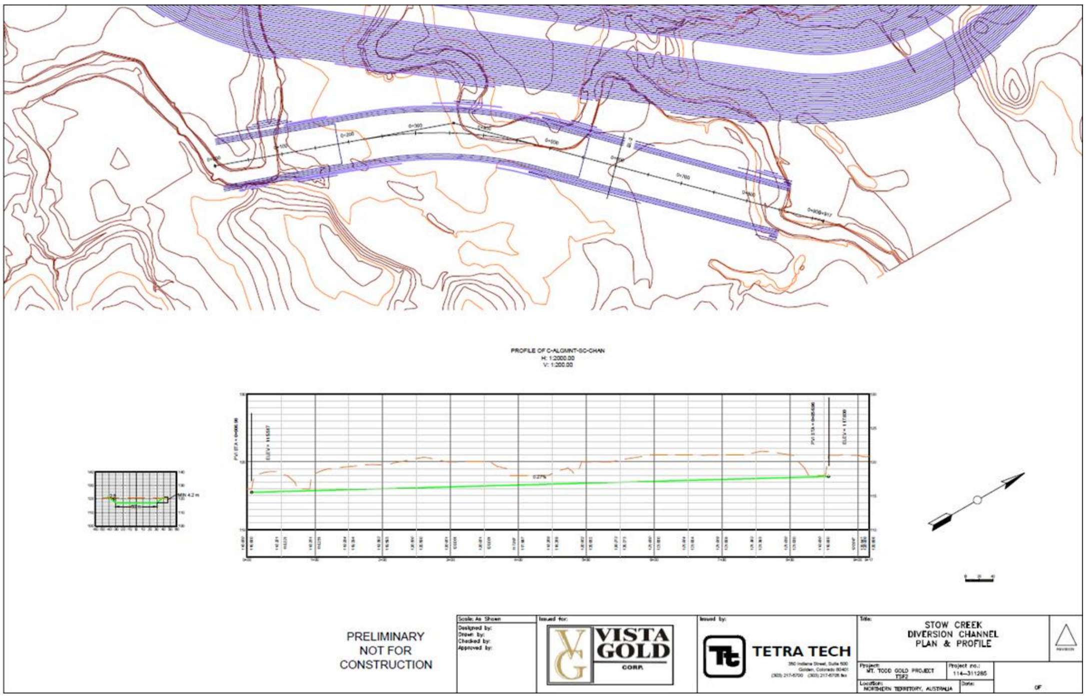

Figure 12 Stow Creek Diversion

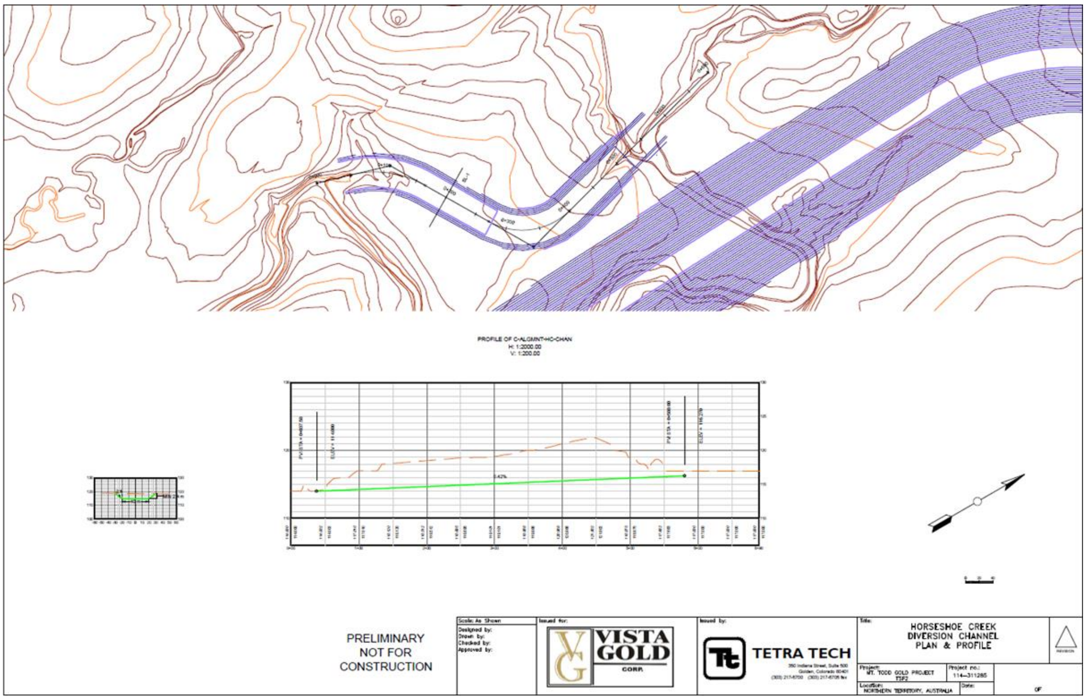

Figure 13 Horseshoe Creek Diversion

4.4 Channel Protection

An indication of the erosion potential of 100-year ARI flood flows has been obtained from the velocity results of hydraulic flood routing. This shows a number of locations along creeks may experience flow velocities of greater than 2m/s (Figure 10).

Whilst the majority of these locations are sufficiently distant from mine infrastructure to be of no immediate risk, the section of Batman Creek adjacent to the processing plant is likely to experience high velocity flows during extreme flood events. Rip-rap protection to earthwork embankments adjacent to the existing drainage channel on the east side of the proposed process plant will be installed for channel protection.

Sections of Stow Creek in the vicinity of the proposed embankment of TSF2 are also expected to experience high flow velocity during extreme flood events. Scour protection measures will include the placement of rip-rap along the proposed channel diversion works.

4.5 Prevention of Surface Water Contamination

The potential for contamination of receiving waters has been reduced by segregation of "clean" stormwater runoff from "dirty" stormwater runoff and the collection and treatment of "dirty" stormwater runoff from areas within the mine site.

"Dirty" stormwater runoff emanates from disturbed mining areas including mine pits (pit water) and material storage dumps. "Clean" stormwater runoff results from rainfall on undisturbed areas.

The method by which surface water contamination is to be minimised is provided below for each of the land use areas.

4.6 Mine Pit Water

Mine pit water will evaporate or be pumped to the water treatment plant where it will re-used in mining operations. The amount of pit water needing treatment has been reduced by minimising the stormwater runoff into the pit by construction of runoff barriers (e.g. engineered mounds/levees) around the mine pit.

4.7 Material Storage Dump Areas

WRD construction will include 8m wide benches at 30m vertical intervals on the face of the WRD and each lift will be constructed at 34^{o}. These benches will function as stormwater drainages and as access for closure cover installation, reclamation activities and maintenance. In general stormwater runoff from material storage dumps has been minimised or will be minimised by:

- Constructing dumps in a manner that dissipates runoff through seepage and evaporation;
- Constructing the outer batter slopes of dumps with inert overburden material;
- Construction of perimeter drains that collect runoff from the outer batter slopes and perimeter areas;
- Construction of drainage lines that convey runoff from dump perimeter drains to water retention ponds; and
- Construction of water retention ponds that are sized to capture an ARI wet season rainfall appropriate to their hazard category plus an appropriate freeboard allowance for sedimentation.

4.8 Processing Plant Areas

Surface water runoff from the plant area may contain traces of heavy metals, dust and soil particles that can reduce surface water quality if allowed into natural watercourses. The plant area will be surrounded by a bund forming a controlled drainage area.

4.9 Undisturbed Areas

Runoff from undisturbed land within and upstream of the mine site will be kept separate from "dirty" runoff from undisturbed areas within the mine site. "Clean" runoff will be diverted downstream of the mine site with no further treatment.

4.10 Extreme Rainfall Event Management

During extreme rainfall events in excess of the water management system design, the following procedures are proposed:

- Regular comparison of storage levels with prescribed Mandatory Reporting Levels will provide advance warning of potential containment issues and the early implementation of measures to help maintain storage levels within design guidelines during higher than normal rainfall periods;
- If all water storages are at or near capacity, excess water will be redirected to the TSF up to the height of beached tailings for temporary storage;
- Additional stand- by pumps will be used to increase the transfer capacity between affected ponds and the TSF or pit; and
- Water retention ponds have been designed to overflow and discharge to the natural environment.

4.11 Surface Water Monitoring

Water monitoring stations will be positioned to obtain the rate of surface water runoff entering and exiting the mine site to assist with the efficient operation of water management and to demonstrate compliance with discharge licence conditions.

In addition, it would be advantageous to obtain data that can be used to validate parameters used in water balance models; this would comprise storage levels, runoff from disturbed areas of the mine and pumping rates between storage infrastructures.

Monitoring of various parameters has been carried out at a number of locations throughout the mine site (Table 21). Whilst this provides valuable information for the operation of infrastructure its value to the long-term management and planning of water containment is often impaired by a lack of information on the duration and rate of flow.

For example, water level during outflow from the WRD into the downstream retention pond is recorded at three weirs on a daily basis. Without information on the duration of outflow it must be assumed that the recorded water level at the weirs is representative of the flow throughout that day, which can lead to gross under or overestimation of flow rates. Also, unless rating curves are established for gauges that record water levels in creeks the rate of runoff from disturbed areas of the mine site cannot be established. An assessment of storage inflow from undisturbed areas by means of water balance calculation is problematic due to the absence of accurate data on the rate of transfer through pumping.

Table 21 Existing Surface Water Level Monitoring

Parameter	Location	Frequency
Rainfall	Yard, Tailings Dam and Security Gate	Daily
Evaporation	Yard	Daily
Syphon flow	WRD retention pond	Continuous during operation
Spillage	WRD retention pond	Continuous during operation
Spillage	Low Grade Ore Pad retention pond	Continuous during operation
Spillage	Stormwater retention pond	Continuous during operation
River stage	Edith River SW2, SW4	Daily
River stage	Horseshoe Creek SW1, SW11	Daily
River stage	Batman Creek SW5	Daily
River stage	Stow Creek SW3, SW12	Daily
Pumping	WRD	Continuous during operation
Runoff	WRD weirs 1, 2 and 3	Weekly
Water level	WRD retention pond	Daily
Water level	Low Grade Ore Pad retention pond	Daily
Water level	Stormwater retention pond	Daily
Water level	Batman Pit	Daily
Water level	TSF	Daily
Water level	HLP	Daily

Recommended improvements to monitoring include:

- Monitoring of water levels at locations on Batman Creek and Horseshoe Creek just upstream of mine infrastructure (low grade ore stockpile on Batman Creek and tailings storage facility on Horseshoe Creek), together with the derivation of stage – discharge relationships for existing monitoring sites just downstream of the mine site, would provide a means of quantifying the runoff from the disturbed areas of the mine. This would also provide information on flows from incremental areas along both creeks and thus a way of calibrating the runoff coefficients used in water balance models. Given the size of catchments it is likely that flows within the creeks are quite variable and therefore a meaningful assessment of runoff requires hourly or continuous monitoring during storm events;
- Installation of hourly or continuous monitoring of water levels at the weirs downstream of the WRD during times of flow would provide a direct assessment of seepage rates from the dump. However, it is recognised that the same information can be obtained from records of water levels in the retention pond so long as records of other inflows and outflows are maintained in tandem; and

- Similarly, continuation of the measurement of transfers between water containment facilities will assist in determining the quantity of runoff entering ponds from disturbed areas and thus provide a means of verifying the required capacity of storage and pumps, and assist with decision making during operation.

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	Peter Dunn	Ian McCardle		Ian McCardle		16/05/2013
2	Brent Murdoch – Vista Gold	edits to table 19 & 20 as per email dates 13/9/2013				