10. Surface Water

This chapter addresses the surface water aspects of the Project. It summarises the existing surface water environment, including water resources, hydrology, water quality and water monitoring in the vicinity of the Project. This chapter provides an assessment of:

- existing water containment infrastructure through water balance modelling;
- flood risk and existing stormwater management;
- current and proposed water quality,
- current and proposed water quality monitoring program.

Potential impacts and mitigation relating to stormwater, flooding, water quality and hazardous substances is discussed.

Detailed surface water assessment is provided in the following Appendices:

- Surface Water Assessment - Hydrology (site water balance models, and stormwater and flood management) - Appendix I; and
- Surface Water Assessment and Monitoring Program (current and future water quality, water treatment plant, monitoring program) - Appendix J.

The potential impacts and associated mitigation measures identified in this chapter form the basis of the surface water component of the project risk assessment undertaken in Chapter 5. The project risk assessment includes consequence, likelihood and residual risk ratings for surface water impacts after management measures are implemented.

Chapter 1 provides a recent history of water management at Mt Todd since Vista Gold assumed control of the site, and Chapter 14 provides a discussion about aquatic fauna impacts and management.

10.1 Existing Environment

10.1.1 Existing Climatic Patterns

The site experiences a tropical climate characterised by a hot, humid Wet Season from October to March, followed by a hot, Dry Season from April to September. Transition periods occur between the Wet and Dry Season, typically lasting one month. The majority of rain falls in the Wet Season. The Katherine region has an average rainfall of approximately 1,188.7mm (BOM 2012).

Average maximum and minimum temperatures are 35.9°C and 20.3°C respectively. Relative humidity at 9am and 3pm are 83% and 60% respectively in February, and 52% and 24% in August. Daily evaporation rates range from 8mm in October to 5mm in June, with an annual average of 6mm.

The seasonal tropical climate results in alternating extremes of river flows, from prolonged dry periods of no flows, to substantial flood events in the Wet Season.

10.1.2 Regional Catchment

The Mt Todd mine site is located in the Daly River Catchment (Figure 10-1). The Daly River catchment supports small industries including agriculture, mining and tourism (CSIRO 2009). The Daly River is one of the Northern Territory's largest rivers with a catchment area of 52,577km^2. It is one of a few catchments in the Northern Territory that has perennial flow (Faulks 1998). Five main tributary river systems are located within the Daly River Catchment; Katherine River, Flora River, Fergusson River, King River and Douglas River (Figure 10-1). Of the five main tributary river systems, the Fergusson River is closest to the mine site, located approximately 15km to the northwest. The Fergusson River is 144km in length and has several creeks and rivers as tributaries, of which the Edith River is the largest.

The Edith River is located immediately south of the mine site.

Table 10-1 summarises stream flow for the main tributary river systems of the Daly River Catchment.

Table 10-1 Summary of River Flow Information

Gauging station number	River	Catchment area (km^2)	Mean annual flow volume (m^3)	Mean annual discharge (m^3/sec)
G8140040	Daly River	47,100	5,750,000,000	213.90
G8140001	Katherine River	8,640	1,922,000,000	87.17
G8140044	Flora River	5,900	762,300,000	30.80
G8140008	Fergusson River	1,490	415,600,000	23.49
G8140068	King River	11,000	207,800,000	7.64
G8140063	Douglas River	842	148,800,000	6.07

10.1.3 Local Catchments

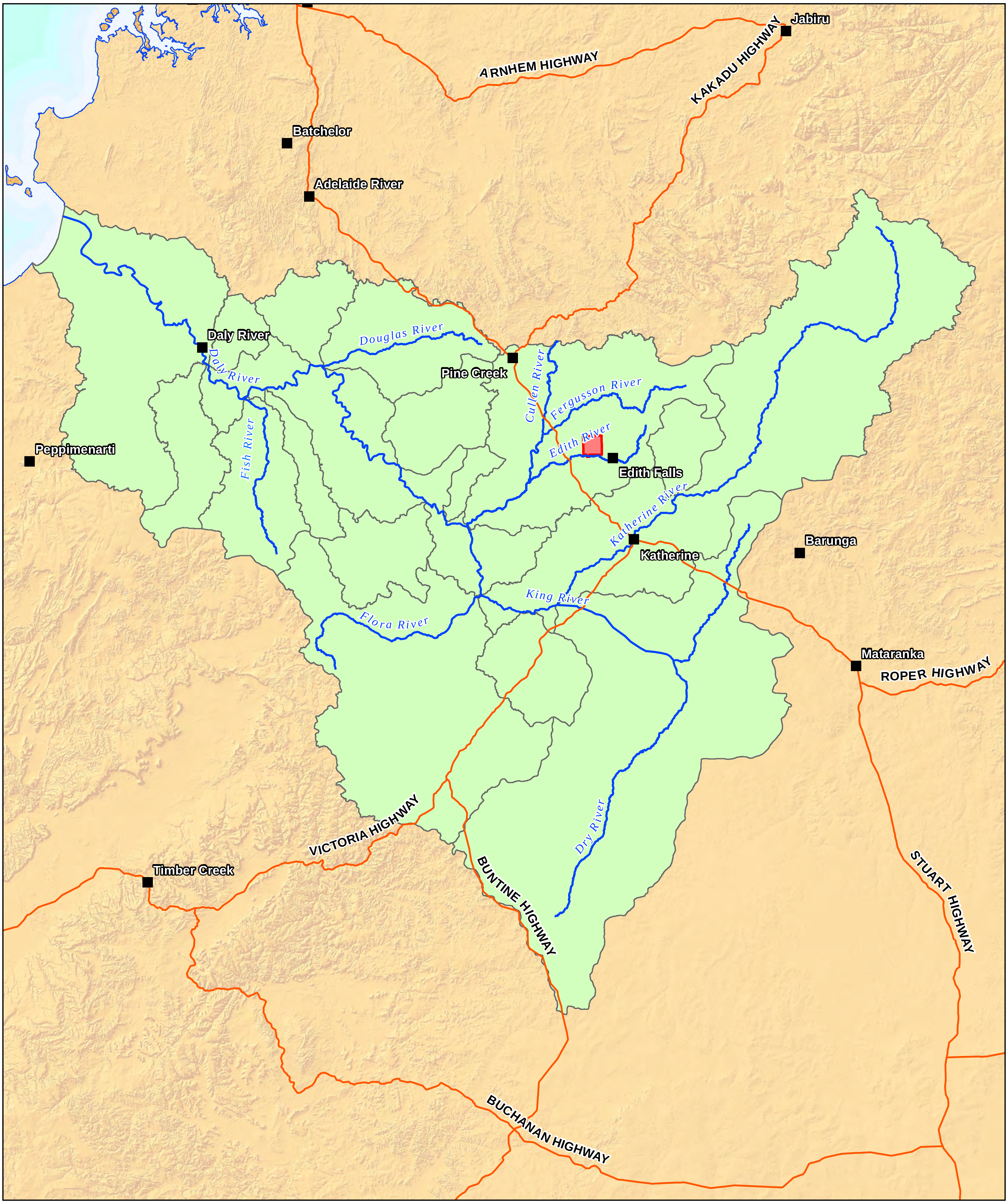
Edith River

Edith River is a 69km tributary of the Fergusson River located to the south of the Mineral Leases. Several tributaries of the Edith River cross, or are close to, the Mineral Leases. Horseshoe Creek and Batman Creek transverse the site and then enter Stow Creek, which runs directly into the Edith River. West Creek and Burrell Creek, located in the south west of the leases, directly enter the Edith River (Figure 10-2).

The catchment area in and around the Mineral Leases comprises mostly foothills located west of the western Arnhem Land sandstone massif. It is dominated by Darwin stringybark (*Eucalyptus tetrodonta*) and Darwin woollybutt (*E. miniata*) open forest, eucalypt woodlands, riparian vegetation and some patches of monsoon thicket. A description of the existing vegetation is provided in Chapter 13.

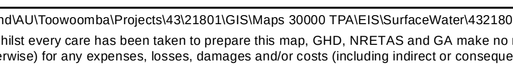
A gauging station is located on the Edith River downstream of the Mineral Leases. The catchment area for the gauge is 671km^2. The maximum recorded river height at this station is 6.44m (NRETAS 2011a). This height was exceeded on 27 December 2011 when a height of 9.4m was recorded.

Under the *Water Act 1992*, the declared beneficial use of surface water from the Edith River and its tributaries is the protection of aquatic ecosystems. Agricultural land use also occurs downstream of the mine site, therefore Edith River water may be used for irrigation or stock watering.



LEGEND

- Populated Places
- Mt Todd Mineral Leases
- Roads
- Daly River Subcatchments
- Waterways



Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 53

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Revision 1
Date 17 Jun 2013

Location of Study Area

Figure 10-1

\\ghdnet\ghd\AU\Toowoomba\Projects\43\21801\GIS\Maps 30000 TPA\EIS\SurfaceWater\4321801_808E.mxd

66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com.au

Data source: NRETAS - Catchments, Waterways, Mt Todd Mineral Lease (2011). GA - Major Roads, Place names, Ocean (2008). Created by: CM

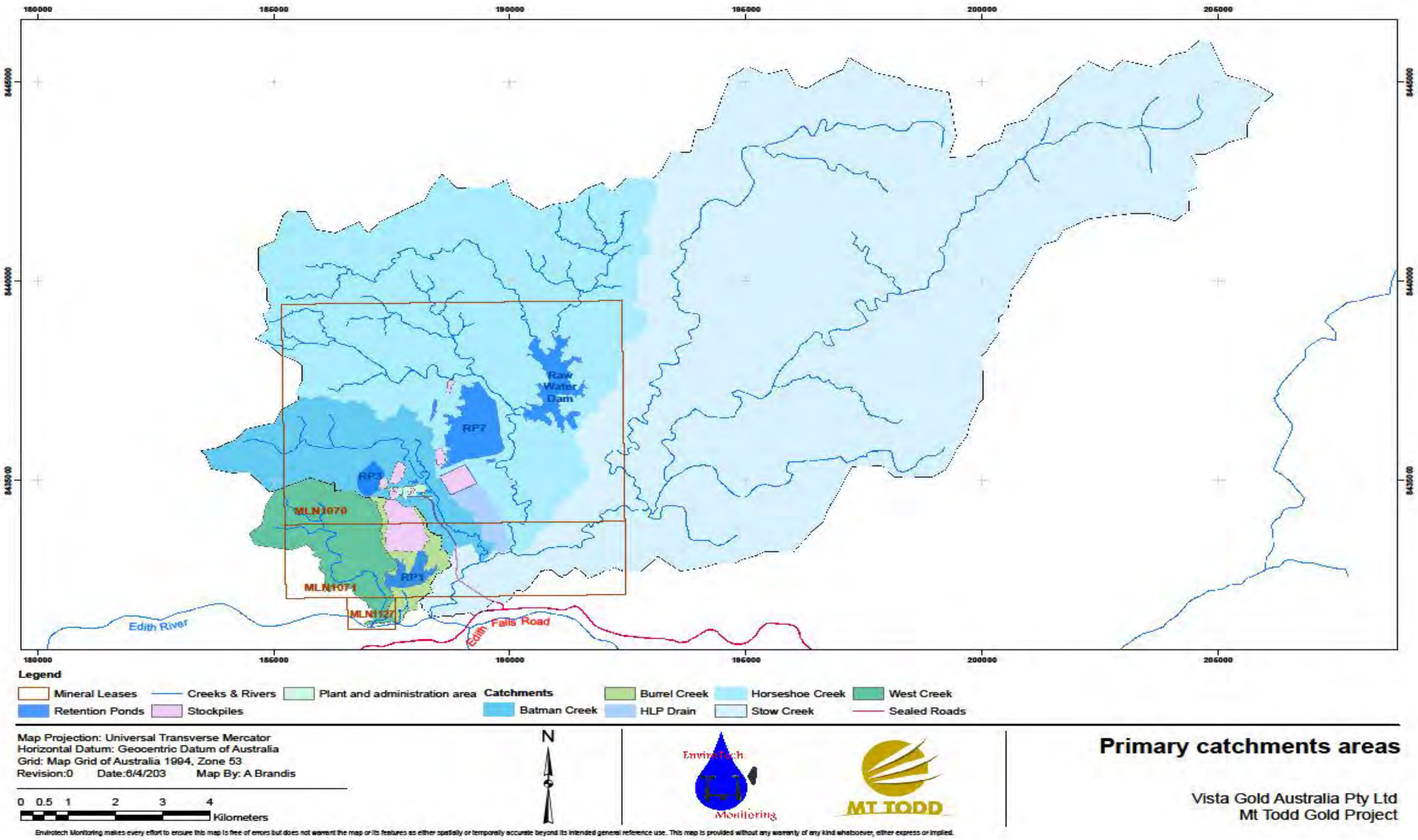


Figure 10-2 Primary Catchment Areas - Edith River

Source: draft Mt Todd Water Management Plan 2012-13 (Vista Gold 2012)

Edith Falls

Leliyn (Edith Falls), on the western side of Nitmiluk National Park and upstream of the mine site, is a popular tourist attraction and important sacred site of the Jawoyn people (Figure 10-1). Tourist visits are controlled around and above the plunge pool leaving downstream sections of the river for the Werenbun community and other Aboriginal people. It is a favoured area for collecting turtles and is a safe place for children due to the relative absence of saltwater crocodiles. Environmental values of this site are:

- water quality for swimming;
- water quality for ecosystem protection; and
- flora and fauna for bushwalking.

Horseshoe Creek

Horseshoe Creek traverses the Mt Todd mine site. It is an ephemeral watercourse fed naturally by its catchment area, including the RWD and a drainage diversion channel north west of RP7 (Figure 10-3). Horseshoe Creek may receive seepage from RP7. The Horseshoe Creek riparian zone east of RP7 contains wetland species and can be classified as a seasonal wetland as it is ephemeral.

Batman Creek

Batman Creek is fed naturally by its catchment area upstream of the mine site during the Wet Season. Batman Creek traverses the Mt Todd mine site and captures discharges and runoff from RP5, RP2 and the HLP (Figure 10-3).

Stow Creek

Stow Creek is an ephemeral watercourse, fed by Batman Creek and Horseshoe Creek (Figure 10-3). Stow Creek does not receive any discharge directly from the existing mine site facilities.

Burrell Creek

A large section of Burrell Creek is covered by the WRD. It receives water from the RP1 siphons during planned discharges. Burrell Creek is an ephemeral creek. It contains wetland-type vegetation and during the Wet Season would be classified as a seasonal wetland (Figure 10-3).

West Creek

West Creek is ephemeral and is located to the west of the WRD. It is fed by the western diversion drain. It also receives water from the RP1 spillway during periods of uncontrolled discharge (Figure 10-3).

10.1.4 Downstream Users

Cropping occurs downstream of the mine site close to the confluence of the Edith River with the Fergusson River. Edith River water may be used for irrigation. Surface water (which is potentially dependent, in part, on locally discharging groundwater) from the Edith River is used in the Edith Farms area for stock and domestic purposes as well as for irrigation.

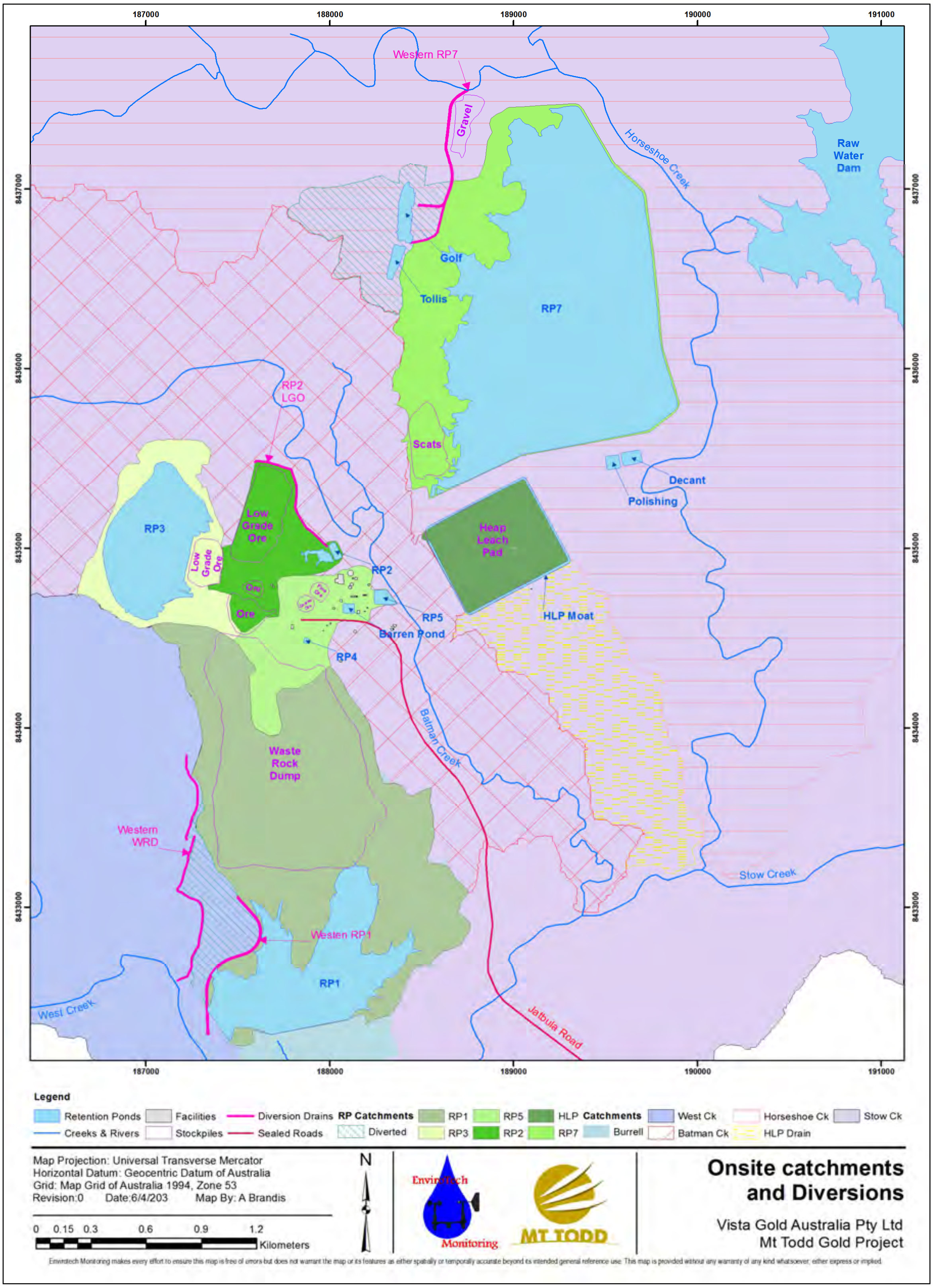


Figure 10-3 Onsite Catchments and Diversions at Existing Site

Source: draft Mt Todd Water Management Plan 2012-13 (Vista Gold 2012)

10.1.5 Surface Water and Groundwater Interactions

Regional groundwater flow at the mine site is generally westwards, mimicking the surface water flow of the Edith River. The regional flow is likely to be interrupted by local groundwater highs and lows associated with groundwater sources and sinks. Local topography is likely to provide localised groundwater high points beneath elevated features such as the Yinberrie Hills and Mt Todd, or low points where groundwater may discharge as springs in surface water courses.

Groundwater is recharged from direct rainfall infiltration, leakage from ephemeral surface water courses that flow after Wet Season rainfall events, and leakage from the perennial Edith River where river levels are above the surrounding groundwater level. High rainfall in the Wet Season, combined with thin alluvial cover and extensive areas of outcrop in surface drainages, will likely result in high rates of aquifer recharge.

Groundwater in the region has a declared beneficial use and is referred to as the Katherine Area groundwater (NRETAS 2011c). Groundwater use includes raw water for drinking, agricultural or industrial purposes (Chapter 11).

10.1.6 Edith River Discharges

Water discharged from the site currently enters the Edith River during the Wet Season from:

- treated RP3 water via Batman Creek;
- RP7 via Horseshoe Creek;
- Stow Creek into the Edith River;
- controlled siphon discharge from RP1 via Burrell Creek; and
- overflow from RP1 via a spillway to West Creek.

No surface flow of mine water enters the Edith River during the Dry Season (MWH 2006). This is because Horseshoe, Batman, Burrell and West Creeks are ephemeral. Groundwater discharge to surface water occurs on-site throughout the year (GHD 2011a).

Stow Creek receives water intermittently from two ephemeral creeks that run through the mine site: Batman Creek and Horseshoe Creek. The creeks receive overflow and seepage during heavy rainfall. These come from several mine site sources including RP7 and the HLP.

Controlled discharge from RP1 has historically been the largest contributor of mine water to the Edith River. Water has been released to the Edith River to increase the holding capacity of RP1 during the Wet Season. Uncontrolled discharge from RP1 (via the spillway) to West Creek has occurred in heavy rainfall events.

Uncontrolled discharge occurs from Stow Creek into the Edith River during periods of Wet Season base flow (approximately January to May). Mine water may make up part of this discharge and potentially originates from a number of sources on-site. Seepage from the LGO stockpile, the Process Plant and the HLP is flushed to Batman Creek and then Stow Creek. Tailings Dam seepage and underflow as well as some seepage from the HLP are flushed into Horseshoe Creek and then Stow Creek. Some seepage from RP7 may occur directly into Horseshoe Creek along the eastern Tailings Dam wall.

The other locations of mine water discharge to the Edith River are the RP1 discharge point and a minor drainage, West Creek. The RP1 discharge point is where controlled siphon pumping from RP1 enters the Edith River. West Creek delivers diverted water from the western side of the WRD via the Western Diversion Drain, and overflow from the RP1 spillway. This creek only delivers mine water to the Edith River when substantial rainfall events cause RP1 to overflow. A conceptual water model for the site is provided in Figure 10-4

10.1.7 Current Surface Water Quality

Surface water quality has been monitored at several locations in the Edith River and on the Mt Todd mine site for many years (Appendix J). These data show that the water quality of the retention ponds on-site has improved dramatically since 2005.

However, AMD in several of the retention ponds is a concern. Exposure of sulfide minerals (associated with the mine's waste rock) to air and water results in the liberation of heavy metal ions such as zinc and copper as well as sulfates into the retention ponds. The liberated sulfate ions can mix with free hydrogen ions in solution leading to the formation of sulfuric acid, lowering the overall pH of the pond. Excesses of heavy metal ions and low pH can have deleterious effects on the aquatic ecosystems of receiving environments.

A monitoring program is in place to assess the quality of surface waters, upstream and downstream of the mine site. In the past, surface water had been analysed for pH, electrical conductivity (EC), sulfate (SO_4), aluminium (Al), cadmium (Cd), copper (Cu) and zinc (Zn). The current sampling program increases the number of analytes to capture anthropogenic chemicals used on-site.

The surface waters at the mine are usually sampled daily from November or December at the start of the Wet Season through to April or May at the end of the Wet Season. This sampling period captures metal levels and indicates if any discharges (controlled or uncontrolled) from the mine site have occurred. Surface waters are also sampled year round on a monthly basis to obtain annual variations in water quality (Section 10.6).

Surface water chemistry data provided by Vista Gold covers Wet Season sampling periods from 2008 to 2011 for the retention ponds and surface waters. Summaries of the median results for major analytes for each surface water site are shown in Figure 10-5. The full data set is provided in Appendix J.

Samples from the start of the Wet Season show high metal concentrations in the first week of sampling. This is due to evaporation of the retention ponds during the Dry Season increasing concentrations of metals in the ponds (Appendix J). Metal concentrations in the ponds decrease continually during the Wet Season and at the end of the Wet Season are approximately half that observed at the start of the season.

Mean monthly water quality parameters from the three Edith River sites (SW2, SW4 and SW10), Stow Creek (SW3) and Batman Creek (SW5) monitoring sites over the 2011 - 2012 Wet Season are provided to demonstrate the general temporal patterns of variation among the sites (Figure 10-5). The monitoring site above the influence of discharges (background) from the mine site (SW2) had a close to neutral pH, and low levels of sulfate, copper and zinc over both Wet Seasons.

A discussion on the water quality of retention ponds and at key monitoring points is discussed in Appendix J.

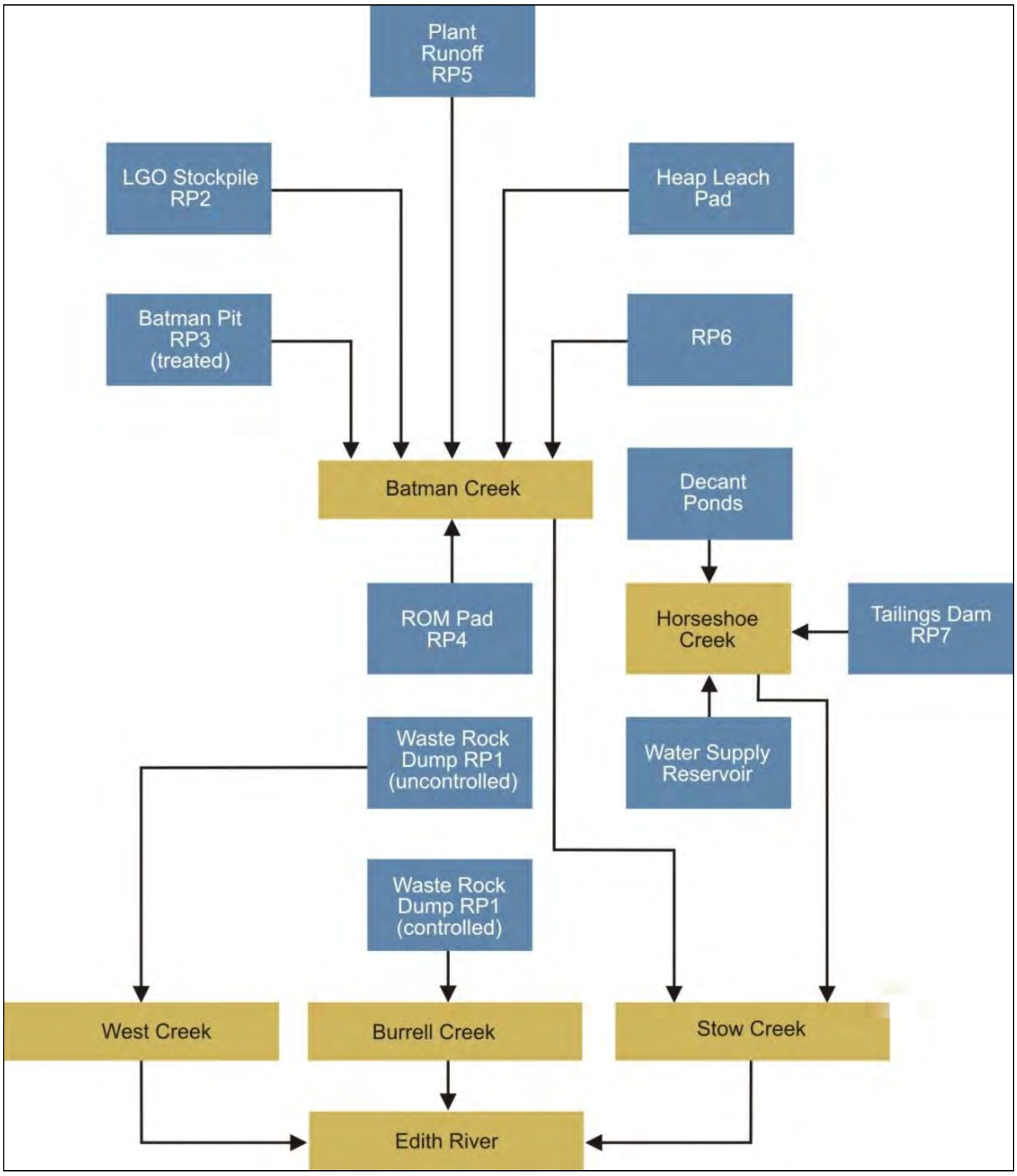
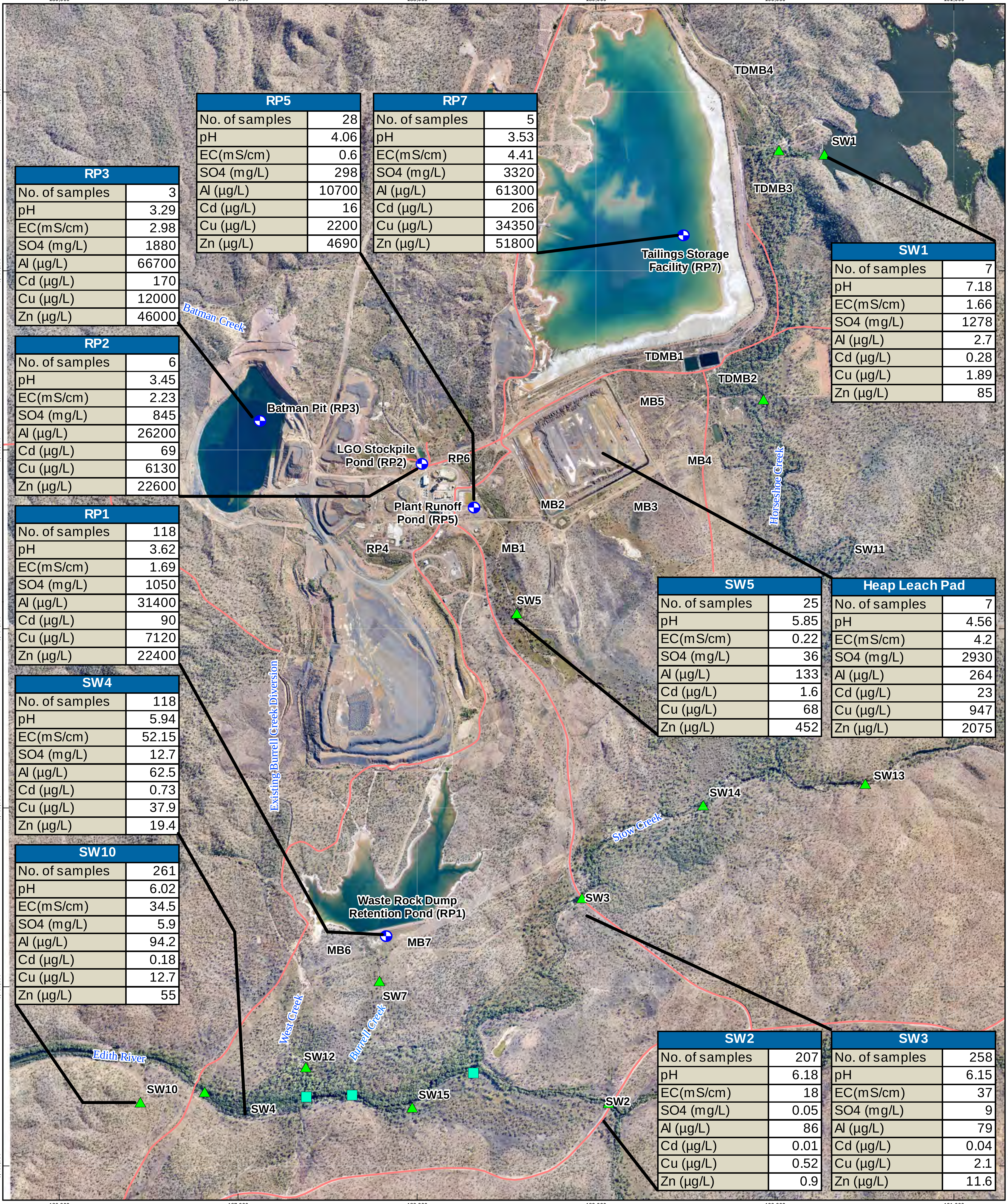


Figure 10-4 Site Conceptual Mine Water Discharge Model



RP5	
No. of samples	28
pH	4.06
EC(mS/cm)	0.6
SO4 (mg/L)	298
Al (µg/L)	10700
Cd (µg/L)	16
Cu (µg/L)	2200
Zn (µg/L)	4690

RP7	
No. of samples	5
pH	3.53
EC(mS/cm)	4.41
SO4 (mg/L)	3320
Al (µg/L)	61300
Cd (µg/L)	206
Cu (µg/L)	34350
Zn (µg/L)	51800

RP3	
No. of samples	3
pH	3.29
EC(mS/cm)	2.98
SO4 (mg/L)	1880
Al (µg/L)	66700
Cd (µg/L)	170
Cu (µg/L)	12000
Zn (µg/L)	46000

RP2	
No. of samples	6
pH	3.45
EC(mS/cm)	2.23
SO4 (mg/L)	845
Al (µg/L)	26200
Cd (µg/L)	69
Cu (µg/L)	6130
Zn (µg/L)	22600

RP1	
No. of samples	118
pH	3.62
EC(mS/cm)	1.69
SO4 (mg/L)	1050
Al (µg/L)	31400
Cd (µg/L)	90
Cu (µg/L)	7120
Zn (µg/L)	22400

SW4	
No. of samples	118
pH	5.94
EC(mS/cm)	52.15
SO4 (mg/L)	12.7
Al (µg/L)	62.5
Cd (µg/L)	0.73
Cu (µg/L)	37.9
Zn (µg/L)	19.4

SW10	
No. of samples	261
pH	6.02
EC(mS/cm)	34.5
SO4 (mg/L)	5.9
Al (µg/L)	94.2
Cd (µg/L)	0.18
Cu (µg/L)	12.7
Zn (µg/L)	55

SW1	
No. of samples	7
pH	7.18
EC(mS/cm)	1.66
SO4 (mg/L)	1278
Al (µg/L)	2.7
Cd (µg/L)	0.28
Cu (µg/L)	1.89
Zn (µg/L)	85

SW5	
No. of samples	25
pH	5.85
EC(mS/cm)	0.22
SO4 (mg/L)	36
Al (µg/L)	133
Cd (µg/L)	1.6
Cu (µg/L)	68
Zn (µg/L)	452

Heap Leach Pad	
No. of samples	7
pH	4.56
EC(mS/cm)	4.2
SO4 (mg/L)	2930
Al (µg/L)	264
Cd (µg/L)	23
Cu (µg/L)	947
Zn (µg/L)	2075

SW2	
No. of samples	207
pH	6.18
EC(mS/cm)	18
SO4 (mg/L)	0.05
Al (µg/L)	86
Cd (µg/L)	0.01
Cu (µg/L)	0.52
Zn (µg/L)	0.9

SW3	
No. of samples	258
pH	6.15
EC(mS/cm)	37
SO4 (mg/L)	9
Al (µg/L)	79
Cd (µg/L)	0.04
Cu (µg/L)	2.1
Zn (µg/L)	11.6

LEGEND

- Impoundment Sampling Location
- Mine to Edith River discharge point
- Monitoring Borehole
- Paired Monitoring Borehole
- Surface Water Sampling Station
- Access Roads

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 53

N

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Mt Todd Gold Project

Job Number 43-21801
Revision 1
Date 19 Jun 2013

Summary of Mt Todd Surface Water Data

Figure 10-5

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66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com.au

Data source: Vista Gold - Imagery (2011). GHD - Sampling Sites, Access Roads (2012). Created by: CM

10.1.8 Current Fate and Effects of Contaminants

Fate and Effects of Discharge Entering the Edith River

Potential water quality impacts for the re-established mine are discussed in Section 10.4.

Currently the Edith River receives discharges of mine water containing elevated metals and depressed pH. Despite this, the Edith River retains a significant benthic macroinvertebrate community. Any potential impacts that have been observed in the past have either been very short-term or transient and no measureable impact has been recorded. This is supported by the sediment chemistry sampled in May 2011 (Table 10-2).

Sediments in the Edith River (SW15 and SW4) below SW2 and in Stow Creek (USSC, SW13, SW12, SW14 and SW3) have large particle sizes and minimal clay content (fines <63µm). This configuration of particle sizes and low total organic carbon (TOC) provides limited binding sites (usually organic particles such as humic acids) for metals to adsorb to the sediments. Metals from mine water discharges are therefore unlikely to remain in the system (Simpson *et al*. 2005). There is some influence of mine discharges on zinc, copper and manganese levels in the sediments. Sediments at SW4 have higher levels than at SW2. These differences are not significant with all metal concentrations at all sites tested below the interim sediment quality guideline low trigger values (ANZECC & ARMCANZ 2000). Sample sites are shown in Figure 10-5.

Macroinvertebrates

Aquatic macroinvertebrate communities were sampled to assess the impact of the former mine discharges on populations downstream from the RP1 discharge site. The populations downstream were compared with populations from reference sites. Macroinvertebrate sampling commenced in 2003 at (Figure 10-5):

- Edith River Upstream of Stow Creek Confluence (ERUS);
- Edith River Downstream of Stow Creek Confluence (ERDS);
- Edith River Downstream of Site SW4 (ERSW4);
- Fergusson River Upstream (FRUS); and
- Fergusson River Downstream (FRDS).

The five sites were sampled using standard Northern Territory AUSRIVAS survey methodology. Macroinvertebrates were generally identified to family level and the actual macroinvertebrate abundances were extrapolated from the percentage identified.

Mine site discharge had no detectable impact on macroinvertebrate populations in the Edith River during the years' 2003, 2005, 2006, 2007 or 2008 (Vista Gold 2008). Based on the statistical method of the historical sampling program, an impact was detected only once, in 2004 (GHD 2011b). Based on these historical data, the mine discharge did not have an adverse impact on macroinvertebrate populations in the Edith River. More recent sampling undertaken in 2011 also supports these findings. Water quality at sites SW3, SW4 and SW10 has not created an adverse impact on the macroinvertebrate populations sampled. The major reason for the lack of impact would be the lack of TOC in the sediments and the large particle size, both of which limit the ability of the sediment to retain metals.

Impacts of Current Surface Water Discharges to Edith River

Macroinvertebrate populations at SW4 show no adverse impacts from exposure to elevated metal, sulfate and EC from mine water even though water quality did not meet previous Water Discharge Licence requirements. Metal deposition in deep pool sediments does not have the potential to adversely impact resident fish populations and related ecosystems (Envirotech Monitoring 2012).

Table 10-2 Mine Site Sediment Quality Data

	USSC	SW13	SW12	SW14	SW3	SW4	SW15	SW2	ANZECC ISQG - low
% Moisture	20	19	19	15	18	22	22	24	NA
pH	5.9	6.3	6.2	6.3	6.1	6.7	6.8	5.9	NA
%TOC	0.19	0.094	0.28	0.046	0.043	0.12	0.16	< 0.005	NA
Metals mg/kg									
Aluminium	2,200	1,500	1,000	760	1,000	1,200	940	990	25519
Cadmium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	1.5
Chromium	< 5	< 5	< 5	8.7	< 5	< 5	5.4	< 5	80
Cobalt	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	-
Copper	< 5	< 5	< 5	< 5	< 5	26	< 5	< 5	65
Iron	14,000	9,000	6,100	9,700	6,400	7,200	8,500	12,000	-
Lead	6.7	< 5	< 5	< 5	13	< 5	< 5	< 5	50
Manganese	41	36	18	44	18	79	130	20	460
Mercury	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.15
Nickel	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	21
Silver	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	1
Zinc	6.4	< 5	< 5	6.9	9.8	24	9.2	< 5	200
Particle Size %									
>2000µm	2.7	2.1	0.1	30	13	0.3	1.1	0.3	NA
1000 - 2000µm	2	4	0.7	12	3.6	2.1	8.8	0.8	NA
500 - 1000µm	9.8	14	38	33	30	8.3	38	21	NA
250 - 500µm	32	30	39	14	23	37	20	28	NA
125 - 250µm	38	42	16	8.3	24	24	5.8	14	NA
63 - 125µm	6.5	2.5	3.7	2.7	1.5	2.3	3	4.9	NA
<63µm	9.3	6.2	2.4	< 0.1	5.7	26	24	31	NA

10.2 Water Containment

10.2.1 Infrastructure

The mine has nine facilities which store water as their primary or secondary function (Table 10-3). Waters are of varying quality, including some with elevated metals such as copper and zinc as a result of oxidation of the native rock in the area. There is also a pipe / pumping network which aims to eliminate overflows from retention ponds during all but extreme rainfall events.

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 (Figure 10-3 and Table 10-4). Diversions are used to divert runoff from disturbed areas of the mine, such as the low grade ore stockpiles, 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.

The water containment management system 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 under WDL conditions (section 10.6).

Table 10-3 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[2]
HLP	67.5	1135.50	31.8
Sediment Pond RP5	13.7	1128.00	3.1
TSF1 RP7	4680	1136.50	0
TSF2	unknown	unknown	unknown
Raw Water Dam	infinite[1]	infinite[1]	infinite[1]
Equalisation pond	30 [3]	1128.00	0

Source: Goldsim Model MtToddWB_Production_PFS_45K

Notes: [1] Goldsim Model assumes infinite storage source

[2] based on output from Pre-production model which in turn relies on observed water elevations and dewatering rules based on current discharge permit (Appendix I)

[3] storage is reported to be equivalent to 5 days water treatment capacity (36ML) but in fact is only 30ML within the Goldsim model

Table 10-4 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 (RP1)	Existing	29,160
Burrell Creek catchment	East drain - WRD retention pond (RP1)	Partly constructed	15,120
Batman Creek	Between Low Grade Ore Stockpile and its pond (RP2)	Existing	Unknown

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

10.2.2 Water Supply and Storage

Raw Water Dam

The RWD is the main source of water supply. It is located approximately 2.5km north east of the proposed ore processing plant site, upstream of previous and proposed mining operations. The RWD was built across Horseshoe Creek forming a sub-catchment covering about 55% of the Horseshoe Creek catchment (approximately 45km^2).

The capacity of the RWD will be increased during pre-production to accommodate water demand during mining operations. The final maximum RWD volume will be approximately 8.4Mm^3, with a spillway elevation of 136.5m. The capacity of the RWD is assumed to be unlimited for the purposes of water balance modelling.

Construction Phase

During construction, water will be supplied from on-site sources. Treated water of an acceptable quality will be used, or water will be supplied directly from the RWD. The capacity of the RWD is believed to be sufficient to meet water demands during the construction phase. Water for dust suppression will be applied using water carts.

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

For more information on water supply and demand during construction, refer to Appendix I.

Operations Phase

A new Ore Processing Plant will be constructed and its water requirements, based on a previous modelled development scenario, are estimated to be 24,230m^3/day (30,000tpd production) for the first three years and thereafter 36,409m^3/day (45,000tpd production) for years 4-12 (Appendix I). The actual water demand for the processing plant based on a production of 50,000tpd is 30,000m^3/day.

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:

- TSF reclaim water;
- WTP; and

- RWD.

Potable water for the operation workforce will be supplied from the RWD.

The water demand for dust suppression is estimated to vary between 220m^3/day and 1,153m^3/day depending on the season and will be supplied from the WTP in the first instance and thereafter from the RWD.

10.2.3 Water Balance Models

This section describes the models used for investigating the ability of infrastructure to contain runoff from disturbed and undisturbed areas of the mine, including climatic inputs. For more detail see Appendix I.

Available Models

The performance of infrastructure has been investigated through the following water balance models:

- Goldsim Model MtToddWB_Production_PFS_45K - simulates the performance of water management infrastructure during the operations phase; and
- Goldsim Model MtToddWB_LOM2011Update_Post-Closure_PPT_Chooser - focuses on quantifying the seepage flows during the post-closure phase.

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 models. The water balance models have been based on a 30,000tpd (yr 1-3) and 45,000tpd (yrs 4-12) production scenario. The mine will actually operate at 50,000tpd production at its peak. The impact of these changes on the water balance has been highlighted where necessary.

A recent water balance has been carried out by Tetra Tech (Appendix K). 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. Results of this study are included in the following discussion.

Climatic Inputs

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

The post-closure 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 the seepage flows over 600 years.

It has been suggested that storm rainfall during the last two Wet Seasons has been in excess of a 100-year Average Recurrence Interval (ARI) and is therefore likely to exceed the design criteria of most existing 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 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 water storage infrastructure will be designed for the containment of at least monthly and likely extreme Wet Season rainfall and should therefore be able to contain rainfall such as that falling in 2010 and 2011. Shorter duration and higher intensity 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 such rainfall during 2010 and 2011.

Operations Phase Goldsim Model

This model represents the daily containment and transfer of rainfall and runoff from catchment areas during the operations phase of the mine.

The model assumes that the WTP is implemented within the first year of mine operations. Transfers to the WTP from the TSF (reclaimed water and seepage), WRD retention pond, LGO pond, stormwater retention pond, Batman Pit and HLP retention pond (seepage) are determined by the model using inputs of daily climate data, rainfall-runoff coefficients and required freeboard criteria. The preservation of freeboard within storage facilities strives to eliminate uncontrolled discharge to the downstream environment. The size of the WTP equalisation pond has been determined by model simulation to ensure that no overflows occur.

It was assumed that the HLP will be closed at the beginning of the operations phase and seepage flows which are transferred to the WTP have been reduced accordingly.

Modelling of the Batman Pit assumes that groundwater inflows and outflows are negligible. Recent work indicates that groundwater inflow could vary between a few litres per second and 31L/s over the operational phase of the mine. Simulations for the operations period commence with a pit water level equivalent to about 1.8Mm^3 (1,081m), about 15% of the reported maximum volume of 12Mm^3 (1,144m).

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. The model assumes that proposed diversion channels to the east and west of the WRD retention pond are constructed and reduce the amount of runoff from undisturbed areas entering the pond.

Post Closure Phase Goldsim Model

This model estimates the annual treatment stream during the post closure phase of the mine determined over a period of 600 years. The treatment stream comprises:

- seepage flows from the WRD;
- seepage flows from the HLP;
- seepage flows from the TSFs; and
- overflows from Batman Pit, should they occur.

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

The water balance of Batman Pit includes runoff from the pit walls and is modelled as 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.

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 inclusive), outflows amount to 5% of rainfall and will take 30 days to reach the WRD outlet. Seepage during the dry period is insignificant.

Surface runoff and seepage from the HLP is also modelled as a 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. These values were obtained by model calibration (Tetra Tech 2010).

A SeepW finite element seepage analysis has been carried out (Tetra Tech 2010) to determine rates of seepage from TSF1 (RP7). Seepage rates from TSF2 (RP8) have been scaled from these rates.

The potential for overflow from the Batman Pit was 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 although recent work indicates that average inflow could vary between a few litres per second to about 31L/s.

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

10.2.4 Water Balance Results

This section describes the main results from water balance simulations for various operational elements over the different phases of mine life, including the TSF's, water containment facilities and WTP. The ability of water storage facilities to meet demands is discussed, and anticipated overflows during operations and post closure are reported.

Tailings Storage Facilities

Operations Phase

Seepage rates during the Dry Season increase slightly from 9,600m^3/day to 10,200m^3/day seven years into the operations phase and is assumed to reflect the change from TSF1 to TSF2. Wet Season seepage remains constant throughout the operations period (19,200m^3/day) with 90% transferred to the equalisation pond and 10% sent directly to the WTP.

Post Closure Phase

Seepage flow from the future TSF1 is estimated to vary between 6.5m^3/day and 52.5m^3/day. Seepage flow from the proposed TSF2 will vary between 25m^3/day and 176m^3/day and will require transfer to the WTP until a passive treatment wetland is constructed.

Water Containment Facilities

Operations Phase

Based on this modelled scenario, the capacity of the equalisation pond (30,000m^3) in association with a WTP rate of 300m^3/h (years 1 to 3) and 500m^3/h (years 4 to 12) is sufficient to receive transfers from RP1, RP2, RP5, TSF1, TSF2 and Batman Pit (RP3) to prevent overflows from these facilities during normal operations. However, the model results show instances of overflow at RP1, RP2 and RP5 during the Wet Season. This is most likely the result of insufficient pump capacity on pipelines to the equalisation pond during extreme rainfall events. Overflows from RP5 are expected given its function as a sediment trap rather than a water retention pond (Table 10-5).

Table 10-5 Simulated Percentage Days when Untreated Water Overflows to Creeks

Pond	Year (% of days overflowing)												
	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

The water management strategy leading up to and during extreme peak rainfall is likely to invoke different operating rules to those used in the Goldsim water balance. This could involve measures such as the temporary transfer of excess water to the TSFs.

Overtopping events from the WRD retention pond (RP1) are less likely during later years of operations 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 67,545m^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 7,615m^3 is utilised on any one day which reflects the decommissioning of the HLP and the consequent reduction in seepage inflow.

Post Closure Phase

Seepage rates from the WRD are estimated to range between 0 and 2,304m^3/day and these will be treated at the WTP until a passive treatment wetland is constructed.

Water levels in Batman Pit are estimated to rise over a long period of time before reaching equilibrium at which point evaporation appears to balance inflow from surface runoff and rainfall. No groundwater flows were included in the water balance which recent studies have shown to be up to 31L/s (2,678m^3/day).

With groundwater flows included, the pit lake water level will rise following cessation of pit dewatering and reach equilibrium after 345 years at an elevation of approximately 15m AHD (Appendix I).

Water Supply

Construction Phase

Water demand is expected to be relatively small and, given the relatively large existing size of the RWD, demand is expected to be met without difficulty.

Operations Phase

Water demand is largely driven by:

- processing - 24,230m^3/day for years 1 to 3 and 36,409m^3/day for years 4 to 12; and

- dust suppression – average daily demand of 562m^3 where the monthly demand has a maximum of 1,153m^3/day in July / August and a minimum of 220m^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 10-6.

The simulation results confirm that processing plant water demands can be supplied without failure by a combination of supply from the WTP, RWD and reclaim water from the TSF. The WTP contributes a minimum daily flow of 6,950m^3/day during years 1 to 3 and 12,000m^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 17,030m^3/day and 17,280m^3/day, respectively.

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 (2,191m^3). 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% of days in each year.

Post Closure Phase

Post closure, it is expected that there will be no on-going demand for water.

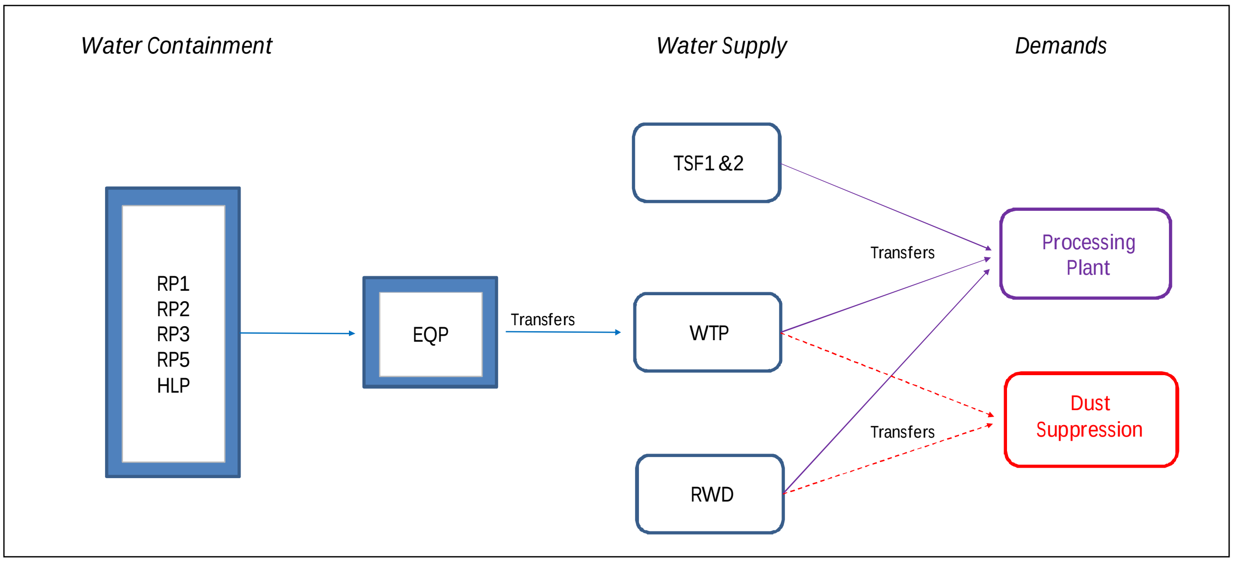


Figure 10-6 Schematic of Mine Water Supply System

Overflows to the Environment

Operations Phase

Water balance modelling shows that the equalisation pond and WTP are able to prevent overflows from retention ponds during normal operating conditions. However, overflow from RP1, RP2, HLP and RP5 can occur during high intensity storms and is the result of insufficient pump capacity on pipelines to the equalisation pond. Overflows from RP5 are expected given its function as a sediment trap. The frequency and simulated rate of overflow during operations is reported in Table 10-5.

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. Operating rules governing water storage will include a requirement to minimise the volume of water stored on-site in retention ponds at the end of the Dry Season, and consequently maximise the available storage should extreme rainfall events occur.

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

- regular comparison of storage levels in accordance with the WDL will provide advance warning of potential containment issues and the early implementation of measures to help maintain storage levels within design guidelines;
- if all water storages are at or near capacity, excess water will be redirected to the TSFs 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 TSFs; and
- water retention ponds have been designed to overflow and discharge to the natural environment as a last resort to ensure that the structural integrity of the storages is maintained.

No overflows from Batman Pit were predicted by the water balance simulation during operations or post closure as evaporation is expected to balance inflows from surface runoff and rainfall.

Post Closure Phase

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

10.2.5 Water Balance Summary

The main findings from the water balance investigation are as follows:

Construction Phase

Water demand is expected to be relatively small and, given the relatively large existing size of the RWD, demand is expected to be met without difficulty.

Operations Phase

The water balance summary for the operations phase is:

- capacity of the equalisation pond (30,000m^3, source 2013 Goldsim model) in conjunction with a WTP capacity of 300m^3/h (years 1 to 3) and 500m^3/h (years 4 to 12) is sufficient to receive transfers from RP3, RP1, HLP and RP2 to prevent overflows from these facilities during normal operating conditions;
- model results show instances of overflow at RP1, RP2, HLP and RP5 to the equalisation pond during high intensity rainfall events which is the result of insufficient pump capacity on pipelines. Overflows from RP5 are expected given its function as a sediment trap;
- simulations indicate no overflow from Batman Pit;
- combined average uncontrolled overflow from retention ponds to the downstream environment is estimated at between 0.02 and 0.06GL/yr. Because simulated overflows from retention ponds to the downstream environment occur as a consequence of extreme rainfall, it is likely that 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;

- water balance has also shown that mine water demands can be met without failure from combined transfers from the WTP, RWD and TSF. However, this assessment assumes the RWD is an unlimited resource. The risk of shortfall in water supply is considered to be an economic risk rather than an environmental impact; and
- simulated annual average output of the WTP varies from 2.6 to 4.4GL/yr over the life of mine and assumes that transfers from RP1, RP2, RP5 and RP3 occur whenever there is spare storage capacity within the equalisation pond. The model shows that a small amount of excess water may be discharged from the WTP to Edith River during the first three years of operation (0.02GL/yr) (when transfers are fixed), with no discharge thereafter (when dynamic controls are used).

The water balance makes a number of assumptions. There is no net groundwater inflow to Batman Pit and the pit is assumed to contain 1,799ML of water at the commencement of the operations phase. A separate water balance has been used to determine the amount of reclaim water and seepage outflow and values then input directly to the Goldsim model. Diversion drains around the WRD are assumed to have been constructed and will divert 29% of catchment runoff away from the retention pond. The RWD is assumed to be an unlimited resource and any impact associated with a limitation to supply has not been addressed.

Discrepancies exist between modelled and reported areas of development footprints for the LGO stockpiles, Batman Pit and to a lesser extent the WRD. Underestimation of the 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.

Post Closure Phase

The water balance summary for the post closure phase is:

- seepage rates from the TSF's are estimated to decrease to 39m^3/day;
- seepage rates from the WRD are estimated to be up to 2,304m^3/day; and
- water levels in Batman Pit are expected to reach equilibrium level of between 25m and 27m AHD (169m and 167m below the 194m AHD top of pit level) after 150 years 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 (Appendix K) has included groundwater inflow to Batman Pit and suggests that water levels will reach equilibrium after 345 years at an elevation of approximately 15m AHD.

It is unclear what design 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 exceeded a 100-year ARI (Section 10.2) 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 storages, together with conveyance infrastructure, might have over-toped.

10.3 Stormwater Assessment

10.3.1 Introduction

This section details the assessment of the potential impacts of flooding from Horseshoe Creek, Batman Creek, West Creek and Stow Creek to confirm the adequacy of existing and proposed stormwater management measures. The 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 flood risk 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 Appendix I. Where existing information was inadequate new modelling was carried out consisting of a hydrological assessment to determine flood peak discharge and hydraulic modelling to determine flood immunity and the potential for scour.

10.3.2 Diversion Infrastructure

The mine site 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 (Figure 10-7).

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

Diversions are also present upstream of the LGO stockpiles and around the HLP with the purpose of collecting runoff from disturbed areas of the mine and directing it into storage ponds.

Diversion drains have been constructed around the eastern and western margins of the WRD retention pond (RP1). The drains reduce the volume of uncontaminated runoff entering the pond and thereby reduce the risk of overtopping. Diverted water flows to local creeks downstream of the pond.

10.3.3 Flood Peak Model

This section outlines the hydrologic modelling 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. These events are compatible with generally accepted guidelines where the former will help assess the adequacy of cross drainage and diversion structures, and the latter provides an assessment of the mine site's flood immunity.

Hydrologic Modelling

Flood peaks in Horseshoe Creek, downstream of its confluence with outflows from the RWD, and within its north-western tributary at the northern end of the TSF were extracted from a previous study (Knight Piësold 1995).

The Rational Method was used to calculate flood peaks in Batman Creek, Stow Creek and Burrell Creek. Figure 10-7 shows the catchments for which flood peaks have been determined.

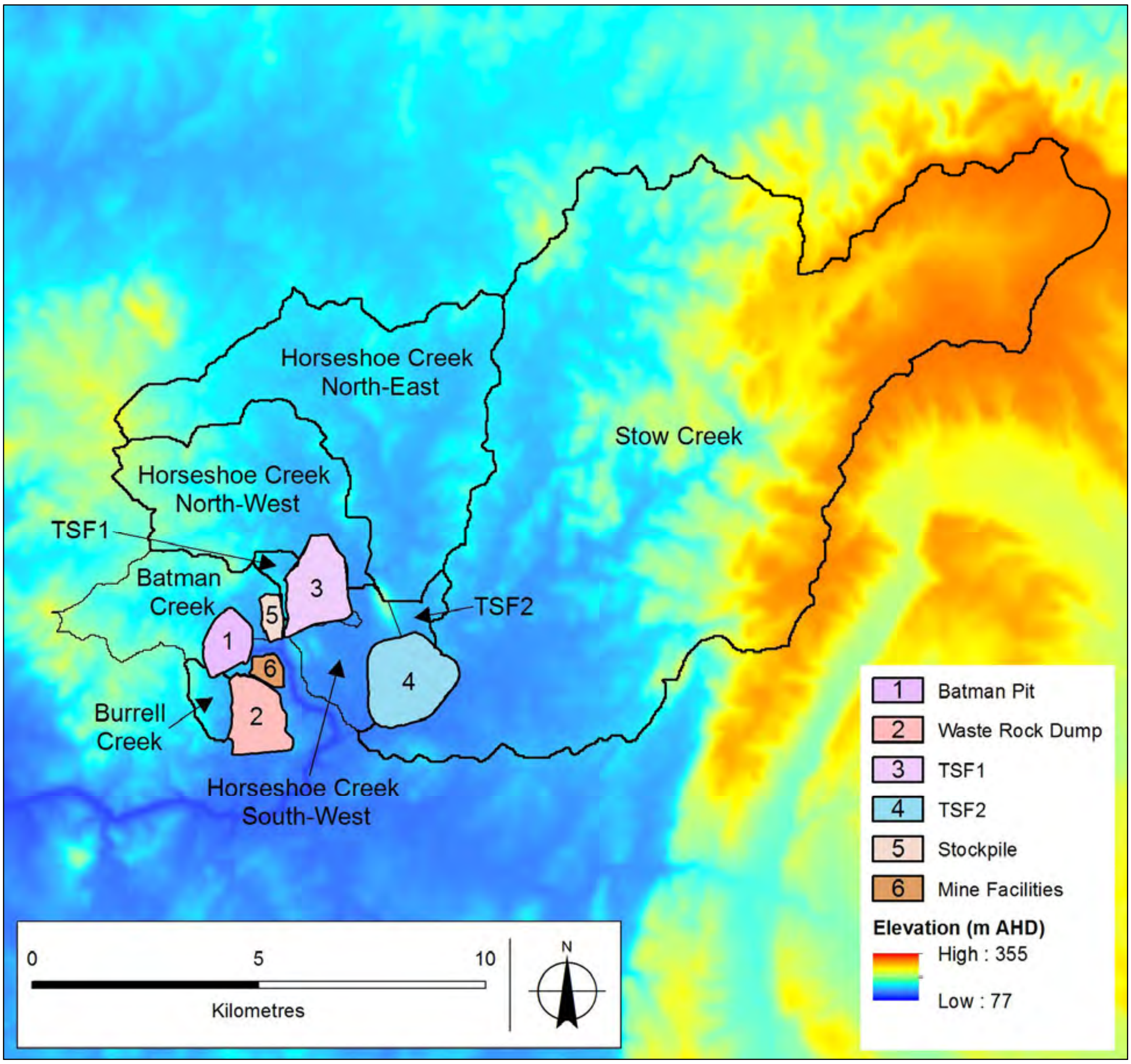


Figure 10-7 Modelled Catchments

Hydrologic Model Data

Design storm rainfall for 10-year and 100-year ARIs was obtained from the Bureau of Meteorology website for standard design storm durations ranging from 15 minutes to 72 hours.

As part of the Rational Method, the Bransby-Williams formula was used to determine the time of concentration at each location (Table 10-6). 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 were determined using the Department of Main Roads Road Drainage and Design Manual (2007), assuming 100% rural catchments.

Table 10-6 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)	44.6	98.4	19.6	- [2]	- [2]
10-year ARI Rainfall Intensity (mm/h)	67.6	67.6	-	- [2]	- [2]

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

Hydrologic Model Results

The results of hydrologic modelling using the Rational Method are reported for significant locations (Table 10-7). The table includes the results for Horseshoe Creek as derived from the Knight Pièsold (1995) study which used industry standard techniques.

Table 10-7 Flood Peaks for Mt Todd Mine

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	691	135	92	227

Notes: [1] source Knight Pièsold (1995)

10.3.4 Flood Extent and Velocity Model

This section describes the modelling approach used to determine flood extent and velocity (hydraulic modelling). Flooding along local 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 likely velocities. Flood immunity and impacts on existing and proposed mine infrastructure, particularly storage embankments is discussed in Section 10.3.5.

Hydraulic Model

Modelling has been undertaken using a 1-D hydraulic modelling approach (HEC-RAS). This methodology has been selected because flows occur in well-defined channels where the interchange of flows between channel and floodplain is not expected to be significant.

Hydraulic Model Data

The geometry of channels and floodplains was defined from a one metre digital elevation map of the mine area. The Manning's 'n' roughness coefficient was used to represent the effects of channel friction on flood peak flows through channels.

There are two road crossings along 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.

Boundary conditions in the hydraulic models consist of inflow hydrographs at the upstream extent of the model and downstream tailwater conditions. Inflow hydrographs were generated using the results of hydrologic modelling. The peak inflows applied in the hydraulic model are provided in Table 10-7.

A water level of 120.5m at the downstream boundary of Batman Creek and Horseshoe Creek models was adopted which corresponds to an extrapolated level from Stow Creek during what was calculated to be a 100-year event (Knight Pièsold 1995). A normal flow depth specified by the stream bed slope was used in the Burrell Creek model 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.

The likely impacts from flooding as indicated by model results are discussed in Section 10.3.5.

10.3.5 Impacts from Flooding and Stormwater

Construction and operation of the mine has the potential to create the following physical surface water impacts:

- inundation of mine infrastructure due to flooding;
- change in the local flow regime due to creek diversion; and
- change in local flow regime due to construction of haulage roads across waterways.

Creek diversions are discussed in Section 10.3.6.

Inundation of Mine Infrastructure

The results of the hydraulic model (Section 10.3.4) have been used to define 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 10-8).

This indicates most of the existing mine infrastructure is located outside the 100-year ARI design flood extent of creeks passing through the mine area. Notable exceptions include:

- 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 the catchment 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
- culverts on Batman Creek create a significant flow obstruction and backwater effect.

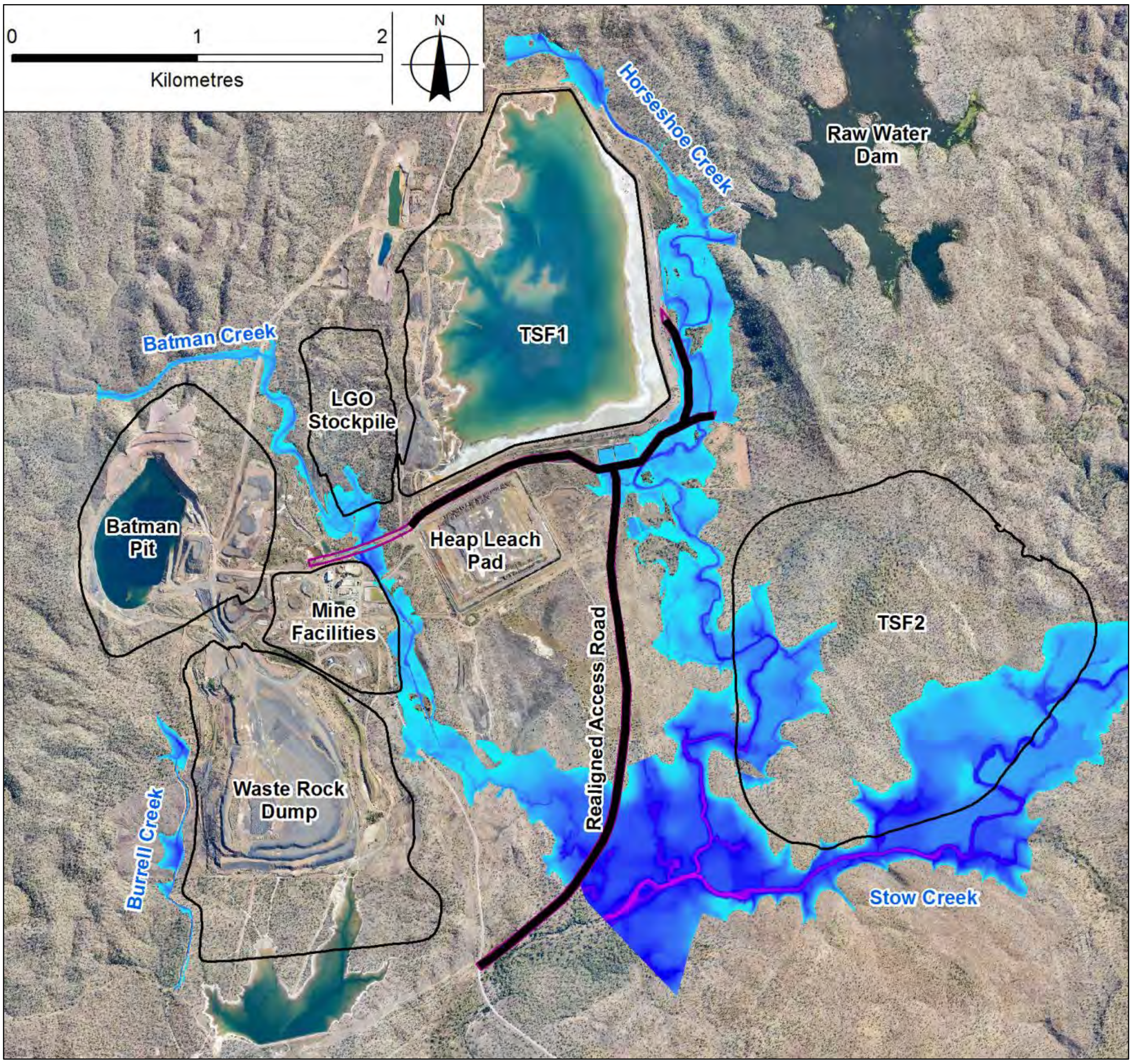


Figure 10-8 Modelled 100-year ARI Flood Extent

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 2m/s have the potential to cause scouring in unlined channels. The locations where flow velocities are simulated to exceed this threshold are depicted in Figure 10-9. 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.

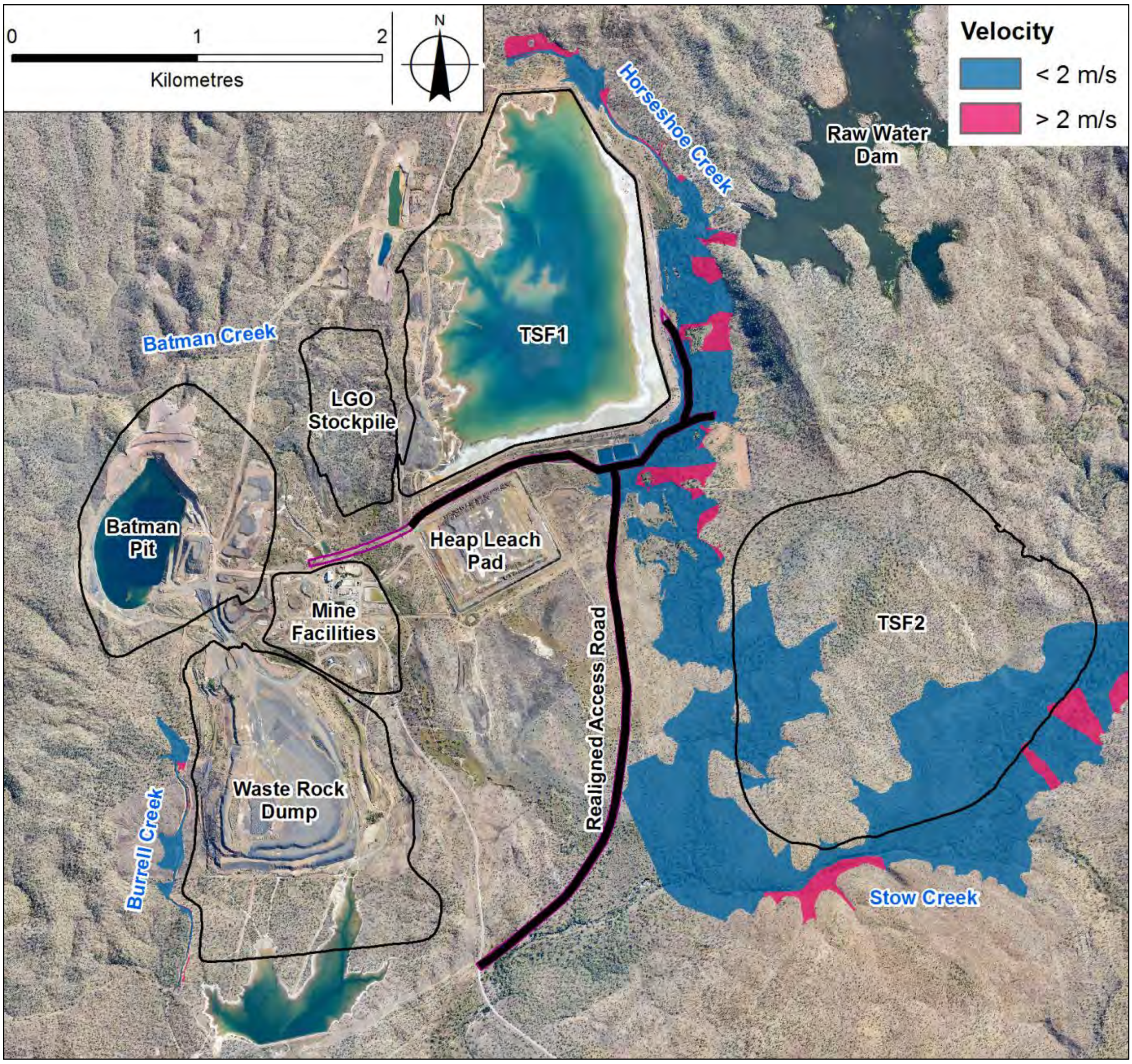


Figure 10-9 Locations of Potential Scour and Erosion

Other Flood Hazards

Flood hazards within the mine site comprise:

- accumulation of direct rainfall in Batman Pit and the HLP creating a pond of potentially contaminated water requiring disposal;
- inundation of Batman Pit and the HLP should the flood levees be breached;
- accumulation of direct rainfall in the TSF's and Equalisation Pond resulting in a breach of embankments and discharge of contaminated water;
- excessive runoff from WRD and LGO stockpiles 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 stockpiles and TSF's possibly resulting in increased sediment loads and a deterioration of downstream water quality;
- erosion of flood levees and increased sediment loads in runoff; and
- localised accumulation of runoff across the site.

Cross Drainage Structures and Haul Roads

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.

Flood modelling shows that existing cross drainage structures on Batman Creek and Horseshoe Creek will be overtopped during the 10-year and 100-year ARI flood events, and a significant length of the road adjacent to the TSF1 will be inundated. 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 unlikely to be a frequent occurrence.

10.3.6 Flood and Stormwater Management Measures

A summary of flood management measures is provided below:

- potential flooding of the pit, process plant area and material storage dumps will be minimised by siting these facilities away from flood inundation areas or through the construction of flood protection barriers/levees around each mine area;
- diversion channels will be designed to minimise channel side slopes to keep maximum velocities below 2.0m/s and channel depths below 2.5m to avoid scouring;
- the new TSF2 will encroach on the 100-year ARI design flood extent. The design includes diversion channels and levees along Horseshoe Creek and Stow Creek to protect the embankment from flooding and erosion. Diversion channels will be 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, with 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;
- WRD construction will include benches to function as stormwater drainages and as access for closure cover installation, reclamation activities and maintenance. Storm water drainage, erosion and sediment controls will be designed and constructed to minimise erosion and channel scour. Stormwater collected on benches will be conveyed to the toe of the WRD through the engineered channel located near the centre of the concave slopes. A surface water collection ditch will be constructed along the down-gradient toe of the WRD. The surface runoff from the reclaimed WRD will be directed to natural drainage lines to separate AMD seepage from the WRD in RP1 from non-contact water;

- upgrading or re-design of existing drains and levees will protect areas of the processing plant against the 100-year ARI flood event along Batman Creek. Bulk earthworks for the process plant have been designed such that there is a mono slope fall from the proposed boundary of the pit toward the existing drainage channel on the east side of the proposed process plant. 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. This will also minimise underground drainage and depth of open drains required on the plant site. Stormwater v-drains will be designed to collect water alongside plant roads and direct them beneath the roads via corrugated steel culverts to prevent scouring of plant roads. All stormwater runoff from within the site will be directed toward the existing drainage channel on the east side of the proposed process plant;
- ROM and additional LGO stockpile will have collection ditches to capture runoff and seepage from stockpiles for conveyance to retention ponds;
- the clay borrow area will have erosion protection and sediment control structures to manage runoff from the low permeability area;
- construction of diversion structures will 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 LGO stockpile 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 WTP. Diversion drains have been constructed around the western and eastern margins of the WRD retention pond to divert uncontaminated runoff away from the pond and thereby reduce the risk of overtopping. Diverted water will flow to local creeks downstream of the pond;
- upgrades to existing stormwater drainage, erosion and sediment controls, including the vegetation of verges, will be designed and constructed to minimise erosion and channel scour. These will minimise damage during less extreme but more frequent storm events; and
- modelling has identified that the section of Batman Creek adjacent to the processing plant is likely to experience high velocity flows during extreme flood events with a subsequent risk of scouring. 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 management procedure for when rainfall events are in excess of water management system design is provided in section 10.1.4.

10.4 Surface Water Contamination

10.4.1 Introduction

This section describes the potential impact and sources of surface water contamination across the site. Mitigation measures for various land use areas are discussed and water treatment options are presented. The operation of the TSF's is also described. The management of chemicals, fuels and oils is discussed in Section 10.5 and the water quality monitoring program is presented in Section 10.6.

10.4.2 Contaminated Water

Potential exposure of sulfide minerals in the mine's waste rock to air and water can result in the liberation of heavy metal ions such as zinc and copper, as well as sulfates. Exposure of these contaminants to the aquatic environment could potentially result in the following adverse effects:

- direct effects to fish through gill exposure to heavy metals, including copper and bioaccumulation through the food chain;
- direct effects to macroinvertebrate populations which could result in the loss of available prey items for fish species; and
- settling of precipitates on stream substrates which can clog interstitial spaces in river bed sediments and restrict availability of habitat to aquatic organisms.

Risks to biodiversity are assessed in Chapter 13, Flora and Vegetation and Chapter 14, Fauna.

Sources of potential contamination include:

- RP1, RP2 and RP5;
- RP3 treated mine water;
- RP7; and
- HLP moat.

Once operations commence, all discharges from site will be via a WTP which will minimise the potential for offsite impact.

10.4.3 Runoff

Spoil dumps may contain contaminated soil that can reduce surface water quality if allowed to discharge into the environment.

Excess water accumulation around the outside of spoil dumps could cause erosion of the dump and release of sediment-laden runoff into natural channels.

Surface water runoff from the plant areas may contain heavy metals and soil that can reduce surface water quality if allowed to discharge to the environment.

10.4.4 Surface Water / Groundwater Interactions

There is potential for surface water / groundwater interactions at the proposed mine site.

Potential anthropogenic groundwater contamination sources at the mine site are the existing TSF1, HLP, LGO stockpile, process plant, unlined earthen surface water diversion drains, pits, WRD and the WRD retention pond, and the proposed TSF2.

10.4.5 Management and Mitigation of Surface Water Contamination

Stormwater Segregation

The potential for contamination of receiving waters will be reduced by segregation of “clean” from “dirty” stormwater runoff and the collection and treatment of “dirty” water runoff within the mine site.

“Dirty” stormwater runoff emanates from disturbed mining areas including the pit and material storage dumps. “Clean” stormwater runoff results from rainfall on undisturbed areas.

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

- Mine Pit

  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 stormwater runoff into the pit by construction of engineered mounds / levees around the pit.

- Material Storage Dump Areas

  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 to 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 Wet Season rainfall events appropriate to their hazard category plus an appropriate freeboard allowance for sedimentation.

- Processing Plant Areas

  Surface water runoff from the plant area may contain 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. Collected runoff will be appropriately treated prior to discharge.

- Undisturbed Areas

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

Water Treatment

Both active and passive water treatment measures are proposed for the Project. The characteristics of the treatment systems are discussed below.

Active Water Treatment

Vista Gold is proposing to build a WTP before the commencement of mining in order to treat future mine waste water.

During operations, water will be managed via a 500m^3/h WTP. Water will be treated for general on-site use and to meet discharge criteria for release to the Edith River or RWD when required. Vista Gold will apply for an appropriate WDL prior to any discharge commencing.

The treatment process is based on lime precipitation conducted in a high-rate solids contact clarifier. Water is pumped from an equalisation pond to the high rate clarifier, where lime is added to increase the pH and ferric chloride is injected to promote coagulation (Figure 10-10). The water is then neutralised and sent through a microfiltration (MF) skid. The MF backwash and all sludges are sent to the TSF for disposal.

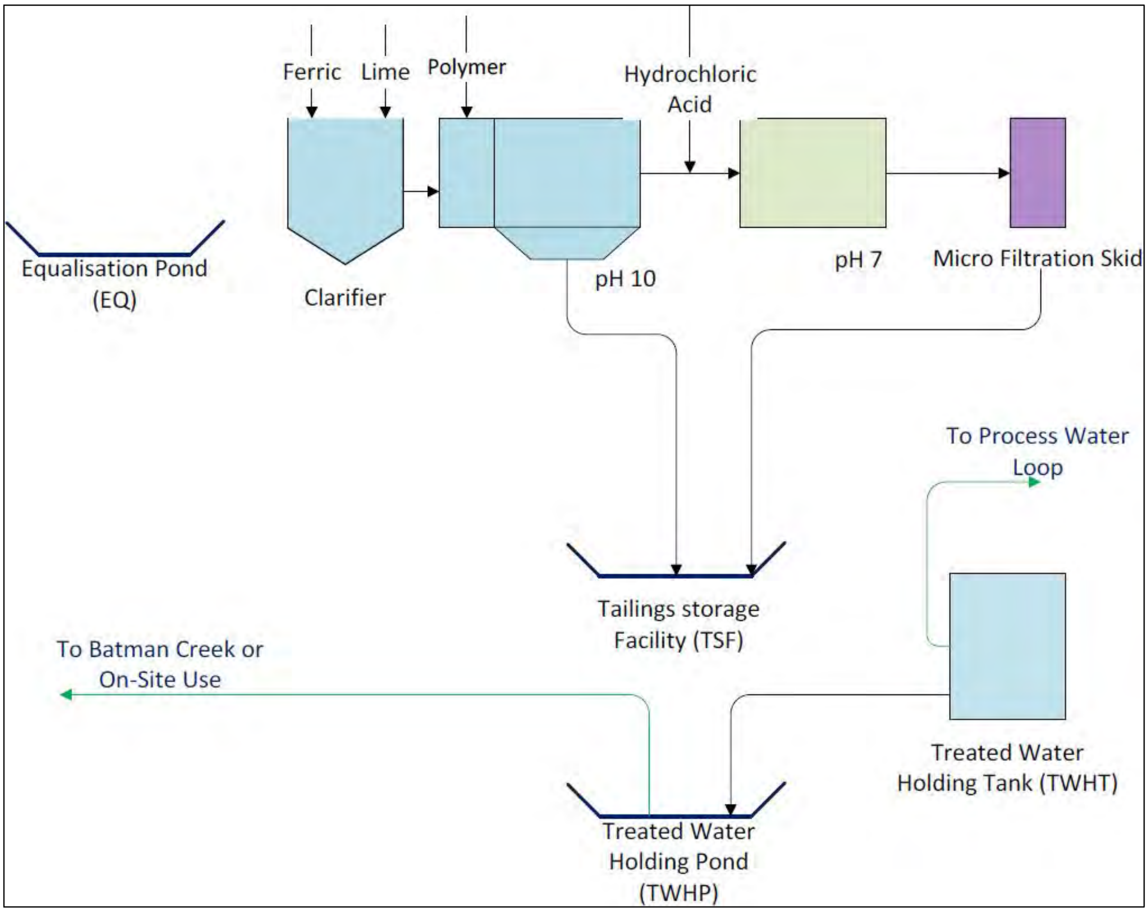


Figure 10-10 WTP Schematic

Some of the treated water (about 1%) will be used as process water for the plant, with the rest sent to a pond for monitoring, and then discharge to Batman Creek or use elsewhere on-site.

The WTP will also treat water for drinking purposes. Potable water (1.7m^3/h) will be treated via filtration, chlorination and ultra violet sterilisation; and stored in a potable water tank.

Waste water from the pre-leach thickener overflow, tailings facility return ponds and equalisation pond will be treated in the new WTP. Treatment will continue until AMD flow and water quality properties are conducive to treatment in passive / semi-passive water treatment systems. During the mine life, approximately 62Mm^3 of AMD flow will be treated in the new WTP.

During the pre-production phase, a lined equalisation pond will be constructed for mixing of AMD from various on-site sources prior to treatment and to temporarily store AMD in case of system upset. A lined sludge disposal cell will also be constructed for the permanent disposal of water treatment sludge.

Passive / Semi-Passive Water Treatment

Vista Gold intends to install passive or semi-passive water treatment on the site. This will treat seepage and runoff from facilities that generate AMD (e.g. RP1) or alkaline but metal-laden water (TSF1 and TSF2). It will become operational after closure of the mine and once flow rates are reduced to levels that make passive treatment viable.

Passive / semi-passive water treatment should:

- eliminate or drastically curtail the costs and continual inputs (e.g. reagents, power, staff) required to operate and maintain the WTP;
- eliminate sludge disposal cell operations and maintenance;
- contain and treat all AMD prior to effluent release; and
- ensure treated AMD complies with the WDL numeric water quality standards.

Passive and semi-passive water treatment systems typically include one or more constructed anaerobic and aerobic wetlands, successive alkalinity producing systems (SAPS), oxic limestone drains, anaerobic limestone drains, sulfate-reducing bacteria bioreactors, aeration and settling basins, waterfalls, permeable reactive barriers as well as other passive treatment methods.

It is estimated that three passive treatment systems (most likely anaerobic wetlands or successive alkalinity producing systems) will be required covering a total area of around 10ha. The three treatment systems are proposed to be staged:

- during operations, AMD flows from TSF1 and HLP will be treated in Passive Treatment System 1;
- following closure, AMD flows from the WRD will be treated in Passive Treatment System 2; and
- post closure AMD flows from TSF2 will be treated in Passive Treatment System 3.

The location and final form of the passive treatment has not yet been determined. It is anticipated that the treatment systems will be designed to substantially reduce contaminants in the AMD and allow the discharge to meet the SSTV prescribed in the WDL. For further information refer to Appendix J.

Sewage Treatment

Sewage treatment will be via either a septic tank system or package treatment plant with water disposal via either irrigation or a lagoon. The facility will cater for the requirements of up to 450 construction personnel and up to 70 operations personnel (remaining 290 operations personnel will be housed offsite). The system will be able to treat 114 litres per minute of effluent. The facility will be licenced by the Department of Health and a WDL will be sought if treated effluent is to be discharged from site.

TSF2

It is proposed that TSF2 will operate as a zero discharge facility with management incorporated into the design in case of mechanical failure and other causes of system overflows or excess drainage. Supernatant process water from the tailings impoundment will be dewatered and returned to the process plant using a pair of skid-mounted electric pumps. Tailings delivery pipelines and the return water pipelines will be installed within specially excavated HDPE lined ditches to provide effective containment of process fluids in case of accidental spills resulting from a breach in the pipelines.

The seepage collection system for TSF2 will consist of a network of underdrains to collect subsurface seepage in the TSF footprint and overdrains to collect tailings pore water drain down. Additionally, toe drains will be installed at the upstream and downstream toes of the stage 1 embankment and will discharge into the over drain seepage collection sump.

A network of French drains with perforated collector pipes will be installed underneath the TSF2 geomembrane liner to collect and convey subsurface seepage emanating from seeps and springs in the TSF footprint. The underdrains will be installed along the natural drainages of the TSF footprint. The water quality of seepage collected in the underdrain seepage collection sump will be monitored regularly and the water discharged directly to natural drainages if its quality meets discharge standards.

It is currently estimated that approximately 10% of the water demand at the process plant (i.e. 40m^3/h during the Dry Season and 80m^3/h during the Wet Season) will be pumped to the water treatment plant equalisation pond from the TSF2 overdrain seepage collection sump.

Overflow from the seepage collection sump under upset conditions such as a mechanical failure of the pumps, will discharge into the adjoining lined seepage overflow collection pond.

10.5 Hazardous Materials

10.5.1 Introduction

The mine will store and use a variety of substances that would be considered harmful to the environment if released. These include chemicals used in processing such as sodium cyanide, caustic soda and hydrochloric acid, explosives and hydrocarbons.

10.5.2 Chemicals and Reagents

Various chemicals and reagents will be stored on site for use in processing. These include cyanide, lead nitrate, sodium hydroxide, flocculant, sodium metabisulfite, hydrochloric acid, activated carbon, fluxes, lead nitrate and quick lime.

All chemicals and reagents will be handled and stored according to the information provided on the MSDSs. This information is required before or upon delivery of substances to site. Site personnel will have access to safety equipment essential for the correct handling of hazardous goods and will be trained in spillage clean-up procedures.

Storage will be a combination of bunded tanks (e.g. sodium metabisulfite, hydrochloric acid, lead nitrate) or dry storage under cover in bulk bags or containers (e.g. fluxes, quicklime, activated carbon).

Cyanide will be transported and handled in accordance with the International Cyanide Management Code. Cyanide will be predominantly delivered to site in bulk isotainers for sparge mixing, however due to the lack of on-site liquid storage, a backup dry solids mixing system will be required which will necessitate the storage of a suitable amount of dry cyanide in boxed form.

10.5.1 Hydrocarbons

Diesel will be stored on-site for mining equipment and owners' vehicles. The current API 650 tank (600kL storage capacity) will store the diesel and distribution will be via a combination of pipelines and fuel trucks. It is planned to have a single diesel storage area close to the heavy equipment workshop. Refuelling facilities will be provided in the heavy vehicle workshop area. It is anticipated that approximately 90,000L of diesel will be used daily. Storage capacity of up to 820,000L will be maintained on-site.

Fuel tanks will be located within bund walls meeting the specifications of AS 1940:2004 - *The storage and handling of flammable and combustible liquids*.

Lubricating oil will be stored in bulk containers inside a bunded area with spill protection.

Waste oil will be stored in a tank within a bunded area to be held for collection by a contractor for reprocessing and recycling.

10.5.2 Explosives Magazines / Depot

The Project will require an explosive storage and handling facility for ANFO. Ammonium nitrate will be stored in sea containers and will be emptied into a hopper / bin for discharge into the explosives mixing truck. The emulsion in gel form will be stored in a self-contained bullet tank and will be pumped into the mixing truck powder magazines. A cap magazine will be built and operated in accordance with Dangerous Goods regulations. Applications for a Magazine Licence or a licence to store dangerous goods will be submitted to the relevant authority before commencing construction of the explosive storage facilities. An average 3,000tpa of explosive will be used.

10.6 Water Quality Monitoring

10.6.1 Waste Discharge Licence

Vista Gold received an updated WDL (WDL 178-2) from the NT EPA in February 2013 (available online: http://www.ntepa.nt.gov.au/news/2013/vista-gold-wdl). The licence outlines environmental requirements for the discharge of treated wastewater from RP3 into the Edith River, and from the RP7 and RP1 siphons. RP1 has been the largest contributor of mine water to the receiving environment by volume to date with no adverse impacts detected.

A Discharge Plan (GHD 2013) has been developed by Vista Gold to address the requirements of WDL 178-2.

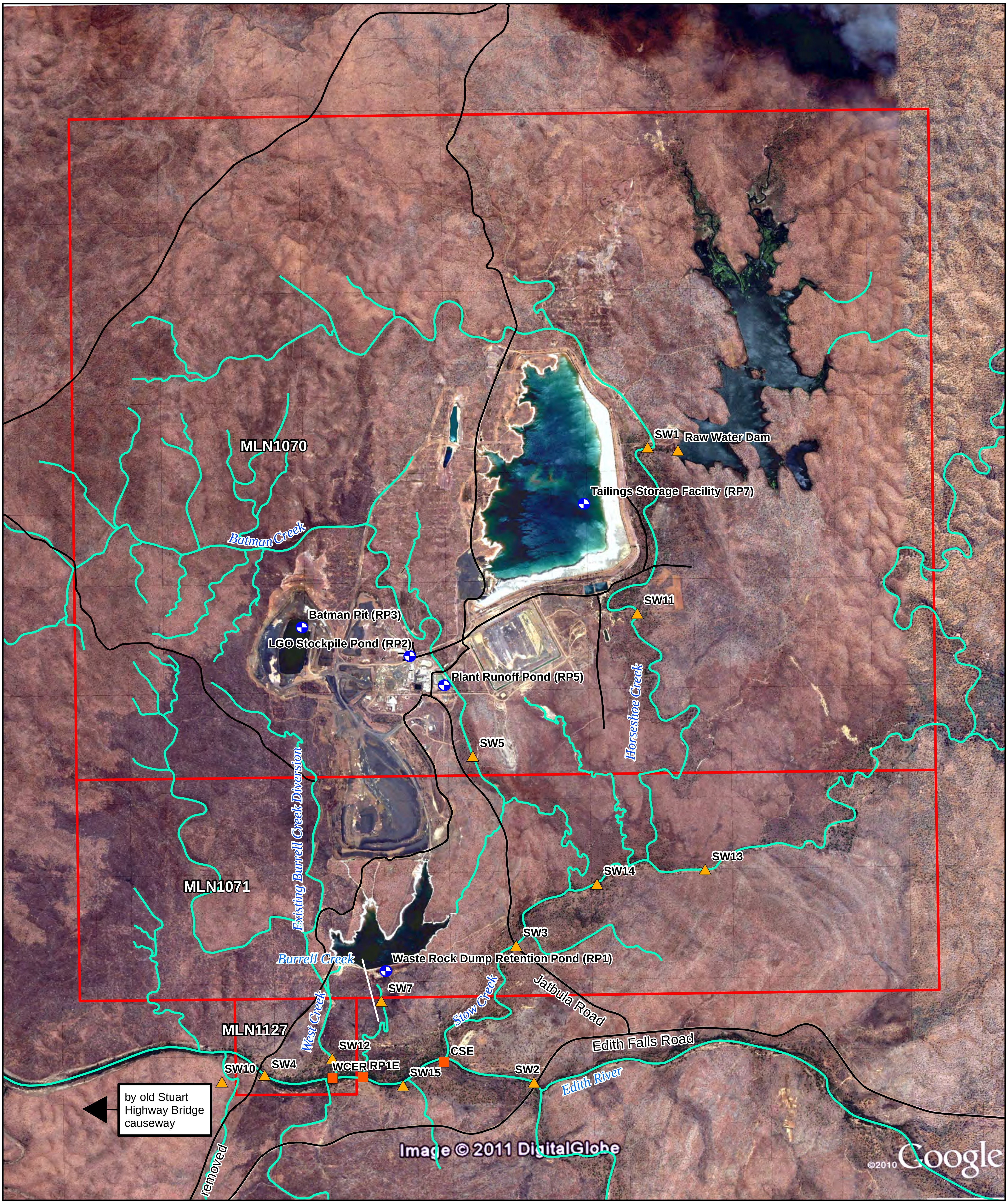
10.6.2 Surface Water Monitoring Program

A program has been developed to address the requirements for surface water monitoring in WDL 178-2. The requirement is outlined in Sections 19, 20, 21 and Appendix 1 of the licence. Sixteen sites have been identified to provide an understanding of water quality in creeks surrounding the mine site (Figure 10-11). The monitoring program has been developed with this in mind, including a suite of parameters chosen to detect the presence and potential effects of AMD and mine associated contaminants on the aquatic ecosystem.

To assess if any chemicals stored on-site (current or future) are entering surface waters, additional analytes have been included into the proposed surface water monitoring program. Nitrate and nitrite have been included on the list of analytes to assess if ANFO is entering the waterways from blasting. Total petroleum hydrocarbons have also been included on the list of analytes to assess if diesel is entering the surface waters. WAD cyanide has also been included in the proposed monitoring program to identify if this contaminant is entering the waterways.

Water quality data will be analysed in conjunction with biological and ecotoxicological studies conducted routinely to provide a weight of evidence approach for assessing the impacts of the Mt Todd mine discharge on aquatic populations in the Edith River.

Appendix J provides more information on the proposed surface water monitoring program.



LEGEND

- Impoundment Sampling Location
- Access Roads
- Mine to Edith River discharge point
- Waterways
- Surface Water Sampling Station
- Mt Todd Mining Leases

0 250 500 750 1,000
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 53

N

Vista Gold Australia Pty Ltd
Mt Todd Gold Project

Job Number	43-21801
Revision	0
Date	07 Jun 2013

Location of Surface Water Sampling

Figure 10-11

G:\43\21801\GIS\Maps 30000 TPA\EIS\SurfaceWater\4321801_807E.mxd

66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com.au

Data source: Google - Imagery (Date extracted: 28/03/2011). NRETAS - Mining Leases (2011). GHD - Sampling Sites, Access Roads, Waterways (2012). Created by: CM

Sampling Parameters

Table 10-8 outlines the parameters to be monitored for each site mentioned above.

Sampling is proposed to be undertaken daily during the Wet Season and prior to the start of the Wet Season to capture metal levels that will indicate if any discharges (controlled or uncontrolled) from the mine site occur. The limited time available to sample surface water each year requires a higher frequency of sampling than is usual for monitoring programs of this type. A monthly sampling event is also proposed to capture annual variations.

Table 10-8 Parameters to be Monitored Monthly

	Parameter
In situ	Flow
	Dissolved Oxygen
	Temperature
	Electrical Conductivity
	pH
Laboratory	Total Suspended Solids
	Total Dissolved Solids at 180° C
	Total Dissolved Salts
	Unfiltered Alkalinity, bicarbonate, carbonate
	Major cations: Na, K, Ca, Mg
	Major anions: Cl, SO_4
	Nitrate and Nitrite
	Hardness
	Cyanide-WAD
	TPH
	Dissolved Metals (45µm) (Al, As (III & V), Cd, Co, Cu, Cr (III & VI), Fe (II & III), Pb, Mg, Mn, Hg, Ni, U, Zn)
	Total Metals (Al, As, Cd, Co, Cu, Cr, Fe, Pb, Mg, Mn, Hg, Ni, U, Zn)

Review of Monitoring Program

As specified in WDL 178-2, an annual report including interpretation of all monitoring data is required as a condition of the licence. The report will include all surface water, biological and sediment monitoring results and interpretation.

The data from the monitoring program will be reviewed on a monthly basis and the requirements for modifying the sampling programs will be assessed. There is potential to reduce the number of sampling sites if monitoring is showing that the mine is not resulting in contaminants being released to the environment. There is also potential to reduce the number of analytes if analytes are consistently below detection limits. Future sampling intensity may also be reduced depending on results obtained.