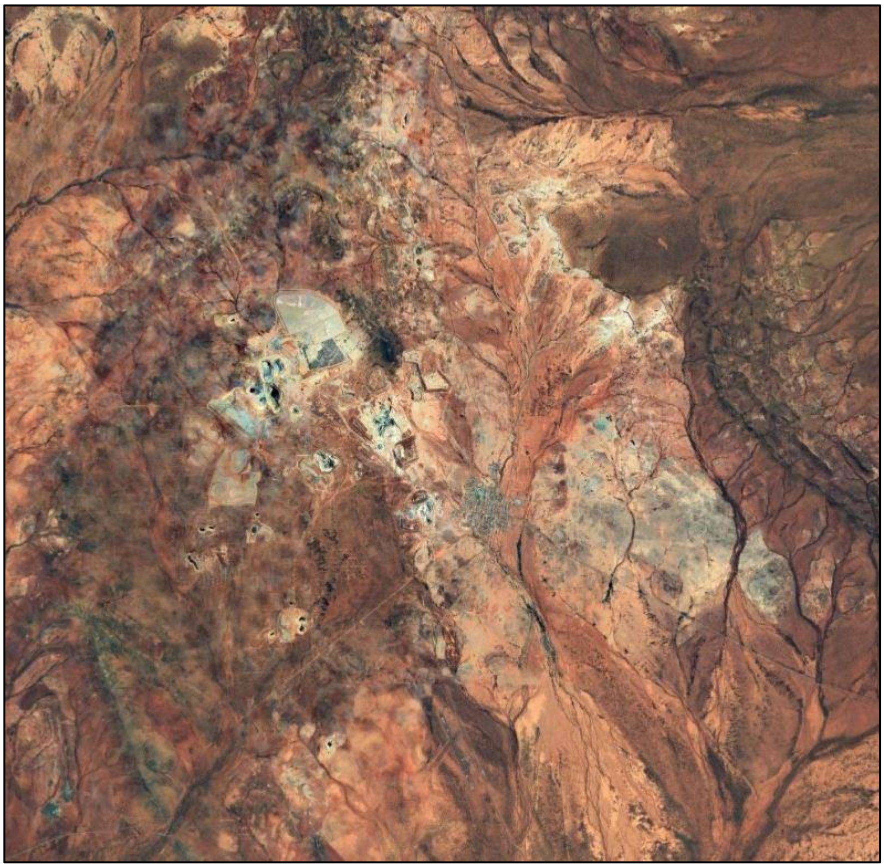
Mt Magnet Gold
Stormwater Management Plan
Revision 3 – December 2020



Mt Magnet 2017

Prepared for:

Mt Magnet Gold Pty Ltd

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December 2020

MWES Hydrological Services

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Document Control

Version	Date	Author	Reviewer
Version 1	5/11/2020	Gary Meyer	
Version 2	9/12/2020	Gary Meyer	Keith Berry

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Glossary

Abbreviations used in this document:

- AEP – Annual Exceedance Probability
- ARI – Average Recurrence Interval
- BoM – Bureau of Meteorology
- CTSF – Checker Tailings Storage Facility
- DER – Department of Environment Regulation (now DWER)
- DoW – Department of Water (now DWER)
- DWER – Department of Water & Environmental Regulation
- MMG – Mt Magnet Gold Pty Ltd
- MWES – MWES Consulting
- PMP – Probable Maximum Precipitation
- SRT – Swan River Trust
- SWMP – Stormwater Management Plan
- TSF – Tailings Storage Facility
- WRD – Waste Rock Dump
- WTH – Water Tank Hill

Management Plan Recommendations

The recommendations arising from the creation of this SWMP include the following:

- Emergency Response Plan: The MMG whole Emergency Response Plan should include:
    - Monitoring of weather forecasts.
    - Monitoring of conditions at surface, in pits and underground.
    - Responses to high rainfall and flooding events.
    - Triggers for evacuation of active work areas if necessary.
- Routine and event based (prior during and after intense rainfall and runoff) inspection of key stormwater structures such as bund walls, diversion drains, floodway road crossings and culverts.
- SWMP to be reviewed triennially or following major changes to site infrastructure or management approaches. Additionally, an annual review of the implementations and Management Actions should be undertaken and could coincide with the DoW water licence year.

1. Introduction

Mt Magnet Gold Pty Ltd (MMG) own and operate the Checker Gold Plant and satellite mining operations near Mount Magnet, Western Australia. MMG is a subsidiary of ASX listed company Ramelius Resources Ltd. The Mt Magnet area has been mined by a sequence of operators on an almost continuous basis since the 1890s over which time development of the town and mining operations have remained intimately linked. MMG have operated continuously since September 2011 following three years of care and maintenance.

The main areas of recent operations Include the Checker Plant and Tailings Storage Facility (TSF), and the Galaxy, Cosmos, Eridanus, Morning Star and St George/ Hill60 mining areas (Figures 1 & 2):

- **Galaxy** The cluster of pits is currently inactive. Was subject to extensive expansion in 2011-2018. There are potential further cut-backs at Vegas and Brown Hill. The upstream Brown Hill Pit continues to receive stormwater input as part of the Plant water supply system.
- **Cosmos** Active mines include the Stellar Pit and the Shannon Underground. Stellar West Pit is used for stormwater harvest and as a transfer pit for sub-potable water supply.
- **Eridanus** Currently the main source of ore from Mt Magnet, a large new pit currently under Stage 2 cutback, which has enveloped the adjacent Lone Pine Pit. Dewatering discharge is used in the Plant water supply via the Franks Tower transfer pit.
- **Morning Star** the Pit has not been mined in recent years and there is a large potential cutback, Pit is proposed. Groundwater is currently pumped to Plant via the Ruby Queen transfer pit from a historical vent shaft.
- **St George**. The active Water Tank Hill and Hill 60 underground mines are accessed via St George. All mine dewatering discharge is returned to the Checker Plant via the Ruby Queen.

This Stormwater Management Plan (SWMP) supercedes previous versions (MWES 2017b, MWES 2019b). It has been prepared primarily to provide background to management of stormwater, including catchments, drainage channels, bunds, weirs, culverts, monitoring devices and water diversions. It is not intended to be a complete technical design document for these structures or a risk assessment but is a guide to the management of the current and proposed surface water infrastructure. It provides proposed surface water management practices and actions. Changes in mining operational decisions may occur at any stage and this may have impact upon the SWMP and its contents.

The SWMP provides the framework and context to other management documents, and it may be incorporated into any other operational, safety and environmental plans across the mining area. The SWMP provides general recommendations on how these existing or new site-wide documents may be expanded to include management of water resources, protection of the water environment and protection of other water users.

Figure 1: Mining Operations and Drainage at Mt Magnet

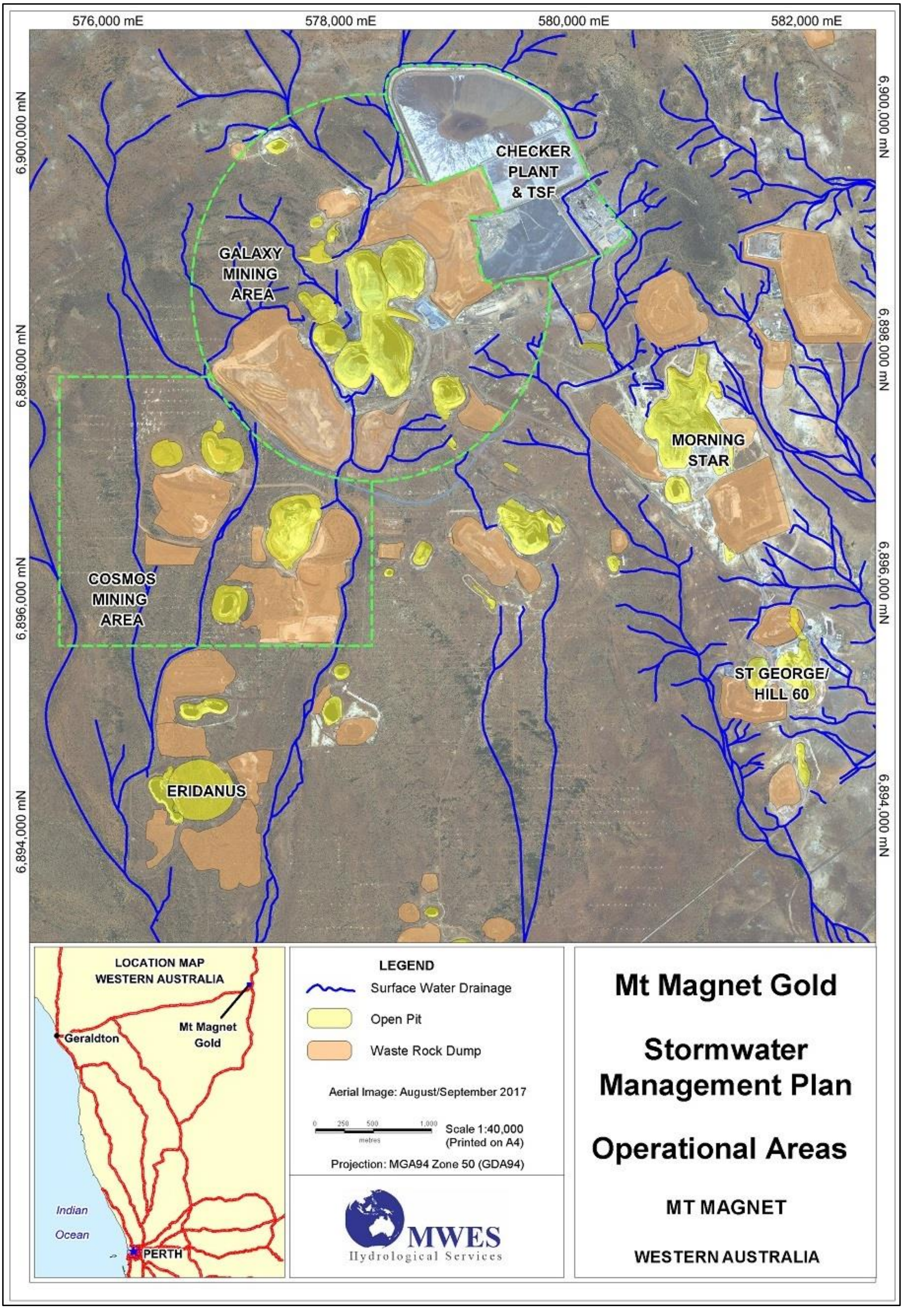


Figure 2: Western Catchment Area with Aerial Image

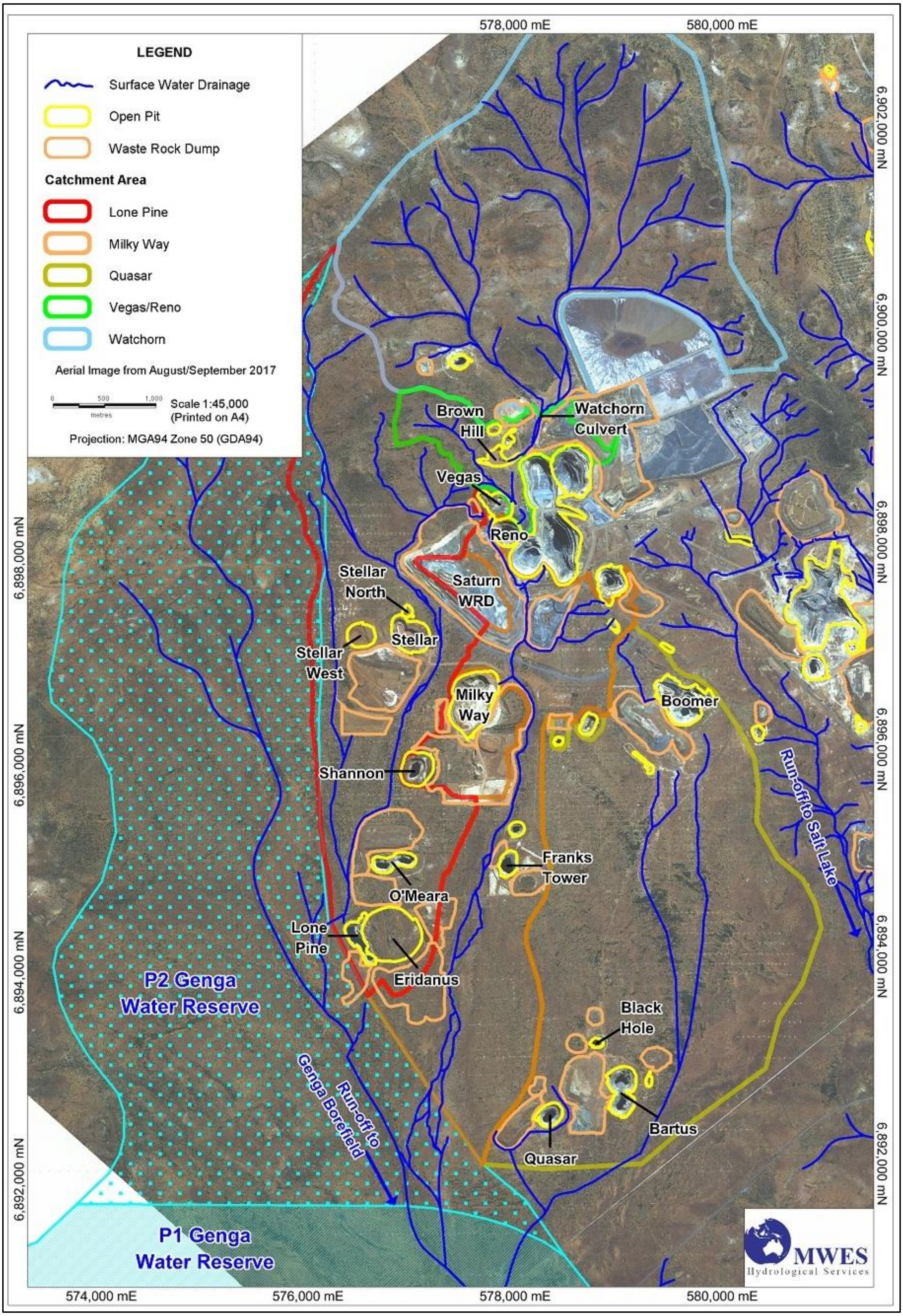
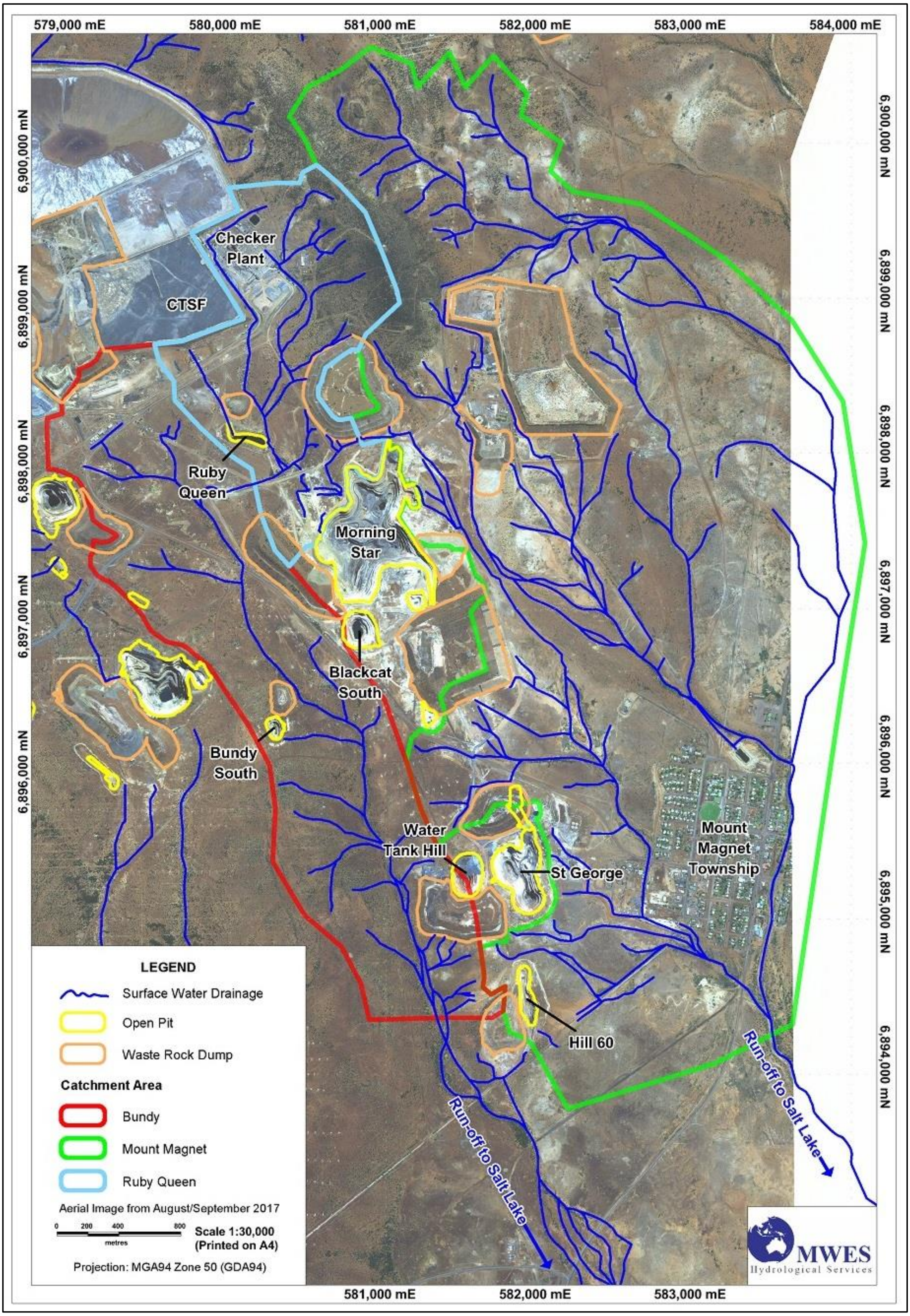


Figure 3: Eastern Catchment Area with Aerial Image



1.1. Location

Mt Magnet is located 330 km east of Geraldton in the uppermost headwaters of the internally draining Salt River catchment and immediately south of the southeast corner of the Murchison River catchment. Two main catchments that cover operations at Mt Magnet:

- The western catchment area includes Lone Pine, Milky Way, Quasar, Vegas/ Reno and Watchorn (Figure 2).
- The eastern catchment area includes Bundy, Mount Magnet and Ruby Queen (Figure 3).

1.2. Hydrological Interventions and Associated Studies

Substantial mining-related surface disturbance started with the advent of large scale open-pit mining in the 1980’s. Surface water intervention has been driven by requirements to prevent stormwater ingress to mines and to harvest stormwater run-off as a water source. The town water supply, Genga Borefield aquifer, is located downstream of the western catchment and is considered a potential environmental receptor.

The upper reaches of Boogardie Creek were diverted in several places throughout 1985 to 2001 due to operations at the Galaxy complex of mines. Lake Watchorn was formed in 1985 by damming Boogardie Creek upstream (north) of Galaxy. Eleven years later, the Mines Department declared the Lake a safety and environmental hazard and ordered it drained. The upper catchment stormwater was then routed to the nearby disused Brown Hill Pit which became, and remains, part of the Checker Plant water supply.

A western stormwater diversion around Galaxy was designed (Pennington Scott 2010) but not implemented and is considered unnecessary and impractical. Minor residual flow from the north has at times been diverted into the Milky Way Pit. From 2000-2017 the disused Stellar Pit was used to harvest stormwater. Lone Pine Pit was also used for stormwater harvesting from 2005.

A hydrological assessment of the water balance upstream of the Genga Borefield was completed by MWES (2015). A site-wide water balance was generated, including calibration of storage (water level) against groundwater and surface water fluxes for each pit over a 15 year record. The calibration determined long term average catchment yield (based on daily initial and ongoing rainfall losses), groundwater inflow as a function of pit water level and pit lake evaporation as a function of lake area.

The main objectives of the hydrological assessment were to:

- Assess the potential for contaminated runoff to reach the Genga Borefield.
- Determine the impact of stormwater diversions on catchment yield.
- Determine post-closure pit lake water levels and show they remain groundwater sinks after closure.
- Evaluate risks to the environment caused by any groundwater flow from pits.
- Provide a basis for impacts assessment of further mine planning.

This report concluded that mining disturbances including stormwater harvesting in parts of the catchment had not impacted water quality or resource quantity at the Genga Borefield.

Following MWES (2015), a stream water sampling device and flow gauge were installed between the Milky Way Pit and the Saturn Waste Rock Dump (WRD). Hydrographs from the gauge allowed the runoff characteristics of the upstream catchment to be determined with more accuracy. A report on installation of measurement equipment and the latest chemistry and flow rate data is included in Appendix A.

The site-wide water balance was formalised as a GOLDSIM model and updates reports dated March 2017 and December 2019 (MWES 2017c, 2019c). Those revisions resulted in recalibration and adjustment of pit-groundwater flux rates and runoff parameters. Updated results continue to support the conclusion of no significant mining related impacts on the Genga Borefield.
Other relevant reports from the western catchment area are listed below:

- Study of peak flows within the main drain area at Galaxy (MWES 2016a).
- Mining proposals for the Multi-Pit Mining Project – since sub-divided into the Galaxy and Cosmos mining areas (MWES 2017a).
- Water management at the Saturn WRD (MWES 2018a).
- Hydrology assessment of the planned cutback at the Morning Star Pit (MWES 2018c).
- Hydrogeology and hydrology of the Eridanus project (MWES 2018d & e, MWES, 2020).
- Stormwater harvesting to the O'Meara and Stellar West pits (MWES 2019).
- Stellar Pit Cut Back Mining Proposal Hydrology (MWES, 2019d)

Less hydrology assessment has been undertaken in the eastern catchment area, where no clear environmental receptors are present. Relevant new and historical reports from the eastern catchment area are listed below:

- Water impacts assessments for the St George/ WTH Underground project (MWES 2016b).
- Hydrology assessment for the redevelopment of the Hill 60 Mine (MWES 2018b).
- Hydrology assessment of a planned cutback of the Morning Star Pit (MWES 2018c).

1.3. Catchment Descriptions

The two main catchment areas comprise several sub-catchments:

The **Western Catchment Area** encompasses disturbed portions of Boogardie Creek system upstream of the Genga Borefield. The pre-development area is about 39 km^2, with mines and waste rock dumps being permanent excisions from the catchment area. (Figure 4) Note that the western limit does not precisely align with the Genga Borefield P2 protection area - presumably the later was drawn using lower accuracy ground elevation control. Sub-catchments include:

- **Watchorn Catchment.** Stormwater flows from the less disturbed, steeper and more efficient northern area have been retained since 1985. Currently the flows are harvested to the Brown Hill Pit. Re-routing to other Galaxy Pits may be dictated by potential future mine expansions. The

Galaxy Pits will permanently receive this flow and have a very large excess volumetric of storage capacity for that inflow.

- **Vegas/ Reno Catchment** A small sub-catchment including extensive disturbed areas. Drainage may require particular consideration if Galaxy Pits are cut-back. In the long term and at closure the area will be amalgamated with the Watchorn Catchment as a permanent part of the Galaxy pit lakes catchment.
- **Lone Pine Catchment** Includes two south-draining tributaries with long, relatively steep courses which can generate significant peak flows. (Note that the two creeklines are very close at one point and the larger eastern creek could there be routed away from the mining area). The creek floodplains intersect the footprint of the of Stellar, Shannon and Eridanus mine landforms and the Saturn West WRD. Stellar West and Lone Pine pits were previously used for stormwater harvesting from these creeks.
- **Milky Way Catchment** The detached southern portion of the Watchorn catchment, isolated from headwaters by the Galaxy pits. A single creekline drains south past the Milky Way and Franks Tower pits. The residual catchment area is small and flat. Minor runoff from the residual catchment has been historically harvested to the Milky Way Pit (MWES 2017a).
- **Quasar Catchment** Rises in low country at the centre of the basin. It has low surface gradients and is largely undisturbed. Includes the Boomer Pit and several smaller pits with relatively little impact of mining disturbance on surface water flow paths.

The sub-catchments drain south through the P2 Genga Water Reserve onto the P1 Genga Water Reserve catchment/ classification area further south. This area defines the Genga Borefield, the main water supply to the town of Mount Magnet.

The **Eastern Catchment Area** as shown in Figure 5 has an area of about 23km^2, including major mining areas subsequently excised from the catchment: Morning Star/Blackcat South/St George/ WTH. Those major mining areas are located along a low NNW trending ridge and therefore have little interaction with the natural stormwater drainage system landforms. Main drainage is to the south-southeast and terminates at 20 kms distant. Sub-catchments delineated for this report include:

- **Ruby Queen Catchment** Drainage from the west slopes of the prominent Mt Warramboo flows toward the Plant and TSF and is diverted south. These flows have long been harvested at the Ruby Queen pit/staging pond. A minor catchment component south of Ruby Queen, terminates against the Morning Star Pit (MWES 2018c).
- **Mount Magnet Catchment.** Includes mostly historical mining disturbances, including the decommissioned Black Cat Plant and tailings dam. The east and south slopes of Mt Warramboo drain through Mt Magnet township. The current Morning Star expansion plan involves an eastern WRD expansion for which design drainage arrangements are in place (MWES, 2018c) .The remaining mines on this alignment are located on slightly elevated ground and have little interaction with surface drainage
- **Bundy Catchment** Rises in low country at the centre of the basin with low surface gradients. Drains SSE via a single creekline, the catchment area is mostly undisturbed.

Figure 4: Western Catchment Area with Sub-Catchment Areas

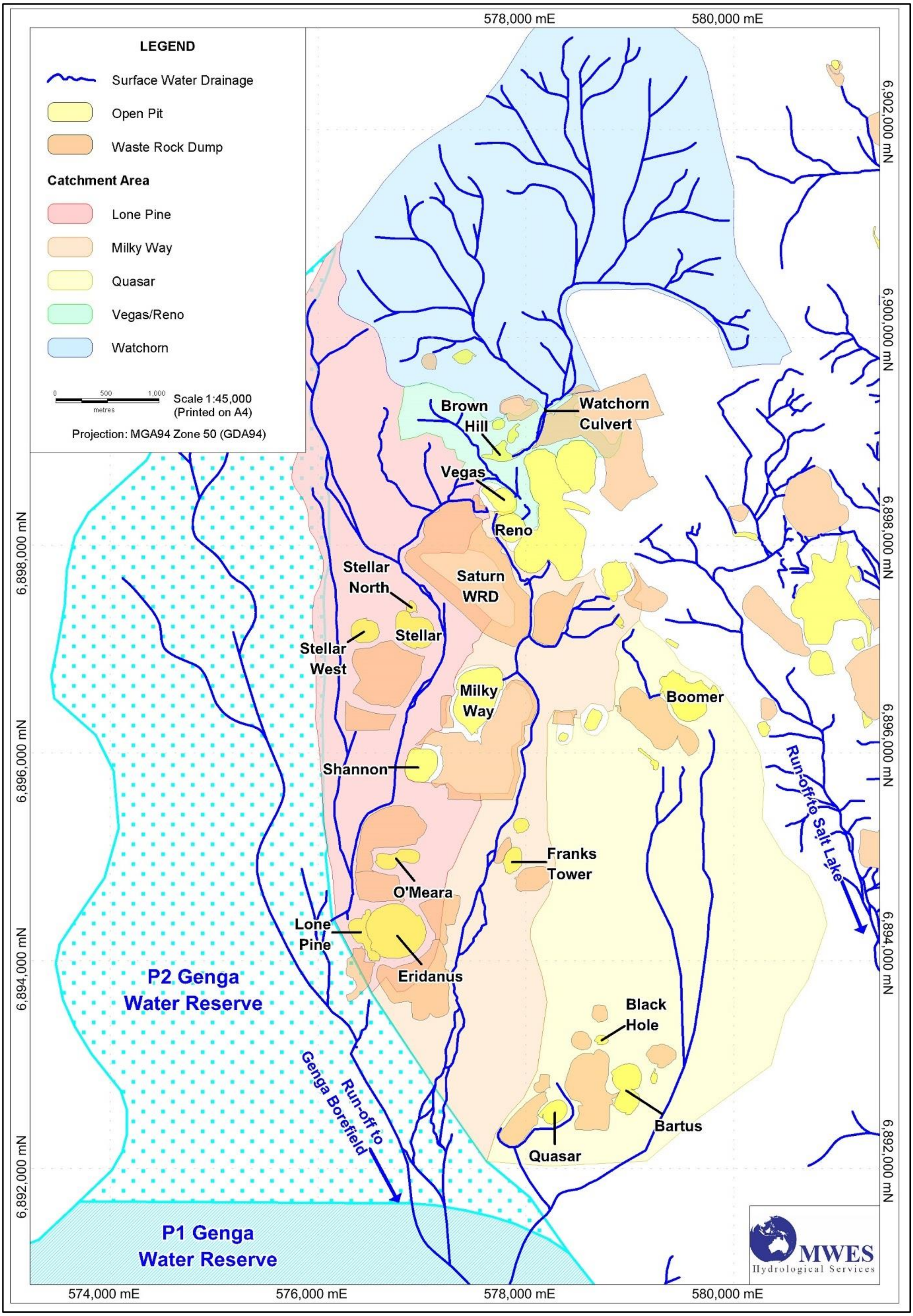
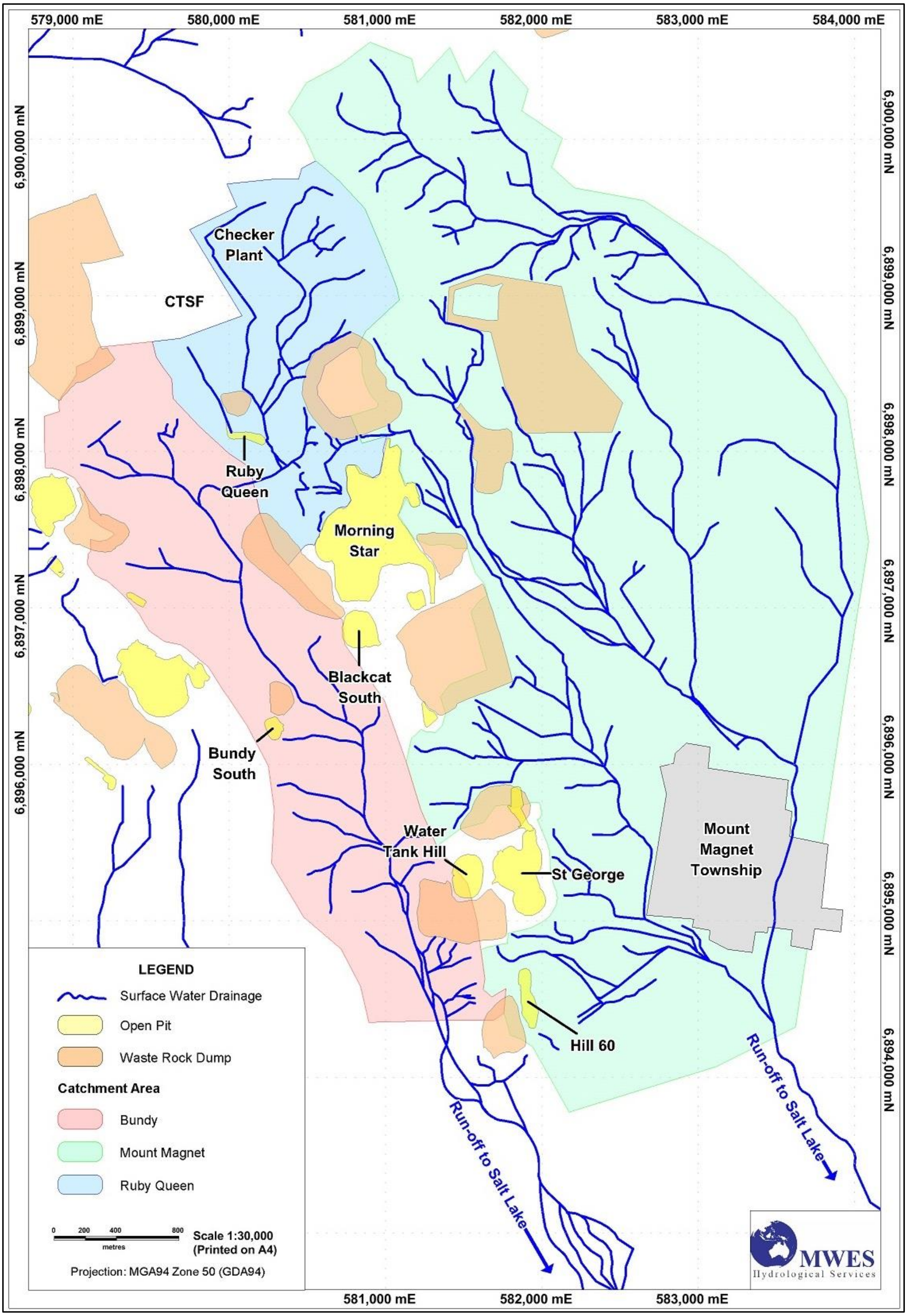


Figure 5: Eastern Catchment Area with Sub-Catchment Areas



1.4. Plan Scope, Objectives and Exclusions

The scope of the SWMP is to provide background to management and impacts assessment for stormwater and related infrastructure. The plan also defines actions and contingency measures. This document lists the organisational procedures and controls in place. All information presented in this document uses existing data, the current mining configuration and conceptualised and proposed operations, and may change depending on alterations to the current or planned mining designs, operations, schedules and closure plans.

Specific objectives included in or supported by the SWMP include:

- Support procedures and contingency plans in case of major cyclonic rainfall events including the Emergency Response Plan.
- Background for design and management to reduce safety, community, and environmental risks in the catchment area and beyond.
- Define baseline conditions and if necessary incorporate management actions if impacts deviate from accepted tolerances.
- Support water-related training, communication, and awareness for relevant staff and contractors.
- Specify any requirements for surface water monitoring equipment.
- Identify and assess suitable opportunities to harvest stormwater in disused pits and to utilise the water for mining and milling operations.
- Reduce drainage issues e.g. flood risk, build-up of stagnant water, algal blooms, mosquito breeding, erosion/sedimentation.
- Efficient stormwater related expenditure budgetary spending
- Assist mine planning and the mine approval processes.

Specifically excluded from the SWMP is management of the tailings storage facility (TSF), in particular issues of freeboard and geotechnical integrity.

1.5. Legislation & Licensing

Relevant legislation relating to the governance of surface water management in Western Australia is provided in the list below. All MMG staff and contractors are required by law to comply with the applicable State and Commonwealth environmental regulations.

- *Mining Act*
- *Rights in Water and Irrigation Act 1914*
- *Country Areas Water Supply Act 1947*
- *Environmental Protection Act 1986*
- *Environment Protection and Biodiversity Conservation Act 1999*

Surface works are undertaken on a mining lease or a miscellaneous licence. Specific projects are subject to DMIRS Mining Proposal approval. These may result in operational conditions stated in the EPA Pollution Control Licence administered by the Department of Water and Environment Regulation (DWER).

1.6. Plan Context

The SWMP integrates into the management of the MMG operations, and can be considered part of the following current management documents:

- Environmental Management Plan
- Groundwater Operating Strategy
- Mine Closure Plan

1.7. Plan Approach

Development of this SWMP occurred through the culmination of historical and current data from across the MMG site. Historical data has been collected and analysed in numerous ways including graphs, maps, formulae, water balance and conceptual modelling. This SWMP was developed in accordance with guidelines suggested in Chapter 5 of the Department of Water's *Stormwater Management Manual for Western Australia* (DoW and SRT 2007).

2. Existing Land Use

Land use within the boundary of the SWMP is generally current mining operations or historical mining infrastructure. Mining landforms include open pits, waste rock dumps, stockpiles, roads and other hard-stand areas. More or less large portions of uncleared land are not necessarily undisturbed, having been subject to pastoral and mine exploration activities. Specifically, within each catchment the division of land use is as follows:

Western Catchment Area:

- **Watchorn Catchment:** mostly uncleared land and the former Lake Watchorn, now drained and used only as a detention basin, minor historical mining disturbance.
- **Vegas/ Reno Catchment:** current mining infrastructure and proposed new mining. A small western undisturbed catchment area drains into the area.
- **Lone Pine Catchment**: Mostly undisturbed with minor component of current and historical mining.
- **Milky Way Catchment**: current mining, with mining infrastructure and large areas of uncleared land.
- **Quasar Catchment**: historical mining only with large majority uncleared land.
-

Eastern Catchment Area:

- **Ruby Queen Catchment:** Includes the CTSF and the Checker gold plant and power station. Outside these features, there has been negligible clearing.
- **Bundy Catchment**: Minor historical mining, mostly uncleared land.
- **Mount Magnet Catchment**: Includes the Mt Magnet township and surrounding significant historical mining, mainly small pits and underground mines. Particularly includes the historical Blackcat TSF and the Morning Star eastern WRD.

3. Catchment Characteristics

3.1. Climate

Rainfall data has been recorded by the Bureau of Meteorology (BoM) at the Mount Magnet Airport since 1995. Average monthly evaporation was determined from gridded values provided by the BoM (Table 1).

Table 1: Monthly Rainfall & Evaporation

Month	Mean Rainfall (mm) Years 1995-2020	Class-A Pan Evaporation (mm)
Jan	25.8	424
Feb	35.4	349
Mar	35.3	308
Apr	18.2	200
May	15.5	135
Jun	21.6	87
Jul	26.6	92
Aug	16.3	116
Sep	9.3	179
Oct	7.0	270
Nov	11.7	331
Dec	19.5	394
Annual	**251.2**	**2885**

Rainfall patterns are highly variable, with averages masking large variations from year to year. Most rainfall typically occurs in the first half of the year, with peaks in February-March and June-July. Evaporation is more consistent from year to year and more strongly seasonal, with very high rates in the summer months.

BoM point rainfall data are aggregated and gridded by the Queensland Dept of Environment and Science and are available via the SILO web portal. The data for the nearby grid point were downloaded and revealed the following statistics for the period of Mt Magnet Gold operation (2011 to present):

- High annual total in 2011 of 452 mm
- 2012-2018 near average annual totals
- Drought commencing July 2019 with a total deficit of 200 mm since then
- An absence of extreme rainfall intensity (24+ duration) over the entire period
- Maximum 24 hour total 44 mm in December 2011
- Maximum 24 hour total in past 5 years 27 mm in March 2016

3.2. Rainfall Intensity-Frequency-Duration

Rainfall intensity frequency duration (IFD) statistics were obtained from the BoM website (issued December 2018 for nearest grid cell 28.0125° S, 117.8125° E). Those statistics are summarised as rainfall totals for various probabilities and durations (Figures 6, 7 and Table 2).

Flood forecasting and management involves peak runoff flow rates determined using rainfall intensity at critical time (duration) which is controlled by catchment size, shape and gradient. For Mt Magnet Operations sites, critical time is mostly in the range 30 minutes to two hours. Management of storage and freeboard involves total rainfall depth over longer periods. Rainfall total curves asymptote's to stable values for durations of about 4 days or more.

Selection of appropriate frequency in is highly context dependent, in particular the life-span and risks being controlled. The 1% AEP (1:100 year average recurrence interval) value was traditionally common, however considering climate changed imposed variations, 1:1000 year ARI may be applicable to high exposure and/or permanent structures.

From an operational readiness point of view, note that the largest 24-hour total in the past 5 years (27 mm) is less than the 1:10 year ARI (10% AEP) total for a 1-hour duration event.

Figure 6: BoM Design Rainfall Depth for Mt Magnet

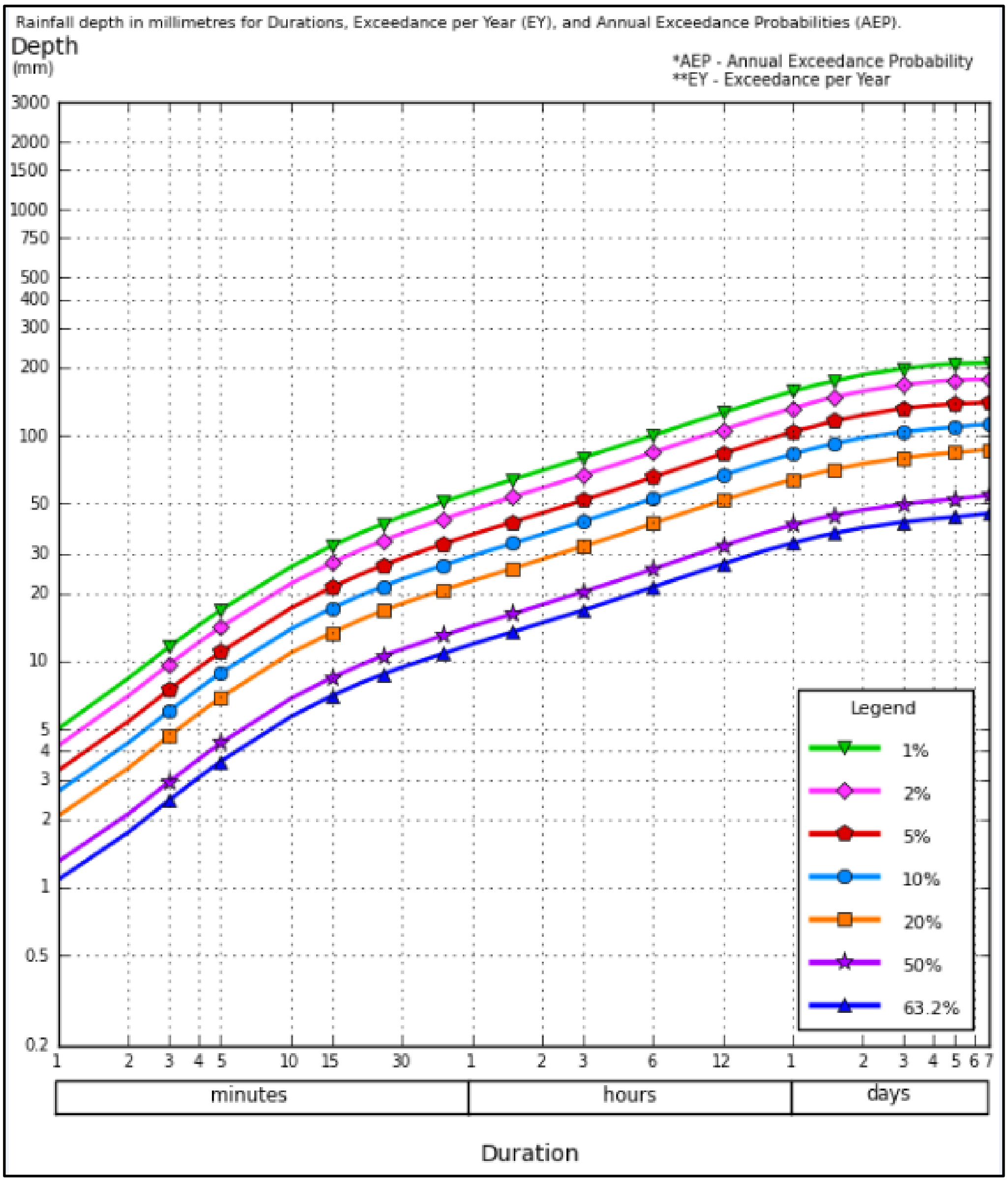


Figure 7: BoM Rare Design Rainfall Depth for Mt Magnet

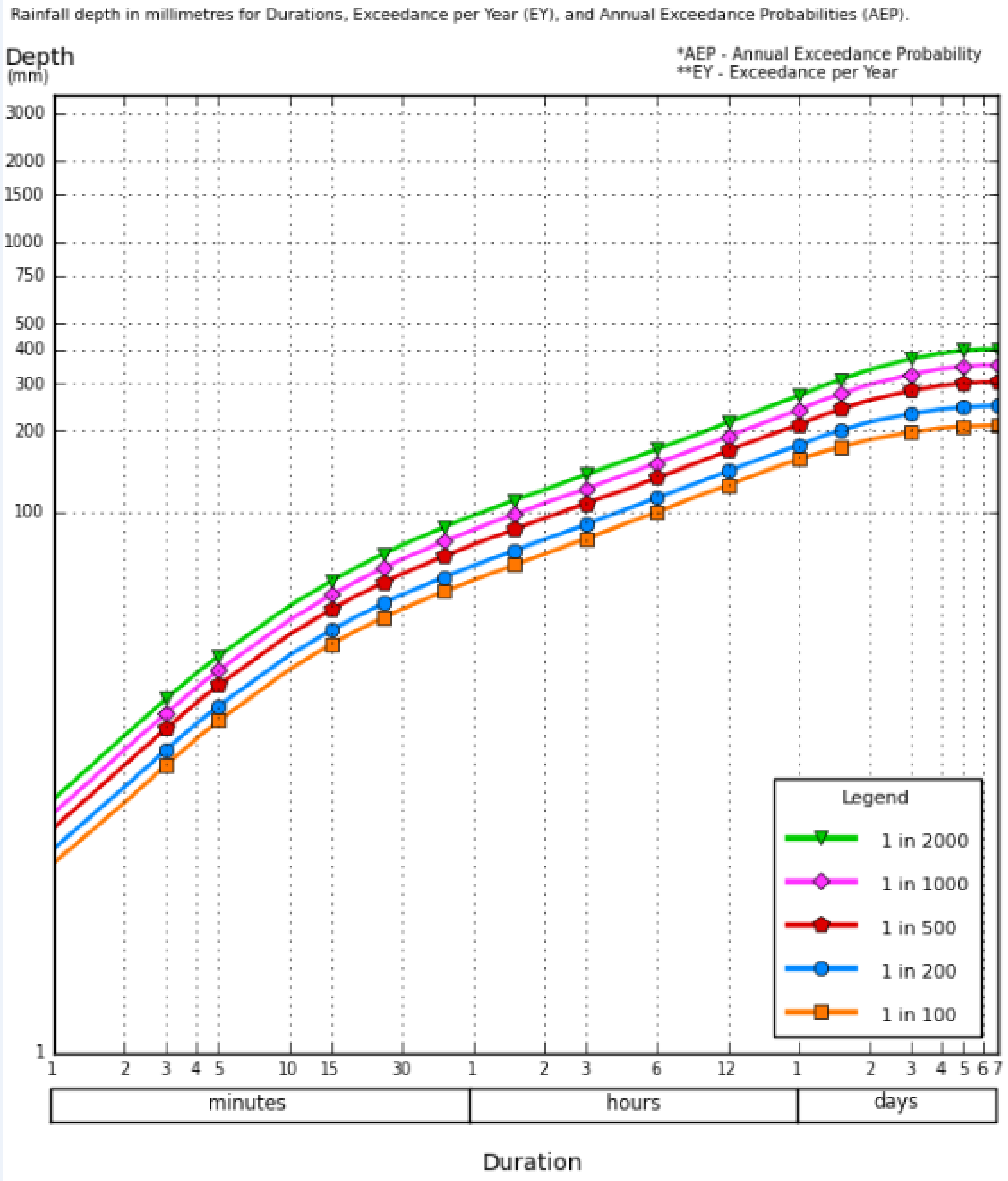


Table 2: Design Rainfall Depth, Duration and Frequency

	Annual Exceedance Probability (AEP)				
Duration	**20%**	**10%**	**5%**	**1%**	**1 in 1000**
10 min	10.9	13.9	17.2	26.2	39.9
15 min	13.4	17.2	21.3	32.5	49.4
20 min	15.3	19.6	24.3	37.1	56.5
25 min	16.8	21.5	26.7	40.7	62.2
30 min	18	23.1	28.6	43.8	67
45 min	20.7	26.6	33.1	50.8	78
1 hour	22.7	29.3	36.4	56	86.1
1.5 hour	25.8	33.3	41.4	63.9	98.3
2 hour	28.3	36.5	45.3	70	108
3 hour	32.3	41.6	51.6	79.8	122
4.5 hour	36.9	47.6	59.1	91.1	139

6 hour	40.8	52.5	65.3	100	152
9 hour	46.9	60.4	75.2	115	173
12 hour	51.7	66.7	83.1	126	191
18 hour	58.8	76.1	95	144	218
24 hour	64	82.8	104	157	240
30 hour	67.8	88	110	167	259
36 hour	70.8	92	116	174	274
48 hour	75	97.7	123	186	297
72 hour	79.8	104	132	198	324
96 hour	82.4	107	136	205	339
120 hour	84.1	109	138	208	346
144 hour	85.5	111	139	209	350
168 hour	86.8	112	140	210	350

3.3. Cyclonic Events

Cyclones generated in the Indian Ocean tropical zone track southeast across the region as rain-bearing depressions. The BoM provides historical cyclone tracks. Between 1906 and 2018, eight cyclone events passed within 100 km and 17 passed within 200 km of Mount Magnet, (Table 3 – closer tacks are highlighted). Associated indicative rainfall totals are based on data from Mount Magnet, Lennonville, and Boogardie weather stations. These show that the impacts of ex-tropical cyclones are highly variable.

Table 3: Mount Magnet Cyclonic Events 1906-2006

Name	Date	Mount Magnet Total Rainfall (mm)	Days
Unnamed#4	**04/02/1918**	**116**	**1**
Unnamed#15	**17/02/1957**	**21**	**1**
Unnamed#5	**27/01/1961**	**33**	**2**
Elsie	23/01/1967	88	2
Ingrid	17/02/1970	16	1
Mavis	**28/03/1971**	**5.6**	**1**
Trixie	22/02/1975	206	4
Joan	10/12/1975	22	2
Amy	**12/01/1980**	**31**	**1**
Gertie	03/02/1985	44	1
Orson	24/04/1989	14	1
Tina	28/01/1990	27	2
Bobby	**27/02/1995**	**157**	**3**
Elaine	20/03/1999	17	1
Vance	**23/03/1999**	**71**	**1**
Steve	**11/03/2000**	**75**	**2**
Emma	01/03/2006	91	1

3.4. Physiography

The mining field is located within an Archean fold-belt. Ground elevation in the defined catchments is in the range 420-545 m AHD (Figure 8) . Upper catchment divides are formed by an outer northern arc of strike-ridges which dictates drainage to the south. The northwest segment of this ridgeline is a regional catchment divide from the Murchison River catchment further north. The northeast segment of the outer arc includes Mt Warramboo. A lower inner arc of strike ridges includes the ridgeline which separates the western and eastern catchments and hosts many of the larger mines.

Local catchments comprise typical up-lying country of the northern Goldfields. The strike ridge line at the top of the catchment is at an elevation of about 480-500 m AHD. On an internal spur ridge Mt Warramboo elevation is 545 m AHD. The southern, downstream limit of the catchments described here is at an elevation of about 420 m.

Surface gradients exceed 10% locally near the catchment divide and on a lower inner arcuate strike ridge. Between the ridge lines and in the central and lower catchment surface decline from about 1% in the north to about 0.5% in the south.

3.5. Soils and Vegetation

There is minimal and patchy alluvial cover to the north. Alluvial cover over clayey weathered bedrock increases to the south. Most widespread surface cover consists mainly of low permeability hardpanised gravelly colluvium and red-brown alluvium clays. There are areas of rocky outcrop near the ridge lines and narrow zones of loose granular alluvium along the lower reaches of the creeks.

Vegetation includes sparse Mulga woodland and grasslands. Vegetation is significantly degraded due to past mining and pastoral activities, including heavy grazing by sheep and goats.

3.6. Rainfall and Runoff

All natural drainage lines in the region are ephemeral, only flowing after heavy rainfalls. Flow within creeks in the catchment is confined to brief periods during and after significant rainfall events. Observations at the mine site indicate that on dry catchments, rainfall of approximately 20mm is required to produce creek flow.

By regional standards the catchments are small and relatively steep, with quite impervious soils and limited vegetation. High intensity rainfall will generate high a runoff coefficient response, with potential for flash flooding.

Rainfall runoff relationships were determined for one particularly high intensity rainfall event where measurable runoff was harvested to a disused pit. Rainfall on March 31st – April 1st 2006 included consistent 24-hour totals at two nearby sites (BoM Station 7600 and 7057). Thirty minute data from one site were used to determine runoff coefficients of 24% at an ARI of 3.5 years and 35% for an ARI of 18 years (MWES 2016b) . The calculated runoff coefficients support the local use of a proportional loss model developed for Leinster and based on 24 hour rainfall and runoff totals from a gauged catchment at Kambalda. The climate and catchment conditions at Leinster are similar to the Lake Watchorn catchment. The applicable runoff coefficients are shown in Table 4 below along with those for Pilbara catchments (David Flavell, pers. comm).

Figure 8: Ground Surface Elevation (2017) and Current Landforms

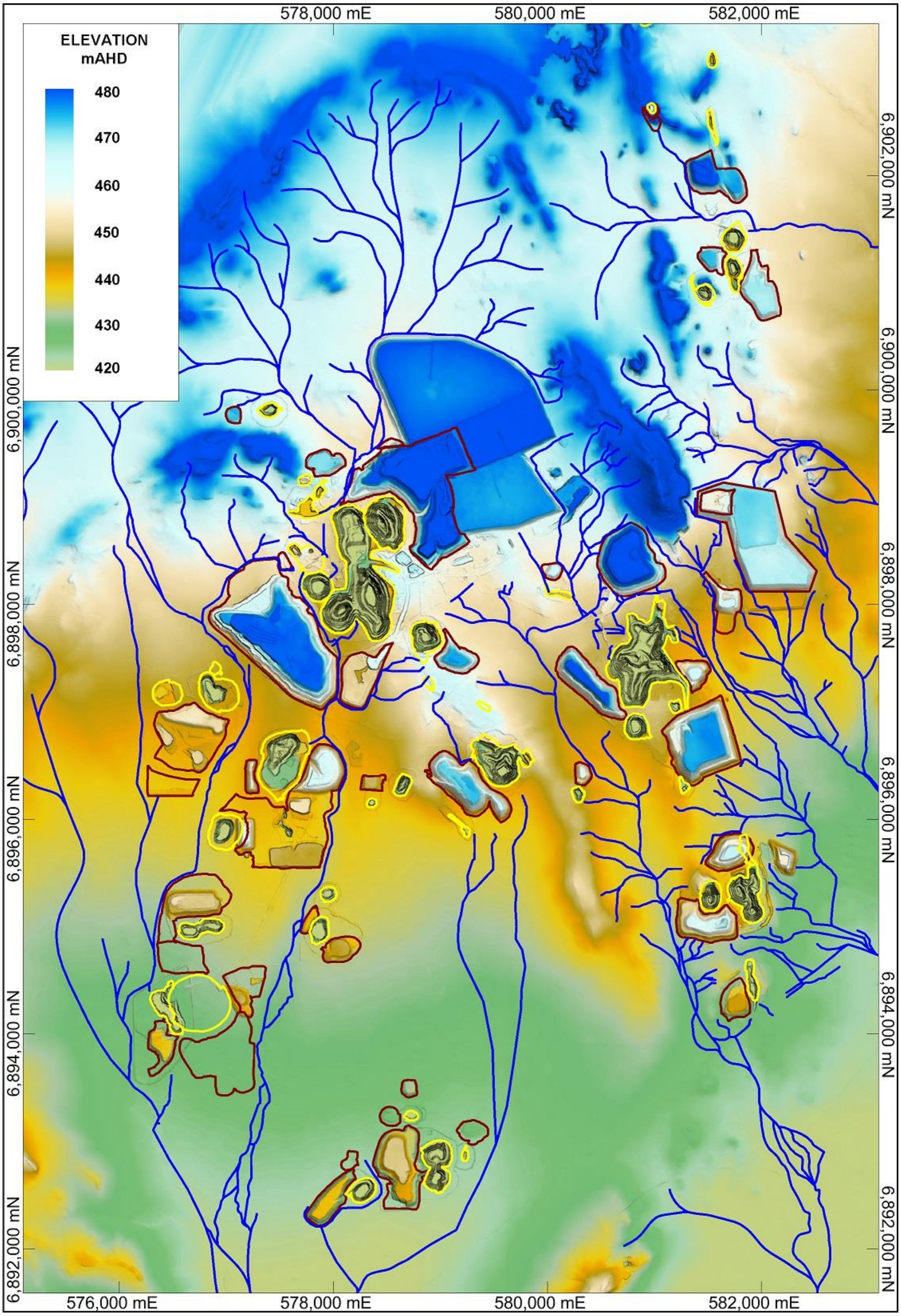


Table 4: Peak Flow Rate Runoff Coefficeints

Region	ARI (years)					
	2	5	10	20	50	100
Leinster	9%	17%	24%	31%	40%	46%
Pilbara	23%	25%	30%	35%	44%	51%

For lower frequency (eg 1:1000 year) events, 100% runoff for the additional rainfall depth can be assumed.

4. Surface Water Management at Existing and Planned Mining Operations

The current site water balance is shown in Figure 9. The Plant process water supply is mostly obtained by pumping from active and inactive pits and mines. At several sites this more or less predominantly groundwater source is augmented by catchment stormwater harvesting. This input positions are labelled "RR" (rainfall runoff) in Figure 9.

4.1. Western Catchment Area

Current and planned mining operations in the western catchment comprise the Galaxy, Cosmos and Eridanus mining areas as well as water abstractions from various inactive pits (Table 5).

Table 5: Western Catchment Area Mining Status (November 2020)

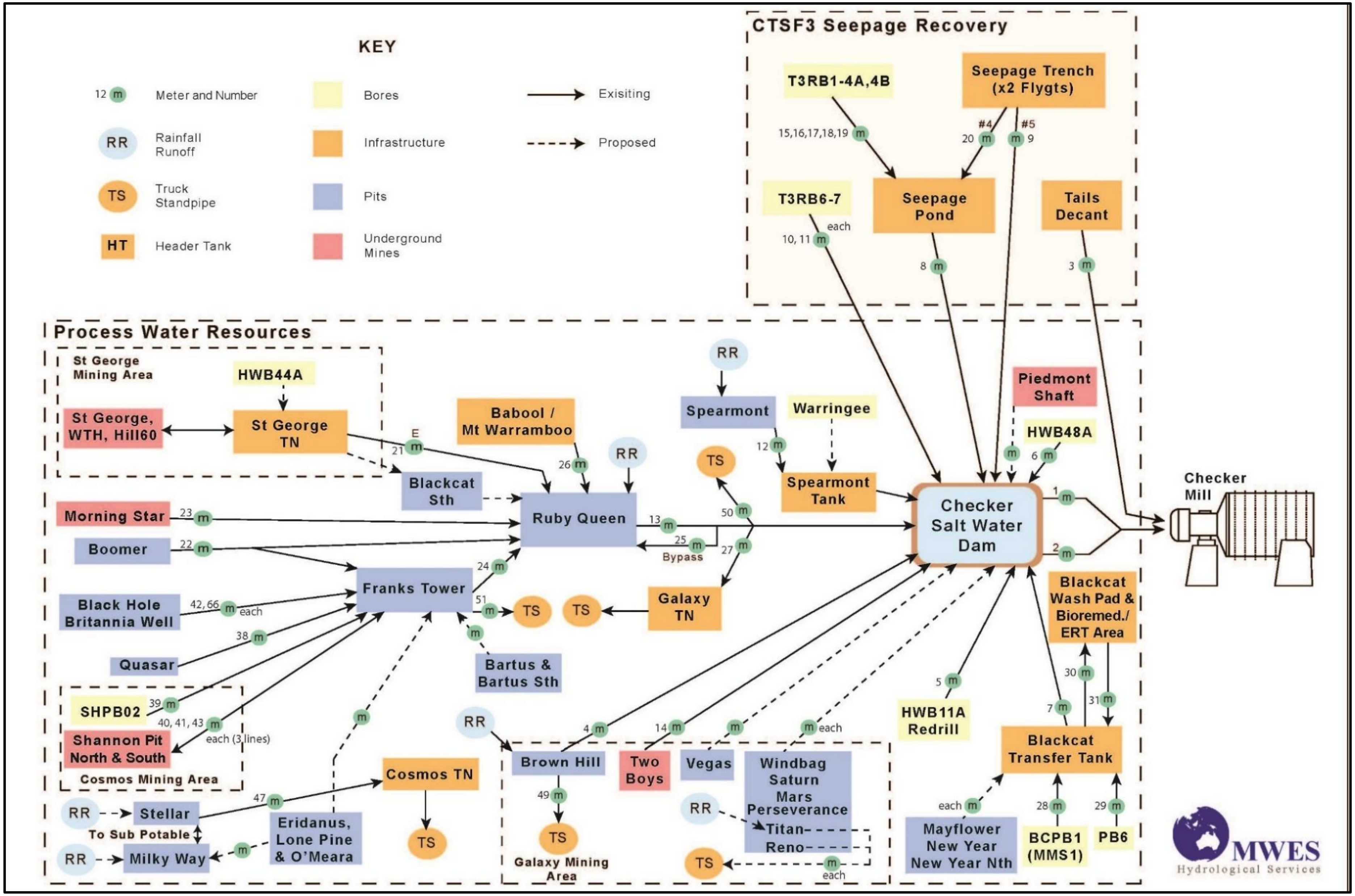
Status	Mining Area	Mine
Current active mine	Cosmos	Shannon U/G
		Stellar Pit
		Eridanus Pit
Proposed mine	Galaxy	Brown Hill
		Vegas Pit
Catchment Harvest	Galaxy	Brown Hill
Proposed Catchment Harvest	Cosmos	Milky Way
	Cosmos	Stellar West
	Galaxy	Reno-Titan

Note: UG = Underground Mine. VS = Vent Shaft

The site water circuit is shown Figure 9 and includes is a schematic diagram of the existing and proposed stream flow diversion schemes in the western catchment area. There are no diversions in the eastern catchment area.

The planned diversion of stormwater from the Vegas/ Reno Catchment to the Reno Pit presents no risk of overtopping, since available storage exceeds the 1:1000 year catchment runoff (MWES 2017a).

Figure 9: Current Water Circuit Diagram



4.1.1. Galaxy Mining Area

The Galaxy Mining Area includes several stormwater control structures which route stormwater into inactive pits with adequate storage (Figure 10).

The former Lake Watchorn has been configured as a detention basin with a low level culvert discharge restricting the discharge flow rate behind a low bund. The design arrangement is shown in Figure 11 and includes a high stage discharge (spillway). The retention basin and low level discharge is expected to manage flow at up to 1:100 year ARI (all durations) with greater peak flows discharging over the bund spillway crest at 455 m AHD (Figures 11-13) (MWES 2016a & 2017a). The as-built configuration and geotechnical integrity of this structure is subject should be subject to operational checking and maintenance.

Currently all runoff from the Lake Watchorn Detention Basin (Watchorn Catchment) flows to the Brown Hill Pit. Brown Hill Pit is full at a water level of 451 m AHD, a condition which occurred in 2006 in response to a <5 year ARI rain event. Minor earthworks are required to route flows in a controlled manner when Brown Hill Pit water level exceeds 450 m RL. This alteration will become necessary when the Vegas pit cut back is commenced. The simplest arrangement would be to use bunds to direct overflow to Mars Pit through a broad-crested (20 m wide) rock spillway at an elevation of 451 m. Storage of excess in other pits of the Galaxy complex may be preferred based on mine planning or infrastructure constraints.

Drainage from the upper western portion of the Reno-Vegas catchment is currently partly retained behind the western abandonment bund. Upper Reno-Vegas stormwater could readily be harvested into the west side of Brown Hill Pit . depending on the schedule of the potential Brown Hill Pit cut-back.

Northern extension of the Saturn West WRD will redirect minor flows from the north and will require toe armouring to combat erosion. The rock armouring can be continuous with the proposed bund at the northwest corner of the WRD which is required to route minor catchment flow under/ across Boogardie Road. The bund should be maintained at a height equivalent to the “1.0-m” depth mark on the nearby Boogardie Rd floodway gauge board (approx. 447.5 m) (MWES 2018a).

Other Boogardie Rd culverts in the Galaxy Mining area that require inspection and maintenance are shown on Figure10.

Figure 10: Galaxy Mining Area

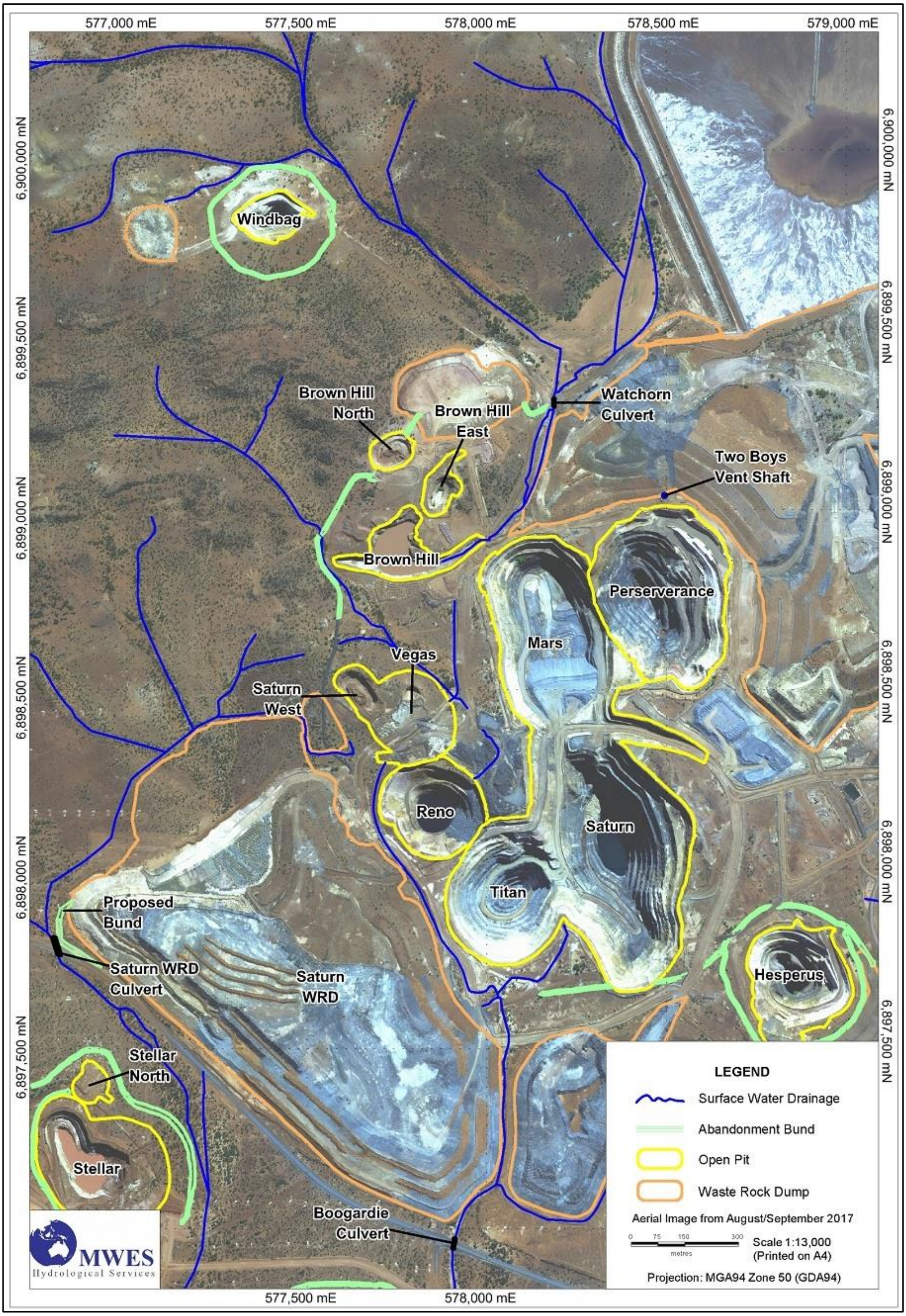


Figure 11: Watchorn Culvert Embankment & Outlet Configuration

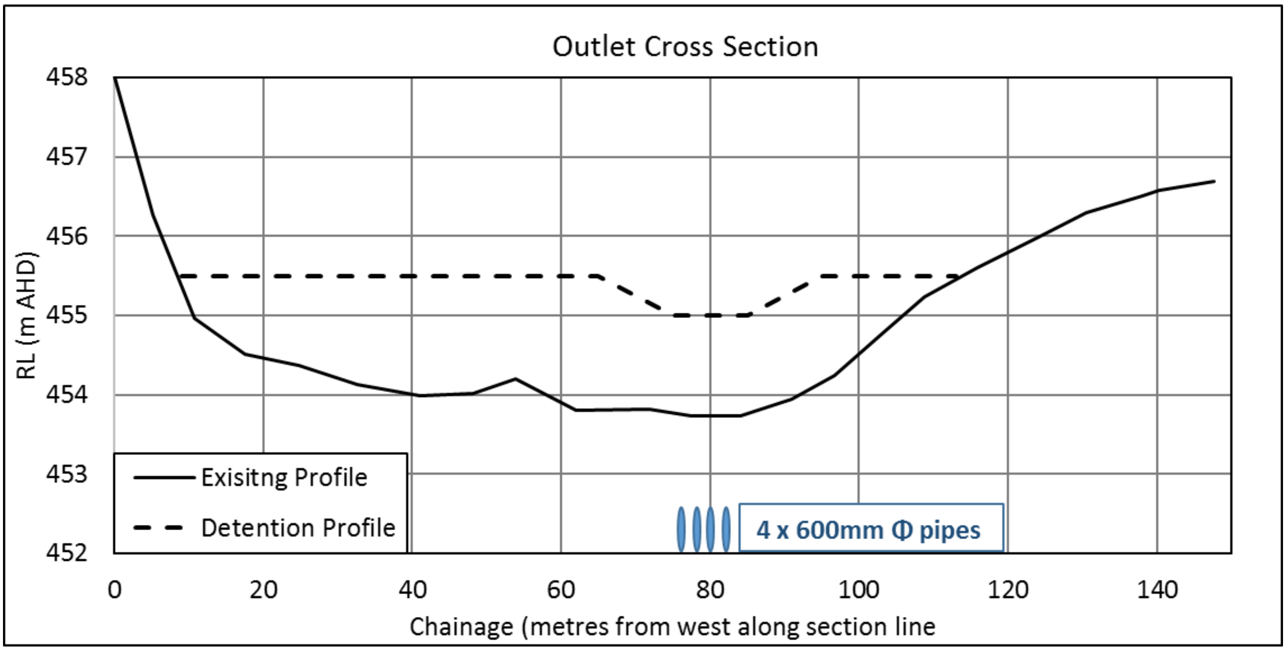


Figure 12: Survey Traverse Line at Existing Outlet

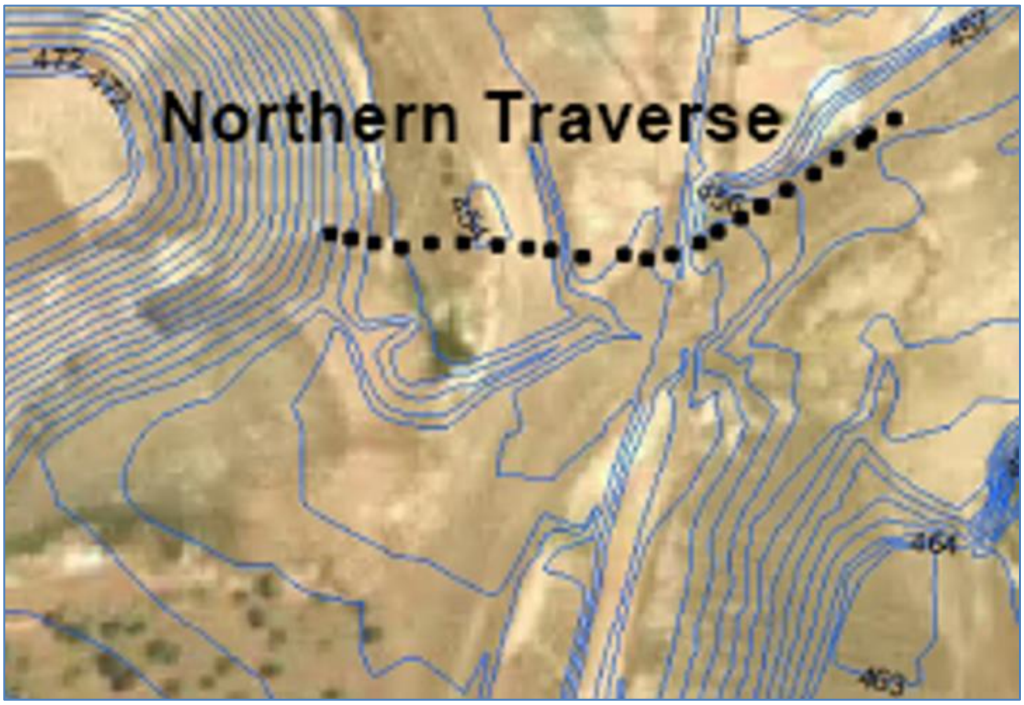
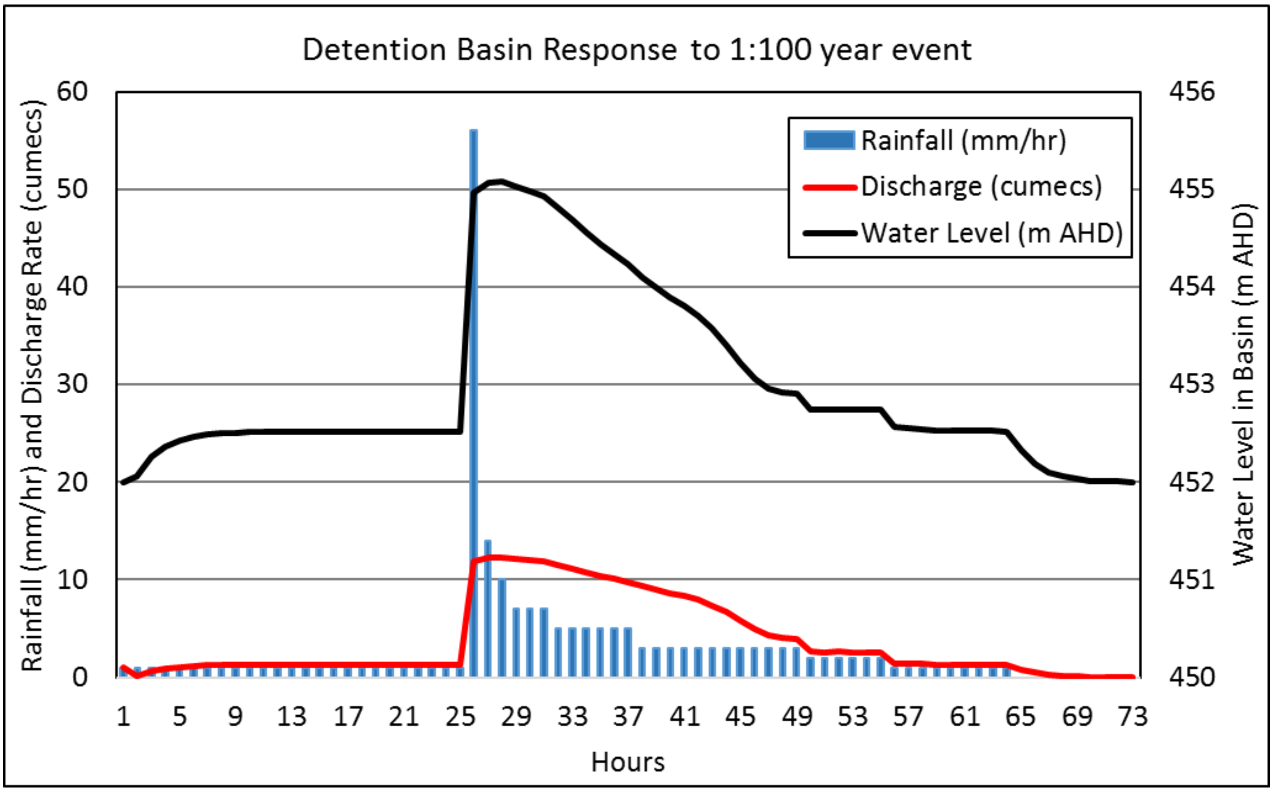


Figure 13: Lake Watchorn Detention Basin – Predicted Flows

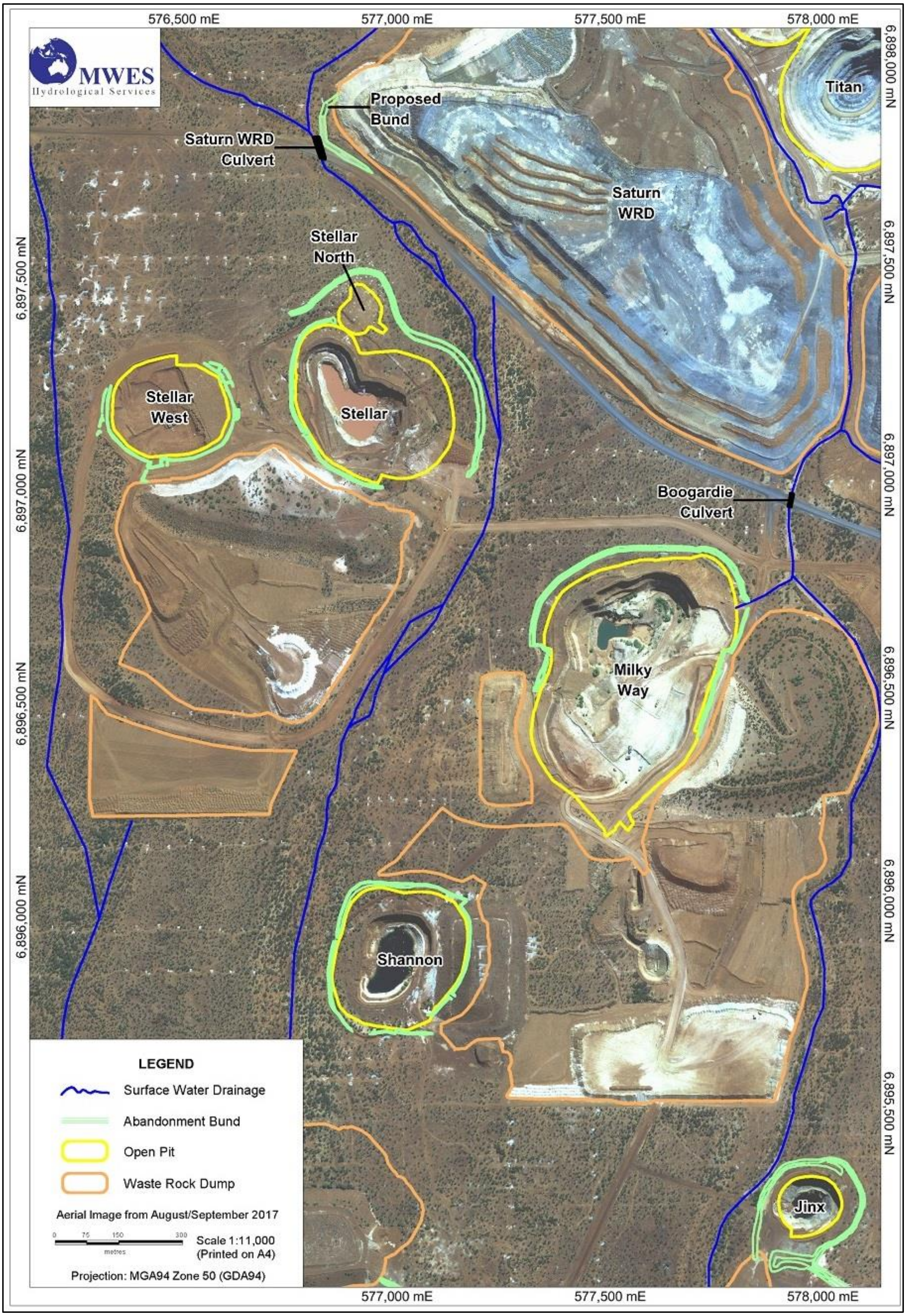


4.1.2. Cosmos Mining Area

Cosmos mines are located in low country adjacent to the floodplains of minor south-draining creeklines which are prone to flash flooding. These mines require flood protection bunding. Flood protection is generally integrated into the abandonment bunds and meets the necessary location and design specifications. In addition, bund segments which are required for flood control bunds should have a crest elevation greater than the 1:1000 year peak flood level.

Three minor creeklines drain south through the area, the largest flows occur in the central creek aligned east of Stellar and West of Shannon Mines. Note that the creeklines are very close further north, such that flows in the central creek could easily be routed to the western creek if it becomes necessary in future. The eastern creekline was the pre-development mainstream of the Western Catchment however flows there are now largely captured by the Galaxy Mines (Figure 14).

Figure 14: Cosmos Mining Area

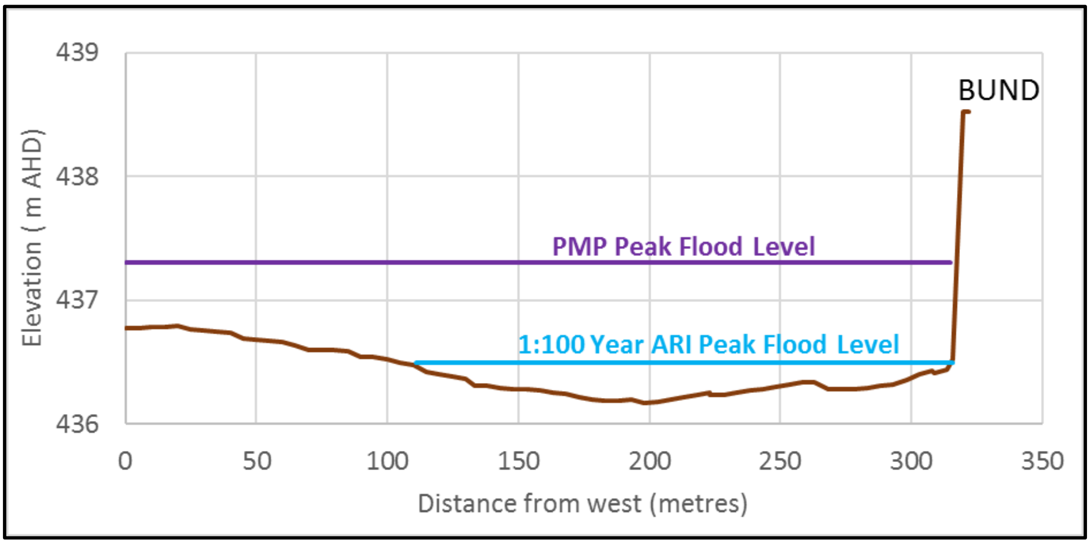


The Shannon underground mine is protected from the creekline to the west. Design specification are as follows (MWES 2018f):

- Coarse rock cladding of outer slope against erosion.
- Road crossings at design bund elevation.
- Pit ramp exits the pit at south-east corner on a slight hump to avoid stormwater ingress.
- Western (north-south oriented) section: 2 m high throughout.
- North end terminates against the waste rock dump.
- South (east-west oriented) section grades from 300 mm ramp hump to 2 m high.

Typical configuration is shown in Figure 15.

Figure 15: Peak Flood Levels West of Shannon Pit



Stormwater harvesting to Stellar West and Milky Way Pits has been undertaken previously but suspended during recent mining phases. Those harvesting arrangements may be reinstated as and when required. Stellar West has greater potential due to the higher yielding catchment

4.1.3. Eridanus Mining Area

Eridanus Pit is currently the major local ore source. The pit is in Stage 2 cutback and incorporates the historical Lone Pine Pit, which was also mined in stages, with the southwest extension backfilled and partly covered by the WRD (Figure 16). Eridanus is located in low lying country immediately east of the mainstream drainage line of the Lone Pine sub-catchment. The baseline drainage line through Lone Pine was diverted west into an adjacent natural drainage line in the 1990's. The bund was breached to facilitate stormwater harvesting at the disused Lone Pine Pit but has subsequently been reinstated and extended north to isolate the Eridanus north WRD area.

The diversion uses a low bund oriented southwest, deflecting the stormwater flow rather than draining it, since there are very low surface gradients and several minor swales naturally coalesce in the area. The arrangement has been successful, allowing flood out of stormwater rather than concentrated drain flow. Flow velocities have evidently remained low as there is little evidence of erosion/ sedimentation associated with the diversion.

The western bund has a specified minimum height of 2 metres which can exclude any foreseeable flood peak. (MWES 2018e).

4.2. Eastern Catchment Areas

4.2.1. Morning Star Mining Area

The area is situated on a low NNW trending strike ridge with natural drainage to the south-southeast via two minor ephemeral creek lines. The larger and high yielding portion of the Eastern catchment comprises the western slopes of Mt Warramboo, which under baseline conditions drained across Ruby Queen Pit site, then southeast across Morning Star where it joined flows from the south side of Mt Warramboo. The Ruby Queen Pit now captures the large majority of that stormwater.

Residual catchment areas south of Ruby Queen are partitioned by several bunds and roadways. An earlier west-flowing diversion drain between the two pits has not been functional for more than 10 years and is unnecessary at present (Figure 17). The proposed Morning Star cut-back includes a northern extension of the western WRD which will block the original valley**. The western diversion drain will need to be re-instated at some time prior to final closure.**

Under the proposed expansion, stormwater flows from the smaller eastern sub-catchment will be routed through a “valley” between two lobes of the eastern WRD. The separation preserves the existing power line and approximately preserves the existing drainage line (Figure 17) (MWES 2018c). The cross-section profile through the valley, along with estimated peak water levels for the 1:10 and 1:100-year ARI and for the PMP rainfall events is shown in Figure 18.

Figure 16: Eridanus Mining Area

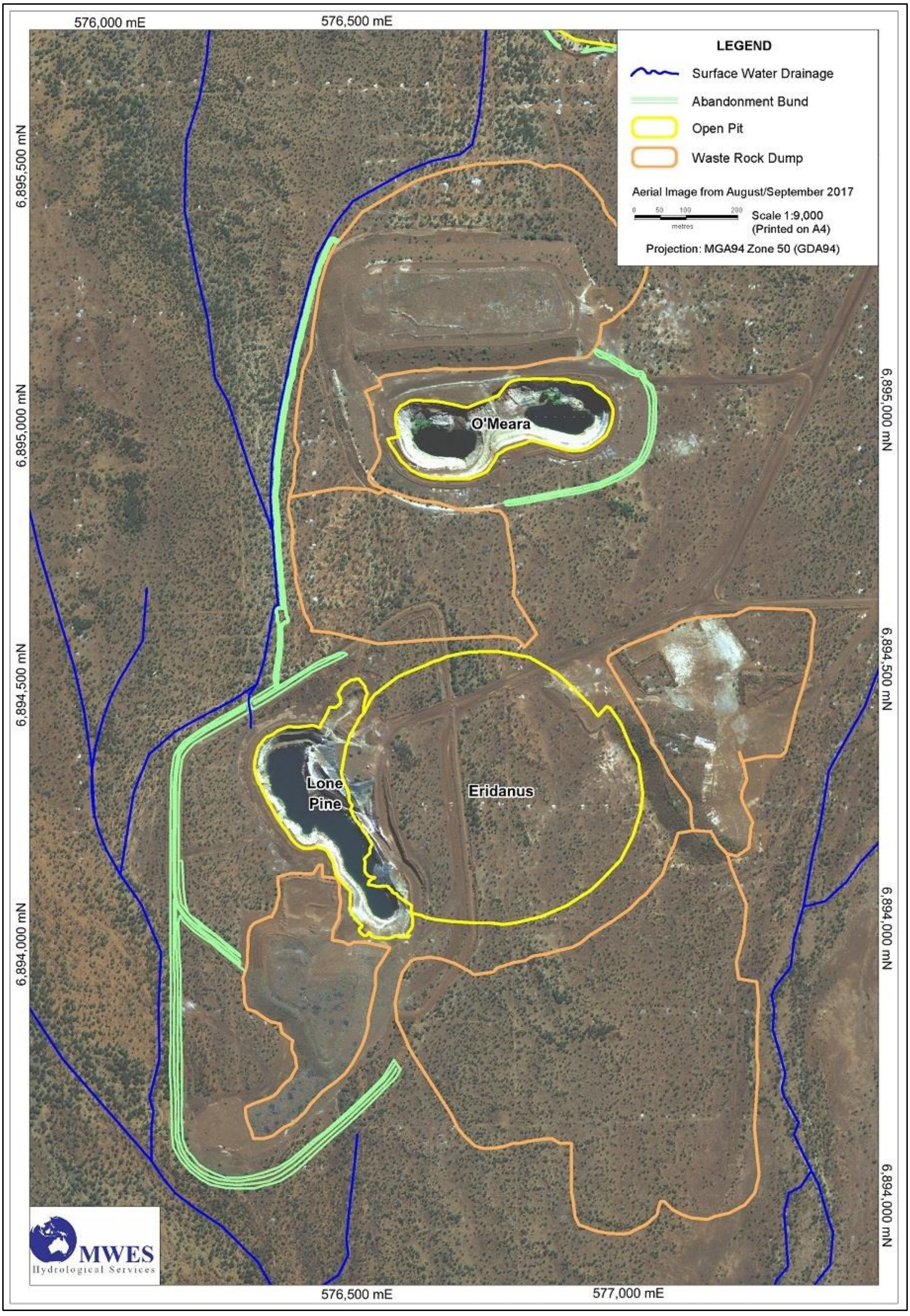


Figure 17: Morning Star Mining Area

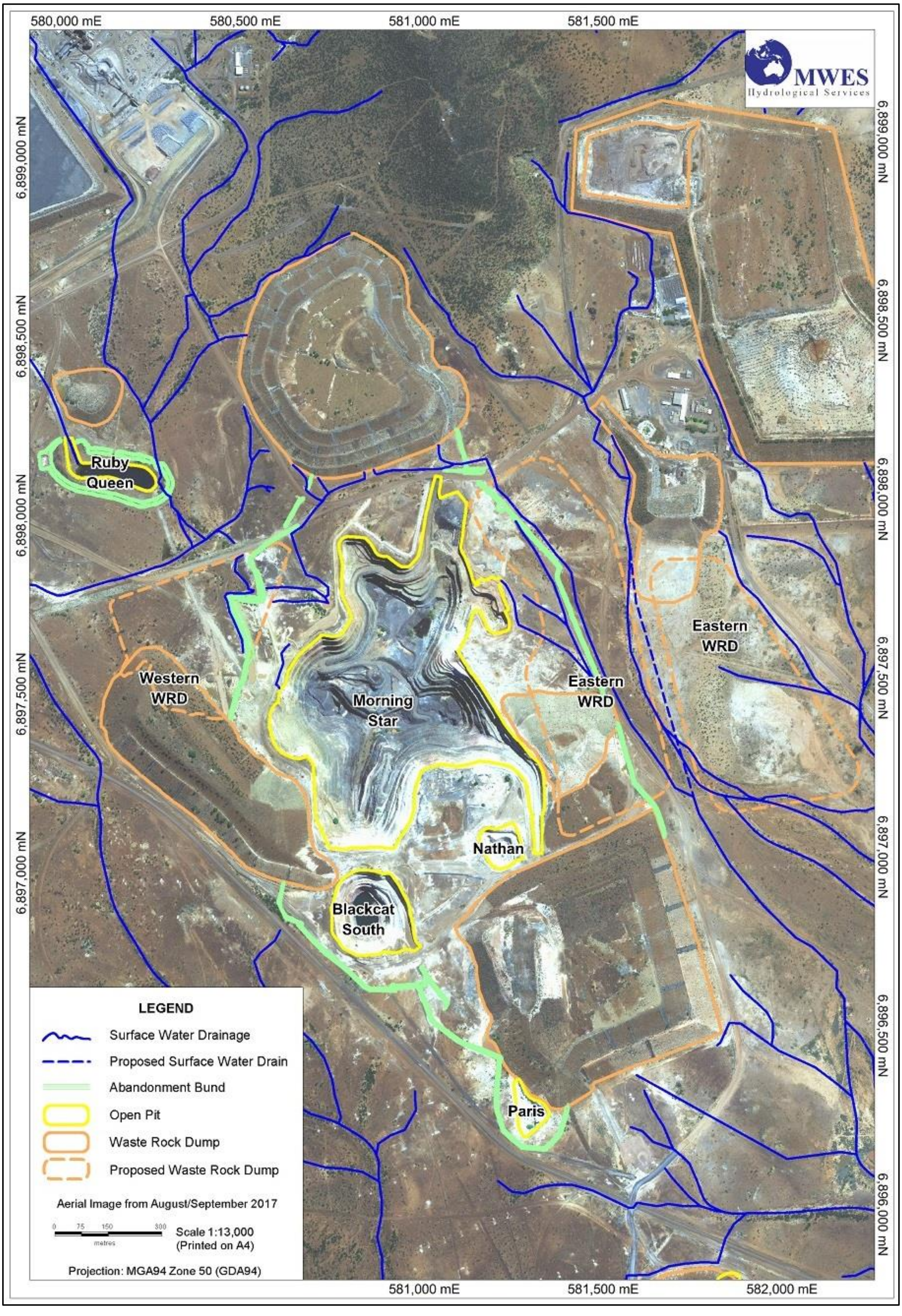
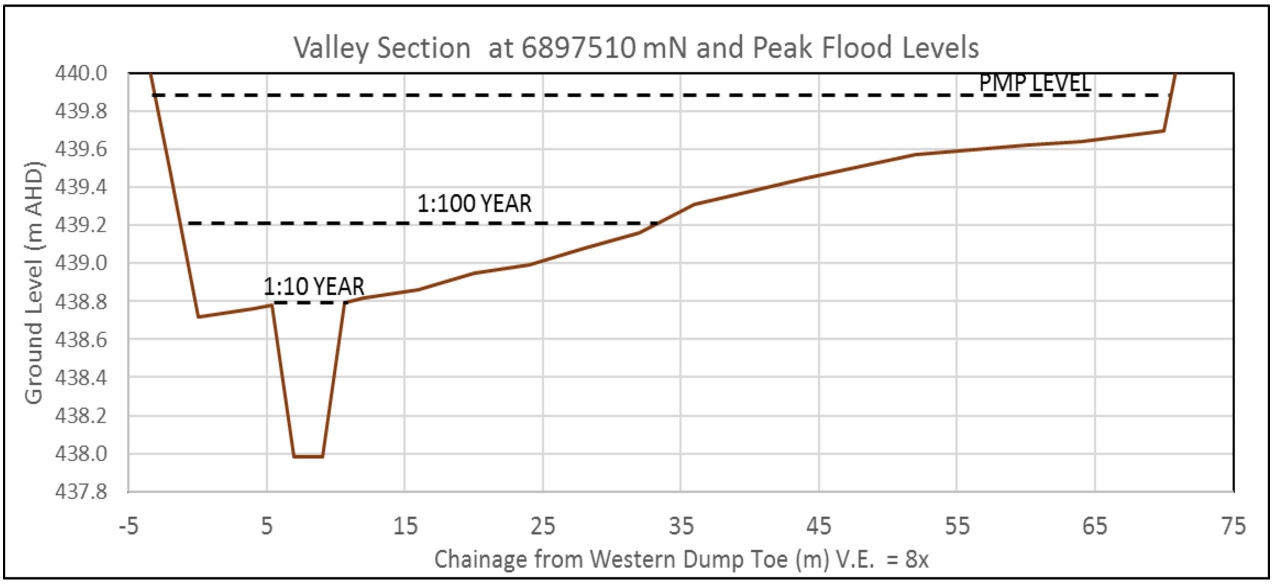


Figure 18: Valley Profile and Flood Levels



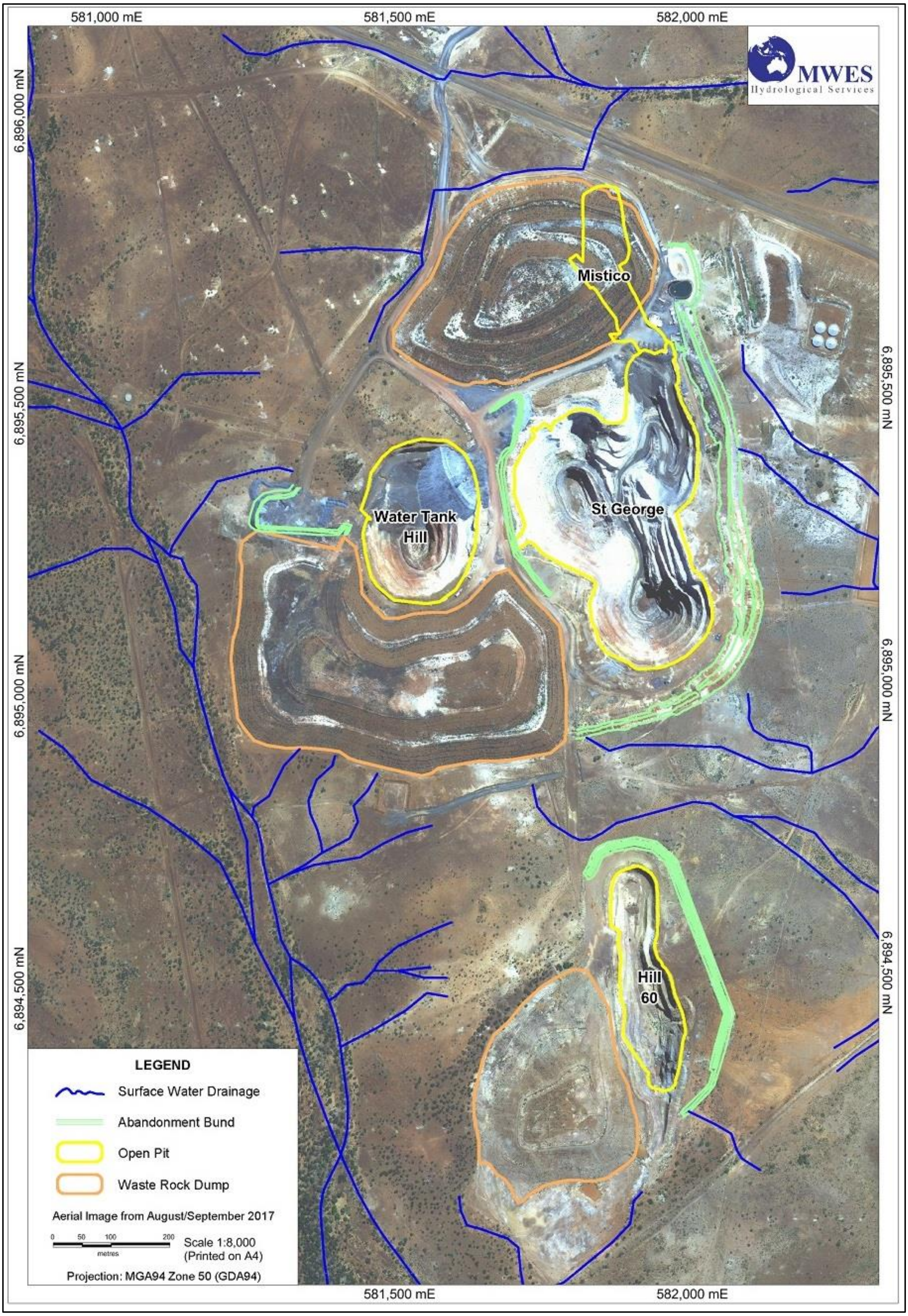
4.2.2. St George/ Hill 60 Mining Area

In the eastern catchment area, the underground mine is accessed from the St George Pit. The mine is favourably located on a low north-northwest trending strike ridge and hence at no risk from stream flood flow.

Natural drainage is to the south in a well-defined creek line on the west side of the existing mines. To the north, the land surface drains away to the east-northeast via a broad swale. Land to the south and east of the mines falls away gently to the southeast. The redevelopment of the WTH underground mine does not extend beyond the current area of disturbance and does not change the area of surface water capture at the mines. The mine has no incremental impact on the broader catchment hydrology, including no impact on yield or water quality in the downstream catchment.

The southern underground from drive from St George has accessed the Hill 60 historical underground workings. The overlying Hill 60 pit is located on a banded iron strike at a natural ground surface at the pit crest in the range 428-437mAHD. The surface falls in all directions away from the pit crest. Due to its elevated location there is no potential for substantial stormwater flow into the pit (Figure 19) (MWES 2018b).

Figure 19: St George/ Hill60 Mining Area



5. Stormwater Management Practices & Processes

Existing management practises at the MMG site include:

- All engineered structures (e.g. mines, waste dumps, TSFs, rehabilitated sites, bunds, channels, diversions, culverts, roads etc.) are permitted and guided by the requirements of the Mining Act, which are specific to the associated MMG's mining leases. Visual inspection and reporting of surface water drainage infrastructure is currently undertaken on a quarterly basis.
- Protection of the Genga Borefield is of paramount importance in this SWMP and is guided by various water quality protection guidelines (DoW & DME 2000 and DoW 2013). Mining activities are restricted (possible with conditions) in the P1 and P2 water reserves, located in catchment of the Genga Borefield, to the west of current and proposed mining activities. If exploration or mining is proposed in these areas, refer to the DoW Water Protection Note (WQPN) number 25 (DoW 2016). Surface water sampling in this catchment is guided by various DoW guidelines (DoW 2009a, b and c).
- Protection of groundwater requires licensing of any mine dewatering discharge effluent into abandoned mines or unlined storage structures.

5.1. Values, Threats & Potential Impacts

Any potential threats to the environment or other water users has been determined through previous studies conducted across the area. Referencing the *Stormwater Management Manual for Western Australia*, a threat is deemed to be any land use or activity with the capacity to adversely impact the local environment's integrity or ecological, economic or social values through changes in stormwater quality or quantity (DoW & SRT 2007).

Some aboriginal and heritage protection areas, historical buildings and tourist sites have been identified within the SWMP catchment areas and need to be considered and avoided when planning surface water infrastructure and activities.

Potential impacts that have been identified and their perceived significance are described in Table 6. These threats and potential impacts are based on both current and proposed mining activities.

Table 6: Potential Impacts from Stormwater & Mining Activities

Potential Impact	Significance Rating	Comments
Safety hazards associated with high flow rates, deep water, and flooding after significant rainfall events.	4	Potentially hazardous conditions to personnel working or driving onsite. An Emergency Response Plan containing actions due to high rainfall/ flooding conditions is prepared, maintained, communicated and implemented.
Degradation of downstream Genga Borefield aquifer via reduced runoff quality and quantity.	2	Previous studies have determined that diversions should not cause adverse impacts on the Genga Borefield (MWES 2015). A water monitoring program is in place. Waste material largely benign and deleterious components geochemically immobile.
Degradation of surface water quality due to contamination from mining.	2	Disturbed areas comprise a minor portion of the SWMP boundary area (MWES 2015). Long history of operations has not resulted in substantial impacts
Erosion and/or sedimentation causing disturbance to surface water regimes.	3	Impacts are poorly defined but are evidently not clearly negative or locally substantial over the long operational history. May persist as a significant issue for WRD closure design.
Impacts to the downstream environment from reduced and/or degraded stormwater flow.	2	There are no GDEs in the SWMP boundary area. A general absence of potential receptors or any mechanism by which impacts may occur. No substantial impacts have been noted over a long operational history
Pit storage overflow.	2	Various studies have determined low probability of storage exceedance MWES (2015, 2017a & 2019). Consequences also moderate.
Runoff or hazards to people outside of the SWMP catchment boundary.	1	No surface water interaction to neighbouring catchments.

Note: Significance Ratings are described as follows:

1 = No significant threat
2 = Minor threat
3 = Moderate threat
4 = Severe threat
5 = Extreme threat
Unknown significance

5.2. Flood Hazard Management

Operations at Mt Magnet are dynamic such that specific flood hazard assessment for all work places and conditions is beyond the scope of this document. However, the following general guidance may be applicable to work place hazard assessment and management:

- Catchment response times are short being of the order of 15 minutes - 2 hours.
- Catchments may display flash-flooding type responses to brief events – e.g. 20mm over 15 minutes.
- Suitable response time may require stormwater hazards to be identified by predicted and observed rainfall as well as observations of surface conditions.

- BoM services are critical including:
  - Mt Magnet weather forecast: http://www.bom.gov.au/wa/forecasts/mount-magnet.shtml
  - Warnings Summary: http://www.bom.gov.au/wa/warnings/
  - Geraldton 512 km radar loop: http://www.bom.gov.au/products/IDR061.loop.shtml#skip
  - Carnarvon 512 km radar loop: http://www.bom.gov.au/products/IDR051.loop.shtml#skip
- Flood hazard is enhanced when the catchment is wet (i.e. substantial rainfall total over prior 14 days).
- Based on assessment of prior rainfall, observations and forecasts, active flood hazard monitoring at key accessible locations may be required for current work areas.
- Flood hazard areas may include, storages, pits, mines, flood-ways, culverts and other structures.
- Triggers for evacuation of active work areas may be necessary.

6. Management of the Plan

6.1. Management Objective

The broad objective of the SWMP is to provide a comprehensive document enabling and guiding decision-making, design, construction, operations, maintenance, and closure.

6.2. Priority Management Issues

The priority management issues across the MMG site and the SWMP management area boundary will depend largely on the planned mining schedule. As different pits are mined at different stages, drainage and pit diversion channels will need to be altered, depending on where mining is occurring at the time. The highest priorities are as follows:

- Protection of site personnel, contractors, and equipment.
- Maintenance of quality and quantity of surface water flow to the downstream environment
- Protection of infrastructure.

6.3. Management Actions

Proposed actions and responsibilities to address onsite stormwater management issues are listed in Table 7.

Table 7: SWMP Management Actions

Management Action	Performance Indicators & Reporting/Evidence	Responsibility
Surface disturbance works to include a risk assessment to determine the likely impacts of proposed changes in the surface water regime. Particularly impacts on site personnel and the Genga Borefield.	All significant risks are incorporated into the design of the stormwater structures.	Design/ development team
Construction checklist to determine if the design complies with all legislation and relevant government guidelines.	Design complies with government legislation and design guidelines	Design/ development team

Management Action	Performance Indicators & Reporting/Evidence	Responsibility
Any new drainage or bunding infrastructure to be designed and constructed in accordance with the outcomes of risk assessments to prevent adverse impacts.	New drainage infrastructure to comply with design specifications	Design/ development team
Design to reduce disruption to surface water flows and prevent unnecessary ponding around structures.	Any new infrastructure to comply with design specifications	Design/ development team
Design to minimise runoff from waste dumps, roads and other non-contained structures.	All runoff contamination risks are incorporated into the design of the structures	Design/ development team
Design stormwater control structures to ensure flow velocity consistent with natural drainage to reduce stream bed erosion/sedimentation.	Any new infrastructure to comply with design specifications	Design/ development team
Implement Emergency Response Plan to include impacts of high rainfall/ flooding conditions.	An Emergency Response Plan including actions in response to high rainfall/ flooding conditions is prepared, maintained, communicated and implemented.	Safety/ training and human resources team
Minimise clearing and disturbance to vegetation to prevent changes in the surface hydrology.	Disturbance completed according to vegetation clearing licence specifications and conditions. Minimal impact on vegetation health, water quality and quantity as assessed from monitoring surveys	Environment/ design/ engineering team
Where possible, protect natural and current drainage lines from impacts of mining or construction activities to preserve water quality and quantity.	New infrastructure and activities from mining to comply with the risk assessment and associated design specifications	Environment/ engineering team
Employ practices to reduce erosion and sedimentation.	Design of structures and materials selection	Environment/ engineering team
Routine visual inspection of condition of stormwater infrastructure including diversion bunds/drains, culverts, waste dump runoff, and pit lake water levels.	Maintenance inspection reports	Engineering/ maintenance team
Visual inspection of relevant stormwater infrastructure during or after major rainfall events.	Maintenance inspection reports, photographs and survey of peak flow levels	Engineering/ maintenance team
Carry out a routine surface water quality monitoring program.	Surface water monitoring (streams and pit lakes) to be incorporated into the current water monitoring plan. Data collected and kept in a database in an accessible format. Data included in annual reports to DWER.	Environment team
Measurement and analyses of relevant surface water data (such as stream flow rates and water quality samples etc.) following major rainfall events.	Data collected and kept in a database in an accessible format. Data included in annual reports to DWER.	Environment team

Management Action	Performance Indicators & Reporting/Evidence	Responsibility
Manage hydrocarbons, chemicals or hazardous substances on site in accordance with relevant legislation and licensing, to prevent contamination of stormwater.	Monitoring data from stream flows or drains etc. downstream of chemical areas to be within accepted baseline limits (triggers).	Anyone on site
Supply hydrocarbon and chemical spill control training to all relevant staff and contractors.		Environment/ training and human resources team
Analysis of compliance to SWMP.	Review the SWMP.	Environment team

6.4. Implementation Plan

Strategies for implementation of the management actions described above are listed in Table 8.

Table 8: SWMP Implementation Strategy

Strategy Item	Strategy Description
Company policy and procedures	Company recognises the existence of the SWMP and implements its Management Actions. Policy documents and procedures need to be readily accessible.
Inductions, plans and responses	All relevant staff on site (including contractors) to be inducted into the relevant elements of the SWMP. For all personnel an awareness of flash flooding hazards and the need to minimise impacts on downstream stormwater quantity and quality.
Communications to design and development teams	All members of the design and development teams to be informed of requirements of the SWMP, including being made aware of any legislative requirements.
Communications to maintenance team	All members of the maintenance team to be informed of requirements of the SWMP, including being made aware of any legislative requirements.
Implement the Emergency Response Plan	The MMG Emergency Response Plan should include tracking of cyclonic and other potential high intensity rain bearing systems and appropriate communications and responses
Implement a maintenance plan	A site-wide maintenance plan to be established and used by all maintenance personnel. This will ensure all surface water structures are consistently inspected and repaired.
Routine and event-based inspections	Maintenance team to conduct visual inspections of all surface water infrastructure as soon as is safe following heavy rainfall events, to determine structural integrity. Routine inspections to be carried out. Any repairs to be actioned within a timely manner.
Routine and event-based monitoring	Monitoring requirements of the SWMP must be implemented, managed, and reported by the environmental team. This includes: • Event-based monitoring of water quality and quantity. • Vegetation and fauna monitoring. • Pit water levels and water quality. • Groundwater levels and quality.

Strategy Item	Strategy Description
Data management	All information, including maintenance reports, monitoring results, annual and event-based reviews, and any other data related to the SWMP to be collated and maintained in a database that is made aware and readily accessible to personnel.
Development of baseline data	Baseline values for major parameters (e.g. pit water levels (allowable freeboard), turbidity, salinity, arsenic, lead, nickel, and selenium) can be determined from long term routine and opportunistic accretion of monitoring results.

7. Performance Monitoring & Review

Routine reviews should include:

- The plans have been developed, communicated, and are kept up-to-date.
- Review of response and outcomes to event-based actions e.g. maintenance, reporting and repairs undertaken of surface water structures, and water quality and quantity measurements captured).
- Response to triggered actions (and contingencies activated where necessary).
- Review of missed routine monitoring events.
- Changes to the potentially impacted stakeholders.
- Changing or new priorities.

It is recommended to review the whole SWMP document every three years or following major changes to site infrastructure or management approaches. Additionally, an annual review of how the plan is implemented on site should coincide with the DWER water licence year.

8. Mine Closure Aspects of the SWMP

MMG have previously developed mine closure criteria as part of their statutory mine closure plan (Botanica 2018). These remain applicable to the expanded pits and waste dumps developed under this proposal. In most cases, constructed drainage and bunding will ensure minimal long-term interaction between the constructed landforms and the post-closure surface water drainage system.

Most pits are readily and permanently isolated from the natural surface water drainage system. The one main exception being the Galaxy complex pits which cannot be isolated from the northern sub-catchment. The storage capacity of these pits has been shown to far exceed catchment runoff from the most extreme rainfall (MWES 2017a). Due to high evaporation rates and low-moderate groundwater inflow rates, closure pit lake water levels will remain below regional groundwater levels and will act as terminal groundwater sinks, preventing any outflow of water or solute.

Key hydrological objectives for mine closure planning are (Botanica 2018):

- Ensure any residual mineralised waste rock is located away from dump faces and well encapsulated by competent material.
- Contouring and drainage measures as required to minimise stormwater capture.
- Minimise erosion from the waste dumps.

Closure design will need to ensure long term geotechnical and erosional integrity to minimise erosional damage in the following key areas:

- The Boogardie Road culverts near the Saturn WRD.
- The Milky Way waste dump - eastern toe.
- The Stellar Pit abandonment bund - eastern side.
- The Shannon Pit abandonment bund - western side.
- The Eridanus/ Lone Pine Pit abandonment bund – western side.
- The Morning Star eastern WRD drain.

9. Conclusions

This SWMP document presents the available current and proposed information relating to management of stormwater at the MMG site. It covers two areas: the western Lone Pine, Milky Way, Quasar, Vegas/ Reno and Watchorn catchments, and the eastern Bundy, Mount Magnet and Ruby Queen catchments. The plan has been written with respect to the current and the latest planned mining schedule. As such, any changes to the planned schedule or change in management approaches may warrant a change in this SWMP. Existing surface water management practices include:

- Infrastructure (culverts, diversions, drains and bund walls).
- Quarterly visual inspections of surface water infrastructure.
- Measurement of stream flows and surface water quality at the Boogardie Culvert site.
- Stormwater harvesting pumping rates and associated diversion of surface water into existing pits.

The priority management areas identified by this SWMP are:

- Safety of personnel on site during stormwater and high rainfall events
- Mitigating risk to the Genga Borefield aquifer
- Maintenance of quantity and quality of stormwater runoff to the downstream environment
- Protection of the operational infrastructure.

Management Actions established to ensure priority management areas are addressed include the following:

- Communication of applicable elements of the SWMP to relevant staff and contractors through inductions, policies and documents.
- Communication of surface water management requirements to design and development teams.
- Ongoing collection of baseline data for key hydrological parameters, through routine and event based monitoring.
- Routine and event-based inspections of stormwater infrastructure and measuring equipment.
- Effective data management including accessibility.

10. Recommendations

The recommendations arising from the creation of this SWMP include the following:

- Emergency Response Plan: The MMG whole Emergency Response Plan should include:
  - Monitoring of weather forecasts.
  - Monitoring of conditions at surface, in pits and underground.
  - Responses to high rainfall and flooding events.
  - Triggers for evacuation of active work areas if necessary.
- Routine and event based (prior during and after intense rainfall and runoff) inspection of key stormwater structures such as bund walls, diversion drains, floodway road crossings and culverts.
- SWMP to be reviewed triennially or following major changes to site infrastructure or management approaches. Additionally, an annual review of the implementations and Management Actions should be undertaken and could coincide with the DoW water licence year.

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Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels; can change in a limited time. Therefore, this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

Appendix A: Report: Installation and Analysis of Streamflow Logger and Rising Stage Sampler, Boogardie Creek