REPORT

AUSTRALIAN MINES LTD

Lucky Break Project

Dingo Dam
Stormwater Management Plan

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1 INTRODUCTION

1.1 Background

Australian Mines Ltd (AML) owns the Lucky Break project located approximately 120km southwest of Townsville and some 90km northwest of Charters Towers, in Northern Queensland. The Lucky Break project is an open cut nickel mine located on Gregory Development Road, encompassing two Mining Leases (ML) known as Dingo Dam (ML 10324) and Lucky Break (ML 10332). Mining operations were undertaken through use of an open-cut pit method from which approximately 114 thousand tonnes (kt) of ore was extracted, before mining ceased in July 2015. Mining was conducted only on the Dingo Dam ML, with the Lucky Break ML undisturbed. The project operates under Environmental Authority (EA) Permit No. EPML00900713 issued by the Department of Environment and Science (DES), dated 9 March 2018. It is understood that the project is currently in Care and Maintenance following mine closure and previous rehabilitation works.

It is understood that the site is currently occupied by the Spyglass Beef Research Station. Discovery of poor water quality in the void has resulted in the need to minimise surface water reporting to the void. As such, AML has commissioned ATC Williams Pty Ltd (ACTW) to develop a Stormwater Management Plan (SWMP) for the Dingo Dam site to help meet regulatory environmental compliance objectives and minimise the potential for environmental harm.

The site stormwater management strategy herein has been developed with the primary objective of minimising water reporting to the void and restoring natural drainage paths where appropriate.

1.2 Scope of Work

The scope of works for the Stormwater Management Plan are as follows:

- Review of available site data, including survey and existing site conditions;
- Review of stormwater management options;
- Development of conceptual water management design to minimise surface water reporting to the ex-mining void and restore natural drainage paths where appropriate;
- Develop peak flow estimates and indicative sizing of required hydraulic infrastructure for the proposed site configuration.

1.3 Structure of Report

The structure of the report, to meet the above scope, is as follows:

Section 2.0 - Outlines details of the site description, providing existing site conditions, topography, drainage and climate conditions.

Section 3.0 - Details the framework for the stormwater management system design, including a review of relevant conditions.

Section 4.0 - Presents the details of the conceptual stormwater model and outlines calculations.

Section 5.0 - Presents concluding statements about the SMWP and its objectives, and makes recommendations for future works as required.

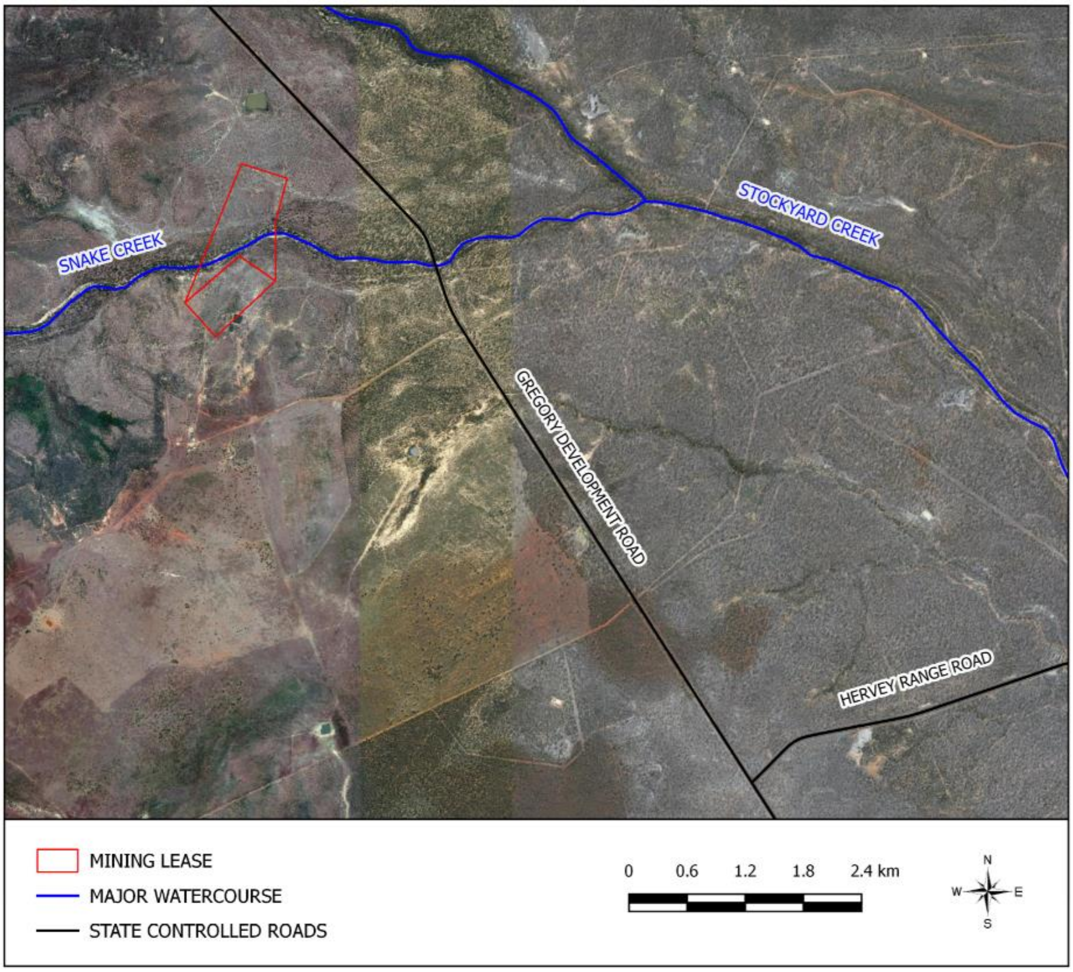
2 SITE CHARACTERISTICS

2.1 Site Description

The Lucky Break Project Site is located approximately 120km southwest of Townsville and some 90km northwest of Charters Towers, in Northern Queensland. The project site comprises of two Mining Leases known as Dingo Dam (ML 10324) and Lucky Break (ML 10332).

The site location is provided in **Plate 1**, shown below.

Plate 1
Site Location



The site is currently occupied by the Spyglass Beef Research Station with the current land use being cattle grazing. The Spyglass Beef Research Station occupies approximately 38,300 hectares, of which encompasses this site.

Key infrastructure associated with the Dingo Dam ML are shown in **FIGURE 001** and includes the following:

- Dingo Dam
- Sediment Dam
- Waste Rock Dump
- Open Cut Pit (referred to as the void)
- ROM Pad
- Various bunds

The existing catchment areas at site as shown on **FIGURE 001** are summarised in **Table 1**.

Table 1
Summary of Existing Catchment Areas

Catchment	Area (ha)
Dingo Dam	26.6
Pit Void	5.1
Pond	47.7
Sediment Dam	86.1
Total Void Catchment	79.4
Total Site to Sediment Dam	165.5

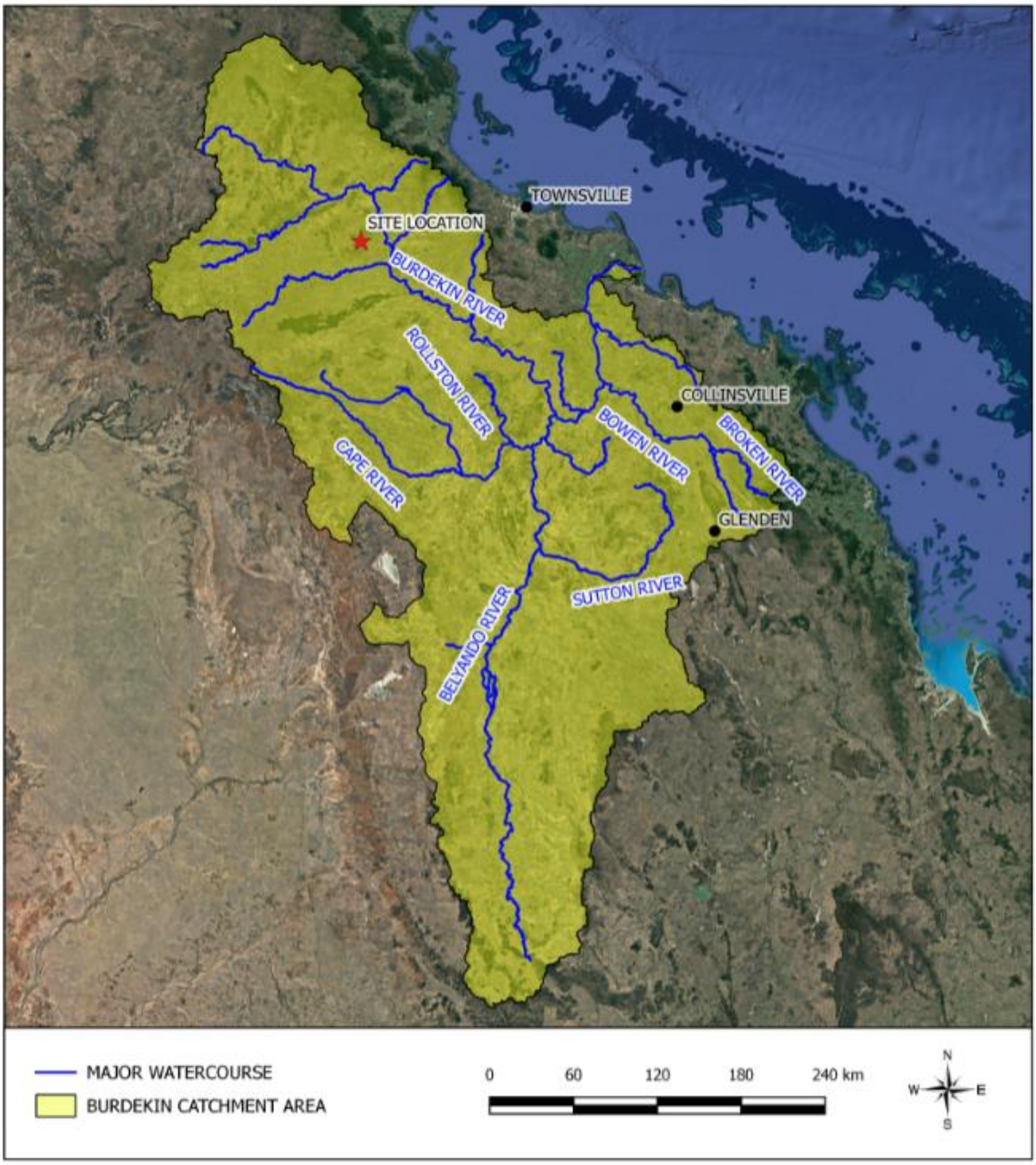
It is noted that under current site (operational) conditions, the total site, including all the sub-catchments as listed in **Table 1**, drains to the Sediment Dam.

2.2 Hydrological Characteristics and Topography

2.2.1 Regional Context

The Lucky Break project site is situated within the Burdekin River Basin (refer **Plate 2**). The site is located some 28km from the Burdekin River channel, and approximately 230km from the confluence with the Burdekin River to Dalrymple Lake (Burdekin Falls Dam). From the Burdekin Falls Dam it is approximately 160km to the Coral Sea. The Burdekin River falls some 620m over its approximately 886km length, to discharge to the Coral Sea.

Plate 2
Burdekin River Basin Catchment Map

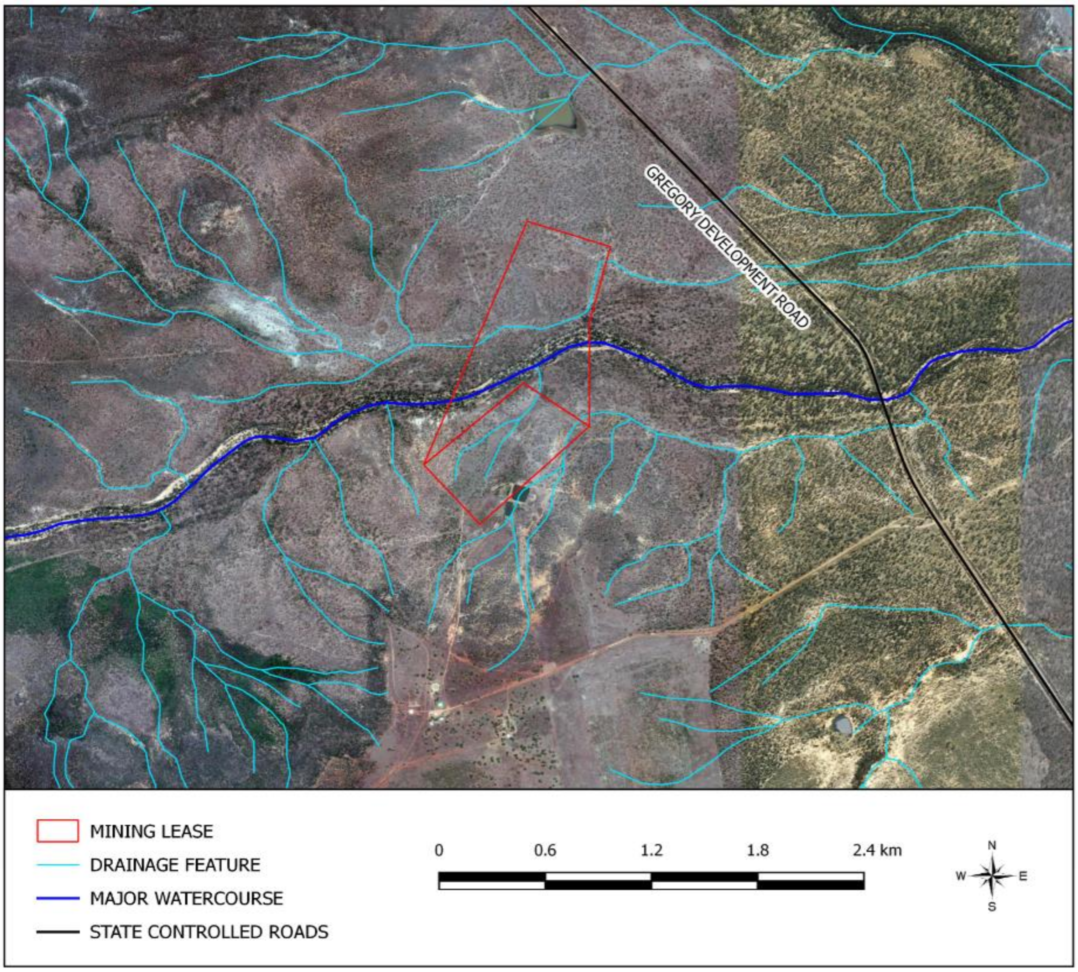


2.2.2 Site Hydrology

Locally, the Lucky Break project site is intersected through the middle of the Mining Leases by Snake Creek, a tributary of Stockyard Creek which reports to the Burdekin River to the east. The topography of the Dingo Dam ML grades away to the north, with overland flows towards Snake Creek, before subsequently joining Stockyard Creek some 4km east of the site. The highest elevation on the site is some RL 365.5m on the south-western extent of the ML, and the lowest elevation is some RL 336.0m on the north-eastern extent. The site location with respect to local hydrological features is provided on **Plate 3**, shown below.

The site is characterised by generally gentle slopes (average 2% to 3%) with overland flow paths becoming channelised upstream of the site infrastructure and subsequently transecting the site. A number of diversion bunds and dams have been previously constructed on the site which has resulted in significant alteration to the natural flow regimes.

Plate 3
Drainage System Proximate to the Project Site



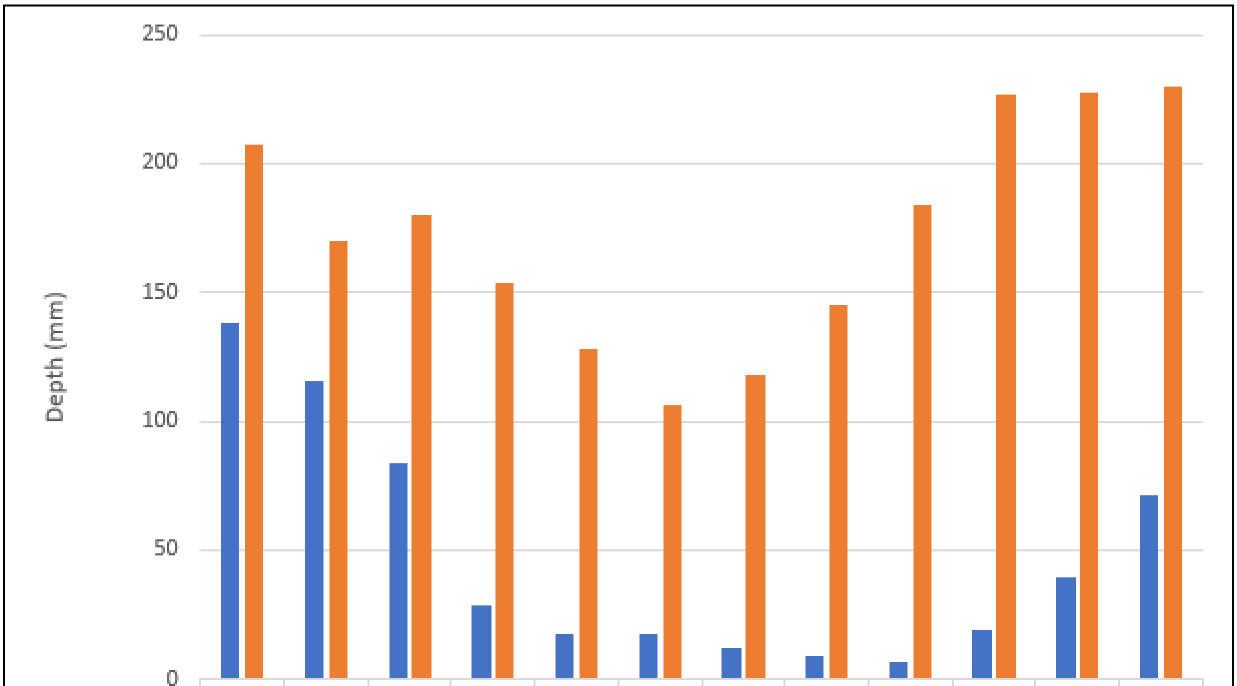
2.3 Climate and Rainfall

The project site, located in Northern Queensland, is subject to a tropical climate. This climate is associated with variable rainfall conditions; however, average values indicate a distinct seasonal pattern with lower rainfall conditions associated with winter months and higher rainfall conditions during the summer months. The wet season occurs from November to March, with 81% of mean annual rainfall occurring during these months.

The nearest meteorological station to the site, with the longest data history, is Hillgrove weather station (No. 30137), located approximately 18km to the south-east. Rainfall data from this station shows that mean annual rainfall is some 553.4mm. The month with the highest average rainfall is January, and the month with the lowest average rainfall is August. Hillgrove station does not have long term evaporation data; therefore, evaporation data has been sourced from a SILO Data Drill specific to the site location.

Plate 4 summarises the average rainfall and evaporation for all months of the year for the site. From the SILO Data series, only evaporation data ranging from 1970 to 2019 was utilized, as Class A evaporation pan data is only available in the region throughout this period.

Plate 4
Mean Rainfall and Evaporation



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	139	115	84	29	18	18	12	9	6	19	39	71
Evaporation	207	170	180	154	128	107	118	145	184	226	228	230

Source: BOM Hillgrove station (No. 30137) and SILO Data Drill requested for the site location (accessed 23 January 2019).

Plate 4 indicates that evaporation exceeds mean monthly rainfall throughout the entire year. On an average monthly basis, maximum evaporation occurs later in the year (October to December). During the dry season months, evaporation is significantly lower, with the lowest monthly total typically occurring in June.

2.4 Regional Flood Mapping

The Queensland Flood Mapping Program 2015 series provided a high-level flood mapping data set for the 1% Annual Exceedance Probability (AEP) and the Extreme Storm Event. Review of the data shows that the Dingo Dam site would not be expected to be inundated by regional storm flow from Snake Creek during the 1% AEP event, but may experience flooding up to 0.5m depth during the Extreme Storm Event.

3 SITE STORMWATER MANAGEMENT PLAN DESIGN BASIS

3.1 Assessment Framework

It is noted that currently no structures on the project site are listed as regulated structures under the site's EA. Consequently, the overarching framework for the stormwater management and design basis in relation to the site has been adopted from the 'Guideline - Stormwater and Environmentally Relevant Activities' (DEHP, 2014). This guideline does not apply to activities defined as resource activities in Schedule 2A of the EP Regulation; although does apply for activities listed under Schedule 2, including ancillary activity 33, as listed under EMPL00900713. This guideline outlines mechanisms that the site must achieve in relation to establishing environmental performance standards to help enhance or protect environmental values. These control mechanisms include the following:

- Preserving existing valuable elements of the natural stormwater system;
- Appropriate management of the quantity and quality of stormwater, at or near the source of potential contaminants;
- Using structural measures, such as treatment techniques or sediment basins, to improve water quality as appropriate; and,
- Management of the receiving water to avoid any residual impacts from stormwater pollutants or flows.

3.2 Relevant Environmental Authority Conditions

The site's EA (EPML00900713) contains a number of conditions related to stormwater management and are summarised in **Table 2**.

Table 2
Summary of Stormwater Related EA Conditions

Number	Condition
D1	**Assessment of Consequence Category (CCA)** The consequence category of any structure must be assessed by a suitably qualified and experienced person in accordance with the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635) at the following times: a) prior to the design and construction of the structure, if it is not an existing structure; or b) if it is an existing structure, prior to the adoption of this schedule; or c) prior to any change in its purpose or the nature of its stored contents.
D2	A consequence assessment report and certification must be prepared for each structure assessed and the report may include a consequence assessment for more than one structure.
D3	Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)
Note	Conditions D4 through D22 may apply depending on the outcome of a CCA
D26	**Register of Regulated Dams** A Register of Regulated Dams must be established and maintained by the holder for each regulated dam:

Number	Condition
Note	Conditions D27 through D31 may apply depending on the outcome of a CCA
C7	**Residual Void Outcome** Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself, and subject to any other condition within this Environmental Authority
Note	A residual void assessment should be undertaken to understand the residual risk to the environment. This assessment would also form part of any CCA.
G1	**Water - General** Contaminants that will, or have the potential to cause environmental harm, must not be released directly or indirectly to any waters except as permitted under the conditions of this Environmental Authority
Note	Conditions G2 through G20 contain relevant information about monitoring of site waters and the associated analytes and trigger limits. Refer to the EA for specific details.
G21	**Water Management Plan** A Water Management Plan must be developed by an appropriately qualified person and implemented by 31 July 2016
G22	Each year the holder of the Environmental Authority must undertake a review of the Water Management Plan prior to the wet season (i.e. by 1 November) and a further review following the wet season (i.e. by 1 May the following year) to ensure that proper and effective measures, practices or procedures are in place so that the mine is operated in accordance with the conditions of this Environmental Authority and that environmental harm is prevented or minimised

There is no list of Regulated Structures within the Site's EA, and as such there is no prescribed hydraulic performance criteria under The Manual[1].

3.3 Adopted Design Basis

The SWMP is based on the design framework outlined in **Section 3.1**, and the scope of this SWMP is outlined in **Section 1.2**. The key objectives of the SWMP for the site are therefore as follows:

- To protect the receiving environment from adverse water quality impacts as a result of overtopping of the void, and
- Maintain appropriate management of peak stormwater flow releases from the site (i.e ensure that peak stormwater flows from the site will not adversely affect the receiving environment).

For the purpose of stormwater management system design, two specific types of stormwater will exist in relation to the site, as follows:

- <u>Clean Stormwater</u>

  Stormwater runoff derived from stabilised surfaces upstream or outside the mine affected footprint or from stabilised/rehabilitated surfaces within the footprint.

[1] Manual for assessing consequence categories and hydraulic performance of structure, Department of Environment and Heritage Protection, 2016.

- Site Stormwater

  Stormwater runoff derived from mine affected/disturbed surfaces located within the site footprint. For the context of this report, 'site stormwater' is essentially limited to the water reporting to the void.

4 STORMWATER MANAGEMENT PLAN

4.1 Stormwater Management Plan Objectives

As stated in **Section 1.2 and Section 3.1,** the objectives are summarised as follows:

- Minimise catchment areas reporting to the ex-mining void to minimise the risk of the void overtopping
- Restore natural drainage paths, where possible, to minimise impounded water
- Minimise potential for environmental harm (ie erosion)

4.2 Stormwater Management Features

The proposed site SWMP developed is presented in this section. The SWMP involves relatively minor earthworks to create new bunds/embankments, remove bunds/embankments at various locations and also locations of levelling or grading works to create new preferable flow paths.

The proposed new site infrastructure features as shown on **FIGURE 002**, are summarised in **Table 3**.

Table 3
Summary of Proposed Stormwater Management Features

Feature (as shown on FIGURE 002)	Description
1	• Cut new trapezoidal spillway/channel through Dingo Dam embankment to direct overflow toward existing natural drainage path • Invert of cut to match downstream existing ground elevation (approx. RL 345.1m) • Base width is to be minimum 8.0m • Batter slopes to be 1 (V) : 2 (H) • Revegetate with grasses
2	• Cut new trapezoidal spillway/channel through existing embankment to allow unrestricted continuation of flow toward existing natural drainage path • Invert of cut to match downstream existing ground elevation (approx. RL 339.2m) • Base width is to be minimum 40.0m • Batter slopes to be 1 (V) : 4 (H) • Revegetate with grasses
3	• Reinstate Dingo Dam embankment to match adjacent crest levels and batter slopes. • Use non-dispersive low permeability earthen fill • Revegetate with grasses
4	• Fill area between Dingo Dam and void to create unobstructed free-draining condition • Base with of area should be approximately 22m (varies) • Batter slopes to be 1 (V) : 4 (H) • Embankment/bund height either side should be minimum 0.5m from toe to crest • Use non-dispersive earthen fill • Revegetate with grasses

5	• Construct embankment/bund along eastern wall of the void • Use non-dispersive low permeability earthen fill • Revegetate with grasses
6	• Cut/remove existing haul road at north-western corner of the void to direct void overflow to the sediment dam via existing ROM pad embankment/bunding • Finish surface level to RL 339.4m to match current void overflow invert • Revegetate with grasses

Note: Table 3 is not intended to be used as a construction specification. Compaction, moisture conditioning and growth media specifications to be determined.

4.3 Proposed Catchment Conditions

Based on the proposed site configuration and the change to catchment areas, the catchment area reporting to the void has been minimised to 4.9ha, a reduction of 74.5 ha. The Feature 2 spillway is proposed to manage the clean water catchment, which currently collects stormwater from the southern bund located to the south of ML 10324 (Dingo Dam). The Pond and Dingo Dam catchment area will be directly released into Snake Creek, whilst the Pit Void catchment area will be managed within the ML area.

The proposed catchments are summarised in **Table 4** and are shown on **FIGURE 003**.

Table 4
Summary of Proposed Catchment Areas

Catchment	Area (ha)
Pit Void	4.9
Feature 1 (Dingo Dam)	26.6
Feature 2	65.0
Feature 4	47.8
ROM	3.1
Sediment Basin	21.2
Total Catchment to Sediment Basin	24.3
Total Catchment to Feature 2	139.4

4.4 Hydrological and Hydraulic Calculations

The Rational Method (Queensland Urban Drainage Manual, 2016) of peak flow estimation was used to assess flow rates at key locations of the site for the 1% Annual Exceedance Probability (AEP) and the 50% AEP storm events, commonly referred to as the 1-in-100-year and 1-in-2-year storm events, respectively. The locations of flow estimations and the catchments areas are relative to the proposed site configuration presented in this SWMP as described in **Table 3** and are shown on **FIGURE 003**.

The peak flow estimations were then utilised to calculate expected flow velocities at the key locations to assess whether an erosion risk exists. The hydraulic calculations presented are relative to proposed site configuration and existing ground conditions (as stated). The calculations are summarised in **Table 5**, and the locations of the features are shown on **FIGURE 003**.

Table 5
Summary of Hydrological and Hydraulic Calculations at Selected Locations

Location / Feature	Peak Flow Estimation (m^3/s)		Peak Flow Velocity Estimation (m/s)		Peak Flow Depth Estimation (m)	
	Q2	Q100	Q2	Q100	Q2	Q100
Feature 1 (Proposed)	1.9	5.6	1.45	2.0	0.2	0.35
Feature 2 (Proposed)	11.5	32.2	1.48	2.25	0.2	0.4
Feature 4 (Proposed)	3.4	10.1	1.2	1.75	0.15	0.3
ROM Overflow (Existing)	0.3	0.8	0.95	1.42	0.1	0.2
Sediment Basin Overflow (Existing)	1.8	5.0	1.45	1.75	0.25	0.4

As is shown in **Table 5**, peak estimated velocities in the Q2 flow events are expected to be low (below 1.5m/s) which is generally considered to not result in erosion to surfaces with average grass cover. As the Q100 peak estimated flow velocities are between 1.42m/s and 2.25m/s, some erosion may occur during such rare flow events. However, the effect of routing attenuation (i.e. the delay of the flow wave caused by the site water storages) has not been considered in these flow estimations, meaning that these peak flow and velocity estimations are conservative. The calculated flow depths also show that none of the proposed or existing bund/embankment features are expected to overtop during the 1-in-100-year storm event.

The hydraulic calculations are provided in **Appendix A**.

4.5 Estimated Storage Structure Volumes

Storage volumes were calculated using the site survey data (provided by client) and are provided for information purposes in **Table 6**. The volumes shown are to estimated spillway invert of the structure.

Table 6
Summary of Proposed Catchment Areas

Storage	Spill Invert (RL m)	Volume (ML)
Dingo Dam	345.0	1.7
Void	339.4	37.7
Sediment Dam	337.3	10.3
Pond	345.7	6.6

4.6 Ex-Mining Void Overtopping

The potential for the ex-mining void to overtop has been assessed on a first principals' basis. The estimated volume of the void is 37.7ML with the proposed catchment area of 4.9ha results in a rainfall depth of some 769mm to completely fill the void, which is in excess of the mean annual rainfall value of 553.4mm as shown in **Section 2.3**. The basic calculation does not consider evaporation losses or infiltration losses. The assessment indicates that during 'average' rainfall conditions the void would not be expected to overtop, however a water balance model would be required to be developed to better understand the spill risk.

5 SUMMARY AND RECOMMENDATIONS

As is shown through the calculation of peak flow rate, depth and velocity estimates, presented in **Table 5**, for key locations of the proposed site configuration presented in this SWMP, it can be concluded that the overall objectives of the SWMP as outlined in **Section 4.1** have been achieved. This is a result of the combination of the catchment area reporting to the ex-mining void being reduced from 79.4 ha to 4.9 ha, and the calculation of relatively low flow depths and velocities at the assessed locations which are not expected to result in significant erosion of the site.

Beyond the scope of this SWMP and to meet the conditions of the site's EA, as shown in **Table 2,** it is recommend that AML engage a suitably qualified consultant to carry out a CCA (for relevant structures) and a residual void assessment to determine whether any of the site's structures are required to be listed as Regulated Structures on the site's EA.

REFERENCES

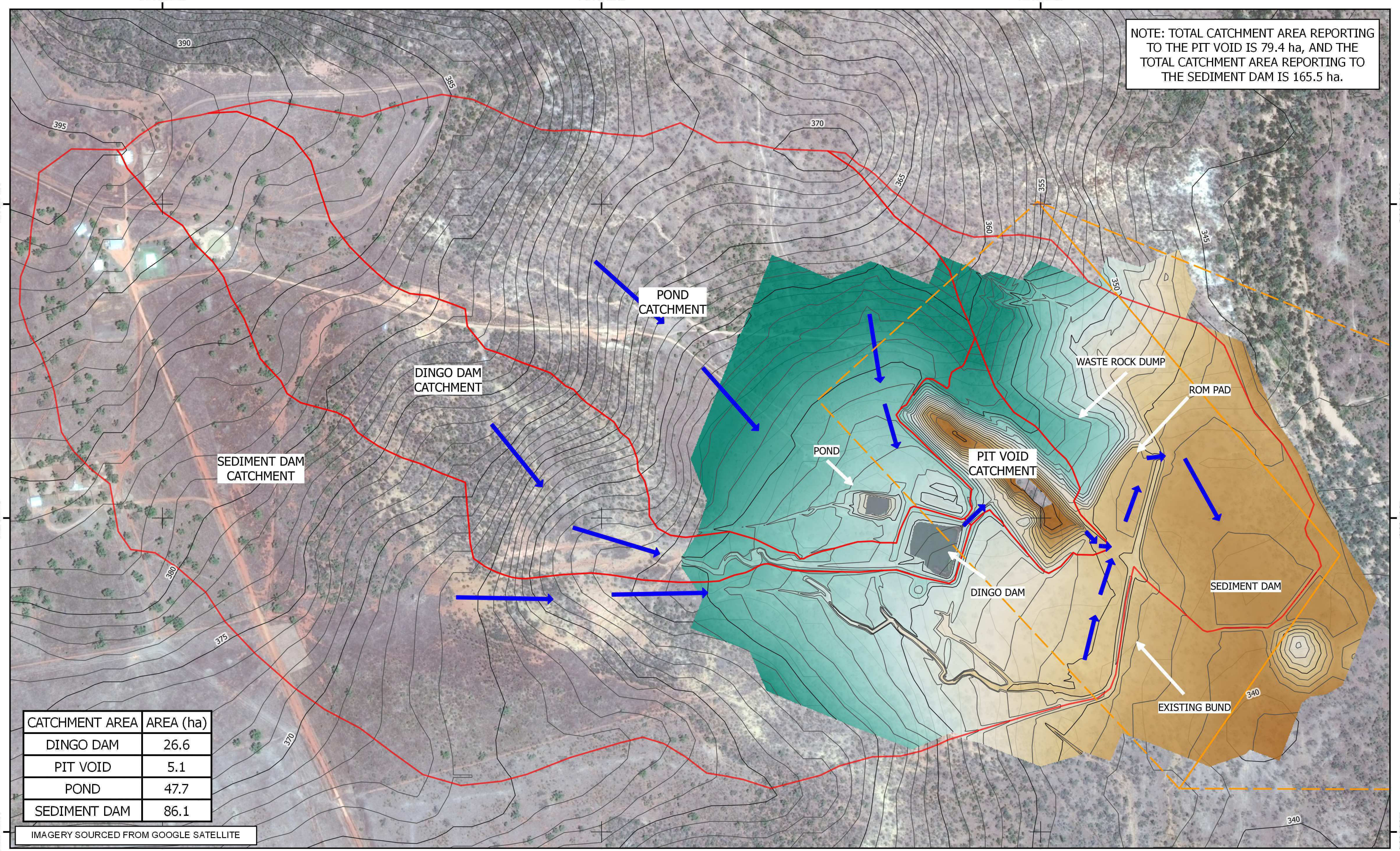
[1] Guideline – 'Stormwater and Environmentally Relevant Activities' (2014). Department of Environment and Heritage Protection.

[2] Queensland Regional Flood Mapping Program 2015, Queensland Reconstruction Authority https://www.qra.qld.gov.au

[3] The manual for assessing consequence categories and hydraulic performance of structures (March 2016). Department of Environment and Heritage Protection.

[4] Queensland Urban Drainage Manual, 2016. Institute of Public Works Engineers Queensland.

FIGURES



CATCHMENT AREA	AREA (ha)
DINGO DAM	26.6
PIT VOID	5.1
POND	47.7
SEDIMENT DAM	86.1

LEGEND

- 1m CONTOURS
- FLOW DIRECTION
- CATCHMENT AREAS
- MINING LEASE AREAS

ELEVATION (RL m)

335.0	345.0
337.5	347.5
340.0	350.0
342.5	352.5

FIGURE 001
AUSTRALIAN MINES LTD

LUCKY BREAK/DINGO DAM PROJECT
EXISTING SITE CONDITIONS

0 75 150 225 300 m

ATC Williams

DATE: 2019-01-29

CRS: GDA94 / MGA Zone 55

SITE DEM SURVEY PROVIDED BY CLIENT, SURROUNDING SURVEY SOURCED FROM ELVIS SPATIAL CATALOGUE

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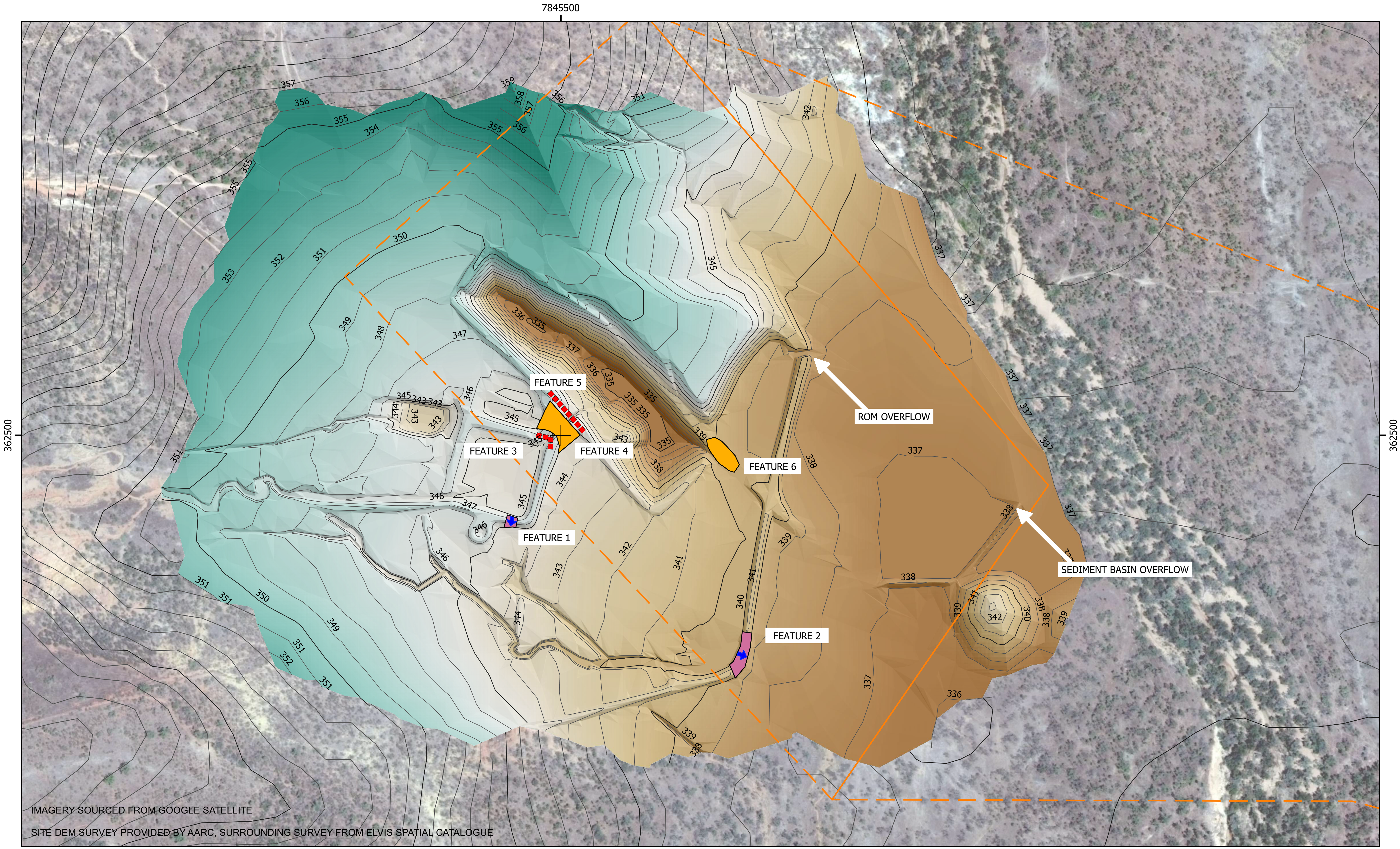


LEGEND

- 1m CONTOURS
- FLOW DIRECTION
- BUND PLACEMENT
- MINING LEASE AREAS
- REGRADE AREA
- BUND REMOVAL

ELEVATION (RL m)

335.0	345.0
337.5	347.5
340.0	350.0
342.5	352.5

0 50 100 150 200 250 m

FIGURE 002
AUSTRALIAN MINES LTD

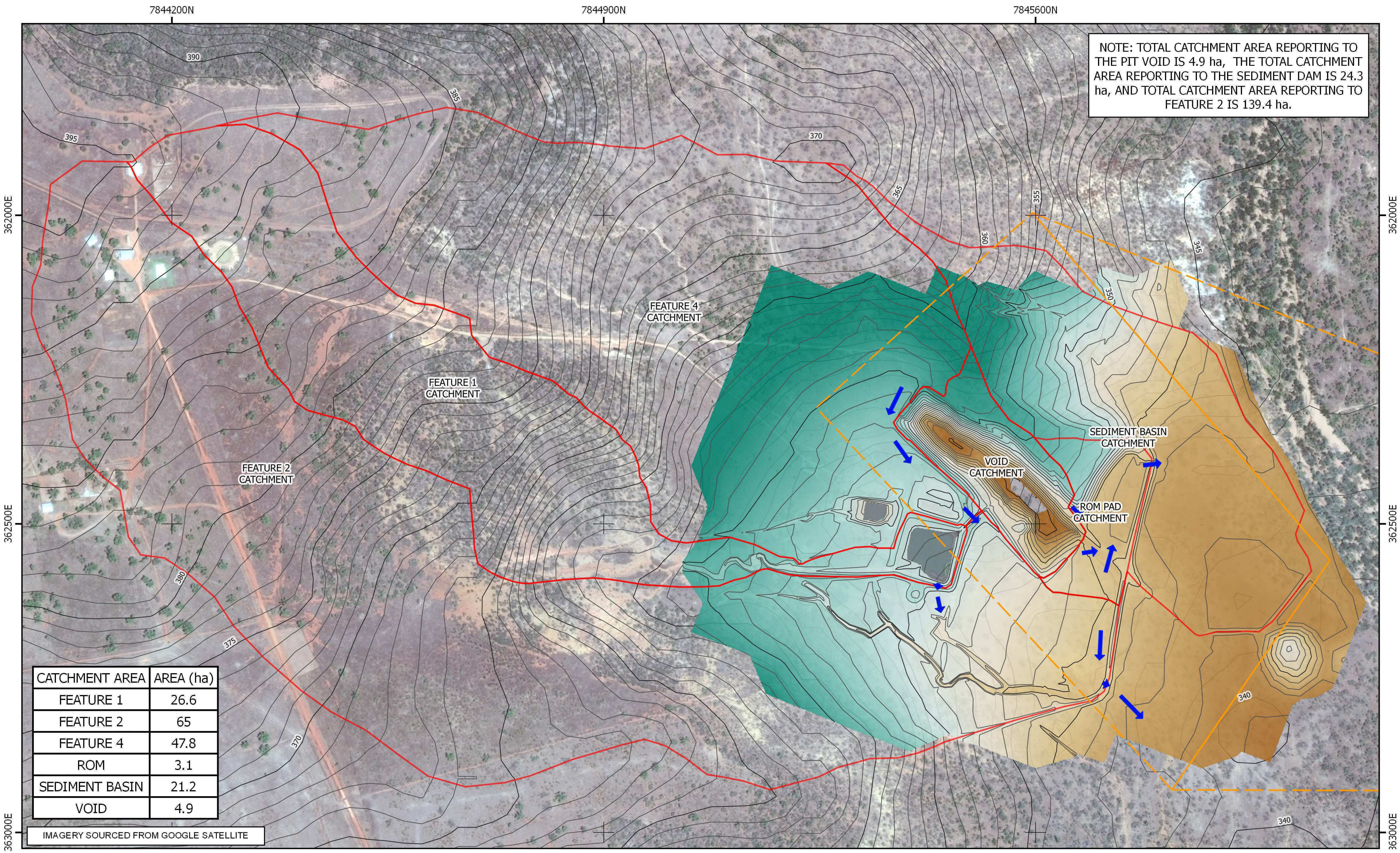
LUCKY BREAK/DINGO DAM PROJECT
PROPOSED STORMWATER MANAGEMENT PLAN FEATURES

ATC Williams

DATE: 2019-06-04

CRS: GDA94 / MGA Zone 55

FILE: 118284-01GIS.qgs REV 1



CATCHMENT AREA	AREA (ha)
FEATURE 1	26.6
FEATURE 2	65
FEATURE 4	47.8
ROM	3.1
SEDIMENT BASIN	21.2
VOID	4.9

LEGEND

- 1m CONTOURS
- FLOW DIRECTION
- CATCHMENT AREAS
- MINING LEASE AREAS

ELEVATION (RL m)

335.0 345.0
337.5 347.5
340.0 350.0
342.5 352.5

SITE DEM SURVEY PROVIDED BY CLIENT, SURROUNDING SURVEY SOURCED FROM ELVIS SPATIAL CATALOGUE

FIGURE 003
AUSTRALIAN MINES LTD

LUCKY BREAK/DINGO DAM PROJECT
PROPOSED CATCHMENT CONDITIONS

0 75 150 225 300 m

ATC Williams

DATE: 2019-01-29

CRS: GDA94 / MGA Zone 55

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APPENDICES

Feature 1 - Dingo Dam Outlet

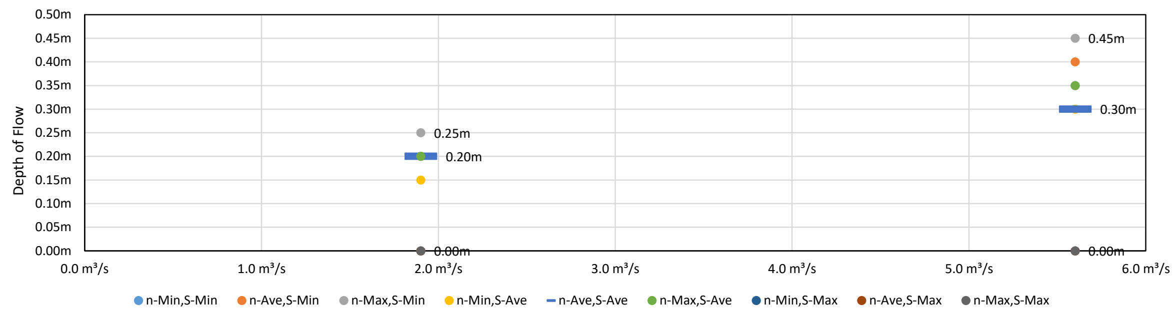
Design Event / Description	Required Discharge Rate (Q_{des})
Q2	1.9 m³/s
Q100	5.6 m³/s

Drain Roughness	Category	Excavated Channels		
	Sub Description	*Earth, straight, and uniform - with short grass, few weeds*		
Use drop down menu for Category, then Sub Description (Top Right). Do not edit the mannings values directly.	Mannings	Minimum	Normal	Maximum
		0.022	0.027	0.033

Geometry	Value
Left Batter	1(V) : 2.0(H)
Right Batter	1(V) : 2.0(H)
Base width	8.0 m
Slope	
Minimum	0.010 m/m
Average	0.020 m/m
Maximum	

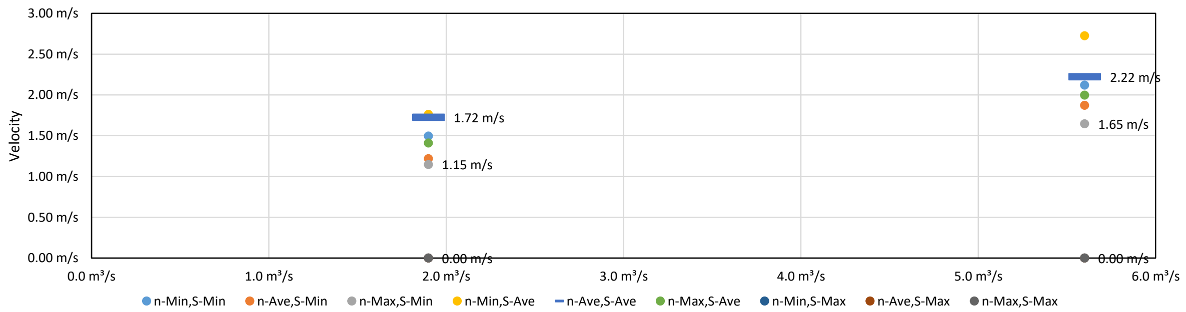
Calculations are based upon the Manning's Uniform Flow Equation. As such, they assume sufficient consistent grade for uniform flow to develop. Mannings 'n' Roughness values are adopted from Ven Te Chow's "Open Channel Hydraulics" Reference (1959). Spreadsheet should not be used for rapidly varying flow. Calculation is innapropriate for high gradient flows, and these should be designed as chutes instead.

Results



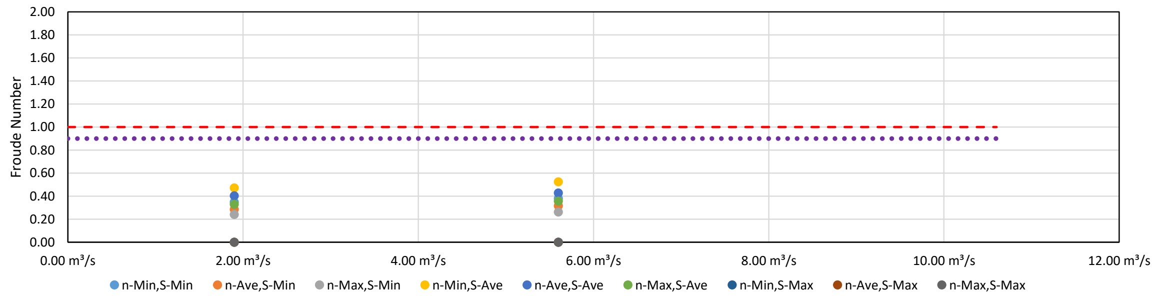
Depth vs. Discharge

Standard Uniform Flow Depth Outcomes by Mannings 'n' and Slope



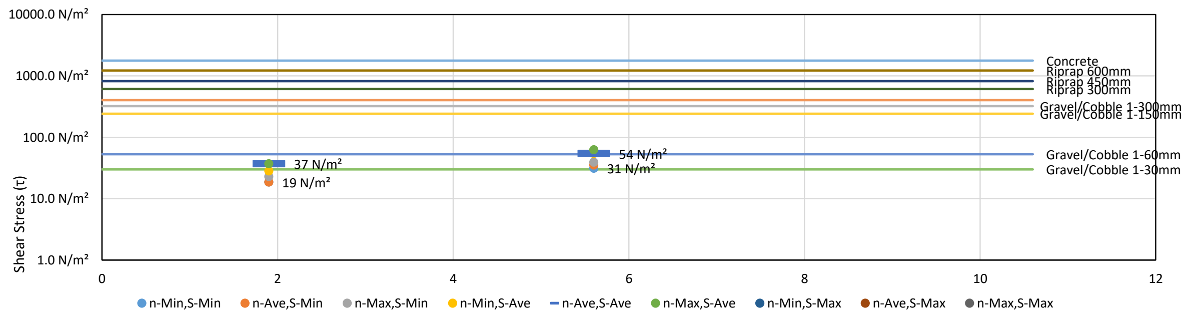
Velocity vs. Discharge

Note that the highest velocity will associate with the lowest Depth



Froude Number vs. Discharge

Note - if the Froude Number is approaching 1, then Free Standing Waves may exist - ABOVE the depth determined in the first graph.
If the Froude Number exceeds 1, then the potential for Hydraulic Jump should be considered.



Shear Stress vs. Discharge

Included to give a first pass indication of required armouring - based on shear stress potential to erode material - If a rough material is required, the mannings value adopted may need to be iterated.

Feature 2 - Break in Bund

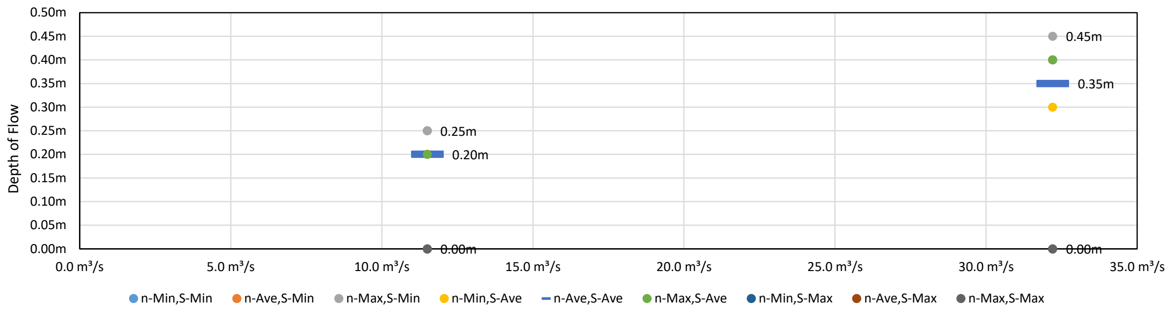
Design Event / Description	Required Discharge Rate (Q_{des})
Q2	11.5 m³/s
Q100	32.2 m³/s

Drain Roughness	Category	Excavated Channels		
	Sub Description	*Earth, straight, and uniform - with short grass, few weeds*		
Use drop down menu for Category, then Sub Description (Top Right). Do not edit the mannings values directly.	Mannings	Minimum	Normal	Maximum
		0.022	0.027	0.033

Geometry	Value
Left Batter	1(V) : 4.0(H)
Right Batter	1(V) : 4.0(H)
Base width	40.0 m
Slope	
Minimum	0.010 m/m
Average	0.020 m/m
Maximum	

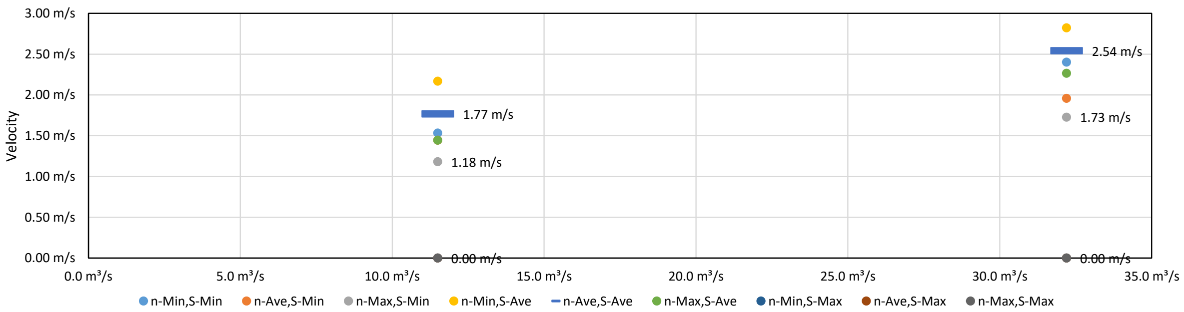
Calculations are based upon the Manning's Uniform Flow Equation. As such, they assume sufficient consistent grade for uniform flow to develop. Mannings 'n' Roughness values are adopted from Ven Te Chow's "Open Channel Hydraulics" Reference (1959). Spreadsheet should not be used for rapidly varying flow. Calculation is innapropriate for high gradient flows, and these should be designed as chutes instead.

Results



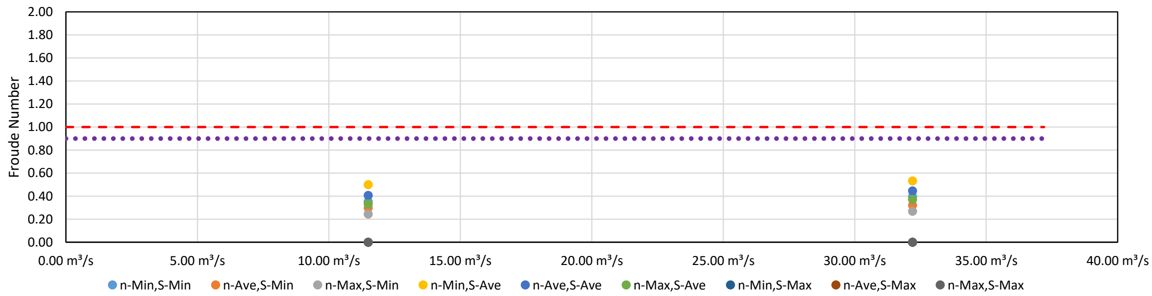
Depth vs. Discharge

Standard Uniform Flow Depth Outcomes by Mannings 'n' and Slope



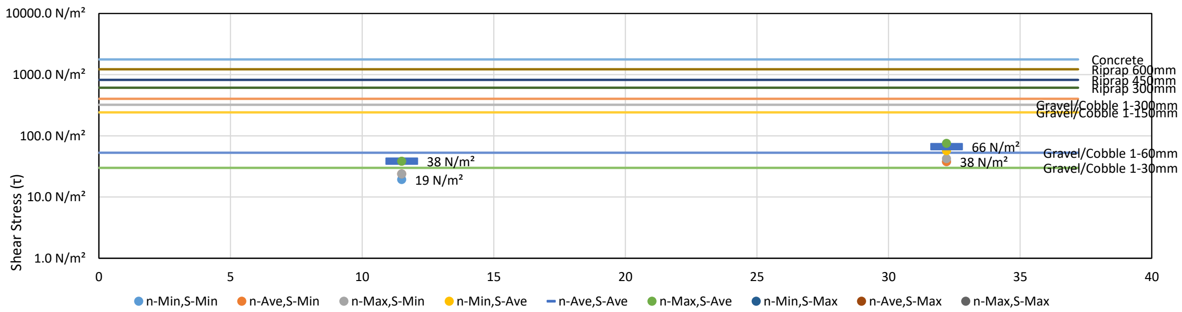
Velocity vs. Discharge

Note that the highest velocity will associate with the lowest Depth



Froude Number vs. Discharge

Note - if the Froude Number is approaching 1, then Free Standing Waves may exist - ABOVE the depth determined in the first graph.
If the Froude Number exceeds 1, then the potential for Hydraulic Jump should be considered.



Shear Stress vs. Discharge

Included to give a first pass indication of required armouring - based on shear stress potential to erode material - If a rough material is required, the mannings value adopted may need to be iterated.

Feature 4 - Channel Section Between Dingo Dam and Void

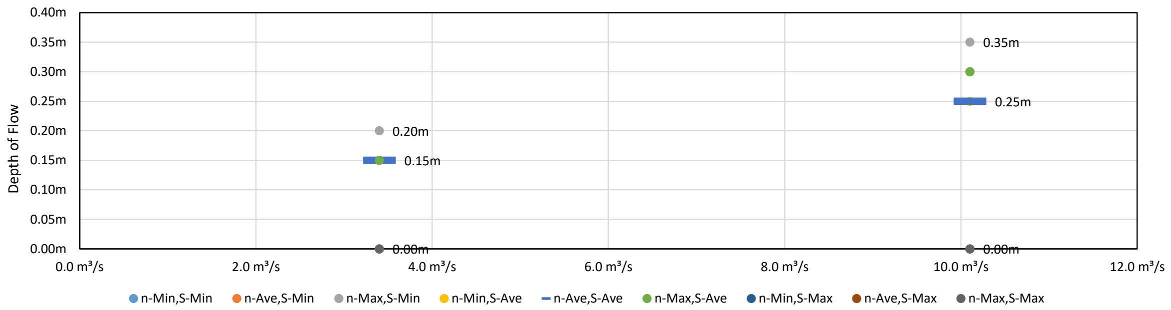
Design Event / Description	Required Discharge Rate (Q_{des})
Q2	3.4 m³/s
Q100	10.1 m³/s

Drain Roughness	Category	Excavated Channels		
	Sub Description	Earth, straight, and uniform - with short grass, few weeds		
Use drop down menu for Category, then Sub Description (Top Right). Do not edit the mannings values directly.	Mannings	Minimum	Normal	Maximum
		0.022	0.027	0.033

Geometry	Value
Left Batter	1(V) : 4.0(H)
Right Batter	1(V) : 4.0(H)
Base width	22.0 m
Slope	
Minimum	0.010 m/m
Average	0.020 m/m
Maximum	

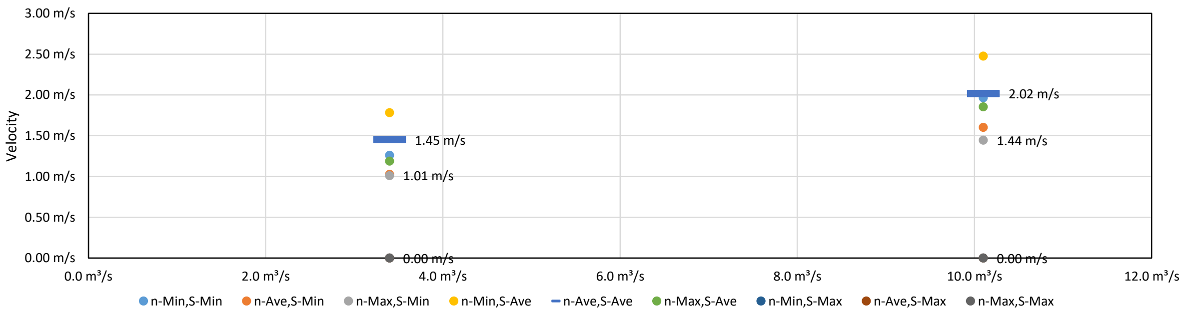
Calculations are based upon the Manning's Uniform Flow Equation. As such, they assume sufficient consistent grade for uniform flow to develop. Mannings 'n' Roughness values are adopted from Ven Te Chow's "Open Channel Hydraulics" Reference (1959). Spreadsheet should not be used for rapidly varying flow. Calculation is innapropriate for high gradient flows, and these should be designed as chutes instead.

Results



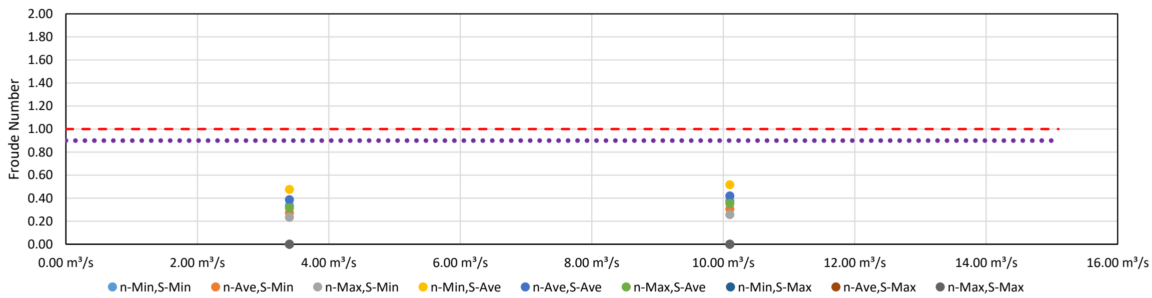
Depth vs. Discharge

Standard Uniform Flow Depth Outcomes by Mannings 'n' and Slope



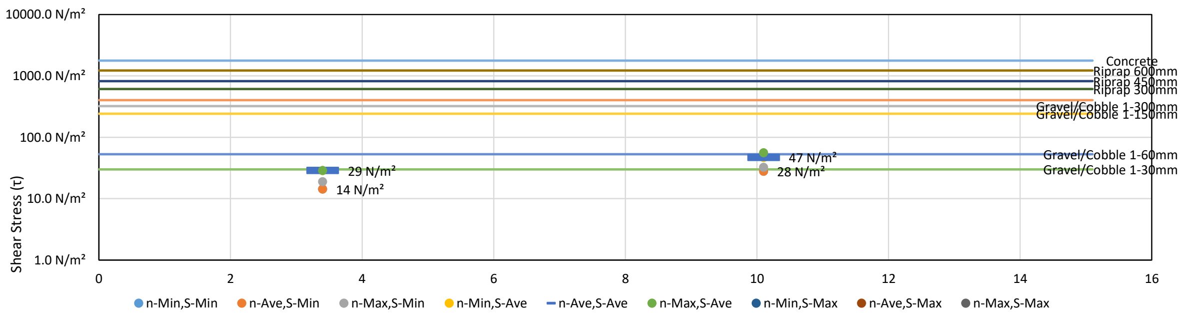
Velocity vs. Discharge

Note that the highest velocity will associate with the lowest Depth



Froude Number vs. Discharge

Note - if the Froude Number is approaching 1, then Free Standing Waves may exist - ABOVE the depth determined in the first graph.
If the Froude Number exceeds 1, then the potential for Hydraulic Jump should be considered.



Shear Stress vs. Discharge

Included to give a first pass indication of required armouring - based on shear stress potential to erode material - If a rough material is required, the mannings value adopted may need to be iterated.

ROM Overflow

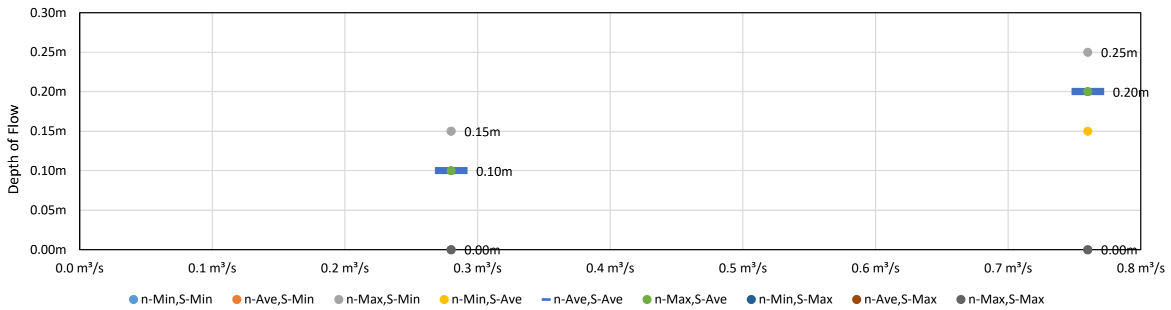
Design Event / Description	Required Discharge Rate (Q_{des})
Q2	0.3 m³/s
Q100	0.8 m³/s

Drain Roughness	Category	Excavated Channels		
	Sub Description	*Earth, straight, and uniform - with short grass, few weeds*		
Use drop down menu for Category, then Sub Description (Top Right). Do not edit the mannings values directly.	Mannings	Minimum	Normal	Maximum
		0.022	0.027	0.033

Geometry	Value
Left Batter	1(V) : 2.0(H)
Right Batter	1(V) : 2.0(H)
Base width	3.0 m
Slope	
Minimum	0.010 m/m
Average	0.020 m/m
Maximum	

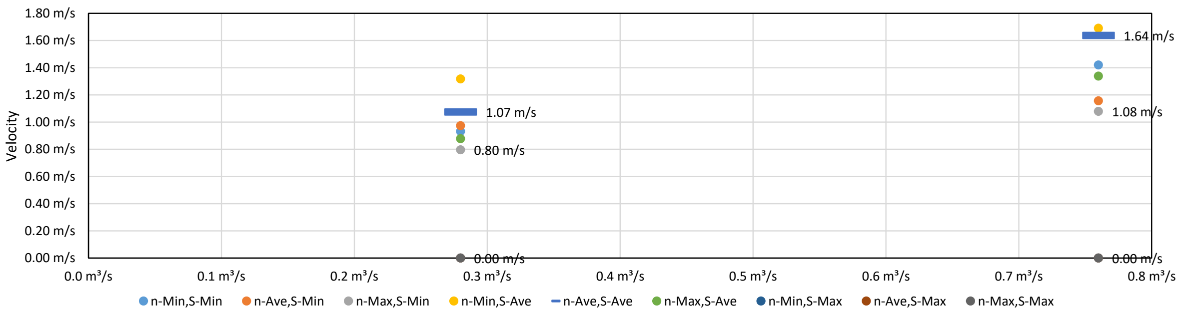
Calculations are based upon the Manning's Uniform Flow Equation. As such, they assume sufficient consistent grade for uniform flow to develop. Mannings 'n' Roughness values are adopted from Ven Te Chow's "Open Channel Hydraulics" Reference (1959). Spreadsheet should not be used for rapidly varying flow. Calculation is innapropriate for high gradient flows, and these should be designed as chutes instead.

Results



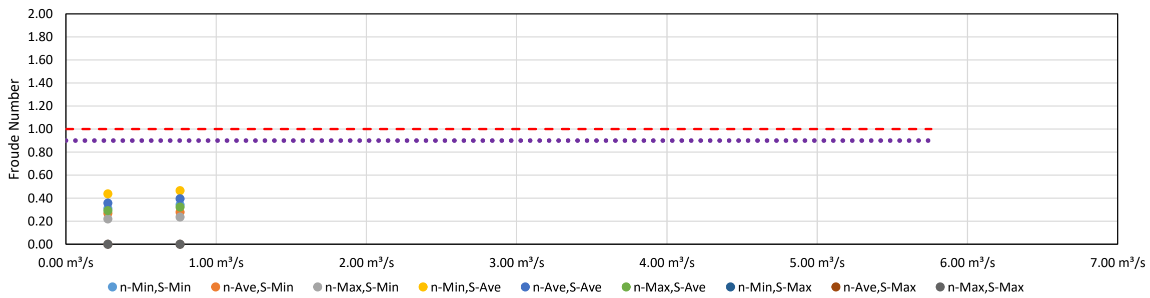
Depth vs. Discharge

Standard Uniform Flow Depth Outcomes by Mannings 'n' and Slope



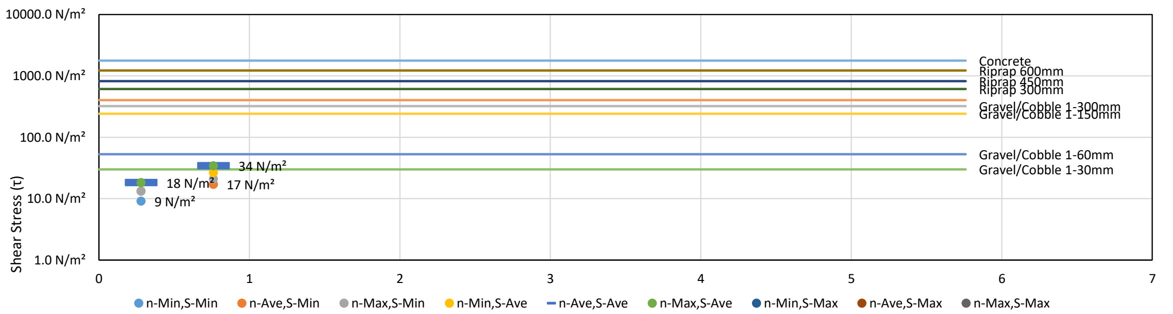
Velocity vs. Discharge

Note that the highest velocity will associate with the lowest Depth



Froude Number vs. Discharge

Note - if the Froude Number is approaching 1, then Free Standing Waves may exist - ABOVE the depth determined in the first graph.
If the Froude Number exceeds 1, then the potential for Hydraulic Jump should be considered.



Shear Stress vs. Discharge

Included to give a first pass indication of required armouring - based on shear stress potential to erode material - If a rough material is required, the mannings value adopted may need to be iterated.

Sediment Basin Outlet

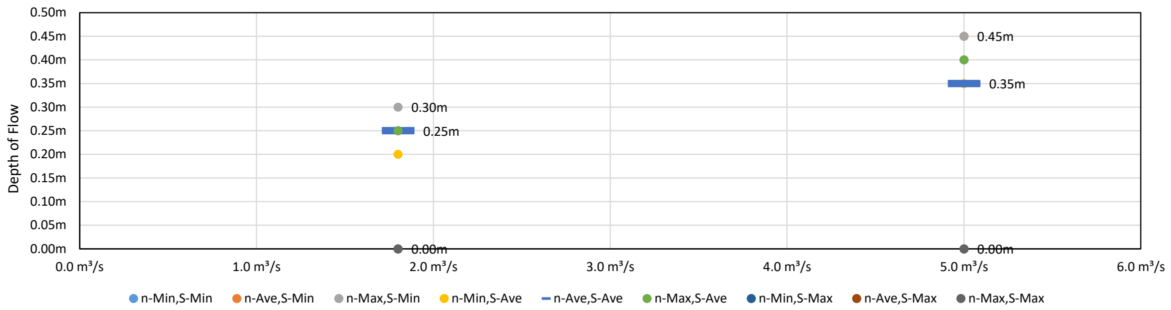
Design Event / Description	Required Discharge Rate (Q_{des})
Q2	1.8 m³/s
Q100	5.0 m³/s

Drain Roughness	Category	Excavated Channels		
	Sub Description	Earth, straight, and uniform - with short grass, few weeds		
Use drop down menu for Category, then Sub Description (Top Right). Do not edit the mannings values directly.	Mannings	Minimum	Normal	Maximum
		0.022	0.027	0.033

Geometry	Value
Left Batter	1(V) : 5.0(H)
Right Batter	1(V) : 15.0(H)
Base width	4.0 m
Slope	
Minimum	0.010 m/m
Average	0.020 m/m
Maximum	

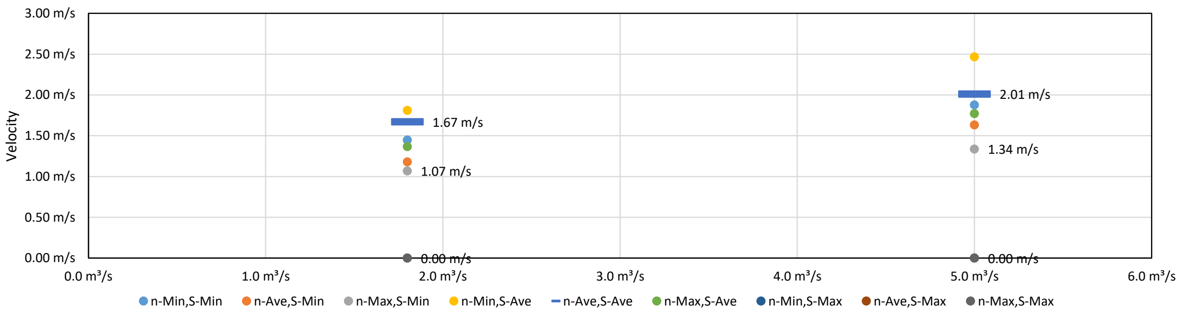
Calculations are based upon the Manning's Uniform Flow Equation. As such, they assume sufficient consistent grade for uniform flow to develop. Mannings 'n' Roughness values are adopted from Ven Te Chow's "Open Channel Hydraulics" Reference (1959). Spreadsheet should not be used for rapidly varying flow. Calculation is innapropriate for high gradient flows, and these should be designed as chutes instead.

Results



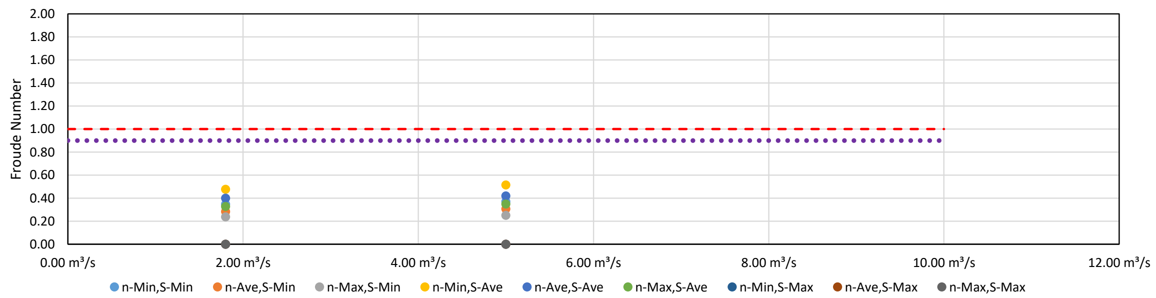
Depth vs. Discharge

Standard Uniform Flow Depth Outcomes by Mannings 'n' and Slope



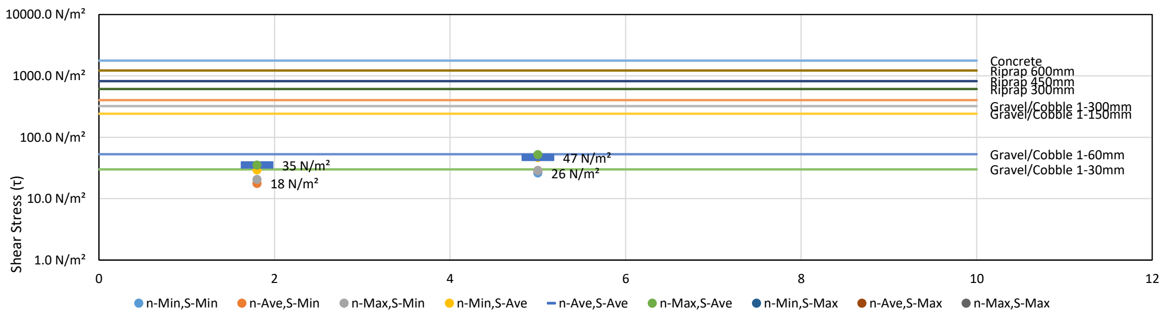
Velocity vs. Discharge

Note that the highest velocity will associate with the lowest Depth



Froude Number vs. Discharge

Note - if the Froude Number is approaching 1, then Free Standing Waves may exist - ABOVE the depth determined in the first graph. If the Froude Number exceeds 1, then the potential for Hydraulic Jump should be considered.



Shear Stress vs. Discharge

Included to give a first pass indication of required armouring - based on shear stress potential to erode material - If a rough material is required, the mannings value adopted may need to be iterated.