Earl Grey Lithium Project
Surface Water Hydrology Assessment

Prepared for Covalent Lithium

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1. Introduction

1.1. Background

Covalent Lithium Pty Ltd (Covalent) is developing the Earl Grey Lithium Project (EGLP), located approximately 100 km south of Southern Cross, Western Australia. The project location is shown in **Figure 1-1**. The site of the EGLP is the former Mt Holland Mine Site that was previously developed by others for gold mining before being abandoned. Covalent commencing mining at the site for lithium in 2021.

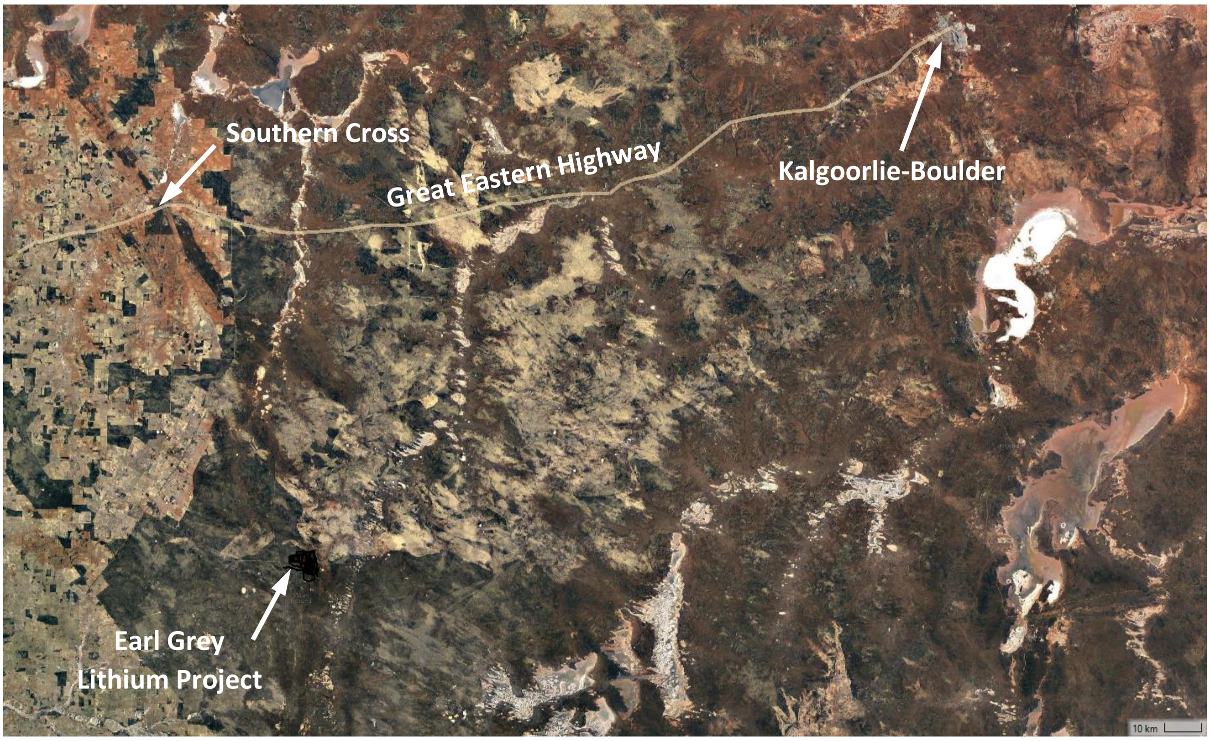


Figure 1-1: Earl Grey site location

1.2. Study Objectives

Surface Water Solutions (SWS) was engaged by Covalent to assess the surface water hydrology at the Earl Grey site in support of the Part IV Environmental Impact Assessment for the life of mine (LoM) footprint and mine layout to support LoM operations.

The assessment addresses key environmental factors related to water management, including requirements to maintain the hydrological regimes and protect environmental values for hydrological processes.

This report presents a surface water assessment of the 1% Annual Exceedance Probability (AEP), 24-hour rainfall event and the 10% AEP, 72-hour rainfall event under the current baseline scenario and for the proposed LoM mining operations. The baseline scenario is based on topographic data acquired in 2022.

1.3. Methodology

This report presents a surface water assessment of the 1% Annual Exceedance Probability (AEP), 24-hour rainfall event and the 10% AEP, 72-hour rainfall event under LoM and baseline scenarios. The baseline scenario is based on topographic details compiled in 2022. Baseline and LoM scenarios are modelled with two-dimensional (2D) rain on grid hydraulic modelling using HEC-RAS Version 6.4.1 software (USACE 2023), with comparisons of flow rates, flow volumes, flood depths, and affected catchment areas presented at key locations.

1.4. Abbreviations

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DEM	Digital Elevation Model
EA	Engineers Australia
EGLP	Earl Grey Lithium Project
IFD	Intensity Frequency Duration
LoM	Life of Mine
MRWA	Main Roads Western Australia
RCP	Representative Concentration Pathway
RFFE	Regional Flood Frequency Estimation
SILO	Scientific Information for Land Owners
USACE	United States Army Corps of Engineers

2. Existing Environment

2.1. Regional Hydrology

The Earl Grey site is located within the 58,000 km^2 Swan Avon Yilgam catchment in the Avon River Basin as mapped by the WA Department of Water and Environmental Regulation (DWER). As depicted in **Figure 2-1**, the site spans a subcatchment divide, with the western portion of the site located within the 4,094 km^2 Yellowdine Subcatchment and the eastern portion located within the 7,582 km^2 Lake Eva Subcatchment. The Yellowdine Subcatchment generally drains to the north, while the Lake Eva Subcatchment is characterised by discontinuous chains of salt lakes along the valley floor.

Figure 2-2 shows catchment delineations and flow paths based on 2022 topography. **Figure 2-3** shows the catchment and flow path alignments relative to the Development Envelope and LoM footprint. The figures also show the locations of adopted comparison points for assessing baseline vs. post-project flow rates, volumes, and impacted catchment areas.

2.2. Meteorology

Precipitation gauge records are available from three sites located near the study area:

- Mulgara (ID 12298) – 49 km NW of the Study Area, 37 years of data between 1984 and 2021;
- Lake Carmody (ID 10670) – 54 km SW of the Study Area, 114 years of data between 1906 and 2021;
- King Rocks (ID 10581) – 62 km WSW of the Study Area, 89 years of data between 1930 and 2019.

Figure 2-4 shows intensity-frequency-duration (IFD) data for the Earl Grey site. As shown in the figure, the 1% AEP, 24-hour precipitation depth is 120 mm, and the 10% AEP, 72-hour precipitation depth is 86 mm.

The Annual Exceedance Probability (AEP) refers to the probability of an event being equalled or exceeded within a year (Ball et al. 2019). The 10% AEP event represents a typical design level for planning of surface water drainage infrastructure. Less frequent events such as the 1% AEP are used to assess performance during very rare floods and to aid in determining design levels for critical infrastructure.

The Queensland government's Scientific Information for Land Owners (SILO) database provides spatial and temporal interpolation of gauge records to estimate local precipitation (Jeffrey et al., 2001). Based on SILO data for the Earl Grey site catchment, the average annual precipitation is 315 mm/year, and average annual pan evaporation is 1987 mm/year (i.e., annual evaporation greatly exceeds annual rainfall). The average maximum daily temperature is 23.9 deg C, and the average minimum daily temperature is 9.6 deg C.

Previous reports by JDA provide further background on the hydrology and flood characteristics of the site (JDA 2018, 2019, and 2022). The reports include additional details on background hydrology, meteorology, gauging, evaporation, soil lithology, vegetation, and surface drainage.

2.3. Regional Flood Frequency Estimation

The Regional Flood Frequency Estimation procedure is not currently available for the arid region around the Earl Grey site. Flavell (2012) and other regression approaches are likewise based on limited data sets with unreliable results. To account for the high uncertainty, this hydrological assessment incorporates conservative temporal patterns, loss rates, and roughness coefficients in developing rainfall-runoff relationships for the EGLP.

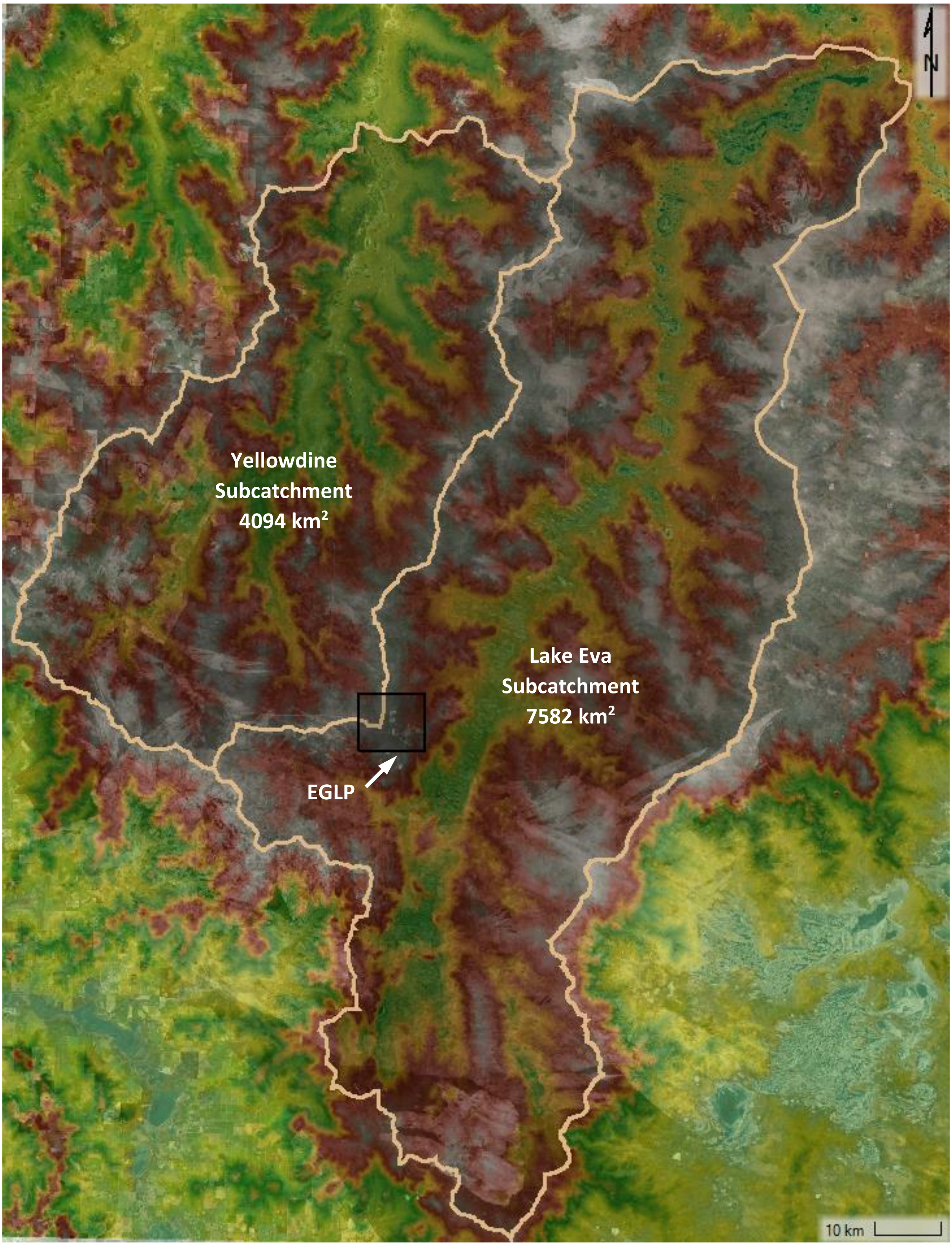


Figure 2-1: Regional Catchments

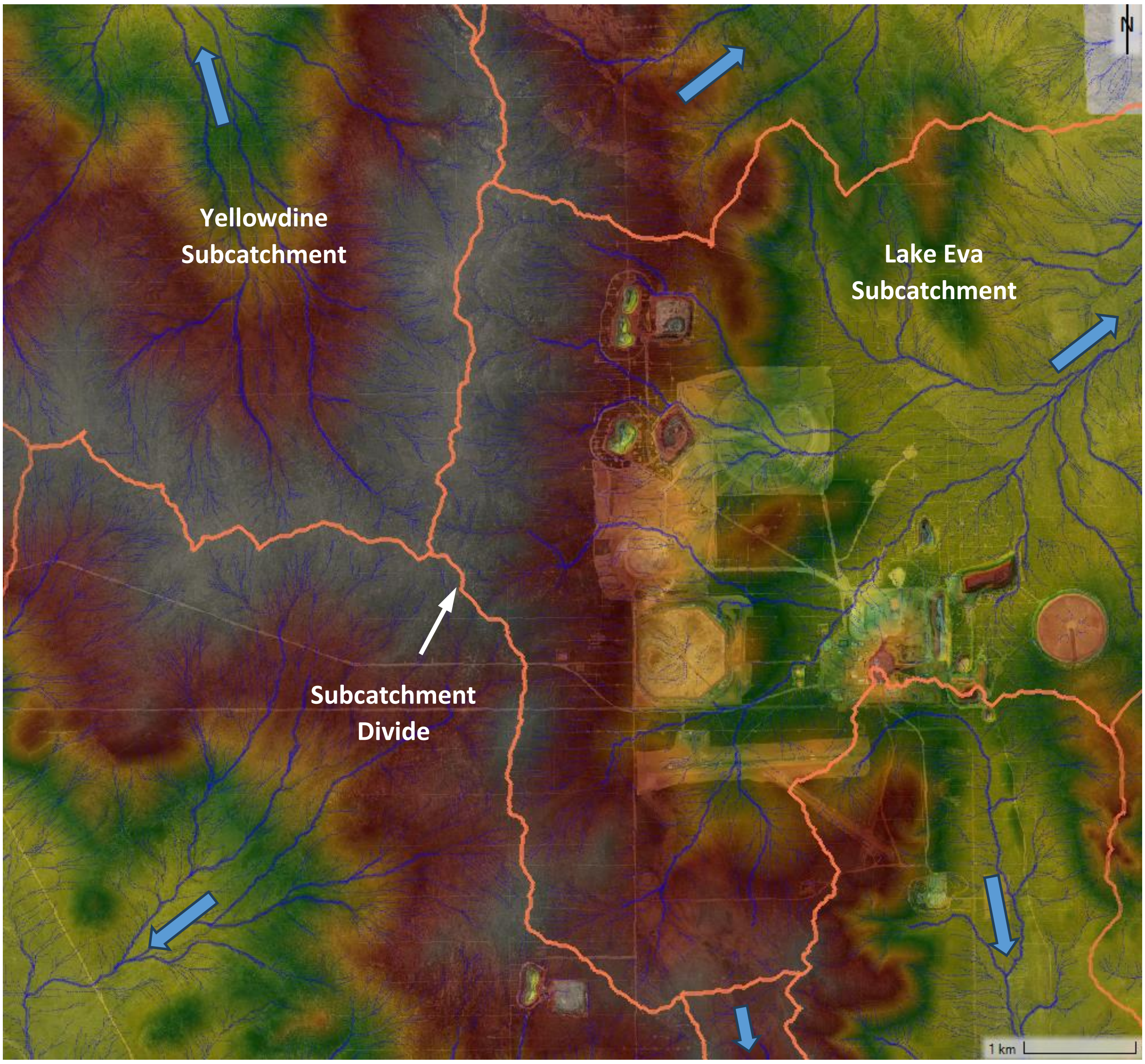


Figure 2-2: Earl Grey local catchments and flow paths

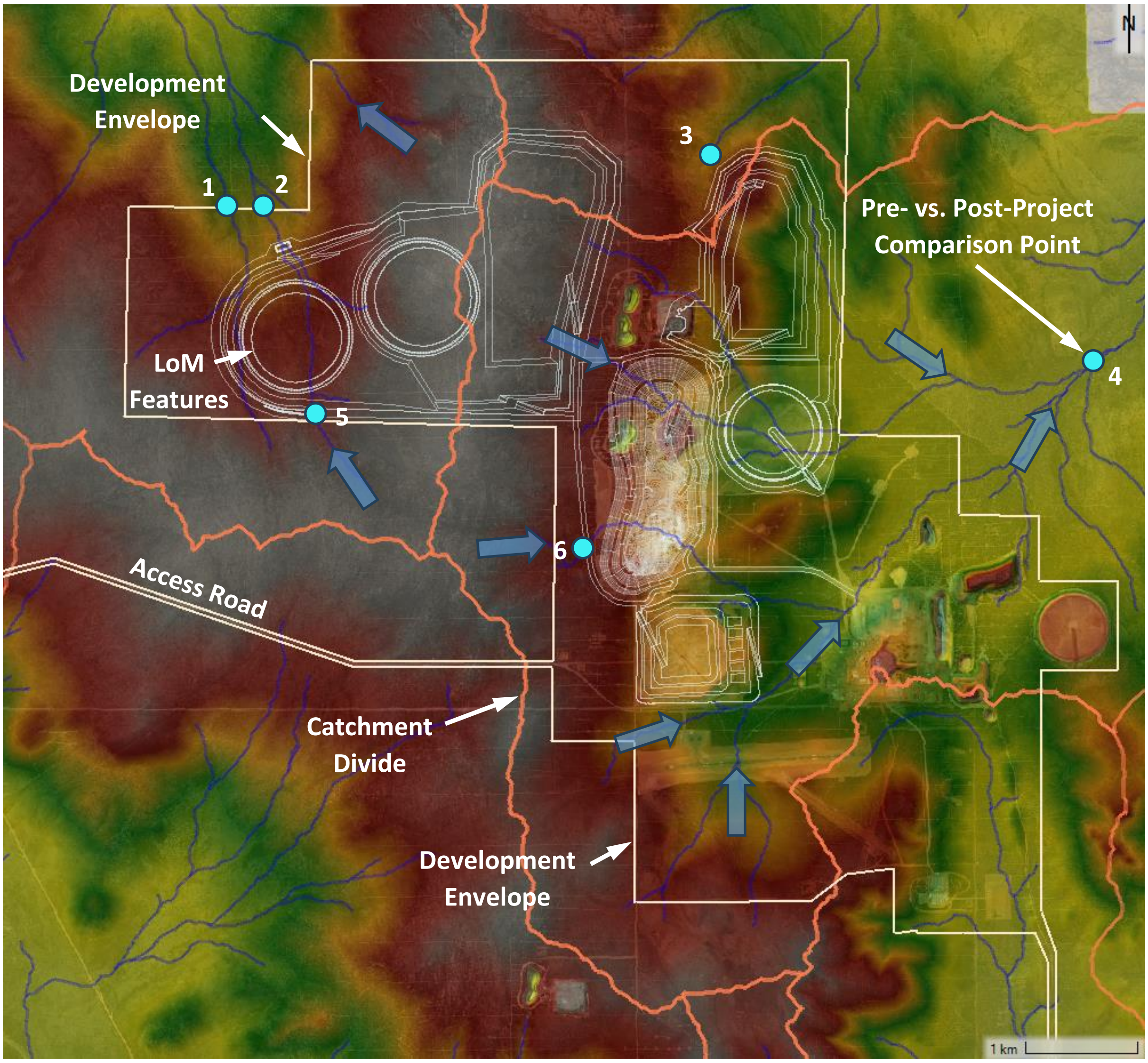


Figure 2-3: Earl Grey development envelope and index points

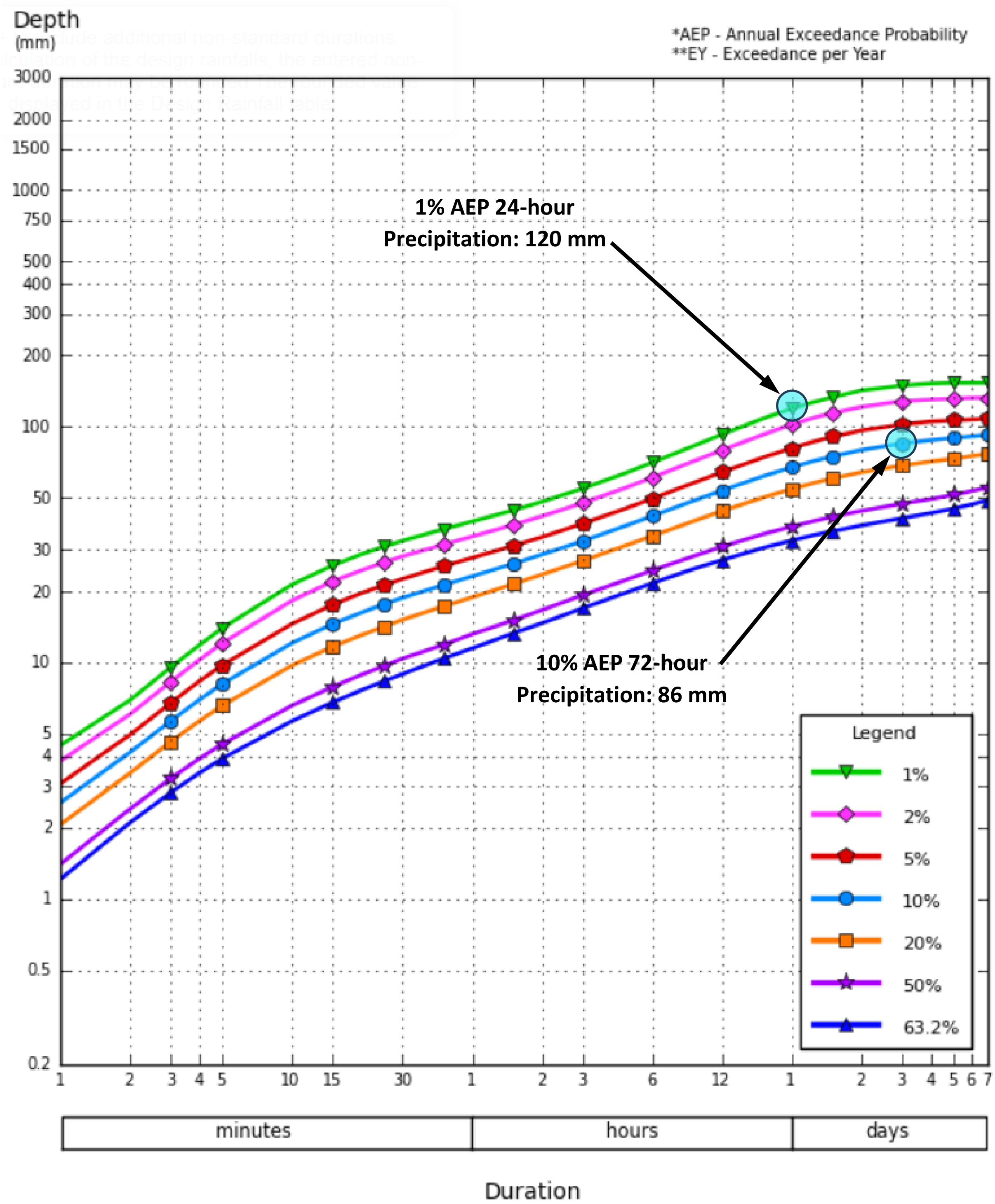


Figure 2-4: Bureau of Meteorology IFD data for Earl Grey

3. Drainage Management Strategy

3.1. Previous Designs

Previous reports by JDA assess the hydrology and flood characteristics of previously proposed designs (JDA 2018, 2019, and 2022) including a main diversion drain routing external runoff into the northern subcatchment. Designs were refined to control surface water drainage.

Since the previous JDA assessments, Covalent has proposed a notable expansion to the mining and processing operations infrastructure for the LoM operations (with the total footprint being approximately double in area). Accordingly, it is appropriate to revisit the surface water modelling and management for the LoM operations.

3.2. Management Strategy for the Life of Mine Footprint

The overall drainage management strategy for the LoM footprint includes diversion of natural fresh water runoff around the external perimeter of landforms across the site. **Figure 3-1** shows the locations of diverted flow paths, proposed diversion drains, and bunds. Waste rock landforms are internally draining, with rainfall runoff from exposed embankment slopes collected in perimeter drains.

3.3. Water Quality

A key element of the drainage management strategy is the separation of fresh water runoff (from rainfall) from potentially saline mine water runoff (from surface water across mining infrastructure upon which saline groundwater may be used for dust suppression). Notable mine water runoff flow paths are shown in **Figure 3-1**. Potentially saline mine water runoff is collected in existing pit voids for reuse during operations or diverted to evaporation ponds.

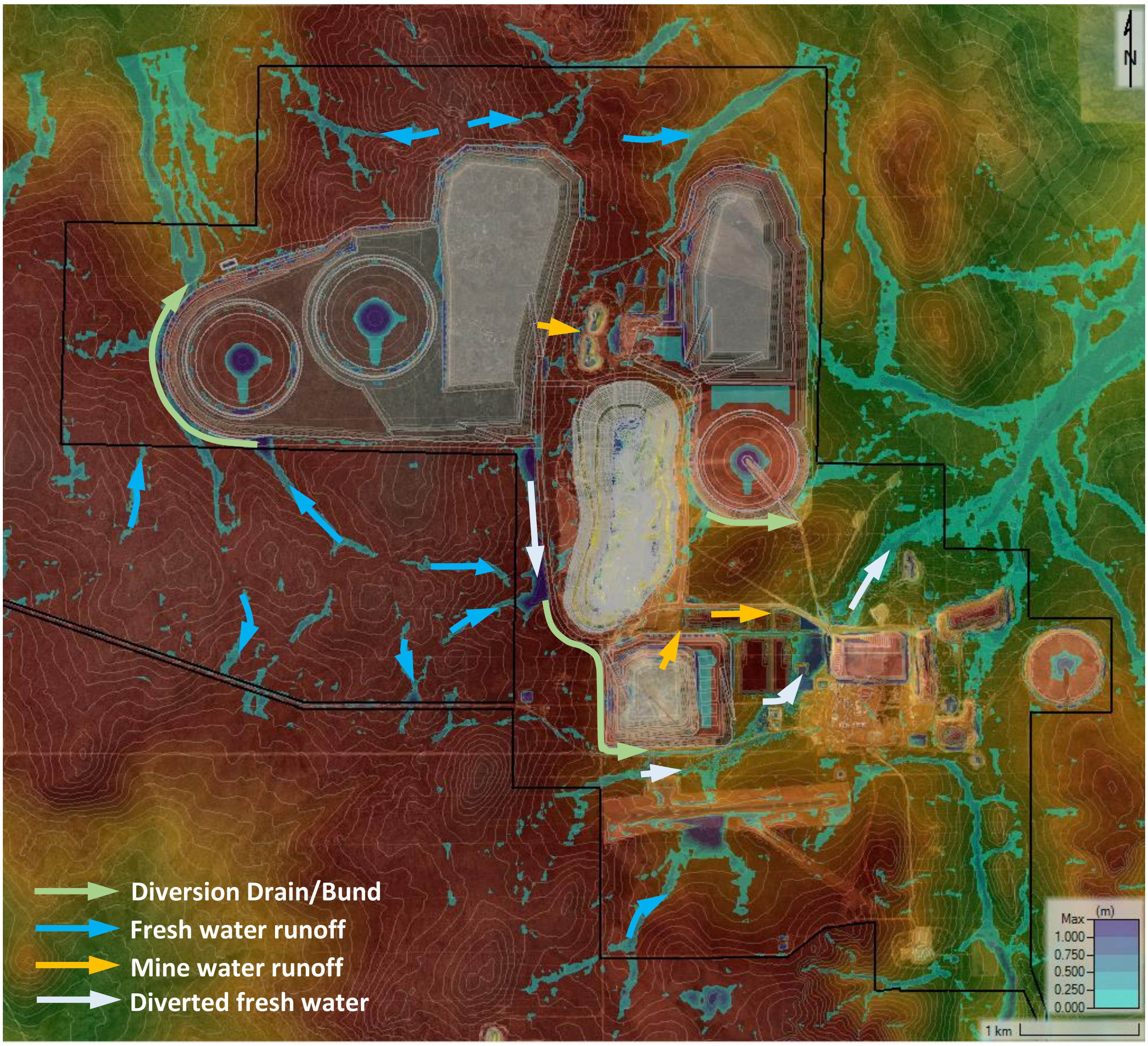


Figure 3-1: Drainage management strategy

4. Hydraulic Model Setup

4.1. Approach

A hydraulic model was set up for the project area catchment in order to assess the baseline and LoM conditions, and to mitigate potential hydrological effects through refinements to the drainage management strategy. Excess precipitation hyetographs were applied to the model using a rain-on-grid or direct precipitation approach. Hydraulic modelling was conducted with a 2D approach using HEC-RAS Version 6.4.1 software (USACE 2023).

The approach to hydraulic modelling used in this assessment is consistent with accepted industry practices used for hydraulic modelling of mining operations throughout Western Australia; accordingly, the level of detail of the hydraulic modelling output is expected to be suitable for mine planning and environmental assessment purposes.

4.2. Terrain

The underlying terrain for the baseline hydraulic model is based on a 2022 digital elevation model (DEM) developed from 0.5 m contour data at a horizontal resolution of 0.5m x 0.5m. For LoM conditions terrain, 2023 LiDAR data was added to the DEM along with 0.5 m x 0.5 m DEM surfaces developed from 2023 design dxf files. The terrain coverage is shown in **Figure 4-1**. The adopted terrain surface represents the maximum physical layout affecting surface water hydrology. Interim mine plans have reduced impacts. All model data are projected to the GDA94 MGA Zone 50 projection. The vertical datum is based on AHD71.

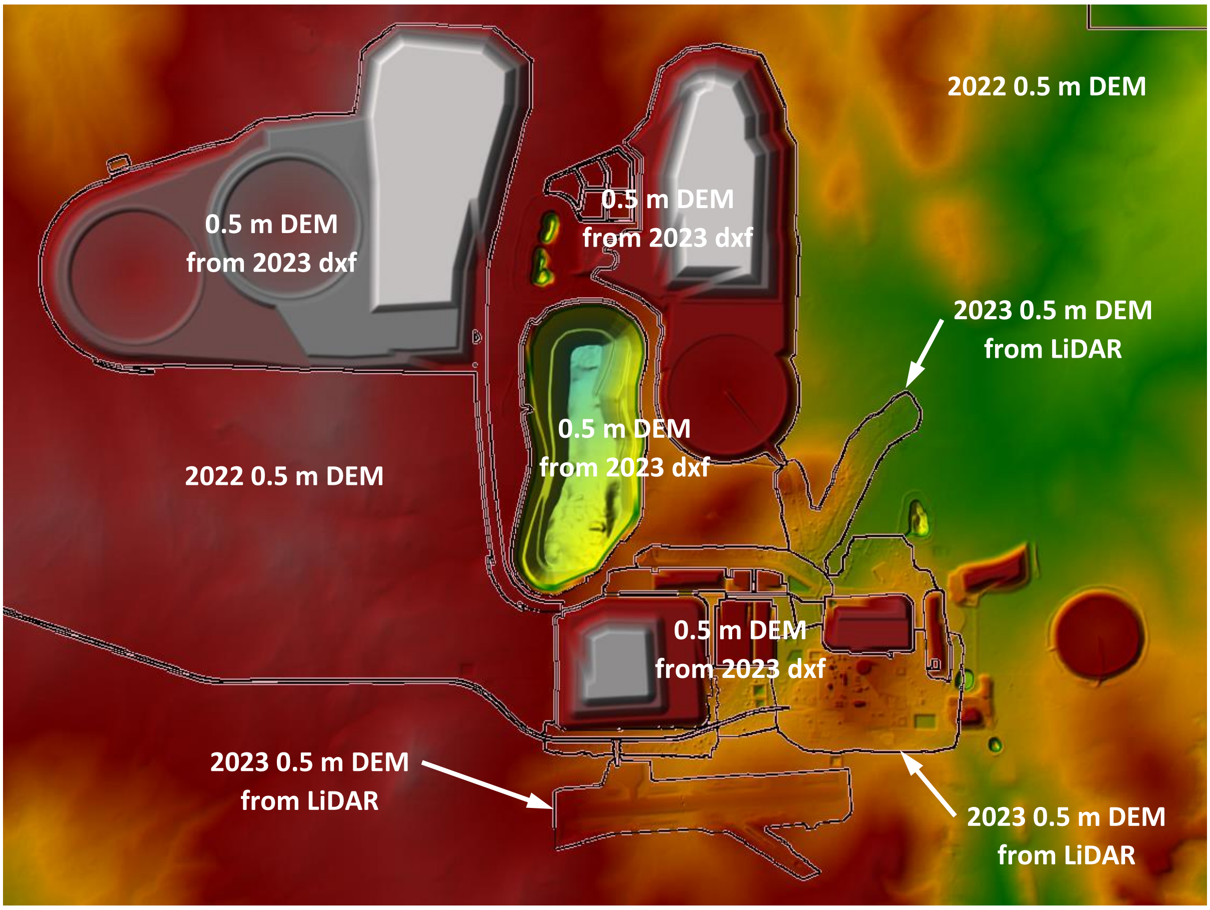


Figure 4-1: Terrain coverage areas

4.3. Computational Mesh

A 81 km^2 2D flow area perimeter was assigned to the site with a computational mesh of 10 m x 10 m as shown in **Figure 4-2**. The mesh was refined using break lines with a resolution of 5 m. Break lines were applied along flow paths and grade breaks as shown in **Figure 4-3** to align cell edges with flow directions.

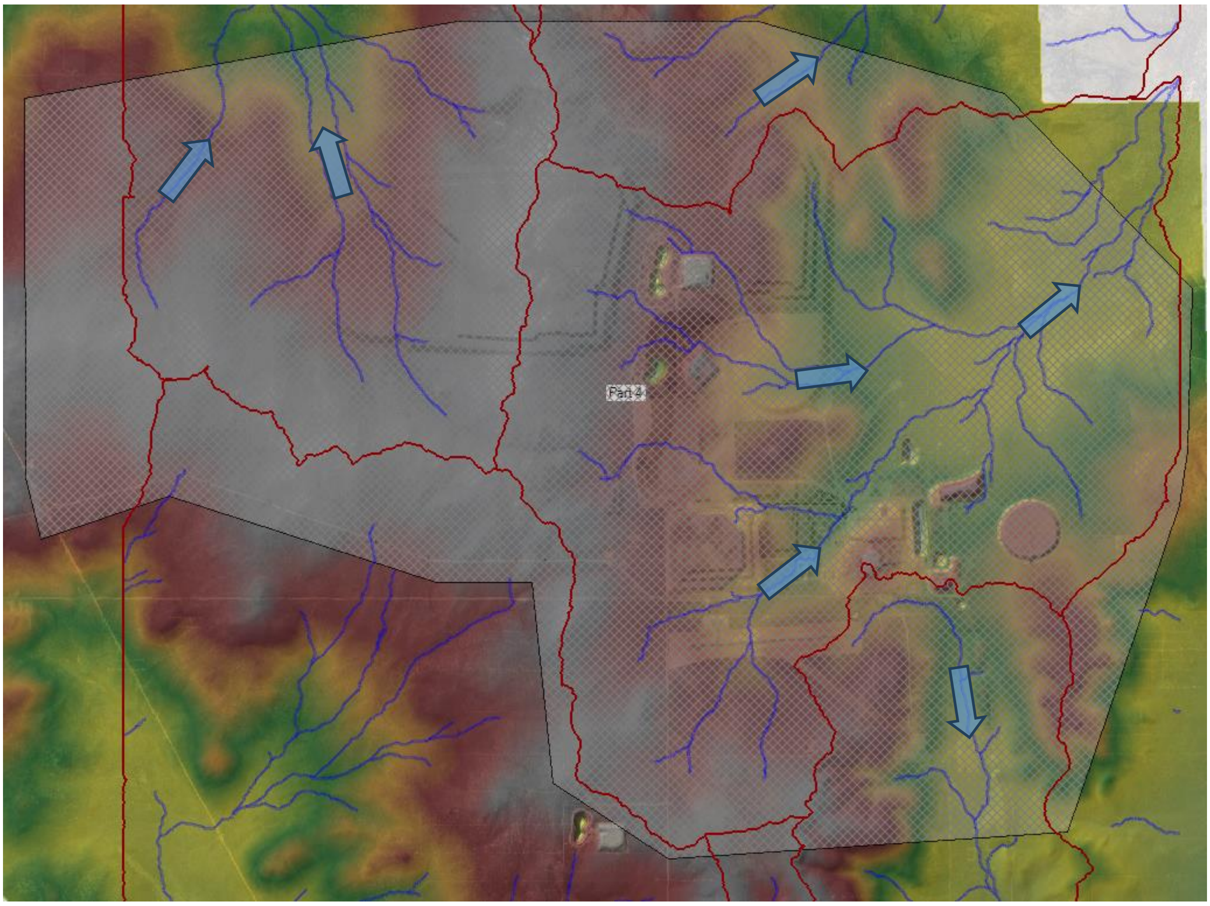


Figure 4-2: 2D model coverage area

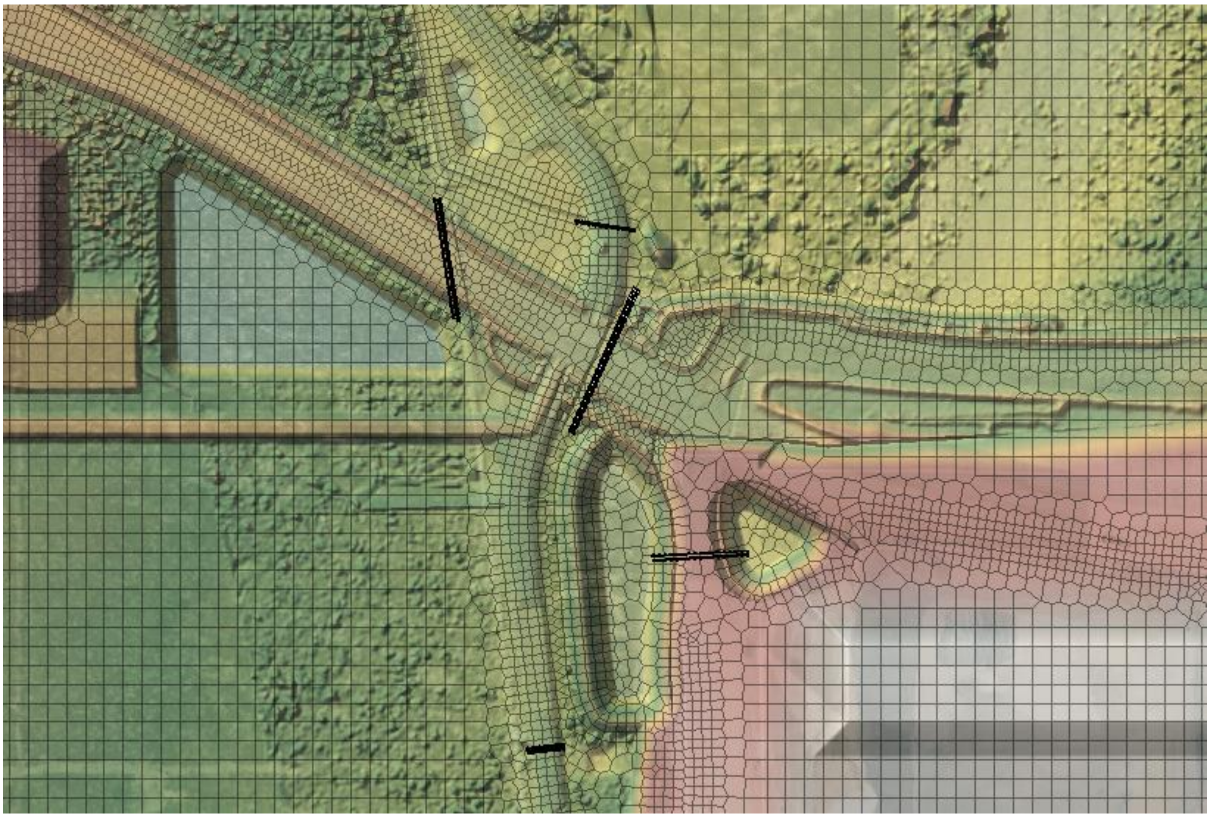


Figure 4-3: Typical computational mesh orientation

4.4. Roughness

Diversion drains and other concentrated flow areas were assigned a Manning's roughness coefficient of 0.035. Shallow sheet-flow areas were assigned a roughness coefficient of 0.08. A sensitivity analysis of the maximum water surface elevation profiles showed elevations ranging approximately +/- 300 mm for uniform roughness values ranging from 0.04 – 0.12 (Appendix C).

4.5. Inflow Boundary Conditions

Intensity-Frequency-Duration (IFD) data were compiled for the site area from the Bureau of Meteorology (BoM) using the 2016 data set. **Figure 2-4** shows the precipitation depths for the 10%, 5%, 2%, and 1% AEP events (BoM 2016). Tabulated IFD values are shown in **Table 4-1**. Additional precipitation data extracted from the Australian Rainfall and Runoff (ARR) data hub are attached in Appendix A, including interim climate change guidance. As tabulated in Appendix A, the Representative Concentration Pathway (RCP) 8.5 scenario for a 30-year life of mine has a recommended increase in precipitation intensity of approximately 10%. Climate change impacts were applied as a sensitivity analysis; however, in light of the conservatism applied in response to the other hydrological uncertainties, including the effect of decreased soil moisture and increased losses under climate change scenarios, baseline model runs have not applied increased precipitation intensities to account for climate change.

Temporal storm patterns were downloaded from the ARR data hub for the Earl Grey site. The rain-on-grid model results were used to determine the critical duration for local site rainfall, with a duration of 3 hour selected for local precipitation events. Centrally loaded, nested frequency storms were developed for use as precipitation time series hyetograph. The hyetographs were applied as unsteady boundary conditions and compared against the ARR ensemble patterns for Southern and South West Flatlands. The frequency storm pattern was found to represent a conservative temporal pattern for local conditions. The use of the frequency storm allows the critical duration events to be simulated in the same model run as the 24-hour and 72-hour simulations for sizing basins and estimating storage volume requirements.

Table 4-1: Precipitation depth summary

Duration	Rainfall Depth in mm			
	10% AEP	5% AEP	2% AEP	1% AEP
1 min	3	3	4	4
5 min	8	10	12	14
10 min	12	15	18	22
15 min	15	18	22	26
30 min	19	23	28	33
1 hour	23	28	34	40
2 hour	29	34	42	48
3 hour	33	39	48	55
6 hour	42	50	61	71
12 hour	54	64	80	93
24 hour	68	82	102	120
36 hour	76	91	115	135
48 hour	80	97	122	143
72 hour	86	104	130	151

4.6. Loss Rates

Due to extreme variation and a lack of local calibration data, the Australian Rainfall and Runoff (ARR) data hub (ARR 2019) does not include estimated loss rates for the Earl Grey area. As a conservative estimate in light of the inherent uncertainty, an initial loss of 10 mm was applied to the catchment-wide rain-on-grid model, with a continuing loss rate of 5 mm/hr.

Median pre-burst depths were removed from the initial loss, and the resulting initial loss depths were removed from the precipitation estimates to compute rainfall excess for the design storm events. Saturated antecedent conditions were applied as a sensitivity analysis for basin spillway sizing, with no losses removed from the precipitation hyetographs (all rainfall modelled as excess).

4.7. Downstream Boundary Conditions

The downstream boundary condition was assigned a normal depth energy gradient around the external perimeter of the 2D flow area. A gradient of 0.5% was assigned as the normal depth energy gradient for the downstream boundary condition.

4.8. Time steps

A 30-hour simulation window was applied to the 1% AEP model runs with a 80-hour simulation applied for the 10% AEP event. Results were checked to confirm that the simulation time adequately captured the rise and recession of peak flows throughout the modelled areas. A variable time step was assigned based on a maximum Courant Number of 2.0. Using this option, HEC-RAS selects an adaptive time step based on the assigned computational mesh size and computed velocities. The adopted time step generally ranged between 2 and 5 seconds. Mass balance errors and water surface elevation convergence errors were checked to ensure model stability and that imbalances remained below reasonable thresholds, confirming compliance with Courant Number criteria in the published guidance (USACE, 2023).

4.9. Structures

Existing and proposed culverts were incorporated in the HEC-RAS conditions model as 2D connections; floodways, basins, bunds, and drains were incorporated as vector modification features. Locations of added features are shown in blue in **Figure 4-4**. Any structures not modelled are assumed to be blocked or ineffective at the modelled flood stages. Existing culvert locations and dimensions are based on available feature survey data. Initial sizing for proposed culverts was based on the most recent available designs provided by Covalent (August 2023), including drains in the locations shown in **Figure 4-4** to prevent ponding and facilitate positive drainage around site features. Drain bottom widths range from 4-8m and side slopes vary from 1.5H:1V to 2.0 H:1V.

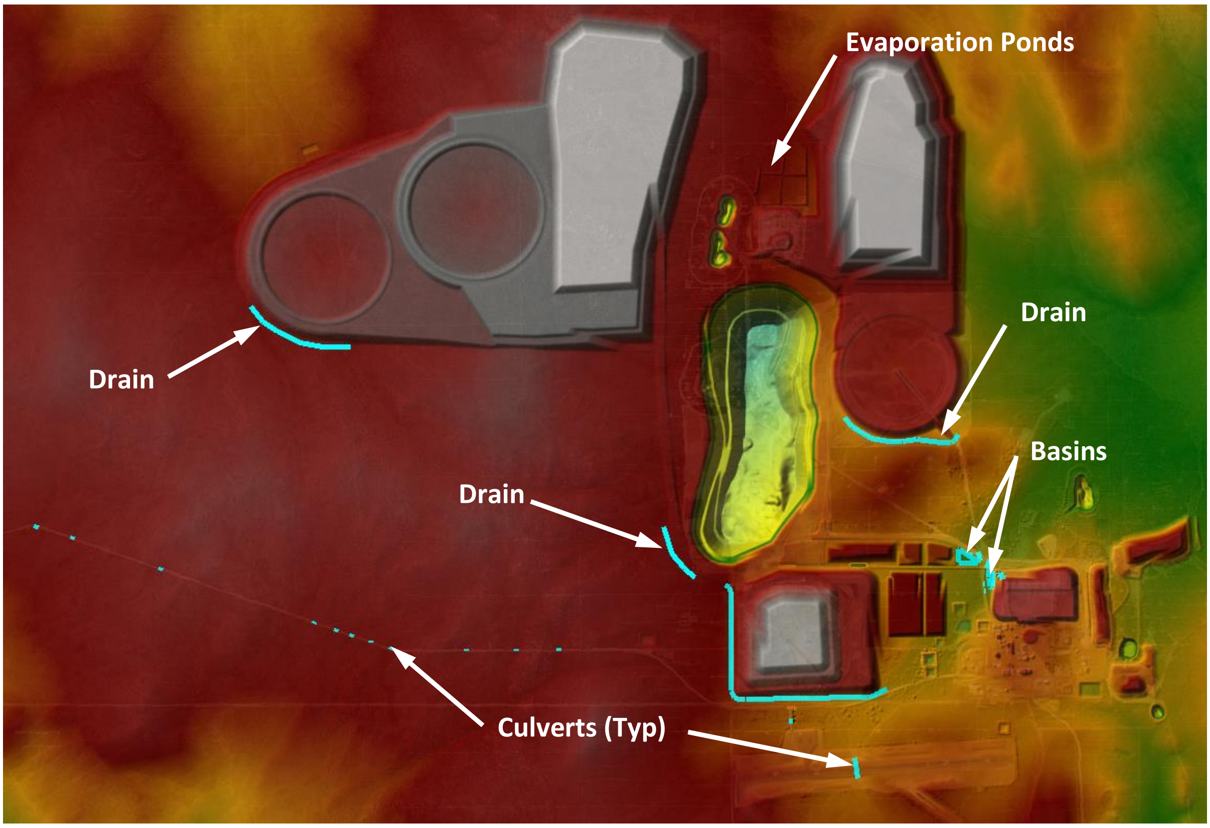


Figure 4-4: Culvert and drain locations

4.10. Calculation Options and Tolerances

The full momentum shallow water equation set was applied to all model runs. Except where otherwise noted, program defaults have been applied to all remaining coefficients, options, tolerances, and model settings.

4.11. Summary

Project conditions model runs were set up based on preliminary and refined designs. **Table 4-2** lists the flood events and geometries associated with each of the final model runs. Project conditions model runs are based on the General Arrangement shown in Appendix D.

Table 4-2: Summary of model parameters

Parameter	Adopted Value
Model Area	81 km^2
Inflow	24-hour and 72-hour precipitation hyetographs
Outflow	Normal Depth Energy Gradient 0.5%
Simulation Window	30-80 hours
Computational time step	2-5 seconds
Computational mesh grid	5-10 m
Roughness	0.035 - 0.080
Equation Set	Full Momentum Shallow Water Equation
DEM Resolution	0.5 m x 0.5 m

5. Potential Impacts and Management

5.1. Inundation

Figure 5-1 shows the maximum life-of-mine inundation extents and depths from the rain-on-grid model for the 10% AEP event. **Figure 5-2** shows the 1% AEP depths. The locations of index points for comparison of discharge hydrographs, flow volumes, and inundation depths are also shown in the figures.

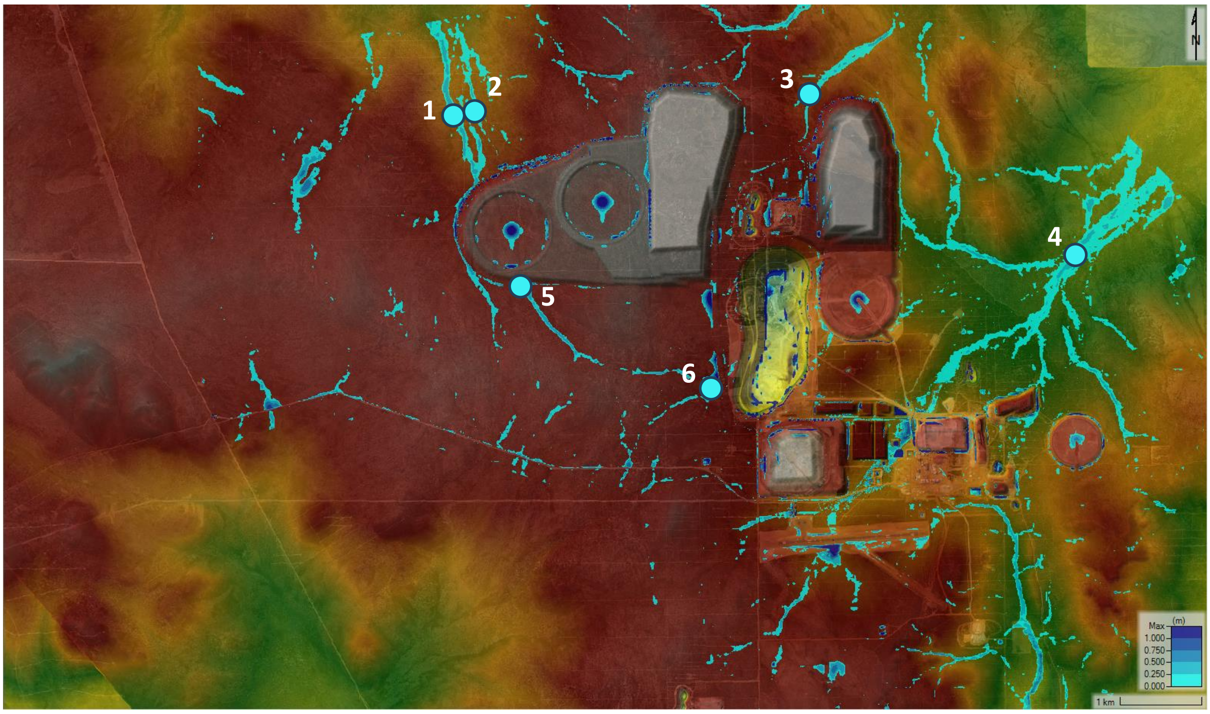


Figure 5-1: 10% AEP inundation extents and flow depths for catchment model

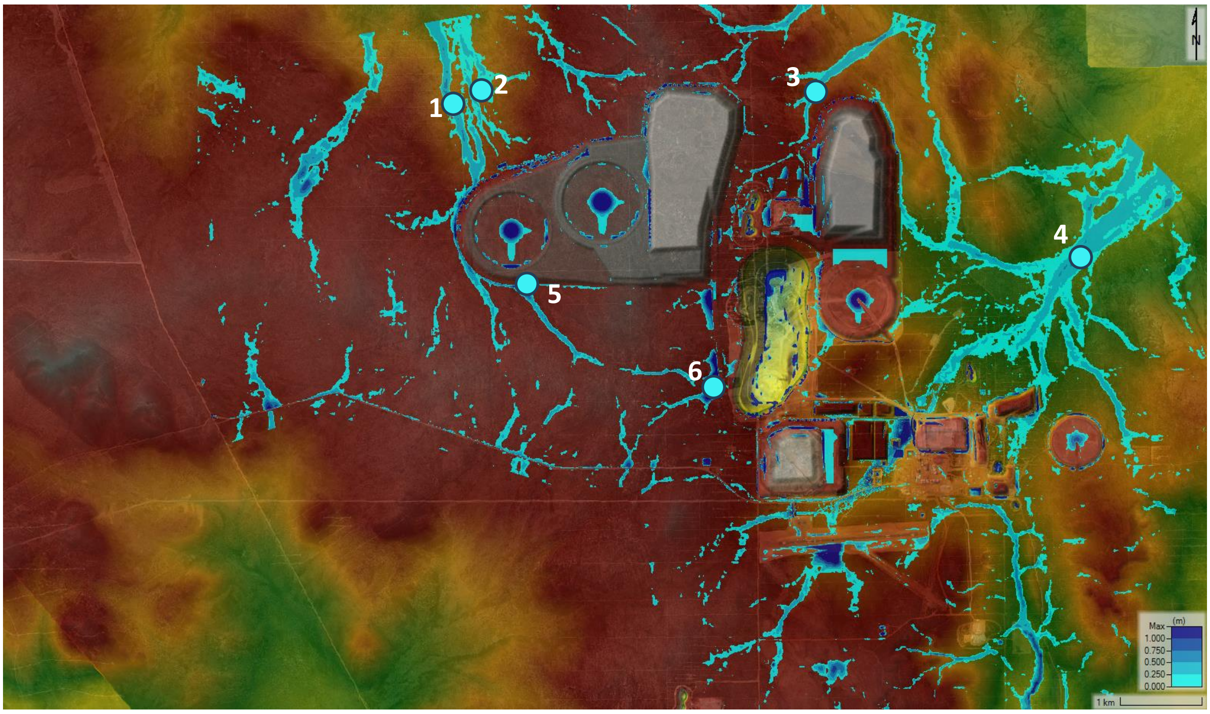


Figure 5-2: 1% AEP inundation extents and flow depths for catchment model

Figure 5-3 shows a comparison of the maximum 10% AEP flood depths between baseline and LoM conditions, and Figure 5-4 shows the 1% AEP depth comparison. Areas with depth increases are shown in red, and areas with depth decreases are shown in green. Appendix B includes additional inundation, maximum depth, and afflux maps for the baseline condition and life-of-mine condition for the 10% AEP and 1% AEP flood events.

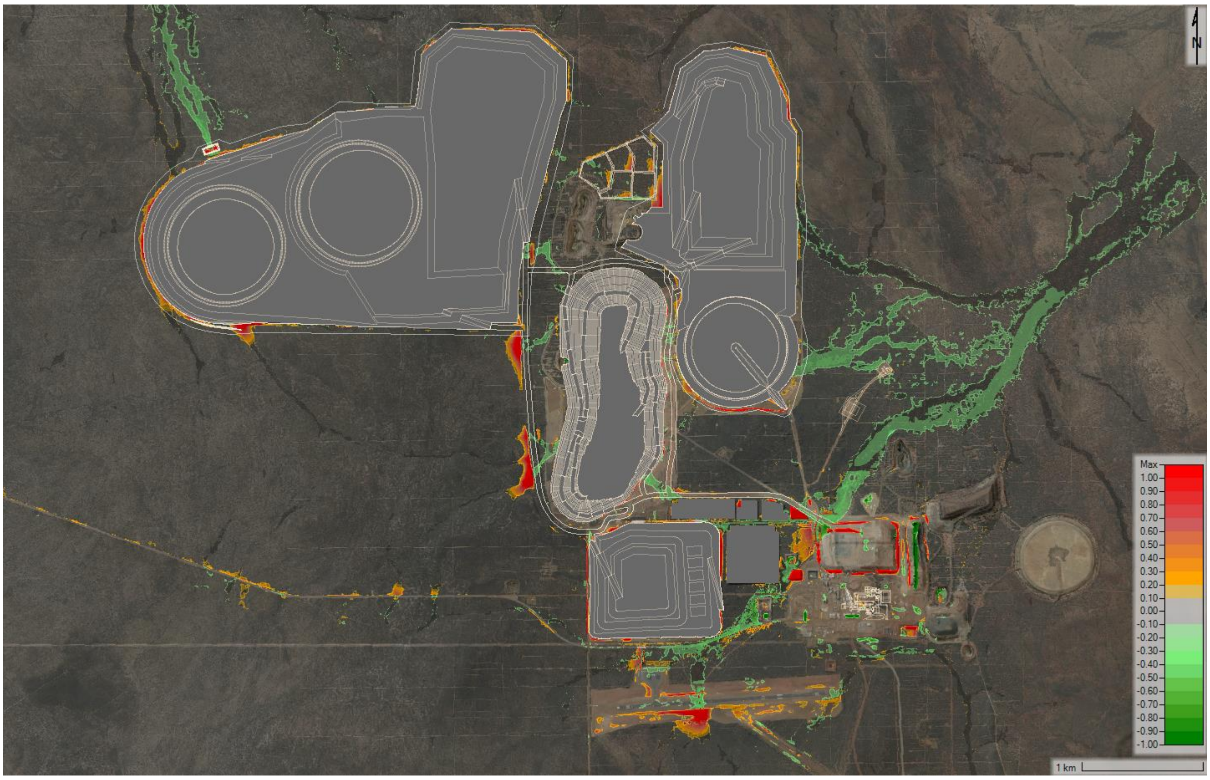


Figure 5-3: 10% AEP maximum water surface elevation afflux

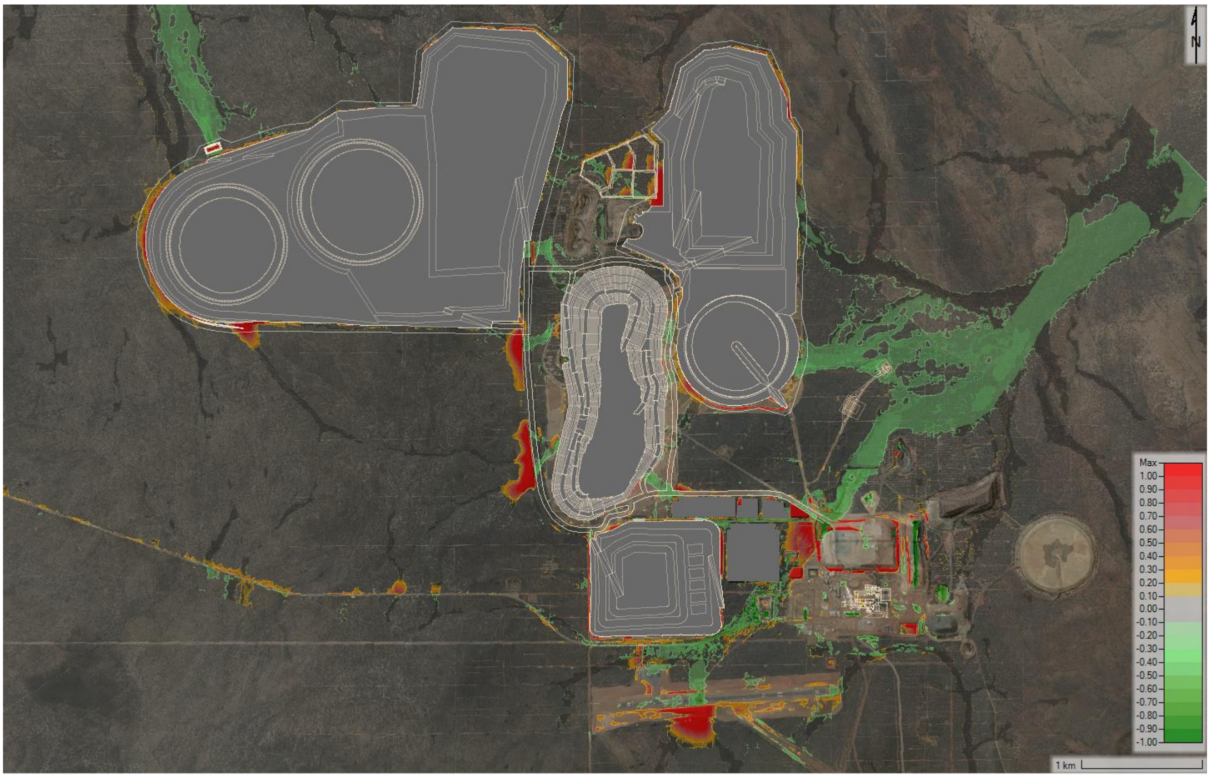


Figure 5-4: 1% AEP maximum water surface elevation afflux

Figure 5-5 shows the time series hydrographs for 1% AEP and 10% AEP baseline and LoM conditions, measured along the channel section at Index Point 1 (locations shown in **Figure 5-1** and **Figure 5-2**). **Figure 5-6** compares the cumulative flow volumes for a 24-hour precipitation event.

Figure 5-7 and **Figure 5-8** show the hydrographs and flow volumes for Point 2. **Figure 5-9** and **Figure 5-10** shows Point 3, and **Figure 5-11** and **Figure 5-12** show Point 4.

The differences are primarily related to capture of runoff in pits and behind landforms. A summary of differences between baseline and LoM conditions for Index Points 1 through 4 are shown in **Table 5-1**. As reflected in the table, peak discharge rates and flow volumes show a slight increase at Point 1 due to additional catchment area being diverted from upstream.

Point 2 exhibits the most pronounced difference as most of its upstream catchment area is diverted toward Point 1 or captured within the proposed landform.

Point 3 exhibits very minor differences in both peak flow rate and volume. Point 4 represents the largest catchment area with a contributing drainage are of approximately 32 km^2. At Point 4, the LoM condition shows a reduction in peak flow rates of approximately 45% in both the 10% AEP and 1% AEP events. The corresponding reduction in flow volume is approximately 35%.

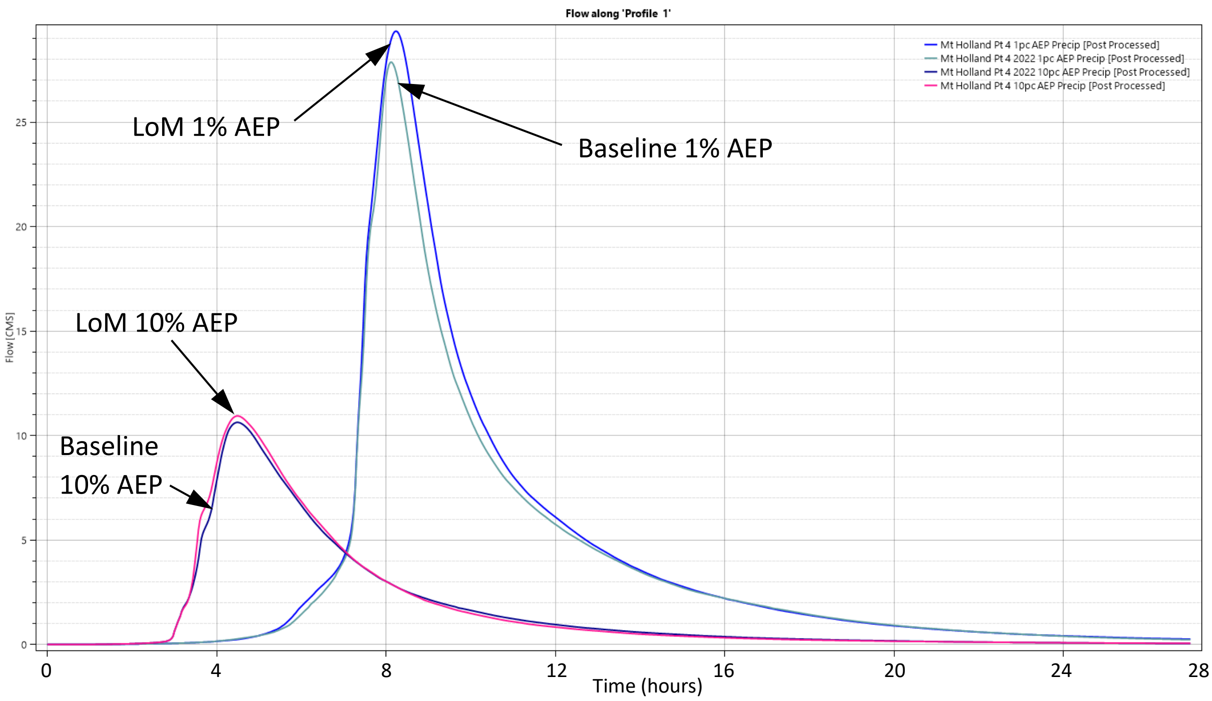


Figure 5-5: Hydrograph comparison between baseline and life of mine conditions for Point 1

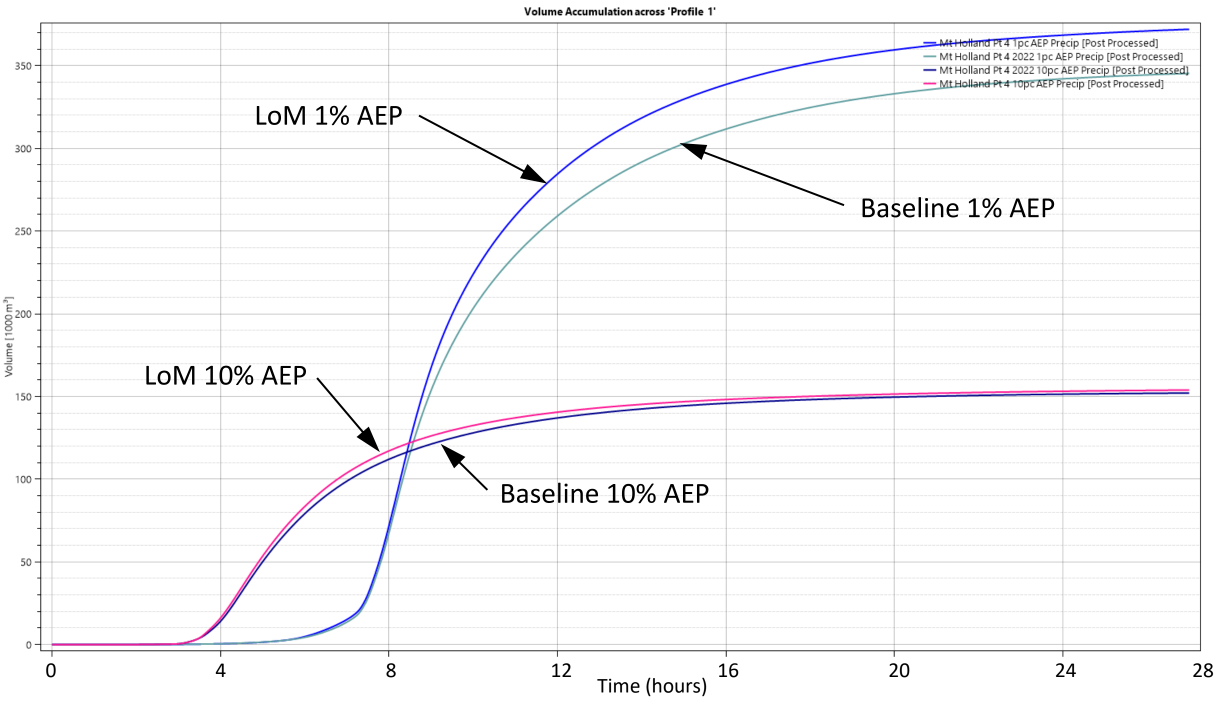


Figure 5-6: Cumulative flow volumes for baseline and life of mine conditions at Point 1

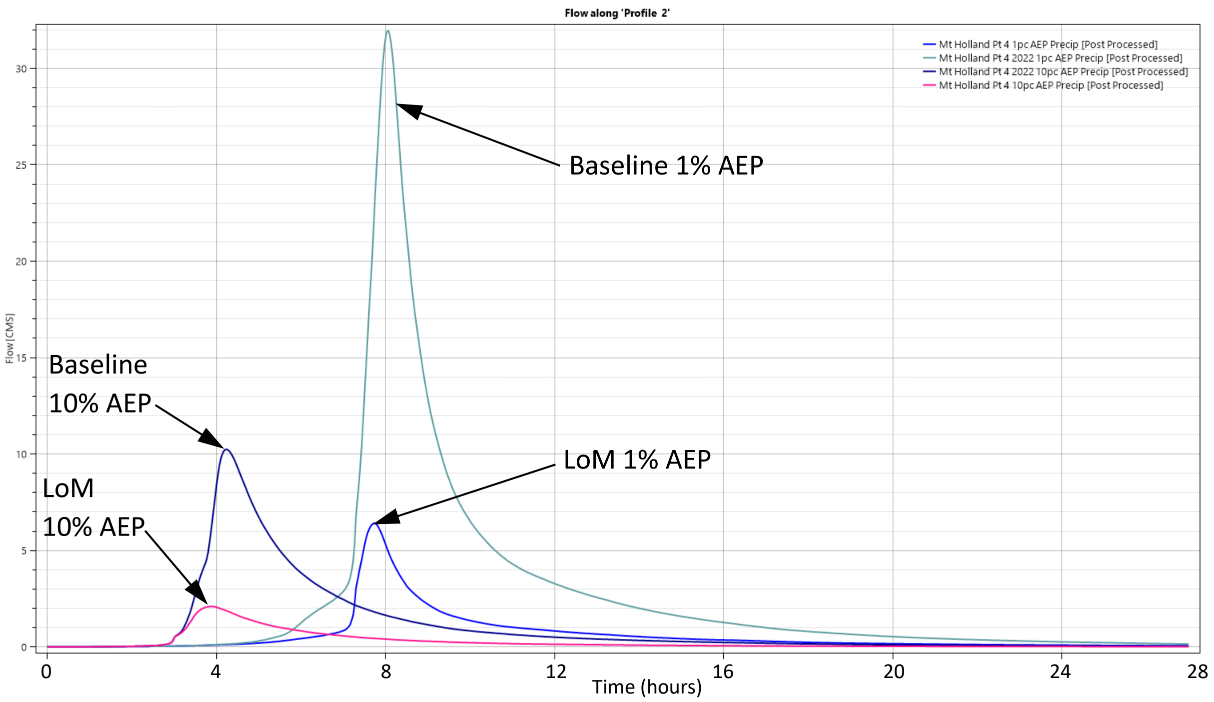


Figure 5-7: Hydrograph comparison between baseline and life of mine conditions for Point 2

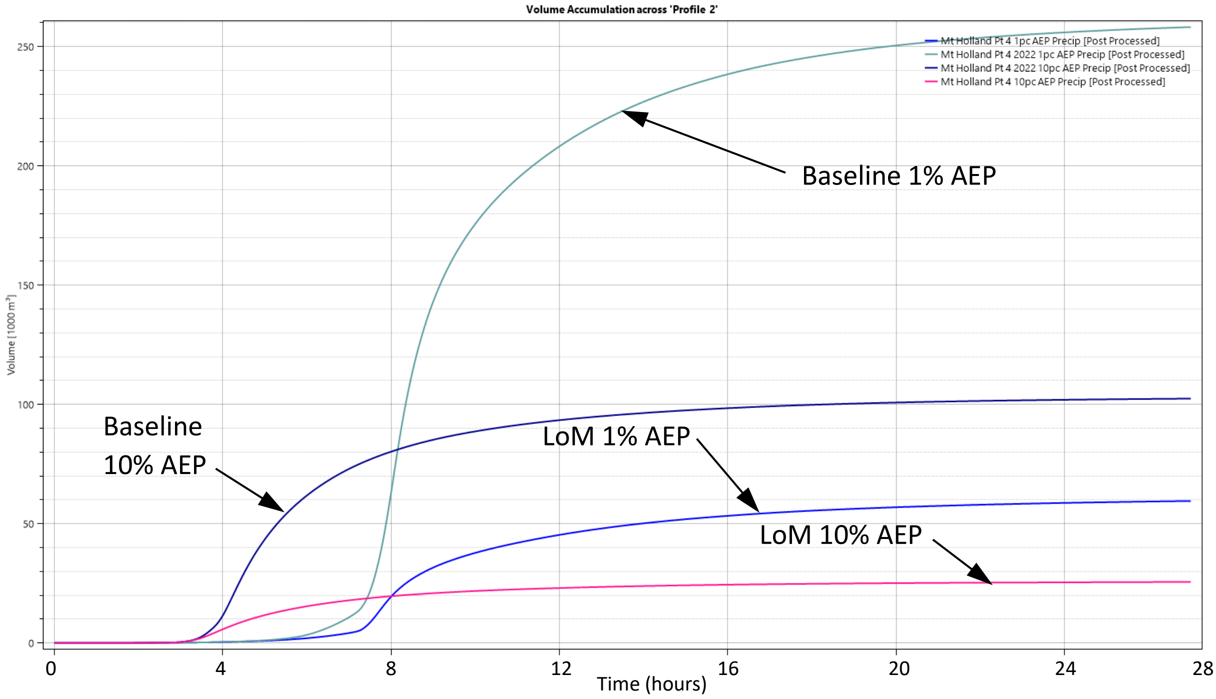


Figure 5-8: Cumulative flow volumes for baseline and life of mine conditions at Point 2

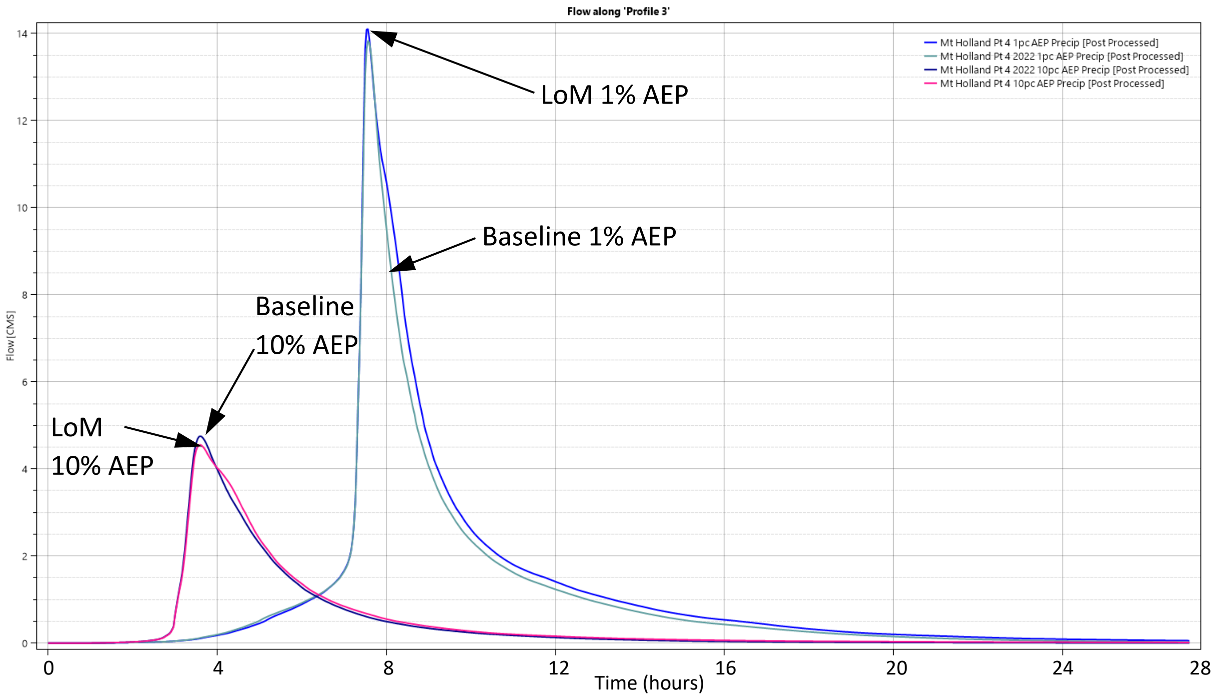


Figure 5-9: Hydrograph comparison between baseline and life of mine conditions for Point 3

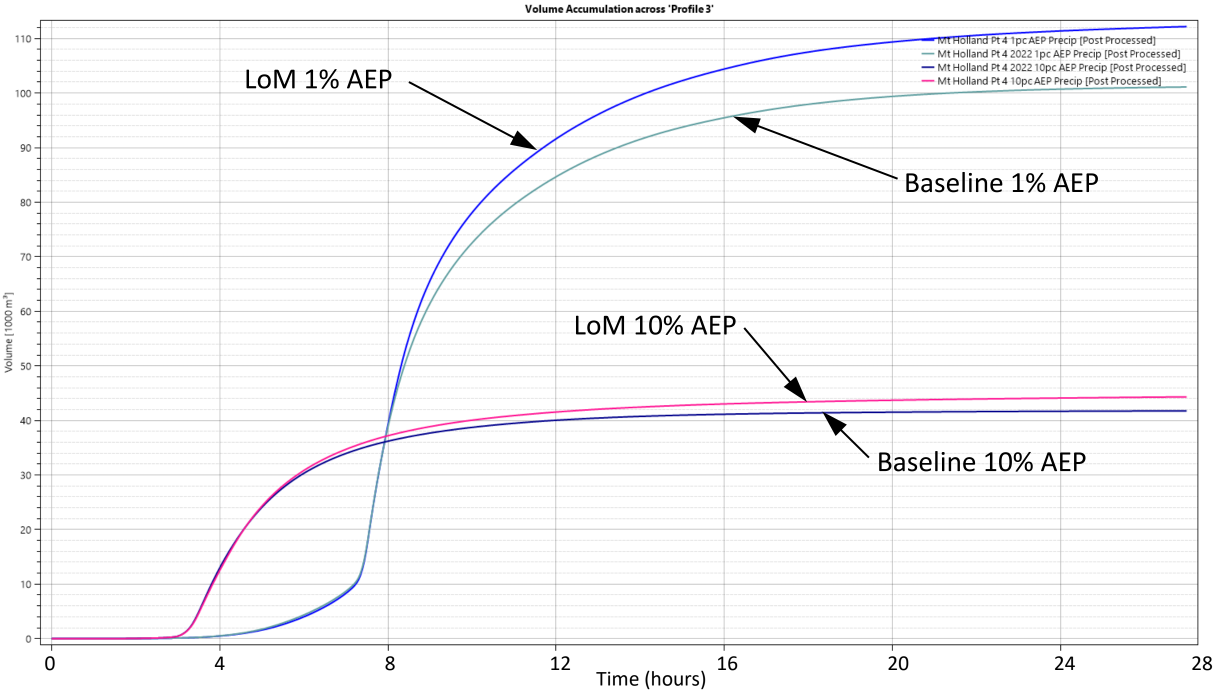


Figure 5-10: Cumulative flow volumes for baseline and life of mine conditions at Point 3

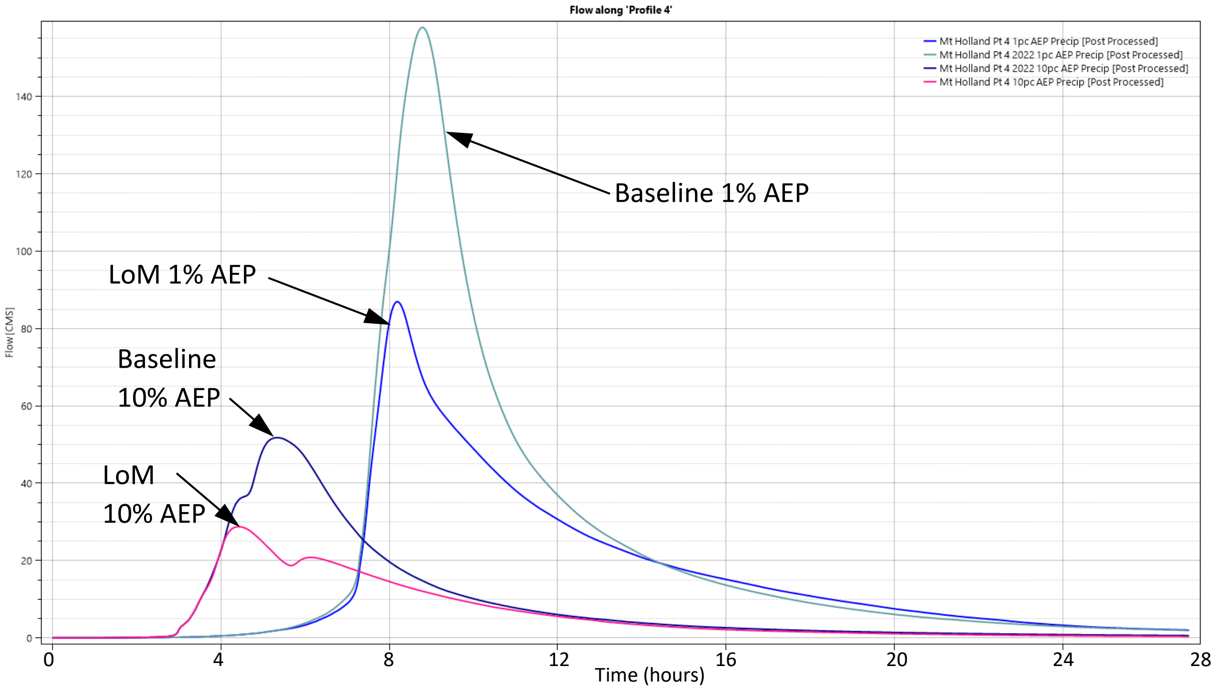


Figure 5-11: Hydrograph comparison between baseline and life of mine conditions for Point 4

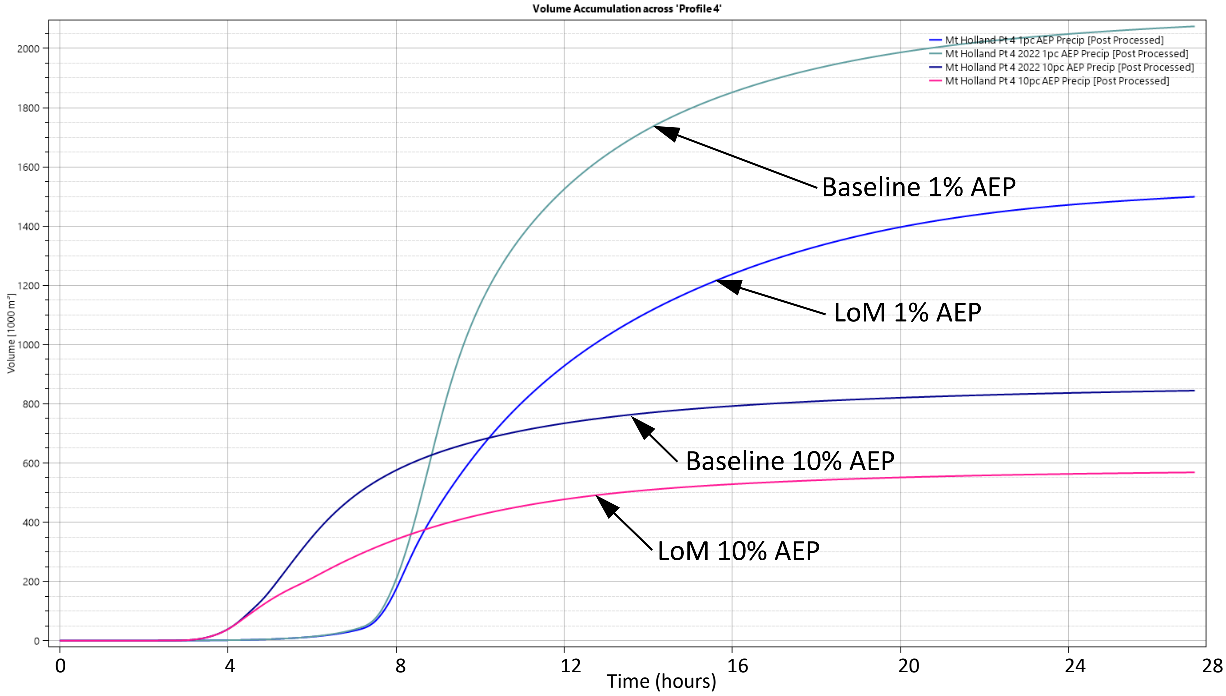


Figure 5-12: Cumulative flow volumes for baseline and life of mine conditions at Point 4

Table 5-1: Summary of impacts on peak flow rates and volumes

Index Profile #	Peak Discharge (m^3/s)						Volume (1,000 m^3)					
	10% AEP			1% AEP			10% AEP			1% AEP		
	Baseline	LOM	Change	Baseline	LOM	Change	Baseline	LOM	Change	Baseline	LOM	Change
1	10.6	10.9	3%	27.8	29.3	5%	152.1	154.0	1%	345.3	372.0	8%
2	10.2	2.1	-79%	31.9	6.4	-80%	102.5	25.6	-75%	258.2	59.4	-77%
3	4.8	4.5	-4%	13.8	14.1	2%	41.8	44.3	6%	101.1	112.2	11%
4	51.8	28.7	-45%	157.8	86.7	-45%	844.5	568.5	-33%	2074.8	1499.3	-28%

Figure 5-13 shows the water surface elevation profile across Point 1. Maximum flow depths are increased by approximately 10% - 20%. **Figure 5-14** shows the water surface elevation profiles at Point 2, with a depth reduction of approximately 50%.

Figure 5-15 shows Point 3, with a negligible change in flow depths. **Figure 5-16** shows Point 4, with a reduction in maximum depth of approximately 20%-30% in the post-development scenario.

Figure 5-17 shows a water surface elevation stage hydrographs for Index Point 5. Maximum water surface elevations at this point are higher in the LoM scenario than the baseline due to the presence of the landform. Runoff in this area enters the diversion drain, and flows recede to baseline levels over time. **Figure 5-18** shows the stage hydrographs for Point 6. In this area, ponded water remains at the level of the drain, and excess water is used for mining operations.

Appendix B also includes afflux mapping comparing the maximum water surface elevation between scenarios. Figures in Appendix B are shown with a 10cm threshold for display.

5.2. Velocity

Appendix B includes maximum velocity plots for the four scenarios under 1% and 10% AEP flow conditions under baseline (2022) and life-of-mine conditions. Maximum velocities are generally below 1.5 m/s. In some areas near culvert inlets and outlets, maximum velocities approach 2 m/s. The diversion drain has been sized to limit velocities to 1.5 m/s.

5.3. Area of Effect

The total disturbance area is approximately 2282 ha, of which approximately 35% is under the previous approval and 65% is under the new application. Of the area under the new application, approximately 30% of this area drains to the Yellowdine subcatchment, with a total catchment area of 409,114 ha. The disturbance area represents approximately <0.2% of the total subcatchment area.

The remaining 70% of the new application area drains to the Lake Eva subcatchment, again representing <0.2% of the catchment area.

The previously approved area represents 0.10% of the Lake Eva subcatchment. The total disturbance area for the approved and new applications draining to the Lake Eva subcatchment is 1724 ha, representing approximately 0.2% of the subcatchment area.

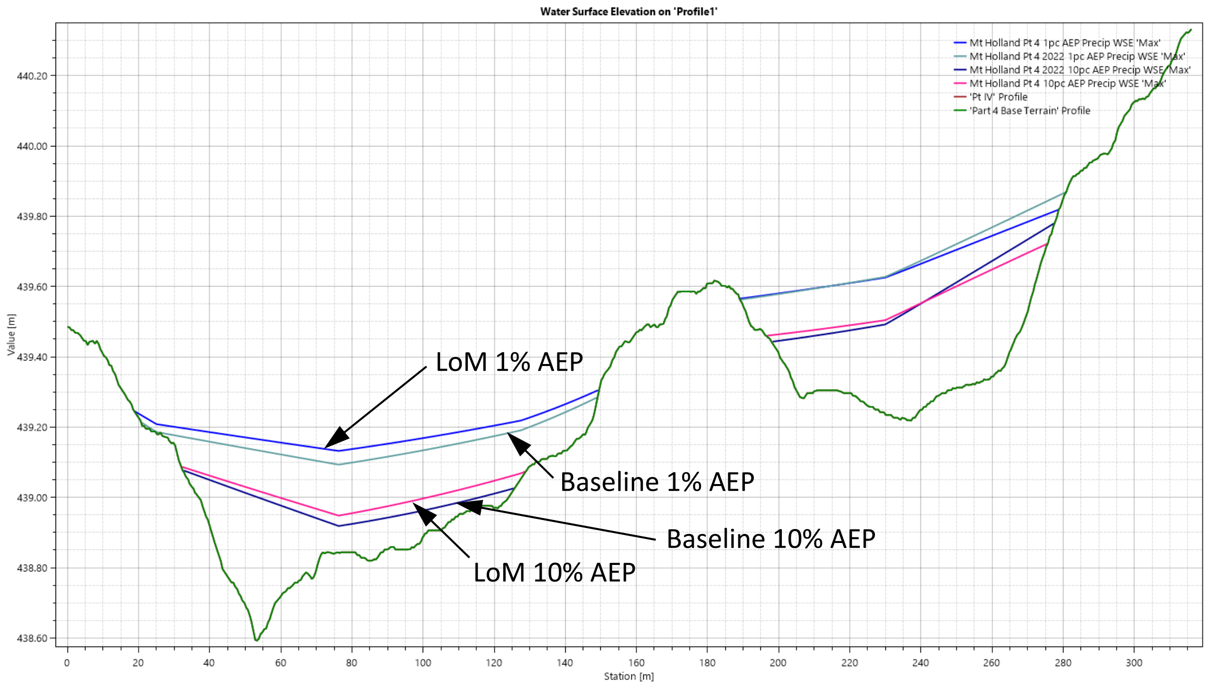


Figure 5-13: Water surface comparison between baseline and LoM conditions for Point 1

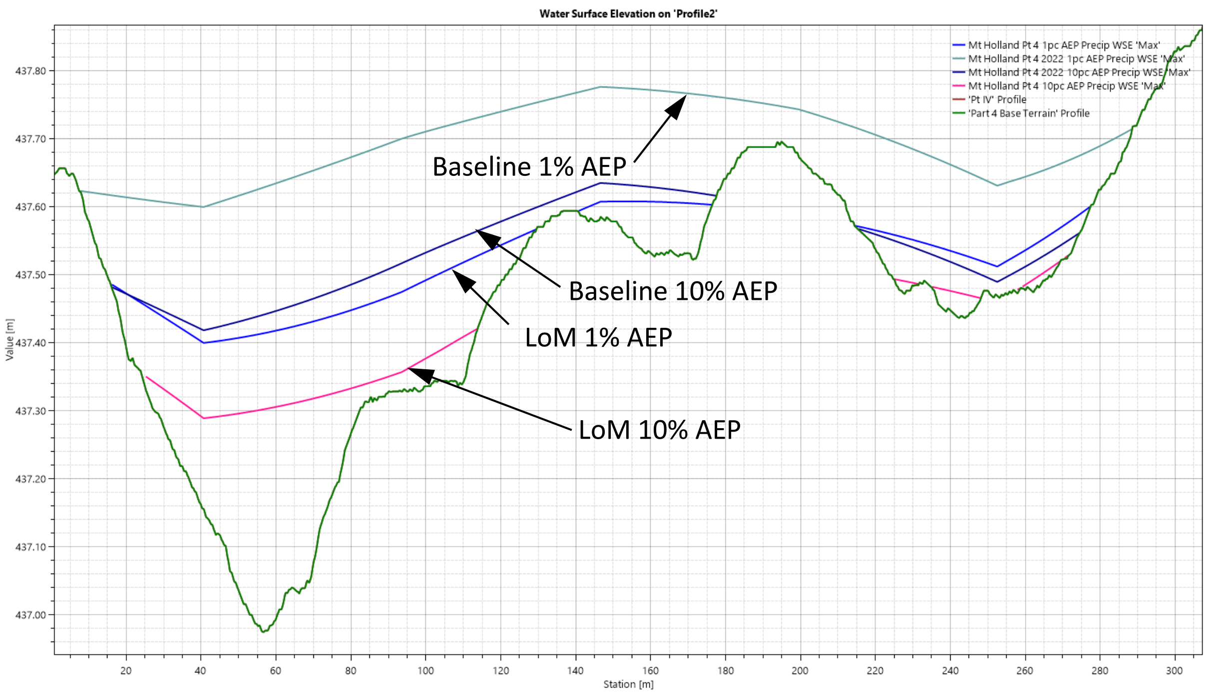


Figure 5-14: Water surface comparison between baseline and LoM conditions for Point 2

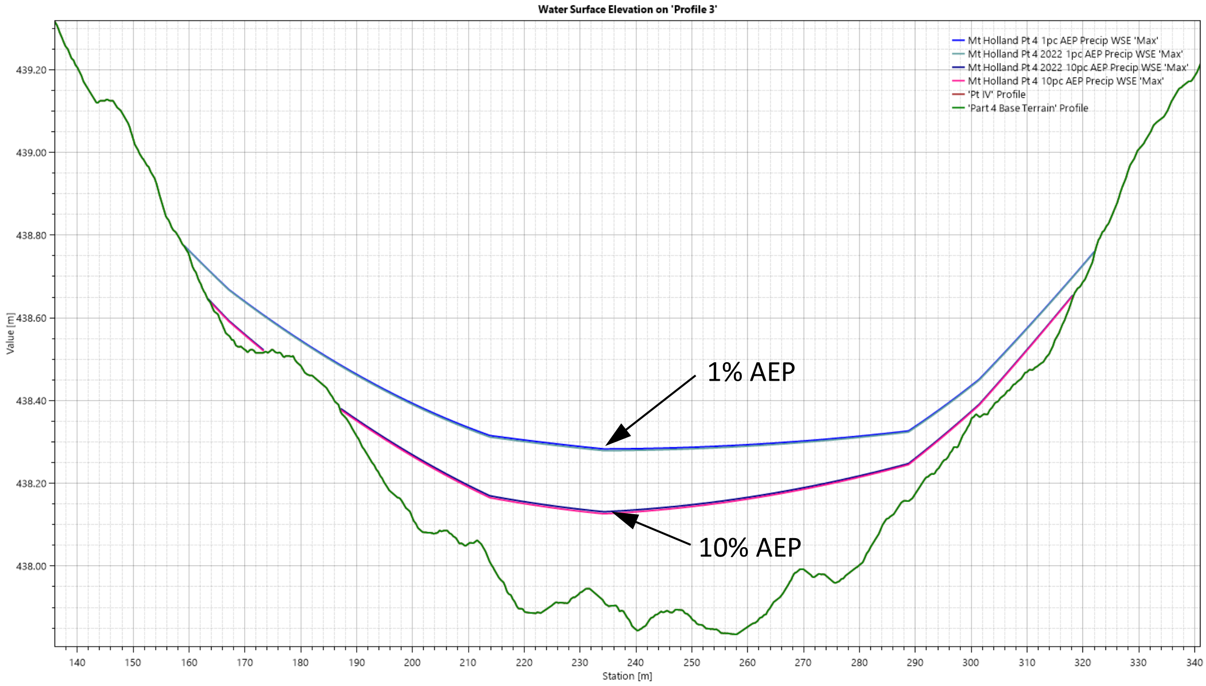


Figure 5-15: Water surface comparison between baseline and LoM conditions for Point 3

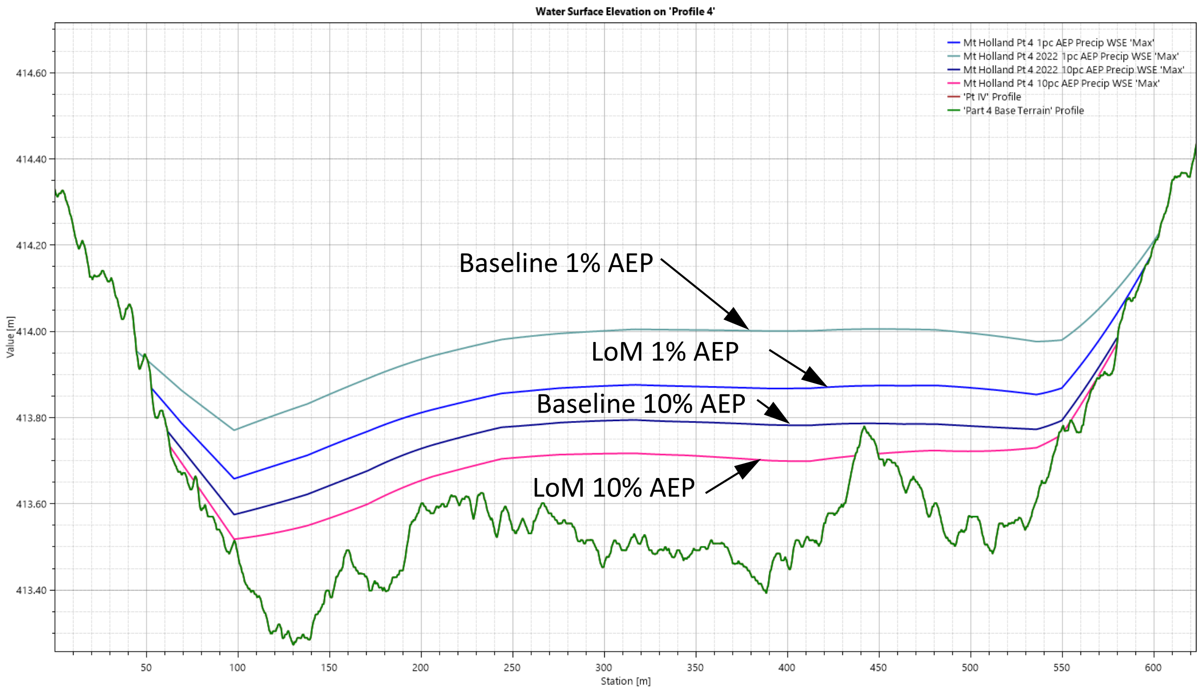


Figure 5-16: Water surface comparison between baseline and LoM conditions for Point 4

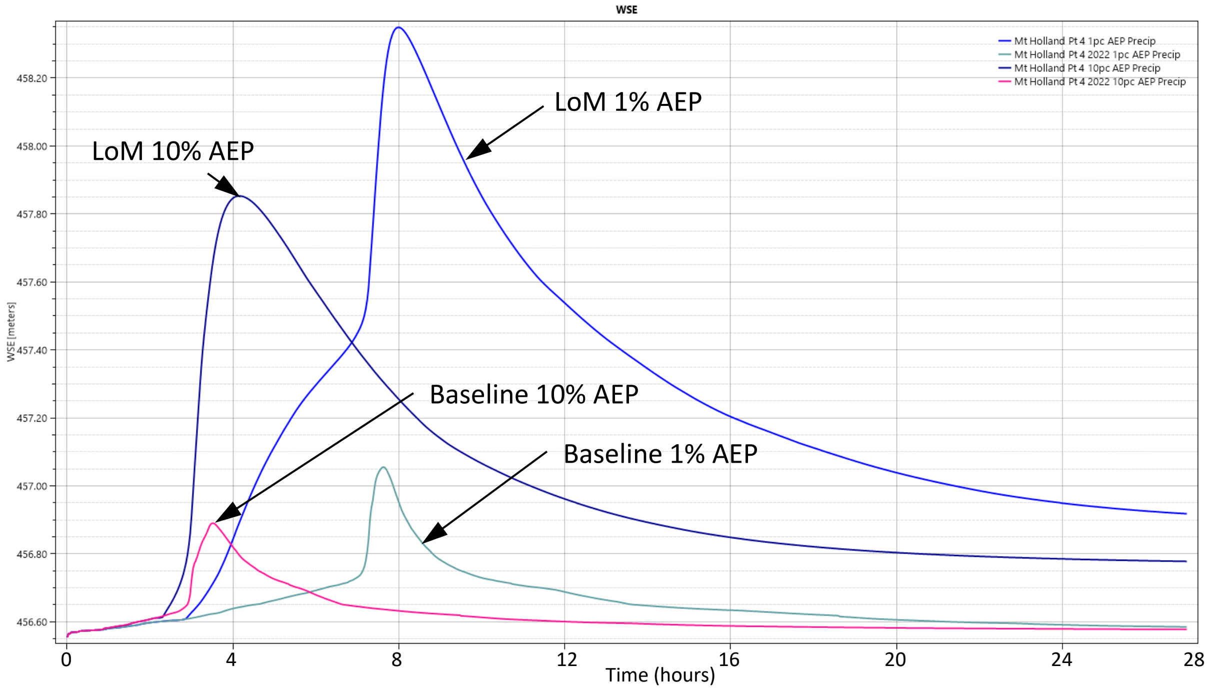


Figure 5-17: Water surface elevation stage hydrographs for Point 5

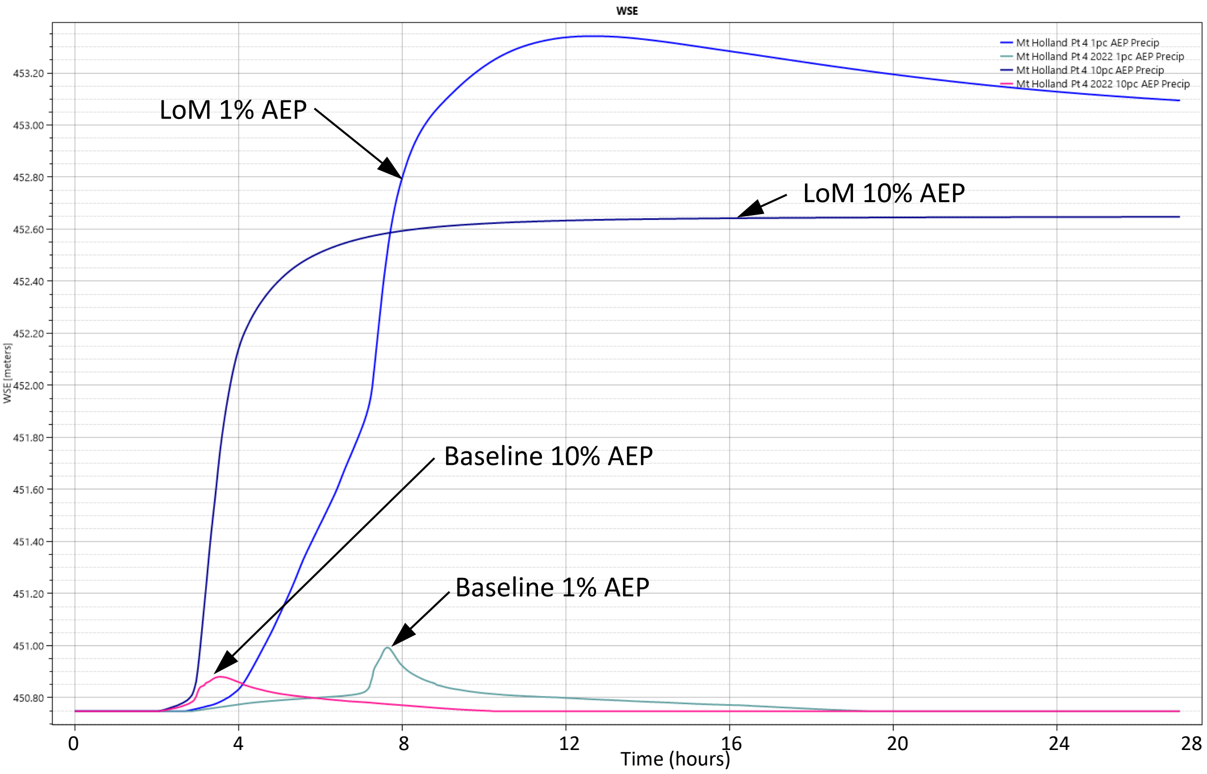


Figure 5-18: Water surface elevation stage hydrographs for Point 6

5.4. Scour protection

Table 5-2 below shows an excerpt from Austroads (2023) highlighting the recommended rock class and section thicknesses associated with specified velocity ranges. Austroads references Main Roads Western Australia (MRWA, 2006) as the data source for the tabulated values. **Table 5-3** defines the gradation and size ranges for standard rock classes. **Figure 5-19** shows the tabulated values graphically. Under the specified hydraulic conditions, smaller rock sizes would risk being mobilised during flood events, with unprotected embankments subject to scour.

As shown in the velocity maps, peak velocities in the 10% AEP flood are generally below 1.5 m/s, which falls below Austroads thresholds for rock protection in both the existing and project condition. Although these velocities fall below the Austroads threshold for requiring armour rock, the placement of coarser material such as Class A or B1 rock is recommended to prevent erosion of bunds, drains, and embankment slopes and preventing adverse impacts, particularly along areas where the flow path has been constricted or where localised runoff concentrates on embankment slopes.

Table 5-2: Rock protection (from Table 3.11, Austroads 2023)

Velocity (m/s)	Class of rock protection (tonne)	Section thickness, *T* (m)
< 2	None	–
2.0–2.6	Facing	0.50
2.6–2.9	Light	0.75
2.9–3.9	¼	1.00
3.9–4.5	½	1.25
4.5–5.1	1.0	1.60
5.1–5.7	2.0	2.00
5.7–6.4	4.0	2.50
> 6.4	Special	–

Table 5-3: Standard rock classes (from Table 3.12, Austroads 2023)

Rock class	Rock size[1] (m)	Rock mass (kg)	Minimum percentage of rock larger than
Facing	0.40	100	0
	0.30	35	50
	0.15	2.5	90
Light	0.55	250	0
	0.40	100	50
	0.20	10	90
¼ tonne	0.75	500	0
	0.55	250	50
	0.30	35	90
½ tonne	0.90	1000	0
	0.70	450	50
	0.40	100	90
1 tonne	1.15	2000	0
	0.60	1000	50
	0.55	250	90
2 tonne	1.45	4000	0
	1.15	2000	50
	0.75	500	90
4 tonne	1.80	8000	0
	1.45	4000	50
	0.90	100	90

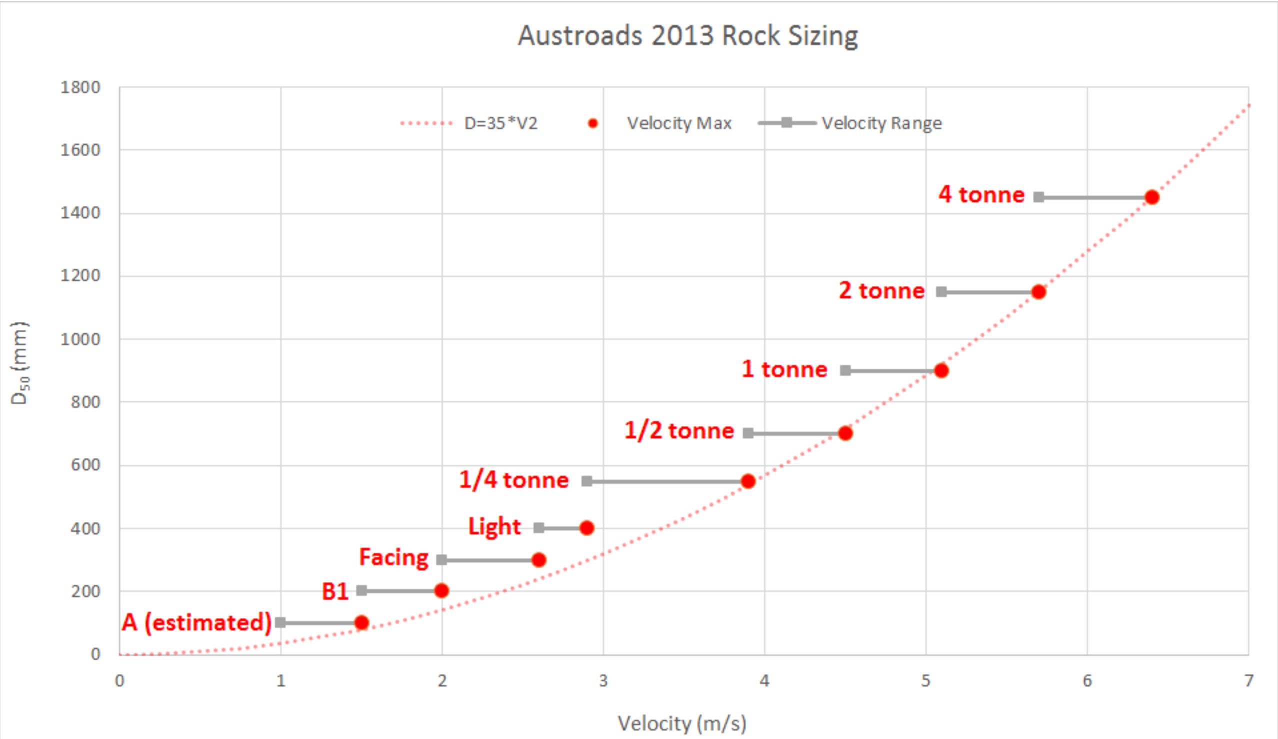


Figure 5-19: Velocity vs. median stone size (based on Austroads 2013)

6. Conclusions

Hydraulic models were developed to simulate flood flows for the 10% AEP and 1% AEP events under baseline (2022) and life-of-mine conditions. The life-of-mine scenario includes a diversion drain that routes flow from the west to the north of the pit. In addition, some flow is captured in mining pits and behind landforms. The total change in peak flow rates ranges from an increase of 5% to a decrease of 80% across the four selected index sections; the total change in flow volume ranges an increase of 11% to a decrease of 77%.

The adopted terrain surface represents the maximum physical layout affecting hydrology during LoM conditions. Interim mine plans have reduced impacts. This report presents 10% AEP and 1% AEP flood hydraulics. The 10% AEP hydraulics are applicable to mine planning and design for general mine features; the 1% hydraulics are presented for evaluation of very rare events and for sizing of critical infrastructure elements.

The results of the modelling show that the diversion drains would be stable in events up to the 1% AEP event without requiring rip rap lining, except at concentrated inflow points. Some upgrades may be required for closure conditions. Site-wide LiDAR data filtered to bare earth would allow more consistent comparisons of the surface water impacts of proposed features.

The afflux figures in this report show where existing vegetation may be subject to deeper or shallower flows in the LoM scenario than in baseline scenarios.

Tailings Storage Facilities and waste Rock Landforms will be internally draining (i.e. ripped, rehabilitated and with back-sloping berms), and significant surface water drainage effects from these features would not be anticipated.

Scour protection will be assessed for individual design features, with erosion control measures adopted to prevent offsite erosion and sedimentation. Surface water drainage for the LoM footprint can generally be managed in accordance with standard mine planning and engineering practices.

7. Limitations

The results presented in this report are limited to the accuracy of the provided terrain data. The models do not account for the presence of any earthworks or features constructed since the acquisition of the terrain data. If more recent or more detailed terrain data become available, or if the proposed LoM landform designs are adjusted, the results of this study should be revisited. Some vertical discrepancies are apparent in the 2023 LiDAR data, generally resulting from a lack of filtering to bare earth. The discrepancies potentially affect predicted flood levels by +/- 0.5 m.

Due to the limited availability of gauge data, the confidence bands around the hydrological results are very wide, particularly for extreme events. Detailed design development should be undertaken with appropriate contingencies and adherence to all applicable guidelines, including ARR 2019, erosion and scour protection guidelines, and other guidelines as appropriate.

The results presented in this assessment do not account for climate change. As rainfall-runoff estimates are refined, additional contingencies should be added to design measures to accommodate climate change based on the proposed design life of individual project elements.

The scenarios modelled for this assessment are for single flood events occurring in isolation. Basins and pits are assumed to be empty at the beginning of the simulation. The scenarios do not include long-term water balance or successive flood events which would result in higher starting water surface elevations in the basins.

8. References

AustRoads, 2023. Guide to Road Design, Part 5: Drainage and Hydrology Considerations.

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019. Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia (Geoscience Australia).

Bureau of Meteorology, 2017. Special Climate Statement 60 – heavy rainfall and flooding in southwest Western Australia.

Engineers Australia, 2019. Australian Rainfall and Runoff Data Hub. https://data.arr-software.org/.

Flavell, D. 2012. Design flood estimation in Western Australia, Australasian Journal of Water Resources, 16:1, 1-20

Geoscience Australia, 2015. Regional Flood Frequency Estimation procedure. Australian Rainfall and Runoff, 4th Edition. https://rffe.arr-software.org/.

Geoscience Australia, 2015. Digital Elevation Model of Australia derived from LiDAR 5 metre grid.

JDA (2022) Earl Grey Lithium Project Surface Water Management, prepared for Covalent Lithium, JDA ref: J6759h, January 2022.

JDA (2019) Mt Holland Project: Surface Water Management, prepared for Covalent Lithium, JDA ref: J6759b, November 2019.

JDA (2018) Mount Holland Project: Surface Water Management Study, prepared for Western Australian Lithium, JDA ref: J6590a, May 2018.

Jeffrey, S.J., Carter, J.O., Moodie, K.B. and Beswick, A.R. (2001). *Using spatial interpolation to construct a comprehensive archive of Australian climate data*, Environmental Modelling and Software, Vol 16/4, pp 309-330. DOI: 10.1016/S1364-8152(01)00008-1.

MRWA, 2006. Floodway Design Guide.

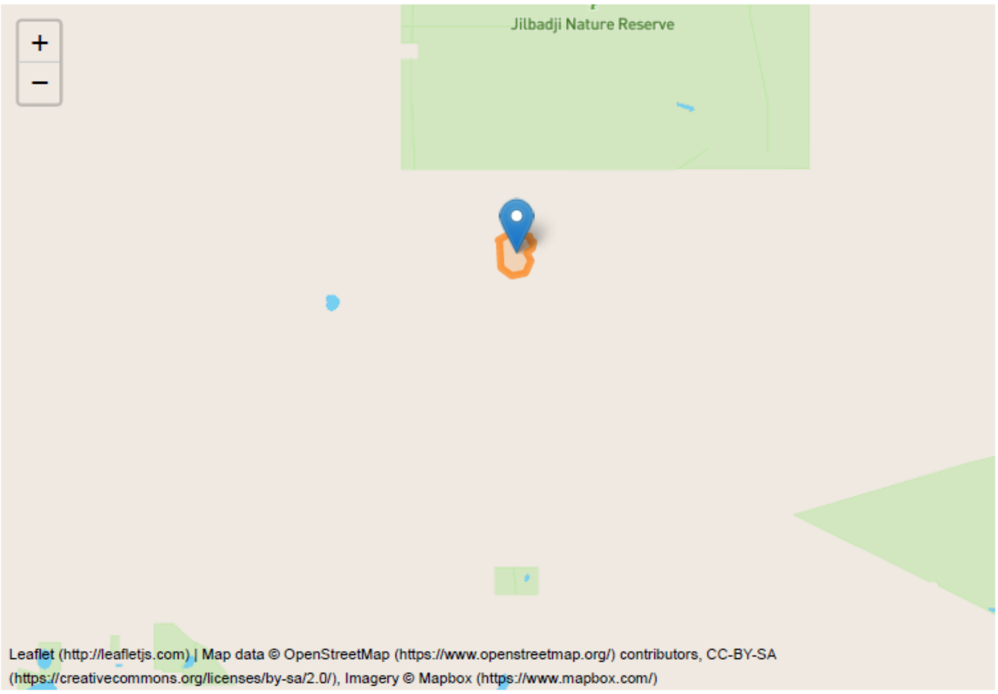
U.S. Army Corps of Engineers, 2023. HEC-RAS 6.4 2D User Manual.

Appendix A. ARR Data Hub Results

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	119.753
Latitude	-32.11
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Baseflow Factors	show



Data

River Region

Division	South West Coast
River Number	13
River Name	Swan Coast-Avon River
Shape Intersection (%)	100.0

Layer Info

Time Accessed	14 April 2023 11:31AM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^b - c\log_{10}Duration\right)Duration^{-d} + eArea^f Duration^g\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i	Shape Intersection (%)
SW WA	0.183	0.259	0.271	0.33	3.85e-06	0.41	0.55	0.00817	-0.00045	100.0

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^2}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Layer Info

Time Accessed	14 April 2023 11:31AM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Storm Initial Losses (mm)	-50.0
Storm Continuing Losses (mm/h)	-50.0

Layer Info

Time Accessed	14 April 2023 11:31AM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/FLTwest.zip)

code	FLTwest
Label	Southern and South Western Flatlands (West)
Shape Intersection (%)	100.0

Layer Info

Time Accessed	14 April 2023 11:31AM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_FLTwest.zip)

code	FLTwest
arealabel	Southern and South Western Flatlands (West)
Shape Intersection (%)	100.0

Layer Info

Time Accessed	14 April 2023 11:31AM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-32.1104347517&longitude=119.753152101&sdmin=true&sdhr=true&sdday=true&user_labe to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	14 April 2023 11:31AM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	1.4 (0.105)	1.9 (0.102)	2.3 (0.099)	2.7 (0.096)	2.3 (0.069)	2.1 (0.053)
90 (1.5)	2.6 (0.172)	2.0 (0.093)	1.6 (0.061)	1.2 (0.039)	2.6 (0.068)	3.6 (0.082)
120 (2.0)	1.6 (0.096)	1.8 (0.075)	1.9 (0.066)	2.0 (0.059)	3.7 (0.088)	4.9 (0.102)
180 (3.0)	1.9 (0.096)	2.1 (0.078)	2.3 (0.070)	2.4 (0.063)	3.3 (0.069)	3.9 (0.071)
360 (6.0)	0.2 (0.007)	1.7 (0.049)	2.7 (0.065)	3.7 (0.074)	2.9 (0.047)	2.3 (0.032)
720 (12.0)	0.0 (0.000)	0.3 (0.006)	0.5 (0.009)	0.6 (0.010)	1.0 (0.012)	1.2 (0.013)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.001)	0.1 (0.001)	0.3 (0.003)	0.4 (0.004)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.1 (0.001)	0.2 (0.002)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	14 April 2023 11:31AM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	RCP 8.5
2030	**0.758 (3.8%)**	0.675 (3.3%)	**0.782 (3.9%)**
2040	**0.970 (4.8%)**	0.868 (4.3%)	**1.132 (5.7%)**
2050	**1.179 (5.9%)**	1.094 (5.5%)	**1.501 (7.6%)**
2060	**1.370 (6.9%)**	1.332 (6.7%)	**1.900 (9.7%)**
2070	**1.526 (7.7%)**	1.564 (7.9%)	**2.342 (12.1%)**
2080	**1.631 (8.3%)**	1.769 (9.0%)	**2.839 (14.9%)**
2090	**1.667 (8.5%)**	1.929 (9.9%)	**3.404 (18.1%)**

Layer Info

Time Accessed	14 April 2023 11:31AM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Baseflow Factors

Downstream	0
Area (km2)	969.95232
Catchment Number	9432
Volume Factor	0.0
Peak Factor	0.08886
Shape Intersection (%)	89.7

Layer Info

Time Accessed	14 April 2023 11:31AM
Version	2016_v1

Download TXT (downloads/ea43418c-b49b-481f-a23b-97362f5ffe1f.txt)

Download JSON (downloads/7947d087-2c15-4f97-9d7b-21dbc2024295.json)

Generating PDF... (downloads/abd0b7be-6731-488d-b8fd-9c2a136b005e.pdf)

Appendix B. Inundation Depth and Velocity Results

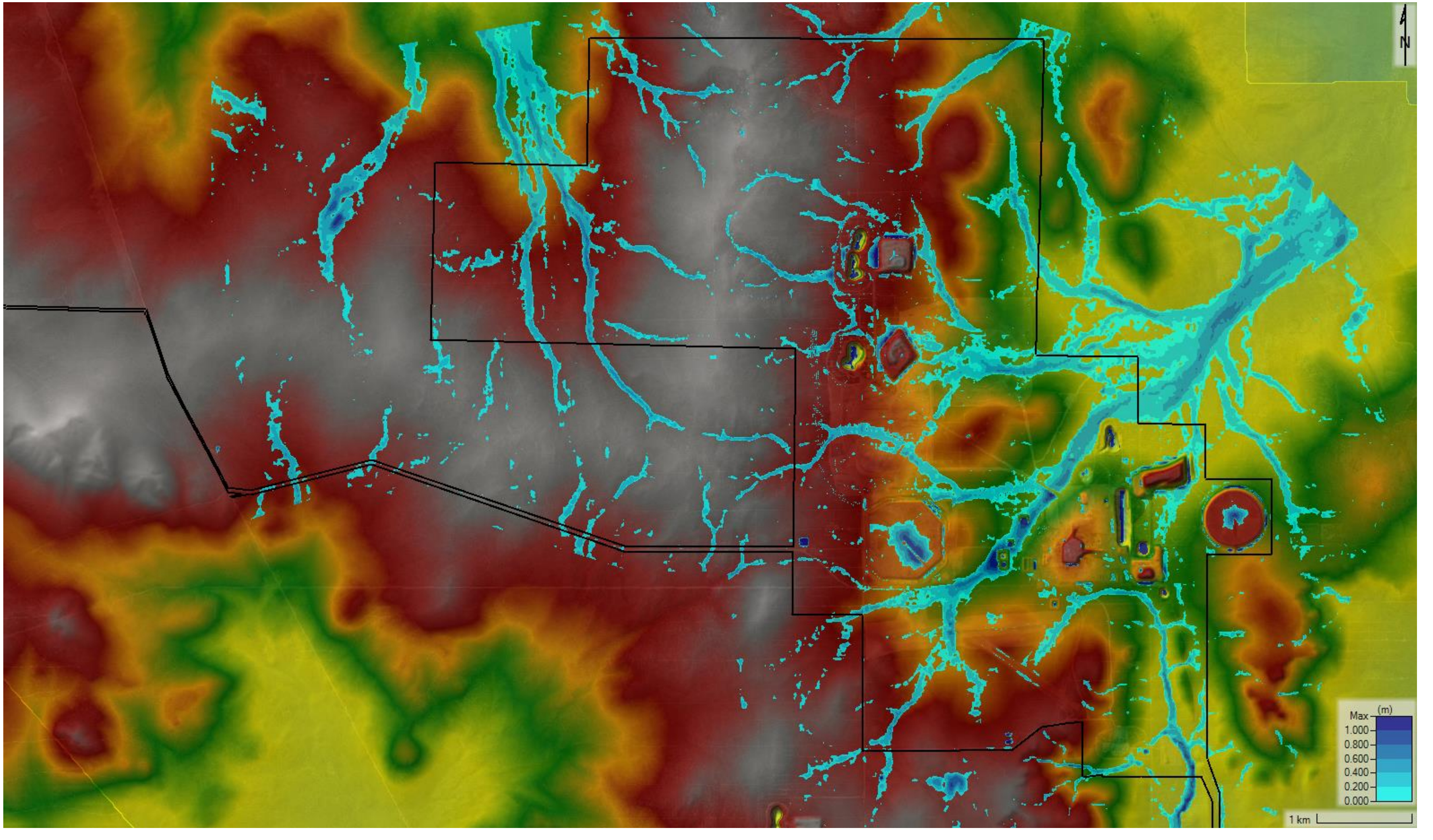


Figure B-1 – 1% AEP Baseline Condition Maximum Depth

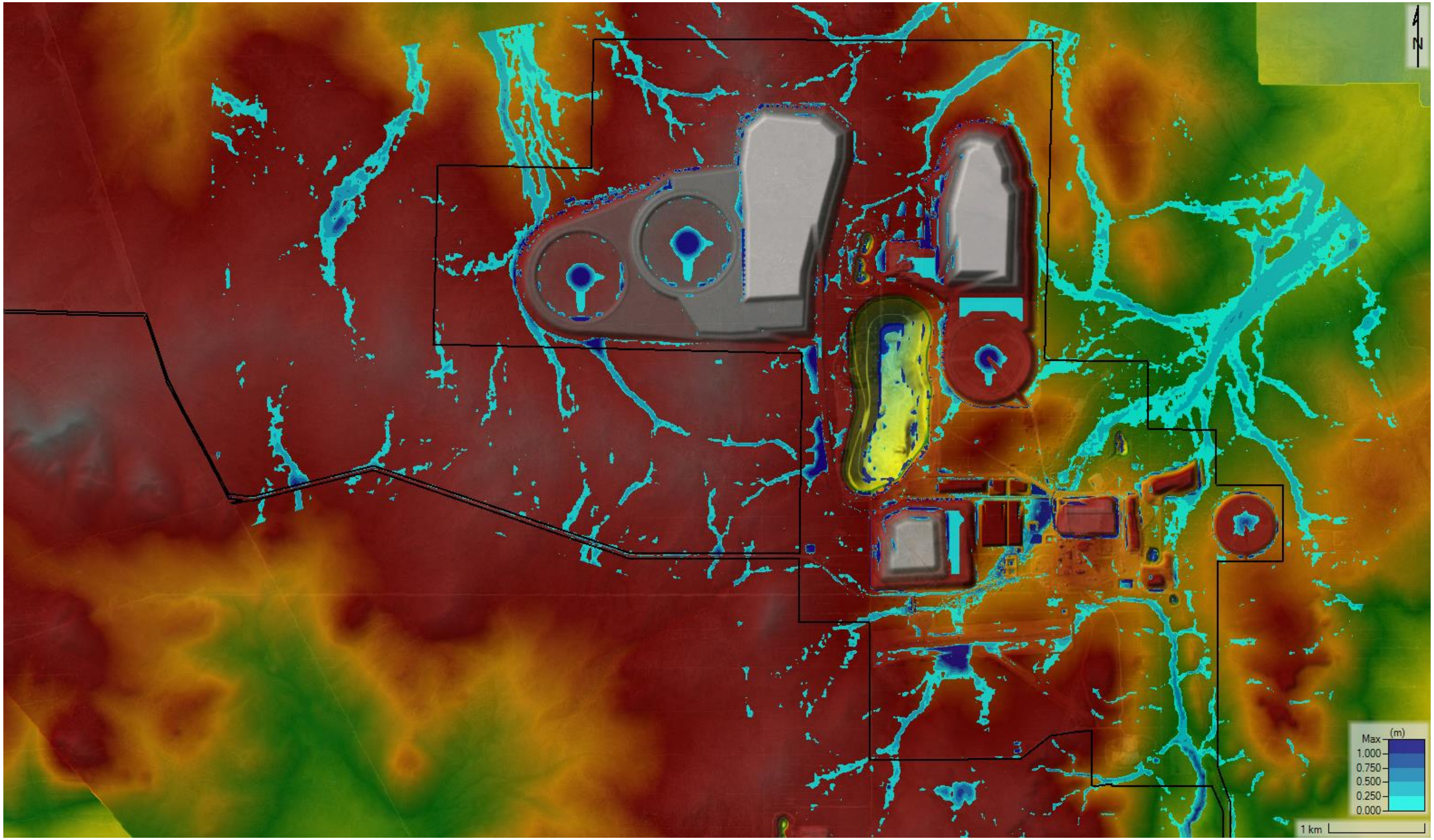


Figure B-2 – 1% AEP Life of Mine Condition Maximum Depth

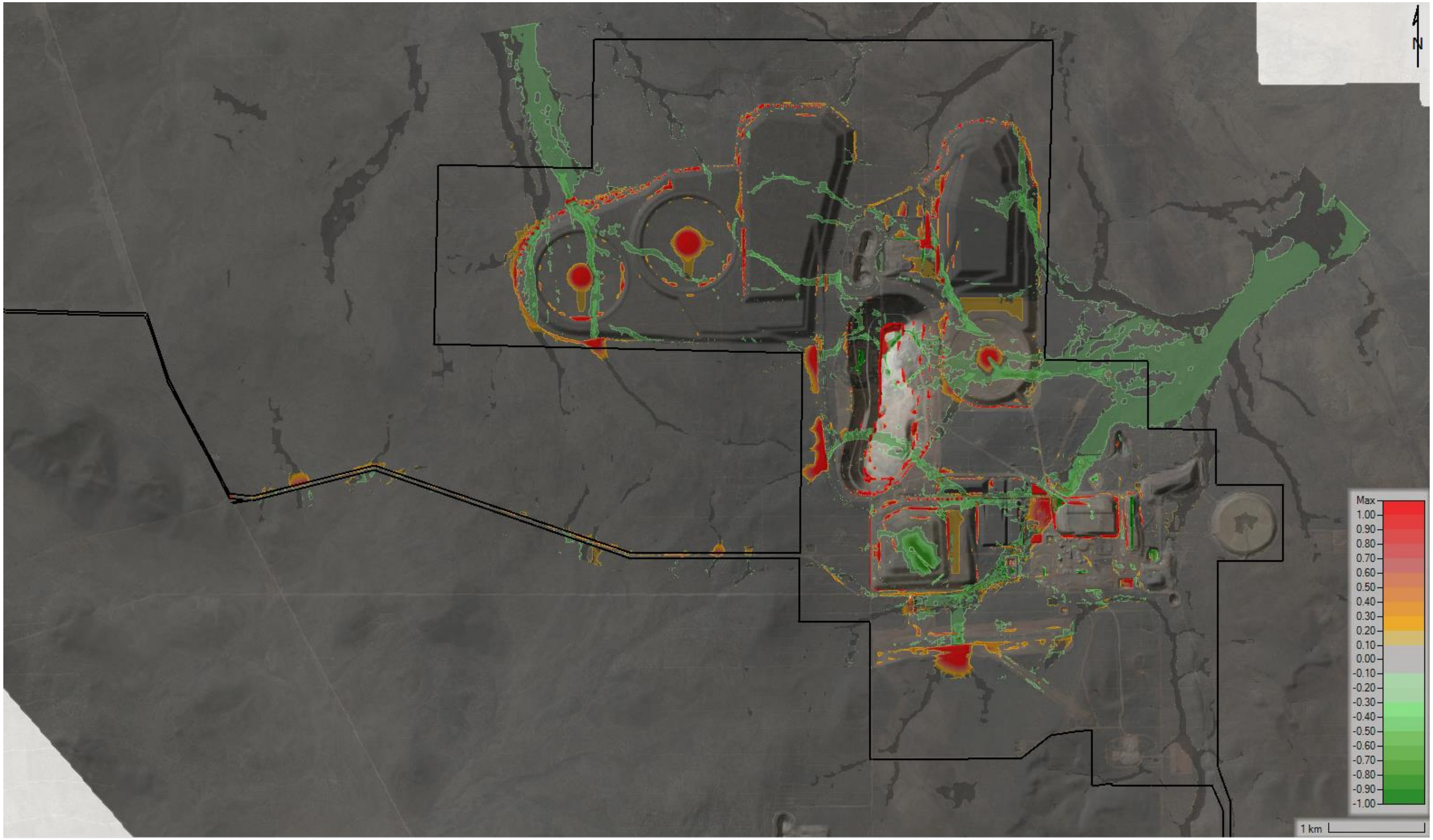


Figure B-3 – 1% AEP Maximum Water Surface Elevation Afflux

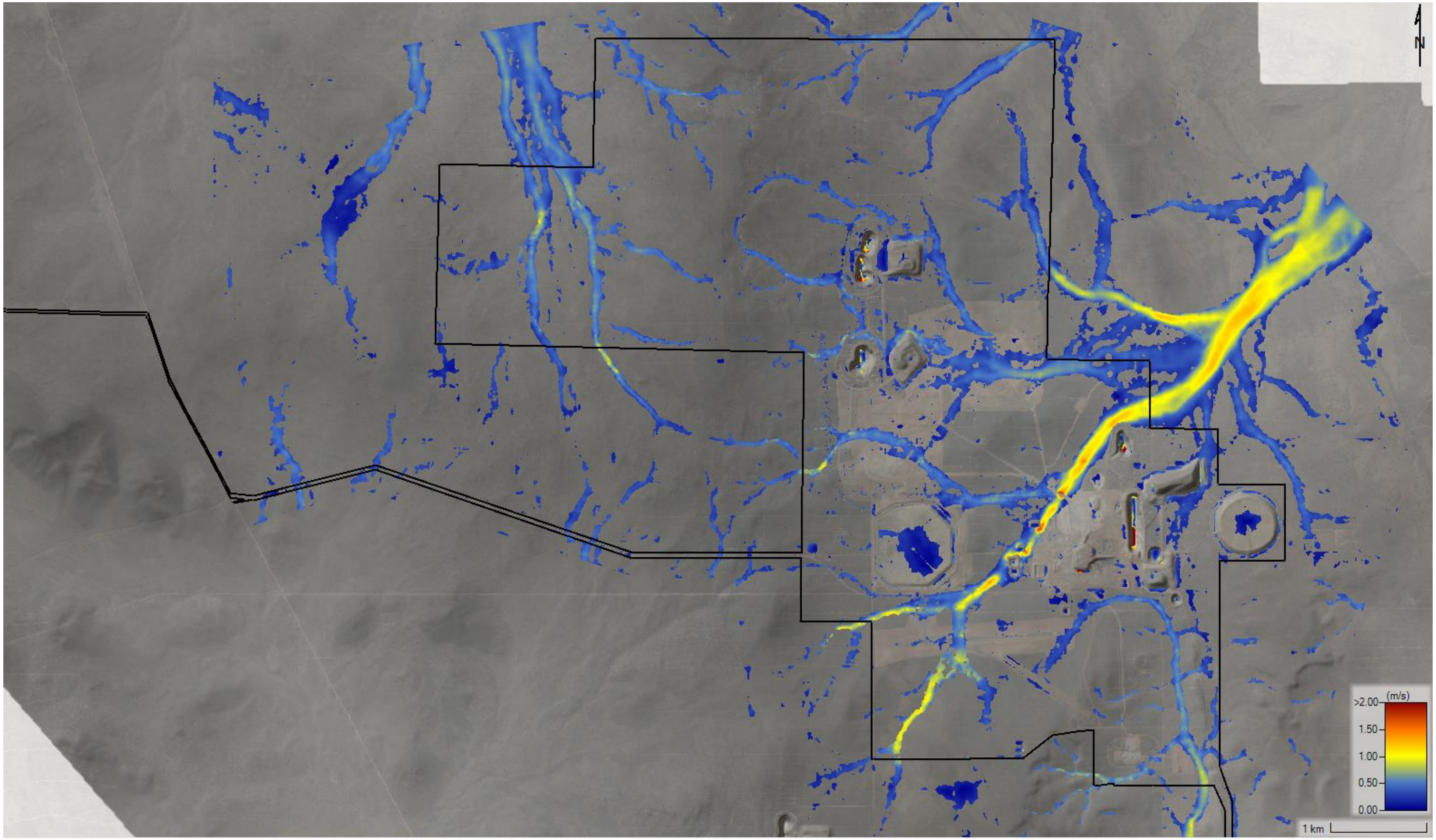


Figure B-4 – 1% AEP Baseline Condition Maximum Velocity

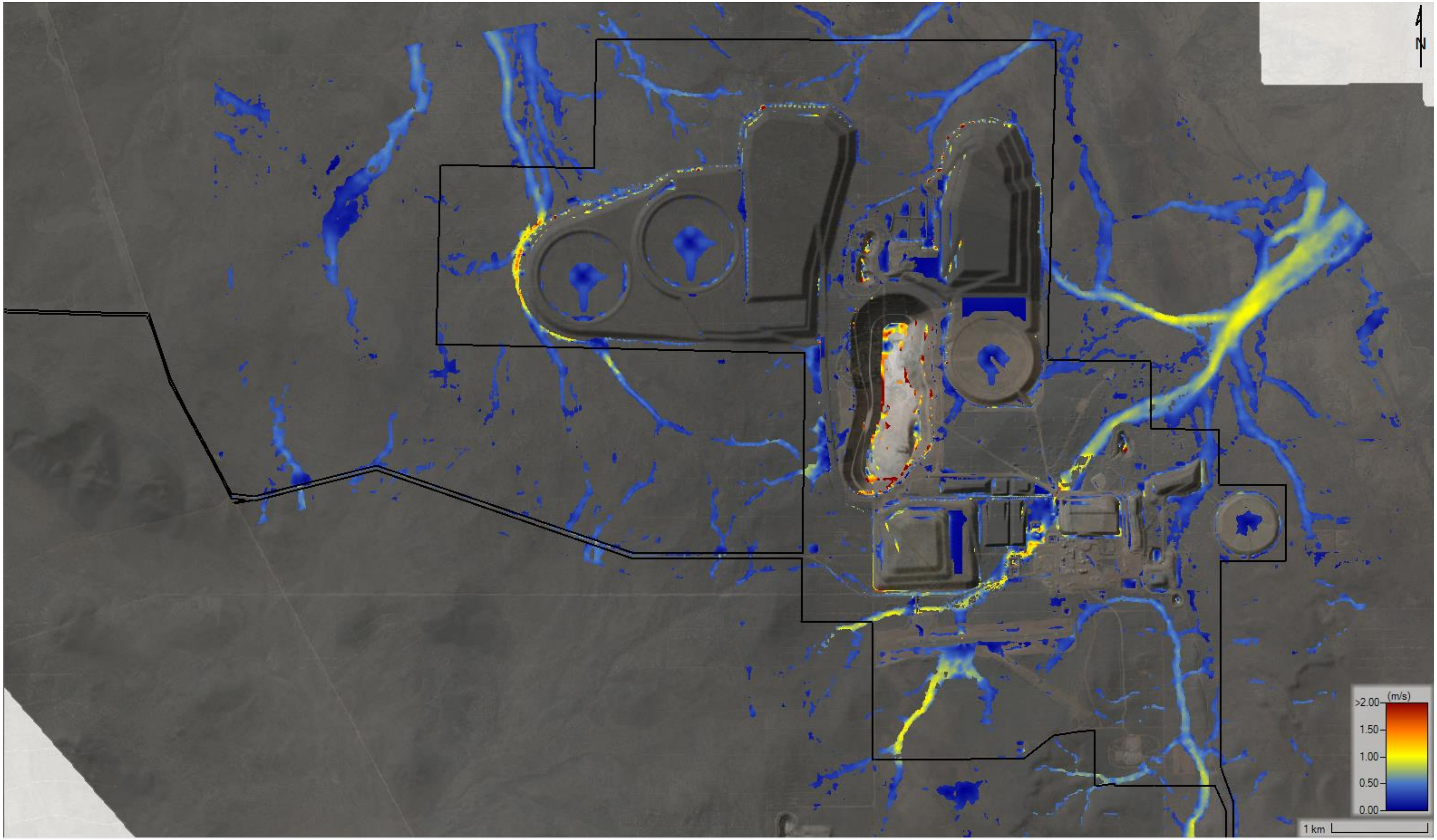


Figure B-5 – 1% AEP Life of Mine Condition Maximum Velocity

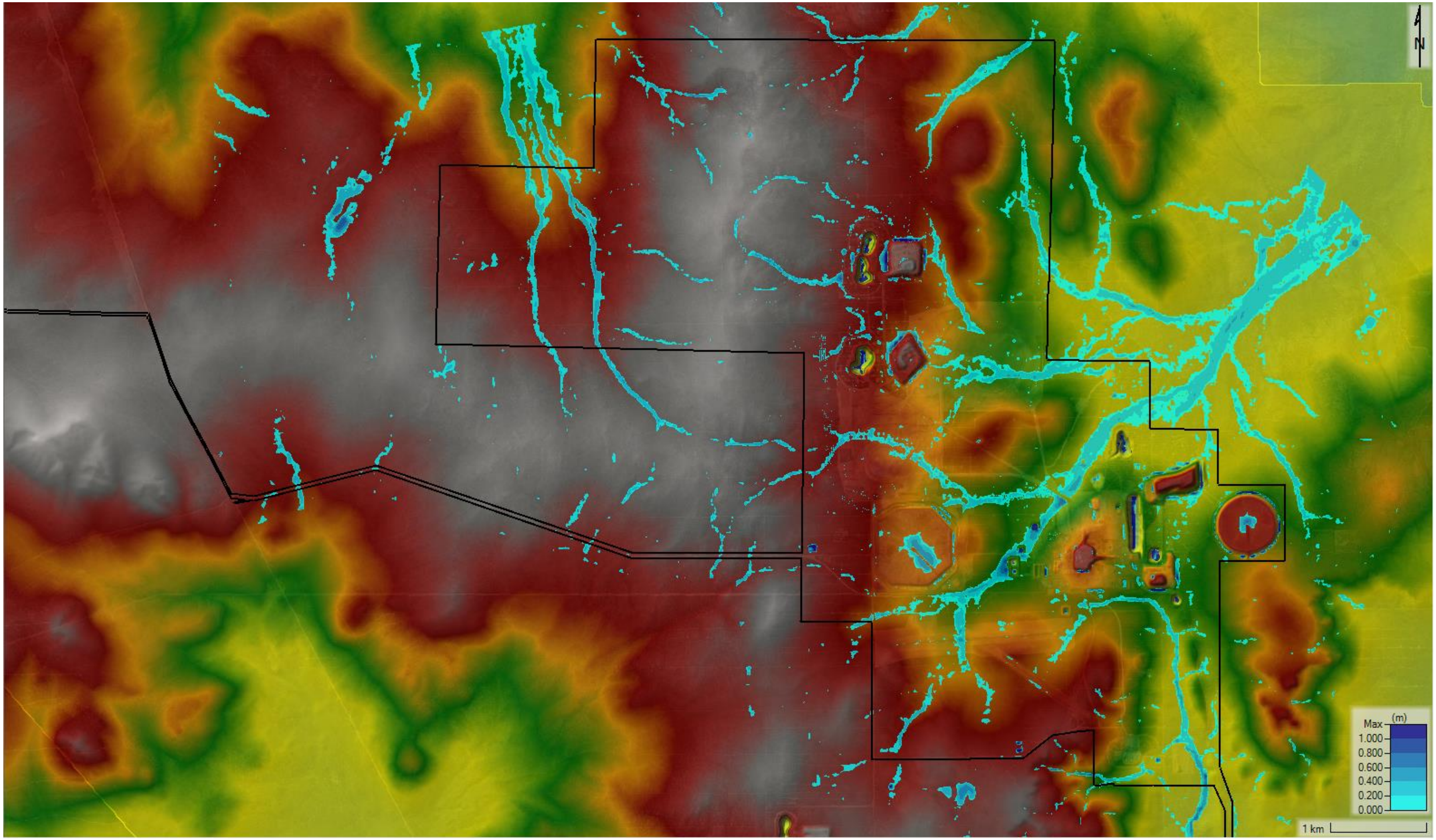


Figure B-6 – 10% AEP Baseline Condition Maximum Depth

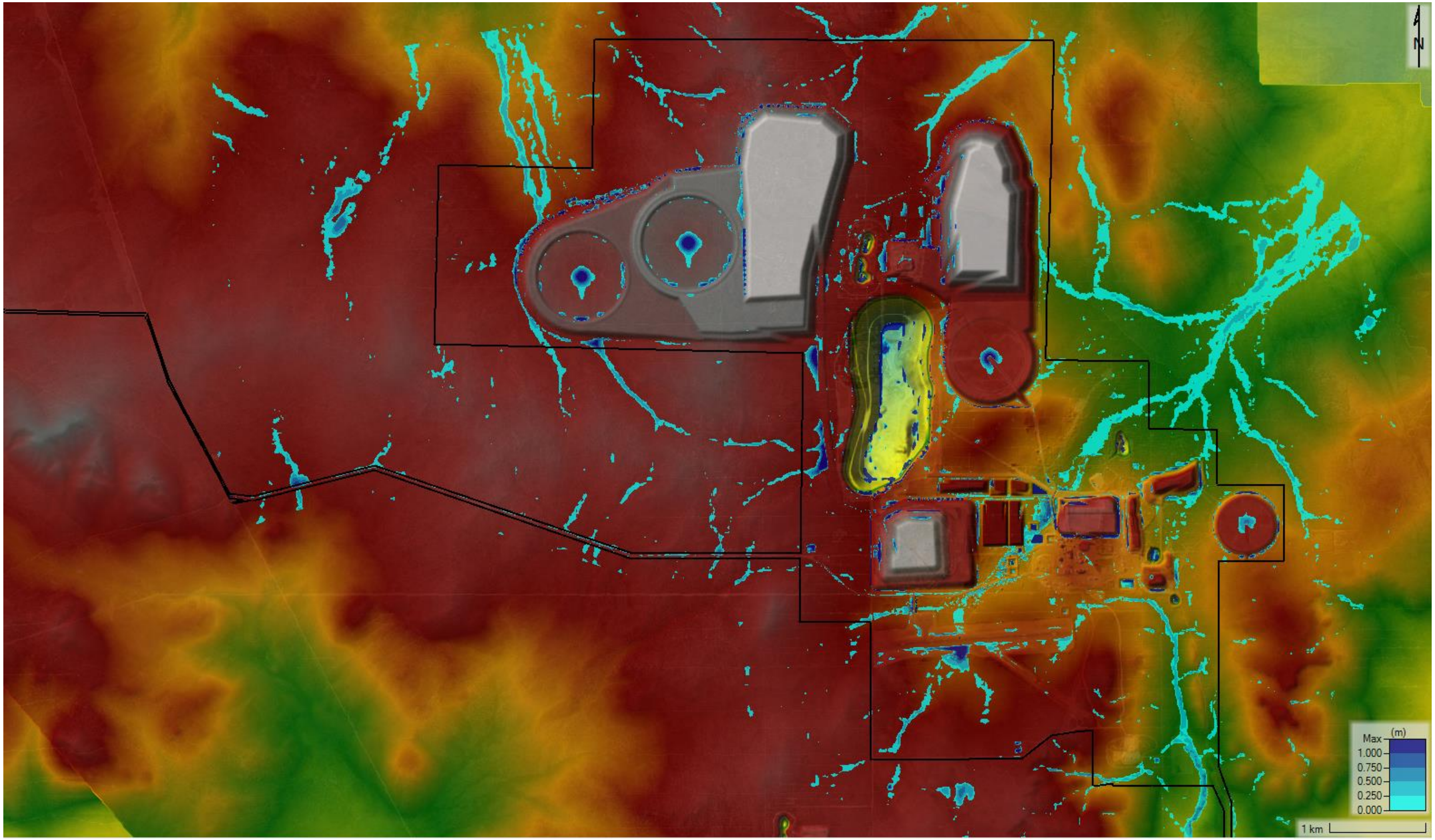


Figure B-7 – 10% AEP Life of Mine Condition Maximum Depth

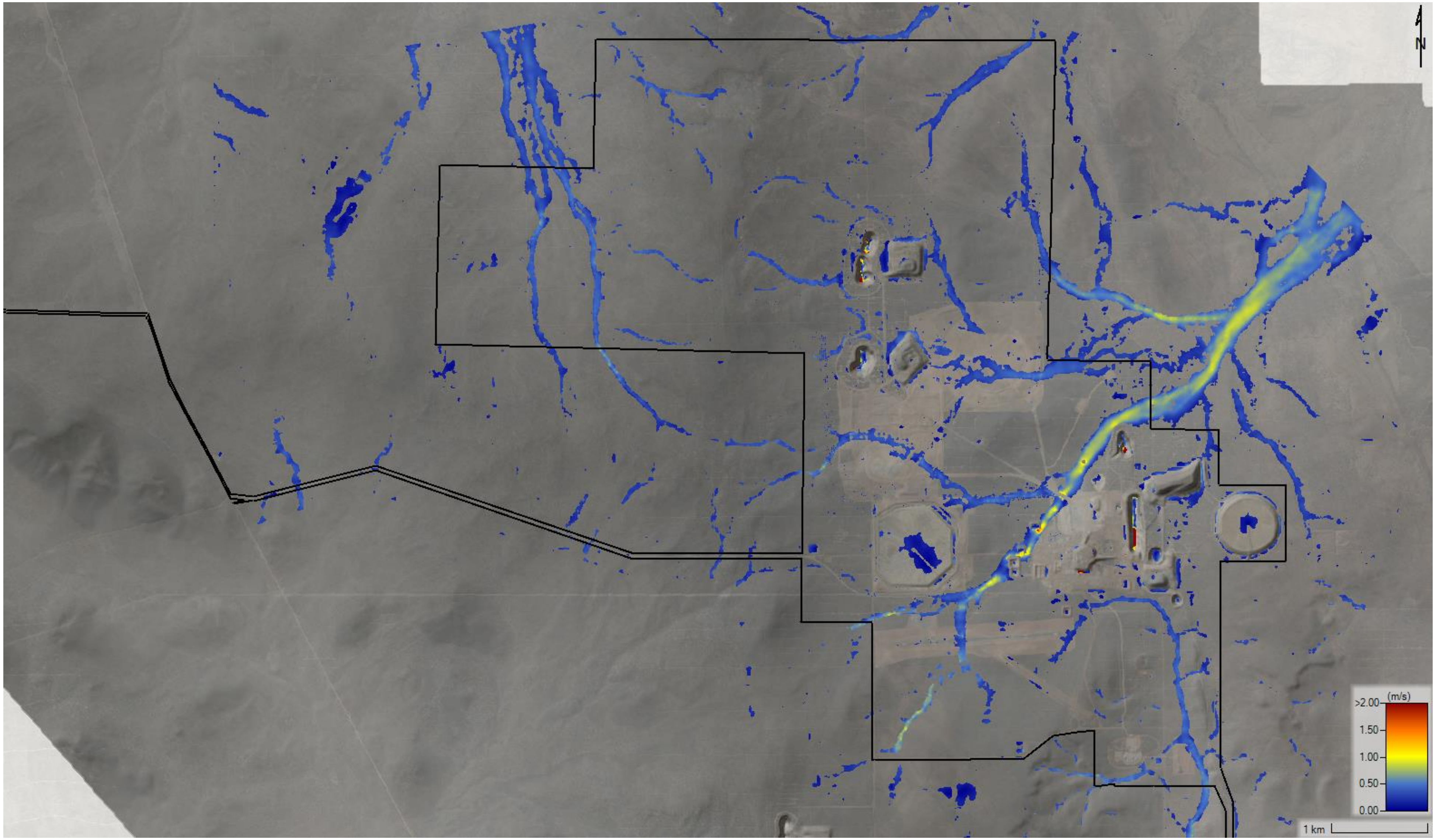


Figure B-8 – 10% AEP Baseline Condition Maximum Velocity

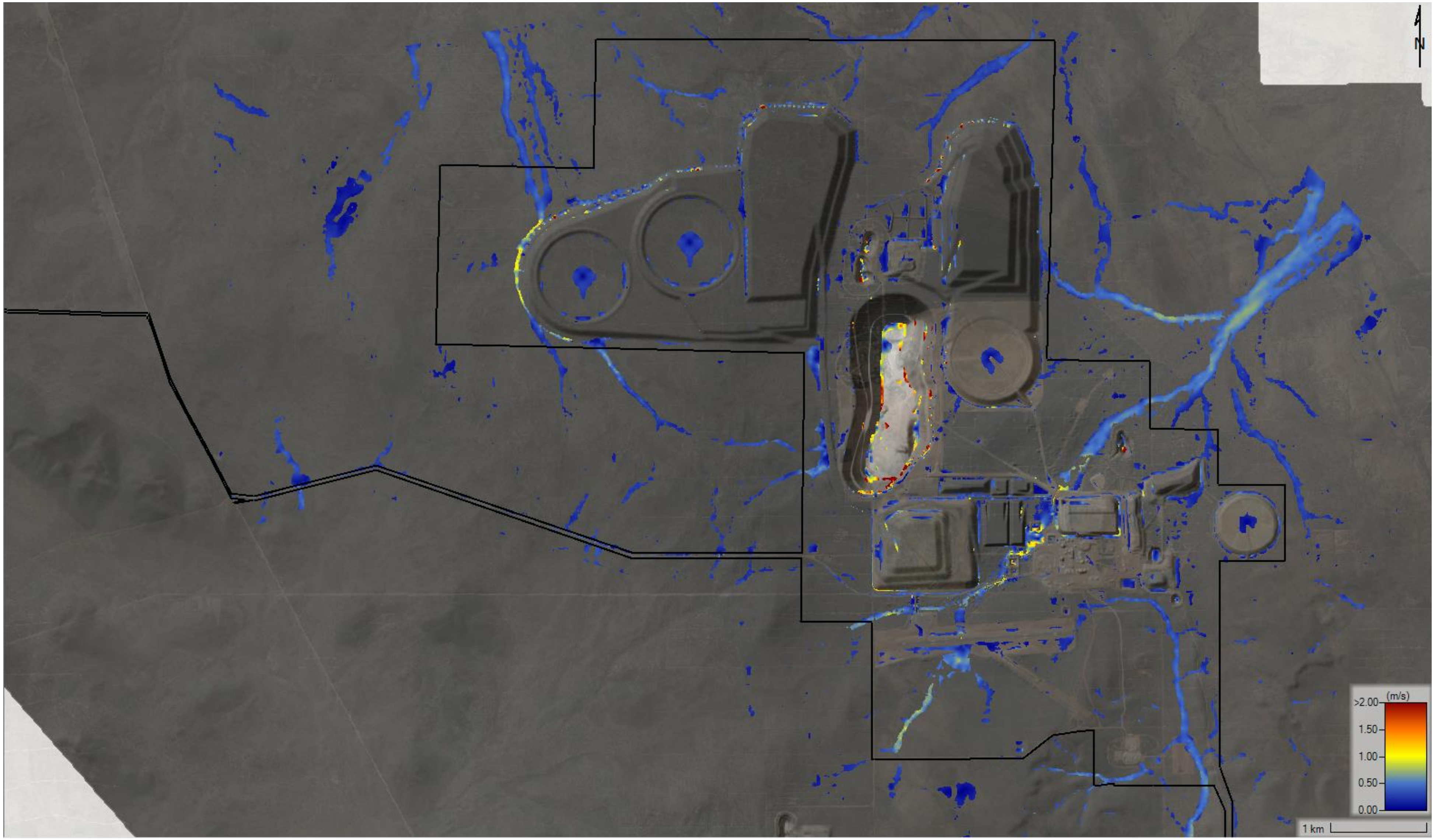


Figure B-9 – 10% AEP Life of Mine Condition Maximum Velocity

Appendix C. Sensitivity Analysis Results

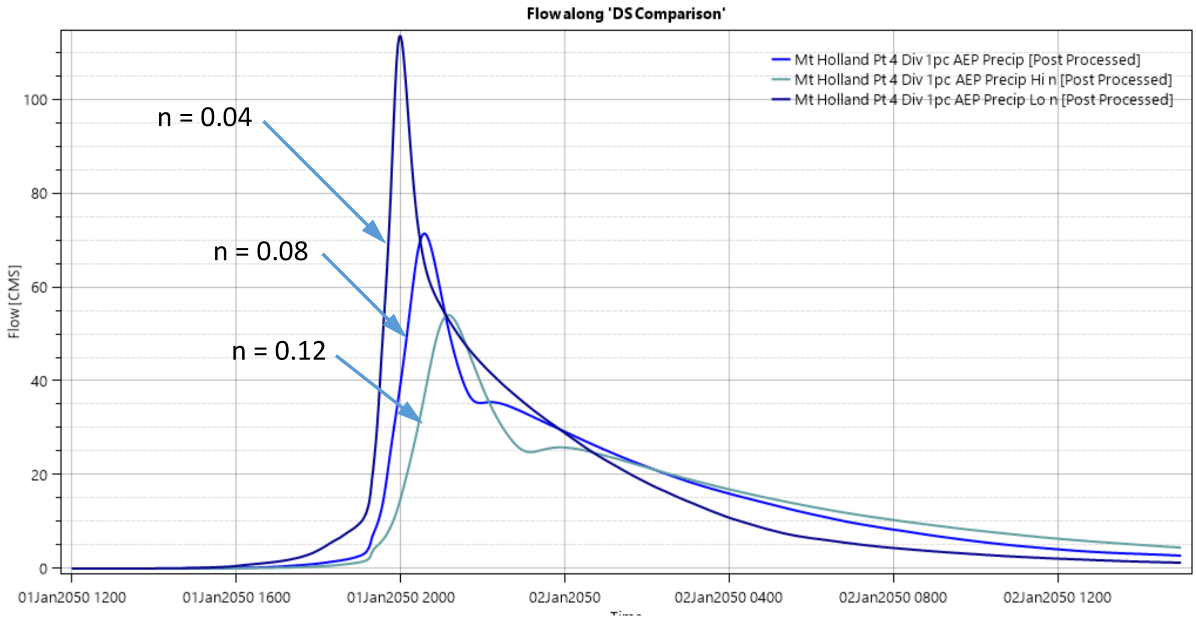


Figure C-1 – Flow hydrograph sensitivity to Manning's roughness

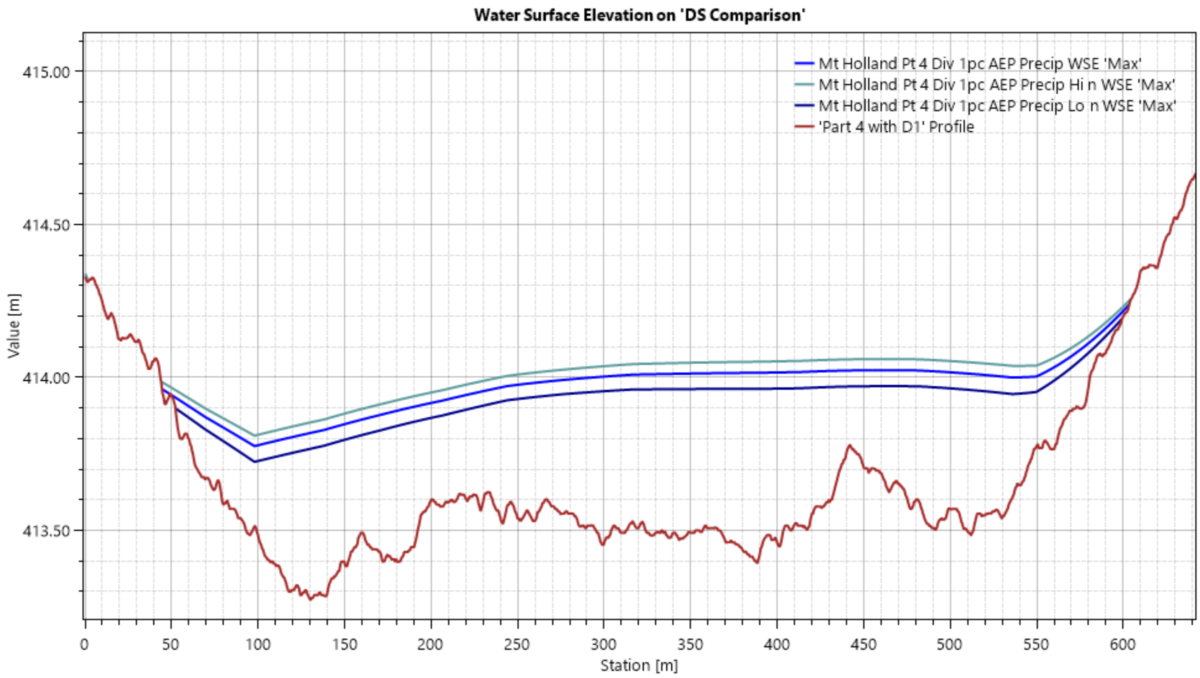


Figure C-2 – Water surface elevation sensitivity to Manning's roughness at DS cross section

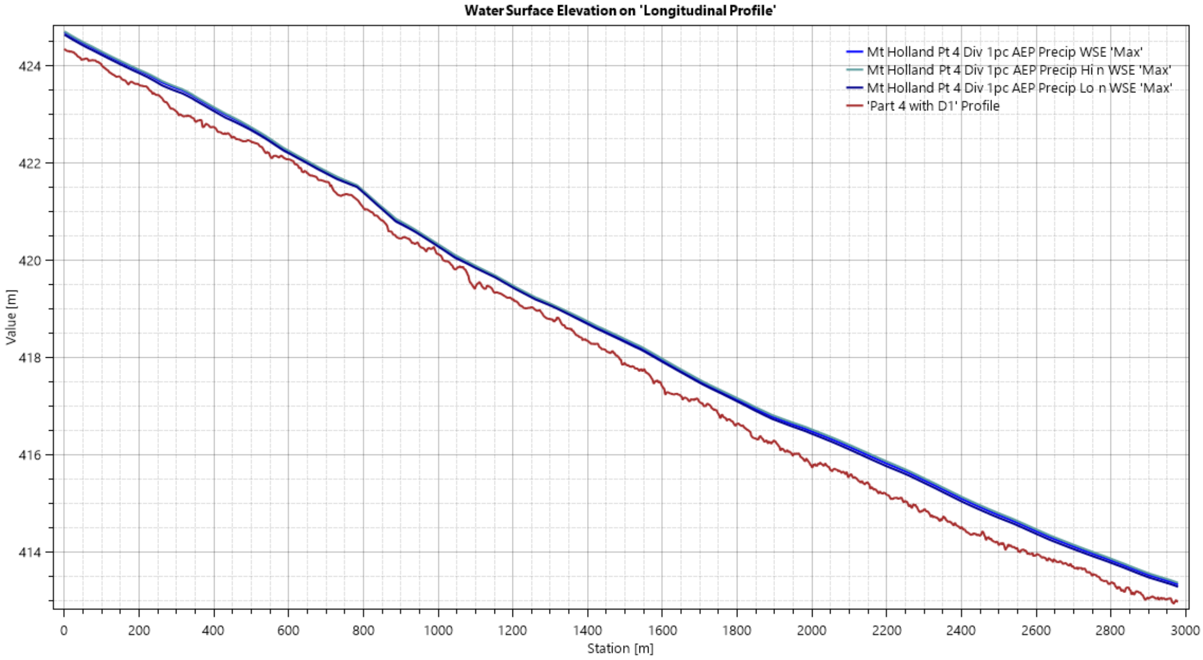


Figure C-3 – Water surface elevation sensitivity to Manning's roughness along DS flow path