Prepared for
Granny Smith Mining Company Pty Ltd
ABN: 42 165 235 030

Granny Smith Renewables Project - Energy Expansion

Wind Turbine Flood Study - Rev B Locations

29-Aug-2024
Granny Smith Flood Study
Doc No. 60719925_0

Granny Smith Renewables Project - Energy Expansion

Client: Granny Smith Mining Company Pty Ltd

ABN: 42 165 235 030

Prepared by

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1.0 Introduction

Gold Fields Australia (GFA) are currently proposing to expand the renewable energy infrastructure for the Granny Smith Mine (GSM) in 2026. Flood modelling is a key consideration for the expansion and placement of future infrastructure.

URS Australia Pty Ltd (now AECOM) undertook a flood study in 2015 to assess potential risk of flooding to the then proposed gas power station. This model was subsequently extended for Aggreko Generation Pty Ltd (Aggreko) in 2018. Additional flood modelling was completed in 2019 to support site-wide closure studies.

This modelling included catchment delineation, hydrological analysis, and hydraulic modelling to determine the potential flood extents and depths associated with the 100-year ARI flood event for the creeks in proximity to the proposed power station and existing solar farm.

Formal permission from Aggreko has been granted (email: Greg Lunt, 14/11/2023) to use the existing flood model developed in 2018 for this revision.

To assess the potential flood risk for the proposed energy expansion, a revision of the existing flood modelling was completed to allow for initial planning of the proposed wind turbine (Rev A locations) infrastructure (AECOM, 2024).

Based on flood modelling results, final locations of the proposed wind turbines (Rev B locations) were modified to areas outside the impact of predicted local flooding. This report presents an update to incorporate the new locations in context to the flood modelling completed.

New (Rev B) wind turbine locations are presented on **Figure 1**.

1.1 Objectives

The key objective of the GSM Hydrology Study and Flood Model Update was to present the flood modelling results in context with the change in proposed Rev B wind turbine locations.

No change in the methodology or modelling results from AECOM (2024) have been made. The results of floodplain mapping for the 1 in 100-year Average Recurrence Interval (ARI) design flood event have been put in context with the new wind turbine proposed locations.

1.2 Scope of Work

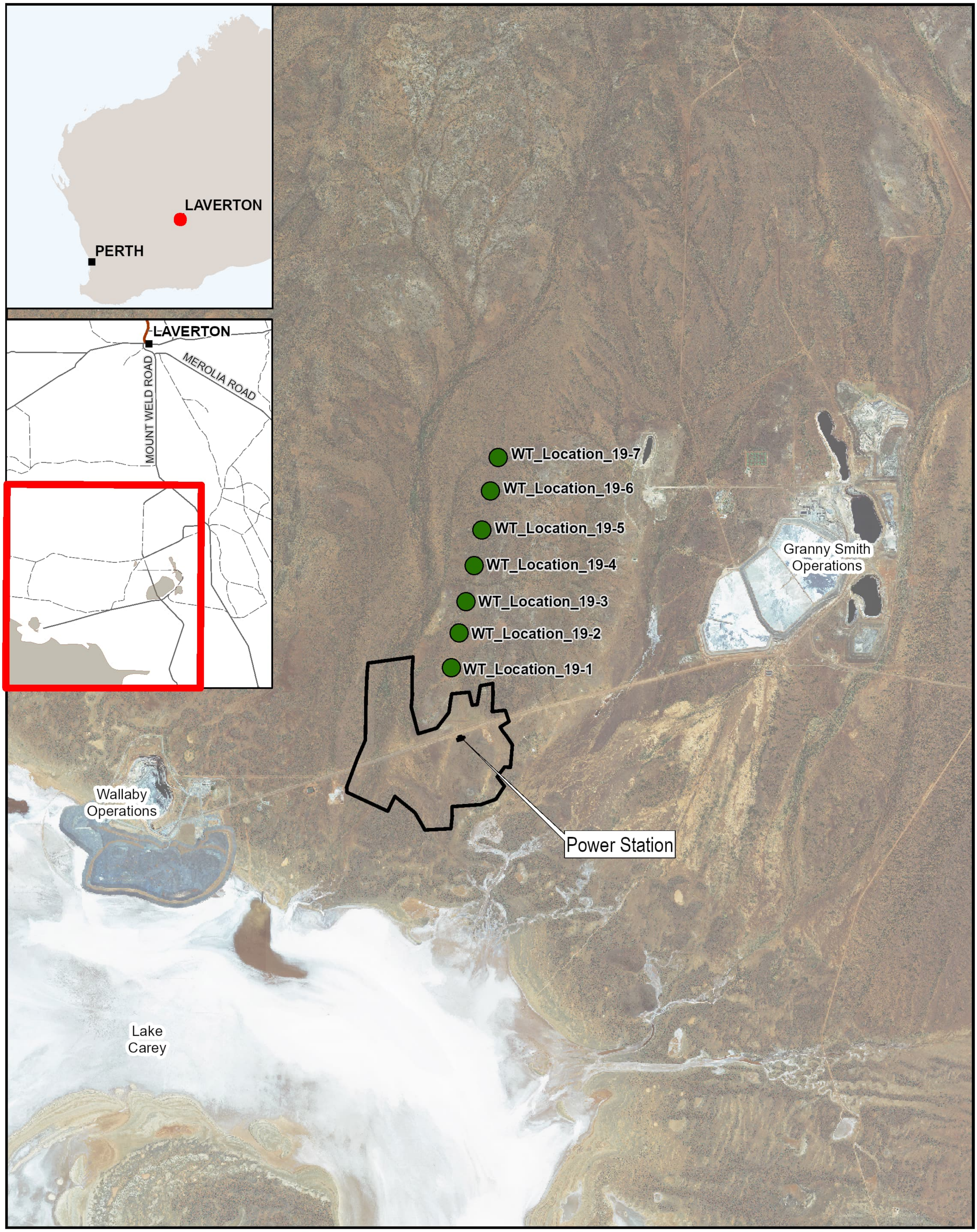
Consistent with AECOM (2024), to achieve the above objective the following scope of work was completed:

1.2.1 Task 1 - Flood Maps

Flood model outputs have been re-created for the 1 in 100-year ARI design event based on current topographic conditions and the proposed renewable energy expansion area (Rev B locations). Outputs from the model include information on floodwater depths, velocity, and flood extent in the vicinity of the proposed renewable energy expansion area.

1.2.2 Task 2 - Deliverable

Consistent with AECOM (2024), this report presents the approach undertaken and the potential flood risk posed to the proposed renewable energy expansion area. Flood maps for the 1 in 100 year-ARI events, presenting maximum water depths and flow velocities across the extent of the area of interest, and information on the sensitivity of the model to assumptions made in the hydrologic and hydraulic modelling, are also included.



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LEGEND
2018 Model Extent
Proposed Wind Turbine Location

Site Location

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GSM WIND TURBINE FLOOD STUDY

Figure
1

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2.0 Hydrological Review

Previous flood modelling has been compiled with:

AECOM (2018). SGM Flood Study. Prepared for Aggreko Generation Pty Ltd

AECOM (2019). GSM Mine Closure Technical Studies-Surface Water Drainage Plan Phase 2. Prepared for GSM Mining Company Pty Ltd

URS (2015). Granny Smith Mine - Gas Power Station Flood Study, prepared for Granny Smith Mining Company Pty Ltd

AECOM (2024). Granny Smith Renewables Project - Energy Expansion Wind Turbine Flood Study, 11 June 2024

The following provides a summary in context with the proposed energy expansion project.

2.1 Topological Data

The Digital Terrain Model (DTM) to define the topographies of the 2018 and 2019 study areas are as follows:

- The 2018 DTM was generated using 0.5 m contour data obtained from Gold Fields from a 2011 aerial fly-over.
- The 2019 DTM was generated using topographic LiDAR data of the Granny Smith Mine (November 2017) 1m grid – MGA51.

Comparison of the two DTMs **(Figure 2)** shows a difference in elevation of approximately 1m.

2.2 Catchment Delineation

Hydrological models developed for both the 2018 flood study and 2019 GSM Mine Closure Technical Study differ and are described below and in **Table 1**. Catchment delineations for the 2018 flood study were taken at the existing culvert crossings the Wallaby Haul Road, which is located to the north of the proposed solar farm site. Three creeks (C1, C2 and C3) were identified. In the absence of streamflow gauged data, rainfall-runoff modelling was undertaken using the XP-RAFTS modelling package to estimate surface runoff from the catchments.

- The 2019 GSM Mine model was developed using a 2-dimensional 'rain-on-grid' TUFLOW model incorporating the rainfall parameters calculated to simulate natural flow paths and flood behaviour for the entire GSM Mine domain. The model was built using the 2017 Light Detection and Ranging (LiDAR) topographic data with a grid mesh of 20mx20m. This provides sufficient detail for the wide floodplain areas but is too coarse for the assessment of drainage structure such as road profile and culvert crossing.
- Unfortunately, Australian Rainfall and Runoff (AR&R) Regional Flood Frequency Estimation (RFFE) modelling could not be undertaken due to the site being within an arid region.

Catchment delineations for the 2018 Flood Study and 2019 GSM Mine Closure Technical Study are presented in **Figure 3**.

Table 1 Hydraulic Model Assumptions

CATCHMENT	C1	C2	C3	C4(WT7)	C5 (WT4)	C6 (WT2)
Area (km^2)	0.63	0.92	44.22	50.52	2.43	1.411
Outlet Coordinate	Not accessed	Not accessed	Not accessed	-28.85811, 122.3373	-28.8534, 122.3539	-28.8504, 122.3625
Centroid Point	Not accessed	Not accessed	Not accessed	-28.78205, 122.35942	-28.8421, 122.3546	-28.8398, 122.3634
2018 XPRafts 1%AEP Peak Flow	3.89	4.01	48.92	information not available due to arid region		
AR&R RFFE	Not accessed	Not accessed	Not accessed	-	-	-

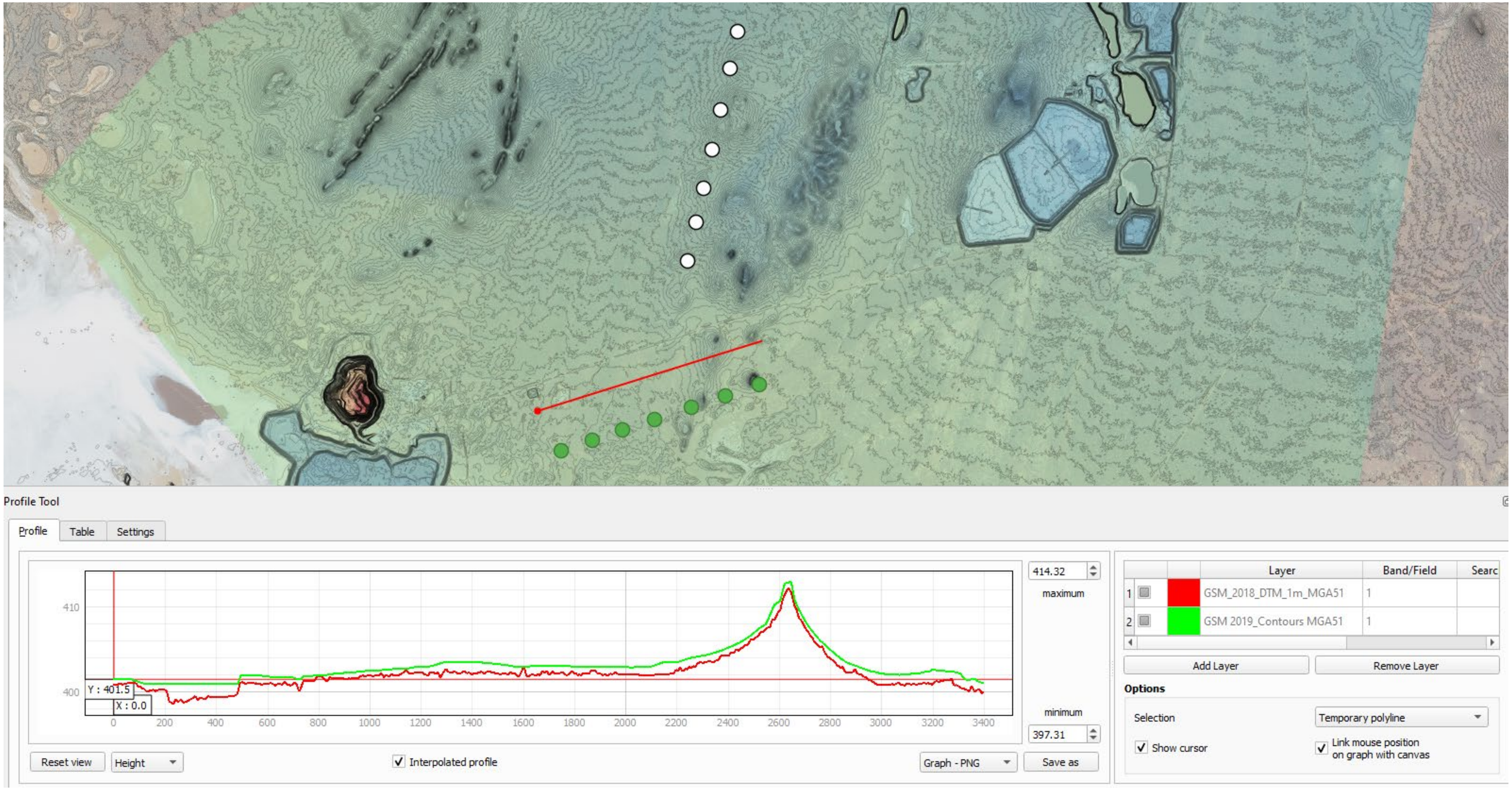
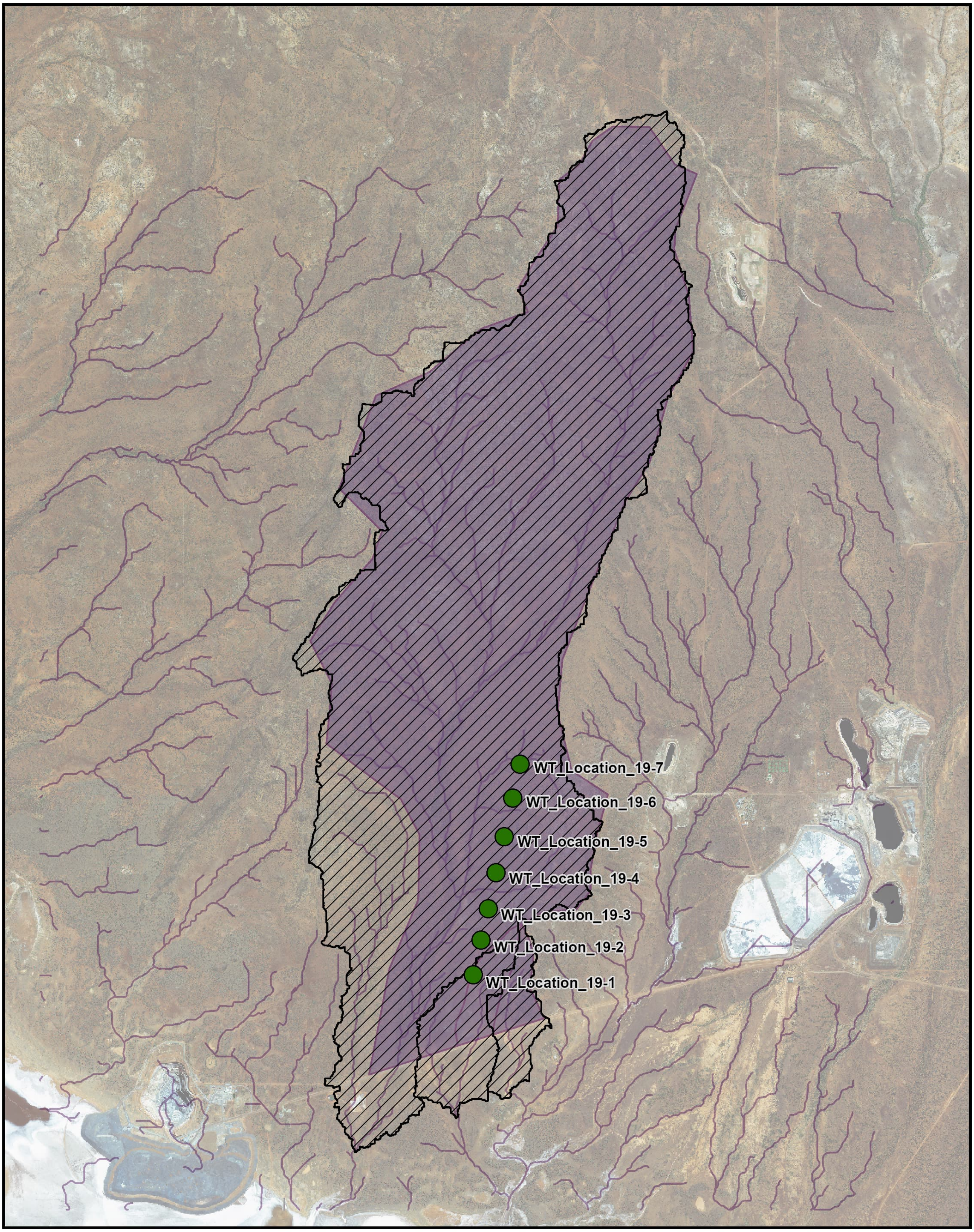


Figure 2 Comparison of 2018 DTM and 2019 DTM



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LEGEND
Stream line
Eind Turbine Flood Study Catchment Divine
2018 Flood Study Catchment Divine
Proposed Wind Turbine Location

Catchment Delineation

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Figure
3

2.3 2015 Hydrological Model

The 2015 hydrological model setup included:

- AR&R losses specific to the arid region (Goldfields). **Table 2** presents the losses applied to the 2015 hydrological model. An initial/continuing loss model was used to generate excess rainfall in the creeks.
- An average Manning's n value of 0.04 was applied to the creek. This value is reasonable based on aerial imagery and site observations.
- Project specific Intensity-Frequency-Duration (IFD) design rainfall intensities for the catchments were generated in accordance with the AR&R (1987) and are presented in **Appendix A**.
- Design rainfall for the 1% AEP event was used to simulate catchment response and identify peak flows.

2.4 2018 Hydrological Model

An updated XPRAFTS model was developed using the 2016 IFD design rainfall intensities, which assesses a range of rainfall patterns for each storm event and updated initial and continuing losses (**Table 2**). The input parameters for catchment size, slope and Manning's values remained the same as the 2015 hydrology. The highest peak flows were selected from the median storm pattern generated in XPRAFTS and are presented in **Table 3**. The peak flows for all creeks C1, C2 and C3 are higher in the updated hydrological model.

The estimated peak discharge rates for each creek derived during the 2015/ 2018 study are presented in **Table 3** for the 1% AEP event and on **Figure 4**. These values were based on the determination of the critical period for each event, i.e. the duration of the storm event that generated the highest peak flow. The hydrographs from the 2015 and 2018 study are presented in **Appendix B**. The hydrological model was not validated as there was no gauged stream flow or level data available.

Table 2 Losses Applied in the Hydrological Models for the 1% AEP Event

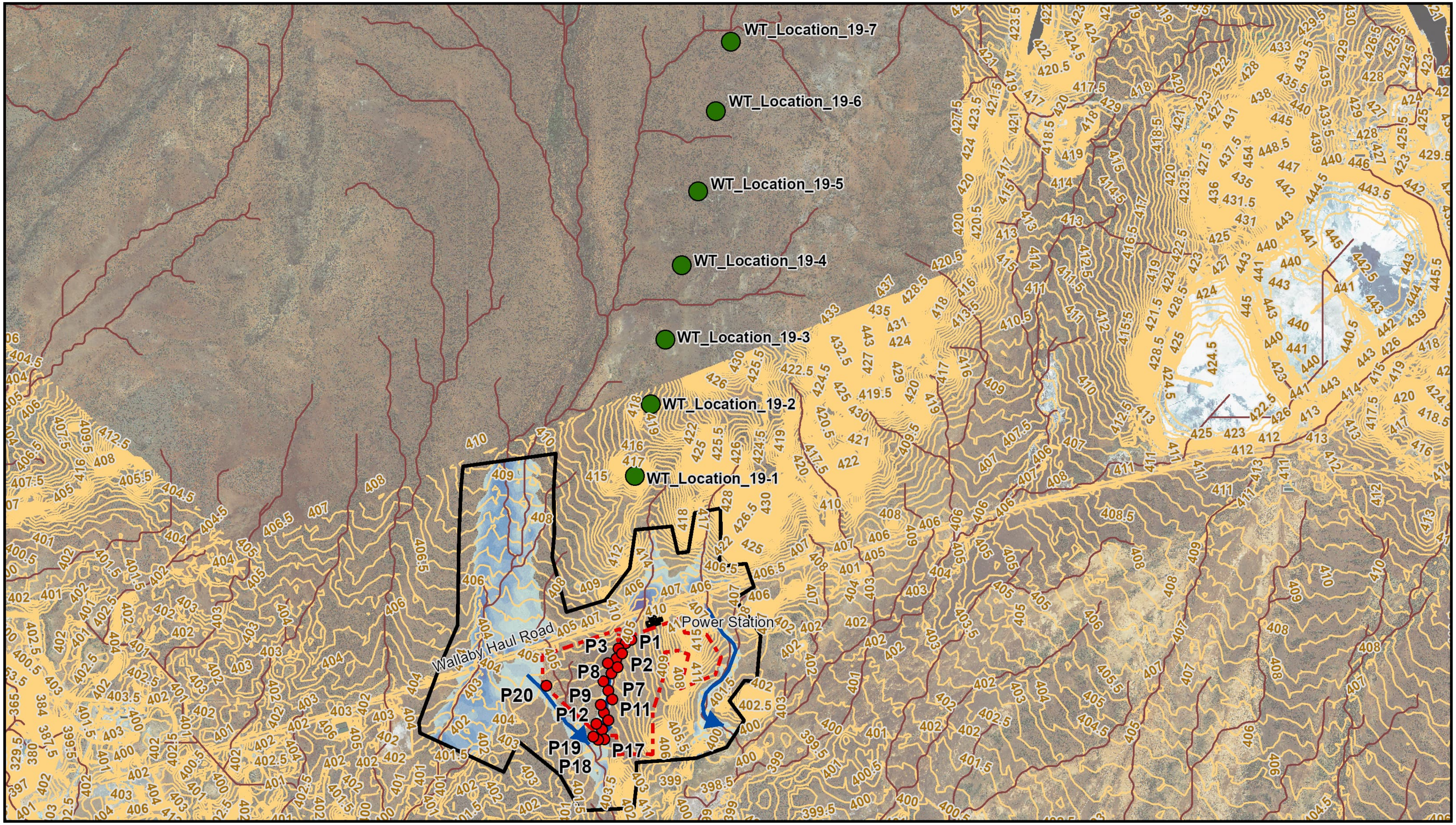
Model	Initial Losses (mm)	Continuing Losses (mm)
2015	24	3
2018/ 2023	31	3

Table 3 Comparison of Peak Flow Rates and Critical Durations for the 1% AEP Event

	C1		C2		C3	
	2015	2018	2015	2018	2015	2018
Peak Flow (m^3/s)	2.46	3.89	2.74	4.01	40.15	48.92
Critical Duration (hour)	6	3	6	3	12	12

2.5 Sensitivity Analysis

Sensitivity analysis was undertaken on the hydraulic model to determine how much the model outputs are influenced by varying some of the model input parameters. The purpose of this analysis is to assess the confidence that can be placed on the model outputs. The sensitivity analysis undertaken and the impacts on water depths and velocities at selected locations in the flooded areas identified in **Figure 4** are presented in **Table 4**, with further data presented in **Appendix C**. The sensitivity analysis suggests that the modelled depths and velocities and extents are not significantly sensitive to the tested model parameters. The largest increase in water depths was for Sensitivity Run 6 (AR&R 2016 Hydrographs with rainfall factored up by 15% for climate change).



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LEGEND

- Proposed Wind Turbine Location
- Locations
- Stream line
- contours_MGA51
- Flowpath_polyline
- Proposed Solar farm area (2018 Flood Study)
- 2018 Model Extent

Indicative Floodwater Depths (m)

- 0.008 - 0.086
- 0.087 - 0.166
- 0.167 - 0.256
- 0.257 - 0.37
- 0.371 - 0.523
- 0.524 - 0.728
- 0.729 - 0.972
- 0.973 - 1.455

Peak Water Depths for the 1% AEP event

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Figure
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Table 4 Sensitivity Analysis Results for Selected Locations

Sensitivity Run	Parameter Tested	Maximum Change in Depth (m)	Maximum Change in Velocity (m/s)
1	Blockage of culverts under Wallaby Haul Road (50%)	+0.02	+0.04
2	Blockage of culverts under Wallaby Haul Road (100%)	+0.05	+0.10
3	Model surface roughness coefficient (+20% Manning's value)	+0.02	-0.03
4	Model surface roughness coefficient (-20% Manning's value)	-0.02	+0.04
5	AR&R 2016 Hydrographs	+0.02	+0.03
6	AR&R 2016 Hydrographs with rainfall factored up by 15% for climate change	+0.10	+0.17

Figure 4 shows the flood extent for the Base Case, compared to the extents for Sensitivity Runs 5 (AR&R 2016 Hydrographs) and 6 (AR&R 2016 Hydrographs with rainfall factored up by 15% for climate change). The flood extent for Sensitivity Run 5 is only slightly larger than the Base Case extent, however, the extent for Sensitivity Run 6 is significantly larger and extends the area of inundation by up to approximately 70m from the Base Case at certain locations. Although the differences in water depths at selected locations is not significant for Sensitivity Run 6, the gently sloping topography combined with the absence of a clearly defined channel for floodwater to be contained within means that the additional volume of water leads to an increased in the lateral spread of the floodwater.

3.0 Flood Model Review

2D hydrodynamic flood model using TUFLOW software to simulate the flow paths of flood water for the 1% AEP event were undertaken for both the 2018 Flood Study and 2019 GSM Mine Closure Technical Study. However comparison of the 1% AEP storm event across the creeks at both upstream and downstream of Wallaby Haul Road shown a substantial differences in maximum depth of water (**Figure 5** and **Figure 6**).

It is noticeable that the 2019 GSM Mine Closure Technical Study estimated a higher flood depth than the 2018 Flood Study.

Differences in maximum depth of water between the two hydraulic models are possible due to the following:

1. Both studies have different boundary conditions and hydraulic input parameters incorporated in the 2D domain. A lower Manning's value of 0.04 was adopted for the 2018 Flood Study compared to a value of 0.07 for the 2019 GSM Mine Closure Technical Study.
2. Inflow hydrographs into the 2D domain were located at the upstream end of the model extent and most of the stream flow were routed through the stream as storage (2018 Flood Study Model).
3. Hydraulic structures such as culvert crossings were incorporated in the 2D domain as analysed as a 1D analysis in the 2D domain (2018 Flood Study).
4. In the 2019 GSM Mine Closure Technical Study, rainfall was progressively added into the stream network over time and water depths were computed cumulatively based on the "Rain on Grid" modelling approach.

3.1 Risk Assessment of the Wind Turbine Location

The maximum flood depth and velocity for the 1% AEP 360 minutes duration storms extracted from the 2019 GSM Mine Closure Technical Study are presented in **Table 5** and shown on **Figure 7** and **Figure 8.**

Modelling results show minimal flood risk in the area of the proposed wind turbine towers.

Table 5 1%AEP Maximum Water Depths and Velocities

Wind Turbine WT No	Easting (mE MGA)	Northing (mN MGA)	Maximum Depth (mm)	Maximum Velocity (m/s)
WT-19-1	437,229	6,810,309	Zero	Zero
WT-19-2	437,341	6,810,864	Zero	Zero
WT-19-3	437,460	6,811,367	Zero	Zero
WT-19-4	437,593	6,811,923	0.04	Negligible
WT-19-5	437,712	6,812,492	Zero	Zero
WT-19-6	437,838	6,813,100	Zero	Zero
WT-19-7	437,957	6,813,649	0.34	Negligible

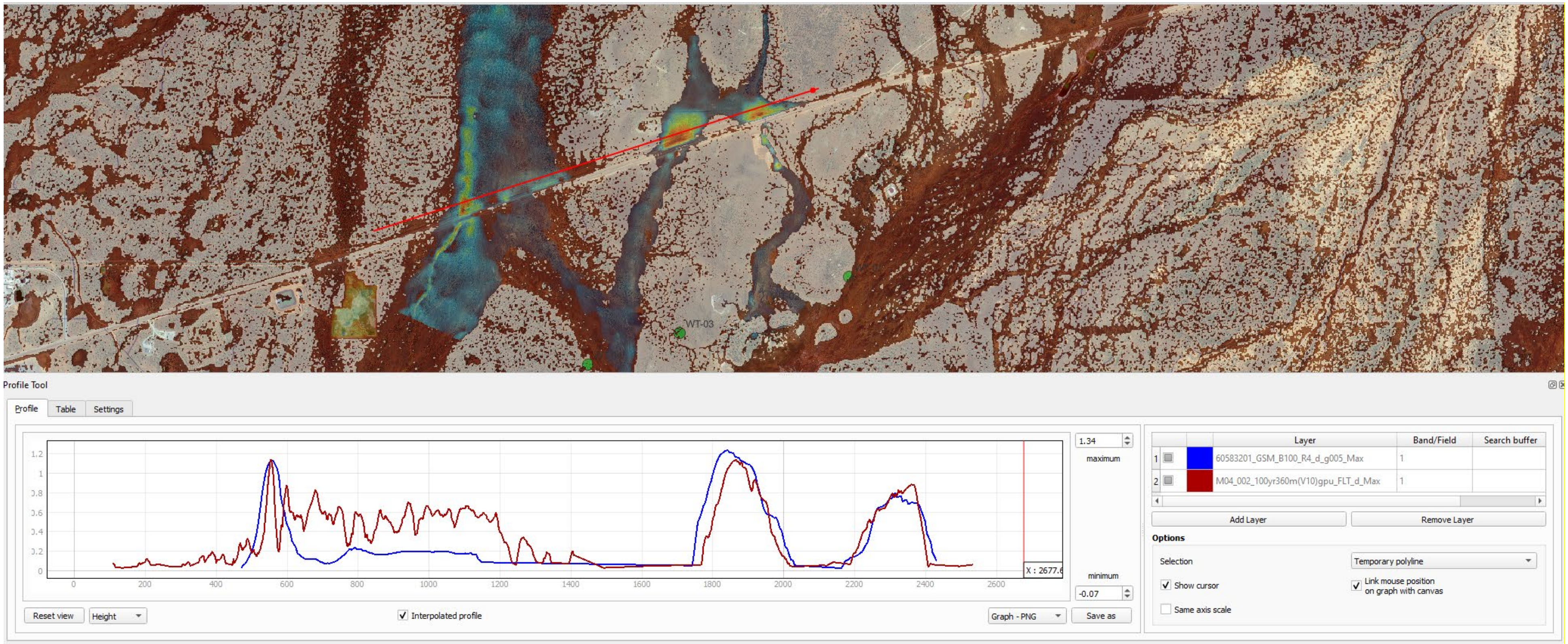


Figure 5 Comparison of 1%AEP Maximum Depth 2018 Flood Study and 2019 Flood Study (Upstream of the Haul Road)

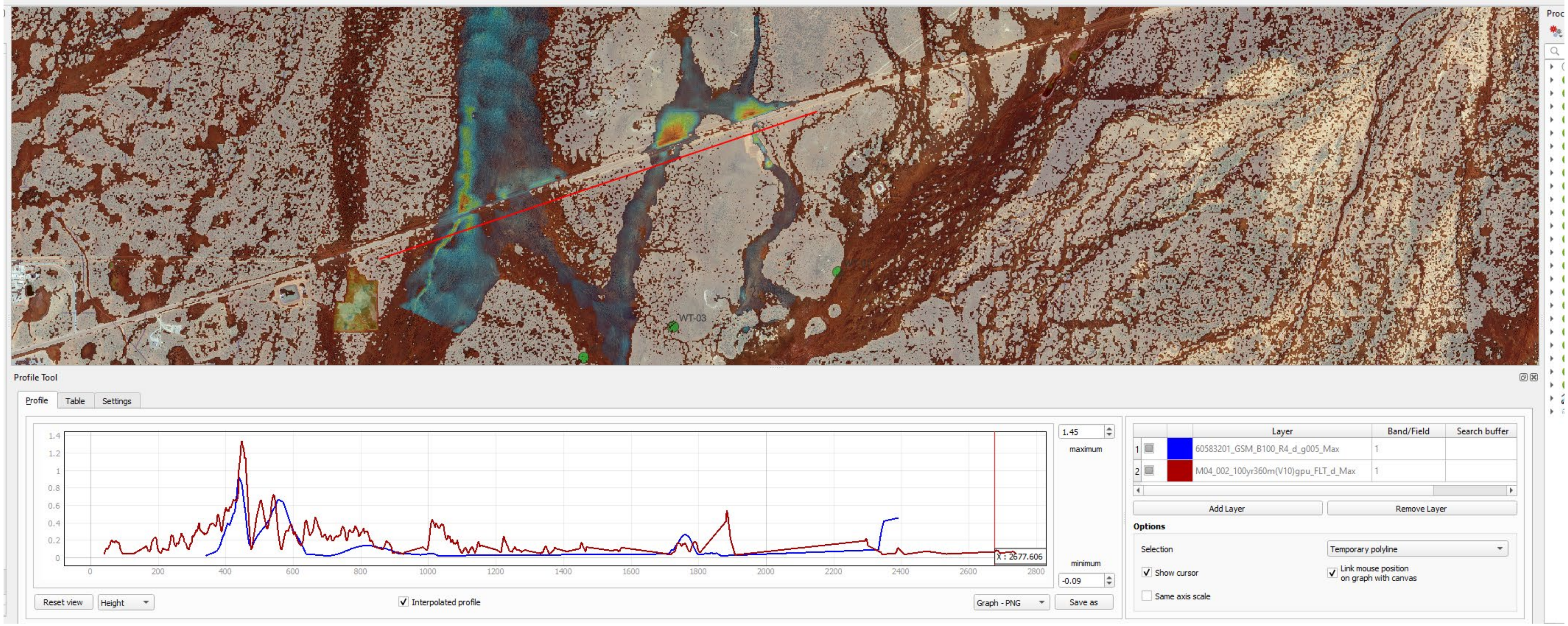
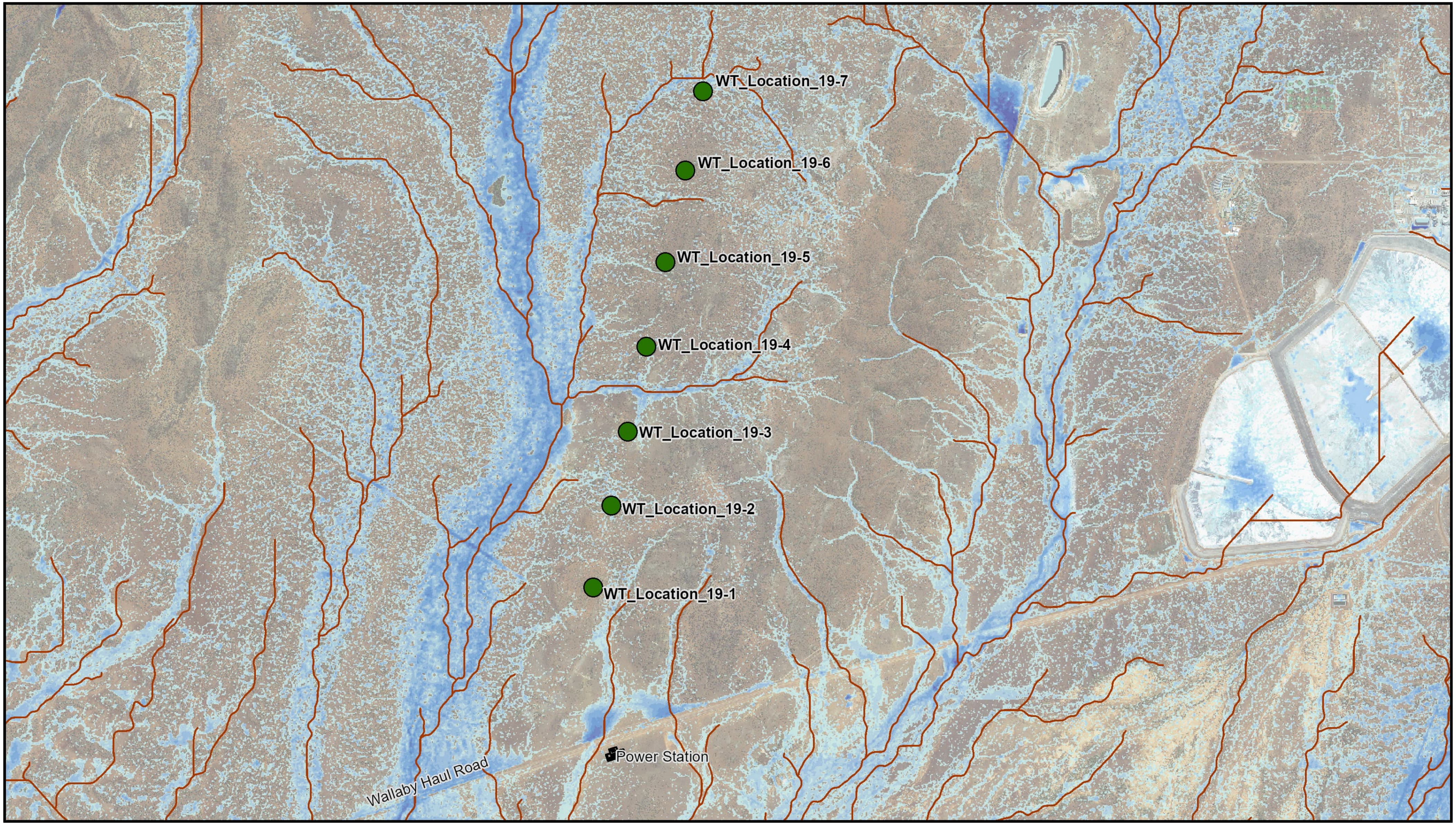


Figure 6 **Comparison of 1%AEP Maximum Depth 2018 Flood Study and 2019 Flood Study (Downstream of the Haul Road)**



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LEGEND
- Proposed Wind Turbine Location
- Stream line
- Power Station

Indicative Floodwater Depths (m)
- 0 - 0.16
- 0.16 - 0.31
- 0.31 - 0.50
- 0.50 - 0.73
- 0.73 - 1.05
- 1.05 - 1.52
- 1.52 - 2.34
- 2.34 - 4.47

1%AEP maximum depth profile along the proposed wind turbine site

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Figure
7

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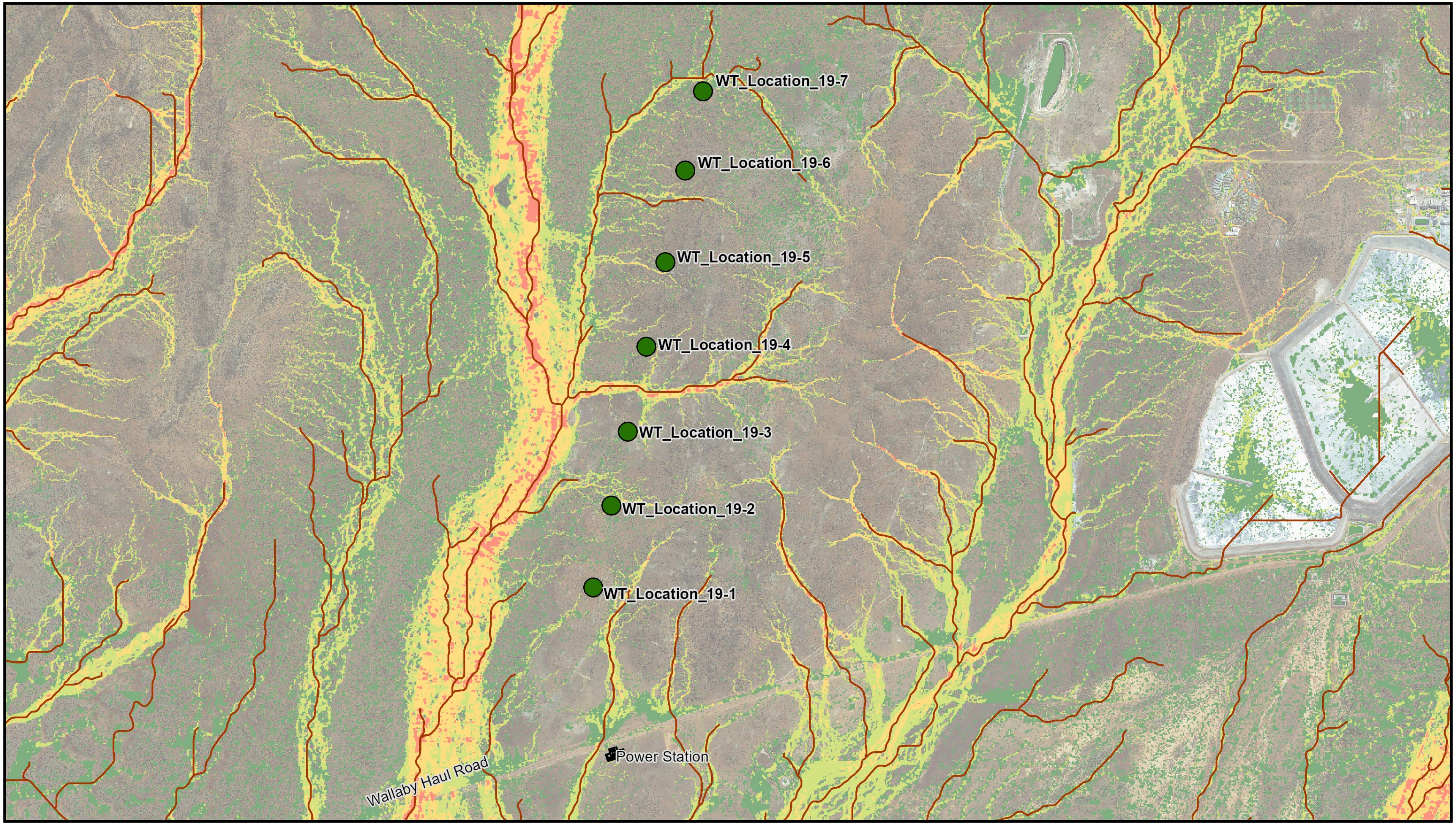

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Data sources:

Base Data: (c) Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate (2010).Geoscience Australia, Streetpro

LEGEND

- Proposed Wind Turbine Location
- Stream line
- Power Station

Indicative Floodwater Velocity (m/s)

- 0 - 0.14
- 0.14 - 0.32
- 0.32 - 0.57
- 0.57 - 2.55

1%AEP maximum velocity profile along the proposed wind turbine site

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GSM WIND TURBINE FLOOD STUDY

Figure
8

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3.2 Assumptions

A number of assumptions were employed in the development of the 2D hydraulic model and are highlighted in **Table 6** below.

Table 6 Hydraulic Model Assumptions

Assumptions
As no calibration and re-modelling of the hydrology and hydraulic models were undertaken, the model output and parameter input extracted from the 2019 GSM Mine Closure Technical Study remain current and unchanged for the purposes of preparing 1%AEP flood mapping.
As culverts beneath the Wallaby Haul Road were not modelled in the 2019 GSM Mine Closure Technical Study, the upstream water level would eventually build up and overtop the roadway. This would present no impact of flood risk to the proposed upgradient wind turbine tower locations.

3.3 Limitations

Limitations with the hydraulic modelling are highlighted in **Table 7** below.

Table 7 Hydraulic Model Limitations

Limitations
The 2018 Flood Study model extent does not cover the proposed wind turbine development area and the 1%AEP design flow at the proposed wind turbine sites were not assessed separately despite an increase in contributing catchment.
Over-estimation of back water build-up upstream of the existing culverts crossing Wallaby Haul Road as the hydraulic structures were not modelled in the 2019 GSM Mine Closure Technical Study.
There are disparities in the development of the DTM into 2D TUFLOW domain for both the 2018 Flood Study and 2019 GSM Mine Closure Technical Study. Comparison of the model output between the two different flood studies is difficult.
The accuracy of the flood water levels and areal extent, simulated by the model, is limited by DTM, grid size and the accuracy of the 0.5 m topographic contour dataset from which the 2018 DTM was generated, whereas the 2019 DTM was based on 1m LiDAR. Grid size for the 2019 DTM is 20mx20m compared to a 5mx5m grid size adopted for the 2018 DTM

4.0 Conclusions

The most southern proposed wind turbine tower site is located approximately 1km north of the existing Wallaby Haul Road and on a topographically high eastern ridgeline area. A number of ephemeral creeks either run through or are in proximity to the proposed wind turbine site. The key outcomes from the flood study are:

- Under current baseline conditions, no turbine locations are located within drainage lines.
- Flood Mapping extracted from 2019 GSM Mine Closure Technical Study results suggest that part of proposed wind turbine WT_Location_19-4 and WT_Location_19-7 are at risk of very minor flooding from the 1% AEP event.
- The maximum floodwater depths at WT_Location_19-7 would be approximately 0.34m.

5.0 References

AECOM (2018). SGM Flood Study. Prepared for Aggreko Generation Pty Ltd

AECOM (2019). GSM Mine Closure Technical Studies-Surface Water Drainage Plan_Phase 2. Prepared for GSM Mining Company Pty Ltd. 60557760_ENV_RPT_002

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Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2016, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia

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Engineers Australia (2001) Australian Rainfall and Runoff: A Guide to Flood Estimation; Produced by the Institute of Engineers Australia

URS (2015). Granny Smith Mine - Gas Power Station Flood Study, prepared for Granny Smith Mining Company Pty Ltd.

Appendix A

Hydrologic Parameters

Appendix A Hydrologic Parameters

Intensity Frequency Duration (IFD) for GSM Site (mm/hr) from 2015 Study

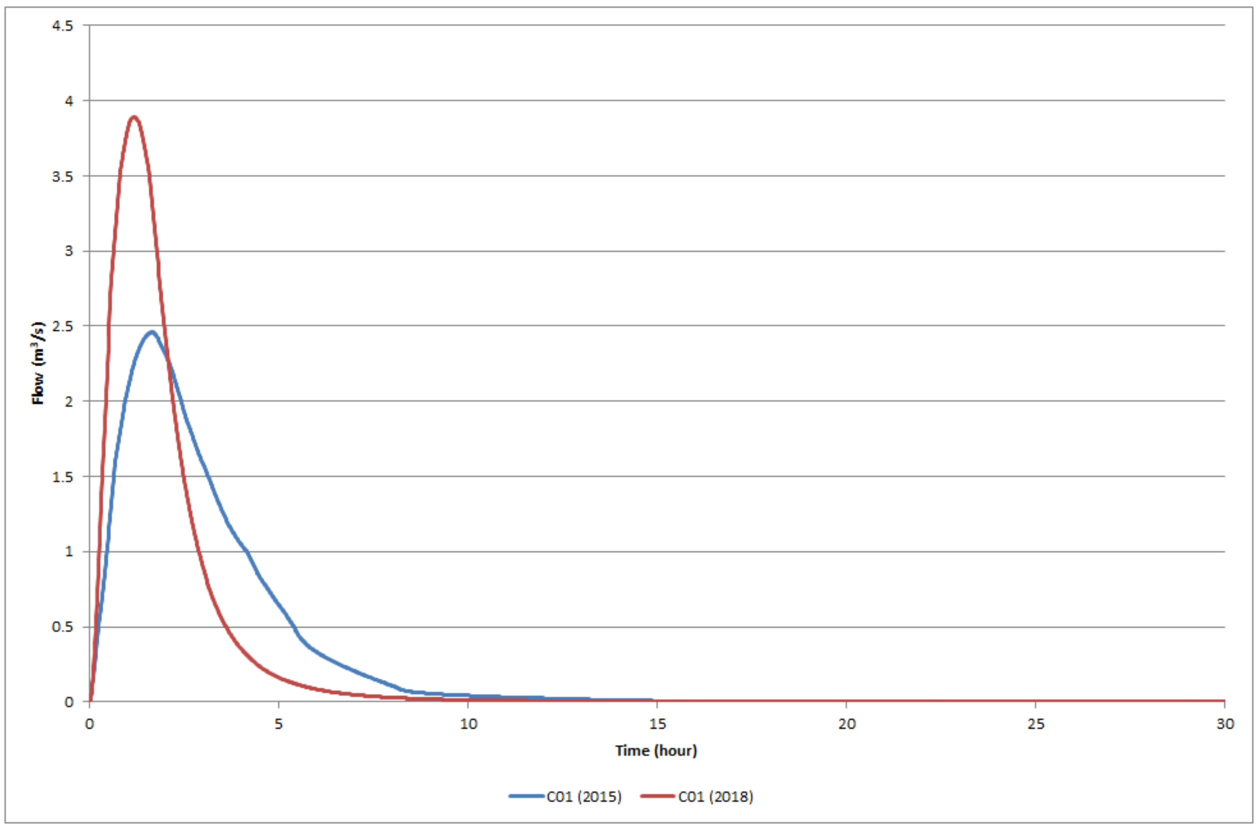
Duration (hours)	1987 IFD	2016 IFD
1	43.9	53.9
2	28.8	33.1
3	22.5	24.7
6	14.8	15.1
12	9.55	9.25
24	5.85	5.71

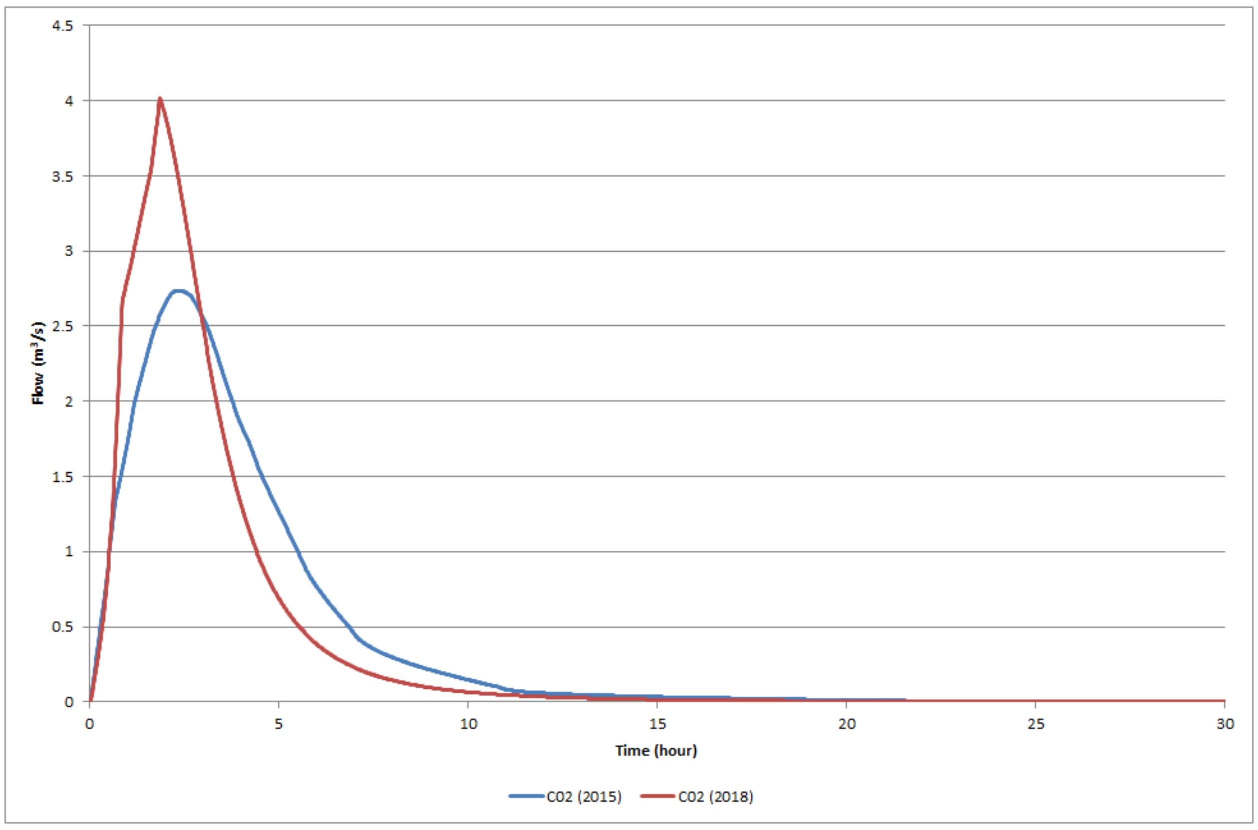
Appendix B

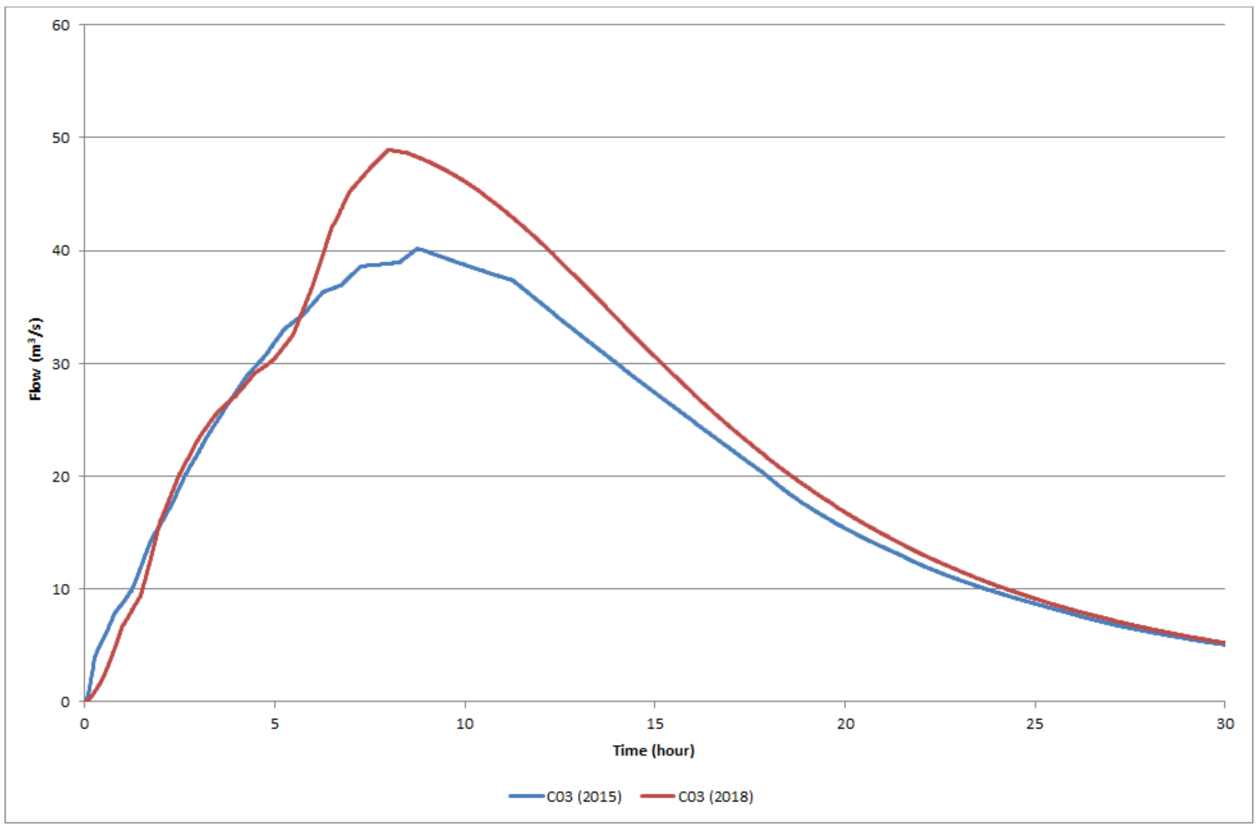
Hydrographs

Appendix B Hydrographs

Hydrographs from the 2015 Hydrological Assessment and the 2018 Update (to reflect AR&R 2016)







Appendix C

Sensitivity Testing

Appendix C Sensitivity Testing

Sensitivity Testing Results – Depths and Difference to Base Case at Selected Locations

	Base Case	Blockage 50%		Blockage 100%		Mannings +20%		Mannings -20%		AR&R 2016		AR&R 2016 + 15% Base Factor (Climate Change)	
Location	Depth (m)	Depth (m)	Difference (m)	Depth (m)	Difference (m)	Depth (m)	Difference (m)	Depth (m)	Difference (m)	Depth (m)	Difference (m)	Depth (m)	Difference (m)
P1	0.06	0.08	0.02	0.11	0.05	0.07	0.01	0.05	-0.01	0.08	0.01	0.16	0.10
P2	0.12	0.14	0.02	0.17	0.05	0.13	0.01	0.11	-0.01	0.13	0.02	0.22	0.10
P3	0.06	0.08	0.01	0.10	0.03	0.07	0.01	0.06	-0.01	0.07	0.01	0.13	0.06
P4	0.06	0.07	0.01	0.09	0.03	0.07	0.01	0.05	-0.01	0.07	0.01	0.12	0.06
P5	0.07	0.09	0.01	0.11	0.04	0.08	0.01	0.06	-0.01	0.08	0.01	0.15	0.08
P6	0.05	0.06	0.01	0.08	0.03	0.05	0.00	0.04	0.00	0.06	0.01	0.10	0.05
P7	0.10	0.11	0.01	0.13	0.03	0.12	0.01	0.09	-0.01	0.11	0.01	0.16	0.06
P8	0.05	0.07	0.02	0.09	0.04	0.06	0.01	0.04	-0.01	0.06	0.01	0.12	0.07
P9	0.05	0.07	0.02	0.09	0.04	0.06	0.01	0.04	-0.01	0.06	0.01	0.13	0.08
P10	0.04	0.06	0.02	0.08	0.04	0.05	0.01	0.04	-0.01	0.06	0.01	0.12	0.07
P11	0.04	0.06	0.01	0.08	0.03	0.05	0.01	0.04	-0.01	0.05	0.01	0.11	0.06
P12	0.03	0.04	0.01	0.06	0.03	0.04	0.00	0.03	0.00	0.04	0.01	0.09	0.05
P13	0.03	0.04	0.01	0.06	0.03	0.04	0.00	0.03	0.00	0.04	0.01	0.09	0.06
P14	0.05	0.06	0.01	0.08	0.04	0.05	0.01	0.04	-0.01	0.06	0.01	0.11	0.07
P15	0.04	0.05	0.01	0.08	0.04	0.05	0.01	0.03	-0.01	0.05	0.01	0.11	0.07
P16	0.04	0.05	0.01	0.07	0.03	0.04	0.01	0.03	-0.01	0.05	0.01	0.10	0.07
P17	0.04	0.05	0.01	0.08	0.04	0.05	0.01	0.03	-0.01	0.05	0.01	0.11	0.07
P18	0.11	0.11	0.00	0.12	0.02	0.12	0.01	0.09	-0.01	0.12	0.01	0.15	0.04
P19	0.10	0.10	0.00	0.11	0.01	0.11	0.02	0.08	-0.02	0.11	0.02	0.14	0.05
P20	0.05	0.05	0.00	0.05	0.00	0.06	0.01	0.03	-0.01	0.06	0.02	0.09	0.04

Sensitivity Testing Results – Velocity and Difference to Base Case at Selected Locations

	Base Case	Blockage 50%		Blockage 100%		Mannings +20%		Mannings -20%		AR&R 2016		AR&R 2016 + 15% Base Factor (Climate Change)	
Location	Velocity (m/s)	Velocity (m/s)	Difference (m)	Velocity (m/s)	Difference (m)	Velocity (m/s)	Difference (m)	Velocity (m/s)	Difference (m)	Velocity (m/s)	Difference (m)	Velocity (m/s)	Difference (m)
P1	0.24	0.27	0.03	0.31	0.07	0.21	-0.03	0.28	0.04	0.26	0.02	0.36	0.13
P2	0.15	0.17	0.03	0.21	0.07	0.13	-0.02	0.17	0.02	0.17	0.02	0.27	0.12
P3	0.25	0.29	0.03	0.34	0.09	0.22	-0.03	0.30	0.04	0.28	0.03	0.40	0.15
P4	0.23	0.26	0.03	0.31	0.08	0.21	-0.03	0.27	0.04	0.26	0.03	0.37	0.14
P5	0.19	0.21	0.02	0.25	0.06	0.17	-0.02	0.23	0.03	0.21	0.02	0.29	0.10
P6	0.21	0.24	0.03	0.28	0.07	0.19	-0.02	0.25	0.04	0.23	0.02	0.34	0.12
P7	0.09	0.11	0.02	0.15	0.06	0.08	-0.01	0.10	0.01	0.11	0.01	0.18	0.09
P8	0.15	0.18	0.03	0.23	0.08	0.13	-0.01	0.16	0.02	0.17	0.03	0.30	0.15
P9	0.09	0.11	0.02	0.14	0.06	0.08	-0.01	0.09	0.01	0.10	0.02	0.19	0.10
P10	0.10	0.12	0.02	0.16	0.06	0.09	-0.01	0.11	0.01	0.12	0.02	0.21	0.11
P11	0.14	0.17	0.03	0.21	0.07	0.13	-0.01	0.16	0.02	0.16	0.02	0.26	0.12
P12	0.09	0.11	0.02	0.15	0.06	0.09	-0.01	0.10	0.01	0.11	0.02	0.20	0.11
P13	0.13	0.16	0.03	0.20	0.07	0.12	-0.01	0.15	0.00	0.15	0.02	0.27	0.14
P14	0.21	0.25	0.04	0.31	0.10	0.19	-0.02	0.24	0.03	0.24	0.03	0.38	0.17
P15	0.09	0.12	0.02	0.15	0.06	0.08	-0.01	0.10	0.01	0.11	0.02	0.20	0.11
P16	0.07	0.09	0.02	0.13	0.06	0.07	0.00	0.08	0.01	0.09	0.02	0.18	0.11
P17	0.08	0.10	0.02	0.14	0.06	0.07	0.00	0.08	0.01	0.10	0.02	0.19	0.12
P18	0.08	0.09	0.01	0.14	0.06	0.08	0.00	0.09	0.01	0.09	0.01	0.17	0.09
P19	0.07	0.06	-0.01	0.08	0.01	0.08	0.00	0.07	0.00	0.10	0.02	0.16	0.08
P20	0.10	0.10	0.00	0.10	0.00	0.10	0.00	0.09	0.00	0.12	0.03	0.17	0.07

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