FORTESCUE FUTURE INDUSTRIES

EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6)

Baseline Hydrology and Impact Assessment

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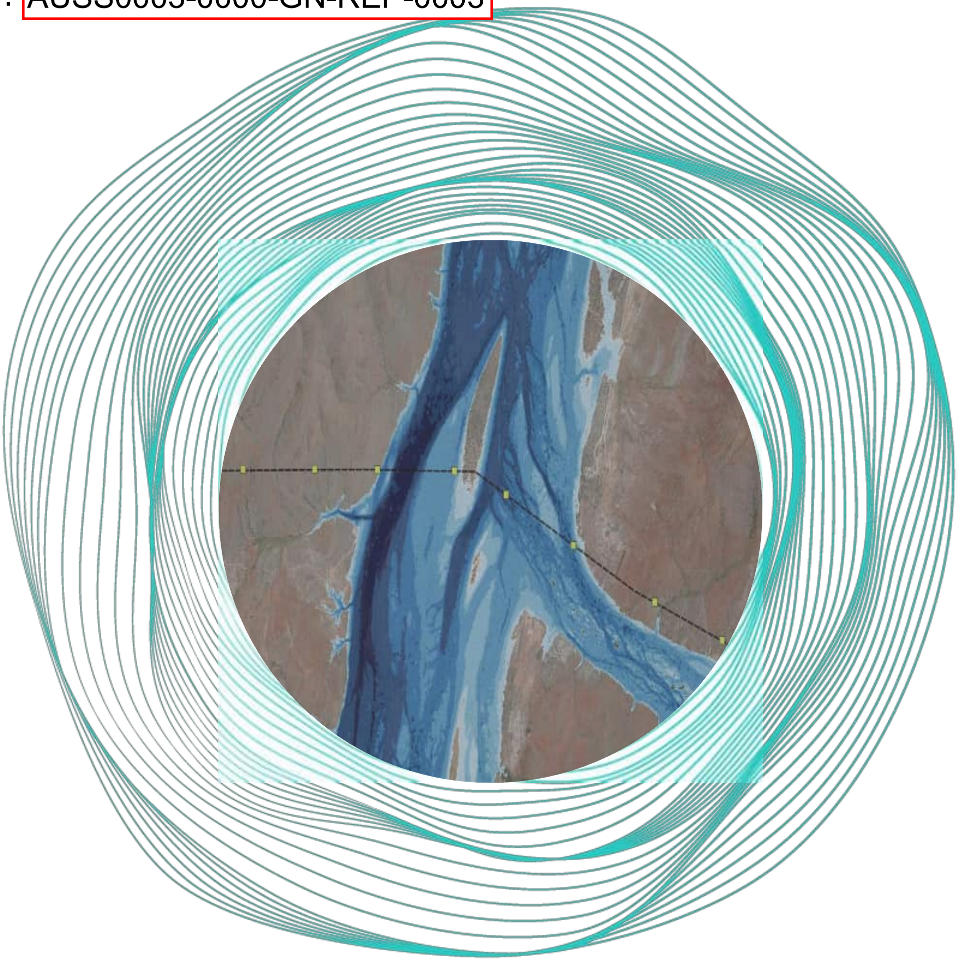

20/08/24

Level 14, 240 St Georges Terrace
Perth WA 6000
Australia

T: +61 8 9278 8111
Worley Services Pty Ltd
ABN 61 001 279 812

worley.com

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PROJECT 411012-01034 - HYD-REP-0001: EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) - Baseline Hydrology and Impact Assessment

Rev	Description	Originator	Reviewer	Worley Approver	Revision Date	Customer Approver	Approval Date
Rev 0	Issued for Use	M. Heyting	Digitally signed by Peter Crichton Date: 2024.08.20 22:01:38 +08'00' P. Crichton	M. Heyting	20 August 2024		

20/08/24

Level 14, 240 St Georges Terrace
Perth WA 6000
Australia

T: +61 8 9278 8111
Worley Services Pty Ltd
ABN 61 001 279 812

worley.com

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Executive Summary

Fortescue Energy is leading Fortescue’s decarbonisation and renewable export agendas by developing a portfolio of projects centred on the production of renewable energy, and other value adding green export products, primarily hydrogen and ammonia.

Fortescue Metals is seeking to achieve 100% decarbonisation of its operations by 2030. In achieving this, Pilbara Energy Connect (PEC), a wholly owned subsidiary of Fortescue, has been working on a series of power transmission projects, aimed at interlinking Fortescue’s operational energy demands.

One of the generation sites identified is the East Pilbara Generation Hub (EPGH). The hub sites were determined based on several factors including, existing studies, environmental approvals pathways, wind resource, and accessible land. Pilbara Transmission Project (PTP) Stage 6 is the 130 km 220 kv double circuit overhead transmission line that connects the EPGH to the Iron Bridge magnetite mining site. The transmission corridor follows east-west alignment crossing a few watercourses. The transmission line structure systems are designed to support a standard 400 m, up to 600 m maximum separation between towers.

This report presents the baseline hydrology study and the qualitative impact assessment conducted for the PTP Stage 6 corridor to support regulatory approval submissions and placement of structure systems. The report assessed the six waterway crossings in detail. These crossings were identified upon review of the transmission corridors as named water courses or crossings that were likely to have a flood extent greater than 400 m in the 1% AEP and require guidance for placing transmission line structure systems.

For the baseline hydrology study, regional flood estimates were completed to estimate flows at key waterway crossings. This included regional flood estimation techniques, as well as undertaking flood frequency analyses at gauging stations on the Shaw and Coongan Rivers. Hydrological modelling was completed using the modelling software RORB to estimate empirical losses for the catchments and to generate hydrographs for input into hydraulic models.

Hydraulic modelling was completed using the software TUFLOW. A range of magnitude events ranging from the 50% to the 1 in 500 AEP event were assessed. The 10%, 1% and 1 in 500 AEP event are presented in this report, with other events provided in GIS format supplementary to the report. A sensitivity analysis was completed for the project to capture the potential effects that climate change scenarios or changes in creek roughness have on the results.

A qualitative impact assessment was undertaken to review the proposed transmission line alignment. The impact assessment considered the potential impact of the transmission line structures (which are 2.15 m in diameter) on flood behaviour. The impacts associated with the structures are expected to be minor with the reduction in flow area small in comparison to the total available waterway area and floodplain width. The following impacts were identified in the assessment:

- **Minor increases in flood levels** – Due to the location of transmission structures within the 1% AEP floodplain, there is the potential for flood levels to increase as a result of the structures. The increases are expected to be localised and not result in the broader floodplain increasing.
- **Scour Potential** – The current locations of structures in general avoid or could be relocated to avoid the higher scour potential locations (high velocity areas). Where high scour potential sites cannot be avoided, scour protection can be included to mitigate the potential impact of scour on the structures themselves and the surrounding environment.
- **Alterations to flow paths -** The inclusion of transmission line structures has the potential to alter the natural flow of water, potentially leading to erosion or sediment deposition in new areas. In general, the structures are located outside of the thalweg and unlikely to impact regular flows. The location of Pad 207 within Glen Herring Creek and Pad 214 within the Coongan River intersect the low flow channels and have the potential to cause impacts on flow behavior in all events.
- **Vegetation Impact -** The clearing of vegetation required for the construction of the transmission line may have an impact at and around the pad locations. These areas represent a small portion of the creek and are not densely vegetated. It is also noted that the expected vegetation impact will be temporary, and any minor loss of vegetation is expected to be restored within a short period.
- **Water Quality -** There is not expected to be significant impact on water quality due to the construction of transmission line structures. Increased sediment loads may occur as a result of construction activities, but in the context of natural catchment sediment loads, this impact is expected to be near intangible and could be adequately managed through standard construction phase erosion and sediment control principles.

Acronyms and abbreviations

Acronym/Abbreviation	Definition
AEP	Annual Exceedance Probability
ARF	Aerial Reduction Factors
ARR	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
CL	Continuing Loss
DEM	Digital Elevation Model
DMIRS	Department of Mines, Industry Regulation and Safety
DPIRD	Department of Primary Industries and Regional Development
DWER	Department of Water and Environmental Regulation
EPGH	East Pilbara Generation Hub
FFA	Flood Frequency Analysis
FFI	Fortescue Future Industries
GDA94	Geocentric Datum of Australia 1994
GEV	Generalized Extreme Value
GIS	Geographic Information System
GSWA	Geological Survey of Western Australia
HQ	Water Level Head versus Flow (TUFLOW Boundary Condition)
IFD	Intensity Frequency Duration
IL	Initial Loss
IL_b	Burst Initial Loss
IL_s	Storm Initial Loss
IPCC	Intergovernmental Panel on Climate Change
Kc	Routing Lag Parameter
LiDAR	Light Detection and Ranging
LPIII	Log Pearson III
MGA	Map Grid of Australia
MSI	Multispectral Imager
PEC	Pilbara Energy Connect
PILF	Potentially Influential Low Flows
PFS	Pre-Feasibility study
PTP	Pilbara Transmission Project
RCP	Representative Concentration Pathways
RFFE	Regional Flood Frequency Estimation
RFFP	Regional Flood Frequency Procedure
RORB	Runoff Routing Burroughs (rainfall-runoff hydrologic modelling software)
SGS	Sub-Grid Sampling
TP	Temporal Pattern

1. Introduction

1.1 Background

Fortescue Energy is leading Fortescue's decarbonisation and renewable export agendas by developing a portfolio of projects centred on the production of renewable energy, and other value adding green export products, primarily hydrogen and ammonia.

Fortescue Metals is seeking to achieve 100% decarbonisation of its operations by 2030. In achieving this, Pilbara Energy Connect (PEC), a wholly owned subsidiary of Fortescue, has been working on a series of power transmission projects, aimed at interlinking Fortescue's operational energy demands.

The hub sites were determined based on several factors including existing studies, environmental approvals pathways, wind resource and accessible land. One of the generation sites identified is the East Pilbara Generation Hub (EPGH) (Figure 1-1). Advisian (now Worley Consulting) have previously completed a baseline hydrology study for the site, documented in *EPGH Baseline Hydrology Study* (311012-01491-EPGH-HYD-REP-001) (Advisian, 2022).

Pilbara Transmission Project (PTP) Stage 6 is the 130 km 220 kv double circuit overhead transmission line that connects the EPGH to the Iron Bridge magnetite mining site. The transmission corridor follows an east-west alignment, crossing significant watercourses of the Coongan and Shaw Rivers, as well as Camel and Glen Herring Creeks. The transmission line structure systems are designed to support a standard span width of 400 m up to a maximum of 600 m separation between towers. Due to this design constraint, it is important to understand the baseline hydrological conditions and potential impacts of the transmission line structure systems if they are located within the estimated flood extent.

This report presents the baseline hydrology study and impact assessment for the PTP Stage 6 corridor to support regulatory approval submissions and placement of structure systems.

1.2 Site Overview

EPGH is located north of the Christmas Creek mine site and is located in Corunna Downs, north of the Nullagine township. The development envelope has a total area of approximately 670 km². A Pre-Feasibility study (PFS) is currently being undertaken by Fortescue to develop two specific wind turbine groups (Group 3 and Group 4) within the EPGH site. The turbine groups, each with a target of 100 turbines, have been selected based on land access and power generation potential.

The PTP Stage 6 transmission line corridor will link EPGH to the Iron Bridge mine site, which is about 100 km west of the power generation area. The corridor will run from east to west and cross several creeks and rivers in the De Grey River Basin, including the Coongan and Shaw Rivers (Figure 1-1). This hydrology study assesses the baseline hydrologic and hydraulic setting and detail potential impacts of the transmission corridor on the hydrologic and hydraulic regime of rivers and other important watercourses which are crossed by the transmission corridor.

The PTP Stage 6 alignment and alternative alignments which deviate near the Coongan River intersection, were analysed in this study (Figure 1-1). The focus of this study is the 10%, 1% and 0.2% AEP flood events, which relates to the minimum design standard for access roads (10% AEP) and the standard design event for critical infrastructure including power generation and transmission lines (1% AEP). The 0.2% AEP is used as a sensitivity analysis for design exceedance events.

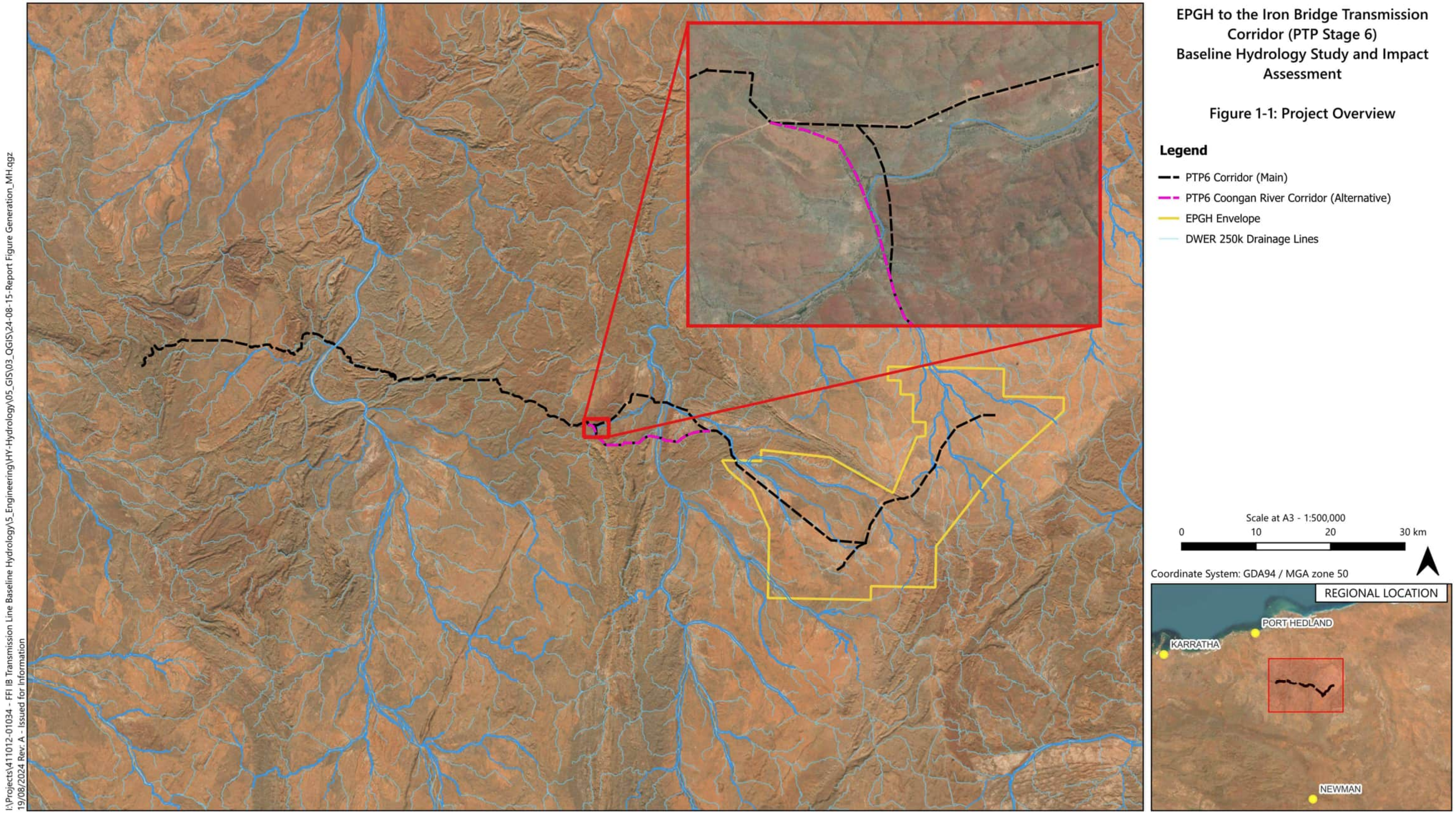


Figure 1-1: Project Overview

1.3 Scope of Work

The scope of work for this study is presented below:

1. Review existing publicly available and Fortescue generated hydrological data, surrounding environmental settings and potential sensitive receptors nearby that would inform the development of the hydrologic and hydraulic models and model boundaries.
2. Review and identify all watercourses of importance crossing the transmission line corridor.
3. Develop hydrologic models to determine the streamflow from design rainfall-runoff events for the identified watercourses that intersect the transmission corridor. The hydrological assessment shall include:
    a. Derivation of site-specific Intensity-Frequency-Duration/design rainfall considering spatial variation in rainfall and appropriate areal reduction factors (ARFs), in accordance with the guidelines provided in ARR2019. The assessment shall be undertaken for design rainfall events ranging from 50% to 1 in 500 annual exceedance probability (AEP).
    b. Catchment delineation, flood hydrograph generation and peak flow rate estimation to all required watercourses for the full range of AEPs. The assessment shall adopt appropriate empirical losses and determine the critical rainfall duration, temporal rainfall patterns and flood estimates at the identified watercourses.
    c. The assessment methodologies shall comprise of regional and rainfall-runoff routing methods/models including Flood Frequency Analysis (FFA), Regional Flood Frequency Procedure (RFFP), Regional Flood Frequency Estimation (RFFE), RORB and TUFLOW, determined to be appropriate for available dataset, the catchment area hydrology and the objectives of the study.
    d. Climate change assessment on hydrological data (rainfall depths/intensities) by evaluation of region-suitable selected scenarios, representative concentration pathways and global climate models for selected time horizons.
4. Undertake hydraulic modelling to assess the baseline flooding regime for the identified watercourses along the PTP Stage 6 corridor.
5. Undertake calibration/verification of the hydrologic and hydraulic models, or parameters thereof within the models, where data exists.
6. Conduct sensitivity analysis on key inputs or parameters within the models, including Manning's 'n' roughness and climate change influences, to assess and quantify changes to design flows and flood characteristic at 1% AEP.
7. Provide baseline flood inundation mapping for the 10%, 1% and 1 in 500 AEP design events. Flood inundation maps shall include at a minimum the maximum flood depth, velocity and flood hazard for the design events as identified above.
8. Undertake qualitative impact assessment of the PTP Stage 6 corridor on the identified crossing watercourses and provide recommendations against identified impacts.

2. Information and data

2.1 Fortescue Energy provided information

Table 2-1 present the information and datasets provided by Fortescue Energy for use on the project.

Table 2-1: Fortescue Energy provided information

Data / Information	Description	File / Format
Aerial Imagery and Topography		
Digital Elevation Model (DEM)	1 m photogrammetrically derived DEM captured in February 2022	PIL_ELEV_FMG_FFI_1M_DEM_FEB2022_trim.tif
	10 m photogrammetrically derived DEM - Landgate	Landgate_10m_mga50.tif
Imagery	High resolution aerial imagery	FFI_East_Pilbara_March_2021_15cm.ecw
GIS Layers		
Transmission Line Alignment	PTP Stage 6 transmission line alignment, including access roads, borrow grounds, laydowns, pad locations, turkeys nests and substations	PTP6Route_06062024.shp AccessRoads_05062024.shp BorrowGrounds_05062024.shp Laydowns_05062024.shp PTP6_Pads_05062024.shp TurkeyNests_05062024.shp Substations_05062024.shp
Alternative Transmission Line Alignment	Alternative alignment across Coongan River	Modified_PEC6_Section.shp
Disturbance footprints	total disturbance footprint, rehabilitation footprint and permanent disturbance footprint.	TotalDisturbanceFootprint_05062024.shp TotalRehabFootprint_05062024.shp TotalPermanentFootprint_05062024.shp
Other Items		
Hydrology Model	Coongan River RORB Model developed for EPGH Baseline Hydrology Study	RORB model files

Data / Information	Description	File / Format
Preliminary design information	V-Suspension Pole - General Arrangement	540PTC0032-5667-DR-EL-0013_0_IFC_02.pdf
	Strain Pole (10 to 75 Degrees) - General Arrangement	540PTC0032-5667-DR-EL-0017_0_IFC_02.pdf
	Standard design tower spacing – 400 m Maximum design tower spacing – 600 m	

2.2 Publicly available data

Hydrology datasets including stream gauging and rainfall data have been sourced from the Department of Water and Environmental Regulation (DWER), Bureau of Meteorology (BoM) and ARR2019 datahub. Geological and soil maps have been extracted form DataWA using the Department of Mines, Industry Regulation and Safety (DMIRS), and Department of Primary Industries and Regional Development, Western Australia (DPIRD) datasets. A 5 m DEM was extracted from the Geoscience Australia National DEM database to confirm the rating curve at North Pole Mine. These datasets are described in later sections.

3. Waterway crossings of interest

Table 3-1 presents the waterway crossings that Worley identified as watercourses of importance requiring further investigation. These sites were selected based on expected flood extents estimated through interrogation of aerial imagery, topographic information, and regional catchment details. The flood extents at these crossings are expected to be larger than 400 m, the standard nominated span for transmission line support systems. In total, six sites were identified and assessed in this report. The crossing locations are presented in Figure 3-1.

Table 3-1: Waterway crossings of interest

Creek Name	Alignment
Camel Creek	PTP Stage 6
Coongan River	PTP Stage 6
Glen Herring Creek	PTP Stage 6
Shaw River	PTP Stage 6
Coongan River	PTP Stage 6 – Alternative Alignment
Glen Herring Creek	PTP Stage 6 – Alternative Alignment

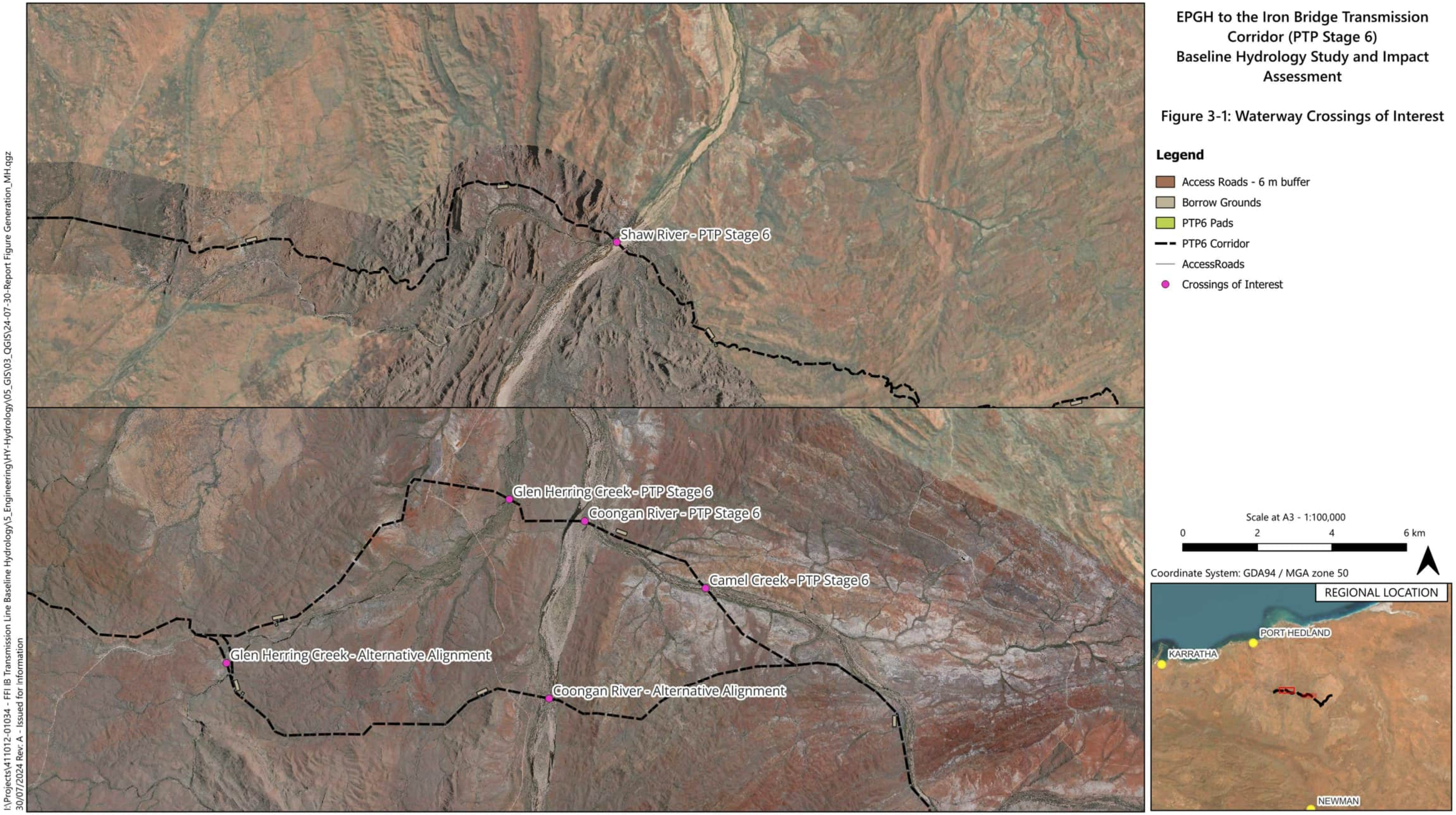


Figure 3-1: Waterway crossings of interest

4. Catchment characterisation

For the waterway crossings identified in Section 3, analysis was completed to hydrologically characterise each catchment. This included catchment delineation and analysis, climate assessment, and review of the geological setting and soils information.

4.1 Catchment characteristics

The catchment details of the waterway crossings of interest are presented in Table 4-1. Catchment delineation and mainstreams for these catchments are presented in Figure 4-1. The details will be used in peak flow estimates as documented in Section 5.

The Coongan River and Shaw River are ephemeral and flow in a northerly direction before discharging into the De Grey River. The total catchment area of the Coongan River is 6,994 km² and the area upstream of the transmission corridor represents approximately 47% of the total catchment. The total catchment area of the Shaw River is approximately 7,900 km², of which approximately 77% of the catchment is located upstream of the transmission line.

Table 4-1: Catchment Details of watercourse crossings

Catchment Name	Area (km²)	Mainstream Length (km)	Centroid Latitude (°S)	Centroid Longitude (°E)	EA Slope (m/km)	Shape Factor (L²/A)
Coongan River at PTP Stage 6	3,264	108	-21.66	119.82	3.83	3.57
Coongan River at Alternative Alignment	2,690	103	-21.71	119.80	3.83	3.94
Camel Creek at PTP Stage 6	537.2	60.5	-21.42	119.92	6.64	7.07
Glen Herring Creek at PTP Stage 6	187.0	35.0	-21.38	119.63	4.98	6.55
Glen Herring Creek at Alternative Alignment	130.0	25.6	-21.41	119.62	5.44	5.04
Shaw River at PTP Stage 6	6,070	148	-21.79	119.39	2.51	3.61

The Coongan and Shaw Rivers are gauged catchments. A flood frequency analysis was completed to provide estimates for design flows. This assessment is completed in Section 5.2.

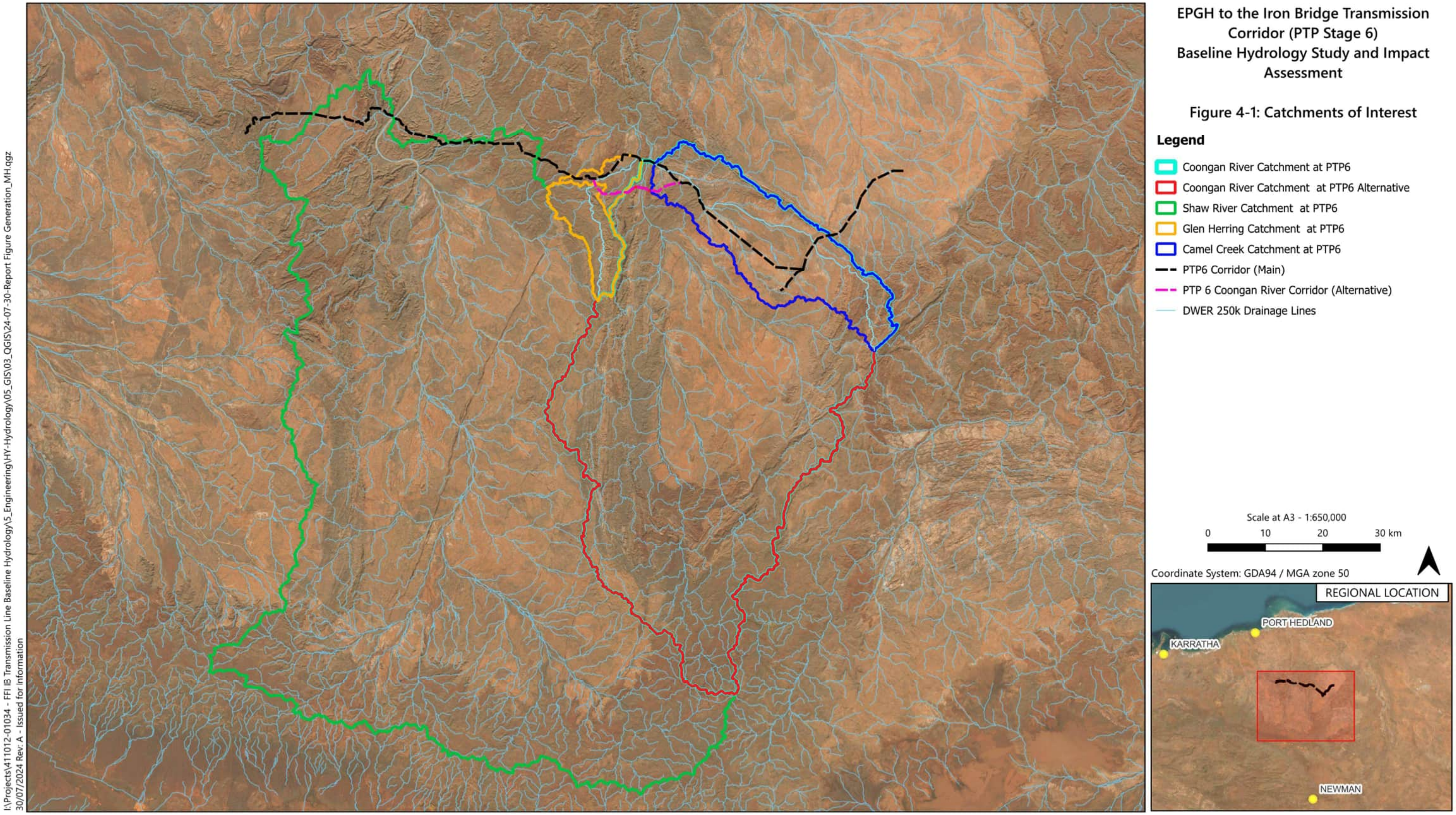


Figure 4-1: Catchments of interest

4.2 Climate

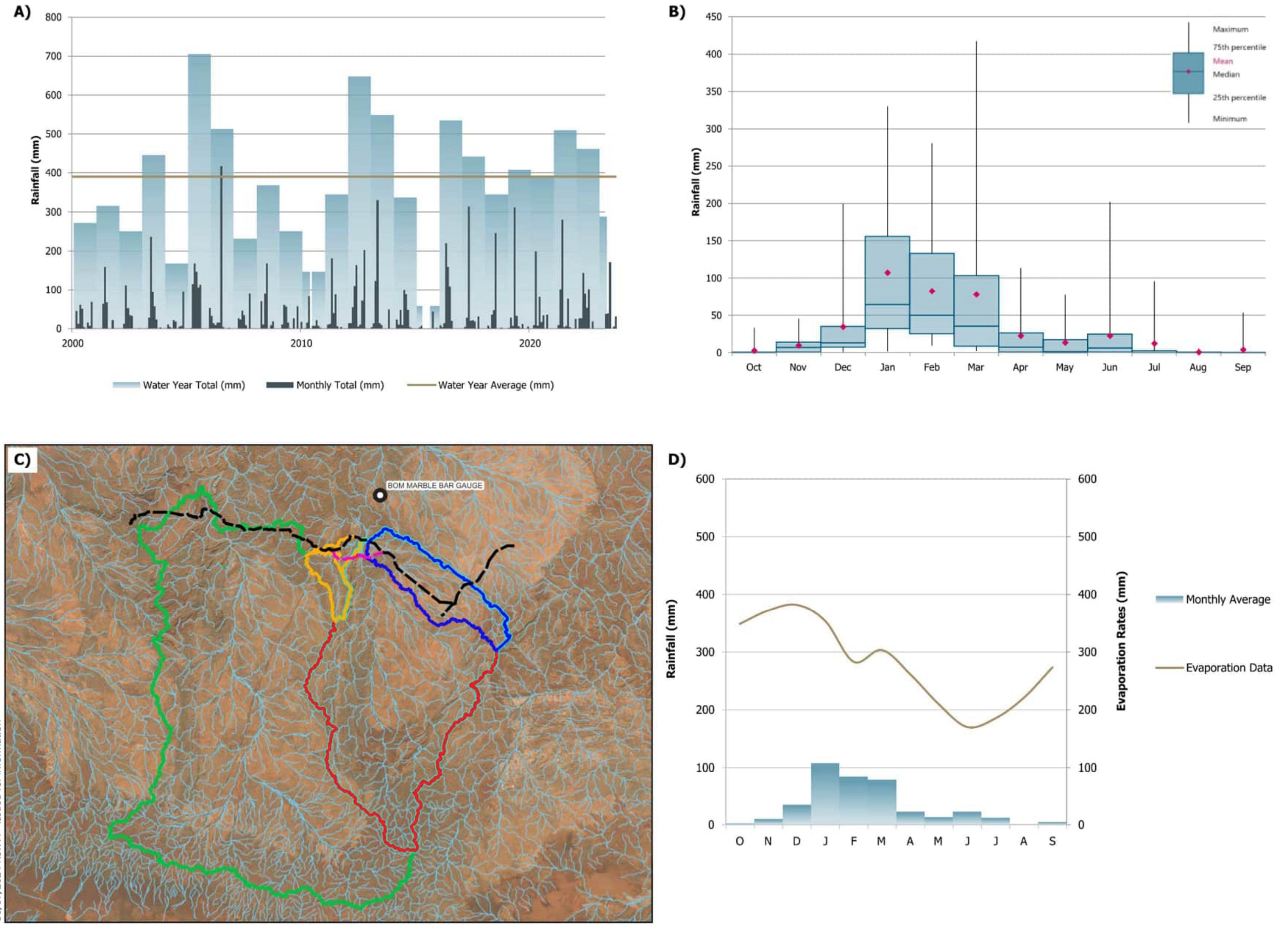
The Pilbara climate is characterised by very hot summers, mild winters and low and variable rainfall (Sudmeyer, 2016). The BoM Koppen climate classification system (Stern et al., 2000) defines the Study Area as a hot desert area with winter drought. Rainfall therefore occurs predominantly in the summer wet season (approximately January to March) from passing ex-tropical cyclones and low-pressure systems. Localised isolated convective thunderstorm activity is also common. Owing to these mechanisms, rainfall is highly variable and extended periods of low rainfall are common.

Point data has been obtained from the Scientific Information for Landowners (SILO) database to enable long term review of rainfall and evaporation data. SILO is a database of Australian climate data from 1889 to the present. It provides daily meteorological datasets for a range of climate variables in ready-to-use formats suitable for biophysical modelling, research and climate applications. SILO datasets are constructed from observational records provided by the Bureau of Meteorology. SILO interpolates the raw data, which may contain missing values, to derive datasets which are both spatially and temporally complete.

The variability of rainfall is demonstrated in Figure 4-2 with mean monthly and annual rainfall totals at Marble Bar (ID: 004020). The annual rainfall average (360.8 mm) is provided for the October to September water year. Mean monthly pan evaporation for Marble Bar (available from 1970 onwards) consistently exceeds mean monthly rainfall, signifying a water limited environment.

EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment

Figure 4-2: Climate Data



Legend

- Camel Creek Catchment at PTP6
- Coongan River Catchment at PTP6
- Coongan River Catchment at PTP6 Alternative
- Glen Herring Catchment at PTP6
- Shaw River Catchment at PTP6
- PTP6 Coongan River Corridor (Alternative)
- PTP6 Corridor (Main)
- DWER 250k Drainage Lines
- BoM Marble Bar Gauge Location

Data Summary

A) Water year and monthly totals
B) Monthly rainfall data
C) Marble Bar rainfall station location map
D) Monthly rainfall vs evaporation data

Scale at A3 - 1:1,300,000

0 20 40 60 km

Coordinate System: GDA94 / MGA zone 50

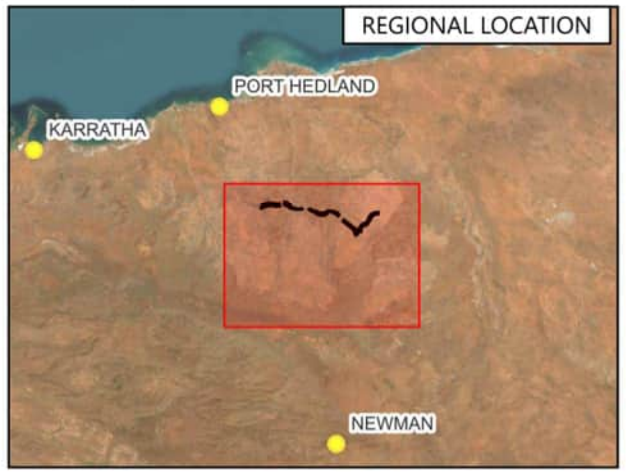


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Figure 4-2: Climate Data

4.3 Catchment soils

Expected soils within the Study Area are variable, with stony soils dominating the headwater areas of both the Shaw and Coongan catchments. Large sections of both catchments are dominated by Red deep sandy duplexes and red shallow sand. The mainstreams of both the Coongan and the Shaw Rivers are dominated by red deep sands, which can be seen at the North Pole Mine Gauging station (Figure 4-3). The DPIRD key soil landscapes of the Study Area are presented in Figure 4-4 (DPIRD, 2019).

The catchment soils mapping indicates that there is likely to be higher runoff potential in the headwater areas where the catchment is dominated by stony soils. High transmission losses are expected in the mainstreams where both river systems are dominated by sands and mainstream longitudinal gradients are low.

Figure 4-3: Shaw River at the North Pole Mine streamflow gauge.

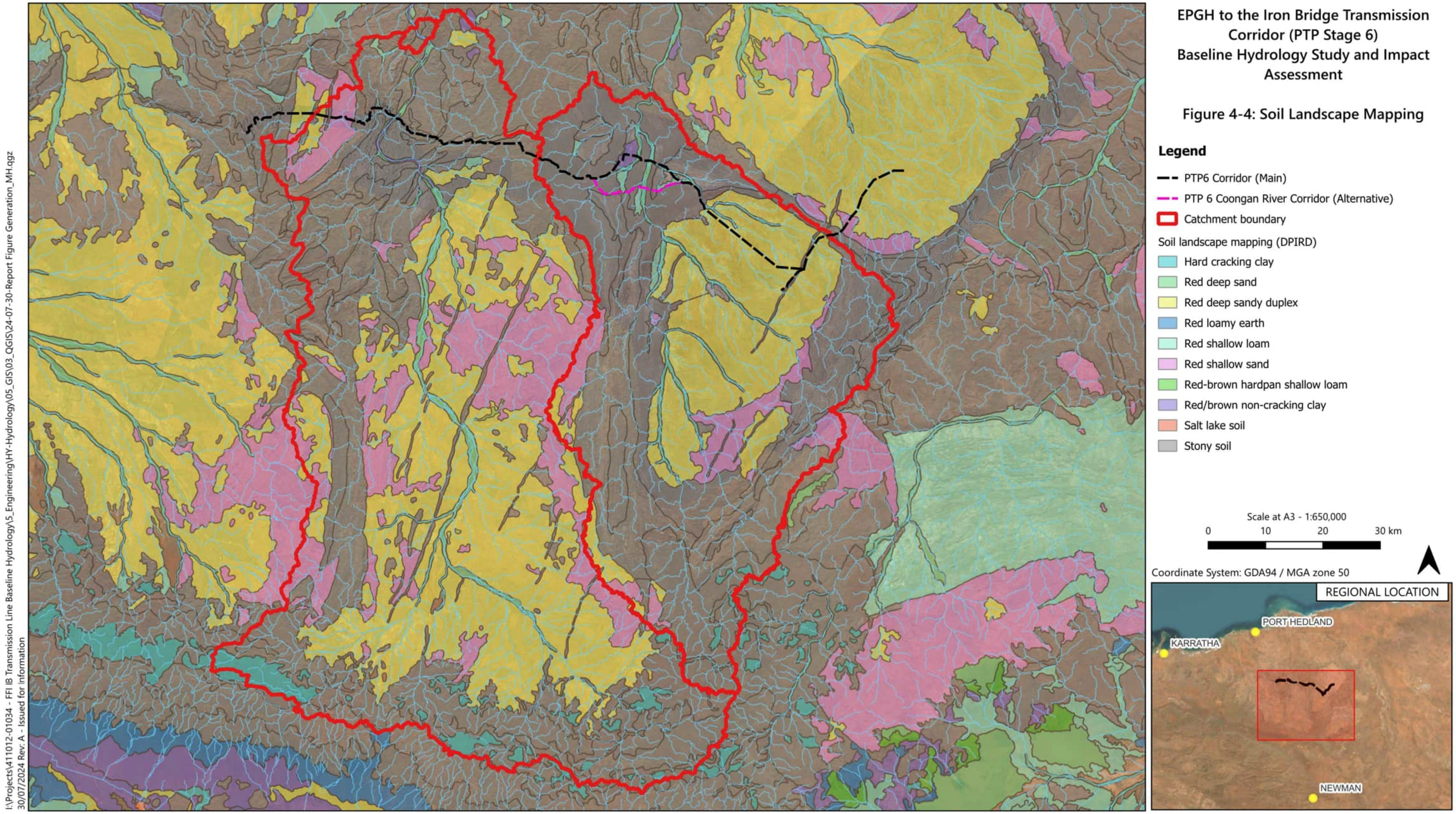

Figure 4-4: Soil Landscape Mapping

5. Regional rainfall runoff characterisation

5.1 Background

To aid in developing appropriate design event discharges at the transmission line crossings, a detailed hydrological investigation was completed for the catchments of interest. This involved undertaking FFA of streamflow data for the Shaw River and Coongan River catchments and using the results to reconcile empirical loss model parameters for hydrologic models developed of the same catchments.

5.2 Flood Frequency Analysis

Long term historic streamflow records from the Coongan River and the Shaw River catchments were available to aid in characterisation of the respective catchment's response to rainfall. This section presents the review of historic streamflow data, rating curves and the FFA completed.

5.2.1 Historic streamflow data

DWER streamflow gauge data is available for the Coongan River at Marble Bar (ID: 710204) and for the Shaw River at the North Pole Mine (ID: 710229). Details of the gauges are presented in Table 5-1 and the locations and associated catchments presented in Figure 5-1.

The FFA was undertaken from the gauged data using the TUFLOW FLIKE FFA software using Annual Maxima (AM) data for respective water years (October to September). The gauges have daily maximum discharge recordings available which were used to derive the water year AM for use in the FFA. The water year AM for Marble Bar is presented in Figure 5-2 and for North Pole Mine in Figure 5-3.

Table 5-1: Gauged catchment characteristics

DWER Stream Gauge	Catchment Area (from DWER) (km²)	Start Date	End Date	Water Years
Coongan River – Marble Bar (710204)	3,736	11/12/1966	-	57
Shaw River – North Pole Mine (710229)	6,479	16/02/1967	-	57

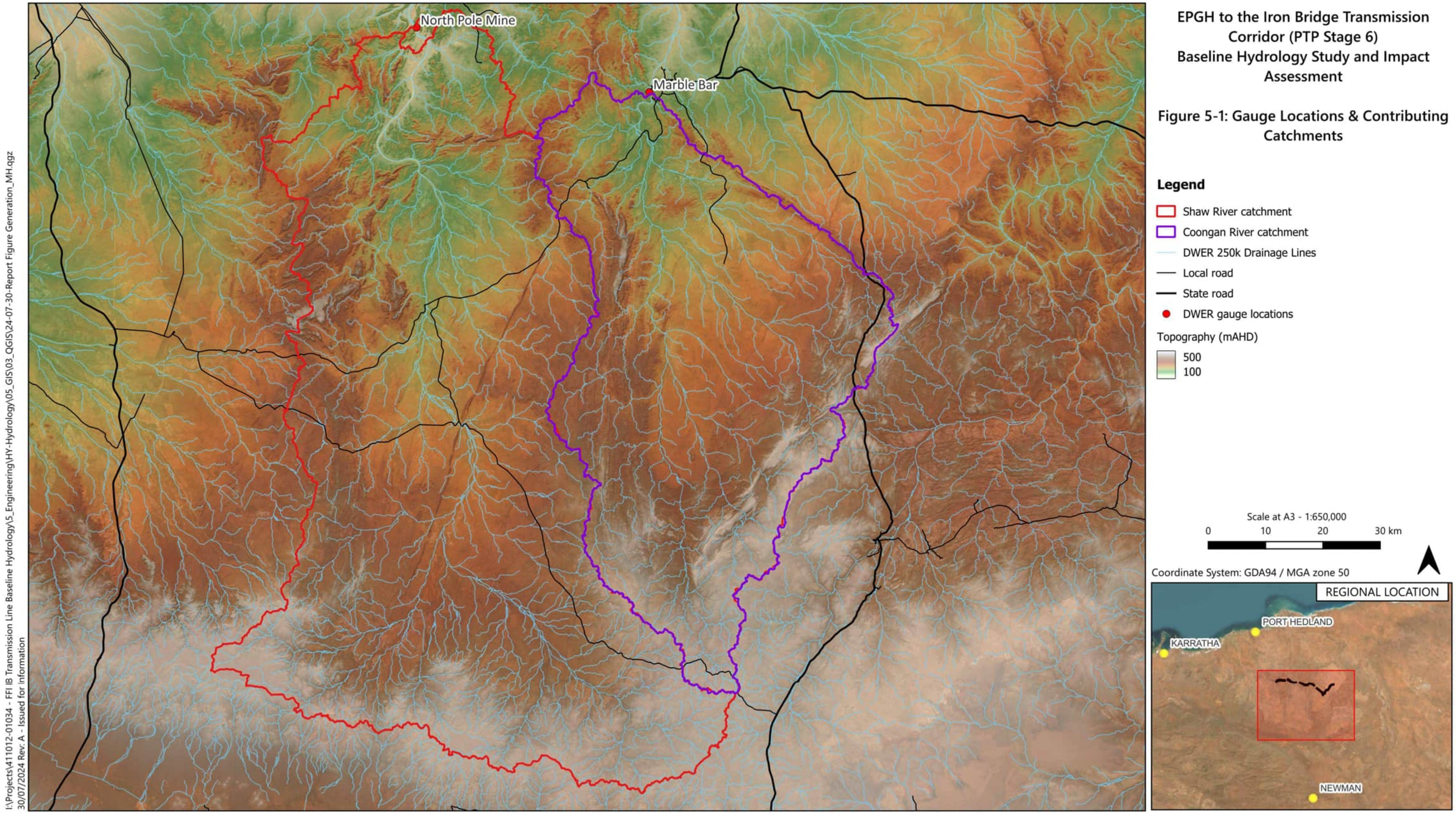

Figure 5-1: FFA Gauge Locations & Contributing Catchments

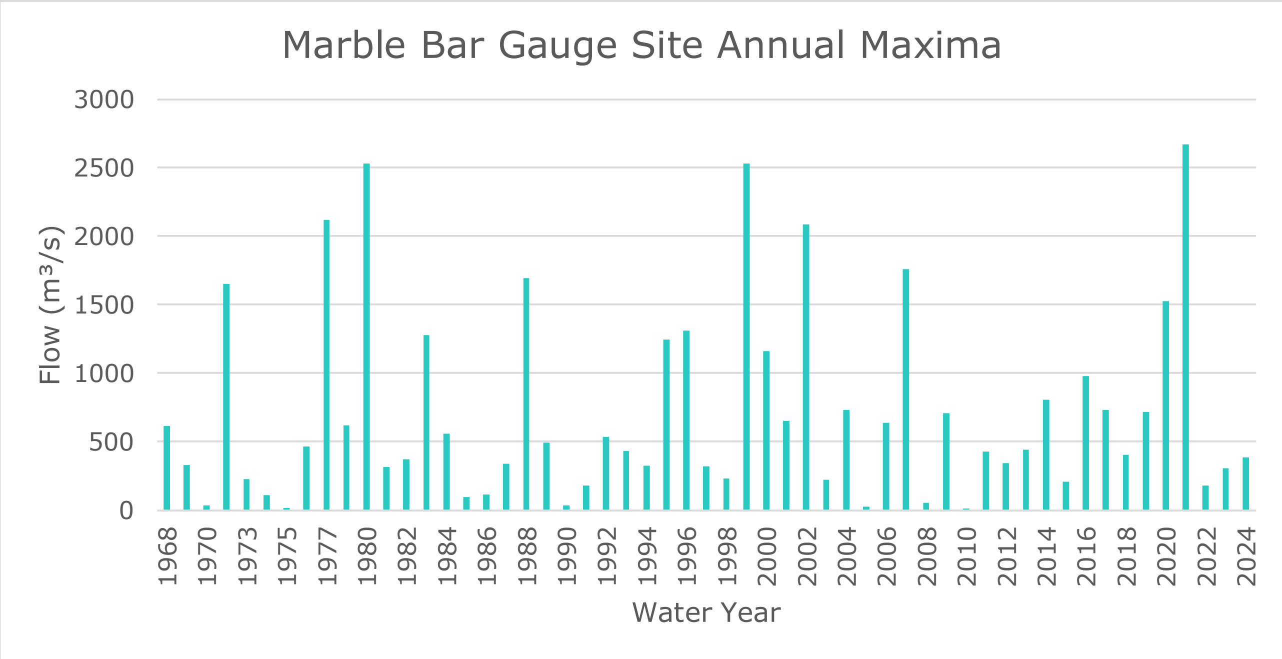

Figure 5-2: Marble Bar gauge site annual maxima

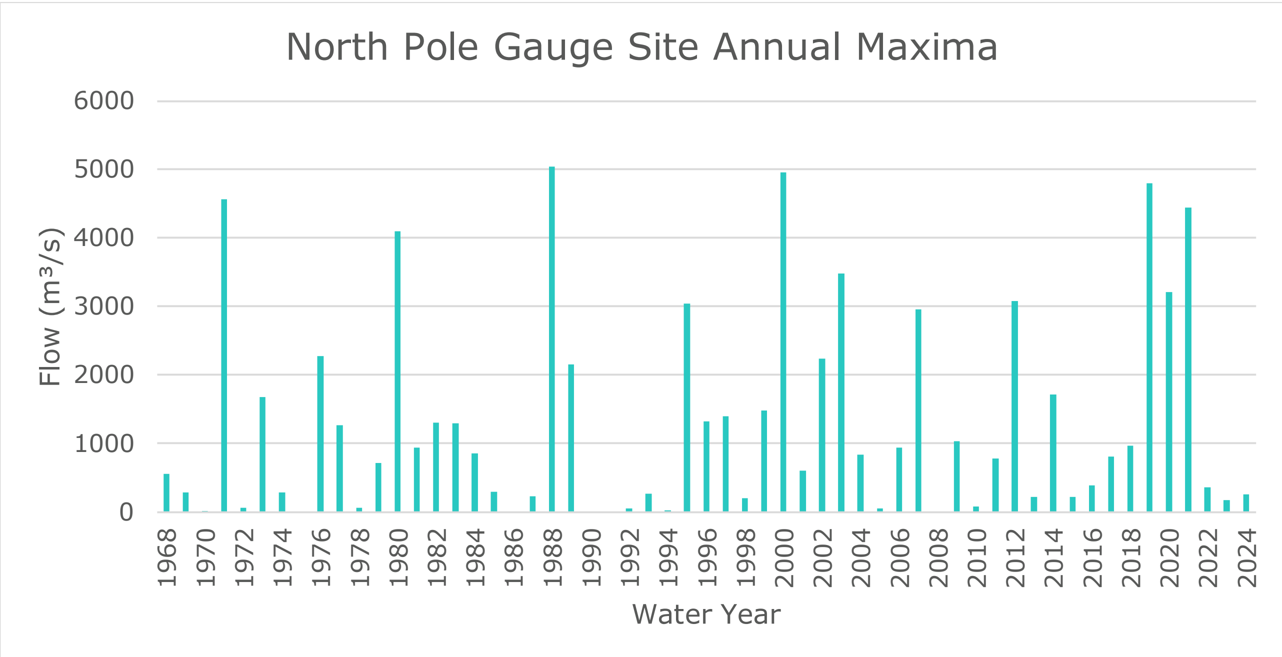

Figure 5-3: North Pole Mine gauge site annual maxima

5.2.2 Streamflow data review

The data associated with the gauged data was reviewed to determine the suitability of data for use in the FFA. The review included interrogation of rating curves, historical flows and sensitivity analysis to extreme events.

5.2.2.1 Rating curve review

5.2.2.1.1 Shaw River

A hydraulic model was set up using LiDAR-derived 5 m resolution DEM data available from DWER to confirm the rating curve adopted for the North Pole Mine gauging station. The modelling involved running a series of steady state flows through a TUFLOW model and extracting flood levels at the estimated gauge location for the given flow. A comparison of the rating curve derived from the TUFLOW compared to the DWER rating curve is presented in Figure 5-4. The review confirmed that based on the analysis completed that the Shaw River rating curve is suitable for use in the FFA.

Historical re-rating of the gauge rating curve did not show significant variation, with minor changes occurring at the flow rates less than 200 m^3/s as shown in Figure 5-5. Manual gaugings align well with the rating curve and demonstrates that historically this gauge data is accurate and suitable for use. The largest manual gauged flow was 3,066 m^3/s in 1971.

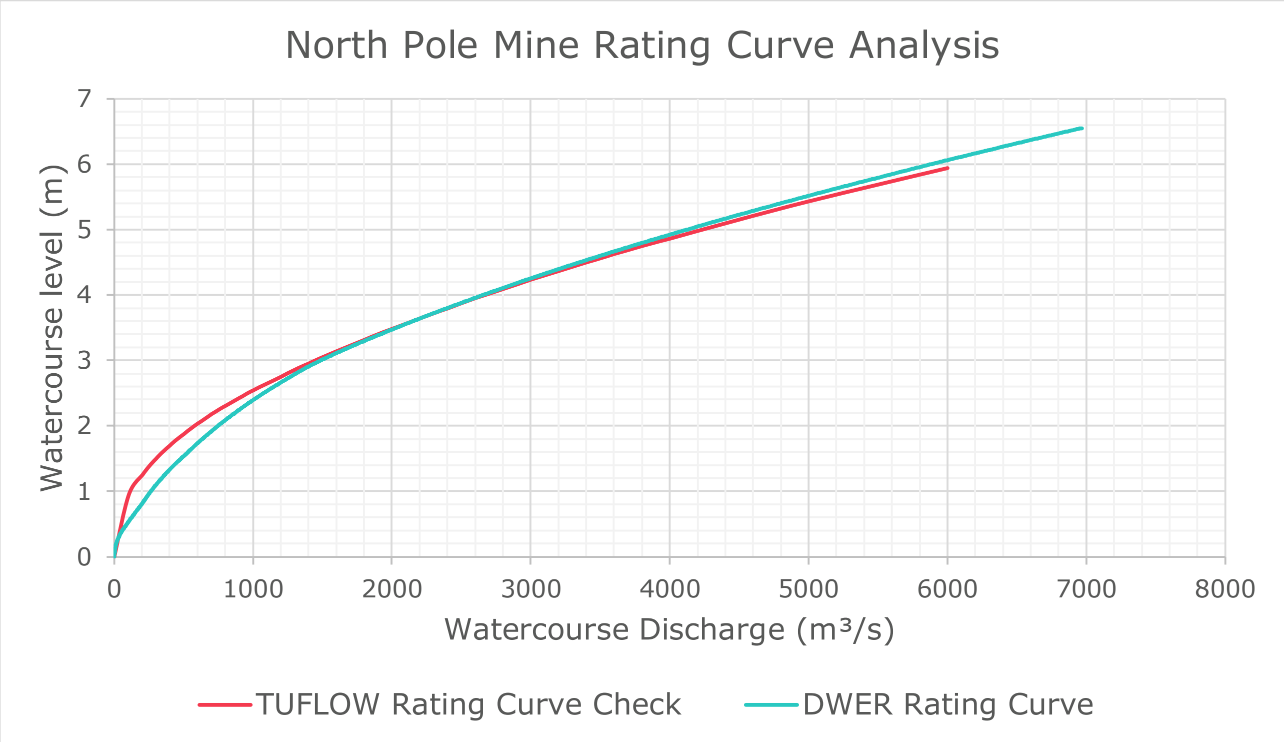

Figure 5-4: Comparison of the TUFLOW and DWER rating curves at the North Pole Mine gauge.

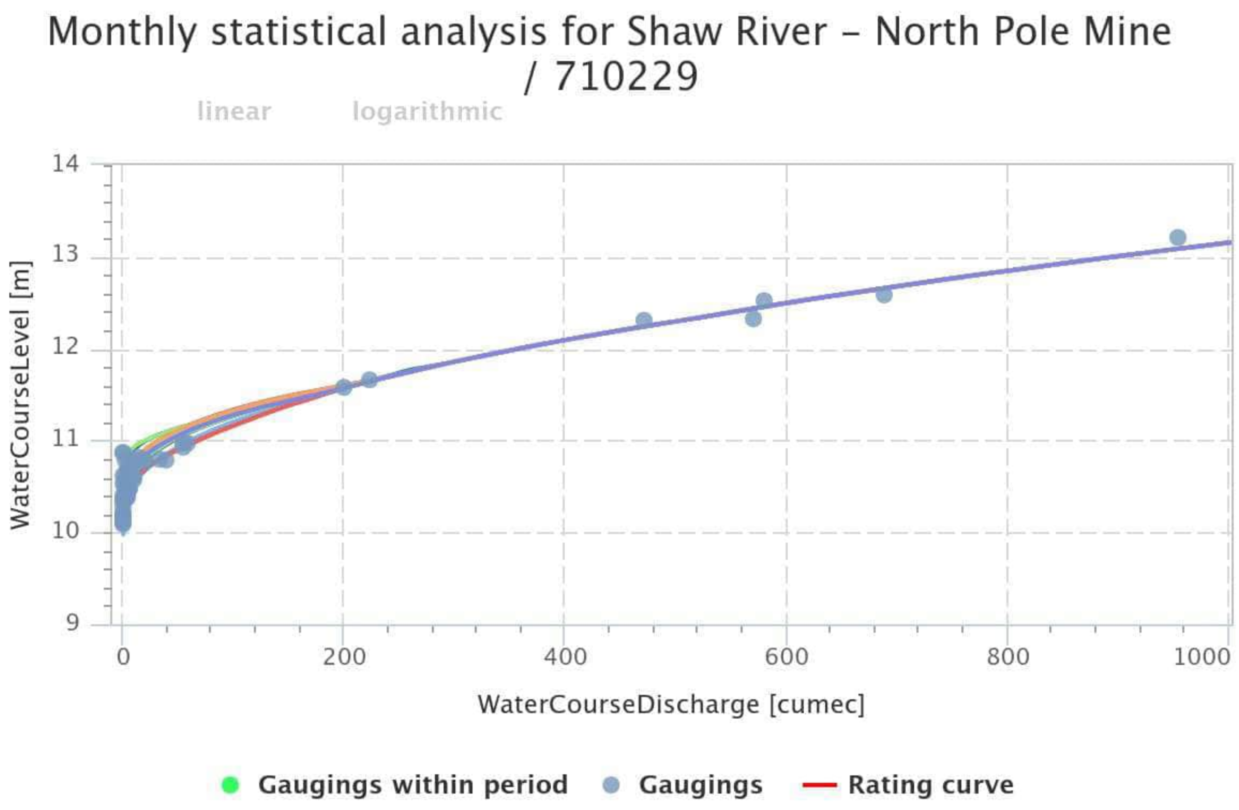

Figure 5-5: Historical gaugings and rating curves for the North Pole Mine Gauge (source: BoM)

5.2.2.1.2 Coongan River

The Coongan River rating curve was reviewed to determine the suitability of the data for use on the project. A review of the historical gaugings and rating curves identified that there is significant variation in the rating curves over the life of the gauging station. There are examples of the different gauge levels resulting in the same flow (derived from manual ratings at different times), this is particularly relevant to low flow events as presented in Figure 5-6. For flows greater than 1,000 m^3/s (which is the focus of this study) the historical rating curves vary significantly, which leads to uncertainty in the results.

The gauge site shows a mixture of alluvium and a stable rock base (including a potential a scour hole adjacent to the gauge) as presented in Figure 5-8. The evolution of the creek over time may contribute to the variation in CTF levels, ratings and rating curves. With the data available, it is not possible to confirm the validity/suitability of the data, particularly in large events (such as 2021 which extends beyond the limits of the rating curve). The largest manual gauged flow was 195 m^3/s in 1971.

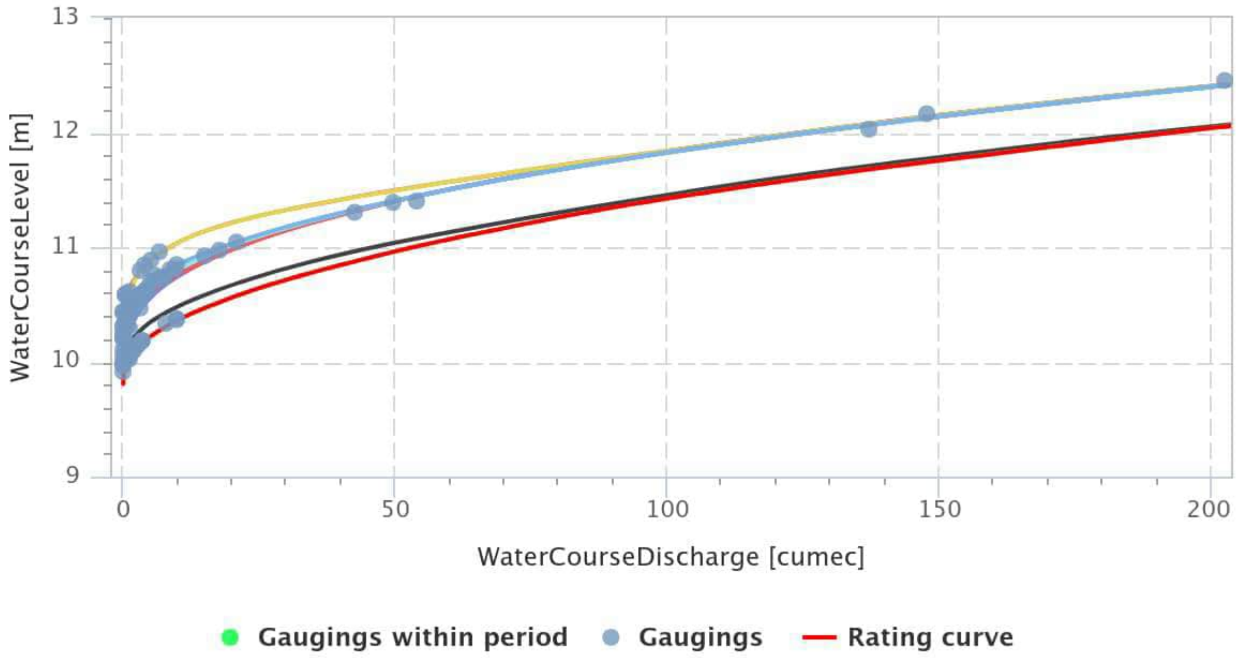

Figure 5-6: Rating curve at Marble Bar for flows less than 200 m³/s (source: BoM)

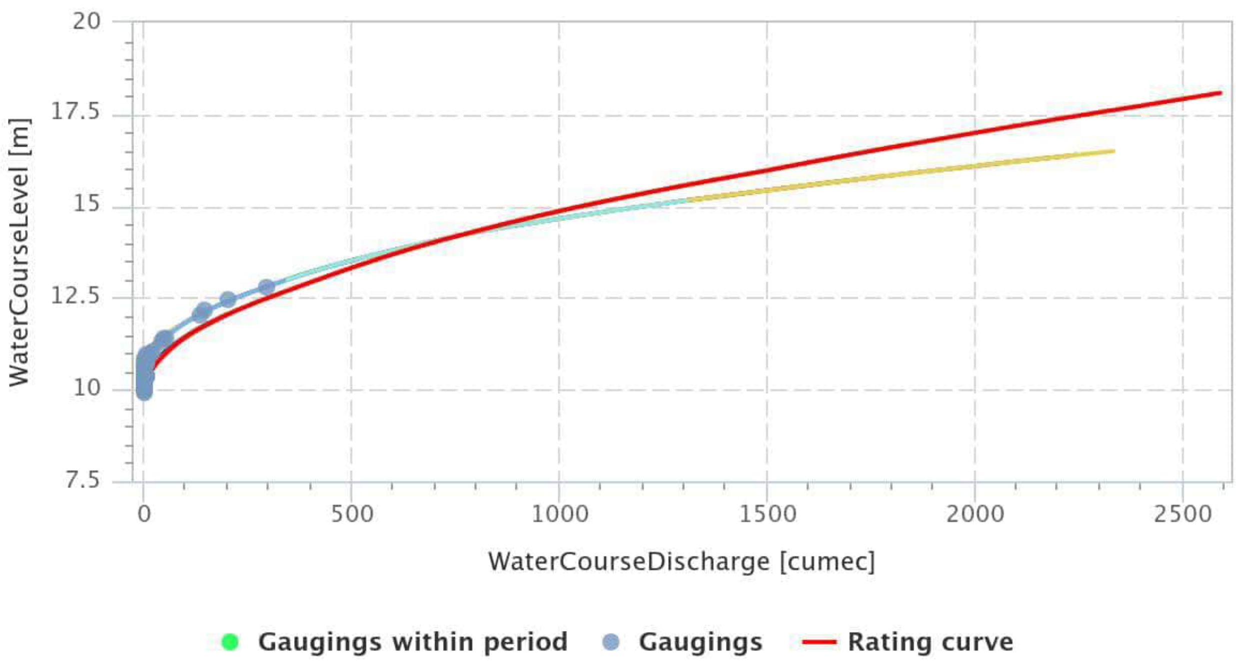

Figure 5-7: Rating curve for flows up to 2,500 m³/s (source: BoM)

Figure 5-8: Gauging station location for the Marble Bar gauge (source: BoM)

5.2.2.2 Periods of missed recording

Manual review of periods of missed recording were undertaken for both gauges. This resulted in the 1967, 1972 and 1978 water years being excluded from the Coongan River analysis and 1967 and 1978 excluded from the Shaw River analysis due to missing data from peak summer rainfall months.

5.2.2.3 Low flow censoring

Runoff in the Study Area is ephemeral, with waterways flowing only after rainfall of sufficient magnitude to produce runoff. Given the climate of the study area, flows are therefore seasonal and subject to high annual variability. This means that there are often years in which there are no floods. The annual maximum records for these years are therefore not representative of the population of floods and can unduly influence the fit of the right-hand tail (larger magnitude events) of the frequency distribution. These lower magnitude flows are often referred to as Potentially Influential Low Flows (PILF). Censoring of PILFs was undertaken for the gauge record using the multiple Grubbs-Beck test as described in Book 3 Chapter 2

ARR2019 (Ball et al., 2019). This resulted in annual maxima values lower than the PILF thresholds below being excluded in the FFA:

- 53.5 m^3/s at Marble Bar (6 years of data out of 55 available years).
- 386.5 m^3/s at North Pole Mine (19 years of data out of 55 available years)

5.2.3 FFA results

The FFA results for each gauge are presented in Figure 5-9 and Figure 5-10, whilst tabulated results are presented in Table 5-2. The Log Pearson III (LPIII) and the Generalised Extreme Value (GEV) probability models were assessed for both catchments to determine which method provided the best fit to the available data in line with guidance from ARR.

For the Marble Bar gauge, both the LPIII and the GEV probability models provide similar fits for events up to the 5% AEP event, with the higher skew of LPIII producing lower than expected growth curves in the rare to very rare range. As such, GEV was selected as the growth curves provided a closer alignment to those provided by preliminary rainfall-runoff modelling results.

For the North Pole Mine gauge, the LPIII fit was adopted as the model provided the best fit for both frequent and rare events recorded at the gauge. The fit for both probability models was similar for events up to the 5% AEP event, but the GEV deviated away significantly in rare events. Given the confidence in the rating curve (Section 5.2.2.1), the LPIII model was selected for use in the FFA.

Table 5-2: FFA results for the Marble Bar and North Pole Mine Gauges

DWER Stream Gauge	50% AEP (m^3/s)	20% AEP (m^3/s)	10% AEP (m^3/s)	5% AEP (m^3/s)	2% AEP (m^3/s)	1% AEP (m^3/s)	0.5% AEP (m^3/s)	0.2% AEP (m^3/s)
Coongan River – Marble Bar (710204)	499	1,113	1,681	2,388	3,621	4,854	6,431	9,211
Shaw River – North Pole Mine (710229)	847	2,455	3,518	4,483	5,622	6,388	7,078	7,882

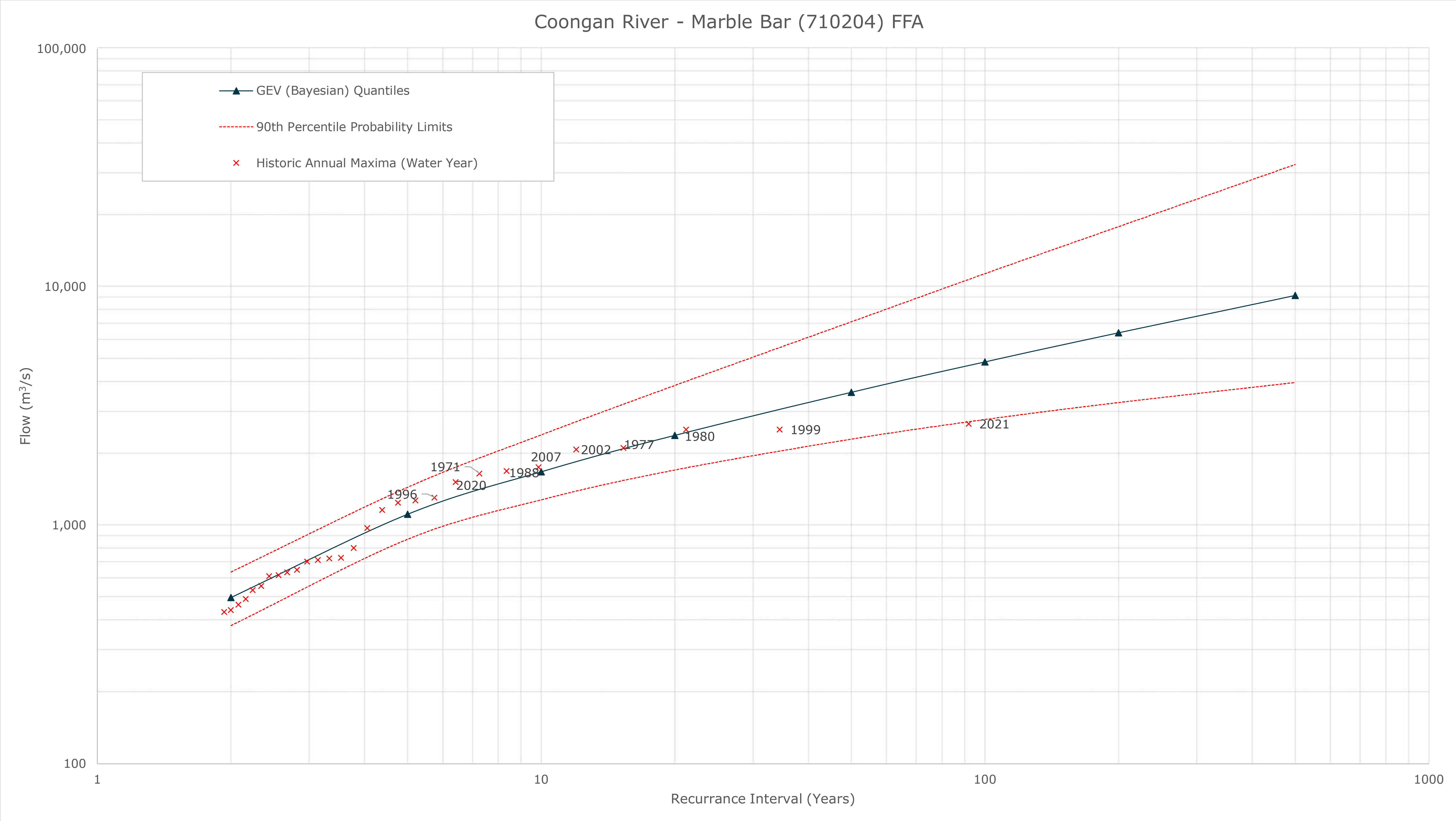

Figure 5-9: FFA for the Coongan River at Marble Bar (710204)

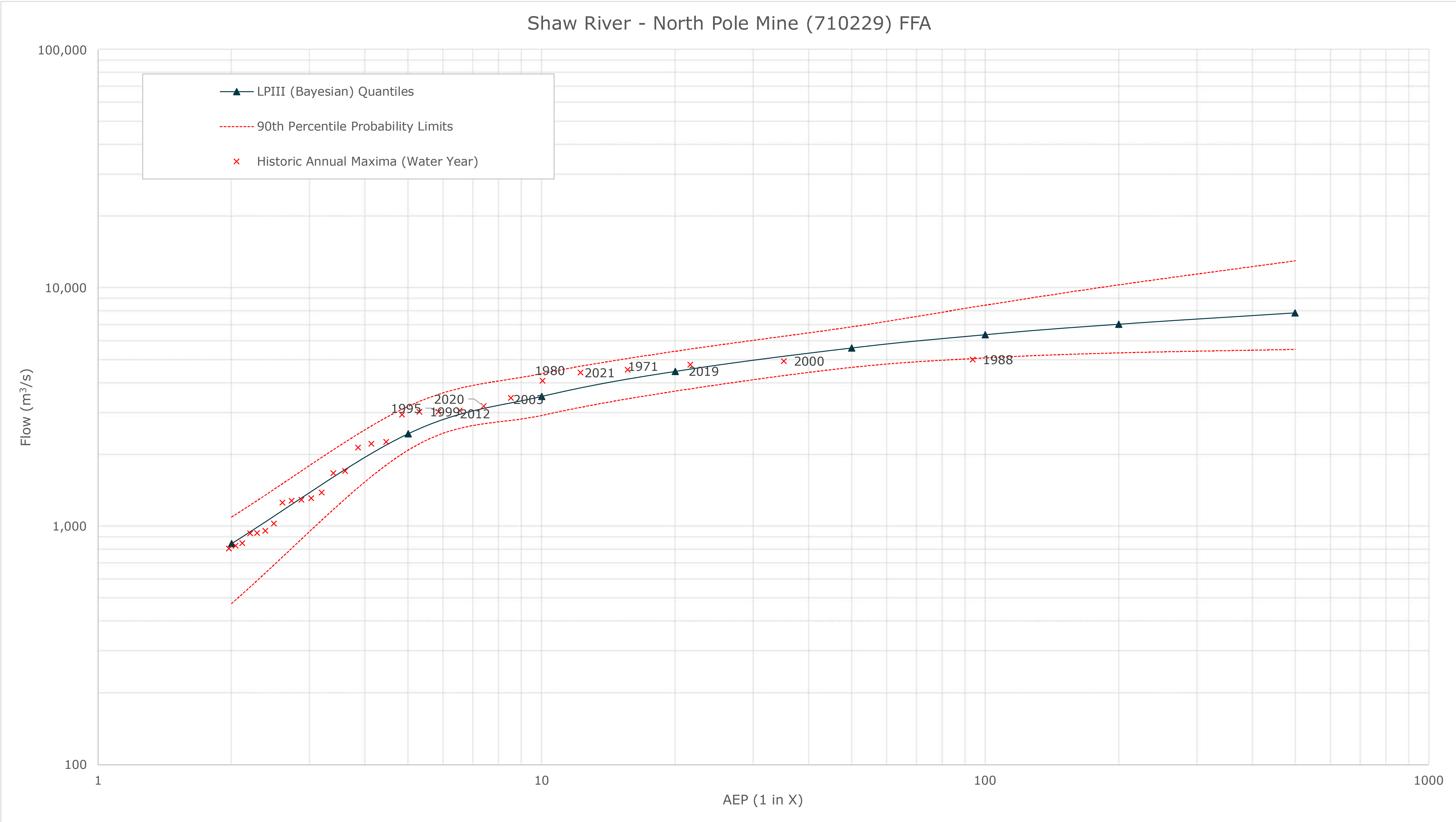

Figure 5-10: FFA completed for the Shaw River at North Pole Mine (710229)

5.4 Regional rainfall-runoff modelling

Rainfall-runoff modelling software RORB (version 6.45) was used to simulate rainfall-runoff in the regional Coongan River and Shaw River catchments for a range of AEP events.

Two RORB models were set up with the outlets at the two streamflow gauge sites. The RORB model schematisation including the nodal-network arrangement for both models are presented in Figure 5-11.

Sub-catchments areas were delineated using Shuttle Radar Topography Mission Hydrology Enforced (SRTM-H) topographic data and manually inspected for conformance to expected catchment divides (aerial imagery).

5.4.1 Model inputs and parameters

RORB models are characterised by a number of input parameters such as rainfall, rainfall losses, temporal patterns, areal reduction factors and pre-burst rainfall as well as two additional parameters to derive storage-discharge relationships which are detailed below.

5.4.1.1 Design rainfall data

The latest IFD data was obtained from the BoM Design Rainfall Data System (BoM, 2016) for use in the study. Point rainfall data was obtained from the centroid of both catchments and presented in Appendix A.

As the catchments are larger than 20 km^2, spatially varied rainfall was applied to the model. This was completed by calculating the average IFD value for each sub-catchment utilising the zonal statistics tool in QGIS and the gridded IFD data available from BoM.

Median pre-burst rainfall depths were extracted from ARR Datahub (Babister et al., 2016). Pre-burst rainfall was removed from the Storm IL (IL_S) prior to simulation in the model to represent the Burst IL (IL_B).

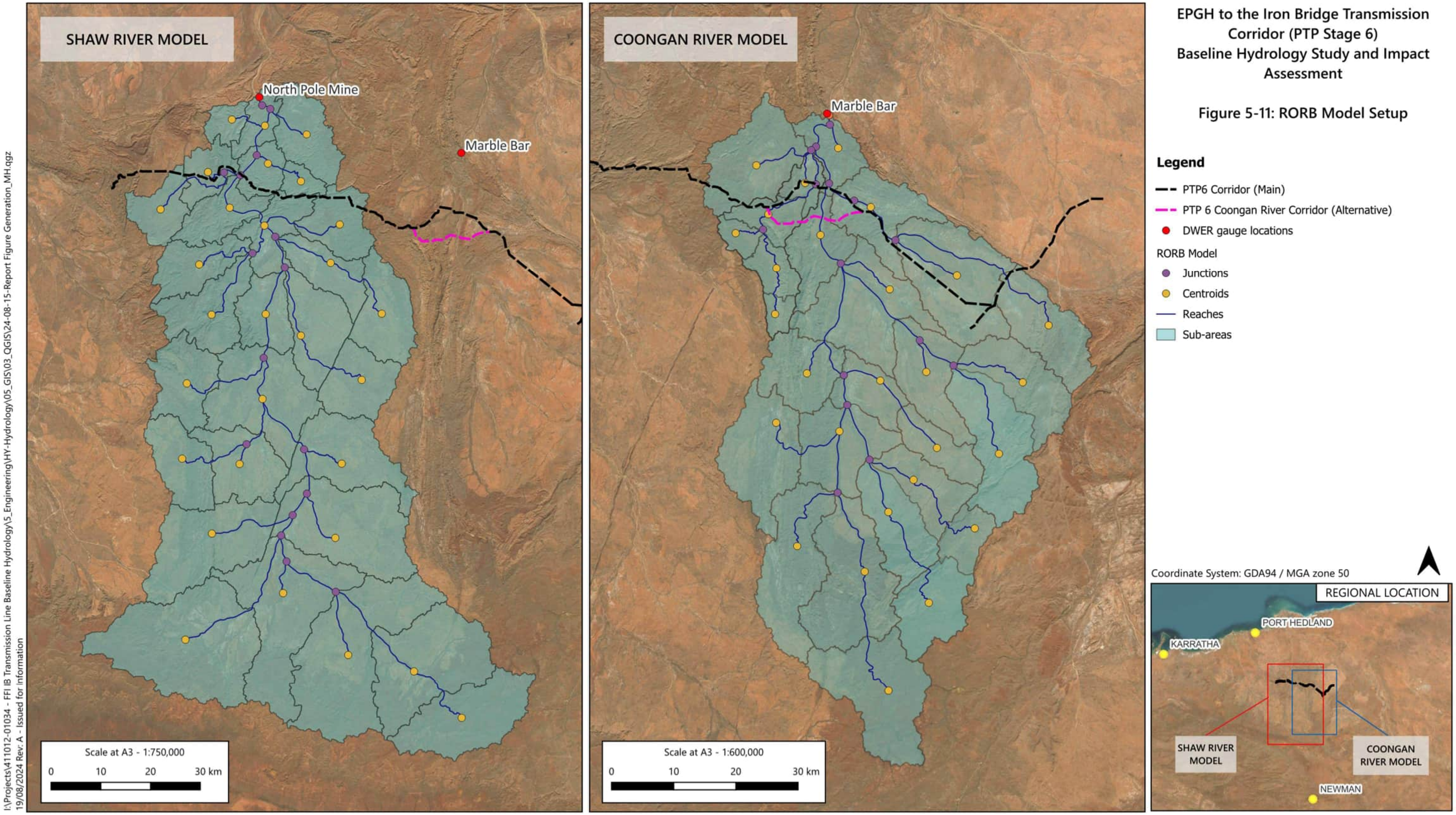

Figure 5-11: RORB model setup for the Coongan and Shaw Rives

5.4.1.2 Areal reduction factors

Given the large size of the catchments, it is unlikely that the spatial coverage of a high intensity storm burst will be consistent across the entire catchment area. To address this issue, it is typical to apply an Areal Reduction Factor (ARF) to the IFD estimates to ensure the preservation of a probability neutral transition between the design rainfall and the design flood characteristics (ARR2019) (Ball et al., 2019). The procedure outlined in ARR2019 (and automated in RORB) were adopted to determine ARFs for both catchments.

5.4.1.3 Loss model

An initial/continuing loss (IL/CL) empirical loss model has been adopted for the study. The losses selected and justification of the losses is presented in Section 5.4.2.

5.4.1.4 Storage-discharge parameterisation

RORB is characterised by two additional parameters to enable calculation of its storage-discharge relationship. These are the exponent m, often referred to as the non-linearity parameter and the coefficient K_c, often referred to as the reach storage parameter.

The standard m value of 0.8 was adopted in the RORB models. This value is typically adopted in uncalibrated catchments or where there is insufficient data to inform a change from this value. This value was also adopted in the works undertaken by Pearcey et al. (2014) which involved the calibration of hydrological models to gauged catchments in the Pilbara region of Western Australia. Pearcey estimated a reach-storage relationship, C, for a number of catchments including the Coongan River and Shaw River in these studies. For the Coongan River and Shaw River the relationship is defined:

- $C_{0.8}$ = 0.48 for Coongan River to Marble Bar; and
- $C_{0.8}$ = 0.66 for the Shaw River to North Pole Mine.

Using the calibrated $C_{0.8}$ values from Pearcey et al. (2014), *Kc* for the developed ROBR models were derived using the following equations:

$$K_c = 0.48 \times d_{av}\ (Coongan\ River)$$

$$K_c = 0.66 \times d_{av}\ (Shaw\ River)$$

Where d_{av} represents the average distance from each sub area to the catchment outlet. This resulted in a K_c of 29.6 and a 64.2 for the Coongan and Shaw River RORB models respectively.

When using this relationship, the K_c values derived in this study may not exactly match those derived by Pearcey et al. (2014) due to potential differences in model schematisation and its effects on d_{av}. To limit the magnitude of this potential difference, it was ensured that a similar number of sub-areas were used to that documented in Pearcey et al. (2014). A small number of sub areas were included in the Coongan River model to increase the number of crossings upstream of the Glen Herring Creek crossings.

5.4.1.5 Temporal patterns

Given the size of the catchment areas, all events were simulated using the Rangelands areal ensemble temporal patterns extracted from the ARR Datahub (Babister et al., 2016).

5.4.1.6 Simulation approach

The assessment of the catchment response to rainfall for both catchments used a Monte Carlo assessment approach for flood quantile estimation.

The Monte Carlo approach provides a framework for simulating the natural variability in the key processes that influence flood runoff: all important flood producing factors are treated as stochastic variables, and the less important ones are fixed. The primary advantage of the method is that it allows the exceedance probability of the flood characteristic to be determined without bias (subject to the representativeness of the selected inputs) (ARR2019) (Batt et al., 2019). The approach is conceptualised in Figure 5-12. For this assessment, temporal patterns and initial loss have been stochastically sampled.

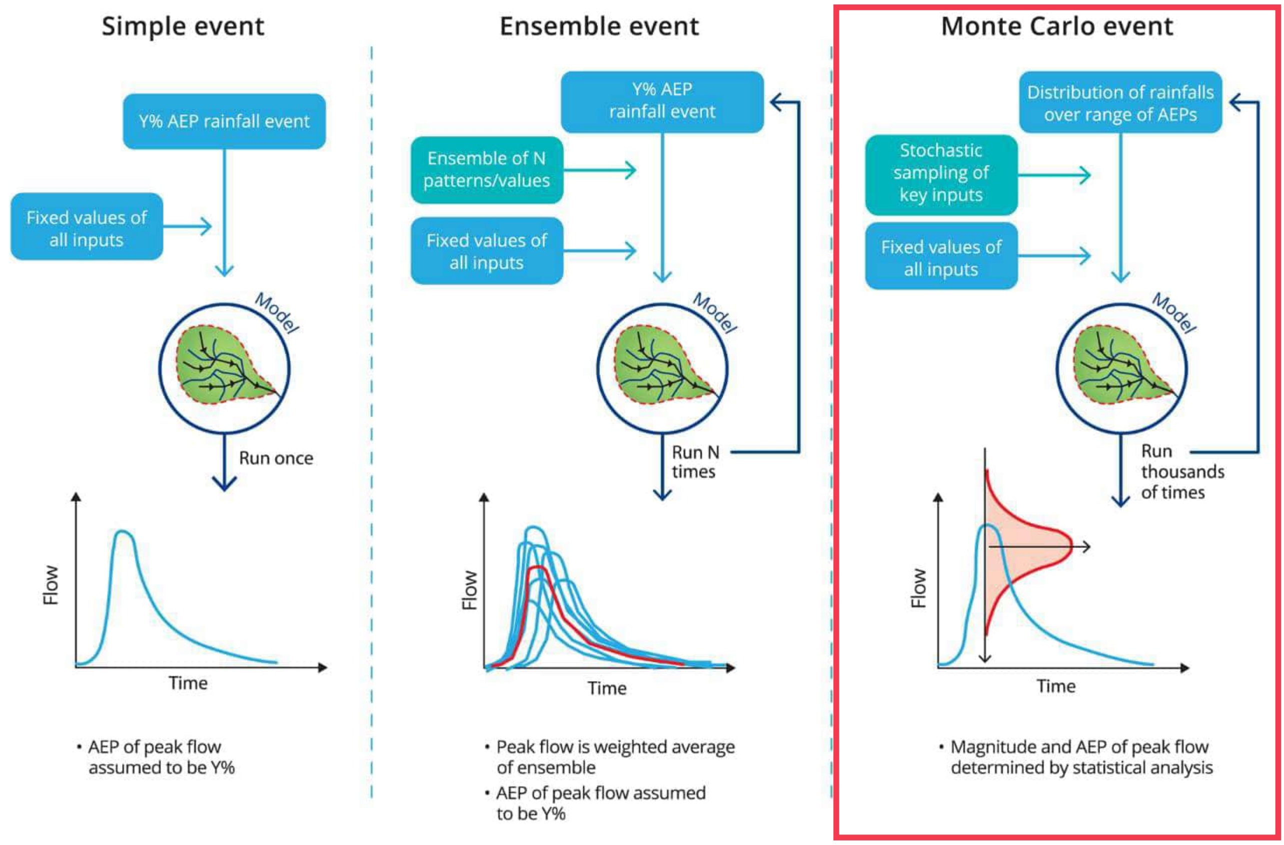

Figure 5-12: Monte Carlo approach conceptual model (Ball et al. 2019)

5.4.2 Results discussion

Several model runs were completed for each study catchment to identify model parameters and losses that provide the best fit to the flood quantiles estimated in the FFAs (documented in Section 5.2). The investigation included testing various loss values as well as sensitivity to other parameters such as k_c.

Worley Consulting and Fortescue Energy agreed that for this study, K_c should remain constant based on the calibration events completed in Pearcey *et al.* 2014.

The calibration of losses was complex, and no single set of parameters selected provided a good fit across all AEP events of interest. Therefore, the initial and continuous losses that minimise the deviation between the growth curves exhibited in the rainfall-runoff modelling and those from the FFA within the 10% to 1% AEP range were adopted. This AEP range was selected in accordance with the Fortescue Basis of Design, which focuses on the 1% AEP event, and the higher certainty in the FFA for more frequent AEP events. A conservative approach was applied to the more frequent events, where the growth curves predicted lower magnitudes, by scaling the hydrograph to match the regional estimates.

For the Coongan River model, loss parameters of 20 mm IL_S and 7 mm/hr *CL* were considered appropriate, whilst for the Shaw River, loss parameters of 20 mm IL_S and 6 mm/hr *CL* were adopted for the study. The results of the Monte Carlo analysis and comparison to the FFA completed on the gauge is presented in Figure 5-13 (Coongan River) and Figure 5-14 (Shaw River) for the AEP range of interest. It was noted that low magnitude events such as the 50% and 20% AEP events could not be replicated within the RORB model. This is likely due to a mixed population of record in the streamflow gauge data, with smaller events captured by the gauges likely being more representative of local convective thunderstorms in nearby tributaries, and larger magnitude events associated with more spatially expansive rainfall events such as those associated with ex-tropical cyclones. This makes replication of flood quantiles across the complete AEP range using the ARR2019 design event approach difficult, particularly without detailed assessment of rainfall mechanisms associated with each AM flood event.

It is also likely that catchment response is not only affected by the adopted empirical losses but in the case of these large systems is likely influence by other AEP-dependant parameters that are not able to be captured within the modelling or explicitly assessed with the available data. Given the expansive mainstream widths and alluvial deposits observed in aerial imagery, it is possible that parameters such as *Kc* are AEP-dependent and not a constant, as is limited in the RORB modelling software.

For hydraulic modelling, the RORB modelling results up to the 10% AEP event (Coongan River) and 5% AEP (Shaw River) are scaled to regional estimates, as the values derived from RORB are found to be lower than flows based on FFA quantiles and the aforementioned limitations surrounding mixed meteorological mechanisms driving rainfall and hence flood behaviours in the catchments.

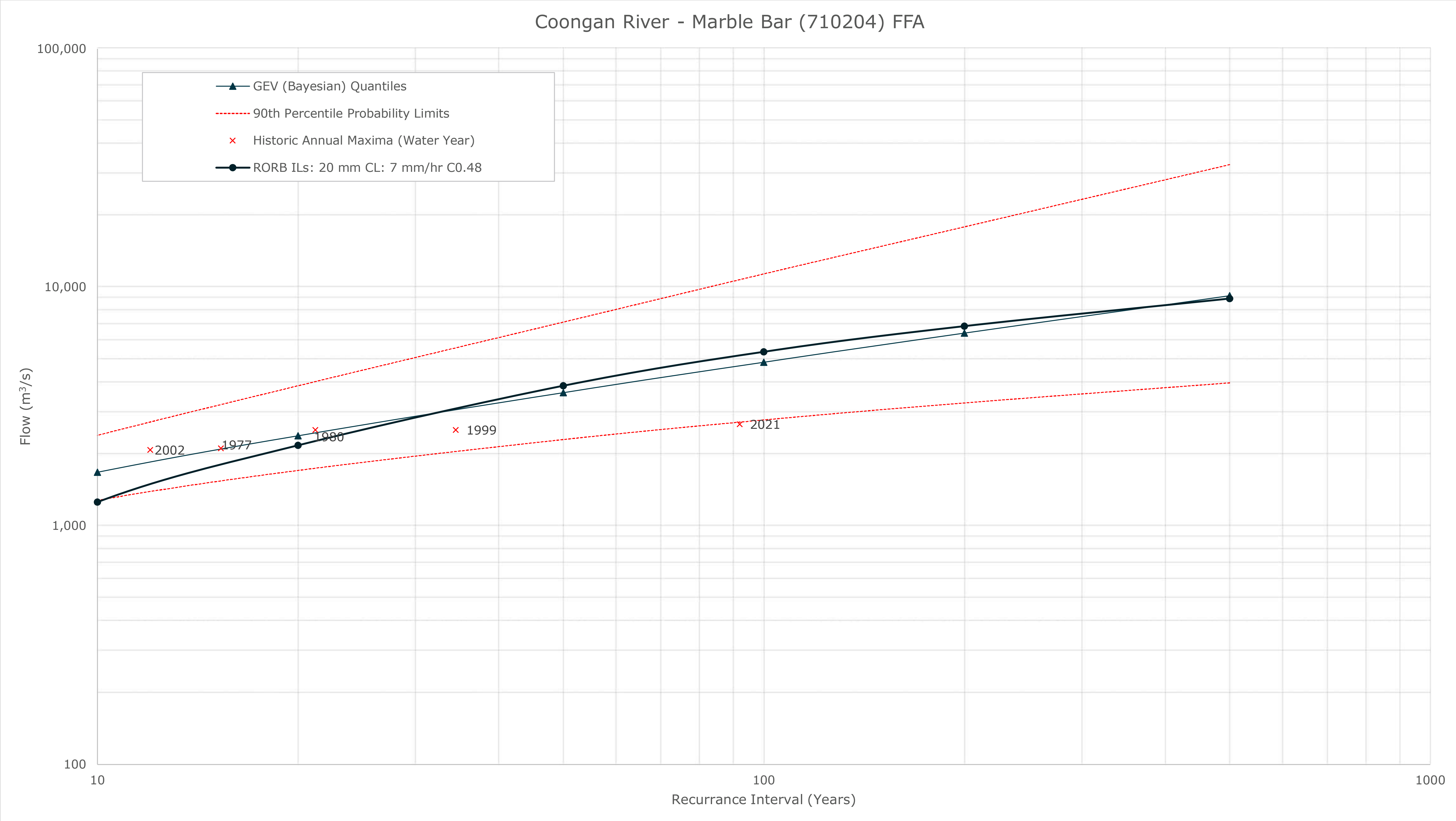

Figure 5-13: Comparison of FFA and RORB for the Coongan River model

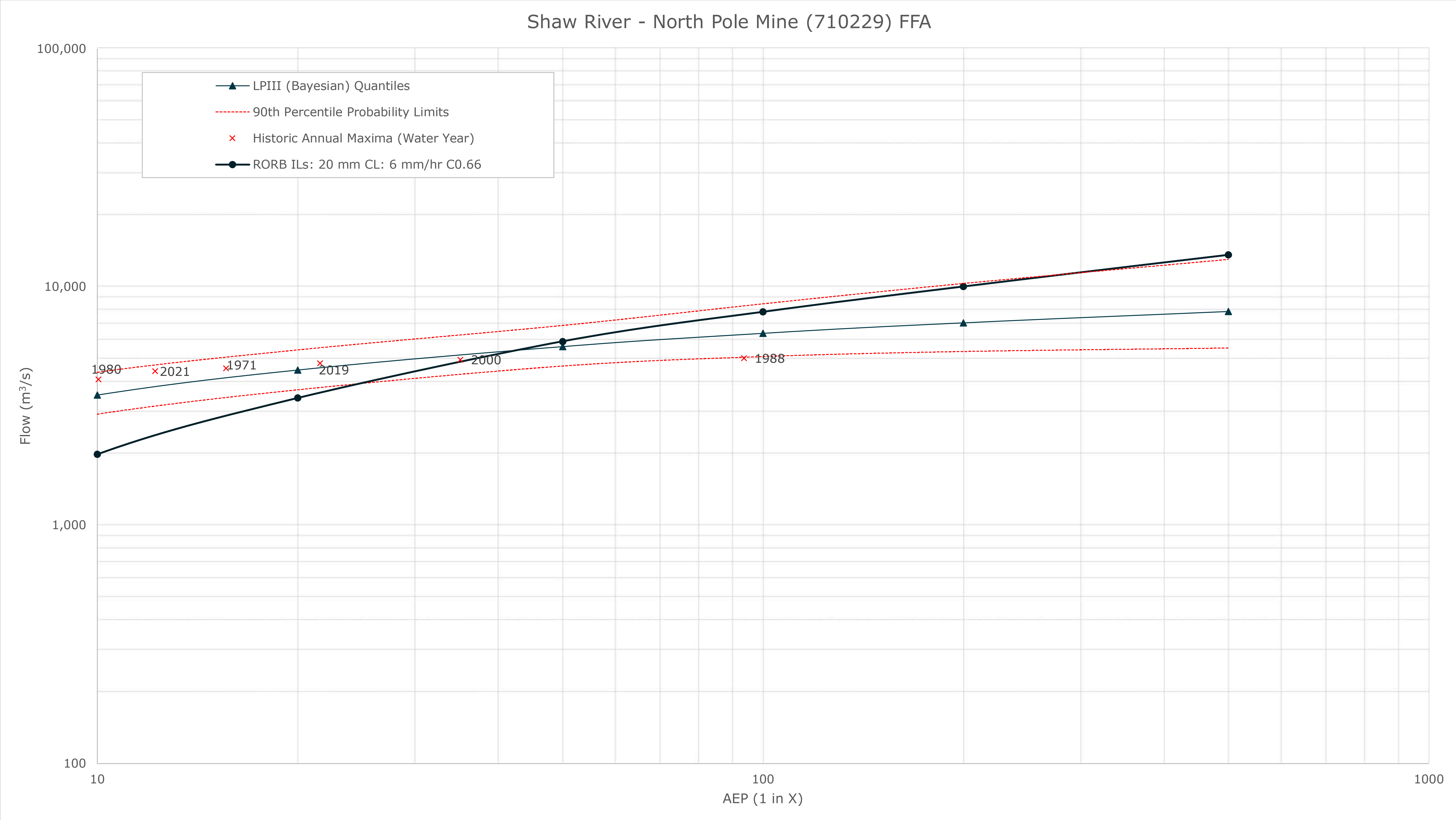

Figure 5-14: Comparison of FFA and RORB for the Shaw River model

6. Design event hydrology

Design event hydrology was completed using the RORB models developed for the Coongan River and the Shaw River based on the model calibration. The model parameters and inputs were modified to represent the catchment areas of interest and produce hydrographs at key inflow locations for hydraulic modelling (described in Section 7). This section outlines the model updates (parameters and domains) and the resulting inflow hydrographs for use in hydraulic modelling and impact assessment.

6.1 Model input and parameter updates

The RORB model extents for the Coongan River and Shaw River models were updated to focus on the catchments of interest. The revised model extents are presented in Figure 6-1. The change in model setup resulted in changes to the ARF applied to the point design rainfall and routing parameter K_c which are discussed below.

6.1.1 Areal reduction factors

The ARF applied to each model was updated based on the area upstream of the crossings. The ARF calculation was updated based on the areas presented in Table 6-1.

Table 6-1: Area adopted for ARF calculation applied for each model

Location of Interest	Area Upstream
Coongan River at PTP Stage 6 crossing	3,264
Coongan River at Alternative Alignment crossing	2,690
Camel Creek at PTP Stage 6 crossing	537
Glen Herring Creek at PTP Stage 6 crossing	187
Glen Herring Creek at Alternative Alignment crossing	130
Shaw River at PTP Stage 6 crossing	6,070

6.1.2 Routing parameters

Routing parameter (K_C) for the local catchment models were scaled to match the respective $C_{0.8}$ values in Pearcey et al. 2014 for the Coongan and Shaw River RORB models. The values adopted for each model domain are presented in Table 6-2.

Table 6-2: K_c and C values adopted for RORB modelling

RORB Model	Catchment Area (km²)	D_{av}	K_c	$C_{0.8}$
Coongan River at PTP Stage 6 crossing	3,261	52.9	25.4	0.48
Coongan River at Alternative Alignment crossing	2,698	56.6	27.2	0.48
Camel Creek at PTP Stage 6 crossing	564	25.2	12.1	0.48
Glen Herring Creek at PTP Stage 6 crossing	208	21.4	10.2	0.48
Shaw River at PTP Stage 6 crossing	5,900	87	57.4	0.66

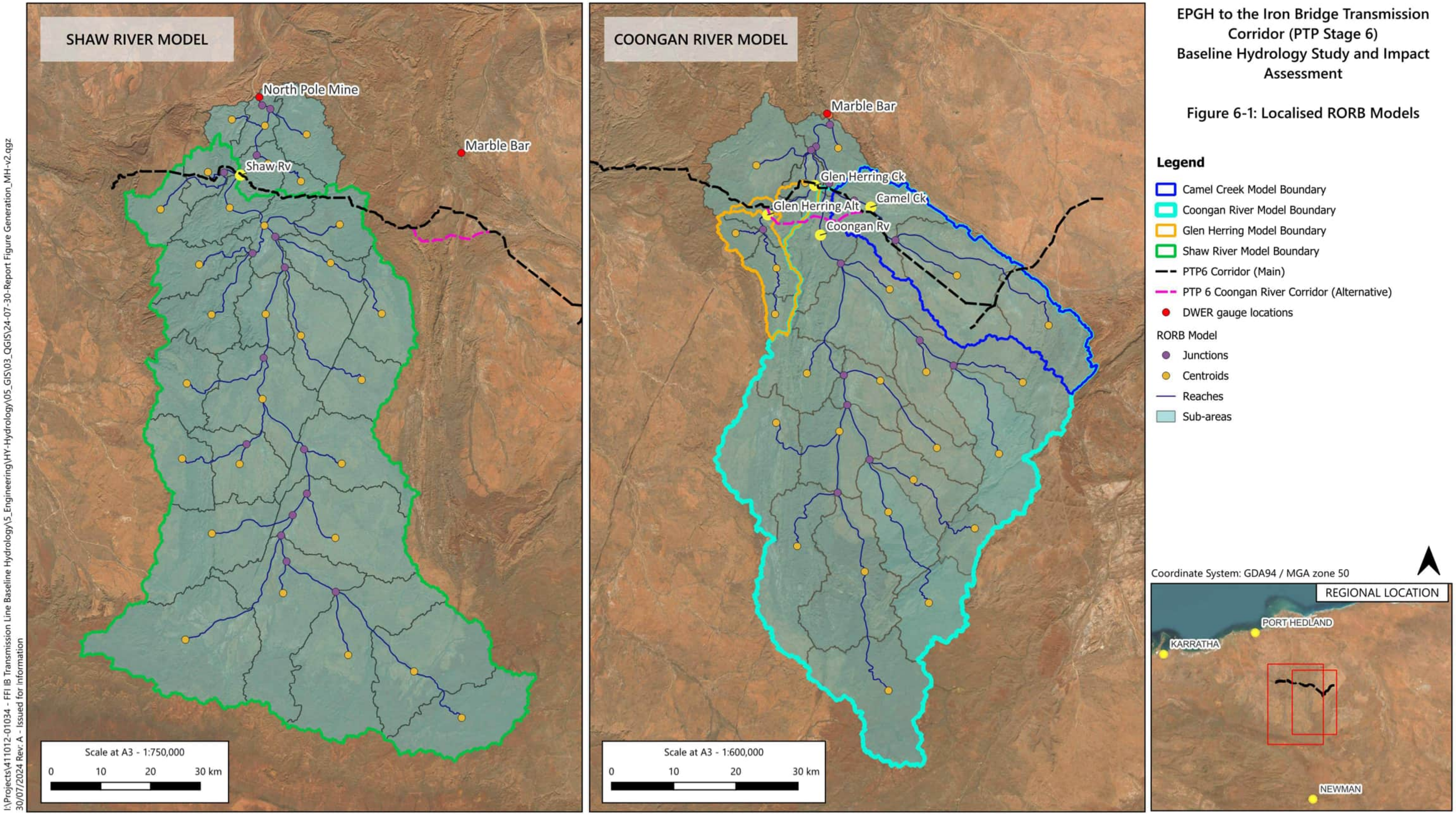

Figure 6-1: Localised RORB models for catchments of interest

6.2 Simulation approach

The design event hydrology was completed by using the ensemble approach as described by ARR2019 and conceptualised in Figure 6-2. The ensemble analysis involves running a range of design storm durations and associated temporal patterns (10) in the hydrological model and selecting the event that results in the highest mean peak. The purpose of this method is to mitigate the potential bias in peak flow estimates from the temporal patterns modelled. The modelled events are presented in Table 6-3, with critical storms identified summarised in Section 6.3.

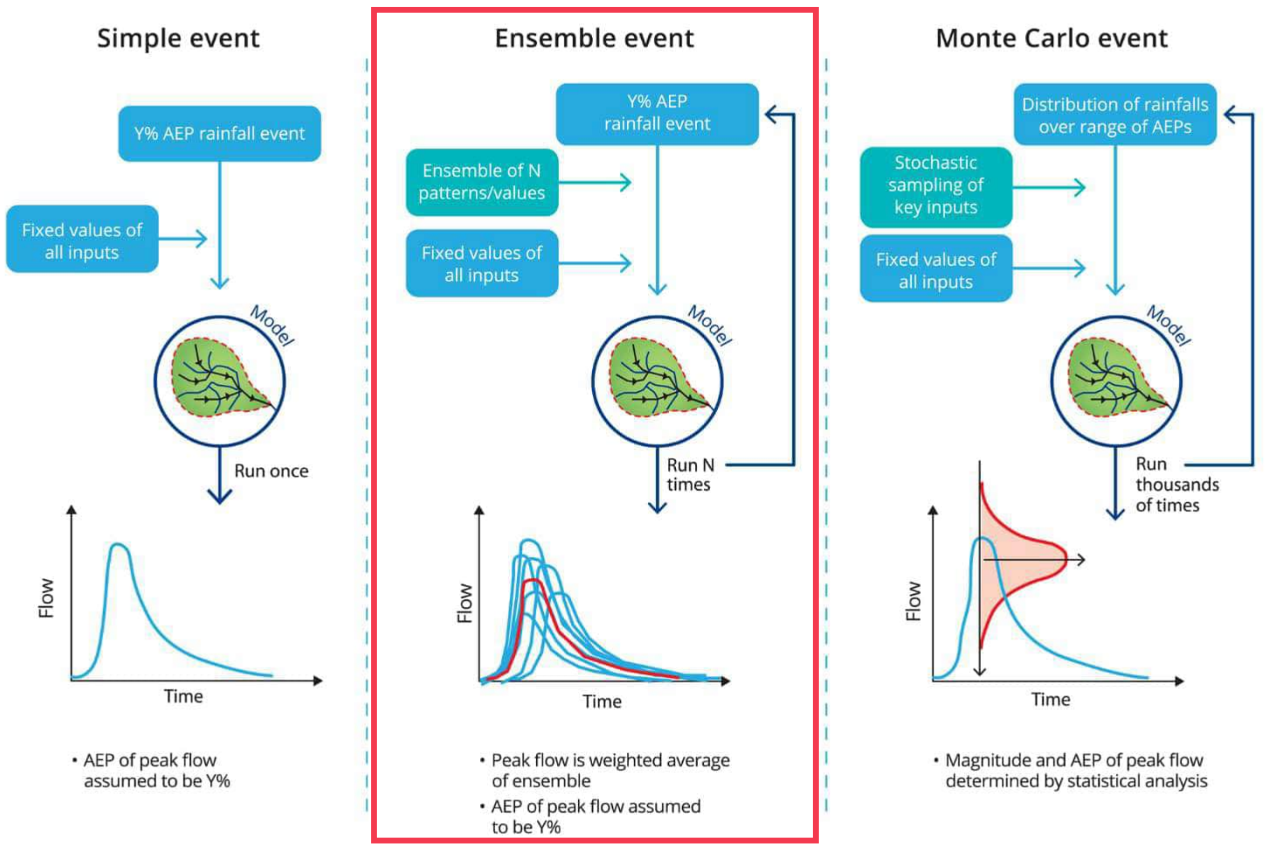

Figure 6-2: Ensemble approach conceptual model (Ball et al., 2019)

Table 6-3: Design storms assessed in the RORB models

Storm	Events assessed
AEP	1 in 500, 1 in 200, 1%, 2%, 5%, 10%, 20% and 50%
Design Storm Durations	720, 1080, 1440, 2160, 2880 and 4320

6.3 Design events

This section presents the results of the design event modelling for each of the key creek crossings as agreed with Fortescue Energy. The results at each crossing location were compared to regional peak flow estimates completed using the RFFP, RFFE and scaled FFA analysis. Plots of the comparison to peak flows for all crossings are shown in Appendix B.

6.3.1 Coongan River – PTP Stage 6 Crossing

The flows estimated for the Coongan River at the PTP6 crossing are presented in Table 6-4. The hydrographs to be input to the hydraulic model for analysis at the confluence of Coongan River and Camel Creek are presented in Figure 6-3 and Figure 6-4 for Coongan River and Camel Creek.

Table 6-4: Comparison of flows for the Coongan River model at the PTP Stage 6 Crossing

Name	Flow Estimate (m^3/s)					
	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Scaled FFA - Coongan River	1,577	2,077	2,721	3,187	3,631	4,178
RFFP	3,220	5,277	10,089	16,572	-	-
RFFE	1,140	1,670	2,350	2,980	-	-
RORB estimate	**1,347**	**2,491**	**3,826**	**5,041**	**6,576**	**8,775**
RORB critical storm	**24hr TP04**	**24hr TP06**	**12hr TP09**	**12hr TP04**	**12hr TP04**	**12hr TP06**

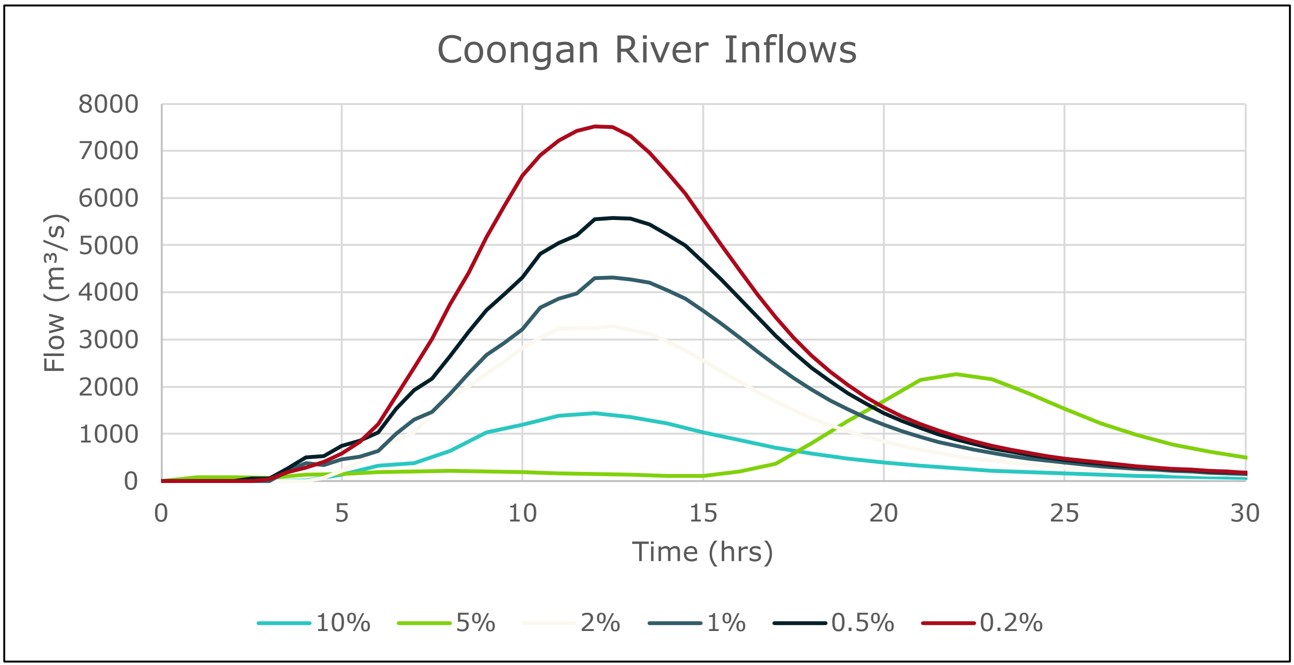

Figure 6-3: Inflow hydrographs for Coongan River for the Coongan River PTP6 crossing model

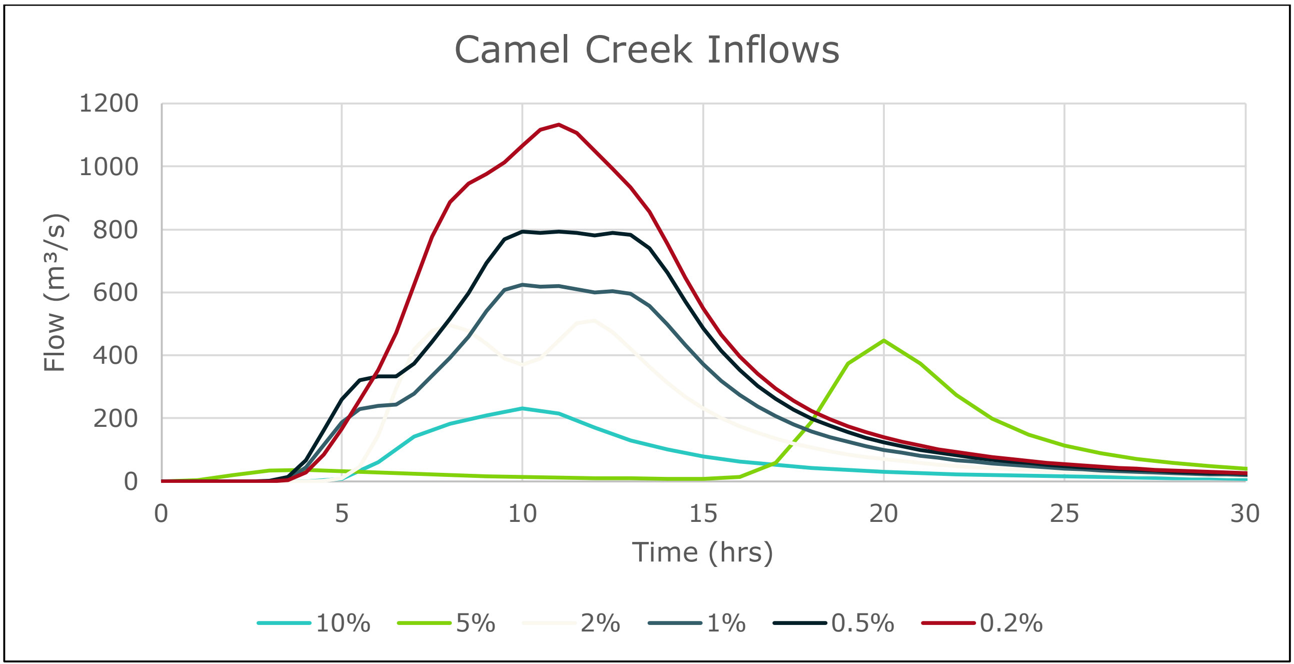

Figure 6-4: Inflow hydrographs for Camel Creek for the Coongan River PTP6 crossing model

6.3.2 Coongan River – Alternative Alignment Crossing

The flows estimated for the Coongan River at the alternative alignment crossing are presented in Table 6-5. The hydrographs to be input to the hydraulic model are presented in Figure 6-5.

Table 6-5: Comparison of flows for the Coongan River model at the alternative alignment

Name	Flow Estimate (m^3/s)					
	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Scaled FFA - Coongan River	1,377	1,814	2,377	2,784	3,171	3,649
RFFP	2,547	4,165	7,944	13,025	-	-
RFFE	1,010	1,480	2,090	2,650	-	-
RORB estimate	**1,261**	**2,076**	**3,571**	**4,622**	**5,878**	**7,640**
RORB critical storm	**18hr TP05**	**12hr TP03**	**12hr TP10**	**12hr TP10**	**12hr TP10**	**12hr TP04**

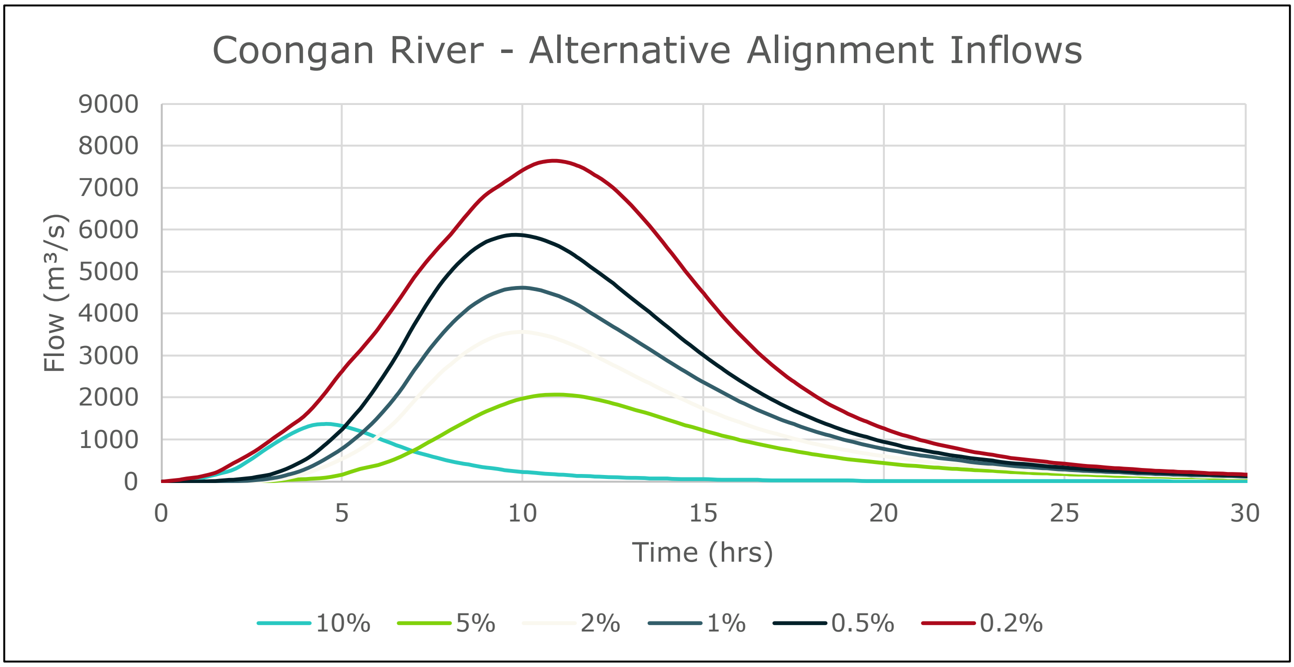

Figure 6-5: Inflow hydrographs for Coongan river at the alternative alignment location

6.3.3 Glen Herring Creek – PTP Stage 6 Crossing

The flows estimated for the Glen Herring Creek crossing are presented in Table 6-6. The hydrographs to be input to the hydraulic models are presented in Figure 6-6.

Table 6-6: Comparison of flows for the Glen Herring Creek crossing

Name	Flow Estimate (m^3/s)					
	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Scaled FFA - Coongan River	213	281	368	431	491	564
RFFP	326	573	1,056	1,687	-	-
RFFE	209	304	434	547	-	-
RORB estimate	**233**	**384**	**554**	**710**	**875**	**1,120**
RORB critical storm	**12hr TP01**	**12hr TP04**	**12hr TP04**	**12hr TP09**	**12hr TP08**	**12hr TP08**

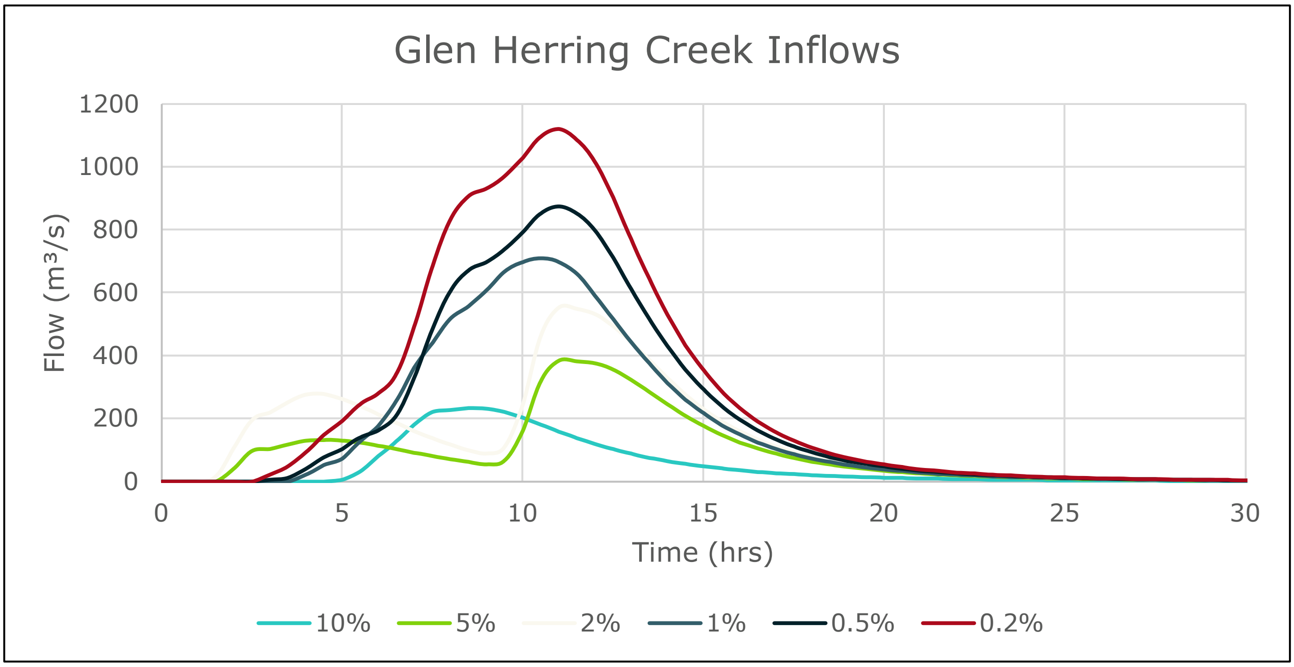

Figure 6-6: Inflow hydrographs for Glen Herring Crossing analysis

6.3.4 Glen Herring Creek – PTP Stage 6 Alternative Crossings

The flows estimated for the Glen Herring Creek crossing are presented in Table 6-6. The hydrographs to be input to the hydraulic models are presented in Figure 6-6.

Table 6-7: Comparison of flows for the Glen Herring Creek crossing

Name	Flow Estimate (m³/s)					
	10% AEP	**5% AEP**	**2% AEP**	**1% AEP**	**0.5% AEP**	**0.2% AEP**
Scaled FFA - Coongan River	165	218	285	334	380	438
RFFP	272	435	798	1,270	-	-
RFFE	173	252	359	453	-	-
RORB estimate	**212**	**307**	**411**	**495**	**590**	**724**
RORB critical storm	**12hr TP02**	**12hr TP06**	**12hr TP02**	**12hr TP02**	**12hr TP02**	**12hr TP02**

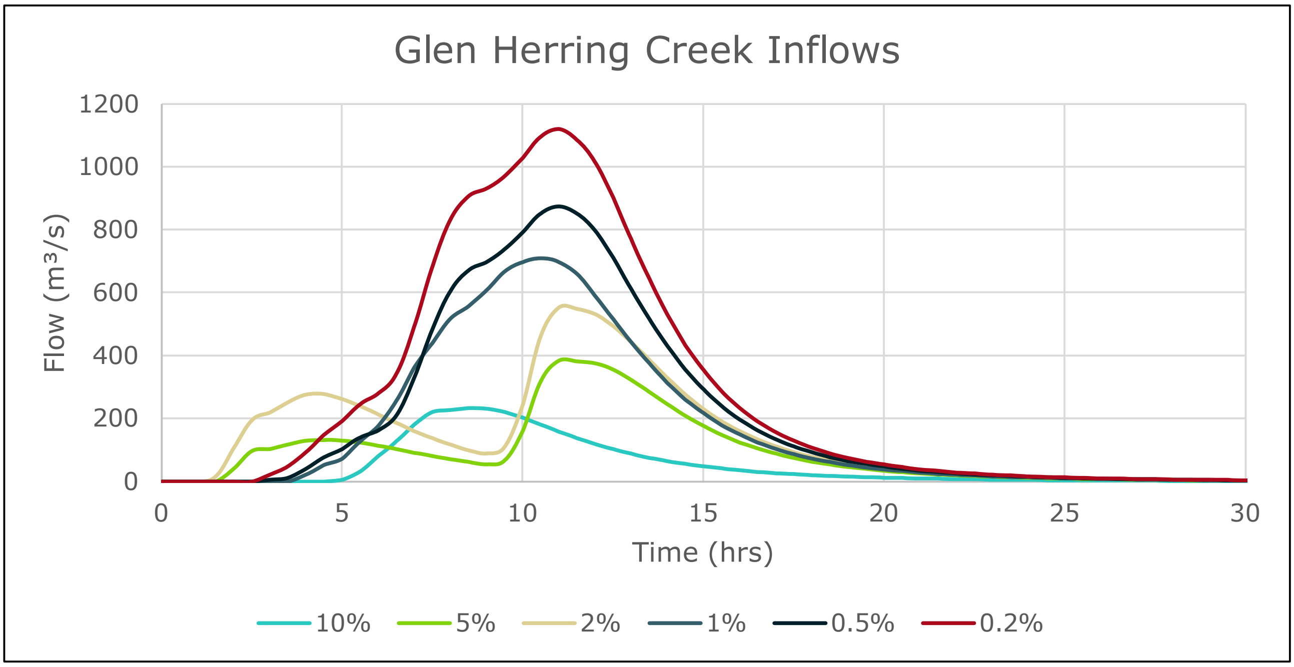

Figure 6-7: Inflow hydrographs for Glen Herring Crossing analysis

6.3.5 Camel Creek – PTP Stage 6 Crossing

The flows estimated for the Camel Creek crossing are presented in Table 6-8. The hydrographs to be input to the hydraulic models are presented in Figure 6-8.

Table 6-8: Comparison of flows for the Camel Creek crossing

Name	Flow Estimate (m³/s)					
	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Scaled FFA - Coongan River	446	587	770	901	1,027	1,181
RFFP	879	1,510	2,823	4,557	-	-
RFFE	327	478	669	852	-	-
RORB estimate	**566**	**820**	**1,265**	**1,563**	**1,874**	**2,394**
RORB critical storm	**12hr TP06**	**12hr TP06**	**12hr TP06**	**12hr TP03**	**12hr TP03**	**12hr TP10**

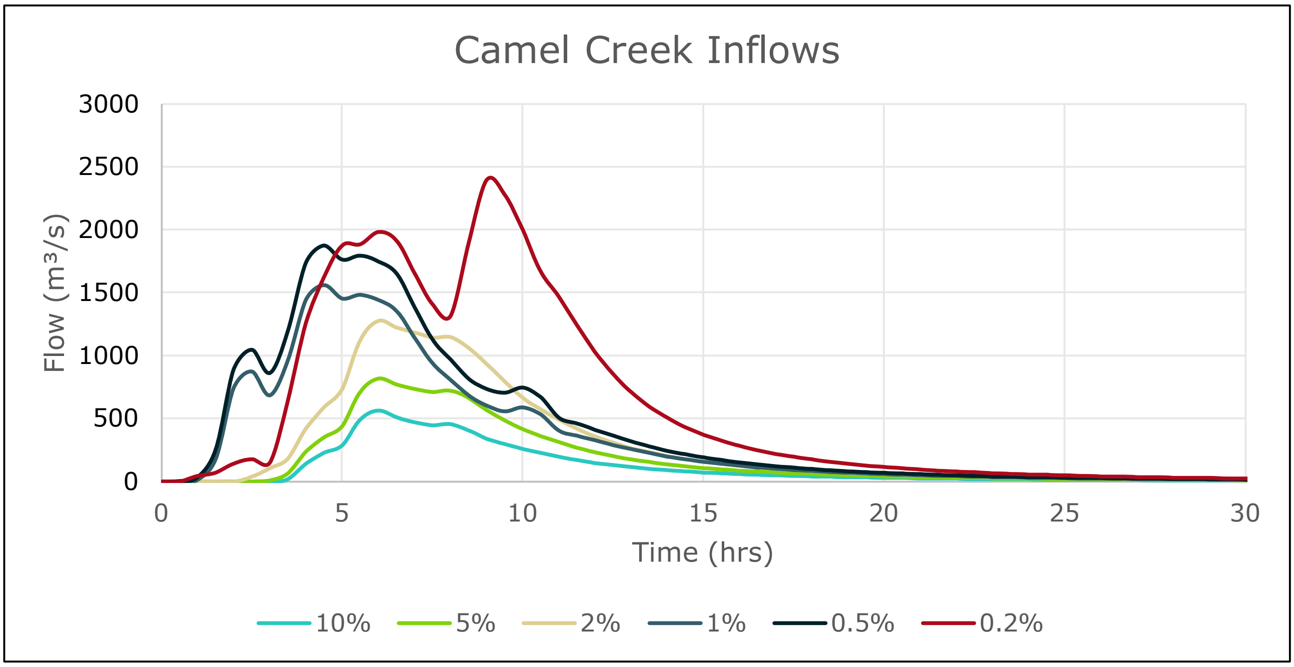

Figure 6-8: Inflow hydrographs for Camel Creek crossing

6.3.6 Shaw River – Design Hydrographs

The flows estimated for the Shaw River crossing are presented in Table 6-9. The critical storm hydrographs to be input to the hydraulic models are presented in Figure 6-9.

Table 6-9: Comparison of flows for the Shaw River model

Name	Flow Estimate (m^3/s)					
	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Scaled FFA - Shaw River	3,329	4,216	5,238	5,909	6,502	7,179
RFFP	3,711	6,119	11,791	19,476		
RFFE	1,880	2,740	3,930	4,930		
RORB estimate	**1,774***	**3,159***	**5,413**	**7,274**	**9,234**	**12,472**
RORB critical storm	**12hr TP05**	**12hr TP05**	**12hr TP02**	**12hr TP02**	**12hr TP02**	**12hr TP02**

**For hydraulic modelling, values scaled to Scaled FFA results*

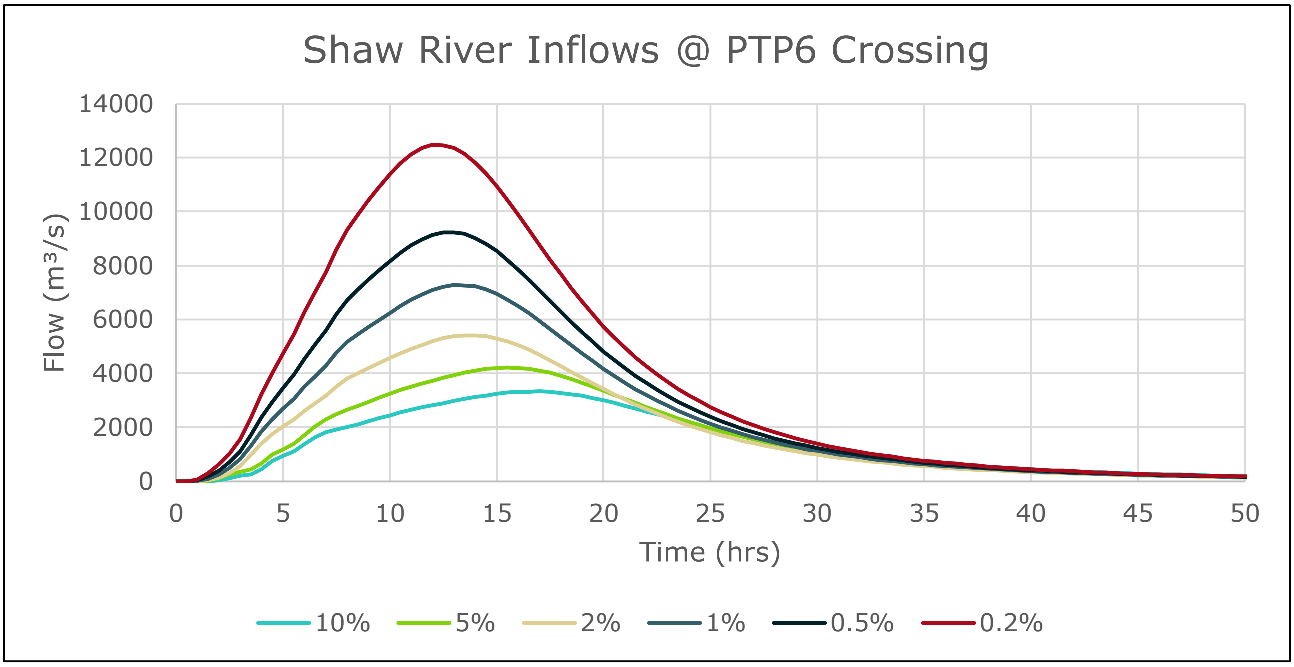

Figure 6-9: Inflow hydrographs for the Shaw River Model

7. Hydraulic analysis

7.1 General approach

The hydraulic analysis was completed using the modelling software TUFLOW (version 2023-03-AE). Inflow hydrographs were input to the model at locations upstream of the study area with the flows routed to the creek crossings. The critical storms identified in Section 6.3 for each crossing were analysed with the results presented in Section 8.

7.2 Model domains and boundary conditions

Flood model domains and key model locations (such as inflow and outflow boundary conditions) are presented in Figure 7-1. The model boundaries have been located a sufficient distance upstream/downstream to ensure that the hydraulics at the crossing locations are not impacted by the boundary condition behaviour.

7.3 Design events

Table 7-1 documents the range of AEP events that have been modelled for the project. Results for the 10%, 1% and 1 in 500 AEP events have been documented in Section 8.

Table 7-1: Flood modelling completed for the project.

AEP	Documented in this report
50%	No
20%	No
10%	Yes
5%	No
2%	No
1%	Yes
1 in 200	No
1 in 500	Yes

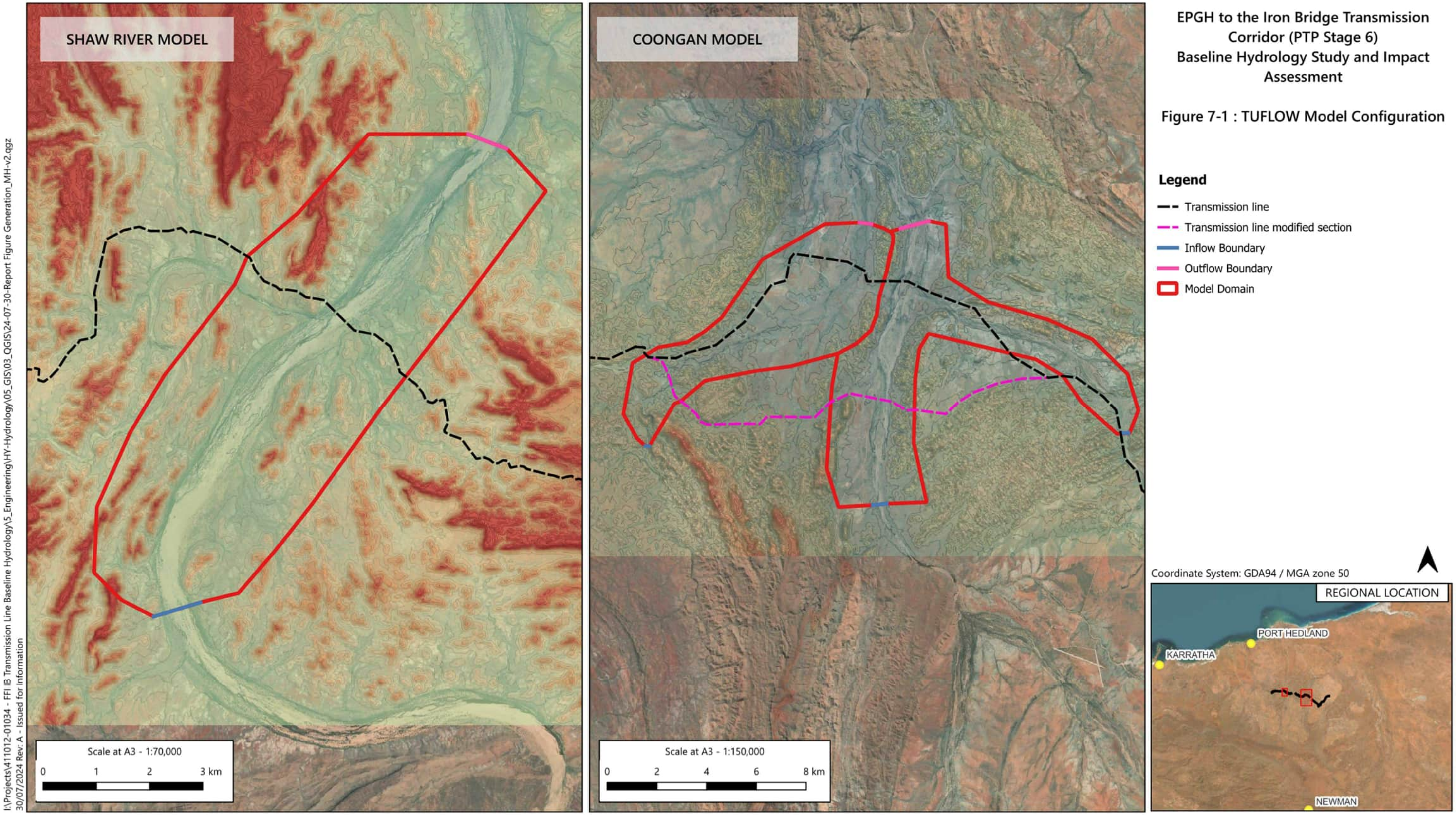

Figure 7-1: TUFLOW Model Configuration

7.4 Model parameterisation

Table 7-2 presents the TUFLOW model parameters adopted for use in the study. Additional details on the delineation of floodplain roughness are documented in Section 7.4.1.

Table 7-2: Adopted TUFLOW model parameters

Model Parameter	Proposed value and description
Topography	• 1 m DEM captured in February 2022 - PIL_ELEV_FMG_FFI_1M_DEM_FEB2022_trim.tif • 10 m photogrammetrically derived DEM – Landgate - Landgate_10m_mga50.tif
Cell size	• 5 m • Sub-Grid-Sampling (SGS) at 1 m enabled to capture sub-grid topography
Boundary Conditions	• Inflow: flow hydrographs sourced from RORB model (presented in Section 6.3) • Automated stage-discharge curve (HQ) with the stream bed slope used as a proxy for water surface slope.
Manning's '*n*' value (Depth Layer 1 (m), Manning's n Layer 1, Depth Layer 2 (m), Manning's n Layer 2)	• Clear alluvial areas (0.1, 0.1, 0.2, 0.03) • Low density vegetation (0.1, 0.1, 0.2, 0.05) • Medium density riparian vegetation (0.1, 0.1, 0.2, 0.06)
Design events (AEP)	• 50%, 20%, 10%, 5%, 2%, 1%, 1 in 200 and 1 in 500

7.4.1 Floodplain roughness

Floodplain roughness delineation was performed using Sentinel-2 satellite data. This satellite carries the Multispectral Image (MSI) and delivers 13 spectral bands ranging from 10 m to 60 m resolution.

10 m resolution data of the Study Area was extracted from data collected on the 16/06/2024 for the Coongan River model and 09/06/2024 for the Shaw River model with the B4 and B8 bands combined using the QGIS raster calculator function. This created a normalised vegetation index grid, representative of the changes in vegetation density and roughness across the study areas.

Aerial imagery of the site was compared with the vegetation index grid to determine the classification bands and assign a material ID corresponding to a Manning's '*n*' value. These values are representative of the vegetation roughness factor in the study area. Depth-varying roughness was assigned to areas of riparian vegetation, consistent with a Manning's '*n'* value of 0.06, and low density vegetation with a Manning's '*n*' values of 0.05.

This approach ensures a consistent floodplain roughness parametrisation across the site and reduces the bias associated with manual delineation. Figure 7-2 presents the Manning's '*n'* allocation based on the classification vegetation index grid. Priority was given to the classification to clear alluvial areas and riparian vegetation rather than accurate definition on hillslope areas due to the intent of the assessment and modelling methodology adopted (hydrograph application in the mainstream rather than rain on grid modelling).

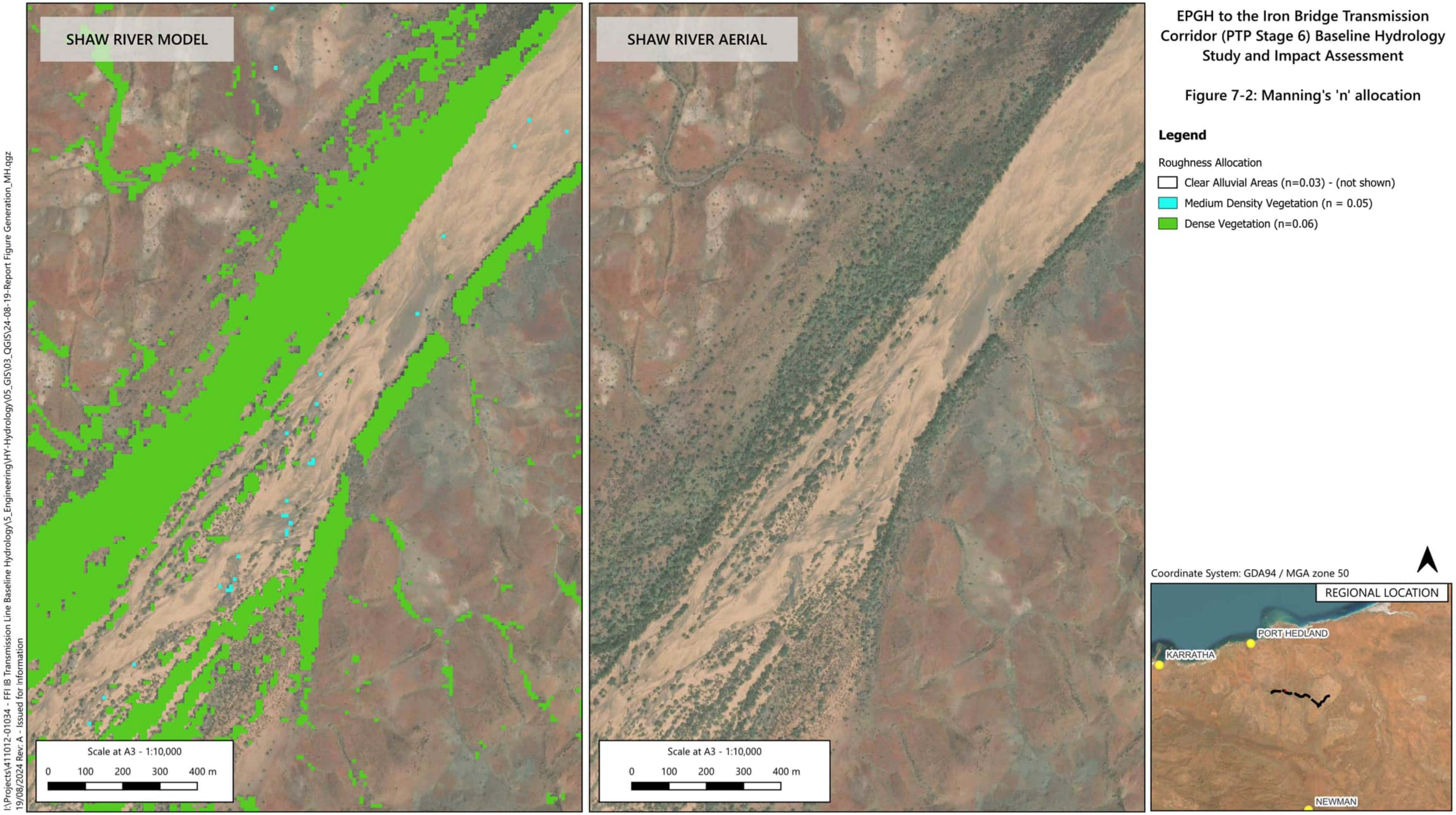

Figure 7-2: Manning's 'n' roughness delineation for model domains

7.5 Sensitivity analysis

A sensitivity analysis was completed on the model parameters and rainfall inputs to understand the sensitivity of the model to parameter uncertainties within the model and to assess the potential impacts of climate change through the proposed design life of the assets. The parameters for the sensitivity analyses are presented below.

7.5.1 Climate change

The sensitivity to climate change was undertaken utilising the predicted changes to rainfall intensity in accordance with ARR2019 guidance for the 2080 climate horizon using the Representative Concentration Pathways (RCP) 4.5 and 8.5 predictions.

The RCP proposed in this assessment are:

- RCP4.5 - which is described by the Intergovernmental Panel on Climate Change as an intermediate scenario. Emissions in RCP4.5 peak around 2040, then slowly decline. And,
- RCP8.5 - where emissions continue to rise throughout the 21st century. RCP8.5 is generally taken as the basis for worst-case climate change scenario.

The hydrological modelling for each model were updated to account for the potential climate change scenarios. The rainfall factors for both catchments are presented in Table 7-3.

This sensitivity analysis was used to determine if the predicted increase in flow estimates in the 2080 future climate scenarios would have a tangible impact on the flood elevations, extent and velocities, and hence pose any additional flood risk to the proposed infrastructure. The results of the climate change sensitivity analysis are presented in Section 8.3.1.

Table 7-3: Proposed design rainfall factors for climate change assessment

Design Horizon (Year)	RCP 4.5 – 2080	RCP 8.5 – 2080
2080	10.6%	19.4%

7.5.2 Hydraulic roughness

The sensitivity of the models to Manning's roughness values were assessed by varying the manning's 'n' values +/- 25% to assess the sensitivity on flow depth and velocity at the crossing locations. This varies from the +/- 20% proposed in the FFI – Hydrology and Flood Risk Assessment Requirements (FFI-0000-WM-SOR-0001_1) but aligns with recent studies completed for Fortescue. The proposed floodplain roughness values for the sensitivity analysis are presented in Table 7-4.

This sensitivity analysis was used to assess the result sensitivity to seasonal or annual variability in vegetative density. The results of the sensitivity analysis are presented in Section 8.3.2.

Table 7-4: Proposed floodplain roughness sensitivity analysis values

Description	Proposed Manning's '*n*' value	Manning's '*n*' Sensitivity Value (+/- 25%)
Clear alluvial areas or barren land	0.03	0.0225 / 0.0375
Low density riparian vegetation	0.05	0.0375 / 0.0625
Moderate density riparian vegetation	0.06	0.045 / 0.075

8. Results and discussion

8.1 Hydraulics summary

Peak flood depth and velocity mapping for the 10% AEP, 1% AEP and 1 in 500 AEP are presented in Appendix C. The results of the 1% AEP for the key water way crossings are presented in Figure 8-2 to Figure 8-7.

The flood modelling results predict that the creek crossings assessed have significant flood extents during the design 1% AEP flood event. The results present a number of locations were proposed pad and poles are proposed in areas of high hydraulic intensity (high velocity and/or deep flow depths). The pads located within the 1% AEP flood plain are presented in Table 8-1 and presented in Figure 8-1, with 12 pads of the 426 located within the floodplain. Further discussion on flood characteristics at each crossing is provided below and the qualitative impact assessment presented in Section 9.

Table 8-1: Proposed pads located within the 1% AEP flood extent

Crossing	Pads located within 1% AEP flood extent
Coongan River at PTP Stage 6	212, 213, 214
Coongan River at Alternative Alignment	407, 408
Camel Creek at PTP Stage 6	221, 222, 223
Glen Herring Creek at PTP Stage 6	206, 207
Glen Herring Creek at Alternative Alignment	-
Shaw River at PTP Stage 6	80, 81

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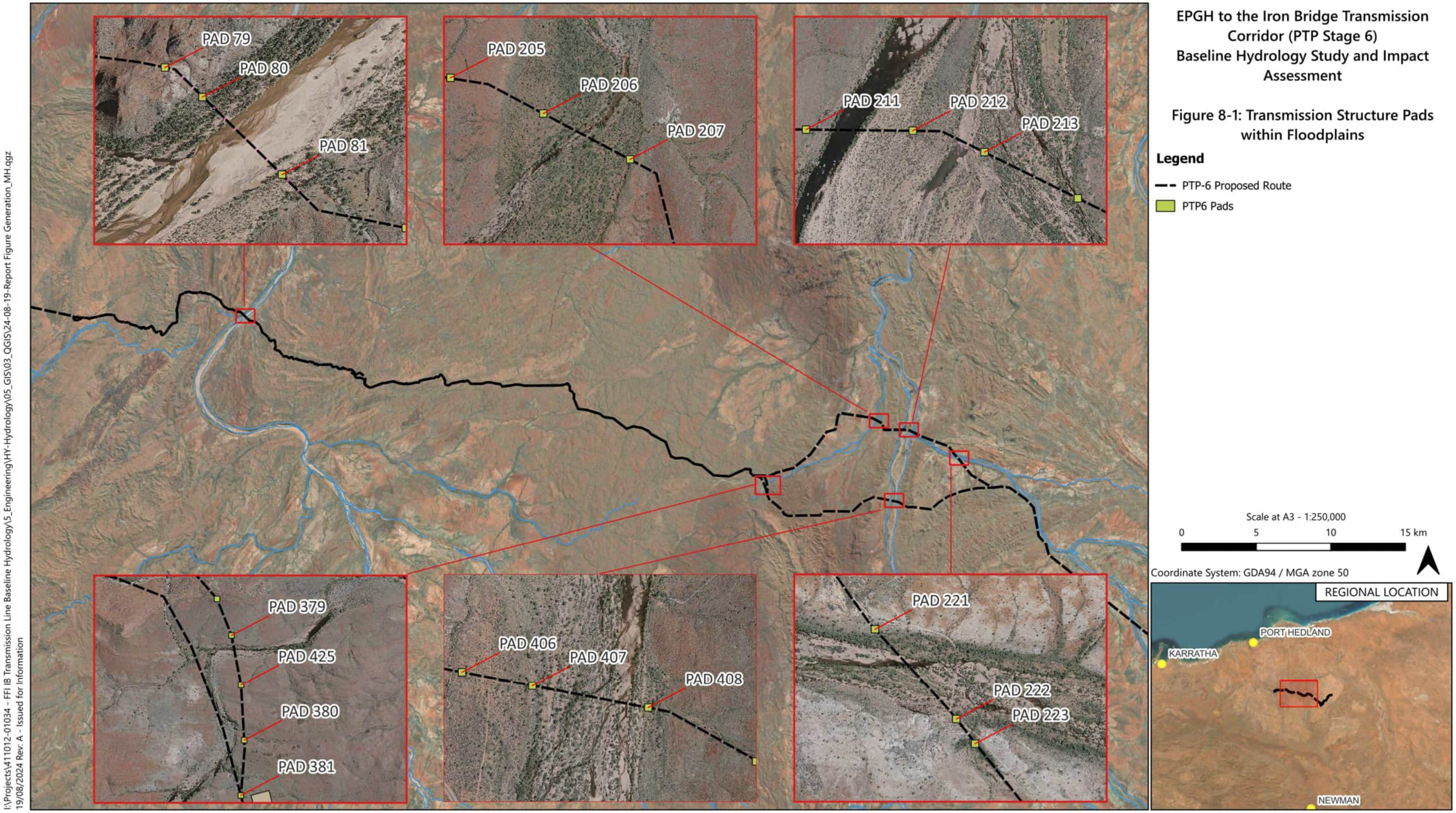

Figure 8-1: Transmission structure pads located within the potential floodplain

8.1.1 Coongan River

8.1.1.1 PTP 6 Crossing

The proposed crossing of the Coongan River along the PTP 6 alignment is located at the confluence of Camel Creek and the Coongan River. This location is expected to be a high energy environment with flows intersecting the alignment from the southern Coongan River and from the southeast via Camel Creek. Investigation into the flood modelling results indicates that at the waterway crossing, there is bifurcation of flows, with the majority of the flows from the Coongan River flowing on the western side of the centre island, while Camel Creek and floodplain flows for Coongan River dominate the eastern flow path. The flood extent in the 1% AEP event is approximately 1,220 m which includes the small island where bifurcation occurs. The flood modelling results for depth and velocity are presented in Figure 8-2. The current location of Pad 212, 213 and 214 is within the 1% AEP flood extent, with flood modelling results for the 1% AEP event presented in Table 8-2.

Table 8-2: Flood modelling results at PTP-6 Pad locations at the Coongan River crossing

Pad ID	1% AEP depth (m)	1% AEP velocity (m/s)
212	1.4	1.6
213	3.0	1.4
214	2.0	1.2

8.1.1.2 Coongan River Alternative Alignment

The PTP-6 alternative alignment crosses the Coongan River at a location where the 1% AEP flood extent is approximately 730 m. Flood modelling results for the 1% AEP are presented in Figure 8-3. At this location, there are two pads (Pad 407 and Pad 408) where transmission line structure systems are proposed. These systems are located within the 1% AEP flood extent and experience high flood depths (greater than 2 m) and velocities less than 2 m/s. The results at the pad locations are presented in Table 8-3.

Table 8-3: Flood modelling results at PTP-6 Alternative alignment pad locations at Coongan River

Pad ID	1% AEP depth (m)	1% AEP velocity (m/s)
407	2.4	1.5
408	4.1	2

8.1.2 Camel Creek

The Camel Creek crossing has three transmission line structure systems potentially located within the 1% AEP floodplain. The flood extent in the 1% AEP flood event is estimated to be 1,090 m. The flood results at this location are presented in Figure 8-4, with results at Pad 221, 222 and 223 presented in Table 8-4. Deeper, high velocity flows are located in the middle of the creek, with depths up to 4 m and velocities up to 2.8 m/s. The transmission line structure systems are located outside of this area, with velocities at all three locations less than 2 m/s. Pad 221 and Pad 222 experience higher flood depths (>1.5 m) in a 1% AEP flood event.

Table 8-4: Flood modelling results at PTP-6 Pad locations at the Camel Creek crossing

Pad ID	1% AEP depth (m)	1% AEP velocity (m/s)
221	1.5	1.2
222	2.2	0.6
223	0.6	0.3

8.1.3 Glen Herring Crossing

8.1.3.1 PTP6 Crossing

The Glen Herring Creek crossing has two proposed transmission line structure systems potentially located within the 1% AEP flood extents, Pad 206 and 207. The estimated flood extent at the crossing is approximately 660 m. The flood depths and velocities for the 1% AEP are presented in Figure 8-5 and Table 8-5. Pad 207 is currently located in a low flow channel and will be subject to flooding in all flow events within the creek.

Table 8-5: Flood modelling results at PTP-6 Pad locations at Glen Herring Creek crossing

Pad ID	1% AEP depth (m)	1% AEP velocity (m/s)
206	1.5	0.7
207	3.1	1.1

8.1.4 Alternative Alignment 1 and 2

The PTP 6 Alternative alignment divides into two separate alignments at the Glen Herring Creek Crossing. This section of Glen Herring Creek is constrained, resulting in high velocities within the channel. The hydraulic results are presented in Figure 8-6. The western alignment does not contain any proposed pad locations for transmission line structure system and the eastern alignment spans over Glen Herring Creek and does not interact with the predicted mainstream flood extent. The flood extent following the western alignment is approximately 450 m, while the eastern alignment is approximately 65 m.

8.1.5 Shaw River Crossing

The Shaw River is a significant river crossing with a flood extent of approximately 700 m width at the proposed crossing location. Flood depths at the crossing exceed 6 m and velocities are up to 2.6 m/s. Flood modelling results for the 1% AEP event are presented in Figure 8-7. Due to the topography of the river, greater flow depths and higher velocities are contained to the main low flow channel. The hydraulic results for Pad 80 and 81 are provided in Table 8-6.

Table 8-6: Flood modelling results at PTP-6 Pad locations across the Shaw River

Pad ID	1% AEP depth (m)	1% AEP velocity (m/s)
Pad 80	4.9	1.6
Pad 81	4.3	2.0

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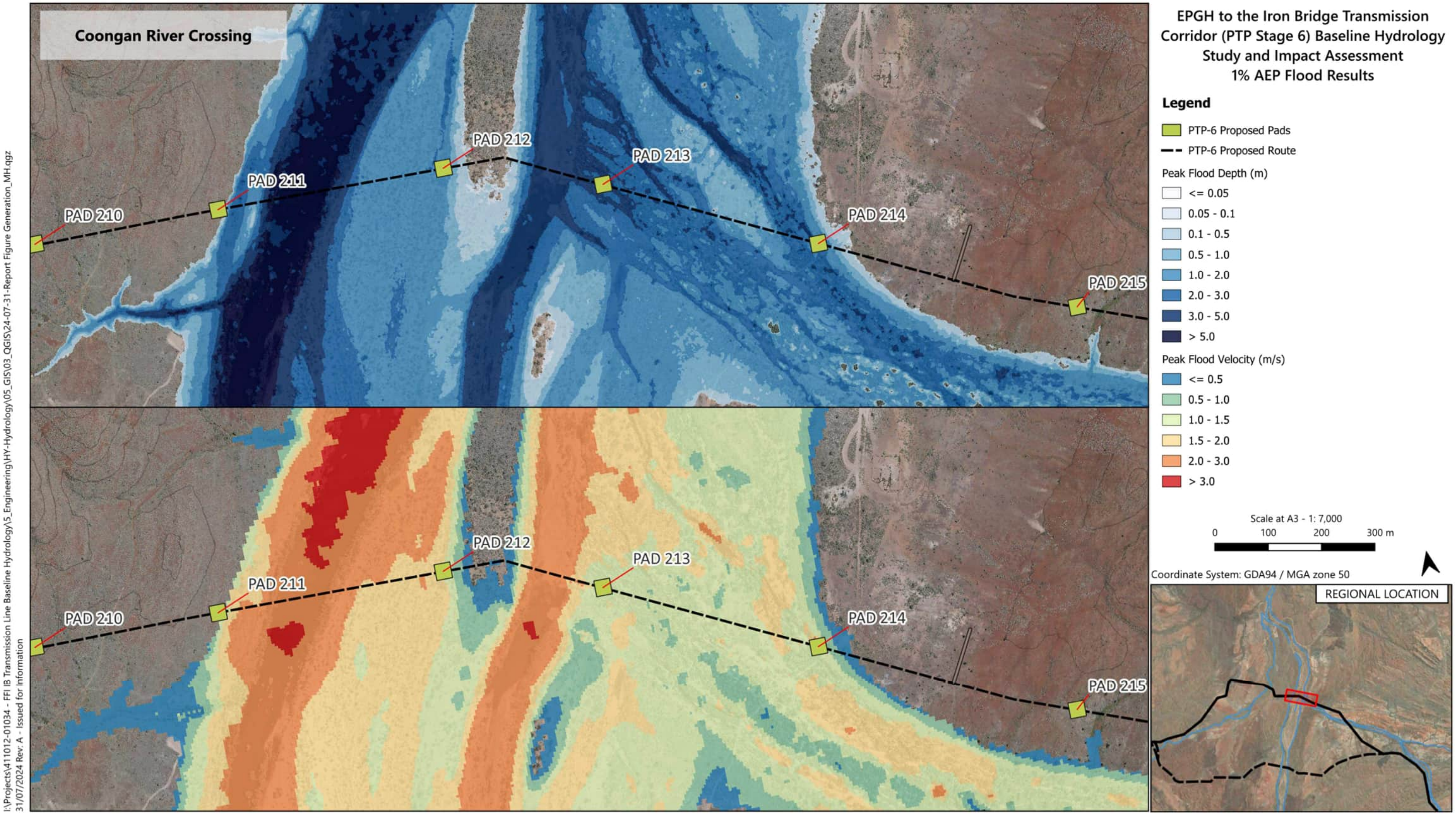

Figure 8-2: 1% AEP results at Coongan River on the PTP 6 alignment

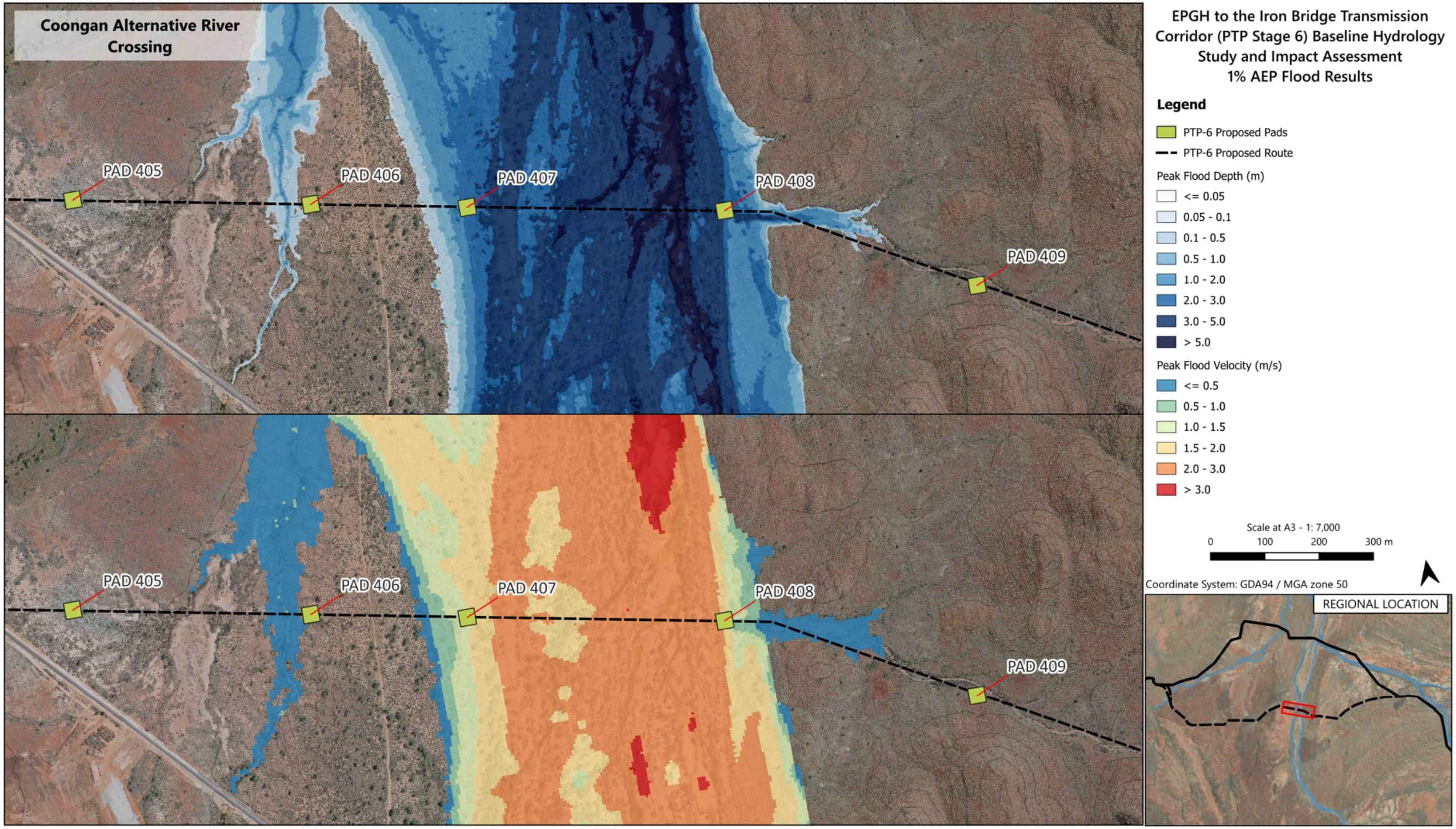

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Figure 8-3: 1% AEP results at Coongan River on the PTP 6 alternative alignment

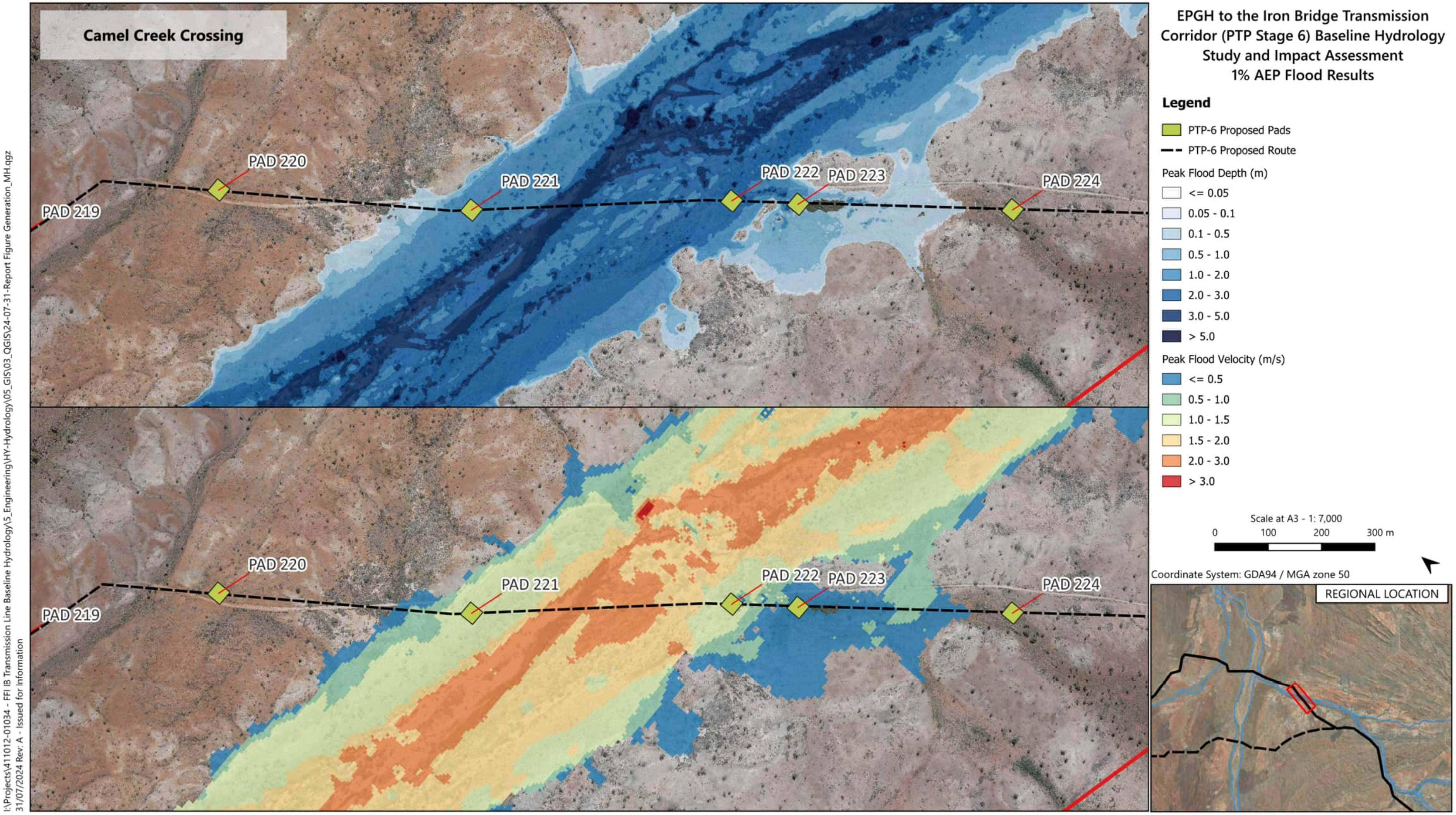

Figure 8-4: 1% AEP results at Camel Creek on the PTP 6 alignment

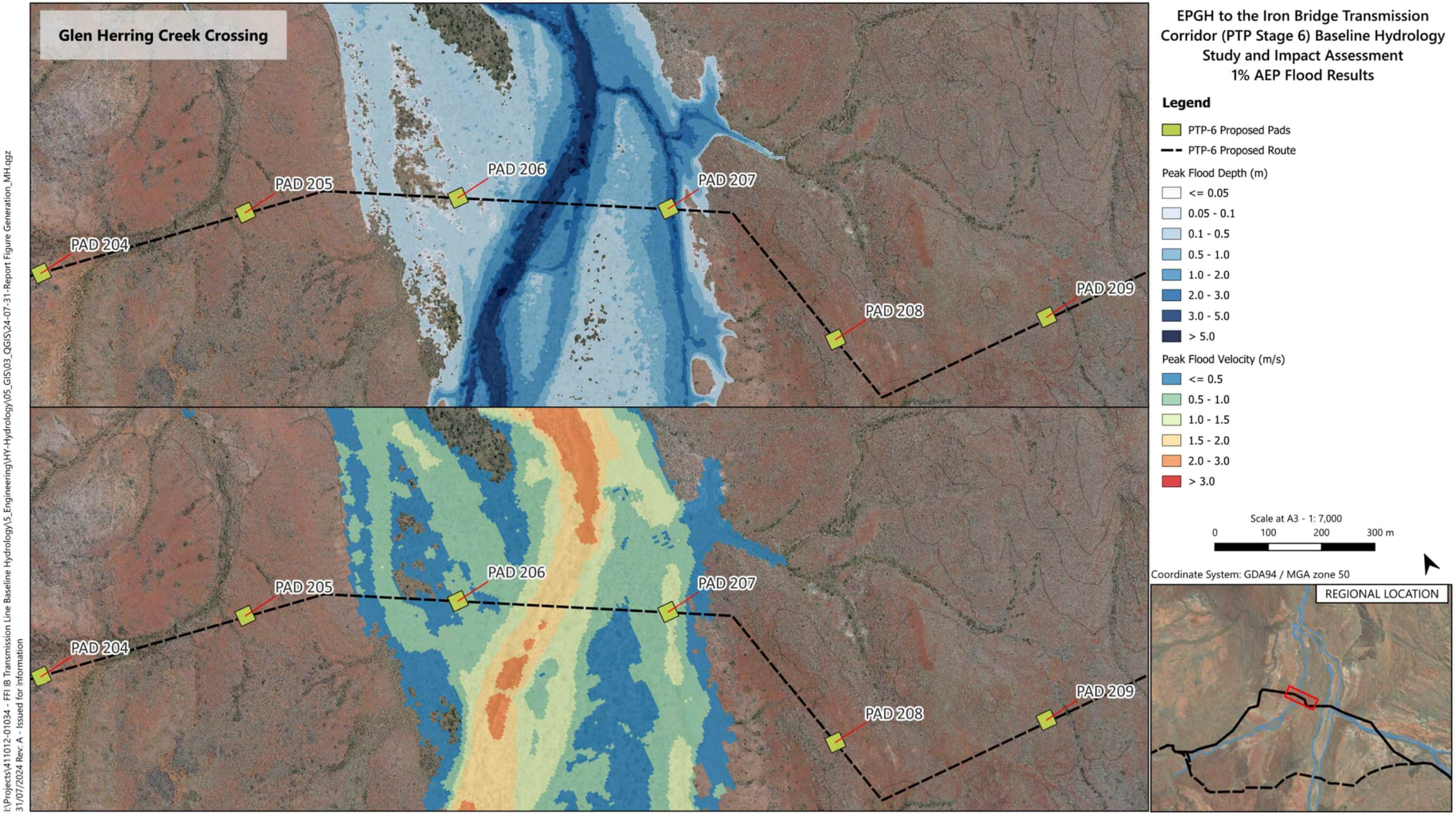

Figure 8-5: 1% AEP results at Glen Herring Creek on the PTP 6 alignment

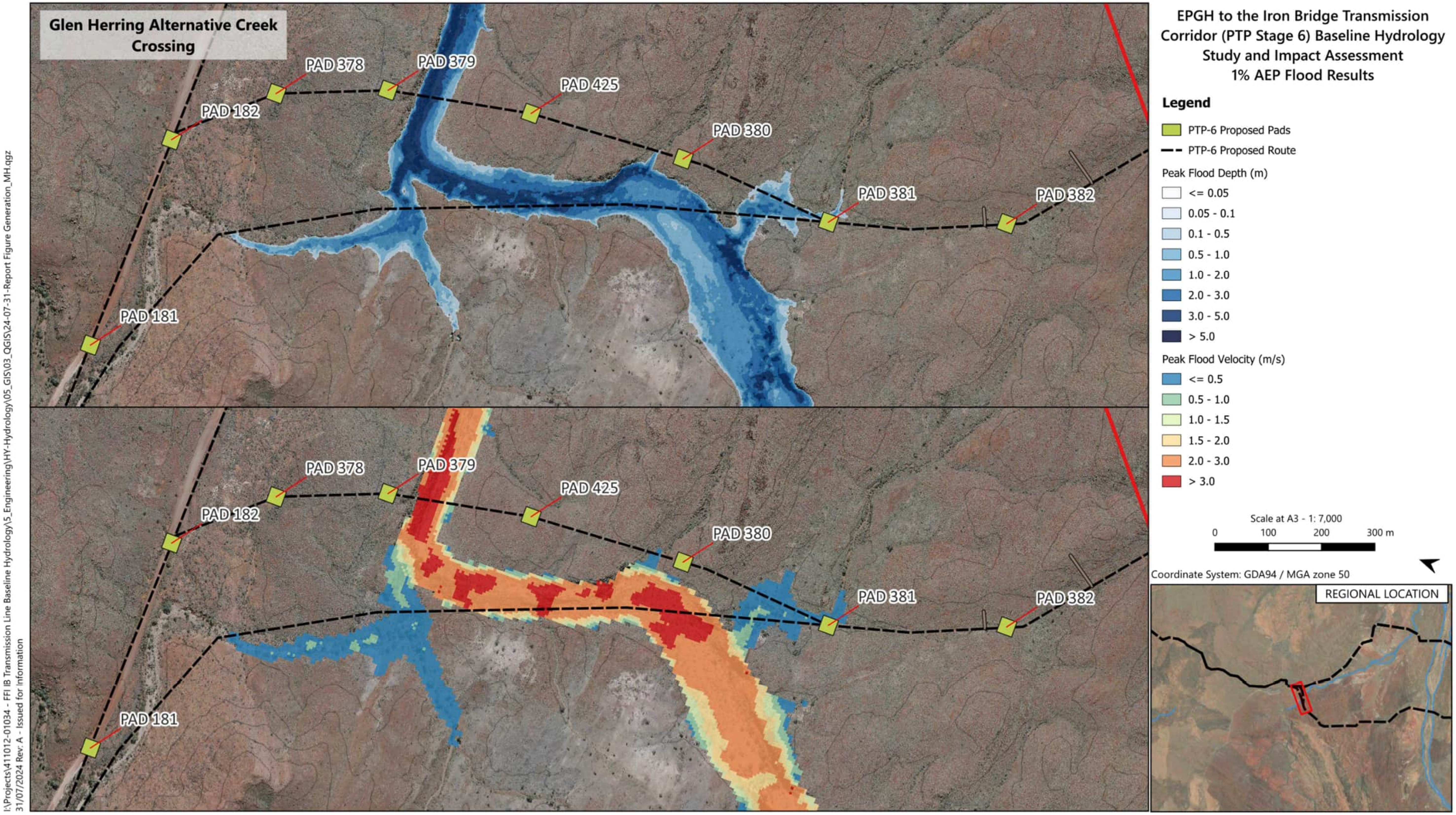

Figure 8-6: 1% AEP results at Glen Herring Creek Crossing on the PTP 6 alternative alignment

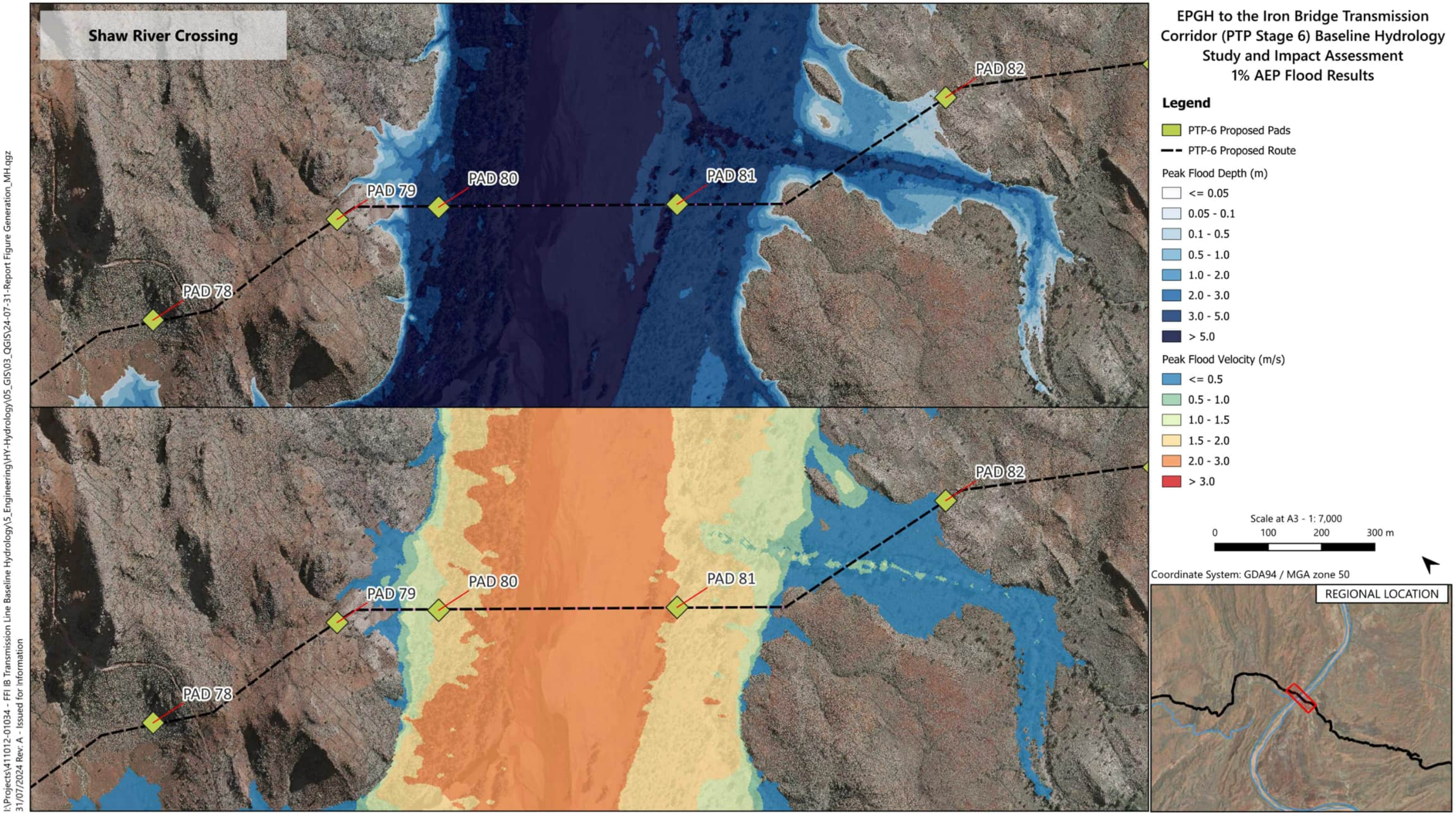

Figure 8-7: 1% AEP results at Shaw River on the PTP6 Alignment

8.2 Accuracy Limitations

The assessment outcomes and associated data in this report are based on information from Fortescue Energy, external sources, as well as that available in the public domain at the time or times outlined in this report.

The results of the hydraulic assessment are therefore inherently reliant on the accuracy of the available input data. For example, the spatially varying vertical accuracy of the photogrammetrically-derived DEMs across the model domain may have an impact on the absolute vertical accuracy of peak flood level results would be commensurate with the accuracy of the baseline topographic dataset.

8.3 Sensitivity Analysis

The following sections documents the results of the sensitivity analysis completed for the proposed waterway crossings.

8.3.1 Climate Change Assessment

The impact on hydraulics as a result of climate change are presented at each of the crossings in Table 8-7. The climate change scenarios result in changes in water depths up to 1.3 m, and velocities up to 0.5 m/s. These changes represent the maximum values along the creek crossing and will likely be the largest changes along the sections. Flood extent differences were also analysed, with flood extents increasing by up to a maximum of 100 m in the RCP 4.5 scenario, with no additional pads impacted. In the RCP 8.5 scenario, an additional pad, pad 406, was impacted due to a new section of floodplain being inundated on the Coongan River resulting in the flood extent increasing by 520 m.

The results indicate that the some of the crossings are more sensitive to changes to the predicated increase in peak flows as a result of climate change.

Table 8-7: Results of the sensitivity analysis completed for the climate change

Location	Baseline condition				2080 (RCP 4.5)				2080 (RCP 8.5)			
	Flow (m^3/s)	Level (mAHD)	Peak Velocity (m/s)	Extent (m)	Flow (m^3/s)	Level (mAHD)	Peak Velocity (m/s)	Extent (m)	Flow (m^3/s)	Level (mAHD)	Peak Velocity (m/s)	Extent (m)
Coongan River at PTP Stage 6	5,041	201.8	2.9	1,220	7,954 (58%)	202.6 (+0.8 m)	3 (+0.1 m/s)	1,270 (+50 m)	9,078 (80%)	203 (+1.2m)	3.1 (+0.2 m/s)	1,290 (+70 m)
Coongan River at Alternative Alignment	4,622	210.1	2.9	730	6,868 (49%)	211.0 (+0.9m)	3.3 (+0.4 m/s)	830 (+100 m)	7,943 (72%)	211.4 (+1.3m)	3.4 (+0.5 m/s)	1,250 (+520 m)
Camel Creek at PTP Stage 6	1,563	210.3	2.5	1,090	2,001 (28%)	210.9 (0.4m)	2.6 (+0.1 m/s)	1,110 (+20m)	2,268 (45%)	210.7 (+0.4m)	2.7 (0.2 m/s)	1,260 (+170 m)
Glen Herring Creek at PTP Stage 6	710	200.8	1.9	660	1,095 (54%)	201 (+0.2m)	2.2 (+0.3 m/s)	680 (+20 m)	1,222 (72%)	201.2 (+0.4m)	2.3 (+0.4 m/s)	690 (+30 m)
Shaw River at PTP Stage 6	7,274	159.8	2.6	720	8,998 (24%)	160.5 (+0.7m)	2.8 (+0.2 m/s)	775 (+55 m)	10,515 (45%)	161 (+1.2m)	3.0 (+0.4 m/s)	790 (+70 m)

8.3.2 Hydraulic roughness

The adoption of a 25% increase in floodplain roughness across the model domains has resulted in increased flood levels at the crossing locations as is to be expected. The changes in level at the waterway crossings is presented in Table 8-8. The small increase in flood level, does not change the flood extents significantly (maximum change of 55 m) and impact the result of the qualitative impact assessment presented in Section 9.

Based on the results of the sensitivity assessment, it is expected that the inter-seasonal annual variability in vegetation density and hence potential variability in floodplain roughness across the study area is not likely to impact the placement of pads associated with the transmission line. The sensitivity to floodplain roughness was predicted to be considerably higher in the Shaw River (0.7 m increase) and at the Coongan River crossing on the alternative alignment (0.5 m increase), final placement of the pads should consider these potential increases.

Table 8-8: Results of sensitivity analysis completed for hydraulic roughness

Location	Base case		-25%		+25%	
	Water Level (m)	Extent (m)	Water Level (m)	Extent (m)	Water Level (m)	Extent (m)
Coongan River @ PTP Stage 6	201.8	1,220	201.5 (-0.3 m)	1,185 (-35 m)	202.1 (+0.3 m)	1,250 (+30 m)
Coongan River @ Alternative Alignment	210.1	730	209.6 (-0.5 m)	700 (-30 m)	210.6 (+0.5 m)	770 (40 m)
Camel Creek @ PTP Stage 6	210.3	1,090	209.9 (-0.4 m)	975 (-115m)	210.6 (+0.3 m)	1,110 (+20 m)
Glen Herring Creek @ PTP Stage 6	200.8	660	200.6 (-0.2 m)	580 (-80 m)	200.9 (+0.1 m)	675 (+15 m)
Shaw River @ PTP Stage 6	159.8	720	159 (-0.8 m)	690 (-30 m)	160.5 (+0.7 m)	775 (55 m)

9. Qualitative impact assessment

This section outlines the qualitative impact assessment completed for the PTP6 Transmission line. The PTP6 Transmission line is the 130 km 220 kv double circuit overhead transmission line that connects EPGH to the Iron Bridge magnetite mining site. The crossings investigated within this study account for ~4% of the total transmission line.

The major waterway crossings assessed in this report, as noted in Section 8, have proposed transmission line structures located within the 1% AEP flood extent. The transmission line structures are proposed to have a base diameter of 2.15 m, with general arrangement drawings presented in Appendix D. As a result of the structures being within the floodplain, the following impacts may occur:

- **Minor increases in flood levels upstream of structures:** The location of proposed transmission line structures within the creek may have a minor impact on flood levels within the waterways during the operational life of the structures. The changes in flood levels are likely to be minor due to the expansive floodplains at these crossing locations and the relatively minor reduction in flow area resulting from the inclusion of the small number of 2.15 m diameter transmission line structures within the respective flow areas. Where possible, these structures have also been located outside of the 1% AEP to mitigate this risk or in areas of low hydraulic energy, which limits the potential impacts on peak flood behaviour. It is expected that impacts will be localised around the crossing and not result in changes to the broader flood extent. Recommendations in Section 11, if implemented, will also reduce the number of structures within the 1% AEP floodplain. Table 9-1 presents the estimated reduction in available flow area with the inclusion of the transmission line structures and the estimated increase in water level based on a desktop assessment.

Table 9-1: Estimated reduction in flow area and resulting water level increase

Location	Estimated reduction in flow area	Estimated water level increase (m)
Coongan River @ PTP Stage 6	0.5%	< 0.02
Coongan River @ Alternative Alignment	0.5%	< 0.03
Camel Creek @ PTP Stage 6	0.3%	< 0.01
Glen Herring Creek @ PTP Stage 6	1.2%	< 0.03
Shaw River @ PTP Stage 6	0.6%	< 0.03

- **Scour potential:** The location of structures within a waterway will have the potential to cause localised scour around the structure during the operational life of the structure. The degree of localized scour will be dependent on a combination of the geomaterials at the proposed structure locations and hydraulic energies. The current locations of structures in general avoid or could be relocated to avoid (see Section 11) locations of higher scour potential (high velocity areas). Where high scour potential sites cannot be avoided, scour protection measures such as rock protection/riprap can be included where required to mitigate the potential impact of scour on the structures themselves and the surrounding environment.

- **Alterations to flow paths:** The inclusion of transmission line structures has the potential to alter the natural flow of water, potentially leading to erosion or sediment deposition in new areas during the operational life of the structures. In general, the structures are located outside of the thalweg and are unlikely to impact on more frequent flows. The location of Pad 207 within Glen Herring Creek and Pad 214 within the Coongan River intersect the low flow channels and have the potential to cause impacts on flow behavior in all events. It is recommended to relocate these pads onto the floodplain or outside of the 1% AEP flood extent. Other recommendation to reduce the number of structures within the 1% AEP floodplain and the potential for alterations to flow paths are provided in Section 11.
- **Vegetation Impact:** The clearing of vegetation required for the construction of the transmission line may have an impact at and around the pad locations. These areas represent a small portion of the creek and are not densely vegetated. It is noted that the expected vegetation impact will be temporary, and any minor loss of vegetation is expected to be restored within a short period.
- **Water Quality:** There is not expected to be significant impact on water quality due to the construction of transmission line structures. Brief increases in sediment loads may occur as a result of construction activities, but in the context of natural catchment sediment loads, this impact is expected to be near intangible and could be adequately managed through standard construction phase erosion and sediment control principles.

Outside the waterway crossings investigated in this baseline hydrology study, the majority of the PTP6 transmission line is located in catchment headwaters or along catchment divides. Other waterway crossings of the transmission line will be minor and can be managed by local surface water management plans as required.

10. Conclusion

This study represents a baseline assessment of the hydrological and hydraulic conditions for the major waterway crossings for the PTP6 Transmission line and an alternative alignment provided by Fortescue at Coongan River. The assessment undertaken involved a review of available data, regional hydrologic characterisation of the catchment and hydrologic/hydraulic modelling. The methods and data adopted are consistent with ARR2019 (Ball et al., 2019), the latest industry guidance on the derivation of hydrological estimates and flood risk.

The following conclusions were found as a result of the study:

- Six waterway crossings were selected for investigation based on expected flood extent and the likelihood of transmission line structure systems being located within the flood plains with the standard 400 m spacing.
- A regional hydrological analysis was completed for the Shaw and Coongan River catchments with the aim of selecting empirical loss parameters for the region. A FFA and hydrological modelling was completed for the Coongan River at the Marble Bar streamflow gauge and the Shaw River at the North Pole Mine stream flow gauge. Empirical loss values were selected for each catchment which provided similar estimates for the 1% AEP flood event and other events where possible. Empirical loss values of 20 mm IL_S and 7 mm/hr *CL* were selected for the Coongan River and of 20 mm IL_S and 6 mm/hr *CL* for the Shaw River. The losses provided suitable estimates for the 1% AEP based on the available datasets, though underestimated flows for lower magnitude events and potentially overestimated the flows in larger magnitude events, based on FFA estimates. It is noted that large magnitude flow estimates from the FFA are themselves subject to some uncertainty due to the length of record and uncertainties around rating quality.
- The empirical losses derived above were applied to localised hydrology models to calculate hydrographs at the six selected waterway crossings. A comparison of peak flows was completed and low magnitude events up to the 10% AEP event (Coongan River) and 5% AEP (Shaw River) were scaled to FFA estimates from the relevant catchments.
- Hydraulic modelling was completed to determine the hydraulic characteristics within the waterway crossings of interest. A list of the transmission line structure systems within the 1% AEP flood extent is presented below, with detailed hydraulic results presented in Section 8.
  - Coongan River at PTP 6 alignment – Pad 212, 213 and 214
  - Coongan River at alternative alignment – Pad 407 and 408
  - Camel Creek at PTP 6 alignment – Pad 221, 222 and 223
  - Glen Herring Creek at PTP6 alignment – Pad 206 and 207
  - Shaw River at PTP 6 alignment – Pad 80 and 81

- Generally, the locations of the pads (and proposed transmission line structure systems) were located on the flood plain of the waterway crossings and were not exposed to high velocities and depths experienced in the main low flow channel.
- A sensitivity analysis to account for potential climate change scenarios and changes in hydraulic roughness resulting from differing vegetation conditions was completed. The results indicate that some crossings were more sensitive to these changes. Larger changes in peak water levels were predicted in the Coongan and Shaw Rivers, though it is not expected that these changes will result in additional pads being located within the 1% AEP floodplain (with the exception of the Alternative Coongan River crossing where Pad 406 is impacted in the RCP 8.5 Climate Change scenario).
- A qualitative impact assessment was completed for the proposed transmission line alignment and associated structures. The impact assessment identified the following potential impacts:
    - Changes in water level: There is potential for changes in water level upstream of the proposed structures. It is expected that due to the expansive size of the waterway crossings and the relatively small size of the structures, these changes in water level will be localised and minor.
    - Scour potential: There is potential for scour to occur at structures located within the flood extent. The location of the poles are outside of the main flow path, which limits the potential for scour in small to medium events. Scour potential in larger events can be managed through the use of rock protection and other design elements.
    - Alterations to flow paths: Due to the relatively small footprint of the structure on the broader floodplain, it is unlikely that there will be significant changes to the flow paths. Pad 207 and Pad 214 may encroach on low flow channels and may be required to be moved to prevent scour and alterations to flow paths.
    - Vegetation impact: The current locations of the proposed structure are typically outside of areas of high vegetation density. It is unlikely that there will be a significant impact to riparian vegetation.
    - Water Quality: There is not expected to be a significant impact to water quality as a result of the transmission line structures being located in the 1% AEP flood extent. Increased sediment loads may occur as a result of construction activities, but could be adequately managed through standard construction phase erosion and sediment control principles.

11. Recommendations

Based on the results of the baseline hydrology and hydraulics study and qualitative impact assessment, the following recommendations are proposed for incorporation into the project:

- The location of Pad 207 within Glen Herring Creek and Pad 214 within the Coongan River intersect the low flow channels and have the potential to cause impacts downstream. It is recommended to relocate these pads onto the floodplain or outside of the 1% AEP flood extent. This can be catered by moving the structures within the standard 400 m maximum span. Figure 11-1 presents the alternative spacing potential for the Glen Herring Crossing.
- Based on advice from Fortescue Energy, the span for the transmission line can be extended to 600 m at specific locations. This is recommended for the Coongan and Shaw River Crossings on the PTP6 Alignment. For the Shaw River the pads/structure locations can be spaced at 600 m to avoid the high velocity and depth areas as presented in Figure 11-2. For the Coongan River, the increase in span distance can be utilised to avoid some structures being located within the 1% AEP flood extent. The placement of the structures could be located on the island formed by the bifurcation of flows which may reduce the risk associated with Pad 212. There is still likely to be one structure within the main creek as the eastern section of river extent is greater than 700 m. This structure should be placed avoiding high risk areas, such as low flow channels and areas of high velocity. A proposed solution is presented in Figure 11-3. This could also be incorporated at the Camel Creek crossing to reduce hydraulics experienced at Pad 221 and 222 (Figure 11-4).
- For the alternative alignment, it is recommended that the increased span of 600 m is utilised over the Coongan River. This will allow for one structure to be located outside the 1% AEP flood extent, or both structures to be exposed to reduce flood depths and velocities. An example of the relocation is presented in Figure 11-5.
- There are two potential crossing locations for the Glen Herring Creek on the alternative alignment. The eastern alignment is preferred as the alignment spans over the creek. Alterations to the western alignment would be required to avoid placement of pads / structures within the high energy flow paths. Potential location of the western alignment pad / structures is presented in Figure 11-6.
- Based on this baseline hydrology study and impact assessment, not considering other disciples, the alternative alignment provides a route with the least amount of interaction with significant creek crossings with only two pads required in the 1% AEP flood plain for the crossings investigated. The main alignment with the recommended modifications will still have up to four pads located within the 1% AEP floodplain.
- Geotechnical and geomorphological investigation is recommended to identify potential channel migration pathways which may impact the outcomes of this assessment. This is particularly relevant to locations where pole locations are located on mobile bed material.

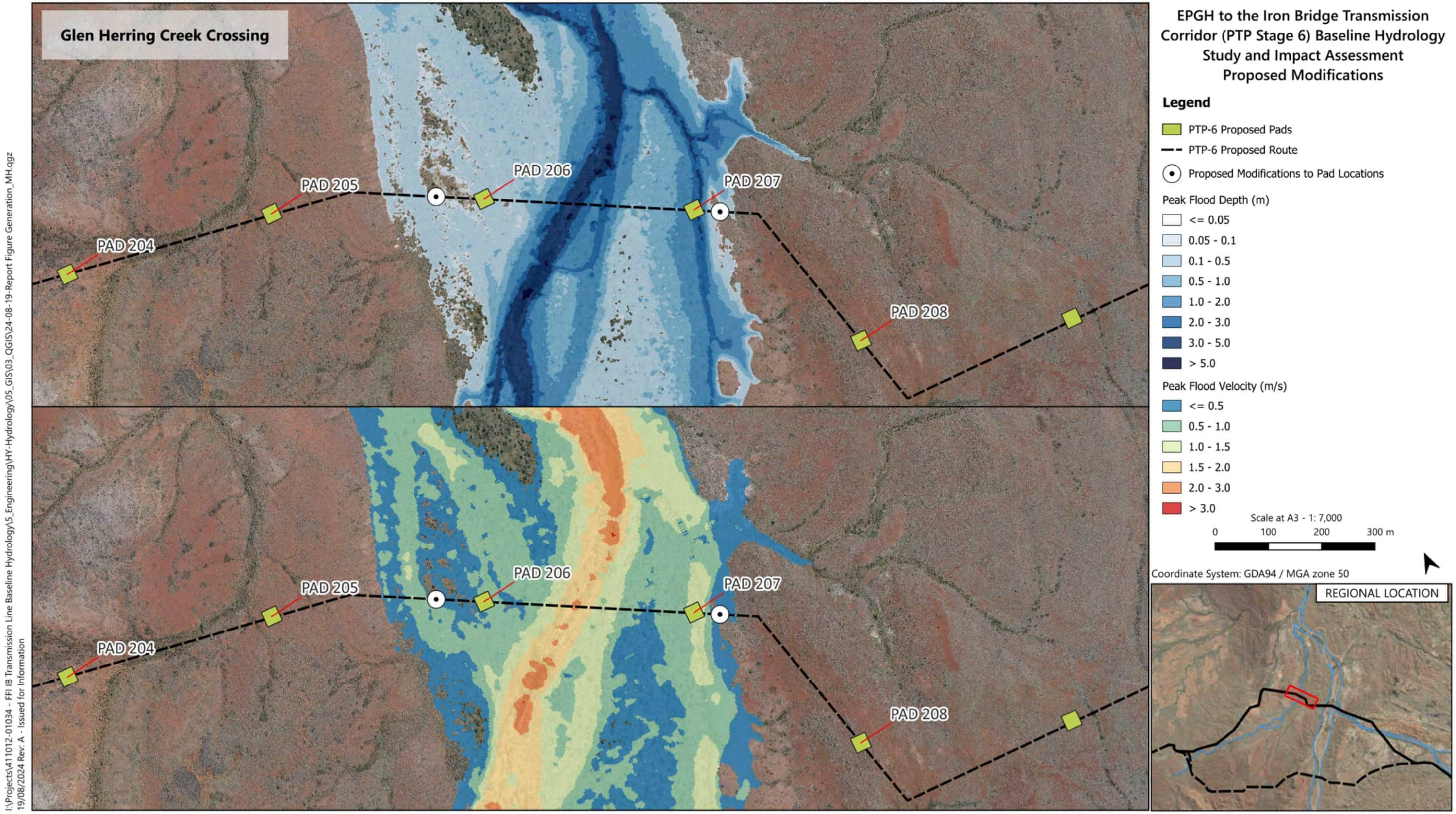

Figure 11-1: Potential modifications for Pad 206 and 207 at Glen Herring Crossing

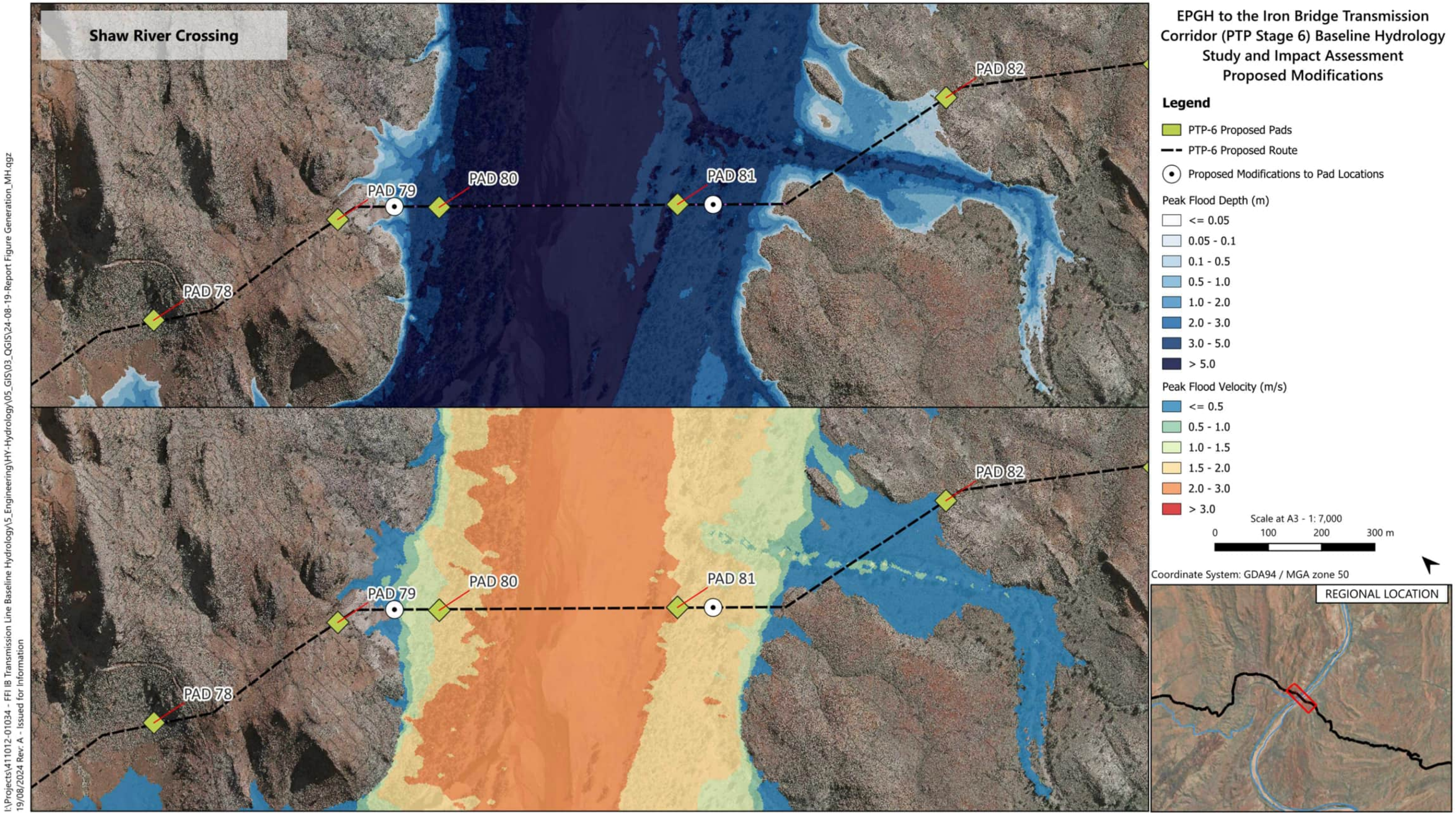

Figure 11-2: Potential relocation of Pad 80 and Pad 81 within the Shaw River waterway crossing

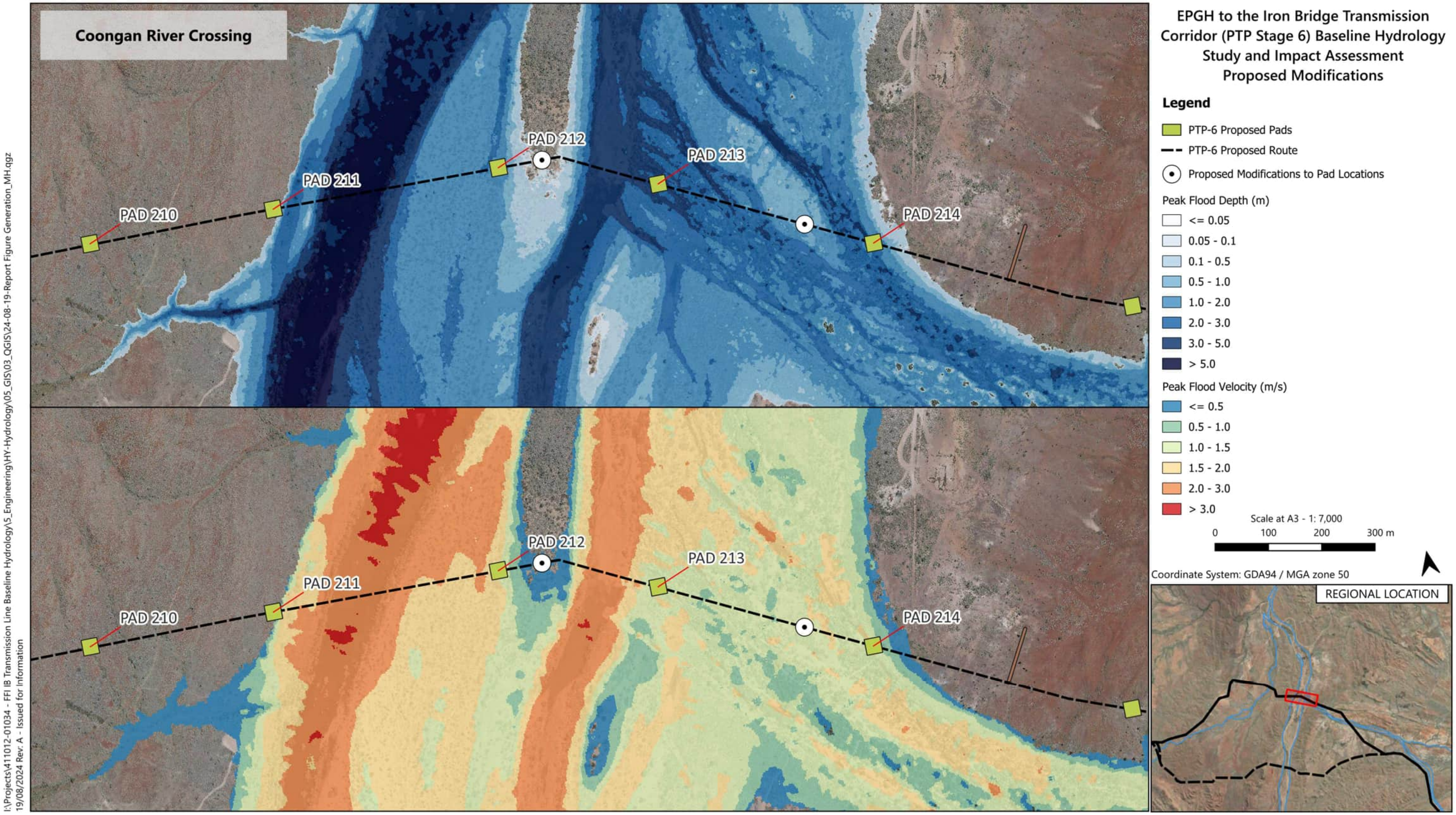

Figure 11-3: Potential modifications for Pad 212 and 213 at Coongan River Crossing

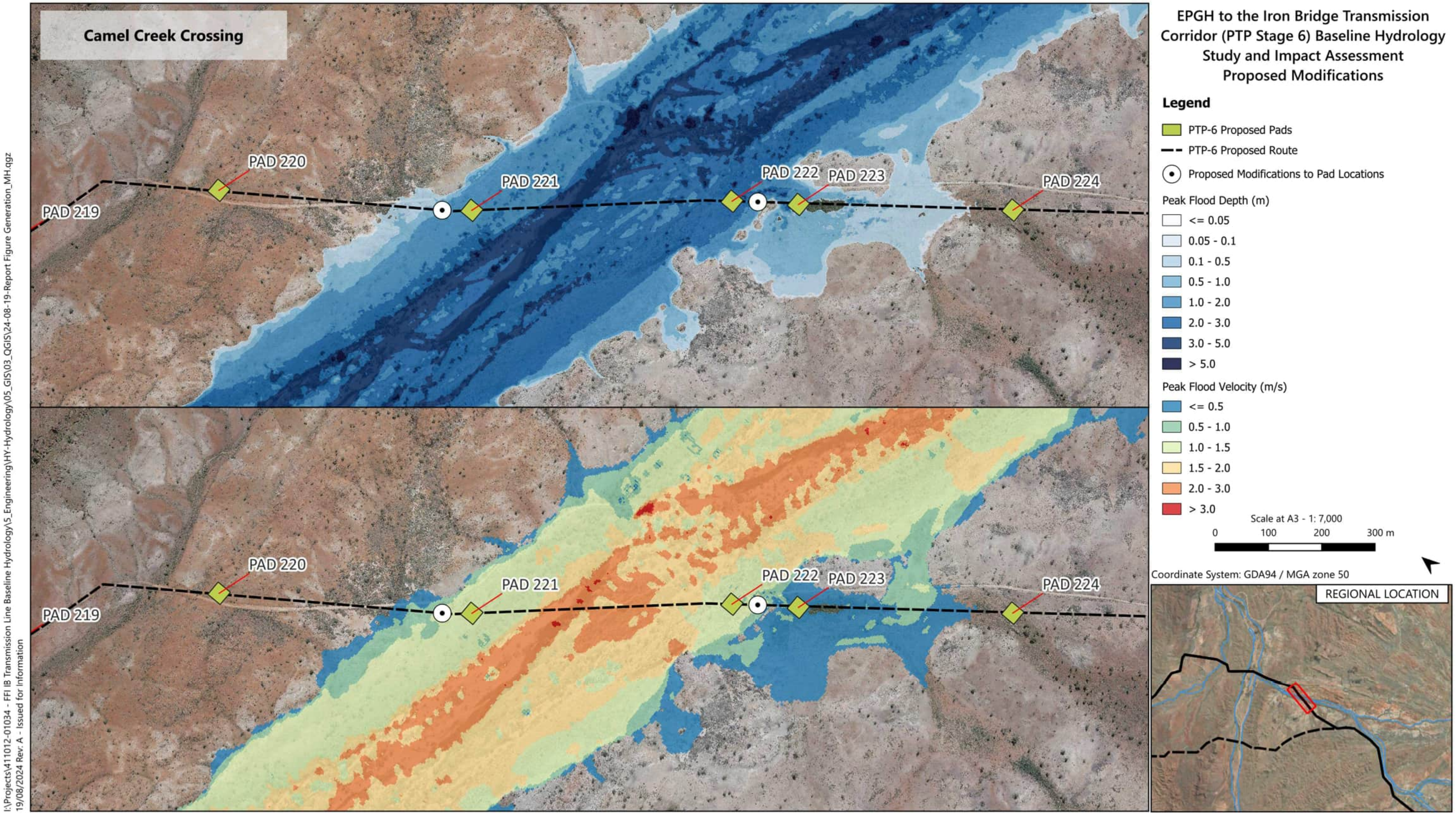

Figure 11-4: Potential modifications for Pad 221 and 222 at Camel Creek Crossing

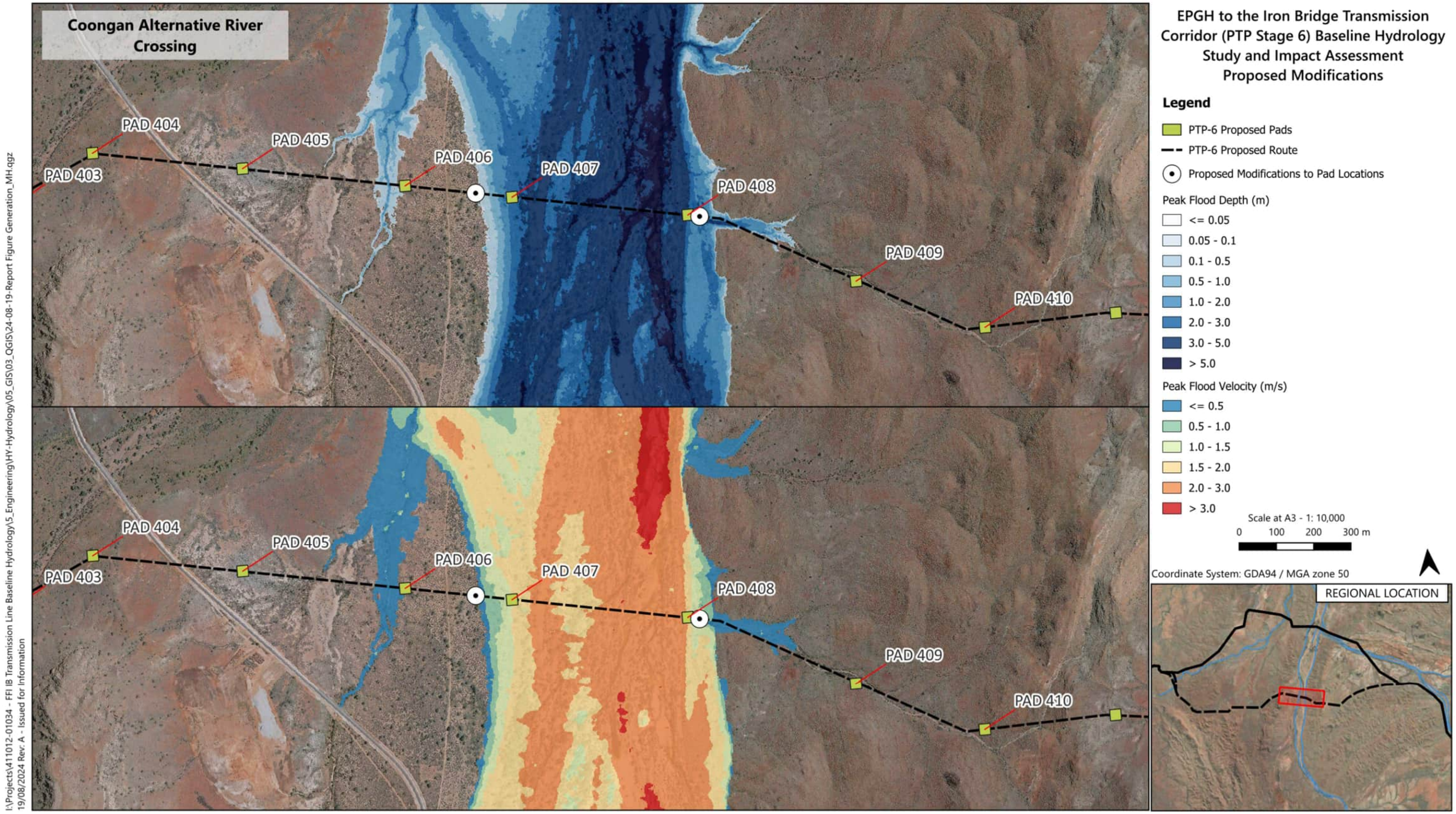

Figure 11-5: Potential modifications for Pad 407 and 408 at the alternate crossing of Coongan River

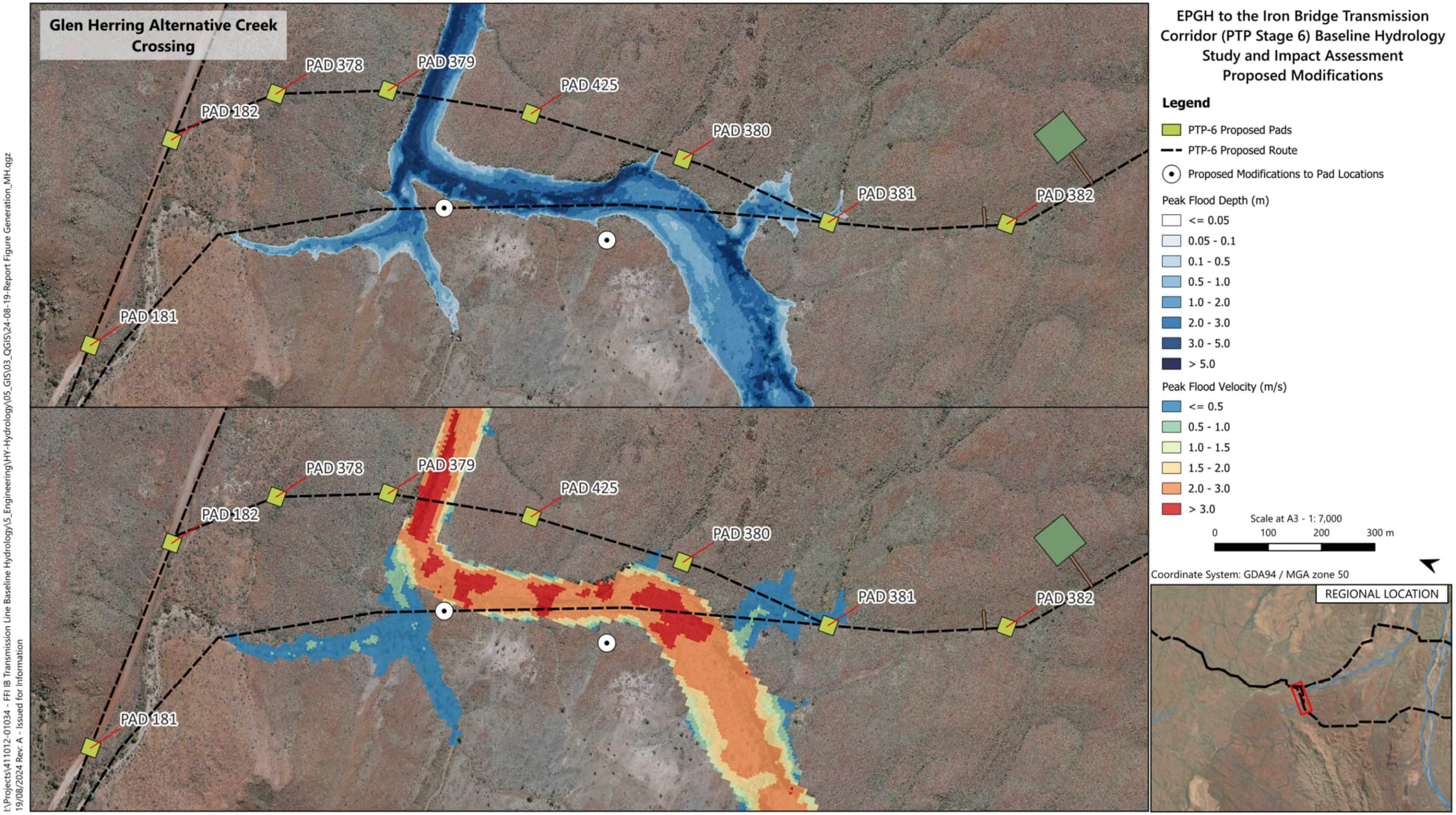

Figure 11-6: Potential locations for pads on the alternative alignment Glen Herring Creek

12. References

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Appendix A. IFD for RORB Catchments

IFD for Coongan and Shaw catchments

IFD for Coongan River RORB model

Extracted from: 21.6125°S, 119.7875°E

Duration (hours)	Rainfall Total (mm)							
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.50% AEP	0.20% AEP
12	57.4	88	111	134	168	195	223	264
18	64.2	99.8	126	154	194	225	257	303
24	69.3	109	138	169	211	245	279	329
30	73.3	115	146	179	223	259	296	344
36	76.7	121	153	187	232	269	306	353
48	81.9	129	163	198	244	280	317	363
72	89	139	174	209	255	289	324	370

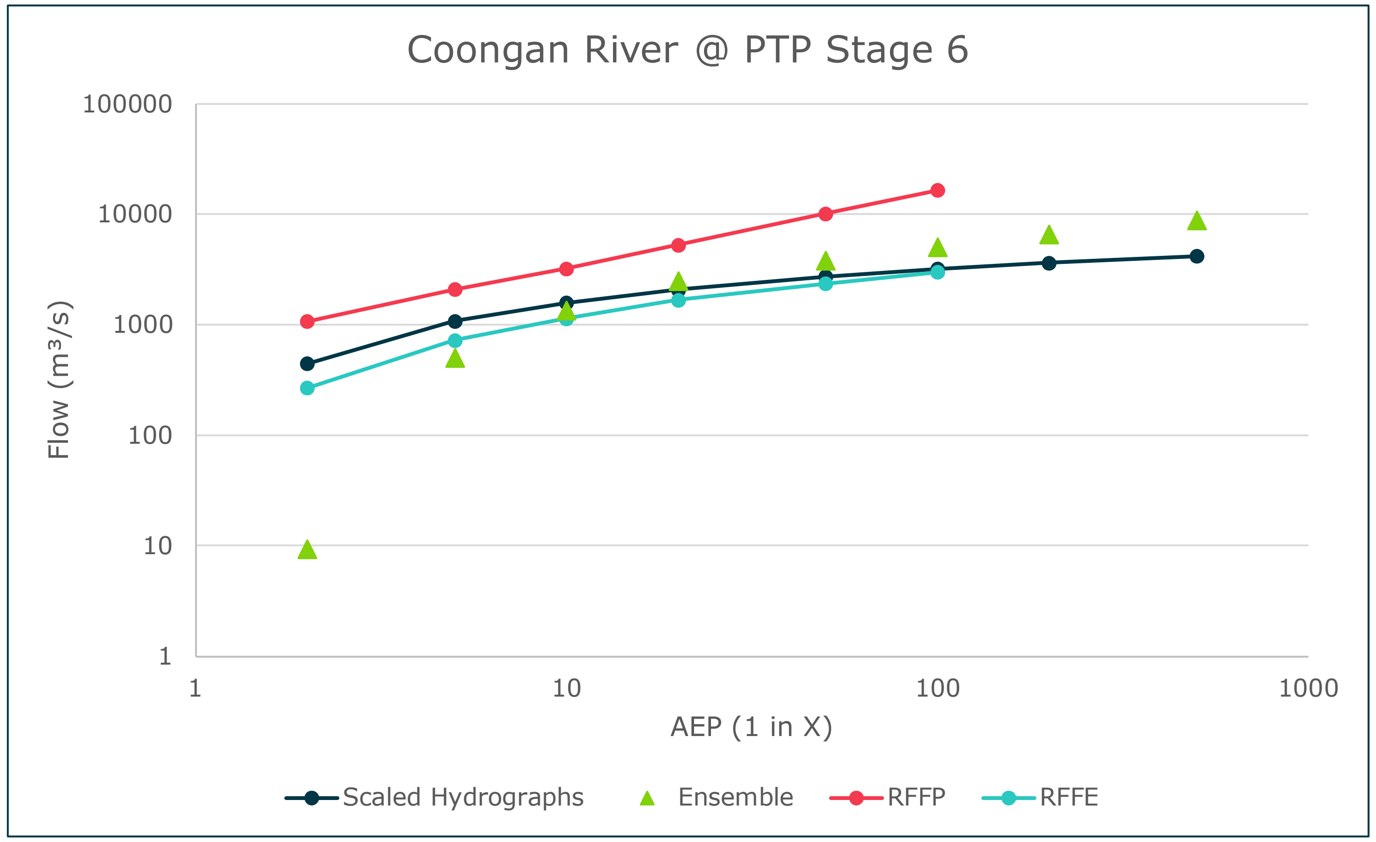
IFD for Shaw River RORB model

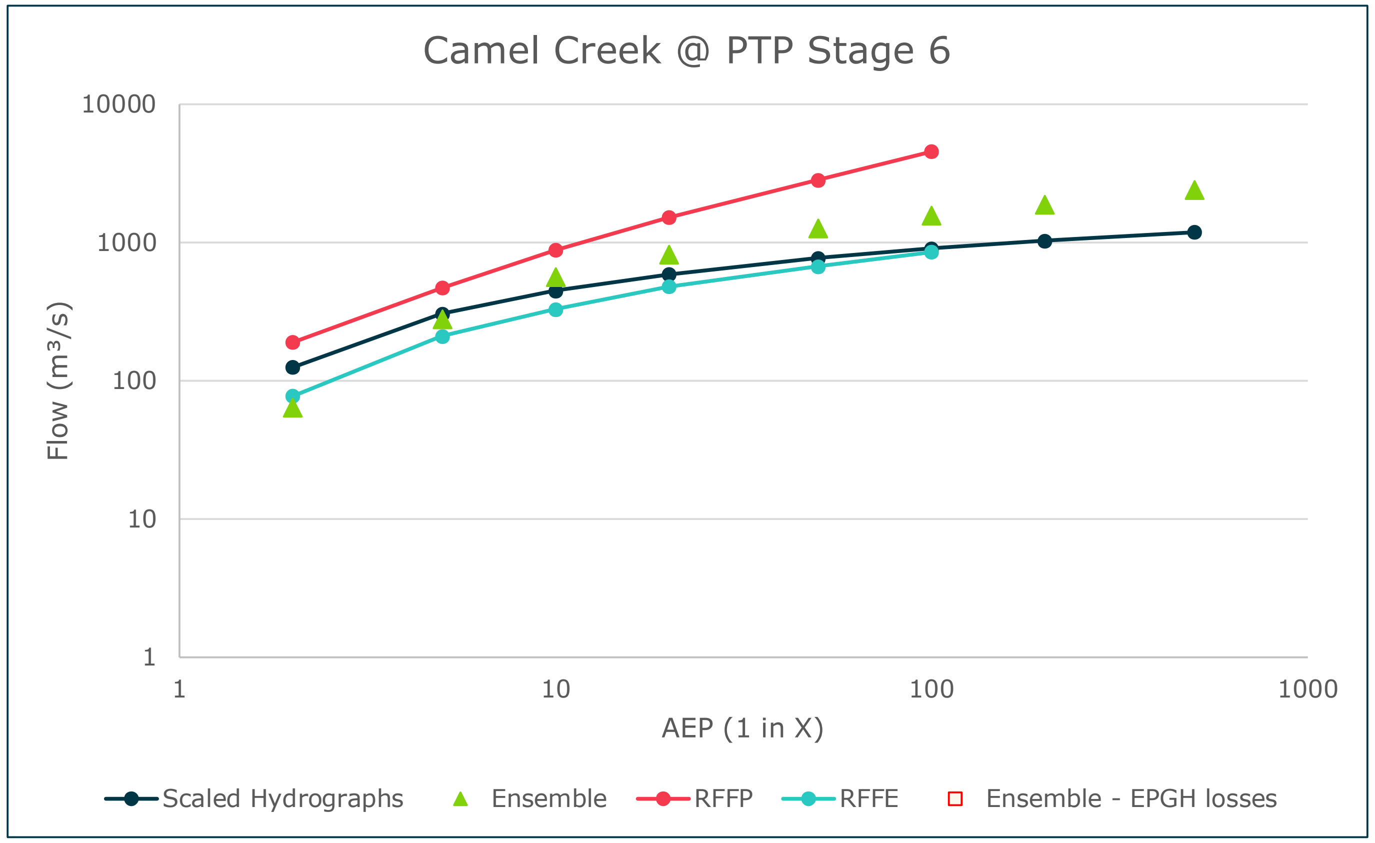
Extracted from: 21.7375°S, 119.3875°E

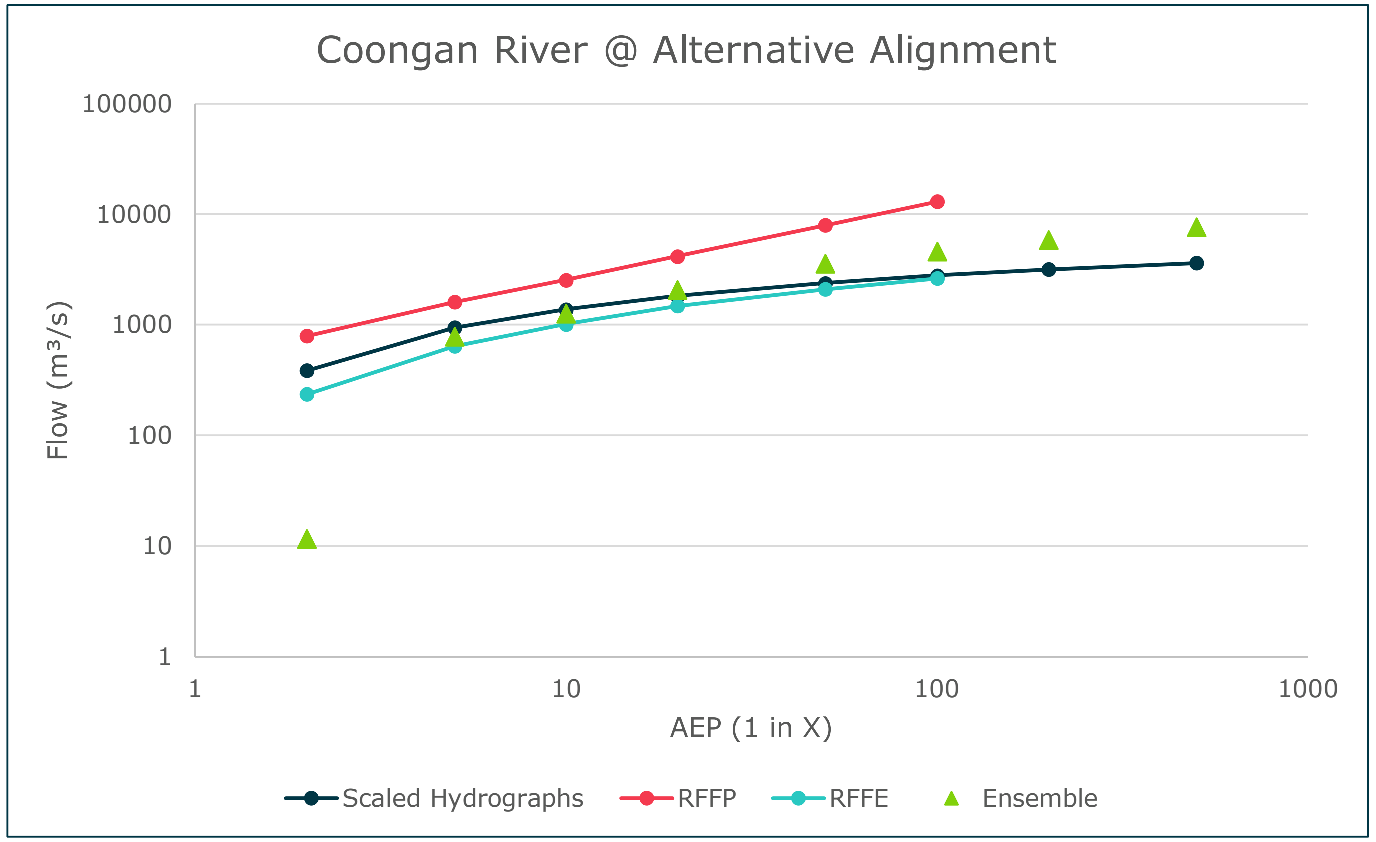
Duration (hours)	Rainfall Total (mm)							
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.50% AEP	0.20% AEP
12	59.5	92.7	117	144	180	210	239	284
18	66.4	105	134	166	209	244	277	329
24	71.8	115	147	182	229	267	303	358
36	79.9	128	164	202	253	294	336	394
48	85.6	137	175	215	267	308	349	406
72	93.4	148	187	228	279	318	357	410

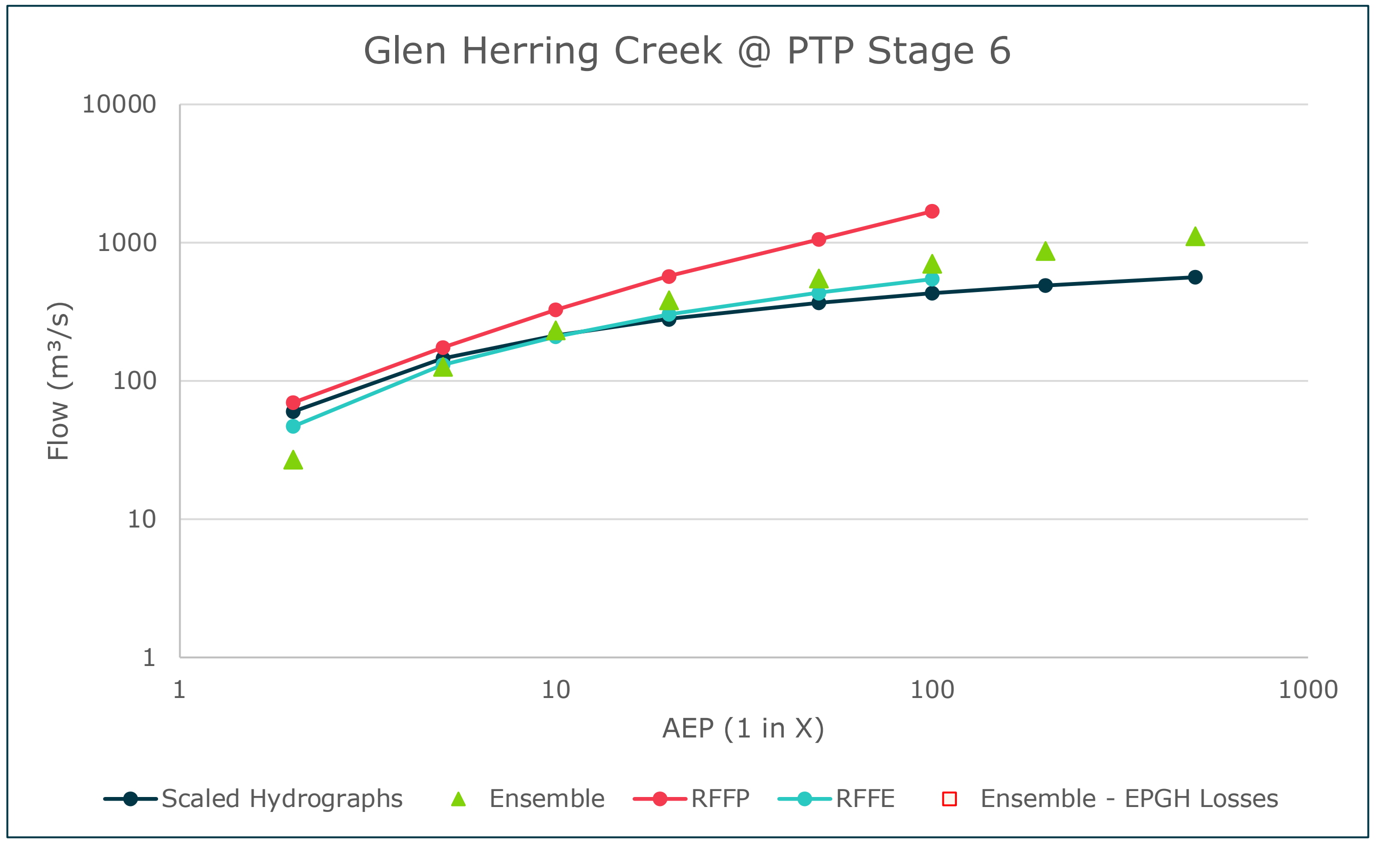
Appendix B. Peak flow estimate comparisons

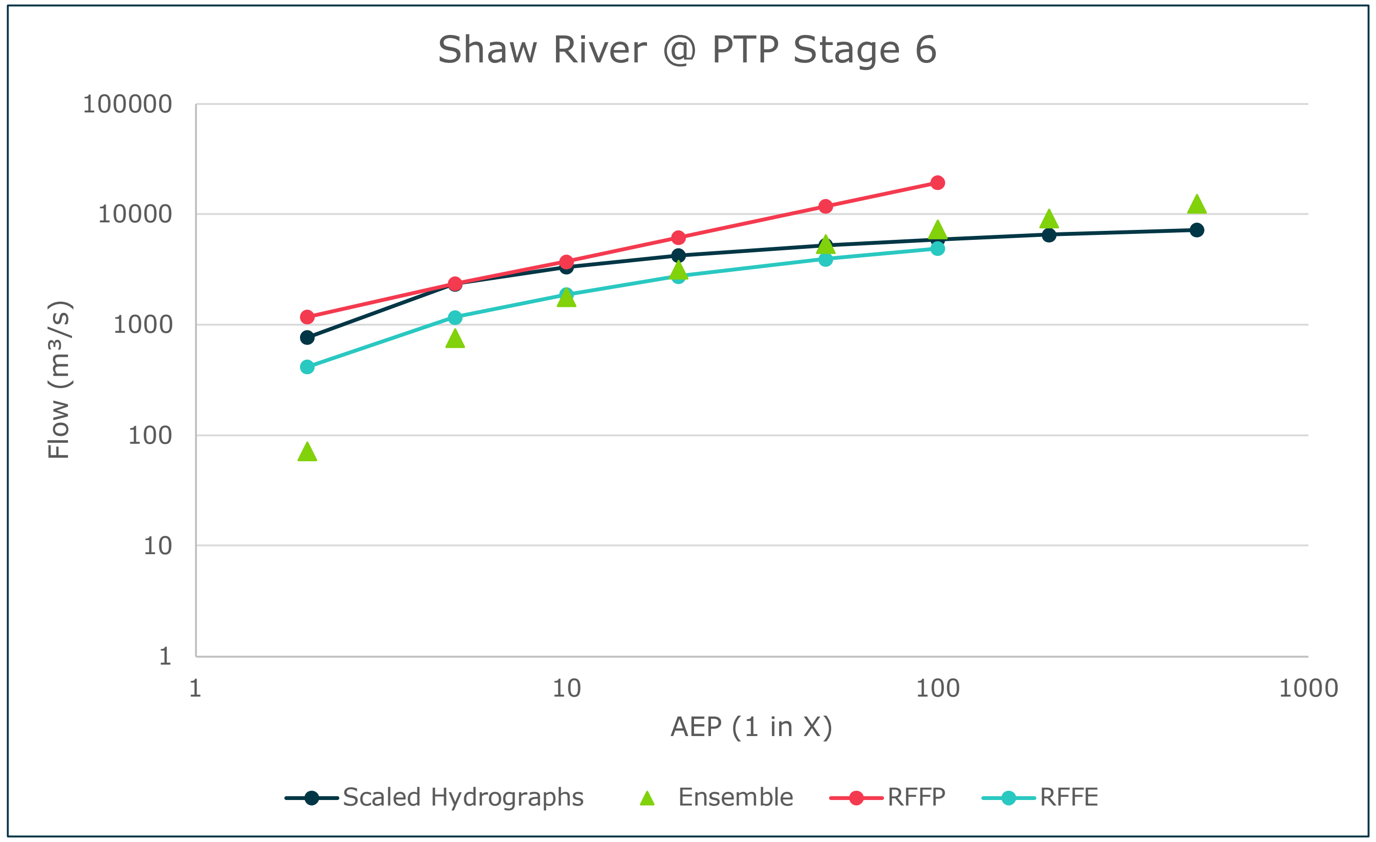
Comparison of design flows to regional estimates

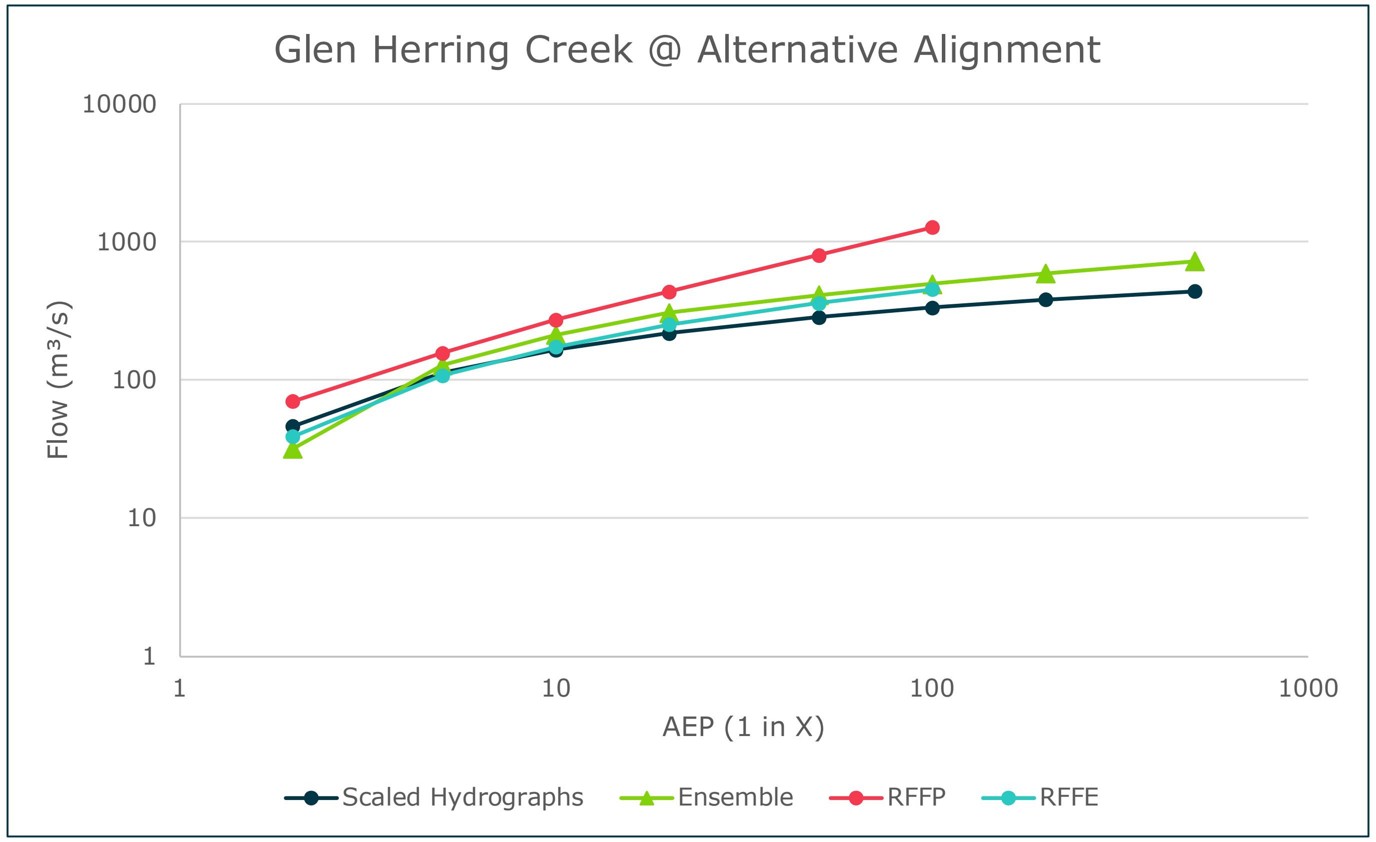

Coongan River @ PTP Stage 6
100000
10000
1000
100
10
1
Flow (m³/s)
1
10
100
1000
AEP (1 in X)
Scaled Hydrographs
Ensemble
RFFP
RFFE


Camel Creek @ PTP Stage 6
10000
1000
100
10
1
Flow (m³/s)
1
10
100
1000
AEP (1 in X)
Scaled Hydrographs
Ensemble
RFFP
RFFE
Ensemble - EPGH losses


Coongan River @ Alternative Alignment
100000
10000
1000
100
10
1
Flow (m³/s)
1
10
100
1000
AEP (1 in X)
Scaled Hydrographs
RFFP
RFFE
Ensemble


Glen Herring Creek @ PTP Stage 6
10000
1000
100
10
1
Flow (m³/s)
1
10
100
1000
AEP (1 in X)
Scaled Hydrographs
Ensemble
RFFP
RFFE
Ensemble - EPGH Losses


Shaw River @ PTP Stage 6
100000
10000
1000
100
10
1
Flow (m³/s)
1
10
100
1000
AEP (1 in X)
Scaled Hydrographs
Ensemble
RFFP
RFFE

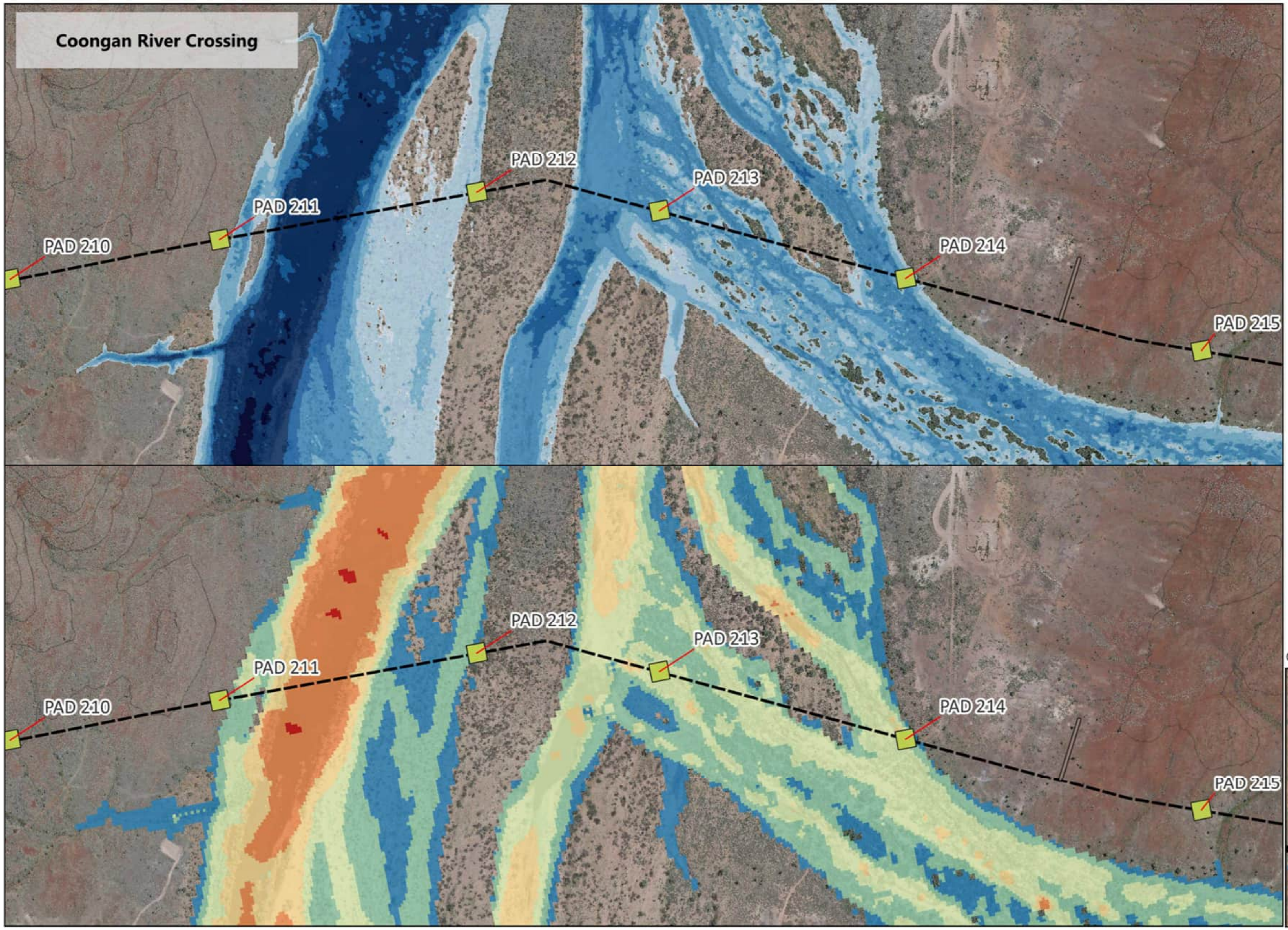

Glen Herring Creek @ Alternative Alignment
10000
1000
100
10
1
Flow (m³/s)
1
10
100
1000
AEP (1 in X)
Scaled Hydrographs
Ensemble
RFFP
RFFE

Appendix C. Flood Modelling Results

Flood Depth and Velocity Maps for 10%, 1% and 0.2% AEP

worley consulting

Fortescue.



EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
10% AEP Flood Results

Legend

- PTP-6 Proposed Pads
- PTP-6 Proposed Route

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- > 5.0

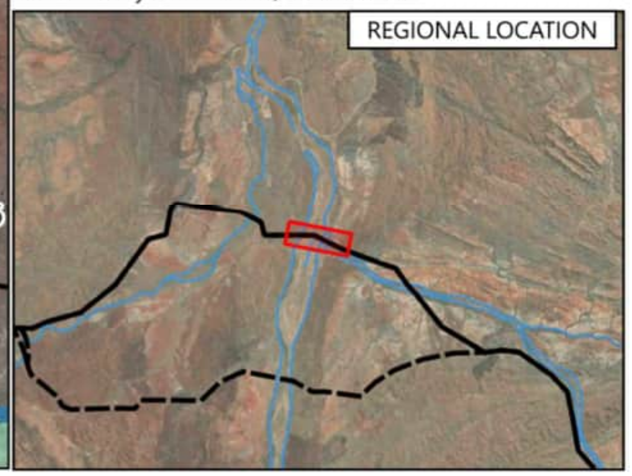
Peak Flood Velocity (m/s)

- <= 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

Scale at A3 - 1: 7,000

0 100 200 300 m

Coordinate System: GDA94 / MGA zone 50



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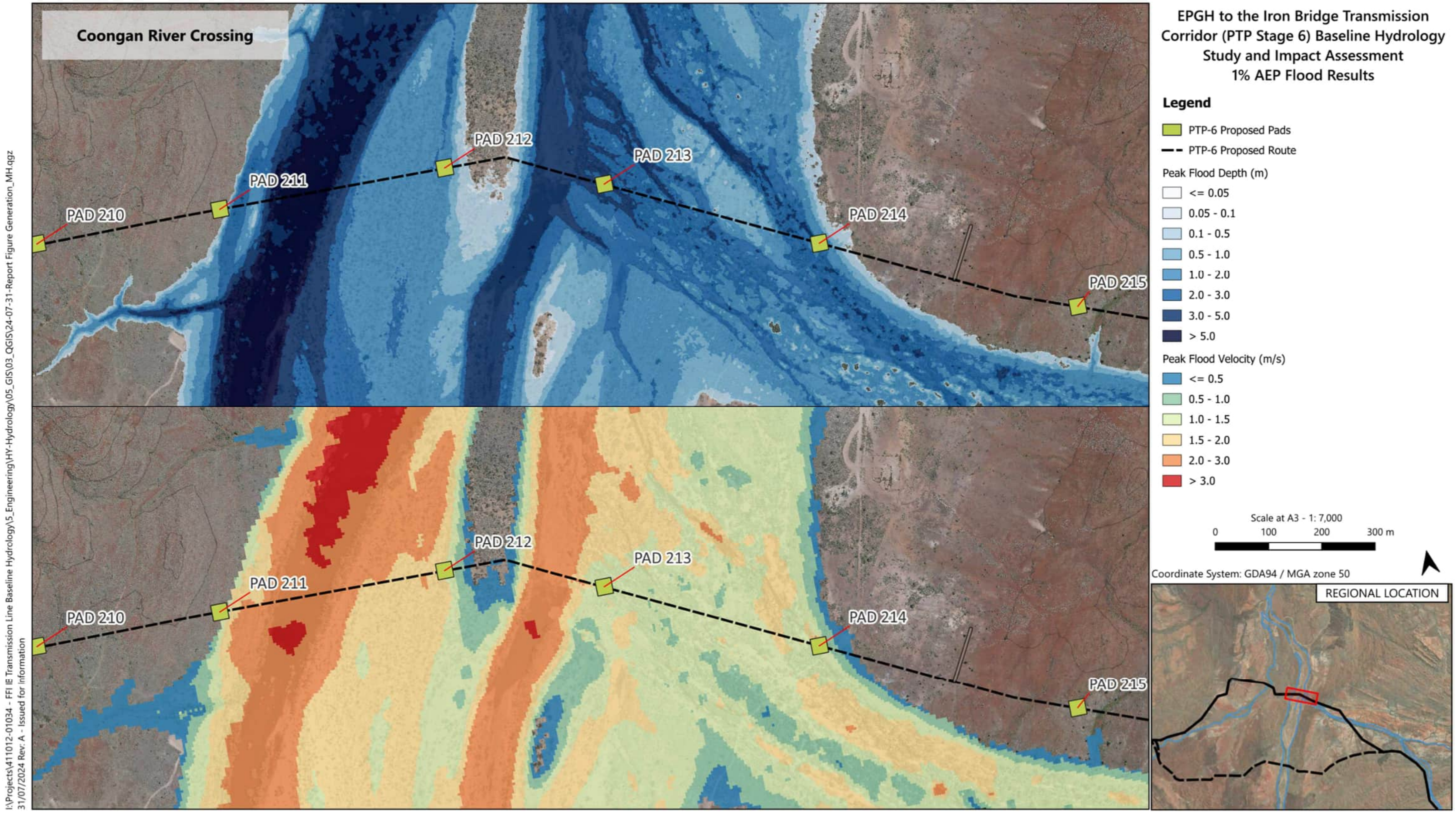

Coongan River Crossing
PAD 210
PAD 211
PAD 212
PAD 213
PAD 214
PAD 215
EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
1% AEP Flood Results
Legend
PTP-6 Proposed Pads
PTP-6 Proposed Route
Peak Flood Depth (m)
<= 0.05
0.05 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 2.0
2.0 - 3.0
3.0 - 5.0
> 5.0
Peak Flood Velocity (m/s)
<= 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 3.0
> 3.0
Scale at A3 - 1: 7,000
0
100
200
300 m
Coordinate System: GDA94 / MGA zone 50
REGIONAL LOCATION
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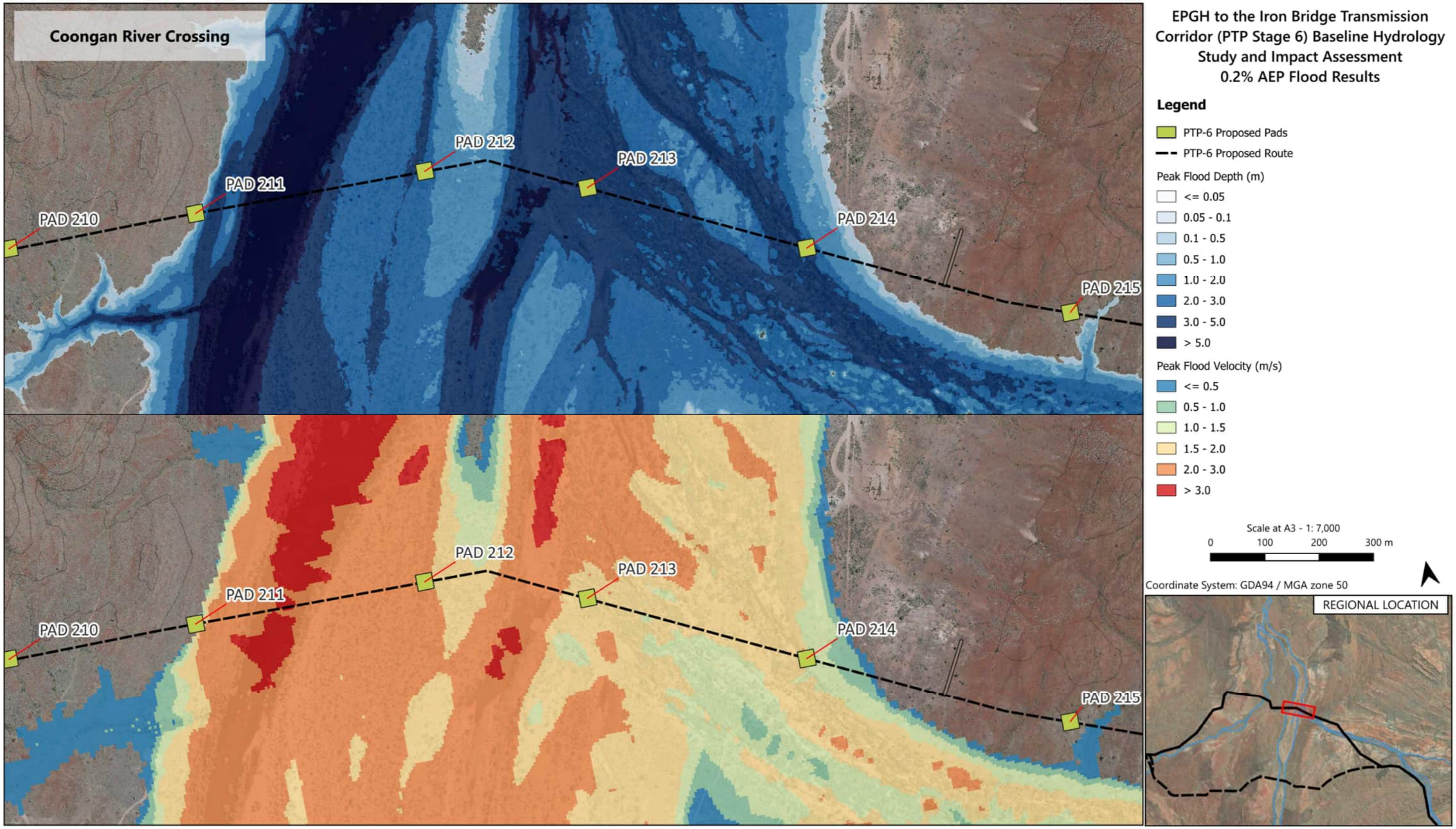

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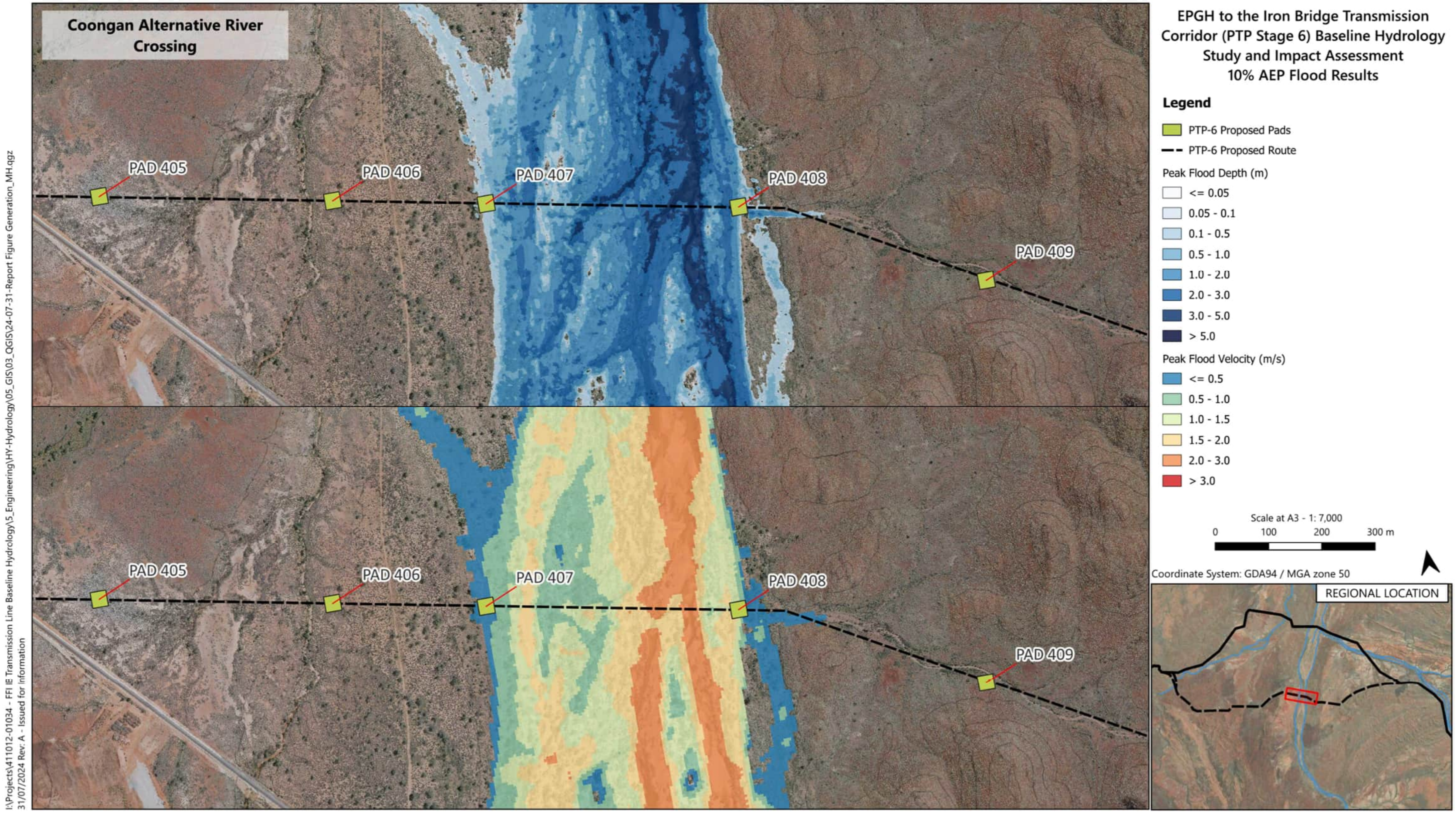

Coongan Alternative River Crossing
PAD 405
PAD 406
PAD 407
PAD 408
PAD 409
EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
10% AEP Flood Results
Legend
PTP-6 Proposed Pads
PTP-6 Proposed Route
Peak Flood Depth (m)
<= 0.05
0.05 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 2.0
2.0 - 3.0
3.0 - 5.0
> 5.0
Peak Flood Velocity (m/s)
<= 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 3.0
> 3.0
Scale at A3 - 1: 7,000
0
100
200
300 m
Coordinate System: GDA94 / MGA zone 50
REGIONAL LOCATION
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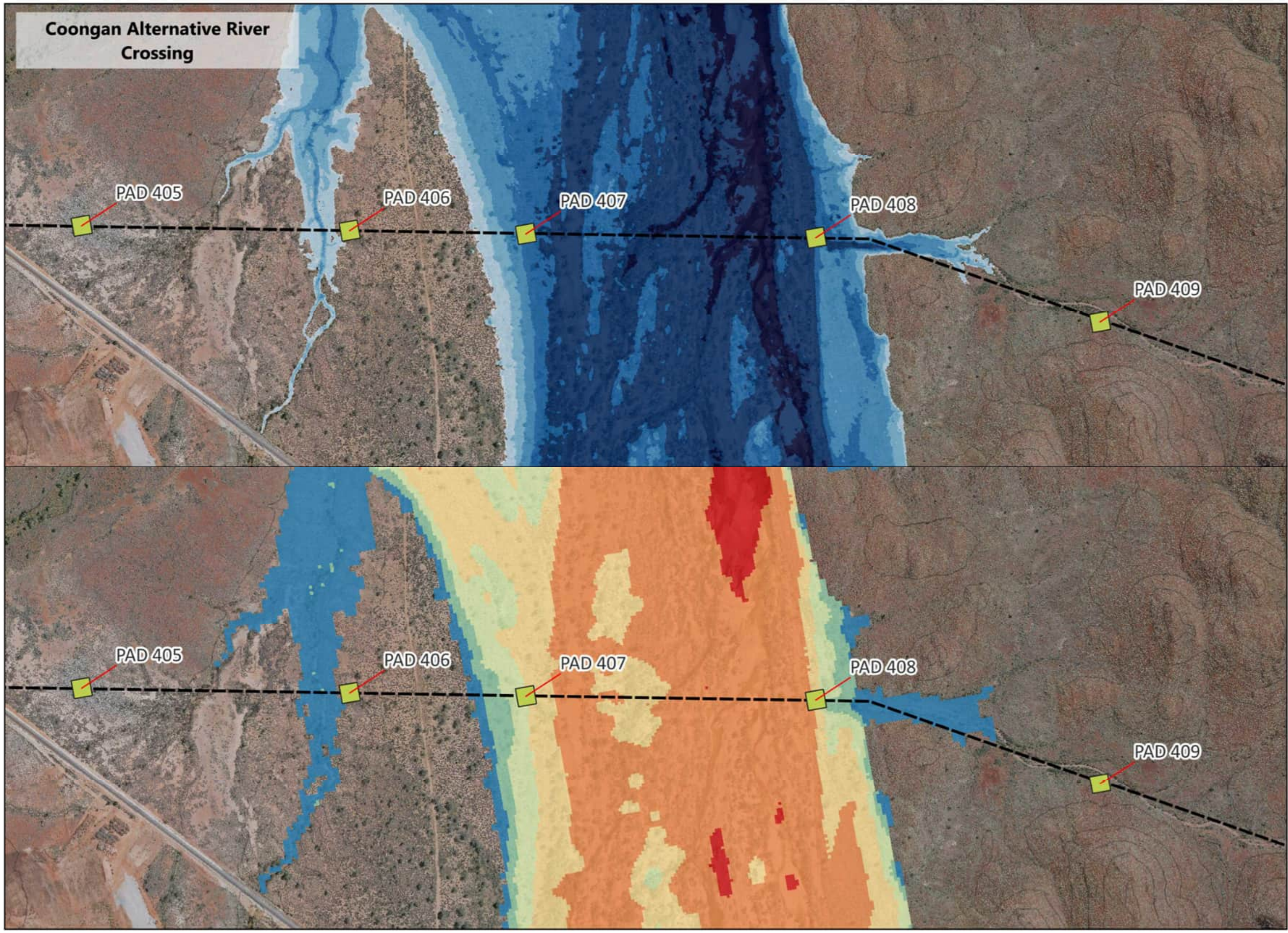


EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
1% AEP Flood Results

Legend

- PTP-6 Proposed Pads
- PTP-6 Proposed Route

Peak Flood Depth (m)

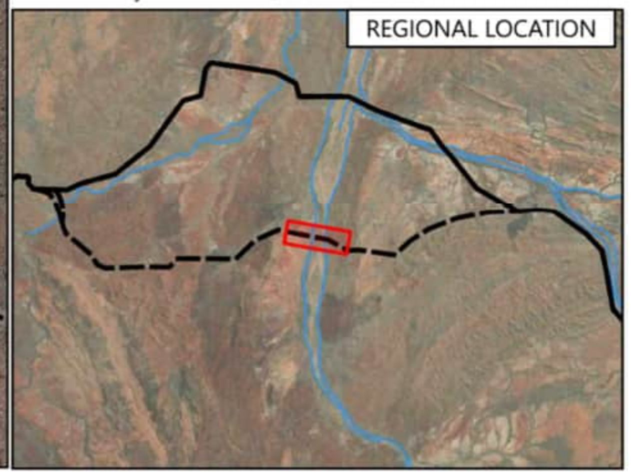
- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- > 5.0

Peak Flood Velocity (m/s)

- <= 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

Scale at A3 - 1: 7,000
0 100 200 300 m

Coordinate System: GDA94 / MGA zone 50



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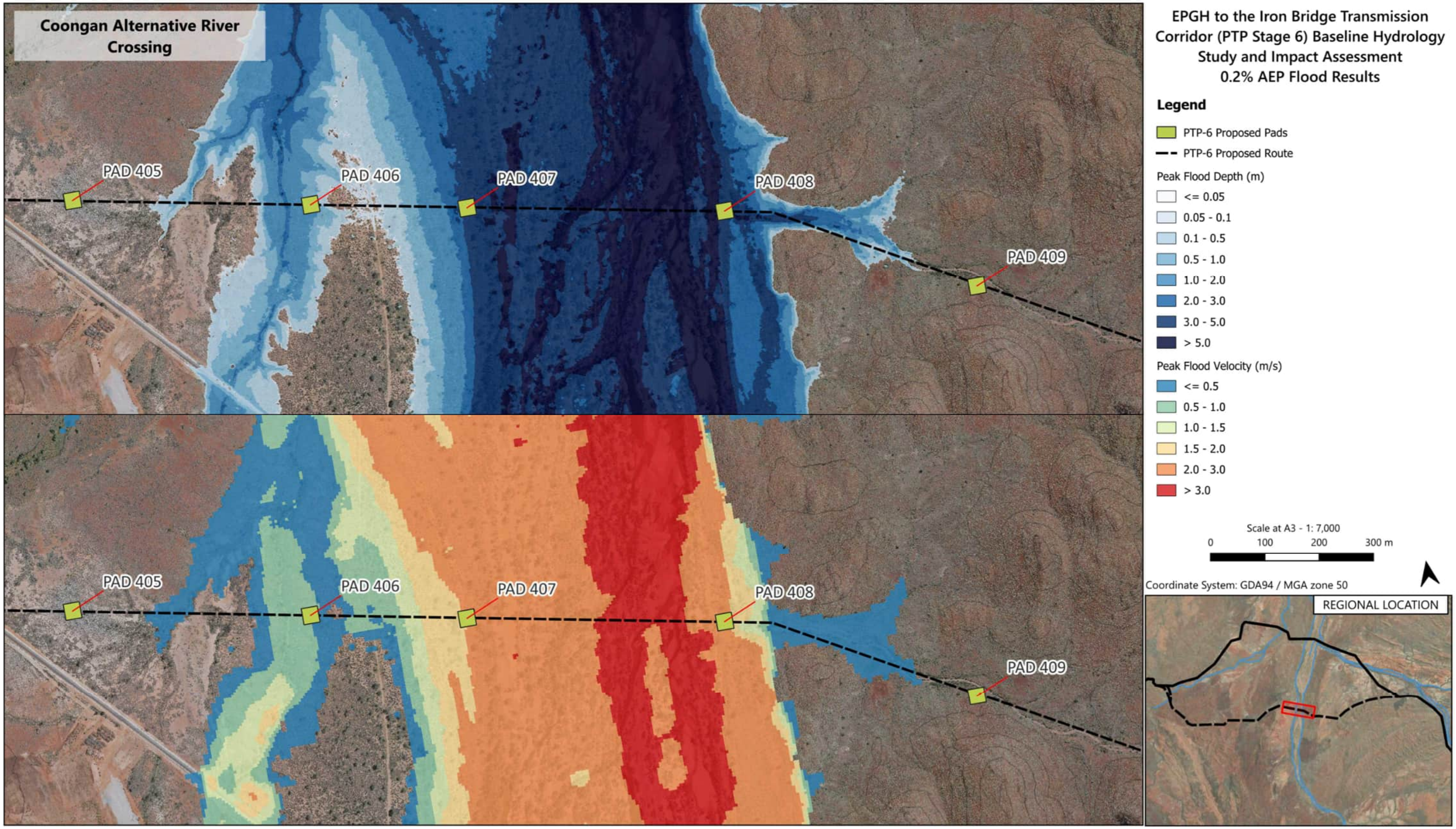

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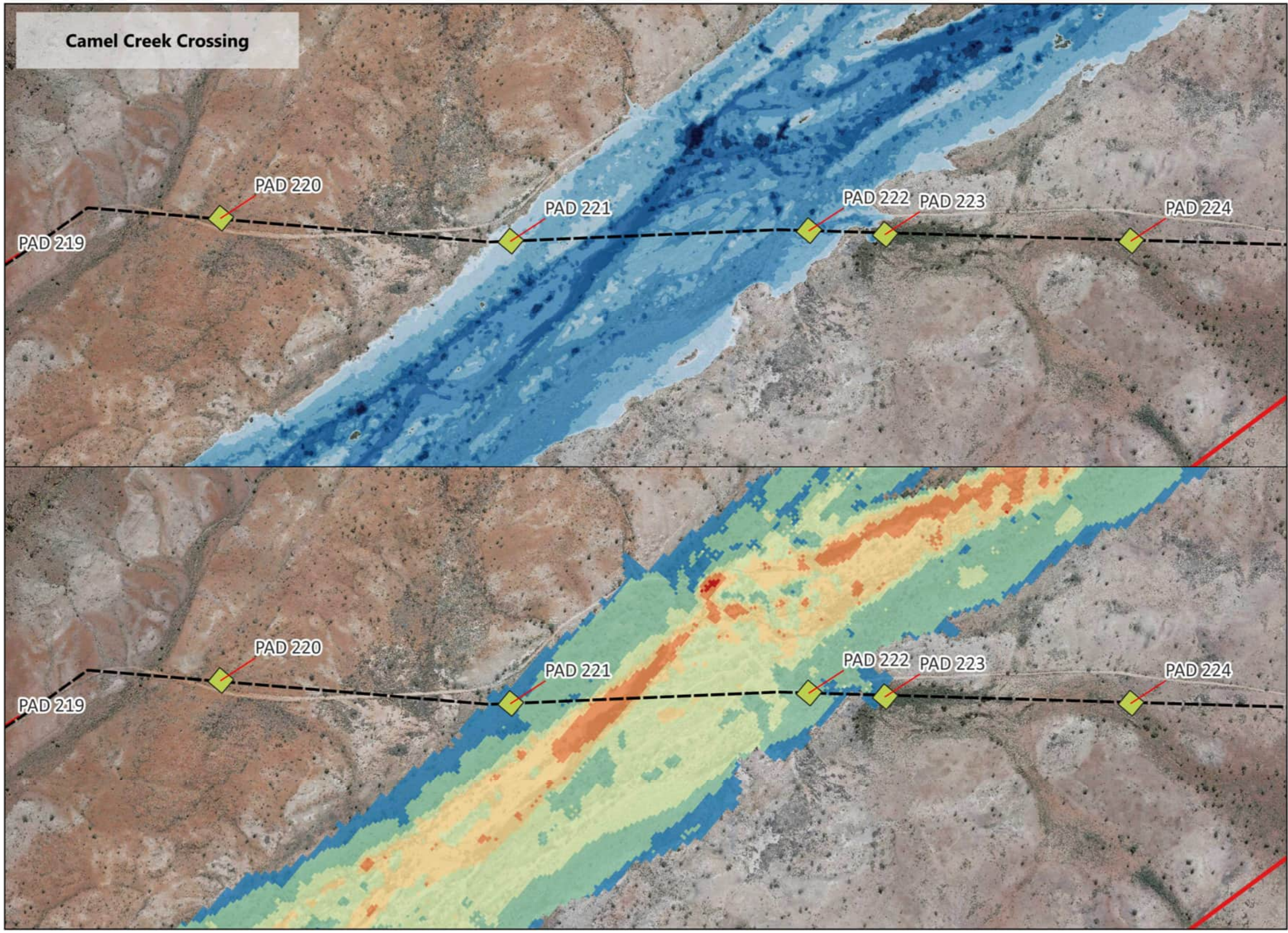


EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
10% AEP Flood Results

Legend

- PTP-6 Proposed Pads
- PTP-6 Proposed Route

Peak Flood Depth (m)

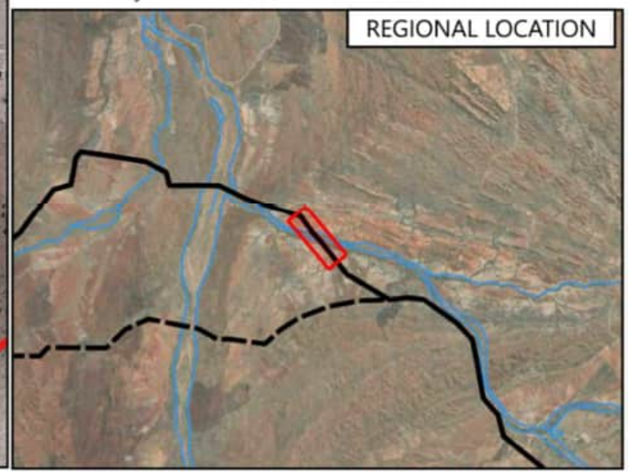
- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- > 5.0

Peak Flood Velocity (m/s)

- <= 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

Scale at A3 - 1: 7,000
0 100 200 300 m

Coordinate System: GDA94 / MGA zone 50



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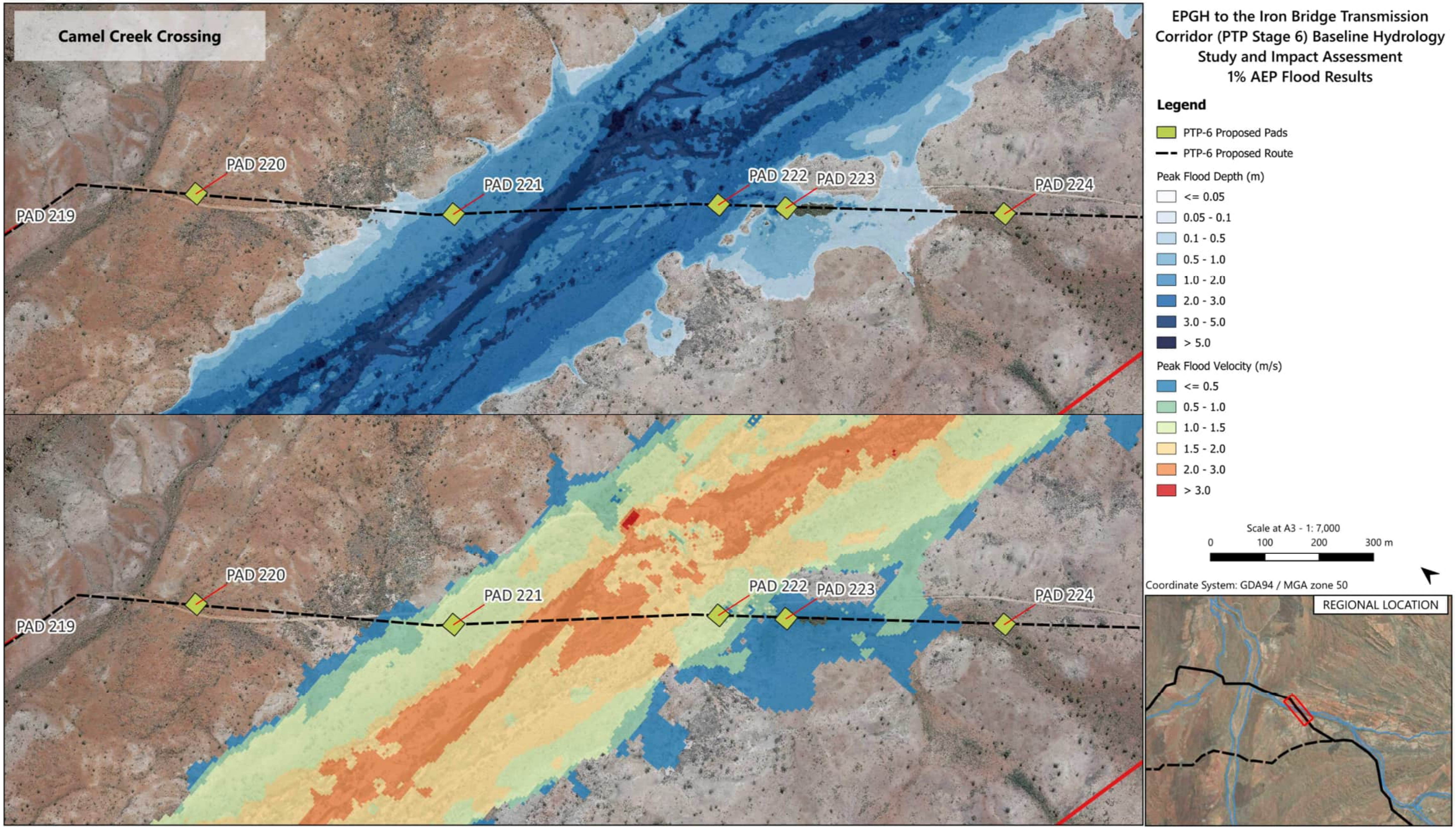

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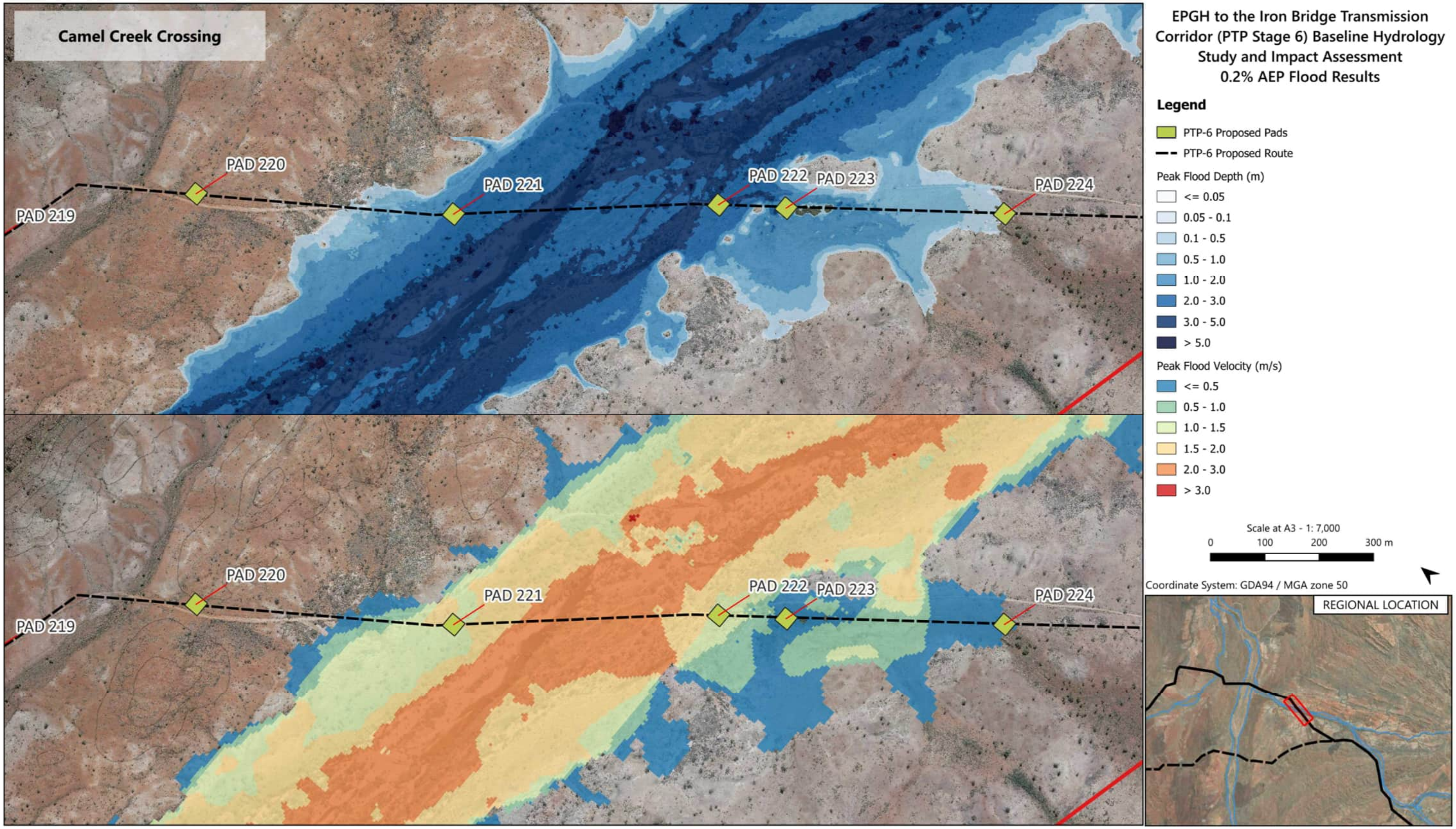

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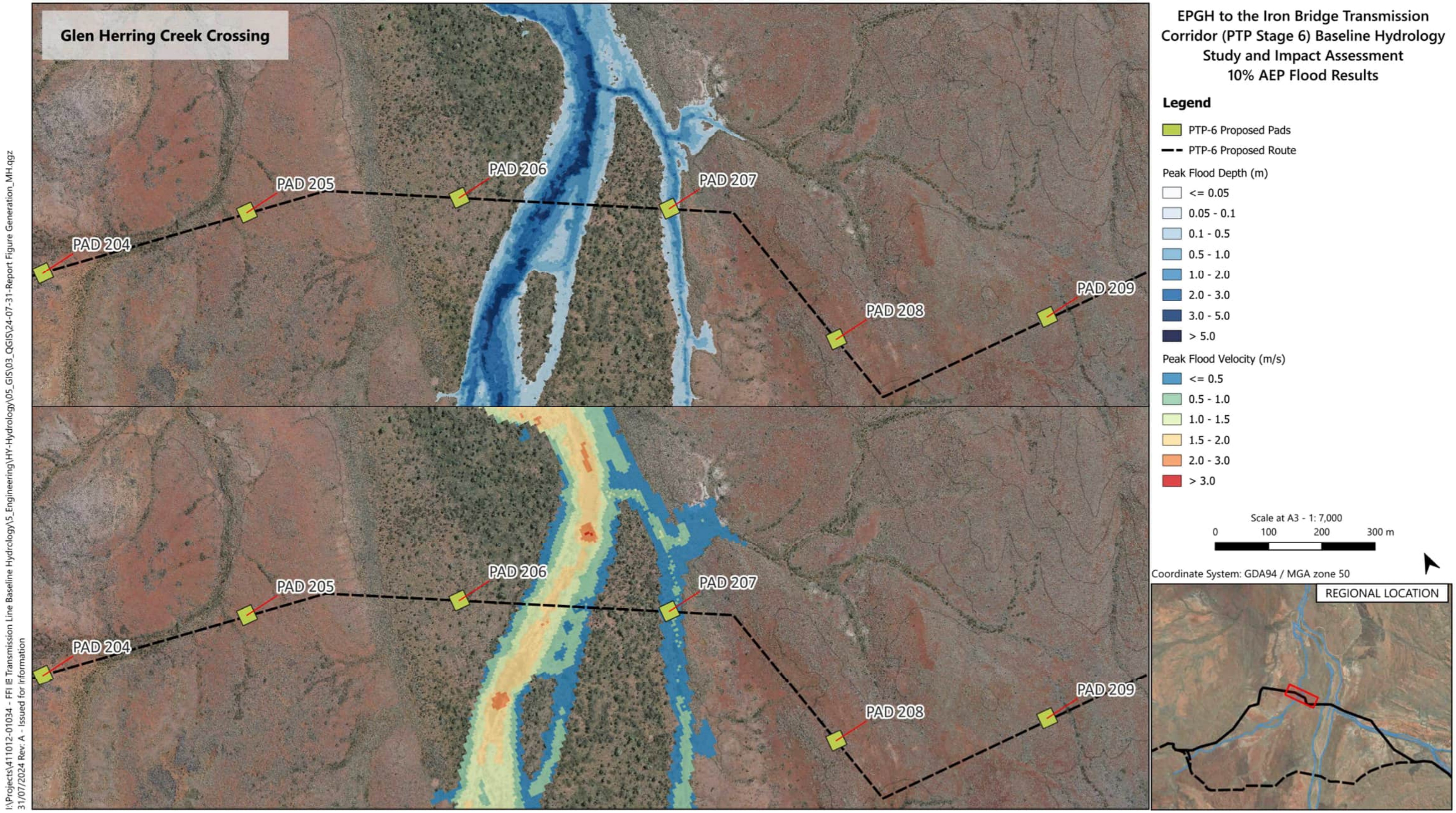

Glen Herring Creek Crossing
PAD 204
PAD 205
PAD 206
PAD 207
PAD 208
PAD 209
PAD 204
PAD 205
PAD 206
PAD 207
PAD 208
PAD 209
EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
10% AEP Flood Results
Legend
PTP-6 Proposed Pads
PTP-6 Proposed Route
Peak Flood Depth (m)
<= 0.05
0.05 - 0.1
0.1 - 0.5
0.5 - 1.0
1.0 - 2.0
2.0 - 3.0
3.0 - 5.0
> 5.0
Peak Flood Velocity (m/s)
<= 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 3.0
> 3.0
Scale at A3 - 1: 7,000
0
100
200
300 m
Coordinate System: GDA94 / MGA zone 50
REGIONAL LOCATION
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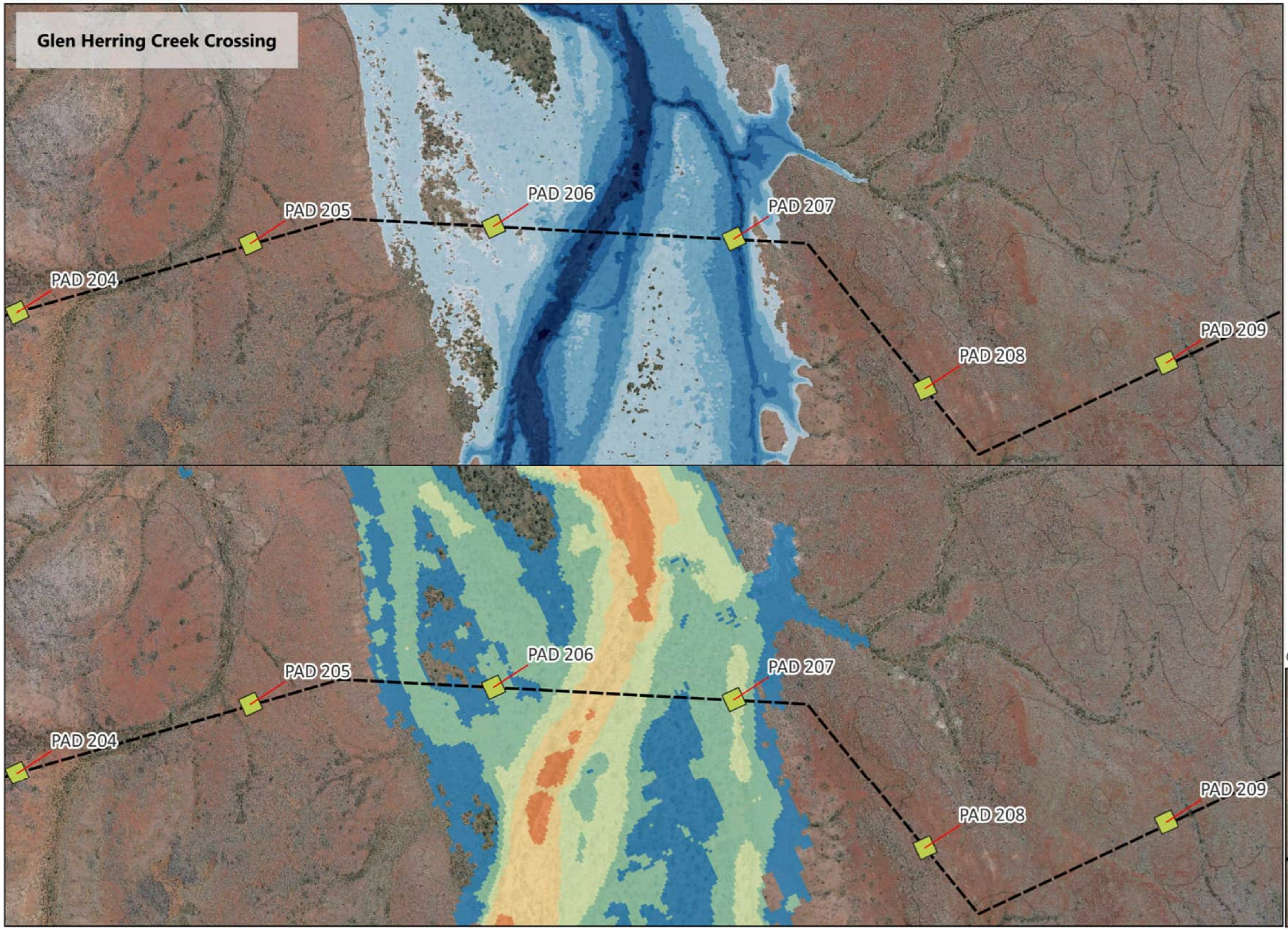
EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
1% AEP Flood Results



Legend

- PTP-6 Proposed Pads
- PTP-6 Proposed Route

Peak Flood Depth (m)

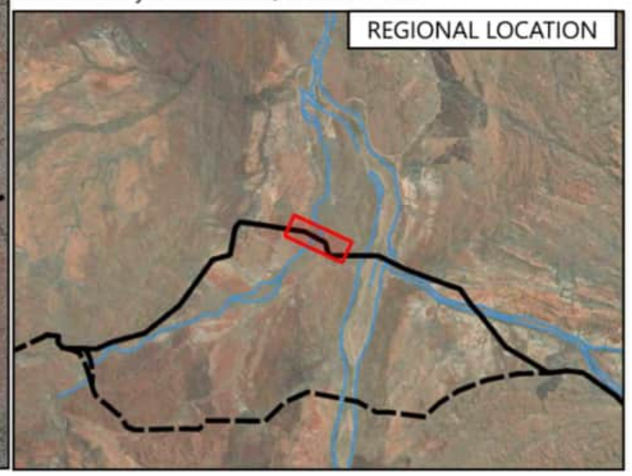
- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- > 5.0

Peak Flood Velocity (m/s)

- <= 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

Scale at A3 - 1: 7,000
0 100 200 300 m

Coordinate System: GDA94 / MGA zone 50



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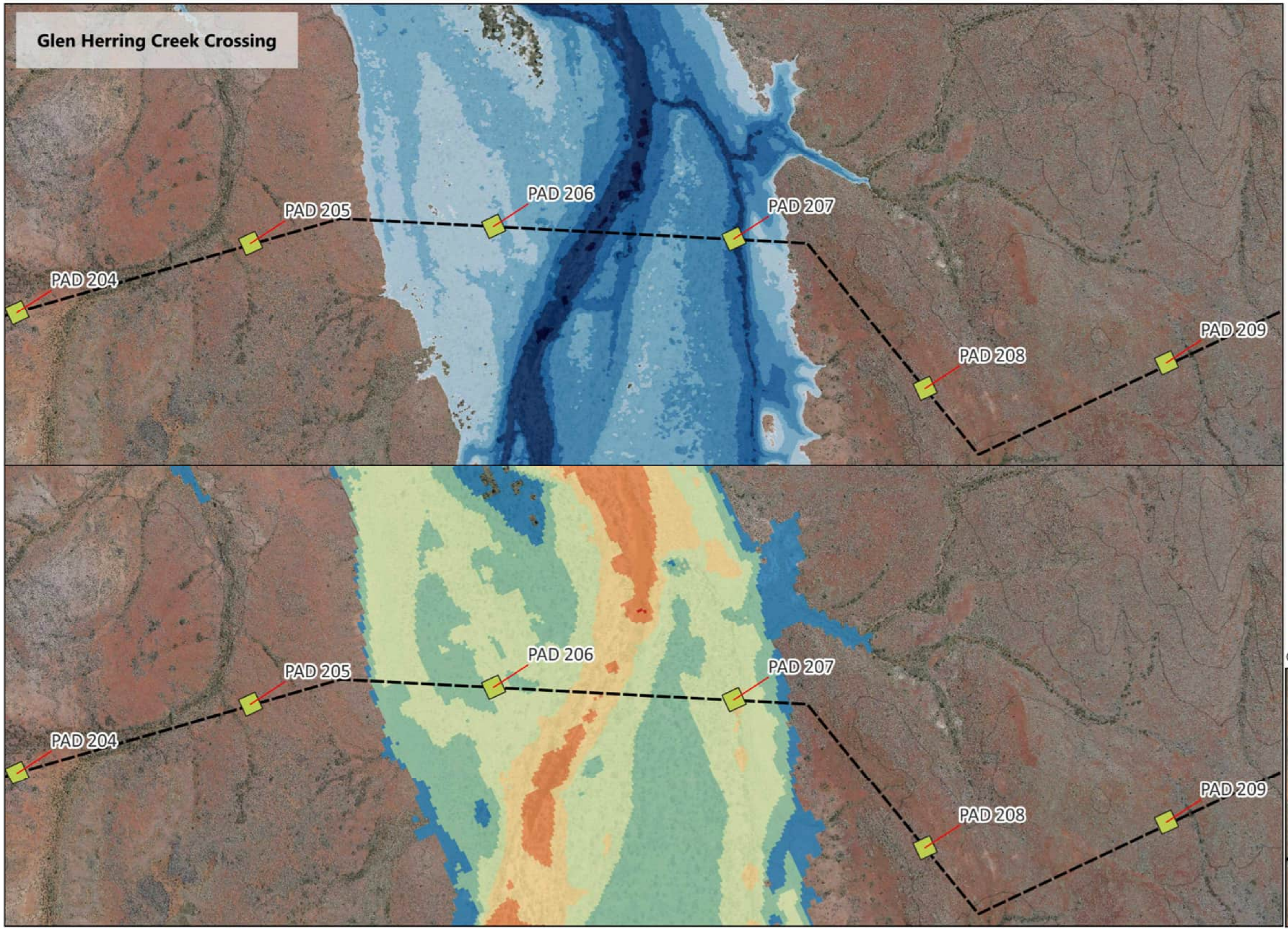
Fortescue.



EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment 0.2% AEP Flood Results

Legend

- PTP-6 Proposed Pads
- PTP-6 Proposed Route

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- > 5.0

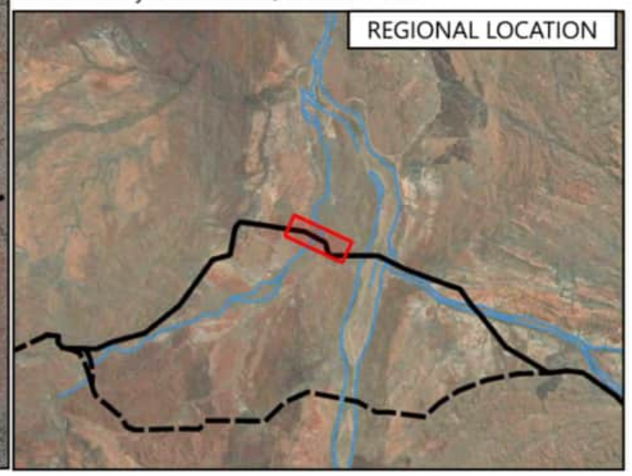
Peak Flood Velocity (m/s)

- <= 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

Scale at A3 - 1: 7,000

0 100 200 300 m

Coordinate System: GDA94 / MGA zone 50



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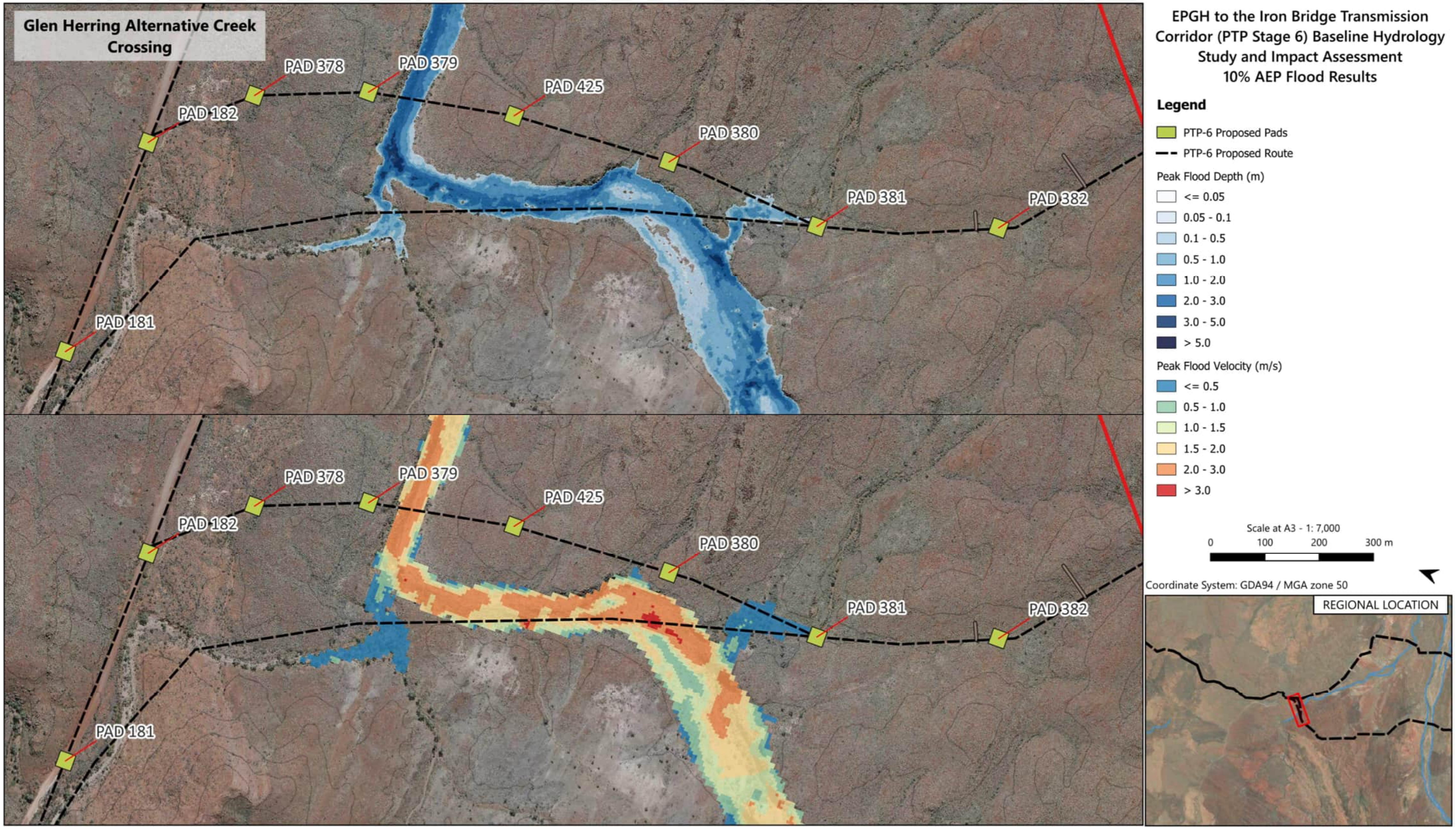

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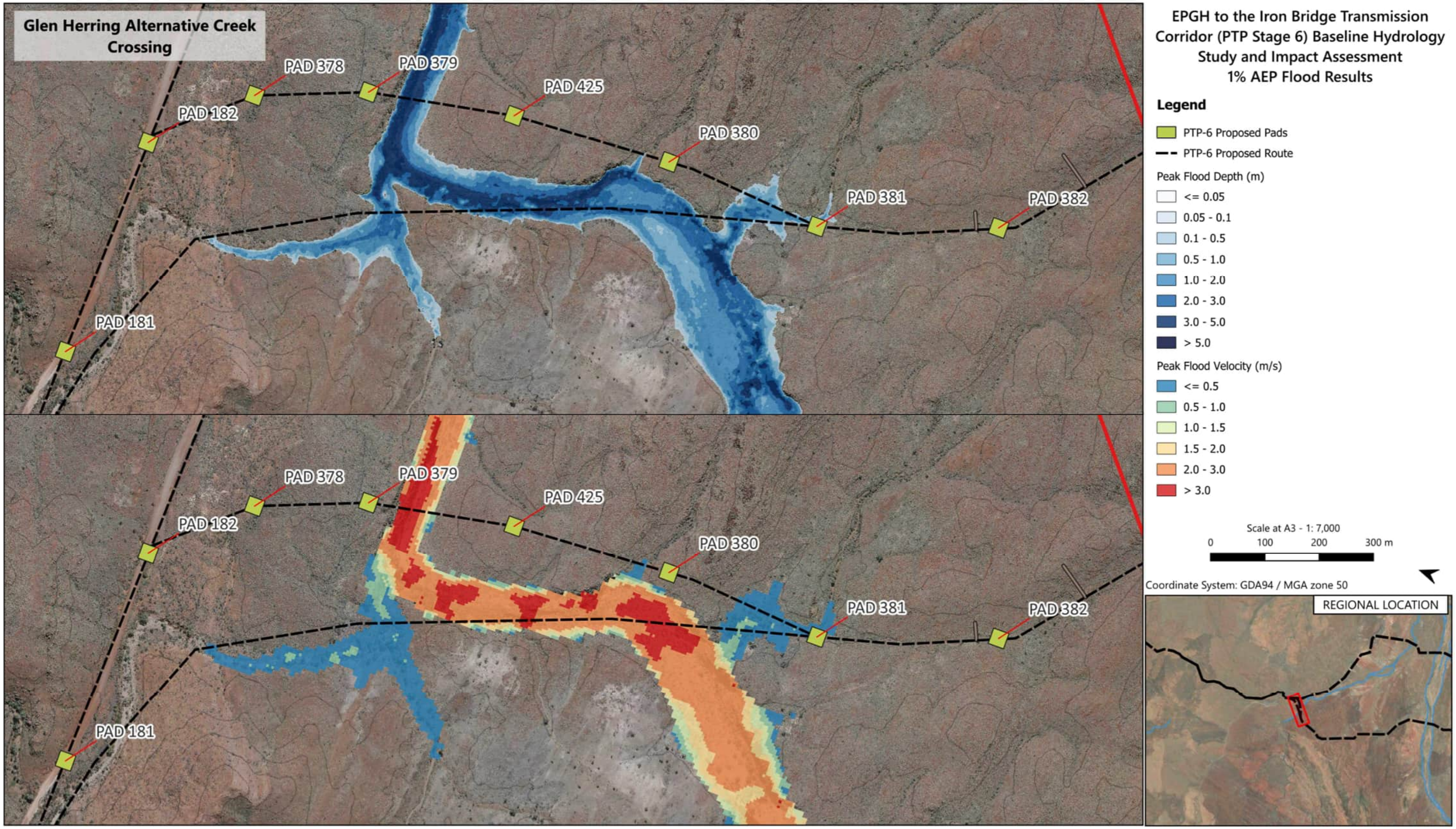
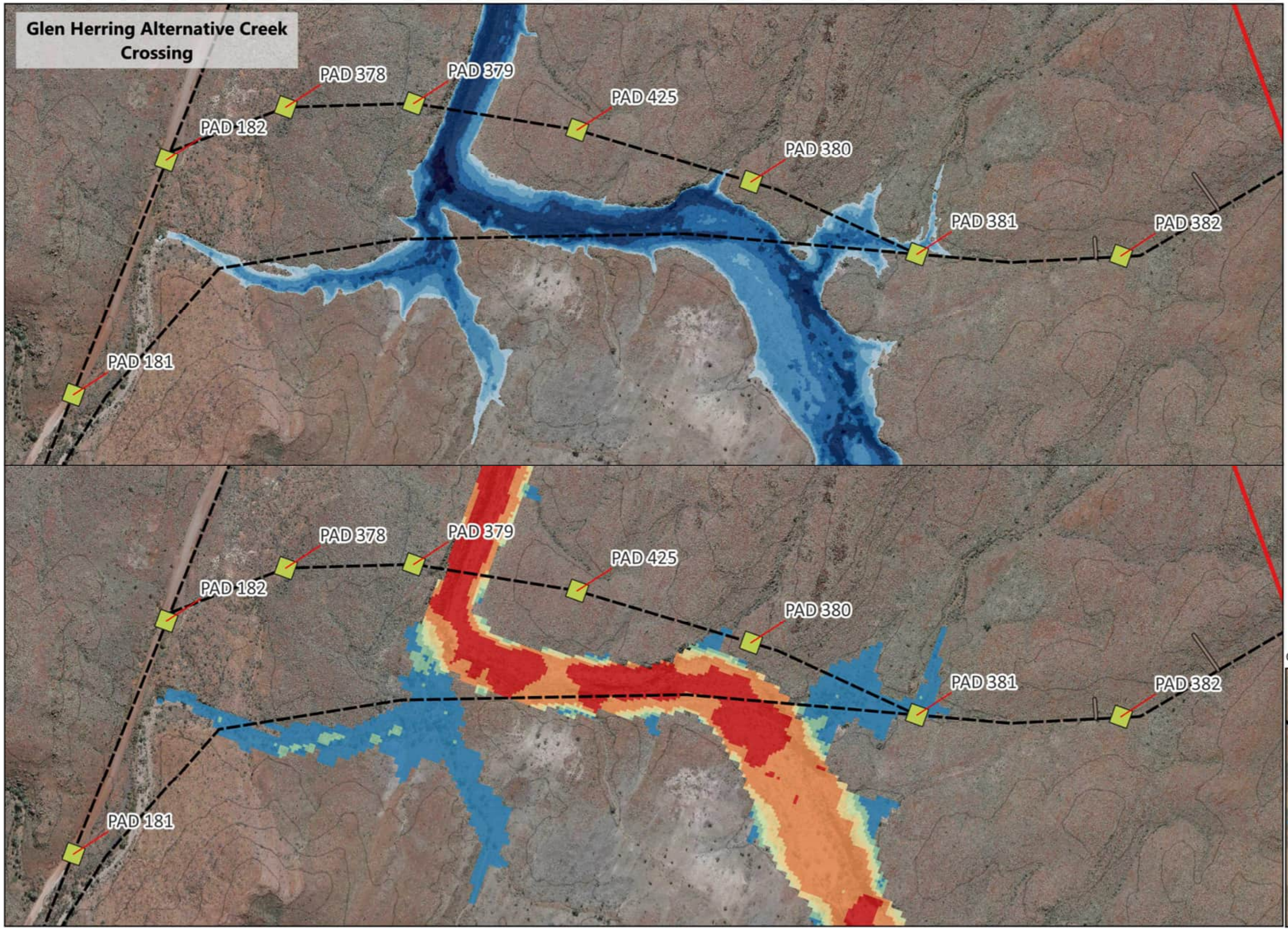
31/07/2024 Rev. A - Issued for Information



EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
0.2% AEP Flood Results



Legend

- PTP-6 Proposed Pads
- PTP-6 Proposed Route

Peak Flood Depth (m)

- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- > 5.0

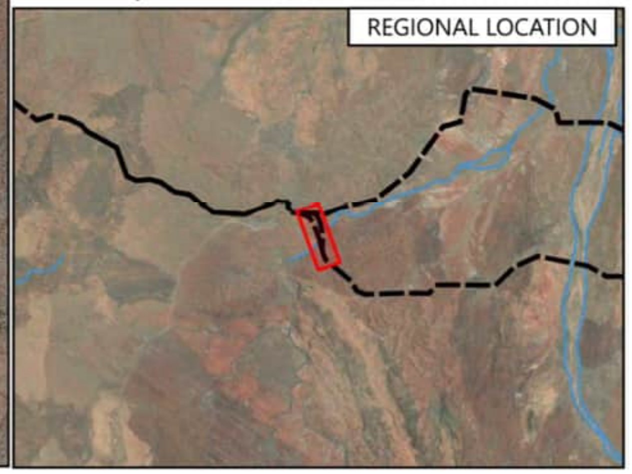
Peak Flood Velocity (m/s)

- <= 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

Scale at A3 - 1: 7,000

0 100 200 300 m

Coordinate System: GDA94 / MGA zone 50



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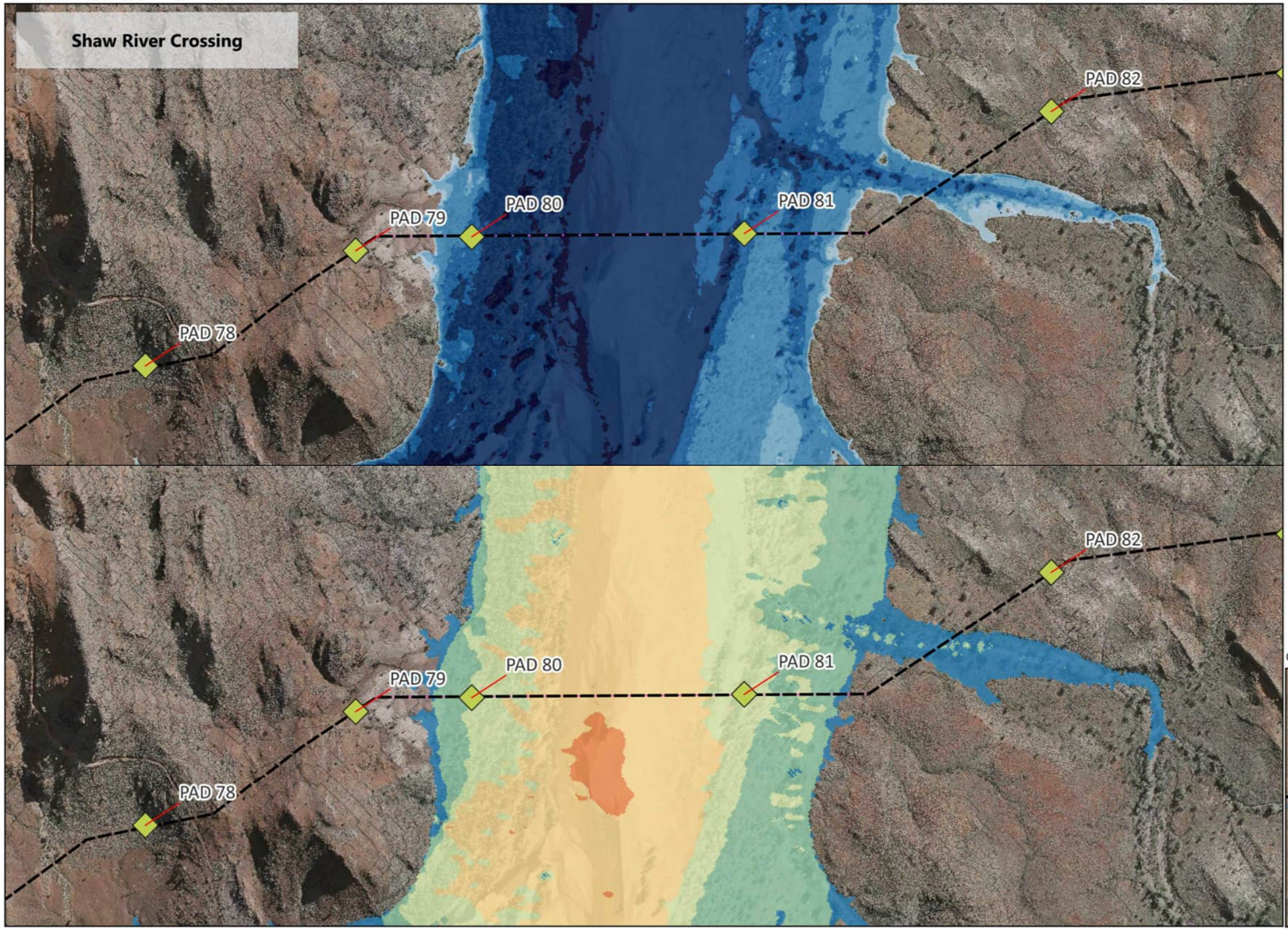
EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
10% AEP Flood Results



Legend

- PTP-6 Proposed Pads
- PTP-6 Proposed Route

Peak Flood Depth (m)

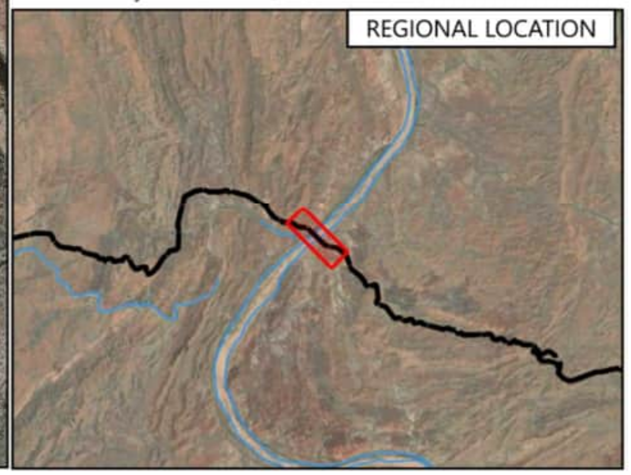
- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- > 5.0

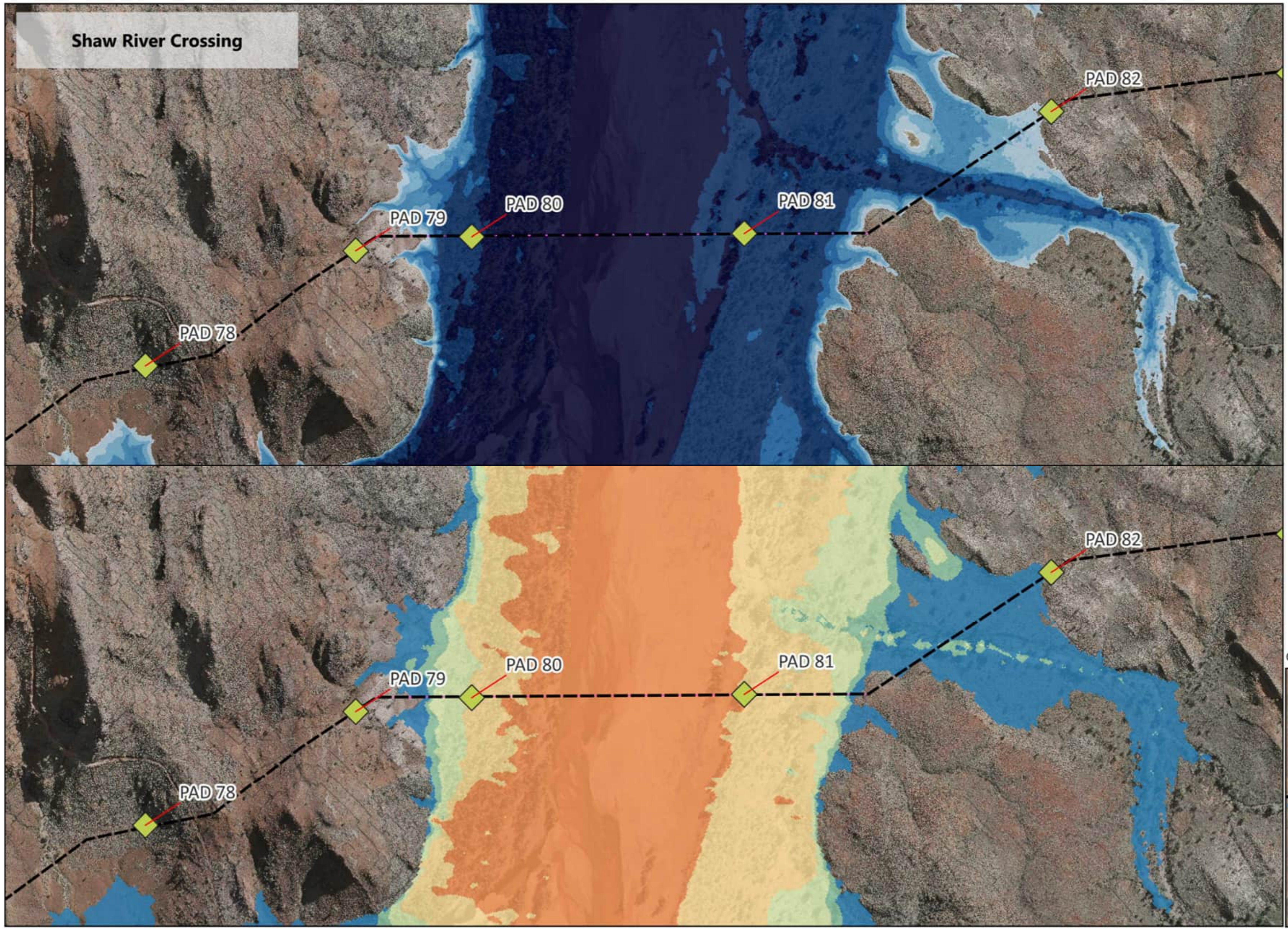
Peak Flood Velocity (m/s)

- <= 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

Scale at A3 - 1: 7,000
0 100 200 300 m

Coordinate System: GDA94 / MGA zone 50





EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
1% AEP Flood Results

Legend

- PTP-6 Proposed Pads
- PTP-6 Proposed Route

Peak Flood Depth (m)

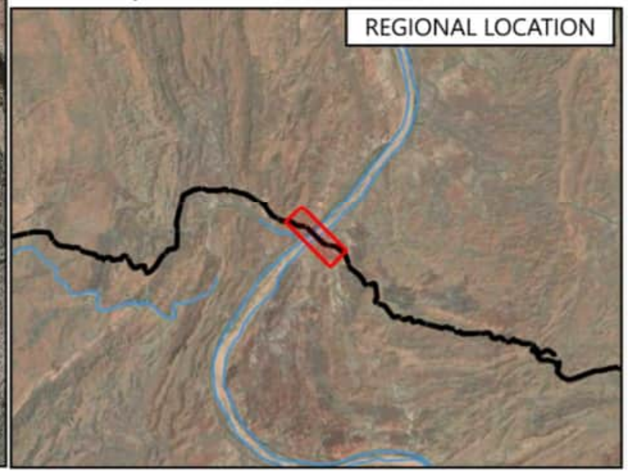
- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- > 5.0

Peak Flood Velocity (m/s)

- <= 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

Scale at A3 - 1: 7,000
0 100 200 300 m

Coordinate System: GDA94 / MGA zone 50



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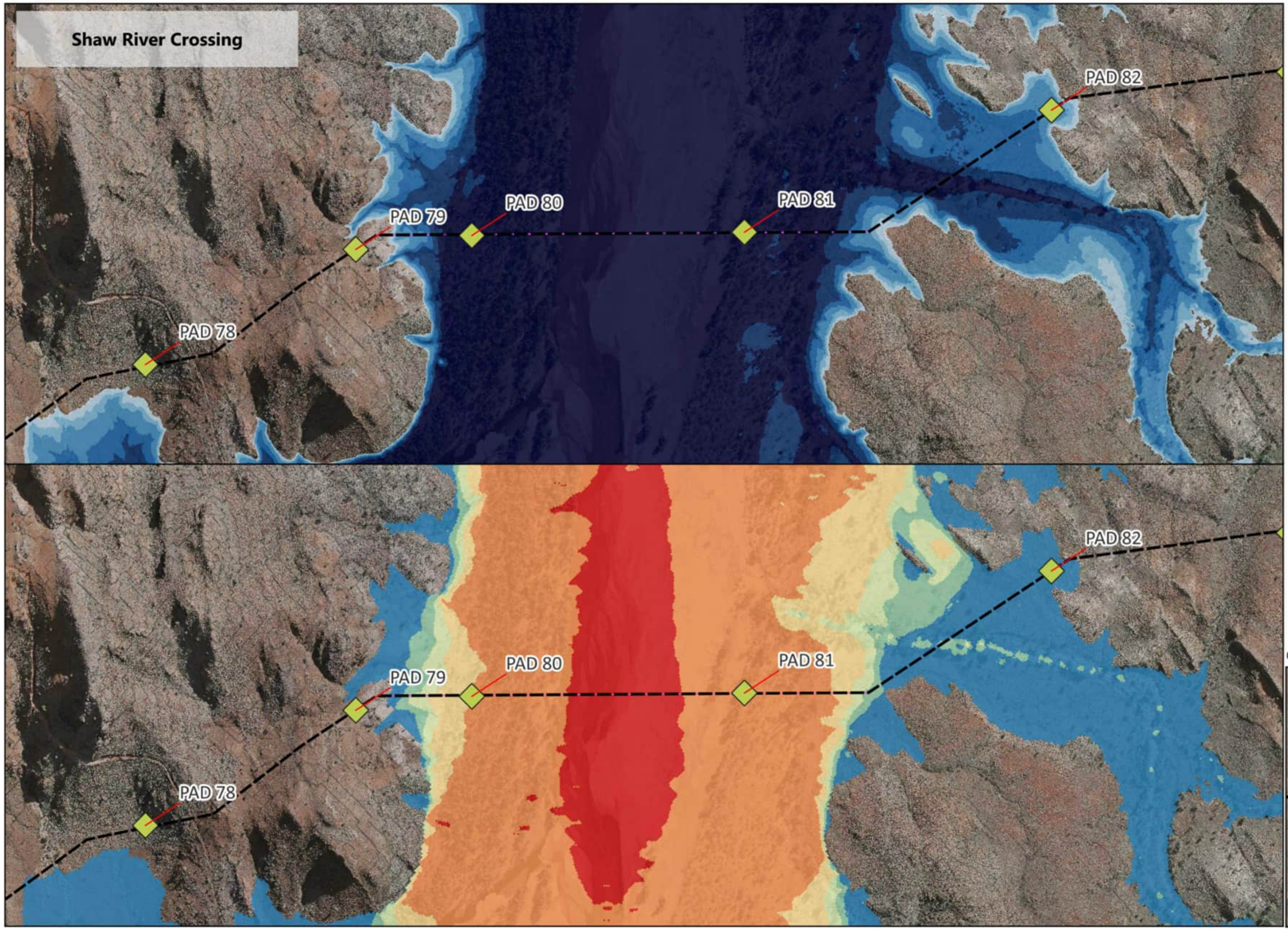


EPGH to the Iron Bridge Transmission Corridor (PTP Stage 6) Baseline Hydrology Study and Impact Assessment
0.2% AEP Flood Results

Legend

- PTP-6 Proposed Pads
- PTP-6 Proposed Route

Peak Flood Depth (m)

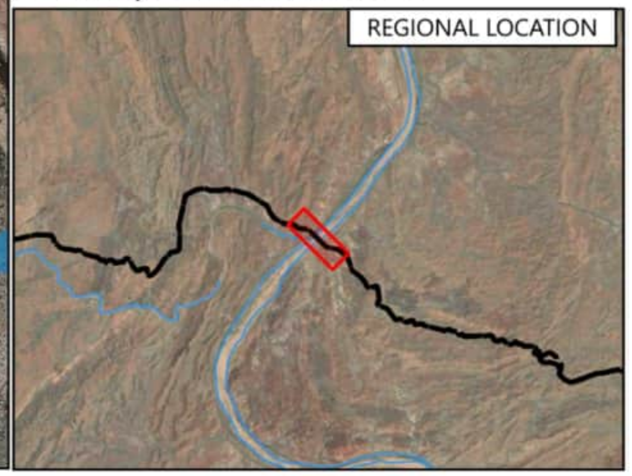
- <= 0.05
- 0.05 - 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- > 5.0

Peak Flood Velocity (m/s)

- <= 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

Scale at A3 - 1: 7,000
0 100 200 300 m

Coordinate System: GDA94 / MGA zone 50



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Appendix D. Transmission line drawings

General arrangement for transmission line structures