M5 Motorway Westbound Traffic Upgrade Concept Design and REF

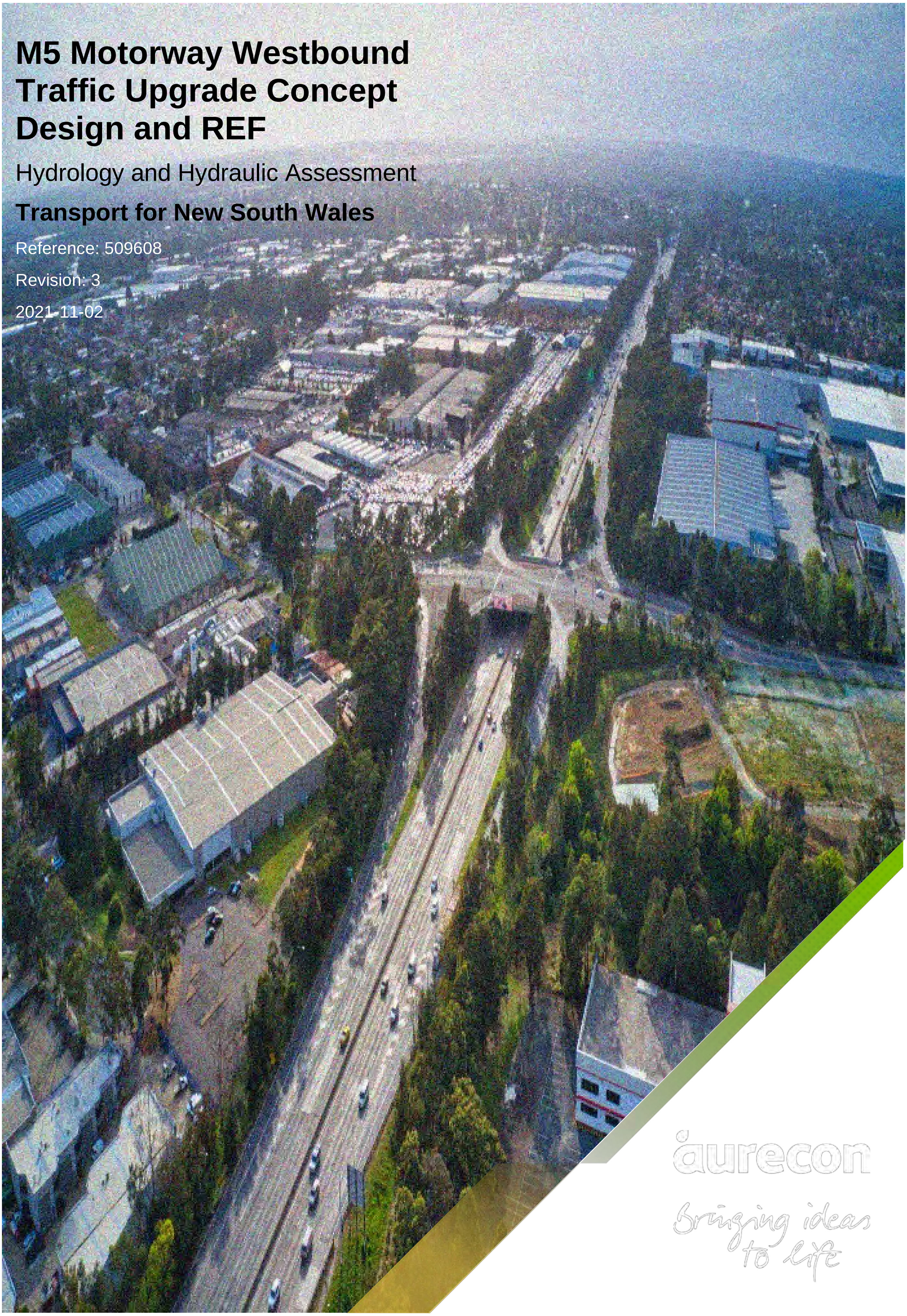
Hydrology and Hydraulic Assessment

Transport for New South Wales

Reference: 509608

Revision: 3

2021-11-02



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Document control						aurecon
Report title		Hydrology and Hydraulic Assessment				
Document code		M5WBU-AUR-NWW-WA-RPT-000001	**Project number**		509608	
File path		M5WBU-AUR-NWW-WA-RPT-000001				
Client		Transport for New South Wales				
Client contact		Michael Corrigan	**Client reference**		19.0000303661.1790	
Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Verifier** (if required)	**Approver**
0	2021-04-22	Issue to Client	AD	YM/PG		CM
1	2021-08-11	Second draft	AD	YM/PG		CM
2	2021-11-02	Third draft	AD	YM/PG		CM
3	2022-08-04	Final	AD			
Current revision		**3**				

Approval			
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1 Introduction

1.1 Proposal overview

Transport for NSW proposes to upgrade the M5 Motorway westbound between Moorebank Avenue, Moorebank and the Hume Highway, Casula. The proposal would ease congestion by improving connectivity between the M5 Motorway and the Hume Highway.

Key features of the proposal include:

- A new two-lane westbound M5 Motorway exit for Hume Highway traffic, located about 1.5 kilometres east of the existing Hume Highway exit. This exit ramp would include:
  - A grade separated underpass beneath Moorebank Avenue
  - A two-lane 290 metre long bridge over the Georges River, Southern Sydney Freight Line, and the T2 Inner West & Leppington and T5 Cumberland rail lines
- Removal of the current M5 Motorway westbound Hume Highway exit
- Upgrade of the M5 Motorway intersection with Moorebank Avenue to cater for future traffic demand
- Upgrade of the Moorebank Avenue westbound entry ramp maintaining access to the M5 Motorway and Hume Highway
- A new shared path on the southern side of the new Hume Highway exit ramp from Moorebank Avenue, across the Georges River on the new bridge and connecting to the Hume Highway and Lakewood Crescent
- Installation of new drainage infrastructure including:
  - Kerb and gutters, pits and pipes
  - Installation of a new operational spill basin under the new bridge, east of the Georges River
  - Removal of the existing spill basin near Yulong Close, Moorebank
- Intelligent Transport Systems (ITS) including installation and adjustments to traffic/SCATS detection, CCTV, a web camera, an emergency breakdown telephone and stopping bay, variable message signs (VMS) and backbone conduit
- Ancillary work associated with the proposal including:
  - Relocating, adjusting or protecting existing utility services that are in conflict with the proposal
  - Installation of new street lighting and various road furniture
  - Delineation including signage, line-marking and other items to facilitate road user safety of the new infrastructure
  - Landscaping
  - Property adjustments where necessary.

Construction is expected to take about 40 months to complete, assuming no unforeseen disruptions. Construction would be staged to minimise disruptions to transport customers and the community. There would be six construction areas across the proposal, with construction stages occurring concurrently to reduce construction time.

1.2 Proposal background

The M5 Motorway currently operates as the key through-traffic arterial connection for south west Sydney. It is used by local and regional motorists, freight carriers and businesses and supports economic and residential growth in the Western Sydney region. The section of the M5 Motorway between Moorebank Avenue and the Hume Highway (the proposal area) accommodates a variety of traffic movements in both directions of the Hume Highway and both directions of Moorebank Avenue, in addition to heavy through-traffic activity.

Congestion is experienced predominately in the afternoon period by motorists travelling westbound through Moorebank. Merging and weaving of vehicles entering the M5 Motorway from Moorebank Avenue and those exiting onto the Hume Highway results in safety and congestion issues for motorists. It is anticipated that future increases in heavy vehicle traffic from the proposed Moorebank Logistics Park (MLP), forecast growth of Liverpool Central Business District (CBD) and regional traffic growth would also add to congestion.

1.3 Purpose of this report

This hydrology and flooding report has been prepared to assess the potential flooding impact of the proposal. It will support a Review of Environmental Factors (REF) being prepared by Transport for NSW under Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.4 Report structure

The structure of this report is outlined below:

- Chapter 1 – Introduction
- Chapter 2 – Scope
- Chapter 3 – Legislation, standards and guidelines
- Chapter 4 – Hydrologic and hydraulic modelling
- Chapter 5 – Existing environment
- Chapter 6 – Proposal
- Chapter 7 – Impact assessment
- Chapter 8 – Conclusion
- Chapter 9 – Recommendations
- Chapter 10 – References.

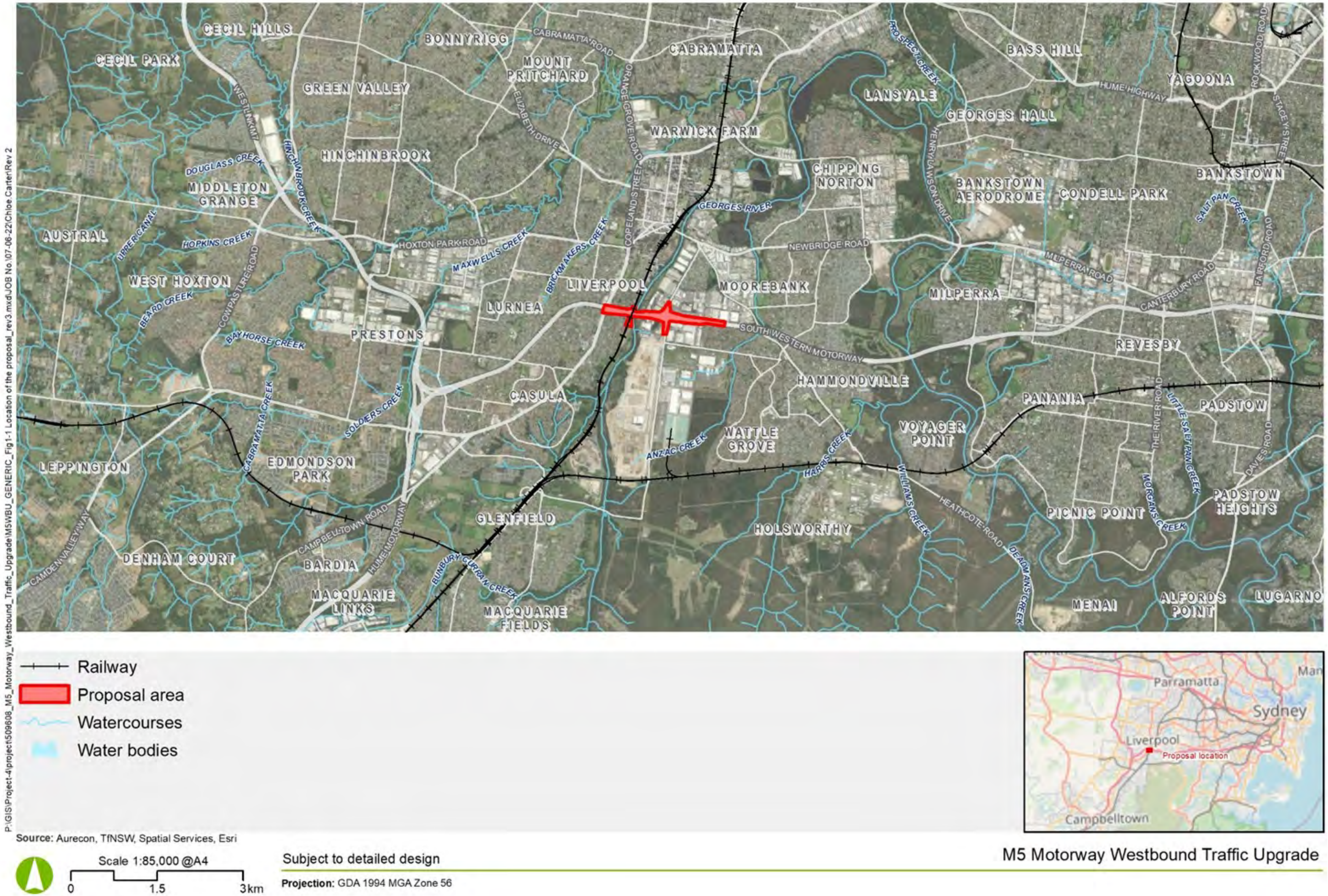


Figure 1-1 Location of the proposal

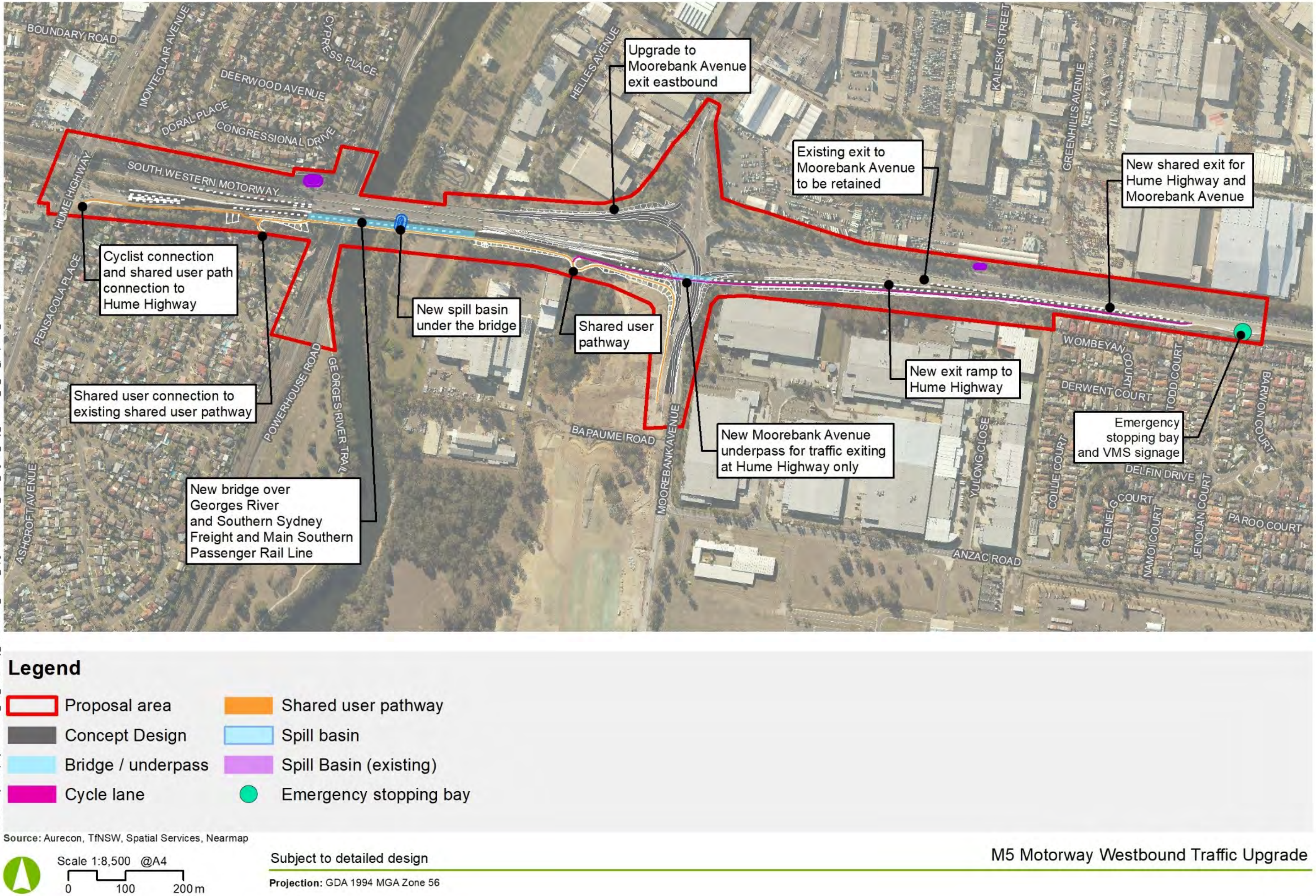


Figure 1-2 **Key features of the proposal**

2 Scope

The scope of the report includes:

- Obtain the most recent flood study undertaken for the Georges River (The Georges River Flood Study (BMT,2020)) including the associated hydrologic and hydraulic models
- Review the current study to acquire an understanding of the flood behaviour in the study area
- Review the hydrological analysis and hydraulic (TUFLOW) model for suitability to adopt as a basis for this current study
- Update the hydraulic (TUFLOW) model to represent the proposal and establish an existing conditions (baseline) model
- Develop a design case TUFLOW model incorporating the proposed road and bridge design
- Run the existing case and design case TUFLOW models for a range of design events
- Assess the flood immunity of the proposed road and bridge based on the modelled results and undertake a flood impact assessment
- Undertake a property impact assessment (if any)
- Inform the bridge design of hydraulic loading
- Prepare a technical report to discuss the assumption, methodology and outcome of the study in support of the 80 per cent concept design for the proposal
- Make recommendations to address hydrologic and hydraulic risks to be considered during detailed design.

2.1 Design criteria

The relevant design criteria for the proposal includes:

- Transport for NSW compliance targets for all cross-drainage features (refer to Table 2-1)
- Assessment of the ultimate effects of the proposal on regional flooding including a range of flood events (eg five per cent, two per cent and one per cent Annual Exceedance Probability (AEP) design events and Probable Maximum Flooding (PMF) event) and details of appropriate flood mitigation
- The terrain model must be updated based on any changes resulting from infrastructure development and the cumulative impacts of these changes included in the flood modelling
- For each bridge or bridge size culvert opening affected by flooding, review the hydrological study to confirm:
  - Serviceability effects of afflux on adjacent properties and the stability of the adjacent road embankment – one per cent AEP design event
  - Ultimate limit state of bridges, major drainage structures and major retaining walls – refer to Table 2-1 for minimum AEP.
- The potential effect arising from climatic change must be considered in the modelling
- The proposal must be designed such that the carriageways are not inundated for a flood event with a Minimum Average Recurrence Interval (ARI) of not less than that specified in Table 2-1.

Table 2-1 Transport for NSW compliance targets for ARI storm events

Item No.	Item	Minimum ARI
1	Channels and open drains	5 years (18% AEP)
2	Major storm event checks for no property damage	100 years (1% AEP)
3	Major storm event checks for no structural damage	2,000 years (0.05% AEP)
4	Temporary working platform for bridges-subject to sensitivity of the crossing	Ranging from 2 to 20 years (39% AEP to 5% AEP)
5	General flooding and flood immunity	100 years (1% AEP)

2.2 Assumptions and limitations

The following limitations relate to this study:

- The hydrological and hydraulic modelling undertaken by BMT (2020) has been assumed to be generally reliable with only minor updates required to suit the current study
- No detailed underground drainage infrastructure has been incorporated in the modelling as they do not interact with the Georges River flooding and were assumed to have an inconsequential effect on regional Georges River flooding. The assessment and design of the cross-drainage has been undertaken as part of the drainage design for the corresponding local catchments.
- All hydrologic and hydraulic modelling assumes existing case catchment development conditions. This means that future developments have not been considered in the development of the existing catchment conditions. This means that future developments have not been considered in the development of the existing catchment conditions. One of the major future development in the area is the Moorebank Intermodal Freight Precinct which located to the south of the proposed M5MA and to the east of the Georges River. It is assumed that the planning and the design of the Moorebank Intermodal Freight Precinct will incorporate stormwater management plan to ensure that post-developed peak discharges do not exceed the pre-developed peach discharges from the site (by the means of on-site detention basins for example) and therefore it impact on the proposed M5MA is anticipated to be minimal.

3 Legislation, standards and guidelines

Changes to the environment from the proposal as well as the management of natural processes are governed by relevant legislation, standards and guidelines. The following sections summarise the key legislation, standards and guidelines relevant to this Hydrology and Flooding assessment of the proposal.

3.1 NSW State legislation

3.1.1 Water Management Act 2000 (NSW)

The NSW *Water Management Act 2000* (WM Act) is administered by the NSW Department of Planning and Environment (DPE) and is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. The WM Act is also intended to provide a formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions.

The intent and objectives of the WM Act have been considered as part of this assessment. Provisions of the WM Act require the development of management plans to deal with flooding regimes and the way they are managed in relation to risks to property and life and to ecological impacts. The WM Act also defines approvals required for carrying out works situated near a river or floodplain via flood work approvals or drainage work approvals. However, the proposal would be exempt from these approvals as it is subject to Division 5.1 EP&A Act.

The main tool in the Act for managing the state's water resources are water sharing plans. These are used to set out the rules for the sharing of water in a particular water source between water users and the environment and rules for the trading of water in a particular water source. The proposal is located within the greater metropolitan region water sharing plan.

3.1.2 State Environmental Planning Policy (Transport and Infrastructure) 2021

State Environmental Planning Policy (Transport and Infrastructure) 2021 (SEPP Transport and Infrastructure) aims to facilitate the effective delivery of infrastructure across the State.

Section 2.108 of SEPP Transport and Infrastructure permits development on any land for the purpose of a road or road infrastructure facilities to be carried out by or on behalf of a public authority without consent. Part 2.2 of SEPP Transport and Infrastructure contains provisions for public authorities to consult with local councils and other public authorities prior to the commencement of certain types of development. Consultation with Liverpool City Council and The State Emergency Service (SES) was undertaken as required by Section 2.12 of SEPP Transport and Infrastructure, as the proposal is located on flood liable land. This is discussed in further detail in chapter 5 of the Project REF.

3.2 Other policies and guidelines

3.2.1 NSW Floodplain Development manual

The *Floodplain Development Manual* (former Department of Infrastructure, Planning and Natural Resources, 2005) and the *Flood Prone Land Policy* and *Floodplain Risk Management Guidelines* provide guidance to local and the NSW Government for managing flood risk.

The main objective of the *Flood Prone Land Policy* is to reduce the impact of flooding and flood liability on owners and occupiers of flood-prone property and reduce public and private losses. The policy recognises the benefits of use, occupation and development of flood-prone land.

The *Floodplain Development Manual* supports the policy and guides councils and the NSW Government through the floodplain risk management process. The manual helps councils develop and implement local floodplain risk management plans and outlines the technical assistance provided by the NSW Government.

The manual details the roles and responsibilities of various NSW agencies and includes information on the following:

- The preparation of flood studies, floodplain risk management studies and plans
- Floodplain risk management options
- Flood planning levels and areas
- Hydraulic and hazard categorisation
- Emergency response planning.

3.2.2 Australian Rainfall and Runoff 2019

The *Australian Rainfall and Runoff* (AR&R) (2019) guideline was published by the Commonwealth of Australia (Geoscience Australia) and is a governing document for hydrological and hydraulic analysis. It provides designers and analysts with tools, information and data for the assessment of design flood estimation in Australia.

3.2.3 Guide to Bridge Technology part 8: Hydraulic design of waterway structures (Austroads 2018)

The *Hydraulic Design of Waterway Structures* provides guidance on the design of waterway structures, design flood standards and estimation methods, and the assessment of scour and associated protection.

This guideline is primarily adopted for the assessment of the hydraulic loss associated with the new bridge sub-structure.

3.2.4 Liverpool Development Control Plan 2008, Part 1-General Controls for All Developments

Liverpool Development Control Plan (LDCP) controls the developments within the Liverpool City Council LGA. Section 9 of LDCP specifically sets out the requirements and limitations for development within the floodplain. It is noted that the DCPs do not apply to Division 5.1 EPA activities; however, the LDCP has been considered in development and planning of the proposal.

The LDCP document outlines the control items which are relevant to each development type depending on the land use risk category of the proposed development and the flood risk category of the proposed development site.

Based on the LDCP document the following can be determined:

- Land Use Category: Bridge does not fit any of the land use categories outlined in the LDCP
- Flood Risk Category: the proposed bridge is located at a section of the Georges River where flood risk is high.

The above does not result in a direct recommendation of the control reference numbers. However, the controls with the reference numbers of 1, 2, 4 and 5 were selected which covers all the possible items regarding the flood effects (Table 3-1). It is noted that the LDCP requirements do not apply to this proposal, however, the relevant controls have been considered in Table 3-1 to illustrate the proposal’s overall compliance with these controls.

Table 3-1 Liverpool Development Control Plan controls

DCP Control Item Reference Number (as referred to in the DCP)	Controls
1	Engineers report required to certify that the development will not increase flood effects elsewhere, having regard to: (I) loss of flood storage; (ii) changes in flood levels, flows and velocities caused by alterations to flood flows; and (iii) the cumulative impact of multiple similar developments in the floodplain.
2	The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: (i) loss of flood storage; (ii) changes in flood levels and velocities caused by alterations to the flood conveyance; and (iii) the cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.
4	A floodway or boundary of significant flow may have been identified in this catchment. This area is the major conveyance area for floodwaters through the floodplain and any structures placed within it are likely to have a significant impact on flood behaviour. Within this area no structures other than concessional development, open type structures or small non habitable structures (not more than 30sqm) to support agricultural uses will normally be permitted. Development outside the Boundary of Significant flow may still increase flood effects elsewhere and therefore be unacceptable
5	Any filling within the 1% AEP flood will normally be considered unacceptable unless compensatory excavation is provided to ensure that there is no net loss of floodplain storage volume below the 1% AEP flood.

3.3 Proposal nomenclature for design events

This assessment adopts the latest approach to design flood terminology as detailed in Australian Rainfall and Runoff (ARR 2019).

Accordingly, all design events are quoted in terms of Annual Exceedance Probability (AEP) using percentage probability. Table 3-2 provides a summary of the relationship between Average Recurrence Interval (ARI) and AEP based on ARR 2019, A Guide to Flood Estimation.

Table 3-2 Event nomenclature (taken from ARR 2019)

Exceedances per year (EY)	AEP (%)	AEP (1 in x)	ARI (years)
1	**63**	1.58	1
0.05	**39**	2.54	2
0.22	**20.00**	5	4.48
0.20	**18**	5.52	5.00
0.11	**10.00**	10	9.49
0.05	**5.00**	20	20
0.02	**2.00**	50	50
0.01	**1.00**	100	100
0.01	**0.50**	200	200
0.002	**0.20**	500	500
0.0005	**0.05**	2,000	2,000

The values shown in bold indicate the preferred terminology.

4 Hydrologic and hydraulic modelling

This section outlines the modelling methodology undertaken to assess the impact of the proposal on flooding and the impact of flooding on the proposal.

4.1 Previous studies

Several flood studies have previously been undertaken to investigate the flood behaviour of the Georges River. The key catchment-wide studies include:

- The Georges River Flood Study (BMT, 2020)
- The Georges River Floodplain Risk Management Study and Plan (Bewsher Consulting, 2004)
- The Georges River Flood Model Study (Bewsher Consulting, 1999)
- The Georges River Flood Study (PWD, 1991).

The Georges River Flood Study (BMT, 2020) hydraulic model was acquired from Liverpool City Council (LCC) and was reviewed in detail with an overview for application to this current study. The Georges River Flood Study (BMT, 2020) incorporated the following:

- A review of the previous flood studies
- A comprehensive hydrological analysis
- Development of a TUFLOW model for the study area
- Prediction of the flood behaviour and preparation of flood maps.

The Georges River Flood Study (BMT, 2020) is recent, comprehensive and covers the proposal study area. Therefore, it was adopted as a guiding document for this assessment.

4.2 Catchment overview

The Georges River catchment encompasses an area of approximately 960 square kilometres, located south-west of Sydney. The river meanders through one of Sydney's largest floodplain areas. The total Georges River catchment area covers a broad geographical extent from Appin, south of Campbelltown, to the coastal outlets at Botany Bay. Major tributaries that drain to the Georges River within this extent include the catchments of Bow Bowing Creek, Cabramatta Creek, Prospect Creek, Salt Pan Creek and the Woronora River. Figure 4-1 was extracted from the Georges River Flood Study (BMT 2020) and represents the catchment delineation for the Georges River catchment (with the current study area shown).

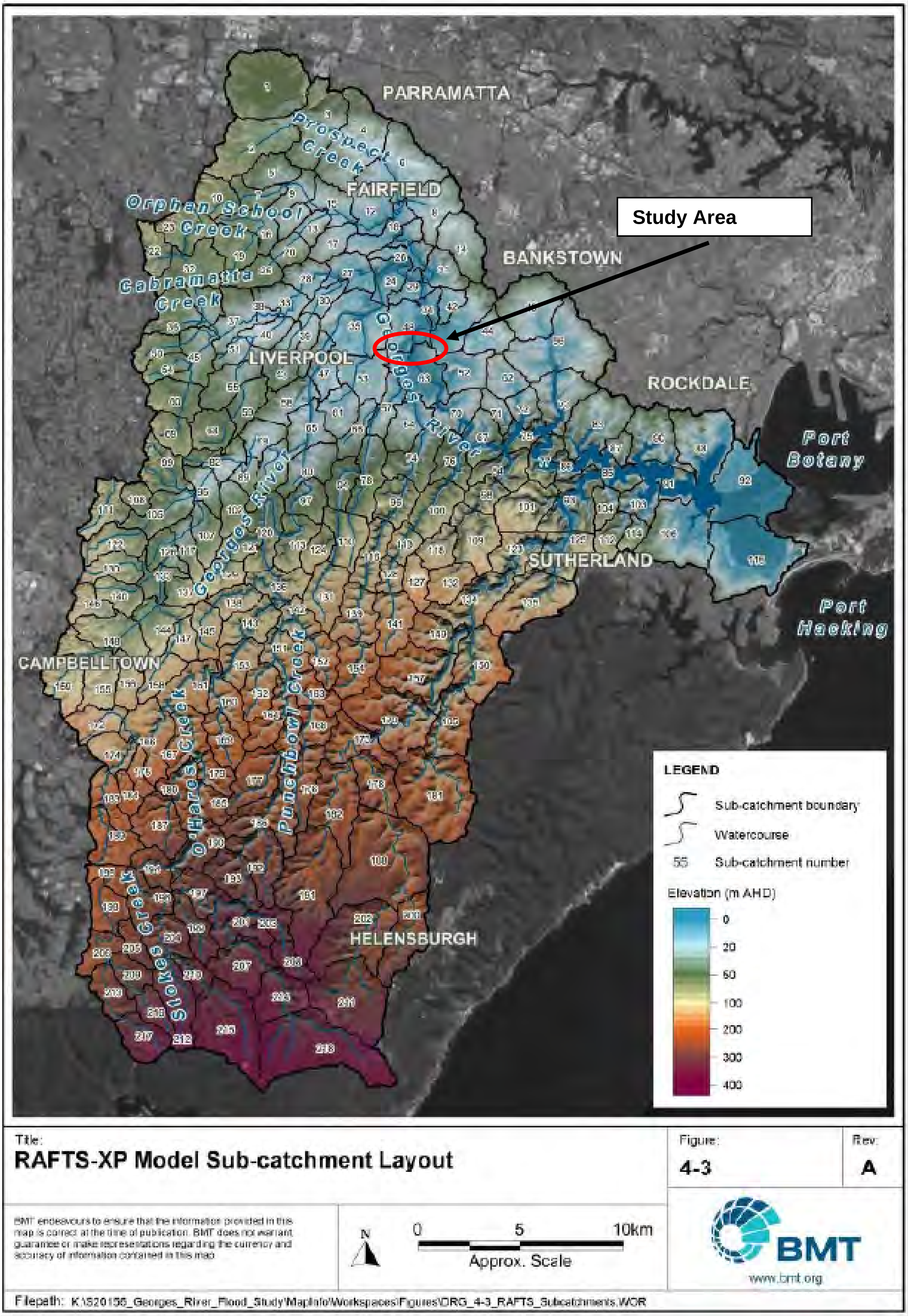


Figure 4-1 Georges River catchment delineation extracted from the Georges River Flood Study (BMT, 2020)

4.3 Data collection

Available information was collected from various sources to assist in understanding the existing environment and provide inputs into the assessment. The following sections detail the information obtained and adopted in the assessment.

4.3.1 Current models

The current LCC approved hydrologic and hydraulic modelling for the Georges River catchment (ie the Georges River Flood Study (BMT, 2020)) was sourced. The hydrological model was not provided; however, the hydraulic (TUFLOW) model was supplied by Council. This model was adopted as a basis for the study to assess the existing and proposed environment. More details on these previous studies are provided in Section 4.1.

4.3.2 Concept design

This assessment is based on the concept design undertaken by Aurecon. At the time of this assessment, the design was at the 80 per cent concept stage.

4.3.3 Road survey

The existing road survey of the M5 Motorway (between Hume Highway, Moorebank Avenue and Heathcote Road) prepared by Cardno (2019) and provided by Transport for NSW was adopted in this study for topographical representation of the existing road.

4.3.4 Existing M5 Motorway bridge drawings

The drawings for the existing bridges in the study area were acquired from Transport for NSW for review and adoption in this assessment.

4.4 Hydrology

4.4.1 Review of the base hydrology

The Georges River Flood Study (BMT, 2020) provides a detailed hydrological assessment of the Georges River catchment. It is noted that no hydrological model was provided within the LCC package. However, the report was reviewed for hydrological information relevant to the study area. The assessment has:

- Undertaken a catchment analysis of the Georges River using XPRAFTS and then calibrated the XPRAFTS model to the historical events
- Analysed for both the ARR 1987 and ARR 2016 methodologies and estimated the flows for a range of design flood events
- Undertaken a Flood Frequency Analysis (FFA)
- Reviewed the hydrologic results of the Georges River Flood Study (PWD,1991)
- Undertaken a comprehensive analysis, comparison and interpretation of the results.

The Georges River Flood Study (BMT, 2020) has concluded that the modelling based on the ARR 2016 methodology significantly under-estimates the peak discharges compared to the ARR 1987 methodology, the PWD (1991) study and the FFA. Following consultation with LCC, it was confirmed that the Georges River Flood Study (BMT, 2020) adopted the 1991 results for the assessment.

Table 4-1 presents a summary of the peak discharges for 1% AEP design event at the Liverpool Weir. Liverpool Weir is located approximately 1.5 kilometres downstream of the study area on the Georges River with no tributaries and confluences between them.

Table 4-1 Comparison of the peak discharges

Study/Method	Estimated 1% AEP Design Event Peak Discharge (m^3/s) at Liverpool Weir
Georges River Flood Study (PWD, 1991)	1,740
Georges River Flood Study (BMT, 2020)-AR&R 1987 Procedure	1,630
Georges River Flood Study (BMT, 2020)-AR&R 2016 Procedure	1,160
Georges River Flood Study (BMT, 2020)-FFA	1,500

Table note: m^3/s = cubic metres per second

It is noted that Georges River Flood Study (PWD, 1991) has identified the 36-hour storm duration as the critical duration at Liverpool Weir for the 1% AEP design event.

4.4.2 Adopted hydrology

The flow hydrographs from the Georges River Flood Study (PWD, 1991) have been adopted for this assessment consistent with the findings of the Georges River Flood Study (BMT, 2020). No requirement for updates or refinement was identified.

The flow hydrographs from the Georges River Flood Study (PWD, 1991) have been provided by LCC within the TUFLOW model set up. These consist of the 18 per cent, ten per cent, five per cent, one per cent, 0.5% and 0.2% AEP design events as well as Extreme Flood Event (EFE). EFE as referred to in the Georges River Flood Study (BMT, 2020) is understood to be equal to the Probable Maximum Flood (PMF) event.

No estimation of the 0.05% AEP design event flows has been undertaken in the Georges River Flood Study (BMT, 2020). To derive the boundary flows for this event, the same interpolation method adopted in the Georges River Flood Study (BMT, 2020) for estimation of the 0.5% and 0.2% AEP design events have been adopted.

Figure 4-2 shows the interpolation chart developed and used in the Georges River Flood Study (BMT, 2020).

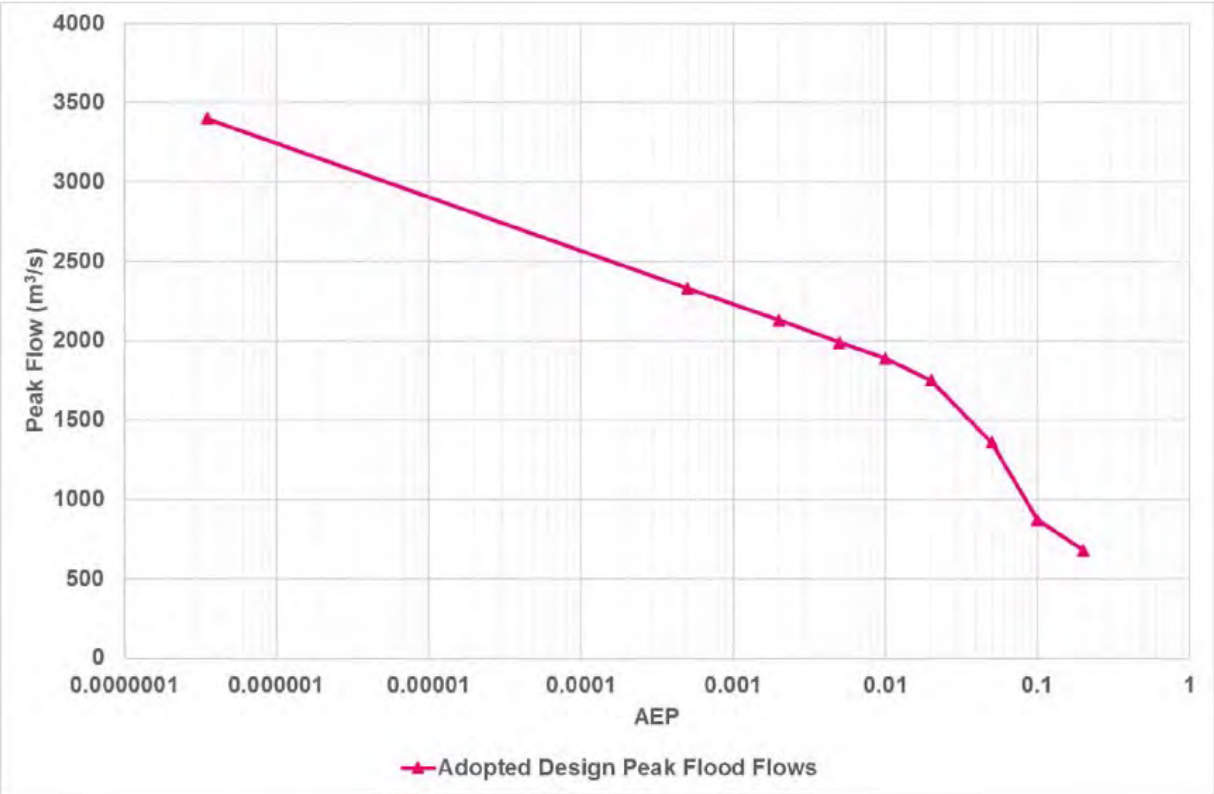


Figure 4-2 Estimation of very rare peak flood flows for the Georges River at Liverpool Weir-extracted from Georges River Flood Study (BMT, 2020)

4.4.3 Climate change

It is noted that ARR 2019 provides interim climate change factors. These factors are considered the latest available predictions on the future climate conditions. ARR 2019 predicts a worst-case increase in rainfall intensity of nine per cent and 19.7% (20%) for the years 2050 and 2090 respectively.

The Georges River Flood Study (BMT, 2020) has investigated sea level rise by reviewing the following documents:

- The East Coast Cluster Report – Climate Change Projections for Australian Natural resources Management Regions (Dowdy et al, 2015)
- NSW Sea Level Rise Policy Statement (Department of Environment, Climate Change and Water NSW (DECCW), 2009).

The Georges River Flood Study (BMT, 2020) adopted an allowance of 0.4 metres and 0.9 metres for sea level rise for the years 2050 and 2100 respectively. This allowance for sea level rise has also been adopted for this study. The climate change scenarios adopted for this study are summarised in Table 4-2.

Table 4-2 Climate change scenarios

Climate Change Scenario	Projection Year	Increase in Rainfall Intensity (%)	Sea Level Rise (metres)
1	2050	9	0.4
2	2090 to 2100	20	0.9

The flow hydrographs for the climate change scenarios were generated by scaling up the one per cent AEP design event hydrographs using the corresponding percentage. This has been undertaken in the absence of a hydrological model where the rainfall intensity values should ideally have been increased by the corresponding percentage increase. The approach adopted for estimation of the flow hydrographs to represent the climate change scenarios involves some approximation and may marginally underestimate the values compared to the typical method.

The tidal boundary for the climate change scenario applied the corresponding sea level rise increases to the tidal signal (cycle) that were adopted in the Georges River Flood Study (BMT, 2020) TUFLOW models.

4.5 Hydraulics

4.5.1 Review of the hydraulic model

The TUFLOW model developed as part of the Georges River Flood Study (BMT, 2020) (base hydraulic model) was reviewed for suitability for this study. The review of the hydraulic model covered various model setup characteristics, which are summarised in Table 4-3. Commentary regarding suitability of the approach and whether updates are proposed is also provided in the table.

Table 4-3 Review of the base hydraulic model

Modelling characteristic	BMT (2020) Study	Update Required (Y/N)
Events modelled	The hydraulic model is set up to run the 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP design events and the PMF event.	Y – The 0.05% AEP design event and climate change will need to be assessed
Historic/ calibration data	The TUFLOW flood model has been calibrated and validated to historic flood data collected in the August 1986, April 1988, April 2015 and June 2016 flood events based on an analysis of hydrologic records and historical flows at Liverpool Weir.	N

Modelling characteristic	BMT (2020) Study	Update Required (Y/N)
Model setup and extents	The extent of the 2-dimensional domain of the existing model covers the Georges River Flood Plain from Glenfield to Lugarno. From Lugarno, the 2d model is connected to a 1-dimensional extension that continues to Botany Bay. The current extent of the 2d model covers 4.5 km upstream and 28 km downstream of the M5 at its intersection with the Georges River at Moorebank.	N
Topography	The existing model has used the NSW Land and Property Information (LPI) LiDAR survey available for the entire catchment. The catchment wide LiDAR data is in the form of a high resolution (1 m grid) digital elevation model (DEM), comprising the following: ▪ 'Nepean River – east' 2011 LiDAR dataset ▪ 'Sydney – North' 2013 LiDAR dataset ▪ 'Sydney – South' 2013 LiDAR dataset ▪ 'Wollongong' 2013 LiDAR dataset.	Y – Incorporation of relevant project survey for better representation of the proposal area.
Computational approach	Model is setup to run with a 10 m grid.	N – Considered suitable to represent the Georges River for this assessment.
Structure data	Existing modelling included structure information for the existing environment which has been adopted for this study (bridges over Georges River)	Y – The modelling of the existing bridges to be reviewed and updated (if required) as these bridges are considered significant hydraulic controls in the study area.
Materials/ roughness values	Table 4-4 and Figure 4-3 extracted from the Georges River Flood Study (BMT, 2020) shows the roughness values and their spatial distribution.	N – Model roughness values considered suitable given the TUFLOW model was calibrated to the historical events.

Table 4-4 Surface roughness/Manning's n values

Land use type	Manning's n	Comments
Channels	0.015 - 0.035	Variable. Adjusted locally (within reasonable bounds) to provide best fit for peak water level profiles.
Floodplain	0.03 – 0.15	Variable. Adjusted locally (within reasonable bounds) to provide best fit for peak water level profiles. Variability largely reflects degree of vegetation and land use on the floodplain (developed, cleared and forested).

4.5.2 Updates to the base hydraulic model

The hydraulic model was updated prior to being adopted for the purposes of this study. The updates made are detailed in the sections below.

Existing bridge on M5 Motorway over the Georges River

Modelling of the existing M5 Motorway bridges over the Georges River (in the study area) was reviewed and updated based on the existing bridge drawings supplied by Transport for NSW. The existing structures have been modelled as one bridge (in the base hydraulic model) whereas the westbound and eastbound carriageways are in fact two separate structures. Not all the piers of the two consecutive bridges are aligned perfectly along the flow direction which consequently leads to increased wetted pier diameter. In addition, the piers of the two existing bridges are 15 metres apart which is greater than the model's grid cell size. This also justifies the modelling of the two existing bridges to be undertaken separately.

The pier loss values were calculated in accordance with AUSTROADS Waterway Design (2018). The loss is based on the ratio of the wetted area of the piers to the gross waterway cross section at this location. The calculated loss values were incorporated in the modelling of the existing bridges in the TUFLOW model.

The pier loss calculations for the existing bridges are provided in Appendix A.

Existing road survey

The TUFLOW model was updated based on the detailed survey for the existing M5 Motorway (for the proposal extent) for better topographical representation of the road. The survey was undertaken by Cardno in October 2019 and was provided by Transport for NSW.

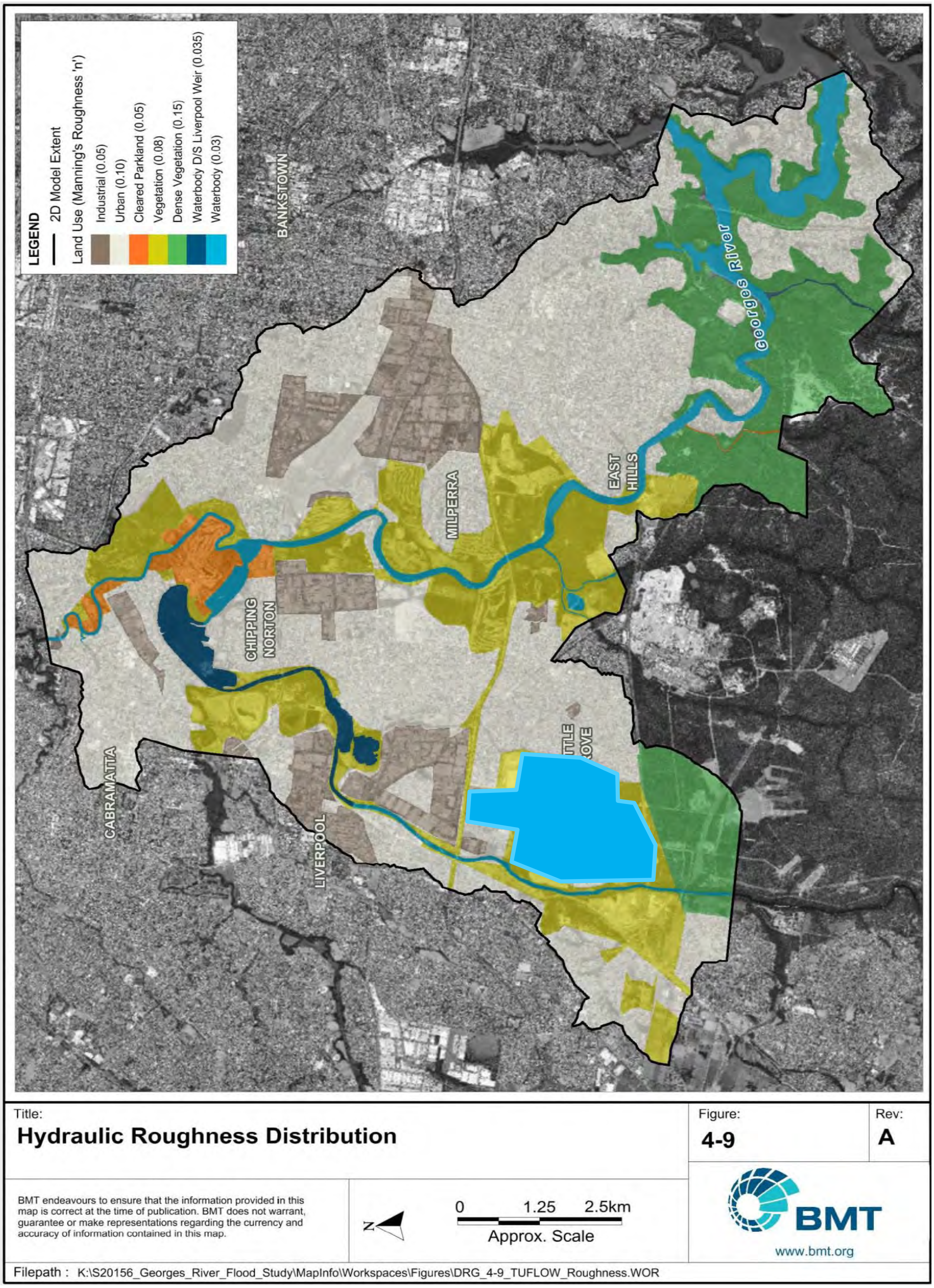


Figure 4-3 Hydraulic roughness distribution extracted from the Georges River Flood Study (BMT, 2020)

5 Existing environment

The study area is located in Moorebank with the proposed upgrade extending from the Hume Highway at the west to about 750 metres west of M5 Motorway/ Heathcote Road intersection.

The proposed upgrade runs through predominantly developed areas. Development on the northern side of the study area predominantly comprises industrial/commercial buildings and residences. Development on the southern side of the study area consists of high-density residential buildings on the western side of the Georges River and low-density industrial/commercial buildings on the eastern side.

At the Georges River crossing, the existing M5 Motorway bridges are the main hydraulic features in the study area.

The baseline scenario was run for the five per cent, two per cent, one per cent and 0.05% design events as well as the PMF event.

5.1 Existing environment model development

A baseline scenario was set up, as described in Section 4.5.1, which incorporated the updates as described in Section 4.5.2.

5.2 Flood behaviour

The baseline scenario results were reviewed for appreciation of the flood behaviour in the study area. The flood behaviour in the study area can be characterised as follows:

- Peak flow velocities of about 3.5 metres per second (m/s) and 4.5 m/s are predicted at the location of the existing bridges in a one per cent AEP design event and the PMF event respectively
- Peak flood levels of up to 10.4 metres and 12.4 metres AHD are predicted just upstream of the existing bridges in a one per cent AEP design event and the PMF event respectively
- Minor break out is predicted from the eastern bank of the Georges River in a one per cent AEP design event approximately 300 metres upstream of the bridges
- No inundation of the existing M5 Motorway is predicted in a one per cent AEP design event. However, minor inundation and overtopping are anticipated in the PMF event.
- The existing bridges are not predicted to be submerged in the flood events up to and including the PMF event.

The flood maps representing the flood depths, levels and velocities in the existing environment are provided in Appendix B.

6 Proposal

6.1 Key features

The proposed environment assessed in this report comprises all work associated with the M5 Motorway Westbound Traffic Upgrade, which includes:

- Upgrades to the M5 Motorway extending about 1,250 metres east and 400 metres west of the Georges River
- A new approximately 290 metre long bridge crossing over Georges River.

The proposed new bridge crossing over the Georges River is anticipated to be the main hydraulic control of the proposal.

The new bridge would comprise seven spans of varying length for a total bridge length of approximately 290 metres. The proposed span lengths would comprise:

- Spans 1, 2 and 3 – 38 metres in length and would span over land on the eastern side of the Georges River
- Spans 4 and 6 – 43 metres in length. Span 4 would be located over land on the eastern side of the Georges River; Span 6 would be located over the southern passenger and freight rail corridor
- Span 5 – 56 metres in length and would span over the Georges River
- Span 7 – 32.8 metres in length and would span over Lakewood Crescent connecting to the Georges River western bank.

The proposed pier spacing and span lengths have been designed to generally match the existing Georges River bridges. Consequently, there would be no skew of the proposed piers in relation to the superstructure and the piers would not line up with the river flow direction.

A schematic representation of the proposed bridge is shown in Figure 6-1.

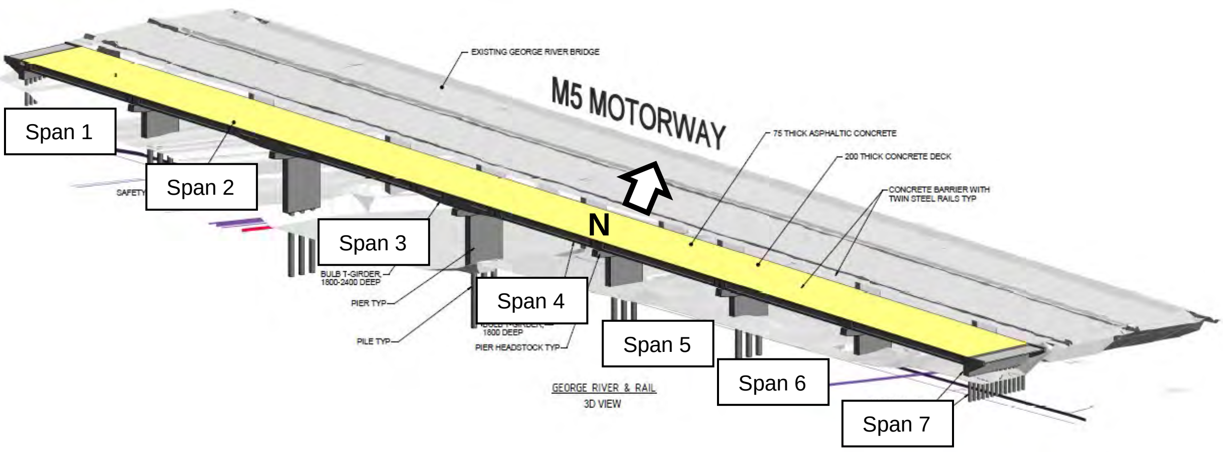


Figure 6-1 Schematic representation of the proposed bridge

6.2 Proposal model development

The proposed environment TUFLOW model was developed based on the existing environment model and application of the following updates:

- A Digital Terrain Model representing the proposed design.
- Proposed bridge design modelled using the 2D Layered Flows Constriction feature in TUFLOW and based on the bridge design drawings for 80% concept design. Refer to Figure 6-1 for a schematic representation of the proposed bridge The pier loss calculation for the proposed bridge is provided in Appendix C.
- The material representation of the TUFLOW model was updated to reflect the changes in the roughness values from Pasture to Road according to the proposed design features.

6.3 Proposal flood behaviour

No significant changes in the flood behaviour is anticipated as a result of the proposed design compared to the existing environment. This is primarily due to the following factors:

- No submergence of the proposed bridge deck is anticipated in the flood events up to and including the PMF.
- No inundation and overtopping of the proposed road are expected in a one per cent AEP design event. Minor overtopping of the proposed upgrade is predicted in a PMF event. However, this is generally consistent with the PMF flooding of the M5 Motorway in the existing environment. Therefore, this is not expected to result in significant changes in flood behaviour. No flooding of the Moorebank Avenue and Moorebank Avenue intersection is predicted in the flood events up to and including the PMF flood event.
- The proposed new bridge piers result in only minimal changes to flow hydraulics as they are consistent with the existing bridge piers in terms of the size, shape, spacing and location.

7 Impact assessment

7.1 Flood immunity

7.1.1 Construction phase

A number of construction activities can potentially be prone to risk of flooding. These include any temporary earthworks as part of the construction activities (eg stockpiles), temporary buildings and site sheds, construction plant or storage facilities that are located within flow paths and have the potential to impact flooding conditions by altering flow depths, velocities or flow paths.

Where it is required to build temporary works in the floodplain (eg waterway crossings) during the construction phase, these could also potentially alter flooding conditions. Portable buildings and large unsecured construction objects have the greatest potential to affect flooding. They can be carried away by deep floodwaters and worsen local flood conditions by blocking bridges, culverts and flood control structures downstream.

Construction phase flood impacts have not been quantitatively modelled as part of the current assessment as construction activities are temporary and highly dynamic and can be designed to accommodate local flood risk.

Figure 7-1 presents the extent of the proposed construction site and the location of ancillary facility. While the ancillary facility would be placed on the east bank of Georges River, the construction activities of the bridge starts from the west bank by short closure of Powerhouse Road. The barge would be mobilised, and appropriate environmental controls would be set up within the waterway and sheet piling would be placed in front of Pier 5 to maintain stability of Powerhouse Road.

Based on the results of the Georges River Flood Study (BMT, 2020) presented in Figure 7-2, Area 4 (construction work for the bridge over George River) and the designated location of the ancillary facility on the east bank are prone to flooding in the 5% AEP (20-year ARI) event. On the west bank, Powerhouse Road is also subject to flooding in a 5% AEP event, but Lakewood Crescent is anticipated to remain flood-free in such an event. Therefore, the ancillary facility and the early construction equipment on the west bank are likely to experience flooding during more frequent flood events.

Due to the short duration of the construction activities the likelihood of experiencing a major flood event during that period is relatively low. However, the following mitigation measures would minimise the flooding risks to the ancillary facility and construction equipment:

- The contractor would undertake a flood impact assessment to quantify the flood risk to their operations and determine the flood impact of their temporary works and/or operations during the construction phase.
- To the extent practicable, construction compounds, site sheds, stockpiles and laydown areas should be located outside the flood-prone areas.
- The timing and duration of the construction activities in vicinity of waterways would be planned to occur at times of year when the chance of major flood events is low.
- Where construction compounds are located on flood prone land, and adverse flood impacts are not acceptable, the construction contractor should consider the use of elevated site sheds that are designed to allow the passage of floodwater beneath the structures.
- Placement of stockpiles, fuels, contaminating material and loose equipment should be avoided within the construction compounds or sites affected by floodwaters or should be located as far as is practical.
- To the extent practicable, the ground surface slopes and imperviousness at the construction sites should be maintained close to the existing conditions.
- Minimise and manage impacts through documentation and implementation of the approved Environmental Management Plan (or similar).

7.1.2 Operations phase

It is a requirement that the proposed road upgrade achieves a flood immunity of one per cent AEP design event. This is predicted to be achieved for the proposed road upgrade based on the flood modelling results. Flood maps included in Appendix B provide further information regarding the flood behaviour and the anticipated road immunity.

7.2 Impacts on flooding conditions

7.2.1 Construction phase

As discussed above and based on the local Council flood study, the proposed locations of Area 4 and ancillary facilities may be subject to inundation in the 5% AEP and rarer events.

The construction activities within Area 4 includes enabling works, excavation, piling and bridge superstructure. The ancillary works include noise walls, utility adjustment, retaining walls and road furniture/signage, lighting, tie-in work, landscaping, earthworks and the like. As shown in Figure 7-2 the ancillary facility on the east bank of the river and the temporary/semi-permanent structures (such as sheds, offices, toilets, vehicle parking, material laydown areas, machinery and equipment) are located within the 5% AEP flow paths and have the potential to impact flooding conditions by altering flow depths, velocities or flow paths. Portable buildings and large unsecured construction objects have the greatest potential to affect flooding. They can be carried away by deep floodwaters and worsen local flood conditions by blocking bridges, culverts and flood control structures downstream.

Construction phase flood impacts have not been quantitatively assessed as part of the current REF as construction activities are temporary, highly dynamic and can be designed to accommodate local flood risk. Owing to the fact that the construction activities would occur over a short period of time, the likelihood of experiencing a major flood event during that period is relatively low. However, to minimise adverse impacts on flooding conditions it is recommended to adopt and implement the mitigation measures in Section 7.1.1.

It is recommended that no occupied facilities (such as semi-permanent offices) be located within the 5% AEP flood extent (see Figure 7-2) without implementation of mitigation measures. It is also recommended that the contractor prepare a flood warning and evacuation plan.

It is also noted that the proposed construction methodology for the bridge would involve the use of a barge. It is understood that due to moveable nature of the barge, it can be mobilised to a safer location along the river where the potential risks can be minimised.

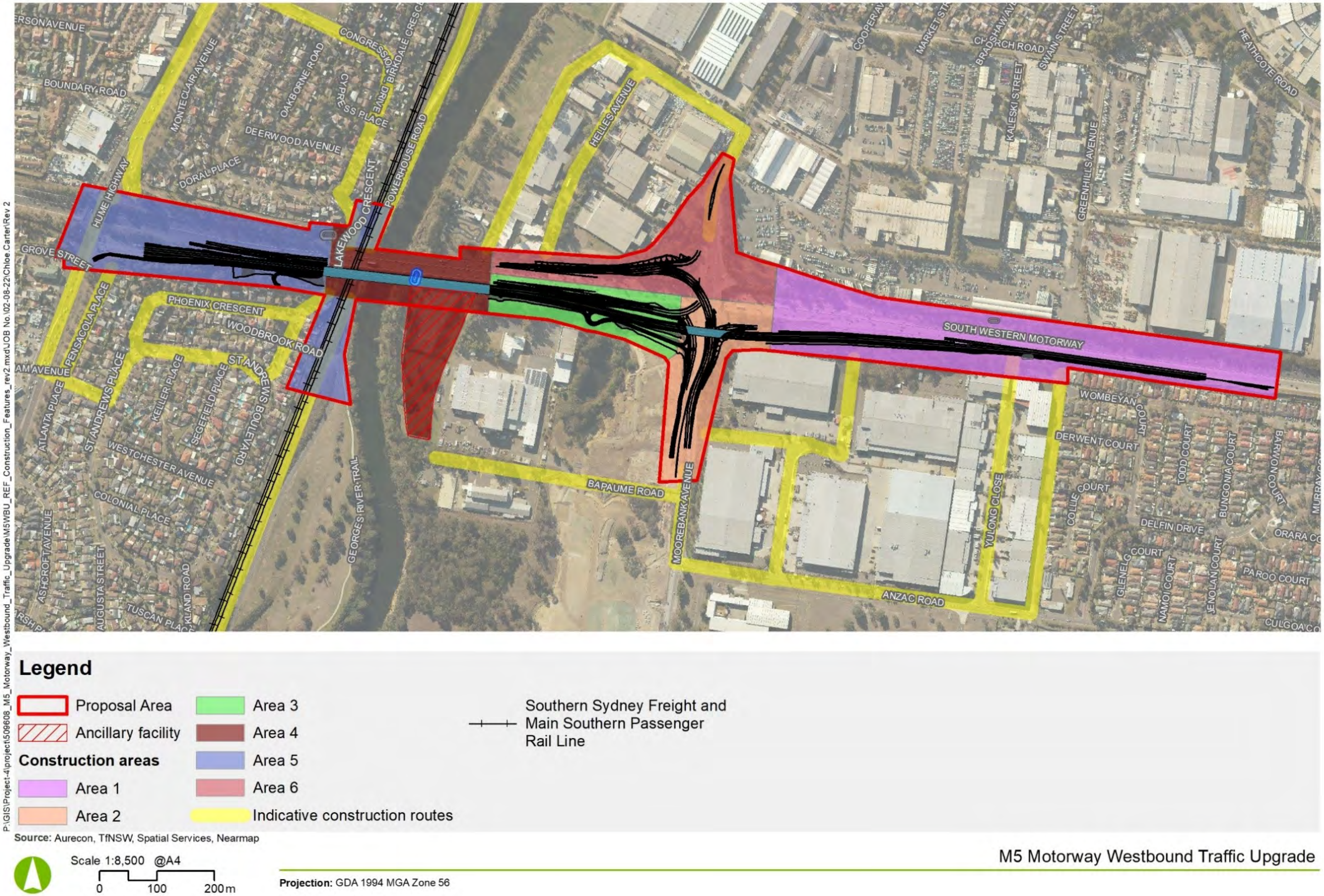


Figure 7-1 Construction features

Figure 7-2 5% AEP Ancillary facilities

7.2.2 Operations phase

No significant changes in the flood behaviour of the Georges River is predicted as a result of the proposal. The changes in flood behaviour are as a result of additional losses imposed by the sub-structure (piers) of the proposed bridge. Increases in peak flood levels (affluxes) of up to approximately 20 millimetres in a one per cent AEP design event and the PMF are predicted upstream of the proposed bridge. This impact is expected to extend to the residential properties to the west and commercial properties to the east. Impacts on these properties are further discussed below.

The only exception to this general predicted afflux is an area located on the eastern floodplain of the river, south of the proposed road embankment and west of Moorebank Avenue within Titalka Park. In this area the LiDAR information indicates a 3m deep depression. The 1% AEP floodwaters break out from the main Georges River channel and flow towards this depression where the floodwaters pond. An afflux of about 200 millimetres is predicted in this depression under the 1% AEP flood event. This area is currently zoned as General Industrial. However, this specific part of the site forms a natural pond and is not recommended for built type developments. The site however, can still be kept as a park or accommodate developments which would generally keep the natural topography of the site (such as sports field). Figure 7-3 shows the affluxes that are predicted in this area. Refer to Appendix B for existing environment, design environment and impact maps.

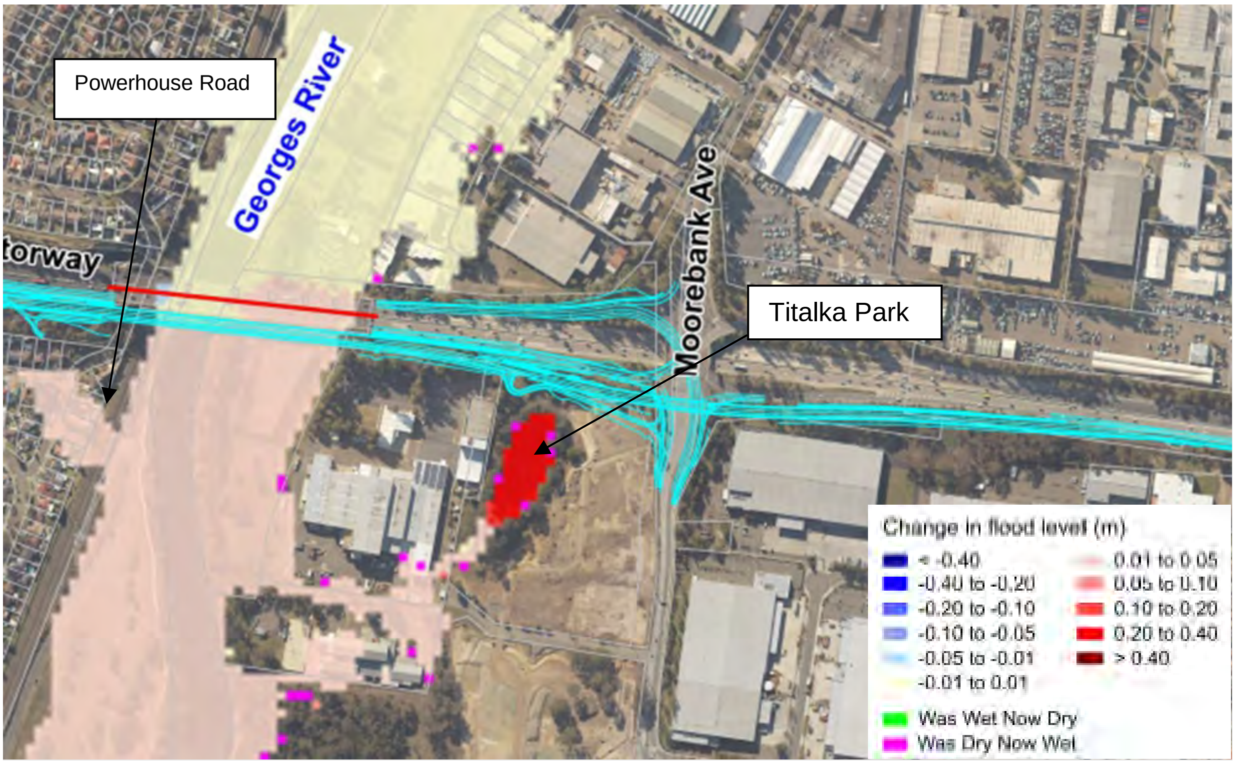


Figure 7-3 Afflux predicted in the pond in Titalka Park in a 1% AEP design event

Impacts on properties

Seven residential properties (to the west of the Georges River) and two commercial properties (to the east of the Georges River) were identified within the predicted afflux zone based on the review of the aerial imagery, cadastre and the predicted afflux extent. The potential impacts on the buildings within these properties cannot be fully assessed in the absence of a detailed building floor level survey. However, the predicted affluxes of up to 20 millimetres are not expected to impose significant risk to the buildings because of the following:

- These properties are predicted to have substantial inundation of up to about one metre in the existing environment and that the predicted increases in the inundation depth of up to 20mm is considered minimal.

- The flow velocities in the existing environment are low (less than 0.2m/s) and that no increase in flow velocities is predicted as a result of the proposal.
- No changes to the flood hazard classification is predicted as a result of the proposal.

The locations of these buildings are shown in Figure 7-4 and Figure 7-5. Details of these properties along with predicted afflux magnitudes (for the one per cent AEP design event) are summarised in Table 7-1. Table 7-2 provides a summary of the predicted velocities and $D^{x}V$ (depth and velocity product) and their predicted increases as a result of the proposal.

Potential impacts on the buildings within these properties could not be assessed at this concept stage. Further assessment, including building floor surveys, is proposed at detailed design stage.

Table 7-1 Potential flood impacts on existing flood effected properties

Lot Number	DP Number	Land Use Type	Afflux in 1% AEP event
2	DP32998	Industrial	<20 mm
3	DP32998	Industrial	<20 mm
970	DP246753	Residential	<20 mm
971	DP246753	Residential	<20 mm
960	DP246753	Residential	<20 mm
959	DP246753	Residential	<20 mm
958	DP246753	Residential	<20 mm
982	DP246753	Residential	<20 mm
957	DP246753	Residential	<20 mm

Table 7-2 Predicted Increase in Flow Velocities and $D^{x}V$ (depth and velocity product)

Lot Number	DP Number	Existing velocities (m/s)	Increase in Velocities (m/s)	Existing V×D (m^2/s)	Increase in V×D (m^2/s)
2	DP32998	0.18	0	0.01	0
3	DP32998	0.03	0	0.002	0
970	DP246753	0.07	0	0.003	0
971	DP246753	0.03	0	0.001	0
960	DP246753	0.07	0	0.007	0
959	DP246753	0.09	0	0.005	0
958	DP246753	0.14	0	0.13	0
982	DP246753	0.09	0	0.06	0
957	DP246753	0.12	0	0.005	0

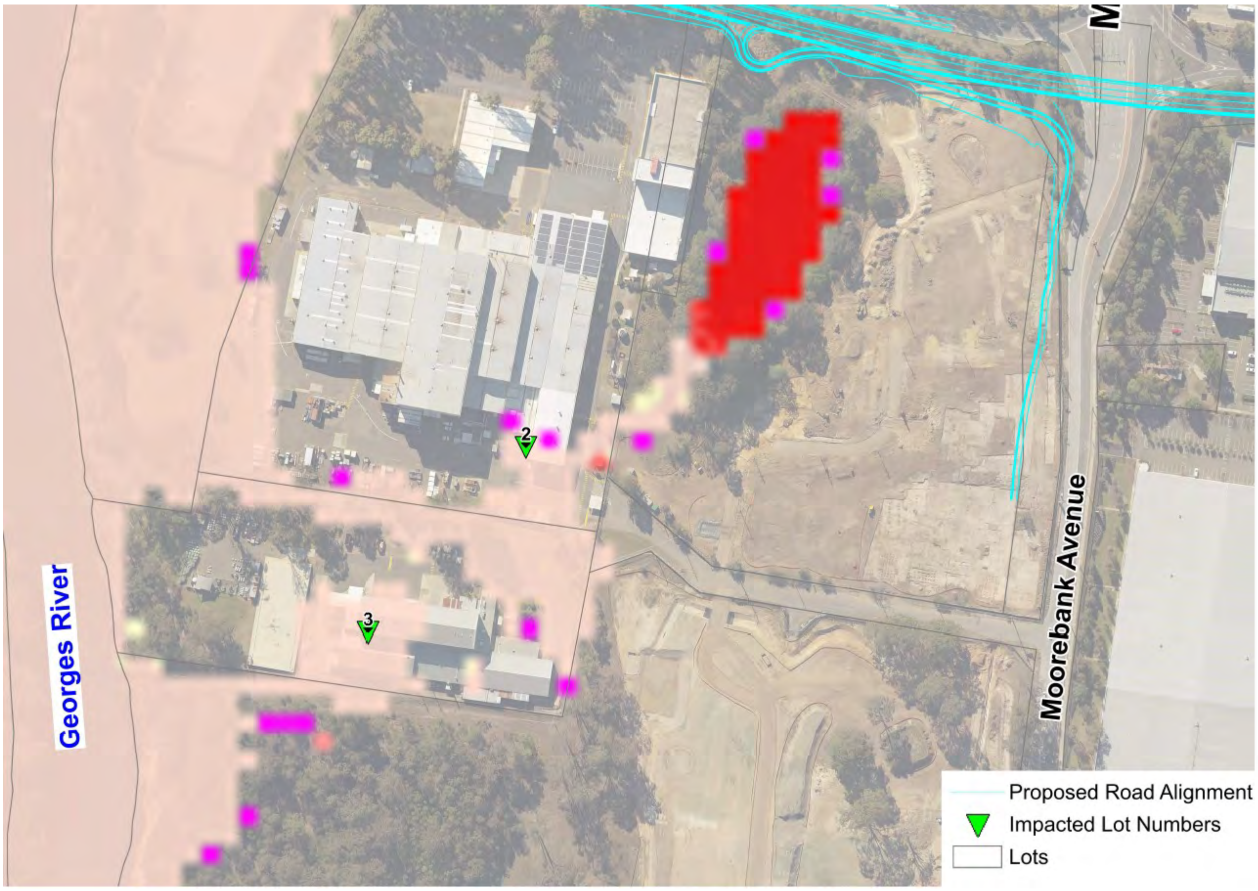


Figure 7-4 Potentially flood sensitive properties – east of the Georges River (1% AEP)

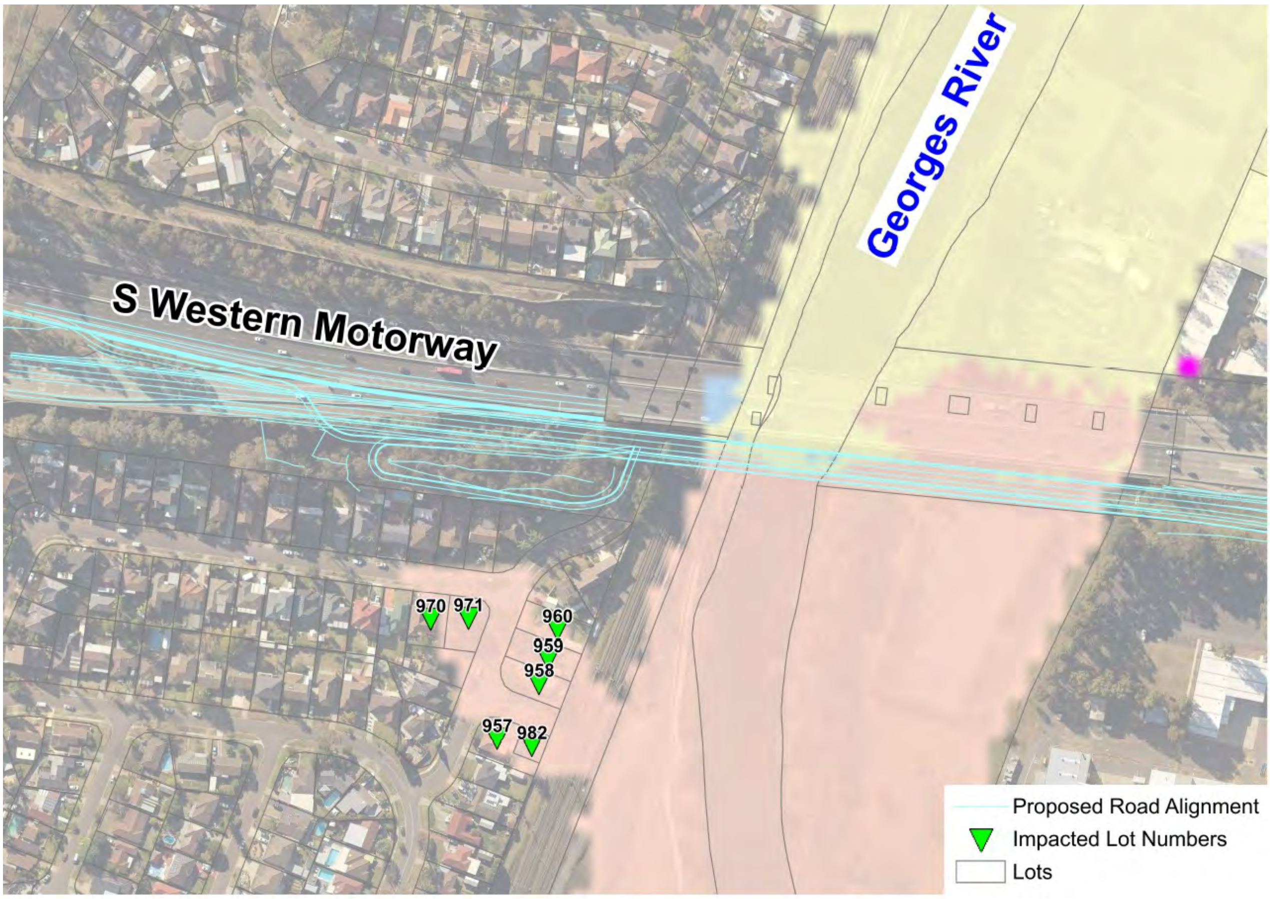


Figure 7-5 Potentially flood sensitive properties – west of the Georges River (1% AEP)

A section of Powerhouse Road and the Woodbrook Road underpass is predicted to be inundated in the five per cent, two per cent and one per cent AEP design events in the existing environment. These sections of the roads are predicted to have an increased peak flood level of less than 20 millimetres as a result of the proposal in the five per cent, two per cent and one per cent AP design events and the PMF. However, no significant increases in the peak velocities and the "peak velocity/peak depth" (V×D) are expected in these sections. Therefore, this impact on the existing road is considered minimal and acceptable. The extent of the impacts on Powerhouse Road is shown in Figure 7-3.

Floodplain storage

The proposed bridge is not expected to result in significant loss of floodplain because of the following:

- The bridge is an open structure
- The bridge deck is not anticipated to submerge in the flood events up to and including PMF event
- The loss of the floodplain storage due to the proposed bridge sub-structure is anticipated to be minimal compared to the available floodplain storage. The proposed bridge abutments are not anticipated to be submerged in the design events up to 1% AEP design event. The eastern abutment may be submerged in the PMF event.

Potential changes in flow velocities

No significant increases in flow velocities are anticipated as a result of the proposed bridge in the flood events up to and including the PMF event. Refer to Figure 7-6 for representation of the changes in peak flow velocities as a result of the proposal in a one per cent AEP design event.

Figure 7-6 Predicted changes in peak flow velocities as a result of proposal – 1% AEP

Limitation of study

It is noted that this current flood assessment is based on Georges River flooding and does not include the flooding from the ANZAC Creek.

7.3 Climate change assessment

The climate change scenarios in Table 4-2 were run for the one per cent AEP design event with the results described in the following sections.

7.3.1 Climate Change Scenario 1

Based on the results, the influence of climate change scenario 1 is predicted to result in increases in peak water levels of up to approximately 300 millimetres upstream of the proposed bridge in a one per cent AEP design event. No submergence of the proposed bridge is anticipated as a result of the Climate Change Scenario 1 influence. However, inundation of the M5 Motorway is predicted as a result of the Climate Change Scenario 1 influence.

7.3.2 Climate Change Scenario 2

The influence of climate change scenario 2 is predicted to result in significant increases in peak water levels of up to approximately 500 millimetres upstream of the proposed bridge in a one per cent AEP design event. No submergence of the proposed bridge is anticipated as a result of the Climate Change Scenario 2 influence. However, inundation of the M5 Motorway is predicted as a result of the Climate Change Scenario 2 influence.

Appendix B includes maps showing the changes in the increase in peak flood levels as a result of the estimated climate change scenarios for the proposed environment in a one per cent AEP design event.

8 Conclusion

The findings of the study can be summarised as follows:

- Based on the existing environment results, the existing bridges are not predicted to be submerged in the flood events up to and including the PMF event. The M5 Motorway is not predicted to be inundated in the design events up to and including a one per cent AEP design event. However, minor inundation and overtopping of the M5 Motorway is predicted in the PMF event.
- No significant changes in the flood behaviour is anticipated as a result of the proposal. This results in increases in peak flood levels of up to 20 millimetres upstream of the proposed bridge in the flood events up to and including the PMF. The changes in the flood behaviour are due to additional losses imposed by the proposed bridge substructure.
- The proposal is predicted to achieve the required flood immunity in the one per cent AEP design event.
- A number of residential properties to the west of the Georges River and commercial complexes to the east of the Georges River are predicted to experience increased peak flood levels of up to approximately 20 millimetres in a one per cent AEP design event and the PMF event as a result of the proposal. These properties currently experience about one metre of inundation during the flood events. Potential impacts on the buildings within these properties could not be assessed at this concept stage. Further assessment, including building floor surveys, is proposed at detailed design stage.
- A section of Powerhouse Road and the railway corridor is also predicted to be impacted by less than 20 millimetres of increase in peak flood levels in a one per cent AEP design event and the PMF as a result of the proposal. However, no increases in peak flow velocities are anticipated. Therefore, the impact is considered minimal.

9 Recommendations

The study has identified a number of properties to be impacted by affluxes of less than 20mm. It is recommended that a building floor level survey be undertaken for these properties and a more detailed assessment be undertaken in the next phase of the study.

It is also recommended that a survey of a section of the Powerhouse Road and the railway (immediately south of the bridge and west of the Georges River where the precited flood overtopping in 1% AEP design event occurs) to allow more detailed assessment of the impacts.

10 References

BMT WBM, 2018, TUFLOW User Manual

BMT, 2020, Georges River Flood Study

Dowdy et al, 2015, The East Coast Cluster Report- Climate Change Projection for Australian Natural Resources Management Regions

Department of Environment, Climate Change and Water NSW (DECCW),2009, NSW Sea Level Rise Policy Statement

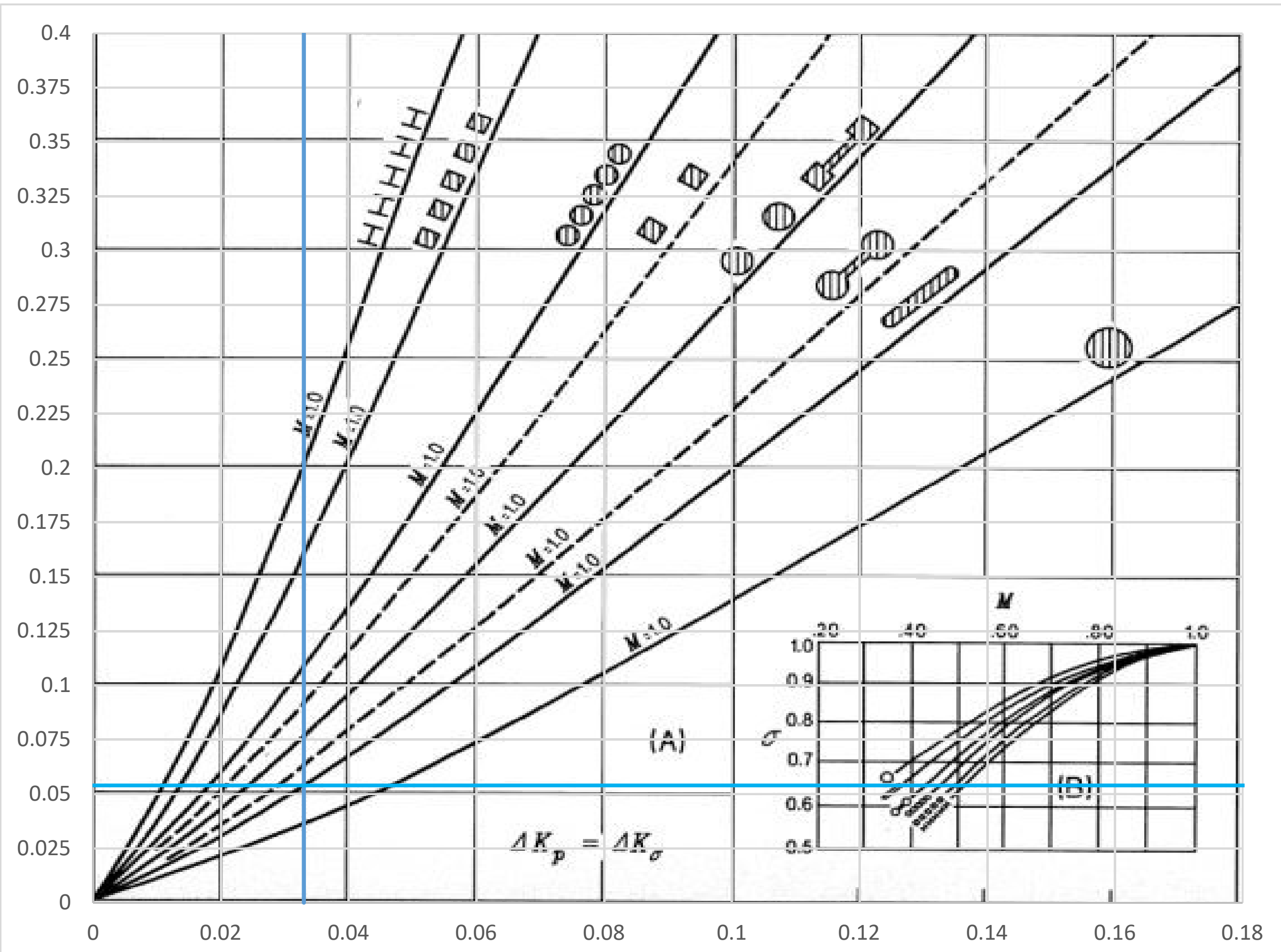
Austroads 2018, GBT08-18 Guide to Bridge Technology Part 8 Hydraulic Design of Waterway Structures

Appendix A - Bridge Pier Loss Calculation

M5-New Existing Bridge

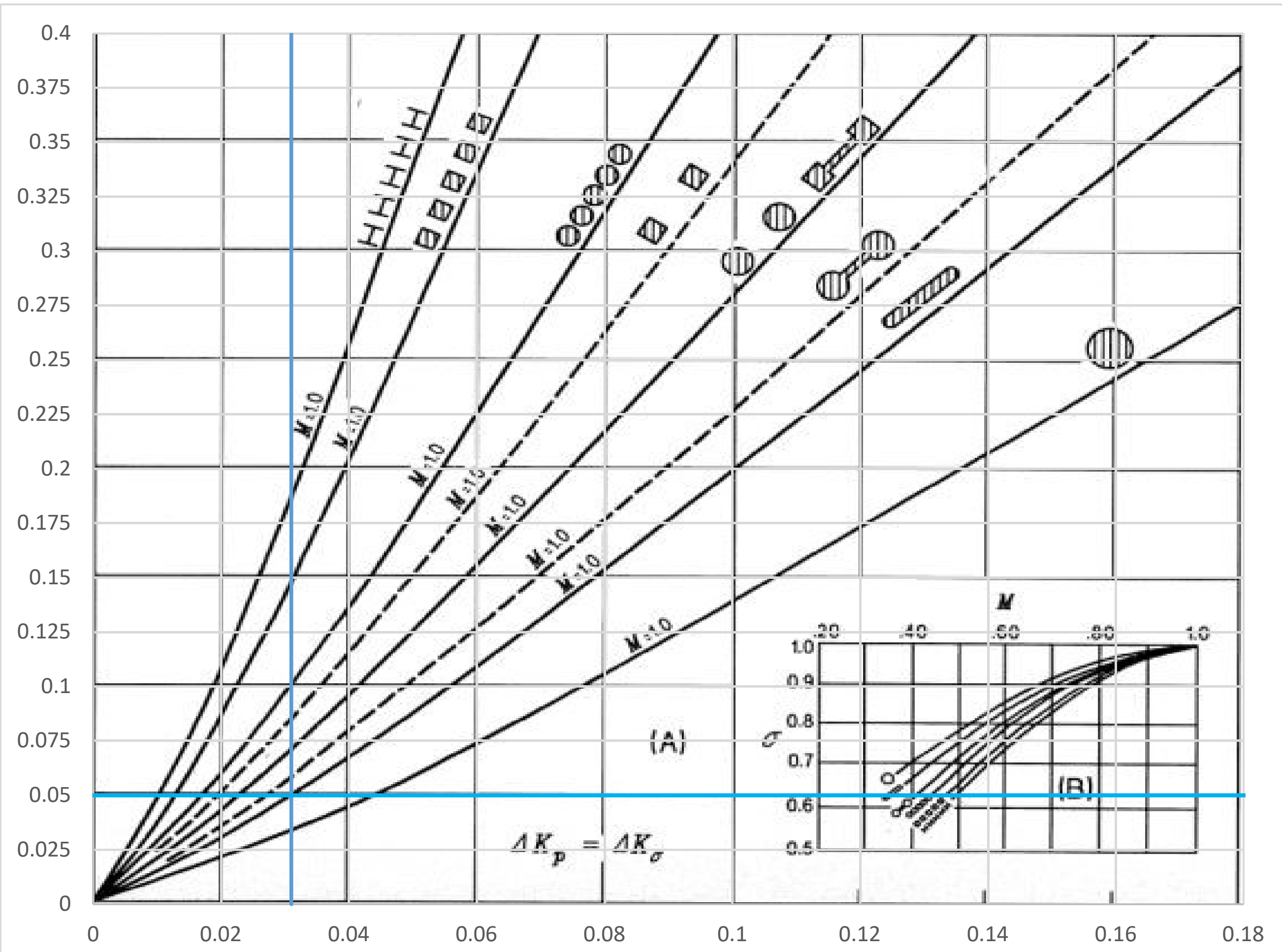
Pier Definition				Enter Manually		
Diameter (m)	1.6	mAHD				
Base Level of Pier 1	7.73	mAHD	Used in calculation	7.73	mAHD	
Base Level of Pier 2	7.54	mAHD	Used in calculation	7.54	mAHD	
Base Level of Pier 3	7.48	mAHD	Used in calculation	7.48	mAHD	
Base Level of Pier 4	4.86	mAHD	Used in calculation	4.86	mAHD	
Base Level of Pier 5	4.53	mAHD	Used in calculation	4.53	mAHD	
Base Level of Pier 6	12.5	mAHD	Used in calculation	12.5	mAHD	
Min Cross-section elevation	0.00					
Max Cross section elevation	22.64					

J	
0.033	0.033
0	0.4
FLC	
0	0.2
0.054	0.054

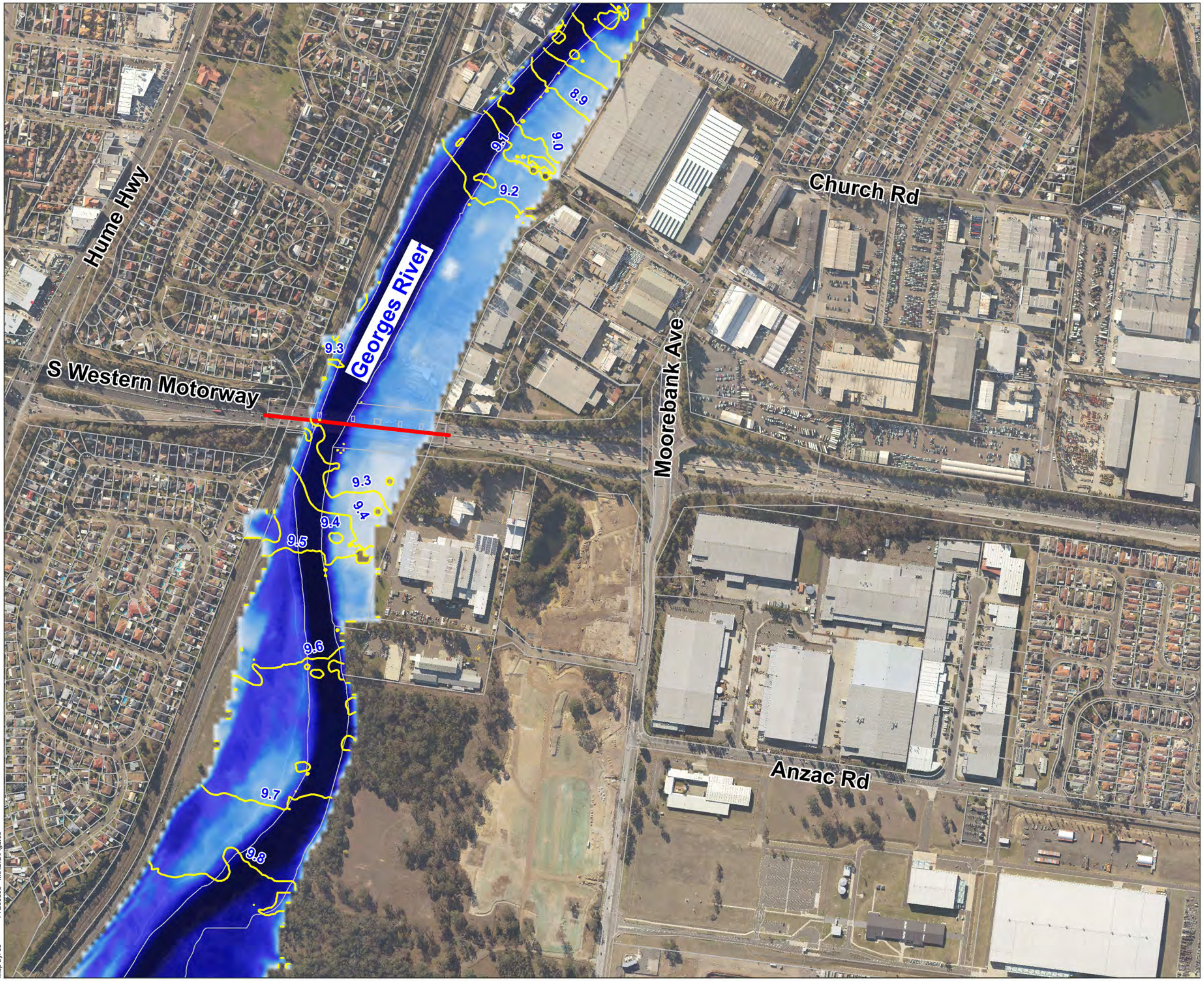


Old Existing M5 Bridge

							J	
Pier Definition			Enter Manually				0.031	0.031
Diameter (m)	1.6	mAHD					0	0.4
Base Level of Pier 1	7.64	mAHD	Used in calculation	7.64	mAHD		**FLC**	
Base Level of Pier 2	7.49	mAHD	Used in calculation	7.49	mAHD		0	0.2
Base Level of Pier 3	7.59	mAHD	Used in calculation	7.59	mAHD		0.05	0.05
Base Level of Pier 4	5.18	mAHD	Used in calculation	5.18	mAHD			
Base Level of Pier 5	5.15	mAHD	Used in calculation	5.15	mAHD		1.4	Girder
Base Level of Pier 6	12.14	mAHD	Used in calculation	12.14	mAHD		0.22	Concrete
Min Cross-section elevation	0.00						0.065	Ashphalt
Max Cross section elevation	22.64						1.685	L2 Thickness



Appendix B - Combined M5 Flood Mapping



aurecon

Legend

Peak Water Surface Level Contour (m AHD)

Existing Bridge

Lot

Depth (m)

0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 2.5
2.5 to 3.0
3.0 to 4.0
4.0 to 6.0
6.0 to 8.0
8.0 to 10.0
> 10.0

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

Date: 02/11/2020 Version: 0 Job No: 509608 Delivery: 20% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade **Hydrology and Hydraulics**

5% AEP Peak Depths
Existing Condition

aurecon

Legend

Existing Bridge

Lot

Velocity (m/s)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

P:\509608 - M5\GIS\Figures

Map by: JJ

A3 scale 1:5,000

0 12.5 m 25 m

Date: 02/11/2020 Version: 0 Job No: 509608 Delivery: 20% Concept Design

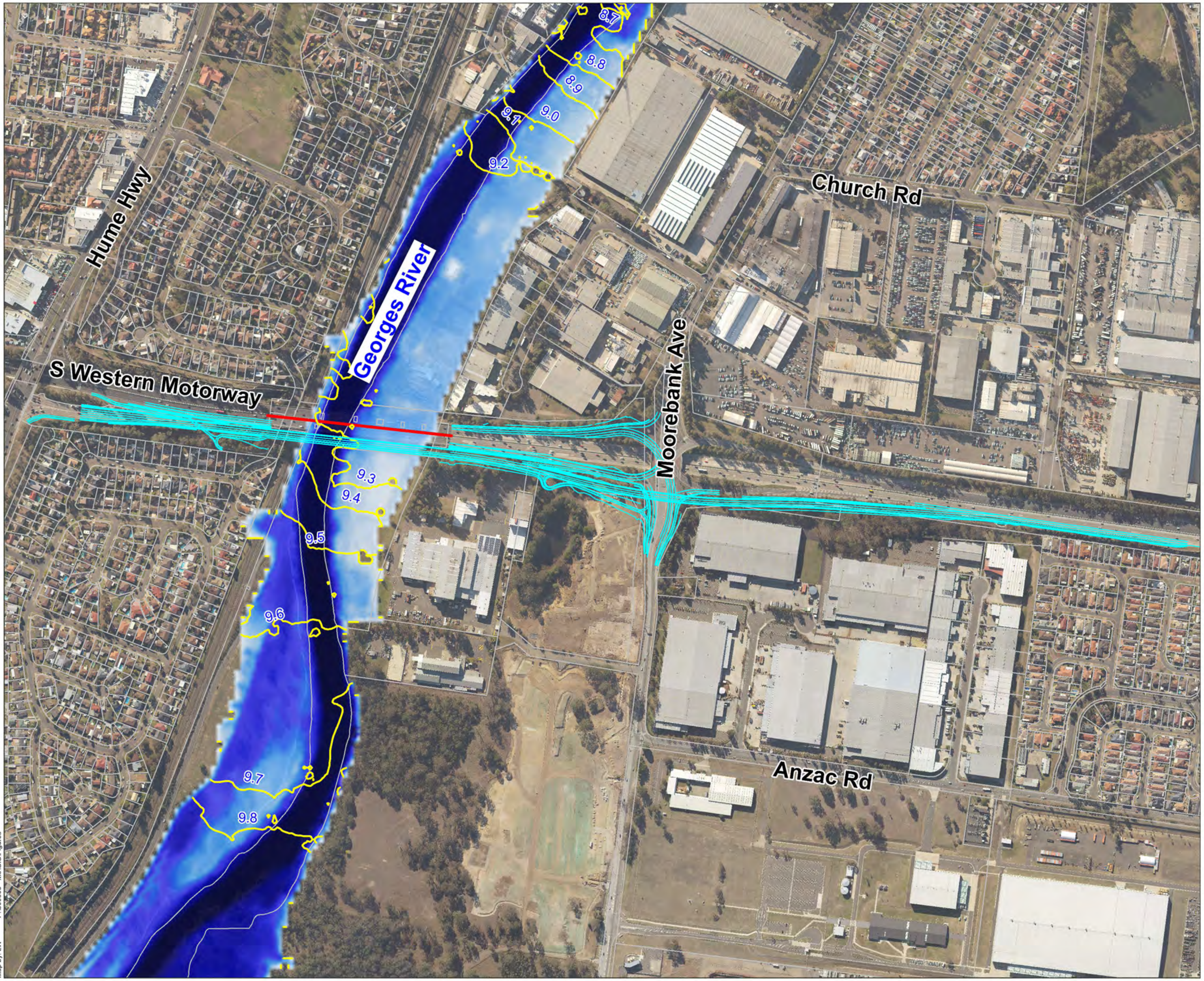
Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

5% AEP Peak Velocities
Existing Condition

aurecon



Legend

- Proposed Design
- Peak Water Surface Level Contour (m AHD)
- Existing Bridge
- Lot

Depth (m)

0.0 to 0.5	3.0 to 4.0
0.5 to 1.0	4.0 to 6.0
1.0 to 1.5	6.0 to 8.0
1.5 to 2.0	8.0 to 10.0
2.0 to 2.5	> 10.0
2.5 to 3.0	

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade **Hydrology and Hydraulics**

5% AEP Peak Depth
Design Condition

aurecon

Legend

Proposed Design

Existing Bridge

Lot

Velocity (m/s)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

Map by: LW P:\509608 - M5\GIS\Figures

A3 scale 1:5,000

0 12.5 m 25 m

Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

5% AEP Peak Velocities
Design Condition

aurecon

Legend

- Proposed Design
- Existing Bridge
- Lot

Change in flood level (m)

< -0.40	0.01 to 0.05
-0.40 to -0.20	0.05 to 0.10
-0.20 to -0.10	0.10 to 0.20
-0.10 to -0.05	0.20 to 0.40
-0.05 to -0.01	> 0.40
-0.01 to 0.01	

- Was Wet Now Dry
- Was Dry Now Wet

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

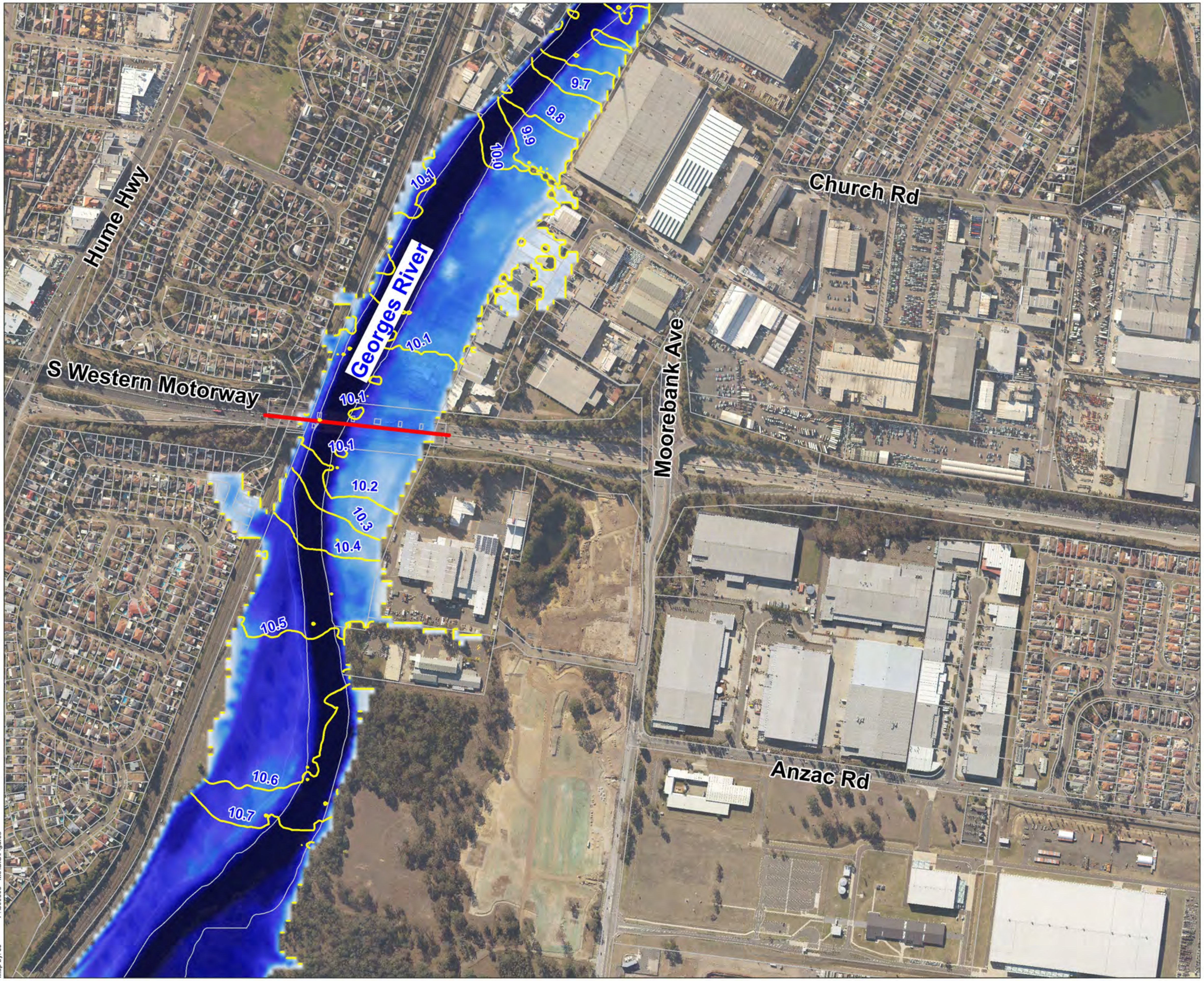
Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

5% AEP Afflux



aurecon

Legend

Peak Water Surface Level Contour (m AHD)

Existing Bridge

Lot

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 4.0
- 4.0 to 6.0
- 6.0 to 8.0
- 8.0 to 10.0
- > 10.0

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

Date: 02/11/2020 Version: 0 Job No: 509608 Delivery: 20% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

2% AEP Peak Depths
Existing Condition

aurecon

Legend

Existing Bridge
Lot

Velocity (m/s)
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 2.5
2.5 to 3.0
3.0 to 3.5
3.5 to 4.0
4.0 to 4.5
4.5 to 5.0
> 5.0

Notes:

P:\509608 - M5\GIS\Figures
Map by: JJ

A3 scale 1:5,000
0 12.5 m 25 m

Date: 02/11/2020 Version: 0 Job No: 509608 Delivery: 20% Concept Design
Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

2% AEP Peak Velocities
Existing Condition

aurecon

Legend

Proposed Design	
Peak Water Surface Level Contour (m AHD)	
Existing Bridge	
Lot	

Depth (m)

0.0 to 0.5	3.0 to 4.0
0.5 to 1.0	4.0 to 6.0
1.0 to 1.5	6.0 to 8.0
1.5 to 2.0	8.0 to 10.0
2.0 to 2.5	> 10.0
2.5 to 3.0	

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

2% AEP Peak Depth Design Condition

aurecon

Legend

Proposed Design

Existing Bridge

Lot

Velocity (m/s)

0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 2.5
2.5 to 3.0
3.0 to 3.5
3.5 to 4.0
4.0 to 4.5
4.5 to 5.0
> 5.0

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade **Hydrology and Hydraulics**

2% AEP Peak Velocities Design Condition

aurecon

Legend

Proposed Design

Existing Bridge

Lot

Change in flood level (m)

< -0.40
-0.40 to -0.20
-0.20 to -0.10
-0.10 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.10
0.10 to 0.20
0.20 to 0.40
> 0.40

Was Wet Now Dry
Was Dry Now Wet

Notes:

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Map by: LW

A3 scale 1:5,000

0 12.5 m 25 m

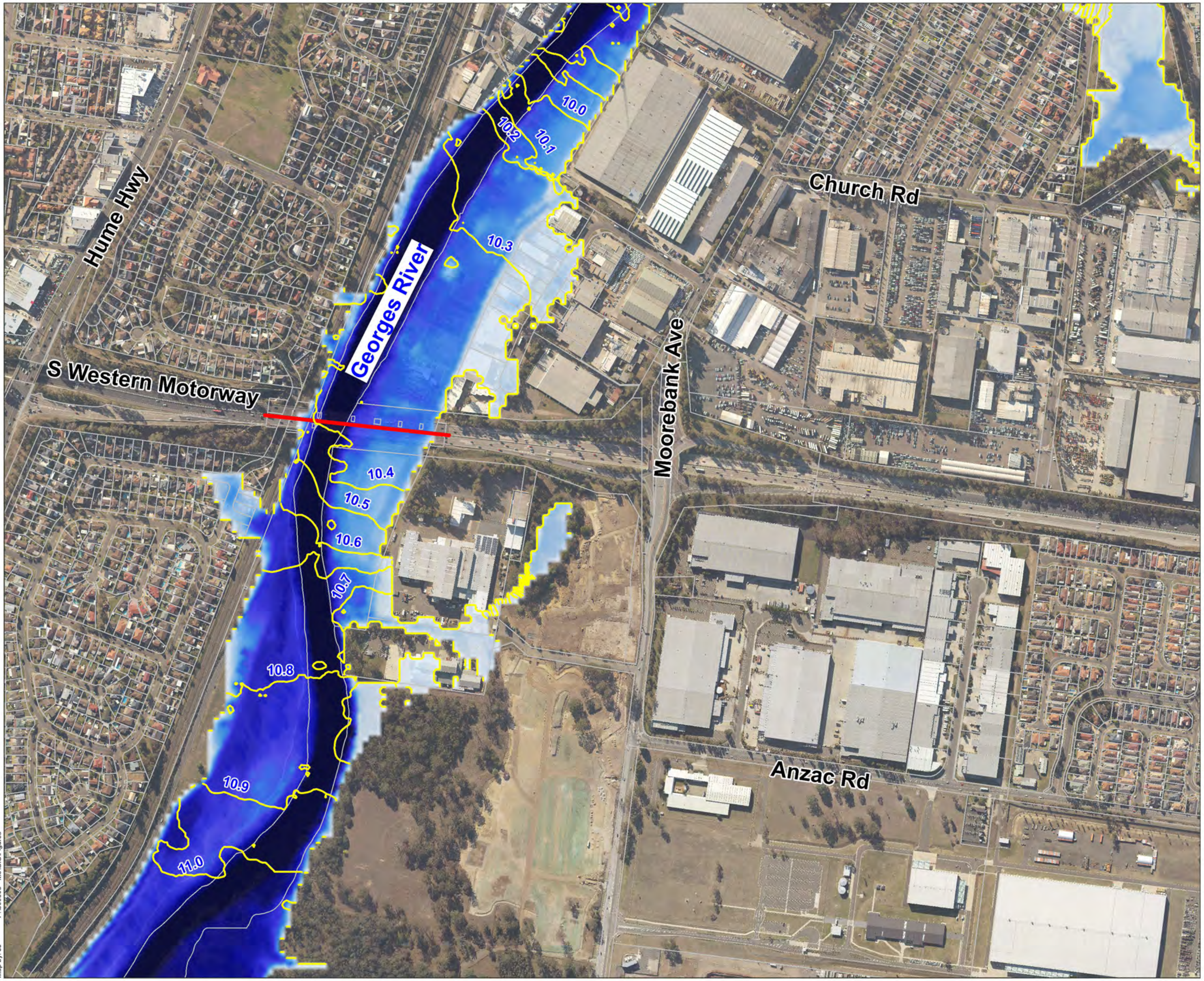
Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

2% AEP Afflux



aurecon

Legend

Peak Water Surface Level Contour (m AHD)

Existing Bridge

Lot

Depth (m)

0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 2.5
2.5 to 3.0
3.0 to 4.0
4.0 to 6.0
6.0 to 8.0
8.0 to 10.0
> 10.0

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

Date: 02/11/2020 Version: 0 Job No: 509608 Delivery: 20% Concept Design

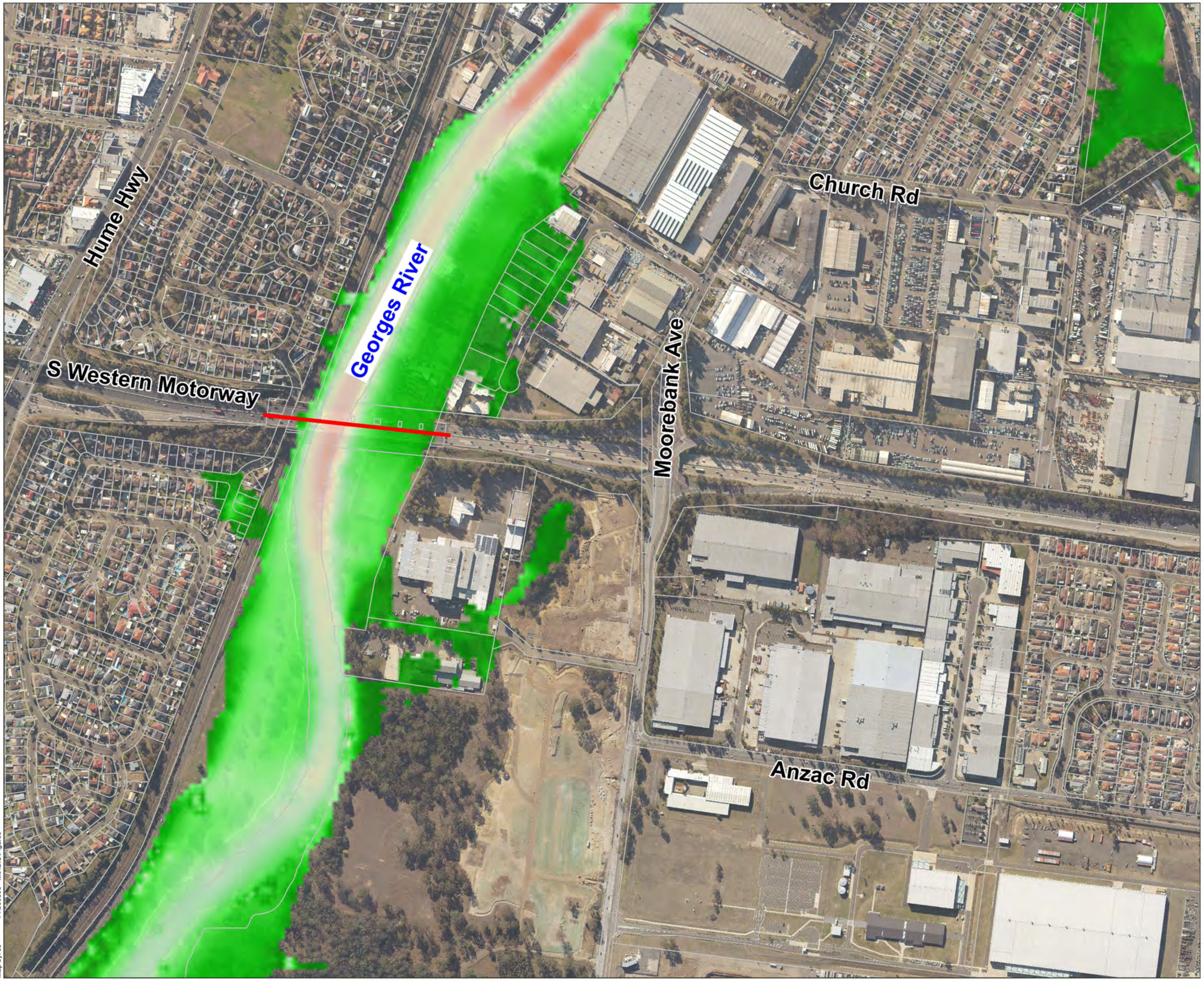
Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

1% AEP Peak Depths Existing Condition

aurecon



Legend

Existing Bridge
Lot

Velocity (m/s)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

A3 scale 1:5,000

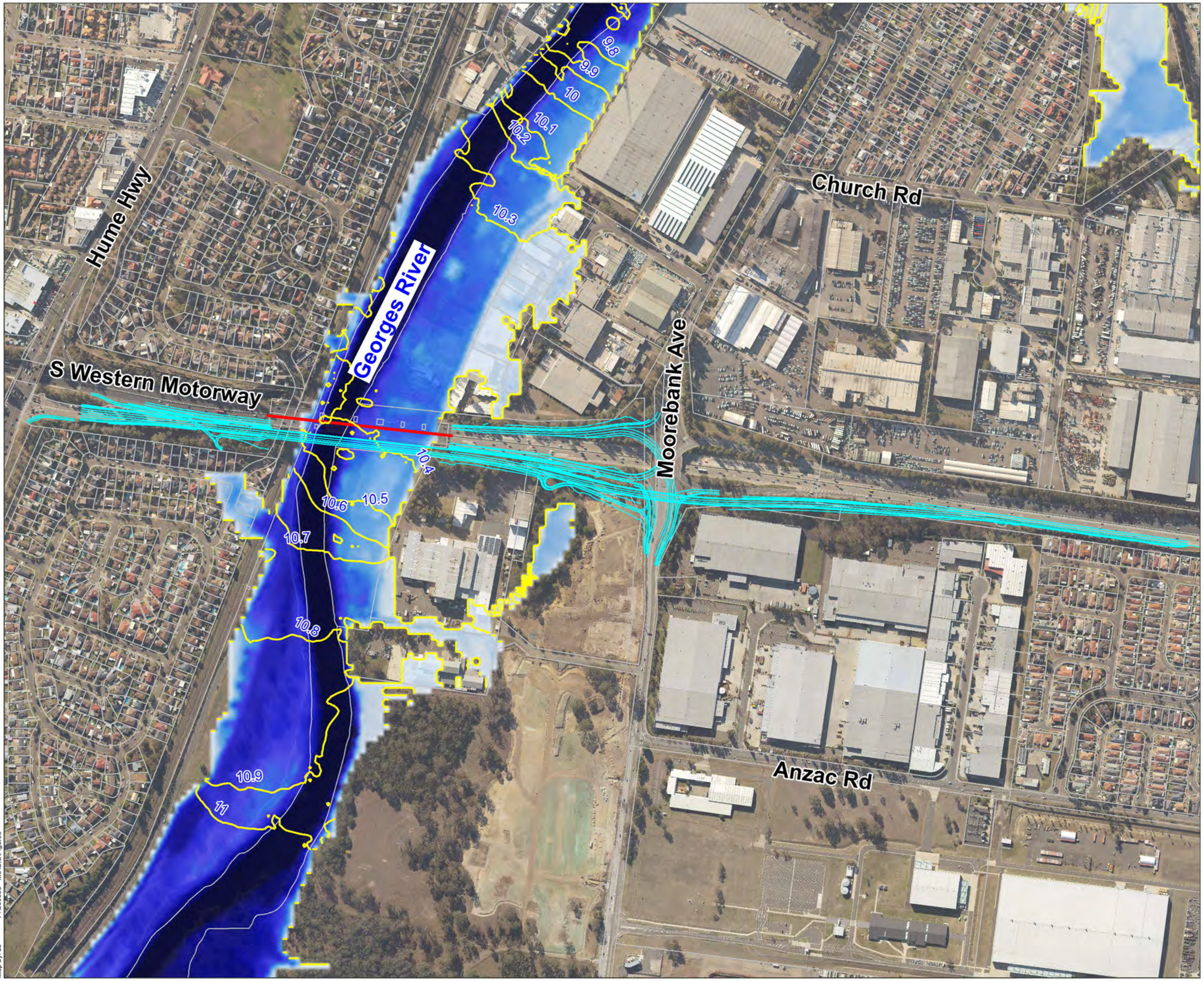
0 12.5 m 25 m

Date: 02/11/2020 Version: 0 Job No: 509608 Delivery: 20% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade **Hydrology and Hydraulics**

1% AEP Peak Velocities
Existing Condition



aurecon

Legend

- Proposed Design
- Peak Water Surface Level Contour (m AHD)
- Existing Bridge
- Lot

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 4.0
- 4.0 to 6.0
- 6.0 to 8.0
- 8.0 to 10.0
- > 10.0

Notes:

A3 scale 1:5,000

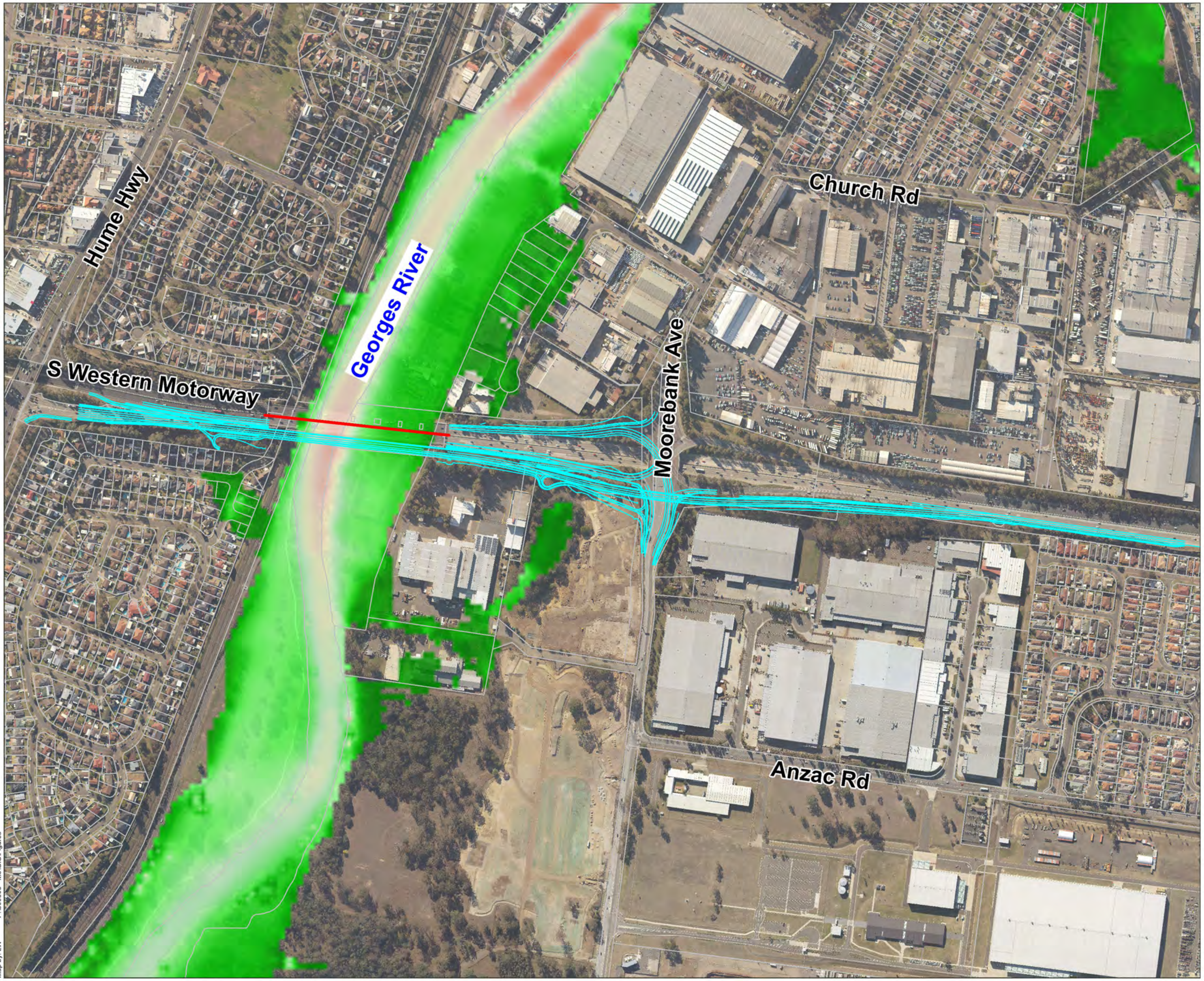
0 12.5 m 25 m

Date: 02/11/2020 Version: 0 Job No: 509608 Delivery: 20% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade **Hydrology and Hydraulics**

1% AEP Peak Depth Design Condition



aurecon

Legend

Proposed Design

Existing Bridge

Lot

Velocity (m/s)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

1% AEP Peak Velocities Design Condition

aurecon

Legend

Proposed Design

Existing Bridge

Lot

Change in flood level (m)

< -0.40	0.01 to 0.05
-0.40 to -0.20	0.05 to 0.10
-0.20 to -0.10	0.10 to 0.20
-0.10 to -0.05	0.20 to 0.40
-0.05 to -0.01	> 0.40
-0.01 to 0.01	

Was Wet Now Dry

Was Dry Now Wet

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

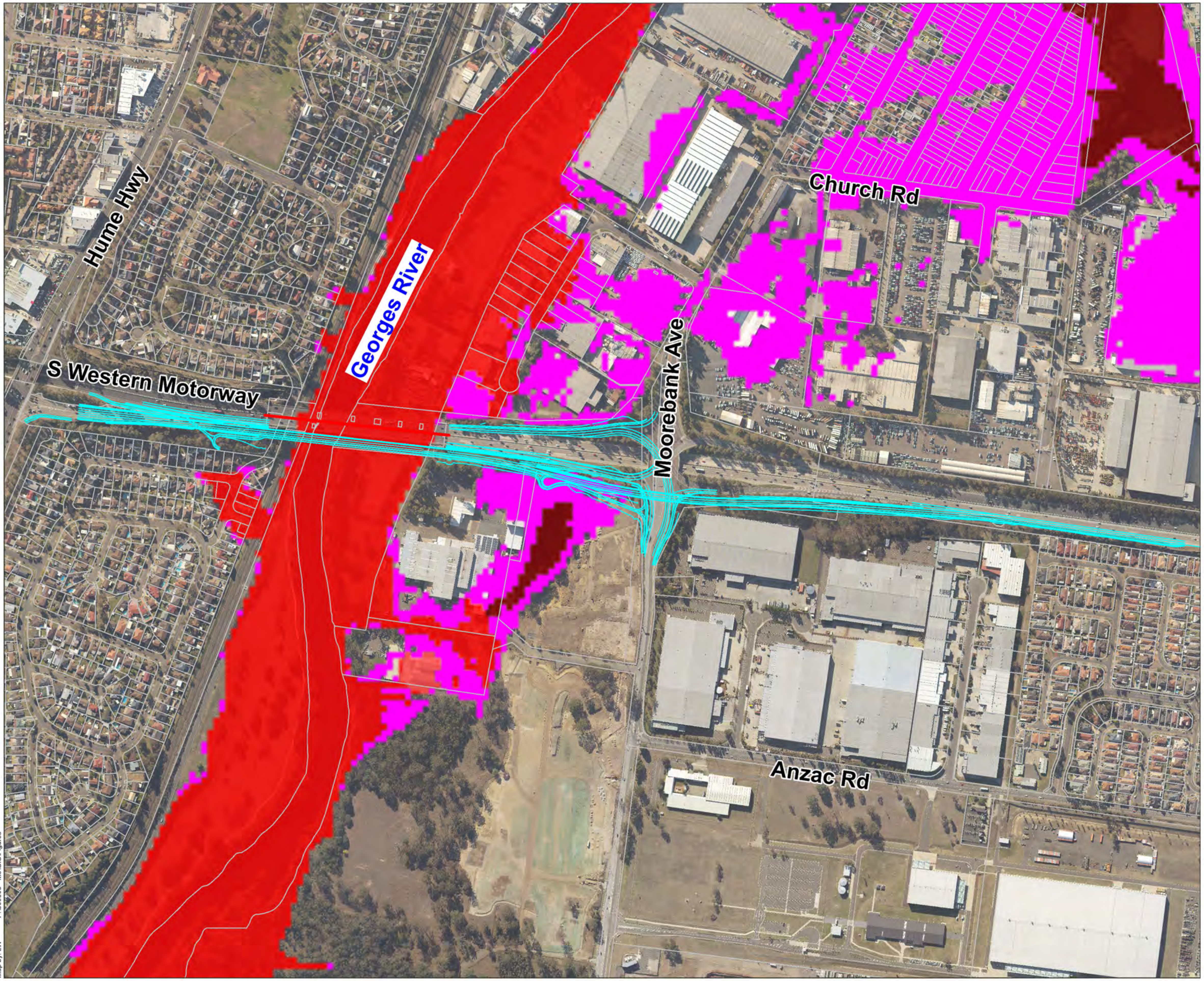
Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

1% AEP Afflux



aurecon

Legend

- Proposed Design
- Existing Bridge
- Lot

Change in flood level (m)

< -0.40	0.01 to 0.05
-0.40 to -0.20	0.05 to 0.10
-0.20 to -0.10	0.10 to 0.20
-0.10 to -0.05	0.20 to 0.40
-0.05 to -0.01	> 0.40
-0.01 to 0.01	

- Was Wet Now Dry
- Was Dry Now Wet

Notes:

P:\509608 - M5\GIS\Figures

Map by: LW

A3 scale 1:5,000

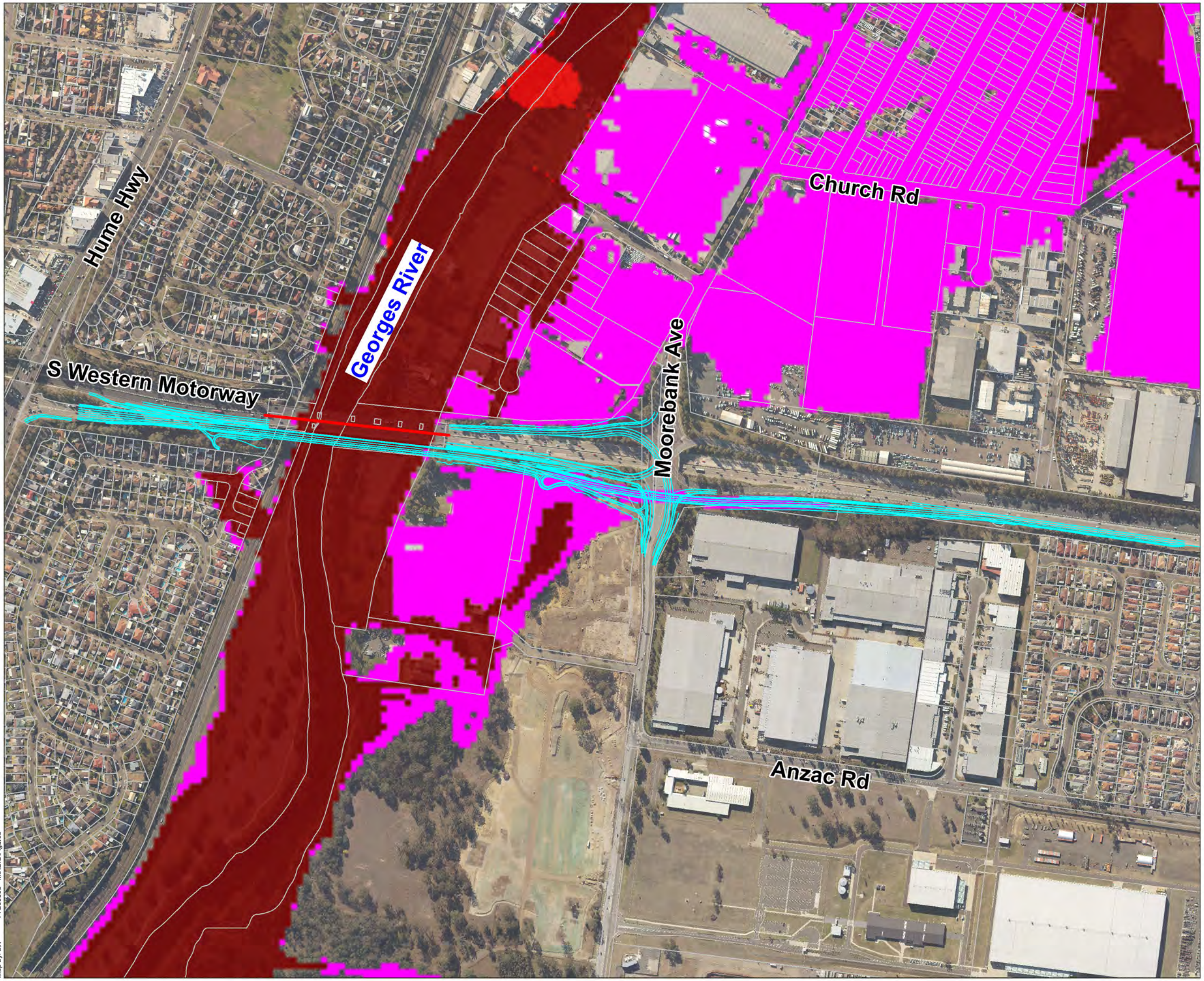
0 12.5 m 25 m

Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade — Hydrology and Hydraulics

Increase in Peak Flood Levels in the Proposed Environment as a result of CC1 in a 1% AEP Design Event



Legend

Proposed Design

Existing Bridge

Lot

Change in flood level (m)

< -0.40	0.01 to 0.05
-0.40 to -0.20	0.05 to 0.10
-0.20 to -0.10	0.10 to 0.20
-0.10 to -0.05	0.20 to 0.40
-0.05 to -0.01	> 0.40
-0.01 to 0.01	

Was Wet Now Dry

Was Dry Now Wet

Notes:

Map by: LW P:\509608 - M5\GIS\Figures

A3 scale 1:5,000

0 12.5 m 25 m

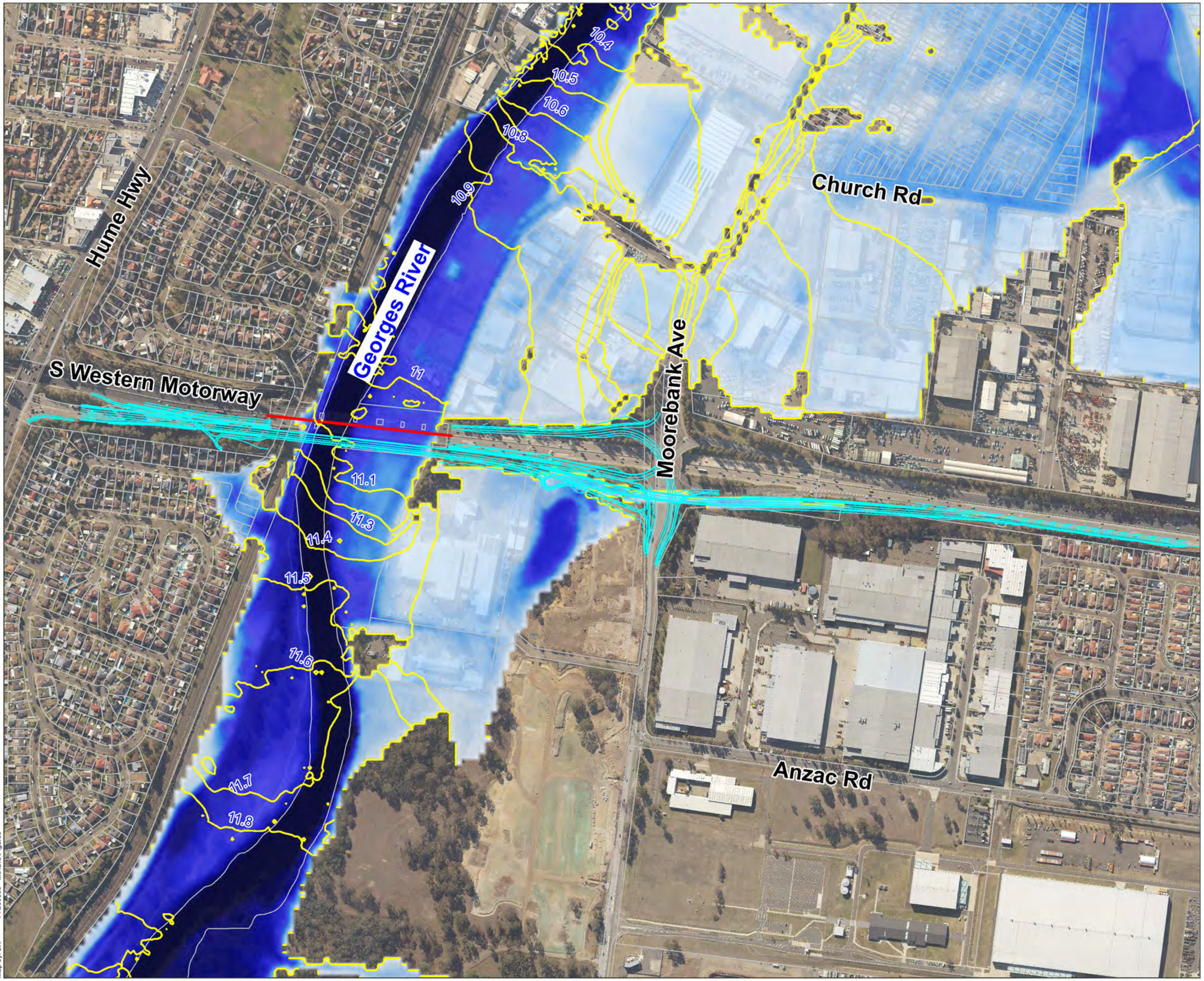
Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

Increase in Peak Flood Levels in the Proposed Environment as a result of CC2 in a 1% AEP Design Event



aurecon

Legend

- Proposed Design
- Peak Water Surface Level Contour (m AHD)
- Existing Bridge
- Lot

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 4.0
- 4.0 to 6.0
- 6.0 to 8.0
- 8.0 to 10.0
- > 10.0

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

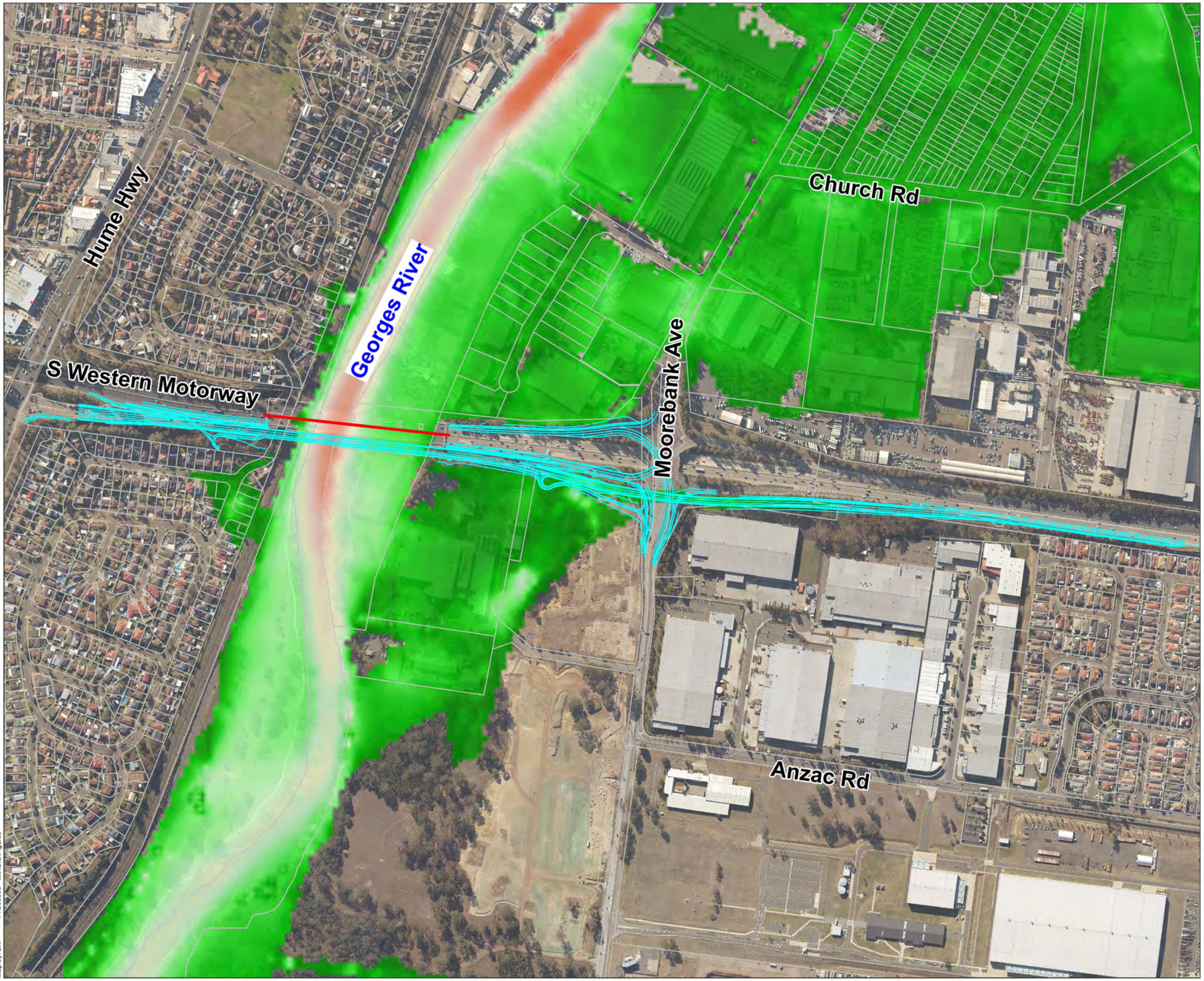
Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

0.05% AEP Peak Depth Design Condition



aurecon

Legend

Proposed Design

Existing Bridge

Lot

Velocity (m/s)

0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 2.5
2.5 to 3.0
3.0 to 3.5
3.5 to 4.0
4.0 to 4.5
4.5 to 5.0
> 5.0

Notes:

Map by: LW P:\509608 - M5\GIS\Figures

A3 scale 1:5,000

0 12.5 m 25 m

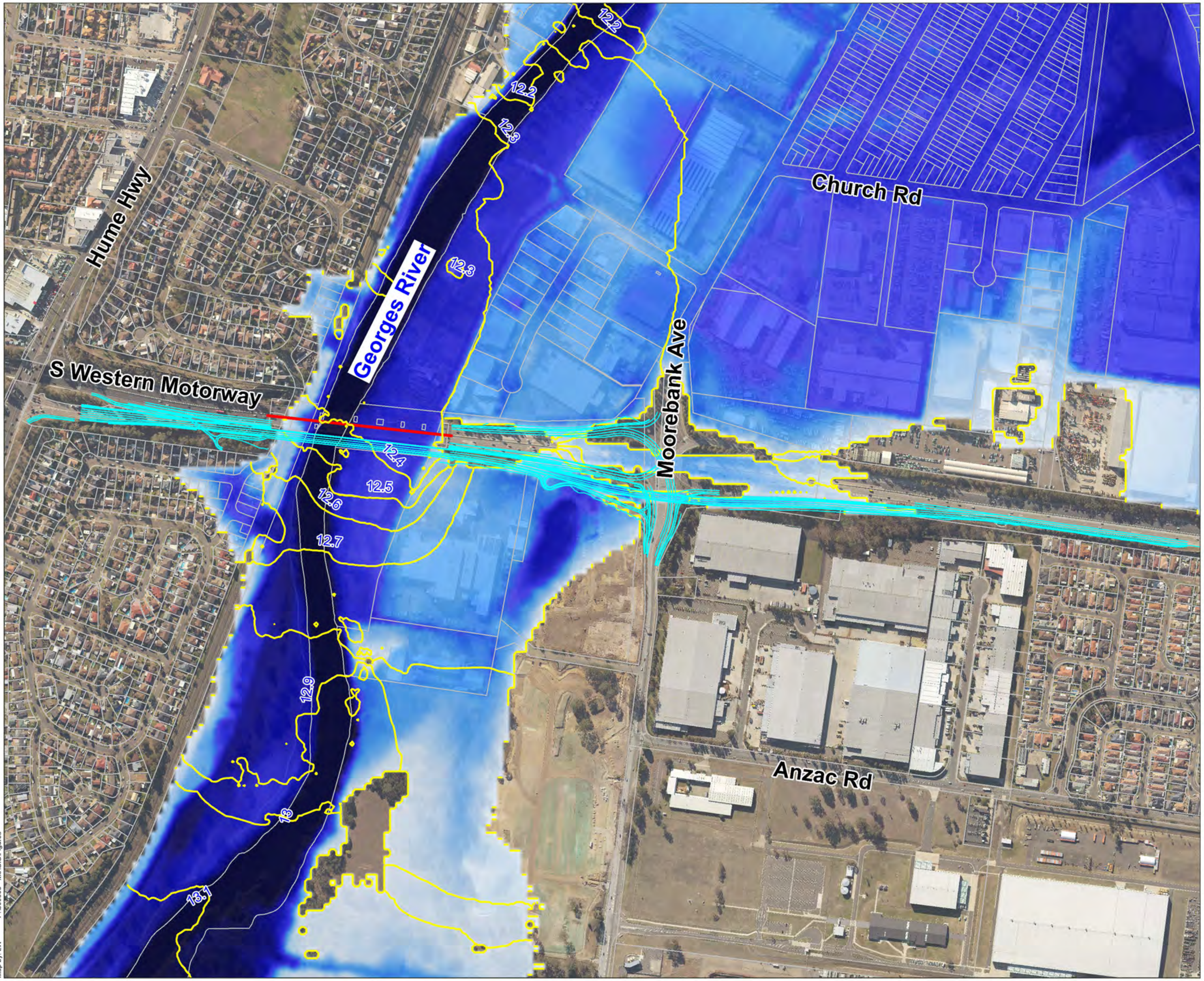
Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

0.05% AEP Peak Velocities
Design Condition



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Legend

- Proposed Design
- Peak Water Surface Level Contour (m AHD)
- Existing Bridge
- Lot

Depth (m)

- 0.0 to 0.5
- 0.5 to 1.0
- 1.0 to 1.5
- 1.5 to 2.0
- 2.0 to 2.5
- 2.5 to 3.0
- 3.0 to 4.0
- 4.0 to 6.0
- 6.0 to 8.0
- 8.0 to 10.0
- > 10.0

Notes:

A3 scale 1:5,000

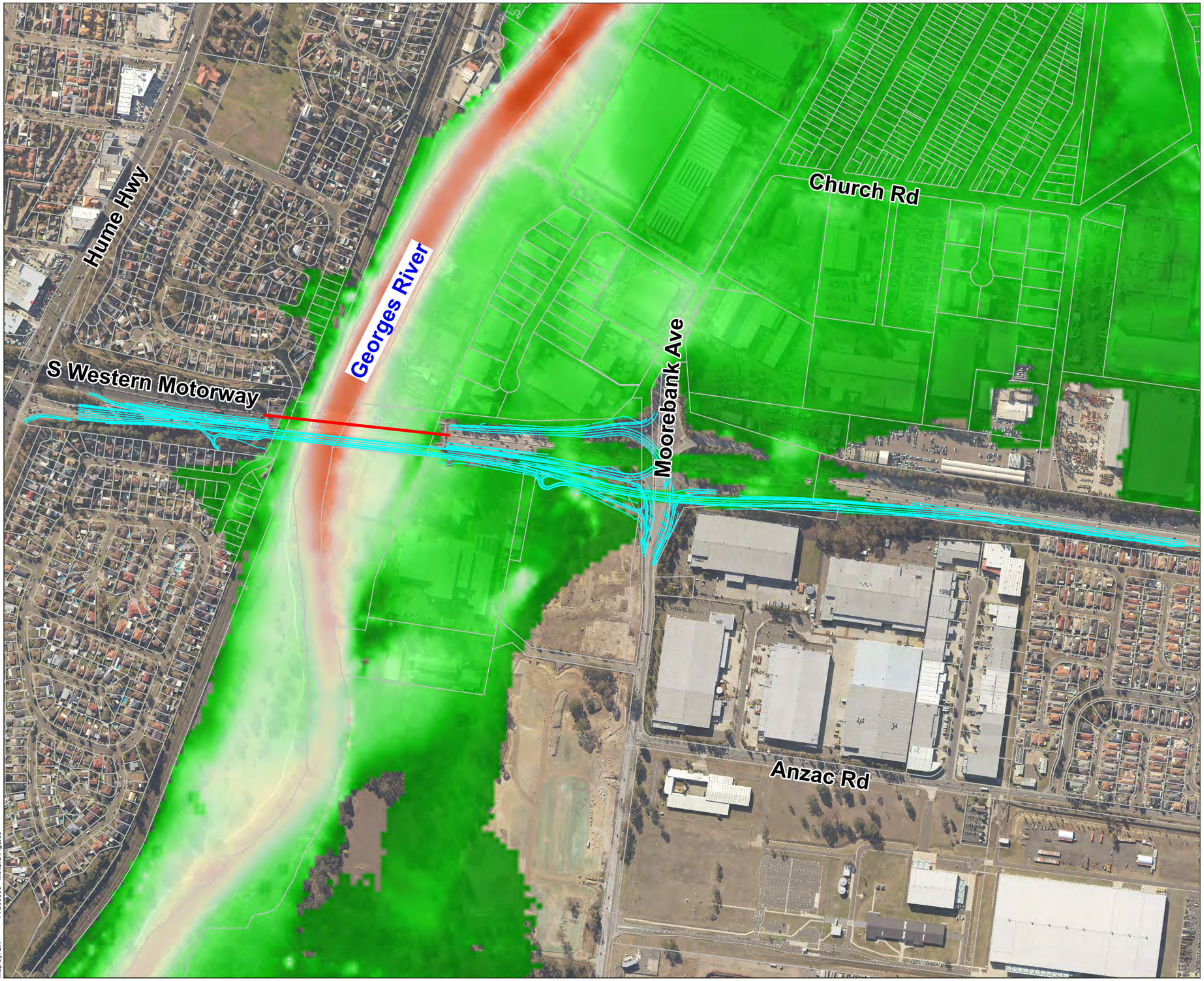
0 12.5 m 25 m

Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade **Hydrology and Hydraulics**

PMF Peak Depth
Design Condition



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Legend

Proposed Design

Existing Bridge

Lot

Velocity (m/s)

0.0 to 0.5	3.0 to 3.5
0.5 to 1.0	3.5 to 4.0
1.0 to 1.5	4.0 to 4.5
1.5 to 2.0	4.5 to 5.0
2.0 to 2.5	> 5.0
2.5 to 3.0	

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

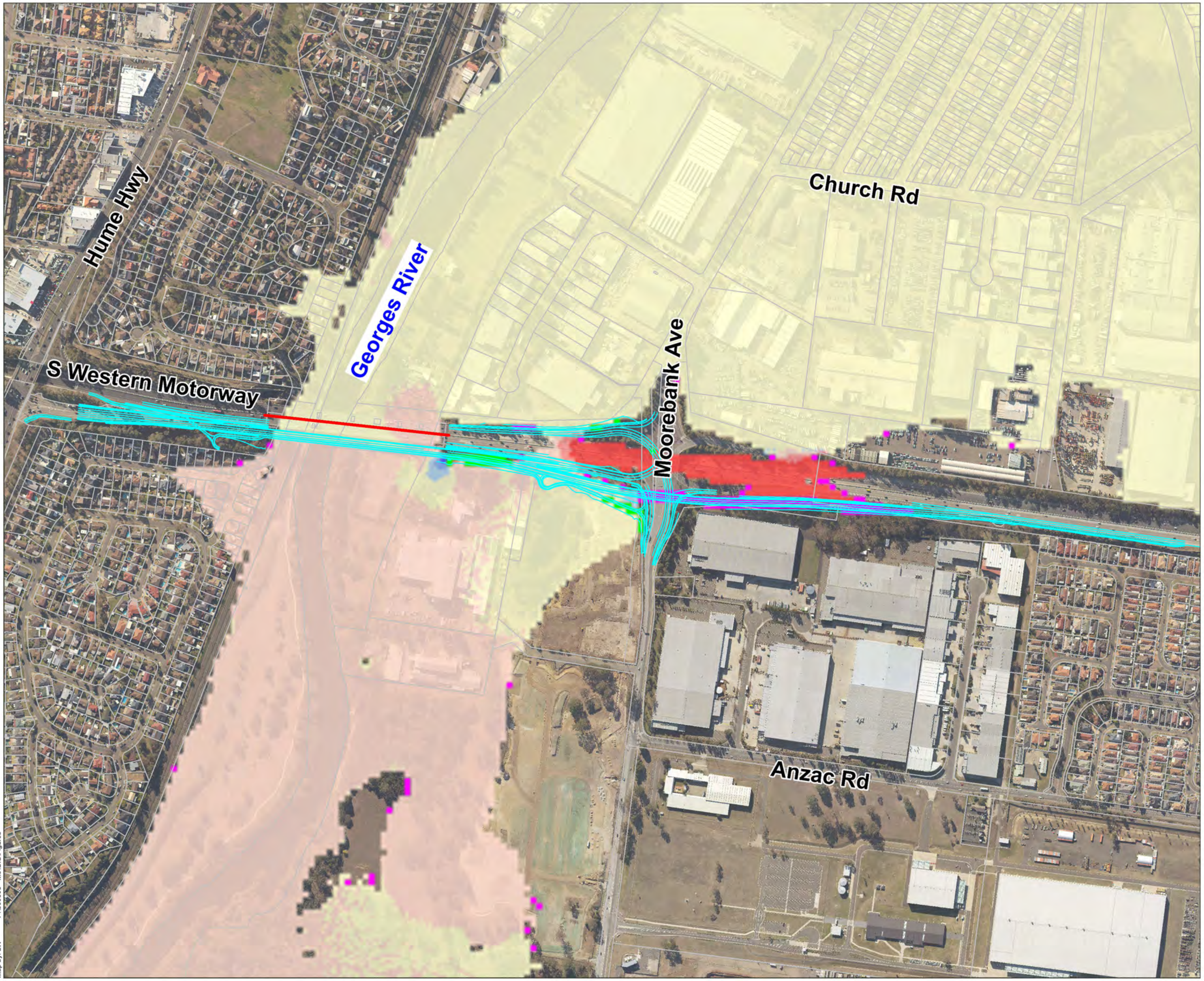
Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade

Hydrology and Hydraulics

PMF Peak Velocities
Design Condition



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Legend

- Proposed Design
- Existing Bridge
- Lot

Change in flood level (m)

< -0.40	0.01 to 0.05
-0.40 to -0.20	0.05 to 0.10
-0.20 to -0.10	0.10 to 0.20
-0.10 to -0.05	0.20 to 0.40
-0.05 to -0.01	> 0.40
-0.01 to 0.01	

- Was Wet Now Dry
- Was Dry Now Wet

Notes:

A3 scale 1:5,000

0 12.5 m 25 m

Date: 05/05/2021 Version: 1 Job No: 509608 Delivery: 80% Concept Design

Projection: MGA Zone 56

M5 Motorway Westbound Traffic Upgrade **Hydrology and Hydraulics**

PMF Afflux

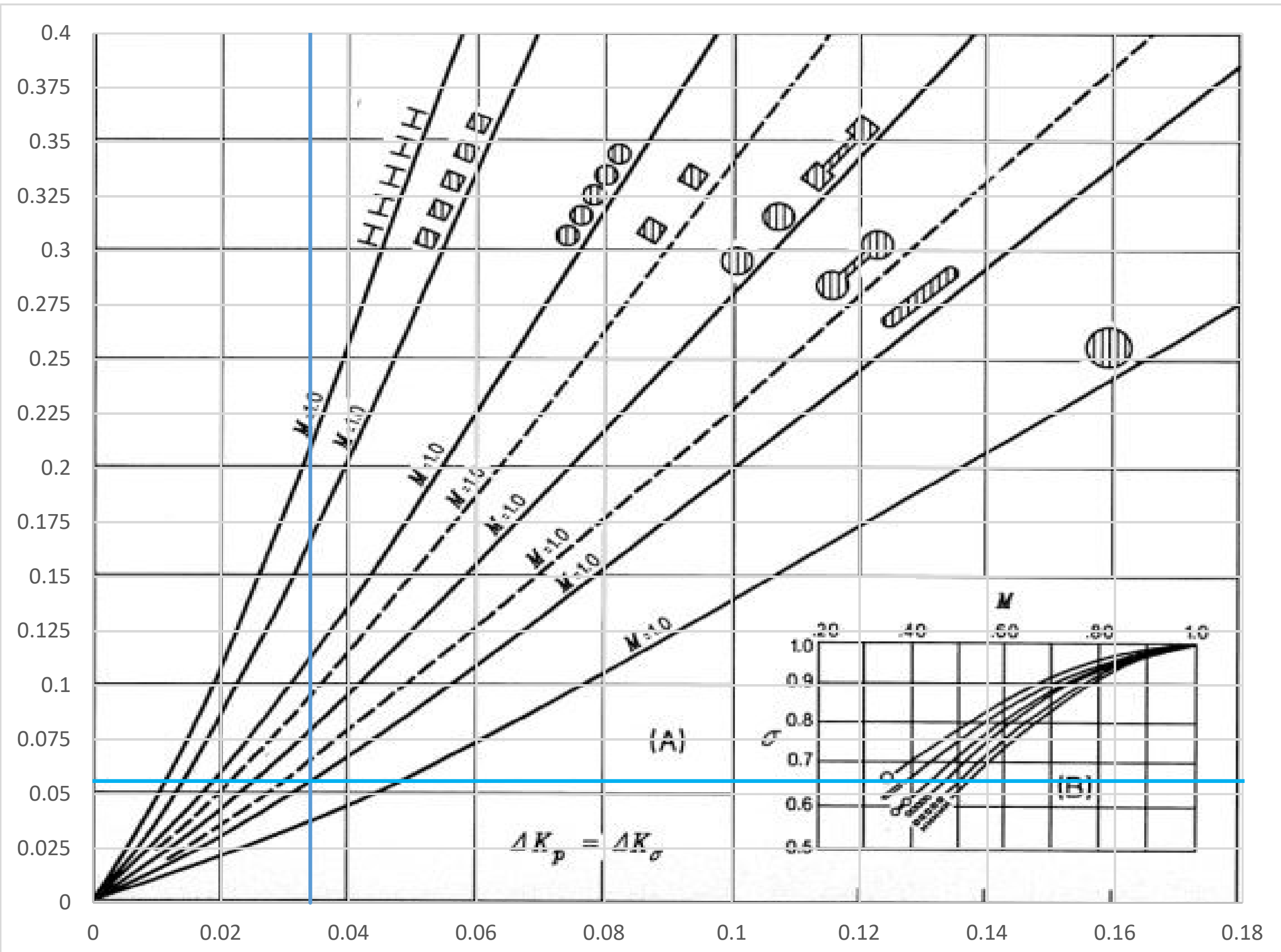
Appendix C - Proposal Bridge Pier Loss Calculations

Proposed Bridge

Pier Definition					Enter Manually		
Diameter (m)	1.6	mAHD					
Base Level of Pier 1	7.8	mAHD	Used in calculation	7.8	mAHD		
Base Level of Pier 2	8.43	mAHD	Used in calculation	8.43	mAHD		
Base Level of Pier 3	7.5	mAHD	Used in calculation	7.5	mAHD		
Base Level of Pier 4	4.75	mAHD	Used in calculation	4.75	mAHD		
Base Level of Pier 5	4.75	mAHD	Used in calculation	4.75	mAHD		
Base Level of Pier 6	11.38	mAHD	Used in calculation	11.38	mAHD		
Min Cross-section elevation	0.00						
Max Cross section elevation	22.64						

J	
0.034	0.034
0	0.4
FLC	
0	0.2
0.056	0.056

1.4	Girder
0.22	Concrete
0.065	Ashphalt
1.685	L2 Thickness



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