Roads and Maritime Services

Nowra Bridge Project

Technical Paper - Flooding and Hydrology Assessment

NB-FHA-RT-0003

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Job number 242129

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Glossary

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ALS	Airborne Laser Scanning
BOM	Bureau of Meteorology
DECC	Department of Environment and Climate Change
DRM	Digital Rainfall Method
DTM	Digital Terrain Model
FLC	Bridge Form Loss Coefficient
GIS	Geographic Information System
mAHD	meters above Australian Height Datum
PMF	Probable Maximum Flood
TUFLOW	one-dimensional (1D) and two-dimensional (2D hydraulic modelling software package
WBNM	Watershed Bounded Network Model (hydrologic computer model)

Executive summary

Arup has provided support to SMEC, who has been commissioned by Roads and Maritime Services (Roads and Maritime) to carry out a concept design and an environmental assessment for a new bridge and associated road works over the Shoalhaven River. The proposed bridge would be located immediately upstream (west) of the existing bridge crossings over the Shoalhaven River at Nowra.

This report details the flooding and hydrology assessment for the proposed bridge.

A TUFLOW hydrodynamic model of the Shoalhaven River was utilised to assess the flood immunity and potential flood impact of the proposed bridge on the floodplain. The flood model was developed as part of the Shoalhaven River Flood Study (WMAwater, 2013). A number of design flood events, ranging from 10% AEP to 0.05% AEP and an extreme flood event, were analysed to determine flood immunity and associated flood impact of the proposed bridge.

The assessment concluded that the proposed bridge design and intersection upgrade at Bridge Road and Illaroo Road achieves flood immunity for the range of flood events up to and including the 1% AEP.

The proposed bridge design results in an increase in peak flood levels of up to 0.15 m upstream of the proposed bridge, mostly within the river banks for up to an including the 1% AEP flood event. No impact is seen on private property for flood events of equal or smaller magnitude than a 5% AEP. However, the proposed design increases peak flood levels at a limited number of properties near Moorhouse Park by about 0.2 m for the 2% and 1% AEP. No flood mitigation measures have been recommended due to the following considerations:

- A flood level increase of 0.2 m is unlikely to increase flood hazard and damage costs for these properties as, under current conditions, these properties are currently inundated by about 2.2 m and 2.8 m in a 2% AEP and 1% AEP flood event, respectively. An additional 0.2 m depth of inundation is considered negligible in comparison
- Any potential flood mitigation option (eg levee) would be very costly and greatly disproportionate to the benefits provided by such mitigation.

An assessment of the potential flood impact due to climate change has been carried out considering the following scenarios:

- Scenario 1 - 10% increase in rainfall intensity of 1% AEP, coupled with 0.4 m seal level rise
- Scenario 2 - 30% increase in rainfall intensity of 1% AEP, coupled with 0.9 m seal level rise.

The results of the model showed increases in peak flood levels upstream of the proposed bridge by 0.4 m and 1.3 m, respectively under the climate change scenarios.

1 Introduction

1.1 Project overview

Roads and Maritime Services NSW (Roads and Maritime) proposes to construct a new bridge on the A1 Princes Highway over the Shoalhaven River. The proposal includes the construction of a new four lane bridge to the west (upstream) of the existing bridge crossings and the removal of existing vehicular traffic from the existing southbound bridge. The proposed works also include the upgrade of about 1.6 kilometres of the Princes Highway near the bridge, as well as providing key intersection upgrades and modifications to the local road network. The proposal would improve access to Nowra and the surrounding areas, improve southbound access for large freight vehicles, and improve traffic flows.

Key design features of the proposal include:

- Construction of a new bridge to the west (upstream) of the existing bridge crossings, including:
  - Four northbound lanes including a dedicated left turn only lane from Bridge Road to Illaroo Road
  - A three-metre wide shared use path on the western side of the bridge connecting the Illaroo Road intersection to the Bridge Road intersection
- Widening of the existing bridge over Bomaderry Creek to the west (upstream)
- Minor lane adjustments on the existing northbound bridge to convert it to three lanes of southbound traffic
- Removal of vehicular traffic from the existing southbound bridge. Additional works would be provided under a separate project to convert the existing southbound bridge for adaptive reuse
- Upgrading of the Princes Highway to provide three northbound and three southbound lanes from Bolong Road through to about 75 metres north of Moss Street
- Widening of Illaroo Road over a distance of about 340 metres
- Upgrading of the Princes Highway and Illaroo Road intersection to provide:
  - Two southbound right turn lanes from the Princes Highway into Illaroo Road
  - Three dedicated right turn lanes and one dedicated left turn lane from Illaroo Road to Princes Highway
  - Acceleration and merge lane for northbound traffic turning into Illaroo Rd from Princes Highway
- Upgrading of the Princes Highway and Bridge Road intersection to provide:
  - Two southbound right turn lanes from the Princes Highway into Bridge Road

   - One left turn lane from Bridge Road to the Princes Highway
- Local road adjustments including:
   - Closing the access between Pleasant Way and Princes Highway
   - Restricting turning movements at the intersection of Bridge Road and Scenic Drive
   - Construction of a new local road connecting Lyrebird Drive to the Princes Highway about 300 metres south of the existing Pleasant Way intersection
- Provision of pedestrian facilities at all intersections
- Dedicated off road shared paths and footpaths along the length of the proposal
- Urban design and social amenity improvements, and landscaping including foreshore pedestrian links to the truss bridge
- Relocation and/or protection of utility services within the affected road corridor
- Drainage and water quality management infrastructure along the road corridor
- Property works including acquisition, demolition, and adjustments to accesses
- Temporary ancillary facilities during construction including site offices, construction compounds, and stockpile sites.

1.2 Review of relevant government policies and guidelines

This section documents the relevant government policies and guidelines which have been reviewed in carrying out the flood impact assessment.

1.2.1 NSW Floodplain Development Manual

NSW Floodplain Development Manual (2005) has been prepared in accordance with the NSW Government’s flood prone land policy.

This manual outlines the general principles and the process of flood risk management. It also provides guidelines and tools to identify and assess a variety of flood mitigation measures to minimise any adverse flood impact and maximise the environmental and economic benefits.

The manual highlights the need for consideration of climate change impact in both the flood study and the flood risk management study since the degree of impact will vary with locations, and may result in a significant impact on flood mitigation measures.

1.2.2 Climate change guidelines

In addition to the NSW Floodplain Development Manual, further climate change guidelines include:

- Floodplain Risk Management Guideline – Practical consideration of climate change (DECC, 2007)
- NSW Sea Level Rise Policy Statement (New South Wales Government, 2009).

Floodplain Risk Management Guideline (DECC, 2007) recommends the sensitivity analysis on climate change impact upon the increase in sea levels and rainfall intensities as below:

- Increase in ocean levels
  - 0.18 m – low level ocean rise
  - 0.55 m – medium level ocean rise
  - 0.91 m – high level ocean rise
- Increase in peak rainfall and storm volume
  - 10% - low level rainfall increase
  - 20% - medium level rainfall increase
  - 30% - high level rainfall increase.

The NSW Sea Level Rise Policy Statement (2009) provides sea level rise recommendations:

- 0.4 m – by the Year 2050
- 0.9 m – by the Year 2100.

Floodplain Risk Management Guideline (DECC, 2007) states that climate change related sensitivity analysis should also consider combined sea level rise and rainfall factors where applicable.

1.2.3 Shoalhaven Development Control Plan 2014

The Shoalhaven Development Control Plan 2014 (Shoalhaven DCP, 2014) has been prepared by Council and provides detailed development guidelines and controls to specific types of development or areas of land. Chapter G9 of Shoalhaven DCP (2014) provides guidance for potential land development on flood prone land.

Chapter G9 outlines one of the requirements for flood assessment reports:

"Appropriate consulting engineers report for earthworks of volumes exceeding 250 cubic metres or with a length of more than 20 metres. This report is to prove that the earthworks will not increase flood hazard, flood damage or adversely affect other properties for a 5% AEP up to the PMF scenario."

1.3 Assessment objectives

The key issues/activities required for this flooding and hydrology assessment study are documented in Section 3.4 of the project brief, and are as follows:

- Carry out a hydraulic modelling under the existing and the proposed concept design conditions for a range of flood events, including the 10%, 5%, 2%, and

1% AEP events, as well as the Extreme Event. The Extreme Event represents a flood with a peak flow over twice the 1% AEP peak flow (Reference 9)

- Identify the existing flood risks in and near the proposed project boundary
- Investigate the flood behaviour under the concept design conditions to ensure that the proposed bridge design meets the flood immunity requirements
- Investigate the ultimate flood effects of the proposed road upgrade
- Investigate the upstream and downstream flood impact of the proposed design to ensure that the proposed project does not cause a significant adverse flood impact on properties
- Investigate the potential flood impact arising from climatic change.

1.4 Flood and flood immunity requirements

The Secretary's Environmental Assessment Requirements (SEARs) are the government's requirements to be addressed in an Environmental Impact Statement (EIS).

An EIS is typically prepared when the environmental impact of the proposal is expected to be significant. Through the development and investigation process of the proposal, it was determined that environmental impacts were not as significant as initially envisaged. As such, a Review of Environmental Factors (REF) was prepared.

While the SEARs are no longer applicable to the project, they have still been used as the basis for the scope of the flooding and hydrology assessment. The SEARs for the flooding assessment are listed in Table 1.

Table 1: Flooding and climate change criteria

Standard SEARs	Report section where addressed
Flooding The Proponent must assess the impact on flood behaviour for a full range of flood events up to the probable maximum flood, including • consistency with relevant floodplain risk management plans • the flood impact on flow velocities and directions, and impact on the bed and bank stability • serviceability effects of afflux on adjacent properties and the stability of the adjacent road embankment – 100 years Average Recurrence Interval (ARI) • ultimate limit state of bridges, major drainage structures and major retaining walls – (item 9 in "Minimum ARI" table - section 4.6.2.2 of Project Brief) Average Recurrence Interval (ARI) • impact on existing community emergency management arrangement any potential flood impact on properties, assets and infrastructure.	Section 5

Standard SEARs	Report section where addressed
Climate change risk The Proponent must assess the risk and vulnerability of the project to climate change in accordance with the current guidelines.	Section 6

2 Review of previous studies

The Shoalhaven River catchment covers an area of 7,000 km2, in which the Lower Shoalhaven River floodplain includes approximately 120 km2 of floodplain downstream of Nowra.

To effectively manage flood risk in the catchment, Shoalhaven City Council completed the following studies for the Lower Shoalhaven River floodplain in accordance with the Floodplain Management Manual (2005):

- Lower Shoalhaven River Flood Study (Webb, Mckeown & Associates, 1990)
- Lower Shoalhaven River Floodplain Risk Management Study (Webb, Mckeown & Associates, 2008)
- Lower Shoalhaven River Floodplain Risk Management Plan (Webb, McKeown & Associates, 2008)
- Lower Shoalhaven River Floodplain Management Study and Plan – Climate Change Assessment (WMAwater, 2011)
- Shoalhaven River Flood Study (WMAwater, 2013).

2.1 Lower Shoalhaven River Flood Study (Webb, Mckeown & Associates, 1990)

The Lower Shoalhaven River Flood Study (1990) was completed by Webb, McKeown & Associates, on behalf of Public Works Department in 1990.

In the flood study, a hydrological Watershed Bounded Network Model (WBNM) was utilised for the entire Shoalhaven River catchment to convert rainfall into flow hydrographs, which were used as input flows to simulate a quasi two-dimensional hydraulic model, termed as the "Cell Model". This hydraulic model defined the flood behaviour in terms of flood levels, velocities and flows within the hydraulic model extent.

The two models were calibrated and verified against the historical flood events of August 1974, June 1975, October 1976, March 1978 and April 1988.

2.2 Lower Shoalhaven River Floodplain Risk Management Study (Webb, McKeown & Associates, 2008)

The Lower Shoalhaven River Floodplain Risk Management Study was undertaken by Webb, McKeown & Associates in 2008. This study is a sequential study following the 1990 flood study, which was aimed at achieving the following objectives:

- Identify the potential flood problems within the study area

- Define the nature and the extent of flood risk for the study area by classifying the floodway and the flood hazard
- Evaluate the feasibility and effectiveness of a range of flood mitigation measures in the context of social, ecological, environmental and economical assessment.

2.3 Lower Shoalhaven River Floodplain Risk Management Plan (Webb, McKeown & Associates, 2008)

Webb, McKeown & Associates completed the Lower Shoalhaven River Floodplain Risk Management Plan in 2008 for Shoalhaven City Council, as a follow-up to the Lower Shoalhaven River Floodplain Risk Management Study. This plan provided recommendations of flood management measures, and developed the plan implementation to effectively manage the flood risk in the Lower Shoalhaven River floodplain.

2.4 Lower Shoalhaven River Floodplain Management Study and Plan - Climate Change Assessment (WMAwater, 2011)

This climate change assessment report is an amendment to Lower Shoalhaven River Floodplain Management Study and Plan (Webb, McKeown & Associates, 2008), which incorporated the climate change scenarios. This report provided a flood impact assessment for various climate change scenarios, and developed adaption strategies for inclusion of climate change impact in development controls and floodplain management plans.

It is noted that the CELLS hydraulic model established in the 1990 Lower Shoalhaven River flood study was utilised for all the above studies.

2.5 Shoalhaven River Flood Study (WMAwater, 2013)

Shoalhaven River Flood Study prepared by WMAwater in 2013 for Shoalhaven Starches supersedes the 1990 Lower Shoalhaven River Flood Study. A 2D hydrodynamic TUFLOW model was developed to define flood behaviour for the 10%, 5%, 2%. 1%. 0.5%, 0.2% AEP design events, and an Extreme Event.

The TUFLOW model was calibrated to ensure its ability to reproduce historical flow behaviour along the floodplain. Historical flood events utilised in the calibrations process were August 1974, June 1975, March 1978 and April 1988. The calibrated model produced results which reasonably matched recorded data, in particular, near the existing Nowra bridge crossings.

The climate change assessment was undertaken for the 1% AEP event by simulating a range of climate change scenarios, including a rainfall intensity increase of 10%, 20%, and 30%, as well as sea level rise of 0.4 m and 0.9 m, respectively. The results indicated that sea level rise have minimal impact on peak flood levels near the existing Nowra bridge crossings.

3 Modelling methodology

Flood behaviour in a floodplain is generally derived using hydrological and hydraulic models to simulate past flood behaviour and estimate likely flooding given a certain rainfall event. A hydrological model converts effective rainfall into runoff and a hydraulic model converts runoff into water levels and velocities.

3.1 Hydraulic modelling - TUFLOW

The current flood assessment utilised the hydrodynamic one and two dimensional (1D/2D) TUFLOW model derived in the Shoalhaven River flood study (WMAwater, 2013) to derive design flood behaviour. The model extent covers an area of about 170 km^2. The model extent and the TUFLOW layout are shown in Figure 1 (presented at the end of the report).

3.1.1 Model terrain

The model bathymetry has been developed using two data sources, namely Airborne Laser Scanning (ALS) and river bathymetry.

Floodplain ground levels were sourced from ALS survey obtained in 2012. The river bed levels were derived from a detailed bathymetric survey of the river completed in November 2006.

The hydrodynamic model adopted a rectangular grid size of 15 m.

3.1.2 Boundary conditions

The inflow hydrographs to the hydraulic model upstream of Nowra Bridge were sourced from the WBNM hydrological model.

The ‘Direct Rainfall’ method (DRM) was applied for Bomaderry Creek, Broughton Creek, and the Crookhaven River.

The downstream ocean conditions of the hydraulic model were defined by two tidal time series at Shoalhaven Heads and Crookhaven River sourced from the 1990 Lower Shoalhaven River flood study.

3.1.3 Hydraulic roughness

The adopted Manning’s ‘n’ roughness values for different land uses are presented in Table 2. These values were obtained and modified through model calibration / validation processes as per the flood study (WMAwater, 2013).

Table 2: Adopted roughness values

Land use type	Roughness value
Heavy Vegetation	0.12
In-bank	0.023
Roads	0.02

Land use type	Roughness value
Isolated High Rough Areas	0.15
Riparian Areas	0.08
Low Vegetation	0.04
House	Null Cell

3.1.4 Model version

The model was run using TUFLOW version 2013-12-AA-w64-IDP to be consistent with the version utilised in the flood study (WMAwater, 2013).

3.2 Bridge modelling in TUFLOW

The alignment of the proposed bridge is straight, parallel to the existing northbound bridge. The proposed bridge alignment and construction boundary are shown in Figure 2 (presented at the end of the report)**.**

The project also includes upgrading road intersections at Bridge Road, Illaroo Road and Bolong Road to achieve an improved interface between the proposed bridge and the bridge approaches. The design surfaces at these intersections were incorporated into the hydraulic model for the design scenario.

3.2.1 Bridge form loss coefficient

The proposed bridge has nine piers which match the spacing and location of the existing bridges' piers. This design minimises flood impact and improves flood conveyance. The proposed bridge was modelled as a 2D flow constriction in the TUFLOW model.

Hydraulics of Bridge Waterways (Bradley, 1978) provides a methodology to derive energy head loss of a bridge. In TUFLOW, this is represented by the bridge form loss coefficient (FLC).

The estimated FLC of the proposed bridge is 0.13. A summary of the bridge pier details and the FLC calculation is presented in Appendix F.

Detailed drawings of the proposed bridge are presented in Appendix G. Drawings for the existing northbound bridge are included in Appendix H.

4 Existing flood risk

The 1990 flood study simulated a range of design events from 18 to 72 hours duration for the 1% AEP, and identified that the critical duration is 36 hours. The 36-hour event was adopted for all the design events in the 2013 flood study. To be consistent with the previous studies, the 36-hour event has also been adopted for all of the design events in this flooding and hydrology assessment study.

4.1 Model modifications

The existing bridges were modelled as 2D flow constrictions. While the model adopted blockage due to pier influence in flood behaviour, no blockage was adopted to represent bridge deck. Additionally, the existing model did not include Bomaderry Bridge.

The Council's existing model has been modified for this flooding and hydrology assessment to better represent flood behaviour when bridges become submerged during large flood events (greater than 1% AEP events) as follows:

- Update the 2D flow constriction layer of the existing bridges to include 100% blockage of bridge deck when the flood level si higher than the bridge soffit level
- Include a 2D flow constriction layer of Bomaderry Bridge.

4.2 Existing flood risk

The peak flood depth figures for the 10%, 5%, 2%, 1%, 0.05% AEP event, and the Extreme Event for the existing scenario are shown in Appendix A. The figure numbers corresponding to these events are summarised in Table 3.

4.2.1 Derivation of 0.05% AEP flood event

Australian Rainfall and Runoff (ARR) 1998 – Book VI provides guidance on the derivation of large to extreme flood events. The guideline prescribes how to interpolate the 1% AEP and PMP rainfall to estimate 0.05% AEP rainfall. The rainfall is then converted into runoff and then applied into hydraulic models to then derive 0.05% AEP runoff (AEP neutrality).

The 0.05% AEP design event was derived by interpolating in Log-Normal space the 1% AEP peak flow and PMF (Extreme Event) peak flow at Nowra Bridge. The shape of the 0.05% AEP inflow hydrograph was derived by scaling the 1% AEP inflow hydrograph for the Shoalhaven river to match the peak flow of the 0.05% AEP obtained from the interpolation.

Table 3: Peak flood depth figures for the existing scenario

Figure No.	Title
A1.1	10% AEP peak flood depth – existing scenario
A1.2	5% AEP peak flood depth – existing scenario
A1.3	2% AEP peak flood depth – existing scenario
A1.4	1% AEP peak flood depth – existing scenario
A1.5	0.05% AEP peak flood depth – existing scenario
A1.6	Extreme Event peak flood depth – existing scenario

4.2.2 Road flood risk

The model results indicate that the intersection of Princes Highway and Bolong Road is overtopped when Bomaderry Creek floods in a 5% AEP event, with depths of flows about 0.35 m at this location (Figure A1.2).

The Princes Highway is seen under minor flooding near Harry Sawkins. During 1% AEP and more frequent flood events road inundation does not exceed 0.1 m depth.

4.2.3 Property flood risk

In inundation events equal or greater than a 2% AEP event, the Shoalhaven River breaks its banks and flows into Moorhouse Park and Nowra Aquatic Park, resulting in a number of properties inundated at these locations. Peak flood depth in this area is seen up to 2.2 m and 2.8 m for the 2% and 1% AEP events, respectively (refer to Figure A1.3 and A1.4).

5 Design model results

5.1 Flood immunity

Peak flood levels immediately upstream of the proposed bridge for the design events are presented in Table 4. The peak flood depth figures for the 10%, 5%, 2%, 1%, 0.05% AEP event, and the Extreme Event are shown in Appendix B. The figure numbers corresponding to these events are summarised in Table 5.

Table 4:Peak flood levels upstream of the proposed bridge

Design event - AEP	Peak flood level (mAHD)
10%	5.12
5%	5.66
2%	6.44
1%	6.87
0.05%	9.06
Extreme Event	13.67

Table 5: Peak flood depth figures for the design scenario

Figure No.	Title
A2.1	10% AEP peak flood depths – design scenario
A2.2	5% AEP peak flood depths – design scenario
A2.3	2% AEP peak flood depths – design scenario
A2.4	1% AEP peak flood depths – design scenario
A2.5	0.05% AEP peak flood depths – design scenario
A2.6	Extreme event peak flood depths – design scenario

The proposed bridge soffit level is similar to the existing bridge soffit (8 mAHD), which is well above the peak flood level of the 1% AEP event. This indicates that the proposed bridge is flood immune in a 1% AEP event.

The proposed road upgrades at Illaroo Road and Bridge Road are flood immune for all flood events up to and including the 1% AEP. The western end of Scenic Drive located at Moorhouse Park is flood immune for flood events up to and including the 5% AEP.

5.2 Peak flood level impact

Figures showing peak flood level impact for the 10%, 5%, 2%, 1%, 0.05% AEP event and the Extreme Event are presented in Appendix C. The figure numbers corresponding to these events are summarised in Table 6.

Table 6: Peak flood level impact figures

Figure No.	Title
A3.1	Peak flood level impact – 10% AEP
A3.2	Peak flood level impact – 5% AEP
A3.3	Peak flood level impact – 2% AEP
A3.4	Peak flood level impact – 1% AEP
A3.5	Peak flood level impact – 0.05% AEP
A3.6	Peak flood level impact – Extreme event

The proposed bridge increases upstream peak flood levels between 0.05 m and 0.15 m in flood events ranging from 10% AEP to 1% AEP events.

The proposed bridge design results in increases in peak flood levels for a limited number of properties at Moorhouse Park by about 0.2 m in a 2% and 1% AEP. This flood impact is considered relatively minor since the peak flood depth at these properties is in already excess of 2.0 m in the 2% AEP under existing conditions. Therefore, this adverse flood impact is negligible for all flood events up to and including the 1% AEP.

The flood levels of Shoalhaven River upstream of the proposed bridge increase by about 1 m in the Extreme Event.

Currently, no flood mitigation options have been considered as the increase in peak flood level at this location is unlikely to exacerbate existing flood risk to property and will not result in significant additional damage costs. It is noted that these properties are located at a sag.

5.3 Peak flood velocity impact

Figures showing the peak flood velocity impact for all the design events are presented in Appendix D. The figure numbers corresponding to these events are summarised in Table 7.

Table 7: Peak flood velocity impact figures

Figure No.	Title
A4.1	Peak flood velocity impact – 10% AEP
A4.2	Peak flood velocity impact – 5% AEP
A4.3	Peak flood velocity impact – 2% AEP
A4.4	Peak flood velocity impact – 1% AEP
A4.5	Peak flood velocity impact – 0.05% AEP
A4.6	Peak flood velocity impact – Extreme event

The model results indicate minimal peak flood velocity impact for the flood events up to and including 1% AEP along the Shoalhaven River. Such increases are not likely to increase scour potential along the river. As such, the proposed design does not result in an adverse impact on the stability of the river embankment and bridge structures.

6 Climate change

Changes to future climate conditions are predicted to impact on sea levels and rainfall intensities. Climate change guidelines have been issued by the NSW Government (Reference 1 & 2). A review of these guidelines is documented in Section 1.2.2.

An assessment of the potential flood impact due to changes in future climate conditions has been carried out for this study by considering the following climate change scenarios:

- Scenario 1 – 10% increase in rainfall intensity of 1% AEP event, coupled with 0.4 m sea level rise
- Scenario 2 - 30% increase in rainfall intensity of 1% AEP event , coupled with 0.9 m sea level rise

The flood impact of the climate change scenarios is shown in Appendix E (Figure A5.1 and A5.2).

Overall, peak flood levels in the Shoalhaven River floodplain increases up to 0.4 m and 1.1 m for the climate change scenario 1 and scenario 2, respectively.

The flood levels of Shoalhaven River immediately upstream of the proposed bridge increase between 0.4 m and 1.3 m due to climate change. As a result, the flood levels at properties in Moorhouse Park increased to the same degree as the flood levels of Shoalhaven River. It is noted that future climate change does not impact on the flood immunity of the proposed bridge.

7 Key findings

The key findings of this flood and hydrology assessment study are:

- The proposed bridge and the intersection upgrade locations at Bridge Road and Illaroo Road are flood immune for flood events up to and including the 1% AEP event. The west end of Scenic Drive located in Moorhouse Park has flood immunity for all the flood events up to and including 5% AEP.
- The flood levels of Shoalhaven River upstream of the proposed bridge increase between 0.05 m and 0.15 m for the 10% AEP to the 1% AEP. It is noted that this increase is seen to extend up to the model's upstream boundary, which is located 2.4 km upstream of the proposed bridge. Due to limitations with the current flood model and data it was not possible to extend the flood model further upstream to determine the entire extent of impact. During the detailed design phase, it is recommended to extend the flood model further upstream to investigate the extent of this impact, however, it is noted that a limited number of properties exist upstream of the current boundary and are probably located outside the main floodplain area.
- There is no adverse flood impact on properties for flood events up to and including the 5% AEP.
- The proposed design results in increases in peak flood levels for a number of properties at Moorhouse Park, that are currently flooded above floor level in excess of 2 m in a 2% and 1% AEP event. The predicted increase in peak flood depth is about 0.2 m. No flood mitigation option has been considered as the land where they are located is likely to be unsafe for people and vehicles during large flood events and the increase in flood level has no impact on the hazard of the land.
- There is no adverse peak flood velocity impact for the flood events up to and including the 1% AEP along the Shoalhaven River.

8 References

Reference 1: NSW Government. (2005). *NSW Floodplain Development Manual.*

Reference 2: NSW Department of Environment and Climate Change (DECC). (2007). *Floodplain Risk Management Guideline*.

Reference 3: NSW Government. (2009). *NSW Sea Level Rise Policy Statement.*

Reference 4:Shoalhaven City Council. (2014). *Shoalhaven Development Control Plan*.

Reference 5: Public Works. (1990). *Lower Shoalhaven River Flood Study*.

Reference 6: Webb, Mckeown & Associates. (2008). *Lower Shoalhaven River Floodplain Risk Management Study*.

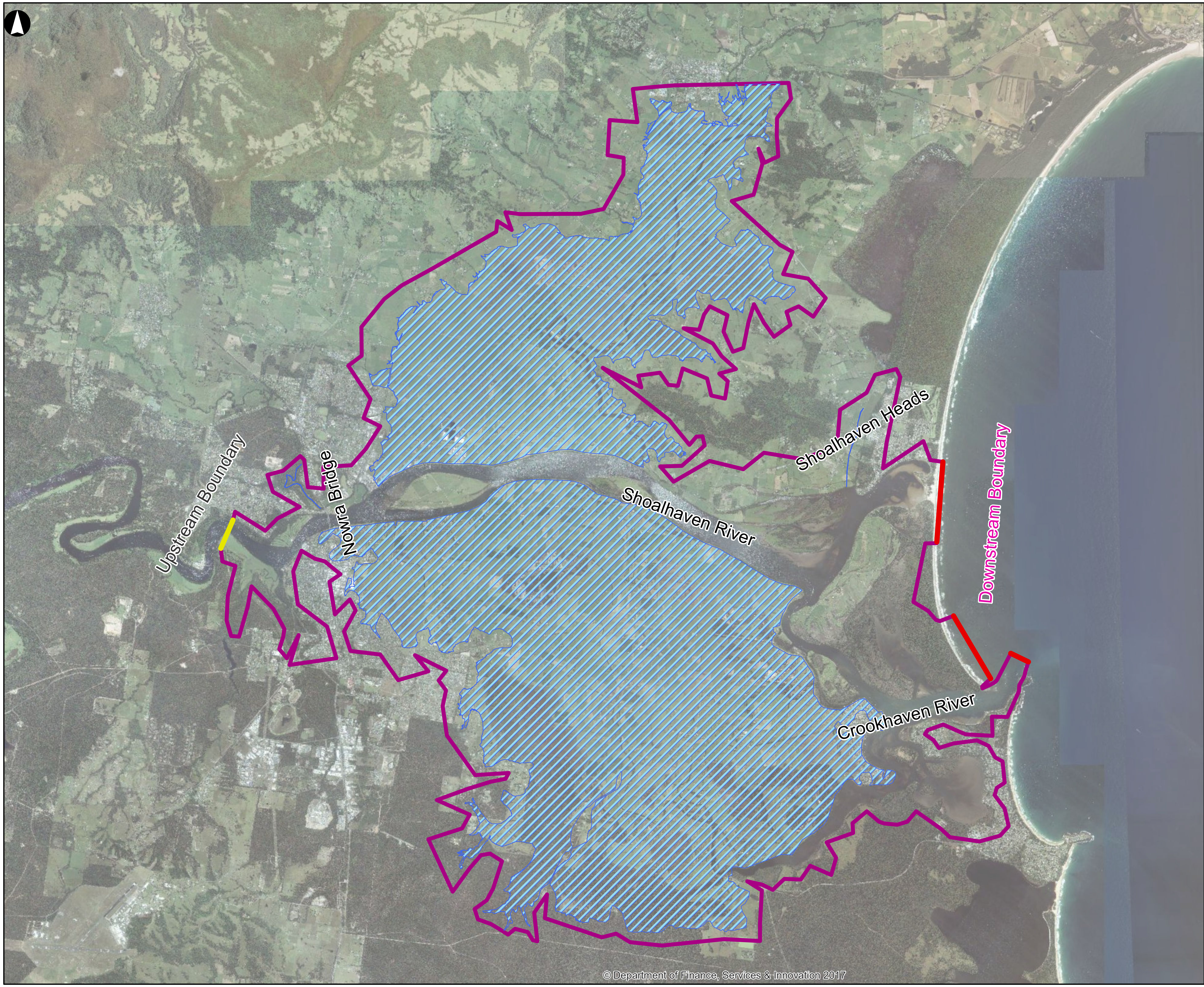
Reference 7: Webb, Mckeown & Associates. (2008). *Lower Shoalhaven River Floodplain Risk Management Plan*.

Reference 8:WMAwater. (2011). *Lower Shoalhaven River Floodplain Risk Management Study & Plan - Climate Change Assessment*.

Reference 9: WMAwater. (2013). *Lower Shoalhaven River Flood Study*.

Figures

A3



Legend

- Model Extent
- Rainfall-on-Grid Zones
- Upstream Boundary
- Downstream Boundary

P1	5/06/2018	TF	IVS	MT
Issue	Date	By	Chkd	Appd

Metres
0 1,050 2,100 4,200

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Client
Roads and Maritime Services

Job Title
Nowra Bridge Concept Design

TUFLOW Model Layout

Scale at A3

Job No
242129-00

Figure Status
80% Concept Design

Figure No
Figure 1

Issue
P1

MXD Location

A3

Legend

- Construction Boundary
- Design Alignment
- Pier Location

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres
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Job Title
Nowra Bridge Concept Design

Proposed Concept Design Alignment

Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

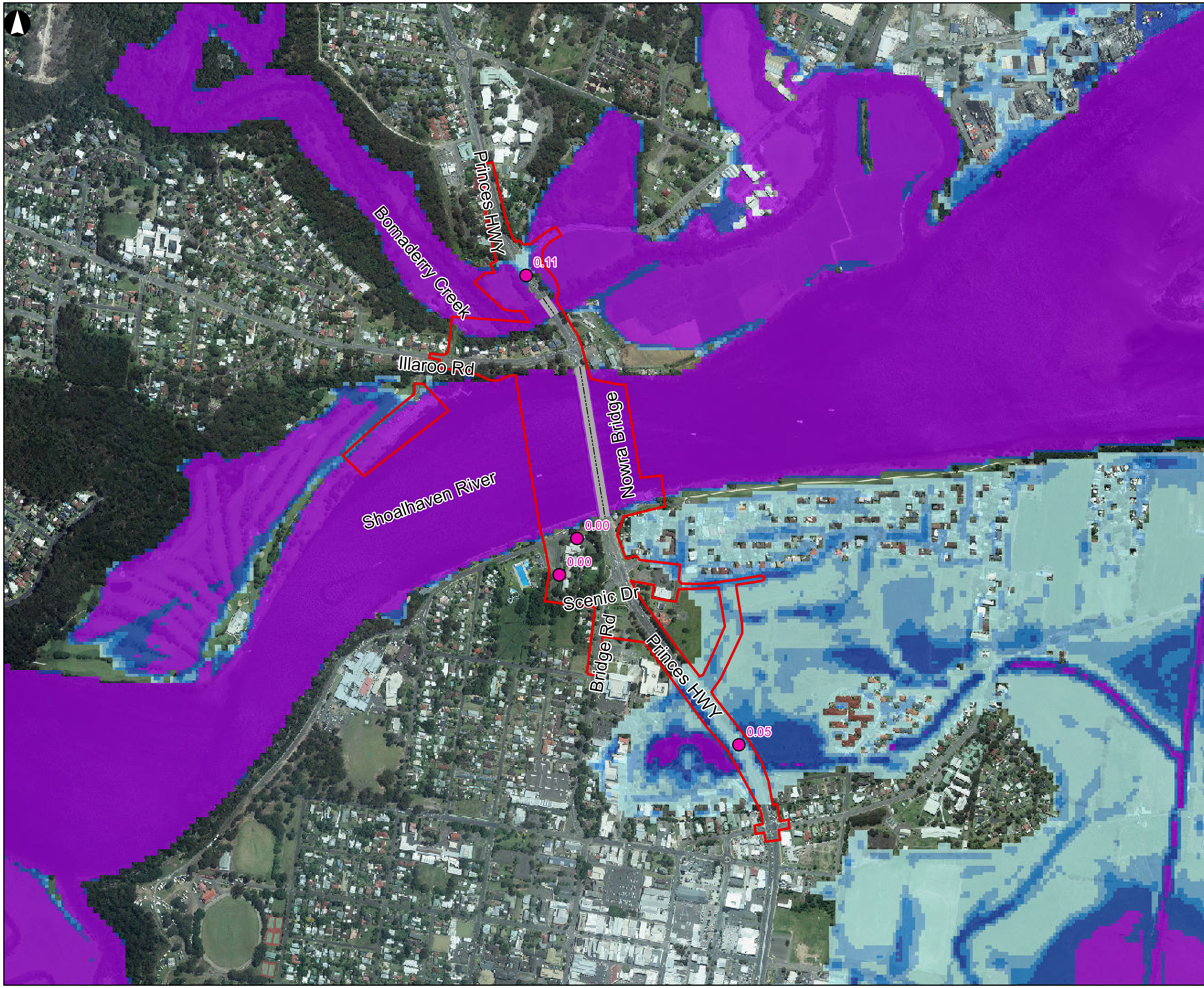
Figure No	Issue
Figure 2	**P1**

MXD Location

Appendix A

Peak Flood Depth Figures - Existing Scenario

A3



Legend

Construction Boundary

Flood Depth (m)

Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
0 115 230 460

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Job Title
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10% AEP Peak Flood Depths Existing Scenario

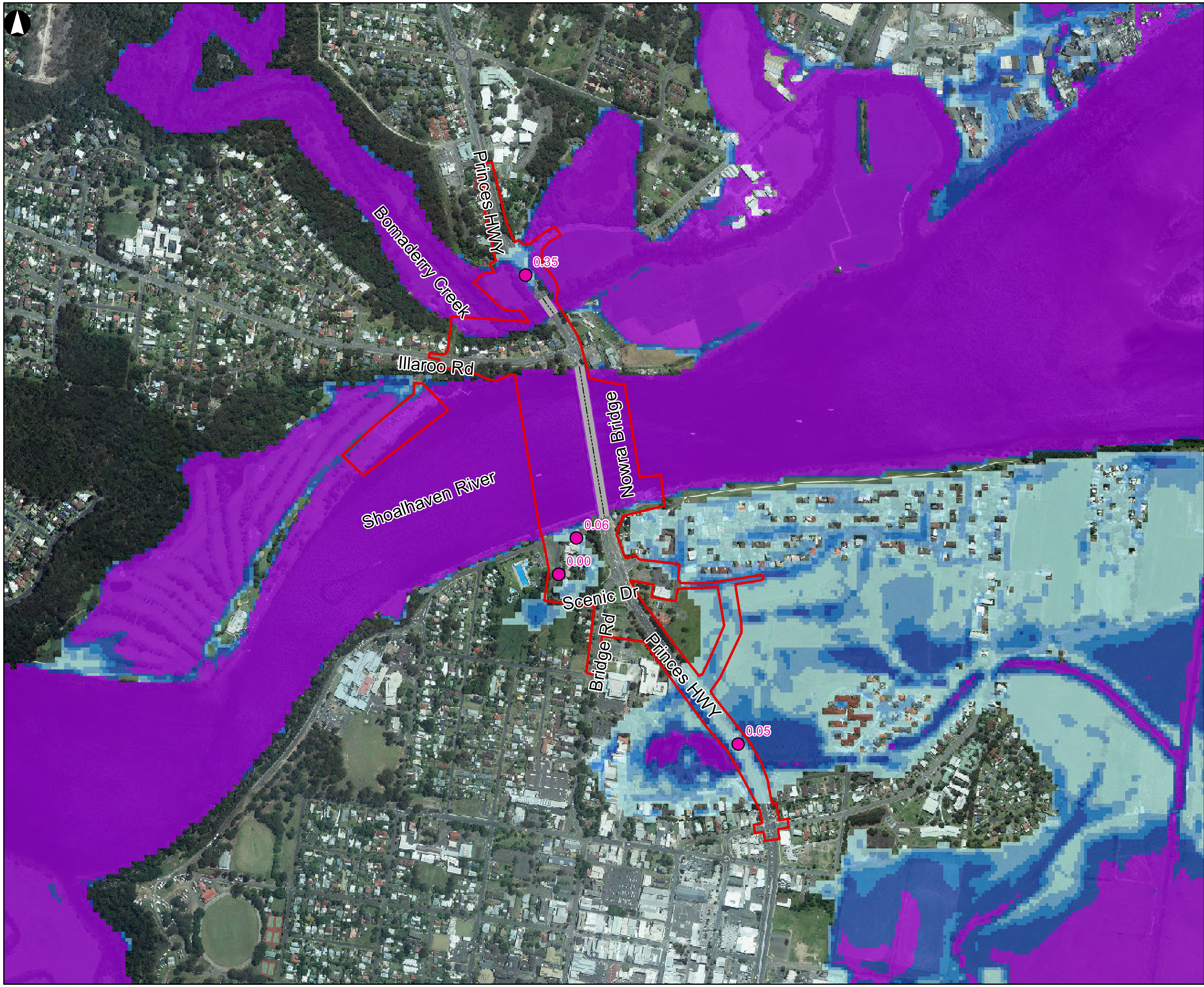
Scale at A3

Job No	Figure Status
242129-00	80% Concept Design

Figure No	Issue
A1.1	P1

MXD Location

A3



Legend

- Construction Boundary
- Flood Depth (m)
- Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
0 115 230 460

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5% AEP Peak Flood Depths
Existing Scenario

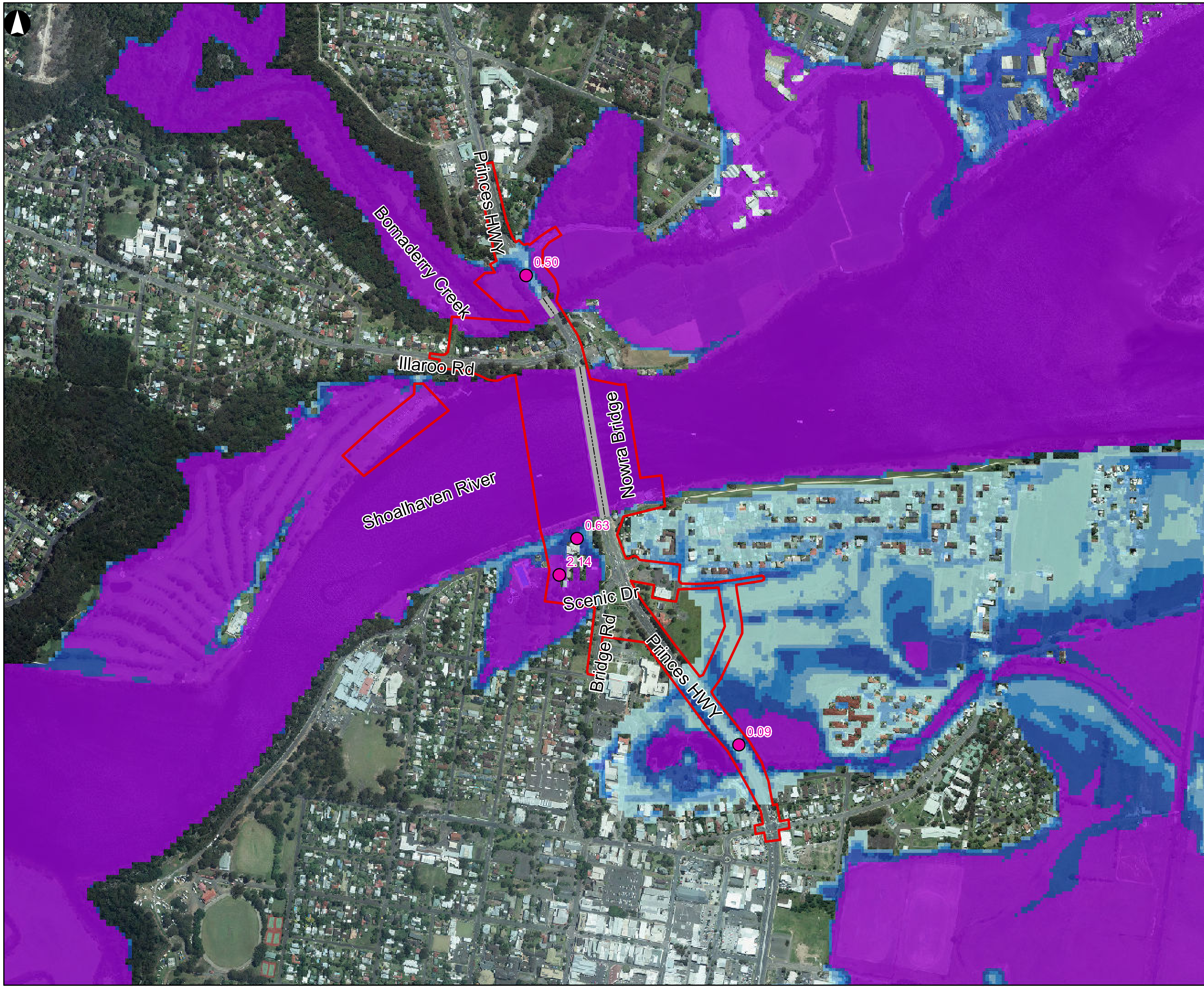
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A1.2	**P1**

MXD Location

A3



Legend

- Construction Boundary
- Flood Depth (m)
- Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
0 115 230 460

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Job Title
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**2% AEP Peak Flood Depths
Existing Scenario**

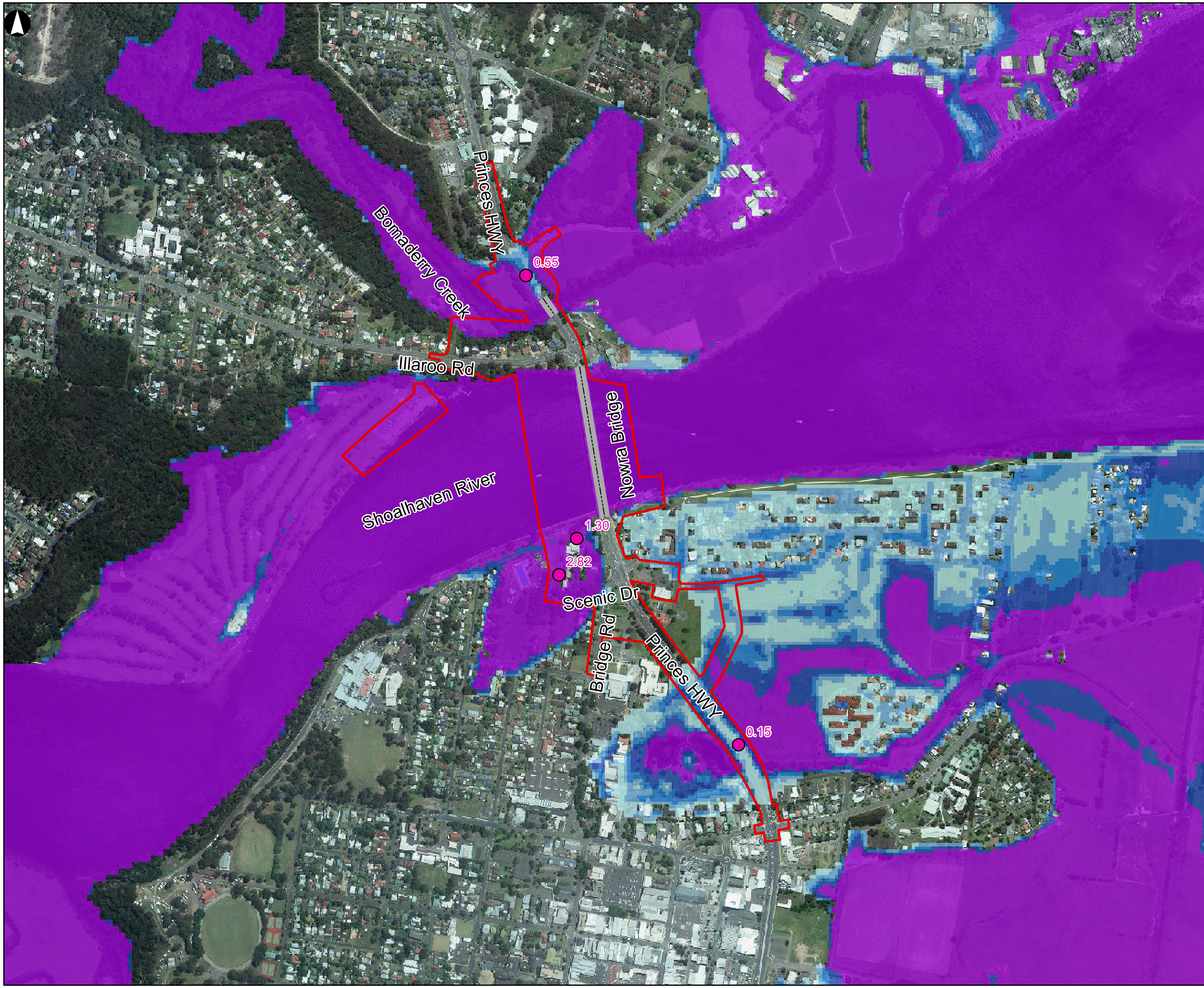
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A1.3	**P1**

MXD Location

A3



Legend

Construction Boundary

Flood Depth (m)

Bridges

Peak Flood Depth (m)

0.0 - 0.1

0.1 - 0.3

0.3 - 0.5

0.5 - 1.0

> 1.0

P1	19-Jun-18	TF	IVS	MT
Issue	Date	By	Chkd	Appd

Metres

0 115 230 460

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Job Title

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1% AEP Peak Flood Depths
Existing Scenario

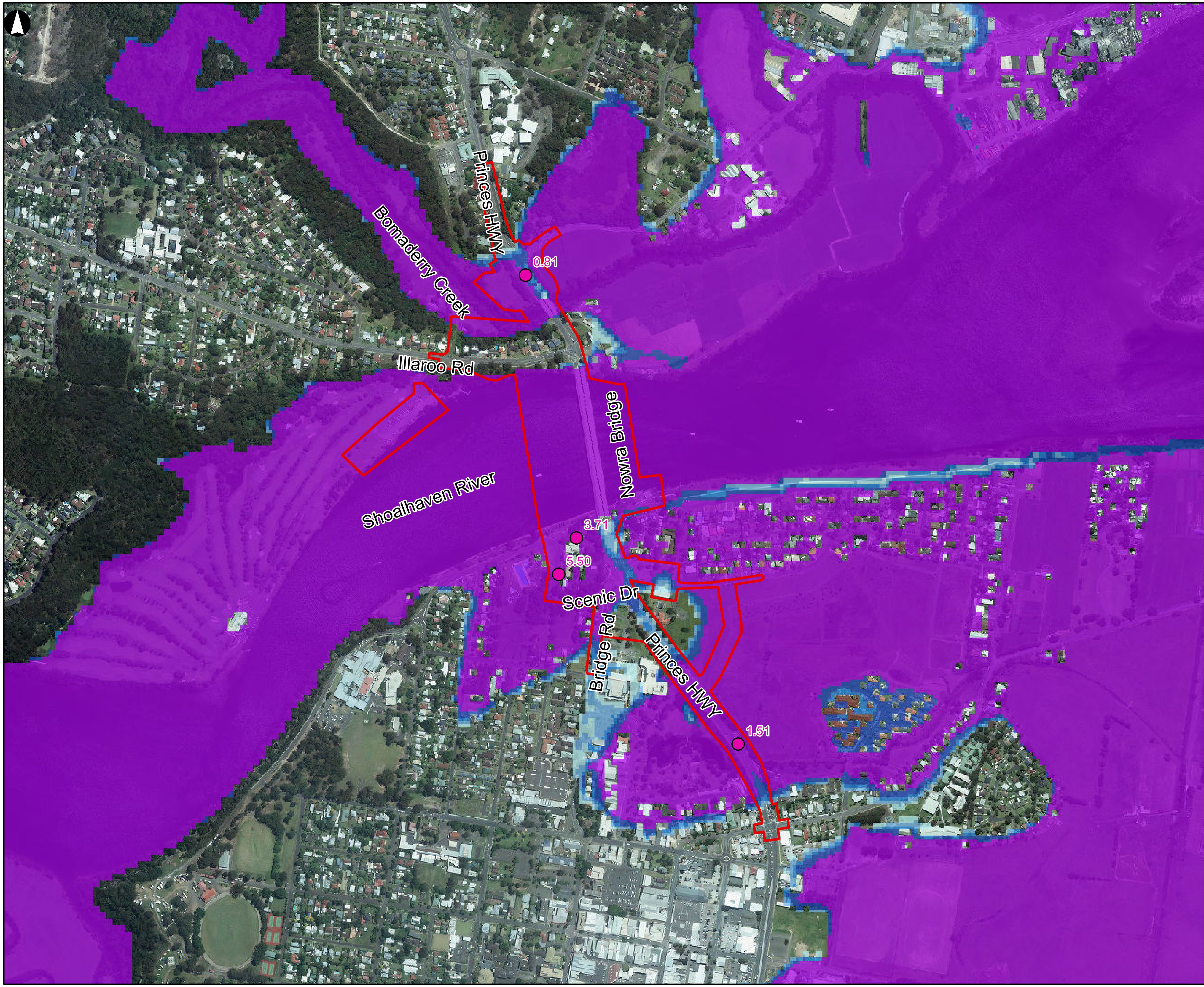
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A1.4	**P1**

MXD Location

A3



Legend

Construction Boundary

Flood Depth (m)

Bridges

Peak Flood Depth (m)

0.0 - 0.1

0.1 - 0.3

0.3 - 0.5

0.5 - 1.0

> 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres

0 115 230 460

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Job Title

Nowra Bridge Concept Design

0.05% AEP Peak Flood Depths Existing Scenario

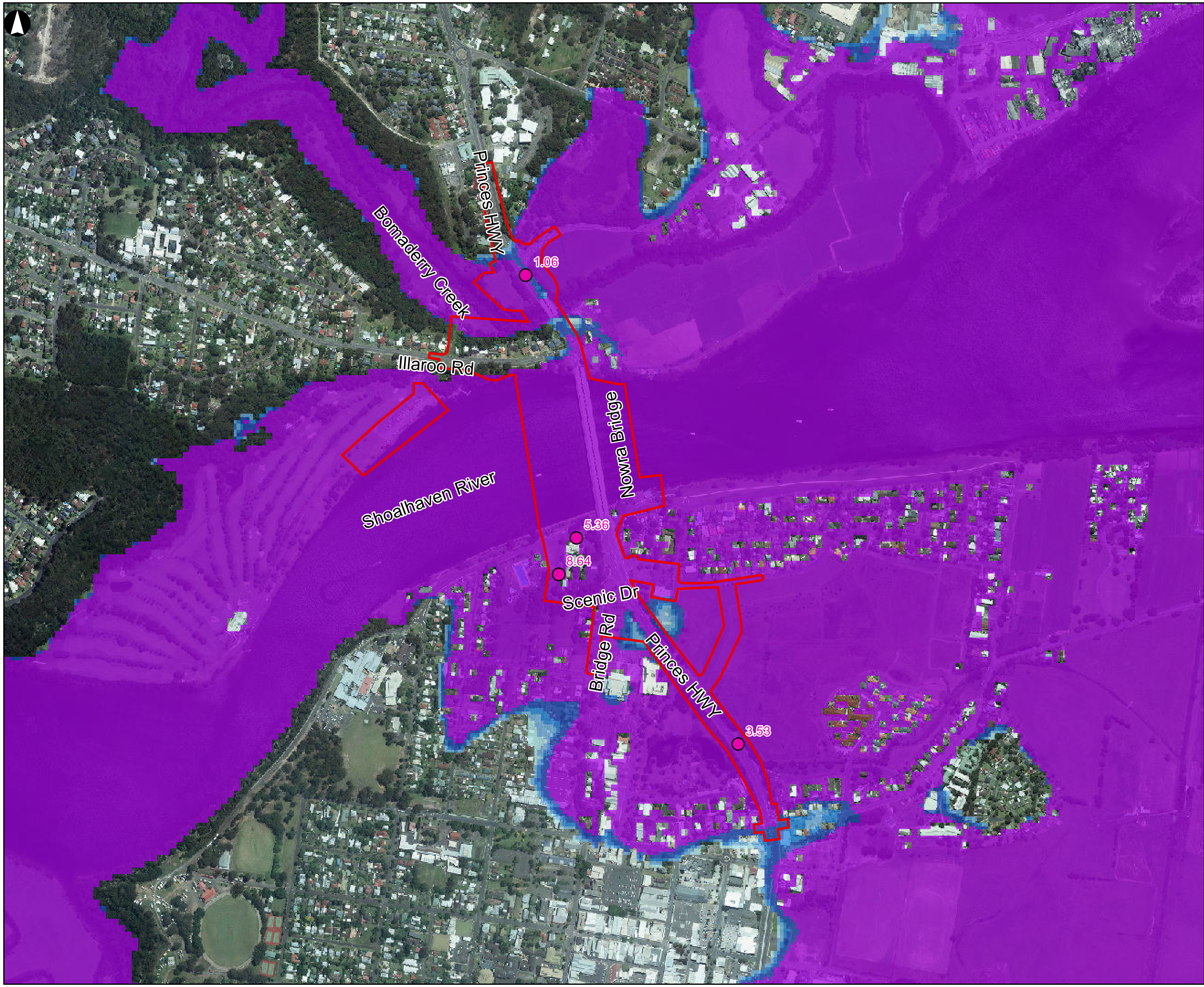
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A1.5	**P1**

MXD Location

A3



Legend

- Construction Boundary
- Flood Depth (m)
- Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
0 115 230 460

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**Extreme Event Peak Flood Depths
Existing Scenario**

Scale at A3

Job No	Figure Status
242129-00	80% Concept Design

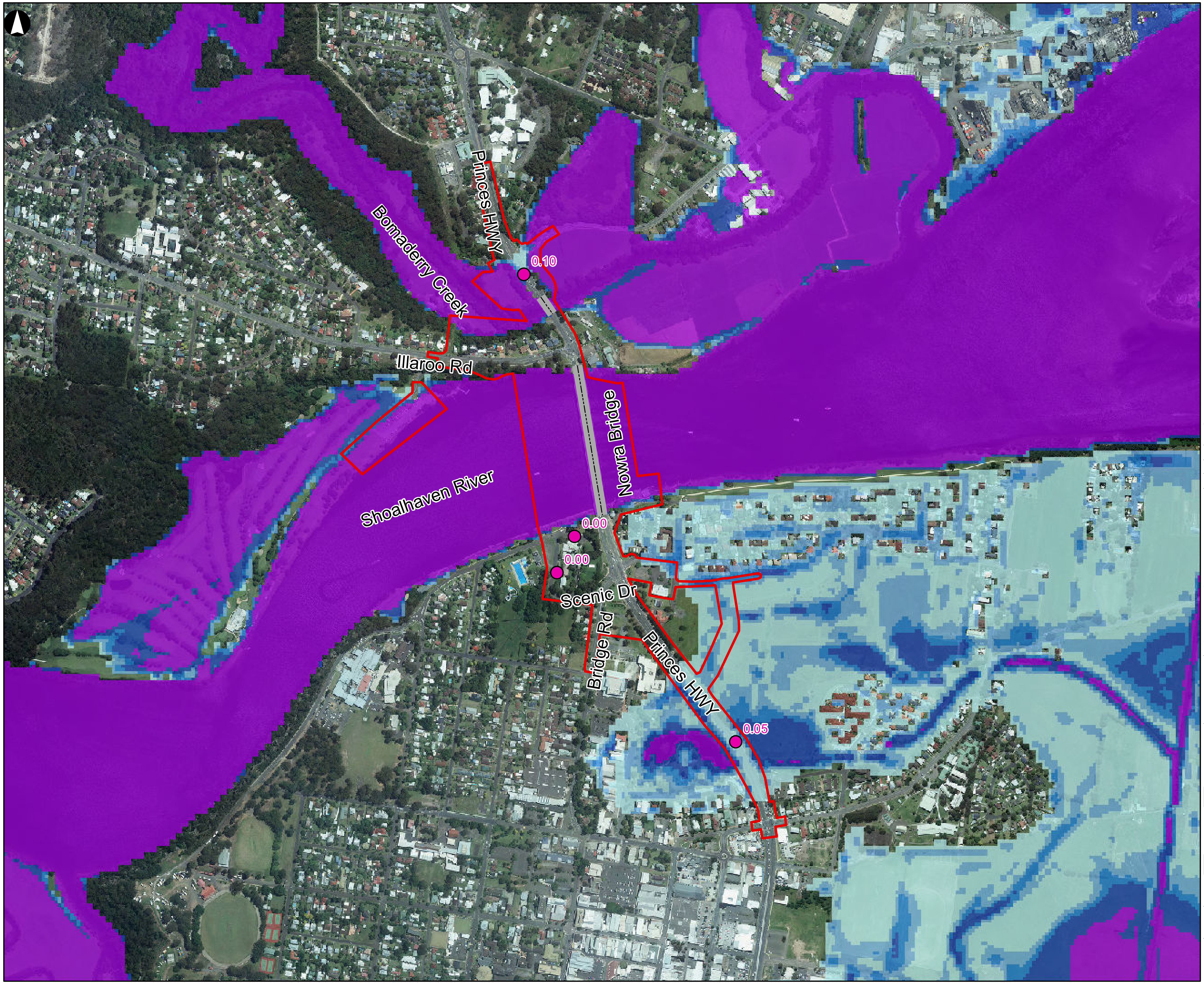
Figure No	Issue
A1.6	P1

MXD Location

Appendix B

Peak Flood Depth Figures - Design Scenario

A3



Legend

- Construction Boundary
- Flood Depth (m)
- Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
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10% AEP Peak Flood Depths
Design Scenario

Scale at A3

Job No
242129-00

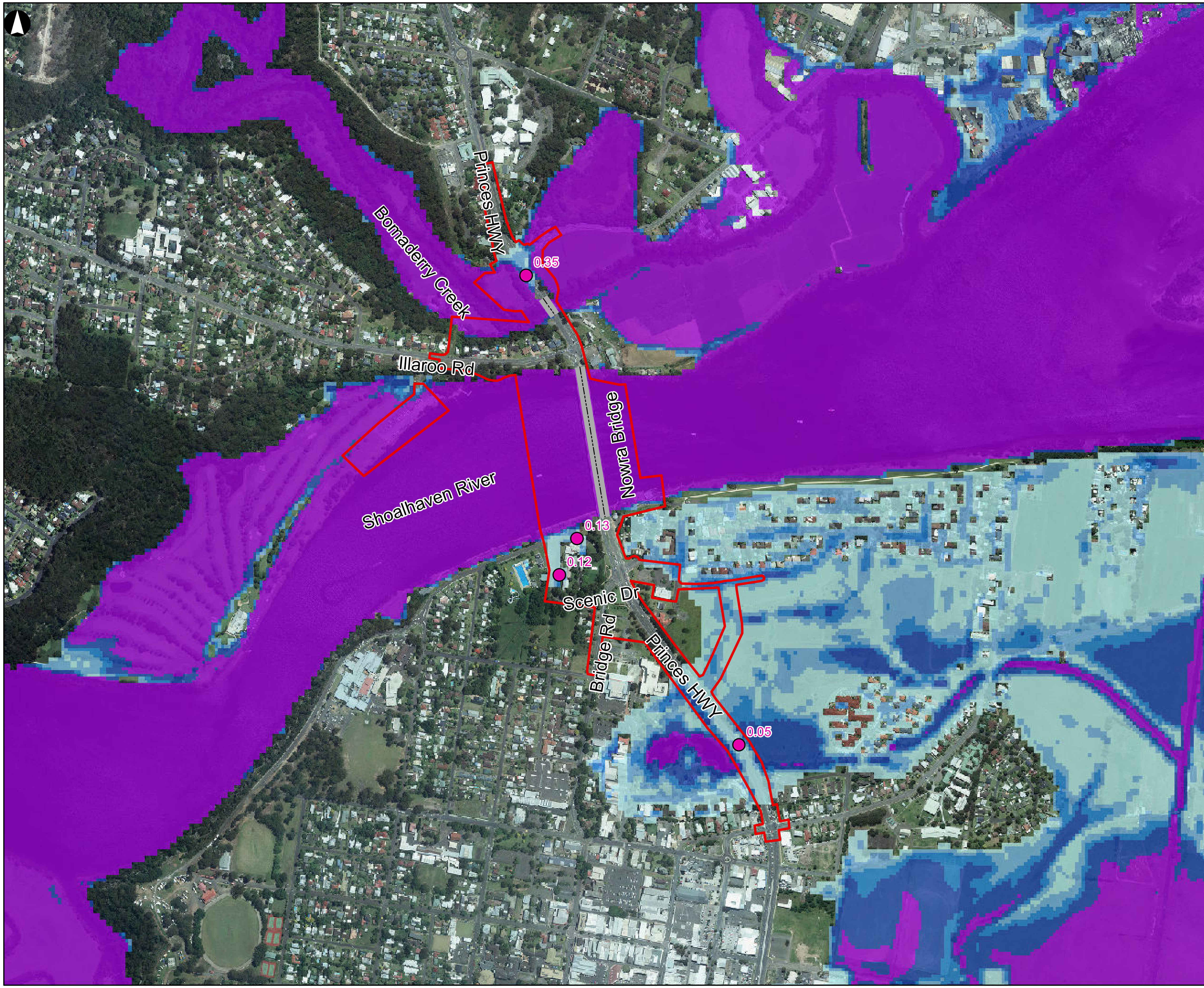
Figure Status
80% Concept Design

Figure No
A2.1

Issue
P1

MXD Location

A3



Legend

- Construction Boundary
- Flood Depth (m)
- Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
0 115 230 460

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Job Title
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5% AEP Peak Flood Depths Design Scenario

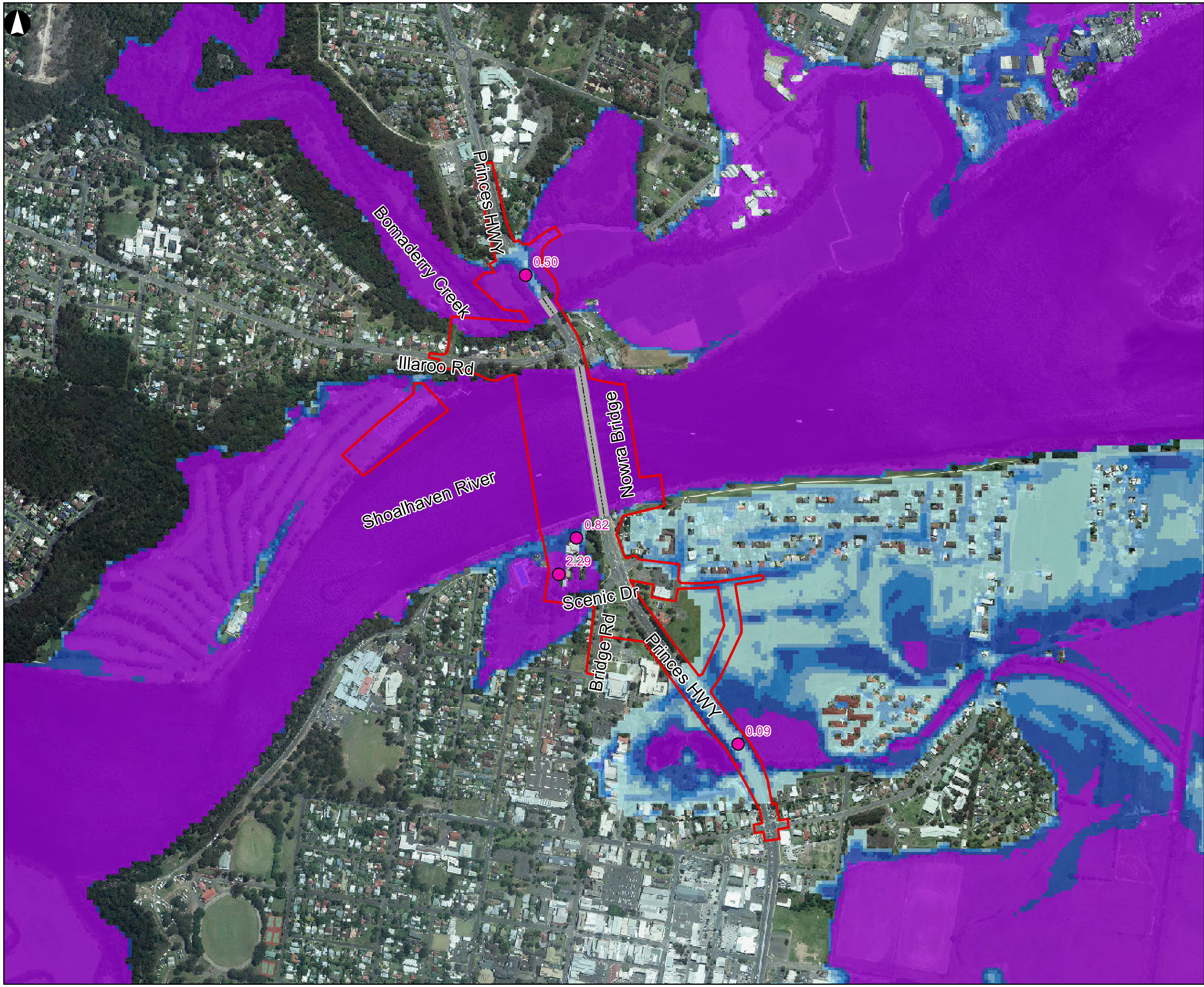
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A2.2	**P1**

MXD Location

A3



Legend

- Construction Boundary
- Flood Depth (m)
- Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
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Job Title
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2% AEP Peak Flood Depths
Design Scenario

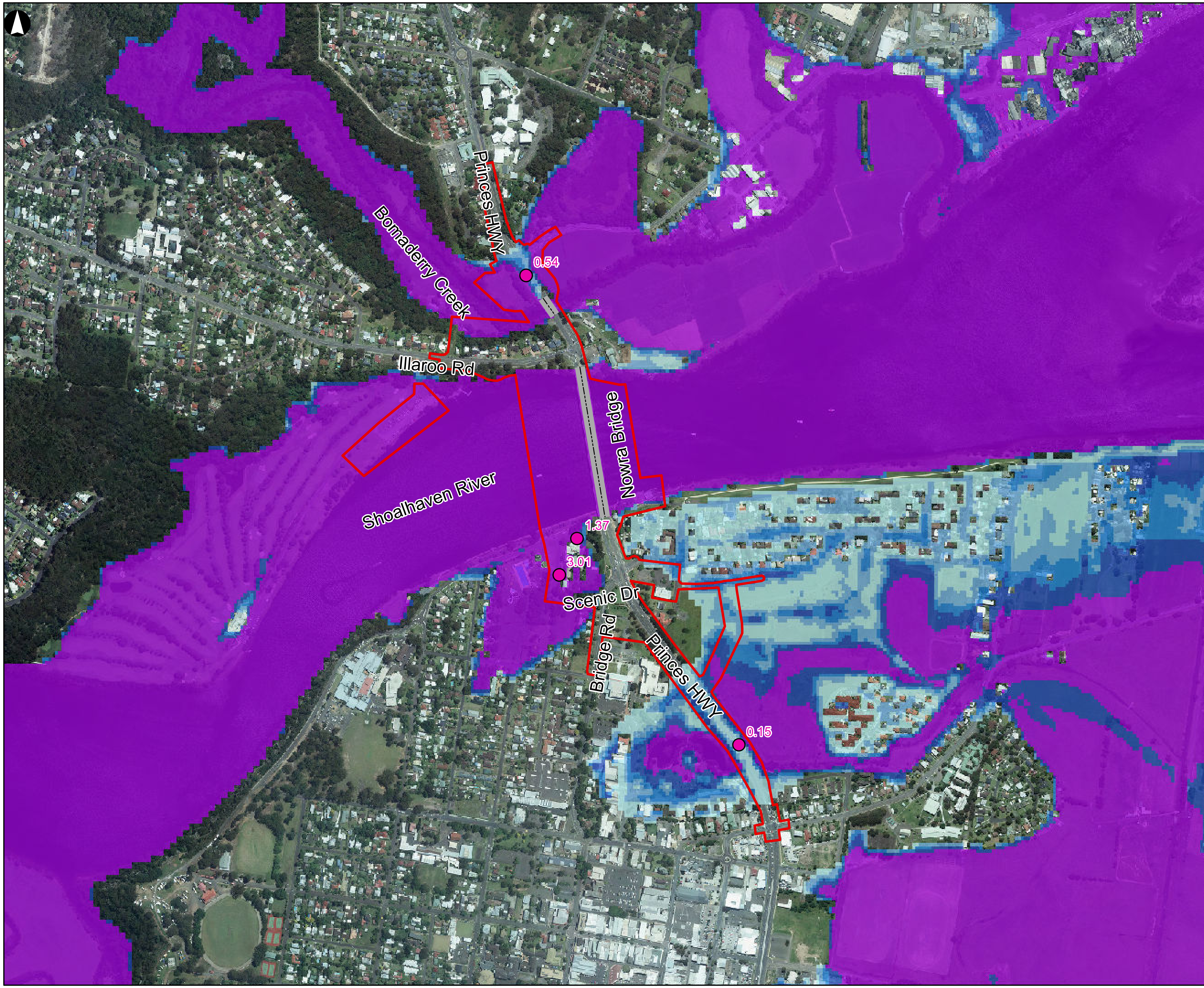
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A2.3	**P1**

MXD Location

A3



Legend

- Construction Boundary
- Flood Depth (m)
- Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
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1% AEP Peak Flood Depths
Design Scenario

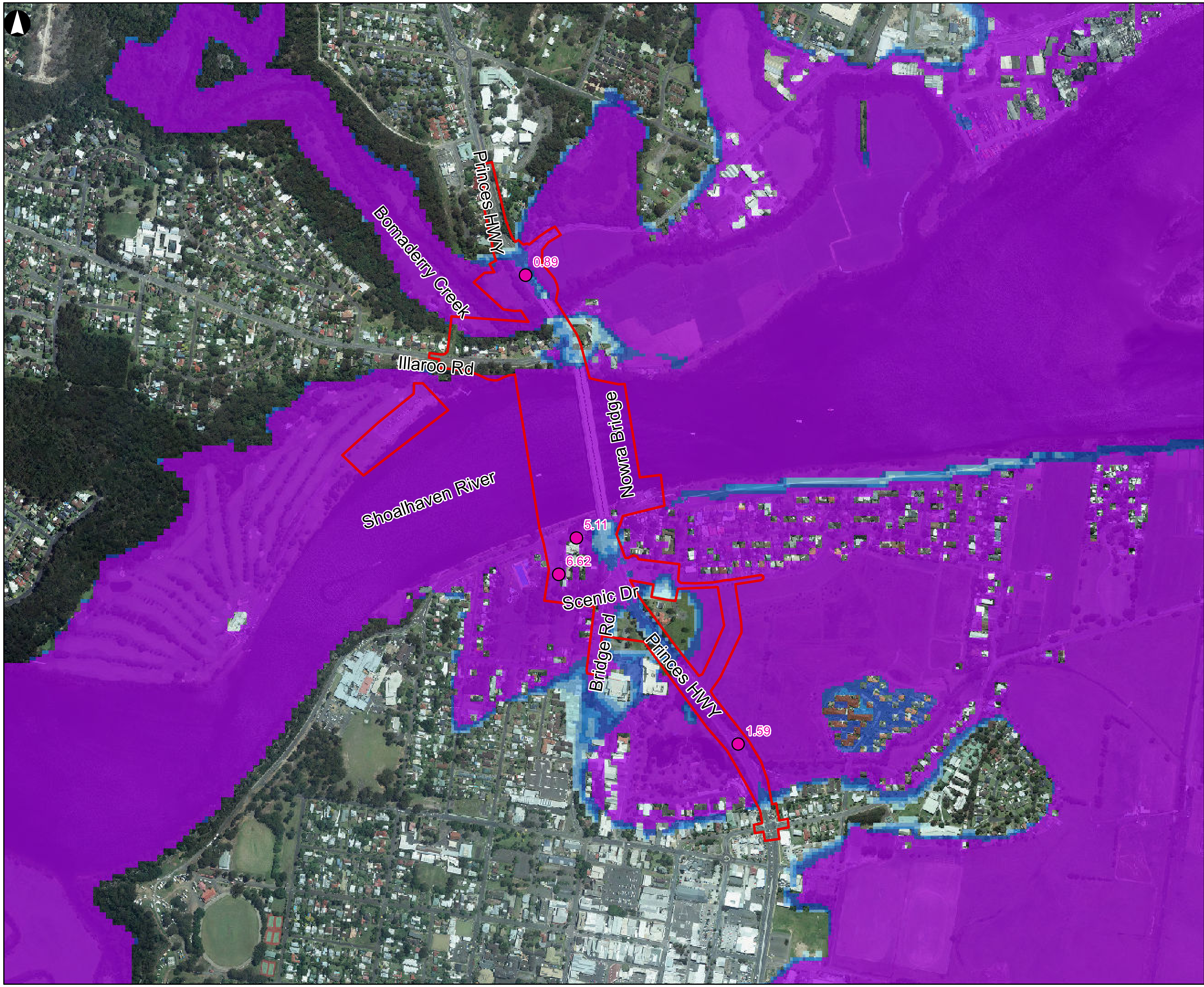
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A2.4	**P1**

MXD Location

A3



Legend

- Construction Boundary
- Flood Depth (m)
- Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
0 115 230 460

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0.05% AEP Peak Flood Depths Design Scenario

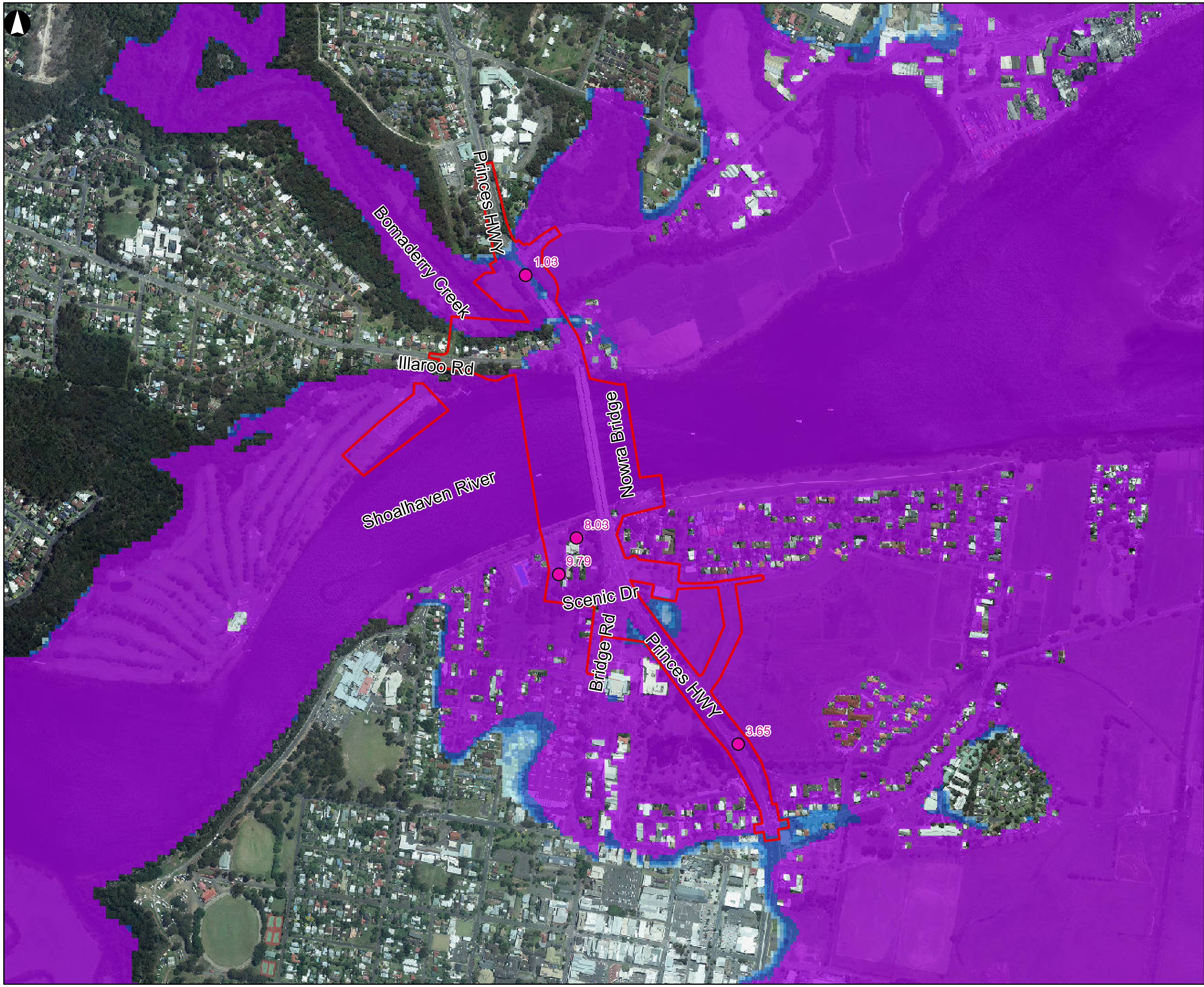
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A2.5	**P1**

MXD Location

A3



Legend

- Construction Boundary
- Flood Depth (m)
- Bridges

Peak Flood Depth (m)

- 0.0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- > 1.0

Issue	Date	By	Chkd	Appd
P1	19-Jun-18	TF	IVS	MT

Metres
0 115 230 460

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Job Title
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Extreme Extent Peak Flood Depths Design Scenario

Scale at A3

Job No	Figure Status
242129-00	80% Concept Design

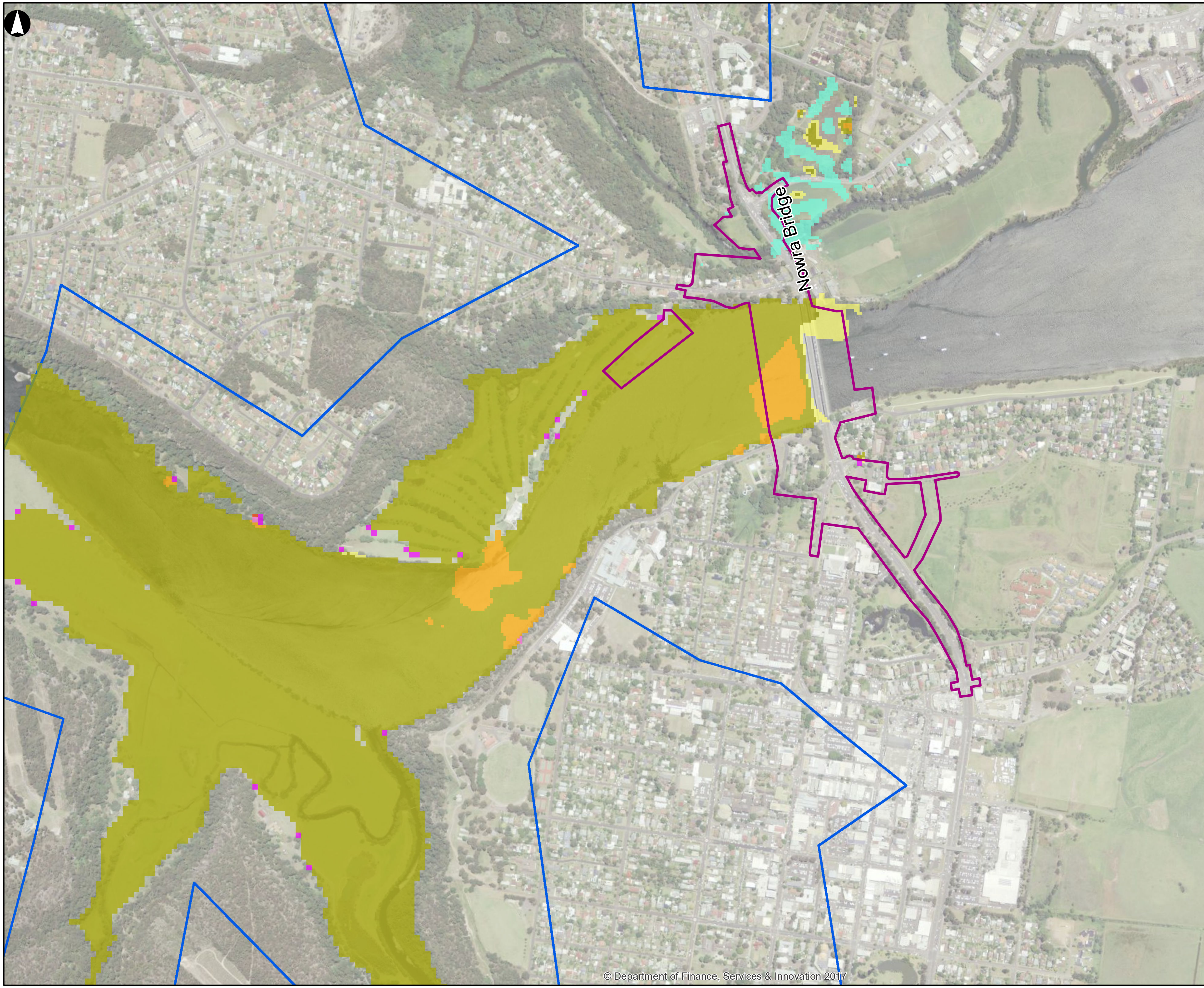
Figure No	Issue
A2.6	P1

MXD Location

Appendix C

Peak Flood Level Impact

A3



Legend

- Model Extent
- Construction Boundary

Flood Level Impact (m)

- <-0.10
- -0.10 - -0.01
- No Impact
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- >0.20
- No Longer Flooded
- Newly Flooded

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres
0 135 270 540

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Job Title
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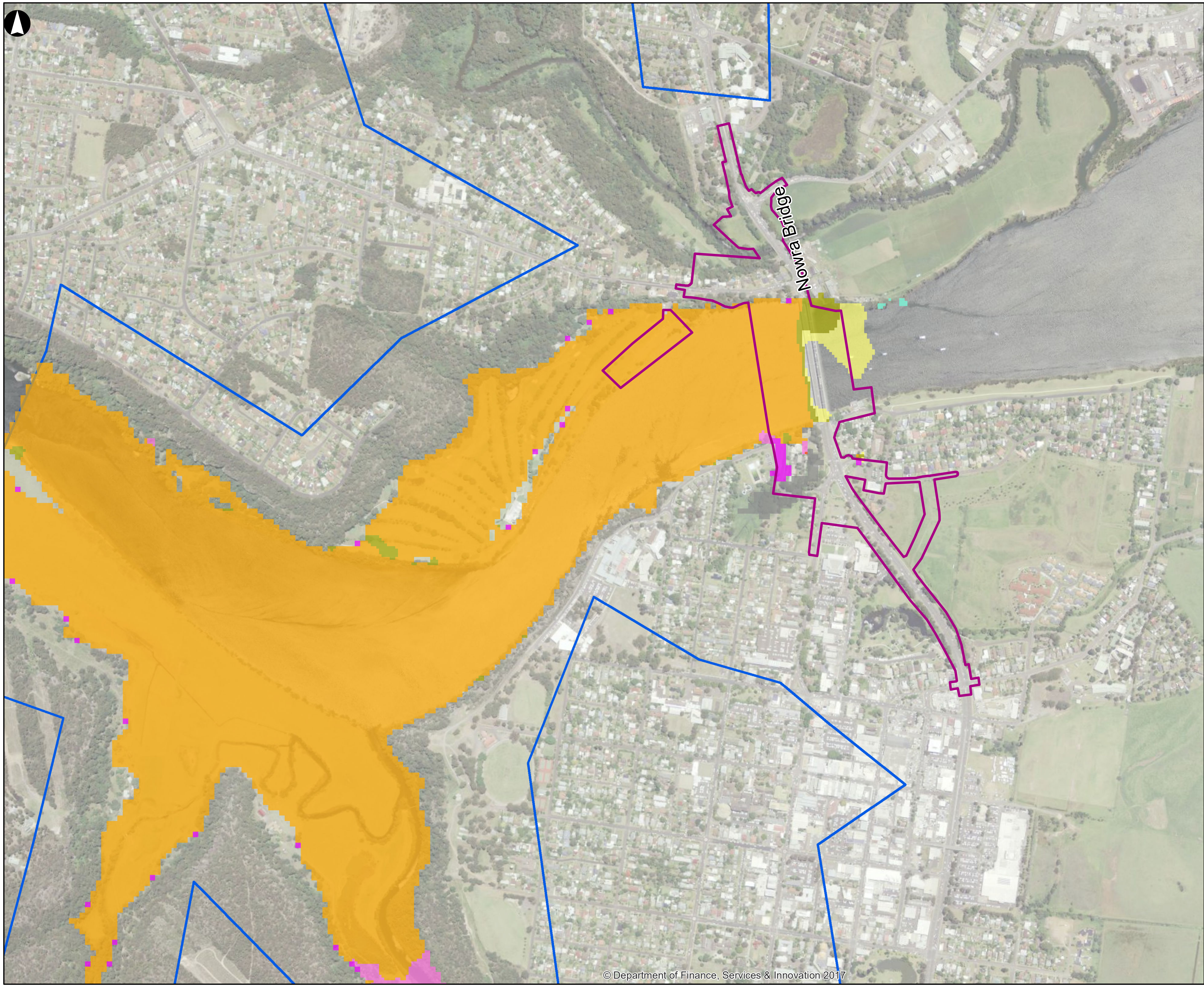
**10% AEP Flood Level Impact
Design Less Existing**

Scale at A3

Job No **242129-00**
Figure Status **80% Concept Design**
Figure No **A3.1**
Issue **P1**

MXD Location

A3



Legend

- Model Extent
- Construction Boundary

Flood Level Impact (m)

- <-0.10
- -0.10 - -0.01
- No Impact
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- >0.20
- No Longer Flooded
- Newly Flooded

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres
0 135 270 540

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Job Title
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**5% AEP Flood Level Impact
Design Less Existing**

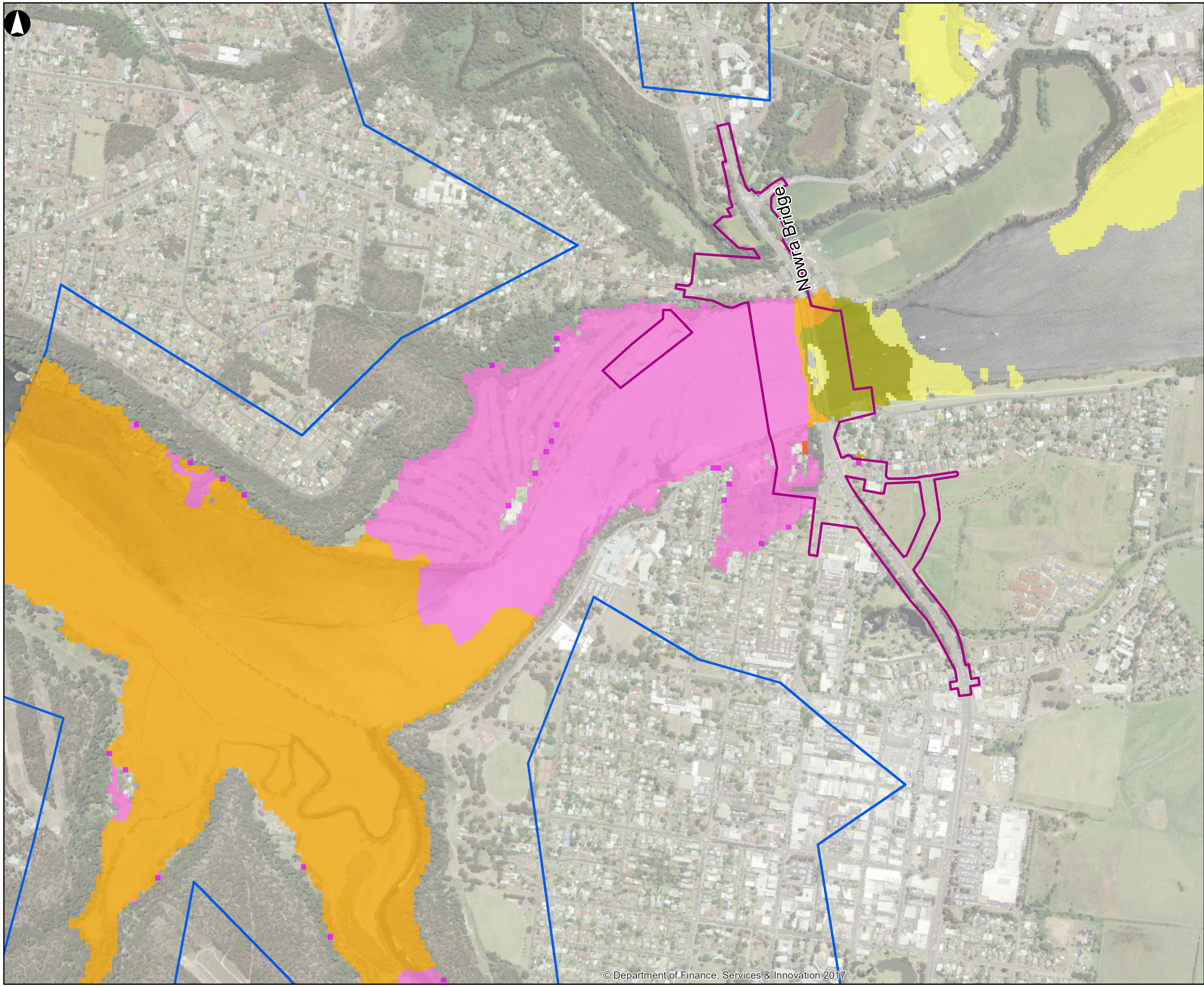
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A3.2	**P1**

MXD Location

A3



Legend

- Model Extent
- Construction Boundary

Flood Level Impact (m)

- <-0.10
- -0.10 - -0.01
- No Impact
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- >0.20
- No Longer Flooded
- Newly Flooded

P1	7/06/2018	TF	IVS	MT
Issue	Date	By	Chkd	Appd

Metres
0 135 270 540

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Job Title
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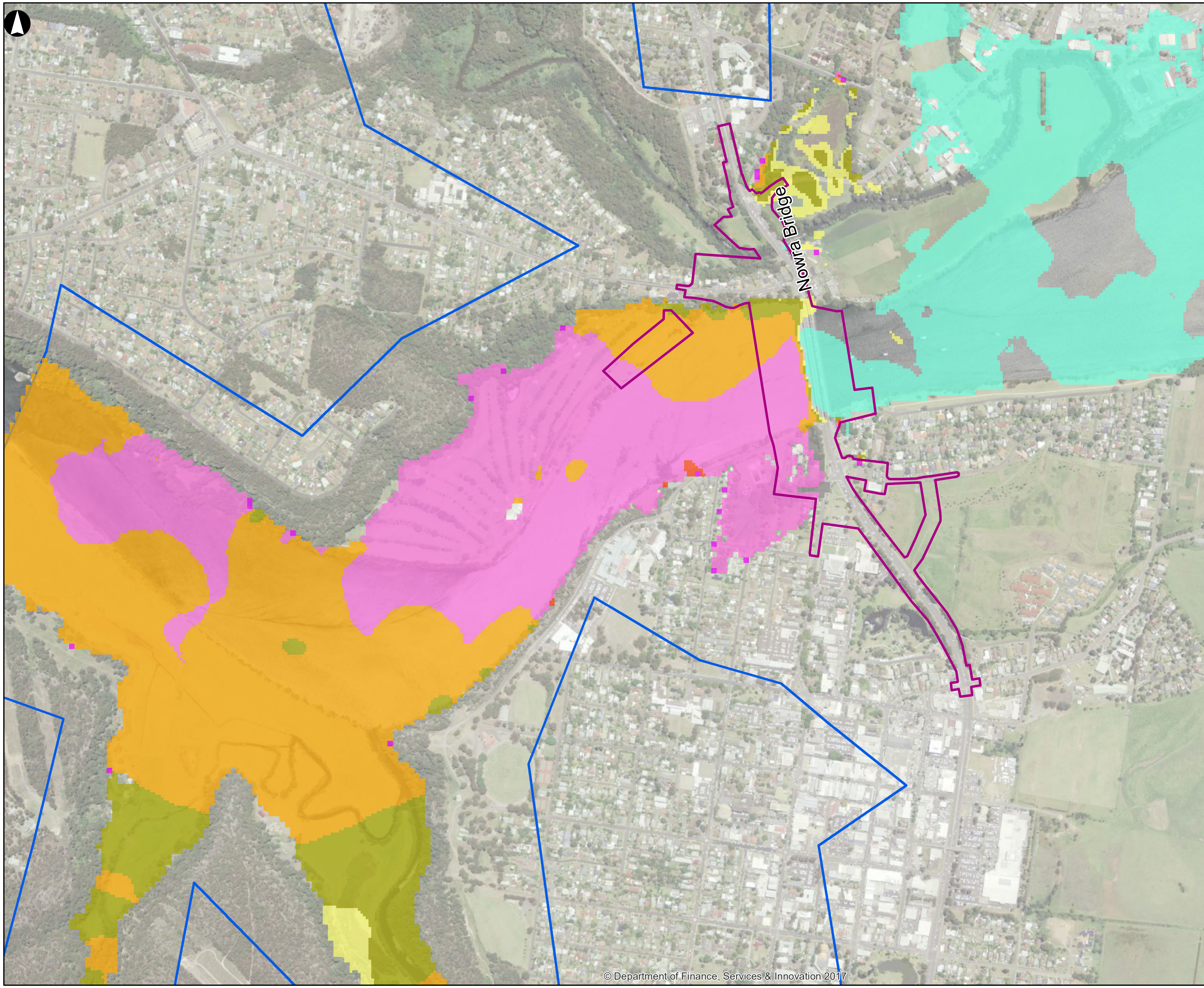
**2% AEP Flood Level Impact
Design Less Existing**

Scale at A3

Job No **242129-00**
Figure Status **80% Concept Design**
Figure No **A3.3**
Issue **P1**

MXD Location

A3



Legend

- Model Extent
- Construction Boundary

Flood Level Impact (m)

- <-0.10
- -0.10 - -0.01
- No Impact
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- >0.20
- No Longer Flooded
- Newly Flooded

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres
0 135 270 540

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Job Title
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**1% AEP Flood Level Impact
Design Less Existing**

Scale at A3

Job No
242129-00

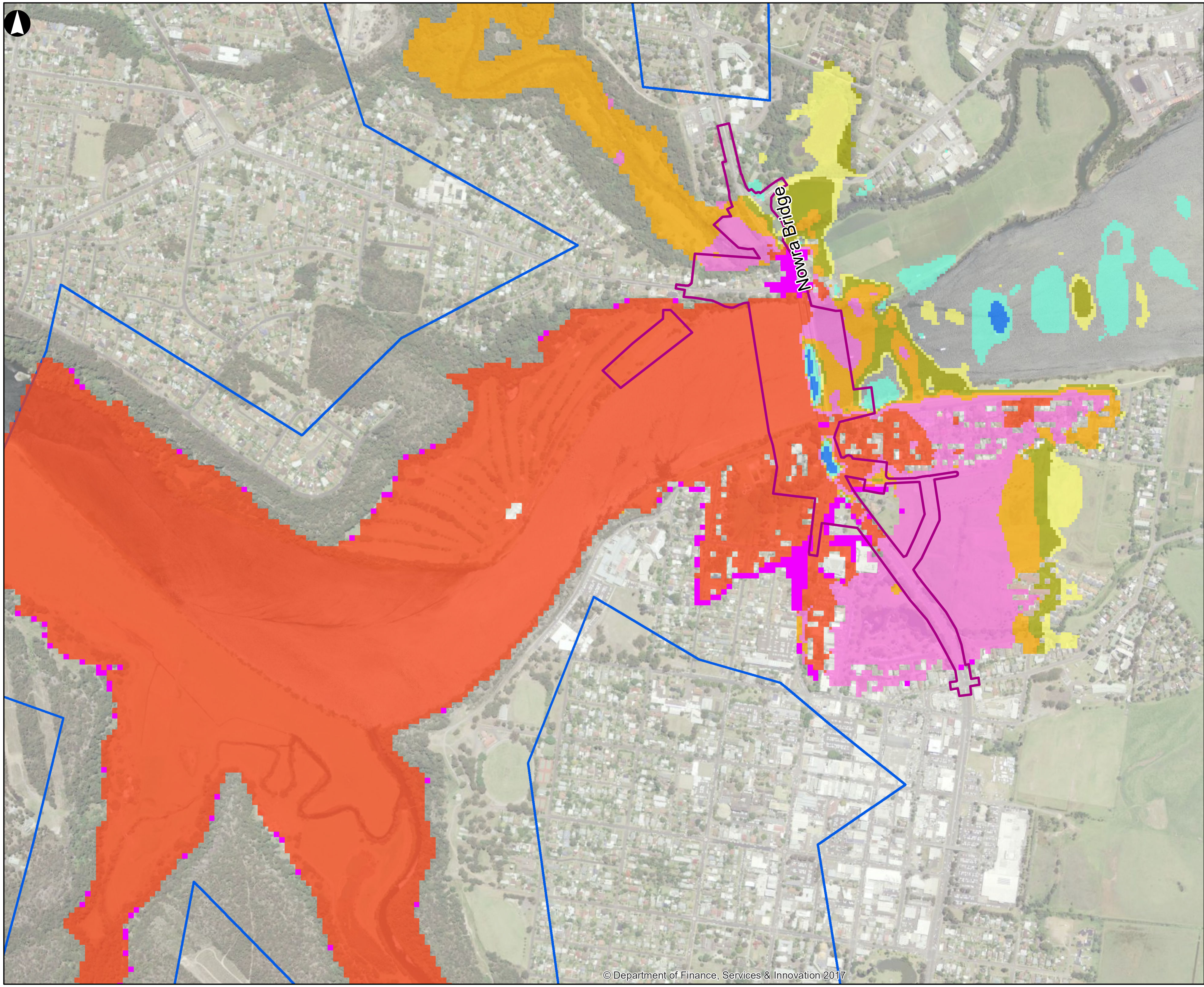
Figure Status
80% Concept Design

Figure No
A3.4

Issue
P1

MXD Location

A3



Legend

- Construction Boundary
- Model Extent

Flood Level Impact (m)

- <-0.10
- -0.10 - -0.01
- No Impact
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- >0.20
- No Longer Flooded
- Newly Flooded

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres
0 135 270 540

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Job Title
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0.05% AEP Flood Level Impact
Design Less Existing

Scale at A3

Job No
242129-00

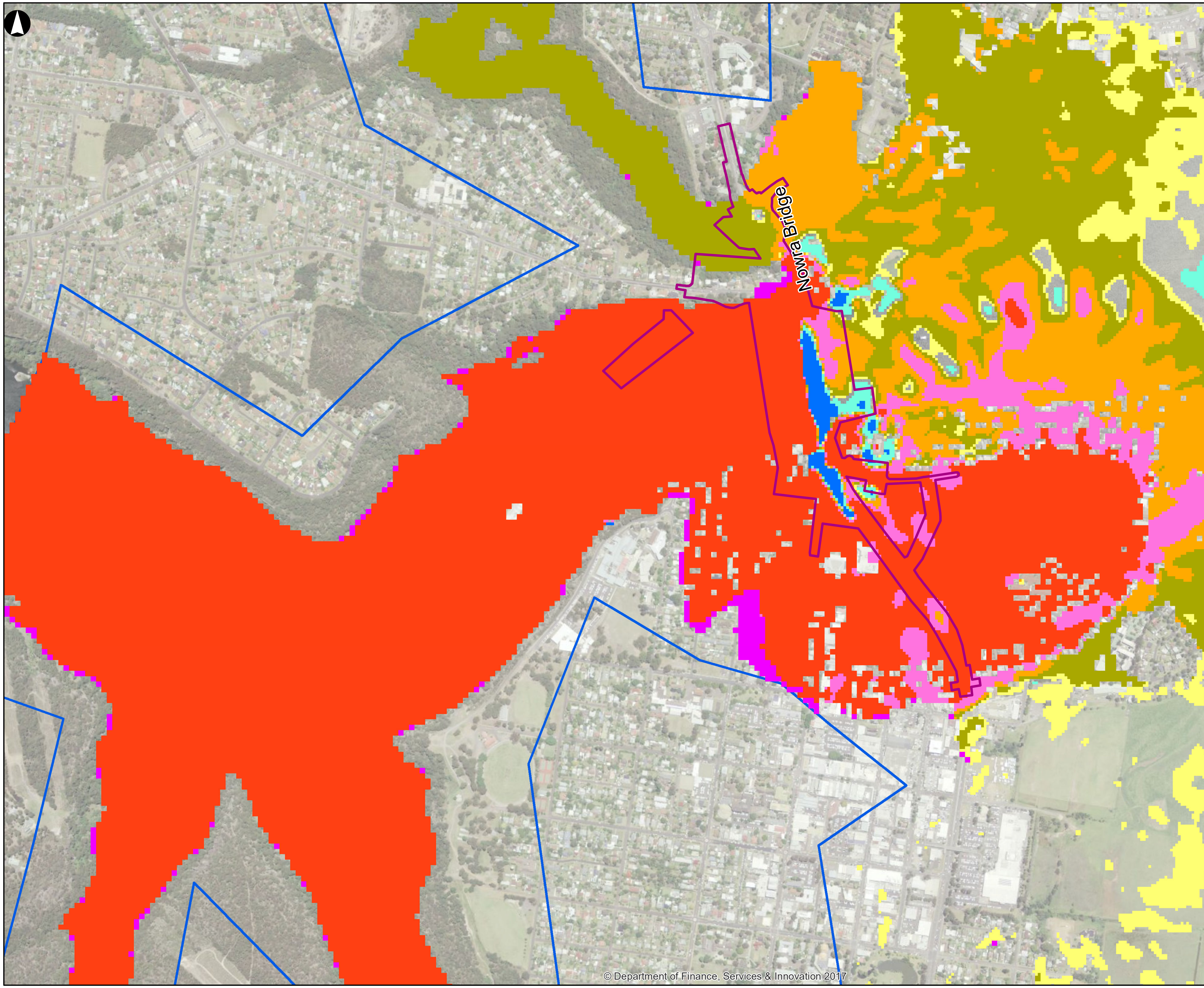
Figure Status
80% Concept Design

Figure No
A3.5

Issue
P1

MXD Location

A3



Legend

- Model Extent
- Construction Boundary

Flood Level Impact (m)

- <-0.10
- -0.10 - -0.01
- No Impact
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- >0.20
- No Longer Flooded
- Newly Flooded

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres
0 135 270 540

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Job Title
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**Extreme Flood Level Impact
Design Less Existing**

Scale at A3

Job No	Figure Status
242129-00	80% Concept Design

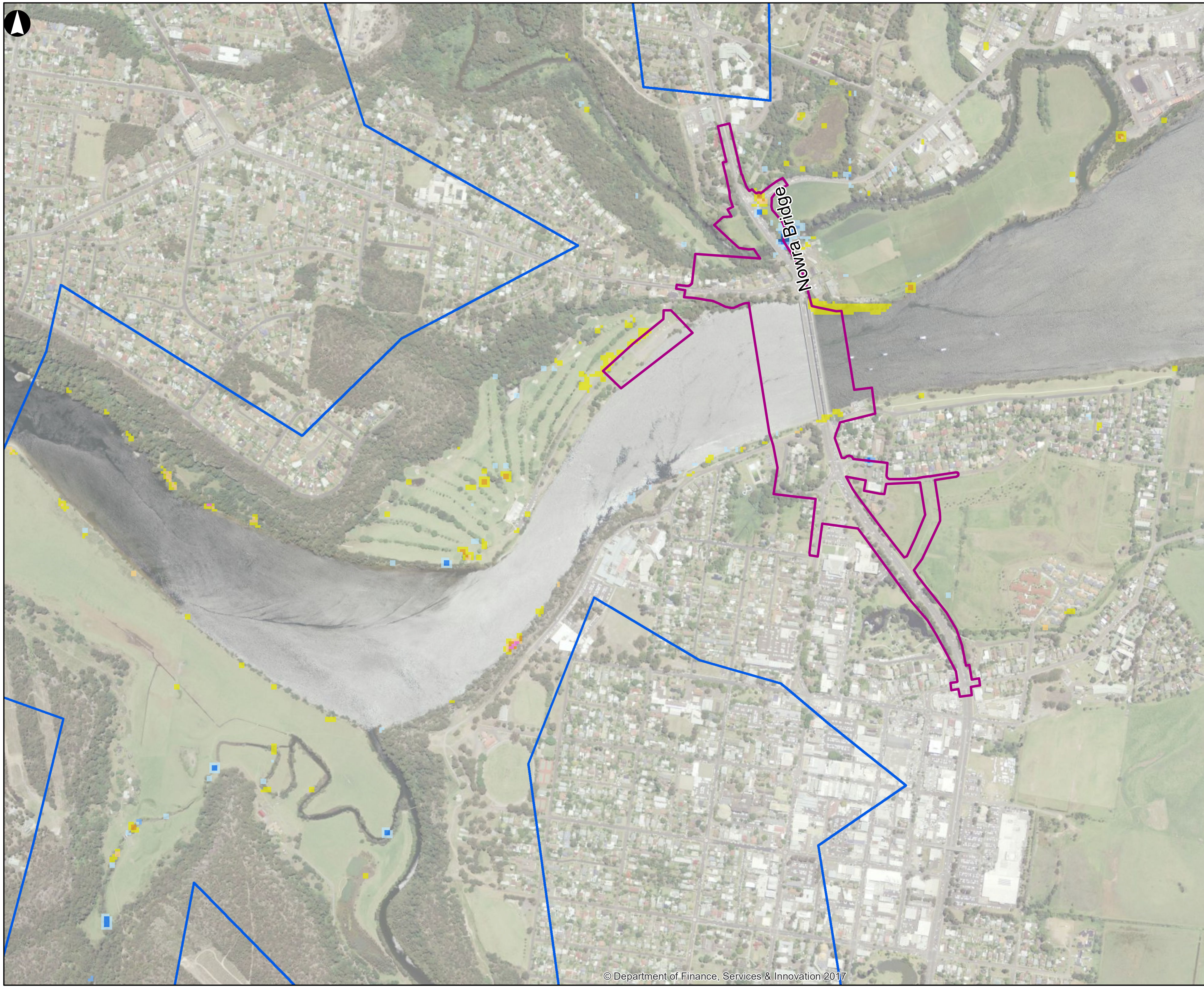
Figure No	Issue
A3.6	P1

MXD Location

Appendix D

Peak Flood Velocity Impact

A3



Legend

- Model Extent
- Construction Boundary

Peak Flood Velocity Impact

- <-1.0
- -1.0 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1- 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- >1.0

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres

0 135 270 540

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Job Title

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10% AEP Flood Velocity Impact Design Less Existing

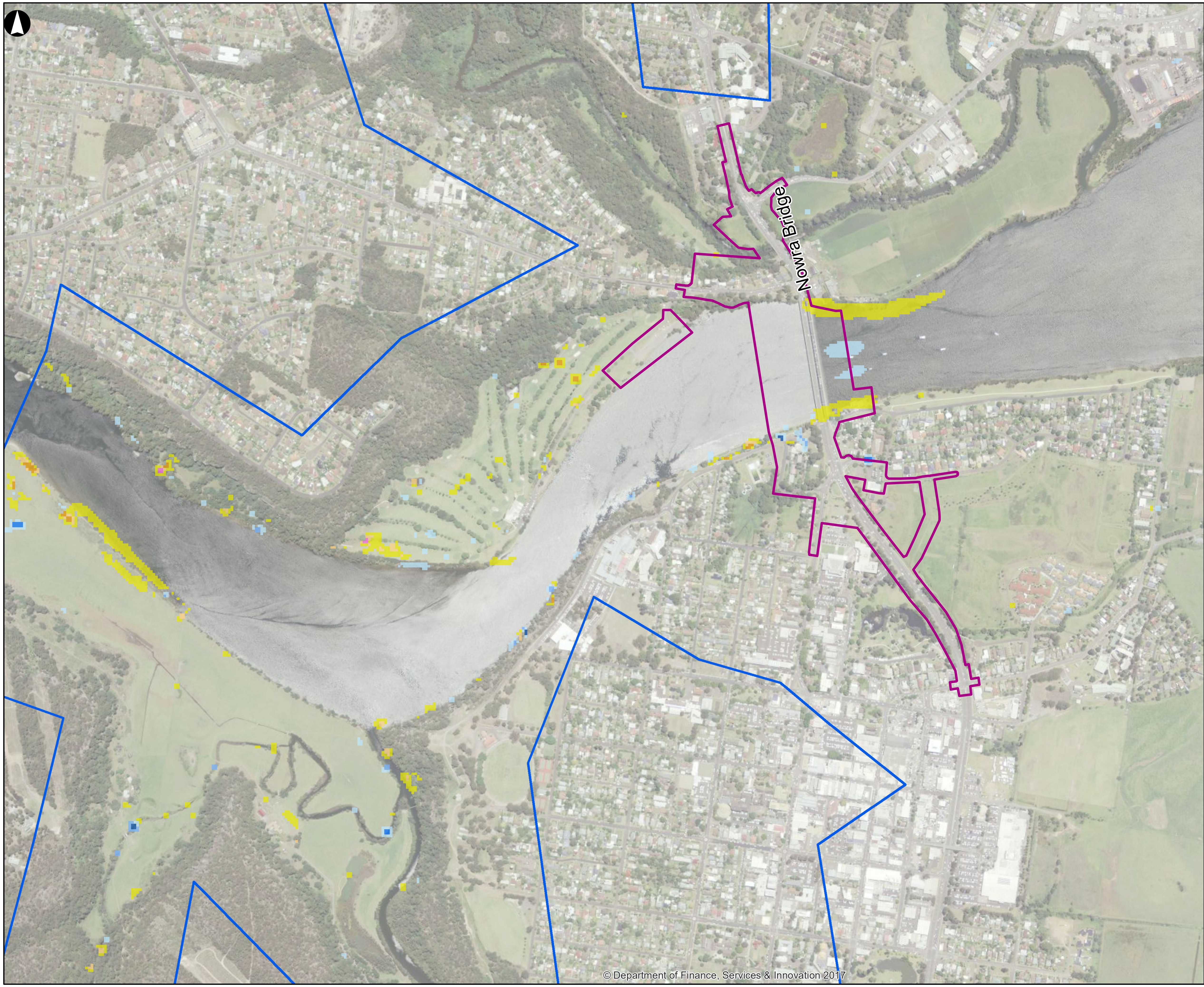
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A4.1	**P1**

MXD Location

A3



Legend

Model Extent

Construction Boundary

Peak Flood Velocity Impact

<-1.0

-1.0 - -0.5

-0.5 - -0.3

-0.3 - -0.1

-0.1- 0.1

0.1 - 0.3

0.3 - 0.5

0.5 - 1.0

>1.0

P1	7/06/2018	TF	IVS	MT
Issue	Date	By	Chkd	Appd

Metres

0 135 270 540

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5% AEP Flood Velocity Impact Design Less Existing

Scale at A3

Job No 242129-00

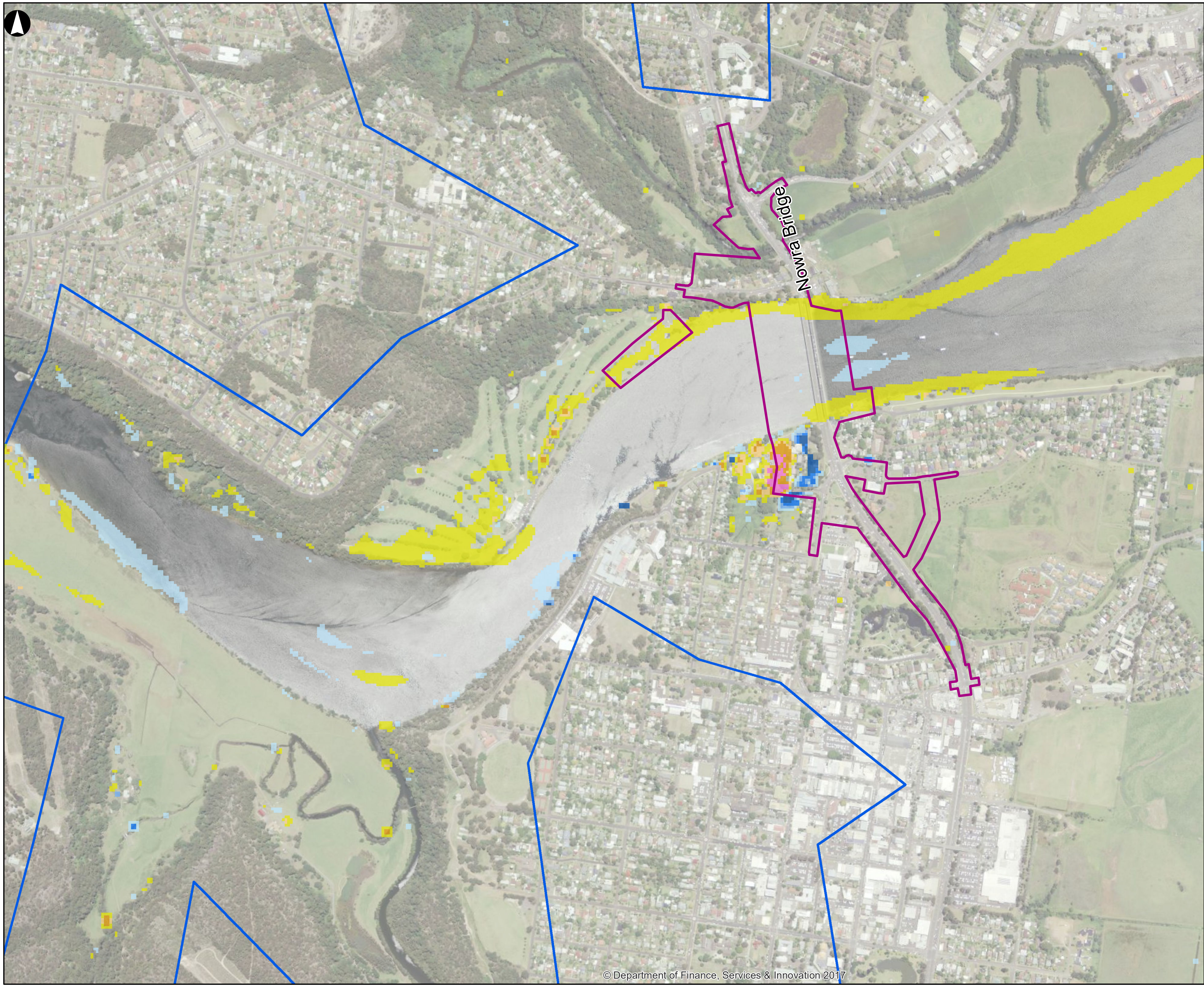
Figure Status 80% Concept Design

Figure No A4.2

Issue P1

MXD Location

A3



Legend

- Model Extent
- Construction Boundary

Peak Flood Velocity Impact

- <-1.0
- -1.0 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1- 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- >1.0

P1	7/06/2018	TF	IVS	MT
Issue	Date	By	Chkd	Appd

Metres
0 135 270 540

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Job Title
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2% AEP Flood Velocity Impact
Design Less Existing

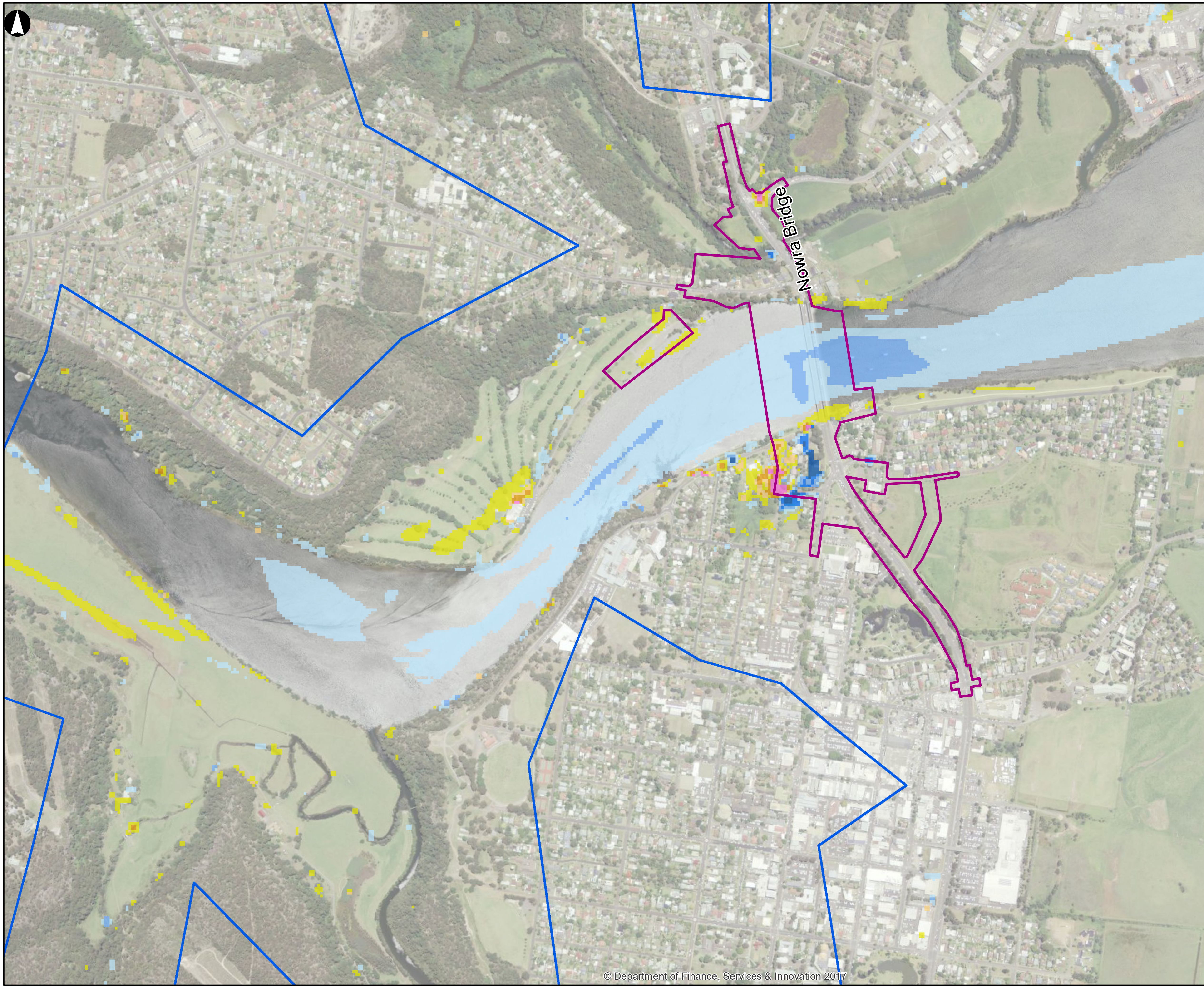
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A4.3	**P1**

MXD Location

A3



Legend

- Model Extent
- Construction Boundary

Peak Flood Velocity Impact

- <-1.0
- -1.0 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1- 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- >1.0

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres
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Job Title
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1% AEP Flood Velocity Impact
Design Less Existing

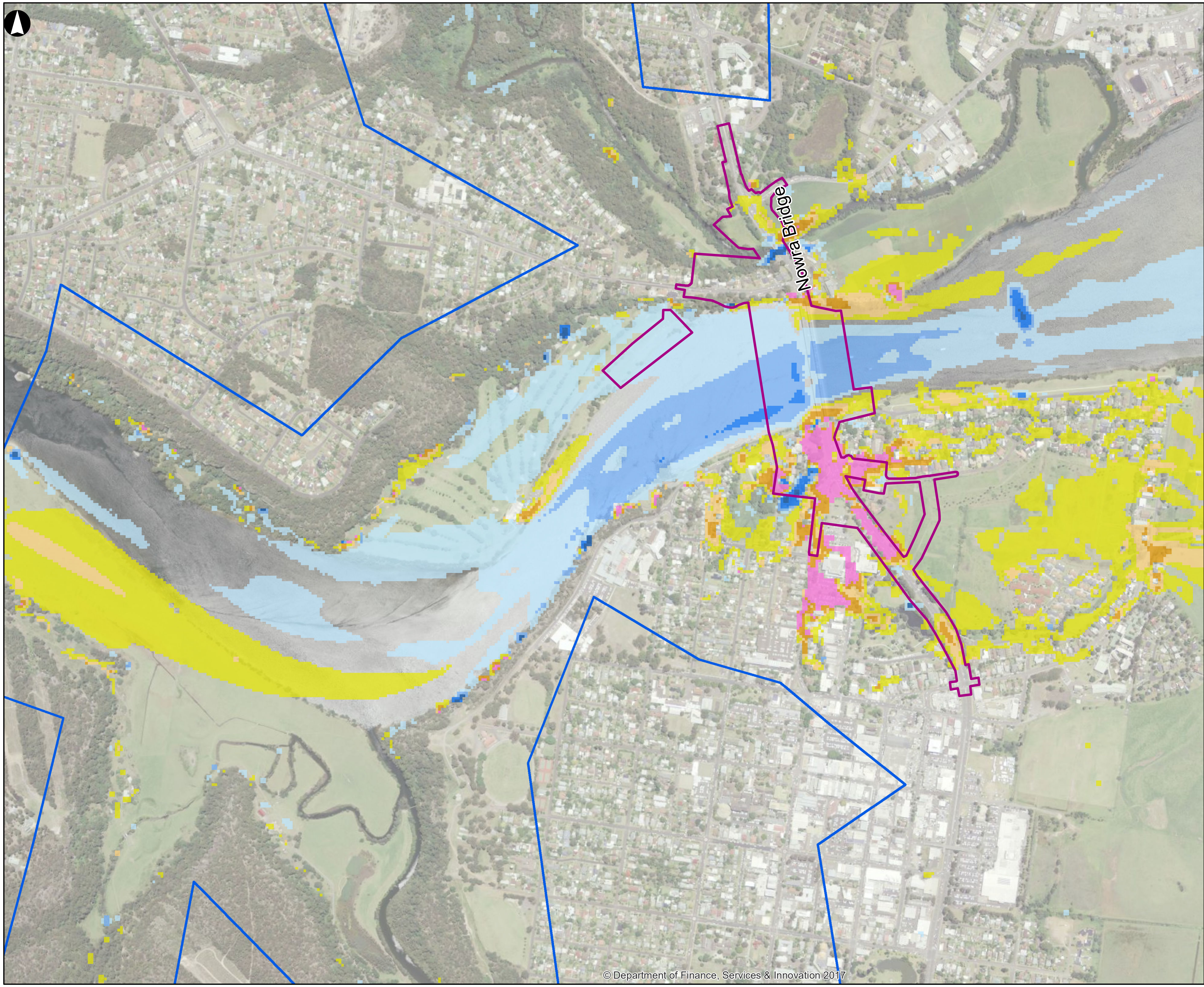
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A4.4	**P1**

MXD Location

A3



Legend

Model Extent

Construction Boundary

Peak Flood Velocity Impact

<-1.0

-1.0 - -0.5

-0.5 - -0.3

-0.3 - -0.1

-0.1- 0.1

0.1 - 0.3

0.3 - 0.5

0.5 - 1.0

>1.0

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres

0 135 270 540

ARUP

201 Kent Street
Sydney 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client

Roads and Maritime Services

Job Title

Nowra Bridge Concept Design

0.05% AEP Flood Velocity Impact
Design Less Existing

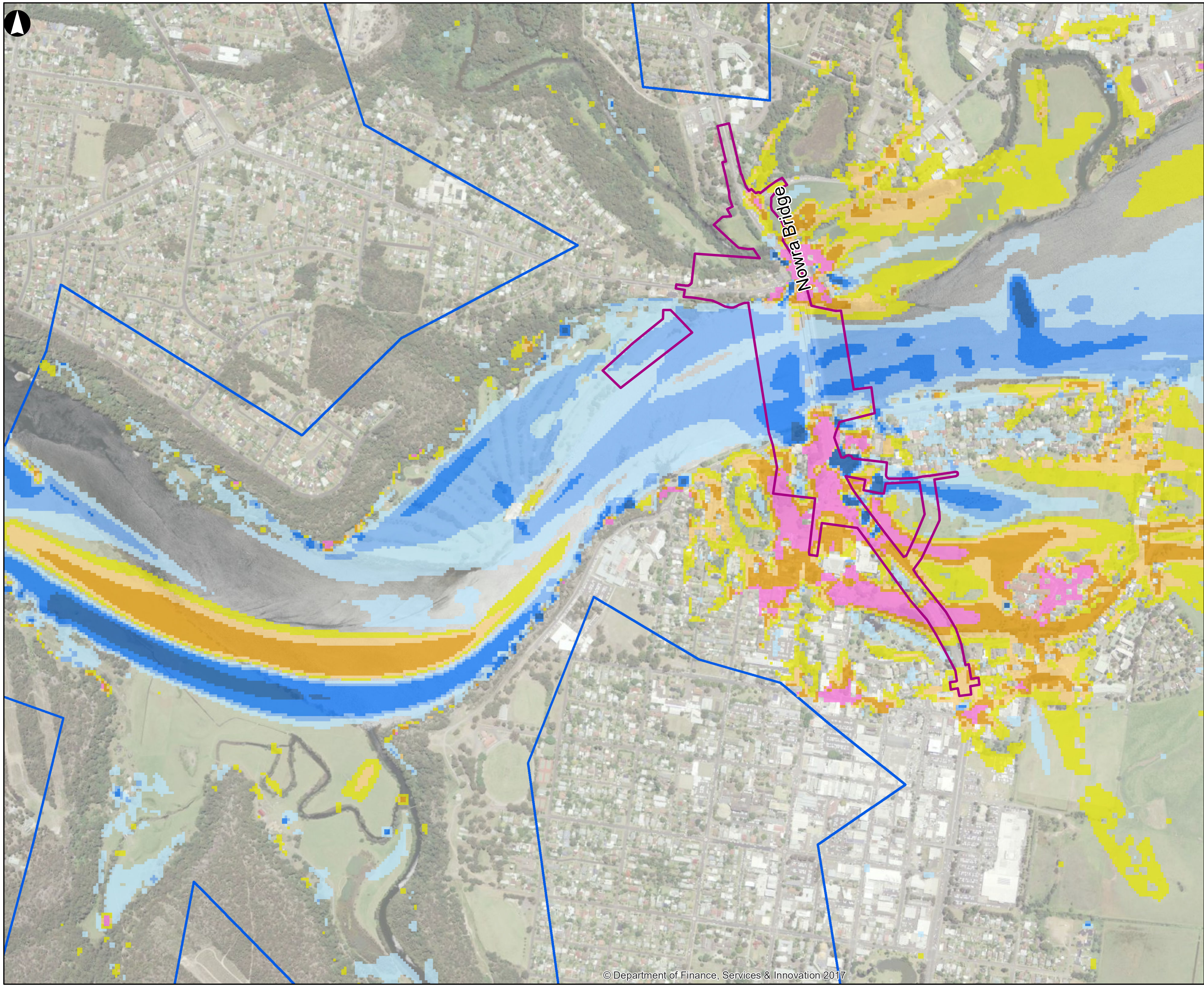
Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

Figure No	Issue
A4.5	**P1**

MXD Location

A3



Legend

Model Extent

Construction Boundary

Peak Flood Velocity Impact

<-1.0

-1.0 - -0.5

-0.5 - -0.3

-0.3 - -0.1

-0.1- 0.1

0.1 - 0.3

0.3 - 0.5

0.5 - 1.0

>1.0

P1	7/06/2018	TF	IVS	MT
Issue	Date	By	Chkd	Appd

Metres

0 135 270 540

ARUP

201 Kent Street
Sydney 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client

Roads and Maritime Services

Job Title

Nowra Bridge Concept Design

Extreme Flood Velocity Impact Design Less Existing

Scale at A3

Job No	Figure Status
242129-00	**80% Concept Design**

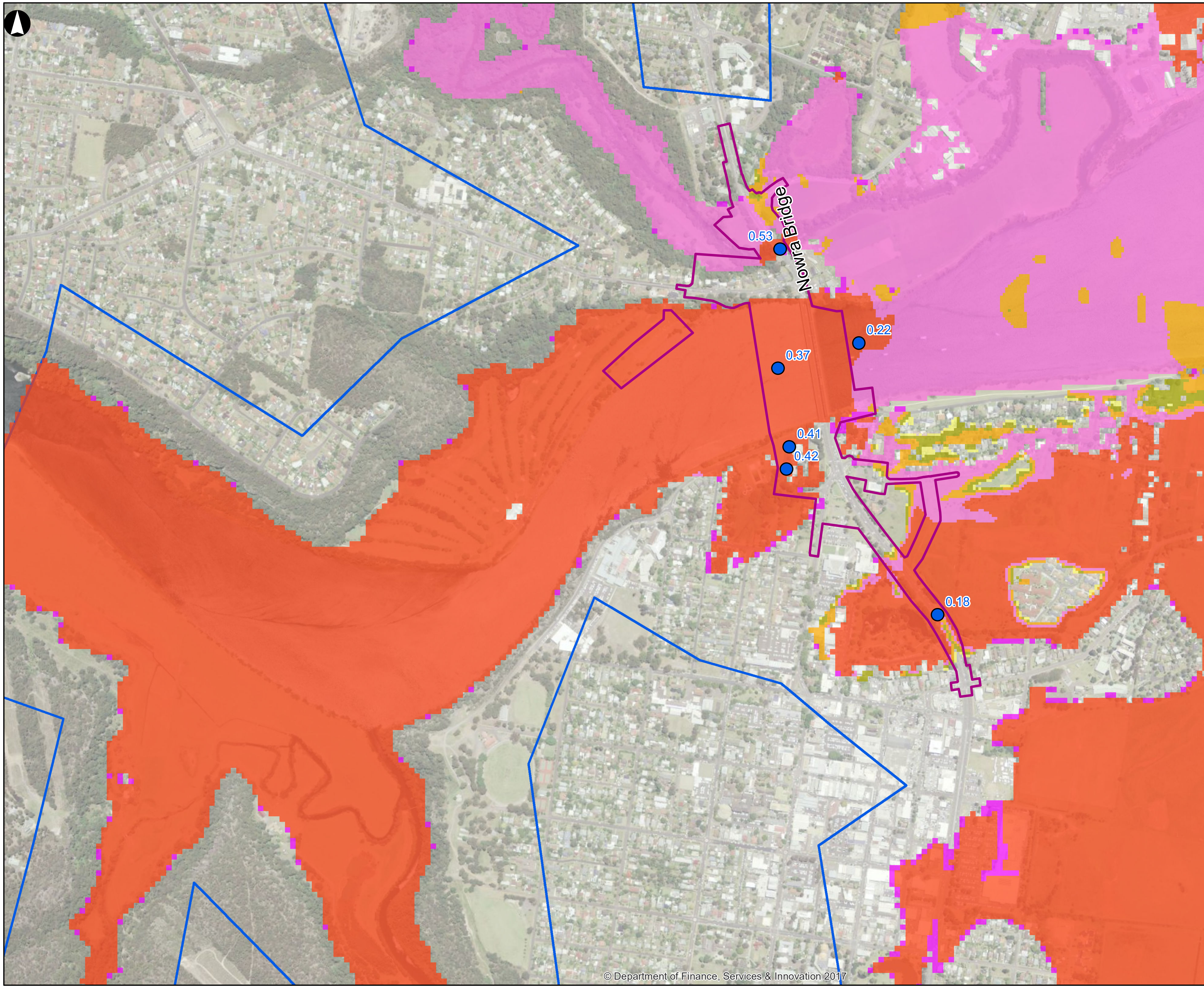
Figure No	Issue
A4.6	**P1**

MXD Location

Appendix E

Flood Impact of Climate Change Scenarios

A3



Legend

- Model Extent
- Construction Boundary
- Flood Impact (m)

Flood Level Impact (m)

- <-0.10
- -0.10 - -0.01
- No Impact
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- >0.20
- No Longer Flooded
- Newly Flooded

P1	7/06/2018	TF	IVS	MT
Issue	Date	By	Chkd	Appd

Metres
0 135 270 540

ARUP

201 Kent Street
Sydney 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client
Roads and Maritime Services

Job Title
Nowra Bridge Concept Design

Flood Level Impact
10% Rainfall Increase of 1% AEP
+ 0.4m Sea Level Rise

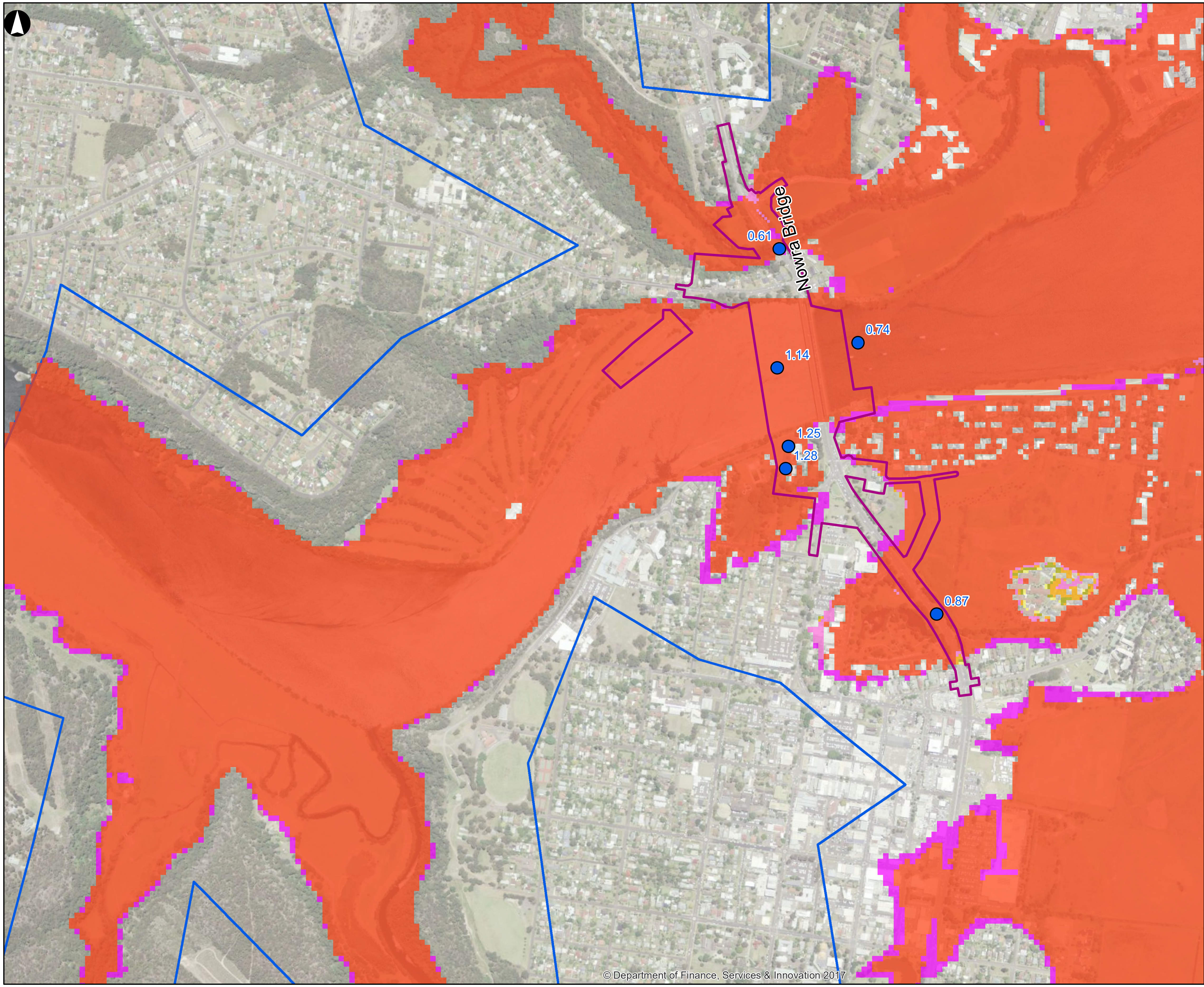
Scale at A3

Job No	Figure Status
242129-00	80% Concept Design

Figure No	Issue
A5.1	P1

MXD Location

A3



Legend

- Model Extent
- Construction Boundary
- Flood Impact (m)
- <-0.10
- -0.10 - -0.01
- No Impact
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- >0.20
- No Flood Anymore
- Newly Flooded

Issue	Date	By	Chkd	Appd
P1	7/06/2018	TF	IVS	MT

Metres
0 135 270 540

ARUP

201 Kent Street
Sydney 2000
Tel +61 2 9320 9320 Fax +61 2 9320 9321
www.arup.com

Client
Roads and Maritime Services

Job Title
Nowra Bridge Concept Design

Flood Level Impact
30% Rainfall Increase of 1% AEP
+ 0.9m Sea Level Rise

Scale at A3

Job No
242129-00

Figure Status
80% Concept Design

Figure No
A5.2

Issue
P1

MXD Location

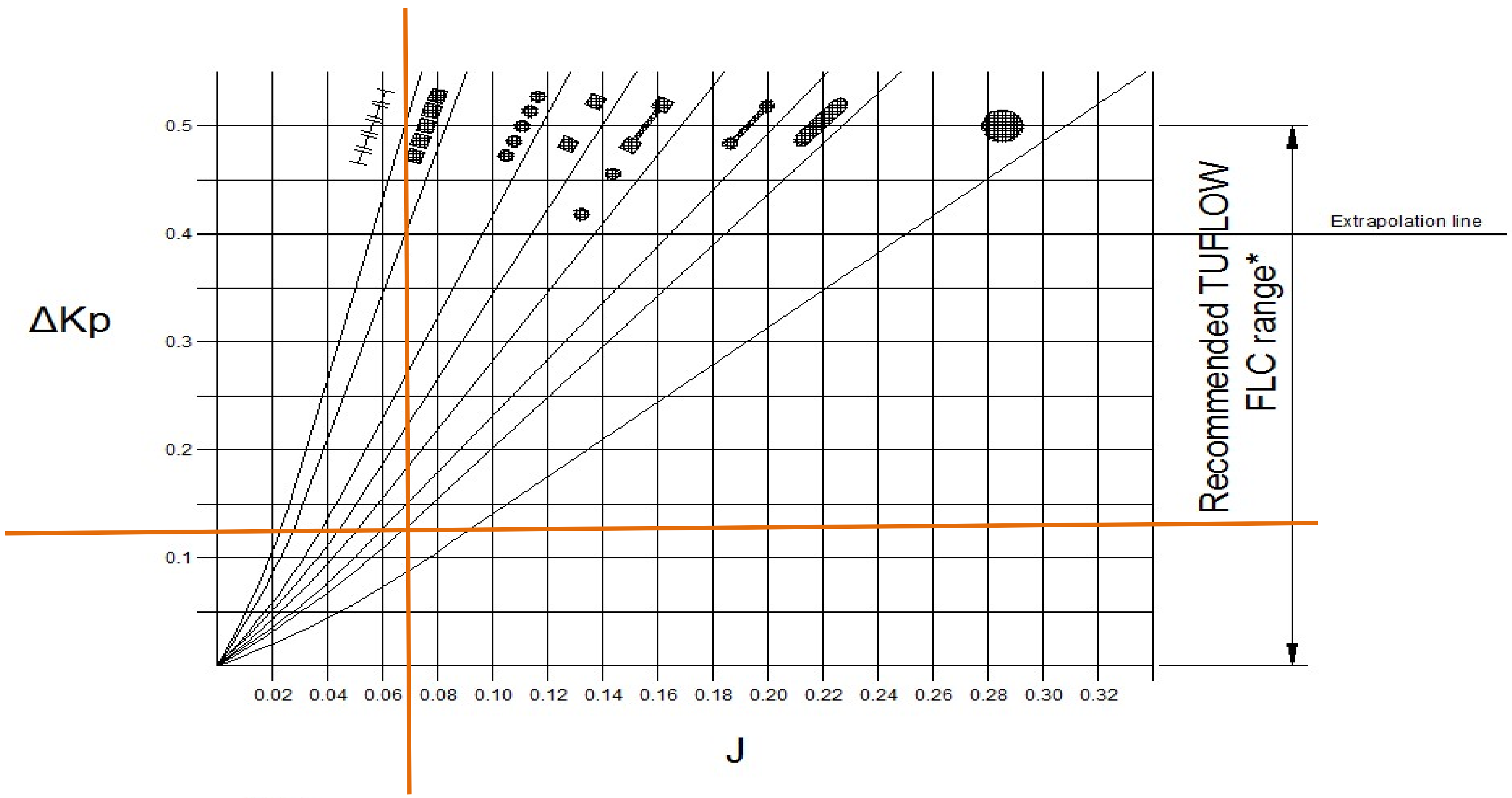
Appendix F

Summary of Piers Details and FLC for the Proposed Bridge

Flood loss coefficien calculation - proposed Nowra Bridge

Pier locatoin	Span (m)	Length (m)	Pile area (m^2)	Pilecap area (m^2)	Column area (m^2)	Pile height (m)	Pipe width (m)	Pilecap height (m)	Pilecap width (m)	Colume height (m)	Colume width (m)	Ground level (m AHD)
1	34.920	34.920	22.729	16.2	6.92	7.576	3 x 1m	9	1.8	6.92	1	-8.276
2	38.500	73.420	14.054	16.2	6.92	4.685	3 x 1m	9	1.8	6.92	1	-5.385
3	38.500	111.920	10.220	16.2	6.92	3.407	3 x 1m	9	1.8	6.92	1	-4.107
4	38.500	150.420	9.354	16.2	6.92	3.118	3 x 1m	9	1.8	6.92	1	-3.818
5	38.500	188.920	8.501	16.2	6.92	2.834	3 x 1m	9	1.8	6.92	1	-3.534
6	38.500	227.420	6.477	16.2	6.92	2.159	3 x 1m	9	1.8	6.92	1	-2.859
7	38.500	265.920	4.725	16.2	6.92	1.575	3 x 1m	9	1.8	6.92	1	-2.275
8	38.500	304.420	4.004	16.2	6.92	1.335	3 x 1m	9	1.8	6.92	1	-2.035
9	31.540	335.960	-	16.2	6.92	-	3 x 1m	9	1.8	6.92	1	0.606
Abutment B	26.760	362.720										

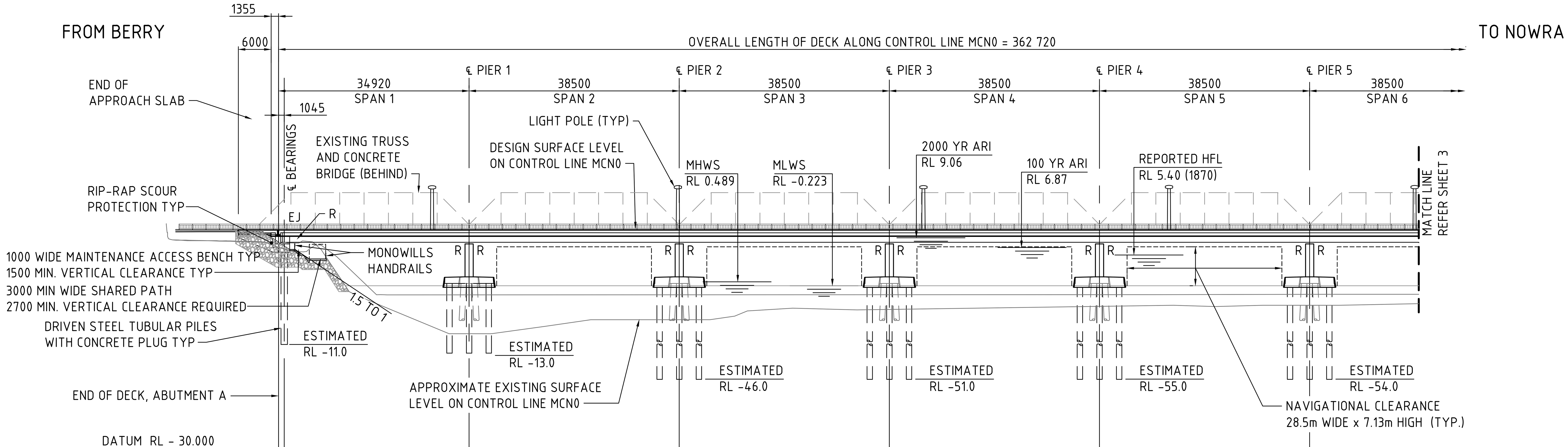
Total area of obstruction (m^2)	288
Total waterway area (m^2)	4088
J	0.070
FLC	0.13



NOTE:
1. Recommended range derived from TUFLOW Forum post by Bill Syme.
2. Extrapolated values are approximate only.

Appendix G

Proposed Nowra Bridge Drawings



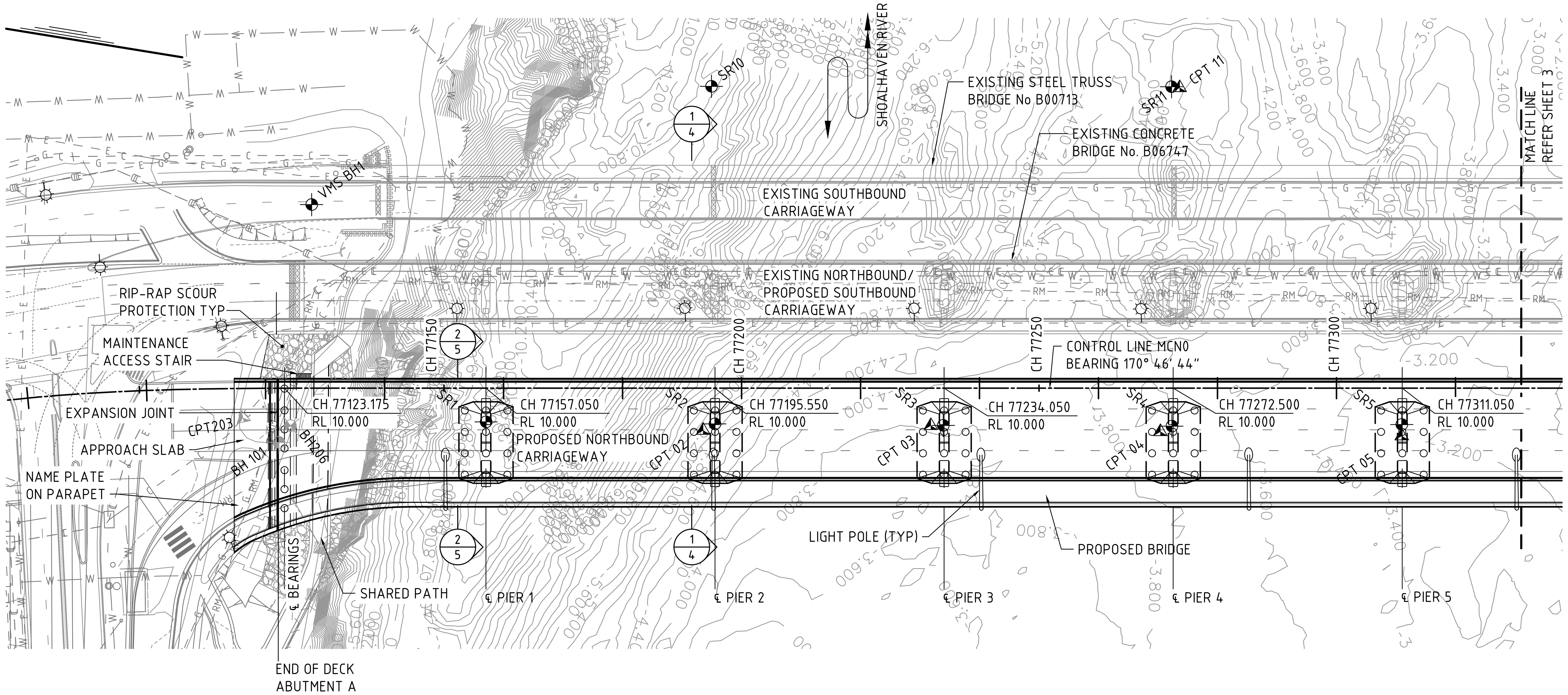
DESIGN SURFACE LEVEL ON MCN0	10.000	10.000	10.000	10.000	10.000	10.000
EXISTING SURFACE LEVEL ON MCN0	7.9	-9.2	-5.8	-4.0	-3.6	-3.4
CHAINAGE ON MCN0	77123.175	77157.050	77195.550	77234.050	77272.500	77311.050

PART ELEVATION

GENERAL NOTES

SCALE 0 5 10 15 20m OR AS SHOWN.

DIMENSIONS ARE IN MILLIMETRES.
CHAINAGES AND REDUCED LEVELS ARE IN METRES.
REDUCED LEVELS ARE TO AUSTRALIAN HEIGHT DATUM.
LEVELS SHOWN RELATIVE TO EACH OTHER BUT NOT RELATIVE TO DATUM
CO-ORDINATES ARE TO MGA ZONE 56.
R DENOTES RESTRAINED BEARING.
EJ DENOTES EXPANSION JOINT.
THE LOCATION OF ALL EXISTING SERVICES TO BE CONFIRMED ON SITE PRIOR TO CONSTRUCTION AND RELOCATED IF REQUIRED.
THIS DRAWING AND DESIGN IS CONCEPTUAL AND IS SUBJECT TO CHANGE THROUGH FURTHER DESIGN STAGES.
NUMBER AND SIZING OF ELEMENTS SHOWN ARE INDICATIVE ONLY.
EXISTING RIVER BED LEVELS ARE SHOWN INDICATIVELY PENDING ADDITIONAL SURVEY INFORMATION.
SCUPPERS NOT SHOWN FOR CLARITY.
FLOOD LEVELS HAVE BEEN TAKE FROM: SMEC DRAFT HYDROLOGICAL REVIEW, MAY 2014.



PART PLAN

LEGEND

— E — E —	ELECTRICAL LOW VOLTAGE
— C — C —	TELECOMMUNICATION CABLES
— W — W —	WATER MAIN
— G — G —	GAS MAIN
— S — S —	SEWER MAIN
— RM — RM —	SEWER RISER MAIN

DENOTES EXISTING BOREHOLE LOCATION
DENOTES PROPOSED BOREHOLE LOCATION
DENOTES EXISTING CPT LOCATION
DENOTES PROPOSED CPT LOCATION

ISSUE	DATE	REVISION	PREP	CHK	AUTH
1	??.04.18	ISSUE FOR 80% CONCEPT DESIGN	PL	BEL	BEL
0	28.10.16	ISSUE FOR 20% CONCEPT DESIGN	PL	BEL	BEL

HIGHWAY No. A1 — SHIRE OF SHOALHAVEN

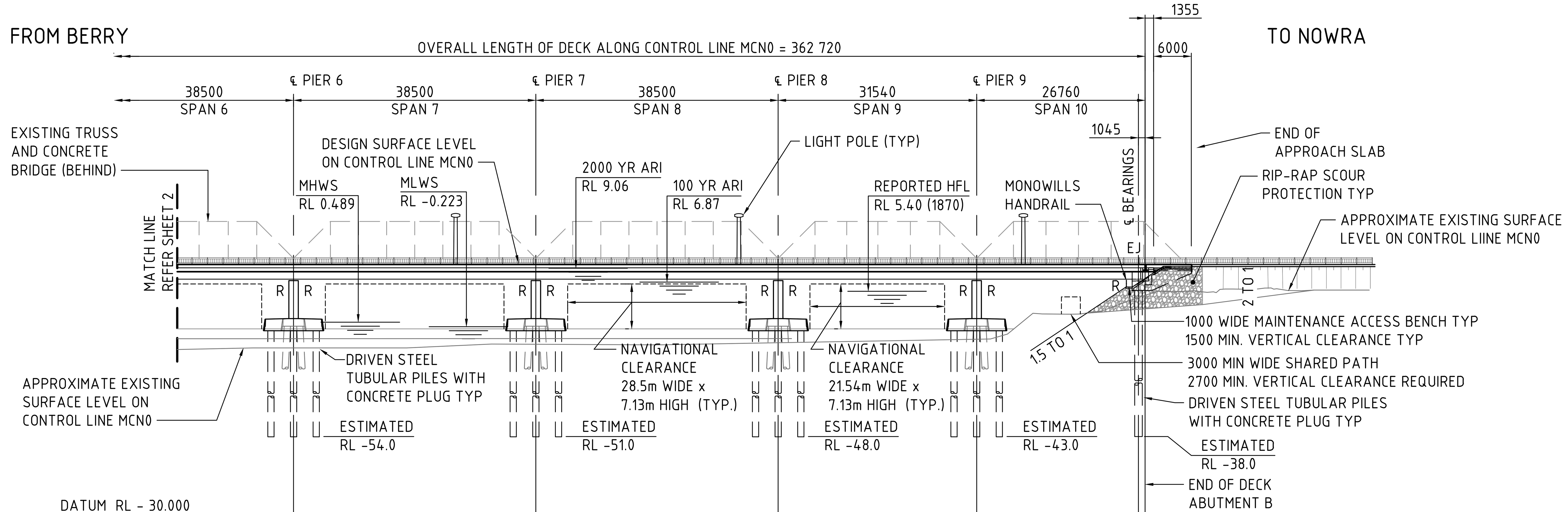
BRIDGE OVER SHOALHAVEN RIVER AT NOWRA

GENERAL ARRANGEMENT - SHEET A

ARUP — SMEC — CLIENT: SOUTHERN REGION — NSW GOVERNMENT Transport Roads & Maritime Services

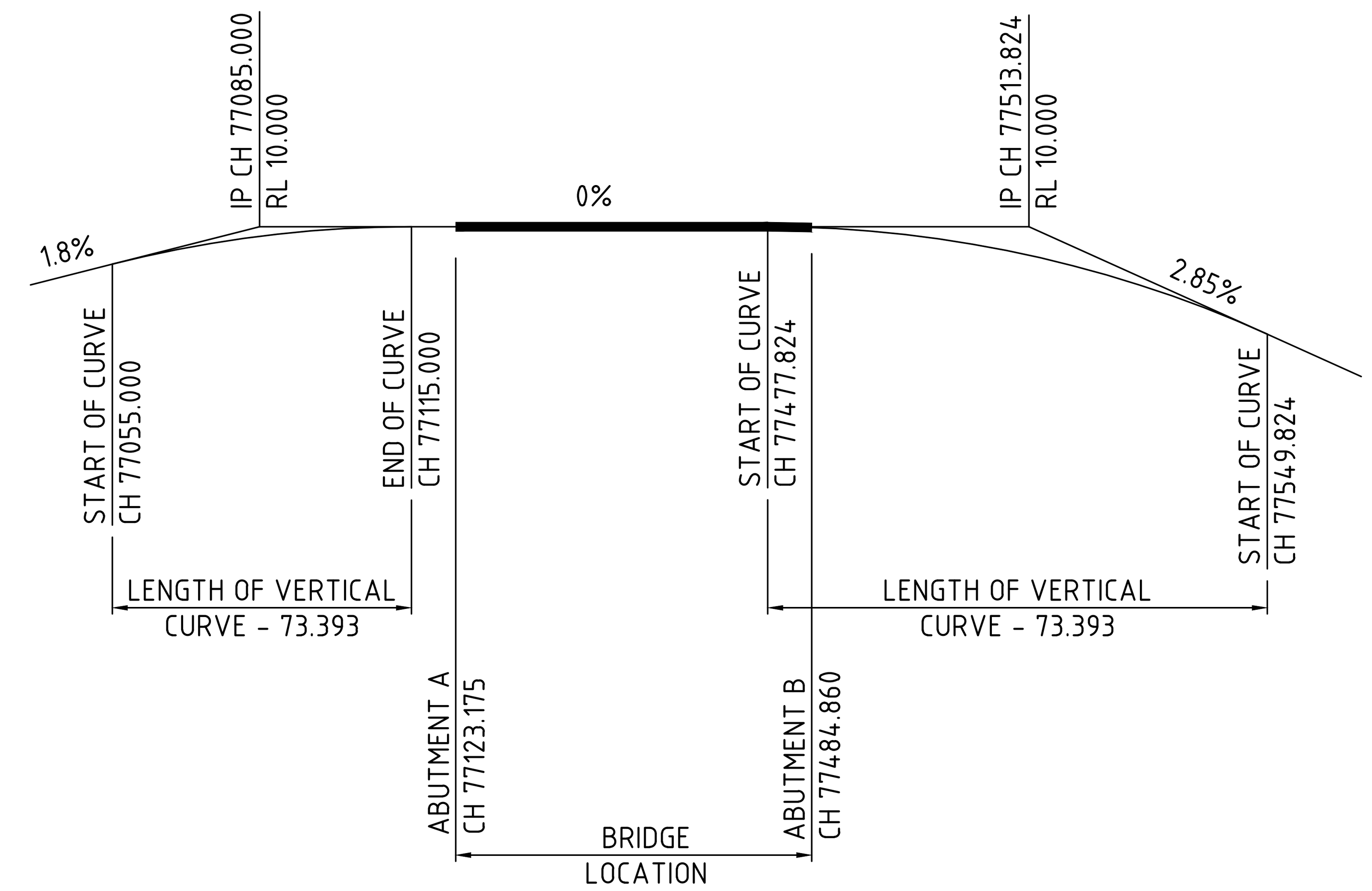
PREPARED: DESIGN S.WONG; DRAWING P.LEES
CHECKED: B.LORD; P.LEES
APPROVED — DESIGN QA RECORDS — DIRECTOR
REGISTRATION No OF PLANS: DS2013-001565
BRIDGE NUMBER: BN 12212
ISSUE STATUS: PRELIMINARY
SHEET No 2 — ISSUE 1
CAD No DS2013-001565-DC-BR-DRG-0002.dwg

PRODUCED: 2 May 2018 AT 3:23:54 PM USER: Peter Lees
FILE PATH: C:\rmpw\sydney\projects\peter.lees\d0143\DS2013-001565-DC-BR-DRG-0002.dwg
PLOT DRIVER: NONE
PEN TABLE: ---



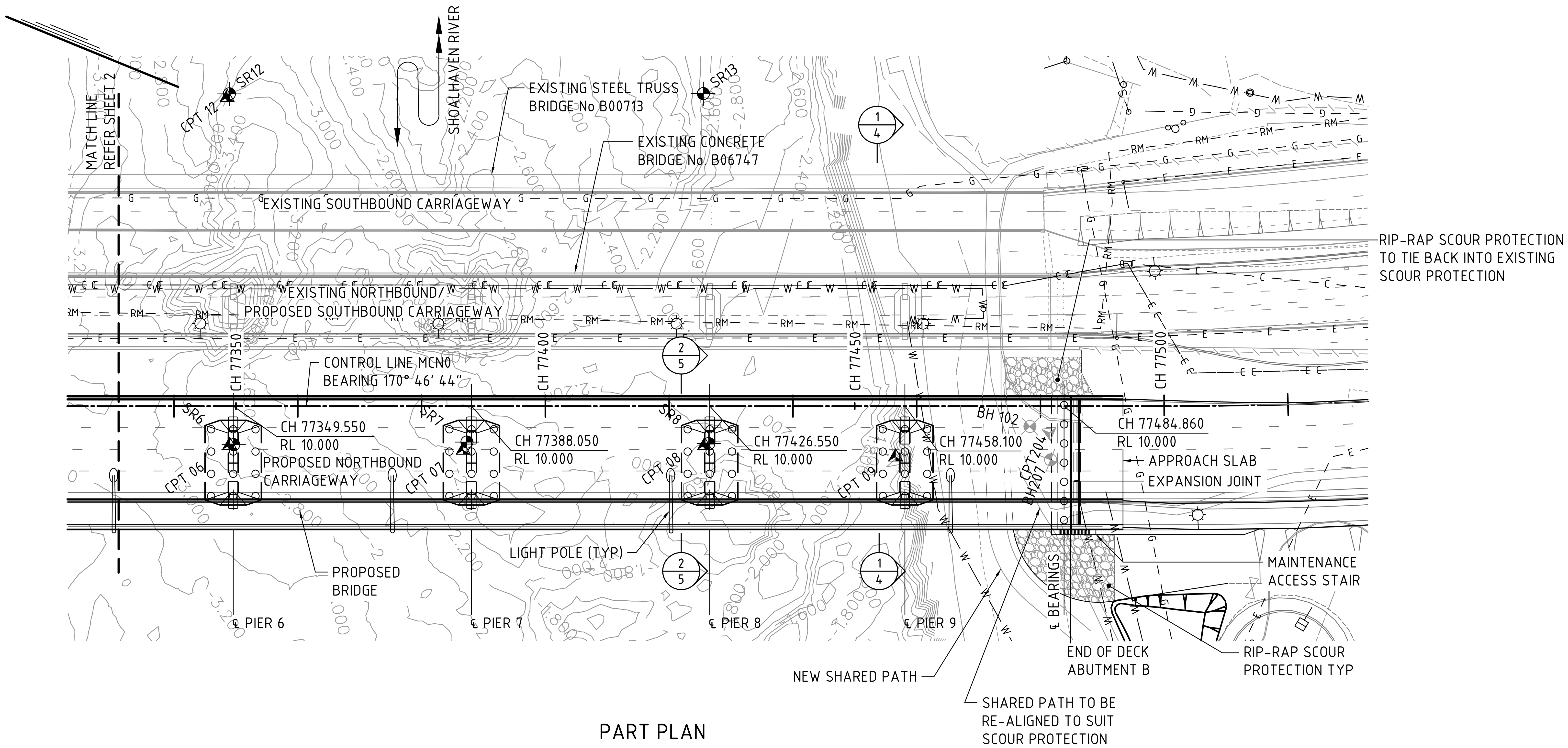
	℄ PIER 6	℄ PIER 7	℄ PIER 8	℄ PIER 9	END OF DECK ABUTMENT B
DESIGN SURFACE LEVEL ON MCN0	10.000	10.000	10.000	10.000	10.000
EXISTING SURFACE LEVEL ON MCN0	-2.2	-2.0	-2.0	-1.2	6.2
CHAINAGE ON MCN0	77349.550	77388.050	77426.550	77458.100	77484.860

PART ELEVATION



VERTICAL ALIGNMENT DIAGRAM - MCN0

NOT TO SCALE



PART PLAN

GENERAL NOTES

SCALE 0 5 10 15 20m OR AS SHOWN.

THIS DRAWING AND DESIGN IS CONCEPTUAL AND IS SUBJECT TO CHANGE THROUGH FURTHER DESIGN STAGES.
THIS DRAWING SHALL BE READ IN CONJUNCTION WITH GENERAL NOTES ON SHEET NO. 2.

ISSUE	DATE	REVISION	PREP	CHK	AUTH
1	??.04.18	ISSUE FOR 80% CONCEPT DESIGN	PL	BEL	BEL
0	28.10.16	ISSUE FOR 20% CONCEPT DESIGN	PL	BEL	BEL

HIGHWAY No. A1 — SHIRE OF SHOALHAVEN

BRIDGE OVER SHOALHAVEN RIVER AT NOWRA

GENERAL ARRANGEMENT - SHEET B

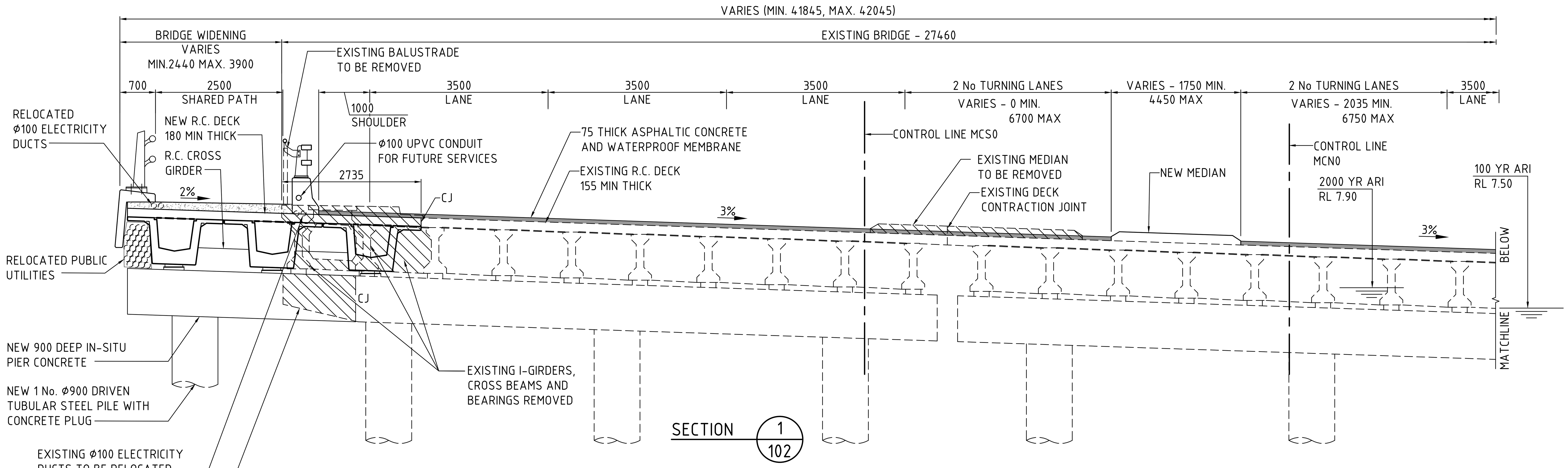
ARUP · SMEC · CLIENT: SOUTHERN REGION · NSW GOVERNMENT Transport Roads & Maritime Services

PREPARED	CHECKED	
DESIGN S.WONG	B.LORD	REGISTRATION No OF PLANS: DS2013-001565
DRAWING P.LEES	P.LEES	BRIDGE NUMBER: BN 12212
APPROVED	DESIGN QA RECORDS	ISSUE STATUS: PRELIMINARY
DIRECTOR		SHEET No 3 · ISSUE 1

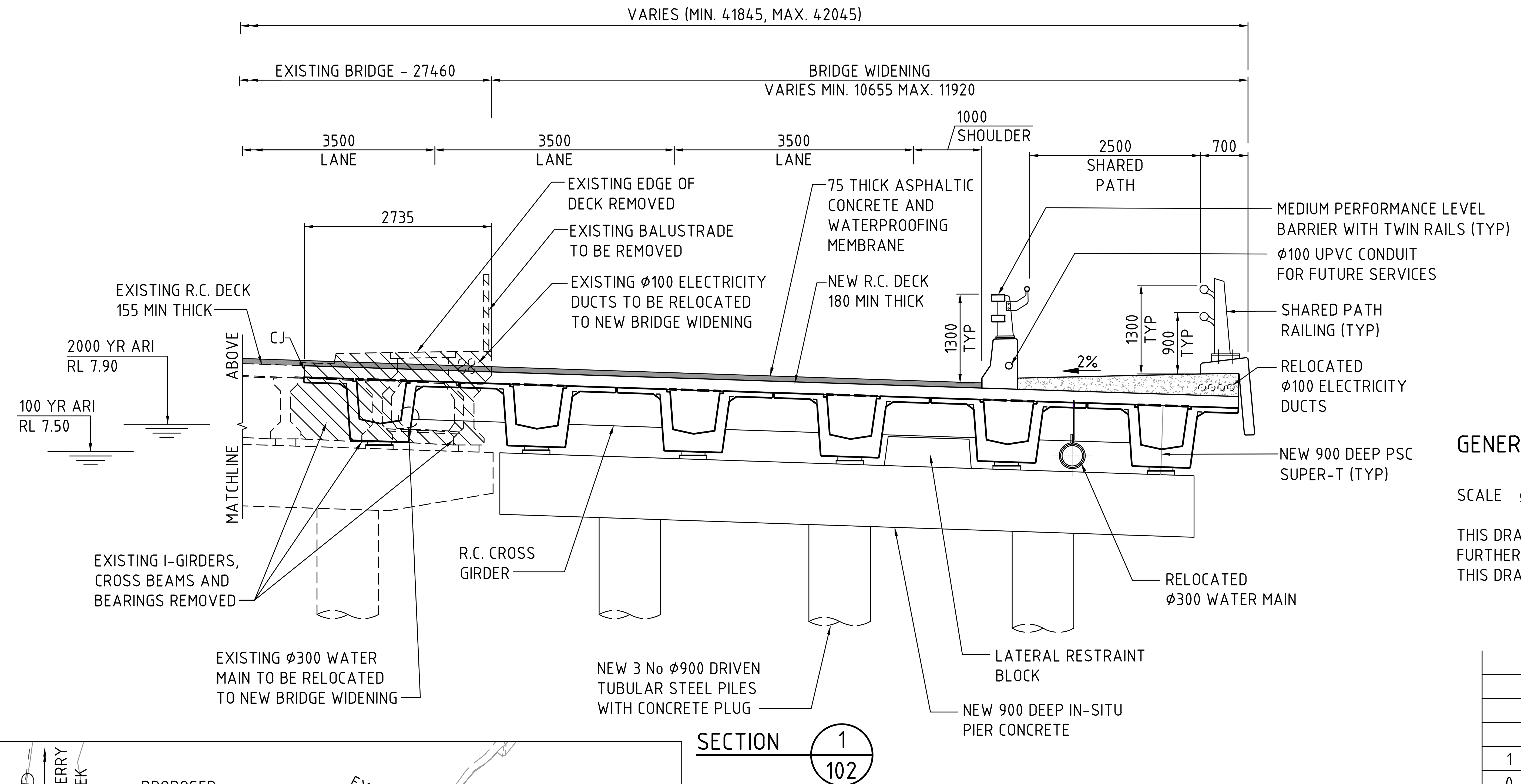
CAD No DS2013-001565-DC-BR-DRG-0003.dwg

CHECK PRINT — DRAWING IN PROGRESS

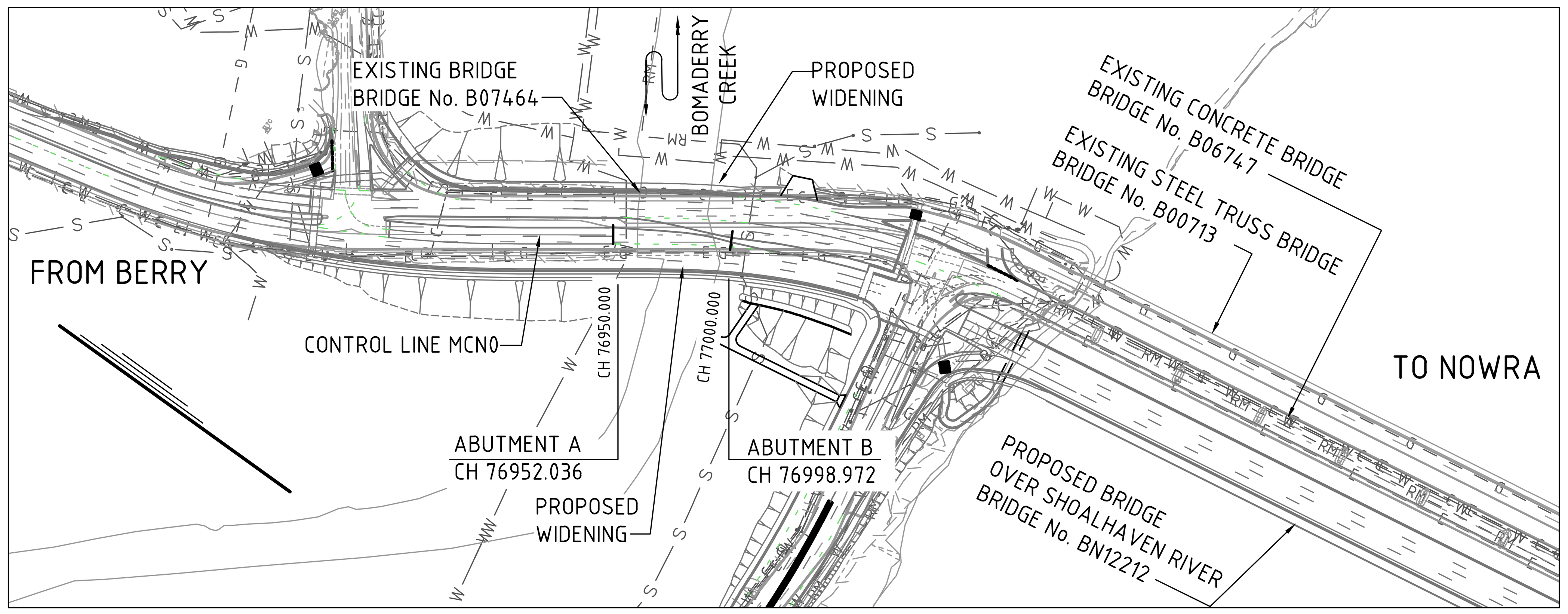
PRODUCED: 2 May 2018 AT 3:23:41 PM USER: Peter Lees
FILE PATH: C:\projectwise\syd_projects\peter.lees\d0143292\DS2013-001565-DC-BR-DRG-0003.dwg
PLOT DRIVER: NONE
PEN TABLE: ----



SECTION 1/102



SECTION 1/102



SITE PLAN

0 50000 100000mm
20000

GENERAL NOTES

SCALE 500: 0 1000 2000mm OR AS SHOWN.

THIS DRAWING AND DESIGN IS CONCEPTUAL AND IS SUBJECT TO CHANGE THROUGH FURTHER DESIGN STAGES.
THIS DRAWING SHALL BE READ IN CONJUCTION WITH GENERAL NOTES ON SHEET NO. 102.

ISSUE	DATE	REVISION	PREP	CHK	AUTH
1	??.04.18	ISSUE FOR 80% CONCEPT DESIGN	SD	BEL	BEL
0	28.10.16	ISSUE FOR 20% CONCEPT DESIGN	SD	BEL	BEL

HIGHWAY No. A1 — SHIRE OF SHOALHAVEN

BRIDGE OVER BOMADERRY CREEK
AT NOWRA

GENERAL ARRANGEMENT - SHEET B

ARUP — SMEC — CLIENT: SOUTHERN REGION, NSW GOVERNMENT Transport Roads & Maritime Services

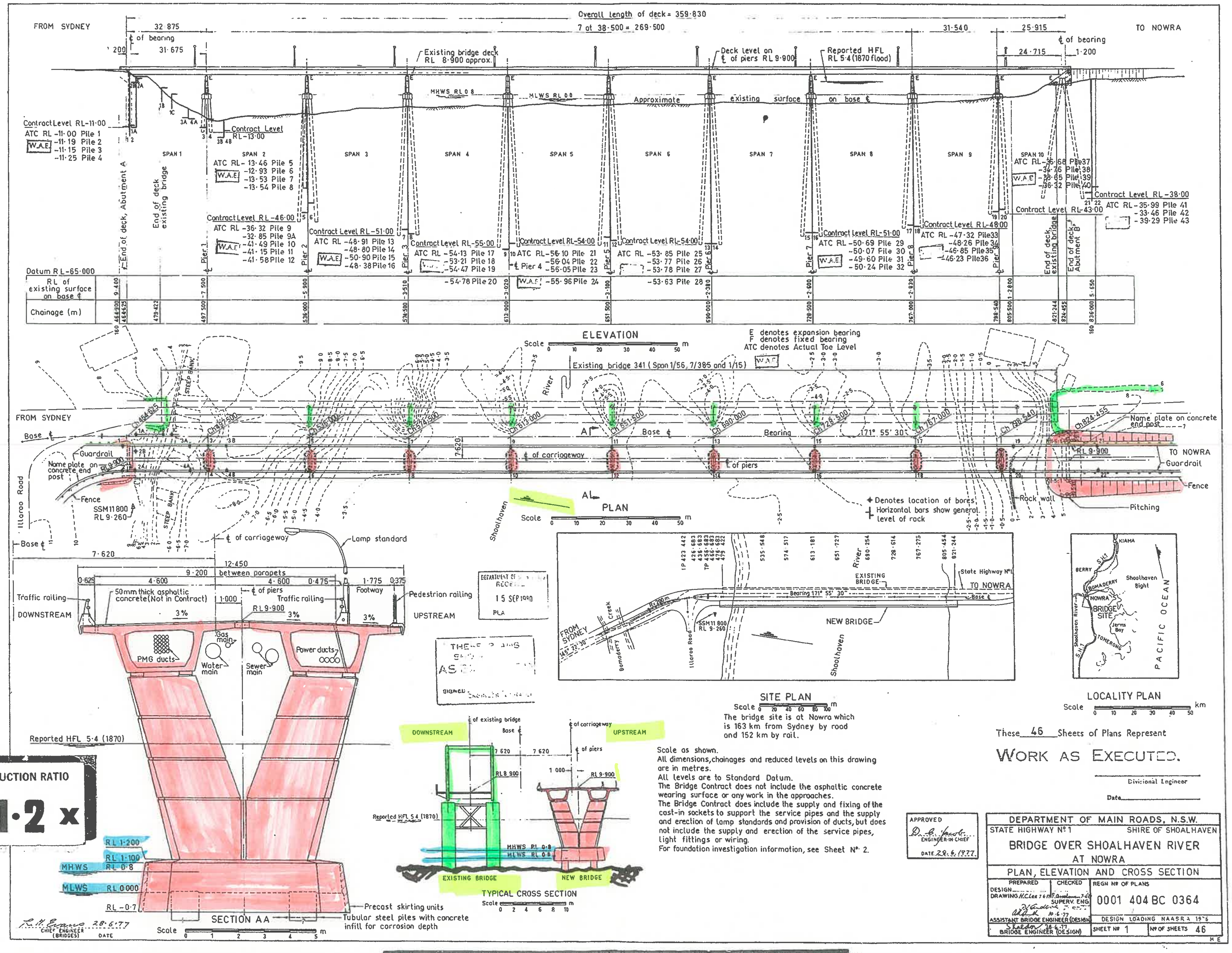
PREPARED		CHECKED	REGISTRATION No OF PLANS
DESIGN	B.LORD	B.LORD	DS2018-000467
DRAWING	S.DICHE	P.LEES	BRIDGE NUMBER: B07464
APPROVED	DESIGN QA RECORDS		ISSUE STATUS: PRELIMINARY
DIRECTOR			SHEET No 103 — ISSUE 1

CAD No DS2018-000467-DC-BR-DRG-0103.dwg

PRODUCED: 2 May 2018 AT 12:01:54 PM USER: Peter Lees
PLOT DRIVER: NONE
PEN TABLE: ---

Appendix H

Existing Nowra Bridge Drawings



Overall length of deck = 359·830
7 at 38·500 = 269·500
FROM SYDNEY
TO NOWRA
Existing bridge deck RL 8·900 approx.
Deck level on ℄ of piers RL 9·900
Reported HFL RL 5·4 (1870 flood)
Approximate existing surface on base ℄
SPAN 1
SPAN 2
SPAN 3
SPAN 4
SPAN 5
SPAN 6
SPAN 7
SPAN 8
SPAN 9
SPAN 10
Datum RL -65·000
RL of existing surface on base ℄
Chainage (m)
ELEVATION
E denotes expansion bearing
F denotes fixed bearing
ATC denotes Actual Toe Level
Existing bridge 341 (Span 1/56, 7/385 and 1/15)
PLAN
Denotes location of bores. Horizontal bars show general level of rock
Name plate on concrete end post
Guardrail
Fence
Rock wall
Pitching
Illaroo Road
Shoalhaven River
SITE PLAN
The bridge site is at Nowra which is 163 km from Sydney by road and 152 km by rail.
LOCALITY PLAN
PACIFIC OCEAN
SECTION AA
12·450 between parapets
50mm thick asphaltic concrete (Not in Contract)
Traffic railing
Pedestrian railing
Footway
Lamp standard
DOWNSTREAM
UPSTREAM
PMG ducts
Gas main
Water main
Sewer main
Power ducts
Reported HFL 5·4 (1870)
Precast skirting units
Tubular steel piles with concrete infill for corrosion depth
TYPICAL CROSS SECTION
EXISTING BRIDGE
NEW BRIDGE
REDUCTION RATIO 21·2 x
Scale as shown.
All dimensions, chainages and reduced levels on this drawing are in metres.
All levels are to Standard Datum.
The Bridge Contract does not include the asphaltic concrete wearing surface or any work in the approaches.
The Bridge Contract does include the supply and fixing of the cast-in sockets to support the service pipes and the supply and erection of lamp standards and provision of ducts, but does not include the supply and erection of the service pipes, light fittings or wiring.
For foundation investigation information, see Sheet Nº 2.
These 46 Sheets of Plans Represent
WORK AS EXECUTED.
DEPARTMENT OF MAIN ROADS, N.S.W.
STATE HIGHWAY Nº 1
SHIRE OF SHOALHAVEN
BRIDGE OVER SHOALHAVEN RIVER AT NOWRA
PLAN, ELEVATION AND CROSS SECTION
0001 404 BC 0364
DESIGN LOADING NAASRA 1976
SHEET Nº 1
Nº OF SHEETS 46